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Refining the criteria for defining areas with a 'low resemblance' to Annex I stony reef

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Summary

On 14 May 2020, the Joint Nature Conservation Committee (JNCC) hosted a workshop with the Statutory Nature Conservation Bodies (SNCBs) to further refine the definition of Annex I stony reef. The workshop was organised to discuss and further refine guidance for defining areas with a 'low resemblance' to Annex I stony reef. Since 2008, the original guidance on defining stony reef (Irving 2009) had been used extensively; applied within the inshore (<12nm) and offshore (beyond 12nm) UK waters, it has been used for tasks ranging from identifying Annex I stony reef through to dealing with appropriate assessments for casework. Generally, the guidance has performed well since 2008, although clarifications were sought in certain areas.

The SNCBs reported on the range of Annex I stony reef in their respective regions, within and outwith their Marine Protected Area networks; they provided feedback on particular challenges they had experienced using the existing stony reef guidance. New concepts were presented and explored using available information on biota to help differentiate various classes of Annex I stony reef. The concept of patchiness was also explored in more detail, following research that had taken place after the initial stony reef workshop in 2008. Overarching guidance was developed which will assist practitioners in using the stony reef guidance in a more structured and repeatable way.

Recommendations coming out of the workshop, and agreed by all participants, will ensure that these new concepts discussed will be tested over the coming year in a variety of different biogeographical regions, ensuring their compatibility across inshore and offshore waters, and with a view to potentially integrating these concepts into further refinement of the Annex I stony reef guidance into the future.

Contents

1 Background

Adopted in 1992, the Habitats Directive[1] sought to conserve a wide range of rare, threatened or endemic animal and plant species. Rare and characteristic habitat types were also targeted for conservation, listed under Annex I of the Directive. Reefs [1170] under Annex I are of particular relevance to this workshop. The Interpretation Manual[2] of European Union Habitats provides greater clarity on the interpretation of Annex I reef with this explanation:

> "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."

The Interpretation Manual[2] also provides these additional clarifications:

- "Hard compact substrata" are: rocks (including soft rock, e.g. chalk), boulders and cobbles (generally >64mm in diameter).
- "Biogenic concretions" are defined as: concretions, encrustations, corallogenic concretions and bivalve mussel beds originating from dead or living animals, i.e. biogenic hard bottoms which supply habitats for epibiotic species.
- "Geogenic origin" means: reefs formed by non-biogenic substrata.
- "Arise from the sea floor" means: the reef is topographically distinct from the surrounding seafloor.
- "Sublittoral and littoral zone" means: the 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.

Within UK waters, three types of Annex I reef have been identified; biogenic, bedrock and stony (Duncan & Pinder 2019). Annex I stony reef was the subject of a workshop with the Statutory Nature conservation Bodies (SNCBs) hosted by JNCC in March 2008 (Irving 2009), with the aim of clarifying the definition of 'stony reef' under the Habitats Directive, and assisting with identifying those areas of the seabed which fell within, and outside the definition. Through this workshop, a consensus was reached on the main characterising features of an Annex I stony reef, summarised in Table 1.

[1] Council Directive 92/43/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043
[2] Interpretation Manual of European Union Habitats https://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf

Table 1: The main characteristics of an Annex I stony reef, as determined during the 2008 Annex I stony reef inter-agency workshop (Irving 2009).

Characteristic	***Not a 'stony reef'***	***'Resemblance' to being a 'stony reef'***		
		Low[3]	**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 25m².* *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:	**<25m²**	← **>25m²** →		
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

Note that in line with the footnote below, areas of the seabed having a 'low resemblance' to stony reef, where 'low' was scored in any of the four criteria (composition, elevation, extent or biota), as highlighted in Table 1 above, required a strong justification for the area to be considered as Annex I stony reef.

2 Purpose and scope of the workshop

Since the first stony reef workshop in 2008, the resulting guidance (Irving 2009) has been used extensively by the SNCBs over the past twelve years. It has been applied within the inshore (<12nm) and offshore (beyond 12nm) UK waters, for example when identifying stony reef or when dealing with appropriate assessments through casework. Generally, the guidance developed in 2008 has worked well, although further clarification was required in some areas. In particular, some criteria to assist the practitioner in better defining areas with a 'low resemblance' to stony reef was required, allowing a stronger justification to be made where areas of seabed identified as stony reef fall within the 'low resemblance' category.

In light of the above requirement, a second inter-agency Annex I stony reef workshop was convened by JNCC, with the aim to develop further guidance when identifying those areas of the seabed with a 'low resemblance' to stony reef. Participants (listed in Appendix 1) from the JNCC, Natural England (NE), Natural Resources Wales (NRW), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Marine Scotland Science (MSS) and the Agri-Food & Biosciences Institute (AFBI), nominated to represent on behalf of the Department of Agriculture, Environment and Rural Affairs, Northern Ireland (DAERA), met 'virtually' via Microsoft Teams on 14 May 2020. Apologies were received from Scottish Natural Heritage (SNH) and DAERA. The final agenda is provided in Appendix 2. Three examples of Annex 1 reef discussed at the workshop are provided in Appendix 3 and discussed in section 8.2.3.

[3] 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.

The workshop was chaired by Neil Golding, a participant of the first workshop held in 2008. During the introductory session, he noted that it wasn’t the intention of this second workshop to reopen a wider debate on what constituted an Annex I stony reef, especially with respect to ‘medium’ and ‘high resemblance’ categories.

The workshop opened with presentations from the participating SNCBs providing a range of perspectives of how they have dealt with areas of ‘low resemblance’ to Annex I stony reef using the existing guidance. New concepts were presented and explored around developing the *biota* criterion to provide a stronger justification for areas of ‘low resemblance’ to stony reef. The concept of patchiness was also explored in more detail, following research that had taken place after the initial stony reef workshop in 2008.

3 Areas with a ‘low resemblance’ to Annex I stony reef: an inshore perspective

3.1 A Welsh inshore perspective

Natural Resources Wales (NRW) provided an overview of Annex I stony reef in Welsh inshore waters. The full presentation can be viewed in Appendix 4.

NRW were seeking clarity regarding the definitions and thresholds for ‘low resemblance’ stony reef. Challenges in using the current Irving (2009) stony reef guidance have also been fed back to NRW from contractors and data analysts, particularly around identifying areas of ‘low resemblance’ stony reef, and what the required *strong justification* may look like.

Welsh inshore waters contain all three sub-types of Annex I reef; bedrock, stony and biogenic. Subtidal stony reef is a component of the Annex I reef feature in the majority of Welsh marine Special Areas of Conservation (SAC), the notable exception being the Dee Estuary. While some areas of stony reef can be easily categorised using the guidance in Irving (2009), other areas have proved more of a challenge. The predominant area providing this challenge was Cardigan Bay SAC.

NRW detailed some specific casework examples where there was a requirement to better distinguish between areas of ‘low resemblance’ Annex I stony reef compared to those areas not classified as reef. Specific examples were shown where multibeam and side-scan datasets, along with interpreted underwater imagery, have been used to identify potential areas of Annex I stony reef.

Key challenges were:

- Where and how to identify the boundaries between reef and sediment along video transects, particularly where mosaics of seabed habitats are prevalent; how should the stony reef guidance be applied in these situations.
- Interpreting the *biota* criteria in Irving (2009) which discusses infaunal versus epifaunal dominated communities.
- The relationship between composition/elevation thresholds and those data collection and analysis methods used, such as multibeam echosounder bathymetry/backscatter and seabed imagery.

