JNCC Methods Report

Method for creating version 8 of the UK Composite Map of Annex I Reefs

Graeme Duncan, Jordan Pinder, Helen Lillis, Harriet Allen

03/2022

ISSN 0963 8901

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

This report should be cited as:
Duncan, G., Pinder, J., Lillis, H. and Allen, H. (2022). Method for creating version 8 of the UK Composite Map of Annex I Reefs. Joint Nature Conservation Committee, Peterborough.

JNCC EQA Statement:
This report is compliant with the JNCC Evidence Quality Assurance Policy
https://jncc.gov.uk/about-jncc/corporate-information/evidence-quality-assurance/

Contents

1 Introduction

1.1 Requirement

Under the Habitats Regulations[1], the UK Government and devolved administrations are required to establish a network of Special Areas of Conservation that will make a significant contribution to conserving the habitats and species identified in Annexes I and II, respectively, of the Habitats Directive (92/43/EEC[2,3]). Reefs are one of the habitats listed in Annex I, and to support site selection, management and reporting the Joint Nature Conservation Committee (JNCC) maintains a composite data product showing the best available data for the extent and distribution of all Annex I Reefs in UK. This is carried out in collaboration with the Country Nature Conservation Bodies[4] (CNCBs) and is updated roughly once per six-yearly reporting period (reporting required under Habitats Regulations). The product is made up of a polygon dataset (described in section 2) and a point dataset (section 3).

Version 7 of the Annex I Reef data product was published in 2013 (Ellwood, 2013). It was created using a predominantly objective and simple method for compiling and aggregating reef data from multiple sources and determining final confidence of reef.

The 2019-2022 update (version 8) incorporates the previous version along with new evidence that has since been collected by JNCC and the CNCBs on the presence of Reef, providing a basis to update the layer where new data is available.

Additionally, for the first time we have produced a separate product showing 'areas to be managed as reef', for more details see section 5.

[1]
- the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales (including the adjacent territorial sea) and to a limited extent in Scotland (reserved matters) and Northern Ireland (excepted matters),
- the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) in Scotland,
- the Conservation (Natural Habitats, &c) Regulations (Northern Ireland) 1995 (as amended) in Northern Ireland, and
- the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) in the UK offshore area.

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043

[3] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

[4] Department of Agriculture, Environment and Rural Affairs (Northern Ireland) (DAERA), Natural England (NE), Natural Resources Wales (NRW) and NatureScot.

1.2 Definition

The Interpretation Manual of European Union Habitats – EUR25 (CEC, 2013) includes the following in its interpretation of "Reef":

"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."

Along with the following clarifications:

- "Hard compact substrata" are: rocks (including soft rock, e.g. chalk), boulders and cobbles (generally >64 mm 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.

From this interpretation, JNCC classifies Reef into one (or more) of the following subtypes:

- Bedrock (encompassing "hard compact substrata", specifically, "rocks (including soft rock, e.g. chalk)" of "geogenic origin");
- Stony (encompassing "hard compact substrata", specifically, "boulders and cobbles (generally >64 mm in diameter" of "geogenic origin");
- Biogenic (encompassing "biogenic concretions").

1.3 Description of Confidence

Throughout the dataset, the data representing extent of reef are classified into two main confidence values, "High" and "Potential".

As in v7 of the reefs layer, these two values are used as a coarse guide to the level of background information underpinning the data. "Potential" reef describes areas or points

where the available data *suggests* that reef may be present as described by the geometry, but there is not a sufficiently high amount of evidence to upgrade the confidence to "High"[5].

In general:

Data classed as high confidence reef:

a) Annex I reef maps from surveys specifically targeting detection of Annex I reef, or
b) Annex I reef maps translated from EUNIS 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
b) Data translated from another classification system showing either a high degree of habitat heterogeneity (e.g. mosaics) where other habitats may also be present, or a translation match to Annex I reef.
c) Annex I reef maps interpreted from broad-scale geological map

2 Method for polygon data

2.1 Data Sources

2.1.1 Reefs v7

The previous version of the reefs layer was used as an input to reduce duplication in compilation effort. The data were split into two sub-datasets, one regarding reef that had been determined to be 'High' confidence, and one 'Potential'.

Several datasets were removed from this source before the dataset was included in the composition method:

- Data derived from the combined EUNIS level 3 map were removed as they would be superseded by the latest version of the combined map extract (see Section 2.1.3);
- Data derived from BGS DigSBS250 (polygons with globally-unique ID = GB001052) were removed as they would be superseded by rock data the semi-automated rock analyses (see Section 2.1.4);

2.1.2 New survey data concerning SACs

Stanton banks

Dataset GB001232, describing surveyed Annex I bedrock reef using data captured from the 2012 NLV Polestar survey within Stanton Banks SAC (Murray et al, 2013) was included as "High" confidence reef.

Wight-Barfleur reef

A composite data product was compiled by JNCC from information analysed from the 2013 survey to the site (CEND0313, Barrio Froján et al, 2014) and expert JNCC site-

[5] Note that the confidence level of "Potential" does not mean that the area has the potential to be or become reef; this is instead defined under the term "Range".

lead advice prior to inclusion in the new reef layer. These data included a full-coverage EUNIS habitat map (GB001322), which was specifically translated to Annex I with expert site-level judgment, and finer-scale information from side-scan sonar boxes within the site (GB003025), which was used in preference of any underlying EUNIS data.

