

Methodology for Creating a Map of Annex I Reef in UK Waters

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1 Summary

This document describes the data sources and processes involved in creating distribution maps of reefs within the boundaries of the UK continental shelf. 'Reefs' here refers to the habitat listed under Annex I of EC Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora – commonly known as the Habitats Directive.

Similar maps will also be developed for the habitats 'mudflats and sandflats not covered by water at low tide' and 'sandbanks slightly covered by seawater all the time'.

Previous maps of reef habitat around the UK showed the potential extent of the habitat; it is now the case that in many areas, there is enough confidence in the data to refer to them simply as *reef*, for which special areas of conservation (SACs) are designated. Broadly, areas mapped as *reef* are a result of surveys that used a combination of remote sensing and ground truthing and/or were specifically designed to identify Annex I habitats. Areas mapped as *potential reef* are a result of broadscale surveys, but further work may be needed to delineate the precise boundaries of the habitat. Where there is enough evidence from other sources, SACs are also designated for areas containing only *potential reef*.

A third layer has also been created, which shows areas known not to contain reef – this is to help distinguish between areas that have not been adequately mapped and/or interpreted and areas that have been found to contain other habitats.

2 Data Sources

Datasets from a wide range of different sources were overlain to produce the map of Annex I reefs in UK waters; these are described in detail below, with a description of how it was decided what is classed as reef and potential reef. Some data were originally collected specifically for identification of Annex I reef habitat, while others were collected for more general nature conservation purposes, or even geological mapping.

2.1 Mapping European Seabed Habitats (MESH¹)

Between 2004 and 2008, MESH collated seabed habitat maps from a wide range of different surveys and converted them into a consistent format, using the European Nature Information System (EUNIS) habitat classification (European Environment Agency, 2007). EUNIS is the European standard for classifying terrestrial and marine habitats, and the marine part is almost identical to the Britain and Ireland Marine Habitat Classification (Connor *et al.*, 2004). This hierarchical system assigns codes of letters and numbers to describe habitats at varying levels of accuracy. The standardised maps were merged to make the MESH combined EUNIS map, currently version 3.2, which continues to be updated by JNCC when new data are created and is a freely available data product.

An equivalency table is available (JNCC, 2010a) which shows the relationship between EUNIS habitat types and Annex I habitats. Based on this table, polygons labelled with EUNIS codes that are wholly included within the definition of Annex I reef habitat were

¹ Development of a Framework for Mapping European Seabed Habitat, funded by INTERREG IIIB; www.searchmesh.net

extracted from the combined EUNIS map and their confidence scores were assessed. Ideally, habitat maps should be derived from remote sensing and ground-truthing data, but it is not always possible for a survey to collect both these data types. The diversity of maps which contributed to the combined EUNIS map means that confidence varies spatially within the layer. The MESH confidence assessment (www.searchMESH.net/Default.aspx?page=1635) was used to assign confidence scores between 0 and 100 for each habitat map included in this layer. It was decided that for the purposes of mapping *reef* (as opposed to *potential reef*), it was important that the map was based on both remote sensing and ground-truthing data. Using this criterion, a confidence score of 58 was identified as the cut-off; below this score habitat maps with confidence of >58 were classed as *potential* habitat.

Further, those polygons with EUNIS codes that are only partially equivalent to the definition of Annex I reefs, were automatically classed as *potential*. Another important factor is data coverage; it was decided that all survey data with a Remote Sensing Coverage score of 0 or 1 (out of 3) should be classed as *potential* because the very nature of interpolation between survey lines means that the mapped habitats are interpolations, and the poorer the coverage, the less certain the interpreter can be of the results. Data derived from surveys using acoustic ground discrimination systems (AGDS) as the only remote sensing technique should also be classed as *potential*; Brown *et al.* (2005) describe the uncertain nature of interpreting AGDS data for seabed habitats. Subsequently, any reef polygons in the intertidal zone (between mean low and mean high water) that were not connected to subtidal reefs were removed, as these are not classed as reefs under Annex I of the Habitats Directive.

As well as identifying areas of reef, areas of *not reef* were also extracted from the combined EUNIS map. The same confidence rules as described above were used and muddy habitats were extracted to produce a layer of *not reef*. A table showing the EUNIS codes used in this layer is given in Appendix 1.

