Definition of Favourable Conservation Status for Reefs

Defining Favourable Conservation Status Project

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About the DFCS project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our FCS definitions are based on ecological evidence and the expertise of specialists.

We are doing this so we can say what good looks like and to set our aspiration for species and habitats in England, which will inform decision making and actions to achieve and sustain thriving wildlife.

We are publishing FCS definitions so that you, our partners and decision-makers can do your bit for nature, better.

As we publish more of our work, the format of our definitions may evolve, however the content will remain largely the same.

This definition has been prepared using current data and evidence. It represents Natural England's view of FCS based on the best available information at the time of production.

The document *Defining Favourable Conservation Status in England* describes the methodolgy used by Natural England to definine FCS.

1. Introduction

1.1 Favourable Conservation Status Definition for Reefs in England

This document sets out Natural England's view on Favourable Conservation Status (FCS) for **reefs** in England. Favourable Conservation Status is defined in terms of three parameters: natural range and distribution, area, and structure and function attributes.

Section 2 provides the summary definition of favourable conservation status in England. Section 3 covers contextual information, Section 4 the units used and Section 5 describes the evidence considered when defining FCS for each of the three parameters. Section 6 sets out the conclusions on favourable values for each of the three parameters. Annex 1 lists the references.

This document does not include any action planning, or describe actions, to achieve or maintain favouable conservation status. These will be presented separately, for example within strategy documents.

2. Summary Favourable Conservation Status Definition

2.1 Favourable Conservation Status in England

Reefs are complex, comprising an interdependent mosaic of subtidal and intertidal habitats. They are divided into two main types: geogenic (formed of rock or stable cobbles and boulders) and biogenic (structures formed by living or dead organisms). In turn, separate sub-types, or sub-features, of geogenic and biogenic reef are recognised which may support complexes of several different biotopes or communities, which vary depending on geographical location and on local environmental conditions such as tidal immersion/emersion, wave and current energy, light penetration, sedimentation and scour.

The extent of geogenic reef is considered stable with localised small-scale losses due to development. Some sub-types of geogenic reef, which have limited geographical distribution and are vulnerable to habitat loss (for example intertidal chalk, peat & clay exposures), are thought to have suffered a reduction in area. In contrast, the extent of biogenic reef is thought to have declined both historically and more recently due to physical damage from benthic fishing methods, but such decline has not been quantified.

Range: The natural range is favourable when the full natural variation of sub-features and biotopes of littoral and sublittoral geogenic and biogenic reefs is represented within each marine region (as geographically and biologically appropriate).

For geogenic reefs this means maintenance of the current range within each of the Charting Progress 2 (CP2) regions as follows: region 1 - 64 hectads (10 km squares), region 2 - 61 hectads, region 3 – 138 hectads, region 4 – 218 hectads, region 5 – 38 hectads.

For biogenic reefs, this means that reefs are able to form and be maintained in all regions suitable for a particular reef-forming species. Evidence indicates that the current range of biogenic reef is likely to be less than favourable due to human pressures, but it is not currently possible to quantify the favourable range. An arbitrary increase of 10% to the current distribution is proposed for favourable status. Therefore, the favourable range within English inshore waters for biogenic reef of different types is:

- *Sabellaria alveolata*: present within 83 hectads largely within the intertidal fringe on geogenic reef (rock and boulder/cobble) of western English coasts in CP2 regions 4 and 5
- *Sabellaria spinulosa*: 111 hectads within the intertidal fringe and subtidal areas of sandy and mixed sediments and geogenic reef exposed to wave and/or tidal action, with supply of suitable sand particles, in all regions.
- *Mytilus edulis*: 132 hectads within sheltered intertidal and shallow subtidal areas of muddy mixed sediments in all regions.

Area: The current area of geogenic reef (4,794 km^2) is the favourable area. For biogenic reef, it is not possible to quantify the favourable area. An arbitrary increase of 10% to 426 km^2 from the current area (387 km^2), within the range of each reef-forming species, is suggested for future maintenance of biological diversity and variation in biogenic reef habitat sub-types.

Structure and function: For favourable status a percentage of the favourable area for each type of reef would need to meet the structure and function requirements, including maintenance of the full

natural zonation of biological communities, maintenance of the natural species composition, age distribution and density, maintenance of structural complexity and the natural physical and chemical properties of the water.

- For biogenic reef and geogenic reef identified as a Habitat of Conservation Interest (HOCI) 100% of the favourable area needs to meet the structure and function requirements,
- For geogenic reefs within protected sites that are not HOCI, 95% by area of structure and function requirements should be met.
- Outside protected sites 75% by area of geogenic reefs should meet the structure and function requirements.

2.2 Confidence

All features of conservation importance (FOCI) associated with the habitat should be Least Concern, when assessed using IUCN criteria.

FCS parameter	Favourable status	Confidence in the parameter
Range and distribution	Geogenic reefs – 519 10 km grid squares within all CP2 regions Biogenic reefs – 326 10 km grid squares	**Low**
Area	Geogenic reefs - 4,794 km^2 Biogenic reefs – 426 km^2	**Low**
Structure and function	Geogenic HOCI habitats – 100% Geogenic reefs within protected sites – 95% Geogenic reefs outside protected sites – 75% Biogenic reefs – 100%	**Low**

2.3 Current conservation status

As at March 2021, based on a comparison of the favourable values with the current values, reefs are not in favourable conservation status. Note, this conclusion is based solely on the information within this document not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

3. Habitat definition and ecosystem context

3.1 Habitat definition

Reefs are habitat complexes comprising an interdependent mosaic of subtidal and intertidal habitats. The two main types of reef are geogenic (rock or stable cobbles and boulders) and biogenic (structures formed by living or dead organisms). They are one of the habitats listed under Annex I of the Habitats Directive (92/43/EEC). A definition of the habitat is provided in the European Interpretation Manual (EC 2013):

"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."