Expert judgment determined that due to the underlying information:
1. EUNIS habitats 'A4' and 'X33' should be assigned to 'High confidence' 'Bedrock' and 'Bedrock and/or stony' Reef respectively;
2. EUNIS habitat 'A5.14' should be assigned to 'Potential' 'Stony' Reef
3. Data assigned an Annex I habitat from the side-scan survey boxes should be assigned to 'High confidence' Reef.

Anton Dohrn seamount
An update to the Plymouth University analysis of the 2009 MV Franklin Survey to Anton Dohrn was made available to better present existing knowledge of Reef within the site. These data were included within the dataset to supersede the underlying original version. The data were assigned a confidence level based on the following criteria:
1. Biogenic reef identified as "Predicted" in the original dataset was assigned a value of 'Potential' due to uncertainty in modelling these data from acoustic information;
2. Stony/bedrock reef identified as "Predicted" in the original dataset was assigned a value of 'High confidence' as these classes can be consistently modelled from acoustic information;
3. All data classified as "Observed" in the original dataset was assigned a value of 'High confidence'.

2.1.3 Full-coverage EUNIS level 3 layer integrating maps from surveys and broad-scale models (version 9.6)

This dataset (Ellwood, 2014), combining JNCC's survey map data holdings with UKSeaMap, was used to extract underlying Annex I data from correlating EUNIS habitats. Broad-scale rock data from UKSeaMap was removed where it fell within the area of analysis of the semi-automated rock mapping dataset (2.1.4), as the latter provided a higher resolution version of the same information[6].

The data were assigned a confidence level based on the following criteria:
1. If the data were a partial match to Annex 1 reef (e.g. a habitat mosaic), they were attributed a value of 'Potential';
2. Dataset with low general confidence scores (e.g. MESH confidence of <58) were attributed a value of 'Potential';
3. Remaining data were attributed a value of 'High'.

Data were flagged as intertidal or subtidal reef based on the EUNIS habitat value for use later in the method.

Mud habitats were extracted and assigned a confidence value of "High" and "Potential" based on confidence scores as above, to use as "Not Reef" data in the method.

[6] Whilst the outputs of the Semi-automated mapping of rock at the surface contracts are used by UKSeaMap as an input substrate dataset to drive output habitats, the coarser resolution of UKSeaMap destroys some information contained within the rock mapping layers.

2.1.4 Semi-automated mapping of rock at the surface

Since 2015, JNCC, BGS and Cefas have worked together to produce a broad-scale modelled overview of rock at the seabed within UK waters (Diesing et al, 2015, Downie et al, 2016, Brown et al, 2017).

These datasets differentiate between subcropping and outcropping rock, providing a clearer understanding of the potential distribution of outcropping reef than DigSBS used in the previous reefs layer.

Data describing outcropping rock were extracted and attributed a confidence value of 'Potential' due to their broad-scale and un-surveyed nature.

2.1.5 OSPAR database of threatened and/or declining habitats (version 2015)

This composite dataset (Ellwood & Duncan, 2015) was used to derive additional biogenic reef information, extracting the OSPAR Habitats "Intertidal *Mytilus edulis* beds on Mixed & Sandy Sediments", *"Lophelia pertusa* Reefs", "*Modiolus Modiolus* beds" and *"Sabellaria spinulosa* Reefs"*.*

Data derived from JNCC's EUNIS habitat maps from survey were removed, as these data were already included via the full-coverage EUNIS level-3 layer (2.1.3). Data derived from GeMS (2.1.8) and the Natural England evidence base (2.1.7) were also removed as these two datasets are included separately within this method.

Confidence was directly translated from the "Certainty" field within the database, with "Uncertain" records translated to "Potential" confidence, and "Certain" records, translated to "High" confidence.

2.1.6 UK Offshore habitat features of conservation importance (FOCI)

This composite dataset (Duncan, 2016) was used to derive additional biogenic reef information not captured by either the OSPAR or NE Evidence base datasets, extracting the UK Habitat FOCI "Blue mussel beds", "Cold-water coral reefs", "Honeycomb worm reefs", "Horse mussel beds" and "Ross worm reefs".

Data derived from JNCC's EUNIS maps from survey, OSPAR, or NE Evidence base were reacted as these data were already captured in their initial form within this method.

Confidence was taken directly from the "certainty" field within the original dataset, as the two fields are equivalent.

2.1.7 Natural England Evidence base

Data was incorporated from the March 2019 wide release version of this Natural England dataset, containing protected marine features. Data from the evidence base's "reef" layer were assigned as "High" confidence based on the MESH confidence scoring system ("High" where score > 58), or, where this information was not available the "MCZ_Survey_quality" field ("High" where value > 1). All remaining data were assigned a confidence of "Potential".

2.1.8 Geodatabase of Marine features in Scotland (GeMS)

Relevant biogenic Data was incorporated from version5 (i18) of the Geodatabase of Marine features in Scotland, a dataset comprising Scottish protected features, extracting the Priority Marine Features "Cold-water coral reefs", "Horse mussel beds" and "Serpulid aggregations".

Data were assigned as "Potential" confidence where the "DETERMINATION" field contained the value 'Uncertain', other values ('Certain' or 'Certain;part record') were assigned "High" confidence.

2.1.9 NRW

Within Welsh waters, NRW undertake a comprehensive analysis of Annex I reef features following similar principles to those used in the generation of this dataset. Polygon data for Welsh waters were therefore retained as only data supplied by NRW.

2.1.10 Additional biogenic reef data

Additional biogenic reef data were gathered from the following datasets identified by JNCC site leads and used to supplement the main datasets

Natural England "Core reef" analysis

A dataset showing "core" *Sabellaria* reef in the Wash – areas consistently containing reef over multiple surveys – was produced by Roberts et al (2016). These data were included as examples of "High" confidence biogenic reef.

