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Understanding the marine environment – seabed habitat investigations of submarine structures in the mid Irish Sea and Solan Bank Area of Search (AoS)

Paul Whomersley, Christian Wilson, Annika Clements, Craig Brown, David Long, Alick Leslie and David Limpenny

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For further information please contact:
Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough
Cambridgeshire
PE1 1JY

Email: offshoresurvey@jncc.gov.uk
Tel: +44 (0)1733 866840
Fax: +44 (0)1733 555948
Website: www.jncc.gov.uk

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1 Summary

- In May 2008 (18-27 May), a survey commissioned by JNCC undertook seabed habitat investigations of two Areas of Search (AoS) for offshore SACs.

- The objectives of this survey, within the *Submarine structures in the mid-Irish Sea* Area of Search (AoS) and the *Solan Bank* AoS, were to acquire high quality acoustic data capable of identifying and delineating habitats listed under Annex I of the 1992 EC Habitats Directive; primarily the Annex I habitat *Submarine structures made by leaking gases* in the former AoS and Annex I *Reef* habitat in the latter AoS. In the case of the Annex I *Reef* habitat, it was important to distinguish between the two sub-types, rocky and stony reef. It was also important to record and describe any new habitat types and propose new biotopes discovered in UK offshore waters.

- Surveys consisted of both broad-scale and fine-scale acoustic techniques, utilising sidescan sonar and multibeam swathe bathymetry, along with a variety of ground-truthing techniques including towed and drop down video/stills and Hamon grab sampling. A Rock dredge was also used at a few stations in order to gather samples of epibiota from hard substrata to assist with the taxonomic identification of the video and still images. The range of sampling techniques employed ensured that any Annex I habitats could be adequately described and characterised. For both Areas of Search survey planning and interpretation of survey data utilised extensive pre-existing data sets.

1.1 Submarine structures in the mid-Irish Sea

- Samples collected showed that the surficial sediments were commonly cemented. Analysis of the cement showed it to be carbonate, high-magnesium calcite or aragonite. This is typical of Methane Derived Authigenic Carbonate (MDAC).

- MDAC was confirmed by ground-truthing within the AoS, indicating that the distribution of MDAC was more extensive than originally thought with coverage estimated to be as much 40km².

- Analyses carried out on the infaunal dataset revealed increased numbers of individuals at the MDAC stations when compared to the adjacent sediments. Surprisingly no difference in species number, richness or diversity were identified.

- MDAC was categorised into three substratum classes, based upon both visual appearance and colonising epi-fauna: High relief MDAC, Low relief MDAC and Uncolonised MDAC.

- Several species not previously identified from the Irish Sea were observed during analysis of the video tows.

- An MDAC habitat does not yet exist in either the EUNIS classification or the Marine Habitat Classification for Britain and Ireland (version 04.05). Therefore it is proposed that a new biotope is added under the existing soft rock biotope complex due to evidence of boring bivalves such as *Hiatella arctica*) to include 2 new MDAC sub-biotopes.

High and low relief MDAC habitats were identified within the AoS. Due to the limited occurance of this habitat type in UK waters, the MDAC habitats identified within this Area of Search could make a valuable contribution to representativity of this habitat in UK waters.

1.2 Solan Bank

- The Solan Bank AoS is within the vicinity of numerous structural features these include the Nun Rock-Sule Skerry highs, East Rona high, North Rona, North Lewis, North Minch and West Orkney basins.

- Within the AoS there are extensive areas of bedrock outcrop with high topography. Linear features within the bedrock having ENE-WSW and SE-NW orientations are thought to be joint planes. These linear features form cliffs with relief of up to 10 m.

- In areas of bedrock outcrop where lineations are less prominent, outcrop boundaries appear very smooth and undulating, suggesting a weathered landscape filled in by sediment. The smooth outline is probably a result of glacial polishing of the bedrock surface.

- Features which were originally thought to be wave forms are now thought to be glacial in origin, representing morainic ridges formed during retreat of ice across the continental shelf towards the end of the last glacial maximum with cross cutting features; possibly esker ridges. These features are locations of coarse grained sediments including boulders at the seabed.

- The substrata encountered ranged from well-sorted sands through to highly fissured bedrock reefs. A coarse grained veneer of sand and shell gravel was present in rock fissures and often on flat surfaces of rock. Large 'crevices' in the bedrock harboured stable boulders and cobbles.

- The majority of reef sites were characterised by encrusting fauna, in particular encrusting bryozoans and encrusting corallines in shallower areas.

- Sediment scour appeared to be a strong structuring force within this AoS. Low relief bedrock areas subjected to scour were found to be less faunally diverse than sites less affected by scour.

- A number of new biotopes are proposed for Solan Bank. This is primarily due to biogeographic variation from existing biotopes in the classification.

- Species of note were an unidentified cup coral, a sponge which has only previously been recorded from fishing trawl records and not seen *in situ* before (*Oceanapia robusta)* and another species of sponge classified as rare (*Poecillastra compressa)*.

2 Introduction

This document presents the findings of the Joint Nature Conservation Committee (JNCC) contract F90-01-1200: "Understanding the marine environment-seabed habitat investigations of submarine structures in the mid-Irish Sea and Solan Bank Areas of Search (AoS)". In May 2008 (18^{th} – 27^{th} May), a survey (CEND 11/08) commissioned by JNCC (Whomersley *et al*, 2008) undertook seabed habitat investigations of two Areas of Search (AoS) for offshore SACs. This report presents detailed geomorphological and biological information pertaining to both AoS.

The JNCC has a statutory responsibility to advise Government on the selection of Special Areas of Conservation, and since August 2007, the UK has had the legal mechanism to designate SACs in the UK offshore marine area (12 to 200nm from the coast and the UK Continental Shelf[1]) under the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007. To this end, this particular project was concerned with the gathering of scientific data to support the assessment of these two AoS (Figure 1) against SAC site selection criteria:

- Submarine structures in the mid-Irish Sea
- Solan Bank

Rocky reefs and other submarine structures are important ecological features, noted for their high biodiversity (Taylor, 1998). They encompass a multitude of rock types which include bedrock outcrops boulder and cobble field (Diesing *et al,* submitted). These surfaces provide a site for a wide range of sessile organisms that require an attachment surface for all or part of their life cycle. The complexity of the surface structure can determine what types of organisms are present (Kostylev *et al,* 2001, Pitcher *et al,* 2008). The solidity of rock and the fractal complexity of its surface therefore provide an abundance of stable niche habitats which are exploited by a wide array of species which include both sessile (bryozoan and cnidarians) and motile (shrimp and crab) invertebrate species. Such cryptic habitats also provide habitat for many fish species leading to the common perception that rocky reefs habitats have high biodiversity.

The ecological value of sublittoral rock reefs and submarine structures (Hiscock 1998) and the vulnerability of such habitats to a range of external pressures resulting directly or indirectly from human activities, such as damage or disturbance by dredging, fishing and offshore construction (Hiscock and Breckels 2007, Kaiser *et al,* 2002) highlights the importance of maintaining such habitats within UK waters. Such communities are also vulnerable to changes in community structure and function through the removal of target and non-target species by fishing and the invasion of non-native species and in response to changing environmental conditions such as temperature, salinity, light penetration, acidity and nutrient levels (Przeslawski *et al,* 2008, Hiscock and Breckels 2007, Kaiser *et al,* 2002, Perrings 2002).

2.1 Location of Areas of Search

2.1.1 Submarine structures in the mid-Irish Sea

The Area of Search (AoS) occurs about half way between Anglesey and Ireland just east of the UK/Ireland median line (Figures 1 and 2). The water depth increases from 70 m in the northeast to 100 m in the southwest (Figure 3).

[1] As set out in Orders made under Section 1(7) of the Continental Shelf Act 1964.

2.1.2 Solan Bank

This AoS occurs approximately 50 km to the north of the Scottish mainland, towards the SW margins of the Solan Bank and Nun Rock-Sule Skerry highs (Figures 1 and 13).

2.2 Main Aims of Project

The main aims of the project were:

- To acquire high quality data from the Submarine structures in the mid-Irish Sea and Solan Bank AoS (Figure 1) within the logistical, time and cost constraints of the project, leading to the production of broad scale habitat maps.

- To acquire acoustic data capable of identifying and describing Annex I habitat from the Submarine structures in the mid-Irish Sea and Solan Bank AoS. In particular, methods used should enable relevant physical sub-types of reef to be distinguished, such as bedrock, stony and biogenic reef (formed by organisms such as *Lophelia pertusa* or *Sabellaria spinulosa*).

- To acquire seabed imagery (digital video and digital stills) to enable the interpretation of geomorphological datasets and to describe the range of seabed habitats and associated epi-fauna that exist within the AoS.

- To acquire seabed samples where permissible, to describe the biological communities which characterise these habitats, and to enable the interpretation of geomorphological datasets.

- To identify and record the nature and location of any obvious human impacts in the AoS (e.g. trawl marks, disposed of or discarded material e.g. fishing gear or nets.

- To record and describe any new habitat types discovered in UK offshore waters.

- To evaluate the effectiveness of data collection methods, techniques and technical equipment.

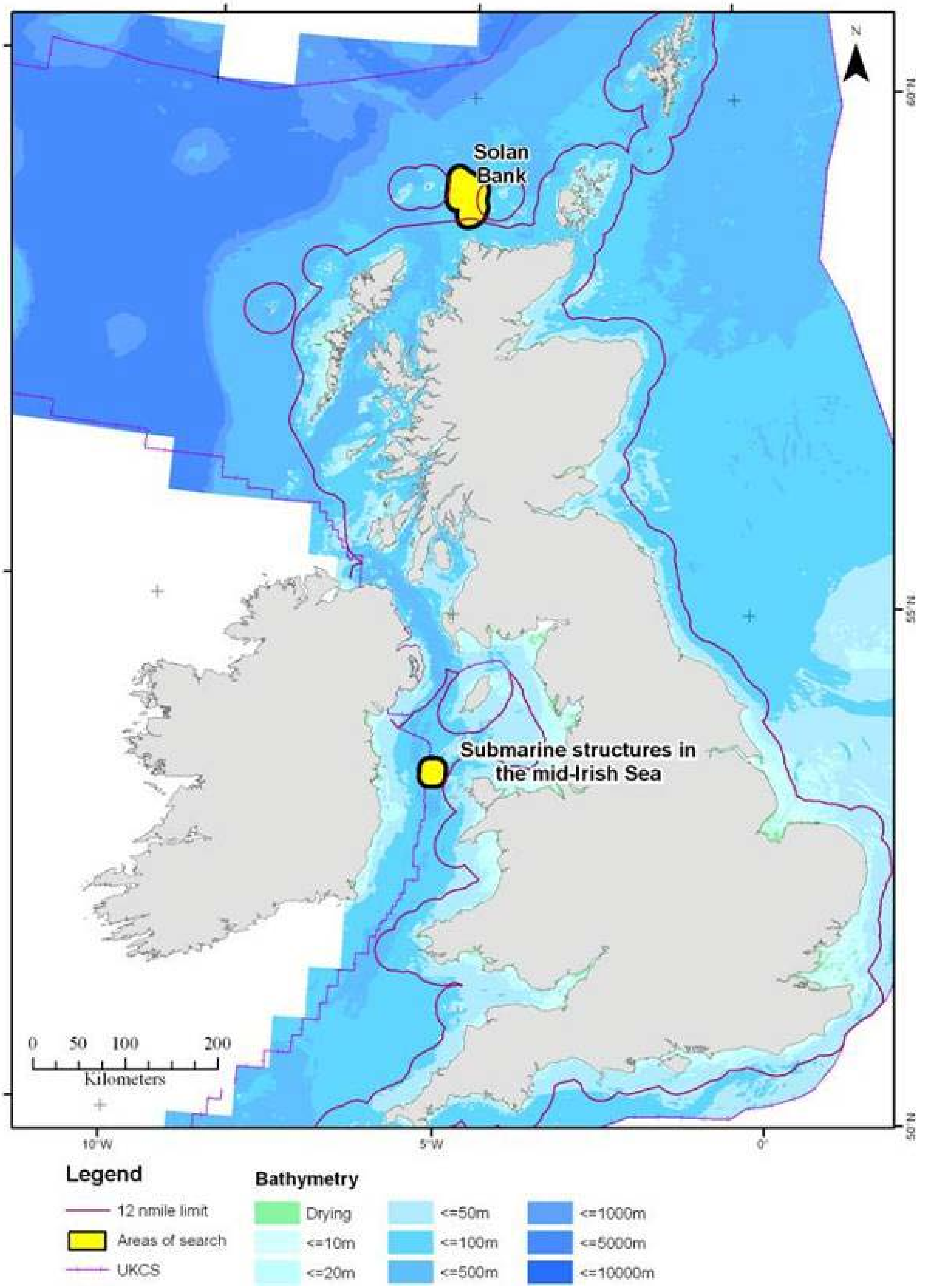

Figure 1. Location of AoS (Submarine structures in the mid-Irish Sea and Solan Bank).

2.3 Submarine structures in the mid-Irish Sea AoS

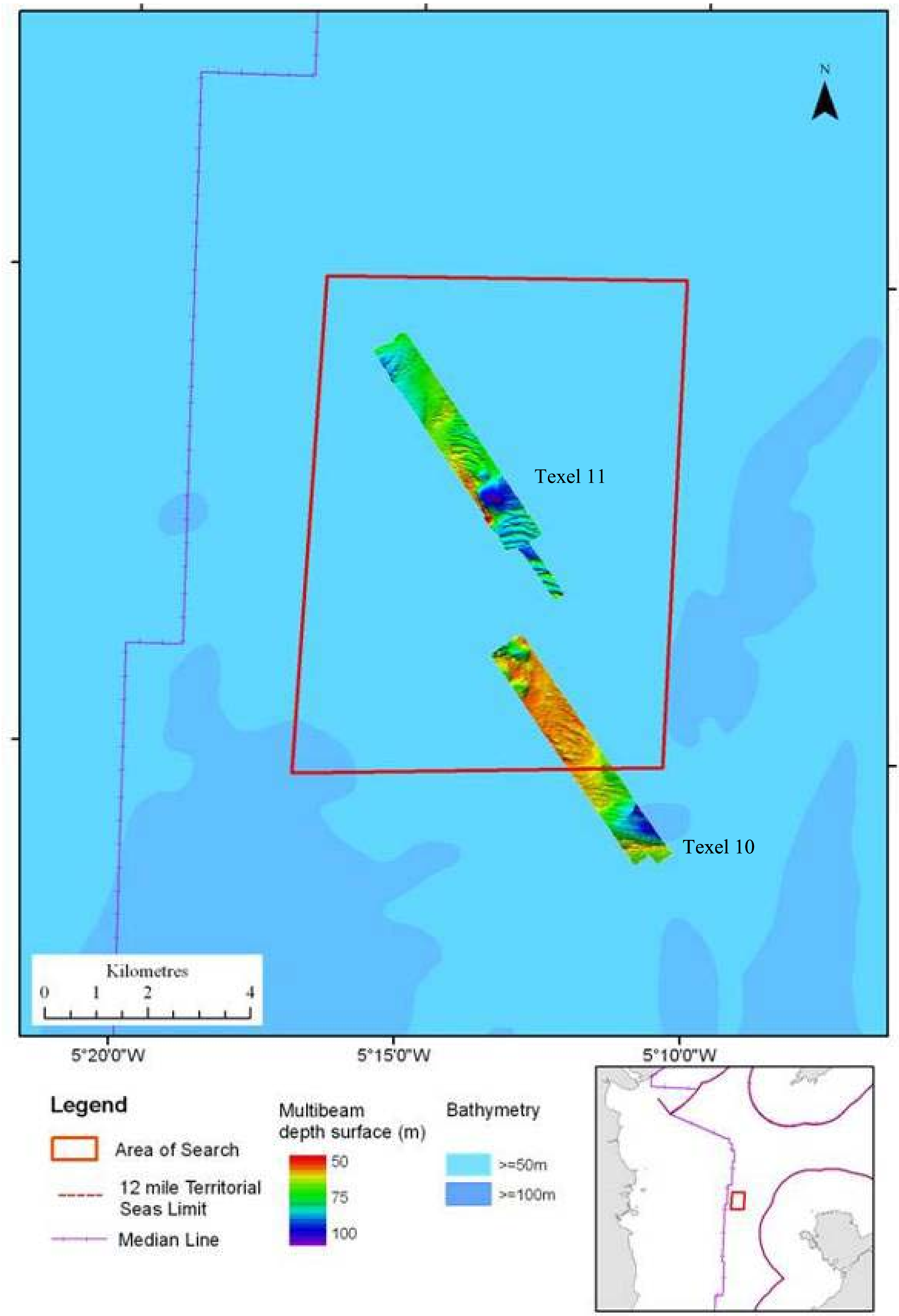

Figure 2. Submarine structures in the mid-Irish Sea AoS (red polygon). Pre-existing multibeam data from SEA6 survey for DTI referred to as Texel 11 and Texel 10.

2.4 Regional geology of the Submarine structures in the mid-Irish Sea AoS

Depressions, 10 - 15 m deep and 300 - 800 m diameter are common on the seabed in the AoS. These depressions are more abundant to the west of the AoS up to and west of the UK/Ireland median line (Figure 3). They can be recognised from the contours plotted on the published 1:250,000 Seabed Sediments map (British Geological Survey, 1990a) but these 10m contours have been simplified on DigBath 250, obscuring the detail. Other morphological features of significance for seabed habitats within the area include sediment waves migrating across a gravel lag. The mobility of the surface sediments reflects that the AoS located in an area of high tidal currents (Figure 4).

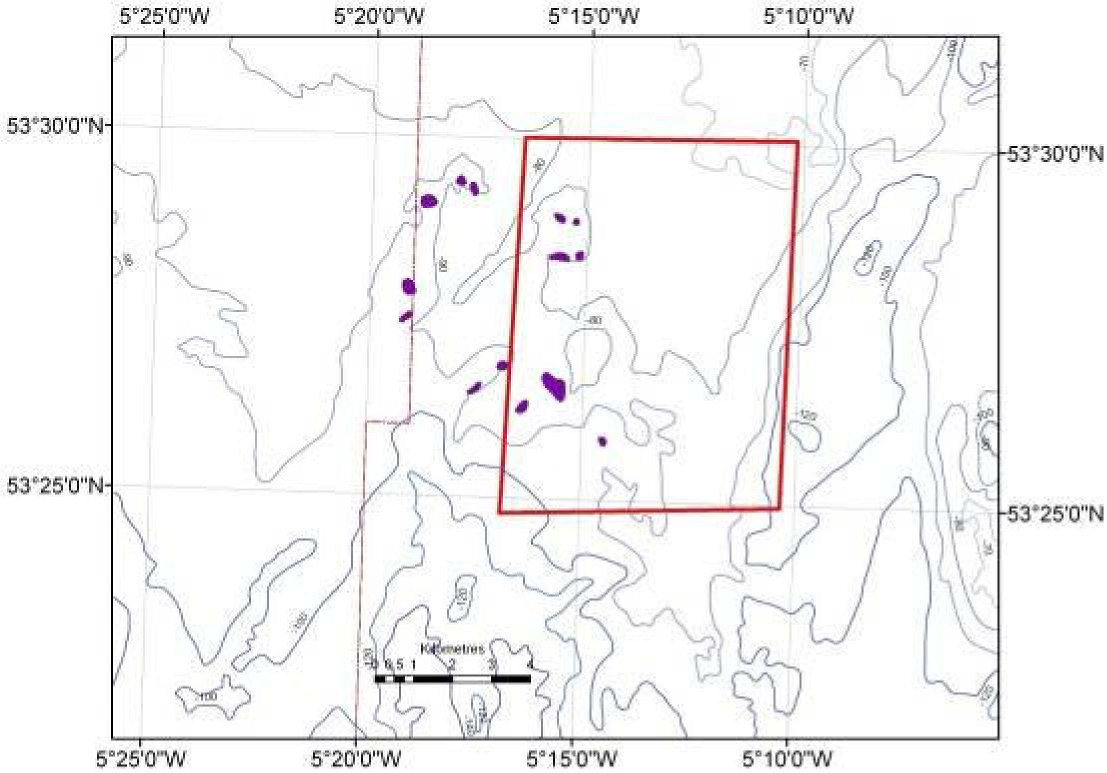

Figure 3. Location of seabed depressions based on BGS Seabed Sediments map

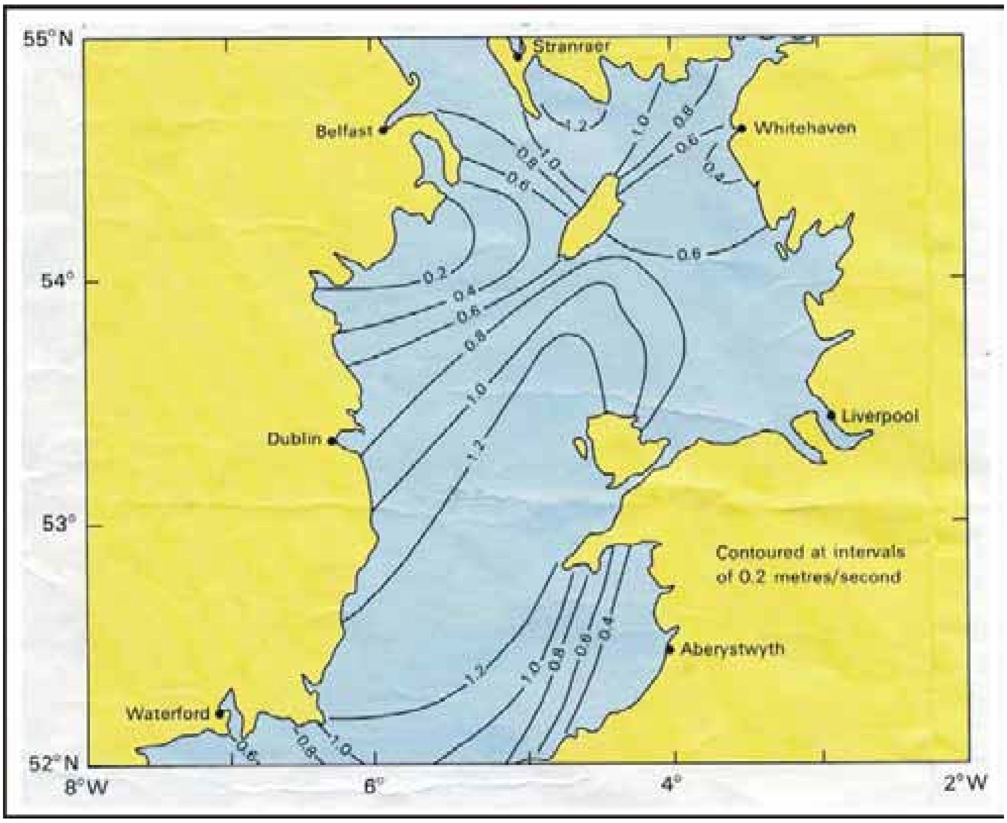

Figure 4. Tidal current speeds m/s. (Data from IOS displayed on British Geological Survey Seabed Sediments map of Anglesey (1990a))

2.4.1 Bedrock Geology

The Irish Sea west of 4°W comprises a series of sedimentary basins formed between Lower Palaeozoic and Precambrian blocks in Ireland and Wales (Figure 5). The AoS in the Irish Sea overlies predominantly Carboniferous sedimentary rocks (Figure 6). These occur on the western flank of the Holy Island Shelf, a Pre-Cambrian massif of schists and gneisses of the Monian Supergroup extending west from Anglesey (Figure 5). Following uplift an erosion during the Caledonian Orogeny, the area was inundated in Carboniferous times leading to the deposition of shelf limestones around Anglesey (Jackson *et al,* 1995).

The basal Carboniferous sequence comprises Dinantian limestones warped into an anticline (Figures 6 and 7). These limestones are overlain by Westphalian (Coal Measures) rocks, Namurian sediments were either not deposited in the area or they have been subsequently removed by erosion (Jackson *et al,* 1995). Based on hydrocarbon drilling in the adjacent Kish Bank Basin to the southwest, sedimentary rocks, within the AoS are thought to comprise thinly interbedded mudstones, siltstones and sandstones (Jenner, 1981, McArdle and Keary, 1986). These are typical of the Coal Measure sequences deposited as tropical deltas that extended out across swamps and into shallow seas. These rocks are the source of the hydrocarbon resources in the Irish Sea. The Westphalian sequence was subsequently uplifted in the Variscan Orogeny. The sub-tropical conditions of the Carboniferous gave way to desert conditions as the landmasses continued to migrate northwards. Permian and possibly Triassic sequence of sandstones and siltstones were deposited on top of the partially eroded Westphalian succession. The Upper Palaeozoic sequence generally dips to the northwest.

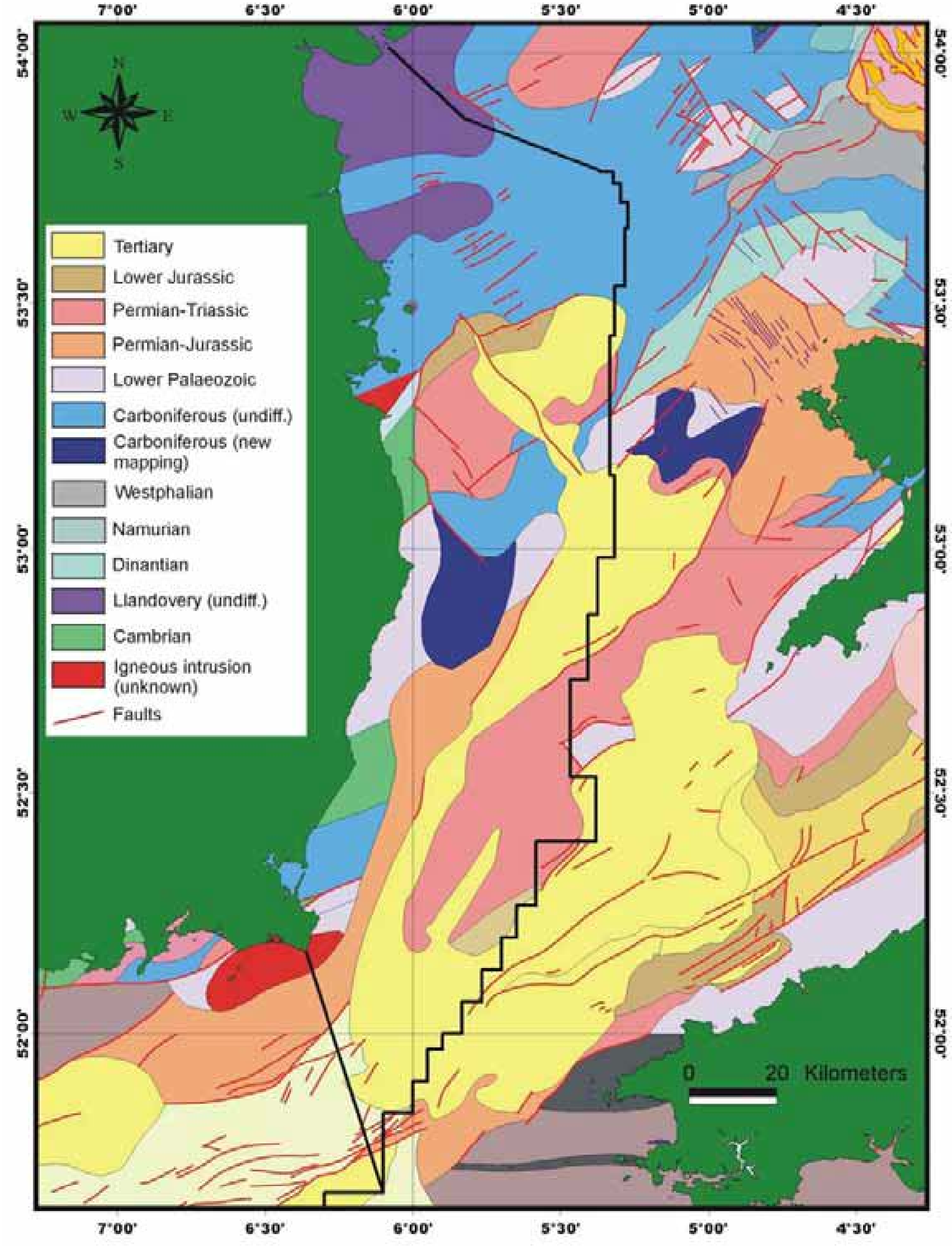

Figure 5. Bedrock geology of the Irish Sea from BGS DigRock 250.

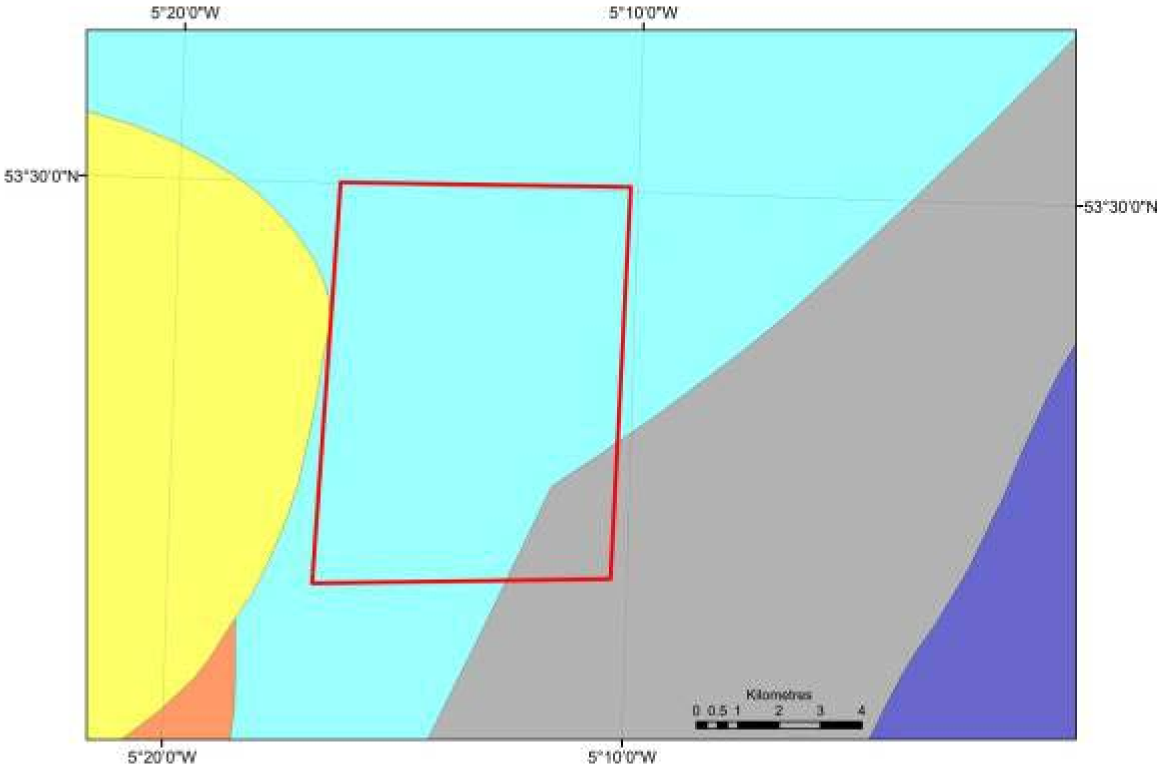

Figure 6. Bedrock geology around the AoS from BGS DigRock 250.

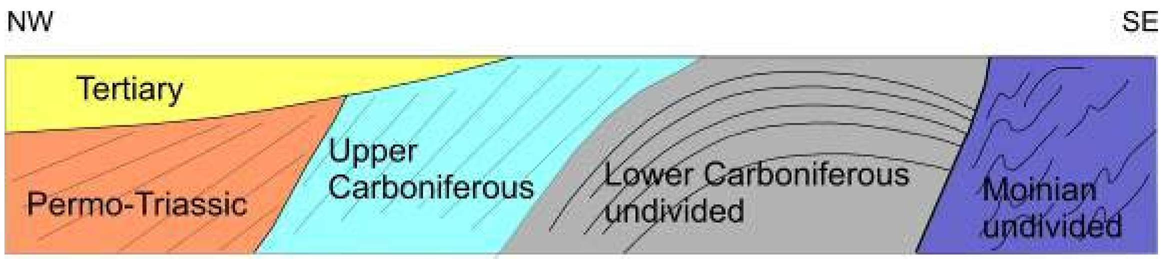

Figure 7. Schematic cross-section across the area of the AoS.

However it should be noted that there is uncertainty to the age of the sediments overlying the Pre-Cambrian due to the difficulty in extrapolating from wells across large faults where there is only limited seismic data. The new 1:250,000 map of the area (British Geological Survey, *in press*) indicates a Lower Palaeozoic sequence beneath the Westphalian rather than the Dinantian limestones of earlier mapping (British Geological Survey, 1982).

Within the Irish Sea, north of the Lleyn Peninsular the post- Triassic Mesozoic succession is largely absent. Quaternary and Tertiary sediments typically rest unconformably on Triassic, Permian or Carboniferous rocks (Croker, 1995) with an area of sediments thought to be Oligocene just to the west of the AoS (Figure 6). These form the Lambay sub-basin. Although not sampled they are thought to resemble those recovered from several basins along the western margin of Britain e.g. in the Mochras borehole, Cardigan Bay and from the Lough Neagh area which comprise fluvio-lacustrine deposits including lignites (Dobson and Whittington, 1979).

2.4.2 Quaternary Geology

The Irish Sea was covered by extensive ice-sheets several times during the Quaternary. With each advance there was extensive erosion of the earlier glacial deposits meaning that the record remaining is predominantly that of deglaciation with only occasional occurrences of sediments pre-dating the last glaciation. There are two competing models of deglaciation for the Irish Sea. In the glaciomarine model of Eyles and McCabe (1989), the Irish Sea Basin was flooded early in deglaciation by marine waters leading to extensive glaciomarine sedimentation. In the opposing terrestrial model (Scourse and Furze, 2001), ice extended to the floor of the Irish Sea and precluded marine inundation.

Although the BGS maps of the area indicate 50 - 100 m of Quaternary sediments there are few seismic lines. Judd *et al* (2007) provided boomer and pinger evidence of the inclined reflectors of the well layered prograded facies of the Late Pleistocene Western Irish Sea Formation dipping northwestwards (Figure 8). There are few samples of it but it has been observed visually where surficial sediments have been eroded to reveal blue-grey clay with coarse sediment (possibly layered) including boulders, probably originating as dropstones. Judd (2005) states that the clay samples are firm to stiff and silty.

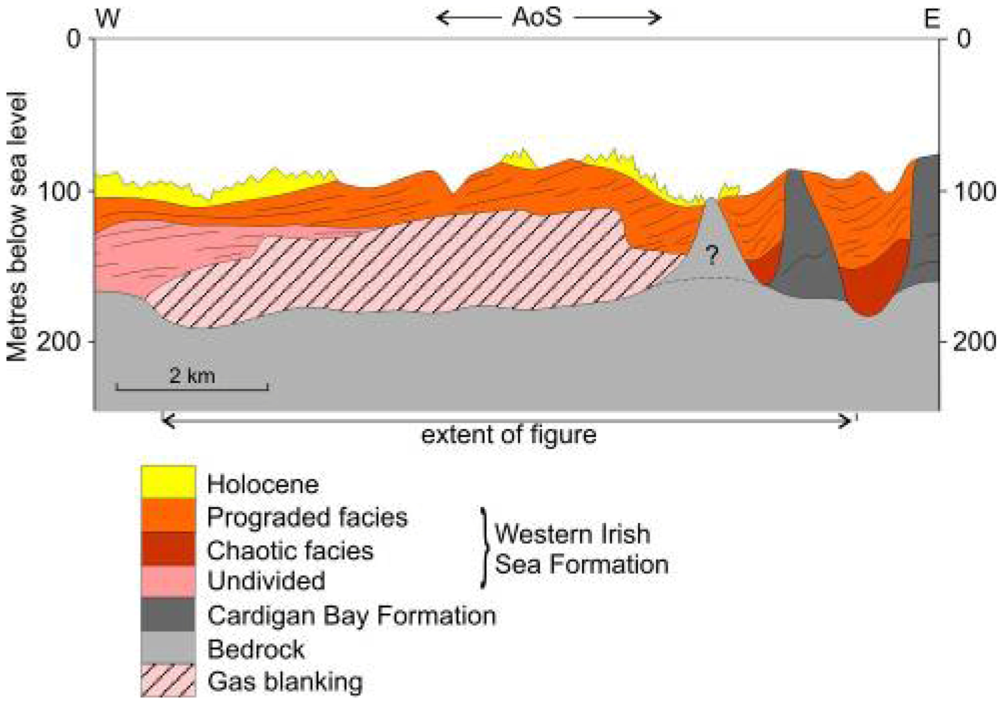

Figure 8. Quaternary cross section.

Within the AoS, virtually the entire area is covered by the Prograding Facies of the Western Irish Sea Formation (WISF) (Figure 7) (BGS, 1990b). To the east of the AoS there are outcrops of the Cardigan Bay Formation. This unit may consist of sub-aerial glacial deposits comprising overconsolidated diamicton. It may occur at depth within the AoS but gas blanking obscures it (Figures 8, 9 and 11). The WISF shows prograding acoustic reflectors and is interpreted as being prodeltaic and glaciomarine (or glaciolacustrine), representing passage from the ice-proximal to ice-distal as the ice retreated. These reflectors dip westwards on the eastern edge of the AoS becoming north-westward dipping in the west. The acoustic layering may reflect fluctuations in the sediment supply. Sedimentalogically the unit is largely composed of sand. The reflectors dip to the northwest indicating a sediment supply from southeast of the AoS where the WISF occupies channels within the older Cardigan Bay Formation. This regional interpretation is supported by recent detailed studies north of Anglesey by Van Landeghem *et al* (2008) who showed that the ice sheet to the east of the AoS was grounded and that it flowed westwards towards the AoS, matching the flow direction evident from the dipping internal reflectors of the WISF. It is uncertain if the icesheet was floating in the vicinity of AoS as the ice front retreated back past the area.

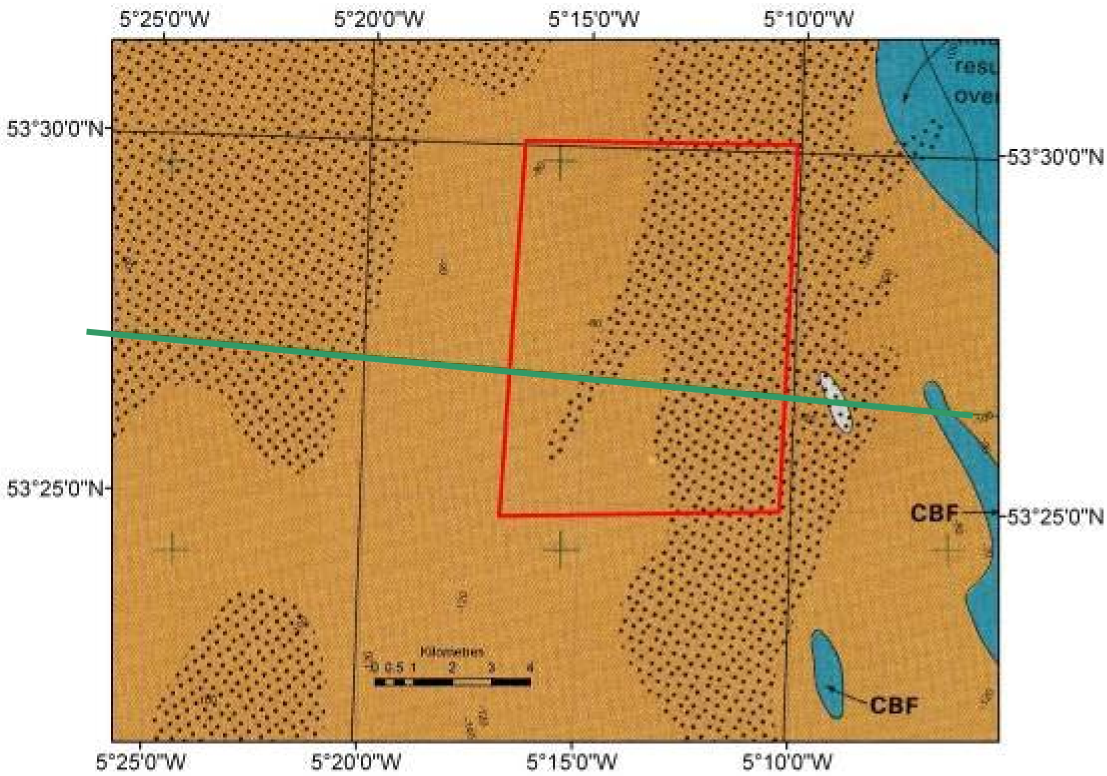

Figure 9. Quaternary geology of the area surrounding the AoS (Taken from BGS, 1990b)
Red box = AoS
Green line = part of cross-section Figure 8
Brown = Western Irish Sea Formation
Blue = Cardigan Bay Formation
Speckled ornamentation = area of Holocene sand waves at the surface

2.4.3 Seabed sediments and morphology

BGS seabed sediment mapping shows the surficial sediments of the AoS to comprise of sand and gravelly sand with a small area of muddier sediment (Figure 10). The areas of sand include sand waves orientated approximately east-west. Judd (2005) indicates the presence of boulders and mounds comprising boulders. Examination of the SEA6 data revealed the waves to be 100 - 150 m in wavelength and up to 5 m in height.