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 vents, sea mounts, vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock and boulder and cobble fields.

Natural England has identified a standard list of sub-features of Annex I reef, used to further describe reef habitats designated within Special Areas of Conservation (SACs) in England (Natural England 2015).

Table 1: Habitat types that may occur within sub-features in English inshore waters

NE sub-feature	Type	EUNIS	UK classification (JNCC 2015a)
Intertidal rock reef		A1.1 A1.2 A1.3 A1.4	LR.HLR High energy littoral rock LR.MLR Moderate energy littoral rock LR.LLR Low energy littoral rock LR.FLR Features of littoral rock
Intertidal stony reef		A1.1 A1.2 A1.3	LR.HLR High energy littoral rock LR.MLR Moderate energy littoral rock LR.LLR Low energy littoral rock
Intertidal biogenic	Mussel beds	A2.7	LS.LBR Littoral biogenic reefs
Intertidal biogenic	*Sabellaria* spp	A2.7	LS.LBR Littoral biogenic reefs
Infralittoral rock reef		A3.1 A3.2 A3.3 A3.7	IR.HIR High energy infralittoral rock IR.MIR Moderate energy infralittoral rock IR.LIR Low energy infralittoral rock IR.FIR Features of infralittoral rock
Circalittoral rock reef		A4.1 A4.2 A4.3 A4.7	CR.HCR High energy circalittoral rock CR.MCR Moderate energy circalittoral rock CR.LCR Low energy circalittoral rock CR.FCR Features of circalittoral rock
Subtidal stony reef		A3.1 A3.2 A3.3 A3.7 A4.1 A4.2 A4.3 A4.7	IR.HIR High energy infralittoral rock IR.MIR Moderate energy infralittoral rock IR.LIR Low energy infralittoral rock IR.FIR Features of infralittoral rock CR.HCR High energy circalittoral rock CR.MCR Moderate energy circalittoral rock CR.LCR Low energy circalittoral rock CR.FCR Features of circalittoral rock
Subtidal biogenic	Mussel beds	A5.6	SS.SBR Sublittoral biogenic reefs on sediment
Subtidal biogenic	*Sabellaria* spp.	A5.6	SS.SBR Sublittoral biogenic reefs on sediment

The sub-features are structurally defined and each may support a wide range of species which vary depending on geographical location of the habitat and on local environmental conditions.

Finer scale biotopes are defined for each of these sub-features in the EUNIS (EUNIS 2017) and UK equivalent marine classification systems (JNCC 2015a; Connor and others 2004), and each has a range of typical species. A total of 136 rock biotopes have been described from the UK, with a further 79 rock sub-biotopes described at greater level of detail, including biogenic reef biotopes (JNCC 2015a).

The intertidal and subtidal rock broad-scale habitats and biogenic reef and 'rocky' Habitats of Conservation Importance (HOCI), identified as part of the process for identifying Marine Conservation Zones, may also fit the definition of 'reef' (NE & JNCC 2010; JNCC & NE 2016).

Other sources: *European Commission 1999; Holt and others 1998; Johnston, Turnbull & Tasker 2002; MarLIN 2016; McLeod and others 2005;*

3.2 Habitat status

Reefs are listed under Annex I of the Habitats Directive (92/43/EEC). The UK holds a large proportion of the European resource compared to other Member States and, consequently, has special responsibility for this habitat.

In the European Red List of Habitats (Gubbay and others 2016) most of the reef habitats are Data Deficient. However, the following reef habitats have been assessed:

- worm reefs in the Atlantic littoral zone (EUNIS A2.7.1) - Near Threatened;
- mussel beds in the Atlantic littoral zone (A2.7.2) – Endangered;
- mussel beds (*Mytilus edulis*) on Atlantic sublittoral sediment (A5.6.2) - Near Threatened; and

mussel beds (*Modiolus modiolus)* on Atlantic sublittoral sediment (A5.6.2) - Near Threatened.

3.3 Ecosystem context

Reefs are often associated with other marine Annex I habitats. Some types of reef occur within **Large shallow inlets and bays** (H1160) or **Estuaries** (H1130). **Submerged or partially submerged sea caves** (H8330) **and Submarine structures made by leaking gases** (H1180) form particular types of rock habitat which in some cases could be described as reef and support fauna and flora characteristic of reef habitat. **Reef** habitat may also grade into **Vegetated sea cliffs of the Atlantic and Baltic coasts** (H1230) on the coast.

Geogenic reefs

Geogenic reefs occur throughout the UK and are extremely variable in structure, reflecting local geology and geomorphology. Topography ranges from vertical rock walls to horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles. Rock type ranges from hard igneous sedimentary or metamorphosed rock, to friable or soft sand and mudstones, chalks and clays. Certain rock types are restricted in their distribution. For example, littoral and sublittoral chalk in England is primarily found on the east and south-east coasts, in particular in Kent and Sussex.

Reefs may be found in deep waters (where light penetration is minimal) to shallow waters and from the lower shore to high up in the splash zone. Environmental conditions are highly variable and range from full salinity to brackish; from very wave exposed shores to very sheltered rias and estuaries and from strong tidal streams to areas with little tidal movement. The combination of

these various environmental conditions determines the communities of plants and animals on the reefs. The main factors affecting the community composition of rock reefs are tidal emersion/immersion, energy level (wave or tidal), turbidity/light penetration, salinity and substratum.

There is a strong vertical zonation. In the intertidal zone, lichens occur at the top of the shore, with littoral biotopes characterised by barnacles, mussels or species of fucoid (wrack) seaweeds. Vertical zonation extends sub-tidally into the circalittoral (below the photic zone).

