2. Habitats directive Annex I habitats in the UK offshore area

Annex I of the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (as amended by Directive 97/62/EC) lists those habitats of Community Interest whose conservation requires the designation of SACs. The Annex is split into groups and sub-groups of habitats. The only sub-groups to occur in the marine environment (below low water) are Coastal and Halophytic Habitats: open sea and tidal areas; and Rocky Habitats and Caves: other rocky habitats. The Interpretation Manual of European Habitats (HAB 96/2 Final – EN version 15/2 October 1999), aids the interpretation of the habitat types listed in Annex I. The habitats in the open sea and tidal areas sub-group are listed in Table 2.1.

Table 2.1 Marine habitats listed in Annex I of Council Directive 92/43/EEC as amended by Directive 97/62/EC.

EU code	*Habitat name*
Open sea and tidal areas	
1110	Sandbanks which are slightly covered by sea water all the time
1120	*Posidonia* beds
1130	Estuaries
1140	Mudflats and sandflats not covered by seawater at low tide
1150	Coastal lagoons
1160	Large shallow inlets and bays
1170	Reefs
1180	Submarine structures made by leaking gases
Other rocky habitats	
8330	Submerged or partially submerged sea caves

Estuaries, mudflats and sandflats not covered by seawater at low tide, large shallow inlets and bays and coastal lagoons are all coastal and do not occur outside territorial waters. *Posidonia* beds are a Mediterranean habitat and not present in UK waters. The remaining four habitats (reefs, sandbanks, structures made by leaking gases and submerged caves) are either known to occur in UK offshore waters or may occur. These habitats are considered further below.

2.1. Habitat definitions and interpretations

In order to assess offshore areas to identify habitats that might be suitable for selection as SACs, and in order to determine the extent of these habitats in UK waters, working interpretations of these habitats need to be refined. There are three layers of definition/interpretation:

a) EC Habitats Directive (EEC 1992) (as amended by Directive 97/62/EC (EC 1997)).

b) EC Interpretation Manual v. Eur 15/2 (EC 1999) (official EC guidance on the definition of the habitats).

c) National/local interpretation (in the UK, partially covered by Brown *et al.* 1997[1] and subsequently throughout the text).

[1] Brown *et al.* 1997 describes implementation of the Habitats Directive in the UK.

Level c) is likely to vary slightly between Member States, reflecting national and local differences in the character of each habitat.

In the UK, a national interpretation for three of the habitats which may occur in offshore waters was developed with regard to inshore waters at the time of SAC site selection within territorial waters (the fourth, submarine structures made by leaking gases, does not occur in UK inshore waters). The correspondence between these Annex I habitats and the marine biotopes described in the MNCR BioMar classification was established (JNCC 1999a). The national definitions were re-examined and clarified for application in the UK offshore environment, whilst ensuring that existing inshore sites fit within the 'envelope' of definition developed for use by the offshore project.

2.1.1. Sandbanks which are slightly covered by sea water all the time

The Interpretation Manual of European Habitats (EC 1999) defines sandbanks as:

> "Sublittoral sandbanks, permanently submerged. Water depth is seldom more than 20 m below Chart Datum. Non-vegetated sandbanks or sandbanks with vegetation belonging to the *Zosteretum marinae* and *Cymodoceion nodosae*.
>
> Plants: *Zostera marina*, free living species of the *Corallinaceae* family. In the Baltic Sea also *Potamogeton pectinatus*, *Ruppia cirrhosa* and *Tolypella nidifica*. Around Tenerife, *Halophila decipiens* communities.
>
> Animals: Important wintering habitat for many bird species, in particular *Melanitta nigra* but also *Gavia stellata* and *Gavia arctica*. Resting places for seals. Invertebrate communities of sandy sublittoral (e.g. polychaetes)."

At a national level, for the purpose of SAC selection for both inshore and offshore sites, the definition of *sandbanks which are slightly covered by sea water all the time* has been further interpreted and clarified:

Substratum: This habitat comprises a range of sandy sediments. In terms of Wentworth's classification it includes all types of sand (particle size range 0.0625-2 mm). In terms of Folk's classification used for BGS geological maps, this habitat may include all sands, muddy sands and gravelly sands, and some forms of sandy gravels (i.e. all sandy sediments in lower right quartile of modified Folk triangle used by BGS, see Figure 2.1). Free-living *Corallinaceae* (i.e. maerl) are explicitly included in the EC definition. Eelgrass *Zostera marina* beds are also referable to this habitat type.

Height boundary: Chart Datum (Lowest Astronomical Tide may technically be more correct, but is in practice less easy to define on a map or chart).

Depth: Predominantly <20 m in depth (but may include channels or other areas >20 m).

Topography: Topography is variable but includes distinct banks (i.e. elongated, rounded or irregular 'mound' shapes) which may arise from horizontal or sloping plains of sandy sediment. Where the areas of horizontal or sloping sandy habitat are associated with the banks, they are included within the Annex I type.

Size: No lower limit, subject to the sandbank being large enough to maintain its structure and functions.

2.1.2. Reefs

The Interpretation Manual of European Habitats (EC 1999) defines reefs as:

> "Submarine, or exposed at low tide, rocky substrates and biogenic concretions, which arise from the sea floor in the sublittoral zone but may extend into the littoral zone where there is an uninterrupted zonation of plant and animal communities. These reefs generally support a zonation of benthic communities of algae and animal species including concretions, encrustations and corallogenic concretions.
>
> Plants: brown algae (species of the *Fucus*, *Laminaria* and *Cystoseira* genus, *Pilayella littoralis*), red algae (e.g. species of the *Corallinaceae*, *Ceramiceae* and *Rhodomelaceae* families), green algae. Other plant species: *Dictyota dichotoma*, *Padina pavonica*, *Halopteris scoparia*, *Laurencia obtusa*, *Hypnea musciformis*, *Dasycladus claveformis*, *Acetabularia mediterranea*.
>
> Animals: mussel beds (on rocky substrates), invertebrate specialists of hard marine substrates (sponges, *Bryozoa* and cirripedian *Crustacea* for example)."

At a national level, for the purpose of SAC selection for both inshore and offshore sites, the definition of *reefs* has been further interpreted and clarified:

Substratum: Bedrock, boulders and cobbles (cobbles generally >64 mm in diameter), including those composed of soft rock, such as chalk. Biogenic concretions, i.e. aggregations of a species to form a hard substratum, thus enabling an epibiota community to develop. Biogenic reef-forming species include *Serpula vermicularis*, *Sabellaria* spp., *Lophelia pertusa*[2], *Mytilus edulis* and *Modiolus modiolus*.

Height boundary: Highest Astronomical Tide (or in practice Ordnance Survey High water) where the intertidal zone is included in the site. (Note that intertidal areas are only included where they are connected to subtidal reefs).

Depth: No depth limit.

Topography: A variety of topographic features in the subtidal zone, including vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock, and boulder and cobble fields. Caves and cave-like features are excluded (these are referable to the Annex I category 'Submerged or partially submerged sea caves). 'Arising from the sea floor' is taken in the sense that the reef is topographically distinct. Rocky structures that are covered by a thin and mobile veneer of sediment are classed as reefs if the associated biota are dependent on the rock rather than the overlying sediment.

Size: No lower limit, subject to the reef being large enough to maintain its structure and functions. Note that some biogenic reefs are inherently patchy and may contain relatively small individual colonies of, for example, *Serpula*.

2.1.3. Submarine structures made by leaking gases

The Interpretation Manual of European Habitats (EC 1999) defines this habitat as:

---

[2] At the meeting of the EC Habitats Scientific Working Group on 9 September 1999 there was a discussion as to whether *Lophelia* structures should be treated as reefs in the context of Annex I of the Habitats Directive. The discussions were inconclusive, but the UK view remains clear – *Lophelia* does form reefs which are referable to this Annex I type.

"Spectacular submarine complex structures, consisting of rocks, pavements and pillars up to 4m high. These formations are due to the aggregation of sandstone by a carbonate cement resulting from microbial oxidation of gas emissions, mainly methane. The methane most likely originated from the microbial decomposition of fossil plant materials. The formations are interspersed with gas vents that intermittently release gas. These formations shelter a highly diversified ecosystem with brightly coloured species.

Animals: Porifera – *Clione celata*; Anthozoa – *Metridium senile, Tealia felina, Alcyonium digitatum*; Polychaeta – *Pomatoceros triqueter, Dodocaceria concharum*; Gastropoda – *Cingula striata, Alvania punctura, Rissoa albella, R. parva*; Decapoda – *Porcellana longicornis, Cancer pagurus*; Echinodermata – *Ophiothrix fragilis*."

Implementation of the Habitats Directive in UK inshore waters did not identify any examples of this habitat, so no national level interpretation or clarification was developed. Further work is required to investigate the possible occurrence of *submarine structures made by leaking gases* in UK offshore waters. Initial investigations suggest that a variation of this habitat type may exist in UK offshore waters:

Substratum: Must consist of a carbonate cement structure resulting from microbial oxidation of gas emissions.

Height boundary: No further national interpretation.

Depth: No depth limit.

Topography: No further national interpretation

Size: No lower limit, subject to the submarine structure being large enough to maintain its structure and functions.

2.1.4. Submerged or partially submerged sea caves

The Interpretation Manual of European Habitats (EC 1999) defines this habitat as:

"Caves situated under the sea or opened to it, at least at high tide, including partially submerged sea caves. Their bottom and sides harbour communities of marine invertebrates and algae."

At a national level, for the purpose of SAC selection for both inshore and offshore sites, the definition of *submerged or partially submerged sea caves* has been further interpreted and clarified:

Substratum: No further interpretation.

Height boundary: No further interpretation.

Depth: No depth limit.

Topography: Needs at least to have some overhanging feature.

Size: No lower limit, subject to the cave being large enough to maintain its structure and functions.

