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The identification of the main characteristics of stony reef habitats under the Habitats Directive

R. Irving

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NIEA Northern Ireland Environment Agency
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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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Executive Summary

Joint Nature Conservation Committee (JNCC) invited representatives from a range of organisations with an interest in stony reefs to a workshop in Peterborough on 26 and 27 March 2008. The main focus of the workshop was to clarify the definition of 'stony reef' under the Habitats Directive and to help with recognising those areas of the seabed which can be classed as stony reef, and those areas which would fall outside this definition.

A number of presentations were made featuring examples of stony reefs, some of which had already been listed as features within Special Areas of Conservation (SACs). These ranged from offshore, deep sea areas such as the Wyville Thomson Ridge off NW Scotland, to near-shore, shallow areas such as an extensive cobble area off the Yorkshire coast. The methods to detect these reefs were similar and included various acoustic techniques (such as multibeam surveys and side-scan sonar), drop and towed video, still photography and grab sampling. Consideration was given to various parameters associated with stony reefs in an attempt to determine which were considered the most important for reef identification:

- Physical composition – To qualify as a stony reef, 10% or more of the seabed substratum should be composed of particles greater than 64mm across, ie cobbles and boulders. The remaining supporting 'matrix' could be of smaller sized material. The reef may be consistent in its coverage or it may form patches with intervening areas of finer sediment.

- Biological cover – this would be determined by the physical nature of the reef and the environmental conditions affecting it. The greater the dominance of epifaunal species the higher the likelihood of an area of habitat being categorised as stony reef. Areas of seabed with a predominance of infaunal species indicate that a habitat would not be categorised as stony reef.

- Elevation – according to the Habitats Directive's Interpretation Manual, areas being considered as stony reefs have to 'arise from the seafloor' (ie be topographically distinct from the surrounding sea floor).

- Extent – it was agreed that the minimum area which could be considered as stony reef would be $25m^2$ (this $25m^2$ also applies to the total area of a patchy reef, rather than the minimum size for a patch). There would be no limit as to a maximum area.

- Quality – a reef's quality (a parameter likely to be of use to managers) could be assessed using a range of factors, including its physical structure, its associated epibiota, its stability and its functionality as a refuge or shelter for mobile fauna such as crustaceans and fish.

- Size & scale – it was appreciated that the assessment of reefs from both deep sea areas and shallow areas has associated with it difficulties of size and scale. For example, video footage along a narrow transect from a deep sea reef would only provide limited data for the reef as a whole.

- Iceberg plough-marks – these typically occur in depths shallower than 500m. They generally comprise two parallel ridges made up of cobbles and boulders separated by

a level area of finer sediment. These features could be considered as Annex I stony reefs if they met the 'reefiness' criteria outlined in Table 3.

- Interpretation – it was suggested that, once a set of parameters had been decided upon which would allow for stony reefs to be identified with some certainty, some form of illustrated leaflet or poster would be helpful for managers and the wider public for interpretation purposes.

The workshop concluded what would and would not be considered an Annex I stony reef; a summary table was produced (Table 3) to aid the assessment of 'reefiness'

Contents

1 Background

Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (commonly known as the Habitats Directive) is a European agreement that sets out a number of actions to be taken for nature conservation. This includes the requirement that Member States designate Special Areas of Conservation (SACs) that support certain habitats and species.

A series of marine SACs have already been designated around the coast of the United Kingdom as a contribution to the Natura 2000 network. JNCC and the Country Conservation Agencies are now working towards the identification of a second tranche of SACs 'away from the coast' (both within territorial waters and offshore waters).

One of the habitats listed in Annex I of the Habitats Directive for protection within Special Areas of Conservation is 'Reefs'. This habitat category includes bedrock, stony and biogenic variants. Stony reefs may comprise areas of boulders or cobble (cobbles are generally considered as being between 64mm and 256mm in diameter, and boulders as being greater than 256mm in diameter) which arise from the seafloor and provide a suitable substratum for the attachment of benthic communities of algae (when shallow enough) and animal species.

In order to assist with identifying those areas of seabed which could be classed as stony reefs, the Joint Nature Conservation Committee (JNCC) invited representatives from a range of organisations with an interest in the identification and management of stony reefs to a workshop in Peterborough on 26 and 27 March 2008. A list of participants is given in Appendix 3.

The main focus of the workshop was to clarify the interpretation of 'stony reef' as a sub-habitat of Annex I 'reefs' under the Habitats Directive and to help with recognising those areas of the seabed which can be classed as stony reef, and those areas which would fall outside this definition.

2 Presentations

2.1 Introduction: Charlotte Johnston, JNCC

This presentation briefly summarised stony reefs in the context of the Habitats Directive; the limitations of the existing definition for SAC selection; and looked at definitions of the relevant terminology.

Three important documents were relevant to the task in hand. These were:

- The Habitats Directive (92/43/EEC), which includes "Reefs" as Annex I Habitat 1170;
- The Interpretation Manual[1] for the Directive (most recently updated in May 2007) which provides explanations of the terms used in the Habitats Directive; and
- Additional, more detailed UK interpretation.

No definition of the term *reefs* is given in the Directive itself. Interpretation at a European level has been documented in several versions of the EC's Interpretation Manual, the most recent of which was agreed in 2007. Reefs are explained thus:

"Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions."

Box 1 lists a number of clarifications of the terms used in the above definition (as included in the Explanation of Terms). (Those in bold are relevant to the consideration of stony reefs.)

[1] Full title: *Interpretation Manual of European Union Habitats*. EUR 27. July 2007. European Commission, DG Environment. Nature and biodiversity.

BOX 1: Clarifications of terms used in the definition of reefs

Biogenic concretions are defined as: concretions, encrustations, corallogenic concretions and bivalve mussel beds originating from dead or living animals, ie biogenic hard bottoms which supply habitats for epibiotic species.

Geogenic origin - reefs formed by non biogenic substrata.***Hard compact substrata*** – rocks (including soft rock such as chalk), boulders and cobbles (generally >64mm in diameter). ***Arise from the sea floor*** – the reef is topographically distinct from the surrounding sea floor.

Sublittoral and littoral zone - reefs may extend from the sublittoral uninterrupted into the intertidal (littoral) zone or may only occur in the sublittoral zone, including deep water areas such as the bathyal.**Such** hard substrata that are covered by a thin and mobile veneer of sediment **are classed as reefs if the associated biota are dependent on the hard substratum rather than the overlying sediment.**Where an uninterrupted zonation of sublittoral and littoral communities exist, the **integrity of the ecological unit** should be respected in the selection of sites. A variety of subtidal topographic features are included in this habitat complex such as: hydrothermal vent habitats, sea mounts, vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock and **boulder and cobble fields.** There is no minimum **size** given for a reef, subject to the reef being large enough to maintain its structure and functions. It may be **patchy** and there is also **no maximum depth** limit.

For UK waters, Annex I reefs have been categorised into three broad sub-types: these are bedrock reefs, stony reefs and biogenic reefs (see Figures 1 and 2). This workshop and report only considered stony reefs as there was a perceived need for further interpretation of what does or does not constitute Annex I stony reef (a previous workshop on defining *Sabellaria spinulosa* reef was held by JNCC in May 2007 (Gubbay, 2007)).

Thus, the two main relevant points from the EC interpretation for stony reefs are:

- They comprise hard, compact substrata (typically boulders & cobbles) which are generally greater than 64mm in size.

- They arise from the seafloor (are topographically distinct from surrounding seafloor).

The following characteristics now need to be addressed:

- Substratum – size/proportion of particle size? How to judge/measure?
- Size/area How to judge/measure?
- Patchiness How to judge/measure?
- Topographic distinctness/elevation How to judge/measure?

Questions:

There is no minimum size for what might be interpreted as a 'stony reef' but is there a maximum limit?

No.

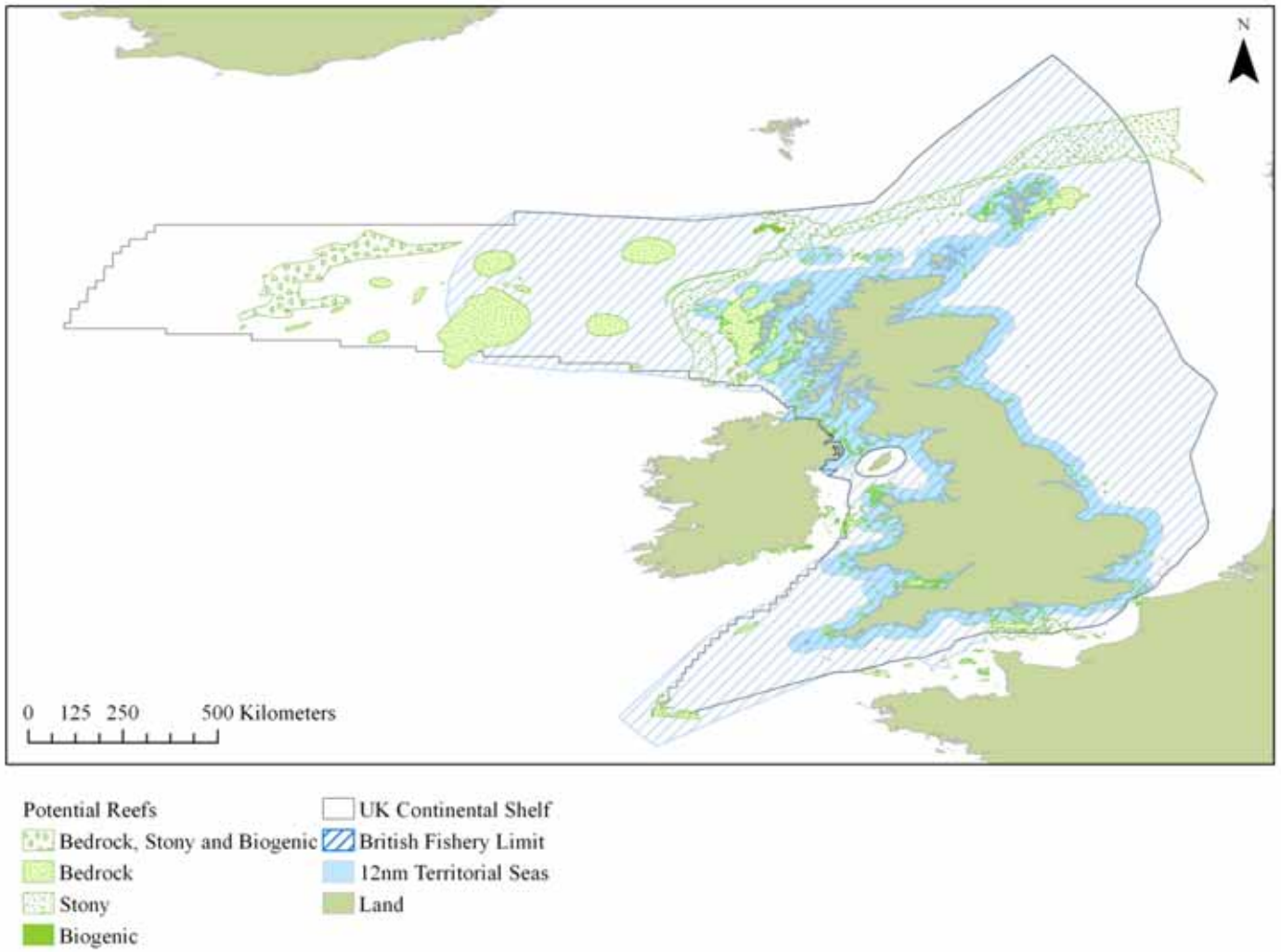

Figure 1. Areas of potential Habitats Directive Annex I habitat in UK waters. Derived from BGS seabed sediment maps at 1:250,000 scale (Graham *et al,* 2001). Note that due to limitations of the data used to derive the reef layer, there may be an underestimate of reef in some inshore areas. Also note that the main offshore 'stony reef' areas of potential interest lie to the west and north of Scotland, in the Irish Sea off north Wales and in the central section of the English Channel.