The greatest variety of communities is typically found where coastal topography is highly varied, with a wide range of exposures to wave action and tidal streams. Habitats extremely exposed to wave action are dominated by a robust turf of sponges, anemones and foliose red seaweed. Reefs in the most sheltered rias support delicate or silt-tolerant filamentous algae, fan-worms and ascidians. The presence of enhanced tidal streams may significantly increase species diversity. In strong tidal streams there are communities of barnacles, the soft coral *Alcyonium digitatum*, massive sponges and hydroids.

In turbid waters, light penetration is low and seaweeds can occur only in shallow depths or in the intertidal zone. However, in such conditions animals have a plentiful supply of suspended food and filter-feeding species may be abundant.

Most reefs are fully marine but in certain marine inlets salinities are variable, or permanently reduced, and rocky habitats support their own distinctive communities.

In the UK species composition is related to temperature, with warm, temperate species such as the sea-fan *Eunicella verrucosa* and the corals *Leptopsammia pruvoti* and *Balanophyllia regia*, occurring in the south, and cold-water species, such as the anemone *Bolocera tuediae* and the red seaweed *Ptilota plumosa*, in the north.

Biogenic reefs

In contrast to the variety of rocky reefs, there is much less variation amongst biogenic reefs. Biogenic reefs are found throughout UK waters, but the reef-forming species vary geographically.

The main species which form biogenic reefs in English inshore waters (from Mean High Water Springs out to 12 nautical miles) are ross worms *Sabellaria* spp. and blue mussels *Mytilus edulis.* Most of the UK *Sabellaria* spp. reefs occur in English waters.

Horse mussels *Modiolus modiolus* and the serpulid worm *Serpula vermicularis* occur throughout the UK, including England, but no reefs formed by these species have been identified in English waters (McLeod and others 2005, updated 2017).

Several other species can form distinct biogenic concretions or beds, but currently these species are not considered to form reefs fitting the Annex I habitat definition (Holt and others 1998), for example native oyster *Ostrea edulis*, sand mason worm *Lanice conchilega*, flame shell *Limaria hians*.

The biogenic reef species create complex microhabitats that can support species assemblages of relatively high diversity. Often, this creates a habitat for species that are not otherwise found on the surrounding seabed (Royal Commission on Environmental Pollution 2004). These complex habitats increase the survival of juvenile commercial fish species by reducing predation pressure. Mussels (*Mytilus edulis)* are an important food source for several species of birds (for example,

eider duck, oyster catcher) and invertebrates (starfish, crabs), all of which can decimate local populations under certain circumstances.

The communities associated with biogenic reefs can also vary according to local conditions of water movement, salinity, depth and turbidity.

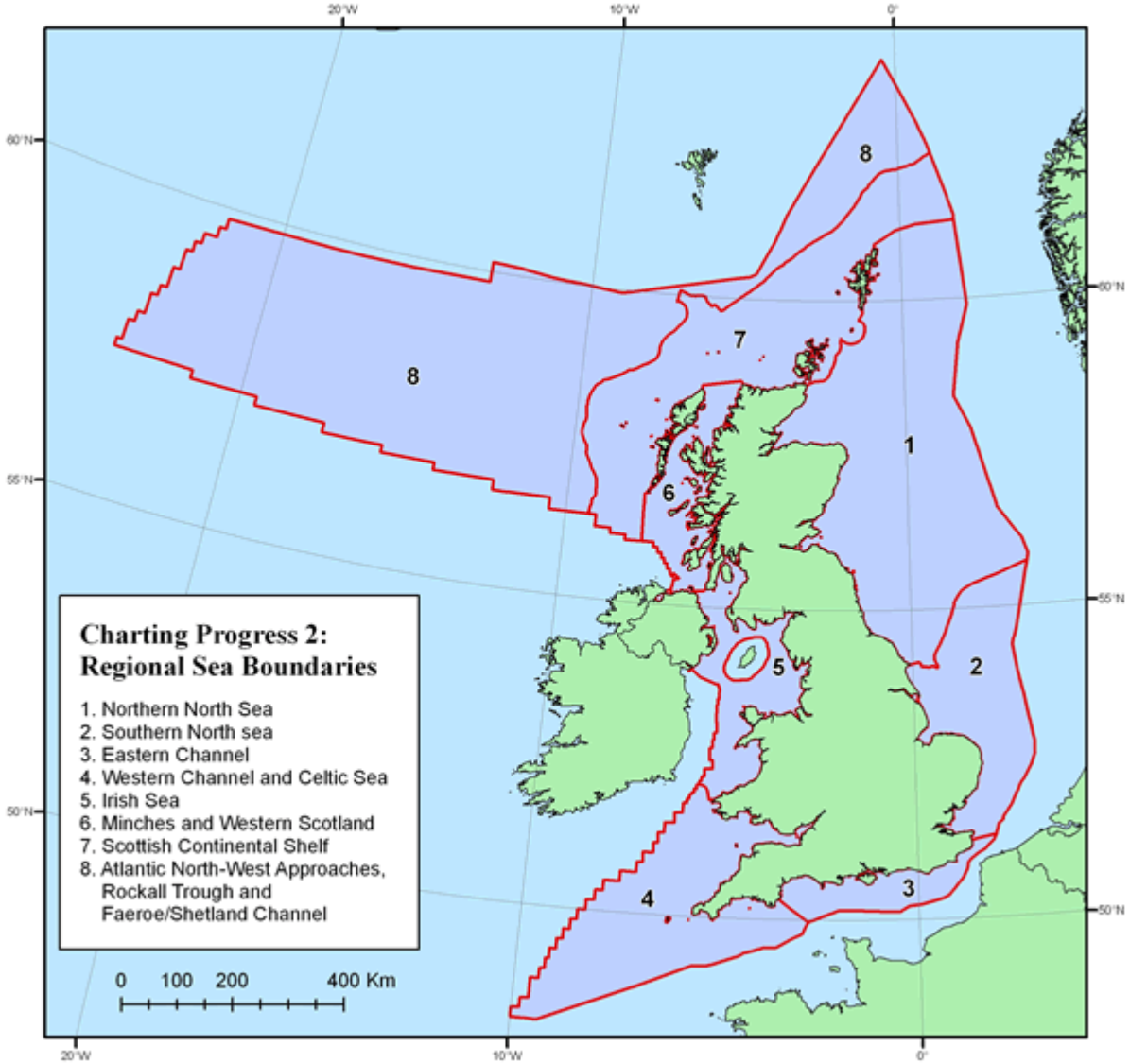
Other sources: *JNCC 2015b; JNCC & NE 2016; MarLIN 2016;*

4. Units and attributes

4.1 Natural range and distribution

10 x 10 km grid squares within Charting Progress 2 (CP2) regions is the recommended unit for range and distribution of reef.