Hanson aggregates Inner Dowsing Race Bank North Ridge data

Data from Hanson Marine Aggregates showing possible *Sabellaria* reef within "Area 480" in the Inner Dowsing, Race Bank and North Ridge SAC. These data were included as "Potential" biogenic reef as the data have not undergone a reefiness assessment.

Eastern IFCA report data

Data showing Sabellaria reef around the area of Inner Dowsing, Race Bank & North Ridge SAC were extracted from the Eastern IFCA reports of Woo (2008), Jessop et al (2009,2010, 2012) and Jessop & Maxwell (2011). Data were highlighted as Potential reef.

East-coast REC

Data from the East Coast Regional Environmental Characterisation (REC) survey (Limpenny et al, 2011) showing the extent of Sabellaria from acoustic sources have been included as "Potential" on advice from site leads as the data have not undergone a reefiness assessment.

2.1.11 Stanton Banks 1971 manned submersible data

BGS gravel data collected from a manned submersible survey on the reef fauna collected from 1969-1970 described fauna characteristic of reef within Stanton Banks SAC (Eden et al 1971). Polygon delineation of this data from BGS was used to delineate the site boundary and here has been included as areas of "Potential reef", providing coverage where areas have not been subsequently surveyed.

2.1.12 Iceberg ploughmarks from AFEN/DTI Tobi sidescan survey

Areas of iceberg ploughmarks were delineated off the north coast of Scotland using Tobi sidescan acoustic data from the 1998 AFEN and DTI RV Colonel Templar Cruises (01 and 02/98). Ploughmarks have been previously determined to contain Annex I reef stony reef sufficiently consistently to be regarded as feature (paragraph 3.1.4 - Irving, 2009). Therefore ploughmarks from this dataset were incorporated as Annex I reef, where they exist in sufficient density. Areas categorised as "Area of iceberg ploughmarks" or "Intense iceberg ploughmarks" were included as "Potential" reef; areas categorised in the dataset as "Partially buried ploughmarks" or "Sparse iceberg ploughmarks" were not included as extent of feature, though were retained as range.

2.1.13 "Not Reef" v2

An extract of the previous version of the "Not reef" layer, supplied alongside the feature layers, was used to remove areas of potential reef. Records were extracted specifically relating to NE, CCW and JNCC survey data regarding Annex I features (Ellwood, 2013, Table 3, Layer 3).

2.2 Method overview

All data sources were ESRI™ shapefiles and geodatabase feature classes, and data processing was carried out in ArcGIS 10.1.

2.2.1 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 EMODnet Seabed Habitats Translated Habitat Data Exchange Format[7] with additional fields.

2.2.2 Correlating EUNIS habitats to Annex I reef sub-type

For habitat maps originally classified in the EUNIS classification system (i.e. the full coverage EUNIS level 3 layer (see Section 2.1.3), a look-up table was used to correlate the EUNIS code to an Annex I reef subtype. The sub-types were correlated as in Table 1, following the correlations used in v7 of the reef layer.

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

EUNIS code	EUNIS description	Annex I reef subtype
A1	Littoral rock	Bedrock and/or Stony
A1.1	High energy littoral rock	Bedrock and/or Stony
A1.2	Moderate energy littoral rock	Bedrock and/or Stony
A1.3	Low energy littoral rock	Bedrock and/or Stony
A1.4	Features of littoral rock	Bedrock and/or Stony
A2.7	Littoral biogenic reefs	Biogenic
A3	Infralittoral rock and other hard substrata	Bedrock and/or Stony
A3.1	Atlantic and Mediterranean high energy infralittoral rock	Bedrock and/or Stony
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock	Bedrock and/or Stony
A3.3	Atlantic and Mediterranean low energy infralittoral rock	Bedrock and/or Stony
A4	Circalittoral rock and other hard substrata	Bedrock and/or Stony
A4.1	Atlantic and Mediterranean high energy circalittoral rock	Bedrock and/or Stony
A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	Bedrock and/or Stony
A4.3	Atlantic and Mediterranean low energy circalittoral rock	Bedrock and/or 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

2.2.3 Resolving overlaps between datasets

After assigning confidence values to data classified as "reef" and "not reef", data were aggregated into a single UK-wide dataset by stacking the data into the order show in Table 2 below. Data were then either used to erase underlying data in the case of "not reef" data, or used to erase underlying data and subsequently inserted (update) in the case of "reef" data.

[7] http://www.emodnet-seabedhabitats.eu/def [Accessed 10/05/2017]

Table 2 - "Stacking" order of input dataset groups in the creation of the Annex I reef layer

Order of layers	Reef data	'Not reef data'
	High confidence reef	
1	New SAC survey data - reef	
2		New SAC survey data – not reef
3	CNCB national databases (high confidence)	
4	Additional biogenic reef data (high confidence)	
5	Reef v7 survey data extract (high confidence)	
6		"Not reef" v2 extract (high confidence)
7		Sandbanks v2 (high confidence)[8]
8	Combined EUNIS level 3 map - reef (high confidence)	
9		Combined EUNIS level 3 map – mud (high confidence)
	Potential reef	
10	CNCB national databases (potential)	
11	Reef v7 survey data extract (potential)	
12	TOBI sidecan identified ploughmarks (potential)	
13	Combined EUNIS level 3 map – reef (potential)	
14		Combined EUNIS level 3 map – mud (potential)
15	Semi-automated mapping of rock at the surface	
16	Reef v7 broadscale extract (GB001135)	

2.3 Manual changes on expert judgement

Producing these composite data products can be a very complex process and is subject to various rounds of quality control with the CNCBs and internally within JNCC. All manual changes are recorded in Appendix I: Manual changes.