- Around the requirement for a **strong justification** if any one of the four criteria fall into the 'low resemblance' to Annex I stony reef category. What does this strong justification mean in practice?

NRW have pursued some work within Welsh inshore waters to help resolve some of the challenges mentioned above (see Section 5).

In addition, the challenges around mosaics and patchiness of Annex I stony reef, along with potential advances in their assessment were presented by JNCC later in the workshop (see Section 6).

3.2 An English inshore perspective

Natural England (NE) provided an overview of Annex I stony reef in English inshore waters; there are eight coastal SACs where Annex I stony reef is a designated sub-feature. Some Marine Conservation Zones (MCZs) also contain examples of stony reef. The full presentation can be viewed in Appendix 5.

Conservation advice for all features was revised a number of years ago. No distinction was made between the different levels of stony reef resemblance, for example, 'medium resemblance' versus 'high resemblance'.

For all features (including Annex I stony reef), NE developed a list of EUNIS[4] habitat codes which sat under each particular feature. Of these codes, two hundred and twelve were recorded as being correlated with Annex I stony reef, although these were primarily EUNIS codes from the rocky part of the classification; in addition to those two hundred and twelve codes identified, there may be some EUNIS codes on the mixed subtidal sediment part of the EUNIS classification which may correlate with 'low resemblance' Annex I stony reef, however these were not identified in the automated process.

Various survey methods used to assess Annex I stony reef within sites were discussed; examples highlighted where Annex I stony reef had been identified through casework or monitoring. These included Walney Extension offshore wind farm (2011), Shell Flat fisheries assessment, Lyme Bay fishery closure and Plymouth and Estuaries SAC. Lyme Bay posed a challenge when considering biota and epifaunal communities; some areas of the seabed which had been disturbed previously often had a reduced epibiota community; would they still be considered as Annex I stony reef? These epifaunal communities could also become re-established with time, following cessation of the disturbance, for example as observed within Lyme Bay. Plymouth and Estuaries SAC (Duke Rock) contained some interesting examples of sediment biotopes (SS.SMp.KSwSS.LsacR.CbPb – red seaweeds and kelps on tide swept mobile infralittoral cobbles and pebbles) which could be considered to have a 'low resemblance' to Annex I stony reef. It was noted that for this example, stability was also a factor for consideration. The Duke Rock example was one where a stable seabed allowed a diverse epifaunal 'reef-like' community to develop, even though from a substratum 'clast-size' perspective, it may not exactly fit the definition of a stony reef.

Following the presentation, one of the questions posed was around biota, and whether criteria such as composition and elevation could be used to 'flag' areas of possible Annex I stony reef in their own right, even if there wasn't a strong biota component visible at that time (maybe due to disturbance for example). From a NE perspective, this would only be relevant where disturbance was suspected to be the cause of reduced biota; NE consider the value of biota key in defining reef. It was also noted that under European Commission (2007), the existence of an epifaunal community is not a prerequisite for an area to be classified as Annex I reef.

[4] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification

4 Areas with a 'low resemblance' to Annex I stony reef: an offshore perspective

JNCC provided an overview of Annex I stony reef in UK offshore waters (beyond 12 nautical miles), using examples from four offshore sites; Pobie Bank SAC and Solan Bank SAC (both which span the 12nm Territorial Sea limit into Scottish inshore waters), Wight-Barfleur Reef SAC and Pisces Reef SAC. The full presentation can be viewed in Appendix 6. Deep sea Marine Protected Areas (MPAs) were not discussed as deep sea MPAs containing Annex I stony reef are considered to be a special case due to the presence of iceberg plough marks, as agreed at the 2008 workshop (Irving 2009). Annex I reef in the deep sea is likely to be more patchy but small amounts of reef can make a great difference to biodiversity in the deep sea.

Pobie Bank SAC contained a mixture of Annex I bedrock and stony reef, as well as mosaics with more sedimentary habitats.

Solan Bank SAC also contained a mixture of Annex I bedrock and stony reef. Seabed imagery data collected and analysed for this site was classified as 'confirmed' Annex I stony reef and 'potential' Annex I stony reef. The site was subject to significant scour, so the diversity of epifaunal communities was reduced as a result.

Wight-Barfleur Reef SAC, located in the English Channel, provided a good example of an offshore SAC with a very complex, heterogenous seabed; a mosaic of bedrock and stony reef, interspersed with sedimentary habitats.

Pisces Reef SAC, located in the Irish Sea, provided an example of how hard substrata, when covered by a veneer of mud, could be classified as non-reef habitat. Noting the statement in the European Commission (2007) Interpretation Manual that "such hard substrata … 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", areas of the seabed at Pisces Reef which appeared as mud at first glance could be classified as reef due to the presence of epifaunal species. Detailed exploration of the seabed imagery from Pisces Reef revealed discrete communities with transitional communities between; the main reef community transitioned into a reef veneer community, which then transitioned into muddy seabed with burrows. Analysis of this seabed imagery from Pisces Reef is ongoing.

The presentation reiterated many of the challenges highlighted by the other workshop participants, around dealing with mosaics of Annex I stony reef and non-reef sedimentary habitats.

5 Consideration of the biota component during Annex I stony reef characterisation; a Welsh inshore perspective

Natural Resources Wales (NRW) reported on work undertaken in Welsh inshore waters which examined available information on biota in more detail to help differentiate between areas classified as having a 'low resemblance' to Annex I stony reef from other areas which were not reef. A detailed working paper covering the methodology and results, submitted ahead of the workshop, is shown in Appendix 7. However, a concise summary is provided here.

One of the key principles to be considered for an area when assessing its 'resemblance' to Annex I stony reef was stability; areas of consolidated and patchy hard substrate may not necessarily fulfil the composition requirements of the Annex I stony reef criteria (i.e. not having the required percentage of cobbles and boulders), yet stability allows a diverse and 'reef-like' epifaunal community to develop. Therefore, is there a way that the biota/biodiversity requirement can be

better defined in the Annex I stony reef guidance to provide greater clarity when assessing areas against that guidance?

Using a Welsh inshore dataset from Marine Recorder (a combination of seabed imagery and diver recordings), the following process was undertaken by NRW to attempt to identify Annex I stony reef records from this dataset. This involved three key steps:

- **STEP 1: Assignment of biotopes**. There will be a suite of biotopes that are clearly associated with (and define) reefs, and an inverse list which are clearly not associated with reefs. There will also be a grey area in the middle where biotopes may (or may not) be associated with reefs.

- **STEP 2: Identification of key species**. These were species selected due to their abundance in bedrock/boulder/cobble habitat. In total, 51 species were identified from Welsh inshore datasets. Note therefore that this list will likely be more extensive if scope is expanded wider than Welsh coastal waters.

- **STEP 3: Identification of reef species**. These were species that had a strong affiliation with stable, hard substrata. Considered as positive indicators of reef habitat.

A number of trials of the above process were run using the same dataset, and the results compared with the actual video tow. One of the primary issues was that species records tend to be from a whole camera tow; in areas of patchy habitat, this can result in the whole tow being tagged as reef. This is more a consequence of the video analysis methodology for the raw data than the above process.

5.1. Strengths of the above approach:

- Uses all of the substratum and species data that are available.
- Biotope assignment filters out a proportion of records, reducing the number of records for which species must be handled.
- Developing a key species list effectively provides a 'shortcut' for those species poor records that have the major characterising species (e.g. A Seasearch Observer of a kelp forest will have kelp).
- Not dependent on having infaunal data.
- Auditable lookup lists created for biotopes, Key species and Reef species.
- Utilises data from different methods with different metrics.