Figure 1: Charting Progress 2 Regional Seas (Frost & Hawkridge 2010)



CP2 Regional Sea boundaries are ecologically based and have been used for previous reporting of change in the marine environment at a UK scale (Frost & Hawkridge 2010). The boundaries reflect broad differences in biogeographic conditions (temperature, depth, currents) which, combined with geology and local environmental conditions, determine the variety of biotopes likely to be found within these areas. Number of 10 x10 km squares within each of the CP2 boundaries relevant to England (1, 2, 3, 4 and 5) represents a more ecologically meaningful metric for range and distribution of reef as it goes some way towards representing the geographical variation in ecological communities associated with reef habitat.

4.2 Area

Km^2 is an appropriate unit for measuring habitat area at a national scale.

4.3 Structure and function attributes

The following are generalised habitat attributes for reef, extracted from Natural England's Marine Features Framework (Natural England 2017). These attributes were developed for setting objectives and defining favourable condition for habitats at a site level, following Common Standards Monitoring (CSM) Guidance (JNCC 2004), and can be applied to habitats at a national level in a generalised form.

Table 2: Structure and function attributes

Attribute name
Structure: presence and spatial distribution of biological communities
Structure: species composition of component communities
Structure: physical structure of rocky substrate
Structure: population density (for biogenic reef)
Structure: non-native species and pathogens
Structure: age / size frequency
Structure and function: presence and abundance of key structural and influential species
Supporting processes: areas with conditions suitable for biogenic reef formation
Supporting processes: energy / exposure
Supporting processes: physico-chemical properties
Supporting processes: sedimentation rate
Supporting processes: water movement and energy for biogenic reef
Supporting processes: water quality - contaminants
Supporting processes: water quality - dissolved oxygen

Supporting processes: water quality – nutrients
Supporting processes: water quality – turbidity

Operational indicators for structure and function of rocky and biogenic habitats under EU Marine Strategy Framework Directive (MSFD) are very similar to those identified for protected sites noted above.

Table 3: MSFD indicators

MSFD criterion for Good Environmental Status (GES) for Biological diversity	Indicator
Descriptor 1 Biological diversity: 1.6 Habitat condition 1.7 Ecosystem structure	1.6.1 Condition of the typical species and communities
	1.6.2 Relative abundance and/or biomass, as appropriate
	1.6.3 Physical, hydrological and chemical conditions
Descriptor 6 Seafloor integrity: 6.1 Physical damage, having regard to substrate characteristics	6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate
	6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types
	6.2.1 Presence of particularly sensitive and/or tolerant species

Other sources: *Burrows, Mieszkowska & Hawkins 2014; Connor and others 2004; Moffat and others 2011*