2.4 Topology corrections

Any remaining instances of overlapping data were resolved using ArcGIS' topology toolbox by creating new, empty data features. Using the "Eliminate" tool, these empty features were then merged into the neighbouring data which shared the largest border.

[B]Biogenic data were not removed on intersection with sandbank data, as Sabellaria reef may feasibly exist in colocation of a sandbank.

Finally, to clean up most gaps and slivers within the dataset, the integrate tool was used with an XY tolerance of 0.1 metres.

2.5 Results

The GIS layer output from this work contains details of the source and decisions in the creation of the dataset (see Table 3).

Table 3: Attribute descriptions for the Reef polygon layer.

Field name	Description
POLYGON	Identifier polygon accompanying GUI of a habitat map brought in to the dataset, if relevant.
GUI	Globally unique identifier of a habitat map brought in to the dataset, if relevant.
ORIG_HAB	Additional habitat information (e.g. EUNIS, UK/EIRE classification, descriptive text) present within the original source file.
HAB_TYPE	EUNIS habitat code for polygon if relevant.
DET_MTHD	Method used to determine EUNIS code if relevant
DET_NAME	Name of person/organisation who determined the EUNIS code if relevant.
DET_DATE	Date the EUNIS code was determined if relevant.
TRAN_COM	Comments recorded during habitat translation.
VAL_COMM	Comments regarding the validation or sense-checking of the polygon.
ANNEX1	The Natura 2000 code for the Annex 1 habitat in question (1170 for Reefs).
SUB_TYPE	The sub-type of Annex 1 reef, as described in the interpretation manual (“bedrock” and/or “stony” and/or “biogenic”).
CONFIDENCE	The confidence in presence of Annex 1 reef (“High” or “Potential”)
MOD_DATE	Date that the polygon was last modified
SOURCE	The original source of the data.

3 Method for point data

Version 7 of the reef dataset was accompanied by a supplementary extract from Marine Recorder, matching biotopes from the Marine Habitat Classification for Britain & Ireland (v15.03) (JNCC, 2015) against Annex I habitats using JNCC’s marine habitats correlation tables (JNCC, 2017). To update this point dataset, a new method was developed to extract suitable data from Marine Recorder using both available biotope and physical information. Supplementary data sources not currently extant within Marine Recorder were appended to this initial extract to further increase the coverage of the final points dataset.

3.1 Data sources

3.1.1 Marine recorder snapshot

Release 2018-03-06 of this UK-wide benthic point dataset was used to capture most reef occurrences within UK waters. Data were extracted and attributed based on both biotope and physical information based on the method described in section 3.2.

3.1.2 Natural England Evidence base

The April 2019 wide release was used to supply reefs points within the coverage of the dataset. Points were extracted using the reef definition query supplied in the layers alongside the dataset and were attributed with pre-identified subtypes.

In addition, points derived from Marine Recorder were removed to mitigate data duplication. In addition, records from the 2009 east coast REC survey were removed as these were included separately with additional confidence attribution.

Points were assigned as “High” confidence where the value in the “MCZ_Survey_quality” was greater than 1. All remaining data were assigned a confidence of “Potential”.

3.1.3 GeMS

Relevant biogenic points were incorporated from version 5 (i18) of the Geodatabase of Marine features in Scotland. Points extant within Marine Recorder were removed to mitigate data duplication.

Data were assigned as “Potential” confidence where the “DETERMINATION” field contained the value ‘Uncertain’, other values (‘Certain’ or ‘Certain;part record’) were assigned “High” confidence.

3.1.4 OSPAR database of threatened and/or declining habitats (version 2015)

Biogenic reef points from the 2015 release of the database was used to derive additional biogenic reef information regarding the OSPAR Habitats “Intertidal *Mytilus edulis* beds on Mixed & Sandy Sediments”, *“Lophelia pertusa* Reefs”, “*Modiolus Modiolus* beds” and *“Sabellaria spinulosa* Reefs". Data derived from Marine Recorder, GeMS and the Natural England evidence base were removed to mitigate data duplication.

Confidence was directly translated from the “Certainty” field within the database, with “Uncertain” records translated to “Potential” confidence, and “Certain” records, translated to “High” confidence.

During QC, some data from the OSPAR database was deemed unfit for inclusion. Data originated from a 2011 Cefas data mining contract which harvested Cefas’ internal data holdings including data from multiple surveys, including individual habitat maps and groundtruthing data points. The data mining dataset contained little, if any metadata surrounding the origin of individual points. Where available, this data was cross-referenced with the original habitat data available internally and externally, and any subsequent non-matching data was removed from the Reefs dataset.

3.1.5 UK Offshore Habitat FOCI layer

Biogenic reef points from v1.1 of the UK Offshore habitat features of conservation importance layer were included where they were not derived from Marine Recorder, OSPAR or the Natural England evidence base, extracting the UK Habitat FOCI “Blue mussel beds”, “Cold-water coral reefs”, “Honeycomb worm reefs”, “Horse mussel beds” and “Ross worm reefs”.

Confidence was directly translated from the “Certainty” field within the database, with “Uncertain” records translated to “Potential” confidence, and “Certain” records, translated to “High” confidence.

3.1.6 Additional biogenic reef data

Additional biogenic reef data were gathered from the following datasets identified by JNCC site leads and used to supplement the main datasets.

SEA7 data – Anton Dohrn
Data from the 2007 RV Kommandor Jack SEA7 survey (Jacobs, 2006) highlighting reef in the Anton Dohrn SAC was included as evidence of high confidence reef within the site. Reef subtype was taken directly from the original classification of the data.

