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