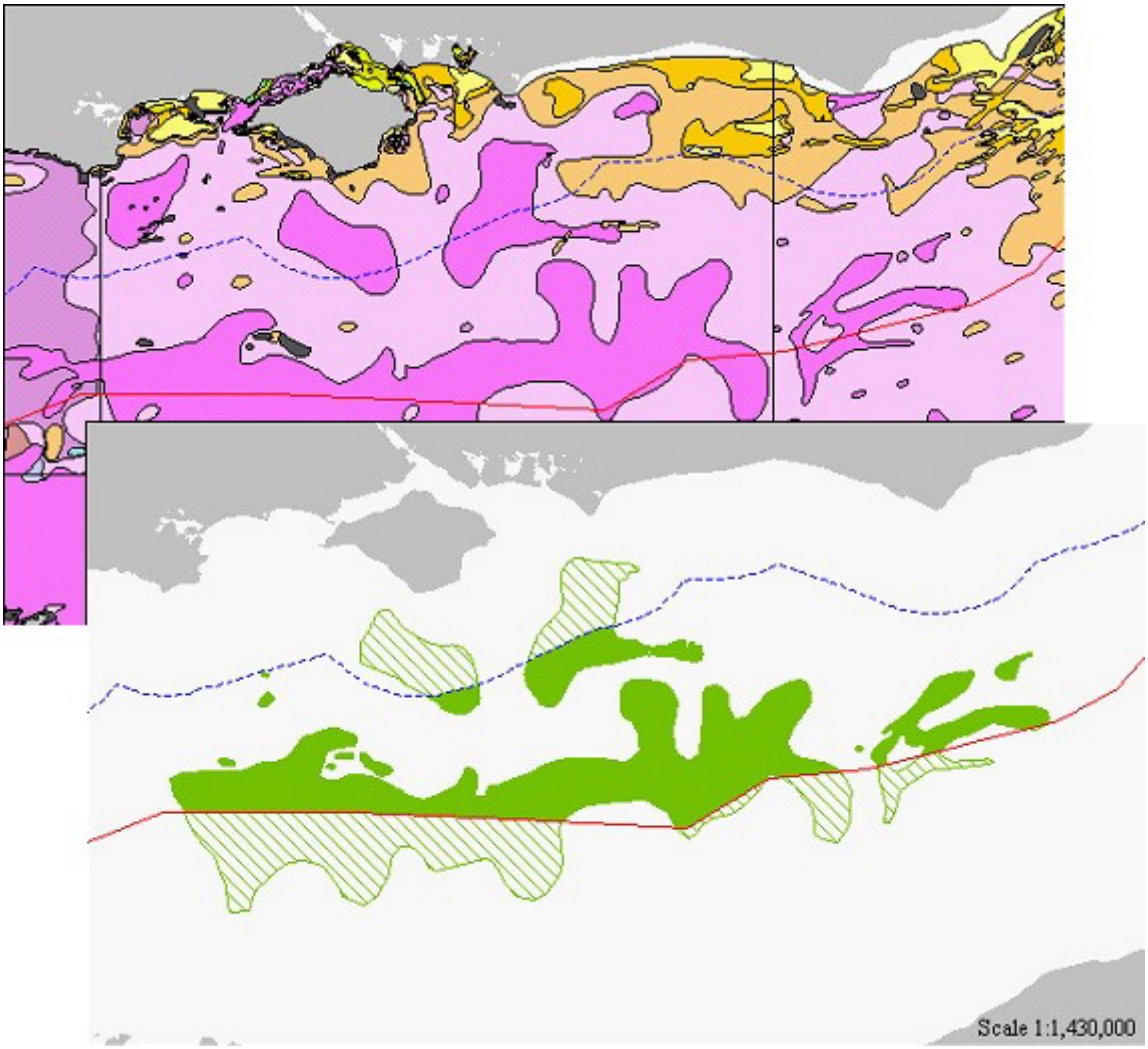

Figure 2. BGS seabed sediment map from the Eastern English Channel (above) used to identify potential reef habitat between the 12nm limit (blue line) and the extent of territorial waters (red line) (below). Green areas indicate 'gravel' areas which potentially may contain Habitats Directive Annex I 'reef' habitat (bedrock or stony sub-type), as well as non-reef finer gravel fractions. Note: new data are now available to refine the seabed sediment maps for this area.

2.2 Examples of areas already identified or designated which contain stony reef

Presentations by country agency staff

2.2.1 Annabelle Aish, JNCC – Wyville Thomson Ridge

The Wyville Thomson Ridge lies on the north-western edge of the Scottish continental shelf (Figure 3). It is approximately 20 km wide and 70 km long and it arises from over 1,000m depth to less than 400m at its summit. It forms a boundary between two water masses: the cold water of the Faeroes-Shetland Channel and the relatively warmer water of the Rockall Trough/Bank. This unique hydrographic regime supports a diverse and interesting fauna

throughout the site (see Plates 1-4). The site has been identified by JNCC as an offshore SAC on account of its stony reef features. The documentation regarding this site (now referred to as a pSAC or possible SAC) has just undergone consultation.

The site comprises an extensive area of stony reef with gravel and bedrock on its flanks. The stony reef has been identified as 'iceberg ploughmarks' which consist of rows of boulders, cobbles and gravel inter-dispersed with finer sediment in troughs about 5-10m deep. These features are believed to have been created by the ploughing movement of icebergs through the seabed at the end of the last ice age (see also Figure 14, section 2.3.5). These areas appear stable and consolidated and were interpreted as Annex I stony reef.

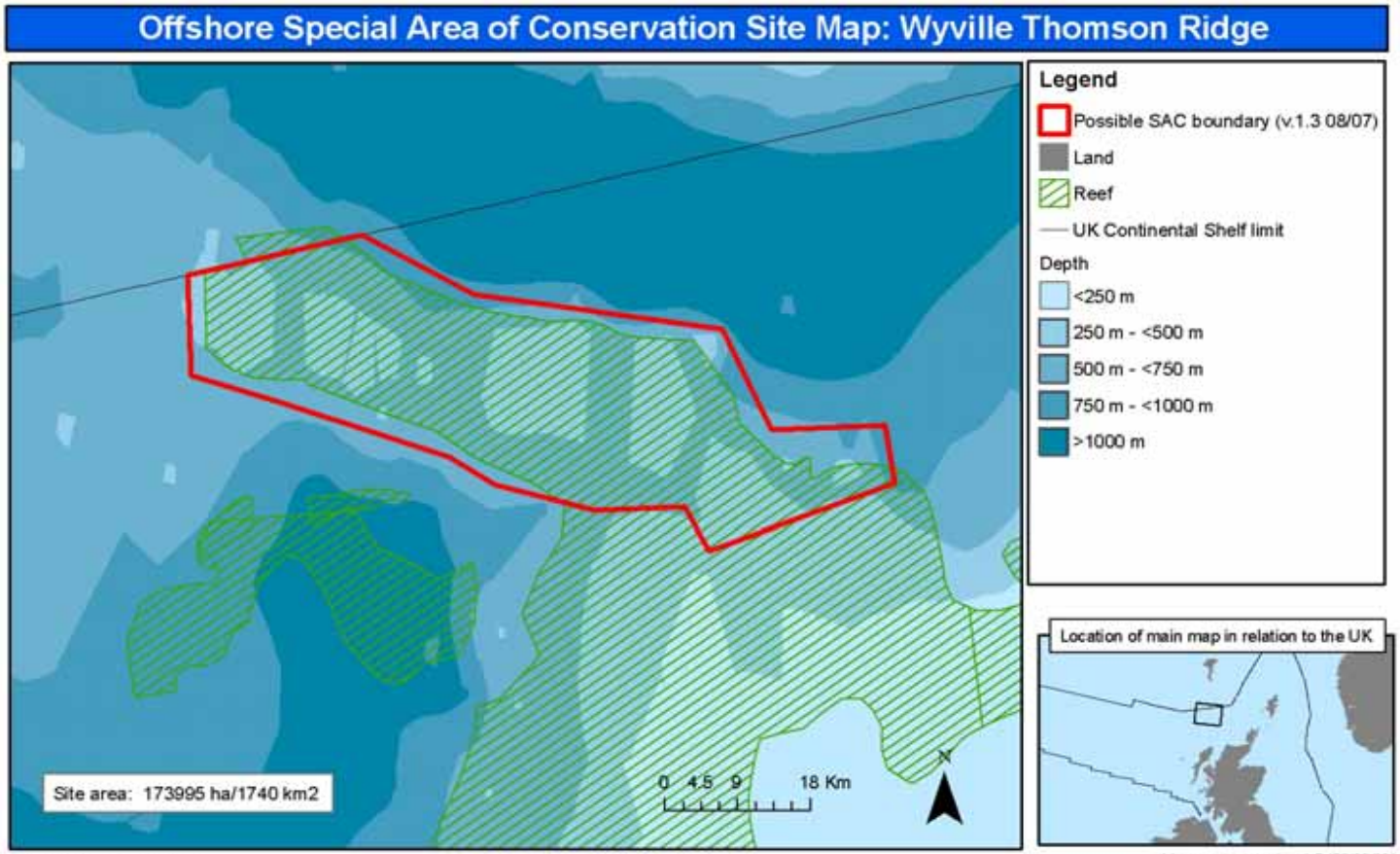

Figure 3. Location and extent of the Wyville Thomson Ridge. (JNCC, 2009)

Plate 1. Wyville Thomson Ridge: stony reef dominated by rounded cobbles with brittlestars and anthozoans. © DTI/Defra/JNCC

Plate 2. Wyville Thomson Ridge: mixed sediments with bryozoan crusts and sea urchins. © DTI/Defra/JNCC

Plate 3. Wyville Thomson Ridge rounded small boulders and cobbles dominated by anthozoans and hydroids. © DTI/Defra/JNCC

Plate 4. Wyville Thomson Ridge: cobbles dominated by echinoderms – yellow featherstars, orange brittlestars and a basketstar (on left). © DTI/Defra/JNCC

2.2.2 Leigh Jones, Natural England

Leigh explained that of their suite of SACs, Natural England considered only three as having examples of stony reef features. These were within the SACs at Flamborough Head, Lundy and South Wight Maritime, where boulder fields, have been identified using remote survey data.

2.2.3 Carol Daniels, Scottish Natural Heritage (SNH)

[This presentation was put together by Ben James, who unfortunately was unable to be present at the Workshop, and was presented (via video-link from Inverness) by Carol Daniels.]