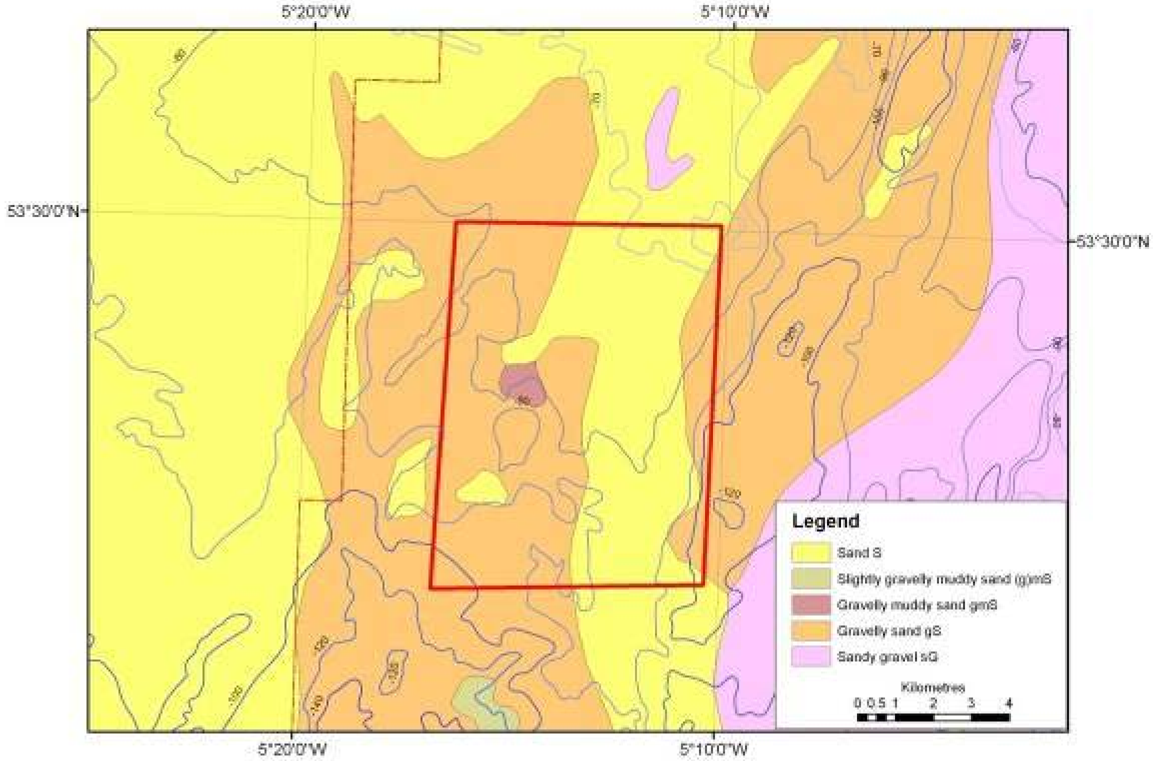

Figure 10. Seabed sediments around the AoS. Taken from DigSBS250.

Seabed samples collected during the SEA6 survey showed that the surficial sediments were frequently cemented. Analyses of the cement showed it to be carbonate, high-magnesium calcite or aragonite. This is typical of methane derived authigenic carbonate (MDAC) (Judd, 2005).

2.4.4 Shallow gas

The first surveys of the western part of the Irish Sea found extensive acoustic turbidity and attributed this to gas blanking particularly in the deepwater to the northwest of the AoS referred to as the Western Irish Sea Mud Belt (WISMB) where the seabed is very muddy with pockmarks noted in the deepest parts (Yuan *et al*, 1992). Yuan *et al* (1992) also suggest the source of the gas was direct biogenic origin associated with increase biological productivity due to the position of a frontal trough boundary between stratified and mixed water masses. However the relationship between biological activity and shallow gas was reversed due to the presence of gas seepage (Judd and Hovland, 2007) as the cause of localized increased biological productivity in the Irish Sea (Savidge *et al*, 1984).

Subsequently cable route survey data used by Croker (1995) showed acoustic turbidity indicative of shallow gas west of Anglesey on seismic records of the Western Irish Sea Formation where the seabed comprises sandy sediments (Figures 11 and 12). Furthermore, Croker suggested that the methane could be thermogenic derived from coal bearing rocks of the Carboniferous sequence that underlies the area. Alternatively it may be microbial methane derived from Oligocene lignites of the Lambay basin or from late- to post-glacial silts and clays.

Based on this evidence, Croker (1995) concluded that the gas is of thermogenic origin, probably derived from Westphalian Coal Measures or the Dinantian / Namurian Holywell Shale which subcrop beneath the Quaternary sediments. In addition Croker (1995) argued that gas would be able to migrate easily through the Quaternary sediments (the Prograded Facies of the Western Irish Sea Formation), and suspected that substantial erosion by escaping gas was responsible for the formation of large trenches in the Central Irish Sea.

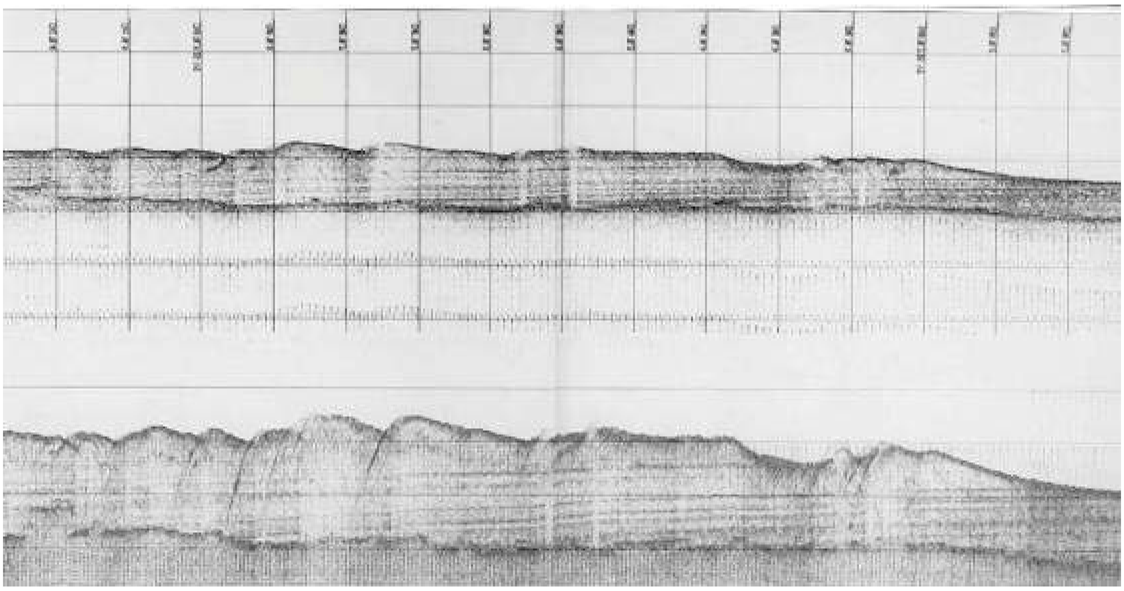

Figure 11. Seismic profiles (pinger above, boomer below) across Texel 11.

The inclined reflections represent the Prograded Facies. Vertical columns are believed to be artifacts caused by signal starvation where sand waves occur on the seabed. The irregular reflections towards the bases of the profiles are caused by acoustic turbidity (Taken from Judd, 2005, originally from Croker, 1994).

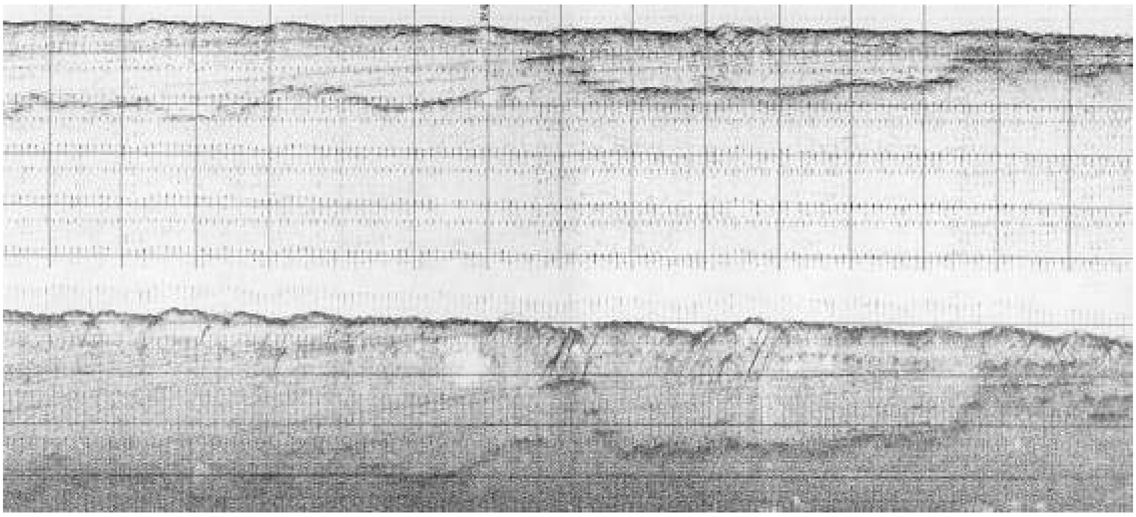

Figure 12. Boomer profile (top) and 5kHz Pinger profile (bottom) from Texel 10 area showing gas enhanced reflectors. (Taken from Judd, 2005, originally from Croker, 1994).

The SEA 6 survey (Judd, 2005) surveyed the Harvey Trench and two smaller areas to the north west termed Texel 10 and Texel 11 that include part of the AoS (Figure 2).

The SEA6 study showed a generally flat seabed within the Texel 10 and Texel 11 areas except for large depressions up to 500 m diameter and small mounds, and sediment waves. The depressions often had steep sides with the largest depression in Texel 11 having a 6-8m high cliff extending 500m. Sidescan sonar records showed strong returns from the cliff and other cemented hard grounds (Judd, 2005). Video surveys and recovered grab samples indicated that the cliff comprises cemented rocks providing a firm substrate exploited by a diverse fauna including bryozoans, hydroids, sponges, anemones, starfish, urchins, crab, lobster, and squat lobster (Judd *et al,* 2007).

Chemical analysis of the SEA6 carbonate cement samples indicated that they were methane derived and were thermogenic in origin. The MDAC is thought to form within the upper part of the sediment column, where rising methane is oxidised and pore waters become supersaturated with respect to calcite (i.e. calcium carbonate). At this point, the calcite precipitates, infilling the pore spaces between sand grains and creating a layer or crust that can develop into a significant hard ground at or just below the sea floor. Judd (2005) considered that the source of the gas was most likely in the underlying Westphalian and Dinantian Carboniferous bedrock.

There is uncertainty (BGS, *in press*) as to the presence of the Lower Carboniferous and whether the unsampled sediments are of Lower Palaeozoic age. Alternatively, gas derived from the Westphalian may migrate laterally upslope within the Western Irish Sea Formation before escaping at the seabed above Dinantian or Lower Palaeozoic bedrock. A chirp profile from Texel 10 area shows the gas-front stepping upwards between reflectors within the Quaternary sequences (Figure 11). It is possible that lignites within the Oligocene sediments of the Lambay sub-basin to the west of the AoS are the source of the gas but this would require even greater lateral migration within the Quaternary sequence and is considered unlikely.

2.5 Biological context

The Irish Sea lies between Britain and Ireland and surrounds the Isle of Man. It covers just over 100,000 km^2. The North Channel and St. George's Channel connect it with the Atlantic Ocean. A relatively shallow sea, it is less than 90m deep in most places with shallow sandbanks off the Irish and north-west English coasts. The sea floor is mostly of mixed sediments, with rocky areas off Anglesey and muddy areas to the west of the Isle of Man.

There are several oil and gas fields in the south-eastern Irish Sea and major shipping lanes running into Liverpool off the coast of north Wales.

The occurrence of hard submarine structures in areas of otherwise soft unconsolidated sediments creates an important habitat for epi-faunal species to colonise. The colonisation by these species results in a more species and functionally diverse ecosystem

Biological communities known to colonise submarine structures such as the ones located within the mid-Irish Sea are primarily epi-faunal species (Judd, 2005). These include echinoderms *Asterias rubens, Crossaster papposus*, *Henricia oculata* and *Echinus* sp., hydroids *Nemertesia* sp. and *Sertularia* sp., bryozoans *Flustra foliacea* and *Alcyonidium diaphanum*, crustaceans Pagurids, *Carcinus* sp., *Galathia* sp and *Munida* sp and finally cnidarians, soft coral *Alcyonium digitatum* and the anemone *Urticinia* sp.

The occurrence of epi-faunal species is dependent on the physical conditions (Warwick and Uncles, 1980) and physical properties of the attachment site. In areas of increased scour fewer epi-faunal species will be present. However, in areas where hard substrate is permanently available for colonisation then epi-faunal species would be expected to be present. The physical properties of Methane-Derived Authigenic Carbonate rock (MDAC) (e.g. the softness of the rock) can provide a suitable substrate for boring species such as the bivalves *Hiatella arctica* and *Pholas dactylus.*

Previous studies in the Irish Sea (Mackie *et al,* 1995; Wilson *et al,* 2001; Blyth-Skyrme *et al,* 2008) identified the following communities and mapped their existence throughout much of the central Irish Sea.

- A Deep Venus community which is equivalent to the Polychaete-rich deep Venus community in offshore mixed sediments biotope (SS.SMx.OMx.PoVen) described in the Marine Habitat Classification for Britain and Ireland version 04.05 (Connor *et al,* 2004).

- A Deep Venus/Hard community, which has no direct equivalent within the Marine Habitat Classification, but which is most closely related to Sublittoral mixed sediment biotope complex (SS.SMx).

Previous studies (Schratzberger *et al,* 2004) carried out as part of the National Marine Monitoring program (NMMP) have shown the southern Irish Sea to support a diverse and abundant infaunal community comprising primarilyannelid worms (*Nephtys* sp., *Lumbrineris* sp., species from the family Spionidae) and molluscs (*Abra* sp.*, Nucula* sp. and *Corbula gibba*).

The presence of static fishing gear encountered during the survey gives anecdotal evidence of the presence of crab (*Cancer pagurus*) and/or lobster (*Homarus gammarus*). Other exploited stocks in the area include cod (*Gadus Morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), herring (*Clupea harengus*) and the shrimp (*Nephrops norvegicus),* which is known to inhabit muddy environments.

2.6 Solan Bank AoS

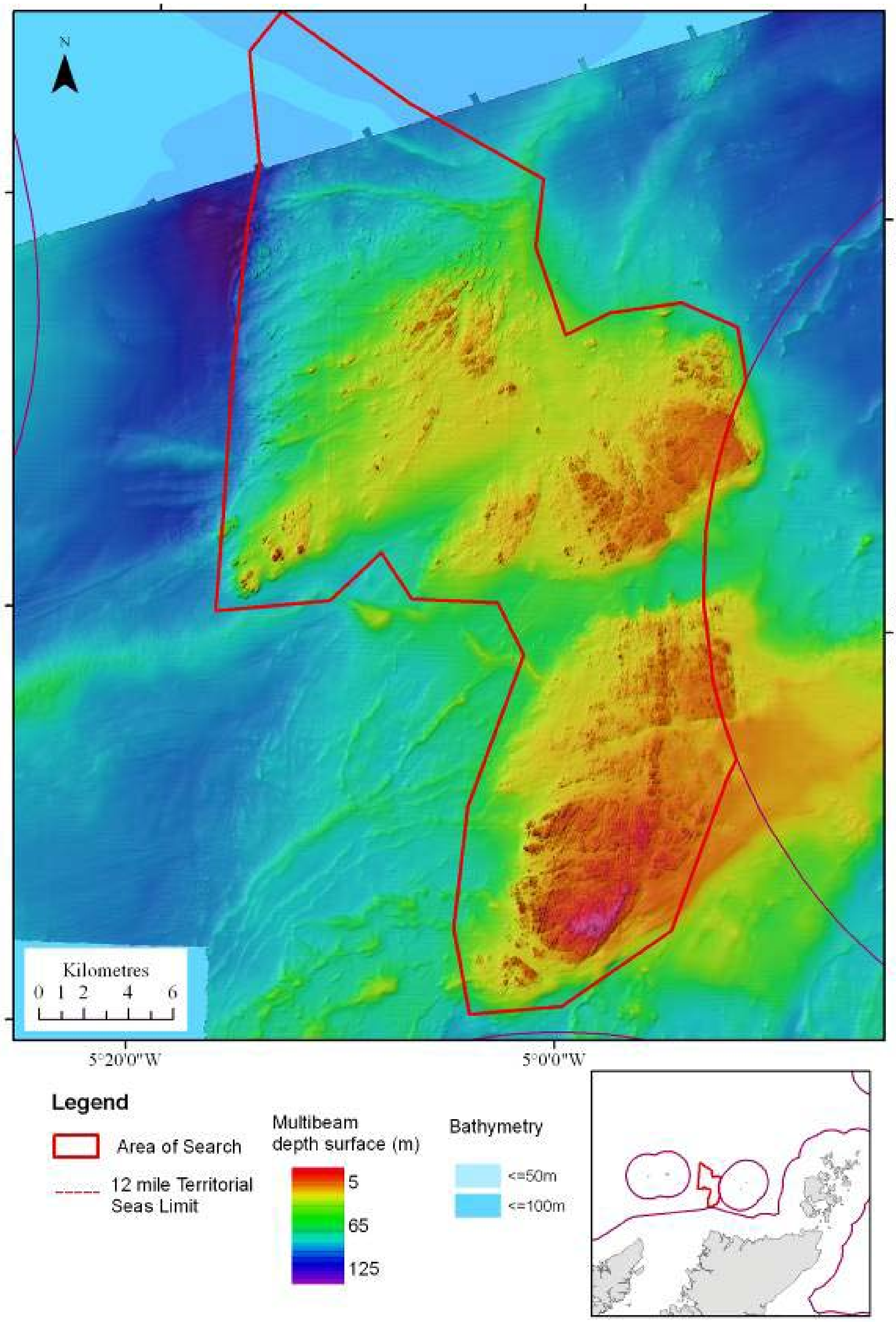

Figure 13. High resolution multibeam bathymetric image of Solan Bank AoS (red polygon) © Crown Copyright. (Data supplied by Maritime and Coastguard Agency. Not to be used for navigation.)

2.6.1 Regional geology of the Solan Bank AoS

In the AoS, outcropping rocks at the seabed were well imaged from Maritime and Coastguard Agency (MCA) multibeam data (Figure 1, 13 and 14). In the autumn of 2007, a BGS seabed sampling cruise by the *RRS James Cook* (Stewart and Gatliff, 2008) drilled a number of boreholes on this rock outcrop in shallow water depths of approximately 30-50m (Table 1).

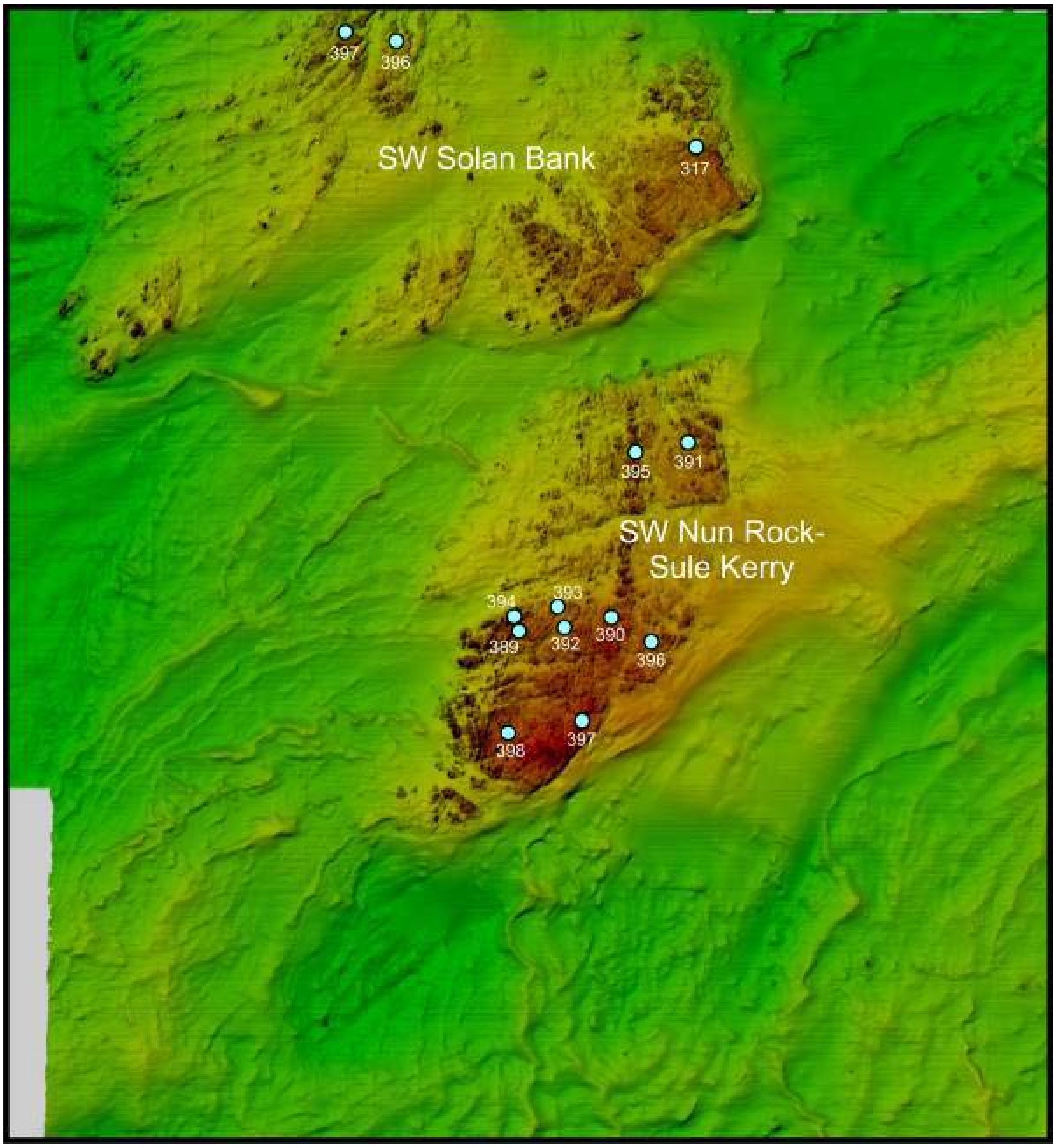

Figure 14. High-resolution bathymetric image of the SW Nun Rock - Sule Skerry and SW Solan Bank highs. Blue circles are samples of granite, banded gneiss and pegmatite recovered in 2007 (Stewart and Gatliff, 2008). High resolution multibeam bathymetric image © Crown Copyright. (Data supplied by Maritime and Coastguard Agency. Not to be used for navigation.)

Table 1. Summary of BGS boreholes drilled in the SW Solan Bank High and SW Nun Rock- Sule Skerry High area (from Stewart and Gatliff, 2008). For locations, see Figures 14 and 15.

SW Solan Bank High		
Sample Number	**Drilled thickness (m)**	**Sample Description**
59-05/317	2.13	schist
59-06/396	1.23	gneiss
59-06/397	1.12	schist
SW Nun Rock High - Sule Kerry High		
Sample Number	**Drilled thickness (m)**	**Sample Description**
58-05/389	0.48	Cobbles of crystalline basement
58-05/390	1.46	pegmatite
58-05/391	1.3	granite
58-05/392	0.93	boulders
58-05/393	0.44	banded gneiss
58-05/394	1.03	boulders on pegmatite
58-05/395	1.39	banded gneiss
58-05/396	1.89	granite
58-05/397	1.16	meta dioritic gneiss
58-05/398	2.79	schist

Between the late 60s and early 90s, the Department of Energy and Climate Change (DECC, formerly known as the Department of Energy) funded a programme to study the structure and geology of the UK continental margin. From the results, maps of seabed (1:250 000) which included cross-sections that illustrated the deep geological structure were produced. To the north of Scotland, the SW Solan Bank High and Nun Rock-Sule Skerry High straddle the boundary of two such maps at 59° North, namely the Rona Sheet covering an area between 59-60° North and 4-6° West (BGS, 1986) and the Sutherland Sheet covering an area of 58-59° North and 4-6° West (BGS, 1989) (Figure 15).

From the results of these DECC-funded investigations in the AoS, six main structural features have been identified. These include the Solan Bank and Nun Rock-Sule Skerry highs, which form generally NW-trending Precambrian basement horst blocks, flanked to the west by the mainly Mesozoic North Rona, North Lewis and North Minch basins, and to the east by the West Orkney Basin (Figure 15). A geological cross-section constructed immediately adjacent to the AoS illustrates the relationship of the ancient Solan Bank and Nun Rock-Sule Skerry highs and the flanking Mesozoic North Rona and West Orkney basins (Figure 16). These basins formed mainly in response to extension of the underlying crust during Permian and Triassic times, although further growth of some of these basins occurred in Jurassic and Cretaceous times. As Precambrian and Mesozoic rocks are considered to outcrop at the seabed over most of the area (Figure 15), a significant part of the Jurassic but particularly Cretaceous and younger geological record is absent. Analysis of commercial well data from 202/19-1 within the West Orkney Basin (Figure 15) suggested that 1.6 km of rocks have been removed from the area (Evans, 1997), most likely due to the effects of uplift and erosion associated with the development of the Iceland Plume in Paleocene times.

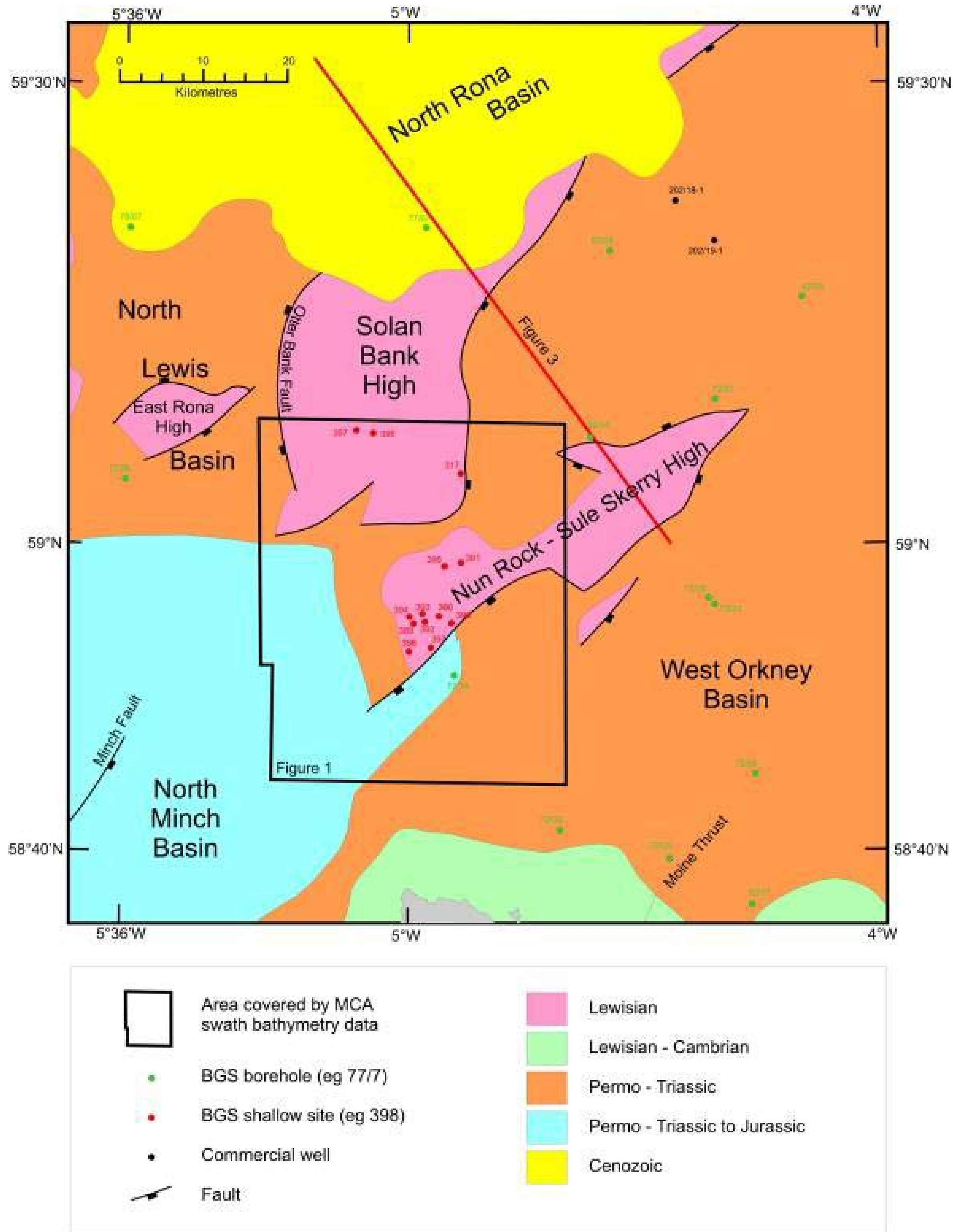

Figure 15. Regional geology of the Solan Bank AoS (modified after British Geological Survey, 1986; 1989).

Note: all BGS shallow sample sites have a unique identifier. This comprises a code for each 1 degree rectangle based on the co-ordinates of the SW corner of the 1 degree rectangle and a sequential number. So within the survey area samples begin 59-06, 59-05 and 58-05 (see Table 1) followed by a sequential number. However only the sequential number is plotted on the figure which leads to the apparent repetition of sample number.

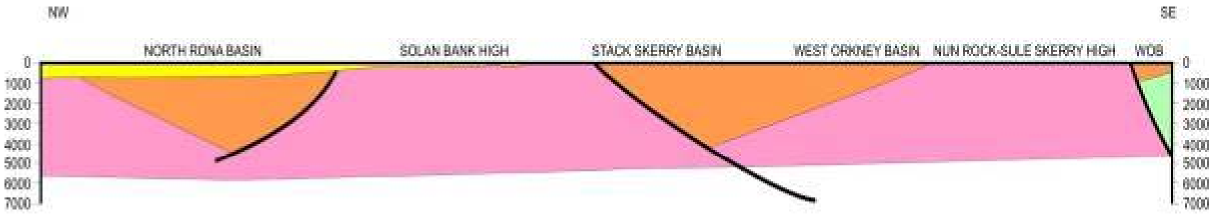

Figure 16. Geological cross-section across the central part of the Solan Bank High and the NE part of the Nun Rock - Sule Skerry High north east of the AoS.

A more detailed description of the nature, age and evolution of these major structural elements is given below.

2.6.2 Major structural features

Nun Rock-Sule Skerry High

The Nun Rock-Sule Skerry High (including the islets of Sule and Stack Skerry) forms an elongate, NE-trending, intra-basinal, Precambrian basement high, 50 km long and up to 15 km wide that occurs mainly within the West Orkney Basin (e.g. Stoker *et al,* 1993). The high is partly fault-bounded, with the NE-trending, SE-dipping normal fault that defines its SE margin with the West Orkney Basin displacing Precambrian basement by approximately 1.5 km (Figures 15 and 16).

The SW extremity of the high occurs within the AoS, and the current-swept rocks that are exposed at the seabed have been drilled in ten different locations (Figure 14), with thicknesses of between 0.5 m and 2.8 m recovered. A provisional description of hand specimens are summarised in Table 1, and include crystalline metamorphic rock types such as granite, schist, pegmatite and high grade gneiss (Figure 17). These ancient hard rocks are very resistant to erosion, and partly explain their upstanding topography at the seabed (e.g. see Figures 12, 25 and 26). The age, mineralogy and geochemistry of the core samples are currently being investigated but it is likely that they will be Precambrian in age, similar to rocks described from the Lewisian Complex of NW Scotland which formed approximately between 2500-1600 Ma.

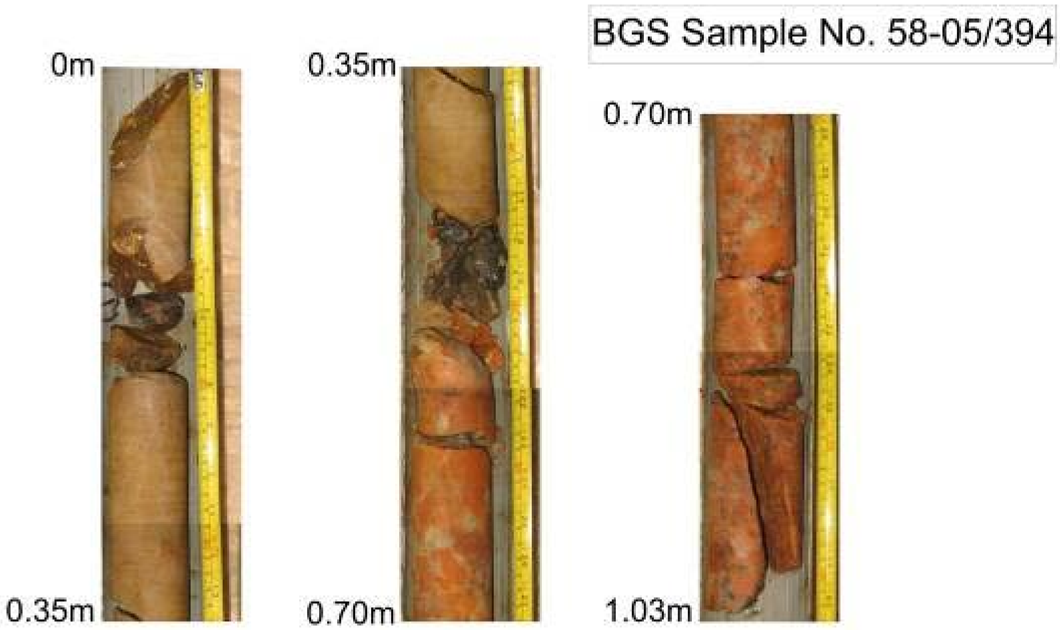

Figure 17. Photograph of BGS sample 58-05/394. Typical basement core recovered by BGS shallow drilling from SW Solan Bank and the Nun Rock – Sule Skerry High. The rock is provisionally

described in hand specimen as a pegmatite (a coarse grained rock mainly comprising quartz and pink feldspar).

From inspection of the MCA multibeam data, it is clear that structural grain of the Precambrian basement rocks trends in a slightly arcuate, but generally northerly direction and is cut by a series of WSW-trending fractures (Figure 14).

Solan Bank High

The Solan Bank High forms a NE-trending Precambrian basement high 130 km long and 25 km wide (Stoker *et al,* 1993). The high is separated from the West Orkney Basin to the SE by a large NE-trending normal fault (Figures 15 and 16). The NW margin of the high is separated from the North Rona by a NE-trending, NW-dipping strand of the Otter Bank Fault (Herries *et al,* 1999).

The rocks that out crop at the seabed at the SW extremity of the Solan Bank High have been cored in three different locations (Figure 15), with thicknesses of between 1.1 m and 2.1m recovered. Hand specimens have been provisionally described as metamorphic rocks including schist and gneiss (Table 1). As in the case for the SW Nun Rock-Sule Skerry High, these samples are currently the subject of further investigation, but they are likely to be of similar age to the Lewisian Complex of NW Scotland (see above). It should be noted that the central part of the Solan Bank High has also been drilled by BGS borehole 77/07 (Figure 15). The borehole terminated after encountering Miocene sands and clays resting unconformably on Precambrian Lewisian amphibolite.

From the MCA multibeam data, it is clear that structural grain of the basement rocks trends towards the NW. It is also possible to infer that there is an element of structural continuity with the SW Nun Rock-Sule Skerry High that lies to the south. If this inference is correct, then this does not support the current interpretation that both highs are discrete entities (Figure 15) with a characteristic generally NE-trending inherited Caledonian orogenic (Early to Mid Devonian) structural grain.

West Orkney Basin

The West Orkney Basin forms a large complex of sub-basins up to 135 km long and 90 km wide (Stoker *et al,* 1993). It is separated from the Solan Bank High to the NW by a NE-trending, SE-dipping normal fault, with Permo-Triassic sediments present within its hangingwall block (Figures 15 and 16). The nature of the boundary with the adjacent North Lewis Basin is largely unknown (Figure 15).

The West Orkney Basin has been drilled by a number of BGS shallow boreholes which proved Permo-Triassic rocks close to the sea-bed (Figure 15). In the far west of the basin where it merges into the North Minch Basin, within the AoS, Lower Jurassic has been drilled (BGS borehole 72/34) recovering brick red bioturbated siltstone with fine sandy lenses. Commercial wells 202/18-1 and 202/19-1 drilled in 1985 recorded 150 m of Cenozoic resting unconformably on 2.95 km of Permo-Triassic rocks. Up to 9 km of strata are thought to occur within the deepest parts of the basin (Enfield and Coward, 1987). The West Orkney Basin is considered to have formed in Permo-Triassic times (e.g. Stoker *et al,* 1993; Doré *et al,* 1999).

North Rona Basin

The North Rona Basin forms a series of NE-trending, SE-dipping half-grabens 90 km long and up to 25 km wide (Stoker *et al,* 1993). The basin is separated from crystalline basement of the Solan Bank High by a combination of the NE-trending; NW-dipping extensional Otter Bank Fault (Figures 15 and 16). The nature of the southwards transition of the basin with the North Lewis Basin is poorly understood. Outwith the AoS to the north, the North Rona Basin has been drilled; five commercial wells proved a thickness of 1 km of Cenozoic, 1 km of Cretaceous, 200 m of Upper Jurassic and 150 m of Triassic strata. Similar to the West Orkney Basin, the North Rona Basin began forming during

Permo-Triassic times (Doré *et al,* 1999), but with later phases of activity during Jurassic and Cretaceous times.

North Lewis Basin

The NE-trending North Lewis Basin forms two half-grabens 90 km long and 50 km wide (Stoker *et al,* 1993). It also includes two intra-basinal basement highs, one of which contains the island of Rona. The North Lewis Basin is separated from the western margin of the Solan Bank High by an N-trending, E-dipping fault (Figure 15).

The North Lewis Basin has been drilled by BGS borehole 72/36, proving Upper Triassic to Lower Jurassic strata at the seabed (Figure 15). However, it should be noted that within this part of the basin, the distribution of the Jurassic succession is likely to be thin and patchy. In terms of its evolution, the basin is considered to represent a mainly westward-tilted Permo-Triassic half-graben complex (e.g. Doré *et al,* 1999).

North Minch Basin

The NE-trending North Minch Basin forms a major Jurassic basin approximately 100 km long and up to 35 km wide (e.g. Fyfe *et al,* 1993). The basin is bounded along part of its western margin by the NE-trending, SE-dipping Minch Fault (Figure 12). This basin extends into the AoS (Figure 15).

The North Minch Basin has been drilled by BGS borehole 72/33 which proved Jurassic sediments close to the sea-bed and by commercial well 156/17-1, which penetrated 360 m of Jurassic and 1 km of Triassic, before bottoming in 130 m of Precambrian Torridonian sediments. However, the northern extremity of the basin, the Jurassic succession is likely to be relatively thin. The North Minch Basin is considered to have been initiated during the Permo-Triassic with a significant additional phase of development during Jurassic times (Fyfe *et al,* 1993), particularly within the central part of the basin.

2.6.3 Post-Jurassic history

There are no rocks younger than the Jurassic within the AoS. This may reflect non-deposition or, more likely, erosion of any such sedimentary rocks. Significant erosion affected the area during the Quaternary when it was covered by thick ice-sheets moving westwards from Orkney out to the shelf break, augmented by ice from northern Scotland. This ice moulded the seafloor preferentially eroding the softer rocks of the Permo-Triassic to Jurassic sequence leaving the harder crystalline rocks of Nun Rock and Solan Bank highs upstanding. However even these rocks were modified by the ice with preferential erosion along joints and the smoothing of some rock outcrops into roche moutonees.

As the ice retreated back across the area it deposited diamictons (till) often in ridges known as moraines that represent temporary standstills in the retreat (Bradwell *et al, in press*). Following de-glaciation currents have modified the moraines, winnowing the surface and exposing boulders. The fine material has accumulated in drifts to the east of the topographic highs due to the strong tidal currents that transport the shell rich surface sands eastwards today.

2.7 Biological context

Annex I Reefs are rocky/stony marine habitats or biological concretions that arise from the seabed. There are two kinds of reef structure, ones where epi-faunal plant and animal communities have colonised the hard substrate (bedrock, boulder and cobble field) and those which marine organisms (*Sabellaria sp, Modiolus modiolus* and *Lophelia pertusa*) have created, which are referred to as biogenic reefs (see http://www.jncc.gov.uk) for definitions of the different reef categories.

Rocky reefs and their communities can be infinitely different and are dependent on numerous factors which dictate the structure of the reef and also the species which inhabit them. The structure of the reef e.g. rock type and complexity and hence niche availability, is governed by the underlying geology and also the prevailing local physical conditions which include depth, temperature, salinity, currents scour and wave exposure. Additional factors which are known to structure epi-faunal communities are biological interactions which include competition and facilitation. The proximity of reef to other hard substrates e.g. rocky coastlines, offshore platforms and harbours can also affect which and how communities develop due to the supply of larvae from these established communities (Whomersley and Picken 2003).

Common epi-faunal species associated with stoney reefs include species of sponge, bryozoan, hydroid, soft coral and anemones. Economically viable shellfish species such as the brown crab (*Cancer pagurus*) and the lobster (*Homarus gammarus)* are also often found inhabiting reef habitats.

Rocky reef structures also provide a habitat which is known to facilitate the aggregation of fish species. This is thought to be due to an increase in food availability and cryptic habitat when compared with sandy/muddy sediments. Research carried out at Loch Sunart, a complex fjordic bedrock reef on the west coast of Scotland highlighted the importance of the reef structure in increasing biodiversity of the area and hence the need to protect reef habitats and the biological resource they supported (Bates *et al,* 2004). Further work carried out on serpulid reef structures identified in Loch Creran and Teacuis also demonstrates the importance of reef structures in increasing biodiversity in areas where limited amounts of hard substratum are available to epi-faunal communities (Moore *et al,* 1998).

Both biogenic and rocky reef have been shown to provide habitat for numerous fish species (Moore *et al,* 1998, Wilson *et al,* 2007). Fish species observed inhabiting reef structures have included cod (*Gadus Morhua*). They are targeted in this area along with other commercially viable fish species such as haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*).