5.2. Weaknesses of the above approach:

- Currently requires extensive spreadsheet manipulation.
- Presence only data are generally not adequate.
- Lookup tables must be maintained, to cover all habitats, across the UK (ideally).
- Does not handle sediment veneers very well.

5.3. Opportunities of the above approach:

- Large datasets can be analysed in one go.
- Thresholds are set (or can be varied) to ensure only the justified records are assigned as Annex I Reef feature.
- Standardised approach can be developed at the UK scale.
- Guidance can be rolled out to third parties, for planning casework (EIA, HRA, *etc.*).

5.4. Threats of the above approach:

- Will likely fail to identify stony reef that has been highly disturbed through fishing or other activities.
- Insufficient survey points.
- Insufficient data associated with a survey point.
- Currently no easy solution to mapping patchy habitats.

The discussion following the presentation by NRW covered a number of points. One was around the *biota* criterion within the current stony reef guidance (Table 1), and the fact that this assumes knowledge (and data) for both the infaunal and epifaunal communities. Typically, survey methodologies over stony reef habitat tend to allow only the epifaunal component of the community to be effectively sampled. This may not be an issue for areas of 'medium' and 'high resemblance' to stony reef, as *composition* (high percentage of cobble/boulder) and *elevation* will drive this determination. However, for areas of 'low resemblance' to stony reef, when consideration of *biota* has additional significance, this presents a challenge. Particularly when at the lowest end of 'low resemblance' to stony reef, the composition of the seabed may be 90% sedimentary and only 10% cobble/boulder. Annex I stony reef is inherently patchy, and so the guidance should take into account the fact that there will be patches of less dense cobbles/boulders interspersed with sediment areas. Patchiness was discussed in more detail during a dedicated session later in the workshop.

6 Consideration of patchiness

JNCC provided an overview of some work undertaken to examine the patchiness of habitats in offshore waters, and potential ways it could be recorded. The full presentation can be viewed in Appendix 8.

A recap was given on how patchiness was originally considered during the March 2008 workshop (Irving 2009). In summary, patchiness was ultimately incorporated within the *composition* criterion. However, work undertaken following the 2008 workshop demonstrated that percentage cover may not be the best mechanism to provide a measure of patchiness. Patchiness, with respect to Annex I biogenic reef (*Sabellaria spinulosa*) was first explored in Jenkins *et al.* (2015) and reported in more detail in Jenkins *et al.* (2018), and an overview of the approach taken was provided to the workshop participants. Jenkins *et al.* (2018) trialled the use of a *patchiness index*; this approach could also be applied to Annex I stony reef, particularly to tackle some of the problems associated with identifying 'low resemblance' Annex I stony reef.

Some of the precursor data analysis work required to trial this approach on Annex I stony reef has already been undertaken around Solan Bank, although this work hasn't been completed. Workshop participants agreed that progressing this Solan Bank work to its natural conclusion would provide a valuable trial of this approach's application to stony reef; this was taken forward as a recommendation from the workshop. A key challenge to this work will be getting the segment length for video analysis correct; too short and you will add a significant time penalty (and resultant financial cost) to any analysis. Conversely, selecting a segment length which is too long will oversimplify the process, reduce the resolution of the variability that can be measured, resulting in some of the patchiness information being lost.

7 Summary of workshop discussion

Following the presentations on various topics related to Annex I stony reef, there was a wide-ranging discussion between the workshop participants on some of the challenges that exist with using the current stony reef guidance. In particular, the ability to distinguish ‘low resemblance’ stony reef with areas that shouldn’t be considered as reef.

During the discussions, the refinement of the existing sublittoral sediment classification for Britain and Ireland being undertaken by JNCC was touched upon. JNCC clarified that the current plan was to expand the definitions of the circalittoral mixed sediment (CMx) and the circalittoral coarse sediment (CCS) which contain a high degree of epifauna. The concept of mixing and matching infaunal and epifaunal components for sediment biotopes was also being explored. While the aim is to provide some refinement to these sections of the classification, this is unlikely to solve the current issues of aligning ‘low resemblance’ Annex I stony reef habitat with areas of stable sediments on the seafloor with pebbles and cobbles, which can afford a habitat for ‘reef-like’ communities to develop, and which cannot be identified as Annex I reef habitat through percentage cover of cobbles and boulders alone.

During this discussion session, there was an opportunity to discuss the Annex I stony reef scenarios that had been shared with the group earlier (see Appendix 3). In the form of an exercise, participants were required to follow the existing Annex I stony reef guidance (summarised in Table 1) to assign each of the three examples as either ‘not a reef’ or having a ‘low’, ‘medium’ or ‘high resemblance’ to Annex I stony reef. Through this exercise, it became clear that the existing guidance could be applied and interpreted in a number of ways, resulting in different final assessments of resemblance to a stony reef. All participants agreed that some overarching guidance for interpreting the existing stony reef guidance (Table 1) was required, to ensure consistency of application across a variety of scenarios. This was carried forward as a recommendation from the workshop, and this overarching guidance has been provided in Section 8.

Following on from discussions around areas of ‘low resemblance’ stony reef typically found on stable, subtidal sediment with low proportions of cobble, the applicability of stability and disturbance to help define ‘low resemblance’ stony reef was considered further. In light of the fact that biota could be treated as a proxy for stability, discussion centred around the approach undertaken by NRW for Welsh inshore waters to better understand the biological communities and specific species associated with stony reef. All participants agreed that this approach could also be trialled in offshore waters, and within English inshore waters.

8 Refinement of guidance for defining areas as Annex I stony reef

8.1 Introduction

An exercise posed to workshop participants (Appendix 3) required them to follow the existing Annex I stony reef guidance (summarised in Table 1) to assign three examples as either ‘not a reef’ or having a ‘low’, ‘medium’ or ‘high resemblance’ to Annex I stony reef. Through this exercise, it became clear that the existing guidance could be applied and interpreted in a number of ways, resulting in different final assessments of resemblance to a stony reef. It was agreed that some overarching guidance for using Table 1 was required, to ensure consistency of application across a variety of scenarios.

8.2 Overarching principles for application of the Annex I stony reef guidance

The following principles should be used alongside Table 1 (shown on Page 4 of this report). For areas of *hard, compact substrata (either on solid or soft seabed)* on the seabed to be considered Annex I stony reef, they must fulfil these four criteria:

1. **Composition** across the area being considered should be at least 10% cobbles (greater than 64mm in minimum diameter) or boulders (greater than 256mm in diameter). This 10% should be considered across the entire area (or at least across the minimum extent of 25m^2). Stony reef habitat is inherently patchy in nature, and although composition is not a measure of patchiness it should take patchiness into account (i.e. on a patchy reef the percent cover of cobbles should take into account areas where cobbles are sparse or absent as well as areas where cobbles are abundant). Composition can be assessed using in-situ (diver) or remote (underwater imaging systems such as drop-camera/Remotely Operated Vehicle) or using acoustic remote sensing such as side-scan sonar or multibeam echosounder backscatter data.

2. **Elevation** of the area under consideration should generally be greater than 64mm. However, matrix supported cobbles >64mm in diameter (partially buried in a sediment matrix) may still function ecologically as a reef with an associated reef community, yet have an elevation less than 64mm. Where the elevation is less than 64mm, particles must have a diameter greater or equal to 64mm to be considered as stony reef. This criterion can include consideration of topographic distinctness from the surrounding seafloor, noting the requirement for the Annex I reef to "arise from the sea floor". Clast size (considered above in composition) could be used as an approximate proxy for elevation. Topographic distinctness (height of the feature) in its broadest term, is best assessed using side-scan sonar or multibeam bathymetry data. Required resolutions of the system will vary dependent on the height of feature.