A number of Scottish SACs have been identified as possessing stony reefs (see Table 1), though all of these have already been designated as having Annex I (rocky) reef habitats. Two composite slides were presented from the Treshnish Isles SAC and Sunart SAC, each showing nine photographs ordered from (top left) actual stony reef to (bottom right) not stony reef (due to the predominance of finer sediments) – see Plate 5. The main criteria being used by SNH to categorise habitat as stony reef being the size and density of the constituent sediment/rock types, and whether there is greater than 50% cover of rock/cobble material >64mm in size. This latter categorisation ensures that patchy areas of cobble/gravel/sand can be included too.

Table 1. Scottish SACs which have been identified as supporting stony reefs.

Dornoch Firth and Morrich More	Loch nam Madadh	St Kilda
Firth of Lorn	Lochs Duich, Long and Alsh	Sullom Voe
Isle of May	Luce Bay and Sands	Sunart
Loch Creran	Mousa	Treshnish Isles
Loch Laxford	Papa Stour	

At present, SNH are in the process of identifying where stony reefs occur within existing SACs, rather than searching for new sites for possible designation. One of the problems which SNH has identified is the difficulty explaining to consultees and the wider public in general what exactly constitutes a stony reef.

The following additional characteristics have been used to categorise stony reef features: stability and epibenthos. One question to ponder is whether we should be considering cobbles on their own, or cobbles with their associated biota? It was pointed out that the present biotope classification has ‘cobble reef’ biotopes listed under the sediment biotopes section. It was suggested that, as an end product of this workshop, an illustrated guide be produced which would illustrate what a stony reef should look like, showing a range of examples of stony reef. This could take the form of a poster or a leaflet. Carol concluded the presentation by showing some stony reef video clips from the Firth of Lorn SAC.

Plate 5. Series of seabed photographs from Sunart SAC grading from reef habitat (top left) to sediment habitat (bottom right), and including intertidal stony reef habitat (top right).

2.2.4 Kirsten Ramsay, Countryside Council for Wales (CCW)

The various reef types represented within the Welsh SACs were presented. It was explained that, when considering intertidal areas, CCW have mainly used the biotopes present (identified by an extensive Phase I survey of the whole of the Welsh coast), verified by expert judgement and local knowledge, to determine whether or not an area can be identified as a stony reef habitat. In the subtidal, this has not been quite so straightforward, and instead various data (including diver observations, biotope data and RoxAnn acoustic data) have been analysed. Some subtidal areas have been identified as 'possible' reef, either because of insufficient survey data or because of doubts about the accuracy of the data.

The Sarns are probably the best examples in the subtidal of 'stony reefs' within Wales. They are glacial moraines and form three extensive parallel reefs running NE/SW within Cardigan

Bay. The largest of these, Sarn Badrig, extends over 20km in length. The seaweed communities here are very important.

Plate 6. Divers recording from weed-covered stony reef on Sarn Badrig, Pen Llŷn a'r Sarnau SAC.

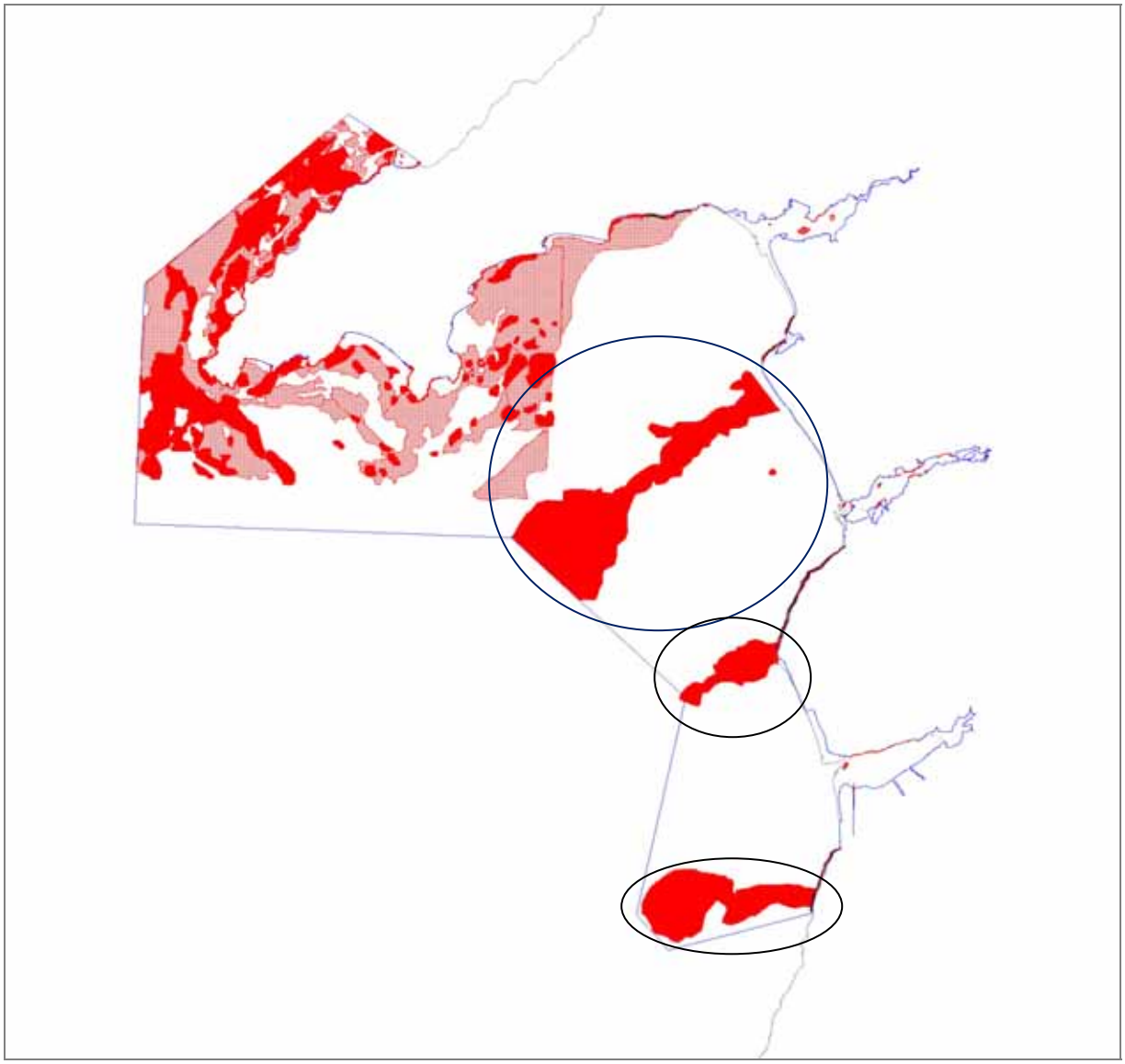

Figure 4. Location of the three Sarnau within Cardigan Bay. Dark red areas = definite reef (all types); light red = possible reef (all types).

2.2.5 Hugh Edwards, Environment and Heritage Service of Northern Ireland

Hugh presented the results of a recent bathymetric survey from Ballycastle Bay to Torr Head (including Rathlin Island) off the north coast of Northern Ireland. This survey has resulted in a number of locations where previously unknown reefs have been shown to exist. Some of these may well be glacial moraines, which are likely to be considered as stony reef. Of the stony reef features already known about, there are boulder slopes extending to 250m depth off the north end of Rathlin Island.

The Environment and Heritage Service of Northern Ireland are considering one particular scallop bed as a stony reef, though it is debatable as to whether it should be classified as such. It is just 10m wide, present at between 30-40m at the foot of a boulder slope and is comprised largely of small pebbles (mostly less than 64mm in size) with a few cobbles. The 'reef' is unusual in that it features an unusual epibiota, dominated by hydroids, bryozoans, cup sponges and cup corals attached to small pebbles and shells. However, it is not elevated from the surrounding seabed – beyond it is a flat sediment plain which, it is thought, has been well-

worked by scallop dredgers. Thus this narrow band of 'reef' is extremely vulnerable to their further attentions. However, can it be classed as 'stony reef'?

Questions:

Does the 'reef' show evidence of concretions in any way (ie binding the pebbles and shells together and supporting considerable epifauna) and thereby help to support its recognition as a reef?

Not really. It's certainly stable, but there are no real concretions as such.

2.3 Examples of UK cobble/boulder aggregations

2.3.1 Matt Dalkin, Environment & Resource Technology (ERT) Limited – Mid Irish Sea Reefs Habitat Mapping Project

A remote acoustic and drop-video survey was undertaken by ERT (Edinburgh) and the National Oceanography Centre, Southampton, during the winter of 2006/07 in the mid Irish Sea on behalf of JNCC and Defra (Dalkin, 2008). The area in question had been identified as consisting of quaternary sediments by an earlier BGS survey and been noted by JNCC as being of potential stony reef interest. Survey techniques included multibeam acoustic survey, back-scatter, AGDS data and drop-video for ground-truthing.

The north of the study area was found to be dominated by sand wave habitats at approximately 60-80m depth; the central section was of mixed habitats – some sand, some pebble and shell, and some cobble areas; whilst the southern end had a deeper channel as its main feature at approximately 150m depth. The dominant habitat was of sand mixed with pebbles and shells (biotopes: SS.SCS.OCS & SS.SCS.CCS.PomB). Elsewhere, what reef there was appeared as patches approximately 10-20m across, though these were often of consolidated mixes of varying sediment types which rarely stood proud of the surrounding seabed. Typically, the slightly deeper depressions had cobbles within them, whilst the shallower seabed either side of these was dominated by sand.

Plate 7. Mixed sediments with sparse fauna (occasional keelworms and barnacles). This was not classed as stony reef. (Biotope: SS.SCS.CCS.PomB)

Plate 8. Consolidated cobble habitat dominated by barnacles, keelworms, dead man's fingers and bryozoans. This was regarded as being stony reef. (Biotope: CR.HCR.XFa.SpNemAdia).

Plate 9. Seabed of mixed sand, gravel, pebbles and cobbles. This habitat was clearly stable as it had associated with it a diverse epifauna. Even very small pebbles <30mm across had hydroids and bryozoans growing on them. However, should a grab sample of this material have been taken it is likely to have revealed a rich infaunal community too.

One difficulty encountered during the analysis of the acoustic data was its resolution, estimated as being 15cm vertically and 4-5m horizontally. This meant it was very difficult to distinguish small cobble patches using this method and a higher resolution technique such as side-scan sonar would need to be employed to be able to do this.

In conclusion, Matt stressed his desire to see the Workshop participants focusing on the reasons why certain areas should be conserved, rather than conserving them simply because they fell within a definition of a reef, regardless of how impoverished from a biological point of view that 'reef' may be. It was likely that a hundred or so years ago those areas of seabed which consist of consolidated gravel and pebbles, which often have a rich epifauna associated with them, were likely to have been far more extensive than they are today. He was keen to see that these areas, which may well not be raised from the surrounding seabed but are actually present in depressions, be included within the definition of a stony reef.

2.3.2 Ceri James, British Geological Survey (BGS) – English Channel and Bristol Channel

Ceri began his presentation by looking at the meaning of the word 'stone' (as in 'stony reefs'), and gave various dictionary definitions of the word. He concluded by stating that it would be necessary to ensure that any definition of stony reefs included an explanation of what was meant by 'stony'.

