A3a.2 BENTHOS

A3a.2.1 Introduction

Available information relating to the benthos of the UKCS has been reviewed in successive SEAs – where appropriate in terms of three divisions; offshore, nearshore (to approximately 5km) from shore, and intertidal (littoral). These distinctions also correspond broadly to differences in survey methods and the coverage of both individual studies and regional programmes. In recent years there have been a number of additional data compilations and analyses, notably the Marine Natural Area profile (Jones *et al.* 2004) by English Nature (now Natural England), the UKSeaMap marine landscape classification (Connor *et al.* 2006) and the Mapping European Seabed Habitats (MESH) programme (MESH Partnership 2008), and some additional acquisition of data. Similarly, there have been developments in terms of conservation with OSPAR establishing a list of threatened and/or declining species and habitats in the North-East Atlantic, revisions to the UK Biodiversity Action Plan, and site designations. Increasing attention has also been focused on the assessment of changes in benthic community structure and function, in relation to the effects of regional climate change.

A3a.2.2 UK context

Over a period of nearly one hundred years, the biology of the seabed has been studied in the context of fisheries ecology and, latterly, in relation to biogeographical patterns of species distribution. More recently, numerous smaller spatial scale investigations of the seabed have been carried out, concerned primarily with environmental monitoring of various industrial activities (e.g. oil and gas developments, aggregate extraction, and sewage sludge dumping.

Benthic communities identified by various authors show consistency at a high level, and strong correlation with habitat (or substrate) type. Benthic communities in deeper water, soft sediment habitats tend to be spatially distributed over large scales, with distinctive species assemblages associated with particular substrate types and present over large areas. However, depending on the intensity and spatial extent of sampling, localised community types or more subtle variations may be distinguished, often associated with topographic features. The spatial scale of habitat and community variability in shallow water is generally much finer.

The Marine Nature Conservation Review (MNCR) was started in 1987 by the Nature Conservancy Council and, subsequent to the Environment Protection Act 1990, was continued by the JNCC on behalf of the conservation agencies (CCW, EHS, SNH, Natural England (formerly English Nature)) up to its completion in 1998. The focus of MNCR work was on benthic habitats and their associated communities, which together are described as 'biotopes' in inshore areas. Hiscock (1998) provides a review of information describing seabed habitats and communities in the north-east Atlantic and inshore areas within each of the 15 MNCR coastal sectors around Great Britain.

The recently completed UKSeaMap project (Connor *et al.* 2007) used available geological, physical and hydrographical data, combined where possible with ecological information, to produce simple broadscale and ecologically relevant maps of the dominant seabed and water column features for the whole sea area under UK jurisdiction. The UKSeaMap project also classified 32,000 samples to habitat type according to the National Marine Habitat Classification (Connor *et al.* 2004), before analysis against the predicted landscape types to

assess their ecological validity. Coastal physiographic features and topographic features on the shelf were very well validated overall; however, there was significant variability across the modelled landscape types, with some appearing to be well validated, whilst others (e.g. *Shallow coarse sediment plains* and *Shelf coarse sediment plains*) seemed to be poorly correlated against ecological information.

UKSeaMap distinguishes between a total of 24 sediment plain landscapes, using criteria of sediment type (coarse, mixed, sand and mud); water depth (shallow, shelf and deep); tidal velocity and (for deep-water) temperature. In comparison, the Marine Habitat Classification for Britain and Ireland (v05.05) distinguishes between 77 biotopes in sublittoral sediments – excluding macrophyte-dominated communities (e.g. maerl, kelp and seaweeds on sediment, and seagrass beds) and an additional eight biogenic reef biotopes on sediment (including *Sabellaria*, *Serpula*, *Modiolus* and *Mytilus* reefs/beds). The hierarchical classification is based on four sediment classes, and in large part on the presence of large (>5mm), visible bivalves and epifauna. The recognised biotopes are also strongly numerically dominated by shallow water examples (only 12 are offshore sediment biotopes).

Developing a Framework for Mapping European Seabed Habitats (MESH) was a four year project which established a framework for mapping marine habitats by developing internationally agreed protocols and guidelines for seabed habitat mapping and generating the first compiled marine habitat map for north-west Europe. The project covered the entire marine areas of Ireland, the UK, Netherlands, Belgium and France from the Belgian border to southern Loire on the Atlantic Coast.

The MESH map of seabed habitats for north-west Europe was derived from a library of over 1,000 data sets. Habitat prediction models were developed either to fill the gaps where existing survey data were not available, or to help understand the distribution of specific habitats using survey data. The same modelling approach was used to create two different types of map: maps showing the likely occurrence of EUNIS habitats and maps showing the distribution of more broadly defined marine landscapes. The MESH website (www.searchMESH.net) is organised around the Product Library, which in turn leads to the MESH webGIS and the MESH Metadata Catalogue allowing users to overlay their own data onto the MESH maps or other web mapping services.

A3a.2.3 Ecological context

The seabed and benthos is a fundamental part of the marine ecosystem, critical to nutrient cycling and of major importance as a food resource for man, fish, birds and other animals. The seabed is the spawning ground of several commercially important species and is the ultimate sink for discharged and spilled materials.

Quantitative studies of the biology of the seabed have been undertaken for the last 100 years, initially in the context of fisheries ecology and biogeographical patterns of species distribution. More recently, numerous smaller spatial scale investigations of the seabed have been carried out world-wide concerned primarily with environmental monitoring of industrial effluent discharges, oil and gas developments, port developments etc. In addition there have been a range of benthic studies undertaken of specific habitats, for assessments of conservation status and for documentation of the biodiversity of an area.

Benthic fauna exhibit a diversity of feeding methods, the primary modes being filter feeding (where particulate food is taken from the overlying water), deposit feeding (where food deposited on the seabed or incorporated into sediments is swallowed, sometimes along with large quantities of sediments), grazing (of algae and other marine plants in shallow waters

and bacterial mats in deeper waters) and carnivory (predators on other animals and carrion feeders). In addition, there are parasites, commensal and symbiotic species.

Benthic animals and plants can significantly affect the seabed in terms of sediment stability (increasing through the effects of e.g. tubes and roots, or decreasing through burrowing activity), sediment accumulation (e.g. fine material in the interstices of mussel beds), habitat creation (e.g. low biogenic reefs formed by the activities of methane metabolising bacteria, aggregations of Sabellaria spinulosa tubes or horse or blue mussels can provide hard surfaces in sedimentary areas), and habitat complexity (e.g. through seabed armouring by large dead shells allowing fine sediment retention in tide swept areas).

A3a.2.4 Features of Regional Sea 1

Stephen's surveys in the 1920s (Stephen 1923, 1930) represent the first large-scale survey of the offshore areas in the northern North Sea, with over 1,000 sublittoral samples as well as littoral sampling, and provide a good historical baseline for further studies. Later, McIntyre (1958) extended the investigations of the benthos of fishing grounds with surveys off the east coast of Scotland, in Aberdeen Bay, St Andrews Bay, and the Smith Bank at the outer reaches of the Moray Firth. Subsequent studies include a series of surveys combined to give North Sea wide coverage coordinated by ICES (Künitzer *et al.* 1992).

The MESH map of seabed habitats for Regional Seas 1 & 2 (i.e. the North Sea) is shown in Figure A3a.2.1.

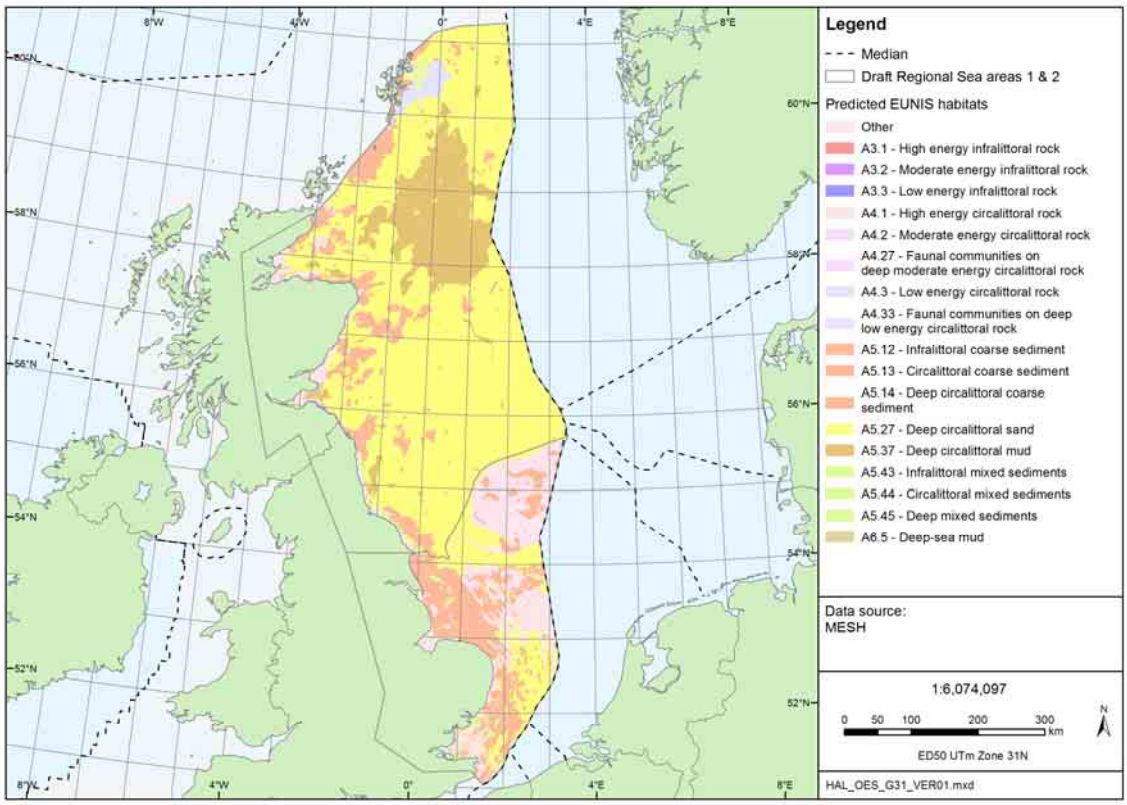
A3a.2.4.1 Offshore habitats and species

The benthic infauna of the offshore northern North Sea in general is characterised by its tendency towards higher diversities than the central or southern areas (Künitzer *et al*. 1992). While these results may be attributable, in part, to the use of finer sieves (typically 0.5mm in the northern area as opposed to 1mm elsewhere), the gradual increase in diversity northward through the southern and central areas would suggest that this gradient does exist. There may be a relationship between this increase and changes in depth and productivity in the area, but the variability of the data makes it difficult to discern clear divisions on smaller scales. Eleftheriou *et al*. (2004) provide a review of community types described from the SEA 5 area, also making major distinctions between areas north and south of 57° 30'N (i.e. well to the north of the Regional Sea Areas 1-2 boundary). Broadscale patterns of offshore macrofaunal distribution are described by Glémarec (1973), Basford *et al.* (1990), Duineveld *et al.* (1990), Künitzer *et al.* (1992) and Jennings *et al.* (1999).

Early studies of benthic epifauna recovered in fishing trawls have been followed by photographic surveys (using a camera attached to the headline of a demersal trawl) (Dyer *et al.* 1982, 1983; Cranmer *et al.* 1984), while Basford *et al*. (1989, 1990) investigated epifaunal community assemblages using a 2m Agassiz trawl, at 38 stations in the area north of Peterhead. Statistical analysis of the latter distinguished two groups of stations in the area:

- fauna inhabiting moderately sorted, coarse sediments with relatively low silt and organic carbon levels characterised by sponges, the bryozoan *Flustra foliacea*, the anemone *Bolocera tuediae*, and the crab *Hyas coarctatus,* typically in the sandy areas extending south of Fair Isle to off Peterhead
- the deeper, finer sediments of the Fladen Ground and its northern extensions where the fauna was typified by the echinoderms *Asterias rubens, Astropecten irregularis* and *Bryssopsis lyrifera*.

Figure A3a.2.1 – MESH classification of marine biotopes, Regional Seas 1, 2



Source: MESH (2008)

The latter group was further subdivided giving a deeper mud-dwelling group in the Fladen area characterised by the seapen *Pennatula phosphorea* and a shallower group in the surrounding area typified by the hermit crab *Pagurus bernhardus,* the shrimp *Crangon allmanni,* the purple heart urchin *Spatangus purpureus* and the gastropod *Colus gracilis*. Similarly, further divisions of the first group separated a shallower (70m) and coarser sediment group inhabiting the sediments between Orkney and Shetland and off the Buchan coast typified by the presence of sponges; and a deeper (100m), finer sediment group typified by tunicates and the shrimp *Spirontocaris lilljeborgi* covering the intermediate flat offshore area. South of 57° 30'N, analysis grouped the majority of the stations together based on the presence of sponges, tunicates, *Spirontocaris lilljeborgi* and the hermit crab *Pagurus bernhardus*.

Infaunal community distribution in the area is relatively well described over broad scales. From 1980 to 1985, Basford *et al*. (1989, 1990) took macrofaunal and sediment samples every 15 miles in a grid extending across the North Sea from just north of Shetland to the Firth of Forth. Analysis of this data in conjunction with the sediments produced two major groups according to the amount of silt present in the sediments. The major group of stations containing less than 20% silt was sub-divided into a fine sand group, inhabited by *Abra prismatica, Ophelina neglecta, Travisia forbesi, Bathyporeia elegans* and *Eudorellopsis deformis*; an inshore, coarser sandy sediment group (near Shetland) where *Hesionura elongata, Dorvillea kefersteini, Protomystides bidentata* and *Tellina pygmea* were present, and a finer (medium to very fine sand) group, which was characterised by *Spiophanes kroyeri, Myriochele heeri, Harpinia antennaria* and *Aricidea wassi*.

A second major group of stations defined by containing more than 20% silt was geographically located in the Fladen Ground. The seabed fauna of the muddy sediments of the Fladen Ground is generally regarded as uniform with moderate species richness and faunal densities, and with moderately high productivity but low biomass. The low biomass may be in part an artefact of inadequate sampling of deep burrowing species such as the crustaceans *Nephrops* and *Calocaris*, and the hagfish *Myxine* which, although contributing substantial biomass, are generally poorly sampled by grab and core samplers (SEA 2).

Basford *et al.* (1990) reported on additional sampling, extending from off Orkney to the inner Moray Firth. These samples indicate a gradient of infaunal density from less than 3,000 individuals /m^2 offshore increasing up to 6,000 in the outer Moray Firth. Species richness varied from 30 to 60 species per station with no detectable pattern. The initial division shown in the analysis of the data revealed an inshore group and an offshore group. These groups were subdivided into a siltier group characterised by the polychaete *Pisione remota*, and a coarser silt group typified by the bivalve *Nucula tenuis*. The offshore group was further subdivided with the polychaete *Spiophanes bombyx* representative of the shallower, less silty group and the amphipod *Eriopisa elongata*, *Thyasira* spp. and other bivalves, and the polychaetes *Lumbrineris gracilis* and *Ceratocephale loveni* representative of the deeper siltier samples.

Several areas in Regional Sea 1 (both offshore and nearshore) were surveyed in 2003 as part of the SEA Programme, in order to address identified data gaps. These included Fair Isle, outer Moray Firth, Pobie Bank, Smith Bank, Sandy Riddle and Southern Trench; and are summarised in SEA 5.

A3a.2.4.2 Pockmarks

Pockmarks are a widespread feature in muddy sediments in the central and northern North Sea that have only recently begun to be explored in detail. The macrofaunal ecology of an active Fladen Ground pockmark (the Scanner pockmark in block 15/25, within Regional Sea 1) was described by Dando *et al.* (1991), who found that the fauna of sediments within the pockmark was characterised by the bivalve *Thyasira sarsi* (which is known to contain symbiotic sulphur-oxidising bacteria) and a mouthless and gutless nematode, *Astomonema southwardorum*, which also contains symbiotic bacteria. Methane derived authigenic carbonate (MDAC) blocks, deposited through a process of precipitation during the oxidation of methane gas, lie in the base of the pockmark and support fauna more typically associated with rocky reef. These carbonate structures are notably colonised by large numbers of anemones (*Urticina felina* and *Metridium senile*) and squat lobsters (Dando *et al.* 2001). The carbon isotope compositions ($\delta^{13}C$) of the tissues of benthic animals from in and around the pockmark indicated that little methane-derived carbon was contributing to their nutrition.

This pockmark area has been proposed by JNCC for designation as a SAC containing the Annex I habitat “Submarine structures made by leaking gases”. A second proposed pockmark SAC, the Braemar pockmarks, consists of a series of crater-like depressions on the sea floor. In this location, large blocks, pavements slabs and smaller fragments of MDAC have been deposited.

Another manifestation of gas seepage, the formation of carbonate cemented columns, has been found in the Kattegat (eastern North Sea) by Jensen *et al*. (1992). Such features are not known to occur in UK parts of Regional Sea 1.

A3a.2.4.3 Nearshore and coastal habitats and species

SEAs 2, 3 & 5 presented a geographical summary of nearshore benthic habitats and communities of the east coasts of Scotland and England north of Flamborough Head – largely drawn from MNCR coastal sector reports and JNCC Coastal Directories. From primarily the same sources, the English Nature Marine Area Profile for Mid North Sea (Jones *et al.* 2004) characterised nearshore benthic habitats of the English part of the area as being composed predominantly of muddy sand, whereas further offshore the sediment is mainly sand with patches of gravelly sand and muddy sand. To support SEA 5, a synthesis of current information on the benthic environment and the benthic communities and associations was produced by Eleftheriou *et al*. (2004); this synthesis covered nearshore habitats and species of the Scottish part of Regional Sea 1.

The major firths of the Scottish east coast – the Moray Firth and Firths of Tay and Forth – together with other significant inlets on the mainland coast (e.g. the Ythan estuary and Montrose Basin) all support habitats which may be characterised as estuarine and sheltered from wave action. These habitats include extensive intertidal sand- and mudflats which are of ecological and conservation importance, and sub-littoral habitats which are distinct from those of adjacent coastal areas. Reed beds and saltmarsh are also characteristic of upper estuary locations.

Open coastlines of the area provide a range of intertidal habitats from bedrock shores, boulders and cobbles, to extensive sandy beaches. Shallow subtidal habitats are predominantly sands, gravels, or a mixture of the two, although extensive areas of exposed rock also occur, with characteristic epifaunal communities. Reasonable survey coverage of rocky intertidal and shallow subtidal habitats in the area has been produced, in part due to work related to the MNCR (Hiscock 1998, Bennett & Foster-Smith 1998). On a UK-wide basis, this work has been the basis for a classification of biotopes (i.e. distinctive habitat with associated flora and fauna) and regional reports. However, Eleftheriou *et al*. (2004) note that for important stretches of hard substrata on the east coast of Scotland there is little or no information available.

A3a.2.5 Features of Regional Sea 2

The MESH map of seabed habitats for Regional Seas 1 & 2 (i.e. the North Sea) is shown in Figure A3a.2.1.

As with the eastern English Channel, the seabed fauna of the southern North Sea has colonised and developed over the last 6 to 11,000 years, in the process being subject to a change from Arctic to more temperate Boreal conditions.

A3a.2.5.1 Offshore habitats and species

In terms of broad community distribution, the ICES survey reported by Künitzer *et al.* (1992) provides a good picture of community distribution in the southern North Sea. Four main communities were distinguished, corresponding to the following habitats:

- fine sands in 50-70m with a fauna typified by the polychaetes *Ophelia borealis* and *Nephtys longosetosa*
- muddy fine sands in 30-50m with the bivalve *Nucula nitidosa*, the shrimp *Callianassa subterranea* and the cumacean crustacean *Eudorella truncatula*

- coarse sediments mainly in less than 30m (1) with the polychaete *Nephtys cirrosa*, the sea urchin *Echinocardium cordatum* and the amphipod crustacean *Urothoe poseidonis*
- coarse sediments mainly in less than 30m (2) with the polychaetes *Aonides paucibranchiata* and *Pisione remota* and the amphipod crustacean *Phoxocephalus holbolli*

Dyer *et al.* (1983) conducted cluster analyses of trawled (primarily epi-) fauna from MAFF groundfish surveys over the whole North Sea, showing the area could be divided into 4 northern and 3 southern groups. The southern groups corresponded to the northern slopes of the Dogger Bank (S3), the shallowest part of the Dogger Bank and other shallow stations on the western side of the North Sea (S2), and the broad area of muddy fine sands off the Dutch coast forming group S1.

The cluster analysis performed by Jennings *et al.* (1999) indicated that the epifauna of the whole North Sea south of the Dogger Bank was similar and formed a single cluster. In contrast, Rees *et al.* (1999) concluded that the area could be divided into 6 groupings based on sediment type and epifauna.

A3a.2.5.2 Offshore sandbanks

A series of sandbanks and tidal sand ridges (the Norfolk Banks) dominate the middle section of the southern North Sea; sandbanks also occur elsewhere in the southern North Sea (parts of the previous SEA 2 and SEA 3 areas) although there is no published quantitative information on the fauna present. Since at the time some sandbanks in waters of 20m or less were under consideration for inclusion in UK Natura 2000 sites (potential SACs), the DTI commissioned detailed surveys of these habitats within the SEA 2, SEA 3 and adjacent areas. Subsequently, JNCC (2007) have consulted on designation of a North Norfolk Sandbanks SAC including Leman, Ower, Inner, Well, Broken, Swarte Banks and four banks called, collectively, the Indefatigables. The banks are considered to support communities of invertebrates which are typical of sandy sediments in the southern North Sea such as polychaete worms, isopods, crabs and starfish (JNCC 2007).

Studies by Vanosmael *et al.* (1982) on the Kwinte Bank of Belgium, suggested that the fauna of offshore linear sandbanks is distinctive in a number of features, in particular the very high densities of interstitial (that is living in the interstices between sediment grains) polychaetes present. These species show very high variability between sampling stations, reflecting either (or both) patchiness of distribution or very tightly defined habitat requirements, so that a small alteration in location of samples results in a large difference in the fauna recorded.