2.2. Site assessment criteria and additional principles used for site selection for Annex I habitats in the UK

The Habitats Directive (92/43/EC) includes, in Annex III, criteria for selecting sites eligible for identification as Sites of Community Importance and designation as Special Areas for Conservation (SACs). It also includes in the text of the Directive, reference to selection of sites using the selection criteria and relevant scientific information. In preparing the UK national list of candidate SACs (for terrestrial and inshore habitats), as well as the Annex III selection criteria, additional principles for site selection have been developed, which interpret and supplement the Annex III selection criteria. These additional principles have been developed in the light of discussions between Member States and the European Commission at the Atlantic Biogeographical meeting in Edinburgh (UK) in 1994 (Hopkins & Buck 1995). The selection criteria and additional principles are listed in Table 2.2 below. The process of applying the selection criteria and additional principles to terrestrial and inshore sites in the UK is described in JNCC Report 270 (Brown *et al.* 1997). Brown *et al.* (1997) is currently being updated to take account of work carried out in the UK in the light of conclusions from the Kilkee and Paris Atlantic Biogeographical Region meetings in 1999 (McLeod *et al.* in press).

Table 2.2 Summary of site assessment criteria and additional principles used for site selection in the UK (from McLeod *et al*. (in press)

Site assessment criteria (Annex I habitats)	***Reference***
Representativity	Annex III Stage 1A(a); Article 1e; Conclusions of 1994 Atlantic Biogeographical Region Meeting (para. 4).
Area of habitat (Relative surface)	Annex III Stage 1A(b); Article 1e; Conclusions of 1994 Atlantic Biogeographical Region Meeting (para. 4).
Conservation of structure and functions	Annex III Stage 1A(c); Article 1e.
Global assessment	Annex III Stage 1A(d).
Additional principles	
Priority/non-priority status	Article 1d; Annex III Stage 1D; Conclusions of 1994 Atlantic Biogeographical Region Meeting (para. 3).
Geographical range	Articles 1e and 3.1.
Special UK responsibilities	Article 3.2; Conclusions of 1994 Atlantic Biogeographical Region (para. 6).
Multiple interest	Annex III Stage 2.2(d); Conclusions of 1994 Atlantic Biogeographical Region Meeting (para. 2).
Rarity	Conclusions of 1994 Atlantic Biogeographical Region Meeting (para. 5).

This section outlines how these site assessment criteria and additional principles (which were used to guide site selection for inshore and terrestrial habitats) should be applied to habitats in the UK offshore area. Relevant extracts of text from the Directive and Annexes, from the Atlantic Biogeographical Meeting in Edinburgh in 1994 (Hopkins & Buck 1995) are referred to in the following sections. The selection criteria and additional principles outlined above are unlikely to change, and there are currently no indications of imminent changes to the list of relevant habitats in Annex I to the Directive or to their definitions in the Interpretation Manual (EC 1999). The more detailed scientific information on habitats included in the following sections of this report, however, is based on currently available knowledge, which for the offshore environment is continually developing. It is provided here only as an *indication* of the aspects of the relevant habitats that are likely to be used to assist in site selection.

Four Annex I habitats are currently being considered for selection of SACs in the UK offshore area and are shown in Table 2.3.

Table 2.1 Habitats considered for SAC selection in UK offshore waters (from Directive 97/62/EC amending Annexes I and II to Directive 92/43/EEC).

EU code	*Habitat name*
1110	Sandbanks which are slightly covered by seawater all the time
1170	Reefs
1180	Submarine structures made by leaking gases
8330	Submerged or partially submerged sea caves

The following Sections (2.2.1. and 2.2.2.) of this report describe application of the criteria and principles set out in Table 2.1, to these four habitat types.

2.2.1. Application of Habitats Directive Annex III Stage 1A criteria

2.2.1.1. Representativity

Habitats Directive Annex III Stage 1A (a): "Degree of representativity of the natural habitat type on the site."

Atlantic Biogeographical Region Meeting Conclusions, paragraph 4: "In considering the degree of representativity of Annex I habitat types on individual sites, Member States will take account of the best examples in extent and quality of the main type, (which is most characteristic of the Member State) and its main variants, having regard to geographical range." (Hopkins & Buck 1995).

The Explanatory Notes to the Natura 2000 Standard Data Form (EC 1995) specifically state that this criterion should be linked to the Interpretation Manual of Annex I habitats (EC 1999) as it provides a definition, a list of characteristic species and other relevant elements for each habitat. This criterion is a measure of how typical a site is for a particular habitat.

Sandbanks which are slightly covered by seawater all the time

Section 2.1.1 gives the full EC habitat definition. Inshore sites were selected to cover the geographical and ecological range of variation of the following categories (Brown *et al.* 1997):

- Gravelly and clean sands;
- muddy sands;
- eelgrass *Zostera marina* beds; and
- maerl (*Corallinaceae*) beds.

Vegetated sandbanks and maerl are not known to occur in the UK offshore area and the three bird species mentioned in the Interpretation Manual (EC 1999) occur primarily within territorial waters.

Offshore sites should be selected to represent the main variants of the habitat occurring offshore, in water depths of less than 20 m, having regard to geographical range (Hopkins & Buck 1995). They should complement the sandbank habitats already represented within the SAC series inshore. On current information, sites selected should include:

- Sandy mounds; and
- the following tidal current sandbank types (from Dyer & Huntley 1999):

Type 1 open shelf ridge sandbanks;

Type 2 estuary mouth sandbanks;

Type 3 headland associated banks.

Sites are also likely to be selected to represent both 'active' and 'relict' banks (indicated by sandwave presence and shape), as their flora and fauna are likely to differ. Within the above categories, sites may also be selected to represent the biological communities of the range of relevant sediment types (see Section 2.1.1).

Reefs

Section 2.1.2 gives the full EC habitat definition. A number of different types of reef with a range of biological communities occur in UK offshore waters. Offshore sites should be selected to represent the main variants of the habitat occurring offshore, having regard to geographical range (Hopkins & Buck 1995). They should complement the reef habitats already represented within the cSAC series inshore. On current information, sites selected are likely to include the following reef types:

1. Different main bedrock types and topographical forms e.g. pinnacles, offshore banks.
2. Stony reefs - cobble and boulder reefs, iceberg ploughmarks (see Section 2.3.3.5 for description).
3. Biogenic reefs - made by cold water corals (e.g. *Lophelia pertusa*) and *Sabellaria spinulosa* (*Modiolus modiolus* reef occurs primarily within 12 nm of the coast).

Within the above categories different biological communities are likely to be represented, e.g. those resulting from differences in water masses, water depths and water currents (cold water reef communities influenced by arctic waters, warmer water reefs influenced by Atlantic waters, transitional areas of reef etc.).

Submarine structures made by leaking gases

Section 2.1.3 gives the full EC habitat definition. Marine columns (the name of this habitat in the original Habitats Directive Annex I), such as those found in Danish waters, are not known to occur in UK waters. However, gas seep depressions (commonly referred to as 'pockmarks'), some of which have carbonate structures within them, do occur in UK waters. It is arguable whether 'pockmarks' with carbonate structures fit within the habitat definition for submarine structures made by leaking gases. If, on further investigation, it is decided that these structures do fit the description, sites should be selected to represent this variant of submarine structures made by leaking gases. If on further investigation the 'pockmarks' with carbonate structures are not deemed to be 'spectacular submarine complex structures', then this habitat will not be represented in UK offshore waters.

Submerged or partially submerged sea caves

Section 2.1.4 gives the full EC habitat definition. Inshore cave sites were selected to encompass the range of structural and ecological variation of sea caves. Selection was confined to well-developed cave systems, with extensive areas of vertical and overhanging rock and those that extend deeply into the rock. Regard was given to rock type and emphasis was given to the selection of habitat in coastal chalk (Brown *et al.* 1997). Offshore cave sites (if found) should have regard to the inshore series and be selected to include a range of rock types, depths and hydrodynamic conditions.

2.2.1.2. Area of habitat (or Relative Surface, EC 1995)

Habitats Directive Annex III Stage 1A (b): "Area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within national territory".

Atlantic Biogeographical Region Meeting Conclusions, paragraph 4: "In considering the degree of representativity of Annex I habitat types on individual sites, Member States will take account of the best examples in extent and quality of the main type, (which is most characteristic of the Member State) and its main variants, having regard to geographical range." (Hopkins & Buck 1995).

The Explanatory Notes to the Natura 2000 Standard Data Form (EC 1995) explain that, in theory, one needs to measure the surface covered by the habitat type on the site, and the total surface of the national territory that is covered by the same habitat type, to be able to select a suitable proportion of the habitat type as cSAC. Although this is evident, it can be extremely difficult to make these measurements, especially those concerning the reference national surface. An estimate of the total surface of the relevant habitats in UK offshore waters is being obtained using existing geological map interpretations, supplemented by other data sources.

Consideration of area of habitat for site selection is related to other principles used for site selection, for example, structure and functions (see below) are most often best conserved in sites that are extensive (Brown *et al.* 1997).

2.2.1.3. Conservation of structure and functions

Habitats Directive Annex III Stage 1A (c): "Degree of conservation of the structure and functions of the natural habitat type concerned and restoration possibilities."

Habitats Directive Article 1 (e) "*conservation status of a natural habitat* means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species within the territory referred to in Article 2.

The conservation status of a natural habitat will be taken as 'favourable' when:

- its natural range and areas it covers within that range are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable as defined in (i)."

The Explanatory Notes to the Natura 2000 Standard Data Form (EC 1995) explain that this criterion comprises three sub-criteria:

1. Degree of conservation of structure
2. Degree of conservation of functions
3. Restoration possibilities

Although these sub-criteria could be evaluated separately, they should nonetheless be combined for the requirements of selection of sites as they have a complex and interdependent influence on the evaluation process (EC 1995). Sites selected (and their boundaries) should reflect the structure and function requirements of the particular habitat.