5. Evidence

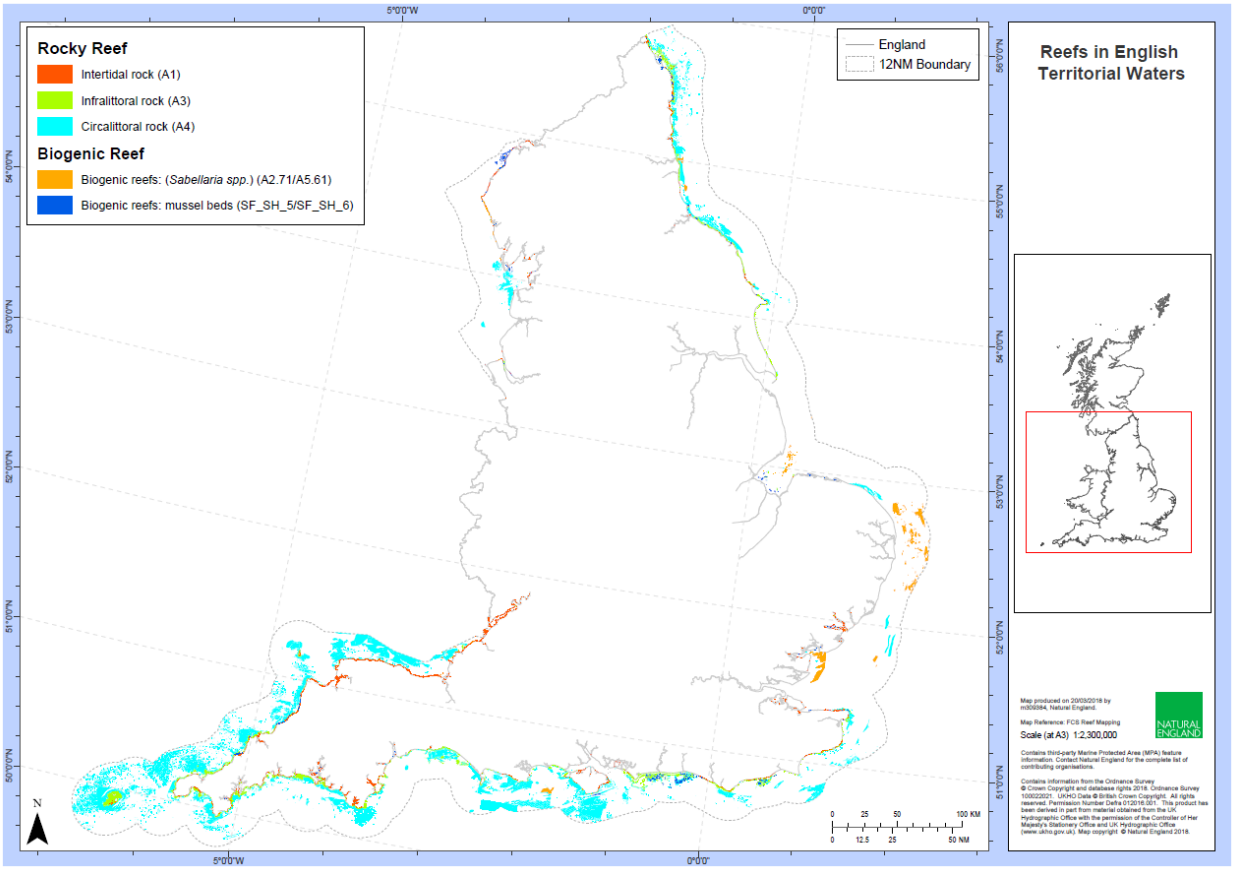
5.1 Current situation

Natural range and distribution

The estimated distribution of reefs in English waters is shown below. Reef distribution cannot be mapped directly, due in part to the way reef habitat is defined, and in part to a lack of a full seabed survey at sufficient resolution. Instead, the extent of bedrock, stony and biogenic reef is derived from a mixture of:

- targeted surveys by remote sensing with ground validation;
- broad-scale habitat surveys (usually without ground validation);
- interpretation of geological maps;
- the exclusion of areas that have been surveyed and determined they contain habitats other than reef; and
- habitat modelling in areas where no other data are available (Ellwood 2013).

Figure 2: Current distribution of different types of reef within English waters (Natural England 2018)



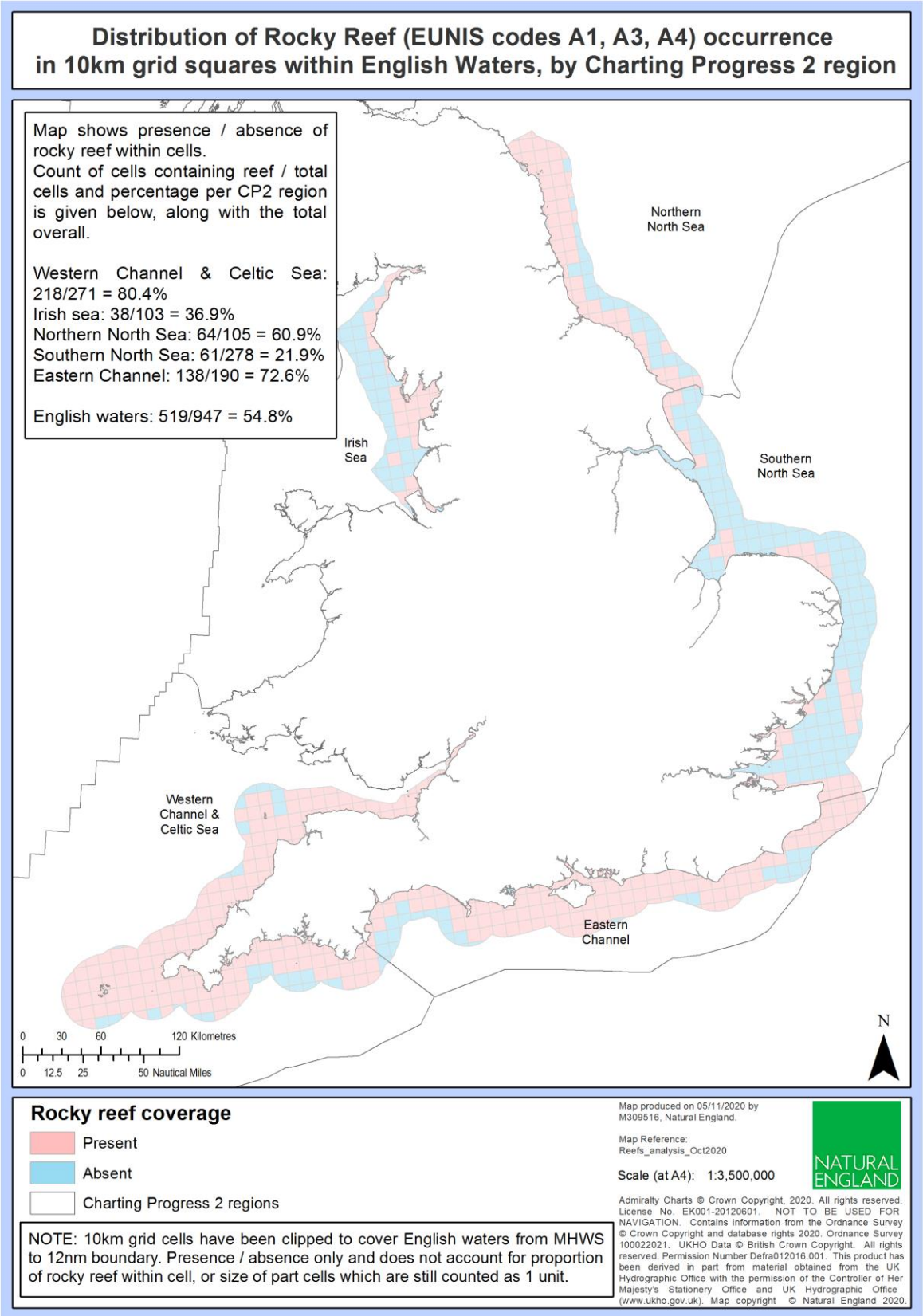
Geogenic reefs

Intertidal and subtidal geogenic reef is widespread, distributed in all CP2 regions. Subtidal geogenic reef is mainly coastal fringing habitat but there are significant offshore reefs in south west English inshore waters (CP2 region 4), particularly off Cornwall.