3 Survey design and methods

3.1 Equipment used

3.1.1 Hull mounted multibeam echo-sounder system

A hull mounted Kongsberg EM3000D which operates at a frequency of 300kHz and has a variable swathe width (dependent on water depth) was used to provide detailed morphological information of the seabed at both AoS. The data was acquired using Kongsberg SIS software and data recorded in the Kongsberg proprietary "ALL" file format.

3.1.2 Towed sidescan sonar

The multibeam bathymetry was complemented by sidescan sonar data which was collected using a dual frequency Benthos SIS 1624 sidescan sonar. This system was chosen since it is capable of collecting data as part of both broad and fine scale surveys (Figure 18). A second system (1500 Chirp sidescan sonar) was also used due to operational problems with the 1624 sonar fish. Acoustic waves are emitted by the sidescan sonar and reflected back from the seabed. The returned acoustic signal is then used to compose a map of the seabed (Figure 18). The resultant image is a composition of the variable strengths of the returned acoustic signal, which is caused by the characteristics of the seabed being surveyed. In simple terms hard substrate (bedrock) will result in strong acoustic return and soft substrates (muds) will result in a weaker return.

Figure 18. Benthos SIS 1624 towed sidescan sonar fish and seabed map. Photograph courtesy of Neil Golding, JNCC

3.1.3 Camera sledge, camera and video equipment

In reef areas and at other sensitive habitats, optical techniques e.g. video and photographic cameras mounted on drop-down and towed platforms (Figure 19a-b) are preferable ground-truthing tools and significantly less destructive than grab or trawl sampling methodologies. The camera sledge was fitted with a forwardly inclined combined digital video and stills camera with a downward facing flash system.The Dynamic Positioning (DP) capability of the *RV Cefas Endeavour* permits the precise positioning of camera systems over areas of interest and also ensures that camera systems are deployed at a surveying speed that facilitates high quality data acquisition and interpretation.

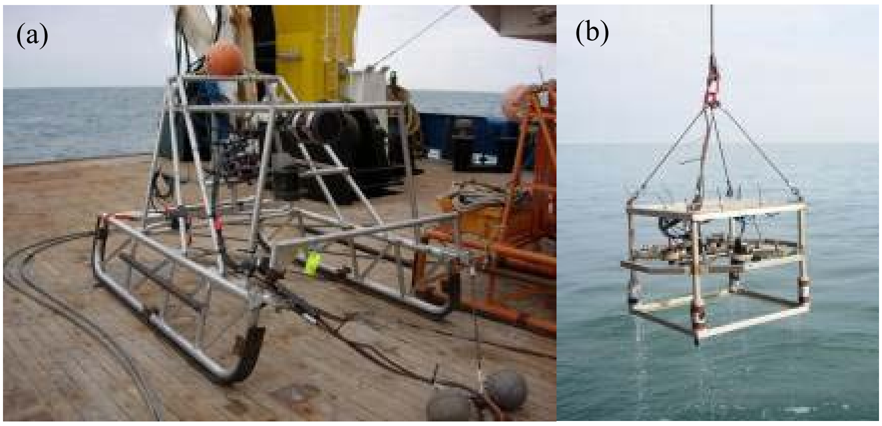

Figure 19. Camera deployment equipment (sledge (a) and drop frame (b)). Video and stills model Kongsberg 14208, Flash model Kongsberg 11242. Photographs courtesy of Neil Golding, JNCC

3.1.4 Benthic ground-truthing equipment (Hamon grab and Rock dredge)

The primary objective of the biological and ground-truth sampling campaign was to determine the physical properties of seabed in the acoustically distinct areas, and to characterise their associated biotic communities so that the seabed habitats and conservation features could be described and mapped.

A 0.1m^2 Hamon grab was used in areas where it was decided that limited damage to reef habitat would occur from the device camera and where sediments capable of supporting benthic infaunal communities had been identified from video analysis. A full account of the methodology and operation of this grab (Figure 20a)and the collection and processing of the physical and biological samples gained from it is given in DTLR Guidelines Report 2002 (Boyd, 2002). This grab also has the added advantage of being able to support a camera system (HamCam), which allows a video image to be taken of the surface of the seabed adjacent to the benthic sample. To obtain samples of epi-faunal communities observed during acquisition of video data a Rock dredge was towed for a set distance to provide semi-quantitative samples of the seabed and associated fauna (Figure 20b).

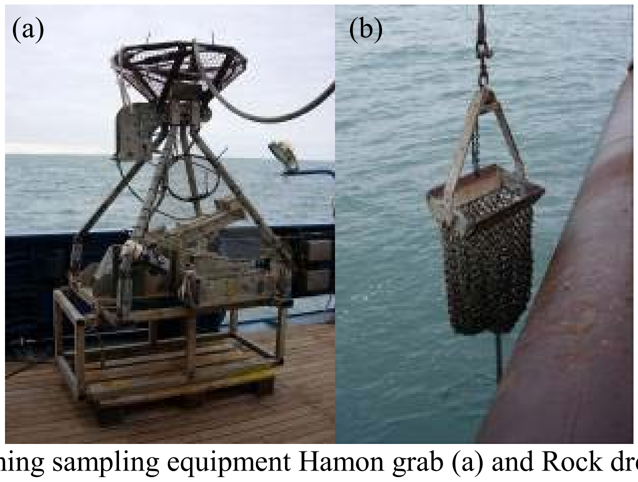

Figure 20. Ground-truthing sampling equipment Hamon grab (a) and Rock dredge (b). Photographs courtesy of Neil Golding, JNCC

3.2 Submarine structures in the mid-Irish Sea AoS

3.2.1 Acoustic survey design and methodology

A CTD cast to calculate the speed of sound through the water column was carried out at the beginning of the acoustic survey and then when deemed necessary.

Initially, six out of the eight planned broad-scale sidescan, multibeam and Acoustic Ground Discrimination System (AGDS) survey lines (Figure 21) were surveyed. The three central lines were initially surveyed to establish an acoustic signature over the area where MDAC had previously been identified during SEA6 (Judd, 2005). The remainder of the planned lines to the west of the AoS were then surveyed, taking the survey area up to the UK/Irish Median line.

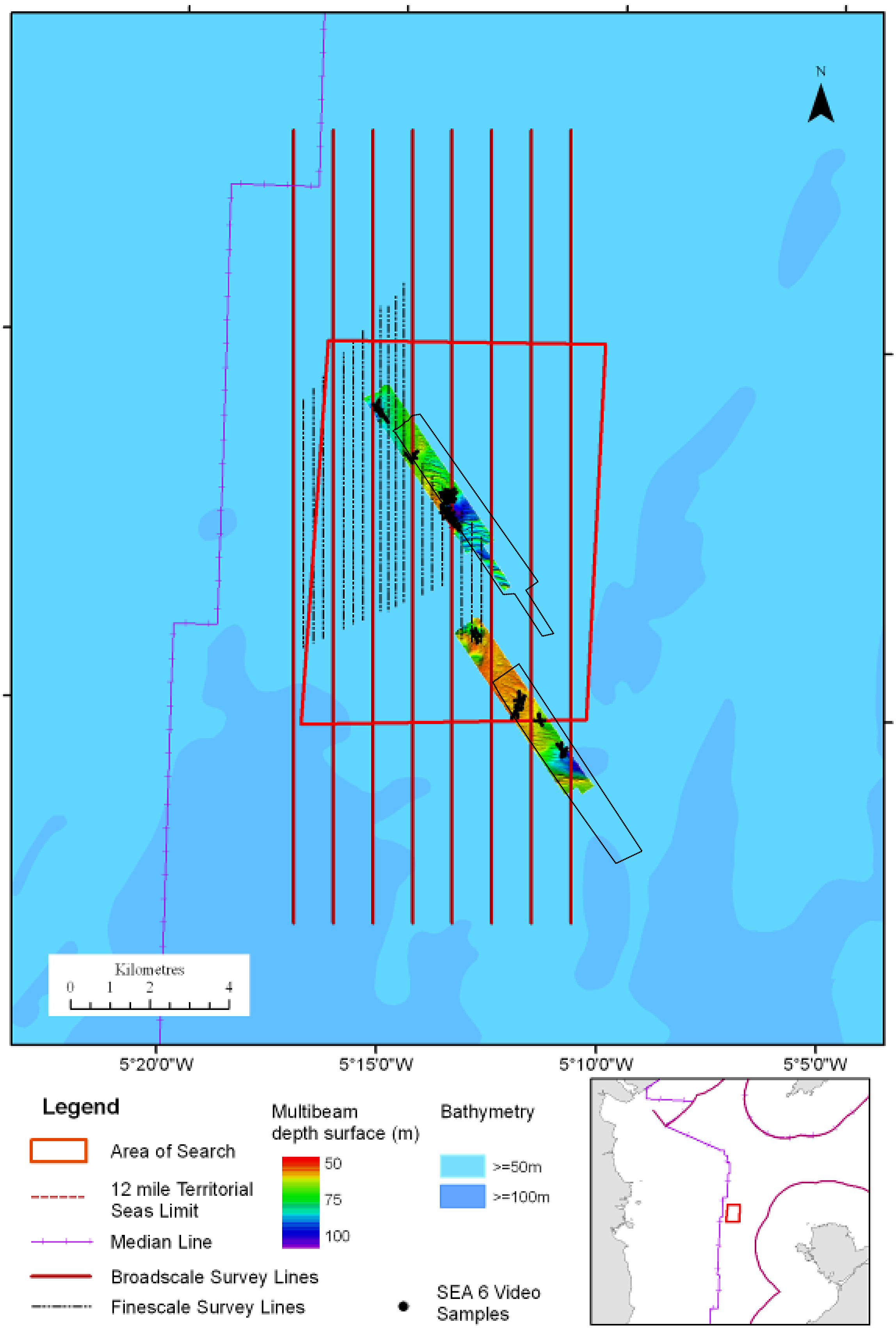

Figure 21. Acoustic survey lines over submarine structures in the mid-Irish Sea AoS.

Acoustic data was processed as it was acquired so geo-referenced acoustic images could be loaded onto a project GIS along with existing data from SEA6 (Texel 10 and Texel 11) (Judd, 2005) and

BGS sediment maps. The GIS data was then used to select sites that would be used to ground-truth the acoustic data (Figure 22). The SEA6 video and acoustic data were used to target areas where there was a degree of confidence that MDAC was present. The acoustic signature from confirmed SEA6 MDAC sites was then used to assist the initial interpretation of acoustic data collected during this survey and hence used to predict the distribution of further MDAC reef/crust structures from the acoustic data. The multibeam data was used to identify positive topographic features that did not appear to be related to seabed sediment transport processes. The sidescan and multibeam backscatter, co-registered with the multibeam data, was used to provide further evidence of reef-like features possibly attributable to MDAC structures (Figure 23).

3.2.2 QTC Multiview and CLAMS processing of mid-Irish Sea EM3000D data

77 data files (154 multiview files- dual head) were processed within QTC Multiview, with no cleaning or masking applied. Rectangle size was set at 257 x 17 pings, which when examined within GIS corresponded to between 15-17m across and 12-14m vertical (variable as source data in decimal degrees so varies across survey area). 154 errors were recorded, possibly due to data artefacts in outer swaths. Full Feature Vectors (FFV's) were merged from the original 154 files created within Multiview, resulting in data for 246380 rectangles.

The Automatic Cluster Engine (ACE) routine was applied to search for the optimal number of classes from a possibility of 3-20 classes, with 5 iterations per class and 15000 records per iteration. This resulted in a clear optimum of 12 classes. A .dat file was created for 12 classes. This was converted to a .csv and then into a shapefile within ArcGIS (projected in UTM Zone 30N).

The .dat file was re-projected into UTM Zone 30N and then read by QTC CLAMS. A number of different grid sizes and search parameters were trialled with the optimum determined as a grid node spacing of 20m by 20m, search radius of 50m and number of datapoints per radius set to 4. The resulting image was exported as a .grd file, and then converted into an ESRI compatible .img file (projected in UTM Zone 30N). There is a minor issue of slight offset at the northernmost extreme of the site due to the conversion between the WGS84 geographic coordinates the data were collected in and the UTM projected data exported from CLAMS.

GIS layer files containing the symbology used for each of the grid and shapefiles have been supplied, however there is not as yet any standard colours used so these can be manipulated to aid visualisation as required.

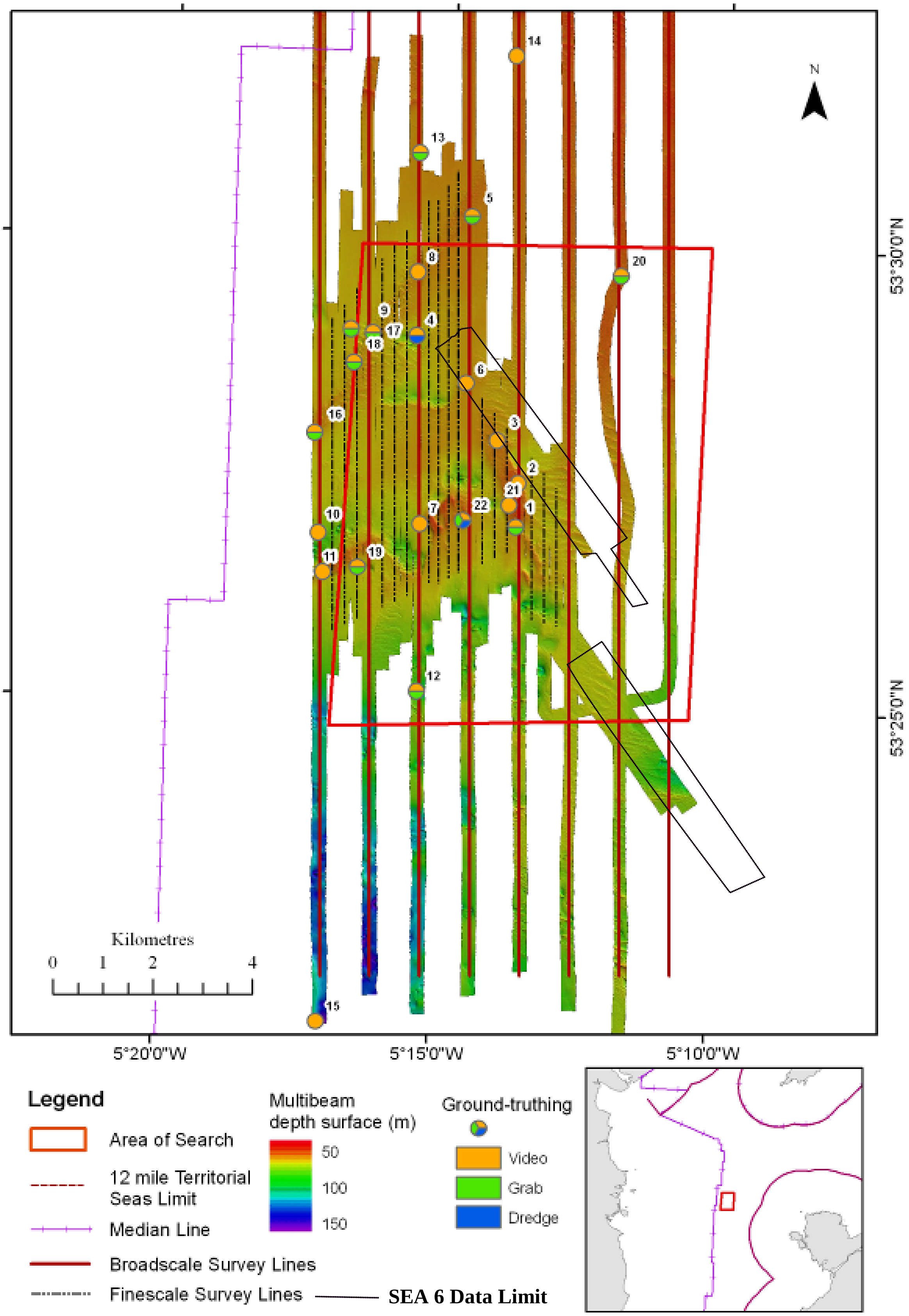

Figure 22. Acoustic survey, camera deployment stations and benthic ground-truthing stations with the pre-existing SEA multibeam data outlined with fine purple dotted line.

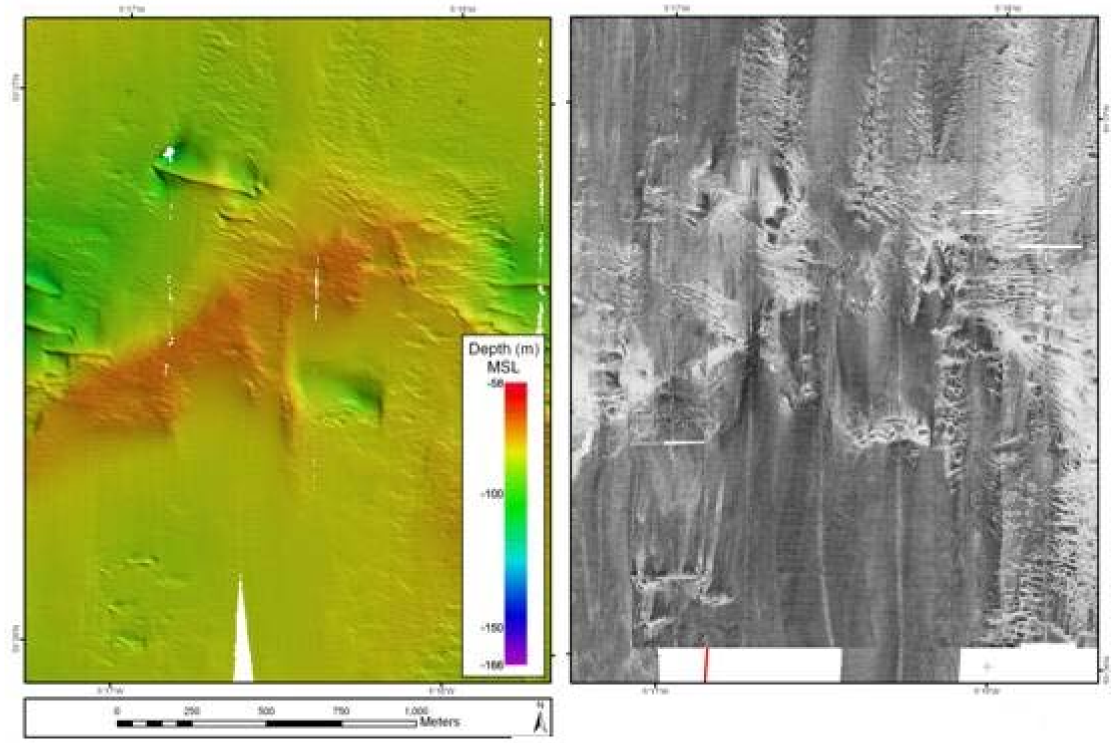

Figure 23. Multibeam and sidescan sonar data over target area.

3.2.3 Video footage and still image acquisition

The initial ground-truthing campaign involved the use of the towed video sledge (Figure 19a) fitted with digital stills and video camera systems, lights and a laser scaling system. Each tow was located over a particular feature of interest and was approximately 200m in length. Towlines were entered into the vessels survey software package and dynamic positioning (DP) used to run each line at a speed of 0.5 kts. Still images were taken at 1 minute intervals and also when features or biota of interest were observed. At Stn CS01 the camera sledge became trapped in a field of MDAC boulders and sustained significant damage. Once the camera sledge had been recovered the camera ground-truthing survey recommenced, using a drop-down camera system. The drop system was fitted with a similar camera/light/laser configuration as the camera sledge (Figure 19b). The drop camera was lowered to within a metre or so of the seabed (the chosen survey height depending on visibility) and towed along a pre-determined survey line using the vessels DP. Video data was recorded to hard drive and digital tape simultaneously. Still images were alsocollected systematically every minute and images taken of species or features of particular interest.

3.2.4 Video footage and still image processing

The protocol followed during this piece of work was adapted from: The Mapping European Seabed Habitats (MESH) Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques (MESH, 2007). To standardise the interpretation of video data, for this piece of work, a biotope was defined as seabed remaining consistent for one minute or longer during video playback (Figure 24).

Prior to biotope analysis, the available video footage was sub-sampled sampled due to the prohibitively large volume of data collected during this project. To ensure representative footage was selected, an approximate ratio of 50% MDAC/reef video tows to 25% boundary area and 25% sedimentary area video tows was used to guide tow selection. 17 video tows were selected for further analysis.

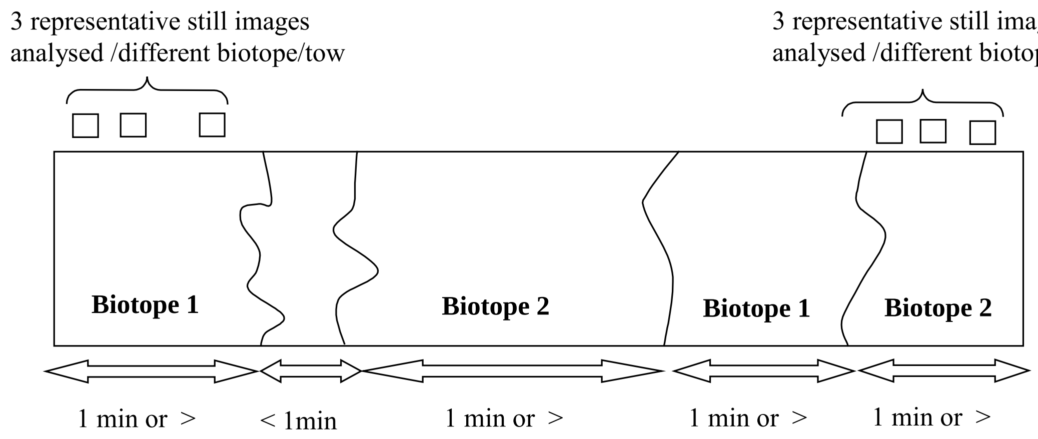

Figure 24. Schematic of video mosaic analyses.

3.2.5 Biotope Analysis

Semi-quantitative analysis of video footage was undertaken (from tows or drop video) through which boundaries between habitats were identified, and biotopes broadly described (both substratum type and species, using 04.05 version of UK Habitat Classification available from the JNCC website www.jncc.gov.uk/marinehabitatclassification). Analysis of the video footage involved following the protocol:

1. The entire video was roughly reviewed, noting the timestamp on the video of approximate biotopes (or biotope complexes) by reference to major changes in seabed and habitat type. This gave an indication of boundaries between sections needed to be analysed in greater detail. If the still images collected during the survey were not time stamped, then during this review the exact time of every strobe flash was noted, to allow the location of the still images to be calculated (required for the stills analysis).

2. Each biotope or biotope complex (Levels 5 and 4 respectively of the Marine Habitat Classification for Britain and Ireland version 04.05) section (video clip) of the video record was reviewed, including the beginning and end points of each section. A representative sample of video for each biotope was taken for inclusion in a video reference collection. The video footage for each biotope section was then analysed as follows:
   a. Taxa were quantified to the lowest taxonomic level possible, using the SACFOR scale (http://www.jncc.gov.uk/page-2684). In addition the life-forms present (e.g. hydroid/algal turf, encrusting sponge mats etc) were briefly described.
   b. The substratum for that biotope was described using MNCR substratum types, which are based on the Wentworth scale. Any additional modifiers such as trawl marks were also noted.
   c. The topography of the area was described using terms from MNCR recording forms e.g. rough, smooth, terraced, fissured, mega-rippled, highly sloping etc.

3. All biotope observation data as above was recorded on the modified intermediate sublittoral habitat recording forms (revised for use in video analysis).

4. Where data from the video did not fit the biotope classification, it was considered whether such areas were transitional between two biotopes and a decision made as to where to locate the change point. However, it should be borne in mind that some parts of the biotopes classification lack data (especially offshore areas). Therefore, if the data did not fit existing biotopes, it may have been deemed necessary to propose a new one. To propose a new biotope, start and end positions were recorded, and a full biological record on a standard 'new

biotope' recording form completed. Where video footage was of low resolution, still images were analysed alongside the video to assist with species identification and semi-quantitative abundance assessment.

3.2.6 Stills Analysis

Quantitative data for further analysis and refinement of the habitat classification was provided through additional analysis of the still images for both sediment and species data.

1. Three representative still images from each different biotope identified (video clip) from each video tow were selected. In each still species present were described using modified MNCR forms. Instead of using SACFOR abundance scale, actual abundance was recorded on the forms, with a preference for percentage cover where suitable over density due to uncertainties in the calculation of actual field of view. Actual numbers of individuals were only counted where such species were not encrusting/massive, and density then calculated using lasers for sizing of photographic quadrate. Any additional modifiers such as trawl marks etc were noted.

2. In addition to the species identification and enumeration the life-forms present (e.g. hydroid/algal turf, encrusting sponge mats etc) were briefly described.

3. Further description of the substrate was undertaken along with percentage cover estimates of each substrate class.

4. The location in decimal degrees (WGS 1984 datum) of each still image was determined in conjunction with the record of the still shown in the video footage.

5. Species identifications where uncertain were confirmed through consultation with a relevant taxonomic expert.

3.2.7 Benthic grab sampling

The proposed grab sampling strategy was designed to collect samples of:

1. MDAC

2. Quantitative samples of sediments/biota closely associated with MDAC.

3. Quantitative samples of sediments/biota present over the wider area not apparently directly associated with MDAC.

To facilitate this analysis of data a paired survey design was adopted e.g. An MDAC sample and also a sample of the sediments closely associated with the MDAC were collected consecutively. At each site, the Hamon grab was lowered close to the seabed as the vessel was driven along a pre-determined line using DP. The video camera was used to locate one of the sediment types targeted (e.g. MDAC, non-MDAC), at which point the grab was deployed and a sample collected. The grab was then deployed again at the same site and the second sediment type was sampled. The video mounted on the grab was used to guide the deployment. Samples were recovered on deck and examples of potential MDAC were treated with phosphoric acid. Samples of MDAC fizzed vigorously, whilst other rocks collected did not. Samples of MDAC were also kept for subsequent laboratory analysis to help understand their formation process. Samples for biological analysis were washed over a 1mm sieve and preserved in 4% formaldehyde for later taxonomic identification. Sediment samples for subsequent particle size analysis (PSA) were also retained.

3.2.8 Particle size analysis

In the laboratory, the sediment samples were split at 1 mm (0.5 ϕ) using wet sieving. Sediment greater than 1 mm was analysed using dry sieving at 0.5 ϕ-intervals between 1 mm and 63 mm (0.5 ϕ to –6 ϕ). A sub-sample of the sediment less than 1 mm was analysed using the Malvern Mastersizer 2000 laser sizer. The dry sieve and laser results were combined to give the full particle size distribution at 0.5 ϕ-intervals between 0.1 µm and 63 mm (11.5 ϕ to –6 ϕ). Sediment statistics derived from this full particle size distribution include mean, sorting, skewness, kurtosis, gravel (%), sand (%) and mud (%). A sediment code under the EUNIS classification scheme was also allocated to each sediment sample.

3.3 Solan Bank AoS

3.3.1 Acoustic survey design and methodology

A CTD cast to calculate the speed of sound through the water column was carried out at the beginning of the acoustic survey and then when deemed necessary throughout the survey.
Two 'prospecting' sidescan sonar lines were run over the AoS to provide backscatter data over the existing MCA multibeam bathymetry survey (Figure 25). These two sidescan survey lines provided some certainty on the distribution of rocky and stony reef that had been inferred from the seabed morphology shown by the multibeam bathymetric data. The sidescan sonar data was processed and mosaiced as the survey progressed and the geo-referenced images loaded into a project GIS. The data underwent an initial interpretation, and 15 ground-truthing (Drop-camera) sites were selected to aid the characterisation of the various habitats encountered (Figure 26). A second set of acoustic lines were then selected to provided broad-scale coverage across the entire AoS. This broad-scale survey also encompassed a large area of seabed outside of the current AoS. This area was included, as it appeared to hold linear topographic features similar to moraine-like features already identified within the AoS. During the sidescan survey the data gathered was continually processed and mosaiced within a project GIS. This acoustic data, along with the MCA multibeam data, was used to produce the second tranche of ground-truthing stations.

3.3.2 QTC Multiview and CLAMS processing of Solan Bank EM3000D data

100 data files processed within QTC Multiview, with no cleaning or masking applied. Rectangle size was set at 257 x 17 pings, which when examined within GIS corresponds to between 15 – 22 m across and 12 – 15 m vertical (variable as source data in decimal degrees so varies across survey area). 200 errors were recorded, possibly due to data artefacts in outer swaths. FFVs were merged from the original 200 files created within Multiview, resulting in data for 381825 rectangles.

The Automatic Cluster Engine (ACE) routine was applied to search for the optimal number of classes from a possibility of 3 - 20 classes, with five iterations per class and 15000 records per iteration. This resulted in a clear optimum of 12 classes. A .dat file was created for 12 classes. This was converted to a .csv and then into a shapefile within ArcGIS (projected in UTM Zone 30N).

The .dat file was re-projected into UTM Zone 30N and then read by QTC CLAMS. A number of different grid sizes and search parameters were trialled with the optimum determined as a grid node spacing of 25 m x 25 m, search radius of 70 m and number of datapoints per radius set to five. The resulting image was exported as a .grd file, and then converted into an ESRI compatible .img file (projected in UTM Zone 30N). There is a minor issue of slight offset at the northernmost extreme of the site due to the conversion between WGS84 geographic projection and UTM projection when exporting from CLAMS.

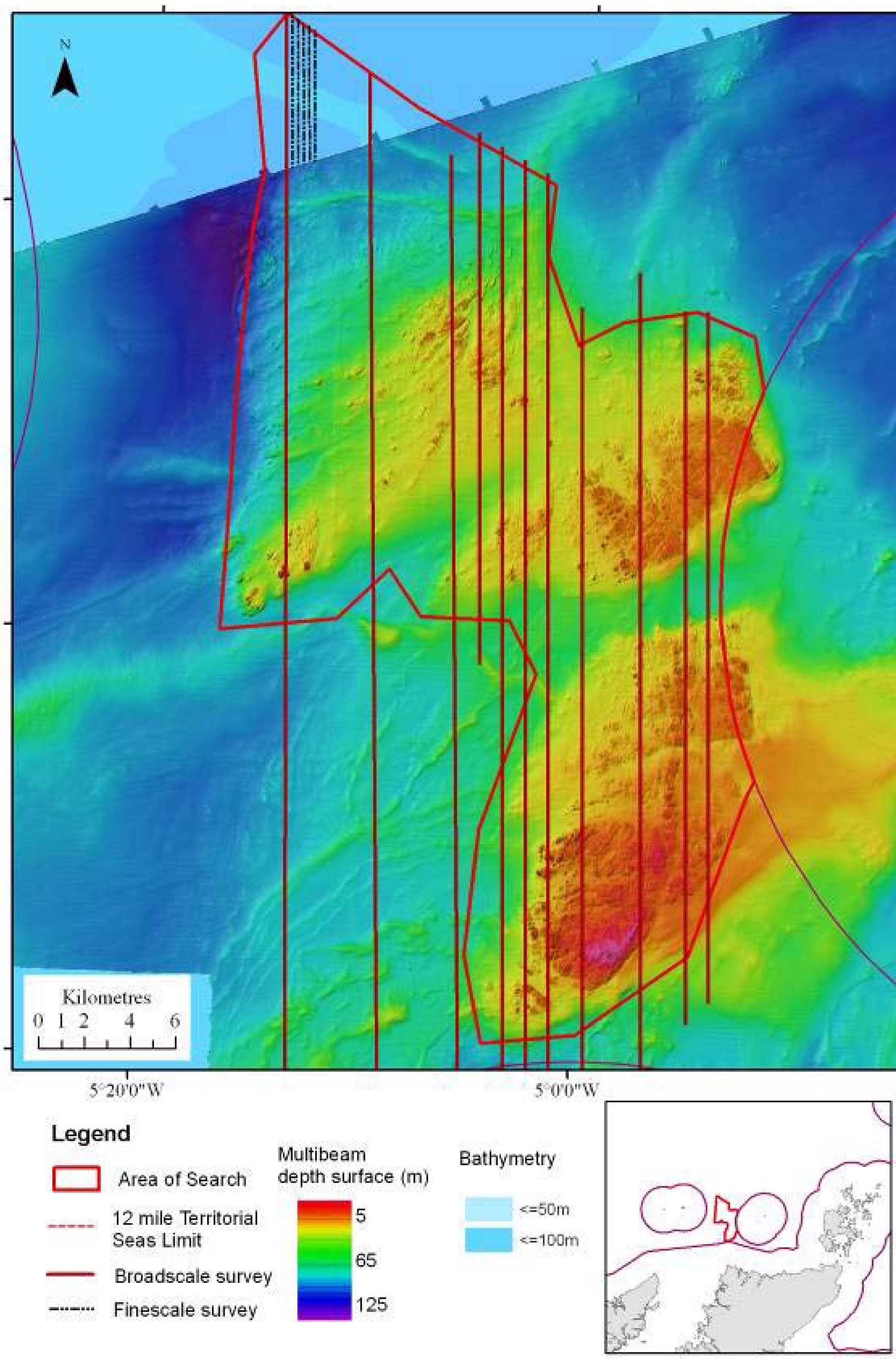

Figure 25. Acoustic survey lines over Solan Bank AoS.

3.3.3 Video footage and still image acquisition

Video towlines were approximately 200 m in length and were positioned in order to characterise discrete habitats and to locate and position boundaries between habitats that had been inferred from the sidescan record (Figure 26). Towlines were entered into the vessels survey software package and DP used to run each line at a speed of 0.5 kts. During the camera tows, the ships position was overlain over the sidescan sonar mosaic in GIS, in order to cross reference the video footage with the sidescan data in real time. Video data was recorded to hard drive and digital tape simultaneously. Still images were collected systematically every minute and images taken of species or features of particular interest.

In total, 44 video tows were completed at Solan Bank. Each tow averaged at least 30 minutes, with an average of 50 high-quality stills taken per tow.

3.3.4 Biotope Analysis

For a description of the methodology employed see section 2.2.5.

3.3.5 Stills Analysis

For a description of the methodology employed see section 2.2.6.

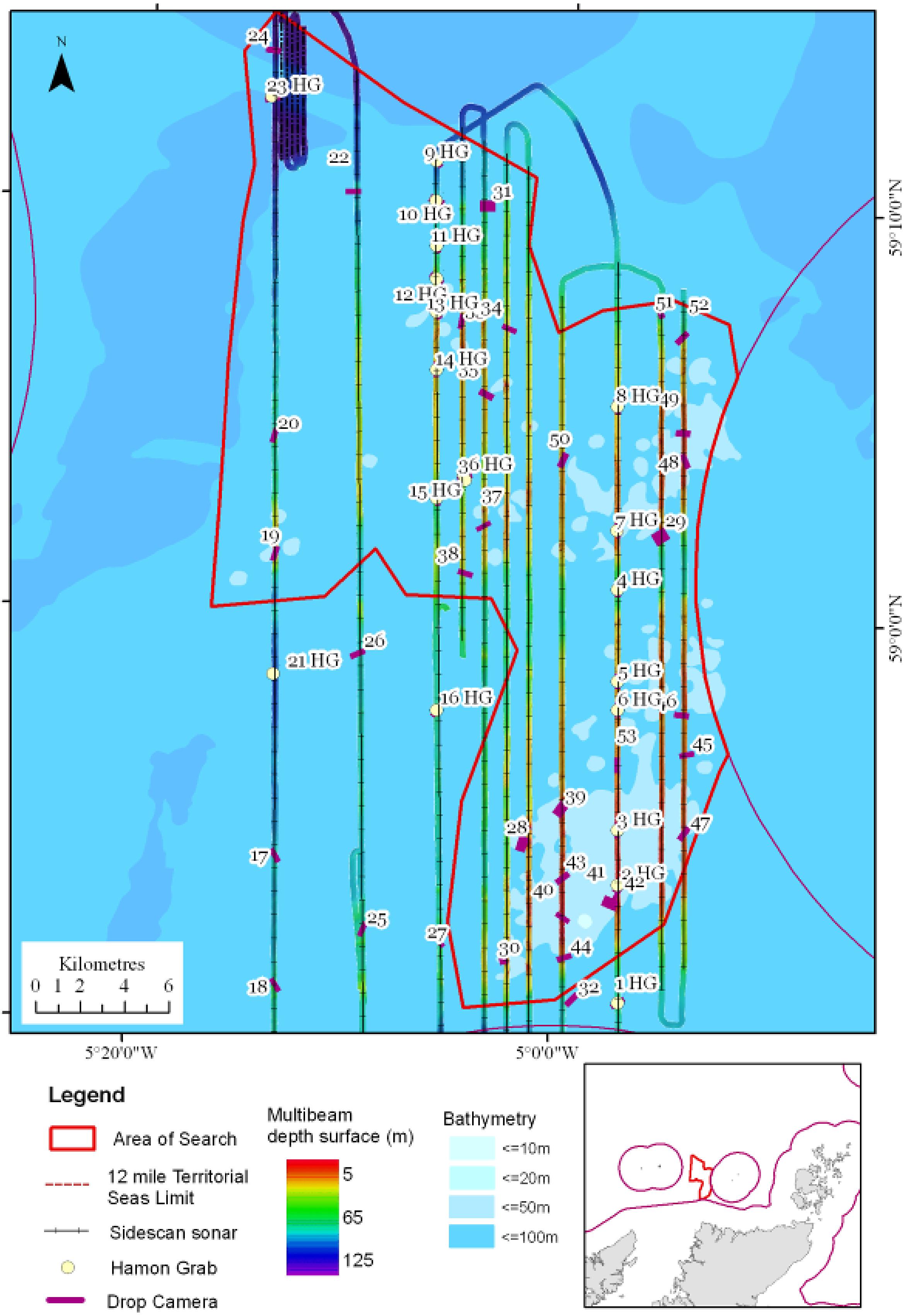

Figure 26. Acoustic survey, camera deployment stations and benthic ground-truthing stations (HG suffix denotes Hamon Grab collected at that station).

3.3.6 Benthic grab sampling

The Hamon grab fitted with a video camera (HamCam) was used to sample sandy areas identified during the deployment of the drop camera. Limited sampling of cobble areas using the rock dredge was also carried out (Figure 13). Hamon grab samples for biological analysis were washed over a 1mm sieve and preserved in 4% formaldehyde for later taxonomic identification. Sediment samples for subsequent PSA were also retained. Rock dredged samples were processed onboard and reference specimens retained of unidentified species.

3.3.7 Particle size analysis

For a description of the methodology employed see section 2.2.8.

3.4 Quality Assurance (QA) procedures

3.4.1 Acoustic data collection and processing

Data were stored digitally. All real-time data was monitored by surveyors and notes made in the sidescan sonar (SSS) log regarding data quality and features of interest for subsequent review. QC of data was carried out during and post acquisition. Processing of SSS data was also carried out almost immediately in order that the data be used to inform fine-scale survey design and ground-truthing. Sidescan sonar data were reviewed at regular intervals with respect to quality, resolution and spatial coverage to ensure that the acquisition programme would provide adequate data to meet the objectives of the survey.

The Kongsberg EM3000D swathe bathymetry system was used to collect multibeam echo sounder data. A patch test was carried out during the mobilisation transit to verify calibration values previously determined for the system. QC of data was carried out during and following acquisition. Surveyors monitored all real-time data closely and notes were made regarding features of interest for subsequent review. Processing was started almost immediately after a line was complete as the bathymetric data were required to inform the fine-scale acquisition and ground-truthing programmes

3.4.2 Video and stills analysis

A taxonomic expert from the Ulster Museum, Dr. Bernard Picton, was consulted early in the project and a training day arranged to improve identification of rarer and more cryptic species. The quality of the stills images, particularly for the Solan Bank site, was excellent permitting identification of many epi-faunal organisms to high taxonomic levels (i.e. to at least genus, but mostly to species). Species identification was undertaken rigorously, to ensure a high confidence in the resulting species lists to permit classification into biotopes.

During the video and stills analysis whenever there was any uncertainty regarding a species identification, example footage was examined by taxonomic experts in other institutions (e.g. Ulster Museum, Scottish Association for Marine Science, Zoological Museum of the University of Amsterdam and Plymouth University), to ensure an accurate identification was made.

Ten percent of the video and stills footage analysed was examined by at least two individuals within the University of Ulster to undertake quality control, through checking consistency of species identifications, quantification and substratum descriptions.

Biotope classification was agreed jointly between three experienced workers within the project consortium. Final confirmation of biotope classes was achieved through consultation with David Connor at the JNCC.

3.4.3 Infauna sample identification

All infaunal sample analysis was undertaken by Unicomarine to National Marine Biological Analystical Quality Control Scheme standards(NMBAQC). Identification and counts of species were checked for each taxon identified. This involved checking for discrepancies in species counts and spelling of species names.

Biomass methodology employed by Unicomarine is Quality Assured. All balances are calibrated annually using test weights that have UKAS and National Standard Calibration certification in accordance with the UK weighing federation code of practice.

3.4.4 Epi-faunal sample identification

Samples were processed during the research cruise. Where species identifications were unconfirmed reference specimens were retained. Identification of these species was then carried out back at the laboratory by two senior biologists. Where uncertainties still arose, an expert was consulted.

3.4.5 Particle size analysis

Sieve samples were weighed before sieving, during sieving and after sieving - Totals were checked and any results with any anomalies were re-sieved. Two repeats were run for each sample on the laser-sizer and compared against set limits. A third repeat was completed for any samples outside expected limits. Outliers were removed and an average taken from the repeat runs completed.

A glass certified reference material is analysed once a month (laser-sizer), as well as an in-house reference material, which is analysed at the start and end of every day that analyses are completed.

Cefas participates in PSA ring tests as part of the NMBAQC scheme, as well as PACQs, a laser proficiency testing scheme organised by the Laboratory of the Government Chemist (LGC).

4 Results

4.1 Submarine structures in the mid-Irish Sea AoS

4.1.1 Geology

Multibeam coverage extended a considerable distance outside the area originally designated (Figure 16). The area covered was approximately 23 km from north to south and 7.5 km east to west. In the western part of the original AoS there was complete coverage of the seabed over an area roughly 10 by 4 km in size, which covered the area of Texel 11 and overlapped with Texel 10 (Judd, 2005). Coverage in the east of the original study area, and to the north and south, was not complete.