With regard to the third sub-criterion the position has been taken by the UK that, "where a sufficient number of examples of habitat types in good condition can be identified, it is considered unnecessary to select sites that are damaged or in relatively poor condition" (Brown *et al.* 1997). In the case of damaged habitat offshore, consideration should be given as to whether activities have profoundly and irreversibly affected the structure and functions of the habitat (as may be the case, for example, for bottom trawl damage to cold water coral biogenic reef) and, therefore, whether restoration would be possible.

2.2.1.4. Global assessment

Habitats Directive Annex III Stage 1A (d): "Global assessment of the value of the site for conservation of the natural habitat type concerned".

The Explanatory Notes to the Natura 2000 Standard Data Form (EC 1995) state that this should be used to assess the previous three criteria in an integrated way and to take into account the different weights they may have for the habitat under consideration.

2.2.2. Additional principles which should be taken into account in site selection for Annex I habitats

2.2.2.1. Priority/Non-priority habitats

Habitats Directive Article 1 (d) "*Priority natural habitat types* means natural habitat types in danger of disappearance, which are present on the territory referred to in Article 2 and for the conservation of which the Community has particular responsibility in view of the proportion of their natural range which falls within the territory referred to in Article 2".

Atlantic Biogeographical Region Meeting Conclusions, paragraph 3: "Member States will give significant additional emphasis in number and area to sites containing priority habitat types and species." (Hopkins & Buck 1995).

None of the habitats that are being considered in the UK offshore area have priority status.

2.2.2.2. Geographical range

Habitats Directive Article 3 (1): "A coherent European ecological network of special areas of conservation shall be set up under the title Natura 2000. This network, composed of sites hosting the natural habitat types listed in Annex I …, shall enable the natural habitat types … concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range".

Favourable conservation status is dependent upon the maintenance of the geographical range of the habitat type or species, amongst other things. The terrestrial and inshore site series for each habitat type has been chosen to reflect its distribution in the UK (Brown *et al.* 1997). This will also apply in the selection of sites to represent habitats in the UK offshore area. However, habitat types vary considerably in their patterns of distribution. In the offshore area of the UK, due to the physical regime, sandbanks are clustered in the south and east of the UK, submarine structures made by leaking gases ('pockmarks') in the North Sea, and reefs in the west (both north and south). No sea cave habitat is currently known in offshore waters.

2.2.2.3. Special UK responsibility/proportion of European habitat

Habitats Directive Article 3 (2): Selection of sites for relevant habitats within a Member State should be made in proportion to the representation of that habitat within the territory of the Member State.

Atlantic Biogeographical Region Meeting Conclusions, paragraph 6: "It is acknowledged that certain habitat types and species listed in Annexes I and II are relatively common and extensive in certain Member States. These Member States will have particular responsibility for proposing a proportion of the resource which is sufficient to contribute significantly to the maintenance of the habitat types and species at a favourable conservation status." (Hopkins & Buck 1995).

Certain habitat types are relatively common and extensive in certain Member States. These Member States will have "particular responsibility for proposing a proportion of the resource that is sufficient to contribute significantly to the maintenance of the habitat types … at a favourable conservation status" (Hopkins & Buck 1995). However, proposed sites will still be subject to the other selection criteria and additional principles so that selection is consistent and the sites of high quality (Brown *et al.* 1997).

The UK does not have special responsibility within the EU for reef, sandbank and sea cave habitats, as, although large areas of these habitats are represented in the UK, they also occur over large areas of the territories of other Member States. The proportion of these three habitats in the UK is unlikely to change significantly by the inclusion of the UK offshore area in the UK territory. If it is determined that some UK examples of 'pockmarks' fit within the definition of 'submarine structures made by leaking gases', then it is possible that the UK may have special responsibility for this habitat, as it is otherwise known in the EU only from Denmark and Italy.

2.2.2.4. Multiple interest

Atlantic Biogeographical Region Meeting Conclusions, paragraph 2: "Acknowledging that outstanding single interest sites in terms of quality, extent or range make an important contribution to the Natura 2000 network, special emphasis will be given to identifying and delimiting sites containing complexes of interests on Annexes I and II as valuable ecological functional units." (Hopkins & Buck 1995).

It is considered unlikely that any of the sites proposed for selection will have multiple habitat interest features due to the nature and scale of the habitats being considered for the offshore area. However, sites proposed for offshore habitats may also contain Annex II species or SPA interest features.

2.2.2.5. Rarity

Directive text: None

Atlantic Biogeographical Region Meeting Conclusions, paragraph 5: "Acknowledging that sites containing Annex I habitat types and Annex II species at the centre of their range will make an important contribution to Natura 2000, Member States will take responsibility for proposing sites containing habitats and species that are particularly rare in that Member State, with a view to preserving the range." (Hopkins & Buck 1995).

Brown *et al.* (1997) lists specific habitats considered to be rare, "because they cover less than 1,000 ha or because there is a significant representation of the habitat type at three or fewer sites". None of the Annex I habitats that are being considered in the offshore area

occur on the list given in Brown *et al.* (1997). Thought will need to be given to adding 'submarine structures made by leaking gases' if it is determined that the habitat exists in the UK, and its extent is calculated as below this threshold.

2.3. Information on Annex I habitats in the UK offshore area

2.3.1. Habitat identification

Identification of the distribution and extent of Annex I habitats in offshore waters was undertaken through a contract with the British Geological Survey (BGS), Edinburgh. The location and extent of reefs (excluding biogenic reefs), sandbanks and submarine structures made by leaking gases were extracted from existing BGS map interpretations of sample and geophysical data (1:250,000 scale seabed sediment map series). These locations were mapped within a Geographical Information System (GIS) and a database was created in MS Access 97 for accompanying data. Each BGS 1:250,000 map covers one degree of latitude and two degrees of longitude, and is based largely on BGS survey data (sampling and seismic, refer to Figure 2.2 for survey coverage). These maps have an average data density of 5-10 km, and therefore depict regional geology, which can in places be very generalised. The published maps cover the entire UK offshore area east of about 10° west. The survey work, interpretation, compilation and publishing of these maps was done mainly from the late 1970's until about 1990 (Graham *et al.* 2001a). Where possible, refinement of the existing map interpretations followed in subsequent phases, using additional information where available, in order to further distinguish between habitat and sub-habitat types.

The habitat maps presented (Figure 2.3 to Figure 2.20) show bathymetric contours for depths greater than 200 m from the GEBCO '97 Digital Atlas (IOC, IHO and BODC 1997). Unfortunately bathymetric contours at less than 200 m depth (mostly relevant to the English Channel and North Sea) are not yet available in a suitable form for the whole of UK offshore waters and are not included on these maps.

Limitations on using existing geological map interpretations to map the location and extent of Habitats Directive Annex I habitats in UK offshore waters were encountered in terms of the depth of sandy sediments to include, and in terms of the Habitats Directive definition of 'reef'.

Sandbanks in terms of the Habitats Directive are in water depth "seldom more than 20 m below Chart Datum", and in terms of UK interpretation of the types of sediments represented, may include any sandy sediments. Existing BGS geological maps use a modified form of the Folk classification (see Figure 2.1), therefore any sandy sediments (those forming the lower right quartile of the Folk triangle) occurring in less than 20 m water depth were included in the GIS as potential sandbank habitat. It is important to note that the maps in this report show only these areas of sandy sediments in 20 m water depth or shallower. Complete sandbanks of which these areas form the summits, extend into water deeper than 20 m. The actual area considered for designation as Annex I habitat may, therefore, need to be increased to incorporate complete sandbank flanks, associated horizontal or sloping sandy habitats and/or channels between banks, to maintain the structure and functions of a sandbank or sandbank system. In the UK offshore area there are also distinct sandbanks in waters much deeper than 20 m, which have not been mapped as part of this project as they do not fit the Annex I habitat definition.

Reef habitat in terms of the Habitats Directive includes bedrock, rocky substrates and biogenic concretions arising from the seafloor (see Section 2.1.2). Areas of bedrock and

rocky substrata are relatively easy to extract from BGS seabed map interpretations. However, areas of 'gravel' according to the BGS modified Folk classification include any solid particles from 2 mm diameter to greater than 256 mm diameter (see Sediment Size table in Figure 2.1). In terms of the Wentworth classification, this category includes 'cobbles' and 'boulders', which would be included within the UK interpretation of the definition of reef, but also includes 'pebbles' and 'granules', which do not fall within the definition of reef. Therefore, during the work to map areas of reef, all those areas on existing BGS maps categorised as 'gravel' were included as potential Annex I reef habitat. More detailed survey work may in future indicate that some of these areas do not fall within the definition of reef. In this report, where the term 'gravel' is used, we have included reference to Folk where appropriate. However, during the literature review as part of this project, the term 'gravel' is not always used in this specific context; we have specified the context in which the term has been used where such information is available.

Individual submarine structures made by leaking gas could not be mapped from existing seabed maps. However, gas seep areas were shown as areas where examples of this Annex I habitat may be found to occur.

It is important to note that the maps only show potential Annex I habitat for UK offshore waters. Where areas of such habitat extend into UK inshore waters, the inshore element is also shown on the maps, and is shaded differently. The same applies to areas of habitat which extend outside UK offshore waters into the offshore areas of other EU states. Therefore, the extent of such habitats in UK inshore waters (0-12 nm) is **not** fully represented – only those areas of habitat which extend further than 12 nm from shore are shown.

Additional information has been acquired from commercial and non-commercial sources in order to determine the nature of habitat in areas identified by the BGS contract. This information has also been used to identify any areas of reef (in particular, biogenic reef) which were not identified through the BGS contract, e.g. *Sabellaria spinulosa* reef. A full list of individuals and organisations which have contributed information is provided in the acknowledgements and where information has been used, a reference is provided.