Table 4: Summary distribution of geogenic reef by CP2 region

CP2 region	No. of 10 km squares with geogenic reef
1 – Northern North Sea	64
2 – Southern North Sea	61
3 – Eastern Channel	138
4 – Western Channel & Celtic Sea	218
5 – Irish Sea	38
Total number of 10 km squares	519

Figure 3: Current distribution of geogenic reef within English waters (Natural England 2020)



Biogenic reefs

The distribution range of each reef-forming species is described below and shown on the maps at Annex 2. They represent the maximum range for biogenic reef of each type.

Sabellaria alveolata reefs are predominantly intertidal and are found where rock occurs in close proximity to sandy sediments with strong wave or tidal action. They have a generally southern and western UK distribution, reaching their north-eastern European distribution limit around Morecambe Bay and the Solway (Connor and others 2004). They occur predominantly in western and southern regions.

Sabellaria spinulosa reefs are predominantly subtidal and occur in areas of sandy and coarse sediments with strong wave and tidal action in all English CP2 regions, predominantly eastern and southern regions.

Blue mussel *Mytilus edulis* reefs are found in estuaries and sheltered muddy coarse sediment shores and shallow subtidal areas and are widespread throughout the UK in all CP2 regions.

Table 5: Summary distribution of biogenic reef by CP2 region

CP2 region/No. of 10 km squares	*Sabellaria alveolata*	*Sabellaria spinulosa*	*Mytilus edulis*
1 – Northern North Sea	0	8	9
2 – Southern North Sea	21	70	33
3 – Eastern Channel	7	19	35
4 – Western Channel & Celtic Sea	27	3	12
5 – Irish Sea	20	1	31
Total number of 10 km squares	75	101	120

Other sources: *Aish and others 2010; Cook and others 2013; Hendrick & Foster-Smith 2006; JNCC 2007; JNCC 2013; JNCC 2018; Natural England 2013*

Confidence: *Low*

Area

Geogenic reef forms the vast majority of the England reef resource by area, based on the figures below, geogenic reef represents 92.5% of the total reef area (4,794 km^2) , and biogenic 7.5% (387 km^2).

Table 6: Figures for current area of different types of reef, from the map at Figure 3, and calculated by Natural England GIS unit March 2018 (figures rounded-up)

Type of reef	Sub-type of reef	Area (km^2)
Geogenic	Rock and stony	4,794
Biogenic	*Sabellaria alveolata*	7
	Sabellaria spinulosa	185
	Sabellaria (unspecified)	126
	Mytilus edulis	49
	Modiolus modiolus	0
	Mussels (unspecified)	19
	Total biogenic	387
Total reef		5,181

Confidence: Moderate

Quality of habitat patches

No comprehensive England-wide assessment of the structure and functions of all types of reef has been carried out.

The UK conclusion from the assessment of structure and function for reefs for the 4th Article 17 reporting in 2019 was that structure and function of reef was 'unfavourable-inadequate'. This conclusion was reached because 23% of the UK reef resource was considered to be in unfavourable condition. 68% of the UK resource was considered to be in favourable condition (JNCC 2019).

The most important pressure categories for reef habitat in England were assessed to be:

i. fishing and harvesting of aquatic resources;
ii. human induced changes in hydraulic conditions;
iii. other ecosystem modifications;

iv. other human intrusions and disturbances;
v. pollution to surface waters;
vi. invasive non-native species; and
vii. interspecific faunal relations.

Confidence: Low

Features of conservation importance

The following rare or threatened habitats and species, relevant to reefs, may occur within English inshore waters. These are a subset of the habitats or species identified as MCZ features of conservation importance (FOCI) suitable for site protection through the MCZ identification process (JNCC & NE 2016)

Table 7: Habitats of conservation importance within reefs

Habitat FOCI overlapping or fitting within 'reef' definition	Annex I reef type
Blue mussel beds	Biogenic reef (*Mytilus edulis*)
Estuarine rocky habitats	Geogenic/rock/stony reef
Fragile sponge and anthozoan communities on subtidal rocky habitats	Geogenic/rock/stony reef
Intertidal underboulder communities	Geogenic/rock/stony reef
Littoral chalk communities	Geogenic/rock/stony reef
Horse mussel (*Modiolus modiolus*) communities	Biogenic reef (*Modiolus*)
Peat and clay exposures	Geogenic/rock/stony reef
Sabellaria alveolata reefs	Biogenic reef (*Sabellaria alveolata*)
Sabellaria spinulosa reefs	Biogenic reef (*Sabellaria spinulosa*)
Tideswept channels	Geogenic/rock/stony reef

Table 8: Species of conservation importance within reefs

Feature of Conservation Importance (FOCI)	Possible occurrence on Annex I reef type
Peacock's tail (*Padina pavonica*)	Geogenic/rock/stony reef (southern species)
Giant goby (*Gobius cobitis*)	Geogenic/rock/stony reef (sheltered rock pools)
Sea fan anemone (*Amphianthus dohrnii*)	Geogenic/rock/stony reef (attached to gorgonians or hydroids)
Pink Sea Fan (*Eunicella verrucosa*)	Geogenic/rock/stony reef (south western species)
Stalked jellyfish (*Haliclystus* spp.)	Geogenic/rock/stony reef (on macroalgae)
Sunset cup coral (*Leptopsammia pruvotii*)	Geogenic/rock/stony reef (south western species)
Stalked jellyfish (*Calvadosia* [*Lucernariopsis] campanulata*)	Geogenic/rock/stony reef (on macroalgae)
Stalked jellyfish (*Calvadosia* [*Lucernariopsis] cruxmellitensis*)	Geogenic/rock/stony reef (on macroalgae)
Stalked barnacle (*Pollicipes pollicipes*)	Geogenic/rock/stony reef (south western species)
Spiny lobster (*Palinurus elephas*)	Geogenic/rock/stony reef

5.2 Historical variation in the above parameters

Physical destruction, or covering, of reef in populated areas through infrastructure development, such as ports and harbours, and changes in sedimentation due to coastal protection, has occurred over long periods of time, but such change has not been quantified for England.