2006 SEASAC data – Wyville Thomson Ridge
Identified Annex I stony reef from the 2006 RV Franklin SEASAC survey (Stewart & Davies, 2007) was included as high confidence evidence within the site.

East-coast REC
Data from the East Coast Regional Environmental Characterisation (REC) survey CEND0909 (Limpenny et al, 2011) identifying *Sabellaria* reef were included. Points attributed as "Low" confidence were attributed as "Potential" reef, and remaining points as "High".

3.2 Method overview for Marine Recorder data

3.2.1 Initial extraction

Data were extracted from the marine recorder snapshot using a SQL query within Microsoft Access. Relevant meta-information was extracted alongside the original biotope code and correlated Annex I reef subtype using the correlation method from version 7.

In addition:

- Physical data was included if present within the original sample;
    - Percentage bedrock;
    - Total percentage of cobbles and boulders ("Stony");
- Records identified as littoral from either the biotope or biozone information were flagged;
- Records marked as 'Uncertain' in the "Qualifier" field were flagged.

3.2.2 Attribution of subtype and confidence

The initial extract was then manipulated using R to further determine reef subtype and to attribute a confidence value.

From the initial extraction, a record with correlating biotope information could have one of the following reef subtypes:

- Bedrock;
- Bedrock and/or Stony;
- Biogenic.

For records correlated as either distinctly "Bedrock" or "Biogenic", no further information was required and the subtype was not altered.

For records correlated as "Bedrock and/or Stony" without existing physical information, the subtype was not altered.

For records correlated as "Bedrock and/or Stony" with existing physical information, the physical information was used to attempt to determine a more precise subtype based on the logic shown in Figure 1.

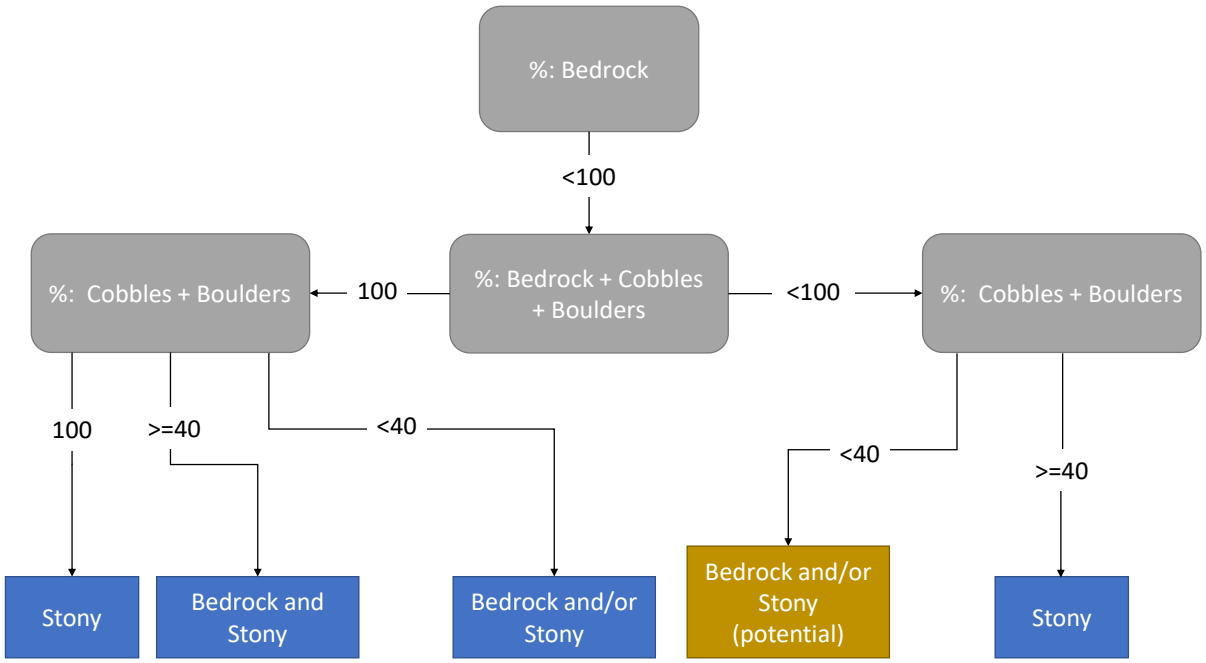

Figure 1: Attribution of reef subtype to "Bedrock and/or Stony" records containing physical information on percentage cover of bedrock, cobbles and boulders. For records resulting in the outcome highlighted in orange, the confidence was set to "Potential", as the physical information suggests a lack of suitable coverage.

For records containing no correlating biotope information, the physical information was used to attempt to determine a reef subtype based on the logic shown in Figure 2.