2.3.2. Sandbanks which are slightly covered by sea water all the time

Sandbanks may originate through different processes which can lead to topographical differences. The two main sandbank types in UK offshore waters are:

a. Sandy mounds

   Sandy mounds may form where the underlying bedrock is uplifted or glacial till has been left and sand has been deposited in an overlying layer.

b. Tidal current sandbanks

   Tidal current sandbanks may form around headlands (banner banks and alternating ridges), in estuary mouths (estuary mouth ridges or tidal deltas), or on the open shelf (open shelf ridges).

In addition to topographic structure, salinity and sediment type are important factors influencing the nature of biological communities in sandbanks, as are temperature and water mass differences in different parts of the UK offshore area. All sandbanks in offshore waters are assumed to be subject to full salinity, as freshwater influences at 12 nm from shore are likely to be negligible.

Figure 2.3 shows the occurrence of sandy sediments (according to the BGS modified Folk classification, see Figure 2.1) in UK offshore waters in less than 20 m water depth. The main aggregations of offshore sandbanks occur around the north and north-east coast of Norfolk, in the outer Thames Estuary, off the south-east coast of Kent and off the north-east coast of the Isle of Man. This section will address the main aggregations of offshore sandbanks in turn with a view to characterising them by sediment type, topographical structure and indicating whether further information is available for them.

2.3.2.1. Dogger Bank (South-West Patch)

The Dogger Bank is an extensive sandy mound in the central North Sea located in both UK, Dutch and German waters. The majority of the bank in UK waters is between 20 and 40 m deep but an area of sandy sediment in the south-west is shallower than 20 m (shown on Figure 2.4), referred to here as the south-west patch. The Dogger Bank is composed of sediment which was deposited during the last glaciation and has subsequently been modified and smoothed by surrounding prevailing currents and storm influences to give its current formation. Sediment varies across the bank from clay to medium-grained sand to pebbles (Veenstra 1965). The seabed sediment in the south-west patch is primarily well-sorted medium to fine sand and some gravelly sand (Graham *et al.* 2001a). Few surveys have been undertaken on the south-west patch and consequently little is known about the biological communities that occur in this area of the bank. An environmental survey for Marathon Oil UK Ltd in 1989 (Aberdeen University Marine Science 1990) on the northern margin of the south-west patch, found that faunal diversity was relatively low in comparison to other regions of the North Sea which lie in deeper water. The low diversity of fauna was regarded as being due to the high degree of turbidity which the south-west patch experiences due to its shallow nature (Aberdeen University Marine Science 1990). The most abundant species throughout the area surveyed were *Bathyporeia elegans* (an amphipod), *Iphinoe trispinosa* (a cumaecean), *Nephtys cirrosa* (a polychaete worm), *Lunatia alderi* and *Fabulina fabula* (molluscs). The 2001 DTI-led Strategic Environmental Assessment 2 (SEA2) survey was conducted a little to the west of the south-west patch and found the predominant species to be *Echinocardium cordatum* (sea urchin), *Fabulina fabula* (bivalve), *Lanice conchilega* and *Owenia fusiformis* (polychaete worms) (DTI 2001) in a community that was generally considered to be richer than those found on the sandbanks off North Norfolk.

2.3.2.2. Norfolk Banks

The sandbanks off the Norfolk coast are a combination of tidal current sandbanks and sandy mounds, with the sandy mounds dominating the western half, north of The Wash. The location and general topographical shape can be seen in Figure 2.4. The water predominantly comes from the north and is southern North Sea water but to the eastern edge of the area there is some mixing with English Channel water.

Norfolk Sandy mounds

The sandy mounds generally occur in the western half of the region and in all but one case are formed of gravelly sands. The western mounds generally are formed of a thin (<1m) layer of sediment over till or clay (Graham *et al.* 2001a). The mounds which lie further east between the linear ridges of Swarte Bank and Haddock Bank are similar in character but the underlying sediment is unknown. In all cases, significant sandwaves are uncommon with only two mounds having a possibility of sandwave presence (Graham *et al.* 2001a). Detailed information for the sandy mounds is minimal. Two mounds in the eastern group were surveyed during the SEA2, which will provide

biological data, images and sediment analysis in 2002. Preliminary results show the area to have a stony and coarse shelf sediment with extensive epifauna (DTI 2001). In the western group there has been some surveying undertaken by oil and gas companies which gives some detailed sediment analysis but very limited biological data.

North Norfolk sandbanks

These sandbanks are the most extensive example in UK waters of offshore linear ridges. The series includes over ten sandbank ridges which are formed of sand and exhibit varying degrees of sandwaves (Graham *et al.* 2001a). The North Norfolk sandbanks were initially formed as Alternating Ridges around the headland and as the Norfolk coast has receded they have been restructured by tidal currents to form their present shape. The tidal currents diminish from nearly 1.5 to 1 metre per second as distance from shore increases (Graham *et al.* 2001a). The inner banks have sandwaves between 4 and 6 m high associated with them which equates to a habitat which is fairly disturbed. The outer sandbanks in the Indefatigable group have small sandwaves or no sandwaves associated with them and hence are likely to support a differing biological community to the sandbanks further inshore (Graham *et al.* 2001a). The SEA2 survey ran transects across the majority of the sandbanks in this group and will yield biological, sediment and image data in 2002. Preliminary results show a fauna typified by *Echinocardium cordatum* (a sea urchin) and *Fabulina fabula* (a bivalve) with two species of sandeels common (DTI 2001). In addition to this, a number of environmental surveys have been conducted for oil and gas companies in this area. However, it is likely that many of the survey points will lie in the troughs between the ridges.

Haisborough Tail, Hewett Ridges & Smith's Knoll

This series of sandbanks is distinct from the sandbanks outlined above as they are undergoing further formative processes that are likely to split the sinuous complex of banks into a series of offshore linear ridges. These banks are currently morphologically classified as Alternating Ridges and are composed of sand. The tidal currents around these sandbanks are greater in magnitude than those of the North Norfolk banks (1.5 metres per second) and have resulted in larger sandwaves occurring on the banks (c. 8 m high on the outer banks) (Graham *et al.* 2001a). The SEA2 survey includes a transect across Smith's Knoll which should supply biological, image and sediment data for that ridge. It is likely that the other ridges in the group will have similar communities to those on Smith's Knoll.

2.3.2.3. Outer Thames Estuary sandbanks

This group of sandbanks is entirely formed of tidal current ridges and can be seen in Figure 2.5. They were formed by the tidal current flow through the Thames Estuary but have been modified by open shelf currents as the coastline has receded. They are different from the Norfolk sandbank groups as the surrounding sediment in the troughs is more mixed and has a higher proportion of gravel as opposed to the predominance of sand in the Norfolk group. The ridges are all predominantly sand with the exception of Outer Gabbard which is predominantly gravelly sand. All the sandbanks have sandwaves on them and in the case of South Falls these may reach as high as 16 m towards the southern end of the bank (which protrudes into territorial waters) (Graham *et al.* 2001a). The water in this area is very turbid and is a combination of English Channel water and southern North Sea water. The different water bodies may have an influence on the communities that occur in this region in comparison to those off the Norfolk coast or the south Kent coast. To the knowledge of the offshore project, no surveys have been conducted on the areas of potential Annex I sandbank habitat which occur in this region.

However, there are likely to be similarities with the communities found on the Haisborough Tail etc. sandbank group.

2.3.2.4. Eastern English Channel

Only one offshore sandbank (Bassurelle) occurs in this region, and it is formed predominantly of sand. Its location can be seen in Figure 2.5 and it is an open shelf ridge. Sandwaves are abundant on the bank and are up to 15 m in height (Graham *et al.* 2001a). The water mass is Channel Water. No surveys are known to have been conducted on the bank.

2.3.2.5. North-east coast of the Isle of Man

Two habitat occurrences are found in this region, their locations can be seen in Figure 2.6.

Sandy mound east of Isle of Man

This mound is glacigenic in origin and is predominantly sand which is around 2 m thick and overlies stony gravelly, glacigenic deposits and bedrock (Graham *et al.* 2001a). It is unknown whether sandwaves occur. No surveys are known to have been conducted on the bank but it is likely that any community would be similar to that occurring on the inshore sand sheet off the west coast of England.

King William Bank

This tidal current ridge is likely to have been formed as a banner bank off the headland of the Isle of Man and has been modified over time and become an open shelf ridge. It is predominantly formed of gravelly sand and is part of a sequence of banks off the Isle of Man (Graham *et al.* 2001a). No surveys are known to have been conducted on the bank.

2.3.3. Reefs

This habitat type encompasses three main types of reefs:

a. Bedrock reefs

   These are made from continuous outcroppings of bedrock which may be of various topographical shapes e.g. pinnacle, pavement, ridge or bank etc. Some bedrock reefs may have a non-continuous, mobile veneer of sediment.

b. Stony reefs

   These consist of aggregations of boulders and cobbles which may have some finer sediments in interstitial spaces.

c. Biogenic reefs

   In offshore waters these may be formed by cold water corals (e.g. *Lophelia pertusa*), by Ross worm *Sabellaria spinulosa*, and possibly by horse mussel *Modiolus modiolus*.

All reefs in offshore waters are assumed to be at full salinity as freshwater influences at 12 nm from shore are likely to be negligible and no freshwater springs are known. Some

examples of the fauna found on different types of reefs in UK offshore waters are given in Plate 2.1 to Plate 2.4.

Figure 2.7 shows the potential extent and location of bedrock and stony reef habitat in northern UK offshore waters. Figure 2.8 and Figure 2.9 show the same for south-east and south-west UK offshore waters. Potential reef habitat is much more common in western UK offshore waters, and is virtually absent from UK offshore waters in the North Sea. Occurrences of reef habitat are described on a regional basis in the following section of the report, with an explanation of the type of reef which is thought or known to be present and any further information on the fauna. Areas on the maps are those reef areas identified from geological maps under the contract with BGS (see Section 2.3.1), with some information from surveys conducted by Southampton Oceanographic Centre for AFEN and the UK Department of Trade and Industry, and from surveys conducted by an aggregate extraction company as part of a licence application.