The presentation then concentrated on work undertaken in the Eastern English Channel, where an attempt had been made to categorise still images from video footage of gravel areas into 'clast-supported' or 'matrix-supported' types (Figure 5).

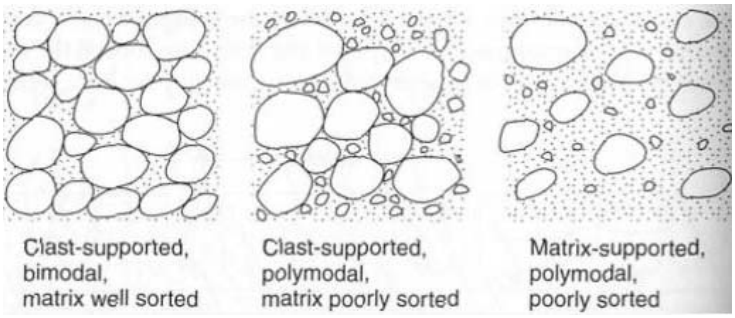

Figure 5. Series of diagrams used by Ceri James to help with the possible interpretation of the constituents of a stony reef. 'Clast-supported' implies that the cobbles are actually touching each other, whereas matrix-supported implies there is finer sediment surrounding each cobble. Note that these terms are used again in Tables 2 and 3, section 3.2.

Ceri had looked at various ways of categorising the clast versus the matrix-supported types. These had included the average number of cobbles within a still video image and also the maximum clast size (ie sand, gravel, cobbles and boulders) of the sediments. However, both of these methods proved unsatisfactory. In order to attempt to define the presence of 'stony' reefs (as opposed to bedrock reefs or other sediments), he then looked at, in turn, the proportion of gravel within the sediment mix, the degree of slope and the rugosity of the seabed. Again, each of these methods had difficulties associated with them (mostly as inaccuracies). The resulting simplified map is presented in Figure 6. Here the coarse sediment category (coloured pink) would be the closest to providing some indication of the distribution of stony reefs within the area, but at a very crude level.

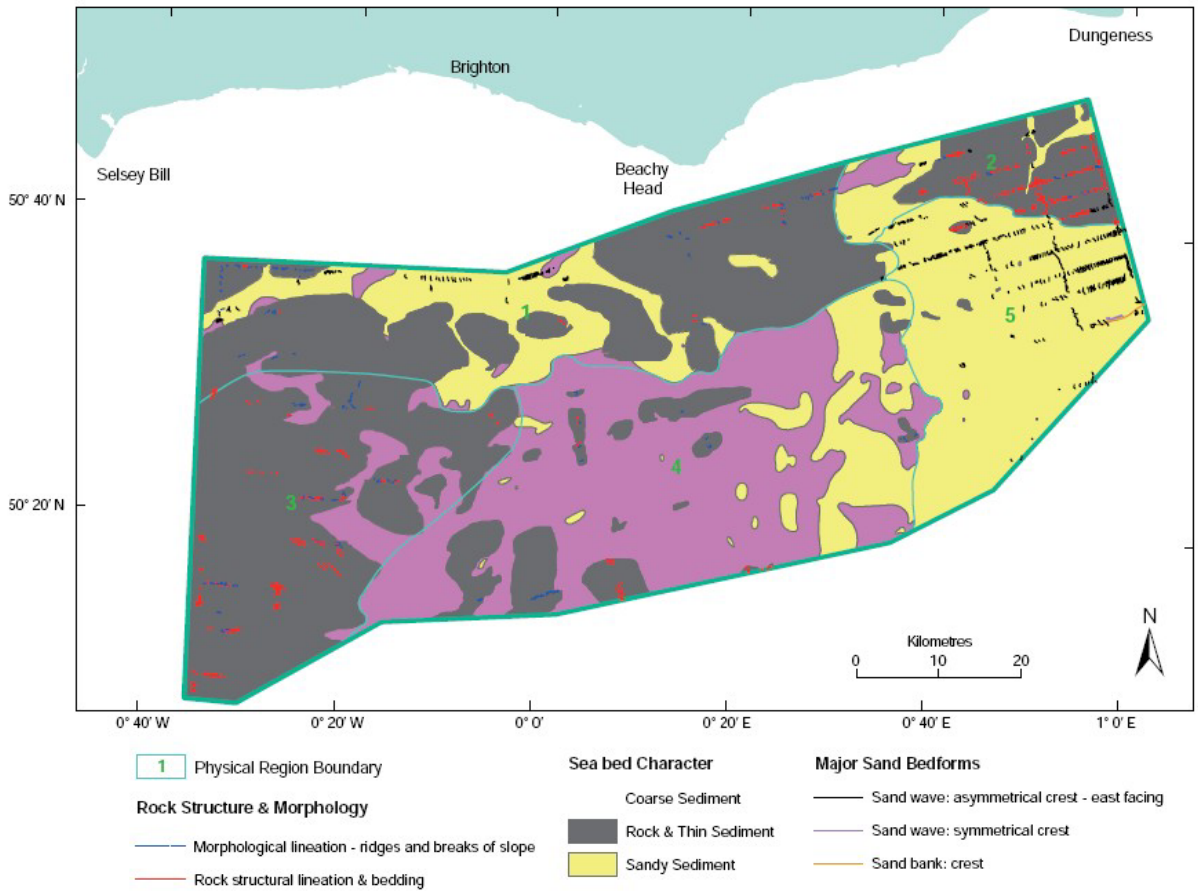

Figure 6. Division of the eastern English Channel study area into just three seabed 'character' classes: coarse sediment (pink), rock & thin sediment (dark grey), and sandy sediment (yellow). Based on sample station data. (from James *et al*, 2007)

Ceri stated he believed that underlying geology beneath the seabed surface should also be taken into consideration when assessing the presence/absence of potential stony reefs. Thus, by using sub seabed seismic surveys as well as multibeam bathymetry, an explanation can be given as to why certain features are present on the seabed. Two examples of sediments overlying chalk and clay are shown in Figure 7 utilising this technique.

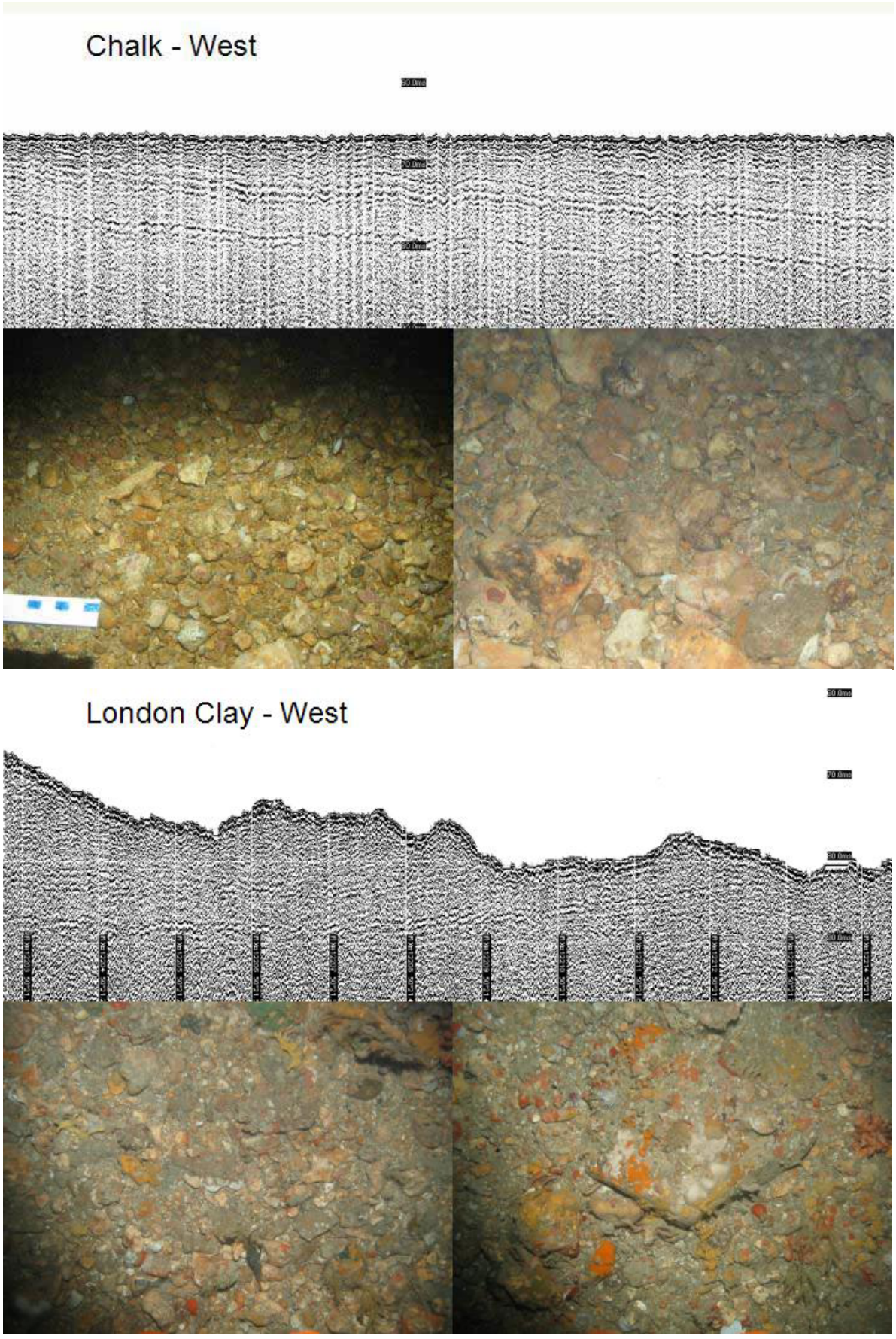

Figure 7. Still images from video footage of stony reef areas overlying Chalk (top) and London Clay (bottom) from the Eastern English Channel.

Finally, Ceri posed a number of questions for consideration by those present. Should the transport of boulders or cobbles be important in defining a stony reef, either by wave action, fluvial systems or glacial transport? Is the underlying substrate relevant, either being hard rock or sediment? And is water depth relevant – coastal, shelf or oceanic? How small a footprint can a stony reef have? Should all methods be used to identify a reef or are some methods more important than others?

Plate 10

Plate 11

Plate 12

Plate 13

Plates 10 to 13. Four images of seabed types within the Eastern English Channel, taken from Ceri James' presentation. Note the lack of epifauna on the rounded flint cobbles in Plate 11, indicating considerable and regular disturbance of the seabed. The presence/absence of epifauna in determining a stony reef is discussed in section 3.1.3 and in Table 2.

2.3.3 Jim Allen, Institute of Estuarine and Coastal Studies (IECS) – Yorkshire Coastline

Jim's presentation, entitled "An ecological assessment of the Yorkshire coast prohibited trawling areas", focussed on the work he and his colleagues at the Institute of Estuarine and Coastal Studies in Hull had been undertaking on behalf of Natural England. There are three No Trawling Areas in place off the Yorkshire coast. The one off the Holderness coast extends from Skipsea in the north to Spurn in the south and covers an area of approximately 53km x 6km (318km^2) (Figure 8). Within this area, a wide variety of seabed types/habitats are present, though the dominant types are extensive areas of gravel, pebbles, cobbles and boulders. Water depths vary from between 0 – 15m (below chart datum). Moderately strong tidal currents affect the site, with periodic high suspended sediment loadings.