2.2 Natural England

Between 2007 and 2008, Natural England undertook surveys and analysed existing survey data to identify Annex I habitats away from the coast in English territorial waters. The habitat maps resulting from these surveys were not included in the MESH combined EUNIS map. Reef habitat identified in these maps is classed as *reef* (as opposed to *potential reef*), because the surveys concerned were specifically targeting detection of Annex I reef. Reefs were identified in the following regions, and maps of these reefs were provided:

- **Prawle Point to Plymouth Sound & Eddystone** (Natural England, 2010a);
- **Studland to Portland** (Natural England, 2010b);
- **Lune Deep** (Natural England, 2010c);
- **Haisborough, Hammond and Winterton** (Natural England, 2010d);
- **Inner Dowsing, Race Bank and North Ridge** (Natural England and JNCC, 2010);
- **Cape Bank** (Cefas, 2008b; Natural England, 2010e).
- **Lyme Bay and Torbay** (Natural England, 2010f);
- **Lizard Point** (Cefas, 2008a; Natural England, 2010g);

During these surveys Annex I habitats other than reef were also identified; namely, sandbanks which are slightly covered by sea water all the time. These were identified in the following regions:

- **Lizard Point** (Cefas, 2008a; Natural England, 2010g);
- **Greater Thames Estuary** (Entec UK Ltd, 2008a);
- **Outer Wash** (Entec UK Ltd, 2008b);

- **Haisborough, Hammond and Winterton** (Natural England, 2010d);
- **Inner Dowsing, Race Bank and North Ridge** (Natural England and JNCC, 2010);
- **Margate and Long Sands** (Natural England, 2010h).

2.3 Countryside Council for Wales

From intertidal survey data collected between 1996 and 2006 (Brazier *et al.*, 2007), and 2003 single beam echosounder data in combination with Admiralty charts, local knowledge and point data stored in the Marine Recorder database (JNCC, n.d.), the Countryside Council for Wales has identified definitive and indicative areas of Annex I habitats within Special Areas of Conservation (SACs). Indicative reef areas were those with limited or unclear remote sensing data, and consequently there is lower confidence in the maps of these areas. The known and possible reef categories were therefore equated to *reef* and *potential reef*. Reef distribution maps were provided for the following SACs:

- **Pembrokeshire, known and possible reefs;**
- **Lleyn Peninsula, known and possible reefs;**
- **Cardigan Bay, known and possible reefs;**
- **Menai Strait, known reefs.**

During these surveys Annex I habitats other than reef were also identified; namely, sandbanks which are slightly covered by sea water all the time. These were identified in the following regions:

- **Pembrokeshire;**
- **Lleyn Peninsula;**
- **Cardigan Bay;**
- **Carmarthen Bay;**
- **Menai Strait.**

2.4 Scottish Natural Heritage

In 2001 and 2005, Scottish Natural Heritage undertook surveys and analysed existing survey data to identify Annex I habitats in two SACs. The habitat maps resulting from these surveys have not yet been included in the MESH combined EUNIS map. Reef habitat identified in these maps is classed as *reef* (as opposed to *potential reef*), because the surveys concerned were specifically targeting detection of Annex I reef. Reefs were identified in the following regions, and maps of these reefs were provided:

- **Loch Laxford** (Bates *et al.*, 2004)
- **Loch Creran** (Moore *et al.*, 2006)

2.5 Joint Nature Conservation Committee

Since 2003 JNCC have been involved in surveys mapping Annex I reefs in offshore waters (beyond 12 nautical miles from the UK coastline). Habitat maps produced by some of these surveys have contributed to the MESH combined EUNIS map. However, detailed maps of *reef* are also available from these surveys, and have been used here to refine the distribution map. Areas for which these data are available are:

- **Saturn Reef** (JNCC, 2010b)
- **Stanton Banks** (JNCC, 2008)

- **Wight-Barfleur** (Coggan *et al.*, 2009)
- **Blackstones Bank** (Mitchell and Service, 2004)
- **North West Irish Sea Mounds** (AFBI *et al.*, 2007)
- **South West Canyons** (Stewart and Davies, 2007)
- **Pobie Bank** (Foster-Smith *et al.*, 2009)
- **West Hebrides** (Mitchell, 2009)

There are three special cases in offshore waters where reef data have been acquired by means different to those described in the methodology here. They occur at:

- **Northwest Rockall** (JNCC, 2010c)
- **Darwin Mounds** (JNCC, 2010d)
- **Hatton Bank** (JNCC, 2009)

These are locations of fisheries closures for the protection of reefs, where there exists a wealth of data from the fisheries industry on the location of the reef – enough data, when combined with other data such as geological maps and other ground-truthing data to enforce the fisheries closures and to provide evidence for their designations as SACs.