Biogenic reefs are not fully represented on these maps, as they could not be identified from existing geological map interpretations, and there is no comprehensive information on their location in UK waters. Where they are known to occur, they are mentioned in the text for each area. Figure 2.10 shows an interpretation of potential distribution of *Lophelia pertusa* in the NE Atlantic (Brian Bett, SOC) based on known locations of the species, its temperature requirements and water depth. It therefore gives an indication of areas where biogenic reefs formed by cold water corals may be found to exist in UK offshore waters. The reef forming worm *Sabellaria spinulosa* is widespread in UK offshore waters, particularly in the North Sea, Irish Sea and English Channel, but the full extent and locations of reefs formed by this organism are not known.

2.3.3.1. North Sea

The regions described in the following sections are shown in Figure 2.11.

Dogger Bank Gravel

To the north-west of the patches of Dogger Bank sandy sediments in less than 20 m water depth (see Section 2.3.2.1 and Figure 2.4), there are superficial mounds of gravel (defined according to modified Folk classification, i.e. of particles from 2 mm to greater than 256 mm diameter), which could be potential Annex I reef habitat (Graham *et al.* 2001a). Further detail on the particle size of the gravel is not known, but other information on the Dogger Bank indicates that it is unlikely that it is composed of particles predominantly greater than 64 mm in diameter, and therefore within the definition of Annex I reef habitat.

Offshore of Humber

This region of potential Annex I reef habitat comprises a series of irregular gravel mounds with superficial gravel overlying other sediments and bedrock (Graham *et al.* 2001a). The majority of the area is under licence for aggregate extraction and environmental survey data, which may establish which areas, if any, have a predominant particle size greater than 64 mm, may be available.

***Sabellaria* Reefs (Licence Area 401/2)**

Sabellaria spinulosa reef has been found in 2000 in the aggregate licence area 401/2, which is approximately 13 nautical miles east of Great Yarmouth (Newell *et al.* 2001). The majority of the licence area lies within territorial waters but the eastern edge lies

within UK offshore waters. The area surrounding the *Sabellaria* reef occurrence is characterised by stable coarse, gravelly sand and it is likely that this habitat is present in the surrounding offshore waters. Therefore, it is likely that with further survey, patches of *S. spinulosa* reef may be found in this region. The actual location of *S. spinulosa* reefs is liable to change over time as cycles of aggregation and degeneration in *Sabellaria* sp. colonies have been reported over periods of 5-7 years (Wilson 1971) and severe storms are likely to disturb the substratum and break up colonies (Holt *et al.* 1998). Fishing also affects the structure and presence of *S. spinulosa* reefs (Vorberg 2000).

2.3.3.2. English Channel

The regions described in the following section are shown in Figure 2.12.

Median Deep

This is a large spread of gravel (according to the Folk classification) which includes cobbles along with other sediment fractions. The northern part of the area is currently under application for an extraction licence and the southern part is under a prospecting licence for aggregates extraction. Surveys undertaken in the area have frequently recorded cobbles but not as the dominant sediment size (Environmental Resources Management 2000). There may be some bedrock outcrop or boulder fields on the western side (close to the median line) (Environmental Resources Management 2000). Sessile epifauna included a wide variety of encrusting bryozoans and smaller quantities of hydroids and soft corals. *Pomatoceros triqueter* (a calcareous tube worm) was very common on cobbles and crevice fauna such as squat lobsters (Galatheidae), syllid worms and small bivalves were abundant (Environmental Resources Management 2000). The particle size analysis of samples taken across the area under licence shows that cobbles and boulders do not dominate the majority of the area and, therefore, it is likely that the majority of this area would not fall within the definition of Annex I reef habitat.

Eastern English Channel Basin

This region is dominated by a large expanse of potential reef habitat which stretches 142 km in length and is 32 km wide. The water depths over the patch are generally 50-75 m with an exception for a linear deep that reaches around 100 m deep. The region has been surveyed by side-scan sonar and is extremely heterogeneous in nature (Graham *et al.* 2001a) with gravel (according to modified Folk classification) and bedrock outcrops present. This is due to the complex geology of the region where folded bedrock is overlain patchily by coarse glacigenic lag sediments (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. The bedrock outcrops tend to occur in the form of ridges which have resulted from folds in the sedimentary rock and softer layers having been eroded (Graham *et al.* 2001b). Further spatial analysis of the potential reef may identify some regions of gravel furrows, sand ripples and sand waves.

Epibenthic fauna such as barnacles and bryozoans have been found encrusting sampled cobbles within the patch of potential reef habitat (Graham *et al.* 2001b). Holme and Wilson (1985) conducted side-scan sonar and video sledge surveys just to the north of the main patch identified by BGS and found very similar mixes of habitat. Of the faunal assemblages identified by Holme and Wilson, two are likely to occur within reef habitat identified by Graham *et al.* (2001a). The first is a stable faunal assemblage with diverse sponge cover which was identified as occurring on the surface of non-mobile hard seabeds such as pebbles, cobbles, boulders and rock outcrops which are not subject to

scour by sand or gravel or periodic cover by sand or gravel. Cobble bottoms tended to be bound together by the growth of sponges, bryozoans and ascidians. *Pentapora foliacea* (Ross coral bryozoan) was also characteristic. The second type of faunal assemblage was one which is present on hard surfaces of rock, cobbles or pebbles that were subject to sand scour and/or periodic submergence by sand. Three sub-types were identified:

a. Well-developed faunal assemblage with *Polycarpa violacea*.

b. Impoverished *Polycarpa violacea-Flustra foliacea* assemblage.

c. Impoverished *Balanus-Pomatoceros* assemblage (Holme & Wilson 1985).

Other occurrences of potential reef habitat in this region are thought to be of similar character to that described above. Recent work off Selsey, east of the Isle of Wight (detailed in Brown *et al.* 2001) describes the seabed in the deeper areas, that coincides with the potential reef occurrence mapped by Graham *et al.* (2001a), as a mixture of coarse material and out-cropping bedrock overlain with areas of sand veneers. The epibenthic fauna could not be sampled with a beam trawl due to the rocky and uneven nature of the seabed but Hamon grab samples showed the polychaete worm *Ophelia borealis* as biologically dominant and the barnacle *Balanus crenatus* to be a numerous species (Brown *et al.* 2001).

2.3.3.3. South-west Approaches

The regions described in the following section can be seen in Figure 2.13.

Western English Channel

A further series of gravel patches (according to modified Folk classification) occur c. 15 nm south west of the Isle of Portland which appear to be very similar in character to those described above as they are described as shelly gravel with occasional rock outcrops (Graham *et al.* 2001a). They occur in around 65 m of water and the current strengths are moderate. Very little is known about these patches and no biological surveys are known within this region.

South of Cornwall are a series of small (c. 3-7 km^2) gravel patches with BGS samples describing the seabed type as sandy gravel or shelly gravel. The underlying rock is chalk/limestone but there is no indication that this outcrops (Graham *et al.* 2001a).

Haig Fras

This habitat occurrence is an isolated bedrock reef 150 km offshore in the Celtic Sea with a steep peak rising to 38 m from 100-110 m depth. Overall the granite exposure measures about 45 by 15 km but the pinnacle measures less than 1 km across. The remaining exposure has been planed down to a rock platform protruding only a little above the sediment (Rees 2000). A camera survey (Rees 2000) demonstrated that the bedrock on the peak has three distinct deep water reef biotopes 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. Photographs of the first three reef biotopes can be seen in Plate 2.1 a, b and c. The biotopes are:

a. Biotope dominated by jewel anemone *Corynactis viridis.*

b. Biotope dominated by Devonshire cup coral *Caryophyllia smithii.*

c. Biotope characterised by cup sponges and erect branching sponges.

d. Complex biotope with red encrusting sponge, *Caryophyllia smithii* and featherstars (crinoids) on boulders and bryozoan *Pentapora membranacea*, squat lobster *Munida* sp. and brittlestars (ophiuroids) also common.

The Rees (2000) survey yielded tentative biotope classifications and descriptions and some images. Further work has produced side-scan images of the outcrop.

South-west Approaches Shelf Break

The bathymetry of the shelf break area in the south-west approaches to UK waters indicates that the shelf break is heavily canyoned. Currents are generally moderate in this region (MAFF 1981) and will have exposed bedrock and kept fine sediments suspended. However, in canyons, the water currents are likely to be greater and a different fauna may occur. In addition to the bedrock reef in this area it is likely that cold water corals are abundant and may well have formed reefs. In similar conditions to the west and east of UK waters, Le Danois (1948) discovered large quantities of *Lophelia pertusa* reef on the shelf break. Fauna associated with *Lophelia pertusa* reef in this region have been found to be different to those on the Faeroe Shelf (Jensen & Frederiksen 1992) and may be different to that found in north-west UK waters. To the knowledge of the Offshore Natura 2000 project, no surveys have been carried out in this section of UK waters and very little is known about the specific nature of the habitat and the biota it supports.

2.3.3.4. Irish Sea

Figure 2.14 shows the distribution of potential Annex I reef habitat occurrences in the Irish Sea. These fall into four main regions which are discussed in turn below. The Irish Sea is distinct from other regions of the UK when considering hydrographic regime and seabed type with the possible exception of the eastern English Channel where there are also moderate currents and mobile sediment lags within a similar salinity regime.