It is clear that there are major sediment and faunal differences between the offshore linear sandbanks (the Norfolk Banks) and the banks in the approaches to the Wash. The Wash approach banks (Galahad field, Dudgeon Shoal, Cromer Knoll and the western end of the Haddock Bank) have a stony and coarse shell sediment with extensive epifauna and infauna. In contrast, the offshore linear banks are sandier with a fauna typified by the sea urchin *Echinocardium cordatum* and the bivalve *Fabulina fabula* with sandeels (two species) common.

The SEA survey samples of the Dogger Bank indicate a richer (more and larger animals of a range of species) fauna than that found on the sandbanks to the south. At the 5mm material level, no major differences were discerned between the various stations sampled across the Dogger Bank (SEA 2). Predominant species were *Echinocardium cordatum*, *Fabulina fabula* and a range of worms including the sand mason *Lanice conchilega* and *Owenia fusiformis*.

The fauna recorded during the DTI survey of the southern SEA 2 sandbanks accords closely in terms of species distribution with previous surveys of the area. Banks off the south Norfolk, Suffolk and Essex coasts are likely to support similar faunal communities.

A3a.2.5.3 Nearshore habitats and species

SEA 3 presented a geographical summary of nearshore benthic habitats and communities of the east coast of England south of Flamborough Head – largely drawn from MNCR coastal sector reports and JNCC Coastal Directories (Irving 1995a, b, 1998). From primarily the same sources, the English Nature Marine Area Profile (Jones *et al.* 2004) characterised benthic habitats of the area as composed predominantly of sandy gravel closer to the shore, whereas further offshore the sediment is mainly sand with patches of gravel, sandy mud and sandy gravel.

Towards the southern end of the southern North Sea a discontinuous belt of gravel and sandy gravel extends offshore from Aldeburgh in Suffolk to the vicinity of Clacton-on-Sea in Essex. To the north of the area many of these sediments generally form a surface layer less than 1 metre thick, with the underlying glacial deposits or bedrock often exposed locally. The gravel habitats found in deeper offshore areas (>30m) generally tend to be less perturbed by natural disturbance than those found closer inshore. These areas also tend to support a diverse marine fauna which may include a wide range of anemones, polychaetes, bivalves and amphipods, and both mobile and sessile epifauna.

Sand habitats are very widespread throughout the southern North Sea and are the dominant habitat type found in the North Sea. They tend to be mobile but accumulate in areas of moderate to strong tidal currents; in such situations the sands are coarse and clean with little silt/mud. More mobile sand habitats tend to be characterised by robust and sometimes impoverished faunas, dominated by organisms which are capable of rapid burrowing, such as certain mobile polychaete worms, burrowing amphipods and thick-shelled bivalves.

Chalk reefs occur at two locations within the southern North Sea, in the south within the Thanet coast Special Area of Conservation (SAC), and in the north within the Flamborough Head SAC. Chalk reef habitats characteristically support a wide range of species, some of which are unique to this type of substrata. Subtidal chalk at Thanet is bored by piddocks *Barnea* spp., *Pholas dactylus*, *Hiatella arctica* and *Petricola pholadiformis;* this piddock-dominated habitat is the most widespread biotope on the subtidal reef and is considered to be scarce in Britain. The chalk reefs at Flamborough support kelp *Laminaria hyperborea* forests with an associated fauna that typically colonises the holdfasts. These kelp communities are considered to be a key structural and functional component of the chalk reefs at Flamborough Head. The chalk reefs at Flamborough also support a variety of faunal 'turf' communities, ranging from low encrusting forms, such as sea mats and sponges, to tall erect forms, such as soft corals and sea fans, plus mobile organisms such as crustaceans, echinoderms, molluscs and fish.

There are larger numbers and a wider range of cave habitats at Flamborough Head candidate SAC than at any other chalk site in Britain; over 200 caves have been recorded at Flamborough Head, although a proportion of these are above Mean Low Water. Flamborough Head is particularly important for its specialised encrusting and filamentous algal communities which include *Hildenbrandia rubra*, *Pseudendoclonium submarinum*, *Sphacelaria nana* and *Waerniellina lucifuga.* The bedrock floors of the caves are characterised by abundant *Sabellaria alveolata* and sponges such as *Leucosolenia* spp. or

the chalk-boring yellow sponge *Cliona celata* and *Polydora* spp. worms, characteristic of the chalk habitats.

A3a.2.5.4 Estuarine habitats and species

The Wash is a large (66,000 ha) sea inlet, about half of it exposed at low water in the form of sand and mudflats, an area comparable in Britain only to Morecambe Bay. In the outer reaches there are deep channels between the sandbanks, the greatest depth (47m) being recorded from the Lynn Deeps, midway between Hunstanton and the Friskney shore. The intertidal flats, amounting to around 40% of the total area of the Wash, consist mainly of fine sands supporting a community characterised by the lugworm *Arenicola marina*, with cockle *Cerastoderma edule*, Baltic tellin *Macoma balthica*, mussel *Mytilus edulis,* the gastropod *Hydrobia ulvae*, the crustacean *Corophium volutator* and the polychaete worm *Nephtys hombergii* (English Nature 1994).

Major river estuary channels, e.g. the Humber and Thames, where tidal scour may be considerable, generally consist of mixed mud, muddy sand and gravel, with a fauna comprised predominantly of capitellids, oligochaetes, nematodes and the polychaete *Polydora* sp. The diversity and quantity of species present is related primarily to salinity and water quality (i.e. organic pollution loading).

Rees *et al.* (1982) describe five main community types in the Humber estuary:

- Impoverished marine sand, in the central channel from Immingham to the mouth, influenced by tidal action and characterised by *Nephtys* spp., mysid shrimps, *Spio filicornis* and *Spiophanes bombyx*.
- 'Transitional' muddy sand, mostly from Barton to Immingham on the south side, influenced by tidal current action, with *Capitella capitata*, *Polydora* sp., mysid shrimps, Gammaridae and *Nephtys* spp.
- Impoverished estuarine muddy sand, from the upper estuary to Paull Roads on the north side, influenced by tidal current action. Sparse fauna, distinguished from transitional muddy sand by the absence of polychaetes.
- Marine sand, at the southern mouth, containing a rich fauna in areas which were presumed to be less exposed than those of impoverished marine sand in the main channel. Characteristic species include *Spiophanes bombyx* and *Spio filicornis*.
- Nearshore mud, off Immingham and Grimsby, with a rich mud fauna including *Polydora* sp. and *Pygospio elegans*.

The sea bed of much of the Thames estuary consists of gravel, pebbles, clay or chalk, with silt and mud occurring in areas of deposition. A 1972 study by MAFF of the sea bed around the sewage sludge disposal sites in the outer Thames Estuary was described by Talbot *et al.* (1982), who identified nine faunal and sediment associations, the most common ones being dominated by the polychaete worms *Nephtys* spp., *Spio* spp. and *Spiophanes* spp., bivalves *Tellina* spp. and amphipods. A survey of 218 sites between Gravesend Reach and the Black Deep approach channel to the outer Thames estuary was carried out in 2001, together with a trawl survey and assessment of the age structure and commercial significance of cockle (*Cerastoderma edule*) populations, as part of an environmental assessment of the proposed London Gateway Port project (Newell *et al*. 2001). In general, the communities were found to be rich in species (for this type of habitat), with high biomass values especially in the intertidal mudflats of the upper estuary. Epifauna was dominated by the swimming crab *Liocarcinus holsatus*, prawn *Pandalus montagui* and brown shrimp *Crangon crangon* with colonial bryozoa *Alcyonidium diaphanum* and hydroids *Sertularia cupressina*. Multivariate analysis of macrofaunal community structure distinguished at least five

communities, corresponding to variation in sediment, water depth, salinity and current velocity. Recent large scale grab and trawl surveys in support of proposed offshore wind farm developments further out in the region of the Long Sand and Kentish Knock sandbanks (LAL 2005) and the Inner Gabbard and Galloper sandbanks (GGOWL 2005) found broadly similar communities; species-poor worm and amphipod communities dominated shallow sandy areas and richer polychaete dominated communities occurred on more stable, often deeper, areas where sediments were usually coarser.

The native oyster *Ostrea edulis* is sufficiently abundant to form an important fishery in some shallow inshore areas of the Thames estuary, notably in areas of mixed shell and gravel over mud, for example off the North Kent Coast between Whitstable and Herne Bay. The introduced slipper limpet *Crepidula fornicata* is also common in similar areas.

A3a.2.5.5 Biogenic habitats

Sabellaria reefs are present within the southern North Sea, in particular offshore from the Wash on sandy gravel substratum (see Foster-Smith & Hendrick 2003). *Sabellaria spinulosa* reef has also been found in an aggregate licence area (401/2) which is approximately 13 nautical miles east of Great Yarmouth (Newell *et al.* 2000). The area surrounding the *Sabellaria* reef is characterised by stable coarse, gravelly sand and it is likely that this habitat is present in the surrounding offshore waters. There is also an area of *Sabellaria spinulosa* reef (now named Saturn Reef; included within the North Norfolk Sandbanks and Saturn Reef pSAC) discovered as part of a survey in 2002 on behalf of ConocoPhillips, located in the southern North Sea sandbank area between Swarte and Broken banks. Samples from the reef indicated an associated community dominated by polychaetes (most abundant species are *Pholoe synophthalmica* and *Mediomastus fragilis*) and epifaunal species otherwise associated with crevice habitats (e.g. *Galathea intermedia*). The gastropod mollusc, *Noemiamea dolioliformis*, believed to an ectoparasite of *Sabellaria spinulosa* (see Killeen & Light 2000) was also recorded (Subsea 7 2003). In 2003, the Saturn reef covered an area approximately 750m by 500m just to the south of Swarte Bank, varying in density over this area (JNCC 2007). More recent survey in the Saturn area did not find the extensive reef found in 2003, but whether this absence is as a result of damage to the reef structures (e.g. by bottom trawling) or whether such reefs are naturally ephemeral is not yet known. However, formation of such a substantial reef of *Sabellaria spinulosa* in this area in 2003 indicates favourable conditions for reef formation.

S. spinulosa aggregations also occur regularly in the outer Thames estuary (e.g. GGOWL 2005, LAL 2005) and as far upstream as Canvey Island (Attrill *et al*. 1996), but do not appear to be so extensive or well developed as around the Wash.

Intertidal mussel beds formed by *Mytilus edulis* are extensively distributed and commercially exploited within Regional Sea 2.

A3a.2.6 Features of Regional Sea 3

Regional Sea 3 (the eastern English Channel) has not previously been assessed by the SEA programme, although benthic habitats and species of the area have been reviewed in the Marine Natural Area profile (Jones *et al.* 2004). Habitat mapping has been carried out under the UKSeaMap marine landscape classification (Connor *et al.* 2006) and the MESH programme (MESH Partnership 2008).

The MESH map of seabed habitats for Regional Seas 3 & 4 (i.e. the English Channel, Bristol Channel and Celtic Sea) is shown in Figure A3a.2.2.

Within the Quaternary period, the topography of the English Channel has been modified by the action of numerous eroding marine transgressions and palaeo-rivers active during glacial low-stands. It has also been postulated that a large proglacial lake to the north-east of the Weald-Artois Anticline ridge developed and subsequently caused the failure which produced a significant outflow of water into the English Channel, probably in the mid-Pleistocene. The most recent major change in status took place about 6000 years ago when the Flandrian transgression occurred. As with the southern North Sea, therefore, the seabed fauna of the eastern English Channel has colonised and developed over the last 6 to 11,000 years, in the process being subject to a change from Arctic to more temperate Boreal conditions.

A3a.2.6.1 Habitats and species

Primarily drawn from MNCR coastal sector reports and JNCC Coastal Directories (Barne 1996, 1998a, b), the English Nature Marine Area Profile (Jones *et al.* 2004) characterised benthic habitats of the area as being composed of an assortment of mixed sediments (especially gravel and shells) with sand and, in sheltered locations, mud. There are also occasional and sometimes extensive exposures of bedrock and boulder reefs, often occurring off headlands such as Beachy Head, Selsey Bill and the Purbeck coast. In deeper water further offshore, the seabed is dominated by sediments, mainly of sand, sandy gravel and gravel.

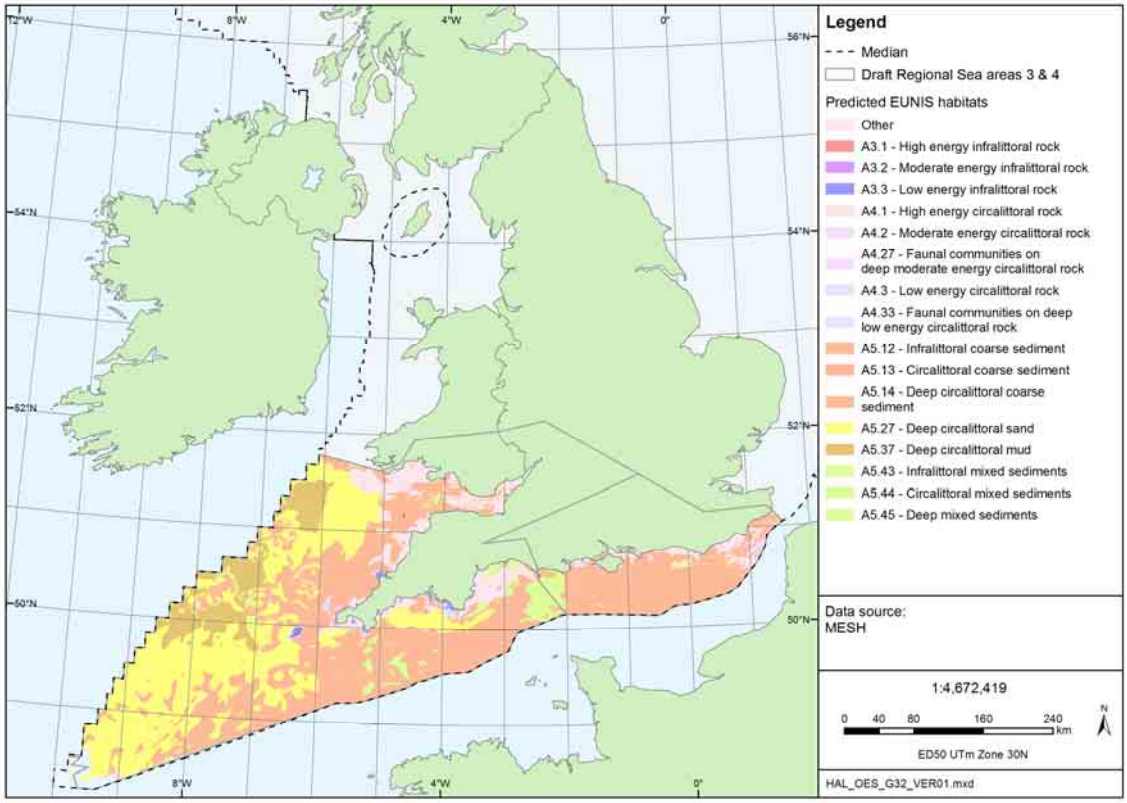
In offshore areas of the Eastern Channel there are extensive deposits of gravel to the south and east of Selsey Bill. Further west there are also significant banks known as the Dolphin and Shingles Banks (within the western approaches to the Solent), the Solent, Brambles and Ryde Middle Banks (Solent), the Horse and Dean and Medmerry Banks (eastern approaches to the Solent), and banks in Poole Bay. In addition to these banks there are several large gravel areas present, some of which exceed 2 metres in height; and several banks of sandy gravel of 'veneer' thickness, i.e. <0.5m thick. The gravel habitats found in deeper offshore areas (>30 metres) have, in general, low levels of natural mobilization (through wave and current action), and support diverse marine fauna which may include a wide range of anemones, polychaetes worms, bivalves and amphipods and both mobile and sessile epifauna.

Nearshore 'mixed sediments' are formed of variable amounts of sand, gravel and cobble, often mixed with dead shells and shell gravel. In areas where these mixed sediments are stable, particularly during the summer months, settlement and subsequent growth of a rich variety of plant and animal species occurs. The slipper limpet *Crepidula fornicata* is a characteristic species of the Solent region (Collins & Mallinson 2000). This non-native species is commonly associated with gravel and its shells can form the main hard substrate in areas of soft sediments.

Extensive brittlestar beds are frequently encountered in deep water (30-50m) in the eastern English Channel (Ellis & Rogers 2000), although they are also occasionally found closer to the coast. Collins (2002) recently found an *Ophiothrix fragilis* bed approximately 2km off Kimmeridge Bay, to the west of Swanage, Dorset.

Sand habitats are found in regions of moderate to strong tidal currents and are characterised by robust and sometimes impoverished faunas, typically venerid bivalves, amphipods (shrimps), polychaetes worms and heart urchins.

Figure A3a.2.2 – MESH classification of marine biotopes, Regional Seas 3, 4



Source: MESH (2008)

Sandbanks within Regional Sea Area 3 tend to be in shallow water and the communities they support are determined by the sediment type and a variety of other physical factors, including geographical location, the relative exposure of the coast and differences in the depth, turbidity and salinity of the surrounding water. These sandbanks provide important nursery grounds for young commercial fish species, including plaice, cod and sole (Brown *et al.* 1997). Patches of a very dense tube mat biotope were found by Rees *et al*. (2004) during fish habitat studies in the eastern English Channel. At three locations in the lows between linear sand banks off the French coast an un-described small polychaete *Chaetopterus* sp. occurred with small *Lanice conchilega* as an enriched sediment stabilizing biotope. This biotope was distinct though with similarities to other tide swept sub-tidal biotopes dominated by *L. conchilega*. Using cameras and side-scan sonar it was seen to overlay heterogeneous cobbles and shell hash with intermittent rippled sand veneer. The patchiness of this enriching biogenic feature contributed to the variability in trawl catches of fish.

Mud-dominated sediment in Regional Sea 3 are located in estuarine harbours and in deeper water 'troughs' or 'deeps' (although these are not deep in the context of other Regional Sea areas). The fauna of muddy sediments in this area is generally dominated by polychaete worms, bivalve molluscs such as cockles, and brittlestars.

A3a.2.6.2 Rock and rock reefs

Offshore, the eastern English Channel basin is dominated by a large expanse of varied bedrock habitat, with gravel and bedrock outcrops. The water depths in the vicinity are generally between 50-75m, with the exception of a linear deep that reaches 100m. The extremely heterogeneous nature of the habitat is due to the complex geology of the region,

where folded bedrock is overlain by coarse sediment patches (gravel, pebbles, cobbles and boulders), and both may be covered in more mobile sandy sediments. The current strengths are sufficient to mobilise fine gravel, which results in a highly disturbed environment. Epibenthic fauna, such as barnacles and bryozoans, have been found encrusting sampled cobbles from here (Graham *et al.* 2001).

The coastline of the south east of England is well known for its chalk cliffs. Chalk is also present in the shallow subtidal, occurring as three main forms which may all be classified as reefs (in the context of the Habitats & Species Directive; Jones *et al.* 2004). These are (1) gently shelving platforms which extend from the shore beyond Low Water Mark; (2) low-lying nearshore outcrops; and (3) sections of low-lying subtidal cliffs. These nearshore chalk exposures occur at Shakespeare Cliff, between Dover and Folkestone (outcrops); between Beachy Head and Seaford Head (platforms); between Newhaven and Brighton (platforms); off Hove and Worthing (cliffs); off Culver Cliff on the east side of the Isle of Wight (outcrops), at the Needles on the west side (outcrops); and at White Nothe on the east side of Ringstead Bay in Dorset (outcrops).

Chalk is a relatively soft rock and a number of species that are capable of boring into the rock tend to dominate the associated subtidal communities. These species include bivalve piddocks (in particular *Pholas dactylus*, *Hiatella arctica*, *Barnea* spp. and *Petricola pholadiformis*), polychaete worms (especially spionids) and sponges. The biotope dominated by piddocks is often the most widespread of the biotopes which occur on these reefs but is scarce in Britain as a whole. The growth of the kelp *Laminaria hyperborea*, which typically grows as 'forests' on shallow parts of reefs elsewhere, is considerably restricted in the Eastern Channel due to the high turbidity and the consequent restricted light penetration. However, there are often lush growths of various red seaweeds such as *Calliblepharis ciliata*, *Delesseria sanguinea* and *Halurus flosculosus* and, slightly deeper, a variety of faunal turf communities. These latter are likely to feature low encrusting forms such as sea mats and sponges to tall erect forms such as soft corals and hydroids, plus mobile organisms such as crustaceans, echinoderms, molluscs and fish.

Sandstone reefs occur from Beachy Head to Selsey Bill, whilst limestone reefs are more commonly encountered in the west, e.g. at Bembridge on the Isle of Wight and off Durlston, Kimmeridge, Lulworth and Portland in Dorset. In shallow water, sandstone and limestone bedrock and boulder surfaces are covered (often up to 80% covered) by foliose algae, with occasional kelp plants *Laminaria* spp. also present. In slightly deeper water, several species of sponge are likely to be conspicuous, including *Esperiopsis fucorum* and *Dysidea fragilis*. *Pentapora fascialis*, a coral-like bryozoan which may grow in clumps up to 40cm tall, is often conspicuous on bedrock outcrops. Overhangs may be dominated by a variety of sea squirts, bryozoans, hydroids, anemones and the soft coral *Alcyonium digitatum*.

Mudstone with a hard, clay-like consistency may be present as smooth, horizontal exposures in a number of nearshore areas, and is often partially covered by mixed sediments (which scour the surface of the mudstone smooth). In the eastern Solent it is often found below a layer of limestone cap rock, and erosion results in large chunks of the limestone breaking off and forming boulder slabs. Soft clay is commonly encountered in nearshore areas off Selsey Bill, most dramatically as the near vertical cliff forming the Mixon Hole. Although little life is obvious on the cliff itself, the clay face is riddled with piddock *Pholas dactylus* holes, with various species of crustacean present on the horizontal ledges (Irving 1999).

Within Sandown Bay and elsewhere on the eastern side of the Isle of Wight, discrete areas of soft mud support reef-like 'beds' that are formed by thousands of mud tubes inhabited by the amphipod crustacean *Ampelisca* (spp). The tubes are packed tightly together to

completely cover the underlying substratum, which may be smooth bedrock or consolidated mixed sediments. Each individual 'bed' rarely covers more than about 25 square metres of the seabed. Few other organisms are specifically associated with these *Ampelisca* 'beds'.