Annex I sandbanks data were also available for **Dogger Bank** (JNCC, 2010e), which were used to remove areas known to not be reef.

2.6 British Geological Survey

Areas marked as gravel or diamicton in version 1 of the British Geological Survey (BGS) seabed sediment map, DigSBS250 (Graham *et al.*, 2001) were extracted and classed as potential stony Annex I reef habitat. This layer covers offshore and inshore areas.

In 2004, a contract let by English Nature updated and filled gaps in inshore English and Welsh areas of the DigSBS250 map described above (BMT Cordah Limited, 2004). As part of the contract, the dataset was compared to ground-truth data where possible. Inshore England and Wales DigSBS250 data were replaced with gravel and diamicton data from this map.

In July 2010 the results of a Defra contract were released, showing potential areas of rock and hard substrate at or near the seabed surface. A maximum sediment thickness of around 0.5 metres was used to describe rock and hard substrate near the seabed surface (Gafeira *et al.*, 2010). This is because if the bedrock is that close to the surface then there is potential for the rock to become exposed. These polygons were added as potential bedrock reef.

2.7 National Oceanography Centre, Southampton

In winter 2009 the results of another Defra contract were released, showing the extent of seabed features in the deep-sea area of the UK continental shelf. This was to contribute to work aiming to extend the EUNIS classification scheme to include more deep-sea habitats (Jacobs and Porritt, 2009).

Areas classed as “mud and sandy mud” and “sand and muddy sand” were extracted from this dataset to remove areas mapped as potential reef in the deep-sea area. Confidence in these data is higher than confidence in the BGS data because these data were derived using the BGS data, amongst other sources.

2.8 Summary of distinction between reef and potential reef

Data classed as *reef*:

- a) Annex I reef maps from surveys specifically targeting detection of Annex I reef, or
- b) Annex I reef maps translated from MESH biotope maps with confidence scores of 59 % or higher, with remote sensing coverage score of 2 or 3 (out of 3) and where remote sensing techniques used were not only acoustic ground discrimination system

Data classed as *potential reef*:

- a) Annex I reef maps translated from MESH biotope maps with confidence scores of less than 59 % and/or with remote sensing coverage score of 0 or 1 (out of 3) and/or where remote sensing techniques used were only acoustic ground discrimination system, or
- b) Annex I reef maps interpreted from geological maps

3 Processing of Data Sources

All data sources were ESRI™ shapefiles, and data processing was carried out in ArcGIS 9.2. Because there were several data sources, a few issues were first corrected before they were merged.

3.1 Standardising attribute tables

Data layers from different sources had different fields in their associated attribute tables. All files' attribute tables were converted to a common format, composed of the MESH Translated Habitat Data Exchange Format (Coltman, 2005) with additional fields, as in Appendix 2.

3.2 Annex I reef sub-type

Some data sources included sufficient information to populate the SUBTYPE field in their attribute table, describing the type of Annex I reef (e.g. bedrock, stony, biogenic). To do this, look-up tables were used for the MESH map and British Geological Survey data. The attribute table of the MESH map was filled in according to Table 1, based on information in the EUNIS code.

Table 1 Relationship between EUNIS codes and subtype of Annex I reefs.

EUNIS code	EUNIS description	Annex I reef subtype
A1	Littoral rock	bedrock/stony
A1.1	High energy littoral rock	bedrock/stony
A1.2	Moderate energy littoral rock	bedrock/stony
A1.3	Low energy littoral rock	bedrock/stony
A1.4	Features of littoral rock	bedrock/stony
A2.7	Littoral biogenic reefs	biogenic
A3	Infralittoral rock and other hard substrata	bedrock/stony
A3.1	Atlantic and Mediterranean high energy infralittoral rock	bedrock/stony
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	bedrock/stony
A3.3	Atlantic and Mediterranean low energy infralittoral rock	bedrock/stony
A4	Circalittoral rock and other hard substrata	bedrock/stony
A4.1	Atlantic and Mediterranean high energy circalittoral rock	bedrock/stony
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	bedrock/stony
A4.3	Atlantic and Mediterranean low energy circalittoral rock	bedrock/stony
A5.6	Sublittoral biogenic reefs	biogenic
A6.1	Deep-sea rock and artificial hard substrata	bedrock
A6.6	Deep-sea bioherms	biogenic
B3.1	Supralittoral rock (lichen or splash zone)	bedrock

The SUBTYPE field for the potential reef files derived from British Geological Survey data were filled in according to Table 2. For offshore polygons, some modifications have been made based on additional data for specific areas, such as removing one possible subtype. These modifications were retained.