4.1.2 Background seabed topography

The area contained a range of seabed morphologies. The new data confirmed the presence of MDAC and extended its distribution in the mid-Irish Sea. In the east and south of the study area the sea floor comprised of a generally planar seabed with wave forms on a number of scales.

Wave crests were complex and commonly had an anastomosing or dendritic pattern (Figure 27). Crests commonly had a NW-SE orientation in the north, becoming closer to W-E in the south, but individual crests undulated. Wavelength between crests was 100 – 200 m. Patches of smaller ripples with wavelengths between 10 and 50 m occurred between the larger wave forms.

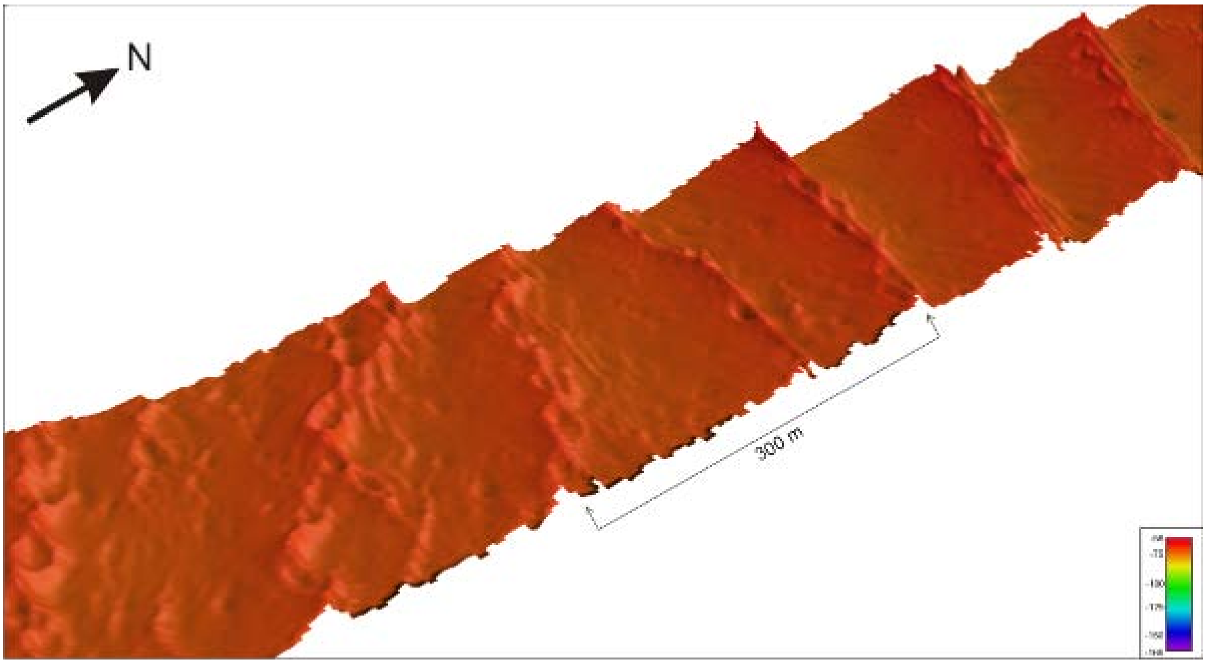

Figure 27. Sediment waves in the south of the area showing anastomosing crestlines (vertical exaggeration of 6).

In the south east of the area terminations of some of the waveforms appeared to be related to depressions in the seabed (Figure 28). The wave terminations were relatively abrupt, and the depressions might have been related to erosion of existing seabed sediment during formation of the waveform or later erosion in the present hydrological regime. The hollows were variable in size and shape. In the southwest, the waveforms were shorter and appeared to be constrained within depressions in the seabed. This suggests that the depressions predate the formation of the sediment waves. A similar relationship was observed within the area containing MDAC.

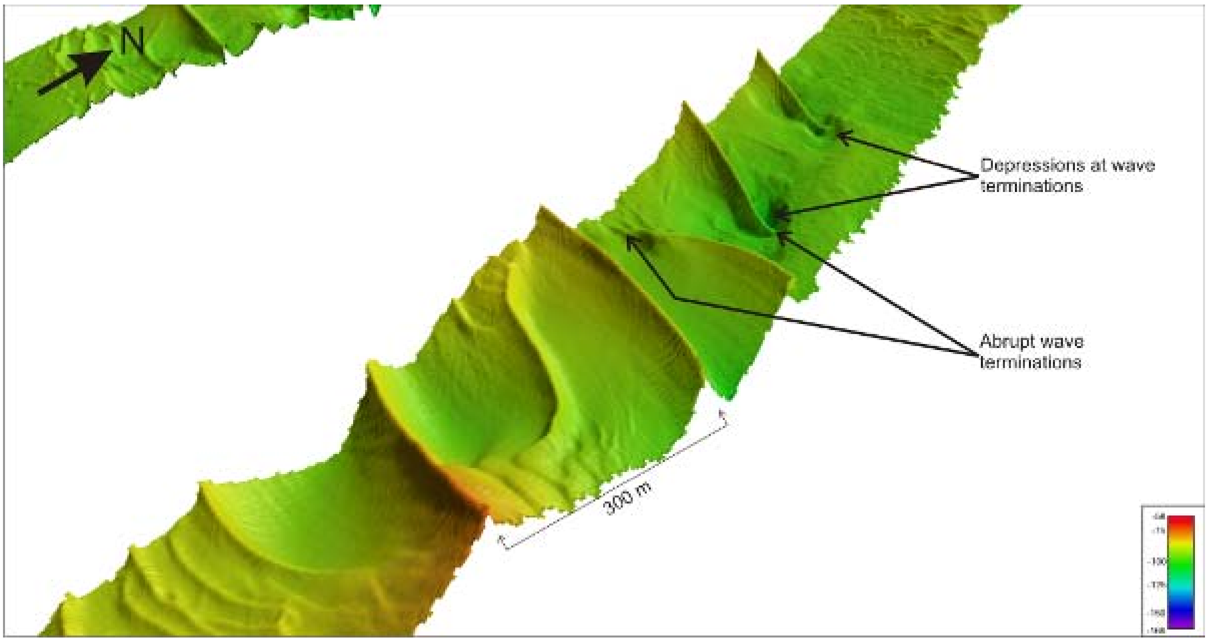

Figure 28. Sediment crest lines with sudden terminations in depressions (vertical exaggeration of 6).

Video camera data suggested that transport of sediment up to small pebble size was taking place. This thin active layer forms features with wavelengths of < 1 m, some of which were observed migrating across the seabed. In some video tows sediment was observed being transported through the lowest 1 m of the water column, obscuring the seabed and indicating a high-energy environment. Particle size analysis indicated that there is medium to coarse grained sand in all seabed samples, with sand grain sizes between 0.2 and 1.0 mm. Mean Spring tidal currents are in excess of 1 m/s (Pantin, 1990) suggesting that coarse sand and gravel will be transported frequently in the area.

In addition to the sand, many samples were bimodal and show a second peak between 2 and 10 mm. This coarse grained sediment may not be active in the present day current regime, although they may relate to storm activity. Therefore, the larger waveforms with wavelengths >10 m, may not relate to the present hydrological regime.

Where the active layer of sediment was discontinuous an apparently harder substrate was exposed, with some faunal encrustation. This might be MDAC over much of the study area, though several sample sites in the south western corner of the AoS also identified clay was present on the seabed.

4.1.3 MDAC

Distribution

In Judd (2005) MDAC was identified in association with a cliff on the seabed (part of the Texel 11 image). Within Texel 11 several additional areas of the seabed were identified as probably containing MDAC. The presence of MDAC in these areas was confirmed by ground-truthing, in addition, the distribution of MDAC was found to be more extensive than originally thought. MDAC was identified in 15 of the 22 ground truthing stations, covering a large part of the area of survey including some areas where there was no geomorphological evidence. The multibeam image of the seabed showed two features with a SSW-NNE orientation (Figure 22).

Northern feature

The northerly feature was 500 m across and in excess of 6 km in length (Figures 22 and 29). The feature was consistent in character over the 6 km of image, but in detail it comprises between 1 and 4 sub-parallel ridges whose crests were embayed and show very irregular outlines (Figure 30).

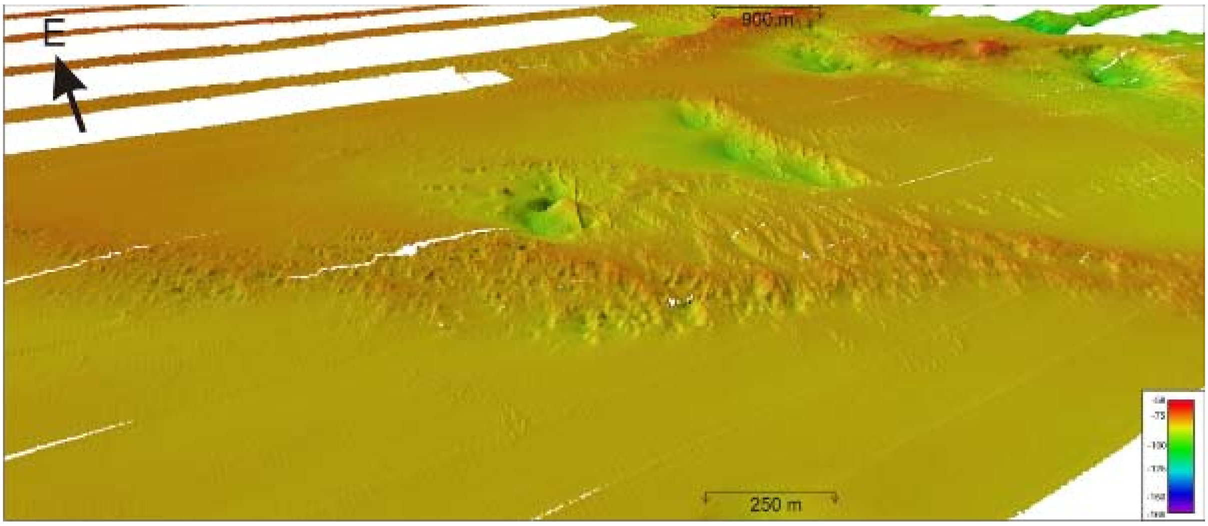

Figure 29. Perspective view of the major ridges that cross the AoS (vertical exaggeration of 6). Northern ridge in the foreground, Southern ridge with two large hollows in the background.

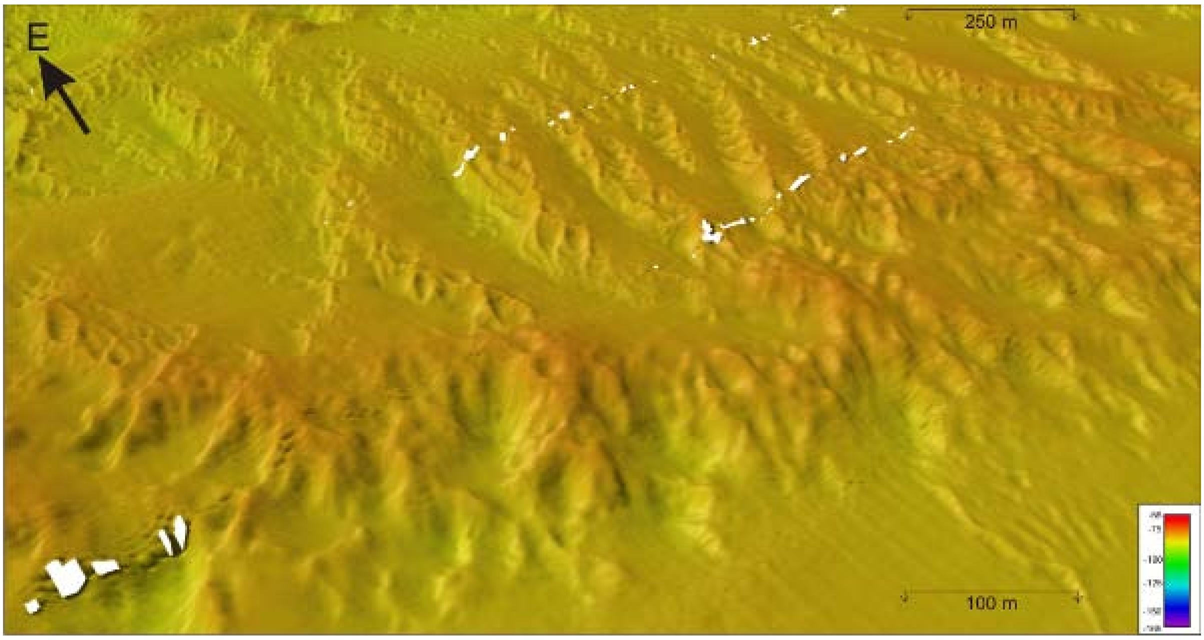

Figure 30. The crest of ridge showing steep northern faces with possible slippage (vertical exaggeration of 6).

The ridges were most pronounced around the areas of sample sites 17 and 18. In this area, three or possibly four ridges were identified. The crest of each individual ridge, in addition to being strongly embayed, was in places slightly oblique to the larger feature, cutting across it in approximately a SW-NE orientation (Figure 29). The orientation of the smaller ridges also changed within parts of the larger feature (Figure 31). The geometry of the steep northern faces of some of these ridges suggests progressive failure and slippage of sediment blocks, with the failure surfaces migrating southwards (Figure 30). This may be related to undercutting of MDAC stabilised sediment. Outside the area of sample sites 17 and 18 the feature was less pronounced and individual ridges could not be distinguished. The feature comprised an area of irregular topography, surrounded by planar seabed.

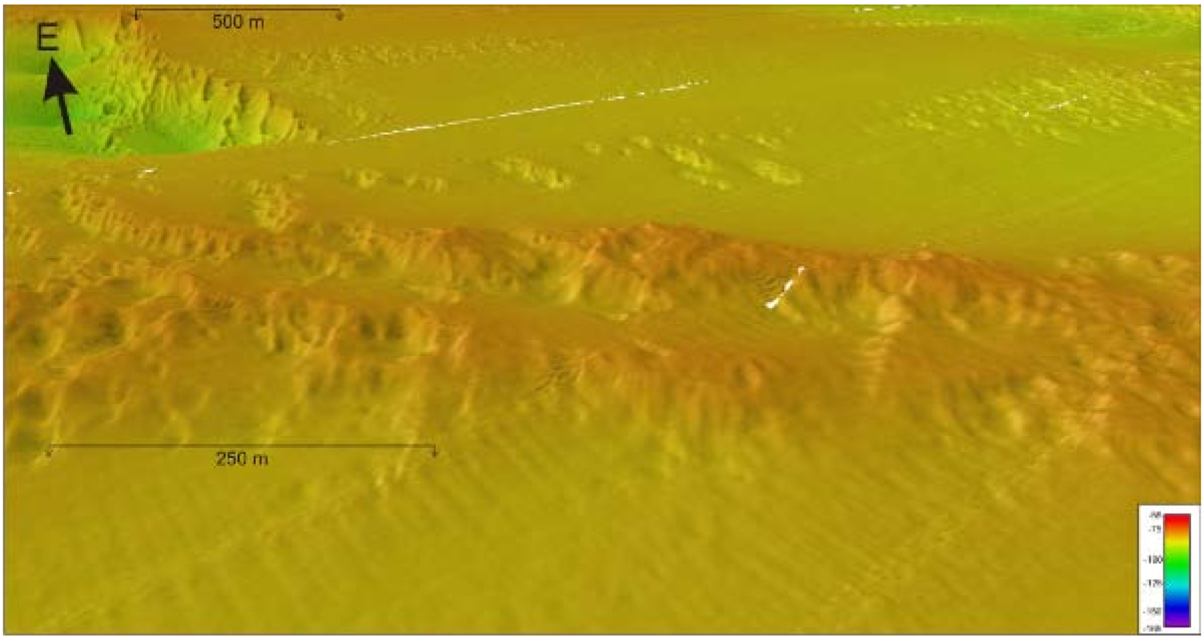

Figure 31. Change in orientation of crest lines along the northern ridge (vertical exaggeration of 6).

Around this feature, video evidence suggested that MDAC at the seabed took the form of blocks and slabs up to 2 m in size.

Southern feature

The southern feature, while having a roughly similar SW-NE trend as the northern feature, was more complex (Figures 22 and 29). While there was a shallowing of the seabed to the NE with its steeper face to the NW, it comprised a series of areas of raised seabed, between which were depressions containing sediment waves. The raised areas combined to form a large feature running from sample site 11 in the SW to sample site 21 in the NE, beyond which was a raised platform 2 km in length and 0.5 km across with a secondary SE-NW trend. The NW margin of this platform was of low relief, but the eastern, southern and south-western margins commonly showed significant relief, including the 6-8 m cliff described in Judd (2005).

To the south of this platform were smaller areas of raised seabed, also showing both SE-NW and N-S trends. The adjacent depressions were irregular but commonly contained an ovoid outline, with the long axis oriented roughly E-W. Many depressions contained a large single symmetrical sediment wave (Figure 32); the crest of which was also oriented E-W, and often reached an altitude as high, and sometimes higher, than the edge of the depression. Boulders of MDAC were common in the depressions. On the platforms of the southern feature, MDAC took the form of a field of boulder-sized fragments. These fragments may have been formed by in-situ weathering of the MDAC, forming a boulder field.

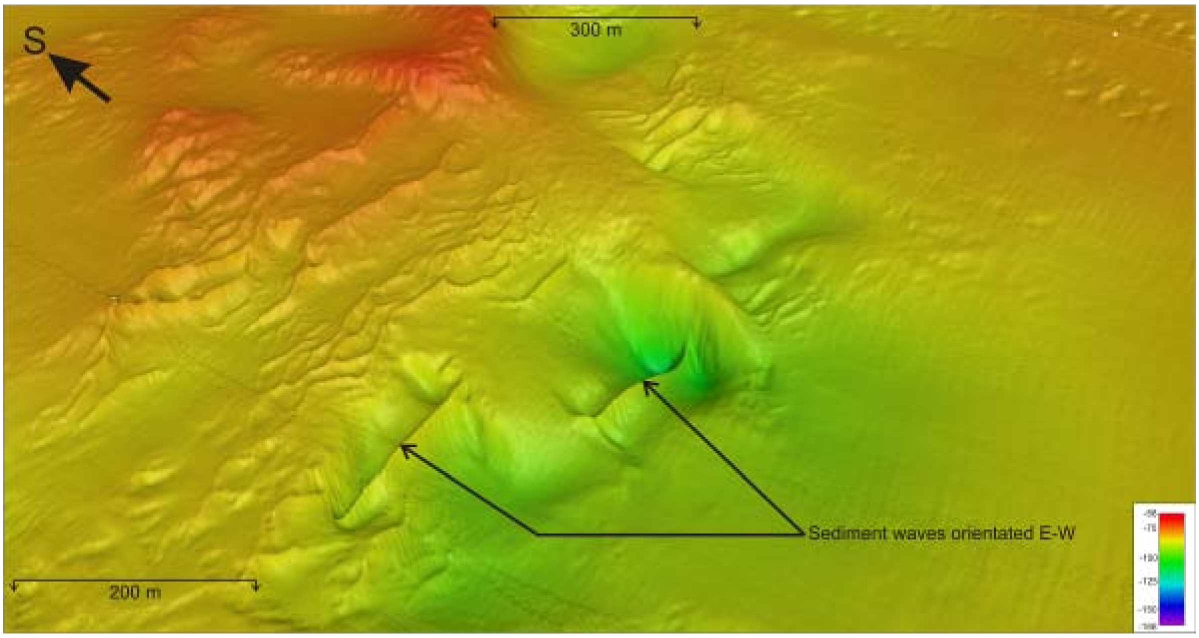

Figure 32. Large single symmetrical sediment waves in depressions (vertical exaggeration of 6).

Other areas where MDAC has been identified

A smaller area of MDAC was also identified around sample site 6. This area was highlighted in Judd (2005) and also observed on video footage as slabs of carbonate overlain by a thin veneer of sand and gravel (Figure 33). In this area, small 'towers' of probable MDAC were identified, with heights of up to 1 m above the seabed.

At sample site 20 there was little evidence of the presence of MDAC from the multibeam image. Video evidence suggested blocks of MDAC alternating with patches of sand and gravel at the seabed. A sample of MDAC was also recovered from this site, suggesting that the distribution of MDAC is more extensive than that suggested by the presence of topographic highs.

Evidence from video footage suggests a 'platform of bedrock' overlain by a patchy veneer of sand and gravel. It is possible that this bedrock is MDAC and that a significant proportion of the seabed in the west of the AoS is underlain by carbonate. The recognition of depressions at the seabed to the west of the AoS indicates that this zone may extend to the west and into Irish waters.

Figure 33. A thin slab of MDAC 'pavement' with sand and gravel covering at Station 6, providing refuge for *Munida rugosa*.

In several places, blue grey clay was also identified and several samples of sandy clay were recovered at sample sites 8, 12 and 15. This clay is probably part of the Quaternary West Irish Sea Formation.

4.1.4 Formation of the MDAC

MDAC forms when methane rising through the sediment column is oxidised as it approaches the seabed (Jorgensen, 1992; Judd, 2001). The precipitation of calcium carbonate appears to take the form of sheets between 5 and 20 mm in thickness. Individual sheets then coalesce to form a unit exceeding 1 m in places. There is some hydrogen suphide (H_2S) within sediment associated with uneroded (presumably fresh) MDAC. Petrographic and geochemical analysis (Appendix 4) indicated that three types of carbonate cement were present within the samples collected. These included a dolomite-dominated cement, a high-magnesium calcite dominated cement and an aragonite-dominated cement. Geochemical analysis of these cements showed that the carbonate precipitation due to methane oxidation was comparable to MDAC reported elsewhere. As the various cement types form under slightly different environmental conditions, they imply that methane oxidation has continued over a period of time although the exact period or duration has not been defined. The isotopic signature of the carbonate cements suggests that they formed in generally cooler conditions to the present day. These could be linked to the cooler conditions found after the last glaciation of the area around 25-15 thousand years before present (ka BP).

It is probable that MDAC forms parallel or sub-parallel to the bedding in the Prograded Facies of the Western Irish Sea Formation (Judd *et al,* 2007), which in the study area dips slightly towards the north and west.

4.1.5 Distribution of MDAC

MDAC was identified over much of the western part of the AoS, and probably extends further to the west across the median line (Figure 3) and may cover an area of up to 40km². Judd *et al* (2007) stated that the carbonate was methane derived and that the most likely source was the coal-bearing Carboniferous rocks, which are common in the region. The exact extent of Carboniferous rocks in the area of study is uncertain but they underlie at least a part of the area with proven MDAC and potential pathways exist for migration of methane to all areas.

The two features with roughly SW-NE orientations were composed of weathered MDAC. The reasons for their having such a prominent relief at the seabed (Figure 34) cannot be proven, but there are two possible reasons:

- The features could represent areas of flexure – large wavelength folds within the Quaternary sediments where the platform of MDAC has been raised sufficiently to allow greater weathering to take place.
- The features may be indicators of bedrock structure. Either areas where faults in the Carboniferous rocks allow greater quantities of methane to reach the surface, or where beds that form efficient gas conduits subcrop beneath the Quaternary.

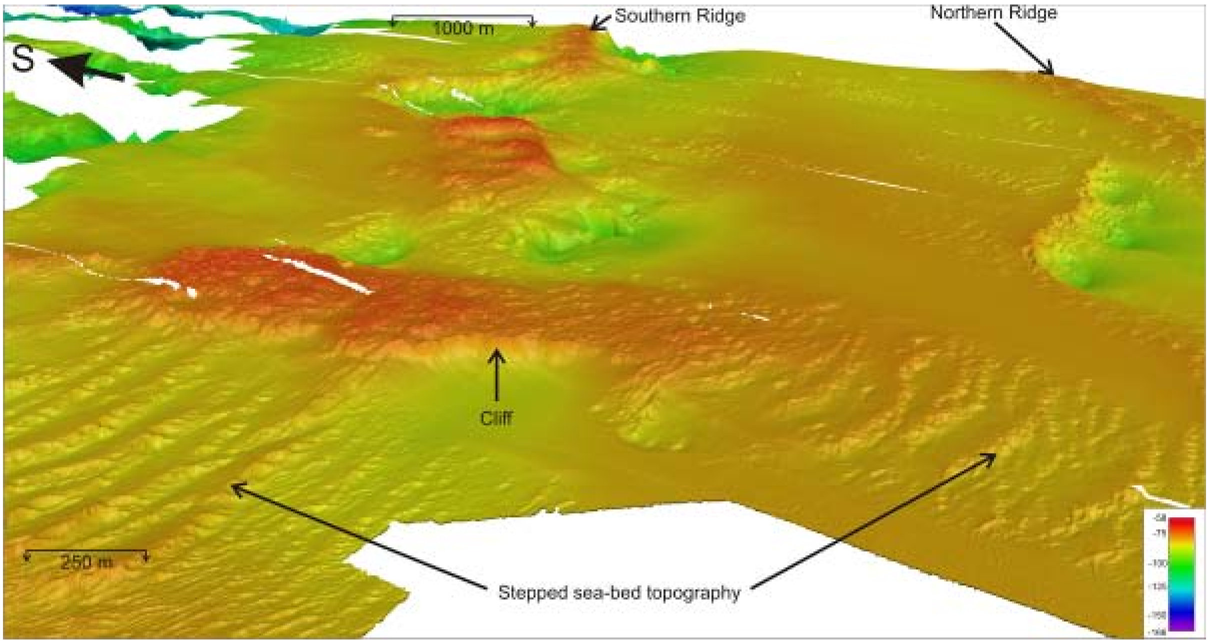

Figure 34. Ridges and stepped seabed caused by outcropping prograding facies sediments, presumably cemented by MDAC (vertical exaggeration of 6).

4.1.6 Weathering of the MDAC

Where the weathered MDAC had been sampled, it appeared to form blocks comprised from amalgamated sheets. Once exposed, the MDAC appears to have been broken down rapidly both through biological activity (Figure 35) and erosion by currents. In depressions with distinct relief it is probable that the cliffs are receding rapidly as the MDAC is undercut. The MDAC samples suggest that there is an evolution from intact sheets of carbonate, through boring on various scales, leading to breakdown of the carbonate to sand and gravel sized fragments.

Erosion of the MDAC takes several forms:

- Cliffs where MDAC has been undercut and the presumably uncemented Quaternary sediment is rapidly eroded, maintaining a scarp.

- Platforms where MDAC is broken down into a palimpsest of boulders. On the platforms that formed much of the two features, boulders of roughly 1 m in size were present. In other areas of seabed pebbles and cobbles of MDAC were common. Whether the size of the MDAC fragments is related to erosion or the dimensions of the original carbonate is unknown.

- Stepped seabed where MDAC cemented beds form individual ridges.

- Areas of seabed where isolated blocks or towers of MDAC roughly 1 m high remain. Whether these are boulders that have not been eroded represent the last remnant of a pre existing sheet of MDAC, is not certain.

- In other areas thin, broken sheets of MDAC were identified at the seabed (referred to as 'slate-like' in the cruise report).

All of these forms of MDAC may form areas comprising 'rocky reef'.

Figure 35. MDAC rock sample with evidence of biological boring.

Other substrates

Bedrock was not identified within the AoS and seismic lines from the 1970s suggest that bedrock in the area is overlain by 20-50 m of sediment, presumably the Quaternary Prograding Facies.

In several sites in the south (sites 12 and 15) and also in the SEA6 area of survey a blue-grey sediment was identified underlying the active layer. This material was not sampled but is likely to be the equivalent of the blue clay described in the SEA6 report. This clay could be a part of the prograding facies identified elsewhere, or another glacigenic deposit. At site 15 a steep (60^o) cliff which forms sub-horizontal steps, possibly indicating bedded Quaternary Prograding Facies outcropping at seabed, which contained blue grey sediment was observed (Figure 34).

Two fragments of soft, clay-cemented sand were recovered in a rock dredge (site 04). This could relate to the blue grey clay of the Quaternary Prograding Facies but the samples were rounded and therefore may have been transported for some distance. These samples were kept for BGS analysis as part of sample 04.

4.1.7 MBES and SS (Bathymetry and Backscatter)

In order to map the full extent of the MDAC, areas that may be overlain with shifting sediment bodies (but based on bathymetric and backscattter data, also have underlying MDAC) were included in the MDAC class 'low relief sediment and MDAC pavement'.(Figure 36). This includes some quite subtle low relief areas with an irregular topography and higher backscatter. The QTC Multiview data, even with the notable survey artefacts, does seem to correctly distinguish many of these areas (Figure 37) (classes 3 and 10). Although in order to combine the ten acoustic classes together, further groundtruthing would be ideal, an initial attempt to combine them using existing groundtruthing resulted in four classes. (Figure 38). These appear to distinguish between Featureless Seabed (Class 1), MDAC (Class 2), Sediment Bedforms (Class 4) and Low Backscatter Sediments (Class 5).

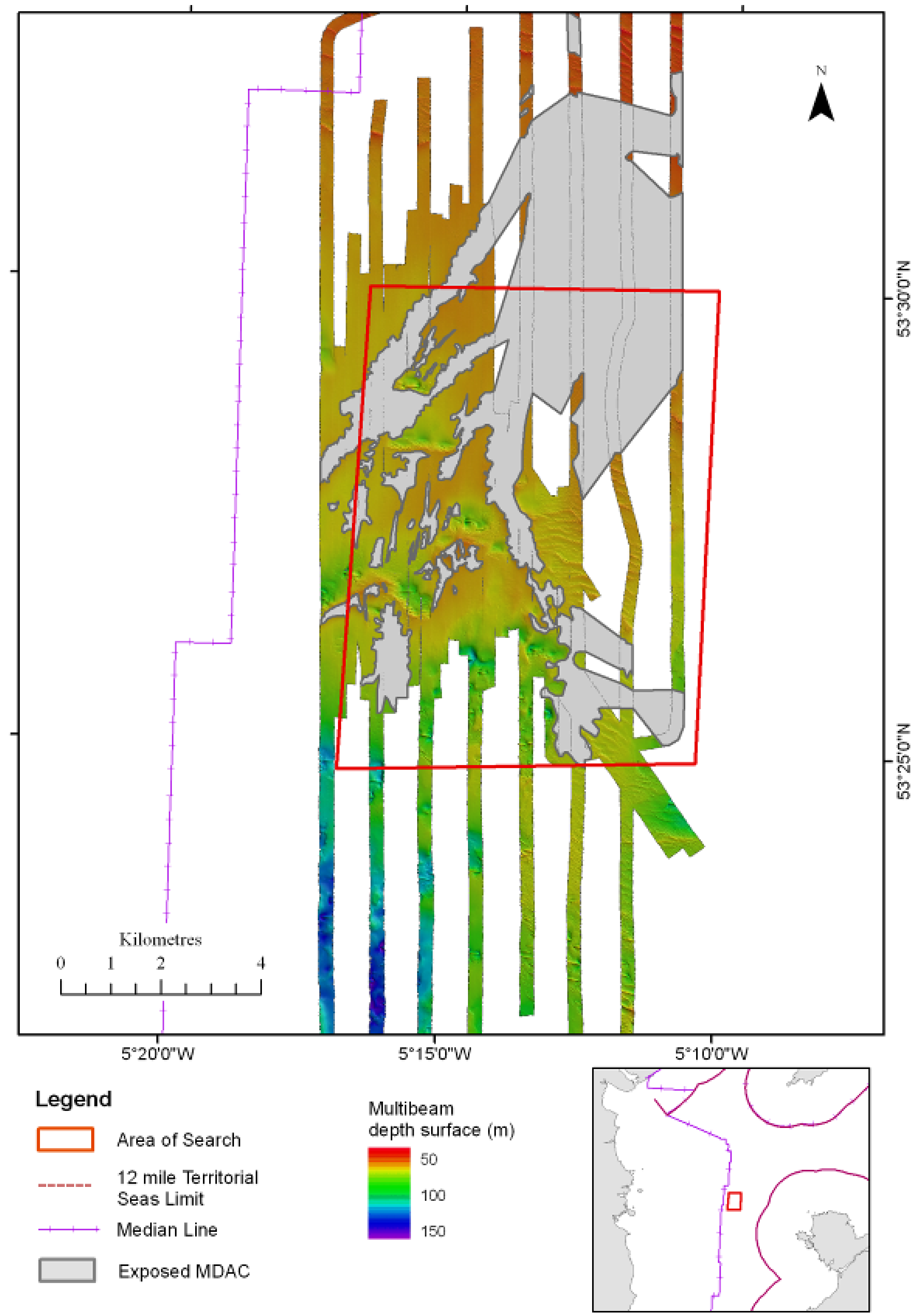

Figure 36. Full extent of MDAC, including areas covered by shifting sediment bodies (boundary of multibeam data shown with dotted line).

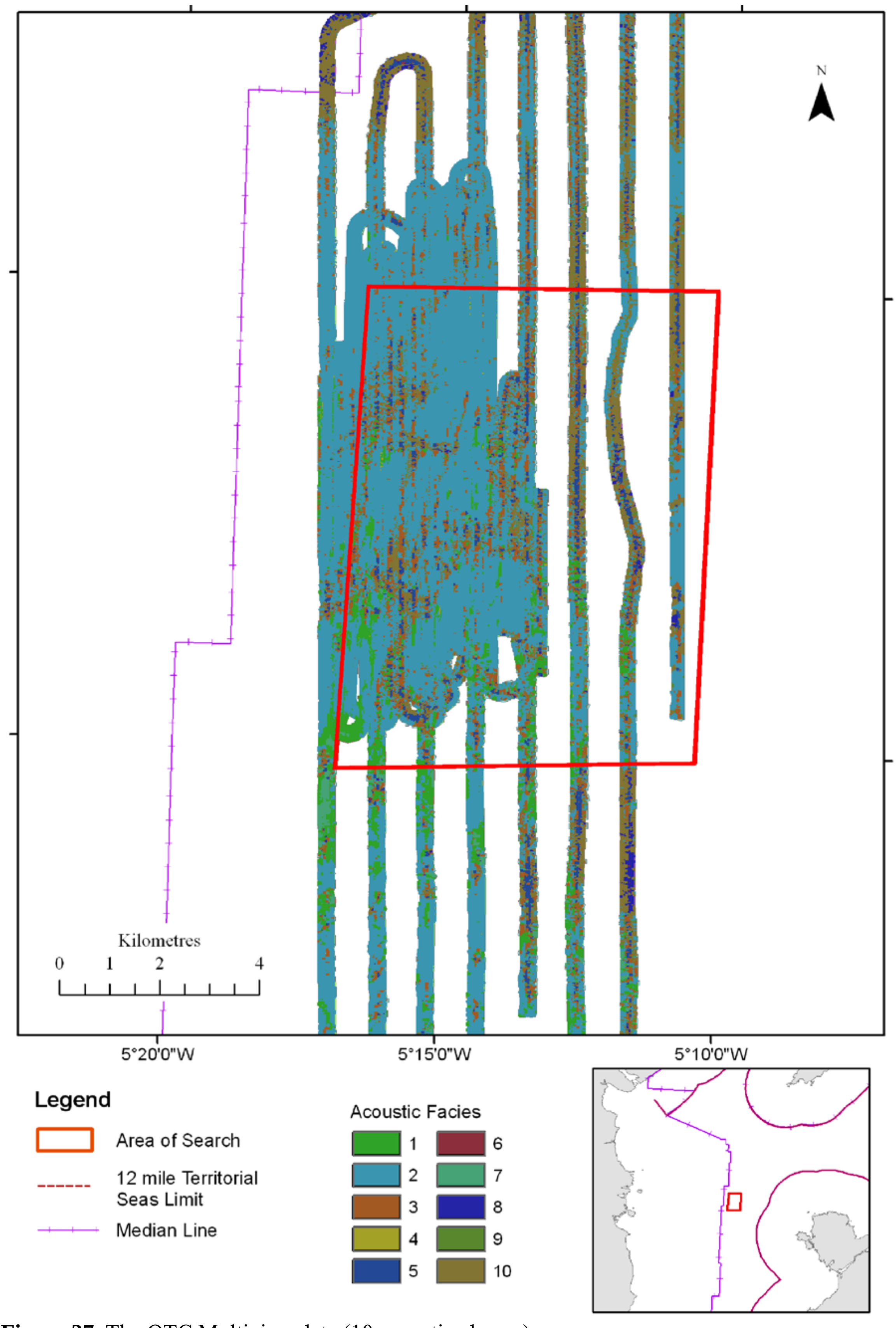

Figure 37. The QTC Multiview data (10 acoustic classes)

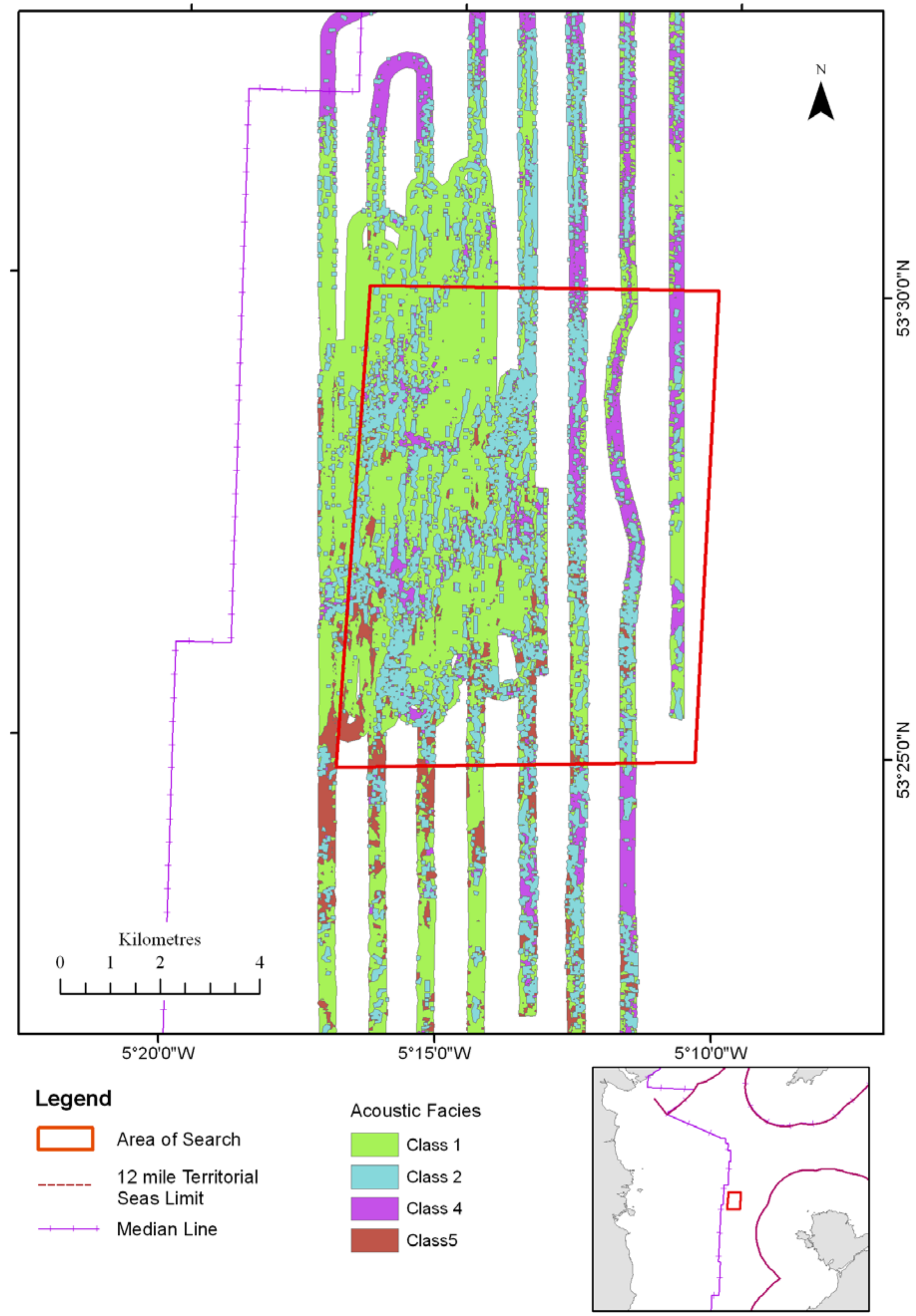

Figure 38. The QTC Multiview data (4 acoustic classes)

Sediment thickness could have a significant influence on the nature and composition of the organisms that would be able to live in any particular area. Therefore, delineating areas based on the thickness of sediment overlying the MDAC would be extremely useful. Without having seabed-penetrating seismic data (such as a sub-bottom profiler), it is not possible to establish the thickness of unconsolidated sediments and their distribution. However, it is possible to map areas with distinctive sedimentary bedforms and use this as a proxy for areas with thicker sediment cover.

The other mapped area that covers a high proportion of the AoS consisted of relatively featureless seabed which had a gradational boundary with the low-relief MDAC. It would seem likely that this boundary was ephemeral depending entirely on the movements of sheets of sandy material which could move freely across the large, low-relief MDAC platform that would appear to underlie most of the area. The boundary between the ridge and valley MDAC and the sedimentary bedforms was also be gradational. It appears as though some of the bedforms may have grown over an underlying MDAC ridge. In order to distinguish between the two forms the MDAC ridges have mapped scarp faces whilst the sediment bedforms have mapped crestlines (Figure 39).