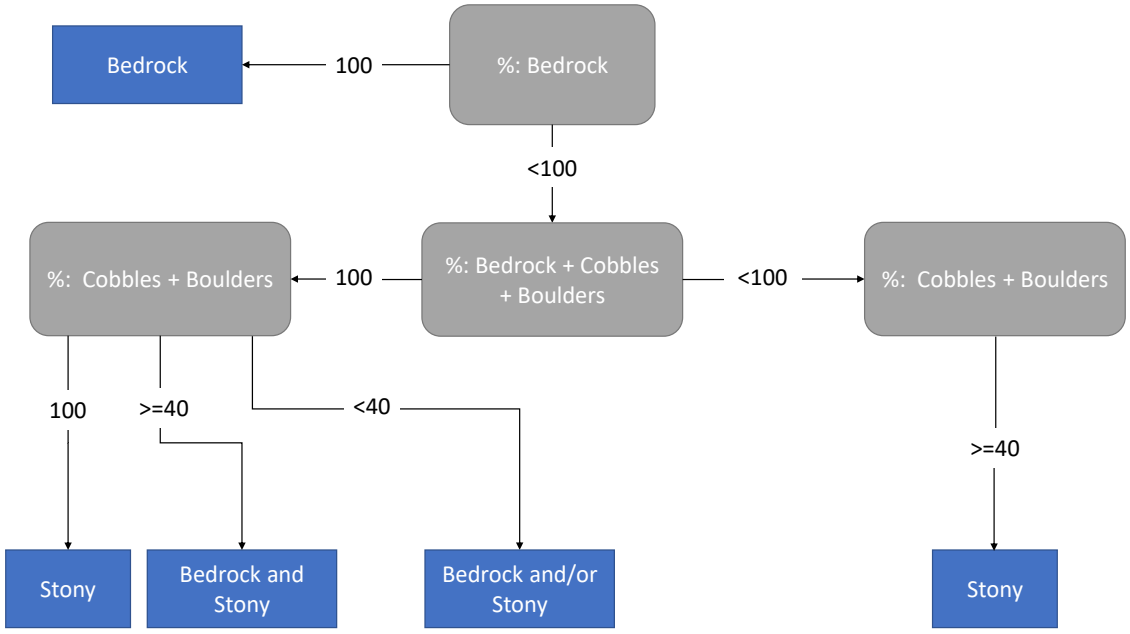

Figure 2: Attribution of reef subtype to uncorrelated records containing physical information on percentage cover of bedrock, cobbles and boulders.

A confidence value was initially determined as "Potential" for a record if it met one of the following conditions:

- No correlating biotope;
- Littoral record;
- Marine recorder qualifier entered as 'Uncertain';

All other records were determined as “High” confidence, unless the physical information recorded less than 100% total coverage of cobbles, boulders and bedrock AND less than 40% total coverage of cobbles and boulders (orange outcome in Figure 1). In this situation, the physical data suggests that the record may not correlate with reef, in conflict with the biotope information.

Physical information was retained in the final product to provide the user with further information and auditing ability and any changes to the record’s confidence were noted in the “VAL_COMM” field.

3.2.3 Additional data

After completion of the Marine Recorder extract, the additional datasets described in section 3.1 were standardised to the output attribute table and appended.

4 Results

The GIS layer output from this work contains details of the source and decisions in the creation of the dataset (see Table 4).

Table 4: Attribute descriptions for the Reef point layer.

Field name	Description
SAMPLE_REF	Sample reference from the input dataset (if available).
LATWGS84	Latitude of record on WGS84 datum.
LONWGS84	Longitude of record on WGS84 datum.
SAMPLEDATE	Date of record
SURVEY	Survey containing the record
REFERENCE	Reference to original dataset/survey (if available).
COPYRIGHT	Copyright/Attribution statement for record
ORIG_HAB	Additional habitat information (e.g. EUNIS, UK/EIRE classification, descriptive text) present within the original source file.
ORIG_CLASS	Classification system in which ORIG_HAB is described
PCT_BROCK	Percentage cover of bedrock as described in Marine Recorder (if available)
PCT_STONY	Total percentage cover of cobbles and boulders as described in Marine Recorder (if available)
ANNEXI	The Natura 2000 code for the Annex 1 habitat in question (1170 for Reefs).
SUBTYPE	The sub-type of Annex 1 reef, as described in the interpretation manual (“bedrock” and/or “stony” and/or “biogenic”).
CONFIDENCE	The confidence in presence of Annex 1 reef (“High” or “Potential”)
DET_MTHD	Method used to determine EUNIS code if relevant
DET_DATE	Date the EUNIS code was determined if relevant.
DET_NAME	Name of person/organisation who determined the EUNIS code if relevant.
TRAN_COM	Comments recorded during habitat translation,
VAL_COMM	Comments regarding the validation or sense-checking of the polygon.
SOURCE	The original source of the data.

5 Additional areas to be managed as Annex I Reefs

We have prepared a supplementary data product showing additional areas to be considered as potential reef to inform JNCC's advice on the management of human activities for the protection of nature.

This is to account for the problem that effective advice on areas to be managed depends on knowledge of the spatial extent of important habitats within the MPAs that are designated to protect those habitats. However, there can be observations of important habitats from in situ sampling, trawls and imagery for which there is no further information available to reliably map their spatial extent.

The scope of this product is *Sabellaria spinulosa* reefs that occur within three offshore SACs beyond 12nm from the UK coast: Haisborough, Hammond and Winterton; Inner Dowsing, Race Bank and North Ridge; and North Norfolk Sandbanks and Saturn Reef.

Sabellaria spinulosa reefs have been identified as being susceptible to disturbance pressures, specifically: habitat structural change and substrate removal; abrasion, penetration and sub-surface disturbance; physical loss of habitat; and siltation rate changes including smothering (Gibb *et al*. 2014). They are therefore protected under the Habitats Directive through the designation of SACs.

We identified additional areas to be managed as *Sabellaria spinulosa* reefs by placing a 500m margin surrounding any point observations of the habitat in offshore waters. Following a policy decision by Defra to apply the margins only within the SAC boundaries (pers. Comm., 2016), the resultant polygons were subsequently clipped to the extent of offshore MCZs and SACs. This layer is to provide additional areas to be managed as reef and are supplementary to the main reef layer; instances of management polygons overlapping with the evidence layer were removed, therefore giving preference to the main reef evidence layer.