Mid Irish Sea

This area consists of numerous outcrops of rock and sediment with one very large patch occurring centrally. These patches are highly variable in sediment type but have occurrences of cobble fields within a matrix of sand and gravel (Graham *et al.* 2001a). Within the large area of potential reef habitat are a series of bedrock outcrops which may have some mobile sediment cover and have a bold hummocky topography. All the potential reef habitat occurrences in this region are likely to be sediment-influenced and to have sediment-tolerant fauna associated with them. The region is approximately 120 m deep in the north and slopes upwards to 70 m in localised areas and reaches depths of c. 100 m in the north of the region. Many of the occurrences of potential reef habitat occur on slopes and rims of depressions (Graham *et al.* 2001a).

A few surveys from the SWISS project were carried out within the large patch of quaternary sediment which dominates this set of habitat occurrences. Sandy gravel was found in the west of the patch and shelly sediment in the north-east, which confirms the variable nature of the patch (Wilson *et al.* 2001). CEFAS beam trawl surveys were conducted on two potential reef habitat occurrences on the north side of the region and found 5.6 kg/hr and 12.9 kg/hr of *Sabellaria spinulosa* (CEFAS pers. comm.). Full species lists with catch per unit effort (CPUE) figures are available for these sites. These indicate the possibility of *Sabellaria spinulosa* biogenic reef within the region. In general, for the area, very little information is held and further survey work is needed to determine where areas of cobble, boulder and bedrock may occur.

Cardigan Bay

In this region there are a number of small gravel (as defined in the modified Folk classification) patches in water depths from 30 to 60 m. Seabed samples have recovered a range of sediment types from cobble, shelly cobble gravel to shelly gravel and sandy gravel, again demonstrating the variability of the seabed (Graham *et al.* 2001a). One CEFAS beam trawl monitoring site is within the region and a full species list with CPUE figures is available. No significant quantities of biogenic reef-forming species were trawled (CEFAS pers. comm.). Other surveys have been conducted in the area for geophysical purposes and these records could be investigated for further information if required.

North of Anglesey

This area extends from the shoreline to beyond territorial waters on the north side of Anglesey. The main occurrence of potential reef habitat is an extensive area of gravel (as defined in the modified Folk classification) which contains patches of gravelly sand and scattered rock outcrops. Within this area, patches of *Modiolus modiolus* reef have been found although the precise location of these is not known (Ivor Rees pers. comm.) and they may be within territorial waters. The surrounding, smaller, areas of potential reef habitat are either gravel patches or outcrops of quaternary material or rock. Cover of mobile sediments is patchy and of variable depth and any reef community is likely to be sediment-influenced (Graham *et al.* 2001a). The water depth is approximately 50 m and tidal currents are strong in the area north of Anglesey (CEFAS 2000). No BIOMOR or SWISS surveys have been undertaken within these patches. One survey was undertaken by CEFAS just within territorial waters and found compact rippled muddy sand with some shell material (Allen & Rees 1999). Other geophysical surveys have been undertaken within the areas of potential habitat and these may be accessed through the BGS if necessary.

West of Isle of Man

The potential Annex I reef habitat identified in this region is generally in the form of rock outcrops which are associated with slopes and small highs in the bedrock at between 70 and 90 m deep. The outcrops have a variable cover of mobile and non-mobile lag sediment and any reef community is likely to be sediment-influenced although tidal currents in this region are moderate to weak (MAFF 1981). A submersible survey on one of these outcrops found rock pavement with boulders and cobbles and a community which included bryozoans, *Flustra* sp., sunstar *Solaster* sp., occasional spiny lobsters, anemones and sponges (Graham *et al.* 2001a). The ISSIA, SWISS and BIOMOR projects in the Irish Sea do not provide any further information for this area, except in the case of one towed sledge survey which showed mud habitat with *Nephrops norvegicus* burrows which is consistent for the mud habitat which is believed to surround the rock outcrops (Allen & Rees 1999). No CEFAS surveys have been conducted over the habitat occurrences in this region. Other geophysical surveys have been undertaken within the areas of potential habitat and these may be accessed through BGS if necessary.

2.3.3.5. West of Scotland

Refer to Figure 2.15 for the location of the following areas of potential Annex I reef habitat.

Blackstones Banks

Blackstones Banks is a complex area of many rock outcrops and intervening sediment-filled hollows in water depths between 40 and 70 m. The rock outcrops are a combination of igneous and sedimentary rock. Surveys by submersible as well as geophysical samples have been taken in the area and photographs show boulders and cobble pavements as well as a vertical rock wall. The epifauna is well developed and includes sponges and anemones (Eden *et al.* 1971). The potential reef occurrences extend into Scottish territorial waters.

Stanton Banks

The Stanton Banks are a group of rock outcrops that protrude above the surrounding sediment seabed. They have steep slopes and the actual banks have a rugged topography with numerous sediment-filled hollows (Graham *et al.* 2001a). Geophysical surveys have been carried out on some of the banks and these may be accessed through BGS if necessary. No biological surveys are known to have been carried out on the Stanton Banks but a photograph from a submersible survey shows brittlestars and other encrusting fauna on clean current-swept bedrock (Eden *et al.* 1971) (Plate 2.2).

Hebrides Shelf

This area of potential Annex I reef habitat is a large patch of bedrock to the west of the Uists and extending upwards towards Lewis and out towards St Kilda. It is elevated from the surrounding sediment seabed but does have patchy sediment cover of a variable thickness and made up of various sediment fractions (Graham *et al.* 2001a). Incorporated into this area is the Flannan Ridge which is a linear feature with frequent pinnacles. The entire platform area has very complex bathymetry (Graham *et al.* 2001a). No biological information is currently available for this region but many geophysical surveys have been undertaken (especially in the southern half) and this information could be accessed through the BGS. Samples of cobbles have been encrusted with bryozoans and tube worms (Graham *et al.* 2001a).

Iceberg Ploughmarks (Hebrides Slope to West Shetland Slope including Wyville-Thomson Ridge)

Iceberg ploughmarks are ridges of boulders and cobbles which have been formed by the ploughing movement of icebergs through the seabed at the end of the last ice age (Belderson *et al.* 1973). Ploughmarks are very common on the outer shelf and upper slope in water depths between c. 140 and 500 m. They are typically 20 m in width and 2 m deep (Graham *et al.* 2001a). They are characterised by ridges made up of larger fractions of sediment and furrows which are lined with pebbles, gravel and sand (Masson *et al.* 2000). Although only the ridges fit into the habitat definition of reef, the furrows are an integral part of the feature's structure and the overall feature is a matrix of the two types. Since formation, many ploughmarks have been degraded by hydraulic and sedimentary processes and the furrows have been filled to varying extents by sediment (Graham *et al.* 2001a). The locations of areas which have been sedimented over or degraded are not fully known. Iceberg ploughmark zones can be seen in Figure 2.15 and Figure 2.19.

The West Shetland Slope region and a segment of the northern Hebrides Slope were surveyed in 1996 and 1998 as part of the work commissioned by the AFEN consortium. Sidescan sonar, targeted cores and photographic tows were used to characterise the seafloor. Sampling of the iceberg ploughmark areas was problematic as cores were generally only successful when sampling sediments finer than cobble. However, the failure of core samples due to rocks caught in jaws etc. was noted by the survey and these can be taken as an indication that Annex I reef habitat is probably present. Photographic tows along the West Shetland Slope showed that visible fauna on the ridges was dominated by cidarid urchins and a variably developed encrusting epifauna. No large aggregations of cold water corals were observed and only two occurrences of *Lophelia pertusa* (both very small colonies) were noted in the entire survey (Bett 2000a).

The hydrography of the area is a major structuring force on the biological communities due to the different water masses occurring at different depths (Bett 2000b). In the Faeroe-Shetland Channel, cold (<-0.5°C) Faeroe-Shetland Channel Bottom Water flows below 600 m deep in a south-westerly direction. Over the top of this flows warm (>8°C) North Atlantic Water from the Rockall Trough in the continental shelf current. Internal tidal waves in the bottom water cause fluctuations in the water mass at around 500-600 m depth which means that communities within this zone have to endure fluctuations in water temperatures from around 8°C to around -0.5°C. Consequentially, the community at this depth is different from shallower communities and potential reef areas at this depth should be considered as different in nature to those in shallower depths. The iceberg ploughmarks of the northern Hebrides Shelf are in North Atlantic Water and the soft sediment communities found in this region were similar to those of the shallow West Shetland Shelf (<500 m deep) (Bett 2000b). It is likely that reef communities would also be similar to those of the shallow West Shetland Shelf.

The DTI commissioned surveys of the Faeroe-Shetland Channel and Wyville-Thomson Ridge regions in 1999 and 2000. These data have been less comprehensively analysed but have provided sidescan information confirming the presence of iceberg ploughmarks on the Wyville-Thomson Ridge and on another part of the West Shetland Slope. The ploughmarks are extremely dense above 500m and in places extend as far downslope as 700 m on the flank of the Ridge. The photography conducted by the 1999 survey revealed that the seafloor in the ploughed zones is characterised by a lag deposit consisting of a carpet of gravel and cobble, with frequent boulders up to a few metres in size (see Plate 2.3). Over two distinct areas of the ridge, bottom current activity has removed the ploughmark traces on the sonar records. In these regions, seafloor photography reveals a similar cover of cobbles and gravels with some areas of sand (Bett 2000c). The Wyville-Thomson Ridge is subject to large fluctuations in water temperature due to the periodic overflow of Faeroe-Shetland Channel Bottom Water over the Ridge which temporarily displaces the warmer North Atlantic Water which flows from the Rockall Trough. Therefore, faunal communities are likely to be different to those which are found on the shallow parts of the West Shetland Slope and northern Hebrides Slope. Photographic tows showed sponges, mobile invertebrates e.g. squat lobsters, cidarid sea urchins, and some octocorals (Bett 2000c).