The main aims of the study (which is still on-going) have been (1) to map the principal benthic habitats within and immediately surrounding the three prohibited trawling areas; (2) to compare and contrast the benthic communities both within and immediately surrounding the three prohibited trawling areas; and (3) to provide some information on mobile fish assemblages both within and immediately surrounding the three prohibited trawling areas. The methods employed to achieve these aims have been acoustic survey using AGDS; ground-truthing of AGDS data using underwater video and grab sampling; and analysis of remote video of fish assemblages.

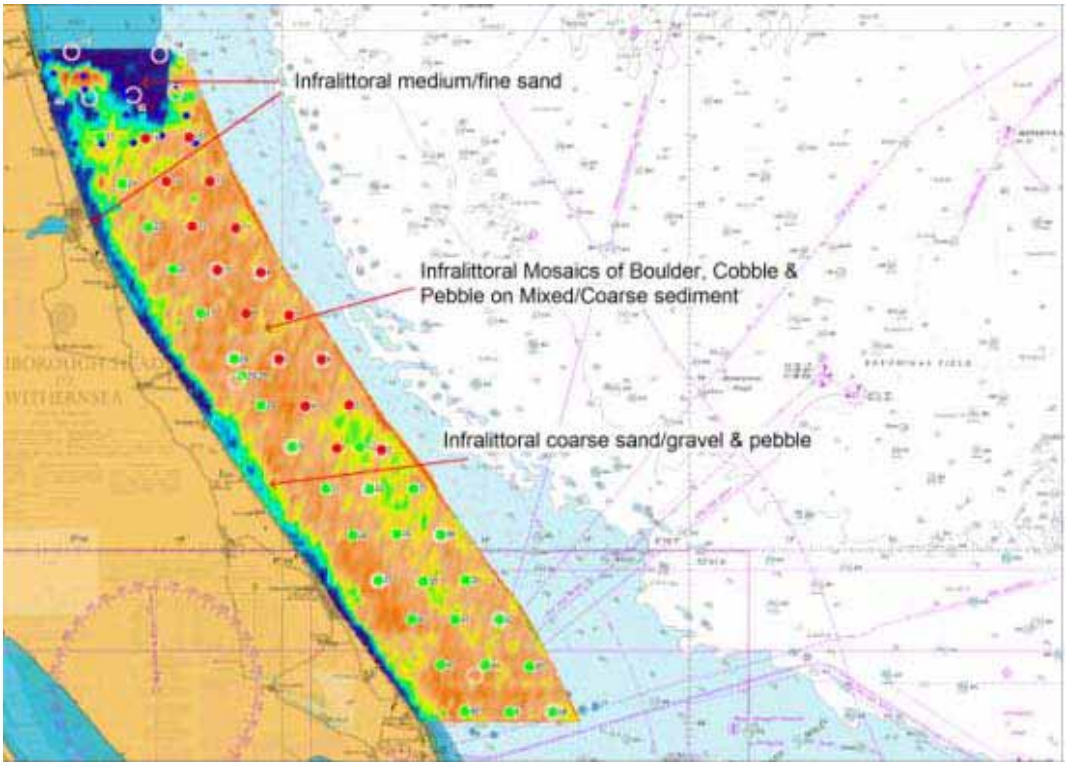

Figure 8. Location of the Holderness Coast No Trawling Area with survey sites marked. Note that all of the extensive orange-coloured area is of stony reef, consisting of mosaics of boulder, cobble and pebble on mixed/coarse sediment. Base chart © British Crown and SeaZone Solutions Limited. All rights reserved. Products Licence No. 042006.003. This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION.

Plate 14

Plate 15

Plate 16

Plate 17

Plates 14-17. Still video images from four separate locations off the Holderness coast. The seabed shown in Plate 14 may not qualify as a stony reef on account of the small particle size.

In conclusion, Jim pointed out that four to five stony/cobble habitats had been distinguished from the study, with varying degrees of 'reefiness'. He and his colleagues are currently assessing a range of criteria to be able to assist with distinguishing these habitats. These criteria included cobble content, cobble size, elevation, coverage of reef fauna/flora, distinctness (from acoustic data) and extent. They were also undertaking image processing and data analysis (e.g. classification / regression trees) to quantify the criteria for different types of cobble reef.

2.3.4 Heather Stewart, BGS – Scottish waters

The BGS (on behalf of JNCC) have been looking at areas off NW Scotland (the 'NW Shelf' – see Figure 9) to assess where there are areas of both rocky and stony reef which could be considered by JNCC as potential SACs.

The 248 sample sites visited by the original BGS survey (which led to the creation of the seabed sediment map shown in Figure 10) were re-visited and sampled using drop-video and a small (4 l) shipek grab. The composition of the seabed was recorded from each site and categorised according to the dominant constituent: definite rock; possible rock; cobbles; and if damage had been caused to the equipment, indicating a hard substratum of some sort was present.

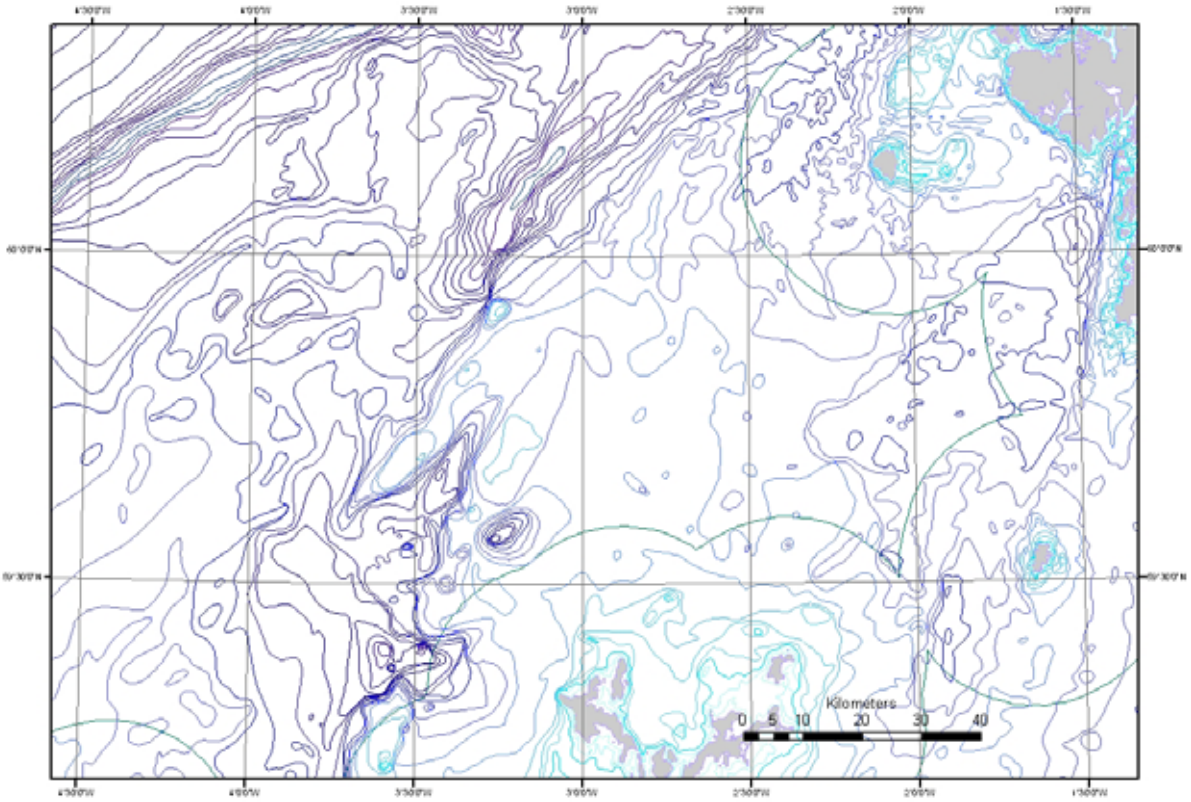

Figure 9. Bathymetric chart showing the location of the NW Shelf to the west of Shetland (top right) and Orkney (bottom centre)

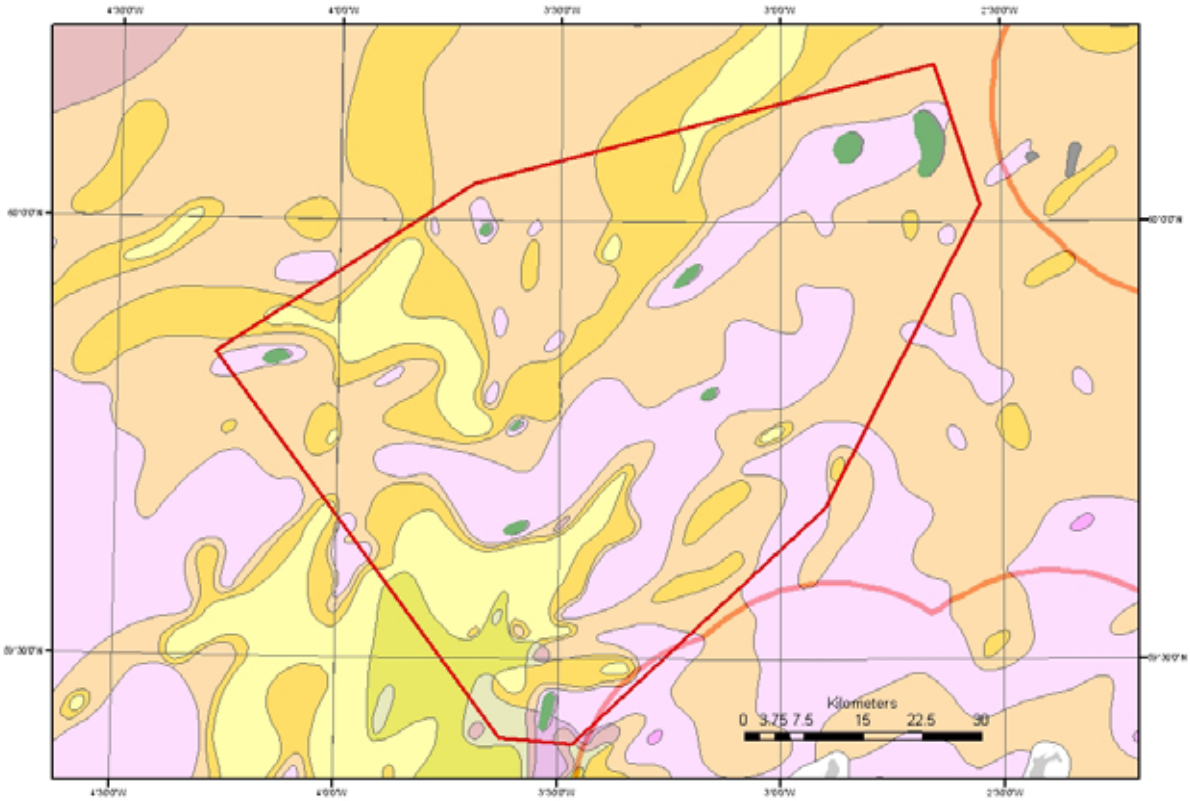

Figure 10. BGS sediment map of the same area. Small areas in green are possible reef areas (both rocky and stony reefs). Red line indicates approximate Area of Search for SAC habitat.