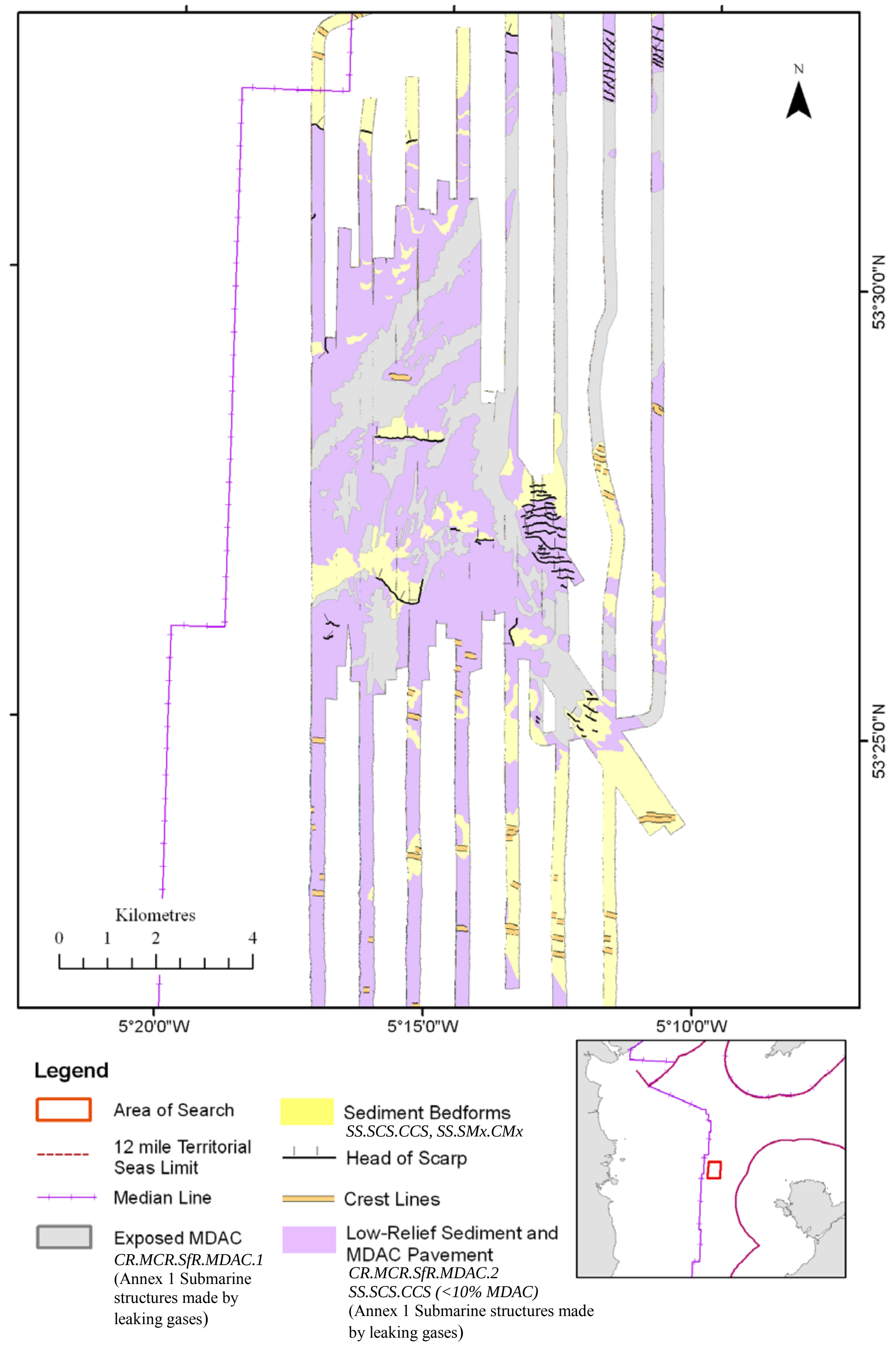

Figure 39. Map depicting Annex 1 habitat, bed forms and associated biotopes

4.1.8 Surface sediments (From PSA, MBES backscatter/sidescan data)

Table 2. Results from Particle size analysis

Station code	Mean (Phi)	Mean (mm)	Sorting	Skewness	Kurtosis	%Gravel	%Sand	%Silt/Clay	EUNIS description	Folk symbol
G1 ADJSED	-0.16	1.12	2.25	-0.07	2.53	34.85	63.95	1.20	coarse	sG
G12SED	0.49	0.71	0.52	-0.40	3.41	0.41	99.59	0.00	sand and muddy sand	S
G9 ADJSED	1.12	0.46	1.94	0.00	5.97	10.95	85.30	3.75	coarse	gS
G9 MDAC	0.55	0.68	2.24	-0.06	4.98	15.49	80.86	3.65	coarse	gS
G5 ADJSED	1.28	0.41	1.68	1.01	7.15	6.76	89.07	4.17	coarse	gS
G13 SED	0.33	0.79	1.41	-2.24	7.53	9.25	90.75	0.00	coarse	gS
G22 MDAC	0.94	0.52	1.58	0.50	7.93	8.99	88.69	2.33	coarse	gS
G22 ADJSED	0.27	0.83	1.84	0.20	4.66	22.07	76.49	1.44	coarse	gS
G19 ADJSED	0.10	0.93	1.72	-1.17	3.67	20.49	79.25	0.26	coarse	gS
G19 MDAC	1.24	0.42	1.44	-1.99	6.47	9.82	90.18	0.00	coarse	gS
G16	0.02	0.99	1.62	-1.07	3.28	19.42	80.53	0.05	coarse	gS
G18 MDAC	0.80	0.57	1.89	-0.41	5.22	15.04	82.32	2.63	coarse	gS
G18 ADJSED	1.17	0.44	1.89	-0.78	7.01	7.59	89.32	3.08	coarse	gS
G17 MDAC	0.62	0.65	1.90	0.04	5.90	17.07	80.30	2.63	coarse	gS
G17 ADJSED	0.14	0.91	2.01	0.19	4.52	26.23	71.66	2.11	coarse	gS
G20 ADJSED	0.70	0.61	0.71	-4.02	25.64	1.98	98.02	0.00	coarse	gS

From the sixteen ground-truthing stations sampled all but one (G12 SED = Sand and muddy sand) were classified as coarse with variable percentages of. gravel, sand and silt/clay (Table 2)

4.1.9 Epi-fauna (Video, stills and rock dredge samples)

Out of the total 22 video tows collected, 17 were successfully analysed yielding a total of 79 identified species and six biotopes/biotope complexes (see Tables 3, 4 and 5). Video footage was of average to poor quality, due to the limited visibility at many sites and strong tidal current. All video tows had at least some MDAC present, surrounded by shelly, highly mobile sand. The MDAC was categorised into three substratum classes, based upon both visual appearance and epi-fauna. "High relief" MDAC was raised at least 20 cm above the surrounding sediment, and was extensively colonised with frequent erect filter-feeders including *Alcyonium digitatum, Tubularia indivisa, Eucratea loricata, Diphasia pinaster*, occasional-rare sponges such as *Cliona celata* and *Iophonopsis nigricans,* and the worms *Sabella pavonina* and *Sabellaria spinulosa.* The anemone *Sagartia troglodytes* was also frequently found on these raised MDAC structures. "Low relief" MDAC did not rise more than 20 cm above the surrounding sediment, and colonised species generally comprised of more scour resistant organisms and fewer large erect filter-feeders. The bryozoans *Flustra foliacea* and *Vesicularia spinosa* were frequently found along with shorter byrozoan turfs including crisids. The hydroids *Tubularia indivisa* and, more occasionally, *Nemertesia spp.* and *Diphasia pinaster* were also associated with this substratum. Notably, the worm *Sabellaria spinulosa* was often found to entirely cover the exposed MDAC, in superabundant numbers. "Uncolonised" MDAC comprised MDAC that must have been recently uncovered by the mobile shifting sands, and had not yet been colonised by visible epi-fauna. The uncolonised MDAC was generally very low relief and distinct from all other substratum types.

In addition to the MDAC and sandy sediments, in one tow (CS03) clay was exposed and probably equates to that seen by Judd (2005). This appeared uncolonised and represented only a small area of the tow. In all tows, the MDAC was very patchy, and interspersed by rippled sand, therefore MDAC percentage cover over an area of approximately 25 m^2 rarely exceeded 40%. The sediment surrounding the MDAC consisted of poorly sorted sand ranging from fine to coarse grain size, with a large proportion of broken shell gravel and whole shells, often forming dense shell patches interspersed by rippled sand. In all tows the sediment was highly mobile.

An MDAC category does not yet exist in either the EUNIS classification or the JNCC Marine Habitat Classification for Britain and Ireland . The fauna supported by MDAC is very similar to that in the communities found on soft circalittoral rock biotope complex, and it is therefore proposed that a new biotope is added under the latter biotope complex. Due to the distinct communities supported by low relief and high relief MDAC, 2 MDAC biotope variants are proposed. In addition, MDAC present in circalittoral coarse sediments (where MDAC represents 10% or less cover) was also recorded as an extra category. The clay is also noted as an additional biotope variant, although it forms a fairly small proportion of the substratum. The large proportion of comminuted and whole shell in the sand sediments may distinguish such areas from other circalittoral coarse sediments, but as yet the JNCC Marine Habitat Classification for Britain and Ireland does not permit the inclusion of shell as a significant substratum in its own right as it is unclear whether it has a major influence on the associated fauna, particularly in highly mobile areas such as this.

Some notable species occurrences were found in the video analysis. The hydroid *Lytocarpia myriophyllum* occurred in many tows, and has not been previously reported in offshore Irish Sea waters (B. Picton, *pers. comm*.). Equally, the ross coral *Pentapora fascialis* was also found in tow CS07, which is rarely encountered offshore in the Irish Sea. In the mid-Irish Sea, *P. foliacea* has a dull beige colour, rather than its usual characteristic orange (Figure 40). In addition, a newly described species of Polymastid sponge was apparent on a few tows, characterised by single or sparse, thin, white papillae protruding above the sandy sediment (Figure 41); here this has been called *Polymastia* cf. *agglutinans* (B. Picton, *pers. comm*.).

Table 3. Submarine structures in the mid-Irish Sea AoS biotope classes in both EUNIS and JNCC Marine Habitat Classification for Britain and Ireland.

EUNIS level	EUNIS code	EUNIS name	JNCC 04.05 code	JNCC 04.05 name	Annex I 'habitat' type
6?	A4.23v1	Communities on high relief MDAC/soft circalittoral rock	CR.MCR.SfR.MDAC.1	Communities on high relief MDAC/soft circalittoral rock	Submarine structures made by leaking gases
6?	A4.23v2	Communities on low relief MDAC/soft circalittoral rock	CR.MCR.SfR.MDAC.2	Communities on low relief MDAC/soft circalittoral rock	Submarine structures made by leaking gases
4	A5.13	Circalittoral coarse sediment	SS.SCS.CCS	Circalittoral coarse sediment	
5?	A5.13v2	Circalittoral coarse sediment	SS.SCS.CCS (.MDAC)	Circalittoral coarse sediment	
5?	A5.13v1	Circalittoral coarse sediment	SS.SCS.CCS (.Clay)	Circalittoral coarse sediment	
4	A5.44	Circalittoral mixed sediments	SS.SMx.CMx	Circalittoral mixed sediments	

Table 4. Mid-Irish Sea biotope descriptions (for example stills images see Annex 2).

JNCC 04.05 code	Substratum description	Characterising species from video
CR.MCR.SfR.MDAC.1	>10% high relief, colonised MDAC, surrounded by low relief MDAC and shelly sand	Erect bryozoans including *Eucratea loricata*, *Flustra foliacea* and *Vesicularia spinosa* frequent, occasional to frequent erect hydroids including *Diphasia pinaster*, *Tubularia indivisa* and *Nemertesia* spp. The anemones *Sargartia troglodytes* and *Ceriathus lloydi* may be locally common, *Urticina* (*eques*) rare to occasional. *Alcyonium digitatum* is occasionally found on tops of high relief outcrops, along with the sponges *Cliona celata* and *Iophonopsis nigricans*. The worms *Sabella pavonina* and *Sabellaria spinulosa* are occasionally to frequently abundant.
CR.MCR.SfR.MDAC.2	>10% low relief, colonised MDAC, surrounded by frequently rippled and highly mobile shelly sand and occasional uncolonised MDAC	Erect bryozoans including *Flustra foliacea* and *Vesicularia spinosa* occasional to frequent, rare to occasional erect hydroids including *Diphasia pinaster* and *Tubularia indivisa*. The anemones *Sargartia troglodytes* and *Ceriathus lloydi* may be locally abundant. The worm *Sabellaria spinulosa* may form a very significant part of the MDAC epifauna, at superabundant numbers in some instances. *Lanice conchilega* and *Sabella pavonina* are rarely to occasionally abundant.
SS.SCS.CCS	Shelly, mobile and rippled sand, frequently >20% shell gravel and >5% whole shell. Sand includes a finer fraction.	Rare to occasional occurrences of the bryozoans *Flustra foliacea*, *Vesicularia spinosa* and *Alcyonidium diaphanum*, and rare occurrences of the hyrdoids *Tubularia indivisa*, *Nemertesia antennina*. Rare occurrences of *Asterias rubens*, *Pagurus* sp. and *Pecten maximus*.
SS.SCS.CCS (<10% MDAC)	Shelly, mobile and rippled sand, frequently >20% shell gravel and >5% whole shell. Sand includes a finer fraction. <10% MDAC.	Rare to occasional occurrences of the bryozoans *Flustra foliacea*, *Vesicularia spinosa* and *Eucratea loricata*, and rare occurrences of the hyrdoids *Tubularia indivisa*, *Nemertesia antennina* and *Diphasia pinsater*. Rare occurrences of *Alcyonium digitatum*, *Urticina* (*eques*), *Sagartia troglodytes*, *Sabellaria spinulosa*, *Sabella pavonina* and *Pagurus* sp.
SS.SCS.CCS (Clay)	Shelly, mobile and rippled sand, frequently >10% shell gravel and >5% whole shell. Sand includes a finer fraction. >10% uncolonised clay.	Rare occurrences of *Flustra foliacea*, *Vesicularia spinosa*, *Pagurus* sp., *Asterias rubens* and *Crossaster papposus*.
SS.SMx.CMx	30% mobile pebbles, 30% whole shells, 30% gravel & 10% fine sand	No fauna observed (highly mobile substrata)

Table 5. Mid-Irish Sea species list.

Aequipecten opercularis	*Eudendrium asbusculum*	*Perophora listeri*
Aglaophenia tubulifera	*Filograna implexa*	*Polycera faeroensis*
Alcyonidium diaphanum	*Flustra foliacea*	*Polydora*
Alcyonium digitatum	*Galathea* sp.	*Polymastia* cf. *agglutinans*
Ascidiella scabra	*Halichondria bowerbanki*	*Polymastia boletiformis*
Antedon bifida	*Haliclona viscosa*	*Pomatoceros triqueter*
Aplidium sp	*Henricia* sp.	*Porifera* cushion pale yellow
Ascidia mentula?	*Homarus gammarus*	*Porifera*- white *Myxilla* or *Microciona* cushion?
Asterias rubens	*Hyas coarctatus*	*Raspailia hispida*
Axinella infundibuliformis	Hydroid turf	*Sabellidae*
Balinidae	*Hymedesmia paupertus*	*Sabellaria spinulosa*
Bispira volutacornis	*Hymedesmia* green	*Sabella pavonina*
Buccinum undatum	*Hymedesmia* yellow	*Sagartia elegans*
Bryozoan turf	*Iophonopsis nigricans*	*Sagartia troglodytes*
Calliostoma zizyphinum	*Inachus* sp.	*Stelligera stuposa*
Cancer pagurus	*Kirchenpaueria pinnata*	*Surtularidae*
Caryophyllia smithii	*Lanice conchilega*	*Tubularia indivisa*
Cellaria spp.	*Liocarcinus*	*Urticina* sp *(eques?).*
Cerianthus lloydi	*Lytocarpia myriophyllum*	*Vesicularia spinosa*
Cliona celata	*Nemertesia antennina*	
Coryphella brownii?	*Nemertesia ramosa*	
Crossaster papposus	*Macropodia*	
Dendrodoa grossularia	*Munida*	
Diphasia nigra	*Myxicola infundibulum*	
Diphasia pinaster	*Ophiocomina nigra*	
Dysidea fragilis	*Ophiura albida*	
Echinus esculentus	*Pachymatisma johnstonia*	
Ebalia sp.	*Pagurus* spp.	
Pilumnus hirtellus	*Pecten maximus*	
Eucratea loricata	*Pentapora fascialis*	

Figure 40. Example still image of the ross coral *Pentapora fascialis* in the Submarine structures in the mid-Irish Sea AoS (tow CS07).

Figure 41. Example still image of *Polymastia* cf. *agglutinans* in the Submarine structures in the mid-Irish Sea AoS (tow CS11; circled right of image).

Figure 42 shows the video tows classified into identified biotopes. It is evident that low-relief MDAC (CR.MCR.SfR.MDAC.2) was found extensively across the Area of Search, and high-relief MDAC (CR.MCR.SfR.MDAC.1) was also found across the site, particularly on higher relief / more heterogeneous areas as identified from the multibeam bathymetric dataset. Coarse sediment (SS.SCS.CCS) was found at the edge of the higher-relief features, with the clay (SS.SCS.CCS (Clay)) appearing in the troughs of the larger sand waves observed to the south of the central area.

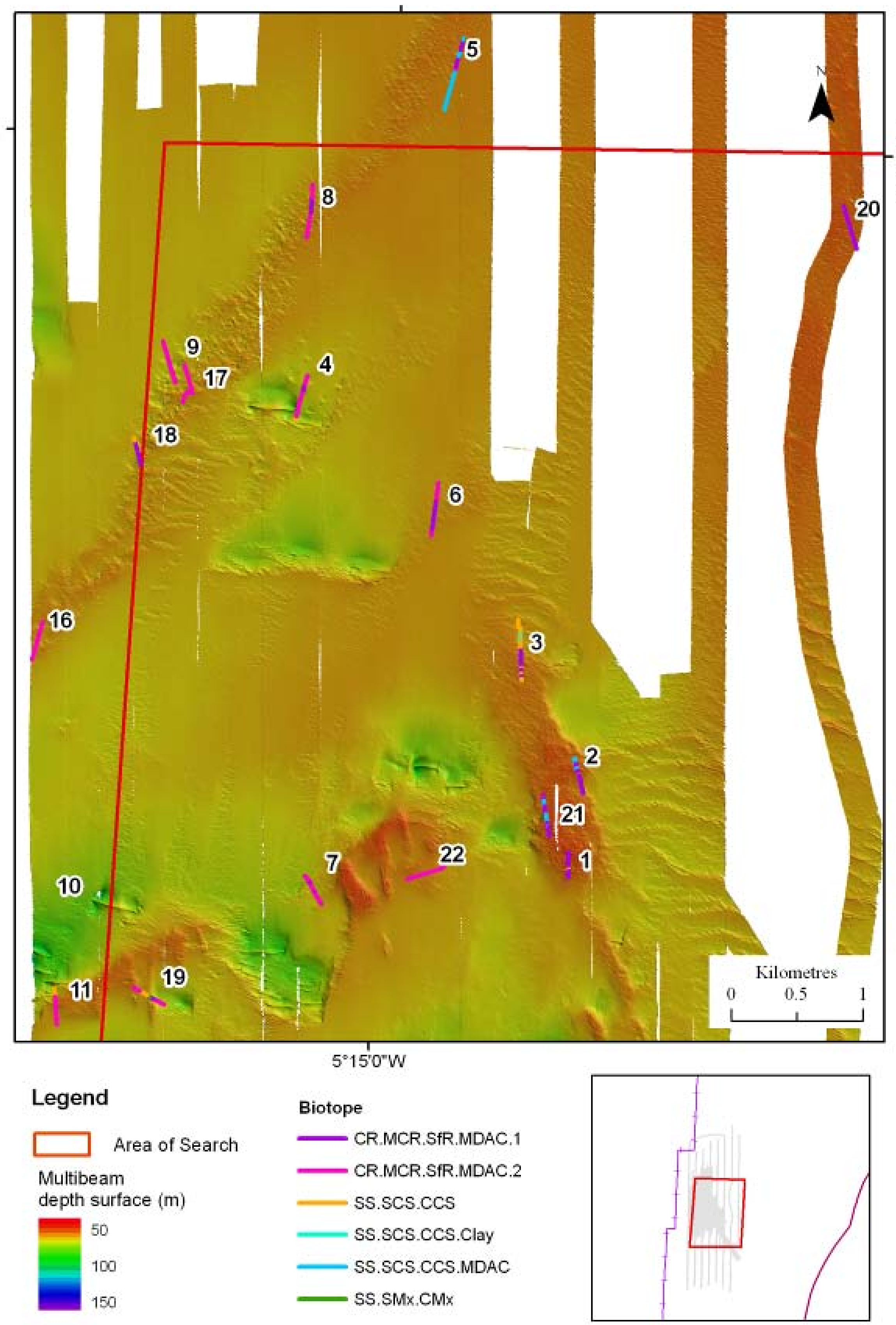

Figure 42. Map of Submarine structures in the mid-Irish Sea AoS showing classified analysed video tows.

4.1.10 Infauna (Hamon grab samples)

Number of individuals (N), species number (S), species richness (d) and species diversity (H') were calculated for the paired samples (MDAC and adjacent sediment) obtained from the submerged structures in the mid-Irish Sea (Figure 43).

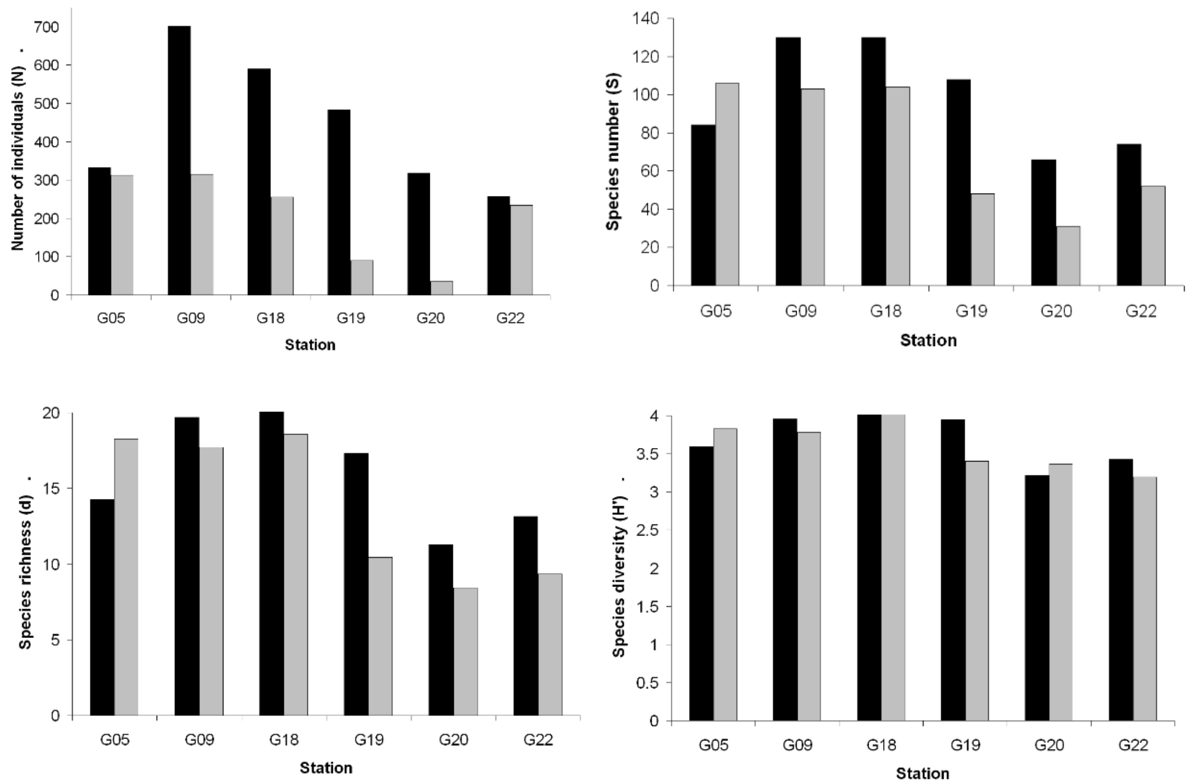

Figure 43. Graphical representation of the metric values for number of individual (N), species number (S), richness (d) and diversity (H').

One-way Analysis of Variance (ANOVA) was carried out to investigate significant differences between the paired samples (MDAC and adjacent sediments, Table 6).

Table 6. Results from 1-way ANOVA (bold = significant (<0.005) result).

Metric	DF	MS	F	P
Number of individuals (N)	1	215214	11.36	**0.004**
Species number (S)	1	5826	4.59	0.049
Species richness (d)	1	88	3.02	0.103
Species diversity (H')	1	1.285	2.03	0.175

Number of individuals (N) was the only metric to identify a significant difference between MDAC and adjacent sediment samples (P = 0.004). A one-way Anovawas carried out to assess differences in biomass of the communities found at the paired sample sites. Although large epifaunal species (Anemones) were collected from the MDAC sites no significant difference in the biomass of the communities was found (P = 0.084). Multivariate community analyses (SIMPER) highlighted differences between the two groups of paired samples. These were primarily due to encrusting species (*Anomidae* sp., *Sphenia binghami* and *Ericthonius punctatus*) and the boring bivalve species *Hiatella arctica* being present at the MDAC stations and not in the adjacent sediments. Infaunal polychaete communities including species from the families Spionidae, Lumbrineridae, glyceridae and Ampharetidae dominated the adjacent sediments. Two species of amphipod from the genus *Ampelisca* were also identified. Interestingly *Ampelisca spinipes* was found to dominate the adjacent sediments stations whereas *Ampelisca diadema* dominated at the MDAC stations.

To facilitate the classification of the benthic habitat around the MDAC outcrops and slabs the SIMPER procedure was carried out on both groups of samples (MDAC and adjacent sediments). The dominant species were then used to classify the biotopes using the JNCC Marine Habitat Classification for Britain and Ireland (Table 7).

Table 7. Classification of infaunal communities from the submarine structures in the mid-Irish Sea.

Station code	Sediment classification	Discriminating species	EUNIS classification	JNCC 04.05 code
G05 ADJ	C	*Ampharete lindstroemi, Ampelisca spinipes, Spiophanes bombyx, Lumbrineris gracilis, Galathowenia* sp	A5.13	SS.SCS.CCS
G05 MDAC	C	*Sphenia binghami, Anomidae* sp, *Autolytus* sp, *Ampelisca diadema*	?New	*?CR MCR SFR MDAC*
G09 ADJ	C	*Phoronis* sp, *Nucula nucleus,Glycera lapidum, Ampelisca spinipes*	A5.13	SS.SCS.CCS
G09 MDAC	C	*Sphenia binghami, Hiatella arctica, Anomidae, Phoronis* sp, *Abra nitida*	?New	?*MCR SFR MDAC*
G18 ADJ	C	*Ampelisca spinipes*, *Chone* sp, *Eulalia bilineata*	A5.13	SS.SCS.CCS
G18 MDAC	C	*Mya truncate, Ampelisca diadema,Ophiothrix fragilis*	?New	*?CR MCR SFR MDAC*
G19 ADJ	C	*Ampharete lindstroemi, Glycera lapidum, Ophelia celtica, Ampelisca spinipes*	A5.13	SS.SCS.CCS
G19 MDAC	C	*Sphenia binghami, Erichonius punctatus, Gammoropsis maculate, Sabellides otocirrata, Anomidae*	?New	*?CR MCR SFR MDAC*
G22 ADJ	C	*Modiolarca tumida, Clymenura* sp, *Syllis* sp, *Nephtys* sp, *Ascidiella aspersa*	A5.13	SS.SCS.CCS
G22 MDAC	C	*Sphenia binghami, Polydora sp, Modiolus* sp, *Monodaeus couchi*	?New	*?CR MCR SFR MDAC*

4.2 Solan Bank AoS

4.2.1 Geology

Multibeam coverage collected by the MCA extended a considerable distance outside the area originally designated as the Area of Search (AoS) (Figure 25). The area covered was approximately 25 km N-S and 20 km E-W. The images in this section use the more extensive, and measured MCA data whilst any interpretations make use of both datasets (e.g. Figure 51).

4.2.2 Seabed morphology

Much of the AoS was covered by a thin veneer of gravelly sand containing shell fragments. This was an active layer being mobilised at the seabed in the current hydrological regime. Video evidence confirmed the active layer to be composed of sand and pebble sized clasts including shell fragments. Particle size analysis showed a bimodal distribution in most samples. A dominant peak in the coarse to very coarse grained sand fraction (0.5-1.5 mm) was interpreted to represent the active layer, while a second peak of coarse grained pebbles (~10 mm) is likely to represent relict Quaternary sediment, although it is possible that some of this material is mobile during maximum current velocity events such as storms. This second peak was variable in size and absent from one site. It is likely that the active layer forms a veneer of varying thickness in the AoS and that the relative size of the second peak is related to the thickness of the active veneer. Mean Spring tidal current velocities are around 0.5 ms^{-1} in the area (Pantin, 1990).

Within the AoS, areas of high topography were identified as bedrock, as described earlier. Linear features with ENE-WSW and SE-NW orientations may be joint planes within bedrock. These linear features formed cliffs with relief of up to 10 m (Figure 44). Some of the most marked bedrock features had a strong NE-SW orientation; this could be a structural trend, related to faults forming the margins of the West Orkney and other basins (Stoker *et al,* 1993)

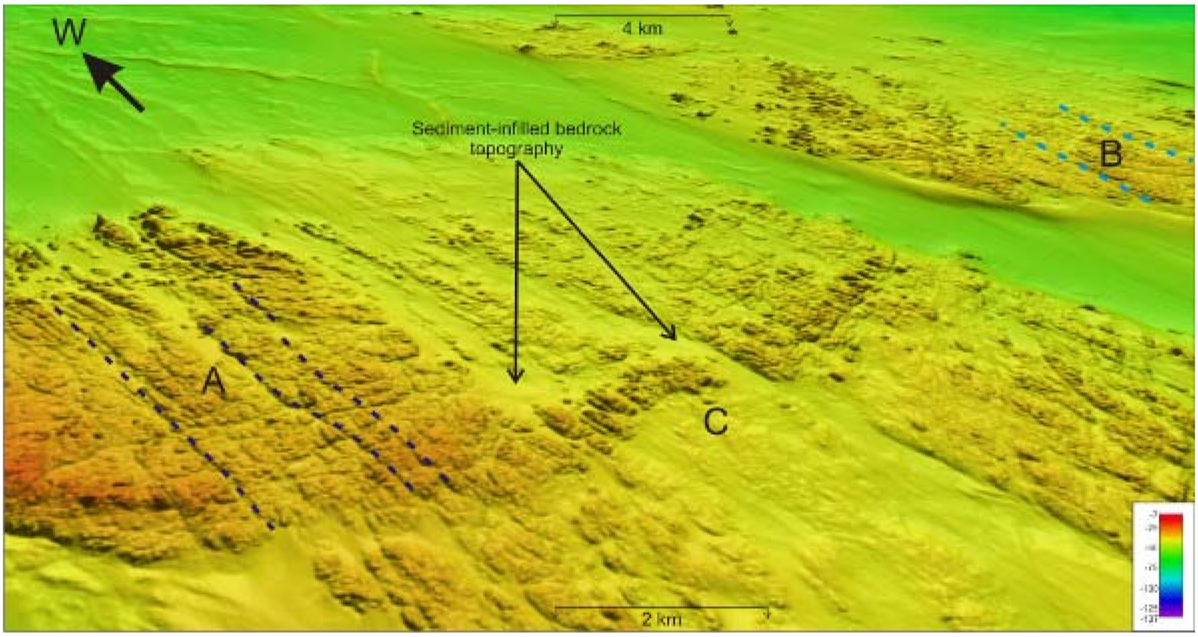

Figure 44. Perspective view across main area of rock outcrop Solan Bank.

Area A Bedrock jointing approximately ENE-WSW exploited by ice moving from east to west.
Area B Bedrock jointing approximately NW-SE.
Area C bedrock smoothed into roche moutonees

In areas of bedrock where lineations were less prominent, outcrop boundaries were very smooth and undulating, suggesting a weathered landscape filled in by sediment (Figure 26). The smooth outline probably resulted from glacial polishing of the bedrock surface, forming features known as roches moutonees similar to those described onshore (Sugden *et al,* 1992).

Where bedrock was not exposed, there were extensive areas of flat seabed with rare patches of ripples and very rare pockmarks. Large, NE-SW or E-W trending lows and ridges might be troughs and waveforms related to seabed currents, where observed ripples denoted a current direction towards the ESE. A number of areas show smaller N-S oriented waveforms forming on the margins of larger ridges described below. These may also represent a recent reworking of the underlying glacigenic sediment. Larger waveforms in the AoS, with crests running predominantly east-west for up to 1 km may only be active during storm events.

Ridges in the NW and SW of the AoS trend ENE-WSW to NE-SW to NNE-SSW, with roughly 4 m relief, had arcuate, concave to south profiles and were commonly sub parallel, forming several series of features on the seabed (Figure 45). In detail there appear to be dozens of features with irregular outlines, (Bradwell *et al, in press*) on several scales.

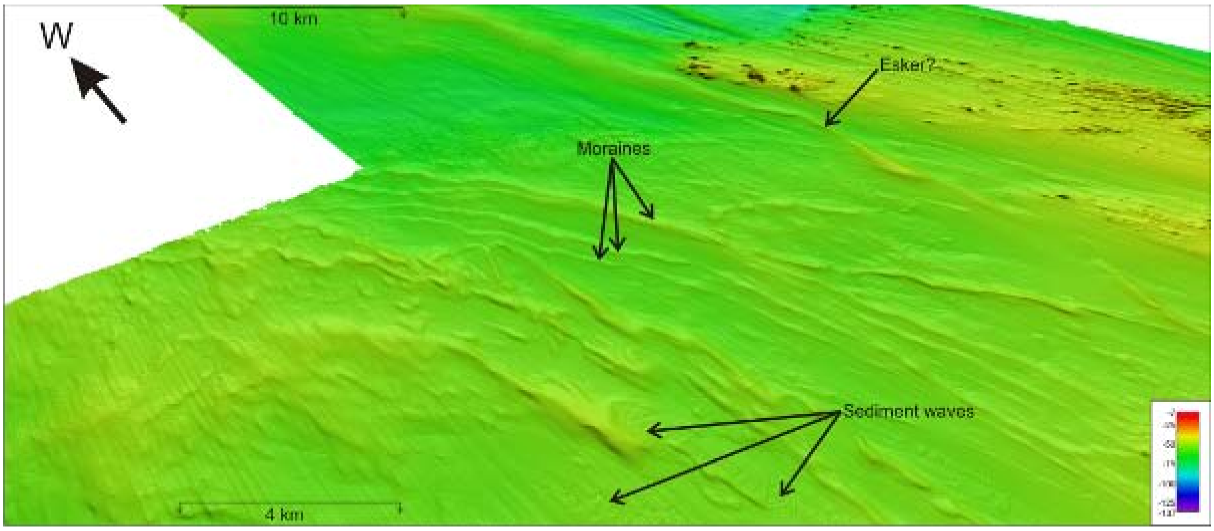

Figure 45. Moraines and other glacial features.

These were originally thought to be wave forms, but are more likely to be glacial in origin, representing morainic ridges formed during retreat of ice across the continental shelf towards the end of the last glacial maximum (Bradwell *et al,* in press). Cross cutting features might represent esker ridges. The nature of these features was confirmed by video evidence,. They were comprised of boulders and cobbles exposed at the seabed due to winnowing, with a thin, commonly absent veneer of sand (Figure 46). These moraines often qualified as Annex I stony reef. It is probable that many of the ridge-like features in the AoS are of similar composition.

Figure 46. Cobbled seabed (From station DC12).

Side scan imagery collected during the cruise identified some areas of flat seabed with a mottled texture. These probably represented fields of boulders on a sandy seabed. These were clearly not related to the present hydrological environment, and were most likely derived from erosion and exposure of glacial debris. A glacial diamict was interpreted to cover much of the AoS outside the areas of bedrock, and erosion of this sheet of sediment would leave a palimpsest of cobbles and boulders at the seabed, partly covered by the active sediment layer.

4.2.3 MBES and SS (Bathymetry and Backscatter)

The Solan Bank AoS was almost all surveyed as part of the MCA's Civil Hydrography Programme (CHP) using a multibeam echo-sounder to produce a high resolution 3D surface (Figure 2). The digital terrain model can be visualised and interpreted to produce a classification of the main physiographic and morphological regions. The classification of these regions is ground-truthed using the seabed sample and image data.

Having examined both the acoustic and optical datasets, the most appropriate set of mapping units that can be followed consistently across the AoS are the moraine ridges, bedrock outcrop and mixed sediments. The moraine ridges are readily identified from the bathymetric data; the video tows reveal that the base of these features, where the moraine and the surrounding seabed sediments meet, can be a gradational boundary and not necessarily coincident with the concave break of slope at the base of the ridge. Wherever possible the backscatter data from the survey lines was used in addition to the MCA bathymetry data to determine the base of the moraine ridges.

The most prominent feature in the Solan Bank AoS was the substantial area of bedrock outcropping at the seabed. This had a distinctive fracture pattern and stood proud of the surrounding sediments often with a steep scarp marking the boundary. Video tows over rock areas showed that the outcropping bedrock with boulders graded into boulder aprons and sediments with no clear boundary between them. The bathymetric data also reflected the gradational nature of the transition from bedrock to sediment. In some areas the distinction between boulders on sediment and boulders on low relief bedrock was not resolvable. In order to map the extent of the bedrock dominated reef areas all the seabed areas that fell within the likely zone of bedrock outcrop and had a topography indicating boulders at seabed were included in the "Bedrock Dominated" class (Figure 48). This class will undoubtedly encompass areas where the boulders are overlying sediment rather than bedrock, however, this results in a high degree of confidence that all areas that do have bedrock reef have been correctly delineated. To isolate areas that contained only high relief bedrock, a map showing the slope of the seabed was produced (Figure 49). Within the areas of bedrock outcrop only the areas of high relief rocks had slopes exceeding 3.5 degrees. These areas were mapped (Figure 50) and it can be seen that the southern area of bedrock has a higher proportion of high relief terrain than the lower relief areas to the north and north-west. An additional mapping class was created by mapping the 48 m contour which represents the lower limit of shallow circalittoral rock (Figure 51). Based on the video tows, which showed the presence of variable densities of kelp, the upper limit of circalittoral, where it becomes ifralittoral, was picked at a depth of 28 m (Figure 51).

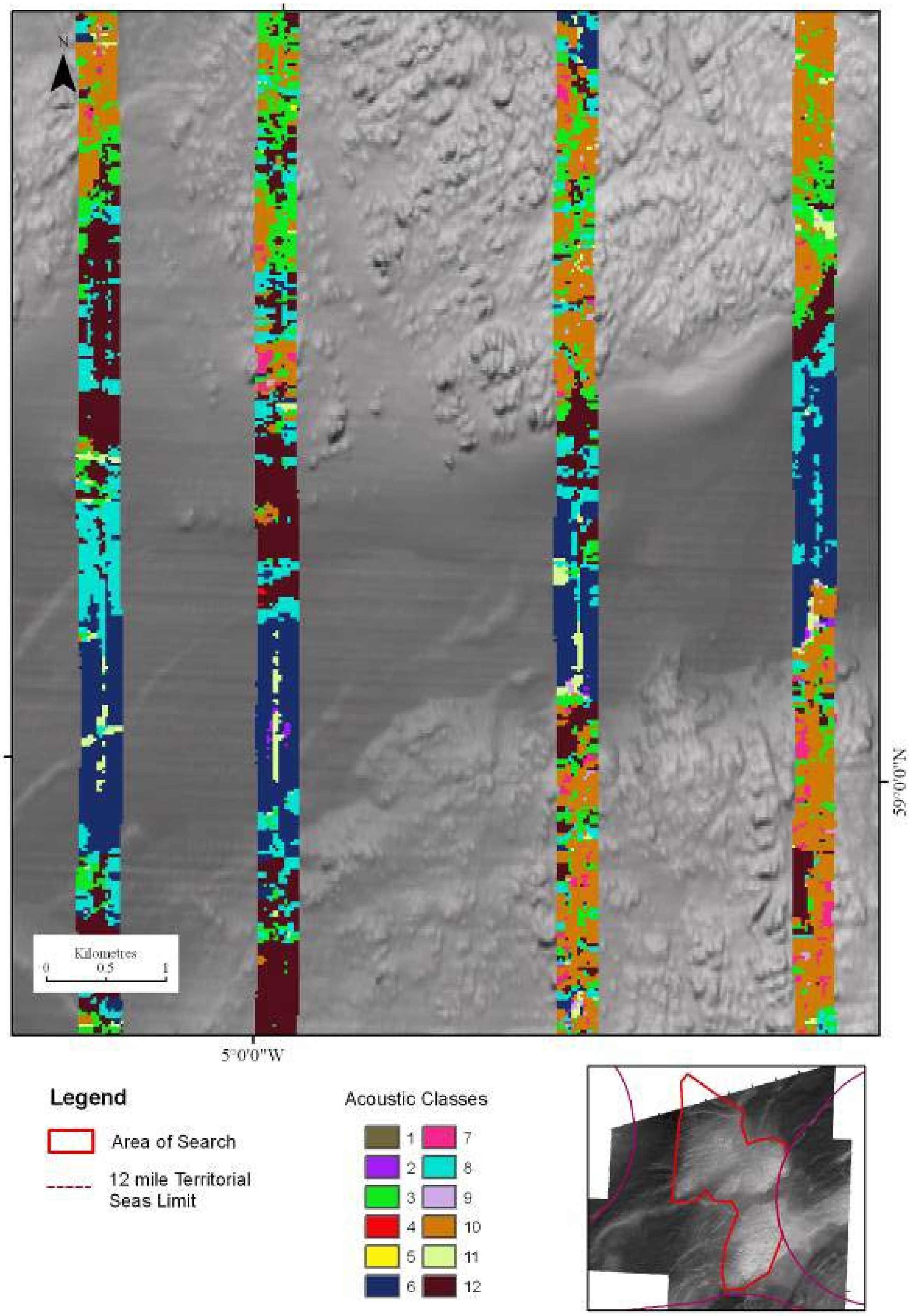

Figure 47. QTC Multiview data categorised into 12 acoustic classes (Zoomed area dotted outline).