The southern part of the Hebrides Shelf was sampled as part of the Shelf Edge Study in the Land-Ocean Interaction Study (LOIS) by a bed-hop camera system. Samples were taken in a transect from 140 m deep to 2000 m. Samples taken at the 140 m and 200 m stations clearly showed the presence of cobbles as a dominant substratum and the expression of iceberg ploughmarks. Cobbles are mostly free of a sediment veneer due to the strong continental shelf current. Thick-spined sea urchins (*Cidaris cidaris*) were common and encrusting bryozoans, cup corals and sponges were abundant (Humphery *et*

al. 1999). Original photographs from these areas are held by J. Humphery at the NERC Proudman Oceanographic Laboratory in Bidston, Merseyside.

2.3.3.6. The Rockall Bank and Rockall Trough region

Rockall Trough is a large basin bounded, in UK waters, by the Hebrides Shelf to the east and the Rockall Bank to the west (refer to Figure 2.16). To the north the trough rises to meet the Wyville-Thomson Ridge and in the north-west it is incompletely bounded by three banks (Lousy, Bill Bailey's and George Bligh). The Rockall Trough is dominated by the influence of Eastern North Atlantic Water (ENAW) which flows at depths less than 1200 m in a clockwise motion and is c. 8°C. Labrador Sea Water (which is slightly cooler at 2-4°C than ENAW) flows in an anti-clockwise direction through the deeper parts of the Rockall Trough (Bett 2000a). Gage (1986) observed differences in faunal assemblages associated with the changes in water masses and these are likely to affect the faunal composition of communities found within potential Annex I reef occurrences.

Hebrides Terrace Seamount

This is the smallest and most southerly of the seamounts which are situated in the UK sector of the Rockall Trough. The seamount rises from c. 2000 m to 1000 m deep and has a narrow summit. Dredge samples have recovered igneous rocks which may indicate that there are exposed areas of rock. It is possible that the flanks may have exposed bedrock areas similar to the other seamounts in the Rockall Trough (Graham *et al.* 2001a). There is currently no biological information for this area of potential reef occurrence but the seamount is within the zone in which cold water corals may be found and, therefore, it is possible that cold water coral may be found on the seamount. Any exposed rock areas are likely to have encrusting fauna growing on them and faunal composition may change below 1200 m due to a change in water masses. Two geophysical survey points are present on the summit of the seamount and the data may be accessed through the BGS if necessary.

Anton Dohrn Seamount

Anton Dohrn Seamount is flat-topped (a guyot) and arises from about 2100 m to a minimum depth of 521 m. The top of the seamount is covered by c. 100 m of sediment but the sediment cover terminates near the outer edges of the summit plateau and basaltic rock is exposed on the steep sides down to a depth of around 1500 m (Jones *et al.* 1994). There is also a small central knoll on the summit where basalt is exposed (Graham *et al.* 2001a). Dredges on the eastern flank have recovered live *Lophelia pertusa* samples of which some fragments measured more than 50 cm (Jones *et al.* 1994). No further biological information is available but a series of geophysical samples were taken across the seamount and these may be accessed through BGS if required. It is likely that Annex I reef habitat on the seamount is patchy and largely confined to the flanks of the seamount but its exact distribution is not possible to define.

Rosemary Bank

The Rosemary Bank is a conical seamount and rises from around 1830 m deep to a domed crest, at around 370 m. The underlying rock is basaltic and very similar to the underlying rock of Anton Dohrn seamount (Dietrich & Jones 1980). Much of the seamount is covered in a layer of sediment which is predominantly sand with some gravel, cobbles and boulders (Britsurvey 1995). On the south-eastern flank of the seamount, surveys have shown little or no sediment cover (Britsurvey 1995; Dietrich & Jones 1980) and rock dredges have brought up corals, bryozoans and sponges from a depth of c. 1000 m

(Dietrich & Jones 1980). Unfortunately, no further work was undertaken on the biological samples and the type of coral found is unknown. Two samples of live *Lophelia pertusa* have been taken from the south flank of the bank (Wilson 1979).

Annex I reef habitat on the Rosemary Bank is likely to be patchy and may be confined to the flanks of the bank. However, at this time, it is not possible to define the exact areas of Annex I reef habitat within the larger location.

Darwin Mounds

The Darwin Mounds are a series of sand volcanoes which are capped with thickets of *Lophelia pertusa* and have "tails" of sediment oriented with the current. There are two main fields of mounds which were discovered by the AFEN surveys in 1998 and 1999 and resurveyed in 2000. These are referred to as the eastern and western groups. The mounds are located at a depth of approximately 1,000 m in the north-east corner of the Rockall Trough, immediately to the south of the Wyville-Thomson Ridge (Bett 2000d) (see Figure 2.17 for location). The data from the 2000 survey have been unavailable thus far but some photographs from it are available (see Plate 2.4).

Around the mounds and tails, the seafloor is a rippled foraminiferous sand, having a fauna typical of similar depths throughout the Rockall Trough. On the tails, the sediment character is apparently the same but there are high densities of the xenophyophore *Syringammina fragilissima*. the appearance of the seafloor on the mounds is variable with some being similar to that of the surrounding seafloor and tails and others showing blocky rubble (possibly cemented sediments and/or coral debris) and living stands of the coral *Lophelia pertusa*. The coral provides a habitat for invertebrates such as sponges and brisingiids (Bett 2000d).

Only one WASP tow was conducted in the eastern area in 1999. The biological zonation around the mounds, i.e. dense xenophyophore populations on the mound tails and coral growths on the mounds themselves, is consistent with the western field. However, rocks on the seabed are more abundant. Coral was not seen to be attached to these rocks (Bett 2000c).

Rockall Bank

This is a large igneous rock feature which rises to the island of Rockall. Sediment cover is patchy with the western and south-western area of the plateau being devoid of sediment. The sediment varies from sandy contourite and mud on the eastern flanks to cobbles and gravels on the western flanks. Seismic surveys on the north-west flank of Rockall Bank have shown bedrock exposed by vigorous bottom current flow (Howe *et al.* 2001). No comprehensive survey of the sediment or benthos has been undertaken on Rockall Bank and therefore, the detailed distribution of reef habitat and the community it supports is unknown.

Wilson (1979) records *Lophelia pertusa* as occurring in discrete patches around the Bank and appearing to be fairly common at depths ranging from 130 to 400 m. They may also be correlated with the occurrence of iceberg ploughmarks (Wilson 1979). Surveys on the south-east slope of Rockall Bank (outside UK waters) have shown frequent occurrences of cold water coral colonies with both *L. pertusa* and *Madrepora oculata* well represented (Kenyon *et al.* 1998). The full extent of cold water coral reefs on Rockall Bank is unknown as a comprehensive survey of the Bank in UK waters has not been undertaken. However, many records of *L. pertusa* have come from trawl nets and it is likely that the abundance of corals has decreased as trawling pressure on the Bank has increased.

Bedrock reef is not confined to the outer regions of the Bank but is also present around the island of Rockall and Helen's Reef (2 miles from Rockall Island) (Graham *et al.* 2001a). These fall within territorial waters but are likely to be contiguous with offshore occurrences of Annex I reef habitat.

To the north-west of Rockall Bank there are three potential reef areas. These are noted by Graham *et al.* (2001a) as superficial gravel mounds, and recent research has shown that these are highly likely to be gravel sediment areas winnowed by strong bottom currents (Howe *et al.* 2001) and, therefore, not Annex I reef habitat.

George Bligh Bank

This area of potential reef habitat is a volcanic mound which is mostly covered in fine sediment with one area of rock outcrop towards the north of the summit. The Bank rises from 1650 m deep to 450 m (Graham *et al.* 2001a). There is one record of live *Lophelia pertusa* from the bank (Wilson 1979). There is currently no further information available for George Bligh Bank.

2.3.3.7. West of Rockall

This region has undergone very little survey work and in general knowledge is restricted to interpretations of seismic surveys. The region can be seen in Figure 2.18. Much of the bottom water of this area is cold water originating from Norwegian Sea 'arctic intermediate water' and Norwegian Sea 'deep water' which has flowed down the Faeroe-Shetland and Faeroe Bank Channels and then turned south to form part of the cold (<-0.5°C) and less saline North Atlantic Deep Water current (Aurora Environmental Ltd & Hartley Anderson Ltd 2001). Therefore, the area west of Rockall is subject to very different conditions compared to the Rockall Trough.

Sandastre

This area is a volcanic, broad, asymmetric dome with a sediment veneer that covers the majority of the mound except in three locations: a double crested cone near the centre of the mound, a 300m high pinnacle in the north-east of the feature and a 2.5 km wide ridge along the south-west side. The sediment veneer is very thin on the south-west slope and there is a possibility of rock outcrops in this region. *Lophelia pertusa* was recovered from a dredge of the south-west flank in 1980, along with sponge, bryozoan and shell debris (Graham *et al.* 2001a).

Swithin

This area of potential reef habitat is a volcanic mound at the north-west edge of Rockall Bank and appears to be an extension of the Rockall Bank. The mound may have a sediment veneer across the entirety of its surface but there have been no samples to establish this (Graham *et al.* 2001a). No further information is currently available on this area.

Lyonesse

This potential Annex I habitat reef occurrence is a volcanic mound which is predominantly covered by a sediment veneer with some bedrock outcroppings in the central and north-east sections of the mound. There are some minor ridges or pinnacles in the east of the area which may outcrop (Graham *et al.* 2001a). No sediment samples

have been taken on Lyonesse and no further information is currently available for this region.

Mammal

Mammal is a volcanic mound with sediment veneer occurring across the majority of the area and some outcroppings of basaltic rock. There are outcrops of rock on a knoll at the top of the bank and on the east-south-east flank. There are steep scarp slopes which may also allow outcropping of bedrock but there are no samples in this area (Graham *et al.* 2001a). No further information is currently available for this region.

Two further areas of potential Annex I reef habitat are present to the south of Mammal. The first occurrence (just to the south of Mammal) is an elliptical mound of volcanic bedrock which may be totally covered by a sediment veneer with the exception of the north side where it is thin or absent and reef habitat may be present (Graham *et al.* 2001a). The second occurrence (south of Mammal and Hatton Bank) is a long sinuous volcanic swell which is probably sediment-covered (Graham *et al.* 2001a). No samples are available for this region and no further information is currently available.