Fishing activities are the most significant human activity causing change in the UK marine environment (de Groot & Lindeboom 1994; Laffoley & Tasker 2004). The effects of fisheries include (Laffoley & Tasker 2004):

- Removal of target species (including genetic effects) – given the size of most fish stocks the fishing pressure exerted upon them is outside safe biological limits
- Mortality of non-target species.
- Physical disturbance of the seabed.
- Shifts in community structure.
- Indirect effects on the food web.

There is also evidence indicating that over-fishing often leads to eutrophication, disease outbreaks, or species introductions (Jackson and others 2001). The combined effect of all these impacts is to reduce the overall stability of marine ecosystems (Royal Commission on Environmental Pollution 2004).

Intertidal reefs are subject to collection of bait and large crustaceans. Where collection involves boulder-turning, substantial damage may be done as boulders are often not returned to their original positions (Sewell & Hiscock 2005).

Removal of species from subtidal rocky habitats occurs as a result of targeted fisheries, especially crustacean fisheries. Removal of crustaceans from reef habitats is increasing in some areas. Excessive levels of exploitation since the 1970s have led to declines in the abundance of spiny lobster, *Palinurus elephas*, to the point of commercial extinction in some areas. These reefs are mainly fished using static gear. The main damage is displacement or crushing of sessile organisms when the gear is placed or retrieved (Sewell & Hiscock 2005). Diver collection of crustaceans is minimal but may significantly reduce stocks of large crustaceans. Tangle nets are used to catch crawfish and sessile invertebrate species may also be tangled and removed (Sewell & Hiscock 2005). Angling may also have a localized impact on territorial fish species on rocky subtidal habitats. These crustacean and fish species can be key functional species in rocky subtidal habitats but their precise role and full consequences of removal are not well understood (Aish and others 2010).

Mobile fishing gear may not directly cross reefs but dredging and trawling on surrounding soft sediments can affect reefs. Dredging results in the suspension of fine sediment which can double the suspended matter content of the water, an effect that is likely to persist for several days. Whilst the increase in suspended particulates may benefit filter feeders, many species are adversely affected by smothering (Hartnoll 1998). In some cases, where reef structures are low-lying and will not damage the gear, reefs are dredged directly. This can have a substantial impact on the communities as seen in Lyme Bay, Devon (Sewell & Hiscock 2005). Such impacts are more significant if the substratum is soft rock, as the reef is vulnerable to irreversible structural damage as well as removal of epifauna which may reduce the communities present.

Local decline and subsequent recovery in quality of reef flora and fauna as a result of human pressures such as acute hydrocarbon and chronic sewage pollution, has been recorded from individual locations between the 1970s and 1990s. Some species are particularly sensitive to contaminants, notably dog whelks driven locally to extinction by tributyl tin leached from anti-fouling paints.

Generally, the effects of chronic impacts on rocky shores are reversible following the cessation of the impact. Recovery (defined as a return to the normal community structure and dynamics) from acute impacts is also possible but may take much longer depending on the scale of the impact.

Biogenic reef may be destroyed through human activities such as benthic trawling or dredging. Certain sub-types of biogenic reef are vulnerable to physical damage and are thought to have declined significantly. There is qualitative evidence for declines in area and structure of several biogenic reef species. The removal of biogenic structures affects not only the benthos but also the associated species that feed and shelter around them (Kaiser and others 1999). In most cases, the first pass of trawl gear is sufficient to damage or destroy some areas permanently (Royal Commission on Environmental Pollution 2004).

S*abellaria alveolata* reefs are easily damaged by physical impact associated with trampling and are also sometimes gathered by anglers for use as bait. However, there is evidence that following physical damage, the worms themselves are often unaffected. (Sewell & Hiscock 2005). It has been suggested that *Sabellaria* reefs may also be able to withstand the impact of a lightweight beam trawl, though this may not be true for repeated trawling (Sewell & Hiscock 2005).

Natural range and distribution

Geogenic reefs

The natural range and distribution may be taken as static. There is no evidence indicating a significant decline in its area and therefore a contraction in distribution.

Biogenic reefs

Environmental conditions within CP2 regions 2, 3 and 5 are the most suitable for biogenic reef to form, and these parts of the range are most affected by damage from human activity. However, there is no quantitative evidence of a decline in distribution.

Sources: *Elwood 2013; Gibb and others 2014; Holt and others 1998;*

Confidence: Low

Area

Mapping of the area of subtidal reefs has improved considerably over recent decades due to improvements in technology. Surface area of reef (geogenic and biogenic) calculated for English inshore waters for the 2013 Article 17 report was 13,068 km^2 (JNCC 2013). This estimate was based on partial high confidence survey data within some Special Areas of Conservation and extrapolation and modelling from geological data. The apparent loss of 7,887 km^2 between current area and area in 2013 (and similar large differences between the 2007 and 2013 figures provided for Article 17 reporting) is due to increased availability of survey evidence, and less reliance on estimation and modelling, rather than representing a real decline in area. Because of these changes in area calculations, it is not possible to quantify any decline in area of reef.

Geogenic reefs

As geogenic reef is a non-renewable resource, formed over geological time, the overall area of reef will have been reduced over many years, but it is not possible to quantify the loss. As the area within England is substantial, it is not thought to have declined significantly at a national scale. However, some scarcer types of reef composed of soft rock, such as chalk, are more vulnerable and are thought to have declined.