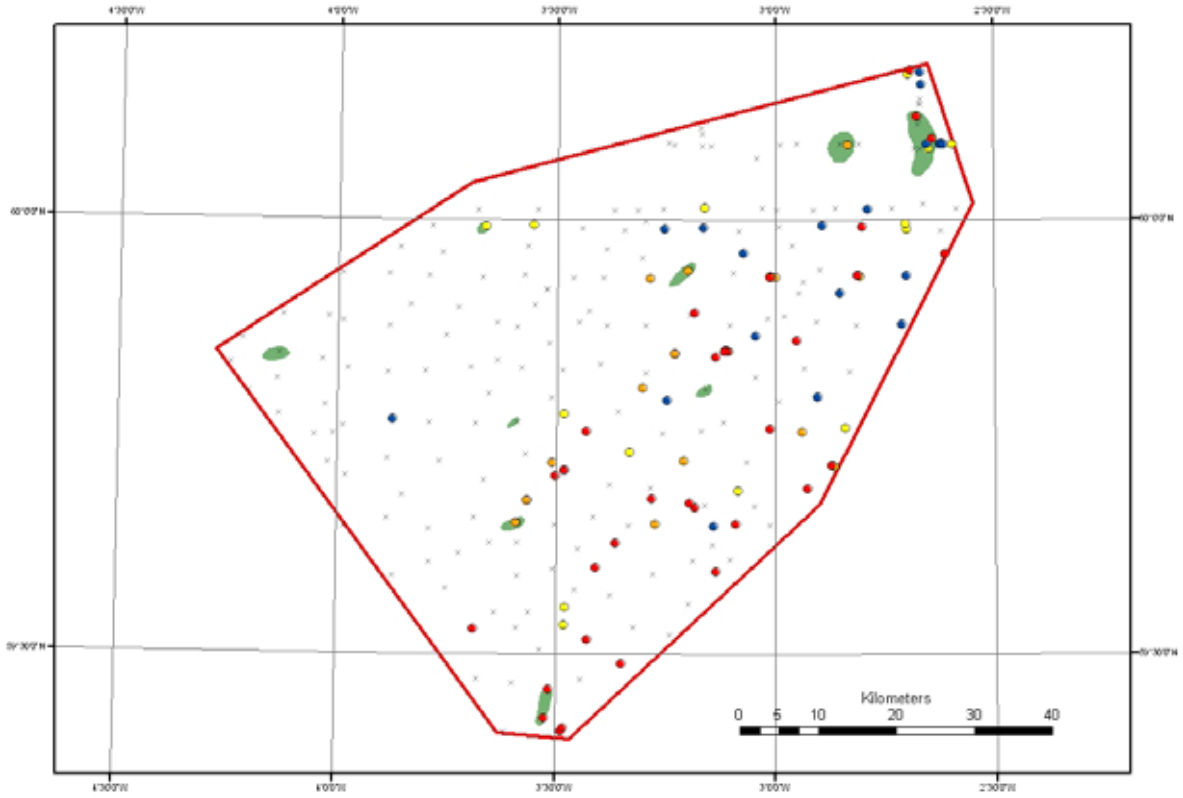

Figure 11. Locations of sampling points where rock (red), possible rock (orange), damaged equipment (blue) and cobbles (yellow) were encountered.

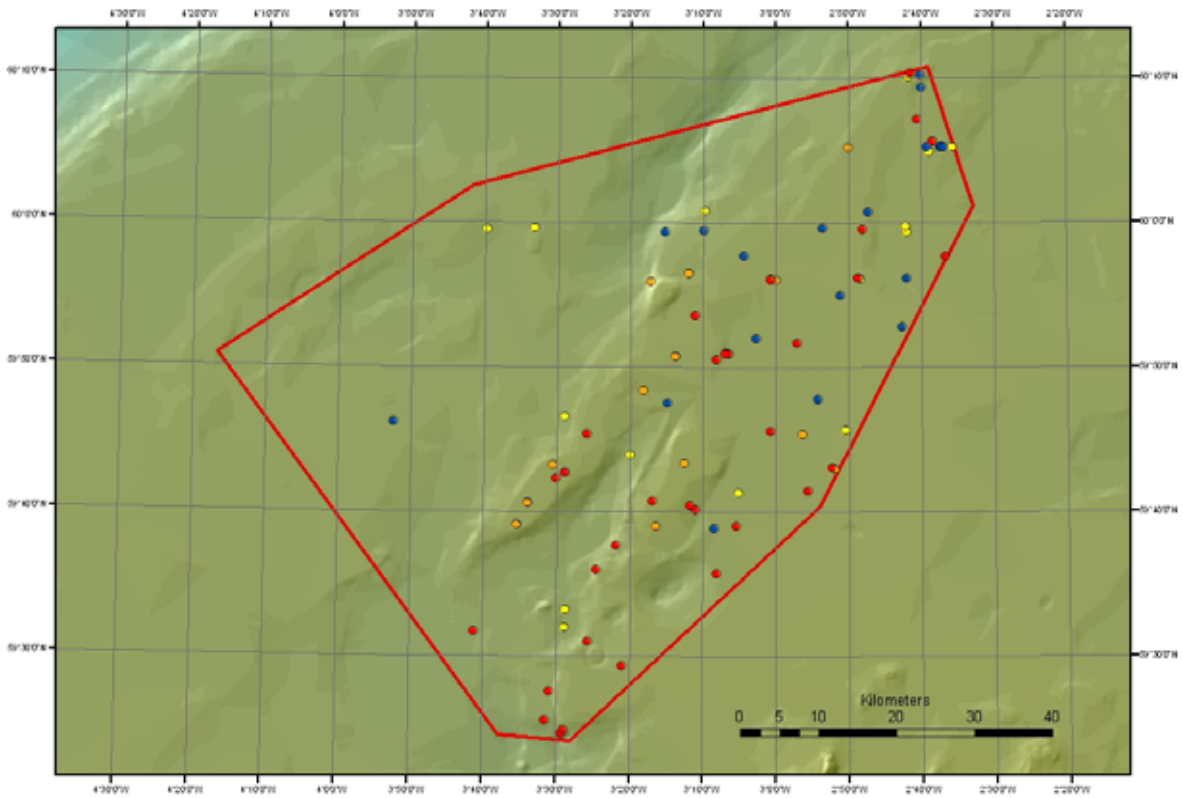

Figure 12. Overlay of Figure 11 onto a bathymetric interpretation of the seabed, showing reasonable correlation between bathymetry and sample sites suggesting possible reefs.

Questions:

Do BGS have plans to update and release digitised seabed maps?

Yes, this is happening gradually. A number of new digitised versions are due out shortly.

2.3.5 Kerry Howell, University of Plymouth - Rockall

Kerry's presentation, which was mostly of video footage, covered deep sea features to the west of Scotland and, in particular, the Rockall Bank. A number of techniques were used for these surveys including multibeam and side-scan sonar, towed sledge video and also drop-frame video. One of the most interesting features, which Kerry is particularly interested in, were iceberg plough-marks in depths shallower than 500m. It seems likely that these should be included within the category of 'stony reefs'. It was noted that, within the Rockall area, cobble patches which have been heavily trawled have less life (epifauna and mobile species) associated with them than other similar areas which have not been fished.

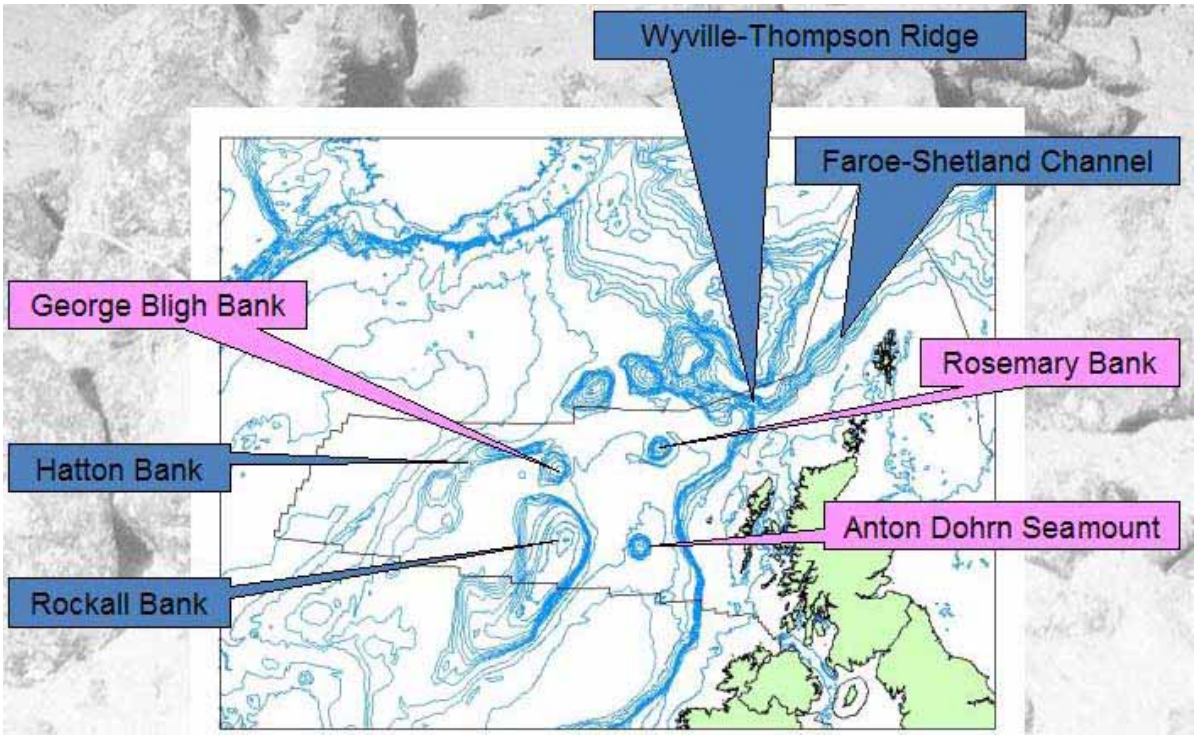

Figure 13. Locations of deep-sea features off the west coast of Scotland.

Figure 14. Representation of how the movement of icebergs creates plough-marks on the seabed.