3. **Extent** of the area under consideration should be greater than 25m^2 (e.g. 5m x 5m / 10m x 2.5m). Note that the inherent patchiness of stony reef should be taken into account when considering extent. For example, individual patches may measure less than 25m^2, but the whole area of patchy reef may exceed 25m^2.

4. **Biota** associated with the area should typically be dominated by epifaunal species. Some areas of seabed subject to scour/disturbance may have an impoverished epifaunal community, yet may still function ecologically as a reef[5]. *Biota* should be considered across the entire area being considered under the *extent* criteria, not just the cobble/boulder fraction being used to consider the *composition* criteria, reflecting the prevalence of an epifaunal or infaunal community. However, more detailed guidance on the *biota* criterion is currently being developed, with respect to assessing which biological communities are typically associated with Annex I stony reef. This may include consideration of particular species which could be used as a proxy for stability.

Meeting the above four criteria (as a minimum) means that the area meets the minimum requirement to be considered as having a 'low resemblance' to Annex I stony reef. Where 'low' was scored for any of these four criteria (composition, elevation, extent or biota), a **strong justification** will be required to consider the area as Annex I stony reef. However, if the majority of the four criteria exceed 'low', then this strong justification could result in classifying the area as having a 'medium resemblance' to Annex I stony reef.

[5] Further work is planned to develop this disturbance/stability aspect, building on initial concepts developed by Brazier (2020) for Welsh inshore waters.

8.2.1 What happens if the area meets the *extent* criteria, with two of the remaining criteria meeting the 'medium resemblance' requirement, and the final criteria meeting 'high resemblance'?

Imagine you are considering an area that meets the minimum requirement for *extent*, i.e. an area greater than 25m^2. For the remaining three criteria, two meet the requirement for 'medium resemblance' to Annex I stony reef (*composition* & *elevation*). The area has also a dense, diverse, epifaunal community. Accepting the current limitations around the *biota* criterion discussed in Section 8.2, the precise percentage ratio of epifaunal to infaunal species is unclear. However, on this occasion, the assumption will be made that this is known, and this well-established, dense epifaunal community meets the 'high' category for *biota* (see Table 3 below). As a general rule, it would be expected that this area would be classified as 'medium resemblance' to Annex I stony reef. Note that not all criteria need to be classed as 'medium resemblance' for the area to be classified as that.

Table 3: A scenario where an area was assessed against the four different Annex I stony reef resemblance criteria, with the end result of a 'medium resemblance' to stony reef classification.

Characteristic	***Not a 'stony reef'***	***'Resemblance' to being a 'stony reef'***		
		Low	**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**

This area could be considered as having a **'medium resemblance' to Annex I stony reef**.

8.2.2 What happens if the area meets the *extent* criteria, with one of the criteria meeting the 'medium resemblance' requirement, and the remaining criteria meeting 'high resemblance'?

Imagine you are considering an area that meets the minimum requirement for *extent*, i.e. an area greater than 25m^2. For the remaining three criteria, one only meets the requirement for 'medium resemblance' to Annex I stony reef (*composition*). *Elevation* meets the requirement for 'high resemblance'. The area has a dense, diverse, epifaunal community. Accepting the current limitations around the *biota* criterion discussed in Section 8.2, the precise percentage ratio of epifaunal to infaunal species is unclear. However, on this occasion, the assumption will be made that this is known, and this well-established, dense epifaunal community meets the 'high' category for *biota* (see Table 4 below). It would be anticipated therefore that this area would be classified as 'high resemblance' to Annex I stony reef. Note that not all criteria need to be classed as 'high resemblance' for the area to be classified as that.

Table 4: A scenario where an area was assessed against the four different Annex I stony reef resemblance criteria, with the end result of a 'high resemblance' to stony reef classification.

Characteristic	***Not a 'stony reef'***	***'Resemblance' to being a 'stony reef'***		
		Low	**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 25m².* *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:	**<25m²**	← **>25m²** →		
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

This area could be considered as having a **'high resemblance' to Annex I stony reef**.

8.2.3 Further worked examples

The following worked examples are based on the three examples provided to workshop participants, listed in Appendix 3. Participants were asked to decide how they would categorise these three examples, either 'not reef', 'low', 'medium' or 'high resemblance' to Annex I stony reef:

1. Extensive area (>25m^2) of seabed (topographically distinct from surrounding seafloor), with an elevation of 2m, composed of gravel.

   Even though the extent and elevation criteria are met, because the mound/bank is composed solely of gravel and has a composition of <10% cobble / boulder, it cannot be considered an area of Annex I stony reef (see Table 5). Irving (2009) makes reference to consolidated gravel banks being considered as Annex I stony reef, "such areas could only be considered if they met the 'reefiness' criteria" in Table 1 (Page 4 of this report); therefore the composition of this gravel bank would need to include a fraction >10% cobble/boulder.

   This area would ***NOT be considered an Annex I stony reef***

Table 5: Example 1 - An extensive area (>25m^2) of seabed (topographically distinct from surrounding seafloor), with elevation >64mm (say 2m), composed of gravel, would *NOT* be classified as an Annex I stony reef.

Characteristic	***Not a 'stony reef'***	***'Resemblance' to being a 'stony reef'***		
		Low	**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 (64 mm) 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. Extensive (>25m^2) banks/mounds of material 2m in elevation, composed of 30% cobbles (>64mm) or larger, with significant epifaunal communities on stable material.

   Meeting the extent criterion, and with a composition of 30% cobbles or larger (e.g. boulders), falling into the 'low resemblance' bracket for this criterion, this area could be classed as 'low resemblance' stony reef. The justification for its classification as Annex I stony reef lies in its elevation, which is 2m, thereby meeting 'medium resemblance' for this criterion. Accepting the current limitations around the biota criterion discussed in Section 8.2, the precise percentage ratio of epifaunal to infaunal species is unclear. However, there is a significant epifaunal community on the stable material. Therefore, this area could be considered as having a 'medium resemblance' to Annex I stony reef (Table 6). This assessment would need to be made on a case by case basis.

   *This area could be considered as having a **'medium resemblance' to Annex I stony reef**.*

Table 6: Example 2 - An extensive (>25m^2) area 2m in elevation (bank/mounds feature), composed of 30% cobbles (>64mm) or larger, with significant epifaunal communities on stable material. This area could be considered as having a *'medium resemblance'* to Annex I stony reef.

Characteristic	***Not* a 'stony reef'**	***'Resemblance' to being a 'stony reef'***		
		Low	**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**

3. Extensive (>25m^2) banks/mounds composed of 100% cobble (>64mm) material. Elevation ranges from 64mm up to ~2m. Significant epifaunal communities on stable material.

   This area meets the extent criteria, has an elevation criteria meeting the 'medium resemblance' criteria, and is composed of 100% cobbles (composition meeting 'high resemblance'). Noting the presence of a significant epifaunal community, this area could be considered as having a 'high resemblance' to Annex I stony reef (Table 7). The area has a dense, diverse, epifaunal community. Accepting the current limitations around the biota criterion discussed in Section 8.2, the precise percentage ratio of epifaunal to infaunal species is unclear. However, on this occasion, the assumption will be made that this is known, and this well-established, dense epifaunal community meets the 'high' category for biota (see Table 7 below).