A3a.2.7 Features of Regional Seas 4 and 5

Regional Sea 4 (the western English Channel, Bristol Channel and Celtic Sea) has not previously been assessed by the SEA programme, although metadata assessment of the proposed SEA 8 area has been carried out (Voisey 2004). Benthic habitats and species of the area have been reviewed in the Marine Natural Area profiles for the South Western Peninsula (Jones *et al.* 2004a) and Western Approaches (Jones *et al.* 2004b) and mapped by the UKSeaMap marine landscape classification (Connor *et al.* 2006) and the MESH programme (MESH Partnership 2008). There has been extensive sampling of coastal and nearshore habitats in the English Channel and Bristol Channel; however, for deeper offshore areas of the Western Approaches, very little information is available.

The pioneering studies of Le Danois in the first half of the 20th Century were described in the 1948 publication "*Les Profondeurs de la Mer*", characterising the marine fauna occurring in the Celtic Sea and Bay of Biscay, from south-western Ireland to the Cantabrian Sea.

The benthic invertebrate fauna of the English Channel has been sampled intermittently from 1899. The longest continuous dataset are those collected by Holme from 1959-1985 (Holme 1966), that have more recently been assessed for quality of the data and potential for resurvey (Genner *et al*. 2001). Holme made a point of resurveying historic sites, e.g. Eddystone Grounds, which had been originally surveyed between 1895 and 1898 and again from 1931 to 1932. Three datasets were produced: 1) survey of seabed species, 2) brittlestar survey and 3) death assemblages. There is also an extensive archive of videotapes, videocassettes and photographic transparencies. The seabed species dataset comprises a qualitative faunal record of echinoderms and molluscs from anchor dredge samples from 324 stations distributed throughout the English Channel. In addition Holme compiled reference lists from comparable historic MBA surveys as far back as 1895. The brittlestar survey used a mini-Agassiz, and provides a quantitative record of all echinoderms from 329 stations on the south coast of England. Death assemblages are a record of all dead-shell material retained in anchor dredges. Offshore areas of the English Channel were further investigated using towed video and still cameras by Holme & Wilson (1985). The area studied, about 37km south of the Dorset coast, was predominantly of hard substrata often with transitory sand cover.

Regional mapping of sedimentary macrobenthic communities in the English Channel has also been described by Cabioch *et al*. (1977).

Other than epibenthic trawling undertaken by CEFAS during groundfish surveys of the area, there have been no published quantitative studies of the benthic assemblages in the offshore Celtic Sea (Marine Institute 1999), although details of the molluscs from a regional benthic survey (Hartley & Dicks 1977) have been published (Hartley 1979) and there is work relating to benthic communities in the adjacent Irish Sea and St. Georges Channel (Mackie *et al*. 1995; Ellis *et al*. 2000) and more extensively to the Porcupine Bank and Goban Spur (Lampitt *et al*. 1986, Flach *et al*. 1998; Flach & Bruin 1999).

Very recently, the Celtic Margin canyons at the extreme SW boundary of Regional Sea 4 have been mapped by the MESH South West Approaches Canyons Survey (MESH Cruise 01-07-01) (Davies *et al*. 2008).

A3a.2.7.1 Offshore habitats and species

In the deep offshore waters of Regional Sea 4, the seabed is dominated in terms of spatial area by sediment habitats which are formed mainly of sand, or mixtures of sand and gravel. Gravel occurs in the east and south of the area, grading to more muddy habitats in the north of the area, and tends to be less perturbed by natural disturbance than that found in shallower coastal waters.

Offshore relict tidal sand-banks occur across offshore areas of Regional Sea 4 as large bedforms, which may be up to 50km long, approximately parallel to the tidal direction (Heathershaw & Codd 1985). Although there are very sparse data, it is likely that these areas of sand are characterised by a fauna comprising polychaetes, molluscs, echinoderms and crustaceans, with the species present varying according to the sediment type.

The most extensive published survey of the benthic fauna of the Celtic Sea is that undertaken in 1974 and 1975 by the Field Studies Council Oil Pollution Research Unit (Hartley & Dicks 1977; Hartley 1979). The fauna at most sites was typical of a 'deep Venus community' as described by Mackie (1990). At the edge of the Celtic Deep, the communities were typical of a 'boreal deep mud association' and included the brittlestars *Amphiura chiajei* and *Amphiura filiformis*, the bivalves *Nucula sulcata*, *Nucula tenuis*, *Thyasira flexuosa* and *Abra nitida*, and polychaetes *Myriochele heeri*, *Lagis koreni* and *Amphicteis gunneri*.

For the northern Celtic Sea adjacent to the St. Georges Channel McBreen *et al*. (2008) analysed data from Mackie *et al*. 1995 and Wilson *et al*. 2001 and some unpublished HABMAP results in a study of sediment characteristics as predictors of benthic biological communities. This indicated that biological assemblages were not only linked to particle size but also to the chemical properties of the sediments, and that the use of particle size as a proxy for biological assemblages in biological habitat mapping risked overlooking distinct and representative habitats.

During the period 2000-2006, approximately 150 tows with a 2m-beam trawl have been undertaken by CEFAS. Ellis *et al*. (2002) used multivariate community analyses to describe two distinct macro-epibenthic assemblages; one dominated by the anemone *Actinauge richardi* found along the edge of the Celtic Shelf and another characterised primarily by the hermit crab *Pagurus prideaux* and its commensal anemone *Adamsia carciniopados*, but with 3 sub categories and dominated by a wider range of species, found in the Celtic Sea.

Warwick *et al*. (1986) and Warwick & Joint (1987) investigated the size distribution of taxa (pelagic and benthic) at a site in the Celtic Sea (CS2, 50º 30'N 07º00'W), in relation to community ecology and the evolutionary constraints on species body size.

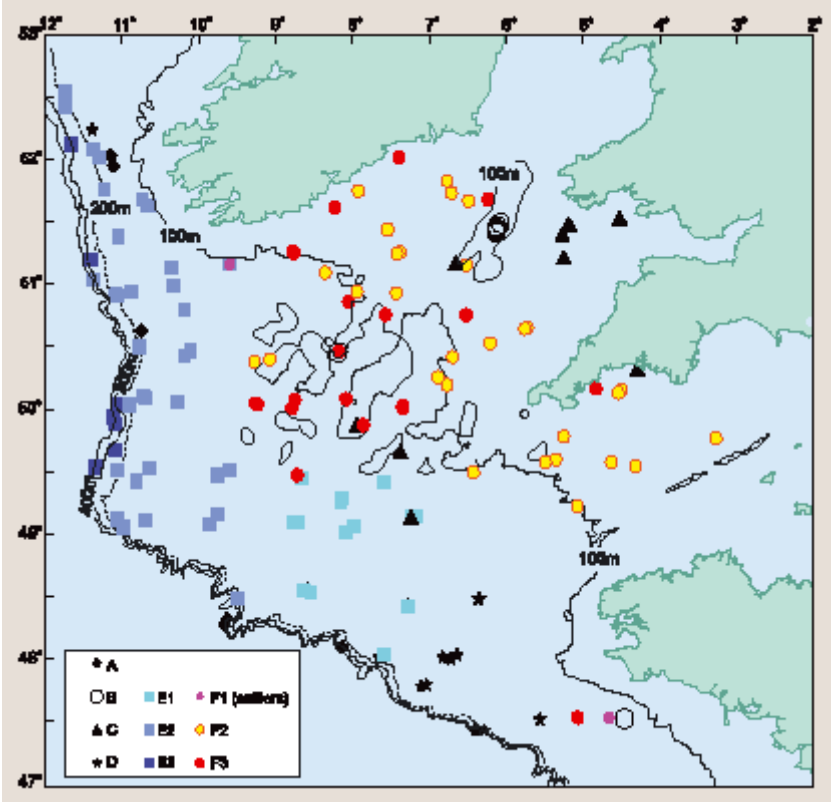
A3a.2.7.2 Offshore reefs

There are two significant areas of offshore rocky reef present within Regional Sea 4. Haig Fras is a distinct topographical feature which is located approximately 150km offshore in the Celtic Sea, consisting of a granite outcrop approximately 45x15km, rising from a surrounding seabed depth of 100-110m to within 38m of the surface. A remote camera survey (Rees 2000) demonstrated that the bedrock on the peak has three distinct deep-water reef biotopes associated with it, with a further, more complex and less well-defined biotope present where boulders and cobbles were partly embedded in sediment at the base of the shoal. The biotopes are:

- Biotope dominated by jewel anemones *Corynactis viridis*
- Biotope dominated by Devonshire cup corals *Caryophyllia smithii*

- Biotope characterised by cup sponges and erect branching sponges
- Complex biotope with red encrusting sponge, *Caryophyllia smithii* and featherstars (crinoids) on boulders with the bryozoan *Pentapora fascialis*, squat lobster *Munida* sp. and brittlestars (ophiuroids) also common

Figure A3a.2.3 – Distribution of epibenthic assemblages in the Celtic Sea, based on CEFAS beam trawls.



Source: Ellis (2007)

The second major reef area is located at the extreme SW boundary of Regional Sea 4, where canyons at the Celtic Margin (approximately 320km south of Cork and south-west of Land's End) were examined as part of the MESH South West Approaches Canyons Survey (MESH Cruise 01-07-01) (Davies *et al*. 2008). It was predicted that these canyons may contain bedrock and biogenic reefs formed by cold water corals (two of the three sub-types for Annex I reef). As this area is more influenced by southerly 'warmer' water bodies, it may contain biological communities very different from those Annex I reefs occurring in the far northwest of the UK offshore area which are influenced by 'cold' Arctic waters.

Interestingly, the canyon interfluves, or canyon tops, were found to comprise numerous mounds up to 10m in height and ~80m in diameter. These mini-mound features were not identified within the shallow sub-surface imaged by the seismic data and it was concluded that they are modern features possibly forming through colonisation and subsequent growth on a relict sea bed rather than accumulation over time. Significant amounts of coral rubble were observed coincident with these mounds. It is likely that this area once hosted diverse carbonate mounds similar to those found on Porcupine Bank (Roberts *et al*., 2003 & 2008) and the northern Rockall Trough (Masson *et al*., 2003; Roberts *et al*., 2003) but have since been destroyed.

All three canyons exhibited a diverse array of substratum types supporting a range of large epifaunal species. Sea cucumbers (Holothurians), squat lobster (*Munida rugosa*), numerous anemone and several starfish species, sea pens, shell debris and fish species were encountered. Thirteen biotopes were described from the canyons, and of these, six were proposed as new EUNIS habitat types. Six clusters were identified during the multivariate analysis of biological data and were used to define new habitat types according to the EUNIS classification hierarchy. Ten new biotopes were defined from the six clusters, with video observation providing further faunal detail. A further three biotopes were identified from video observations as either no fauna were present on which to undertake cluster analysis or the communities were not sampled by the images.

The biological communities observed in and around the canyons are similar to those observed at comparable depths and temperatures on other deep-sea features in the UK's offshore area. However, the hard substrate communities observed at other offshore areas in the NW of Britain were, in general, more species-rich than those observed in the canyons of the SW approaches. It is possible that this may be a sampling error resulting from the poor-resolution images of bedrock and coral reef obtained in this survey and the limited observations of reef habitat obtained. However, video observations suggest sediment scour and smothering may prevent many species from colonising the available hard substrate. Importantly, one biotope observed in the SW canyons has not been observed during surveys of other deep-sea features. This biotope was found on muddy sand and characterised by the seapen *Kophobelemnon* sp. and cerianthid anemones. This biotope was similar to that of the shallow EUNIS habitat type Circalittoral fine mud, which is characterised by the seapens *Virgularia mirabilis* and *Pennatula phosphorea* together with the burrowing anemone *Cerianthus lloydii* and the ophiuroid *Amphiura* spp. This newly described biotope could be considered a deep-water version of this shallower habitat type.

- Biotope 1 Sand/mud with burrowing (*Amphiura* sp.) and surface dwelling ophiuroids
- Biotope 2 Mud with sea pens (*Kophobelemnon* sp.), seastars (*Pseudarchaster* sp.), anemones (*Bolocera* sp.) and holothurians (*Benthogone* sp.)
- Biotope 3 Bedrock ledges with annelids/hydroids and anemones
- Biotope 4 *Lophelia pertusa* reef, with predominantly sediment clogged *L. pertusa* and live *Madrepora oculata*
- Biotope 5 Coral rubble with squat lobsters (*Munida* sp.), ophiuroids and crinoids
- Biotope 6 Mixed sediments with squat lobsters (*Munida* sp.), ophiuroids and crinoids
- Biotope 7 Bedrock with a sand veneer, little visible fauna
- Biotope 8 Bedrock /boulders with little visible fauna
- Biotope 9 Bedrock with sand veneer, with anemones
- Biotope 10 Bedrock with barnacles (poss. *Bathylasma* sp.)
- Biotope 11 Mud/sand with signs of bioturbation and occasional cerianthid anemones
- Biotope 12 Mud with abundant cerianthids, and little other fauna
- Biotope 13 Bedrock with reef like fauna (corals/crinoids)

Annex I biogenic reef (biotope 4), reef rubble (biotope 5) and bedrock reef (biotopes 3 and 13 and limited examples of biotope 6) were all observed within the canyons of the SW Approaches. Annex I stony reef was not observed. Cold water coral (*Lophelia pertusa*) reef was observed within and at the seaward entrance to the Explorer Canyon between depths of 743-925m. It was associated with areas of sediment covered and exposed bedrock on the canyon flanks. In addition, areas of reef rubble were observed in the vicinity of intact reef within the canyon but more commonly on the interfluves of Dangaard Canyon associated with mini-mound structures. It is likely that these mound structures support or once supported live *Lophelia* reef. Bedrock supporting reef-like fauna was observed in all canyons. Bedrock reef communities were observed at the heads, on the flank and on the

canyon floor from 237-1030m. The megabenthic fauna of the bedrock reef areas appear similar to bedrock reef areas on other UK offshore features at similar depths (Narayanaswamy *et al*., 2006; Howell *et al*., 2007) although a combined analysis of both datasets would be required to establish this conclusively. In addition, much of the encrusting fauna of bedrock reef habitat is difficult to identify below phylum level without physical samples. Thus faunal differences may exist that are undetectable at the resolution achievable with video and image sampling.

A3a.2.7.3 Nearshore habitats and species

As described by Jones *et al.* (2004a), the nearshore benthic habitats of the South Western Peninsula Natural Area are varied, ranging from the fine muds of sheltered estuaries and rias (drowned river valleys, resulting from post-glacial rise in relative sea level), to exposures of granite bedrock, and to a lesser extent sandstone, limestone, shales and mudstone. In general, the nearshore seabed is composed of an assortment of mixed sediments (especially gravel and shells) with sand and, in sheltered locations, mud. There are also occasional and sometimes extensive exposures of bedrock and boulder reefs, often occurring off headlands. In deeper water, which may not be that far from the shore, the seabed is dominated by sediments, mainly of sand, sandy gravel and gravel. Nearshore rocky reefs extend along the north coast of Cornwall and Devon, particularly adjacent to hard cliffs and shores. The reefs around the Isles of Scilly and the island of Lundy are of particular importance.

Several areas of gravel occur offshore towards the east of Regional Sea 4. Inshore and adjacent to Chesil Beach, gravels occur out into Lyme Bay, though as a result of their mobile nature these support a relatively impoverished epifauna. Further west off Start Point, the seabed is composed of areas of mobile sand and gravel, interspersed with bedrock outcrops covered in a rich turf of animal species (Barne *et al*. 1996d). In general, the gravel habitats found in deeper offshore areas (>30m) tend to be less affected by natural disturbance than those found closer inshore.

The Fal Estuary supports what is probably the best developed maerl bed in UK waters outside of Scotland (Anon 1999).

Sand habitats are widespread, particularly in the west of Lyme Bay, in the large embayment between Salcombe and the Lizard, in Mount's Bay, to the south west of the Isles of Scilly, off Port Isaac Bay, in Bideford Bay and in the approaches to the outer Bristol Channel. The communities which these sand areas support are determined by a number of factors including the exact nature of the sediment, the relative exposure of the coast and differences in the depth, turbidity and salinity of the surrounding water. More mobile sand habitats tend to be characterised by robust fauna and sometimes impoverished faunas; venerid bivalves, amphipods (shrimps), polychaetes (worms) and heart urchins are particularly characteristic.

Subtidal sediments consisting of muddy sand are either restricted to areas sheltered from the prevailing winds and currents (e.g. the western side of Lyme Bay), or to areas of seabed deeper than 50m where there is little or no wave action (such as in the approaches to the outer Bristol Channel). Sediments of muddy sand in Lyme Bay support a community dominated by the bivalve *Corbula gibba*, the polychaete worms *Chaetozone setosa* and *Magelona filiformis* and the amphipod *Bathyporeia tenuipes* (Ambios Environmental Consultants 1995). Other notable species records from Lyme Bay include the worm anemone *Scolanthus callimorphus*, the polychaete *Sternapsis scutata* and the mantis shrimp *Rissoides desmaresti*. Most of the rias within the region have areas of shallow or intertidal sandbanks, often with areas of subtidal muddy gravel. On the south coast of Devon, the

seabed of Tor Bay is of relatively uniform muddy sand that supports a diverse burrowing community dominated by bivalves, brittlestars and anemones. A small yet important population of the burrowing red band fish *Cepola rubescens,* which appears to be more or less restricted to Regional Sea 4 in British waters, was discovered in the Bay (Devon Wildlife Trust 1995), with other small populations reported from Brixham Harbour (as well as from more muddy sediments).

A small area of fine sand and mud sediment off Whitsand Bay to the west of Plymouth Sound supports infaunal communities dominated by polychaetes but including burrowing sea cucumbers *Leptosynapta inhaerens* and *Trachythyone elongata* and the burrowing shrimp *Callianassa subterranea*. A number of the sediment-dwelling species that occur off the south coast of Devon and Cornwall have a distribution which is limited to south western waters. Of particular note is the rich shell fauna, including southern species such as the bivalve *Callista chione*. Areas of clean sand off Plymouth Sound support an infaunal community featuring *Dosinia exoleta* and *Abra prismatica* (Hiscock & Moore 1986).

Subtidal rock in the Lyme Bay area consists largely of rocky reefs which fringe the coastline, particularly adjacent to hard cliffs and shores. Also of particular note are offshore bedrock reefs which emerge from sediment. These discrete reefs, most of which are between 3 and 8km offshore, support rich faunal communities with some conspicuous, though rarely encountered, Mediterranean-Atlantic species. These include the bryozoan *Pentapora fascialis*, dense stands of the pink sea fan *Eunicella verrucosa* and a population of the rare solitary coral *Leptopsammia pruvoti* (at Saw Tooth Ledges). The occurrence of these last two species is of national importance (Barne *et al*. 1996d).

The Manacles, a small group of rocks about 2km offshore, are characterised by dense growths of sponges, hydroids and sea squirts. The East Rutts rock outcrop rises from the seabed at 35m to 9m below the surface just west of Salcombe. A similar sub-surface outcrop occurs a little further west at the Eddystone Rocks, which is some 20km south of Plymouth Sound and is formed of flat-faced, angular vertical cliffs with overhangs, colonised by a turf of bryozoans, hydroids, anemones and extensive patches of jewel anemones *Corynactis viridis*. A high proportion of southern species are present here with similar communities being found off Hands Deep, a rock outcrop to the north west of Eddystone.

In the Isles of Scilly, subtidal bedrock reefs fringe the coastline, particularly adjacent to rocky shores, though there are also reefs further offshore which emerge from sediment. Off the sheltered east coast of St Mary's, in depths of 25-35m, several south west species of nature conservation importance are found, including the branching sponge *Axinella dissimilis*, the corals *Leptopsammia pruvoti* and *Hoplangia durotrix*, and the pink sea fan *Eunicella verrucosa*. Eighteen sub-types of subtidal rock habitat have been identified around the islands (Hiscock 1984), reflecting the wide range of environmental conditions present.

Much of the coastline of south Devon and Cornwall is wave exposed, although further offshore wave stress is lower, and extremely rich animal communities are present, often with spectacular growths of dead man's fingers *Alcyonium digitatum*, *Eunicella verrucosa*, jewel anemones *Corynactis viridis* and Devonshire cup corals *Caryophyllia smithii*. Similarly, along the north Cornwall coast, rock may extend into the sublittoral zone adjacent to rocky shores; with communities in the infralittoral zone dominated by algae (most noticeably the brown algae *Dictyopteris membranacea* and *Dictyota dichotoma*) to depths in excess of 20m. Extensive bedrock reefs are present off the west and north coasts of Cornwall, with smaller outcrops occurring in Mount's Bay, south west Cornwall.

At Lundy, the granite or slate bedrock reefs range from west-facing bedrock reefs, which are very exposed to wave action, to more sheltered east-facing reefs. Each contains a diverse

range of features, such as vertical surfaces, overhangs, gullies and upward-facing silted surfaces; there are also sheltered boulder slopes close to the east coast of the island. This diversity of habitats leads to a wide range of marine life, including many south western species which have a limited occurrence elsewhere in the area (English Nature 1997c). A more detailed description of benthic habitats and communities around Lundy is given in Barne *et al.* (1996a).

The sublittoral habitats and communities of the Bristol Channel and the Severn Estuary have been well studied. Here, grab and dredge sampling on a grid of 155 stations in 1972/3 provided information on the composition and distribution of communities within the system (Warwick & Davies 1977). These were divided into five main community types indicated in Table A3a.2.1.

Table A3a.2.1 – Sublittoral Communitites of the Bristol Channel and Severn Estuary

Community	Habitat description	Notes/associated species
Bivalve *Venus* community	Sands, especially in the outer Bristol Channel	A bivalve *Tellina* community on hard-packed sand, and a bivalve *Spisula* community on loose sands.
Bivalve *Abra* community	On silty or mixed bottoms in the outer Channel	The bivalve *Abra alba*, the polychaetes *Scalibregma inflatum* and *Lagis koreni*, and others
Horse mussel *Modiolus* community	On hard substrate, mostly in the central Channel	The hermit crab *Pagurus bernhardus*, the scaleworm *Lepidonotus squamatus*, the brittlestar *Ophiothrix fragilis*, and others
Reduced species diversity hard substrate community	On rocky substrate subjected to strong tidal scour, mostly in the inner part of the Channel	The polychaetes *Typosyllis armillaris*, *Eulalia tripunctata*, *Sabellaria alveolata*, *Sabellaria spinulosa* and others
Reduced species diversity soft substrate community	In fluid muds of the inner Channel	The polychaetes *Tharyx marioni*, *Nephtys hombergii* and *Peloscolex* spp.