The attribute table contains metadata for their originating source providing a simple audit trail and allow users to efficiently track the original data in the reefs point layer described in section 3.

6 References

Barrio Froján, C., Diesing, M., Rance, J. 2021. Offshore seabed survey of Wight-Barfleur Reef SAC. JNCC/Cefas Partnership Report Series No. 24. JNCC, Peterborough. ISSN 2051-6711.

Barrio Froján, C., Diesing, M. & Curtis, M. 2015. Mapping of the Haig Fras Site of Community Importance (SCI). JNCC/Cefas Partnership Report Series, No. 4.

Brown, L.S., Green, S.L., Stewart, H.A., Diesing, M., Downie, A.-L., Cooper, R. & Lillis, H. 2017. Semi-automated mapping of rock in the Irish Sea, Minches, western Scotland and Scottish continental shelf. JNCC Report No. 609, JNCC, Peterborough.

Commission of the European Community (CEC). 2013. The Interpretation Manual of European Union Habitats - EUR28 [online]. Brussels: European Commission DG Environment. Available from: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf [Accessed December 2016]

Connor, D.W., Gilliland, P.M. Golding, N. Robinson, P., Todd, D. & Verling, E. 2006. UKSeaMap: the mapping of seabed and water column features of UK Seas, ISBN 86107 590 1

Diesing, M. Green, S.L., Stephens, D., Cooper, R. & Mellett, C.L. 2015. Semi-automated mapping of rock in the English Channel and Celtic Sea. JNCC Report, No. 569

Downie, A.L., Dove, D., Westhead, R.K., Diesing, M., Green, S. & Cooper, R. 2016. Semi-automated mapping of rock in the North Sea. JNCC Report No. 592. JNCC, Peterborough.

Duncan, G. 2016. Method for Creating a Composite Map of Offshore Habitat Features of Conservation Importance (FOCI). Available from: https://hub.jncc.gov.uk/assets/aae93643-e74c-4f4a-a2e6-95be4f4df1d1#20161206-uk-offshore-habitat-foci-map-method-v1-0.pdf [Accessed January 2022]

EDEN, R.A., ARDUS, D.A., BINNS, P.E., MCQUILLIN, R., & WILSON, J.B. 1971. Geological investigations with a manned submersible off the west coast of Scotland 1969-1970. Institute of Geological Sciences Report No. 71/16. 28-30.

Ellwood, H. 2013. Method for Creating a Composite Map of Annex I Reef in UK Waters. Available from: https://webarchive.nationalarchives.gov.uk/ukgwa/20180804082009/http://jncc.defra.gov.uk/pdf/20130607_AnnexI_Reef_Map_Methodology_v2.pdf [Accessed January 2022]

Ellwood, H. 2014. Creating a EUNIS level 3 seabed habitat map integrating data originating from maps from field surveys and the EUSeaMap model. Available from: https://hub.jncc.gov.uk/assets/9503ef3f-d53f-4a2e-a046-305dfed88272#20140311-combined-eunis-l3-map-method-v1-0.pdf [Accessed January 2022]

Ellwood, H., and Duncan, G. 2015. Creating a composite OSPAR threatened and/or declining habitat map for the UK (version 1.0). Available from: https://hub.jncc.gov.uk/assets/3ece951d-d2a8-441d-b50d-f06d97587a47#20150610-composite-ospar-habitat-map-method-v1-0.pdf [Accessed January 2022]

Barrio Froján, C., Diesing, M. & Curtis, M. 2015. Mapping of the Haig Fras Site of Community Importance (SCI). JNCC/Cefas Partnership Report Series, No. 4. Available from:

https://hub.jncc.gov.uk/assets/2f7f7a1a-1365-4da1-9b8f-d759a568dd31#JNCC-Cefas-4-FINAL-WEB.pdf [Accessed January 2022].

Gibb, N., Tillin, H.M., Pearce, B. & Tyler-Walters H. 2014. Assessing the sensitivity of Sabellaria spinulosa to pressures associated with marine activities. JNCC report No. 504. Available from https://hub.jncc.gov.uk/assets/126dba2e-e3cc-472a-9a29-adde6752d0d0#JNCC-Report-504-FINAL-WEB.pdf [Accessed June 2019]

Jacobs, C.L. 2006. An appraisal of the surface geology and sedimentary processes within SEA7, the UK Continental Shelf. Southampton, UK: National Oceanography Centre, Southampton. (National Oceanography Centre Southampton Research and Consultancy Report, No. 18) (Unpublished manuscript).

Jessop, R.W., Harwood, A.J.P., Woo, J.R. 2009. Eastern Sea Fisheries District Research Report 2009. Eastern Sea Fisheries Joint Committee. King's Lynn.

Jessop, R.W., Hinni, S., Skinner,J., Woo, J.R. 2010. Eastern Sea Fisheries District Research Report 2010. Eastern Sea Fisheries Joint Committee. King's Lynn.

Jessop, R.W., Maxwell, E. 2011. Eastern IFCA Research Report 2011. Eastern IFCA. King's Lynn.

Jessop, R.W., Åkesson, O., Smith, L.M. 2012. Eastern IFCA Research Report 2012. Eastern IFCA. King's Lynn.