   This area could be considered as having a ***'high resemblance' to Annex I stony reef****.*

Table 7: Example 3 – An extensive (>25m^2) banks/mounds composed of 100% cobble (>64mm) material. Elevation ranges from 64mm up to ~2m. Significant epifaunal communities on stable material. This area could be classified as *'high resemblance'* to Annex I stony reef.

Characteristic	***Not a 'stony reef'***	***'Resemblance' to being a 'stony reef'***		
		Low	**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**

9 Summary of recommendations & actions

The workshop generated a number of recommendations and actions, and these are summarised below, with a short explanation beneath each. Some of the actions listed below have been addressed within this workshop report.

9.1 Recommendation 1

JNCC and NRW to complete an Annex I stony reef patchiness assessment on existing seabed imagery. From a JNCC perspective, the imagery analysis for data collected from around Solan Bank SAC has already taken place to allow this work to happen. It should be possible to develop a patchiness index (for cobbles and larger) from seabed imagery data collected around Solan Bank, adopting the same principles described in Jenkins *et al.* (2018). This index, using appropriate thresholds, could help inform decisions around determining areas of the seabed as 'low', 'medium' or 'high resemblance' to stony reef, or not reef at all. There is also value in this stony reef patchiness assessment being tested in Welsh inshore waters by NRW.

9.2 Recommendation 2

JNCC to test the NRW approach of assessing stability and biodiversity in UK offshore waters with respect to refining methods to identify ‘low resemblance’ Annex I stony reef. NRW have piloted an approach detailed in Section 5. There is an opportunity to test this approach in UK offshore waters (for example Solan Bank SAC) to see if the methods are equally applicable in a different biogeographical area. The work will also include a more detailed consideration of stability, through the use of stability indicator species.

9.3 Recommendation 3

Natural England to test the NRW approach of assessing stability and biodiversity in English inshore waters with respect to refining methods to identify ‘low resemblance’ Annex I stony reef. NRW have piloted an approach detailed in Section 5. There is an opportunity to test this approach in English inshore waters.

9.4 Recommendation 4

All to meet in one years’ time to take stock of progress following completion of the work outlined in Recommendations 1 and 2. Work highlighted for completion following this workshop is required to fill some of the gaps in knowledge that have been identified following extensive use and testing of the existing Annex I stony reef guidance. Upon completion of this work, the integration of its results will allow the Annex I stony reef guidance to be further refined, and a better understanding and description of what may constitute a strong justification for areas which fall into the ‘low resemblance’ stony reef category.

9.5 Action 1

ASM and JNCC to draft some overarching guidance on using the existing Annex I stony reef guidance summarised in Table 1 (Page 4 of this report) and to be included in the workshop report. Worked examples should be used to help ensure consistency of application of the guidance across a variety of scenarios, by Friday 29th May 2020.

9.6 Action 2

JNCC to update Scottish Natural Heritage (SNH) on the key outputs from this workshop. By Friday 26th June 2020.

References

Brazier, P. 2020. *Defining ‘Reefiness’ – inclusion of ‘low stony reef’ as Annex I Reef feature.* Working paper by Natural Resources Wales. NRW. 11pp.

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Appendix 1

A list of workshop attendees and affiliation

Name	Affiliation
James Albrecht	Joint Nature Conservation Committee (JNCC)
Yolanda Arjona	Joint Nature Conservation Committee (JNCC)
Paul Brazier	Natural Resources Wales (NRW)
Alex Callaway	Agri-Food & Biosciences Institute (AFBI), nominated representative on behalf of the Department of Agriculture, Environment and Rural Affairs (DAERA)
Anna Downie	Centre for Environment, Fisheries and Aquaculture Science (CEFAS)
Neil Golding (Chair)	Aquarius Survey & Mapping (ASM)
Elly Hill	Joint Nature Conservation Committee (JNCC)
Fionnuala McBreen	Joint Nature Conservation Committee (JNCC)
Amy Ridgeway	Joint Nature Conservation Committee (JNCC)
Karen Robinson	Natural Resources Wales (NRW)
Trudy Russell	Natural England (NE)
David Stirling	Marine Scotland Science

Appendix 2

Final workshop agenda

09:30 – 09:45	Welcome & Introductions	Fionnuala McBreen (JNCC)
09:45 – 10:00	Purpose & scope of the workshop *Agree criteria for the defining areas with a 'low resemblance' to stony reef (Table 1)*	Neil Golding (ASM)
10:00 – 10:45	Areas with a 'low resemblance' to stony reef: an inshore MPA perspective	Karen Robinson (NRW) Trudy Russell NE (NE)
10:45 – 11:00	**Coffee\Tea Break**	
11:00-11:30	Areas with a 'low resemblance' to stony reef: an offshore MPA perspective	Fionnuala McBreen (JNCC)
11:30 – 12:30	NRW proposal for biota assessment	Paul Brazier (NRW)
12:30– 13:30	**Lunch**	
13:30 – 13:45	Potential application of a *patchiness assessment method* from seabed video imagery (based on offshore *Sabellaria* reef & Seapen methods & Solan Bank)	James Albrecht (JNCC)
13:45 –15:15	Discussion of options and revised criteria for defining areas with a *'low resemblance'* to stony reef	ALL (Chaired by Neil Golding)
15:15 - 15:30	**Coffee\Tea Break**	
15:30 – 16:15	Present summary of options and agree • Actions • Recommendations • Format of workshop report • Deadlines	Neil Golding

Appendix 3

Annex I stony reef examples for discussion

Three examples of what may constitute Annex I stony reef were provided to workshop participants, in order to stimulate discussion about the existing guidance outlined in Irving (2009). These were discussed during the afternoon discussion session. Participants were asked to decide how they would categorise these three examples, either ‘not reef’, ‘low’, ‘medium’ or ‘high resemblance’ to Annex I stony reef.

1. Extensive area (>25m^2) of seabed (topographically distinct from surrounding seafloor), with elevation >64mm (say 2m), composed of gravel.

2. Extensive (>25m^2) banks/mounds of material 2m in elevation, composed of 30% cobbles (>64mm) or larger, with significant epifaunal communities on stable material.

3. Extensive (>25m^2) banks/mounds composed of 100% cobble (>64mm) material. Elevation ranges from 64mm up to ~2m. Significant epifaunal communities on stable material.

Appendix 4

Areas with a ‘low resemblance’ to Annex I stony reef: a Welsh inshore perspective. Presentation by Karen Robinson, Natural Resources Wales.

This presentation is included as supplemental information on the report entry:

JNCC-Report-656-Appendix4-NaturalResourcesWales.pdf

Appendix 5

Areas with a ‘low resemblance’ to Annex I stony reef: an English inshore perspective. Presentation by Trudy Russell, Natural England.

This presentation is included as supplemental information on the report entry:

JNCC-Report-656-Appendix5-NaturalEngland.pdf

Appendix 6

Areas with a ‘low resemblance’ to Annex I stony reef: a UK offshore perspective. Presentation by Fionnuala McBreen, Joint Nature Conservation Committee.

This presentation is included as supplemental information on the report entry:

JNCC-Report-656-Appendix6-JNCC.pdf

Appendix 7

Working paper exploring the inclusion of 'low resemblance' stony reef as an Annex I feature in Welsh inshore waters, considering disturbance and stability.