Table 2 Relationship between rock/sediment types and Annex I reef subtype for potential reef files derived from British Geological Survey data.

Rock/sediment type	Annex I reef subtype
rock	bedrock
rock and sediment	bedrock/stony
rock or diamicton	bedrock/stony
undifferentiated solid rock	bedrock/stony
gravel	stony
diamicton	stony

3.3 Removing overlaps between data sources and areas known not to be reef

Some of the data from different sources described above are spatially overlapping. In order to decide which data source ‘wins’ in an overlapping area, the data sources were ranked in order of data quality, as shown in Table 3.

Table 3 Summary of data sources for Annex I reef map. The layers with the highest ranking were used to cut out overlapping areas from layers with lower rankings.

Order of layers	Reef data	‘Not reef’ data (used to remove reef data with lower confidence)
Habitat		
1	NE, CCW and SNH inshore and JNCC offshore survey data (surveyed and reefs found)	
2	MESH data with confidence > 58% (EUNIS codes translated to definite Annex I reef)	
3		NE and CCW inshore and JNCC offshore survey data (surveyed and reefs not found/other Annex I habitats found)
4		MESH data with confidence > 58% (EUNIS codes containing ‘mud’ in habitat description)
Potential habitat		
5	CCW survey data – potential reef	
6	MESH data with confidence ≤ 58% (EUNIS codes translated to Annex I reef)	
7		NOC deep-sea substrate ‘sand and muddy sand’ and ‘mud and sandy mud’
8	BGS rock and hard substrate	
9	BGS DigSBS250 version 1 gravel data & BMT Cordah data	

For more information about the procedure for removing overlaps, see Appendix 3.

4 Further Updates

Version 1 of this UK-wide extent map of Annex I reefs will be published by September 2010 for use in the Marine Biodiversity Monitoring Programme.

Future versions will be released according to needs of various requirements, including marine assessments such as Article 17 conservation assessments (every six years; next report due in 2013) and Marine Strategy Framework Directive assessments (every six years; next report due in 2012), analysis of MPA networks and for the national Marine Biodiversity Monitoring Programme.

Because of the various requirements for the data to be updated, there will not be a fixed frequency of update. However, the period between each update will be somewhere between once a year and once every six years, depending on the need and the availability, amount and quality of new data.

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Appendix 1: EUNIS Codes Extracted from MESH for use in 'Not Reef' Layer

Table A1 EUNIS habitats/biotopes used to create 'not reef' layer from MESH combined EUNIS map. Note: habitats/biotopes refer to those stated and all sub-biotopes.

EUNIS 2004 code	Habitat Description
A2.2	Littoral sand and muddy sand
A2.3	Littoral mud
A2.41	<i>Hediste diversicolor</i> dominated gravelly sandy mud shores
A2.5	Coastal saltmarshes and saline reedbeds
A2.6	Littoral sediments dominated by aquatic angiosperms
A2.86	Hydrolittoral muddy substrata
A5.24	Infralittoral muddy sand
A5.26	Circalittoral muddy sand
A5.3	Sublittoral mud
A6.4	Deep-sea muddy sand
A6.5	Deep-sea mud