Source: after Warwick & Davies (1977)

The Severn estuary contains a variety of intertidal habitats, which together with the very large tidal range makes it one of the largest and most important intertidal zones in Britain. Thirteen community types have been identified from areas of littoral sediment within the Severn Estuary (Severn Tidal Power Group 1989). Their distribution appears to be determined primarily by sediment type and the level of consolidation, with salinity being of lesser importance. Communities within sediments are characterised by polychaete worms (the most dominant species being ragworms *Nereis* spp. and *Neanthes* spp. and the lugworm *Arenicola marina*) and amphipod crustacean (*Corophium* spp. and *Bathyporeia* spp.); those on top of the sediment are characterised by gastropod molluscs (in particular the spire shell *Hydrobia ulvae*). The rich invertebrate biomass present within these extensive intertidal sediment flats supports internationally important numbers of wading birds.

In the sublittoral, the Severn Tidal Power Group (1989) identified ten species associations within the Severn Estuary from grab samples, the associations again being determined largely by sediment type and exposure to tidal currents. Coarse sediments of consolidated gravel, pebbles and cobbles were dominated by the reef-building polychaetes *Sabellaria* (mainly *S. alveolata*, although some *S. spinulosa* was also recorded). These *Sabellaria* reefs may cover extensive areas of the sea bed, particularly where there are tide-swept hard

substrata affected by turbid water - a feature rarely found in other UK estuaries. Indeed, the richest association of species within the estuary (up to 25 species per sample) was associated with these reefs. Areas of medium/fine sand in shallower water close to both north and south coasts were characterised by a mix of bivalves, amphipods and polychaetes.

A major integrated survey of the geology, sediments and fauna of the outer Bristol Channel was undertaken between 2003 and 2005 (Mackie *et al*. 2006). The seabed was mapped using multibeam and sidescan sonar, and sub-bottom profiling, augmented with groundtruthing video and camera tows, beam trawl and grab sampling of sediments and fauna. The survey area could be divided into 4 main physical regions, Carmarthen Bay and its approaches, the outer Bristol Channel sands (divided into 2 sub-regions, the north with extensive fields of sandwaves up to 19m in height, and the south where there were few sandwaves over a gravelly sediment pavement), the Lundy platform and the Morte platform (off Ilfracombe), both with significant rock outcrops. Nearly 1000 species were found in the surveys including a number of rarities (see for example Holmes *et al*. 2006). Faunal analysis revealed 5 main benthic assemblages which corresponded to 8 infaunal and 3 epifaunal biotopes:

- Infralittoral mobile clean sand with sparse fauna
- Infralittoral sand with *Nephtys cirrosa* and *Bathyporeia* spp.
- Infralittoral compacted fine muddy sand with *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods
- Circalittoral muddy sand or slightly mixed sediment with *Abra alba* and *Nucula nitidosa*
- Offshore circalittoral sand or muddy sand with *Owenia fusiformis* and *Amphiura filiformis*
- Infralittoral mobile coarse sand with interstitial polychaete worms notably *Hesionura elongata* and *Microphthalmus similis*
- Circalittoral coarse sand or gravel with *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves
- Offshore mixed sediment with a polychaete rich deep *Venus* community
- Stable circalittoral mixed sediment with *Sabellaria spinulosa*
- Tide-swept circalittoral mixed sediment with *Flustra foliacea* and *Hydrallmania falcata*
- Tide-swept sublittoral sand with cobbles or pebbles and *Sertularia cupressina* and *Hydrallmania falcata*

There is comparatively little offshore information available for the Cornish coast of this region but studies for the proposed WaveHub facility some 20km off St Ives provide detailed information from seabed mapping, sampling and photography for the offshore area and potential cable routes to shore (SWRDA 2006). Multivariate analysis of grab samples indicated 4 statistically significant clusters each with characterising species, as follows:

Cluster A comprised inshore cable route stations characterised by taxa typically observed in shallow sublittoral sandy sediment environments, including three amphipod crustaceans, *Urothoe poseidonis*, *Bathyporeia guilliamsoniana* and *Bathyporeia tenuipes* and the polychaetes *Chaetozone setosa* and *Nephtys cirrosa*.

Cluster B included stations on the cable route with very poorly sorted pebble sediments. Characteristic species included the crab *Pisidia longicornis*, serpulid and *Typosyllis* sp. polychaetes.

Cluster C included WaveHub and other offshore stations with poorly sorted pebble sediments. Characteristic species were as for cluster B but present at higher densities.

Cluster D included WaveHub and other offshore stations with coarse to very coarse sand. The fauna was dominated by polychaetes *Glycera lapidum*, *Typosyllis* sp., *Eunice* sp., *Kefersteinia cirrata*, *Ehlersia cornuta*, *Protodorvillea kefersteini* and *Polygordius* sp.

Multivariate analysis of trawl samples showed 3 statistically significant clusters across the survey area as follows:

Cluster A of trawl stations on fine sands within St Ives Bay characterised by a sparse epifauna with low numbers of fish including sand gobies *Pomatoschistus* spp. and sole *Solea solea*.

Cluster B comprised trawls from the southern offshore area as well as the nearshore and offshore cable route and was characterised by *Pisidia longicornis* and the brittlestar *Ophiothrix fragilis*.

Cluster C included trawls from the northern parts of the offshore area and was dominated by queen scallops *Aequipecten opercularis* and the hermit crab *Pagurus prideaux*.

A3a.2.8 Features of Regional Sea 6

Regional Sea 6, the Irish Sea between St George's Channel and the North Channel, corresponds closely to the SEA 6 area and benthic habitats and species were reviewed as part of the SEA process in 2005. A variety of reports and survey work was commissioned to support SEA 6 including:

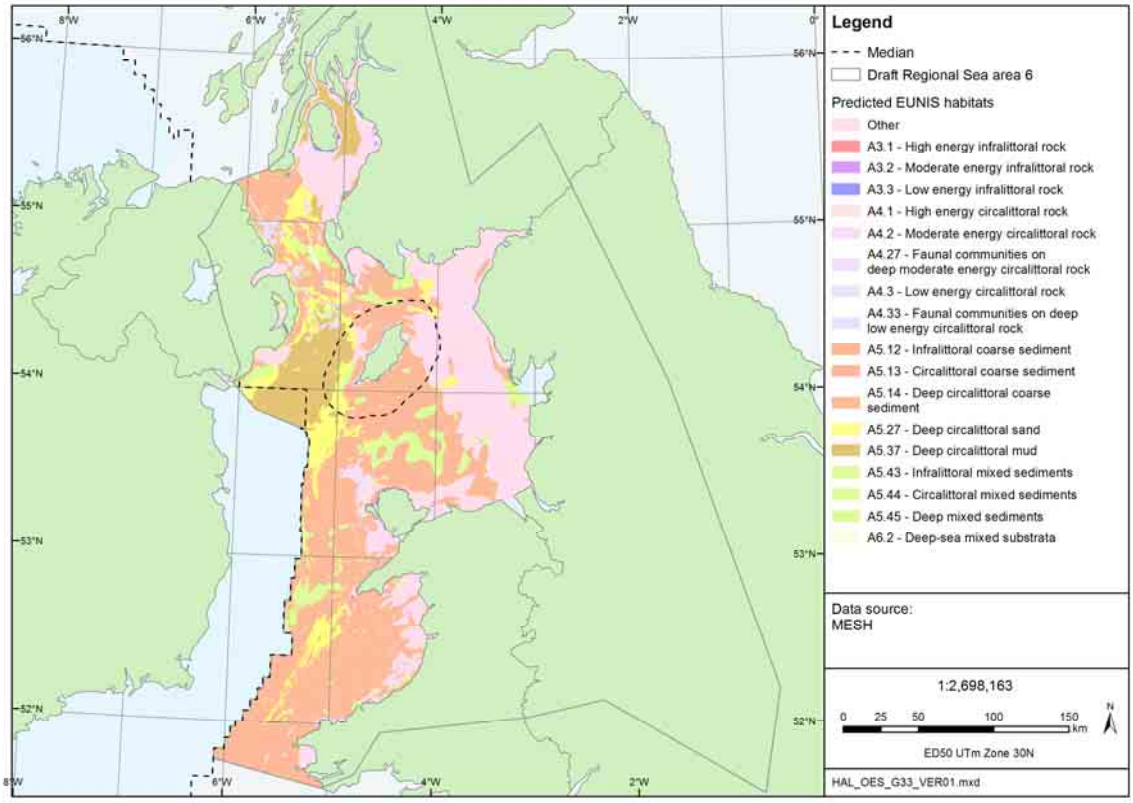
- A synthesis of current information on the benthic environment and the benthic communities and associations of the SEA 6 area (Wilding *et al*. 2005a).
- A synthesis of information on the benthos of SEA 6 Clyde Sea area (Wilding *et al*. 2005b).
- Survey report assessing the status of horse mussel beds in the Irish Sea off North West Anglesey (Rees 2005).
- Survey report detailing the distribution and extent of methane-derived authigenic carbonate within the SEA 6 area (Judd 2005).

Additional sources of information include:

- A variety of survey work commissioned by oil and gas operators, including broadscale seabed surveys and drilling surveys in the vicinity of the Isle of Man and St George's Channel and pre and post development surveys of oil and gas facilities in the Liverpool Bay area
- BIOMÔR reports 1 and 2, benthic biodiversity studies in the Southern and South West Irish Sea
- Output from the Irish Sea Study Group, in particular the Irish Sea environmental review
- Reports detailing rare species/communities including scientific papers detailing *Limaria hians* presence within the SEA 6 area and the atlas of marine Biodiversity Action Plan produced for the Countryside Council for Wales
- CCW intertidal habitat mapping studies.

The MESH map of seabed habitats for Regional Sea 6 is shown in Figure A3a.2.4 overleaf.

Figure A3a.2.4 – MESH classification of marine biotopes, Regional Sea 6



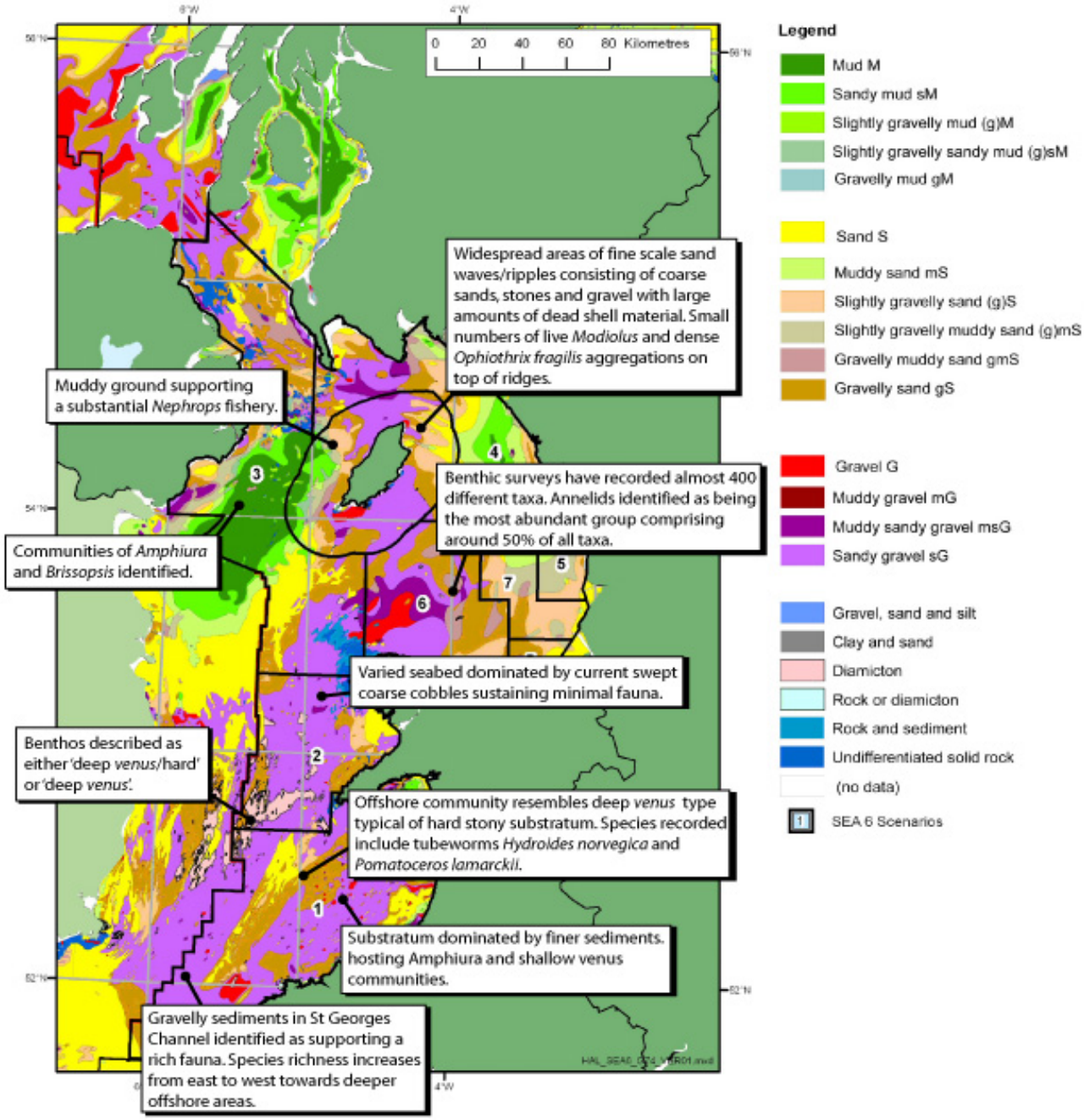
Source: MESH (2008)

A3a.2.8.1 Offshore habitats and species

Available information on offshore benthic communities of the Irish Sea are well summarised in Mackie (1990) where source references are also provided. In addition, benthic biodiversity of the southern Irish Sea from Anglesey to the Celtic Trough was surveyed in 1989 and 1991 by Mackie *et al*. (1995) during the BIOMÔR 1 project. An abundant and diverse polychaete dominated fauna was found, comparable to other deep water communities, and included a number of new species and species previously unrecorded in UK waters. The BIOMÔR 2 project (Wilson *et al*., 2001) survey the south-west Irish Sea but also included areas to the north of Anglesey, part of Cardigan Bay, St. Bride's Bay and the Celtic Deep.

Offshore sediments in the Irish Sea are predominantly sedimentary many of glacial origin consisting mostly of sands and muddy sands (Figure A3a.2.5). Most of the benthos of the Celtic Trough is described as either 'deep *Venus*/hard' or 'deep *Venus'* by Mackie (1990). The deep *Venus* community is characterised by the urchin *Spatangus purpureus* and the bivalves *Glycymeris* sp., *Astarte sulcata* and *Venus*. In sand wave areas the communities also often contain elements of both shallow (*Spisula* sub-communities) and deep *Venus* communities. These two communities are the most dominant in the offshore benthic environment of Regional Sea 6. Other reports confirm the generalisations made by Mackie (1990). For example, to the east of Tremadog Bay, the seabed is varied but dominated by current swept coarse cobbles sustaining, in places, minimal epifauna (Rees, 1993). However, in areas with micro-relief (formed by the presence of cobbles protruding into the current) the bivalve *Glycymeris glycymeris* was common. Accumulations of *Glycymeris* have also been recorded from the St. Georges Channel (Rees, 2004).

Figure A3a.2.5 – Offshore benthic communities of the Regional Sea 6 area



The southern Irish Sea, considered to represent a boundary between different biogeographical regions with several species reaching their distribution limits, is regarded as a significant source of benthic biodiversity (Mackie *et al*., 1995). During the BIOMÔR 1 project, Mackie *et al*. (1995) recorded 4 dominant assemblages, arranged in a continuum of overlapping mosaics. The deep soft muds of the Celtic Trough were characterized by small polychaete species, 12 of which were exclusive to this assemblage, including *Glycera rouxii*, *Prionospio dubia* and *Ampharete falcata*. A second assemblage was primarily associated with inshore sands and muddy sands and showed similarity to the '*Amphiura'* and 'shallow *Venus'* communities. The richest assemblage, and that with the most extensive

geographical coverage, was that associated with gravelly sediments and included conspicuous serpulids, other large polychaetes (*Polydora* spp.), an exclusive tubiculous ampharetid species and the amphipod *Guernea coalita*. A fourth less strongly defined assemblage appeared to be associated with shallow stony ground in Cardigan Bay and included polychaetes, gastropods, bivalves and crustaceans, none of which were exclusive to the assemblage.

Megafaunal burrowing communities are present in the deep muds of the northern Irish Sea (Swift 1993, Hughes & Atkinson 1997) and the Celtic Deep (Mackie *et al*. 1995) producing considerable biogenic topography on the seabed, and including seapens, *Virgularia mirabilis* and *Pennatula phosphorea*, together with several burrowing crustaceans (*Calocaris macandreae*, *Callianassa subterranea* and *Goneplax rhomboides*). Several epibenthic species are also common and include *Amphiura* spp., *Asterias rubens*, *Pagurus bernhardus* and *Liocarcinus depurator*.

A large broadscale seabed survey carried out in 1997 by the University of Liverpool, on behalf of BP (Holt *et al.* 1997), in the region east of the Isle of Man identified the area as being relatively uniform, probably consisting of fine and medium sands with various amounts of stones and shell. Sidescan sonar and video survey identified widespread areas of fine scale sand waves or ripples. A total of 475 taxa were recorded during this survey (Holt *et al.* 1997). Video analysis indicated that the areas of fine/medium sands were colonised by *S. purpureus*, *A. rubens*, *Pagurus bernhardus* and *A. irregularis* whilst coarser areas of seabed were commonly inhabited by *O. fragilis*. The sand waves/ripples identified consisted of much coarser sands, stones and gravel often with very large amounts of dead shell material including *Ensis*, *Modiolus* and *Glycymeris*. Living fauna varied from smaller numbers of *Modiolus* to dense feeding aggregations of *O. fragilis* on the tops of ridges. Areas of rich epifauna abundance were extremely rare and limited to small areas of coarse sand with stone, gravel or shell.

Muddy ground exists in only a few patches in the area, the largest of which occurs to the west of the Isle of Man and supports a substantial *Nephrops* fishery. Smaller pockets occur locally, for example to the south-west of the Lleyn Peninsula and off the Cumbrian coast. Deep water offshore bedrock outcrops are also uncommon, examples can be found west and north-west of Anglesey and off Strangford Lough (Barne *et al.* 1995d).

The Liverpool Bay area has been subject to considerable oil and gas exploration and production activity, and aggregate extraction, in recent years and consequently there is a wide variety of data available on the benthic communities of the area (e.g. Holt & Shalla 2002; Westminster Gravels Ltd 2006). Seabed surveys carried out around five of the main production installations in Liverpool Bay in 2001 recorded nearly 400 different taxa. Sampling identified slightly differing benthic compositions at each site although annelids were recorded as being the most abundant group at each often comprising around half of the total taxa found (Holt & Shalla 2002).

Survey of offshore areas northwest of Lleyn Peninsula indicated that the seabed is varied but dominated by current swept coarse cobbles sustaining minimal epifauna. However, in areas with micro-relief (formed by the presence of cobbles protruding into the current) the long lived bivalve *Glycymeris glycymeris* was common (Rees 1993).

In offshore parts of Cardigan Bay, finer sediments dominate the substratum. The sedimentary environment off Aberystwyth, where some of the earliest grab sampling work in the UK was done (Laurie & Watkin 1922), consists of muddy sand and is locally referred to as the 'Gutter'. The ground here supports an *Amphiura* type community (Rees 1993). The benthic biotopes of Cardigan Bay consist of fine sediments hosting *Amphiura* and shallow

Venus communities while muddier areas contain spionid polychaetes, the tubicolous ampharetid *Mellina palmata*, *A. filiformis* and the bivalve *A. alba* (Mackie 1990). In addition, the large burrowing crustacea *Upogebia deltaura* and *Callianassa* sp. have been recorded. Further offshore the community resembles the deep *Venus* communities typical of a coarse gravel/shell substratum exemplified by the presence of tubeworms such as *Hydroides norvegica, Pomatoceros lamarckii* and *Sabellaria spinulosa* and the ascidian *Dendrodoa grossularia.*

Investigations in the St George's Channel area by Mackie *et al*. (1995) identified that gravelly sediments sampled had the richest fauna and suggested that species richness increased from east to west toward the deeper offshore gravels of the channel. In addition, the number of taxa also increased from the Celtic Deep in the south toward the southern Irish Sea. Mackie *et al*. (2005) suggest that the Irish Sea gravels (with an average of 145 species per $0.2m^2$) represent one of the richest shelf habitats currently known. However, it is worth noting that equivalent richness has been reported elsewhere in the UK e.g. from the North Sea (Hartley 1984) and Shetland (May & Pearson 1995) and in such cases the richness can be interpreted as a reflection of the habitat complexity introduced by the presence of large bivalve shells (Hartley 1984). Outwith the Irish Sea area, comparable gravelly sediments and faunal communities are described from the English Channel (Holme & Wilson 1985, Kaiser & Spence 2002) and Fair Isle Channel (Wilson 1986).

Benthic epifauna, including demersal fish species, were surveyed using beam trawls in the Irish Sea, St Georges Channel and Bristol Channel by Ellis *et al*. (2000). They described six major assemblages; those in the inshore areas of the northern Irish Sea were generally ascribed to their "*Pleuronectes-Limanda* (plaice-dab) assemblage", where the hermit crab *Pagurus bernhardus*, the sand star *Astropecten irregularis*, and the flatfish dab *Limanda limanda* and solenette *Buglossidium luteum* were important discriminators. Beyond the 20m contour in Liverpool Bay, they found a "*Microcheirus-Pagurus* assemblage" dominated by starfish *Asterias rubens*, sole *Solea solea* and dragonet *Callionymus lyra,* with the thickback sole *Microcheirus variegatus* and the hermit crab *Pagurus prideaux* as important discriminating species, while a single site north east of Llandudno was dominated by dead man's fingers *Alcyonium digitatum*, *A. rubens,* and *L. limanda*, with high catches of species typical of hard or stony ground such as the anemone *Metridium senile* (*Alcyonium* assemblage).