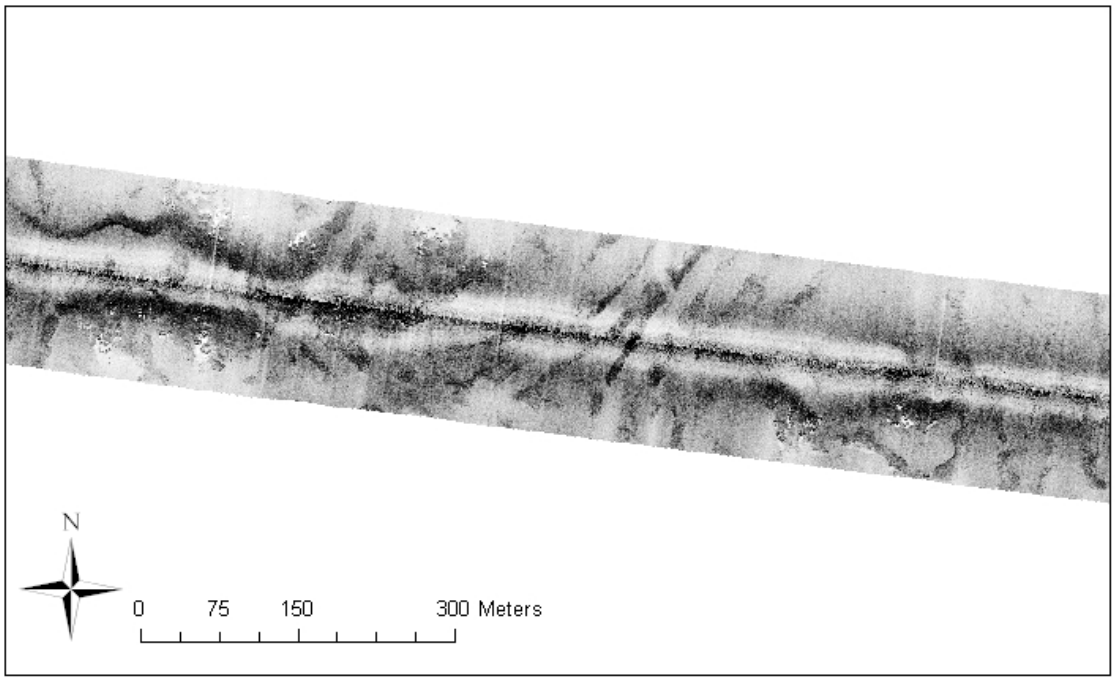

Figure 15. Side-scan sonar image of iceberg plough-marks. [Note that the dominant line running through the whole image is not a plough-mark but a 'shadow' of the sonar fish.]

The main points which should be considered from this presentation were:

- Patchiness – within the plough-mark feature, cobble cover is patchy.
- Faunal cover – this is mostly low-lying and does not project far into the water column.
- Structural role – cobbles provide structural habitat for mobile species (in particular, fish and crustaceans).

2.4 The assessment of stony reef characteristics

2.4.1 Annabelle Aish, JNCC – Consideration of the relevance of a scoring system for assessing *Sabellaria spinulosa* reefs

[Note that this presentation was given on the morning of Day 2, prior to the break-out session]

On 1 and 2 May 2007, JNCC hosted a Workshop on interpretation of *Sabellaria spinulosa* reefs under the Habitats Directive (see Gubbay, 2007). One of the presentations was given by Vicki Hendrick from Newcastle University who described a multi-criteria scoring system she and Bob Foster-Smith had devised which could be used to give an overview of various characteristics considered important to the 'reefiness' of *Sabellaria spinulosa* aggregations. It was thought that such a scoring system could be relevant to assessing the characteristics of stony reefs in a similar way.

Each of the characteristics can be scored as **Low**, **Medium** or **High** and be weighted according to the perceived importance of that characteristic. Confidence limits can also be attached to the scores.

The primary characteristics considered were: **spatial extent** (m^2) or; **patchiness** (% cover); and **elevation** (average tube height). Secondary characteristics (which could also be taken into account but were thought to be of less importance) included: stability, consolidation and longevity.

It was felt that this system would provide a good structure for decision making, it would be consistent and comparable between sites, and it would also show where data were lacking. It could also be used to state when a possible reef was not a reef.

These scoring levels and the characteristics proved a useful basis for the assessment of stony reefs within the break-out group session which followed.

3 Discussion

The following points were raised during question sessions at the end of presentations and also during discussion sessions during both Day 1 and Day 2. Similar topics have been grouped together and are not necessarily presented here in chronological order.

3.1 Main Points

3.1.1 Definitions

Charlotte Johnston, as Chair of the Workshop, emphasised that the main point of the Workshop was not to come up with a new definition of what stony reefs are, but that the interpretation of the existing definition should be refined to make it more useful.

Hard compact substrata – meaning given: "rocks, boulders and cobbles (generally >64mm in diameter)."

This means that particles less than <64mm across (pebbles and gravel) are excluded. However, these smaller particles are still likely to be present as part of the matrix material which supports the larger cobbles and/or boulders.

Arise from the sea floor – meaning given: "the reef is topographically distinct from the surrounding sea floor."

The consideration of elevation was discussed and was found to be somewhat restrictive. Effectively, by keeping to the strict definition ("arise from the sea floor") this excludes troughs and depressions where cobbles may form aggregations.

Distinguishing stony reefs: the question "when is a reef a stony reef?" was discussed in association with the definition given in the Interpretation Manual. It was felt that it should not be too much of a problem to distinguish a stony reef from a rocky (bedrock) reef, but there may be considerable difficulty in distinguishing it from finer sediments, e.g. mixes of pebbles, gravel and sand. It was hoped that the Workshop participants may be able to come up with a solution to this. Associated with this problem was the possible confusion with mixed boulder/cobble/pebble/gravel biotopes being listed under the 'Sediment' sections of the Biotope Classification and not under the 'Rock' sections.

3.1.2 Physical characteristics and biological characteristics

One question which arose on more than one occasion was "what should be **driving the definition** of a stony reef? Should it be the physical nature of its constituent parts (ie a mix of sediment types dominated by cobbles) or should it be the biology associated with this? SNH have taken the view that the physical structure of the reef is of primary importance in defining stony reef habitat in accordance with the EU interpretation manual for habitats listed on Annex I of the Directive. The associated biology is of course fundamental to an assessment of the conservation value of the stony reef once the habitat has been identified. When reviewing video footage or photographs, they have found it important to be able to sort out what is beneath the biology to determine if it is a reef or not: their view is that the underlying geology is paramount.

It was acknowledged that there was a considerable **range of biota** that could be found associated with stony reefs. Could this be categorised in some way? Clearly, it is the *characteristic* fauna and flora associated with stony reefs that is important and not just whether reefs have a dense or rich associated biota. Thus scoured or heavily grazed reefs should not necessarily be excluded from consideration.

It was pointed out that, whilst there is little emphasis within the definition of a stony reef about the associated biology, there would need to be some biological interest for a reef to be included as a specific feature within an SAC. This interest may not necessarily be because the biota is particularly rich or diverse but could also be because it is sparse, 'possibly as a result of extreme physical conditions, such as turbidity or wave exposure'.

The question "should areas of **consolidated gravel** be included within definition?" was posed. Such areas could only be considered if they met the 'reefiness' criteria in Table 3. It was highlighted that such areas could be very extensive, for instance huge swathes of the English Channel and the Irish Sea could be included. However, these would need to be elevated from the surrounding seabed in order for them to be considered as 'stony reefs'.

Other questions which arose within this topic were: **how much cobble should there be** for an area of mixed sediment to be termed a stony reef? Do we have to define it or would that impose too much of a restriction on what could or could not be classed a stony reef? These were considered practical questions which would help in deciding whether an area was thought to be a reef or not. It was suggested that the proportion of clast to matrix could provide a useful guide here (see Figure 5).

JNCC had spent some time assessing whether it was useful to assess percentage of **cobbles, pebbles and gravel** within a mixed sediment seabed in order to help decide whether to characterise it as a stony reef. No definite conclusion was reached on this, though it was found that even where there was only a small proportion of cobbles, but the infill between those cobbles was composed of hard substrata, that epifauna characteristic of 'reef' were supported.

KEY MESSAGE

Both the physical nature and the biology of potential stony reefs should be taken into consideration in the assessment of their status.

3.1.3 Size and scale

It was felt that a minimum size of area should be agreed upon which would define a stony reef as an entity. It was not considered necessary to have a maximum size. It was noted, however, that in the case of the cobble reef off the Holderness coast, the reef extended for several tens of kilometres. Would it be necessary to divide this up into the 'best bits' or could the whole area be regarded as a single stony reef? Matt Dalkin mentioned in his presentation that much of his study area in the Irish Sea had featured small patches of cobbles just 10-20m across. Could these be grouped in some way to include the intervening finer sediment and calling the whole entity 'stony reef'. Drawing a boundary around such an area was likely to be difficult. It was appreciated there was bound to be some variation in the composition of the seabed within a given area, which would then give rise to varying degrees of 'reefiness'.

It was pointed out that there was no mention in the definition of stony reefs of the proportion of the constituent types (ie gravel, pebbles, cobbles, boulders etc) which would make up a reef. There is also no guidance as to the sample size one should be looking at. One difficulty associated with this is that, on the one hand there are major topographical features at a large scale that can be seen by means of remote sensing techniques, while on the other hand there are point samples on a small scale where we are able to assess, say, the density of cobbles within a given area. When viewing video footage, one may only be looking at a tiny sample of what may be a very large structure. Within the definition, no indication is given of percentage cover, or what area you should take into consideration to assess percentage cover etc.

It was also mentioned that it would be useful to agree on a minimum number of sample stations that would be required within a given area in order to justify defining a boundary around potential stony reef habitat. Some kind of analysis would be required in order to assess the range of the samples across the whole area.

3.1.4 Iceberg ploughmarks: a special case

Iceberg plough-marks are unusual features that occur along the UK continental shelf edge off northern and western Scotland and provide patchy areas of hard substratum on the seabed in areas otherwise dominated by soft sediments.

Iceberg plough-marks give rise to raised areas of cobbles and small boulders either side of a central furrow. The distribution of the cobbles is not even and in some places there are none to be seen at all within the width of a video image. It was emphasised that the plough-mark itself had to be regarded as a whole feature when contemplating it as a stony reef. Clearly, the cobble areas within that feature were going to be patchy.

Some areas of iceberg ploughmarks could be considered as stony reef; they would need to meet the ‘reefiness criteria’ as outlined in Table 3.

3.1.5 Structure and functionality

The **structural role** of stony reefs was emphasised, particularly as they can often act as refuge areas for mobile fauna such as fish and crustaceans. This was particularly true in deep sea areas where finer sediments may dominate the seabed, and stony reefs can act as ‘oases’. There may also be associations with higher trophic levels. For instance, within Cardigan Bay, some stony reef areas are thought to be associated with dolphin feeding grounds.

The **functionality** of a reef should also be considered. If it acts like a reef, should it then be called a reef? The question was then asked as to what would happen if the reef was destroyed (probably as a result of trawling activity) and lose its inherent interest? Should you then exclude it? It was thought likely that extensively damaged areas would usually have to be excluded during selection of areas as SACs, although consideration should be given to restoration potential.

It was pointed out that in instances where there was a thin veneer of sand overlying a cobble area, and then if there were hydroids sticking up through the sand, the area should still be called a stony reef, especially as the veneer may come and go over time.

KEY MESSAGE

The structural role of stony reefs, for example as shelters for mobile species such as fish and crustaceans should not be overlooked.

3.1.6 Detectability and methods of detection

From a management perspective, it is important to have confidence in our ability to be able to identify where stony reef features are located. It is possible that lessons could be learnt from other marine disciplines in how to do this, such as the identification of palaeo-channels in the English Channel. This is particularly relevant to offshore, deep water sites. Methods of detection include various types of acoustic surveys, such as multibeam and side-scan sonar; towed sledge video; drop-down video; and grabs etc.

It was pointed out that the cost of mounting new surveys for offshore areas was very high, often prohibitively so. Consequently, it was necessary either to collaborate with existing survey or to make the most of existing data that may have been collected for some other purposes. It was pointed out that, when conducting an offshore survey, it was important to conduct a geo-physical survey first and then hone in on the most interesting bits to assess the biology.