Author: Paul Brazier (NRW), 2020

Defining Reefiness – inclusion of 'low stony reef' as Annex I Reef feature

This paper has been prepared to define a method of identifying those biological records that are defined as low stony Reef (boulder and cobble cover is less than 40%), which can justifiably be included as Annex I 'Reef' feature.

1.1. Background

Definition from the Habitats Directive (92/43/EEC), for "Reefs" as Annex I Habitat (1170)
"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."

Building on definitions defined in Irving, R. 2009. The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008. *JNCC Report* No. 432. Some key outcomes of the JNCC report:

- Boulder and cobble reef: "predominantly cobbles and boulders ranging in size from 64mm upwards, excluding bedrock".
- Dominated by epibiota.
- Irving recommendation suggests (p19) not to be concerned by elevation from the sea floor. The elevation is considered to be the height of the substratum particles e.g. 64mm for cobbles.
- Multibeam and sidescan can be used to define reef and on occasion to define levels of reefiness, but not reliably.
- From the JNCC workshop (Irving 2009) "*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.*" See Table below.

Table of workshop consensus from Irving (2009).

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 25m². 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:	**<25m²**	← **>25m²** →		
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

1.2. Evaluating the importance of 'Low Stony Reef' as a Reef feature

Two criteria are considered to be useful in determining the value of Low Stony Reef:
Stability: substrata that are mobile, or largely surrounded by mobile substrata (cobble, pebble, gravel and sand) do not exhibit the characteristics normally associated with Reef.
Biodiversity: in part linked to the stability of the substratum, but also the temporal nature of covering of the rock by sediments and to severe scour. The biodiversity is an important component of the value of a habitat as Reef.

1.3. Stability

There are few attributes that are recorded during remote acoustic, remote video, Phase 1 or Phase 2 recording of marine habitats that provide clues to the stability of the habitat. Looseness of the substratum can be evaluated from video footage, in addition, during Phase 2 survey, the following fields can be helpful: Features-Rock (Stability 1-5; Scour 1-5); Modifiers (accelerated tidal stream). However, stability is often inferred, based on the species assembly. Therefore, stability *per se* cannot be used to define Reef feature.

1.4. Biodiversity

1.4.1. Biotopes

The biotope code that is derived from a combination of substratum and species information is a strong indication of whether a record is Reef feature. In general, a particular biotope does not define the quality of the habitat or the biological community, however there are some biotopes that will consistently be assigned as Reef, due to the necessary stability and species richness. Certain biotopes that are less stable and are typically species poor are unlikely to be assigned as Stony Reef feature.

Stage 1 of confirming Reef feature: draw up a list of biotopes that are stable and contain sufficient species (Reef biotope list). In addition, there are those biotopes that are clearly not Reef feature due to the high proportion of infaunal species and there will be some biotopes that lie in the transition between Reef and Non-Reef habitats.

Reef biotopes:

- stable and relatively species diverse habitat,
- good cover of perennial erect species,

Possible Reef biotopes:

- has partial cover of perennial erect species and some less robust species,

Non-Reef biotopes:

- infaunal and other sediment dependent species,
- have annual or short-lived erect species,
- have scour tolerant and or crustose species.

Examples of Reef biotopes would be those characterised by, for example, perennial kelp plants, since there is the necessary stability to permit kelp plants to become established. Examples of Non-Reef biotopes would be those that are characterised by robust crusts of barnacles or keel worms along with a low abundance of any erect species.

Annex A assigns biotopes to Reef, Not Reef or indeterminate (draft).

There remain those biological records that, due to low species richness or low level of recording species, are not easy to assign to a biotope. These records are not realistically identifiable as Reef feature based on the biotope code alone. In addition, some biotopes vary in character from stable (although usually sediment influenced) through to much less stable habitats and these are not useful to define Reef feature. Amir, F.H. (2018. *An Exploration in the use of Ground-truthed Multibeam Echo Sounder Data for Mapping Annex I Stony Reef. MSc Dissertation Bangor*) found that there are occasions where habitat variability is so great that it is not possible to reasonably characterise the biotope.

Habitat records where the substratum is between 10% and 40% of cobbles or larger (i.e. low stony reef) are often interpreted as a matrix of biotopes, therefore such a biological record is often tagged with multiple biotope codes. The decision must be made as to whether a rocky biotope code characterises sufficient of that record to warrant it being identified as Reef feature.

A consideration not explored in this paper is the extent of the habitat that has been characterised by a single point record. In this paper, we can define whether a record can be classified as Stony Reef, but mapping of the feature will depend on further decisions on the mapping techniques used. Whilst the minimum extent is >25m^2, guidance is required, to describe how point data are interpolated to a mapped area. Point data that have been derived from towed video footage can be re-interpolated to provide a better understanding of the Reef coverage of the seabed.

1.4.2. Identifying Key Species to use as indicators

key characterising species that strongly indicate a stable stony reef habitat can be used to assign a record as Reef feature. This is not dissimilar to how biotopes are identified and tagged to a species record but does not need to assign to biotope level.

Stage 2 of confirming Reef feature: Select those species that are clearly strong indicators of stable substratum and/or of a mature community: referred to as Key Species.

Annex B contains a table of Key Species, which have been identified as particularly indicative of stable substratum. Key Species have been identified through selecting:

- those species (in a test Sarnau dataset) that are exclusive to bedrock/boulder/cobble habitats (i.e. not in pebble/gravel/sediment habitats);
- those species (in a test Sarnau dataset) that have a much higher abundance in bedrock/boulder/cobble habitats compared with pebble/gravel/sediment habitats;
- species selected from the biotope biological comparative tables (source JNCC), that are exclusive to bedrock/boulder/cobble habitats (i.e. not in pebble/gravel/sediment habitats). This could be done, through setting some ground rules, to generate a definitive list of species for the UK.

These species have been tested against real data, although are open to review and additions, where this improves the outcome of stage 2. Trials have shown that, to improve the reliability and confidence in this process, at least 3 Key Species must be recorded to be considered as Low Stony Reef.

Table 1 Key species required to assign a record to Low Stony Reef

	Species count	**Abundance**
Reef	>=3 Key Species	All
Possible Reef	>1 and <3 Key Species	All
Not Reef	No Key Species	-

Possible Stony Reef can be considered further through reviewing the video or still images. Non-Reef records at this stage may still be flagged as Reef in Stage 3 – Reef-Species richness.

Seasearch (Wales), Phase 2 (UK) and geographically constrained (Pen Llyn a'r Sarnau SAC) datasets were analysed in PRIMER to help identify those species in Annex B. The list of species can be developed further in a few ways.

1.4.3. Reef-species richness threshold

Many species, although they are not clear indicators of reef habitat (as Key Species above), have a strong affiliation with stable hard substrata and can be considered positive indicators of reef habitat. These species, when in sufficient diversity and abundance, can be used to identify habitats that should be included in the Low Stony Reef feature.

Stage 3 of confirming Reef feature: Identify a reef-species richness threshold, below which is not considered of value as Reef feature.

The full species list in each record includes many species that are not necessarily closely affiliated with the habitat, so the first exercise is to remove all those species that are pelagic, infaunal and mobile species from the list. Included in the 'mobile species' category are such animals as starfish and crabs (referred to as 'Surface' species), that may be present in many habitat types. The remaining species on the list are therefore species associated with hard substrata. Of these, some species can be very widespread and be found on pebble gravel substrata, which are not in scope for identifying Reef feature ('Wide' species). The species richness of just 'Reef' or of 'Reef' and 'Wide' habitats can be calculated. A Lookup table can be used to complete this task.