Appendix 2: Format for Attributes Tables

Field	Definition	Input
FID	Numbers polygons starting from 0	Generated automatically
Shape	Point/line/polygon	Generated automatically
POLYGON	Identification number for each polygon	FID+1 for each original GUI
GUI	Globally unique identifier for each original file	e.g. "GB001037"
ORIG_HAB	Non-EUNIS habitat type	e.g. "Circalittoral rock with faunal turf"
HAB_TYPE	EUNIS habitat type	e.g. "A4.3"
VERSION	Version of habitat classification scheme used	e.g. "EUNIS_version_2004"
DET_MTHD	Method of determining EUNIS code	e.g. "redetermination by class"
DET_NAME	Name of determiner	e.g. "Joe Bloggs"
DET_DATE	Date of determining EUNIS code	e.g. "31/12/2009"
TRAN_COM	Translation comments	Comments relevant to translation process between ORIG_HAB and HAB_TYPE
T_RELATE	How EUNIS code (HAB_TYPE) relates to ORIG_HAB	=/≈/</>/#/S (see JNCC, 2009 for explanation)
VAL_COMM	Validation comments	Comments relating to validation of translated data
ANNEX1	Name of Annex 1 habitat	"Reefs"
REF_ID	Individual code to refer to each polygon	e.g. "K01234"
SUBTYPE	Subtype of Annex 1 habitat	"Biogenic", "Bedrock" and/or "Stony"
CONFIDENCE	<i>Reef</i> or <i>potential</i>	"Reef" or "Potential"
SACTYPE	Type of SAC if data are within a SAC	"dSAC", "pSAC", "cSAC" or "SAC"
SACNAME	Official name of SAC the data are within	e.g. "Lands End and Cape Bank"
MOD_DATE	Date file was last modified	e.g. "31/12/2009"
SOURCE	Source of data	e.g. "Natural England"

Appendix 3: Procedure for Removing Overlapping Polygons using ArcGIS 9.2

Layers with the highest ranking as given in Table 3 of this document were used to cut out overlapping areas from layers with lower rankings using the Erase tool (in ArcInfo) with an XY tolerance of 0.1 metres; this value was arbitrarily chosen to reduce the number of 'slivers', assuming that the data are no more accurately mapped than this.

To remove any overlapping polygons within shapefiles, the topology toolbox (in Editor mode in ArcInfo) was used to identify and fix these errors – this often required the arbitrary choice of which polygon to cut out and which was to remain intact. The procedure was as follows:

1. Import files into a file geodatabase and create a topology with the rule that there be no overlaps. A layer is created showing overlapping areas in red.
2. For many cases, each overlap must be removed one at a time using the 'Fix Topology Error Tool' on the topology toolbar in Edit mode. Right click on an overlap error, and choose one of three options: **Subtract** (erase both bits of overlapping polygon to leave a gap), **Merge** (choose one bit of polygon to stay and one to be deleted) or **Create Feature** (creates a new polygon with empty attributes). Only Subtract and Create Feature work on multiple errors, because Merge requires a preference between the two polygons to be chosen; however, this is the tool that needs to be used.
3. If one polygon overlaps several others and it is decided that it should 'win', then select it and use Editor>Clip; this will remove all overlaps with this polygon.
4. As the errors are fixed, the topology layer showing the errors updates automatically and removes the red areas.

To clean up most slivers (tiny polygons and tiny gaps between polygons), the Integrate tool can be used with an XY tolerance of 0.1 metres.

Appendix 4: Version Control

BUILD STATUS:

Version	Date	Author	Reason/Comments
1.0	10 Jan 2011	Helen Ellwood	Final touches
0.9	16 Nov 2010	Helen Ellwood	Updated to describe new data from SNH, NE and JNCC.
0.8	9 July 2010	Helen Ellwood	Incorporated comments made by SNH and NE after the MPA Technical Working Group meeting.
0.7	19 May 2010	Helen Ellwood	Made information about 'not reef' data and order of layer confidence clearer. Finalised document for release to country agencies for checking after MPA Technical Working Group meeting on 18 May 2010. Merged website version and internal version into one document.
0.6	25 Feb 2010	Helen Ellwood	Described changes discussed in meeting on 5 Feb 2010.
0.5	25 Jan 2010	Helen Ellwood	As version 0.4, but using MET template and document control, and with minor corrections.
0.4	25 Jan 2010	Helen Ellwood	Updated to fill in gaps as recommended in comments in version 0.2. Some links in References section updated.
0.3	15 Jan 2010	Natalie Coltman	As version 0.2, with changes accepted.
0.2	15 Jan 2010	Natalie Coltman	Comments added and wording improved by Natalie Coltman.
0.1	06 Jan 2010	Helen Ellwood	First draft

DISTRIBUTION:

Copy	Version	Issue Date	Issued To
Electronic	0.7	25 May 2010	Members of the MPA Technical Working Group
Electronic	0.1	06 Jan 2010	Natalie Coltman, Marine Ecosystems Team, JNCC