A3a.2.8.2 Nearshore habitats and species

As a result of bathymetry, inshore waters of the Irish Sea, including littoral areas, occupy a proportionately large spatial area within Regional Sea 6 in comparison to other regions of the UKCS. A summary of the nearshore habitats and species is given below.

Nearshore habitats along the west coast of Wales from the Lleyn Peninsula at the northern limit of the scenario to Milford Haven in the south are characterised by a mixture of sandy gravel and gravel. Near shore sediments in the northern limits of the area comprise mainly sand and gravel. Further south in the Cardigan Bay area, sediments are primarily sandy in nature. Large glacial features known as sarns in the north of Cardigan Bay consist of long (>10km), narrow ridges of poorly sorted glacial outwash and moraine, frequently 6-8m in height and up to 500m across. Sarn environments are occasionally exposed during low spring tides and as a consequence the associated biota is somewhat ephemeral in nature. Most of the coastline is exposed or very exposed, the one exception being Milford Haven which is very sheltered, although with strong tidal currents in places. Nearshore sediments in the area are generally of a coarse nature, composed of gravel and sand although the substratum around Skomer between St Annes Head and Strumble Head is rock based. The

coast around Strumble Head and Skomer consists of a series of bays separated by headlands characterised by a relatively impoverished fauna determined by the degree of exposure.

The nearshore environment of this area is relatively current swept and consequently composed of coarse bedrock with sedimentary cover. Benthos identified in this nearshore area is typical of the substratum, characterised by dense coverings of bryozoans, sea squirts, the hydroid *Nemertesia antennina*, the crinoid *Antedon bifida*, dead man's fingers *Alcyonium digitatum* and the sponge *Cliona celata*. The south-west entrance to the Menai Strait was also reported to contain the highest number of sea cucumbers (Holothuroidea) in the Irish Sea (Ellis & Rogers 2000). CCW's Regulation 33 advice (CCW 2005) for the Pembrokeshire Marine SAC notes that there are six geographically distinct areas of reef recognisable within the SAC. In the shallowest areas the sublitoral reefs are dominated by *Laminaria* forest, with rich understories of red algae and a variety of animals and fish. In many of these reef areas a "tidal rapids survey" of Wales (Moore 2004) described a variety of mostly animal dominated communities, with numerous sponges, hydrozoans, encrusting and foliose bryozoans, and tunicates (sea squirts). Even at depths of 15-20m, however, there is also often a considerable cover of foliose red algae such as *Delesseria sanguinea* and *Erythroglossum laciniatum* on upward facing rocks. Sanderson (1995) noted that nationally rare and/or scarce seabed species are very numerous in the general area of west Pembrokeshire in comparison to most parts of the UK, but the majority are from the well studied areas in the immediate vicinity of Skomer or from within Milford Haven, and many are simply southern species at around their northern limit of distribution in the British Isles; for example the pink sea fan *Eunicella verrucosa.*

Strangford Lough is situated in County Down and is a shallow, glacially formed sea lough 24km long, 4-8km wide and linked to the Irish Sea via the 'narrows'. The lough is a complex tidal estuary and tidal flows through the narrows can reach 4.1 metres/second (Nunn 1994). The wide variety of habitats and conditions in the lough makes it an area of high biological diversity.

Sediments around the Isle of Man are predominantly sand and gravel mixed with various quantities of shell fragments (Bradshaw *et al.* 2003) or exposed bedrock.

The coastal area from the Mull of Galloway and the Solway Firth to Morecambe Bay, the Ribble Estuary, Liverpool Bay, the Dee Estuary, Colwyn Bay and the northern entrance to the Menai Strait encompasses a range of habitats but is predominantly sedimentary in nature and includes some of the UK's most extensive sand/mud flats. Polychaete and cockle communities dominate much of the central intertidal area of Morecambe Bay and form the basis of an extensive fishery. Numerous recent surveys in connection with proposed and actual offshore wind farm developments, notably off the north Wales and Wirral coasts (e.g. COWL 2002, Seascape Energy 2002, NPower Renewables 2005), but also extending to the Solway Firth, have added further detail. Since some of these surveys extend out almost to the area of the Liverpool Bay oil and gas related surveys, the Liverpool Bay area is arguably now one of the most intensively surveyed sediment areas in UK waters. These surveys have broadly confirmed previous understanding of the habitats and communities, these being largely sands containing variants of the "shallow *Venus*" community, interspersed with sparser polychaete and amphipod communities, often with dense heart urchins *Echinocardium cordatum*, in more mobile sandy areas, and with richer pockets of gravelly or muddy sediments (e.g. Mackie 1990).

Loose, well-sorted medium sands off the North Wales coast are the preferred habitat for the thumbnail crab *Thia scutellata*. This species has a limited distribution in Wales and the U.K. (Rees 2001), possibly because the precise conditions it prefers are limited even within fields

of sand waves. The Countryside Council for Wales considers it to be a "species of concern" (Moore, 2002). Rees (2001) considered the main UK populations to be 6-12 miles offshore from the North Wales coast, but recent surveys have identified important populations closer inshore, especially off Rhyl and Prestatyn (e.g. NPower Renewables 2002, Cowl 2002).

A3a.2.8.3 Biogenic habitats

A number of habitat and community types were identified by SEA 6 as being of potential conservation significance.

Modiolus communities have been identified in a variety of locations in Regional Sea 6. Pre and post drilling surveys in block IOM 112/29, north east of the Isle of Man, identified a community based around *Modiolus* which appeared to have formed an extensive network of reefs raised up to around 0.5 or 1m above the surrounding seabed, occupying an area of approximately 6km^2 (Holt & Shalla 1997). A dedicated survey to assess the status of *Modiolus* beds in the Irish Sea off North West Anglesey was also commissioned for the SEA 6 assessment. This survey identified *Modiolus* in four localities within the survey area, Blocks 109/12, 13, 16 and 22, in sufficient quantities to be considered as beds (Rees 2005). *Modiolus* probably occurred in other areas however due to the patchiness of communities they could have been easily missed on side-scan. The survey identified that *Modiolus* from very tide swept hard ground were noticeably smaller than those identified in areas subject to less current stress. This variance in growth appears to be due to possible sand/grit scour in more extreme environments. Previously extensive *Modiolus* communities off the south-east Isle of Man (Jones 1951) are now much reduced in extent, possibly due to the effects of scallop dredging (Holt *et al.* 1998).

Another reef forming species of conservation significance identified in the SEA 6 area is the file shell *Limaria hians*. Although recorded distribution of *L. hians* is patchy they are known to occur on the west coast of the British Isles, in particular Scotland where isolated areas with *L. hians* have been found in the Clyde Sea and Mull of Kintyre area. At present there is insufficient data to describe the current status of *L. hians*, but it is likely that its numbers and distribution have declined dramatically over recent decades (Hall-Spence & Moore 2000). Available data suggests that these bivalves have now disappeared from previous strongholds in the Clyde such as Skelmorlie Bank, Stravanan Bay and the Tan Buoy where only their dead shells remain. Scallop dredging is the likely cause of their decline. *L. hians* was recorded in the Liverpool Bay area during a 2001 survey where two individuals of the bivalve were identified in a post drilling survey at sample stations around the Douglas platform. The numbers found in this survey are however very low and not indicative of an important population (Holt & Shalla 2002).

As discussed below, aggregations of tubebuilding worm *Sabellaria spinulosa* may form dense subtidal reefs which can stabilise cobble, pebble and gravel habitats, providing a biogenic habitat that allows many other associated species to become established. Previously in Regional Sea 6 area a thick clump of *S.spinulosa* tubes was collected by E.I.S. Rees west of Anglesey in the 1960s. Seabed video footage taken by CCW from an area north of Lleyn Peninsula also showed some large clumps of tubes that appeared to *S. spinulosa*. More recently, the SEA 6 survey of the North West Anglesey coast to assess *Modiolus* distribution (Rees 2005) also identified areas of *S. spinulosa* within Blocks 109/17, 18, 19 and 22. Reportedly there were previously dense areas of *S. spinulosa* at the entrance to Morecambe Bay, loss of which was attributed to the activities of prawn fishing in the approach channels to the Bay (Mistakidis 1956, Taylor & Parker 1993) although based on southern North Sea experience, natural change may be a significant factor in apparent appearance/disappearance of aggregations of the species.

The related species *Sabellaria alveolata* forms extensive intertidal reefs in many parts of the region, particularly in much of Cardigan Bay, the Cumbrian coast and parts of the Scottish Solway coast (Holt *et al*. 1998). Elsewhere in the U.K. extensive reefs are found only in Regional Sea 5. These reefs can sometimes have a stabilising function on unconsolidated sediments, thus adding considerably to the biodiversity of the shore. Off some parts of the Cumbrian coast they can extend for considerable distances in the shallow subtidal down to several metres below LAT.

One further community of conservation significance within the Irish Sea is methane-derived authigenic carbonate (MDAC). These MDAC 'reefs', as they are known, are formed as a consequence of the anaerobic oxidation of methane by consortia of microbes. Prior to SEA 6, there were no previously published reports of MDAC in the area. However, carbon isotope data have confirmed that the cemented hard grounds of two areas studied for SEA 6, Texel 11, and Holden's Reef, are composed of MDAC (Judd 2005). These MDAC reefs are seen to comprise hard material colonised by a variety of benthic fauna in marked contrast to the normal seabed sediment. Texel 11 'reefs' are colonised by an abundant fauna, including: bryozoans, hydroids, sponges, anemones, starfish, urchins, lobster, and squat lobster (*Munida sp.*), whereas in some places close to Holden's reef, sediments are discoloured by the presence of sulphides (black) and associated bacterial mats (white), assumed to be the sulphide-oxidiser *Beggiatoa.* Apart from the benthic macrofauna attracted to the hard substrate (the MDAC), it is likely that there are benthic micro-, meio-, and macro-faunal communities associated with the anaerobic methane oxidation which has resulted in MDAC formation.

A3a.2.9 Features of Regional Sea 7

The benthic communities present in the coastal region of Regional Sea 7 are complex and varied and are described by Hiscock (1998), and summarised in SEA 7. The benthic environment of this area was also reviewed by SAMS in support of the Scottish Marine Renewables SEA (Wilding *et al*. 2005c). The complex coastline of the mainland and islands supports a wide range of habitats from those characteristic of extremely exposed conditions to extremely sheltered conditions. There is considerable local variation with for example the Loch Duich, Alsh and Long complex holding deep mud and rock communities in extreme shelter from wave action and tidal streams but with narrows areas having typical tidal stream-swept communities. In many of the sheltered locations on the west coast, deep water extends close inshore and many deep-water species occur in rocky habitats near to the coast. Distinctive communities are also present in areas of very strong tidal streams such as the Gulf of Corryvreckan, the Sound of Mull and the Sound of Jura (Hiscock 1998).

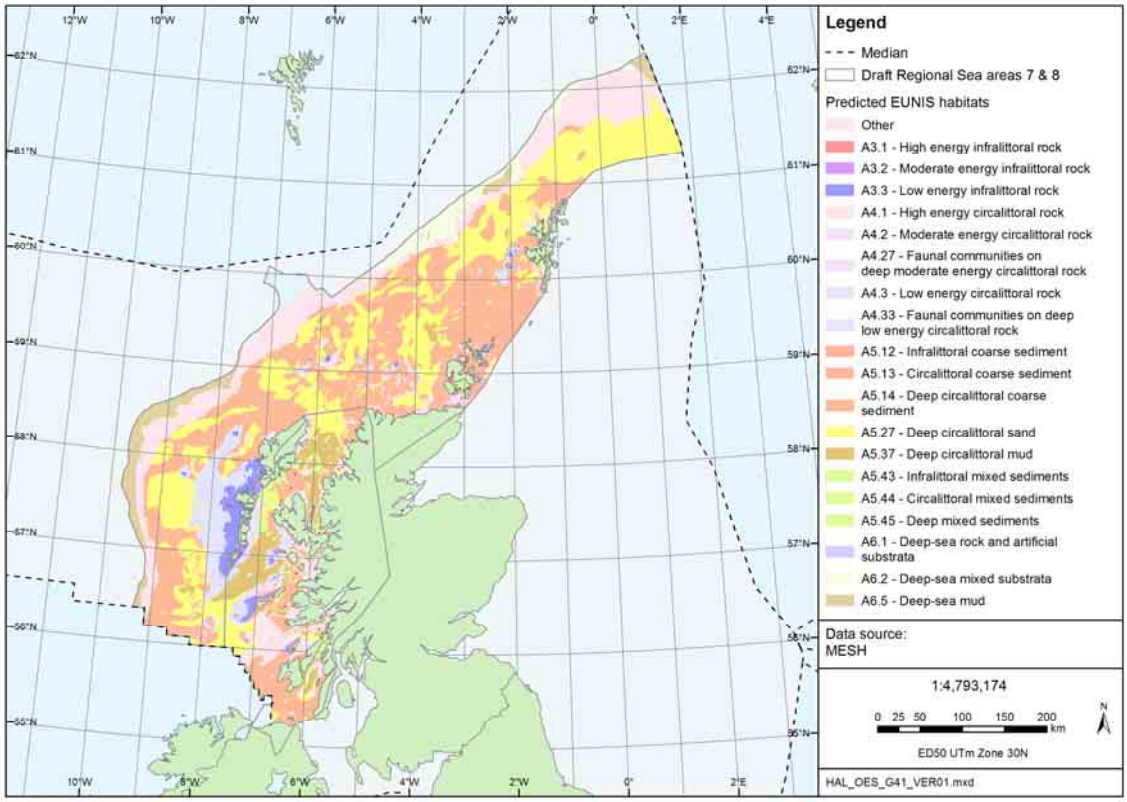
Inshore waters have been extensively surveyed through the Marine Nature Conservation Review (e.g. the sealoch survey programme led by CM Howson, 1988-92), preceding NCC work, and subsequent work by SNH to support SAC designations and other conservation initiatives.

The Minch seabed has been surveyed mainly as a part of fisheries investigations and a programme of studies using acoustic survey and ground-truthing by video and grab sampling was initiated by the SOAEFD Marine Laboratory in 1995. Acoustic mapping to determine the presence of cold water corals provided further details of seabed biotopes in the Minch and Sea of the Hebrides (Roberts *at al.* 2005). The survey concentrated on an area to the east of the island of Mingulay where prominent mounds (up to 5m high and 15m in diameter) were found along seabed ridges (water depths varying between 72-215m). Seabed video

showed the mounds to be characterised by extensive areas of live *Lophelia pertusa* coral interspersed with dead reef framework and coral rubble.

The MESH map of seabed habitats for Regional Sea 6 is shown in Figure A3a.2.6.

Figure A3a.2.6 – MESH classification of marine biotopes, Regional Seas 7&8



Source: MESH (2008)

A3a.2.9.1 Habitats and species

In the Minch, four broad groupings (or biotopes) have been identified and related to sediment types (Pinn *et al*. 1998). Gravel substratum was dominated by the featherstar *Antedon bifida* (Community A). Also present, but in lower numbers, were the cloaked hermit crab *Pagurus prideaux* with its commensal anemone *Adamsia carciniopados*, the cushion star *Porania pulvillus* and the squat lobster *Munida rugosa*. Soft mud was dominated by burrowing decapods such as *Calocaris macandreae* and *Nephrops norvegicus,* with the seapen *Virgularia mirabilis*, the echiuran *Maxmuelleria lankesteri* and the polychaete *Sabella pavonina* also commonly observed (Community B). Mixed sediments supported a variable fauna of which the cnidarian *Abietinaria abietina* was the most commonly observed (Community C). Boulders and bedrock were dominated by echinoderms (e.g. *Ophiothrix fragilis*, *Ophiocomina nigra*, *Asterias rubens* and *Echinus esculentus*) (Community D).

In the area of the Mingulay mounds, on a substrate of dead reef framework and coral rubble, suspension-feeding megafauna were abundant, in particular the stalkless crinoids *A. bifida* and *Leptometra celtica*, various erect sponges (*Axinella* sp., *Phakellia* sp.) and many rocks showed dense cover of zoanthids (*Parazoanthus anguicomus*). The large cerianthid anemone *Pachycerianthus multiplicatus* was often seen in sediment-filled areas in the rubble surrounding the reef mounds. In deeper areas, heavily bioturbated muddy sediments were

found with *Nephrops* present as well as the smaller mud-burrowing shrimp *C. macandreae* (Roberts *et al*. 2005). At other mapped areas west of Skye and the Sound of Rum surveyed as part of this study, crinoids were abundant on hard substrata, and areas dominated by sponges and zoanthids were also seen.

As noted above, MNCR coverage of coastal habitats in Regional Sea 7 is extensive, with a correspondingly large number and variety of biotopes recorded. Spatial complexity of habitat distribution is high, in response to wide variations in depth, salinity, seabed topography and composition, wave exposure and tidal current regime. Specific areas noted by Wilding *et al*. (2005c) – in the context of wave and tidal power generation – included the Sounds of Harris and Barra in the Western Isles; Kyle Rhea between the mainland and Skye; Sound of Mull; Falls of Lora in Loch Etive; Firth of Lorne and surrounding area (including Corryvreckan); Sound of Islay and the area west of Islay. This selection emphasises the distribution of habitats and communities associated with high tidal stream velocities.

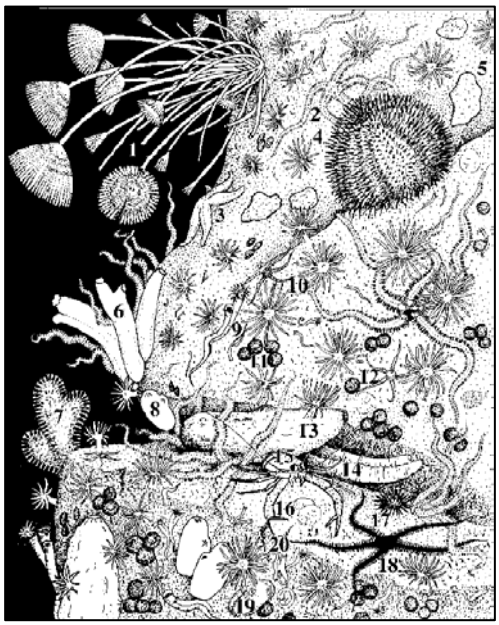


Figure A3a.2.7– Rock wall circalittoral community typical of fjordic sea lochs.

The illustration is based on locations in Loch Duich. Species illustrated include: 1. Sabella pavonina, 2. Ophiothrix fragilis, 3. Asterias rubens, 4. Echinus esculentus, 5. Parasmittina trispinosa, 6. Ciona intestinalis, 7. Alcyonium digitatum, 8. Ascidia virginea, 9. Serpula vermicularis, 10. Protanthea simplex, 11. Neocrania anomala, 12. Ophiura albida, 13. Ascidia mentula, 14. Chaetopterus variopedatus, 15. Munida rugosa, 16. Terebratulina retusa, 17. Psammechinus miliaris, 18. Ophiocomina nigra, 19. Corella parallelograma, 20. Pomatoceros triqueter. From Howson, Connor & Holt (1994). (Drawing by Sue Scott.)

The MNCR sealoch survey programme, reported as a series of Nature Conservancy Council CSD studies and summarised by Howson *et al*. (1994), surveyed a wider range of habitats from fjordic and fjardic systems, including soft muds typical of sealoch basins and deeper parts of the Minch and Hebridean Sea. However, as elsewhere around the UK, rock habitats (especially in the form of spectacular vertical wall formations) have attracted disproportionate survey effort by SCUBA (and recently ROV survey), and a correspondingly detailed distinction of biotopes.

In addition, as noted by Wilding *et al*. (2005c), a majority of the species data reported in MNCR documents are based on visual surveys. Visual surveys are subject to bias, particularly in those surveys conducted underwater using divers, which, in addition, are expensive to conduct and logistically difficult. The logistical problems are exacerbated in areas that are remote particularly where exposed to waves and/or tidally driven currents. In particular, mobile, coarse and sandy sediments may offer little to the observer in terms of recordable megafauna. This makes them ‘unattractive’ and, consequently, they are often undersampled.

Monitoring studies, for example the historic work in relation to the Loch Eil pulp mill discharge (a series of papers by Pearson, most recently Feder & Pearson 1988), or more recent work in connection with the effects of organic enrichment and of medicine residues from aquaculture sites, have provided quantitative (and in many cases more statistically robust) descriptions of macrobenthic community structures in soft sediment habitats, which are considerable more spatially extensive than hard substrates. As a representative example, Pearson (1970, 1971) divided the sediment communities of Loch Eil/upper Loch Linnhe into six main community types influenced by substratum, depth and current-speed:

- a deep mud fauna characterised by *Amphiura chiajei*, *Myrtea spinifera* and *Terebellides stroemi*
- an inner loch transition fauna with *Eupolymnia nebulosa*
- a sandy mud fauna with *Turritella communis* and *Corbula gibba*
- a sand fauna containing *Venus striatula* (now *Chamelea gallina*), *Echinocardium cordatum* and *Cucumaria* (now *Trachythyone*) *elongata*
- a medium depth transition fauna with *Lucinoma borealis*
- a hard ground fauna with *Ophiopholis aculeata*, *Ophiothrix fragilis*, *Psammechinus miliaris*, *Astarte elliptica* and *Eunice pennata*.

The bivalve mollusc *Thyasira gouldi* was believed to be endangered and restricted in distribution to a few west of Scotland sea-lochs and so a UK Biodiversity Action Plan was developed for the species. However, a recent study into the identity of all the species of *Thyasira* found on the UK shelf (Oliver & Killeen 2002) has shown that the species is more common and widespread that previously thought and thus the species no longer appears on the latest (October 2008) UK List of Priority Species and Habitats.

A3a.2.9.2 Biogenic habitats

As noted above, the reef-forming coral *Lophelia pertusa* has been recorded from sites with Regional Sea 7, notably at the Mingulay mounds site in the Sea of the Hebrides.