JNCC. 2015. The Marine Habitat Classification for Britain and Ireland Version 15.03 [Online]. Available from: https://mhc.jncc.gov.uk/

JNCC. 2017. Marine Habitat Correlation Tables version 2017 [Online]. Version 2018 available from: https://mhc.jncc.gov.uk/resources#correlationtables

Limpenny, S.E., Barrio Froján, C., Cotterill, C., Foster-Smith, R.L., Pearce, B., Tizzard, L., Limpenny, D.L., Long, D., Walmsley, S., Kirby, S., Baker, K., Meadows, W.J., Rees, J., Hill, J., Wilson, C., Leivers, M., Churchley, S., Russell, J., Birchenough, A.C., Green, S.L., and Law, R.J. 2011. The East Coast Regional Environmental Characterisation. Cefas Open report 08/04. 287pp.

Murray, J., Rance, J., Schinaia, S. 2013. Characterisation Survey of Stanton Banks SCI. JNCC/Cefas Partnership Report Series. (awaiting publication)

Stewart, H.A., Davies, J.S. 2007. Habitat investigations within the SEA7 and SEA4 areas of the UK continental shelf (Hatton Bank, Rosemary Bank, Wyville Thomson Ridge and Faroe–Shetland Channel). British Geological Survey Commissioned Report, CR/07/051.

Woo J.R, 2008. The "reefiness" of Sabellaria spinulosa in The Wash: a report on the results of the 2007 AGDS survey. Eastern Sea Fisheries Joint Committee, Kings Lynn.

7 Appendix I: Manual changes

Haig Fras
Although habitat maps specifically targeting Annex I features exist for the Haig Fras SAC, the EUNIS broadscale habitat map "GB001518", presenting the broad habitats within the Greater Haig Fras MCZ, provides the most up to date habitat mapping of the site. As such, the translated EUNIS map (see Table 1) superseded the existing Annex I data (GB001115), against the standard order in Table 2. In addition, due to a lack of evidence for stony reef within the SAC (Barrio Froján et al, 2015), all polygons within the SAC were changed to the reef subtype "Bedrock" rather than the default correlation of "Bedrock and/or Stony" as in Table 2.

It was noted not that some Marine Recorder data within the point dataset did not correlate with the latest available evidence in the site. The monitoring report from a joint Cefas & JNCC 2011 survey (Froján et al, 2015) found the surveyed data did not meet the published criteria for stony reef. The Marine Recorder points overlapping these areas were subsequently removed following advice from the site lead.

Haisborough, Hammond and Winterton
The biogenic (*Sabellaria*) reef around the Norfolk Wash area has been analysed by Natural England under the "Core reef analysis" project to determine areas consistently occupied by this ephemeral habitat. Due to the inclusion of the core reef analysis into the reef dataset, all other "High" confidence areas of reef from single surveys within the site were downgraded to "Potential".

Wyville-Thompson Ridge
An amendment to reef subtype was made within the Wyville-Thompson Ridge SAC. Dataset GB003011, describing EUNIS habitats within the site was originally correlated to a reef subtype of "Bedrock" from EUNIS habitat "A6.11 - Deep-sea bedrock". The EUNIS map stems from BGS substrate mapping exercise in the area, showing "Undifferentiated solid rock" in the described areas. However, groundtruthing within the described areas suggests a prevalence of Stony, and as such, a more inclusive subtype of "Bedrock and/or stony reef" was attributed to these polygons.

Additionally, per Section 2.1.1, data removed from BGS DigSBS250 dataset within the SAC area resulted in large holes within the iceberg ploughmark extent; these holes were backfilled with the ploughmark polygons per request from the site lead.

Pobie Bank
A data reversion was carried out within the Pobie Bank SAC. The EUNIS map GB200054, carried through in the full-coverage EUNIS level 3 layer (2.1.3), and translated into correlating Annex I features, was removed in its entirety and replaced with GB200053, its spatially identical Annex I equivalent, which was extant in reefs v7. This was undertaken as GB200053 contains areas of "Potential" reef, determined through expert judgement, which would be otherwise superseded by the data in the high MESH confidence scoring EUNIS map in the standard method.

Greater Haig Fras
It was noted not that some Marine Recorder data within the point dataset did not correlate with the latest available evidence in the site. The Marine Recorder data was attributed to the survey cruise report as opposed to the final biotope analysis outputs; it was agreed that a total of six point records should be removed.

Skerries and Causeway
During the QC with the SNCBs, colleagues from DAERA noted a number of missing bedrock and stony reef data which were mapped in the Skerries and Causeway SAC. Since the missing data was used in the UK Stocktake and Network analysis as they were part of the original high-resolution habitat map commissioned as part of the SAC designation process, it was agreed that the data would be included in the final composite reef layer.

Solan Bank
Outputs from the Semi-automated mapping of rock at the surfaceproduct predicted additional area of "rock at the surface" within the site. In addition to the product's broad-scale and un-surveyed nature, the additional areas lacked any groundtruthing points and were contradicted by the site's higher resolution habitat map which showed the areas as "not reef". Following discussions with JNCC's fisheries and site lead colleagues the decision was made to discount these additional areas.

8 Appendix II: Minor Updates

Version 8.1 (2021)
Amendment – corrections to data availability from v8.0

Version 8.2 (2021)
Amendment – corrections to a merging error occurring between v7 and v8. Polygons in Rockall reef had been merged, blending the attributes.

Version 8.3 (2022)
Amendment – corrections to data availability from v8.2 for both the point and polygon datasets.
Amendment – corrections to address overlaps between polygons in the Shetland Islands, Scotland
Amendment – removal of points from the Haisborough, Hammond and Winterton SAC following updated advice
Amendment – Correction of a GUI in Pobie Bank Reef SAC following updated advice

Version 8.4 (2022)
Amendment – removal of duplicate points and corrections to data availability from v8.3 the points dataset.

Version 8.5 (2022)
Amendment – removal of duplicate points from v8.4 of the points dataset.