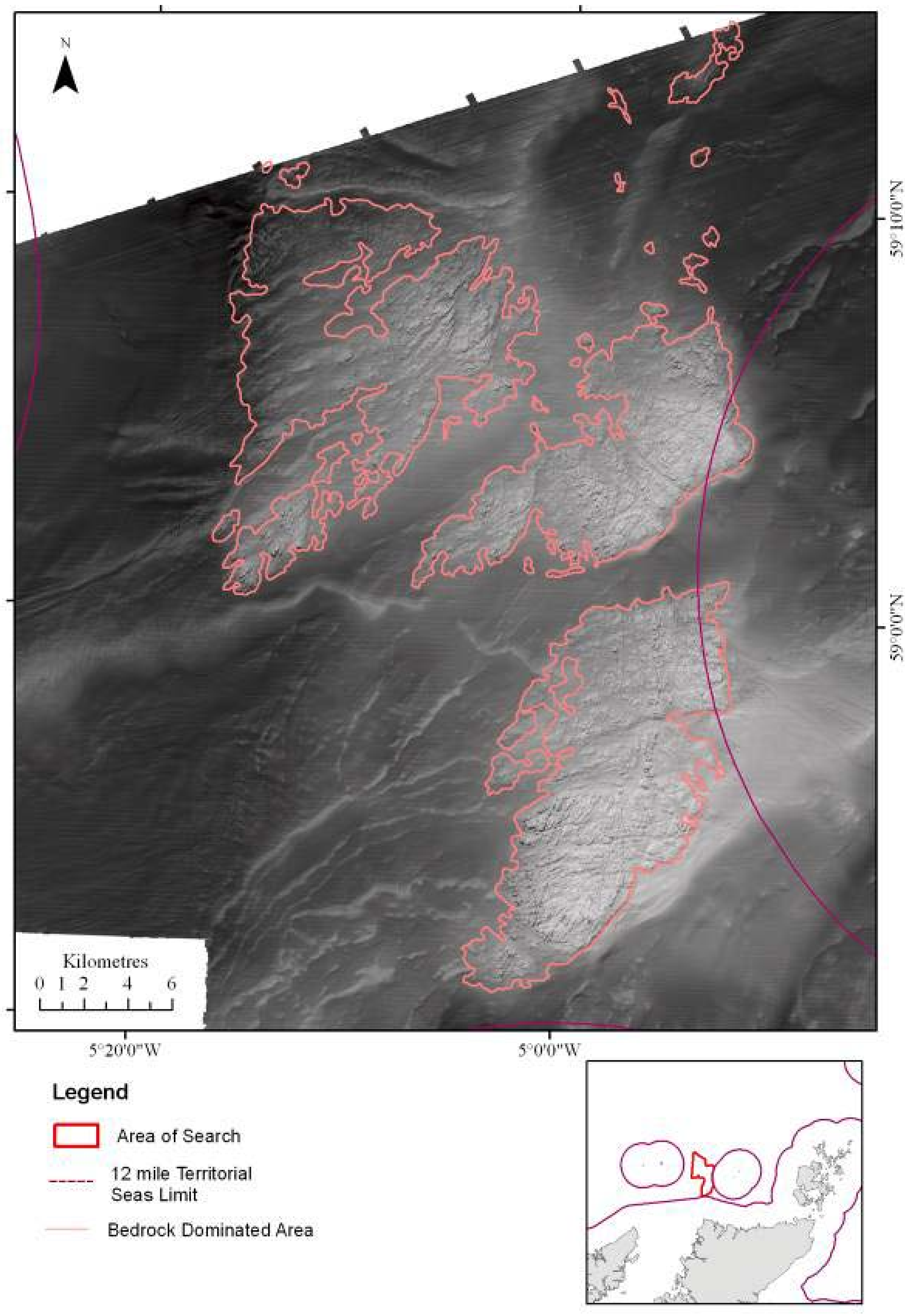

Figure 48. Map depicting bedrock dominated area (Annex I bedrock and stony reef).

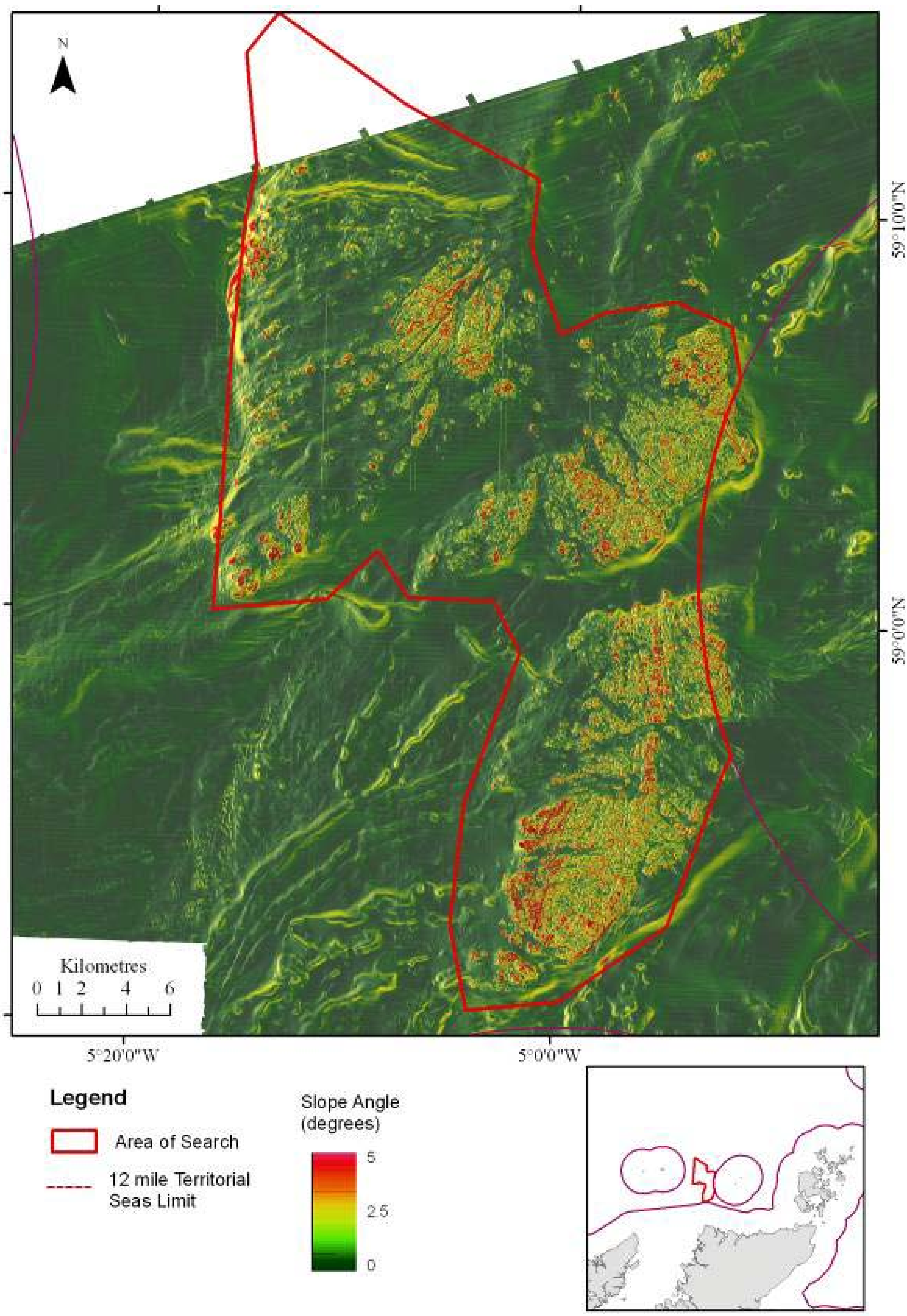

Figure 49. Map depicting the slope of the seabed.

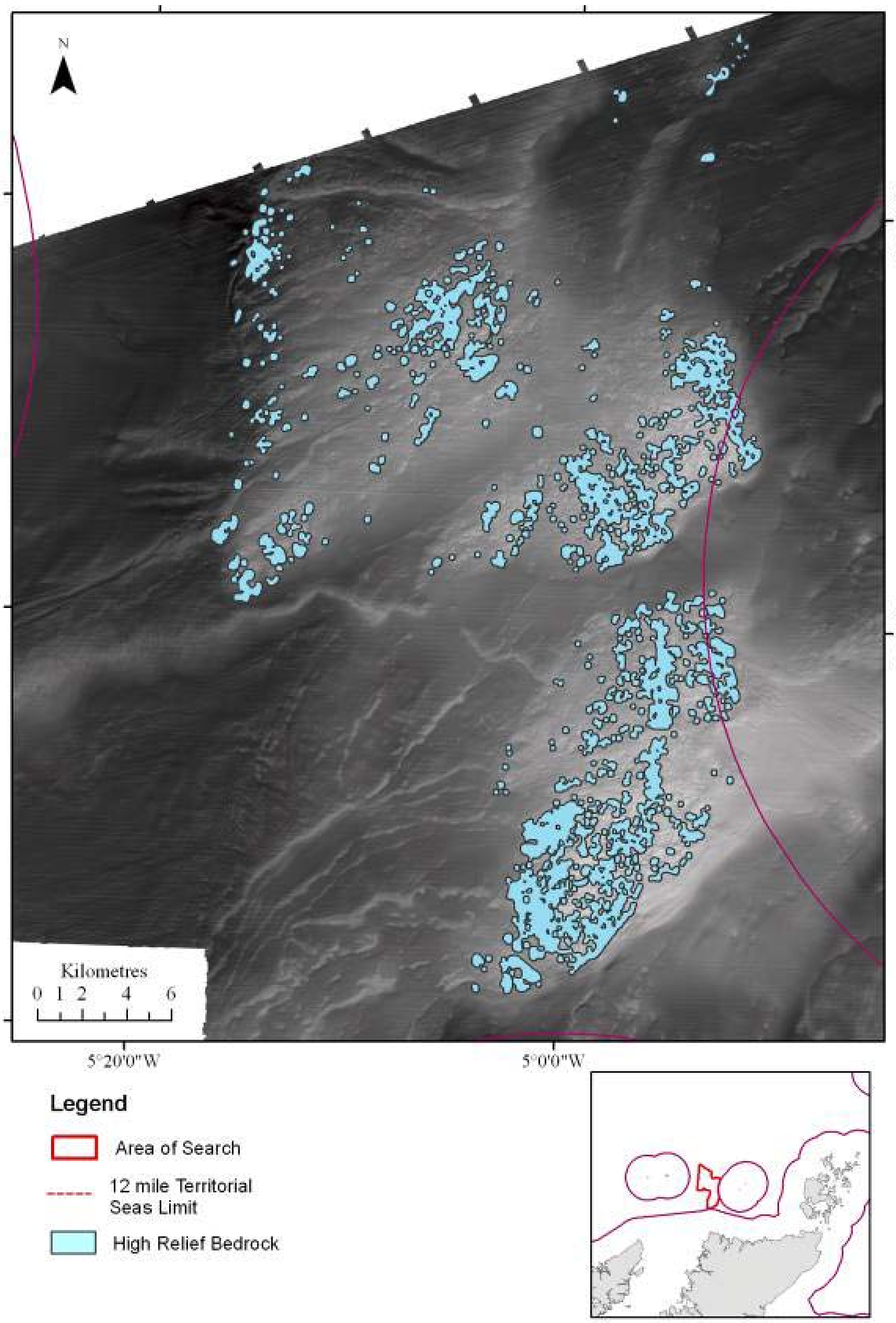

Figure 50. Map depicting high relief bedrock (Annex I bedrock reef).

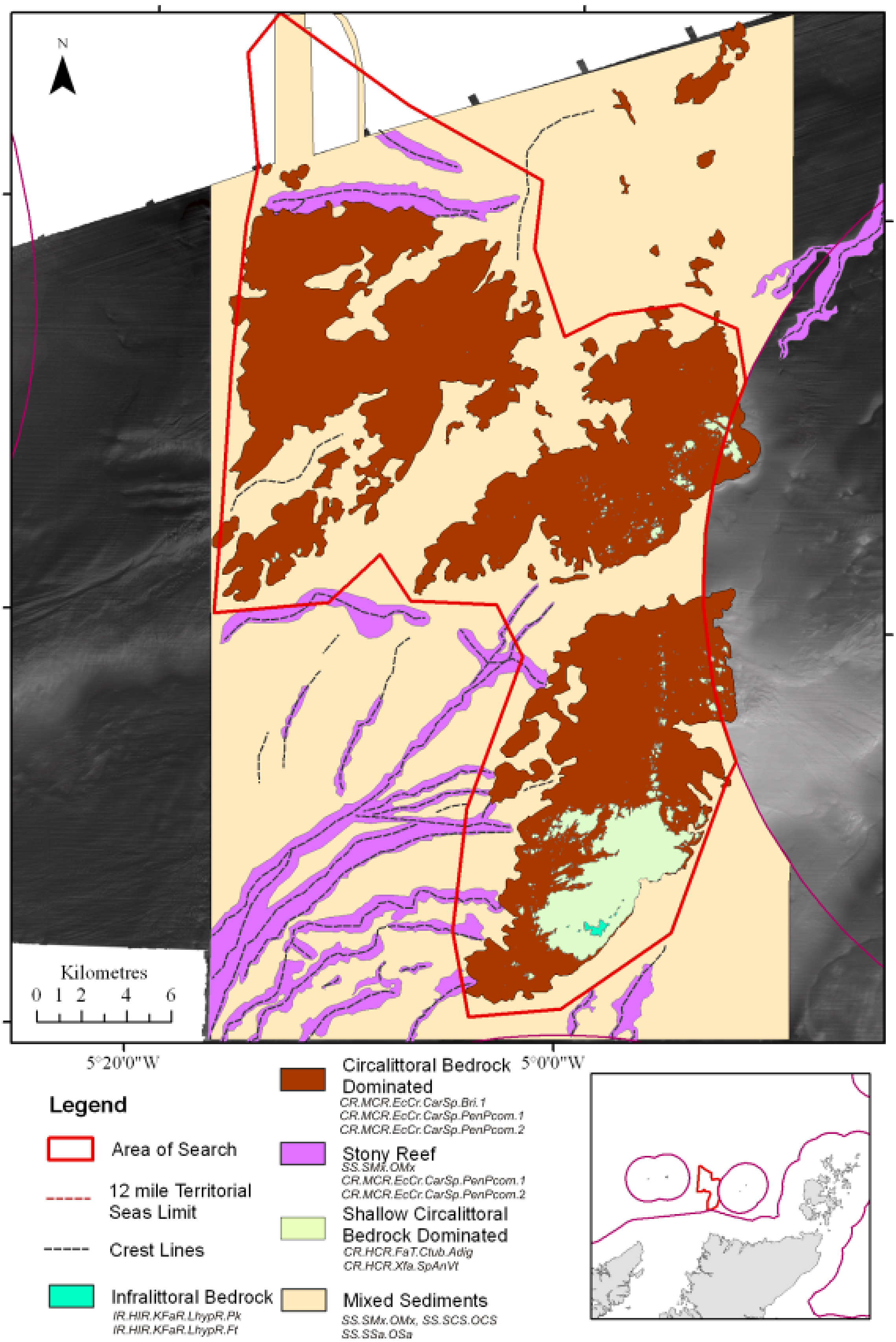

Figure 51. Map depicting bed forms and associated biotopes

4.2.4 Surface sediments (From PSA, MBES backscatter/sidescan data)

Table 8. Results from particle size analysis.

Station code	Mean (Phi)	Mean (mm)	Sorting	Skewness	Kurtosis	%Gravel	%Sand	%Silt/Clay	EUNIS description	Folk symbol
HG 15	-1.27	2.42	1.52	-0.10	1.98	53.51	46.49	0.00	coarse	sG
HG 11	-1.75	3.37	2.29	0.27	2.39	52.38	47.07	0.54	coarse	sG
HG 23	-0.99	1.98	1.48	0.91	5.99	51.39	48.00	0.61	coarse	sG
HG 21	1.22	0.43	1.64	0.65	6.06	4.48	91.63	3.89	sand and muddy sand	(g)S
HG 36 A	-0.68	1.61	1.92	-0.75	2.23	32.26	67.74	0.00	coarse	gS
HG 36 B	-1.67	3.18	1.85	0.24	1.68	60.60	39.40	0.00	coarse	sG
HG 43	-0.16	1.11	0.59	-0.23	4.45	3.63	96.37	0.00	sand and muddy sand	(g)S

From the seven ground-truthing stations sampled all but two (HG21 and HG43= Sand and muddy sand) were classified as coarse. Although the remaining samples were given the same classification the samples varied in percentage content of gravel, sand and silt/clay (Table 8)

4.2.5 Epi-fauna (Video, stills and rock dredge samples)

From a total of 52 video tows 25 were successfully analysed yielding a total of 141 identified species with 10 biotopes/biotope complexes recognised (see Tables 9, 10 and 11). The video footage was of good quality, and the stills of excellent quality, due to the exceptional visibility throughout the site. The substrata encountered ranged from well sorted sands through to bedrock reefs. The bedrock was highly fissured, although the surface often appeared fairly smooth. A coarse sand and shell gravel veneer was present in rock fissures and often on flat surfaces of the rock, indicating that sediment scour is a significant factor across the site. Large 'crevices' in the bedrock harboured stable boulders and cobbles, which were also present at the bedrock boundary with the surrounding sand. In addition, at the north of the AoS, boulder and cobble-fields were found on a moraine. Some areas of these morainic sites showed evidence of substratum mobility, with a sparse associated epi-fauna, while other areas had a more established epi-fauna on stable or embedded cobbles and boulders.

The distinction between Annex I bedrock and stony reef was made during the classification of the video footage, with "stony reef" classed as having 40% or greater cover of cobbles or boulders, dominated by epi-fauna. The demarcation of bedrock reef and stony reef is provided in the Annex I habitat attribution of the GIS shapefiles

The majority of reef sites were characterised by encrusting fauna, in particular encrusting bryozoans (e.g. *Parasmittina trispinosa* and *Cellapora pumicosa*) and encrusting corallines in shallower areas, with rare to common occurrences of the erect calcareous bryozoan *Porella compressa*. Cup corals were frequently encountered, including an as yet unrecognised species of small colonial cup coral (Figure 52), and *Caryophyllia smithii* in shallower areas. Scour-resistant fauna were also characteristic, including *Flustra foliacea, Securiflustra securifrons, Tubularia indivisa, Rhizocaulus verticillatus, Sertularella gayi, Nemertesia* spp., and *Abietinaria abietina.* In some sites, generally those subject to less sand scour, a range of sponges were present, including *Hymedesmia paupertus, Axinella infundibuliformis, Tethya norvegica/hibernica, Quasilina brevis, Stelligera stuposa* and *Polymastia boletiformis.* In low relief bedrock areas subject to considerable scour a lower diversity of animals was supported, and much of the rock was covered by the keel worm *Pomatoceros triqueter*. The anemone *Urticina eques* was distributed widely across all bedrock and stony reef areas.

Shallower areas where the bedrock outcrops were further away from the scour of the surrounding coarse sediment supported a greater diversity of bryozoan and hydrozoan turf species, and were often characterised by increasing abundance of *Alcyonium digitatum*, *Caryophyllia smithii, Corynactis viridis, Metridium senile* and in the shallowest sites foliose red algaes (e.g. *Delesseria sanguinea*) and kelp (*Laminaria hyperborea*). This was confirmed during drop camera 28 (not analysed) where Kelp forest was observed at a depth of 28m. Many bedrock and stony reef sites were covered by an abundance of the brittlestars *Ophiocomina nigra* and *Ophiothrix fragilis*, although these appeared to be in areas which were less bryozoan dominated (e.g. less *Porella compressa*). *Ophiactis balli* was also frequently encountered at all reef sites.

The echinoids *Stichastrella rosea, Asterias rubens, Luidia ciliaris, Marthasterias glacialis* and *Echinus esculentus* were notable on all reef sites. Additionally, many sites supported a considerable population of the gastropod *Hinia incrassata*, and, to a lesser extent, *Polinices pulchellus*. The ascidians *Ascidia mentula* and *A. virginea* were encountered regularly on all reef sites.

A number of new biotopes have been proposed for Solan Bank. This is partly due to the location of the site in the north of UK waters, with a consequential representation of northern species that are not currently well represented in the JNCC Marine Habitat Classification for Britain and Ireland (ver. 04.05) or EUNIS classifications, but also because although the communities observed would fit partly into existing biotopes, some key characterising species differ. Many records were similar to the CR.MCR.EcCr.CarSp.PenPom biotope, but there was no *Pentapora foliacea* present, and instead, the abundance of the encrusting bryozoan *Cellapora pumicosa* was significant, which was not listed in the existing contributing species. Biotope proposal forms with more detail are attached in the Appendix 3.

Two species other than the as yet unidentified cup corals may also be significant for this site. The sponge *Oceanapia robusta* has been recorded from fishing trawl records but not seen *in situ* before, and is thought to be a deeper water species (Figure 53). This species was found in tows DC16 and DC35, on bedrock reef. Another sponge, *Poecillastra compressa*, that is apparently rare (B.Picton, *pers.comm.*), was seen on tows DC19 and DC34 (Figure 54).

Table 9. Solan Bank biotope classes in both EUNIS and JNCC Marine Habitat Classification for Britain and Ireland (ver. 04.05) (note that codes in italics are provisional proposed biotopes only).

EUNIS level	EUNIS code	EUNIS name	JNCC 04.05 code	JNCC 04.05 name	Annex I 'habitat' type
6	A4.1122	*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock	CR.HCR.FaT.Ctub.Adig	*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept circalittoral rock	*reef*
6	*A4.2122v1*	*Caryophyllia smithii* and sponges with *Pentapora foliacea*, *Porella compressa* and crustose communities on wave-exposed circalittoral rock	*CR.MCR.EcCr.CarSp.PenPcom.1*	*Porella compressa* with cup corals, sponges, *Cellapora pumicosa* and crustose communities on wave-exposed circalittoral rock	*reef*
6	*A4.2122v2*	*Caryophyllia smithii* and sponges with *Pentapora fascialis*, *Porella compressa* and crustose communities on wave-exposed circalittoral rock	*CR.MCR.EcCr.CarSp.PenPcom.2*	*Porella compressa* with cup corals and sparse crustose communities on wave-exposed circalittoral rock	*reef*
6	*A4.2121v1*	Brittlestars overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock	*CR.MCR.EcCr.CarSp.Bri.1*	Brittlestars overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock, northern version	*reef*
6	A3.1152	*Laminaria hyperborea* park with dense foliose red seaweeds on exposed lower infralittoral rock	IR.HIR.KFaR.Lhyp.Pk	*Laminaria hyperborea* park with dense foliose red seaweeds on exposed lower infralittoral rock	*reef*
5	A4.139	Sponges and anemones on vertical circalittoral rock	CR.HCR.XFa.SpAnVt	Sponges and anemones on vertical circalittoral rock	*reef*
4	A5.45	Deep mixed sediments	*SS.SMx.OMx*	Offshore circalittoral mixed sediment	
4	A5.14	Deep circalittoral coarse sediment	*SS.SCS.OCS*	Offshore circalittoral coarse sediment	

EUNIS level	EUNIS code	EUNIS name	JNCC 04.05 code	JNCC 04.05 name	Annex I 'habitat' type
4	*A5.27*	*Deep circalittoral sand*	*SS.SSa.OSa*	*Offshore circalittoral sand*	

Table 10. Solan Bank biotope descriptions (for example stills images see Appendix 2)

JNCC 04.05 code	Substratum description	Characterising species from video
CR.HCR.FaT.Ctub.Adig	High relief bedrock with an occasional coarse sand veneer in crevices	*Alcyonium digitatum* (abundant), encrusting coralline algae (abundant), abundant brittlestars (*Ophiothrix fragilis, Ophiocomina nigra*), *Caryophyllia smithii* (occasional), *Corynactis viridis* (occasional), *Metridium senile* (rare to frequent), *Flustra foliacea* (rare to frequent), foliose red algae (frequent in shallowest areas), rare short kelps (in shallowest areas), *Tubularia indivisa* (rare to abundant, depending on aspect and incline of rock)
CR.MCR.EcCr.CarSp.PenPcom.1	Predominantly bedrock with significant veneer of coarse, mobile sand, interspersed with stable/embedded boulders/cobbles in larger fissures	*Porella compressa* (occasional to frequent), encrusting bryozoans including *Parasmittina trispinosa* and Cellapora pumicosa (frequent to common), Caryophyllia smithii (occasional), sponges including notably *Hymedesmia paupertus*, *Axinella infundibuliformis*, *P*olymastia boletiformis, *Tethya norvegica/hibernica* and *Stelligera stuposa*, *Securiflustra securifrons* (occasional)
CR.MCR.EcCr.CarSp.PenPcom.2	Predominantly bedrock with significant veneer of coarse, mobile sand, interspersed with stable/embedded boulders/cobbles in larger fissures; sparse version also found in cobble/boulder fields ("stony reef")	*Porella compressa* (occasional to frequent), encrusting bryozoans including *Parasmittina trispinosa* (frequent), encrusting corallines where appropriately shallow, common keel worms (*Pomatoceros triqueter*), unidentified cup corals (occasional) and rarely *Caryophyllia smithii*, sponges including Hymedesmia *paupertus* and *Axinella infundibuliformis*; *Flustra foliacea* and *Securiflustra securifrons* frequent; more sand-scoured and sparse than CR.MCR.EcCr.CarSp.PenPcom.1
CR.MCR.EcCr.CarSp.Bri.1	Stable boulders and cobbles or bedrock, with significant proportion of mobile coarse sediments	*Alyconium digitatum* rare to frequent, dominant bryozoan crust (inc. *Parasmittina trispinosa*- frequent), encrusting corallines where appropriately shallow, dominated by brittlestars (*Ophiothrix fragilis, Ophiocomina nigra*), keel worms frequent (*Pomatoceros triqueter*); *Hinia incrassata*, *Antedon pertasus*, *Stichastrella rosea*, *Axinella infundibuliformis, Caryophyllia smithii* & *Urticina eques* also characteristic though occur occasionally to rarely
IR.HIR.KFaR.Lhyp.Pk	Bedrock, often sloping but generally smooth surface	Varying densities of the kelp *Laminaria hyperborea*, common foliose red algaes inc. *Delesseria sanguinea*, and common encrusting corallines, frequent *Alcyonium digitatum*, abundant-superabundant *Corynactis viridis*. In deeper water this merges into CR.HCR.FaT.Ctub.Adig

JNCC 04.05 code	Substratum description	Characterising species from video
CR.HCR.XFa.SpAnVt	Highly sloping bedrock	Abundant-superabundant *Corynactis viridis*, patches of dense *Caryophyllia smithii*, frequent Axinellid sponges and *Hymedesmia paupertus*, *Myxilla incrustans* and *Hymedesmia jecusculum*. Occasional *Porella compressa*. Common short bryozoan and hydrozoan turf. In deeper water this merges into CR.MCR.EcCr.CarSp.PenPcom.1
SS.SMx.OMx	Fairly stable cobbles and occassional boulders on coarse sand & shelly gravel	Occasional encrusting bryozoans, frequent keel worms (*Pomatoceros triqueter*) and erect bryozoans including *Flustra foliacea* and *Securiflustra securifrons*, occasional hydroid turf and rarely *Polymastia boletiformis* and *Hymedesmia paupertus*
SS.SCS.OCS	Mobile cobbles, pebbles and shelly gravel on coarse sand; often rippled	Rarely encrusting bryozoans, keel worms (*Pomatoceros triqueter*), brittlestars *Ophiocomina nigra* occasional when not far from bedrock; on more stable pebbles/cobbles occasional hydroid/bryozoan turf
SS.SSa.OSa	Coarse, clean, mobile sand, with small amount of comminuted shell gravel	rarely *Corymorpha nutans*

Table 11. Solan Bank species list.

Abietinaria abietina	*Drachiella spectabilis*	*Polymastia penicillus*
Aequipecten opercularis	*Dysidea fragilis*	*Polymastiid*
Alcyonidium diaphanum	*Ebalia*	*Polyplumaria flabellata*
Alcyonium digitatum	*Echinus esculentus*	*Pomatoceros triqueter*
Antedon petasus	*Edwardsia*	*Porania pulvillus*
Aplidium punctum	*Epizoanthus couchii*	*Porella compressa*
Aplidium/Sidnyum	*Eudendrium annulatum*	Porifera (Qual = "cushion, white")
Ascidia mentula	*Eudendrium arbusculum*	Porifera indet crusts (+Qual = "cushion, yellow/orange")
Ascidia virginea	*Flabellina pedata*	*Poecillastra compressa*
Asterias rubens	*Flabellina pelucida*	*Psammechinus miliaris*
Asterina gibbosa	*Flustra foliacea*	*Quasillina brevis*
Atelecyclus rotundatus	*Foliose rhodophyta*	*Reteporella beaniana*
Axinella infundibuliformis	*Galathea spp.*	*Rhizocaulus verticillatus*
Balanidae	*Goniodoris nodosa*	*Sabellidae*
Botryllus schlosseri	*Grey encrusting sponge*	*Sagartia elegans*
Bryozoa indet crusts	*Halecium halecinum*	*Sagartia troglodytes*
Bryozoan turf	*Haliclona oculata*	*Salmacina dysteri*
Buccinum undatum	*Haliclona urceolus*	*Scalpellum scalpellum*
Bugula spp.	*Henricia spp.*	*Scinaia furcellata*
Calliostoma zizyphinum	*Hinia incrassata*	*Securiflustra securifrons*
Cancer pagurus	*Hormathea coronata*	*Sertularella gayi*
Caryophyllia smithii	*Hydrozoa* (+Qual="turf")	*Sidnyum spp.*
Caryophylliidae (+Qual = "small colonial cup")	*Hymedesmia* (+ Qual = "green")	*Solaster endeca*
Cellaria spp.	*Hymedesmia jecusculum*	*Stelligera stuposa*
Cellepora pumicosa	*Hymedesmia paupertus*	*Stichastrella rosea*
Cereus pedunculatus *Cliona celata*	*Inachus spp.*	*Stomphia coccinea*
Corallinaceae (+Qual="Encrusting")	*Iophonopsis nigricans*	*Suberites ficus*
Corella parallelogramma	*Janolus cristatus*	*Tamarisca tamarisca*
Corymorpha nutans	*Kirchenpaueria pinnata*	*Tethya (Qual = "norvegica/hibernica")*
Corynactis viridis	*Laminaria digitata*	*Thuiaria thuja*
Coryphella browni	*Lanice conchilega*	*Tubularia indivisa*
Crimora papillata	*Lepstasterias muelleri*	*Ulva spp.*
Crossaster papposus	*Leptochiton asellus*	*Urticina eques*
Delesseria sanguinea	*Luidia ciliaris*	*Urticina felina*
Diazona violacea	*Polymastia* (+Qual="white")	
Diphasia fallax	*Polymastia boletiformis*	

Figure 52. Example of the unidentified colonial small cup corals from Solan Bank (DC16).

Figure 53. Example of *Oceanapia robusta* from Solan Bank (DC16).

Figure 54. Example of *Poecillastra compressa* from Solan Bank (DC34).

Figures 55 and 56 below show the analysed video tows classified into the biotopes described above. To the north of the area illustrated by Figure 55 the two tows crossing the moraine are shown, with mixed sediment (SS.SMx.OMx) on the southern flank followed by moderately exposed encrusting fauna-dominated circalittoral rock biotopes the two CR.MCR.EcCr.CarSp.PenPcom represented. The western site showed evidence of increased sand scour, with fewer sponges and erect bryozoans. In addition to the southwest of the site another tow (DC16) crossed a moraine running SW-NE. This moraine area was wider and less “pronounced” than the northern moraine, and was dominated by embedded cobbles, occasional boulders and mobile coarse sand and pebbles. The more scoured version of the CR.MCR.EcCr.CarSp.PenPcom biotope was present here (v2).

The bedrock reefs to the south of the northern moraine all fall into the CR.MCR.EcCr.CarSp.PenPcom biotopes. In Figure 56 the shallower areas of bedrock reef are predominantly classed into the CR.HCR.FaT.CTub.Adig biotope, with the very shallowest areas (DC42) showing a transition into kelp park (IR.HIR.KFaR.LhypR.Pk). Both of these biotopes show a dominance of the anemone *Coryactis viridis* not found in the surrounding deeper areas. There is one area recorded as the exposed vertical rock biotope CR.HCR.XFa.SpAnVt, to the western edge of the site. Deeper sites, which are likely to be subject to greater sand scour, are dominated by encrusting fauna, extensive areas of dense brittlestars and the calcareous bryozoan *Porella compressa*.

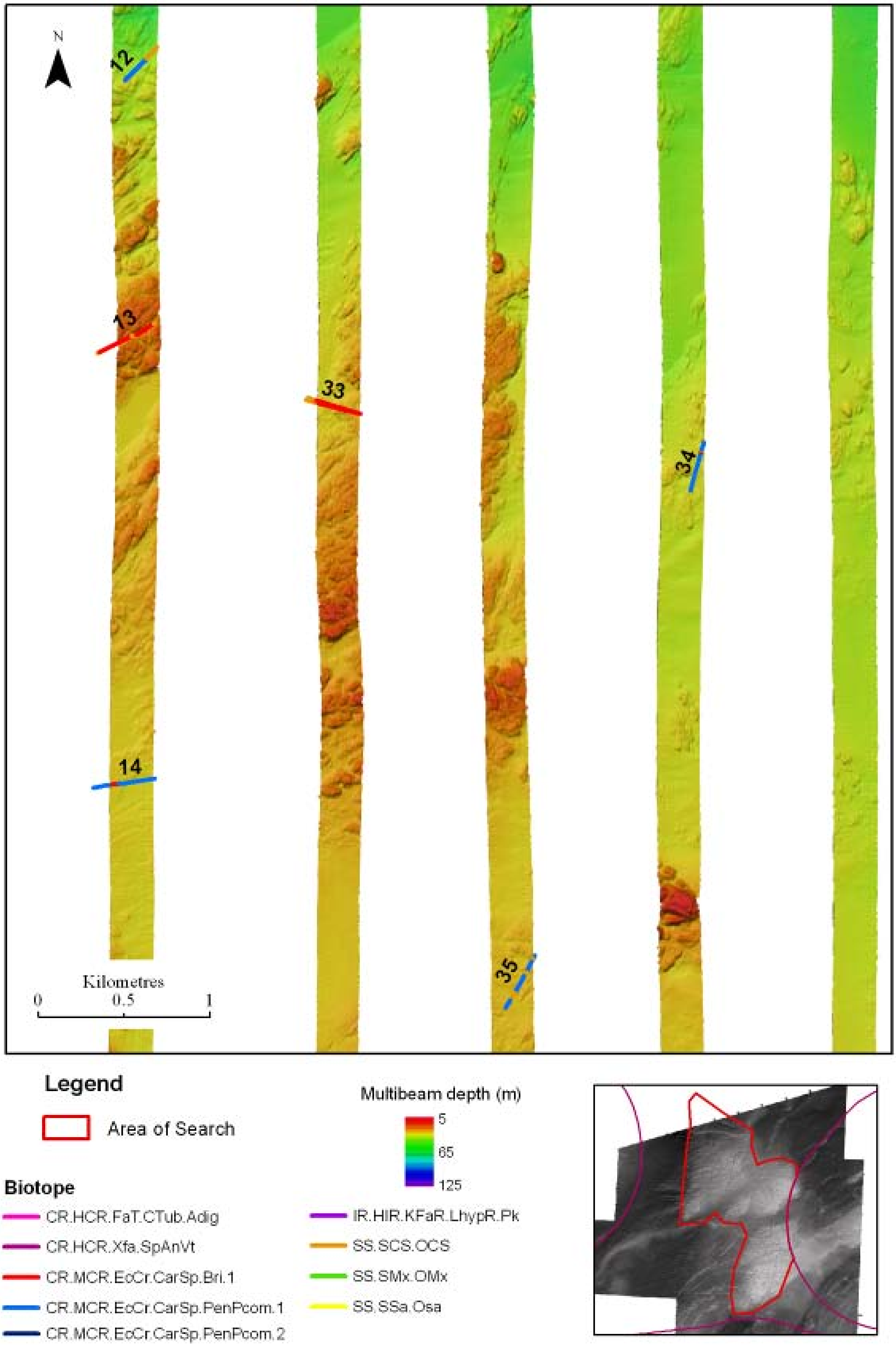

Figure 55. Map of northern Solan Bank area showing classified analysed video tows.

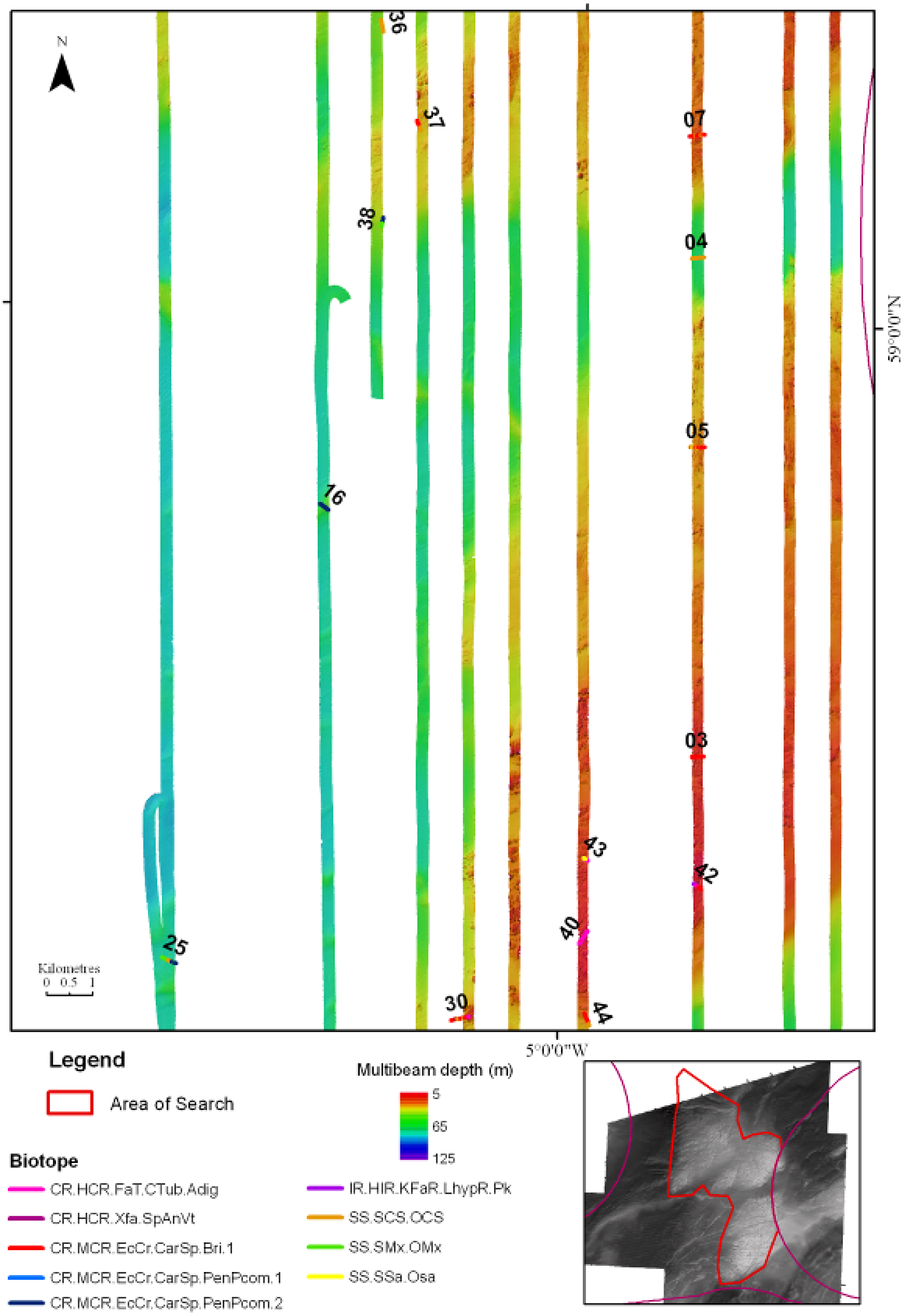

Figure 56. Map of central and southern Solan Bank area showing classified analysed video tows.

4.2.6 Infauna (Hamon grab samples)

Number of individuals (N), species number (S), species richness (d) and species diversity were calculated for ground-truthing samples collected using the Hamon grab (Figure 57). The results were plotted graphically to observe any differences across the area. Due to only one replicate being taken at each station no univariate statistical analyses were carried out on this data set. Multivariate community analysis revealed that stations relatively close together (stations 15, 36 A-B and 43) and (stations 11 and 23) were grouped together indicating some small scale homogeneity within the Solan Bank AoS.

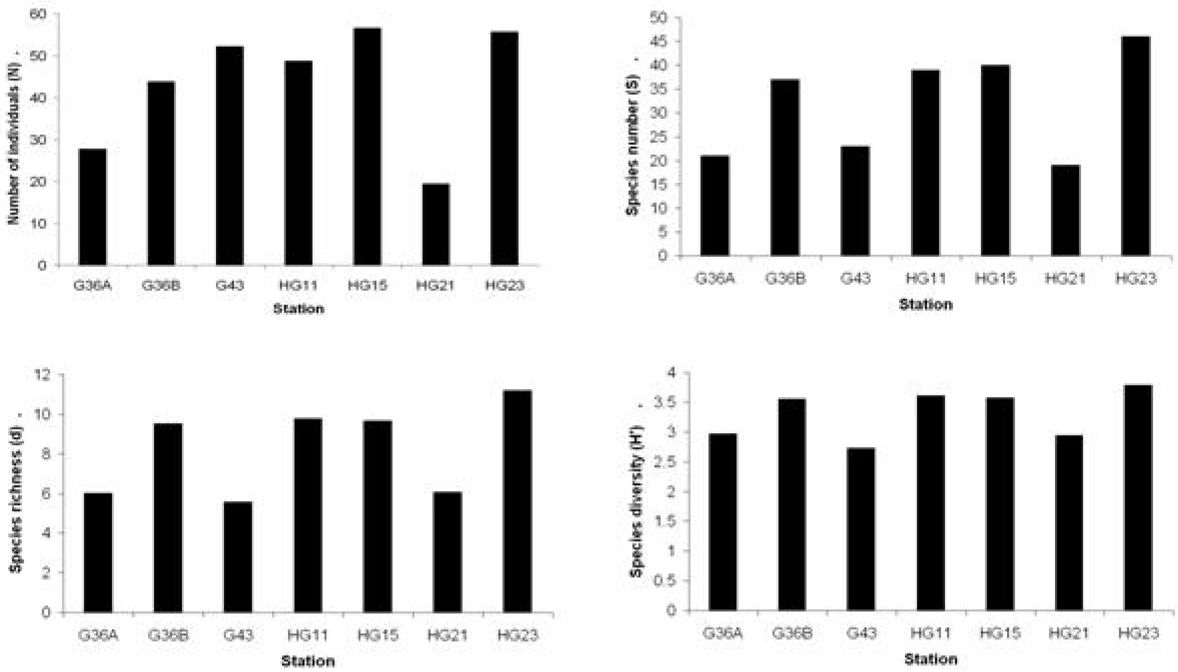

Figure 57. Graphical representation of the metric values of number of individual (N), species number (S), richness (d) and diversity (H').