Modiolus communities have been also identified in a variety of locations in Regional Sea 7, including areas designated as SACs (e.g. Loch Creran SAC, Lochs Alsh, Long and Duich SAC).

Loch Creran, situated at the northern end of the Firth of Lorn, is particularly notable for biogenic reefs of the calcareous tube-worm *Serpula vermicularis*, which occur in shallow water around the periphery of the loch. This species apparently has a world-wide distribution but the development of reefs is extremely rare; Loch Creran is the only known site in the UK to contain living *S. vermicularis* reefs and there are no known occurrences of similarly abundant reefs in Europe.

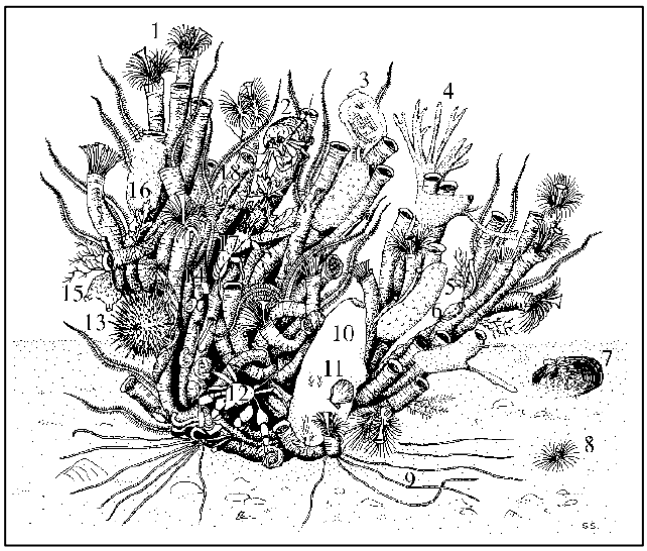


Figure A3a.2.8 – A small reef of the calcareous tube-worm *Serpula vermicularis* with associated fauna.

1. Serpula vermicularis, 2. Pagurus prideaux, 3. Corella parallelograma, 4. Esperiopsis fucorum, 5. Didemnidae indet., 6. Pisidia longicornis, 7. Modiolus modiolus, 8. Chone infundibuliformis, 9. Terebellidae indet., 10. Ascidiella aspersa, 11. Chlamys distorta, 12. Inachus dorsettensis, 13. Psammechinus miliaris, 14. Dendrodoa grossularia, 15. Pyura sp., 16. Phycodrys rubens, 17. Galathea sp., 18. Pomatoceros triqueter. (Drawing by Sue Scott.)

A3a.2.10 Features of Regional Sea 8

Regional Sea 8 extends in continental shelf depths from the Irish median line to the Norwegian median line and is considered by JNCC (2004) to represent two distinct biogeographic provinces (Lusitanean and Boreal) south and north of the Fair Isle Channel respectively. This contrasts with the major division in deeper water faunas, which are clearly different on either side of the Wyville Thomson Ridge (which separates the SEA 1&4 and SEA 7 areas), associated with a major separation of water masses.

The southern part of Regional Sea 8 – i.e. south of the Wyville Thomson Ridge, west of the Western Isles – remains one of the least well-characterised areas of the UKCS in terms of benthic communities, with the exception of the immediate vicinity of St Kilda and the Stanton Banks proposed SAC which have both now been extensively surveyed for shallow-water biotopes. Sealochs on the west coast of the Western Isles have been surveyed by the MNCR programme and subsequent work by SNH. Marine habitats at North Rona SAC have also been surveyed (SNH 2006); however, there remains virtually no information on the benthic communities of the offshore Hebrides shelf. The Regional Sea 8/10 boundary follows the 1000m isobath, and the Hebrides slope has been sampled by transects at depths below *ca*. 400m (Gage 1986, Gage *et al.* 2000). Seabed photographs show a clear transition of sediment type with depth, with shallower stations dominated by coarser sediments and deeper stations having much finer sediments.

There have been two recent surveys that have covered both the intertidal and subtidal habitats around St Kilda. A survey conducted by SNH in 1997 involved a complete mapping of the intertidal biotopes for all the islands and the main stacks, together with broadscale mapping of the seabed in the areas adjacent to the islands using a RoxAnn acoustic ground discrimination system with ground truthing provided by scuba diver observations, underwater video and grab samples. A second survey in 2000 by SNH and the Fisheries Research Services laboratory, Aberdeen mapped the areas of seabed between the islands and an area to the northwest of Soay. This survey employed a range of acoustic survey techniques including RoxAnn, multibeam swathe bathymetry and sidescan sonar together with towed video and ROV and grab sampling in the areas of soft sedimentary seabed (St Kilda World Heritage Site Management Plan 2003-2008 (2003)).

Stanton Banks, just on the west side of the Regional Sea 7/8 boundary, have been proposed as an offshore SAC. Five surveys have been conducted which confirm the presence of rocky reef and identify the biological communities present (JNCC 2008e). A British Geological Survey (BGS) manned submersible survey of an area within the Stanton Banks confirmed the presence of reef habitat and described characteristic reef fauna (Eden *et al*. 1971). A collaborative survey between JNCC and DARDNI (Department for Agriculture and Rural Development, Northern Ireland) was undertaken in 2003 (Service & Mitchell 2004). Two areas of Stanton Banks (Stanton 1 and 2) were surveyed acoustically using RoxAnn acoustic ground discrimination system (AGDS) and multibeam to characterise the physical properties/morphology of the seabed. Biological ground truthing of these areas using video tows and stills camera images confirmed the presence of bedrock reef and identified the major faunal communities. Further survey was undertaken by the North Western Shelf consortium, as part of the MESH2 project in 2005 and 2006 (MESH 2005, 2006). This included multibeam survey of three further areas (Stanton 1, 3 and 4) and biological ground truthing of Stanton 4 using drop-down video and ROV (remotely operated vehicle).

The Wyville Thomson Ridge, which is also under consideration as an offshore SAC, has a minimum water depth of less than 400m and was surveyed in 1999, 2000 and 2006 as part of the SEA programme (JNCC 2008f).

North of the Wyville Thomson Ridge, extensive regional mapping and habitat assessment on the continental shelf west of Shetland has been carried out under the AFEN and SEA programmes; however, intensive seabed sampling data exists only in the vicinity of oil & gas developments and pipeline routes towards the north of the area. There is very little biological data for the continental shelf seabed west of Orkney. Shallow water benthos of the west Shetland shelf (together with coastal littoral and sublittoral habitats of Orkney and Shetland) was reviewed for SEA 4 by Eleftheriou (2003).

In nearshore areas, the MNCR programme targeted a number of coastal sites in Orkney and Shetland, and there has been more recent survey effort on behalf of SNH at SACs in Regional Sea 8 for which Reef is a qualifying interest feature i.e. Sanday and Papa Stour. There has been considerable survey and monitoring effort in connection with Sullom Voe in Shetland.

A3a.2.10.1 Habitats and species

As noted above, there is a very uneven distribution of benthic data for the Scottish continental shelf; ranging from extremely sparse for extensive areas of the west Hebrides and west of Orkney shelf, to relatively detailed data for coastal features and the specific "hotspots" either designated or under consideration as conservation sites. Davies *et al*. (2006) review of the SEA 7 area focuses on slope and trough areas, and provides sparse information on shelf areas (i.e. <1000m water depth). On the Hebrides slope, megafaunal samples from 885m or less contained mainly the ophiuroid *Ophiocten gracilis*, although at a lower density than comparable sites within the northeast Atlantic, such as the Porcupine Seabight (Duineveld *et al*. 1997). Analysis of bryozoan distribution showed that on the upper Hebrides Slope (569 - 855m) the substratum is often rich in coarser sediment with finer granulation downslope, which may provide attachment substrate for sessile organisms (Roberts *et al*. 2000). The species found on the slope are in accord with the known distribution of bryozoans within the north-east Atlantic; for example, *Diplosolen obelia*, *Entalophoroecia deflexa* and *Onocousoecia dilatans* are common in shallower samples between 569 and 665m, and *Disporella hispida*, *Escharella octodentata* and *Celleporina pygmaea* most common in deeper samples between 740 and 810m.

For the SEA 4 area west of Shetland, Eleftheriou (2003) was able to review considerably more data, and considered that seabed habitats showed extreme heterogeneity of sediments and bedform structures. For example, a survey of the Clair development and surrounding areas (Hartley Anderson 2000) described pebbles, cobbles and boulders colonised by a wide range of encrusting or sessile animals, chiefly sponges, hydroids, bryozoans, anemones, and motile species such as sea urchins, starfish and crustaceans. Closer to Shetland and in the vicinity of Yell Sound, the varied fauna reflected the varied seabed types. Epifaunal cover was typically extensive, with almost 100% of exposed surfaces colonised by hydroid turf, sponge and bryozoan mats. The best-developed encrusting fauna was seen in areas with limited sand presence. Where cobbles and boulders were part buried in sand, hydroid turf was the predominant fauna. In addition to encrusting animals, a range of erect sessile species was observed, including the bryozoan *Cellaria* sp., other bryozoans, the anemones *Hormathia digitata*, *Parazoanthus anguicomus* and *Bolocera tuediae*, several sponges and what were believed to be small hard corals (up to 2cm high). In addition to encrusting and erect sessile fauna, the hard seabed is typified by a range of motile animals, the most common of which are the sea urchins *Cidaris cidaris* (slate pencil urchin) and *Echinus esculentus*, the starfish *Stichastrella rosea*, *Asterias rubens* and *Porania pulvillus* (cushion star), brittle stars including *Ophiothrix fragilis*, and squat lobsters *Munida rugosa*.

Patches of sand and gravel supported a relatively uniform boreal shelf sand macrofaunal community dominated by tubicolous polychaetes such as *Galathowenia oculata*, a characteristic species of stable sediments, as well as polychaetes such as *Pisione remota* and *Hesionura elongata*, typical of more mobile, well sorted grades. On pebbles and gravel, starfish (*Porania*), brittlestars (*Ophiura*), anemones (*Bolocera tuediae*), encrusting and erect sponges and bryozoans were present, while on cobbles and pebbles there was a variable but well-developed epifauna consisting of erect and encrusting hydrozoans, sponges, anemones (*Parazoanthus anguicomus*), sea urchins (*Echinus*) and serpulid polychaetes.

Quantitative survey of the west Shetland shelf fauna commenced with the work of Stephen (1923), who sampled a station (No.126 at 60° 40'W in 144m) just southwest of the Clair oilfield and reported a fauna numerically dominated by the free living tube worm *Ditrupa arietina* (360/m^2) with the only other species recorded being the brittle star *Ophiura* sp. Stephen characterised the fauna as belonging to a "pure *Ditrupa*" community, which he had also found at a number of locations to the west and north of Shetland. Dyer *et al*. (1982) also recorded *Ditrupa* to the west of Shetland and included a photo of the seabed showing numerous tubes present.

On the basis of trawls and underwater photographs, Dyer (1983) described a sparse epifauna from the west Shetland shelf dominated by northern species such as the asteroids *Hippasteria phrygiana*, *Stichastrella rosea* and *Solaster endeca*, the anthozoan *Adamsia palliata*, the polychaete *Hyalinoecia tubicola*, and the sponges *Tetilla* and *Phakellia* with the echinoid *Echinus tenuispinus*, and additional species the asteroids *Pteraster militaris* and *Pontaster tenuispinus* and the anthozoan *Hormathia digitata* in the deeper northern stations. Cranmer *et al*. (1984) extended this work and noted the presence, in small densities, of the anthozoan *Actinauge richardi* (common around Shetland), the squat lobster *Munida rugosa* and the zoantharian *Epizoanthus incrustatus* (=*papillosus*) found in association with an anomuran crab. Basford *et al*. (1989) described epifauna from two stations west of Fair Isle as sparse and in low numbers, consisting of a few asteroids (*Asterias rubens*, *Porania pulvillus* and *Luidia ciliaris*) and echinoids such as *Spatangus purpureus* and both varieties of *Echinus acutus* (*E.a. flemingii* and *E.a. norvegicus*).

Macrofaunal samples from the Clair field taken by grab were analysed by ERTSL (2001) who found that 79% of the species were annelids while the remainder was made up of arthropods (6.9%), molluscs (9.4%), echinoderms (0.9%) and miscellaneous phyla (3.4%). The analysis suggested a relatively uniform community dominated by tubicolous polychaetes characteristic of stable sediments. This interpretation may be influenced by the difficulties encountered in sampling the coarser sediments, or may reflect the tolerance of the dominant species to a range of sediment types. Faunal composition also suggests the presence of mixed or overlapping communities. An environmental survey of two prospective Foinaven-Sullom Voe pipeline routes recorded species richness considerably lower than that recorded in the Clair area where over 500 taxa were found; the reasons for such a discrepancy remain unexplained (Hartley Anderson 2000). In deeper water (>100m), a generally sparse and patchy macrofaunal community was dominated by the tubicolous polychaetes *Myriochele* (=*Galathowenia*) *oculata* agg. and *Aonides paucibranchiata* consistent with the communities described from the AFEN and Clair baseline studies. Shallower stations generally had coarser sand substrate, and supported a community dominated by *Prionospio* (*Minuspio*) *cirrifera*, together with a number of surface-inhabiting species exploiting the greater niche heterogeneity of these sites which had more gravel.

In general, fauna of the west Shetland continental shelf varies according to the nature of the seabed sediments, and is typical of a boreal mixed sediment community. The analysis of the infaunal communities data from the Shetland sedimentary habitats by Pearson *et al*. (1994) suggested that they are comparable only with the infaunal communities, assemblages and associations described from other subtidal sedimentary habitats in boreal areas of western Europe in the most general terms, and they are only loosely comparable to those defined for the North Sea as a whole. The difficulties in making comparisons from similar sedimentary habitats in boreal areas of Europe result from the poorly sorted nature of sediments at the examined sites, and the relatively high variability of habitats. Thus, community types are frequently mixtures of two or more of the classical Petersen/Thorson community types.

A3a.2.10.2 Offshore islands and banks

The following description of benthic communities at St Kilda is derived from SNH advice under Regulation 33(2) of The Conservations (Natural Habitats, &c) Regulations 1994 (as amended) (SNH 2006a). The St Kilda SAC contains extremely wave-exposed reefs consisting of hard, igneous rock, forming steep and vertical reefs around the entire island group with few low-lying areas. Rock faces extend to over 300m above sea level, and sublittorally reach depths of between 60-80m on a subtidal plateau that encircles the island group. Typical intertidal reef communities extend several metres above mean high water into the littoral zone because of wave exposure. These reefs support characteristic populations of the exposed shore fucoids *Fucus distichus* and *Fucus spiralis* var. *nana*. Littoral communities of interest span a height range of 6 to 8m or more, with supralittoral green algae extending for tens of metres up the cliffs.

The clarity of the Atlantic sea water is high and sublittoral fringe communities dominated by *Alaria esculenta* reach depths of at least 15m. Below this zone, dense kelp forests of *Laminaria hyperborea* with a rich associated flora and fauna occur as deep as 35m; *Laminaria saccharina* replaces the *L. hyperborea* at a depth of 25m in some locations and *L. digitata* can reach depths of 50m in sparse kelp park. Circalittoral rock below 35m is dominated by diverse communities including large and colourful expanses of anemones, sponges and soft corals with hydroids and bryozoans characteristic of conditions in surge gullies. The invertebrates within this zone are primarily encrusting or low-growing species such as the jewel anemone *Corynactis viridis*, the dwarf form of the plumose anemone

Metridium senile, the anemone *Sagartia elegans*, polyclinid ascidians, sponges such as *Myxilla incrustans* and *Halichondria panicea*, and numerous thin encrusting species. Effectively the circalittoral zone found in this site is deeper than that found in any other of the suite of marine SACs, and the type of community found in this area is characterised by erect sponges such as *Axinella* spp. and *Phakellia* spp., as well as bryozoans, including *Porella* spp, along with associated encrusting sponges. Occasionally, at depths of 70m, there are patches of pink encrusting algae, which emphasise the uniqueness of this community, as littoral algal species are not usually found at these depths. There are also brittlestars *Ophiocomina nigra* and squat lobsters *Munida* spp. amongst the boulders on the bedrock plane, where the rarely recorded, erect coral-like cyclostome bryozoan *Coronapora truncata* was found. Overall these reefs provide some of the richest and most extensive examples of very exposed rock habitats in the EU.

Basalt and dolerite dykes throughout the island group have eroded to form caves and tunnels above and below the water which are a major feature of the islands, and are the most extensive of such systems in the UK. They support diverse communities that reflect the degree of surge to which they are exposed. In shallow water, within areas most affected by surge, little can survive other than the encrusting sponge *Myxilla incrustans*, which blankets the cave walls. With a reduction in surge, anemones such as the northern anemone *Phellia gausapata*, jewel anemone *Corynactis viridis* and *Sagartia elegans* are abundant along with thin encrusting sponges and bryozoans. Hydroids such as *Tubularia indivisa* dominate some of the larger systems; in all cases, there is a diverse fauna and flora associated with these characteristic dominant species. Microhabitats in the deeper caves show a wave exposure gradient with species usually found in more sheltered conditions, such as the fan worm *Sabella pavonina* and the burrowing anemone *Cerianthus lloydii*, present in the inner regions. Rarely recorded nocturnal species have also been found in the inner caves, most notably the crab *Bathynectes longipes* and the anemone *Arachnanthus sarsi*. The cave floors are typically lined with rounded boulders. The deeper caves show a wave exposure gradient with microhabitats comprising species typically found in more sheltered conditions present in the inner regions. The cave floors support communities dominated by the Devonshire cup-coral *Caryophyllia smithii*, calcareous tube worms and the urchin *Echinus esculentus*, with the squat lobsters *Galathea strigosa* and *Galathea nexa* living between the boulders.

North Rona SAC, Papa Stour SAC and Sanday SACs all provide a variety of littoral and subtidal reef habitats (SNH 2006b, c, d), supporting rich marine communities characteristic of conditions ranging from highly exposed (North Rona) to relatively sheltered (Sanday). The reefs support animal and algal species, which are highly influenced by wave exposure and water quality. The influence of the North Atlantic Drift is apparent in the presence of many southern species, but colder sub-arctic water accounts for the northern elements of the fauna and flora. The well developed sea caves found at North Rona and Papa Stour contain species characteristic of those found in northern latitudes, and associated communities that are representative of a range of exposures to wave action. Sanday SAC also supports sandbank, mudflat and sandflat Annex I habitats.

On Stanton Banks pSAC, survey by MESH (2005; 2006) confirmed that smooth, silty bedrock in the lower circalittoral zone is characterised by extensive encrusting coralline red algae, numerous barnacles, brittlestars, small sponge crusts (including *Hymedesmia paupertas*), axinellid sponges (*Axinella infundibuliformis*) and massive sponges (*Mycale lingua* and *Pachymatisma johnstonia*). Sea urchins (*Echinus* sp.) and colonies of filamentous tubeworms (*Filograna* sp.) were also common. On the slopes, there is a transition from smooth bedrock to fissured rock outcrops, boulder and cobble with featherstars (*Leptometra celtica*), dead man's fingers (*Alcyonium digitatum*) and robust

hydroids (*Tubularia* spp.). Cold water coral (*Lophelia pertusa*) has been observed on Stanton Banks but distinct biogenic reefs have not been identified (Roberts *et al*., 2003).

Figure A3a.2.9 – Stanton Banks habitats

*Notes: Left: featherstars (*Leptometra celtica*), calcareous tube worms and the blue sponge crust* Hymedesmia paupertas *on bedrock and boulder reef. Right: boulder and bedrock reef habitat with* Mycale lingua*.*
Source: MESH (2006)

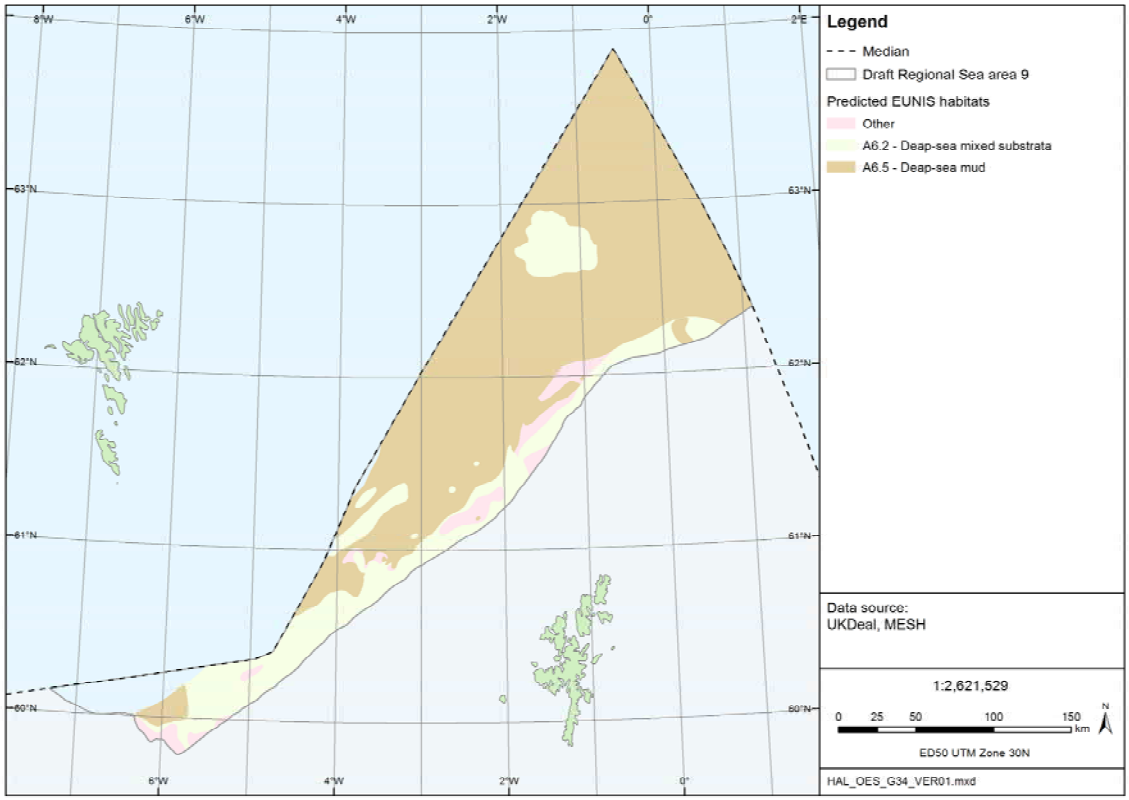
A3a.2.11 Features of Regional Sea 9

Regional Sea 9, comprising the deep waters of the Faroe-Shetland Channel (below 600m water depth), was included in SEA 1 and SEA 4. The area was described in SEA 4 as one of the cradles of deep sea research, with the early ground breaking studies exemplified by the popular accounts published by Wyville Thomson (1874) and Murray and Hjort (1912). To a large extent, later work has amplified rather than altered the general patterns identified by the earlier exploration. The seafloor of the channel was the subject of 5 major mapping and sampling cruises between 1996 and 2002, funded initially by the Atlantic Frontier Environmental Network (AFEN) and latterly by DECC as part of its SEA process. In addition, there have been a number of programmes of academic investigation of features identified by (or subjects highlighted by) the AFEN and SEA surveys (see e.g. Grehan & Freiwald 2001).