3.1.7 Regional variations

The topic of regional variations in the biota of stony reefs was touched upon. These variations are recognised but are they important? It was thought that it was important to recognise these variations but that it would be impractical to include these variations in a description of what actually constitutes a stony reef. It was added that the challenge will be ensuring that the interpretation of stony reef is broad enough to include all regional variations.

3.1.8 Other considerations

Rugosity – Ceri James had considered this in his assessment of stony reef areas within the Eastern English Channel. However, his conclusion was that the method used to detect the 'roughness' of the seabed was not sufficiently accurate to be able to pick out definite stony reef areas.

Transport – Could this be used in agreeing what constituted a stony reef – ie that the constituent parts were once mobile and had been transported at some time in the past to their present position. This would then distinguish them from bedrock reefs which clearly had not moved. It was felt that this was an unnecessary complication to include within any definition or explanation of terms.

Sensitivity – the question was asked as to whether we should be concentrating on areas which are considered sensitive to potential damage? No response was forthcoming to this question as such, though it was felt that it was important to agree what a stony reef was to begin with, before consideration was given as to their sensitivity.

3.1.9 Justifying management decisions regarding the status of stony reefs

Several individuals (notably Charlotte Johnson and Ian Reach) stressed the need for Agency staff to be confident with decisions that might have to be taken regarding the definition of areas of the seabed as stony reefs. How easy or difficult will it be to be able to identify boundaries around stony reef areas from a management point of view? Managers will need to be able to defend their decisions as to why a particular 'stony reef' has been identified/designated.

A stony reef needs to be a structure you can actually identify and one which we can draw a boundary around.

3.1.10 Illustrative material to help recognise stony reefs

Carol Daniels made the suggestion that a leaflet or poster would be useful as an end product of this Workshop which could provide a visual interpretation of what a stony reef is and what it is not. Others agreed this was a good idea. A number of individuals offered assistance with the provision of photographs for this. The JNCC plan to take this suggestion forward, working with the Country Conservation Agencies to produce some stony reef guidance material.

3.2 The identification of stony reef characteristics

Table 2 sets out a summary of the conclusions drawn up by three independent 'break-out' groups, each consisting of seven workshop participants (see Appendix 2). The groups were asked to come up with what they thought were the key characteristics which could be used to identify stony reefs with some certainty, in an attempt to arrive at some kind of agreed standardisation for their identification. Three main 'characteristic' categories were suggested for consideration to start with: **extent**, **elevation** and **patchiness**, following the example of the assessment of *Sabellaria spinulosa* reefs.

Each group was requested to come up with other categories, several of which were very similar (albeit under another name/title). Within the Table, the categories are listed in order of what was considered to be the most important characteristic first. A 'consensus' row (shaded) has been inserted in an attempt to indicate what was considered the most reasonable limits for all of the groups combined. Table 3 presents the final (agreed) characteristics, after a post-Workshop consideration of Table 2 via e-mail.

Table 2. Initial attempts to categorise the main characteristics of 'stony reefs'.

Characteristic	Gp	Not a 'stony reef'	'Reefiness' Low	Medium	High
Composition					
	1	<64mm	Matrix- supported		Clast- supported
	2	Not suggested	Not suggested		
Boulders / cobbles (>64mm)	3	<10%	10-40% Matrix- supported	40-95%	>95% Clast- supported
Consensus:		**<10%**	**10-40% Matrix supported**	**40-95%**	**>95% Clast supported**
Elevation					
	1	Flat, featureless seabed	<64mm	64mm-5m	>5m
(Topographical distinctiveness)	2	Must be an identifiable feature distinct from the surrounding seabed (could use MESH definition as a standard here)			
	3	<0.05m	0.05-0.30m	0.30m-5m	>5m
Consensus:		**Flat or undulating seabed**	**<64mm**	**64mm-5m**	**>5m**
Extent					
	1	Not suggested	Not suggested		
	2	<5m x 5m	← >25m² →		
Total Area	3	<25m²	25m²-1km²	1-10km²	>10km²
Consensus:		**<25m²**	**← >25m² →**		
Biota [B]					
Ecosystem function	1	Dominated by infauna	Use SACFOR scale		>80% epifauna
Biological component	2		Should be biased towards physical aspects with less emphasis on biology. Should be characteristic of biogeographic region		
Function	3	Impossible to quantify			
Consensus:		**Dominated by infauna**			**>80% epifauna**
Patchiness					
(100% cover of 1m x 5m) [A]	1		1m x 50m area Clast-supported 20% cover of 1m x 5m patches	↔	1m x 50m area Matrix-supported 60% cover of 1m x 5m patches
% cover of hard substrata (>64mm constituent) within 'reef'	2		>50% coverage by hard substrata, but at least 25% (of the 100%) needs to be cobble-sized or larger if smaller sediments are present.		
(100m² *or* 100m x 1m transect) [A]	3	<10%	10-50%	50-75%	>75%
Consensus:		**<10%**	**10-50%**	**50-75%**	**>75%**
Stability [B]					
	1	Not stable enough to support epifauna	Could support encrusting epifauna	↔	Able to support erect epifauna
	3	Did not think that the size of physical constituents could be quantified, or the composition of the biota			
Distinctness	3	Impossible to quantify			
Sub-seabed structure	3	Group was not able to progress this further due to lack of time			

Notes:

A	**1m wide areas suggested here as 1m approximates to the width of the seabed viewed by video.**
B	**The term 'Biota' was not given as a category to be considered by the separate break-out groups. However, each group came up with their own title which, on reflection, appear very similar & are therefore grouped together.**

Further discussion of the terms and categories included in Table 2 (via e-mail), (with contributions from Matt Dalkin, Kirsten Ramsay, Viv Blyth-Skyrme, Ian Reach & Jim Allen).

Patchiness

The issue of 'patchiness' was considered and, after much discussion via e-mail after the Workshop, it was generally agreed that this category should be incorporated within the 'Composition' category as the two were considered (as an afterthought) to be very similar. However, some further explanation is required. The basic question is how much reef material is required within a given area before it can be classed as a reef?

The minimum size of a reef has been agreed as being >25m^2 and it must consist of >10% cobbles (or larger particles, ie small boulders). The critical part appears to be the amount/extent of sediment forming the matrix within which the cobbles (clast material) are found. The greater the sediment component then the more patchy the stony reef feature is likely to be and consequently of lower 'reefiness'.

Stability

Lack of time meant that discussion of this category at the end of the Workshop was cut short. Some individuals still believe that stability is an important category which should be considered in the characterisation.

Quality

Is it possible to put some value on this? It is likely that managers will need to assess the quality of any particular reef in order to decide if it should be included within a boundary or excluded from it.

[Jim Allen]: The biological component (whether it's community/trophic structure or diversity) is likely to be intrinsically linked to reef 'structure' in a physical sense (and can be used as a surrogate for stability or habitat complexity). Certainly, in some of the areas I have surveyed it would be difficult to justify an assessment of reef structure or status (and in some cases impossible!) based purely on physical criteria. Without going into too much detail re. habitat quality (which will need to be assessed on a site by site basis), I think some basic assessment of 'biota' could be included if required, if only to determine if dominant/characteristic taxa are primarily those dependant on the reef habitat (cobbles etc) or the underlying substrata. Initially, this could be determined by relative proportions of the number of infaunal and epifaunal species/taxa, although no doubt more elaborate taxonomic/trophic criteria could be developed in the future.

Table 3. The main characterising features of a stony reef.

Characteristic	Not a 'stony reef'	'Resemblance' to being a 'stony reef'		
		Low[2]	Medium	High
Composition:	**<10%**	10-40% Matrix supported	**40-95%**	**>95% Clast supported**
Notes: *Diameter of cobbles / boulders being greater than 64mm.* *Percentage cover relates to a minimum area of 25m^2.* *This 'composition' characteristic also includes 'patchiness'.*				
Elevation:	**Flat seabed**	<64mm	**64mm-5m**	**>5m**
Notes: *Minimum height (64mm) relates to minimum size of constituent cobbles.* *This characteristic could also include 'distinctness' from the surrounding seabed.* *Note that two units (mm and m) are used here.*				
Extent:	**<25m^2**	← **>25m^2** →		
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

[2] When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a **strong** justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive.

4 References

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Appendix 1 Workshop agenda

Inter-agency workshop on Stony Reefs

JNCC, Monkstone House, Peterborough

13:00 – 17:00 26 March; 09:30 – 12:10 27 March 2008

Day 1 Wednesday, 26th March: Defining stony reefs

13:00	1	**Charlotte Johnston: Introduction** – stony reefs in the context of the Habitats Directive – limitations of existing definition in SAC selection. Define terminology.
13:20	2	**Country Agencies outline areas already designated as stony reef** – example photographs of sites
	2.1	**JNCC** – The Wyville Thomson Ridge – Annabelle Aish
13:25	2.2	**Natural England** - Leigh Jones
13:35	2.3	**SNH** – Carol Daniels *via* video conference link
13:45	2.4	**CCW** – Kirsten Ramsay
13:55	2.5	**Environment and Heritage Service of Northern Ireland** – Hugh Edwards
14:05	3	**Group 'show and tell'**: examples of UK cobble/boulder aggregations (photos and descriptions); which you do consider to be reef under the Habitats Directive, some that you don't and what are the reasons. Illustrate with habitat maps and pictures. This session will include informal presentations from the following as well as general examples from the floor: • Matt Dalkin (ERT Ltd.) – Irish Sea Project • Ceri James (BGS) – English Channel and Bristol Channel • Jim Allen (IECS) – Yorkshire coastline
15:20		**Group 'show and tell'**: examples of UK cobble/boulder aggregations (cont.) • Heather Stewart (BGS) – Scottish waters • Kerry Howell (University of Plymouth) – Rockall
16:20	4	**Interactive session to identify the main characteristics of stony reef habitats**
17:00		Close

Day 2 Wednesday, 27th March: Defining and quantifying stony reefs

09:30	1	**Summary of key points** from previous day's discussion (Robert Irving)
09:40	2	Annabelle Aish: **Consideration of the relevance of a scoring system** used for *Sabellaria spinulosa* reefs for the interpretation of stony reefs
10:00	3	**Identification of stony reef characteristics** – in small break-out groups
11:15	4	**Presentation of results from each group**. Agreement on characteristics and quantification of stony reef habitats (and the weighting of different characteristics in decision making)
11:55	5	Conclusions
12:10		**End of workshop**

Appendix 2 Break-out groups

Three 'break-out' groups were convened on Day 2 (participants for each chosen at random), each one tasked with reviewing and refining certain key topics (see section for a list of what these were). After 75 minutes of discussion, each group then reported their conclusions to the others (via the rapporteurs). A summary of their conclusions is presented in Table 2.

GROUP 1	GROUP 2	GROUP 3
Charlotte Johnston [1]	Ian Reach [1]	Heather Stewart [1]
Paolo Pizzolla	Annabelle Aish	Amy Ridgeway
Hugh Edwards	Jaime Davies	Kirsten Ramsay
Ceri James	Kerry Howell	Neil Golding
Carol Daniels [2]	Matt Dalkin	Steven Benjamins
Jim Allen	Emma Verling	Viv Blyth-Skyrme
Chris Pirie	Simone Pfeifer	Zoe Crutchfield

[1] Rapporteur for group
[2] via video link