To facilitate the classification of the benthic habitat around and within the reef the SIMPER procedure was carried out. The dominant species within each sample were then used to classify the biotopes using the JNCC Marine Habitat Classification for Britain and Ireland (ver. 04.05) (Table12).

Table 12. Classification of infaunal communities from the Solan Bank.

Station	Sediment classification	Discriminating species	EUNIS code	JNCC 04.05 code
G36a	Coarse	*Pisione remota, Syllis* sp, *Thracia* sp, *Goodallia triangularis, Nephtys* sp, *Morella pygmaea*	A5.13	*SS.SCS.CCS*
G36b	Coarse	*Protodorvillea kefersteini, Scolelpis Korsuni, Streblospio shrubsolii, Gari tellinella, Timoclea ovata*	A5.132	*SS.SCS.CCS.MedLum Ven*
G43	Sand and Sandy Mud	*Polygordius* sp, *Syllis* sp, *Pisione remota*, Nematode, *Spisula eliptica*, *Tellimya ferriginosa, Glycera lapidum*	A5.13	*SS.SCS.CCS*
HG11	Coarse	*Pistella lornensis*, *Chone*, *Spiophanes kroyeri,Aphelochaeta* sp, *Chaetozone christiei*, *Syllis* sp	A5.13	*SS.SCS.CCS*
HG15	Coarse	Edwardsiidae, *Ampelisca spinipes, Typanosyllis coeliaca, Nephtys. Cirrosa, Nephtys Kersivalensis, Lumbrineris lattreilli, Owenia fusiformis, Polinices pulchellus*	A5.26	*SS.SSa.CMuSa*
HG21	Sand and Sandy Mud	*Cerianthus lloydii, Lumbrineris latreilli, Chaetozone christiei, Clymenura* sp, *Lanice conchilega, Spisula eliptica, Abra prismatica*	A5.26	*SS.SSa.CMuSa*
HG23	Coarse	Notomatus sp, Edwardsiidae, *Pistella lornensis*, *Clymenura* sp, *Scalibregma celticum*, *Dosinia* sp.	A5.26	*SS.SSa.CMuSa*

5 Discussion

5.1 Area of Search overview and conservation interest

5.1.1 Submarine structures in the mid-Irish Sea Area of Search (AoS)

Seabed samples collected during this study and the SEA6 survey showed that the surficial sediments were frequently cemented. Analysis of the cement showed it to be carbonate, high-magnesium calcite or aragonite.. Detailed analyses are and geochemical interpretation is are given in Appendix 4. This is typical of Methane Derived Authigenic Carbonate (MDAC) (Judd, 2005). Judd (2005) identified MDAC associated with a cliff on the seabed (part of the Texel 11 image) and several additional areas. During the present study the presence of MDAC in these areas was confirmed by ground-truthing, indicating that the distribution of MDAC was more extensive than originally thought (Judd, 2005). Methane derived authigenic carbonate was identified over much of the western part of the AoS, and thought to extend further to the west. Total MDAC coverage is estimated to be as much as $40km^2$. Methane derived authigenic carbonate was identified at 15 of the 22 ground-truthing stations covering a large part of the area of search. These included areas where there was no obvious geomorphological evidence. However during analysis of camera tows MDAC was found to be very patchy, and interspersed by rippled sand. The actual percentage cover over an area of approximately $25m^2$ rarely exceeded 40%. This is not to say that MDAC was not underlying the observed mobile bodies of sediment. The sediment surrounding the MDAC consisted of poorly sorted sand ranging from fine to coarse grain size, with a large proportion of broken shell gravel and whole shells, often forming dense shell patches interspersed by rippled sand. In all tows the sediment was highly mobile.

Bedrock was not identified in the AoS. This concurs with seismic lines carried out in 1970 which suggested that bedrock in the area is overlain by 20-50 m of sediment, presumably the Quaternary Prograding Facies. At several sites in the south (sites 12, 15 and camera tow CS03) blue-grey sediment was identified. This material was not sampled but is thought to be the equivalent of the blue clay described in the SEA6 report.

Analyses carried out on the infaunal dataset revealed increased numbers of individuals at the MDAC stations when compared to the adjacent sediments. Surprisingly no difference in species number, richness or diversity and biomass were identified. This is probably due to comparing two distinct habitats e.g. an eroded MDAC habitat with some hard surfaces still present with an infaunal community. This is in agreement with multivariate community analyses (SIMPER) which also attributed the difference in communities to encrusting species (*Anomidae sp*, *Sphenia binghami* and *Ericthonius punctatus*) and the boring bivalve species *Hiatella arctica* being present at the MDAC stations and not in the adjacent sediments. Many of the infaunal species identified occurred at both sets of samples. Two species of amphipod from the genus Ampelisca were also identified. Interestingly, *Ampelisca spinipes* was found to dominate the adjacent sediments stations with *Ampelisca diadema* dominating at the MDAC stations.

Methane derived autogenic carbonate was categorised into three substratum classes, based upon both visual appearance and colonising epi-fauna.

- High relief MDAC: raised at least 20cm above the surrounding sediment, and was extensively colonised with frequent erect filter-feeders including *Alcyonium digitatum, Tubularia indivisa, Eucratea loricata, Diphasia pinaster*, occasional-rare sponges such as *Cliona celata* and *Iophonopsis nigricans,* and the worms *Sabella pavonina* and *Sabellaria spinulosa.* The anemone *Sagartia troglodytes* was also frequently found on these raised MDAC structures.

- Low relief MDAC: less than 20cm above the surrounding sediment, and colonised species generally comprised of more scour resistant organisms and fewer large erect filter-feeders. The bryozoans *Flustra foliacea* and *Vesicularia spinosa* were frequently found along with shorter byrozoan turf, including crisids. The hydroids *Tubularia indivisa* and, more occasionally, *Nemertesia spp.* and *Diphasia pinaster* were also associated with this substratum. Notably, the worm *Sabellaria spinulosa* was often found to entirely cover the exposed MDAC, in superabundant numbers.

- Uncolonised MDAC: MDAC that had been recently uncovered by the mobile shifting sands, and had not yet been colonised by visible epi-fauna. The uncolonised MDAC was generally very low relief and indistinct from all other substratum types.

Several species not previously identified from the Irish Sea were observed during analysis of the video tows. These included the hydroid *Lytocarpia myriophyllum* and a newly described species of Polymastid sponge *Polymastia* cf. *agglutinans* (B. Picton, *pers. comm*.). The ross coral *Pentapora fascialis* which is rarely encountered offshore in the Irish Sea was also observed. An MDAC category does not yet exist in either the EUNIS habitat classification or the JNCC The fauna supported by MDAC is very similar to that in the "Soft Rock" categories, and it is therefore proposed that a new category is added to the existing soft rock classification. Due to the distinct communities supported by low relief and high relief MDAC, two new MDAC sub-biotopes are proposed.

Within the AoS, both high and low relief MDAC were identified. These areas of exposed MDAC met the definition of the Annex I habitat *Submarine structures made by leaking gases*.

As the known occurrence of these habitats is fairly limited in UK waters, the MDAC habitats within this AoS could make a valuable contribution to representativity of this habitat in UK waters. Previously this habitat has been mainly associated with large pockmarks formed through the expulsion of shallow gas. These pockmarks are commonly found in the Fladen and Witch Grounds in the northern North Sea

5.1.2 Solan Bank AoS

The Solan Bank AoS is within the vicinity of numerous other structural features. These include the Nun Rock-Sule Skerry highs, East Rona high, North Rona, North Lewis, North Minch and West Orkney basins. The Solan Bank high forms a NE-trending Precambrian basement high 130 km long and 25 km wide (Stoker *et al,* 1993). The rocks that outcrop at the seabed at the SW extremity of the Solan Bank have been provisionally described as metamorphic rocks including schist and gneiss. The central part of the Solan Bank High has also been drilled by BGS borehole. However, the borehole was terminated after encountering Miocene sands and clays resting unconformably on Precambrian Lewisian amphibolite.

From the MCA multibeam data, it is clear that structural grain of the basement rocks trends towards the NW. It is also possible to interpret that there is an element of structural continuity with the SW Nun Rock-Sule Skerry High that lies to the south. If this suggestion is correct, then this does not support a current interpretation that both highs are discrete entities with a characteristic generally NE-trending inherited Caledonian orogenic (Early to Mid Devonian) structural grain.

In the AoS areas of high topography are defined as bedrock. Linear features with ENE-WSW and SE-NW orientations are thought to be joint planes within the bedrock. These linear features can form cliffs with relief of up to 10 m. Some of the most marked bedrock features have a strong NE-SW orientation; this may be a structural trend, related to faults forming the margins of the West Orkney and other basins.

In areas of bedrock where lineations are less prominent, outcrop boundaries appear very smooth and undulating, suggesting a weathered landscape filled in by sediment. The smooth outline is probably a result of glacial polishing of the bedrock surface, forming features known as roches moutonees similar to those described onshore. Where bedrock is not exposed there are extensive areas of flat seabed with rare patches of ripples and very rare pockmarks.

Features which were originally thought to be sediment wave forms are now thought to be glacial in origin, representing morainic ridges formed during retreat of ice across the continental shelf towards the end of the last glacial maximum (Bradwell *et al, in press*). Cross cutting features are thought to represent esker ridges. The nature of these features was confirmed by video evidence during this present study. They comprise bounders and cobbles with a thin, commonly absent veneer of sand. They qualify as Annex I stony reef. It is postulated that many of the ridge-like features in the AoS are of similar composition.

The substrata encountered during this study ranged from well-sorted sands through to highly fissured bedrock reefs. A coarse sand and shell gravel veneer was present in the rock fissures and often on flat surfaces of the rock, indicating that sediment scour is a significant factor across the site. Large 'crevices' in the bedrock harboured stable boulders and cobbles, which were also present at the bedrock boundary with the surrounding sand. In addition, at the north of the site boulder- and cobble-fields were found on a moraine. Some areas of these morainic sites showed evidence of substratum mobility, with a sparse associated epi-fauna, while other areas had a more established epi-fauna on stable or embedded cobbles and boulders.

The majority of reef sites were characterised by encrusting fauna, in particular encrusting bryozoans (e.g. *Parasmittina trispinosa* and *Cellapora pumicosa*) and encrusting corallines in shallower areas. Sediment scour appeared to be a strong structuring force within this AoS. Low relief bedrock areas subjected to scour were found to be less diverse with much of the rock surface covered by the keel worm *Pomatoceros triqueter.* At sites less affected by sand scour a greater diversity of organisms were observed, including, a range of sponges *Hymedesmia paupertus, Axinella infundibuliformis, Tethya norvegica/hibernica, Quasilina brevis, Stelligera stuposa* and *Polymastia boletiformis.*

Shallower sites where the bedrock protruded further from the surrounding sand supported a greater diversity of bryozoan and hydrozoan turf species, and were often characterised by increasing abundance of *Alcyonium digitatum*, *Caryophyllia smithii, Corynactis viridis, Metridium senile* and in the shallowest sites foliose red algaes (e.g. *Delesseria sanguinea*) and short kelps (*Laminaria hyperborea*).

A number of new biotopes have been proposed for Solan Bank. This is partly due to the location of the site in the north of UK waters which resulted in the observation of northern species that are not currently well represented in the JNCC Marine Habitat Classification for Britain and Ireland (ver. 04.05) or the EUNIS habitat classification. The second reason is because although the communities observed would fit partly into existing biotopes, some key characterising species differed. Many records appear to fit the CR.MCR.EcCr.CarSp.PenPom biotope, but there is no *Pentapora foliacea* present, and the encrusting bryozoan *Cellapora pumicosa* appears significant which is not listed in the existing contributing species.

An unidentified cup coral and the sponge *Oceanapia robusta*, which has only previously been recorded from fishing trawl records and not seen *in situ* before, were observed within the AoS. The sponge *O. robusta* was identified from three video tows (DC16, DC19 and DC35). Another sponge, *Poecillastra compressa*, that is considered rare (B.Picton, pers.comm.) was also observed in four video tows (DC 16, DC19, DC31 and DC34).

Numerous examples of reef structures have already been designated as Special Areas of Conservation (SAC) in the north of the UK. These include The Firth of Lorn, Loch Creran, Papa Stour (Shetland Isles), Sanday, St Kilda and Stanton Banks. The selection of representative reef sites has so far favoured extensive examples with diverse community structure. Sites already chosen represent the ecological and regional (North and South) range of this extremely variable habitat type. The Solan Bank Reef would be an important addition to this list due to its varied and complex reef types (rocky and stoney), newly proposed regional biotopes, example of rare sponge and the yet unidentified species of colonial cup coral.

5.2 Acoustic interpretation

5.2.1 Submarine structures in the mid-Irish Sea AoS

QTC Multiview analysis revealed an optimum of 10 acoustic classes identified from the MBES backscatter data (Figure 37). The classification was successful in picking out regions dominated by sediment cover (predominantly class 2), and regions of high-relief MDAC reef (predominantly acoustic classes 3 and 10), and the analysis undoubtedly facilitated the delineation of seabed features of ecological significance, and the production of the habitat maps (Figure 39). However, it should be noted that semi-automated backscatter classifications of this type based on image patterns should be interpreted with caution. Some of the acoustic classes likely relate to backscatter artefacts (angular range artefacts and issues relating to scale of feature on the seafloor e.g. class 5). The maximum resolving capability of the classification is intrinsically linked to the size of rectangle on which the classification is based (e.g. ~15m x 12m – see methodology section). The choice of 10 acoustic classes was also based on the automated clustering routine within the Multiview software package, and previous research into this process has demonstrated that this method often over-segments the backscatter. This has been simplified to four classes based on expert interpretaion (Figure 38) but in order to use the classification for the purposes of habitat delineation, classes should be merged back together or removed if they relate to artefacts, and this process should be based on ground-truthing evidence (McGonigle *et al,* 2009). To achieve this, targeted ground-truthing of each acoustic ground-type is required to ascertain what each acoustic class relates to on the seafloor, which is beyond the scope of this study.

5.2.2 Solan Bank

QTC Multiview analysis revealed an optimum of 12 acoustic classes identified from the MBES backscatter data (Fig 47). The analysis at Solan Bank proved more successful than at the Mid Irish Sea site, probably due to the better match in the scale of seabed features and the resolving capability of the classification approach based on the choice of rectangle size (~22m x 12m – see methodology).

The classification was successful in picking out regions dominated by soft sediment cover (predominantly class 6, 8 and 12), and regions of hard ground relating to bedrock and boulder reef (predominantly acoustic classes 2, 3 and 10). This classification facilitated the delineation of seabed features of ecological significance, and the production of the habitat maps for this site (Figure 51). However, as for the MIS data set, it should be noted that semi-automated backscatter classifications of this type based on image patterns should be interpreted with caution. Some of the acoustic classes likely relate to backscatter artefacts (e.g. angular range artefacts such as class 5). The maximum resolving capability of the classification is also not capable of facilitating the delineation of the two types of reef (bedrock and boulder reef). Further detailed analysis of the classified data, such as that detailed by McGonigle *et al* (2009) would be required, coupled with targeted ground-truthing of each acoustic class, in order to relate with certainty each acoustic class with a ground-type (which is beyond the scope of this study).

Within the Solan Bank AoS comparison of video sledge data and multibeam bathymetry data proved difficult to correlate. The video tows were focused on the areas of potential reef and within these tows a continuum of seabed types were encountered from fine sands to pebbly and cobbled sediments up to boulders and bedrock. There were two major issues extrapolating the detailed information, as logged on the video data, to broader mapping units. The first difficulty is in the contrasting resolutions of the two datasets. The video data can show differences on the centimetric scale whilst the acoustic data is on the scale of meters. The relatively lower resolution of the acoustic data means that there are changes in seabed type that can be resolved on the optical datasets that cannot be resolved on the bathymetric data.

The second and related difficulty is as the seabed images have such a focused coverage it is difficult to determine the broad-scale (and acoustically resolvable) environment that they are recording. For example, from the video it may not be possible to distinguish between a thin sand veneer over a large low relief bedrock outcrop, from a sandy seabed outside a rocky area or a sand-filled gully within a high-relief rocky area, all of which are potentially resolvable from the broad-scale bathymetric data. This difference in data resolution introduced a degree of uncertainty to the differentiation between reefs consisting of boulders and those consisting predominantly of bedrock. The classified backscatter data output by QTC Multiview may have assisted in the differentiation of these two classes. However, the coverage was too sparse to allow extrapolation of the classes between survey lines.

5.3 Suitability and cost-effectiveness of techniques utilised for seabed investigations within both Areas of Search

The techniques utilized in the surveys at the two study sites were highly appropriate for mapping benthic habitats and the features of interest. The methodology was based on standards and protocols specified in the MESH guidelines (MESH, 2007) and on methods employed in similar studies reported in the scientific literature (e.g. Brown and Blondel, *in press*; Brown and Collier, 2008; Brown *et al,* 2002, 2004a, 2004b, 2005; Cochrane and Lafferty, 2002, Edwards *et al,* 2003, Kostylev *et al,* 2001, Lathrop *et al,* 2006; McGonigle *et al,* in press; Pickrill and Todd, 2003; Roberts *et al,* 2005, Rooper *et al,* 2007). The combination of MBES and SSS offers an ideal survey strategy, providing data on seafloor topography (from the MBES bathymetry) and surficial seafloor characteristics (e.g. hardness, roughness, texture from the SSS backscatter), and these methods are widely accepted in the scientific literature as the most suitable for habitat mapping applications (Brown and Blondel, in press; Brown and Collier, 2008; Brown *et al,* 2002, 2004a, 2004b, 2005; Cochrane and Lafferty, 2002; Edwards *et al,* 2003; Kostylev *et al,* 2001; Lathrop *et al,* 2006; McGonigle *et al,* in press; Pickrill and Todd, 2003; Roberts *et al,* 2005; Rooper *et al,* 2007).

The ground-truthing methodology for this study utilized a complimentary range of survey techniques, each targeting a particular component characteristic of the seafloor environment. Such surveys strategies are widely reported to provide the most robust means of characterising seafloor biotopes (e.g Brown and Collier 2008; Brown *et al,* 2002; McGonigle *et al, in press*), and results from this study support the use of this multi-technique strategy. The combination of grab, trawl, video and stills enables the full cross spectrum of seafloor features and species to be identified and described, which led to the successful identification of 14 biotopes at the two sites.

At Solan Bank one of the main features of interest was the Annex I reef. The general reef features were clearly discernable from the wide-coverage UKHO MBES bathymetry data (Figure 13). However, the video revealed that regions of bedrock reef and areas of stony reef were often intermixed, which posed a problem with the requirement to delineate and map these two sub-types of reef separately. The scale of transition between the stony and bedrock reef, which was clearly recognized from the underwater video data, were difficult to identify from the sidescan data sets, with both sub-reef types having similar acoustic properties. These two reef types are therefore unable to be resolved and mapped with confidence using currently available acoustic survey methodology. It is possible that detailed analysis of the UKHO complete coverage MBES backscatter data may have facilitated further delineation of these features, but this data set was not available for the purposes of the current survey reporting. The lack of the UKHO backscatter data also severely limited the ability to delineate and map the three types of soft sediment biotopes from this AoS. It may have been possible to accurately delineate bedrock and stony reef areas had full coverage sidescan sonar been undertaken across the entire Area of Search, although this would have added significant cost to the survey.

Within the Submarine structures in the mid-Irish Sea AoS, the acoustic and ground-truthing data revealed that the seafloor was extremely heterogeneous. Large areas of the AoS appeared to contain out-cropping MDAC, smothered with various thicknesses of, probably mobile, sediment. The scale of change of these features precluded their delineation, and the subsequent habitat maps produced are the best results achievable based on currently available survey methods. In future, further information could be sought on the thickness of sediment veneer overlying the MDAC structures by using high resolution seismic equipment such as surface towed boomer.

One major limitation of the surveys at both sites was the adoption of a "corridor" survey approach – imposed by budgetary restrictions. Spacing acoustic survey lines (at times several km apart) in order to cover a greater area of seafloor undoubtedly leads to major problems in producing complete coverage habitat maps due to the requirement to interpolate features between lines where no acoustic data exists. This issue is reported in the scientific literature for single-beam surveys (e.g. Brown *et al,* 2005), and equally applied to the collection of swathe acoustic data sets. However, it should be noted that there are certain occasions (such as homogenous seabed) where the use of a corridor approach can provide satisfactory results (Boyd *et al, 2008*) depending on the resolution of the mapping required. While in an ideal world, full coverage acoustic surveys would be undertaken, and should be recommended where possible – there are cases such as this project where budgetary restrictions effectively limit the survey operation to gathering acoustic corridors, which may affect the confidence that can be placed on the final habitat mapped products.

6 Conclusions

6.1 Submarine structures in the mid-Irish Sea

- Methane derived authigenic carbonate (MDAC) is present at or near to the seabed over a significant part of the AoS. MDAC probably also extends to the west of the AoS.

- MDAC provides a habitat similar to stony reef.

- Regional distribution of MDAC might be related to deep structure, in detail distribution might be related to the geometry of beds in the Quaternary Prograding Facies and their outcrop at the seabed. This outcrop of MDAC enhanced sediment has formed some linear features in the AoS. The distribution might also relate to the location of conduits (faults) which allow migration of methane towards the seabed.

- Much of the MDAC on the sea floor is derived from erosion of crusts and takes the form of boulder or cobble sized fragments. This erosion has formed hollows and cliffs with significant topography at the seabed.

- Freshly exposed MDAC appears to be less extensively burrowed and associated with the presence of H_2S within finer grained sediment.

- Geochemical analysis of these cements show that the carbonate precipitation due to methane oxidation and is comparable to MDAC reported elsewhere

- The isotopic signature of the carbonate cements suggests that they formed in generally cooler conditions to the present day.

- In the Submarine structures in the mid-Irish Sea AoS, MDAC was the predominant reef-like habitat, but exposure of Quaternary clay rich sediments might also provide some substrates. The features in the AoS can be subdivided into exposed MDAC, areas with sediment bedforms (and thus possibly thicker sediment accumulation), and areas with low-relief shifting sediments over MDAC pavement.

- MDAC substratum can be split into 3 sub-types, high relief, low relief and uncolonised MDAC

- Though number of benthic individuals were found to be greater at MDAC ground-truth stations when compared to adjacent sediments no difference in species number, richness, diversity and biomass were observed.

- Several rare epi-faunal species were identified including a newly described species of sponge

- The submarine structures identified within the current AoS could be of great UK significance, due to the limited occurrences of other similar structures within UK waters.

6.2 Solan Bank

- Three forms of reef habitat are present within the Solan Bank AoS. These are; rocky reef outcrop of Lewisian basement rocks with joint planes and abundant fauna, with troughs infilled by sandy sediment, stony reef with linear ridges of eroded Quaternary moraine comprising boulders and cobbles and stony reef comprising fields of cobbles within areas of planar seabed. While the ridges of stony reef can be identified with some certainty from seabed imagery, the exact extent and nature of boulder fields are more difficult to predict.

- The seabed is covered in part by active sediment e.g. patches of rippled sand. Larger waveforms are rare.

- The majority of reef sites were characterised by encrusting fauna.

- An unidentified cup coral, and two species of sponge (*Oceanapia robusta)* and (*Poecillastra compressa*) classified as rare were identified within the Solan Bank AoS.

- Shallower sites where the bedrock protruded further from the surrounding sand supported a more diverse epi-faunal community.

- A number of new biotopes have been proposed for the Solan Bank. This is partly due to the location of the site in the north of UK waters.

- A limitation of the surveys at both sites, imposed by budgetary restrictions, was the adoption of a "corridor" survey approach.

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Appendix 1

1.1 Species Lists

1.1.1 Grab sample summaries: Submarine structures in the mid-Irish Sea AoS

Station code	Depth (m)	Selection criteria	Sediment description
G1	66	Ground truthing	Black anoxic sandy gravel with shell
G5a	70	Adjacent sediment	Fine to medium silty sand with shell fragments
G5b	70	MDAC	Two large fragments of MDAC. Very little sediment
G9a	80	Adjacent sediment	Very coarse gravel, intact and shell fragments present
G9b	80	MDAC	Crust with very fine sand and silt.
G12	93	Ground truthing	Coarse – very coarse shelly sand
G13	70	Ground truthing	Shelly sand
G16	75	Ground truthing	Muddy shelly gravelly sand with MDAC
G18a	77	MDAC	Silty coarse gravelly sand with MDAC and shell fragments
G18b	77	Adjacent sediment	Silty coarse gravelly sand with MDAC and shell fragments
G19a	76	MDAC	Muddy gravelly sand with cobbles
G19b	76	Adjacent sediment	Muddy sand with MDAC
G17a	71	MDAC	Silty medium to coarse clay rich sand, shell and MDAC fragments
G17b	71	Adjacent sediment	Silty medium to coarse clay rich sand, shell and MDAC fragments
G20a	67	MDAC	MDAC
G20b	67	Adjacent sediment	Sand
G22a	75	MDAC	MDAC with shelly sand
G22b	75	Adjacent sediment	Shelly, pebbly sand with cobbles

1.1.2 Species list generated from Hamon grab samples: Submarine structures in the mid-Irish Sea AoS

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
	ANIMALIA (eggs)	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
	Astrorhiza	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	Lagotia viridis	-	-	-	-	-	-	-	-	-	-	P	-	P	-	-	-	-
C0001	PORIFERA	-	P	P	P	P	P	P	-	P	P	P	-	-	-	-	-	-
C0053	*Leucosolenia* (?)	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-
C0133	*Scypha ciliata*	-	-	-	-	P	-	-	-	-	P	-	-	-	-	P	-	-
C0475	*Cliona*	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D0158	Tubulariidae	-	P	P	P	P	P	P	P	P	P	P	P	P	-	P	P	P
D0216	FILIFERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-
D0218	*Eudendrium*	-	-	P	P	-	-	-	P	-	P	P	-	-	-	-	-	-
D0246	*Bougainvilliidae*	-	P	-	-	P	-	-	-	-	-	-	-	-	-	P	-	-
D0306	*Modeeria rotunda*	-	P	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
D0348	*Calycella syringa*	-	P	-	P	-	-	-	-	-	-	-	P	-	-	-	-	P
D0386	*Lafoea dumosa*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
D0390	*Halecium*	-	-	-	-	-	-	-	P	-	-	-	P	-	-	-	-	-
D0413	*Diphasia*	-	-	P	P	P	-	-	-	-	P	P	-	-	P	-	-	P
D0424	*Hydrallmania falcata*	-	-	-	P	-	-	P	-	-	-	-	-	-	-	-	-	-
D0427	*Sertularella*	-	-	P	P	P	-	-	-	-	P	P	-	P	P	-	-	-
D0433	*Sertularia*	-	-	-	-	-	-	-	-	-	P	-	P	-	P	-	-	P
D0462	*Nemertesia*	-	-	-	-	P	-	-	-	-	-	P	-	P	-	-	-	-
D0482	*Aglaophenia tubiformis*	-	P	P	-	P	P	-	-	-	-	-	-	-	-	P	-	-
D0491	*Campanulariidae*	-	-	-	-	-	-	-	P	-	-	-	P	P	-	-	P	-
D0499	*Rhizocaulus verticillatus*	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-
D0503	*Clytia hemisphaerica*	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D0597	*Alcyonium digitatum*	-	-	-	-	P	-	-	-	-	-	P	-	P	-	-	-	-
D0632	*Cerianthus lloydii*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
D0649	*Epizoanthus couchii*	-	-	-	-	-	-	-	-	-	16	-	-	-	-	-	-	-
D0662	ACTINIARIA	-	1	1	1	14	-	-	2	12	4	9	-	8	-	1	6	7
G0001	NEMERTEA	-	17	2	9	20	2	-	-	2	2	7	3	6	-	4	6	12
HD0001	NEMATODA	88	2	2	1	10	6	1	11	-	4	7	2	6	-	1	2	2
K0045	*Pedicellina*	-	P	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-
K0050	*Barentsia*	-	P	-	-	-	-	P	-	-	P	-	-	-	-	-	-	-
N0014	*Golfingia elongata*	-	-	3	1	11	-	-	4	-	1	28	2	4	-	1	1	1
N0017	*Golfingia vulgaris*	-	-	1	-	-	-	-	-	-	-	2	1	1	1	-	-	-
N0025	*Nephasoma minutum*	-	-	-	1	8	-	-	2	-	4	5	-	-	-	-	-	-
N0028	*Thysanocardia procera*	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
O0009	*Thalassema thalassemum*	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	1	-
P0015	*Pisione remota*	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
P0019	*Aphrodita aculeata* (juv.)	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0032	*Subadyte pellucida*	-	-	-	P	1	-	-	-	-	1	-	-	-	-	-	-	-
P0058	*Harmothoe extenuata*	-	-	-	1	1	-	-	-	1	2	2	-	-	-	-	-	-
P0059	*Harmothoe fragilis*	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
P0065	*Harmothoe impar*	-	-	-	1	-	-	-	-	-	1	3	-	-	-	-	-	1

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
P0062	*Malmgreniella glabra*	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0067	*Malmgreniella arenicolae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
P0082	*Lepidonotus squamatus*	-	-	3	-	4	-	-	-	-	-	4	-	4	-	2	1	-
P0084	*Polynoe scolopendrina*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
P0092	*Pholoe baltica (sensu petersen)*	-	4	-	-	2	-	-	3	1	-	2	-	2	-	-	3	2
P0094	*Pholoe inornata (sensu petersen)*	-	1	3	1	-	-	-	-	-	-	-	1	2	-	-	-	-
P0107	*Sthenelais boa*	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
P0114	*Phyllodocidae (epitoke)*	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
P0122	*Hesionura elongata*	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
P0143	*Anaitides longipes*	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
P0152	*Eulalia bilineata*	-	-	1	2	2	-	-	1	2	3	-	-	2	-	-	1	2
P0153	*Eulalia expusilla*	-	-	1	-	1	-	-	-	-	-	-	-	-	1	-	-	-
P0155	*Eulalia mustela*	-	1	-	-	-	-	-	2	-	-	-	-	1	-	-	1	-
P0156	*Eulalia ornata*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0167	*Eumida sanguinea*	-	-	-	-	1	-	-	2	-	1	-	1	-	-	-	-	1
P0174	*Notophyllum foliosum*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
P0191	*Sige fusigera*	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
P0256	*Glycera alba*	-	-	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-
P0259	*Glycera fallax*	-	-	-	1	-	-	-	-	1	-	-	-	1	-	-	-	-
P0260	*Glycera lapidum* (agg.)	-	4	-	5	1	-	-	7	4	1	-	1	-	-	1	2	4
P0262	*Glycera oxycephala*	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
P0263	*Glycera rouxii*	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
P0268	*Glycinde nordmanni*	-	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1
P0271	*Goniada maculata*	1	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
P0272	*Goniada norvegica*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0276	*Goniadella gracilis*	-	-	-	-	-	-	P	-	-	-	-	1	-	-	-	-	-
P0305	*Psamathe fusca*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
P0311	*Nereimyra punctata*	-	-	-	-	2	-	-	-	-	-	1	-	1	-	-	-	-
P0317	*Ophiodromus pallidus*	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
P0319	*Podarkeopsis capensis*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
P0321	*Syllidia armata*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
P0338	*Ancistrosyllis groenlandica*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
P0358	*Syllis*	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	2	-
	Syllis "species A"	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0365	*Syllis armillaris*	-	-	1	-	7	-	-	4	-	4	2	4	3	-	-	-	-
P0349	*Syllis cornuta* (agg.)	-	-	-	-	-	-	1	5	-	-	-	1	5	-	-	1	-
P0371	*Syllis variegata*	-	-	1	1	7	-	-	-	-	2	8	-	4	-	1	-	-
P0380	*Eusyllis blomstrandi*	-	1	3	3	1	-	-	1	-	-	1	-	3	-	-	-	1
	Palposyllis	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
P0406	*Syllides*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
P0406	*Syllides* (epitoke)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
P0422	*Exogone naidina*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0423	*Exogone verugera*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
P0430	*Sphaerosyllis taylori*	-	-	-	1	-	-	-	1	-	-	-	-	-	3	-	-	-
P0434	*Autolytus*	-	-	7	-	1	-	-	-	-	4	2	-	1	-	-	-	1

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
P0434	*Autolytus* (epitoke)	-	-	-	-	-	-	-	-	-	2	1	-	2	-	-	-	-
P0451	*Proceraea*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P0455	*Procerastea*	-	-	P	1	-	-	-	-	-	-	2	-	-	-	-	-	-
P0458	*Nereididae*	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
P0475	*Eunereis longissima*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
P0478	*Nereis zonata*	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
P0487	*Websterinereis glauca*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0493	*Aglaophamus rubella*	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-
P0494	*Nephtys* (juv.)	-	1	-	1	1	-	-	-	-	-	1	-	1	-	-	-	-
P0502	*Nephtys kersivalensis*	-	1	1	2	-	-	-	-	1	1	11	-	2	-	4	1	-
P0528	*Euphrosine foliosa*	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
P0556	*Eunice harassii*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
P0560	*Eunice vittata*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0562	*Lysidice ninetta*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P0564	*Marphysa bellii*	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0568	*Nematonereis unicornis*	1	2	1	1	2	-	-	1	2	-	1	-	3	-	1	4	2
P0579	*Lumbrineris gracilis*	-	12	-	14	14	-	-	1	10	P	6	1	8	-	1	2	2
	Scoletoma magnidentata	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	1
P0589	*Drilonereis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
P0597	*Notocirrus scoticus*	-	P	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
P0638	*Protodorvillea kefersteini*	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
P0661	*Orbinia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
P0672	*Scoloplos armiger*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
P0684	*Aricidea catherinae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
P0685	*Aricidea cerrutii*	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
P0690	*Cirrophorus branchiatus*	-	-	-	3	1	-	-	1	2	-	-	-	-	-	-	1	1
P0699	*Paradoneis lyra*	-	-	-	-	1	-	-	2	2	-	2	-	-	-	-	-	1
P0712	*Apistobranchus tullbergi*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0718	*Poecilochaetus serpens*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P0722	*Aonides oxycephala*	-	-	-	P	-	-	-	-	1	-	-	-	-	-	-	-	-
P0723	*Aonides paucibranchiata*	-	2	-	-	-	-	-	15	-	-	-	4	3	1	-	-	-
P0731	*Laonice* (juv.)	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0733	*Laonice bahusiensis*	-	1	-	-	3	-	3	1	3	-	-	1	2	-	-	1	-
P0750	*Polydora caeca* (agg.)	-	1	1	1	16	-	-	2	1	2	2	1	5	-	2	-	3
P0751	*Polydora caulleryi*	-	-	1	1	-	-	-	3	-	-	1	-	1	-	-	-	1
	Scolelepis korsuni (?)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
P0796	*Spiophanes kroyeri*	-	7	-	11	5	-	-	10	7	2	6	2	14	-	10	24	9
P0818	*Spiochaetopterus*	-	-	P	-	1	-	-	-	-	2	-	-	1	-	-	-	-
P0823	*Aphelochaeta*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	Aphelochaeta "species A"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
P0829	*Caulleriella alata*	-	1	-	-	1	-	-	-	1	1	2	-	6	-	-	1	-
P0836	*Cirratulus cirratus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0838	*Cirriformia* (juv.)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0840	*Dodecaceria*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P0843	*Monticellina*	-	-	-	1	2	-	-	-	3	-	-	-	-	-	-	-	1
P0846	*Tharyx killariensis*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
P0881	*Flabelligera affinis*	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
P0884	*Pherusa flabellata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
P0906	*Capitella*	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P0919	*Mediomastus fragilis*	-	9	-	7	10	-	-	13	6	-	9	1	5	-	1	1	2
P0920	*Notomastus*	-	-	-	2	3	-	-	5	2	-	3	2	9	-	-	2	P
P0925	*Peresiella clymenoides*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
P0955	*Clymenura*	-	4	-	1	-	-	-	4	1	-	-	7	3	-	-	4	-
P0964	*Euclymene oerstedii*	-	1	-	4	-	-	-	-	4	-	-	-	-	-	-	6	6
P0971	*Praxillella affinis*	-	2	-	1	-	-	-	-	4	-	-	1	2	P	3	3	9
P0982	*Nicomache trispinata*	-	-	P	-	29	-	-	1	-	3	2	-	-	-	-	-	-
P0985	*Petaloproctus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P1000	*Ophelia celtica*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
P1022	*Asclerocheilus intermedius*	-	-	-	-	-	-	-	7	-	1	1	1	1	-	-	-	-
P1029	*Sclerocheilus minutus*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
P1062	*Polygordius*	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-
P1093	*Galathowenia oculata*	-	13	-	8	15	-	-	-	2	P	6	-	7	P	2	9	10
P1098	*Owenia fusiformis*	-	2	-	2	10	-	-	2	2	2	5	1	1	-	2	4	1
P1102	*Amphictene auricoma*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P1117	*Sabellaria spinulosa*	-	12	46	66	50	-	-	30	47	12	32	19	59	P	69	29	60
P1122	*Melinna elisabethae*	-	1	2	-	2	-	-	-	1	-	3	-	5	-	16	12	4
P1139	*Ampharete lindstroemi*	-	55	-	16	14	-	-	-	25	3	16	1	23	1	15	38	24
P1147	*Anobothrus gracilis*	-	6	1	2	-	-	-	-	5	-	8	-	1	-	4	3	4
P1160	*Sabellides octocirrata*	-	-	-	7	5	-	-	1	5	1	12	-	10	-	13	3	11
P1175	*Terebellides stroemi*	-	4	-	1	-	-	-	-	1	-	1	-	4	-	-	1	1
P1177	*Trichobranchus glacialis*	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-
P1179	*Terebellidae* (juv.)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P1185	*Amphitritides gracilis*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
P1187	*Axionice maculata*	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-
P1189	*Eupolymnia nebulosa*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
P1190	*Eupolymnia nesidensis*	-	-	-	-	1	-	-	-	1	1	1	-	-	-	2	-	-
P1193	*Lanassa venusta*	-	-	-	7	1	-	-	-	-	-	-	-	2	-	2	-	-
P1195	*Lanice conchilega*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P1210	*Nicolea venustula*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P1211	*Nicolea zostericola*	-	1	2	-	1	-	1	-	-	-	1	-	-	-	1	-	-
P1215	*Phisidia aurea*	-	-	5	5	1	-	-	-	-	2	4	-	1	-	1	-	-
P1235	*Polycirrus*	-	3	1	P	1	-	-	7	P	1	2	1	1	-	1	-	-
P1254	*Thelepus cincinnatus*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P1263	*Branchiomma bombyx*	-	1	1	1	7	-	-	-	-	-	2	-	-	-	1	-	-
P1264	*Chone*	-	3	7	3	-	-	-	-	-	2	-	-	3	-	-	-	-
P1269	*Chone filicaudata*	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
P1271	*Demonax*	-	-	-	-	2	-	-	1	-	1	-	-	-	-	-	-	-
P1277	*Euchone*	-	3	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-
P1290	*Jasmineira elegans*	-	2	2	1	9	-	-	-	1	5	22	-	-	-	-	-	-
P1298	*Myxicola*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P1316	*Pseudopotamilla reniformis*	-	-	-	-	-	-	-	-	-	1	1	-	3	-	-	-	-
P1318	*Sabella discifera*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
P1320	*Sabella pavonina*	-	-	-	-	1	-	-	-	-	-	-	-	1	-	5	-	-
P1324	*Serpulidae*	-	-	-	1	1	-	-	-	2	-	2	-	-	1	P	-	-
P1334	*Hydroides norvegica*	-	1	1	1	-	-	-	-	-	1	8	-	-	-	-	-	-
P1343	*Serpula vermicularis*	-	-	3	-	-	-	-	-	-	-	-	-	3	-	-	-	-
P1362	*Spirorbidae*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
P1490	*Tubificoides benedii*	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
P1524	*Grania*	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Q0015	*Achelia echinata* (agg.)	-	-	12	1	18	-	-	1	-	1	8	-	4	1	4	-	-
Q0032	*Callipallene*	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Q0044	*Anoplodactylus petiolatus*	-	-	-	1	-	-	-	-	-	2	-	-	-	-	1	1	3
R0015	THORACICA	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
R0022	*Scalpellum scalpellum*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R0041	*Verruca stroemia*	-	-	-	-	15	-	-	-	-	4	2	3	3	1	-	-	-
R0076	*Balanus balanus*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R0120	*Sacculina gerbei*	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
R0142	COPEPODA (parasitic)	-	1	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-
S0151	*Stenopleustes nodifer*	-	-	5	-	-	-	-	-	-	1	1	-	-	-	-	-	-
S0158	*Amphilochus manudens*	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
S0191	*Metopa alderi*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
S0193	*Metopa borealis*	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
S0213	*Stenothoe marina*	-	2	1	2	-	-	-	-	1	-	2	-	1	-	3	-	1
S0275	*Acidostoma obesum*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
S0303	*Lysianassa ceratina*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
S0381	*Iphimedia nexa*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
S0429	*Ampelisca diadema*	-	1	8	1	15	-	-	1	3	-	11	-	32	-	48	5	3
S0438	*Ampelisca spinipes*	-	23	-	17	1	-	-	2	5	2	-	1	-	-	-	14	2
S0541	*Gammaropsis maculata*	-	2	-	1	8	-	-	1	1	3	5	-	21	P	-	-	1
S0552	*Photis longicaudata*	-	1	7	2	2	-	-	-	-	1	-	-	2	-	-	-	2
S0561	*Ericthonius* (female)	-	3	8	1	13	-	-	-	-	11	12	-	35	-	13	-	-
S0564	*Ericthonius punctatus*	-	2	8	-	7	-	-	-	-	6	4	-	20	-	14	-	-
S0577	*Aoridae* (female)	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1
S0583	*Autonoe longipes*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
S0588	*Leptocheirus hirsutimanus*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
S0621	*Unciola crenatipalma*	-	1	-	3	2	-	-	8	6	1	-	-	-	-	-	-	-
S0657	*Phtisica marina*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
S0659	*Pseudoprotella phasma*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S0792	*Gnathiidae* (female)	-	1	4	-	-	-	-	1	-	-	-	-	-	-	-	-	-
S0792	*Gnathiidae* (juv.)	-	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-
S0794	*Gnathia dentata*	-	1	7	-	-	-	-	-	1	2	1	1	-	-	-	-	-
S0901	*Munna*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1140	*Pseudoparatanais batei*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
S1197	*Bodotria scorpioides*	-	1	-	-	1	-	-	1	1	-	1	-	-	1	-	-	-
S1276	DECAPODA (eggs)	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
S1276	DECAPODA (zoea)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
S1421	*Upogebia stellata*	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
S1445	*Paguridae* (juv.)	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
S1448	*Anapagurus hyndmanni*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
S1474	*Galathea nexa*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
S1482	*Pisidia longicornis*	-	-	3	-	8	-	-	-	-	3	11	2	5	-	4	-	-
S1504	*Ebalia* (juv.)	-	-	-	3	-	-	-	-	-	-	-	1	-	-	-	-	1
S1508	*Ebalia tuberosa*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
S1518	*Hyas araneus* (juv.)	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
S1519	*Hyas coarctatus* (juv.)	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	-
S1522	*Achaeus cranchii*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
S1525	*Inachus* (juv.)	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-
	Macropodia parva	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1535	*Eurynome* (juv.)	-	-	1	-	-	-	-	-	1	1	1	-	-	-	1	-	1
S1536	*Eurynome aspera*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
S1555	*Atelecyclus rotundatus*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1609	*Monodaeus couchi*	-	-	-	-	8	-	-	-	1	3	5	-	7	-	2	-	5
	DIPTERA	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W0035	*Eleutheromenia sierra*	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
W0053	*Leptochiton asellus*	-	1	-	7	3	-	-	-	8	-	3	-	5	-	-	1	2
W0116	*Diodora graeca*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
W0377	*Pusillina sarsi*	-	-	1	-	2	-	-	-	-	2	3	-	-	-	-	-	-
W0371	*Onoba semicostata*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Polinices (juv.)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W0634	*Melanella alba*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
W0747	*Hinia incrassata*	-	-	-	-	1	-	-	-	-	3	3	-	2	-	-	-	-
W1028	*Cylichna cylindracea*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
W1243	NUDIBRANCHIA (eggs)	-	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W1317	*Trapania maculata*	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
W1267	*Dendronotus frondosus* (juv.)	-	1	-	-	3	-	-	-	-	-	-	-	1	-	-	-	-
W1270	*Doto*	-	-	6	2	1	-	-	-	1	-	8	-	3	-	1	-	-
W1292	*Embletonia pulchra*	-	-	-	-	-	-	-	1	-	-	-	-	2	1	-	-	-
W1482	*Aeolidiidae*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
W1445	*Eubranchus*	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
W1415	*Flabellinidae*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
W1431	*Cuthona*	-	-	-	-	-	-	-	-	-	-	1	-	-	1	3	-	-
W1570	*Nucula nucleus*	-	-	-	4	-	-	-	-	-	-	8	-	-	-	2	1	1
W1595	*Jupiteria minuta*	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
W1718	*Modiolarca tumida*	-	7	8	5	29	-	1	-	-	2	23	-	4	1	-	16	-
W1698	*Modiolus* (juv.)	-	1	-	2	3	-	1	-	1	-	2	1	1	-	-	-	4
W1702	*Modiolus modiolus*	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-
W1743	*Limaria loscombi*	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	-	-
W1768	*Pectinidae* (juv.)	-	-	1	-	5	-	-	-	-	2	-	-	9	-	-	-	-
	Palliolum furtivum (?)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	2
W1786	*Palliolum tigerinum* (juv.)	-	-	-	-	2	-	-	-	-	-	3	-	1	-	2	-	-
W1779	*Chlamys varia* (juv.)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
W1773	*Aequipecten opercularis* (juv.)	-	-	1	-	-	-	-	-	-	-	1	-	1	-	2	-	-
W1805	*Anomiidae* (juv.)	-	-	7	-	18	-	-	-	-	10	15	-	9	-	2	-	-
W1814	*Pododesmus patelliformis*	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
W1864	*Diplodonta rotundata* (juv.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
W1882	*Semierycina nitida*	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-
W1892	*Montacuta substriata*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
W1906	*Mysella bidentata*	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
W1921	*Astartidae* (juv.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
W1925	*Astarte sulcata*	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
W1929	*Goodallia triangularis*	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
W1951	*Parvicardium ovale*	-	-	-	-	4	-	-	-	-	1	-	-	-	-	-	-	1
W1977	*Spisula solida*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
W1982	*Lutraria*	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
W2059	*Abra alba*	-	6	51	2	-	-	2	-	7	4	5	-	5	-	-	-	1
W2061	*Abra nitida*	-	-	-	-	21	-	-	-	-	-	-	-	-	-	8	-	-
W2062	*Abra prismatica*	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
W2091	*Circomphalus casina* (juv.)	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-
W2110	*Tapes* (juv.)	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
W2113	*Tapes rhomboides*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
W2104	*Timoclea ovata*	-	13	1	1	-	-	-	-	2	1	3	1	2	3	1	3	3
W2147	*Mya truncata* (juv.)	-	-	-	3	-	-	-	-	1	-	11	-	-	-	-	1	-
W2152	*Sphenia binghami*	-	-	7	-	27	-	-	6	1	12	5	3	9	-	7	-	3
W2157	*Corbula gibba*	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
W2166	*Hiatella arctica*	-	2	10	-	6	-	-	8	1	5	9	1	6	-	1	-	-
W2227	*Thracia* (juv.)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W2247	*Lyonsia norwegica*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
W2252	*Pandora pinna*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0013	*Crisia*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
Y0027	*Tubulipora*	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0039	*Eurystrotos compacta*	-	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0054	*Entalophoroecia deflexa*	-	-	-	-	-	-	-	-	-	P	-	-	P	-	-	-	-
Y0076	*Alcyonidium diaphanum*	-	P	P	P	-	-	-	-	P	-	P	-	-	-	-	-	P
Y0080	*Alcyonidium mytili*	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
Y0081	*Alcyonidium parasiticum*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
Y0091	*Nolella*	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
Y0131	*Vesicularia spinosa*	-	P	-	P	P	-	P	-	-	P	P	-	-	P	-	-	-
Y0153	*Aetea*	-	-	-	P	-	-	-	-	-	-	P	-	-	-	-	-	-
Y0165	*Eucratea loricata*	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	P
Y0180	*Pyripora catenularia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-
Y0187	*Flustra foliacea*	-	-	-	P	-	-	-	-	P	P	-	P	P	P	P	-	-
Y0204	*Callopora dumerilli*	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0208	*Alderina imbellis*	-	-	-	P	-	P	-	-	-	-	-	-	-	-	-	-	-
Y0241	*Bugula avicularia*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
Y0256	*Bicellariella ciliata*	-	-	-	-	P	-	-	-	-	-	P	-	-	-	P	-	-
Y0261	*Beania mirabilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-
Y0279	*Scrupocellaria scruposa*	-	P	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
Y0299	*Cellaria*	-	P	-	P	-	-	-	P	-	P	-	-	P	-	-	-	-
Y0344	*Chorizopora brongniarti*	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-
Y0364	*Escharella immersa*	-	-	-	-	-	-	-	P	-	-	-	P	P	P	-	P	-