The AFEN and SEA surveys used a combination of seafloor mapping and physical or photographic sampling, which has allowed the broad distribution of habitats and species to be distinguished across the area.

Sediments in the Faroe-Shetland Channel are largely glacial in origin (Masson *et al*. 2003), and the band of numerous iceberg ploughmarks or scars along the upper slope between 200 and 450m provides evidence of past glacial activity. The sediments follow a general pattern of decreasing grain size from sand and gravel at the shelf break to mud in the deeper waters. The pattern is not uniform across the area since strong water currents occur at depth, resulting in the presence of coarser sediments than might be expected. In particular, the occurrence of large areas of gravel substrate on the continental slope and in places on the basin floor is regarded as unusual. A group of mud diapirs (mud “volcanoes”) are present in the north of the area. These are often associated with fluid escape or expulsion and on occasion with specialised seep biological communities, although no evidence of this has been found on these diapirs. No large reefs or colonies of cold water corals were found, which accords with the conclusions of Long *et al*. (1999) and Roberts *et al.* (2003).

Figure A3a.2.10 – MESH classification of marine biotopes, Regional Sea 9



Source: MESH (2008)

AFEN (2000) and Bett (2001 and 2003) have emphasised the biological importance of the hydrographic effects of the physical barrier presented by the Wyville Thomson Ridge, confirming the findings of the early studies described by Wyville Thomson (1874). To the north of the Wyville Thomson Ridge a major faunal division occurs at around 500m, reflecting the change from warm north Atlantic water near the surface to cold Faroe-Shetland Channel bottom water derived from the Norwegian Sea. Bett (2001) indicated that the cold water faunal group can be subdivided into three, reflecting stations below 1200m, those between 500 and 1200m to the north of Shetland, and those between 500 and 1200m to the west of Shetland.

Bett (2003) provides a range of seabed photographs selected to illustrate the variation of seabed composition and associated epibenthic communities within the Faroe-Shetland Channel. In the mouth of the Faroe-Shetland Channel and the Norwegian Basin there are large areas of level-bottom "typical deep-sea" soft sediment habitat with the mud diaper province (see above) introducing local seabed habitat heterogeneity. The deep waters (c. 1000-1200m) of the opposite end of the SEA 4 area (Faroe Bank Channel and southern reaches of the Faroe-Shetland Channel) are rather different in character, having sandier sediments that are home to a more abundant population of megabenthos – white stalked sponges being the visually most striking component of the fauna. Towards the southern edge of the Faroe Plateau and the lower slope of the Faroe Plateau, sediments become progressively coarser, indicative of significant bottom water currents, while barchan sand dune fields and sandy contourite deposits are also indicative of significant bottom water flows that result in the transport of fine sediments. Coarse sediment habitats are also widespread on the upper slope (c. 300-500m) in a more-or-less continuous band throughout the region known as the "iceberg ploughmark zone"; during glacial periods, grounding icebergs gouged furrows in the seabed turning coarser sediments (cobbles and boulders)

aside in an action similar to that of a plough harrow (see Belderson *et al*. 1973). The action of bottom currents has subsequently, at least partially, infilled the furrows with finer sediments. These processes have acted to produce a complex, spatially heterogeneous, mosaic habitat that can repeatedly alternate from "piles of boulders" to open fine sediment areas. The coarse sediment (cobble and boulder) area can support diverse biological communities that exhibit significant local variation in their composition and abundance.

A3a.2.12 Features of Regional Seas 10 and11

Regional Sea 10, comprising the Rockall Trough and Bank in water depths greater than 1000m, was described in SEA 7, with specific survey effort and technical studies (Davies *et al*. 2006) commissioned to support the assessment.

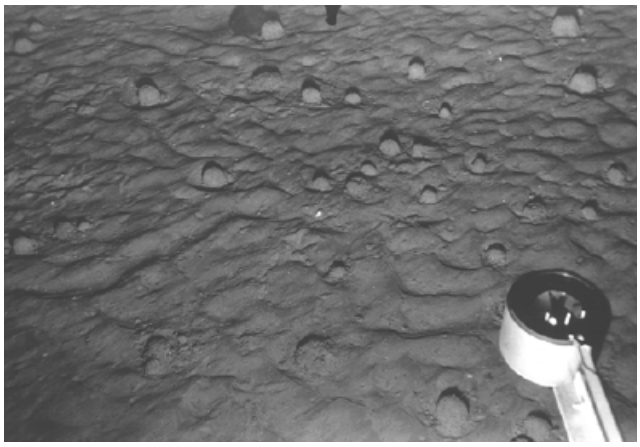
A3a.2.12.1 Hebrides slope

Observations made by the SEA 7 survey on the Hebrides slope (*ca*. 650-2,200m) largely supported existing datasets (Gage 1986, Gage *et al.* 2000), with some areas showing evidence of hydrodynamic activity at shallower stations with a relatively low megafaunal density and diversity. The most frequently seen species were the echinoid *Echinus acutus* and the ophiuroid *Ophiomusium lymani.* The dominant species present on the fine sediments of deeper stations of *ca*. 1,300m, were the octocoral *Acanella arbuscula*, pennatulids such as *Kophobelemnon stelliferum* and hexactinellid sponges such as *Hyalonema* sp. (Jones *et al.* 1998, Roberts *et al.* 2000). Although the majority of the community on the Hebrides slope followed the expected distributional patterns for the north-east Atlantic, some species were found at unusual depths; for example, *A. arbuscula* is usually found at depths greater than 1,500m (e.g. Hughes & Gage 2004), rather than 1,300m as here. These differences are most likely explained by the local hydrodynamic regime along with species association with the sediment types found throughout the area (Jones *et al*. 1998).

The macrofaunal community on the Hebrides Slope is composed principally of polychaetes (accounted for *ca*. 53% of individual specimens and *ca*. 43% of all species collected), crustaceans (*ca*. 20% of individuals and *ca*. 34% of species) and molluscs (*ca*. 10% of individuals and *ca*. 12% of species) (Jones *et al.* 1998). Total macrofaunal biomass decreased linearly with increasing depth, falling within the established pattern for the continental margin worldwide (Rowe 1983). However, the abundance of the population did deviate somewhat from the expected depth related trend, with polychaete abundance increasing by *ca*. 50% between 1,100-1,300m, potentially as a result of local hydrodynamic conditions and disturbance (Jones *et al.* 1998).

Dense fields of xenophyophores (possibly *Syringammina fragilissima*) were found on muddy sediments at 1,108m on the Hebrides Slope, achieving densities of up to $10m^{-2}$. Xenophyophores are large protozoans found exclusively in the deep sea (Hughes & Gooday 2004). They agglutinate sediments to form elaborate tests which are often large (>25cm), either on or within sediments or on rock surfaces. The presence of xenophyophores appears to significantly increase the abundance of macrofauna and meiofauna in the immediate area (e.g. Hughes & Gooday 2004). *S. fragilissima* may perform many different roles, such as providing hard substrate for epifaunal species, elevating suspension feeders above the seafloor and increasing food available to deposit feeders resulting from the deposition of fine particles. The tests of xenophyophores may also passively trap larvae, leading to concentrated prey populations which may benefit predators, as well as forming a habitat for mating, reproduction and nursery functions (Hughes & Gooday 2004).

Figure A3a.2.11 - Fields of the xenophyophore *S. fragilissima* on the Hebrides Slope



Notes: Photographed at 1,108m (Enterprise Oil block 154/1).
Sources: Jones et al. (1998), Gage (2001)

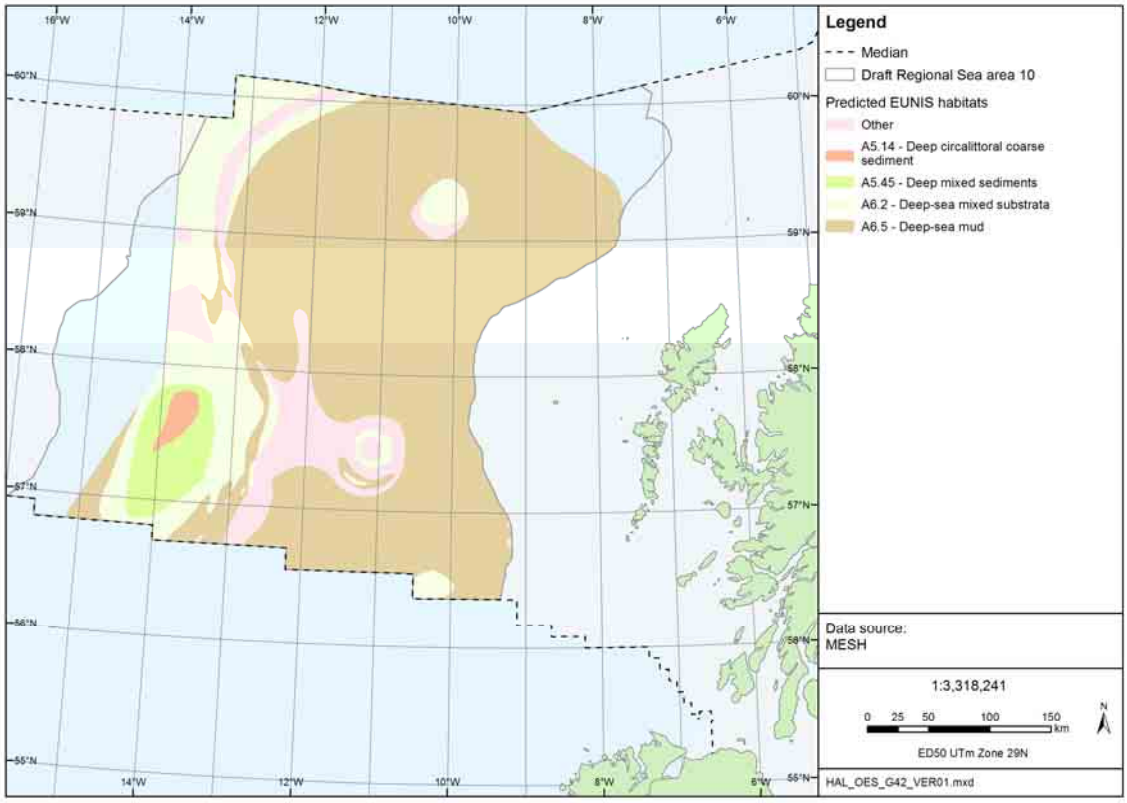
Sponge beds may have many of the same effects on the benthic community as xenophyophores. The north-east Atlantic deep sea contains abundant aggregations of the hexactinellid sponge *Pheronema carpenteri* at depths of *ca*. 1,000-1,300m (e.g. Hughes & Gage 2004). The sponge aggregations appear to be directly related to increased abundance and richness of the macrofauna, particularly where there are large deposits of sponge spicules in the immediate area (e.g. Bett & Rice 1992). Dense spicule mats may have several effects on the benthic community, such as providing hard substrate, suitable for colonisation by species such as actinarians, hydroids and bryozoans (Bett & Rice 1992). Spicule mats and sponge bodies may also serve as refuge for prey species, as well as serving to trap particulate matter and phytodetritus.

A3a.2.12.2 Rockall and Hatton Basins

At 1,920m depth, the Rockall Trough contains a community dominated by the octocoral *A. arbuscula* and the ophiuroid *O. lymani* (Hughes & Gage 2004). Sessile suspension feeders were most abundant, accounting for 77% of the total megafaunal standing stock biomass. Further west, Hughes & Gage (2004) sampled the Hatton-Rockall Basin at 1,100m. At this shallower site, the hexactinellid sponges (*P. carpenteri*) and ceriantharian anemones (species unspecified) were the most abundant, with mobile crustaceans such as *Munida tenuimana* relatively common. Sessile suspension feeders accounted for 92% of the total megafaunal biomass at this depth.

At all sites within the Rockall Trough and Hatton-Rockall Basin, polychaetes were the most abundant macrofaunal group, accounting for 55-58% of the total number of individuals and 57-79% of the biomass (Hughes & Gage 2004). In the Hatton Basin, small errant polychaetes (e.g. Hesionidae, Glyceridae, Amphinomidae, Nephtyidae) numerically dominated the fauna (69% of total individuals), but some other families *e.g*. Capitellidae, Chaetopteridae, Lumbrineridae, Polynoidae, Ampharetidae contained much larger individuals that dominated the overall biomass. On the Feni Ridge in the Rockall Trough, surface deposit and interface (species which can alternate between suspension and deposit feeding) feeders (e.g. Ampharetidae, Onuphidae, Cirratulidae) dominated the fauna (77% of total individuals). These community differences were most likely a result of differences in local hydrodynamic regime and food supply (Gage *et al.* 2000).

Figure A3a.2.12 – MESH classification of marine biotopes, Regional Sea 10



Source: MESH (2008)

A3a.2.12.3 Banks and seamounts

The Rockall Bank was the most intensively sampled area in the SEA 7 survey. Samples showed the bank to consist of different sedimentary regions, with the south-east mainly composed of fine muddy sand, with the echinoid *E. acutus* the most common mobile megafauna. The eastern flank of the bank has extensive areas of exposed bedrock with evidence of strong sediment scour (Narayanaswamy *et al.* 2006). To the west and north-west of the bank, several areas of live coral reef framework composed of *Lophelia pertusa* and *Madrepora oculata* were recorded (see Roberts et al. 2008), as reported from submersible observations from the 1970s (Wilson 1979).

The Hatton and George Bligh Banks have been less studied than the Rockall Bank and Trough. However, both these areas have extensive live and dead coral framework comprised of *L. pertusa* and *M. oculata*, with a diverse associated community, including the cnidarian *Phelliactis* sp., the antipatharian coral *Stichopathes* sp., many hydroids/bryozoans, and mobile epifauna such as crustaceans and ophiuroids (Narayanaswamy *et al.* 2006).

According to the same authors, the Anton Dohrn Seamount showed evidence of strong hydrodynamic activity on the flanks and plateau. There were no discoveries of large sessile epifauna such as gorgonians, corals or massive sponges. Instead, the sessile community was mainly composed of brachiopods and barnacles, whereas the mobile megafauna were mainly composed of echinoderms such as the echinoids *Calveriosoma* cf. *fenestratum* and *Cidaris cidaris*.

A3a.2.13 Biogenic habitats

Although a range of biogenic habitats exist in UK coastal waters (e.g. maerl, kelp beds), four biogenic habitats are considered to be of particular relevance to this SEA, because of distribution, statutory conservation designations and potential significant effects of the proposed activities – three associated with the reef-forming species *Sabellaria spinulosa*, *Modiolus modiolus* and *Lophelia pertusa* – and seagrass beds. Two additional reef-forming species – *Limaria hians* and *Serpula vermicularis* were noted above in Regional Seas 6 and 7 respectively.

A3a.2.13.1 *Sabellaria* reefs

Dense, subtidal aggregations of the small, tube-building polychaete worm *Sabellaria spinulosa* can stabilise cobble, pebble and gravel habitats, providing a consolidated habitat for other species. *Sabellaria spinulosa* reefs are solid structures, at least several centimetres thick, raised above the surrounding seabed, which persist for many years and provide a biogenic habitat that allows many other associated species to become established. Reefs found in mixed sediment areas are important, as they allow fauna and crevice infauna to become established in areas where they would normally be absent. The MNCR biotope classification scheme (v04.05) defines a single *S. spinulosa* biotope: *Sabellaria spinulosa* on stable circalittoral mixed sediment (SspiMx).

S. spinulosa is naturally common around the British Isles. It is found in the subtidal and lower intertidal/sublittoral fringe with a wide distribution throughout the north-east Atlantic, especially in areas of turbid seawater with a high sediment load. However, in most parts of its geographical range *S. spinulosa* does not form reefs, but is solitary or in small groups encrusting pebbles, shell, kelp holdfasts and bedrock. It is often cryptic and easily overlooked in these habitats. Where conditions are favourable, much more extensive thin crusts can be formed, sometimes covering extensive areas of seabed. However, these crusts may be only seasonal features, being broken up during winter storms and quickly reforming through new settlement the following spring. There are extensive examples of this form of colony in the Berwickshire and North Northumberland Coast cSAC. These crusts are not considered to constitute true *S. spinulosa* reef habitats because of their ephemeral nature, which does not provide a stable biogenic habitat enabling associated species to become established in areas where they are otherwise absent.

Sabellaria reefs are present within the southern North Sea (Regional Sea 2), in particular offshore from the Wash on sandy gravel substratum. *Sabellaria spinulosa* reef has also been found in an aggregate licence area (401/2) which is approximately 13 nautical miles east of Great Yarmouth (Newell *et al.* 2000); and in the Saturn Reef area included within the North Norfolk Sandbanks area under consideration as an SAC.

Sabellaria spinulosa biogenic reefs have been recorded 4 kilometres east of Swanage Pier in Dorset, Regional Sea 3 (Jones *et al.* 2004), where the percentage coverage of *Sabellaria* on the seabed was estimated at between 5-80%. The reef was reported to be free of silt and many mollusc shells had been incorporated into the structure of the reef, particularly single valves of *Nucula* spp. and fragments of cockles and venerids. This would imply that currents capable of moving such items must affect the site from time to time.

Extensive reefs formed by the congener *Sabellaria alveolata* have been described in the subtidal within Bridgwater Bay in the upper Bristol Channel (Regional Sea 4) and may be unique to the Bristol Channel (although *S. alveolata* reefs do penetrate some way into the subtidal off parts of the Cumbrian coast, whilst aggregations - mixed with *Sabellaria*

spinulosa - have been seen in waters deeper than 10m off the Eastern Irish coast). These *Sabellaria alveolata* reefs may cover extensive areas of the seabed, particularly where there are tide-swept hard substrata affected by turbid water, which is the case further into the Severn Estuary.

A3a.2.13.2 *Modiolus* beds

The horse mussel (*Modiolus modiolus*) is a widely distributed species which in suitable conditions can establish dense and persistent beds. Although the species is not listed in the Annexes to the EU Habitats and Species Directive, it may be afforded protection under the Directive by virtue of forming biogenic reefs. These beds influence the seabed topography, sediment type and fauna present and can be considered as biogenic reefs.

Modiolus beds are recorded particularly from nearshore areas in Regional Seas 6, 7 and 8 (i.e. on the west coast from the Irish Sea north to Shetland). This habitat is represented in a number of coastal SACs.

A3a.2.13.3 *Lophelia* reefs

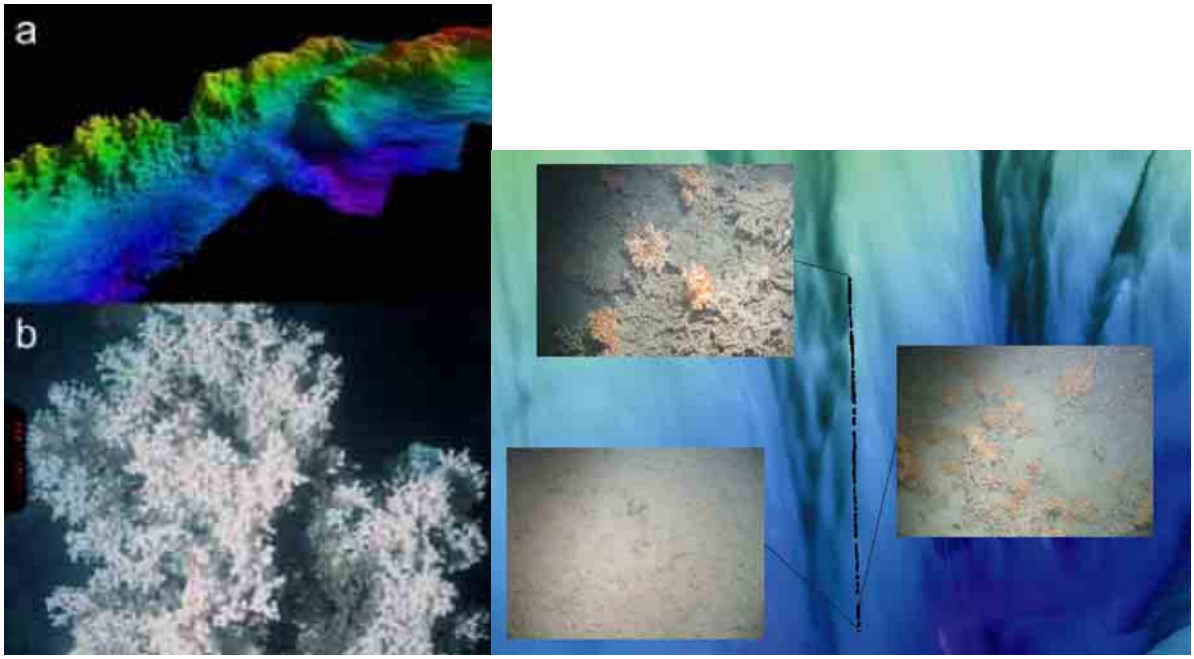
Lophelia pertusa is generally a relatively deep water species recorded in continental shelf edge areas in Regional Seas 4, 8, 9 and 10. A relatively shallow-water reef (the Mingulay complex) is present in the Sea of the Hebrides (Regional Sea 7) and there are scattered records of individual colonies in Regional Sea 1, notably from oil platforms.