Hatton Bank

This series of potential Annex I reef occurrences is formed from an underlying basaltic mound with an extensive sandy sediment veneer. Surveys have revealed some pinnacles in the western portion of the main southern area which may be basaltic in nature or may be coral bioherms (Graham *et al.* 2001a). The main northern area also has an irregular surface with pinnacles that may be basaltic in nature or coral bioherms. Live *Lophelia pertusa* has been sampled from the northern area (Graham *et al.* 2001a). Very little is known about Hatton Bank but the topography and possible presence of large coral bioherms indicate a need for further survey.

2.3.3.8. North of Scotland

The regions described in the following section can be seen in Figure 2.19.

Judd Deeps

This is a region that was not identified from existing BGS seabed sediment maps but was revealed by 3D exploration seismic survey conducted for the oil industry and benthic survey of the Faeroe-Shetland Channel commissioned by the DTI and conducted in 1999. The Judd Deeps are large troughs, up to 200 m deep, which run along the edge of the Faeroe Plateau at the south end of the Faeroe-Shetland Channel and are kept sediment free by bottom waters flowing south-westwards and cascading over the scarps (Aurora Environmental Ltd & Hartley Anderson Ltd 2001). They mainly fall within the Faeroese sector but protrude into the UKCS in two places. Three photographic surveys along the edge of the Faeroe Plateau at the edge of these formations revealed the seabed as having a dense gravel cover with frequent rock, boulder and cobble occurrences which sometimes become the dominant substratum (Bett 2000d). The surveys were conducted at depths between 1000 and 2000 m and the water at this depth is Faeroe-Shetland Channel Bottom Water which is less than -0.5°C and has a salinity of less than 35‰. Encrusting fauna was abundant with sponges, featherstars and octocorals common (Bett 2000d). A further survey for the DTI in 2000 re-visited the area but the results are currently unavailable. Further information and possibly survey work is needed to fully identify the extent of reef in this region and assess the communities present.

Solan Bank

The potential Annex I reef occurrences in this region can be divided into two categories; bedrock outcrops and gravel patches (according to modified Folk classification). The water depth is as shallow as 60 m on the top of Solan Bank and falls off to c. 100 m deep in the surrounding area. The rock outcrops mainly occur on the top of and to the west of Solan Bank in the channel between Sule Skerry and North Rona. The gravel patches tend to occur more to the north and south of the rock outcrops. BGS surveys indicate that the rock outcrops have some cover of mobile sediment (generally shelly sands and gravels). The gravel patches consist of superficial irregular mounds of gravel of varying grades (Graham *et al.* 2001a). No biological survey information is available for these areas but some geophysical surveys have been conducted in the region and could be sourced from BGS if required.

To the north of the Solan Bank area, AFEN and BGS surveys have sampled cobbles or rocks which may be indicative of further patchy reef habitat (Bett 1996; BGS 2001). However, this was not identified by the BGS during habitat identification and further information is needed to clarify the type of seabed in this area.

Turbot and Otter Banks

The series of potential Annex I reef occurrences in the region of the Turbot and Otter Banks are made up of gravel patches (according to modified Folk classification) and rock outcrops. They lie in water between c. 75 and 125 m deep. Two rock outcrops lie close to the Shetland Islands and have a patchy sediment coverage which varies from sand to cobbles and boulders. The remaining occurrences are gravel (as defined by the Folk classification) patches, and BGS sampling shows that the sediment is frequently made up of boulders, cobbles and gravel (Graham *et al.* 2001a). No biological samples are available for this region and no geophysical surveys apart from BGS surveys are known to have been conducted. It is likely that epifaunal communities in this set of occurrences are sediment-tolerant.

Shetland Islands

The main potential Annex I reef habitat occurrence in this region is a composite of sedimentary rock platform (the East Shetland Shelf) and a basement high (the Pobie Bank). Sediment cover is patchy over the rock surfaces, generally very thin when present and mainly consists of gravelly sand (Graham *et al.* 2001a). The region is between 100 and 200 m deep and is contiguous with similar habitat which runs into the coast of the Shetland Islands. *Lophelia pertusa* samples have been recovered locally but are likely to be at the extreme edge of their range and potentially poorly developed (Wilson 1979). One biological sample was taken in this region by the Institute for Marine Research, Norway as part of a wider epibenthos survey of the North Sea. The species taken in the trawl indicate a sediment-influenced community with a non-mobile substratum present (CEFAS pers. comm.). No further surveys are known in this region.

2.3.4. Submarine structures made by leaking gases

Pockmarks with carbonate structures formed by leaking gases are the only features known to occur in UK offshore waters which may conform to this Annex I habitat. In UK waters ‘pockmarks’ are large depressions in areas of generally fine muddy sediments. Due to the scale of the data available, only two ‘pockmarks’ in UK waters are known to have carbonate structures within them (see Figure 2.20). These carbonate structures form pavements and blocks, or possibly vase shaped structures (the latter only known from

one historical record recovered in fishing gear from St Magnus Bay, in Shetland). Pockmarks are commonly found in the Witch Ground formation in the northern North Sea (shown in Figure 2.20). Pockmark fields are also located in the Irish Sea and, although carbonate structures have been found in some of those located in Irish waters, no structures have been found in those seeps located in UK waters.

Scanner, Block 15/25, North Sea

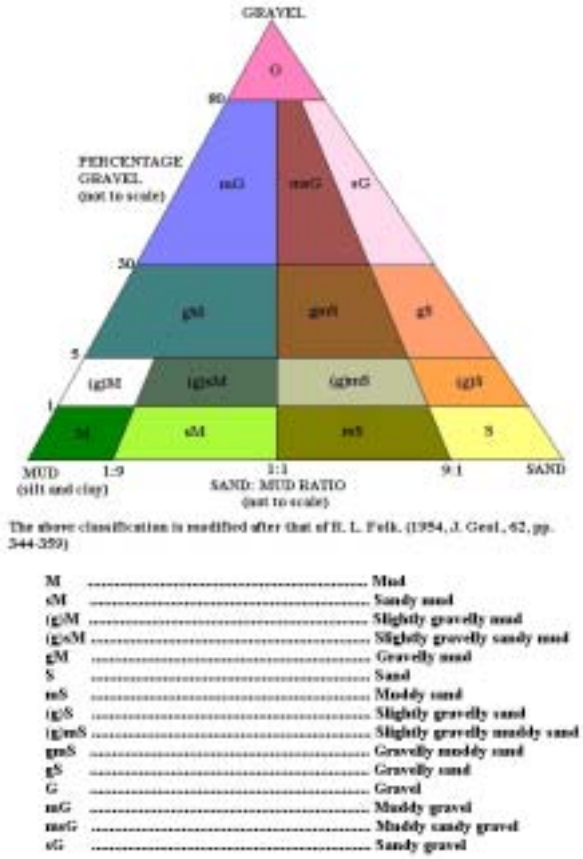
This is a single large pockmark within the Witch Ground field, which may be a composite pockmark with two major craters containing subsidiary depressions. The pockmark itself is 17 m deep and the side-wall angles range from 1-10 degrees. The location of this pockmark can be seen on Figure 2.20. At the base of the pockmark a gravelly lag deposit is exposed (Graham *et al.* 2001a). Slabs of carbonate-cemented sediment (clay, sand and gravel) were found to be present in or near to the edges of the gravelly lag areas and in some cases appeared to be supported centrally by a pillar or pedestal (Hovland & Judd 1988). The cement comprises of aragonite and calcite. The pockmark is open and active with streams of gas bubbles issuing from under the edge of the carbonate cemented sediment that is sometimes concealed by a thin layer of silty clay. Fauna at the base of the pockmark differs from that of the sides. The carbonate-cemented slabs and lag layer are colonised by anthozoans e.g. *Metridium senile*, *Bolocera eques* and *Cerianthis* sp.; Ophiuroids, whelks and hermit crabs were also observed on the hard substratum (Graham *et al.* 2001a). Fish were abundant and frequently seen to be occupying single pockmarks or hiding in hollows underneath slabs of cemented sediment (Hovland & Judd 1988). The meiofauna in the sediments surrounding the carbonate slabs and pockmark were dominated by nematodes, especially *Astonema southwardoorum* (Austen *et al.* 1993). Polychaete worms and crustaceans were also common.

Unnamed pockmark, Block 16/3, North Sea

As part of the Braemar field development the environmental assessment commissioned by Marathon Oil UK Ltd identified the presence of large and small pockmarks in oil and gas licence block 16/3 (see Figure 2.20). Further subsequent investigation by photography and grab sampling has shown the presence of hard substratum interpreted as carbonate cemented material in a number of the pockmarks. In most of the pockmarks most material appears to be old and much of it has been overturned (assumed to be by trawling). In one pockmark, larger blocks of carbonate cemented material were seen with some epifauna present (hydroids, anemones and crabs). Photographs, grab samples and sidescan images may be available in 2002 from the environmental assessment documentation.

2.3.5. Sea caves

Sea caves are not currently known to occur in UK offshore waters.



SEDIMENT SIZE				
phi value	milli-metres	SIZE CLASS		
		WENTWORTH		FOLK
-8	256	Boulder		Gravel
-6	64	Cobble		
-2	4	Pebble		
-1	2	Granule		
-0.5	1.41	Very coarse	Sand	Sand
0	1			
0.5	0.71	Coarse		
1	0.5			
1.5	0.35	Medium		
2	0.25			
2.5	0.17	Fine		
3	0.125			
3.5	0.088	Very fine		
4	0.0625			
8	0.0039	Silt		Mud
		Clay		

Figure 2.1 Sediment size classification and the relationship between Wentworth and Folk classification systems (Pantin 1991)