Annex C is a list of positive indicator species for reef habitats (in relation to Low Stony Reef habitats). This list has been derived from PRIMER analyses of a number of datasets in Wales, to eliminate those species that might frequently be found in pebble, gravel, sand and mud dominated habitats.

As might be expected, species in the lists are dominated by perennial and long-lasting species that include solitary and colonial ascidians, bryozoans particularly erect bryozoans, some hydroids and an assortment of red and brown algae. There are some species within these groups that appear to

cope with mobile or heavily scoured and disturbed habitats and these could be considered on a separate list of negative indicator species.
The following categories are proposed, when considering Reef-Species that characterise Reef feature.

Table 2 Reef-species required to assign a record to Low Stony Reef

	Species count	**Abundance**
Reef	>20 species	All
Possible Reef	>5 and <20 species	All
Not Reef	<5 species	-

1.5. Conclusions

The following steps are required:

- Identify those samples that are in doubt as to whether they represent Reef feature or not. This may be just Low Stony Reef, since Medium and High Stony Reef are already considered as Reef feature, based on the substratum criteria.
- Ensure that substratum, biotope and species data are all available in a single row of data for a sample.
- Identify and label records with a biotope that is considered Reef feature.
- Generate a Lookup table for all species in the samples, each species being assigned to a 'Lifestyle'. See Wales species Lookup table for a Lookup table for samples across all Wales that are <50% stony substratum.
- Filter the data and generate the species richness of Key Species and Reef-Species for each sample.
- Filter the data, based on species thresholds:

	Key Species count	**Reef-Species count**
Reef	>=3 Key Species	>20 species
Possible Reef	>1 and <3 Key Species	>5 and <20 species
Not Reef	No Key Species	<5 species

- Identify and label samples that meet the Reef feature thresholds.

Further requirements:

- Expand the biotope list that are definite Reef feature for UK and generate a Lookup table.
- Review those species that are assigned as Key Species, using the full biotope biological comparative tables. JNCC may already have worked on these, when developing the biotope classification (e.g. Primer analysis of whole biotope comparative tables dataset).
- Review those species that are assigned as Reef-Species, with careful consideration of the more Widespread species being excluded (e.g. *Alcyonium digitatum*, *Hydrallmania fulcata*, *Brongniartella byssoides*, *etc*.).
- Review the possibility of only using higher abundance for certain species, especially for Key Species, which would eliminate the rare occurrence of the species from the dataset. Trials of removing all Rare records made the analysis too conservative, which is probably exacerbated by the use of species data from Seasearch and drop- down video, where there are likely to be more Rare or Present species records.

Annex A (draft) Reef and Non-Reef Biotopes

Shortlist biotopes identified in Wales as Low Stony Reef. Those biotopes labelled 'Reef' means that all records of that biotope will be assigned as Reef feature; those labelled as '?' are where some examples may be Reef; Non-Reef biotopes have not been included in the list here. Biogenic Reef and Maerl are treated separately.

Seasearch Codes	
ABB – Animal bed brittlestar	?
ABM – Animal bed mussel	Biogenic Reef
EPA – Encrusting pink algae	?
KF – Kelp forest	Reef
KP – Kelp park	Reef
MS – Mixed seaweeds	?
SAT – Short animal turf	?
TAT – Tall animal turf	Reef
SLA – Sediment with life apparent	Not Reef

UK/EUNIS biotope codes

Infralittoral rock	
IR.FIR.IFou	?
IR.FIR.SG	Reef
IR.FIR.SG.CC	Reef
IR.FIR.SG.CC.Mo	Reef
IR.FIR.SG.CrSpAsDenB	Reef
IR.FIR.SG.DenCcor	Reef
IR.FIR.SG.FoSwCC	Reef
IR.HIR.KFaR	Reef
IR.HIR.KFaR.Ala	Reef
IR.HIR.KFaR.Ala.Ldig	Reef
IR.HIR.KFaR.Ala.Myt	Reef
IR.HIR.KFaR.FoR	?
IR.HIR.KFaR.FoR.Dic	?
IR.HIR.KFaR.LhypFa	Reef
IR.HIR.KFaR.LhypR	Reef
IR.HIR.KFaR.LhypR.Ft	Reef
IR.HIR.KFaR.LhypR.Pk	Reef
IR.HIR.KFaR.LhypRVt	Reef
IR.HIR.KSed	?
IR.HIR.KSed.DesFilR	?
IR.HIR.KSed.LsacChoR	?
IR.HIR.KSed.LsacSac	?
IR.HIR.KSed.ProtAhn	?
IR.HIR.KSed.Sac	?
IR.HIR.KSed.XKHal	?
IR.HIR.KSed.XKScrR	?
IR.LIR.IFaVS	?
IR.LIR.K	Reef
IR.LIR.K.LhypLsac	Reef
IR.LIR.K.LhypLsac.Pk	Reef
IR.LIR.K.Lsac.Ft	Reef
IR.LIR.K.Lsac.Ldig	Reef
IR.LIR.K.Lsac.Pk	Reef
IR.LIR.K.Sar	Reef
IR.MIR.KR	Reef
IR.MIR.KR.HiaSw	Reef
IR.MIR.KR.Ldig	Reef
IR.MIR.KR.Ldig.Bo	Reef
IR.MIR.KR.Ldig.Ldig	Reef
IR.MIR.KR.Lhyp	Reef
IR.MIR.KR.Lhyp.Ft	Reef
IR.MIR.KR.Lhyp.GzPk	Reef

Infralittoral rock	
IR.MIR.KR.Lhyp.Pk	Reef
IR.MIR.KR.LhypT	Reef
IR.MIR.KR.LhypT.Ft	Reef
IR.MIR.KR.LhypT.Pk	Reef
IR.MIR.KR.LhypTX	Reef
IR.MIR.KR.LhypTX.Ft	Reef
IR.MIR.KR.LhypTX.Pk	Reef
IR.MIR.KR.XFoR	?
IR.MIR.KT	?
IR.MIR.KT.FilRVS	?
IR.MIR.KT.LdigT	Reef
IR.MIR.KT.XKT	Reef
IR.MIR.KT.XKTX	Reef
Circalittoral rock	
CR.FCR.Cv	?
CR.FCR.Cv.SpCup	?
CR.FCR.FouFa	?
CR.FCR.FouFa.Aasp	?
CR.HCR.FaT	?
CR.HCR.FaT.BalTub	?
CR.HCR.FaT.CTub.Adig	?
CR.HCR.FaT.CTub.CuSp	?
CR.HCR.XFa	?
CR.HCR.XFa.ByErSp	Reef
CR.HCR.XFa.ByErSp.DysAct	Reef
CR.HCR.XFa.ByErSp.Eun	Reef
CR.HCR.XFa.ByErSp.Sag	Reef
CR.HCR.XFa.CvirCri	?
CR.HCR.XFa.FluCoAs	Reef
CR.HCR.XFa.FluCoAs.SmAs	Reef
CR.HCR.XFa.FluCoAs.X	Reef
CR.HCR.XFa.FluHocu	Reef
CR.HCR.XFa.Mol	Reef
CR.HCR.XFa.SpAnVt	?
CR.HCR.XFa.SpNemAdia	?
CR.HCR.XFa.SubCriTf	?
CR.MCR.CFaVS	?
CR.MCR.CFaVS.CuSpH	Reef
CR.MCR.CFaVS.CuSpH.As	Reef
CR.MCR.CFaVS.CuSpH.VS	Reef
CR.MCR.CMus.CMyt	Biogenic Reef
CR.MCR.CMus.Mdis	Biogenic Reef

Infralittoral rock	
CR.MCR.CSab	Biogenic Reef
CR.MCR.CSab.Sspi	Biogenic Reef
CR.MCR.CSab.Sspi.As	Biogenic Reef
CR.MCR.CSab.Sspi.ByB	Biogenic Reef
CR.MCR.EcCr	?
CR.MCR.EcCr.AdigVt	?
CR.MCR.EcCr.CarSp	?
CR.MCR.EcCr.CarSp.Bri	?
CR.MCR.EcCr.CarSp.PenPcom	?
CR.MCR.EcCr.FaAlCr	?
CR.MCR.EcCr.FaAlCr.Adig	?
CR.MCR.EcCr.FaAlCr.Bri	?
CR.MCR.EcCr.FaAlCr.Car	?
CR.MCR.EcCr.FaAlCr.Flu	?
CR.MCR.EcCr.FaAlCr.Pom	?
CR.MCR.EcCr.UrtScr	?
CR.MCR.SfR	?
CR.MCR.SfR.Pol	?