Lophelia pertusa reefs frequently occur on the exposed hard substrate of banks, seamounts and shelves usually between depths of 200-400m, but may occur in shallower and much deeper depths. *Lophelia* colonies are distributed sparsely to the west of Shetland, but are more abundant on the south and west flanks of the Rockall Bank (Wilson 1979), Wyville Thomson Ridge, Lousy Bank and Hatton Bank (Roberts *et al.* 2003, 2008); in the Sea of the Hebrides; and at the Celtic Margin (South West Approaches Canyons). During the SEA 7 survey *Lophelia* was also found in the northern part of the Rockall Bank as well as George Bligh Bank (Narayanaswamy *et al.* 2006). Adjacent to the UKCS, *Lophelia* is widely distributed around the Faroese plateau margin and in three well-delineated mound provinces in the Porcupine Seabight and on the Porcupine Bank (Irish waters): the Belgica Mounds (500-1000m) on the eastern flank, the Hovland Mounds in the north and a large number of buried Magellan Mounds further to the northwest.

During the AFEN surveys of the northern Rockall Trough, colonies of *Lophelia* were discovered capping mounds, known as the Darwin Mounds, at depths of *ca*. 900-1,000m. These mounds are up to 75m in diameter and 5m high, and host an associated community of sessile suspension feeders that occur in close association with the coral (Masson *et al.* 2003), such as the xenophyophore *Syringammina fragilissima* at densities of up to $7m^{-2}$ (Bett 2001). The mounds were designated recently as the UK's first offshore Special Area of Conservation.

Lophelia and other cold-water corals such as *Madrepora oculata* and *Solenosmilia variabilis* create three-dimensional habitats in waters where the seafloor may be relatively featureless. In turn, these corals provide habitat for a wide variety of different species, including fish (Costello *et al.* 2005) and invertebrates (Jensen & Frederiksen 1992).

Figure A3a.2.13 – *Lophelia pertusa* colonies in Regional Seas 4 and 7



Left: (a) Multibeam echosounder survey showing characteristic mounds formed by L. pertusa *in the Sea of the Hebrides, (b) Seabed photograph of one of these* L. pertusa *mounds. Source: Roberts et al. (2005)*
Right: MESH South West Approaches Canyons survey camera tow of C_2_14 showing a biogenic reef, comprising dead and live Lophelia pertusa*, with abundant live growths of* Madrepora oculata*.*
Source: Davies et al. (2008)

Diverse invertebrate fauna have been recorded on living reefs, the dead coral framework and the adjacent coral rubble areas. Jensen and Frederiksen (1992) collected 25 blocks of *Lophelia* and found 4,626 individuals belonging to 256 species, while a further 42 species were identified amongst coral rubble. The Darwin Mounds support a macrofaunal community that appears to be taxonomically distinct from the majority of other sites within the north-east Atlantic. For example, several species such as *Porella laevis*, *Stegopoma plicatile* and *Eunice norvegica* occurred >75% of the time with *Lophelia* and were absent from neighbouring sites such as the Wyville Thomson Ridge and Faeroes Plateau (Henry & Roberts 2004).

Hall-Spencer *et al.* (2002) observed widespread damage to coral reefs caused by the trawls of commercial fishing vessels on the shelf edges of Ireland and Norway. The passage of the trawl may increase mortality of the coral by crushing, burying or wounding corals, thus increasing susceptibility to infection and epifaunal recruitment which may eventually smother corals (Fosså *et al*. 2002). The destruction of the coral reduces the three-dimensional structure to rubble, decreasing the complexity of the habitat with potential impacts on the associated community composition (Koslow *et al.* 2001, Fosså *et al.* 2002). In studies conducted on the Hebrides slope off Scotland, trawling marks were clearly visible in 2-12% (Roberts *et al.* 2000) and 5-47% of seabed photographs (Lamont & Gage 1998).

A3a.2.13.4 *Zostera* beds

Seagrass beds develop in intertidal and shallow subtidal areas on sands and muds, and are present in all the coastal Regional Seas. They may be found in marine inlets and bays but also in other areas, such as lagoons and channels, which are sheltered from significant wave action. The current distribution and extent of seagrass beds is a small fraction of the

historic coverage prior to widespread fungal wasting disease outbreaks in the 1920s-30s (Tubbs 1995).

Three species of *Zostera* occur in the UK, and all are considered to be scarce (present in 16-100 ten km squares; UKBAP). Dwarf eelgrass *Zostera noltii* is found highest on the shore, often adjacent to lower saltmarsh communities, narrow-leaved eelgrass *Zostera angustifolia* on the mid to lower shore and eelgrass *Zostera marina* predominantly in the sublittoral. The plants stabilise the substratum, are an important source of organic matter, and provide shelter and a surface for attachment by other species. Eelgrass is an important source of food for wildfowl, particularly brent goose and widgeon which feed on intertidal beds. Where this habitat is well developed the leaves of eelgrass plants may be colonised by diatoms and algae such as *Enteromorpha* spp, *Cladophora rectangularis, Rhodophysema georgii*, *Ceramium rubrum*, stalked jellyfish and anemones. The soft sediment infauna may include amphipods, polychaete worms, bivalves and echinoderms. The shelter provided by seagrass beds makes them important nursery areas for flatfish and, in some areas, for cephalopods. Adult fish frequently seen in *Zostera* beds include pollack, two-spotted goby and various wrasse. Two species of pipefish, *Entelurus aequoraeus* and *Syngnathus typhle* are almost totally restricted to seagrass beds, while the red alga *Polysiphonia harveyi,* which has only recently been recorded from the British Isles, is often associated with eelgrass beds.

Five different community types have been identified for seagrass beds from the southern North Sea and the Channel (UKBAP), and 16 microhabitats including the seagrass itself, sessile epifauna, infauna and free swimming animals not confined to a special part of the community. The diversity of species will depend on environmental factors such as salinity and tidal exposure and the density of microhabitats, but it is potentially highest in the perennial fully marine subtidal communities and may be lowest in intertidal, estuarine, annual beds.

Although there has been an identified requirement within the UKBAP action plan for seagrass beds (a priority UKBAP habitat) to compile and publish an up-to-date record of the extent, quality and distribution of seagrass around the UK, this has not yet been comprehensively achieved. Available information from the late-1990s was compiled by Davison (1997) and Davison & Hughes (1998). National distribution patterns for the three *Zostera* species are collated by the MarLIN database, showing patchy distribution within the southern North Sea coastal fringe. Maplin Sands is estimated to have the largest surviving continuous population of dwarf eelgrass in Europe (covering around 325ha).

A3a.2.14 Evolution of the baseline

Over recent geological timescales (ca. 11,000 years) seabed habitats around the UK have been subject to continuous processes of change associated with post-glacial trends in sea level, climate and sedimentation. In the shorter term, seasonal, inter-annual and decadal natural changes in benthic habitats, community structure and individual species population dynamics may result from physical environmental influences (e.g. episodic storm events; hydroclimatic variability and sustained trends) and/or ecological influences such as reproductive cycles, larval settlement, predation, parasitism and disease.

Kröncke (1995) reviewed a series of studies of long-term changes in North Sea benthos, concluding that consistent changes were evident (south of 58°N) for coastal regions and open sea (excepting the Wadden Sea):

- Increase in biomass (2.5 to 4-fold, peak values 8-fold)

- Increase of opportunistic, short-living species, mainly small polychaetes and bivalves, and ophiuroids and echinoids
- Decrease of long-living sessile species such as several bivalves

Although Krönke (1995) considered the potential effects of hydroclimatic factors, including storm frequency, sea surface temperature (SST) and Atlantic inflow, she concluded (at that time) that entirely natural factors did not explain the large-scale changes found in the communities of the entire North Sea. On the other hand, Krönke (1995, and earlier papers) considered that there was evidence that the changes found were related to anthropogenic impacts such as increased fisheries, eutrophication (via diffuse inflow of nitrates from coastal regions or via the atmosphere) and pollution (point source and diffuse).

Austen *et al.* (1991) compared long-term (1971-88) trends in species abundance data for benthic communities off Northumberland and the Skagerrak, and pelagic data collected in corresponding areas (1958-88) by Continuous Plankton Recorder (CPR). Statistical analysis (multi-dimensional scaling ordination) showed that changes in community structure at the two benthic stations showed a high degree of similarity, characterised by a transition in the late 1970s. However, there was a less marked transition between the 1970s and 1980s in pelagic community structure from the eastern North Sea, and no discernible temporal pattern in pelagic data from the Skagerrak. The main focus of this study was benthic-pelagic coupling, and there was no clear identification of the responsible factors (including eutrophication and/or pollution).

Clark and Frid (2001) reviewed long-term changes in the North Sea ecosystem, at all trophic levels, and concluded that in the northern, western and central areas of the North Sea, long-term changes are predominantly influenced by climatic fluctuations. Here, primary productivity during a particular year is related to the effect of weather on the timing of stratification and the resulting spring bloom. In the southern and eastern areas of the North Sea, the lack of stratification and the large inputs of nutrients mean that primary productivity is more strongly influenced by variations in anthropogenic nutrient inputs, and is only weakly related to climatic variation. However, the weight of evidence shows that long-term changes in the ecosystem may ultimately be related to long-term changes in either climate or nutrients, although the long-term dynamics of certain taxa and communities do show evidence of being influenced by both anthropogenic factors and/or internal factors such as competition and predation.

The Marine Climate Change Impacts Partnership Annual Report Card 2007-2008 Scientific Review - Seabed Ecology (Frid & Moore) concludes that although UK lacks any national programme to assess the state of the sea floor ecosystem,

- The available data show that climatic processes, both directly, e.g. winter mortality, and indirectly, via hydrographic conditions, influence the abundance and species composition of sea bed communities.
- These variations will directly affect the availability of food for bottom feeding fish such as cod and haddock, impact on shellfish populations (*Nephrops* and scallops/clams) and potentially alter patterns of biodiversity and ecological functioning.
- The alteration in the seafloor communities could alter rates and timing of processes such as nutrient cycling, larval supply to the plankton and organic waste assimilation.
- At local (although still large) spatial scales there is also evidence of effects resulting from fishing impacts and at smaller scales habitat modification e.g. wind farms, and impacts from contaminants e.g. oil and gas exploration, waste dumping.

There is reasonable scientific consensus that a regime change – a large, decadal-scale switch from one dynamic regime to another – took place in the North Sea in the period 1982-88 (Reid *et al.* 2001, Beaugrand 2004, Weijerman *et al.* 2005, van Nes *et al.* 2007). Similar regime shifts have been observed at a variety of scales, notably in the north Pacific in the mid-1970s. Biological and ecosystem indicators of regime shift include phytoplankton and zooplankton, benthic biomass, fish spawning stock biomass and fish recruitment, i.e. principally pelagic components of the ecosystem. It should also be noted that some studies (e.g. Taylor 2002) have found only weak evidence of regime shift at large geographical or ecological (i.e. across trophic levels) scales. It has been hypothesised (Beaugrand 2004 and references therein) that the regime shift resulted from the conjunction of three main (interlinked) features:

- A change in local hydro-meteorological forcing
- A displacement of oceanic biogeographical boundaries to the west of the European continental shelf
- An increase in oceanic inflow into the North Sea

Similar conclusions were reached by Weijerman *et al.* (2005), who described a comprehensive analysis of long-term data series on a wide range of physical and biological parameters from the 1960s to the mid 2000s, using principal component analysis, chronological clustering and regime shift analysis to identify the extent and timing of regime shifts in NW Europe. Their analysis – which included a wider range of pelagic, benthic, fisheries, bird and marine mammal data – indicated that substantial regime shifts occurred in the marine ecosystem in 1979 and 1988 and perhaps also in 1998, although results were less clear-cut in the latter case. These regime shifts were most evident among the biological data series, but they appeared to have been triggered by earlier shifts in a number of environmental factors. Salinity and weather conditions played an important role in the 1979 shift, while in the 1988 shift, temperature and weather conditions were the predominant factors. The North Sea and Wadden Sea results were consistent with a similar analysis of North Pacific data, with concomitant changes in physical and biological indices suggesting a shift in climate–ocean interactions throughout the entire temperate zone of the Northern Hemisphere.

Consideration of the relative importance and interactions between causal factors is based on a combination of statistical correlations, theoretical process interactions, and the sequential timing of supposed forcing factors and biological indicators. There are various conceptual and methodological problems in interpreting the data, and although Beaugrand (2004) speculates that observed changes over the last two decades are “likely to have had profound consequences for exploited resources and geochemical cycles”, the actual causes, significance, longevity and reversibility of regime shift remains uncertain.

Possible mechanisms for a “regime shift” in benthic communities at the Frisian Front in the southern North Sea, from a brittle star *Amphiura filiformis* dominated state to a burrowing mud shrimp *Callianassa subterranea* dominated situation, were modelled by van Nes *et al.* (2007). This study found no indications that food levels or other relevant conditions in this part of the North Sea had changed significantly, suggesting that the change represented a transition between alternative stable community states, possibly related to feedback between the benthic community and sediment stability causing both the shrimp dominated state and the brittle star dominated state to be stable under the same external conditions. Simulation of this mechanism indicated that a modelled system with alternative attractors can show a striking regime shift in response to a randomly fluctuating environment, even if no obvious trigger such as an environmental anomaly or fluctuation appears to be present.

In the western English Channel, fluctuations in benthos have been related to sea temperature, notably exceptionally cold winters, immigrant species, dinoflagellate blooms, and, increasingly, heavy fishing gear (Holme 1983). Fluctuations in western species (cold water e.g. *Munida rugosa*, *Echinus acutus* and *Dentalium entalis*) are likely to relate to temperature, as are fluctuations in Sarnian species (warm water e.g. *Octopus vulgaris*, *Venus verrucosa* and *Dentalium vulgare*) (Holme 1966). However, the increased use of toothed scallop dredges and heavy chains on trawls to catch sole were recognised as increasingly important factors in determining benthic communities (Holme 1983). In 1998 selected benthic communities were resurveyed to test hypotheses regarding resilience of megabenthic species (*Glycymeris glycymeris* and *Paphia rhomboides*) to fishing disturbance (Kaiser & Spence 2002). Most sites showed temporal changes in bivalve and echinoderm communities, as would be expected over a 40-year period, although two out of ten did not, suggesting that a few areas of the seabed exist with a similar community composition to that before the general increase in bottom-fishing disturbance. These results reflect the patchy nature of benthic communities and highlight the need for further work in this area to interpret such spatial and temporal inconsistencies.

An additional aspect of the evolution of the baseline is the potential for new discoveries of small scale habitats and biotopes which may be of scientific, ecological and conservation importance and changes in perspectives on the relative importance of individual species or biotopes. The deployment of new seabed imaging techniques and methods of investigation such as benthic landers, ROVs and malacochronology has resulted in several such discoveries/reassessments, and there is the expectation that more will follow in the future.

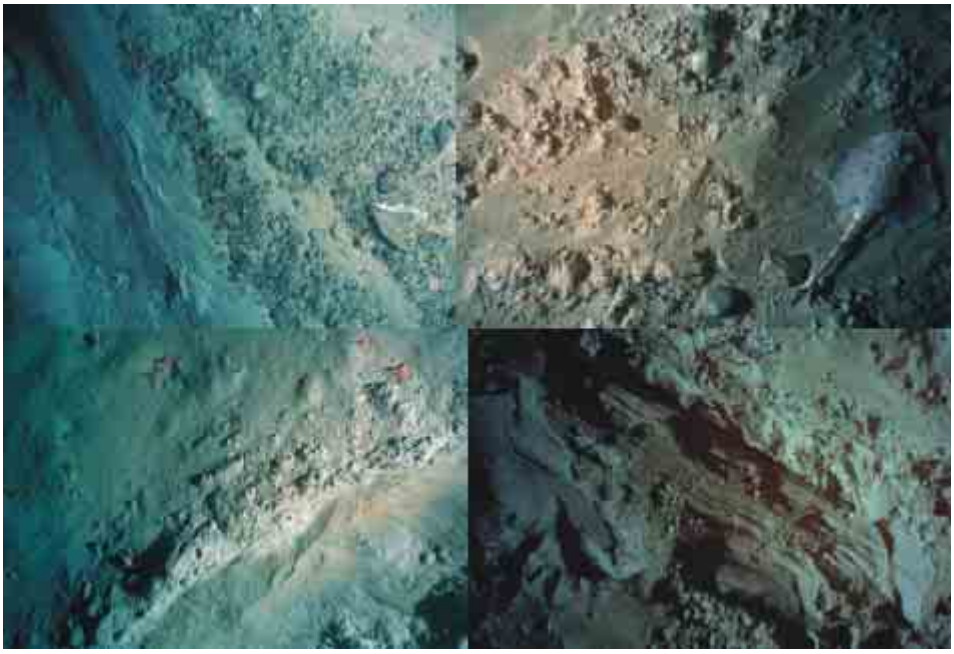
A3a.2.15 Environmental issues

A3a.2.15.1 Fishing

For some time, the extent and nature of changes at the seabed resulting from fishing activity have been apparent and the subject of reviews including de Groot & Lindeboom (1994), Jennings & Kaiser (1998) and Kaiser & de Groot (2000), with the bibliography of Dieter *et al*. (2003) listing 758 citations on the subject. Effects at the species level may be positive or negative for example, physical damage of large, long lived and fragile species can lead to mortality and potentially local extinction, while other species such as hermit crabs which survive trawling may increase in number, finding a rich supply of food in the discards of fish and killed or damaged benthic organisms. At the ecosystem level, a shift towards a seabed community where shorter generation, more opportunistic species predominate has been proposed and for which evidence is beginning to accumulate e.g. Frid & Hall (1999) and Hiddink *et al.* (2006).

Virtually all parts of the worldwide continental shelf are, or have been, fished intensively and the types of seabed effects noted above are to be expected in the area. In the UK Regional Seas, only the oceanic (abyssal depths) seabed in Regional Seas 5 and 11 might be expected to be reasonably free of the effects of fishing. For example, Bett (2000) documents the observations of potential fishing impacts recorded during the AFEN 1996 and 1998 and DTI 1999 surveys – in the form of trawl marks and discarded/lost fishing gear observed on the seabed, and a core sample taken in (presumed) trawl disturbed ground. The SEA 4 survey in 2000 recorded the presence of trawl marks in the iceberg ploughmark zone to the north of Shetland. The effects of deep-sea trawling on benthic communities is little known, though clearly is likely to be highly destructive to communities of sessile organisms (e.g. corals and sponges) (see Bett, 2000 and Gage *et al*. 2005).

Figure A3a.2.14 – Seabed photographs showing physical disturbance ("trawl marks") of the seabed presumed to result from the action of demersal trawling in the Faroe-Shetland Channel



Source: Bett (2003)

A3a.2.15.2 Aggregate extraction

Aggregate extraction takes place at numerous discrete, licensed areas in the southern North Sea, English Channel, Bristol Channel and northern Irish Sea (Regional Seas 2, 3, 4 and 6) where sand and gravel is removed by dredger for use on land (or for coastal replenishment). Such extraction removes the habitat and kills or disperses the seabed fauna. The effects of this localised activity have been reviewed by Newell *et al*. (1998) and appear to be similar to the effects of major storms where extensive sediment redistribution occurs followed by recolonisation and an ecological succession. There can be considerable variation in the time taken for complete recovery of communities following aggregate extraction depending upon the environmental conditions, with periods of 5-10 years sometimes being necessary in deeper, moderately stable areas (Newell *et al.* 1998, Robinson *et al.* 2005). The resulting benthic community may be different from that which existed previously as the sediment type may be different (e.g. muddy sand as opposed to clean sand as a result of the changed seabed topography).

A3a.2.15.3 Dumping

With the exception of maintenance dredging from harbours and shipping channels, no wastes are now dumped in the North Sea. Previously, dredged material, industrial wastes and sewage sludge were dumped at defined licensed sites resulting in a range of effects at the seabed related to the nature of the site and the type and volume of wastes. These effects included physical smothering, alteration of sediment type, chemical contamination and organic enrichment with ecological effects ranging from none detectable to substantial alteration of community type (QSR 1993 and OSPAR 2000).

A3a.2.15.4 General contamination of the North Sea

The North Sea (especially the southern part), and to some extent the English Channel, Irish Sea and Clyde, are surrounded by large centres of population, agriculture and industry and serviced by some of the busiest shipping lanes in the world. These have resulted in substantial diffuse inputs of nutrients, contaminants and sediments either directly or from atmospheric fallout, which have resulted in a wide range of ecological effects. These effects range from sublethal changes to individuals (e.g. the endocrine disruption caused by tributyltin antifouling paints) and bioenergetic changes, through enrichment of the seabed by enhanced phytoplankton productivity to the asphyxiation of benthic animals by low concentrations of oxygen in following intense phytoplankton blooms.

These effects are well summarised in QSR (2000) and various OSPAR reports and in general are viewed as declining in intensity as control measure take effect. OSPAR is currently in the process of compiling a new QSR, due in 2010. Such effects are also not regarded as significantly affecting the seabed fauna of offshore waters although Krönke (1992) suggests that the faunal changes noted on the Dogger Bank might be due to eutrophication (although system changes resulting from fisheries interaction is an alternative explanation).

A3a.2.15.5 Wrecks and artificial substrates

The deliberate and accidental placement of hard substrates where the seabed is predominantly sand and mud will allow the development of “island” hard substrate communities. Such “islands” occur naturally, for example on glacial dropstones and moraines, but the substantial expansion of the number of hard surfaces due to wrecks and other artificial substrates has a number of potential implications for seabed fauna. Firstly, the additional surfaces can provide “stepping stones” allowing species with short lived larvae to spread to areas where previously they were effectively excluded from. The rapid colonisation of new oil and gas platforms has been documented a number of times (e.g. Forteath *et al*. 1982) and such colonising species can have very rapid growth rates (e.g. the horse mussel *Modiolus modiolus*, Anwar *et al*. 1990), and cause slight enrichment at the seabed through dislodged animals and settlement of the wastes produced (Southgate & Myers 1979). Similarly rapid colonisation of monopiles associated with offshore wind turbines and meteorological masts has also been reported more recently (e.g. Marineseen & CMACS 2004). In the context of the natural availability of hard substrates (including extensive distribution of glacial dropstones over much of the continental shelf), such effects are only minor.