SDC	Taxon name	G01.ADJSED	G05.ADJSED	G05.MDAC	G09.ADJSED	G09.MDAC	G12.SED	G13.SED	G16.MDAC	G17.ADJSED	G18.ADJSED	G18.MDAC	G19.ADJSED	G19.MDAC	G20.ADJSED	G20.MDAC	G22.ADJSED	G22.MDAC
Y0370	*Escharella ventricosa*	-	P	-	P	-	-	-	-	-	-	P	-	-	-	-	-	P
Y0421	*Phylactella labrosa*	-	P	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0440	*Escharina johnstoni*	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0463	*Smittoidea reticulata*	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y0480	*Microporella ciliata*	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
Y0495	*Cellepora pumicosa*	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
Y0504	*Turbicellepora avicularis*	-	P	-	-	P	-	-	-	-	-	-	-	P	-	-	-	-
ZA0003	*Phoronis*	-	1	15	2	98	-	-	1	1	16	65	-	1	-	8	1	-
ZB0124	*Ophiothrix fragilis*	-	-	-	-	-	-	-	-	-	-	3	-	-	1	-	-	-
ZB0124	*Ophiothrix fragilis* (juv.)	-	-	1	1	3	-	-	-	-	-	10	-	-	-	-	-	-
ZB0148	*Amphiuridae* (juv.)	-	-	-	4	6	1	-	-	-	-	5	-	-	-	-	-	-
ZB0154	*Amphiura filiformis*	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
ZB0161	*Amphipholis squamata*	-	3	11	9	5	-	-	2	7	3	19	-	8	-	6	2	10
ZB0165	*Ophiuridae* (juv.)	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
ZB0190	ECHINOIDA (juv.)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
ZB0212	*Echinocyamus pusillus*	-	4	-	2	-	-	-	-	-	-	-	2	1	-	-	-	-
ZB0266	*Cucumariidae* (juv.)	-	1	-	-	2	-	-	-	1	-	1	-	2	-	1	-	1
ZB0272	*Paracucumaria hyndmani*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
ZB0291	*Leptosynapta*	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
ZC0012	ENTEROPNEUSTA	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	2	-
ZD0002	ASCIDIACEA	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
ZD0002	ASCIDIACEA (juv.)	-	-	12	1	2	-	-	-	-	11	7	-	1	-	-	-	-
ZD0041	*Didemnidae*	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ZD0078	*Perophora listeri*	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
ZD0084	*Ascidiella aspersa*	-	-	-	-	-	-	-	-	1	-	4	-	-	-	-	2	-
ZD0107	*Styela partita*	-	-	-	-	-	-	-	-	-	3	1	-	1	-	-	-	-
ZD0120	*Dendrodoa grossularia*	-	-	-	-	5	-	1	-	-	-	-	-	-	-	-	-	-
ZD0141	*Pyura tessellata*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
ZD0151	*Molgula manhattensis*	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-

1.1.3 Rock Dredge summaries and species list: Submarine structures in the mid-Irish Sea AoS

Rock dredge species list

Species	RD 04	RD 22
Acanthocardia sp.		
Aequipecten opercularis	P	
Alcyonidium diaphanum	P	
Alcyonium digitatum	P	
Ammodytes sp.	2	
Amphiura sp.		
Anomia sp	P	
Aphroditidae sp	P	
Ascidia conchilega	P	P
Bugula sp	P	
Caryophyllia smithii	P	
Cellaria sp	P	
Chlamys distorta	P	
Corynactis sp	P	
Ebalia sp		P
Eurynome sp	P	
Flustra foliacea	P	P
Galathia sp	P	
Holothuriidae sp		P
Hydrallmania falcata		P
Hydroids mixed		P
Hymedesmia sp	P	
Inachus sp	P	
Lanice conchilega	P	
Lepadomorpha sp		P
Lepidopleuridae sp		P
Nemertean sp		P
Nemertesia ramosa	P	P
Ophiothrix fragilis	P	
Ophiura ophiura		
Orbiniidae		P
Pagurus bernhardus	P	
Paphia rhomboides		P
Porifera sp	P	
Psammechinus miliaris	P	
Raspailia sp	P	
Sabella sp	P	
Sagartia elegans	P	P
Serpulidae	P	P
Sertularia sp	P	
Tubularia sp	P	

1.1.4 Hamon Grab sample summaries: Solan Bank AoS

Station code	Depth (m)	Selection criteria	Sediment description
G11	80	Ground truthing	Slightly gravelly sand with shell
G15	74	Ground truthing	Gravelly coarse sand
G21	97	Ground truthing	Clean sand
G23	101	Ground truthing	Muddy sandy gravel
G36a	71	Ground truthing	Coarse shelly sand
G36b	70	Ground truthing	Coarse shelly sand with gravel
G43	51	Ground truthing	Broken shell

1.1.5 Species list generated from Hamon grab samples: Solan Bank AoS

SDC	Taxon Name	G36 a	G36 b	G43 a	HG11 a	HG15 a	HG21 a	HG23 a
	ANIMALIA	-	-	P	-	-	-	-
	Lagotia viridis	-	P	-	-	-	-	-
D0632	*Cerianthus lloydii*	-	-	-	-	-	1	-
D0662	ACTINIARIA	-	-	-	-	-	-	1
D0759	Edwardsiidae	-	-	-	1	3	1	3
G0001	NEMERTEA	-	-	-	-	-	2	3
HD0001	NEMATODA	13	2	113	-	12	-	1
N0034	*Phascolion strombus*	-	-	-	-	1	-	-
N0047	*Aspidosiphon muelleri*	-	-	-	-	-	1	-
P0015	*Pisione remota*	2	-	50	-	3	-	2
P0062	*Malmgreniella glabra*	-	1	-	1	-	-	-
P0070	*Malmgreniella mcintoshi*	-	-	-	-	-	-	2
P0155	*Eulalia mustela*	-	1	-	-	-	-	P
P0156	*Eulalia ornate*	-	1	-	-	-	-	-
P0260	*Glycera lapidum* (agg)	2	1	21	-	3	-	-
P0276	*Goniadella gracilis*	3	2	P	3	2	-	1
P0305	*Psamathe fusca*	-	-	-	1	-	-	-
P0346	*Syllidae* (epitoke)	-	-	-	-	1	-	-
P0358	*Syllis*	-	P	-	-	-	-	-
	Syllis "species G"	-	-	5	-	-	-	-
P0365	*Syllis armillaris*	-	-	-	1	-	-	-
P0349	*Syllis cornuta* (agg)	1	-	-	-	2	-	-
P0362	*Trypanosyllis coeliaca*	-	-	1	-	2	-	-
P0377	*Dioplosyllis cirrosa*	-	-	2	-	-	-	-
P0391	*Opisthodonta pterochaeta*	1	-	-	-	-	-	-
P0423	*Exogone verugera*	1	-	-	-	-	-	-
P0425	*Sphaerosyllis bulbosa*	-	1	1	-	-	-	1
P0475	*Eunereis longissima*	-	-	-	-	-	-	3
P0493	*Aglaophamus rubella*	P	1	-	-	-	-	-
P0498	*Nephtys cirrosa*	1	-	-	-	-	-	-
P0502	*Nephtys kersivalensis*	-	-	-	-	1	-	-
P0539	*Aponuphis bilineata*	-	-	-	1	-	-	1
P0582	*Lumbrineris latreilli* (Type A)	-	-	-	-	1	1	-
P0579	*Lumbrineris gracilis*	-	-	-	-	-	-	1

SDC	Taxon Name	G36 a	G36 b	G43 a	HG11 a	HG15 a	HG21 a	HG23 a
P0638	*Protodorvillea kefersteini*	-	3	1	-	1	-	-
P0642	*Schistomeringos neglecta*	-	-	-	-	1	-	-
P0723	*Aonides paucibranchiata*	2	1	-	-	4	1	3
P0750	*Polydora caeca* (agg)	-	-	-	1	-	-	-
	Scolelepis korsuni	-	1	-	-	-	-	-
P0790	*Spio filicornis*	1	3	-	-	1	-	-
P0796	*Spiophanes kroyeri*	-	-	-	2	-	-	-
P0799	*Streblospio shrubsolii*	-	1	-	-	-	-	-
	Aphelochaeta "species A"	-	-	-	2	-	-	-
	Chaetozone "species D"	-	-	-	-	-	1	-
	Chaetozone christiei	-	-	-	2	-	1	-
P0889	*Macrochaeta*	-	-	-	-	-	-	1
P0920	*Notomastus*	-	P	-	1	1	1	5
P0955	*Clymenura*	-	-	-	-	-	P	1
P1022	*Asclerocheilus intermedius*	-	-	-	1	-	-	-
P1026	*Scalibregma celticum* (Type A)	-	-	-	-	-	-	1
P1062	*Polygordius*	1	-	42	-	-	-	2
P1093	*Galathowenia oculata*	-	-	-	-	-	P	-
P1098	*Owenia fusiformis*	-	-	-	-	1	-	1
P1117	*Sabellaria spinulosa*	-	-	P	-	-	-	-
P1118	*Ampharetidae* (juv)	-	-	-	-	-	-	1
P1190	*Eupolymnia nesidensis*	-	-	-	-	-	-	6
P1195	*Lanice conchilega*	-	-	-	1	-	1	2
P1211	*Nicolea zostericola*	-	1	-	-	-	-	-
P1218	*Pistella lornensis*	-	-	-	4	-	-	3
P1235	*Polycirrus*	-	1	-	2	1	1	1
P1249	*Parathelepus collaris* (?)	-	-	-	2	1	-	-
P1264	*Chone*	-	-	-	3	-	-	-
P1338	*Placostegus tridentatus*	-	-	-	1	-	-	-
P1524	*Grania*	1	-	-	-	-	-	-
Q0015	*Achelia echinata* (agg)	-	-	-	-	-	1	-
Q0044	*Anoplodactylus petiolatus*	-	-	-	-	-	1	-
R0041	*Verruca stroemia*	-	1	-	-	-	-	-
R0142	COPEPODA	2	11	1	2	9	-	1
S0031	*Mysidae*	-	-	-	-	-	-	P
S0296	*Hippomedon denticulatus*	-	-	-	-	1	-	-
S0413	*Atylus vedlomensis*	-	1	-	-	2	-	-
S0438	*Ampelisca spinipes*	-	-	-	1	2	-	1
S0539	*Gammaropsis cornuta*	-	-	-	-	-	-	1
S0544	*Gammaropsis sophiae*	-	-	-	-	-	-	1
S0792	*Gnathiidae* (juv)	-	1	-	-	-	-	-
S0793	*Gnathia* (Type A)	-	1	-	1	-	-	-
S1159	*Pseudotanaidae*	-	-	-	-	-	-	1
S1218	*Campylaspis legendrei*	-	-	-	-	1	-	-
S1447	*Anapagurus chiroacanthus*	-	1	-	-	-	-	-

SDC	Taxon Name	G36 a	G36 b	G43 a	HG11 a	HG15 a	HG21 a	HG23 a
S1472	*Galathea intermedia*	-	-	-	1	-	-	-
S1472	*Galathea intermedia* (megalopa)	-	-	-	1	-	-	-
S1508	*Ebalia tuberose*	-	-	-	-	-	-	1
W0053	*Leptochiton asellus*	-	-	-	4	-	-	-
	Polinices (juv)	-	-	-	-	1	-	-
W0491	*Polinices pulchellus*	-	-	-	1	-	-	-
W1715	*Crenella decussate*	-	-	1	-	1	-	-
W1746	*Limatula subauriculata*	-	1	-	-	2	-	1
W1768	*Pectinidae* (juv)	-	-	-	13	-	-	-
W1786	*Palliolum tigerinum*	-	-	-	-	1	-	-
W1803	*Similipecten similis*	-	-	-	-	-	-	4
W1902	*Tellimya ferruginosa*	-	-	2	-	-	-	-
W1929	*Goodallia triangularis*	1	-	4	-	-	-	-
W1973	*Spisula* (juv)	1	1	1	-	-	-	-
W1975	*Spisula elliptica*	-	-	-	-	-	1	-
W1975	*Spisula elliptica* (juv)	-	-	1	-	1	-	-
W2023	*Moerella pygmaea*	3	1	4	-	-	1	-
W2049	*Gari tellinella* (juv)	-	1	-	-	-	-	-
W2062	*Abra prismatica*	-	-	-	-	-	1	-
W2126	*Dosinia* (juv)	-	-	-	-	-	-	1
W2104	*Timoclea ovata*	-	1	-	-	-	-	-
W2227	*Thracia* (juv)	1	-	2	-	-	-	-
Y0027	*Tubulipora*	-	-	-	P	P	-	-
Y0039	*Eurystrotos compacta*	-	P	-	-	P	-	P
Y0054	*Entalophoroecia deflexa*	-	-	-	-	-	-	P
Y0057	*Hornera lichenoides*	-	-	-	-	-	-	P
Y0066	*Disporella hispida*	-	-	-	-	P	-	P
Y0149	CHEILOSTOMATIDA (Type A)	-	P	-	-	-	-	-
Y0222	*Amphiblestrum auritum*	-	-	-	-	-	-	P
Y0223	*Amphiblestrum flemingii*	-	-	-	-	P	-	-
Y0332	*Hippothoa divaricata*	-	-	-	P	-	-	-
Y0333	*Hippothoa flagellum*	-	-	-	-	-	-	P
Y0344	*Chorizopora brongniarti*	-	-	-	P	-	-	-
Y0370	*Escharella ventricosa*	-	-	-	-	-	-	P
Y0423	*Schizoporella*	-	-	-	P	-	-	P
Y0465	*Parasmittina trispinosa*	P	P	-	P	-	-	-
Y0474	*Schizomavella linearis*	-	-	-	P	-	-	-
Y0480	*Microporella ciliata*	-	-	-	-	P	-	-
Y0508	*Omalosecosa ramulosa*	-	-	-	P	-	-	-
ZA0003	*Phoronis*	-	-	-	-	-	-	1
ZB0075	*Crossaster papposus* (juv)	-	-	-	1	-	-	-
ZB0124	*Ophiothrix fragilis*	-	-	-	-	P	-	-
ZB0148	*Amphiuridae* (juv)	-	-	1	-	2	-	1
ZB0154	*Amphiura filiformis*	-	1	-	-	-	-	-
ZB0157	*Amphiura securigera*	-	-	-	-	-	-	1

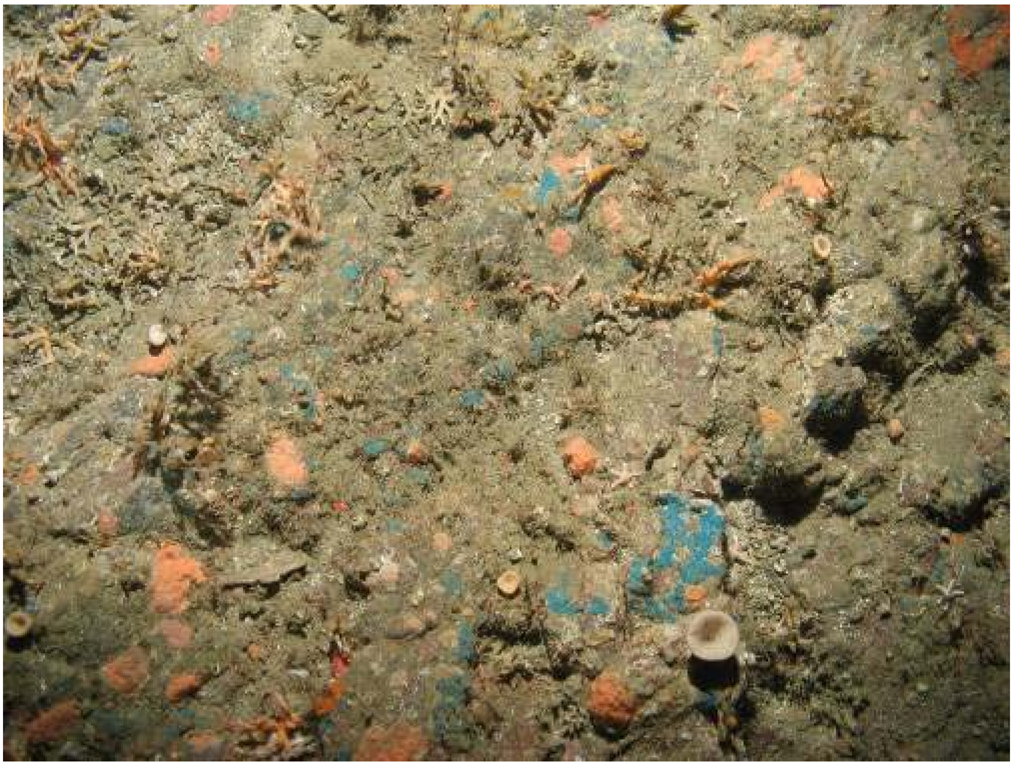
SDC	Taxon Name	G36 a	G36 b	G43 a	HG11 a	HG15 a	HG21 a	HG23 a
ZB0165	*Ophiuridae* (juv)	1	6	-	2	13	-	3
ZB0212	*Echinocyamus pusillus*	-	-	-	2	-	-	-
ZB0213	SPATANGOIDA (juv)	-	-	-	1	-	-	-
ZD0002	ASCIDIACEA (juv)	4	3	-	1	16	-	-
ZD0112	*Polycarpa fibrosa*	-	-	-	-	-	1	-
ZD0116	*Polycarpa scuba*	-	1	-	-	1	-	-
ZD0159	*Eugyra arenosa*	-	1	-	2	2	-	-
	Branchiostoma lanceolatum	-	-	1	-	-	-	-
ZG0001	OSTEICHTHYES (eggs)	-	-	1	-	-	-	-
ZG0443	*Ammodytes marinus*	-	-	1	-	-	-	-

1.1.6 Species list generated from Rock dredge samples: Solan Bank AoS

Species	RD 09	RD 10	RD 16	RD 18
Encrusting bryozoa		P	P	P
Asterias rubens		P		
Amphiura sp.	P	P		P
Anomia sp.	P			
Ascidia sp.				P
Flustra foliacea			P	
Hydroids mixed	P	P	P	P
Encrusting *Porifera* sp.	P		P	
Porella sp.		P	P	
Serpulidae	P	P	P	P

Appendix 2. Example biotope stills images

CR.HCR.FaT.CTub.Adig



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CR.MCR.EcCr.CarSp.Bri.1


CR.HCR.XFa.SpAnVE

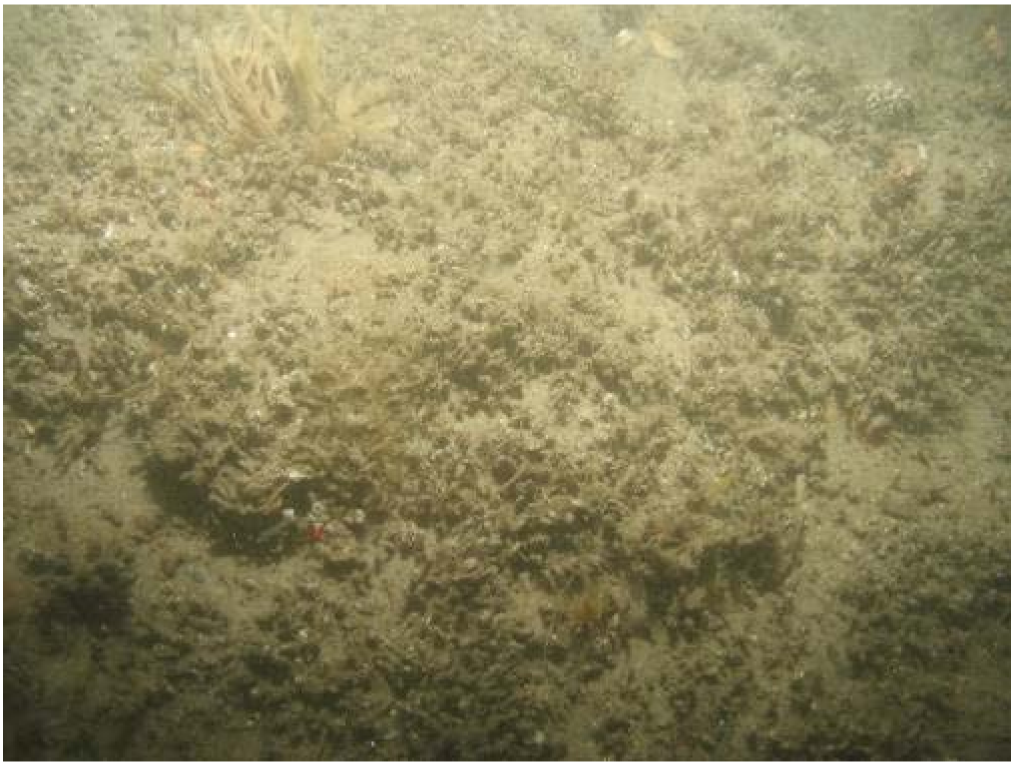

IR.HIR.KFaR.Lhyp.Pk

SS.SMx.OMx

SS.SCS.OCS

SS.SSa.OSa

CR.MCR.SfR.MDAC.1



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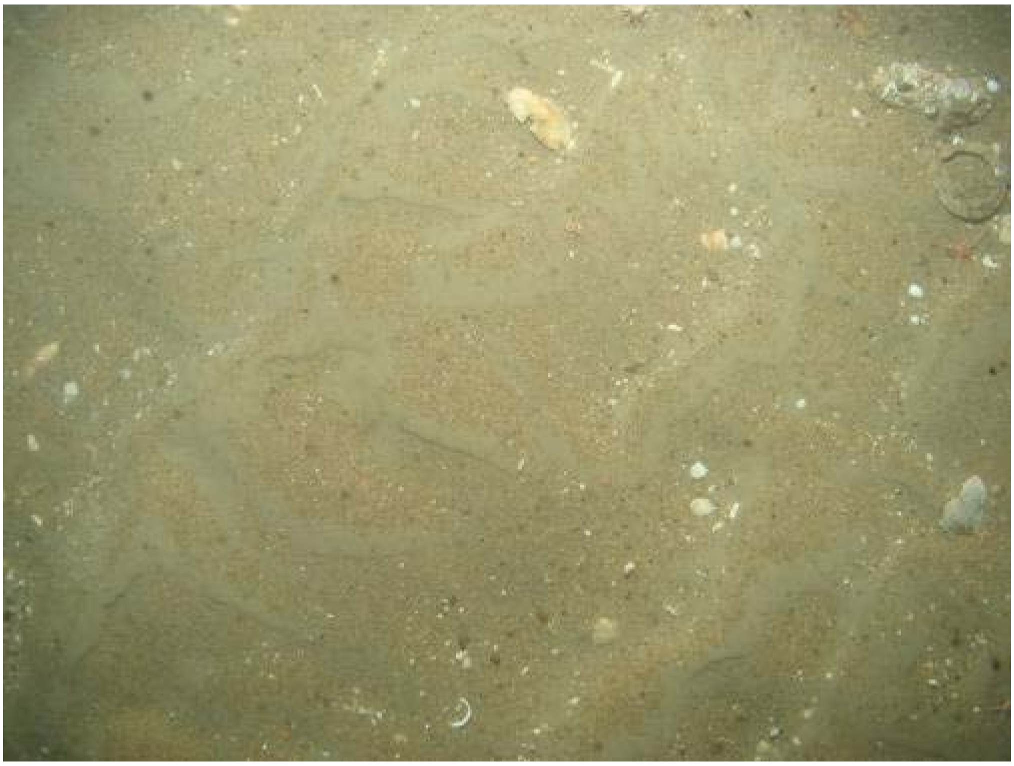
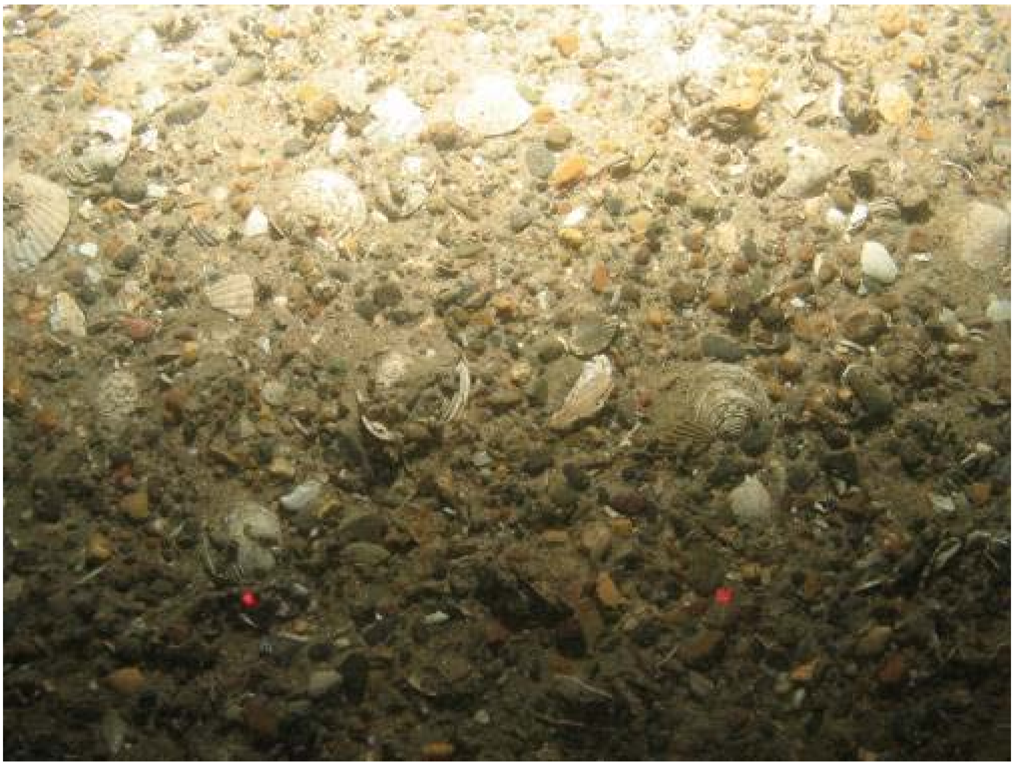


SS.SCS.CCS

SS.SCS.CCS.MDAC

SS.SCS.CCS.Clay



SS.SMx.CMx

Appendix 3. New biotope proposal forms

Unique ID	Fits within higher EUNIS type	Change in definition of higher type	Why proposed habitat differs from other types?	Habitat title	Salinity	Wave exposure	Tidal streams	Substratum	Zone
EUNIS database table					Salinity	Exposure	Exposure	Substrate	Altitude
A4.23_UK01	A4.23	Should mention that soft rock can include methane-derived authigenic carbon	Consistently different substratum; rock is MDAC and possibly supports a different species assemblage as well as being a fairly unique substratum	Erect bryozoans and hydroids with *Sabellaria spinulosa* and anemones on MDAC	Full (30-35ppt)	Sheltered	Moderately strong	Soft rock (MDAC) with significant proportion of fine to medium sand and muddy sand	Circalittoral
A4.2122_UK01	A4.2122	None required	Very similar to existing CR.MCR.EcCr.CarSp.PenPcom but consistently no *Pentapora fascialis*, and northern variants of other species	*Porella compressa* with cup corals, sponges, *Cellapora pumicosa* and crustose communities on wave-exposed circalittoral rock	Full (30-35ppt)	Moderately exposed	Moderately strong	Bedrock or stable boulder dominated, with frequent coarse sand veneer	Circalittoral

Unique ID	Fits within higher EUNIS type	Change in definition of higher type	Why proposed habitat differs from other types?	Habitat title	Salinity	Wave exposure	Tidal streams	Substratum	Zone
EUNIS database table					Salinity	Exposure	Exposure	Substrate	Altitude
A4.2121_UK01	A4.2121	None required	Very similar to existing CR.MCR.EcCr.CarSp.Bri but notable northern variants of species	Brittlestars overlying coralline crusts, Parasmittina trispinosa and Caryophyllia smithii on wave-exposed circalittoral rock, northern version	Full (30-35ppt)	Moderately exposed	Moderately strong	Stable boulders and cobbles or bedrock, with significant proportion of mobile coarse sediments	Circalittoral

Height/depth band	Features	Habitat description	Situation	Temporal variation	Anthropogenic influence	Geographic distribution
Depth	Geomorphology					
50-100m	Methane derived authigenic carbon representing >10% of substratum, surrounded by mobile fine sand and muddy sand, with significant whole and broken shell	In deep, circalittoral fine sand with a significant proportion of shell (less than 5% silt/clay) soft rock structures consisting entirely of MDAC, and accounting for >10% of the seabed, exhibit notable populations of erect bryozoans including *Eucratea loricata*, *Flustra foliacea* and *Vesicularia spinosa*, along with the erect hyrdoids *Diphasia pinaster*, *Tubularia indivisa* and *Nemertesia* spp. The anemones *Sargartia troglodytes* and *Ceriathus lloydi* may be locally common, and *Urticina* (*eques*) also notable in many areas. *Alcyonium digitatum* is occasionally found on tops of high relief outcrops, along with the sponges *Cliona celata* and *Iophonopsis nigricans*. The worms *Sabella pavonina* and *Sabellaria spinulosa* are occasionally to frequently abundant. The MDAC itself is burrowed by *Hiatella artica*, and in many areas *Sabellaria spinulosa* tubes entirely cover lower relief MDAC. *Lanice conchilega* may also be locally abundant. This biotope is similar to other soft rock biotopes but made unique by the lithology. Two versions of the biotope may be described: one showing significant proportions of high relief MDAC outcrops (>10% colonised high relief MDAC) and thus a more established community of erect filter feeders including *A. digitatum*, *D. pinaster*, *T. indivisa* and sponges; second showing significant proportions of low relief MDAC outcrops (>10% low relief MDAC) which are characterised by *Sabellaria spinulosa* and other worm tubes.		Unknown	Natural	Irish Sea
40-110m		In deep, moderately exposed circalittoral bedrock or boulder dominated areas, notable populations of the erect calcareous bryozoan *Porella compressa* occur along with significant encrusting bryozoans, including *Parasmittina trispinosa* and *Cellapora pumicosa*. Cup corals (*Caryphyllia smithii*, and an unidentified smaller coral) and the sponges *Hymedesmia paupertus*, *Axinella infundibuliformis*, *Polymastia boletiformis*, *Tethya norvegica*/*hibernica* and *Stelligera stuposa* are notable. *Securiflustra securifrons* is also occasionally encountered. The biotope shows some evidence of sand scour, and appears to exhibit a different assemblage from the existing CR.MCR.EcCr.CarSp.PenPcom biotope. Two variants are proposed: one showing a less sand-scoured assemblage, replete with a richer diversity of sponges and erect hydroids, and a second more sand-scoured variant, showing an increase in the cover of keel worms (*Pomatoceros triqueter*), fewer sponges and increased erect bryozoans *Flustra foliacea* and *Securiflustra securifrons*.		Unknown	Natural	Scottish Continental Shelf

Height/depth band	Features	Habitat description	Situation	Temporal variation	Anthropogenic influence	Geographic distribution
Depth	Geomorphology					
48-110m		In deep, moderately exposed circalittoral boulder-dominated and occasionally bedrock dominated areas abundant populations of the brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* result in a scoured environment of bryozoan and coralline crusts, with *Parasmittina trispinosa* frequent, and significant populations of the keel worm *Pomotoceros triqueter* and the gastropod *Hinia incrassata* characteristic. The cup coral *Caryophyllia smithii* and anemone *Urticina eques* also characterise this environment, along with rare to occasional *Alcyonium digitatum*, *Antedon pertasus*, *Stichastrella rosea* and *Axinella infundibuliformis*.		Unknown	Natural	Scottish Continental Shelf

A4.23_UK01: Erect bryozoans and hydroids with *Sabellaria spinulosa* and anemones on MDAC

Epibiota: Taxon abundance type	Semi-quantitative (SACFOR) - mean
Eucratea loricata	Frequent
Flustra foliacea	Frequent
Vesicularia spinosa	Frequent
Diphasia pinaster	Occasional
Tubularia indivisa	Occasional
Nemertesia antennina	Occasional
Nemertesia ramosa	Occasional
Sagartia troglodytes	Frequent
Cerianthus lloydi	Occasional
Alcyonium digitatum	Occasional
Cliona celata	Rare
Iophonopsis nigricans	Rare
Urticina eques	Rare
Sabella pavonina	Occasional
Sabellaria spinulosa	Abundant
Lanice conchilega	Occasional
Asterias rubens	Rare
Pagurus	Rare
Sphenia binghami	Present
Anomidae sp.	Present
Autolytus sp.	Present
Ampelisca diadema	Present
Hiatella arctica	Present
Phoronis sp.	Present

A4.2122_UK01: *Porella compressa* with cup corals, sponges, *Cellapora pumicosa* and crustose communities on wave-exposed circalittoral rock

Epibiota: Taxon abundance type	Semi-quantitative (SACFOR) - mean
Porella compressa	Frequent
Parasmittina trispinosa	Common
Cellapora pumicosa	Frequent
Caryophyllia smithii	Occasional
Unknown colonial small cup coral	Rare
Hymedesmia paupertus	Frequent
Axinella infundibuliformis	Occasional
Polymastia boletiformis	Occasional
Tethya norvegica/hibernica	Rare
Stelligera stuposa	Rare
Securiflustra securifrons	Occasional
Flustra foliacea	Rare
Encrusting corallines	Rare
Ophiactis balli	Occasional
Pomatoceros triqueter	Occasional

A4.2121_UK01: Brittlestars overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock, northern version

Epibiota: Taxon abundance type	Semi-quantitative (SACFOR) - mean
Ophiothrix fragilis	Superabundant
Ophiocomina nigra	Abundant
Parasmittina trispinosa	Frequent
Pomatoceros triqueter	Common
Hinia incrassata	Occasional
Antedon pertasus	Rare
Stichasterlla rosea	Rare
Axinella infundibuliformis	Occasional
Caryophyllia smithii	Occasional
Alcyonium digitatum	Occasional
Urticina eques	Rare