Infralittoral rock	
Sublittoral coarse and mixed sediment	
SS.SCS.CCS.PomB	?
SS.SCS.ICS.HchrEdw	?
SS.SCS.ICS.SSh	?
SS.SCS.SCSVS	?
SS.SMp.KSwSS	?
SS.SMp.KSwSS.LsacGraFS	?
SS.SMp.KSwSS.LsacGraVS	?
SS.SMp.KSwSS.LsacR	?
SS.SMp.KSwSS.LsacR.CbPb	Reef
SS.SMp.KSwSS.LsacR.Gv	?
SS.SMx.CMx	?
SS.SMx.CMx.ClloMx.Nem	?
SS.SMx.CMx.FluHyd	?
SS.SMx.CMx.OphMx	?
SS.SMx.IMx	?
SS.SMx.IMx.CreAsAn	?
SS.SMx.IMx.SpavSpAn	?

Annex B (draft) Strong indicators of Reef habitats (example)

Some epibiota are dependent on particularly stable substrata and are therefore valuable indicators of Reef habitats (Key Species). Species in Table 3 are derived from an analysis of those typical reef species that are recorded only rarely on pebble, gravel and sediment habitats. This table contains some species that are not good indicators. The species in Table 4 are selected based on a SIMPER analysis of data from the Sarnau in mid-Wales, taking those species of sufficient abundance and most influencing the differences between substratum clusters (i.e. rock vs sediment). The species in Table 5 are derived from a combination of species from the Primer analysis of Sarnau data and species from the biotope biological comparative tables, selecting those species that are not found in pebble, gravel and sediment habitats.

Table 3 First trial of Key Species

Amphilectus fucorum	*Calliblepharis ciliata*	*Laminaria hyperborea*
Cliona celata	*Phyllophora* species	*Laminaria digitata*
Nemertesia antennina	*Dilsea carnosa*	*Halidrys siliquosa*
Alcyonium digitatum	*Chondrus crispus*	*Dictyota dichotoma*
Balanus crenatus		
Pentapora foliacea		
Botryllus schlosseri		
Clavelina lepadiformis		
Semibalanus balanoides		

Table 4 Second trial of Key Species

Abietinaria abietina	*Calliblepharis ciliata*	*Saccharina latissima*
Aglaophenia pluma	*Ceramium spp*	*Laminaria digitata*
Alcyonium digitatum	*Chondria dasyphylla*	*Laminaria hyperborea*
Amphilectus fucorum	*Chondrus crispus*	*Fucus serratus*
Ascidiella scabra	*Corallina officinalis*	*Cutleria multifida*
Botryllus schlosseri	*Cordylecladia erecta*	*Sphacelaria*
Electra pilosa	*Cryptopleura ramosa*	*Cladostephus spongiosus*
Flustrellidra hispida	*Furcellaria lumbricalis*	*Ulva spp*
Leucandra ananas	*Jania rubens*	
Patella vulgata	*Mastocarpus stellatus*	
Perophora listeri	*Phyllophora crispa*	
Semibalanus balanoides	*Phyllophora pseudoceranoides*	
Vesicularia spinosa	*Plocamium cartilagineum*	
	Polysiphonia fucoides	
	Pterothamnion crispum	
	Rhodomela confervoides	
	Rhodophyllis divaricata	

Table 5 Third trial of Key Species

Based on SIMPER analysis of the Sarnau data, taking those species of sufficient abundance and most influencing the differences between substratum clusters.

Hemimycale columella	*Bicellariella*	*Ceramium diaphanum*
Myxilla	*Bicellariella ciliata*	*Ceramium pallidum*
Myxilla incrustans	*Bugula*	*Chondrus crispus*
Leucandra ananas	*Bugula flabellata*	*Corallina*
Pachymatisma johnstoni	*Bugula plumosa*	*Corallina officinalis*
Suberites	*Bugula turbinata*	*Halurus flosculosus*
Suberites carnosus	*Crisia*	*Jania*
Suberites ficus	*Crisia denticulata*	*Jania rubens*
Suberitidae	*Crisia eburnea*	*Mastocarpus stellatus*
Tubularia	*Crisidia*	*Phyllophora pseudoceranoides*
Tubularia indivisa	*Crisidia cornuta*	*Alaria esculenta*
Abietinaria abietina	*Crisiidae*	*Fucus serratus*

Caryophyllia inornata	*Flustrellidra hispida*	*Laminaria*
Corynactis viridis	*Polyclinidae*	*Laminaria digitata*
Semibalanus	*Polyclinum aurantium*	*Laminaria hyperborea*
Semibalanus balanoides	*Perophora listeri*	*Laminaria ochroleuca*
Patella pellucida		
Patella ulyssiponensis		
Patella vulgata		

Annex C (draft) Species associated with Reef

The biotope biological comparison tables published by JNCC can be used to identify Reef-Species. Species from all infralittoral and circalittoral biotopes that are characterised as boulder or cobble that are not found in sediment biotopes can be selected. The spreadsheet Stony reef biotopes Biotopes Species matrix shows an interim assessment of species, which have been classified on a scale of 1 to 5 according to their affiliation to rock habitats or sediment habitats (scour and stability assessment also attempted).

Using BIOTIC, biotope biological comparative tables and a considerable amount of expert judgement, the species from xx samples have been assessed as follows.

Table 6 Assessment of 'lifestyles' of species

Tag	Number of species	Reasoning
Reef	573	Species that are typically associated with rocky habitats.
LifeForm	7	Higher Taxa that provide some useful information to evaluating Reef.
Biog	8	Species that characterise biogenic reef habitats.
Wide	200	Species that are typically associated with hard substrata, but are not reliably associated with just stable Reef habitats.
Surface	242	Surface dwellers that may or may not be associated with Reef, they have little dependency on rocky substrata and are often living on other biota.
Mobile	198	Mobile species that readily move between habitats and so not reliably associated with Reef.
HighTaxon	59	Taxa at a high level of resolution that are not useful in assigning habitats as Reef.
Sedi	88	Species that are typically associated with sediment habitats.
Infauna	125	Species typically associated with the sediment, as infauna.

Annex D (draft) Flow diagram for defining the Reef feature

Appendix 8

An overview of work undertaken to examine the patchiness of habitats in UK offshore waters, and potential ways it could be recorded. Presentation by Joint Nature Conservation Committee.

This presentation is included as supplemental information on the report entry:

JNCC-Report-656-Appendix8-JNCC.pdf