There may be natural fluctuations in area of geogenic reef locally as areas of rock are covered or uncovered by sediments through natural processes, but these are likely to balance each other out and be insignificant at a national scale.

Biogenic reefs

Areas and specific locations of biogenic reef are known to fluctuate over relatively short time periods (one or two years) either due to natural development and die back or as a result of damage from human activities.

Gibb and others (2014) summarise the evidence of physical damage affecting *Sabellaria spinulosa* reef habitats. *S. spinulosa* reefs in the Wadden Sea suffered great losses in the 1950s in association with shrimp fishing. Similar damage from shrimp fisheries has been reported from the Thames Estuary, the Wash, possibly also from Morecambe Bay (Holt and others 1998) and by fishermen at Ramsgate in the Thames Estuary. There were reports of substantial reefs being lost in Morecambe Bay, the Wash and the Thames (Taylor & Parker 1993, Warren & Sheldon 1967, in OSPAR 2008). More recent losses are noted from the Swanage area in Dorset, Hastings Shingle Bank off Sussex, and Thanet Offshore windfarm site. As more offshore seabed surveys have been carried out in recent years, particularly for pipeline and windfarm developments, more reef-like structures have been discovered.

There is evidence of decline of intertidal reefs formed by *Mytilus* in German, Dutch and Danish waters, and such reefs may have been more extensive in England in the past. However, there is no evidence of widespread decline in *Mytilus* reef in England, and *Mytilus* fisheries are controlled through fisheries regulations (Holt and others 1998, OSPAR 2008).

Declines in *Modiolus modiolus* reef area and structure and function have been reported for Northern Ireland and Scotland. Although there are historical and recent records of *Modiolus* as a species in English waters, there are no good records of *Modiolus* reef occurring in English waters, and therefore no recorded declines.

Other sources: *Aish and others 2010; Elwood 2013*

Confidence: Moderate

Quality of habitat

Assessments of structure and function for reefs occurring within Special Areas of Conservation were compiled for the 2nd Habitats Directive Article 17 reporting in 2007 using Common Standards Monitoring (CSM) condition assessments. The attributes assessed were: Extent (area); Biotope Composition; Distribution and spatial pattern of biotopes; and the site-specific attributes: Presence of representative/notable biotopes or species.

However, these assessments could not accurately represent the situation with respect to reef overall within England as:

i. the calculations relied on very approximate estimates of total reef area;
ii. only a very small proportion of the total UK reef area at that time was within SACs;
iii. condition in England was assessed per 'unit' of area and only within intertidal SSSIs, and a single unit could include multiple habitats, including terrestrial habitats.

For the Special Areas of Conservation that were assessed, 55% of the area and 29% of the number of assessments were Unfavourable, and at least 1% of the total UK reef area was in Unfavourable condition (JNCC 2007). The summary statistics do not distinguish between geogenic and biogenic reef.

Other sources: *Aish and others 2010; Holt and others 1998; OSPAR 2008*

Confidence: Moderate

5.3 Future maintenance of biological diversity and variation in the habitat

Reefs are likely to be affected by changes associated with climate warming.

Increased storminess and windiness and sea level rise will affect shoreline areas and the distribution and extent of some shoreline habitats (Brooker & Young 2005). Populations of some rocky shore species, particularly those at the edges of their latitudinal ranges, are particularly sensitive to temperature changes and have been used as indicators of climatic change (Hill and others 1998).

There has been a major change in plankton communities, both in terms of species composition and abundance, in a large area of the North Atlantic since the early 1980s, which appears to be linked to changes in the North Atlantic Oscillation and climate (Defra 2005). Changes in the length of growing and breeding seasons, community composition and species ranges are likely to continue. Generally, warm water species are likely to replace cold water species, with cold water species moving to more northerly latitudes or greater depths (Brooker & Young 2005).

Increasing temperatures can alter the timing of ecological processes and there is therefore potential for temporal mismatch between trophic levels.

Depletion of the northern ozone layer may result in depth distribution changes and reduced productivity of kelp species, with uncertain consequences for the kelp biotopes (Birkett and others 1998).

Species-specific responses to climate change are uncertain, due to factors such as current flow; the capacity of species to migrate; the possible influx of new invasive species; the impact of increasing ocean acidity due to absorption of atmospheric CO_2. The 'positive' effects of increased temperatures, for example increased primary productivity, may be offset by the negative impacts of increased disturbance from wave and storm surge action (Brooker & Young 2005). In addition, sectoral activities – for example, managed retreat to enable persistence of some coastal habitats - might be inhibited by coastal development and construction of sea defences (Defra 2005).

The principal anthropogenic pressures affecting biogenic reefs are incidental damage due to benthic fishing using heavy towed gear (*Sabellaria spinulosa*, *Modiolus modiolus*) and targeted fishing for adults and juveniles (*Mytilus mytilus*). Cook and others (2013) document the destructive impact of passes of trawls and scallop dredges on *Modiolus modiolus* reefs and the effect on sublittoral *Mytilus* reefs is likely to be similar.

Natural range and distribution

The ecological communities present on reefs vary depending on biogeography and prevailing environmental conditions. Therefore, for the natural range to support the biological diversity associated with reef habitat, each of the Charting Progress 2 regions should include the full variety of littoral and sublittoral reef sub-habitat types naturally present.

It is not possible to expand the range of natural geogenic reef habitat as it is formed through geological processes. Artificial reefs may be created which may support diverse biological communities similar to those found on natural geogenic reefs (Hunter & Sayer 2009) but these are not considered to be natural habitats in terms of this definition. Therefore, favourable status will require maintenance of the current range and distribution.

Evidence indicates that the current range of biogenic reef is likely to be less than favourable due to human pressures. All the UK biogenic reef-forming species have a wider range than the current distribution of reef structures (Tyler-Walters & Hiscock 2017). Extension of the current distribution of biogenic reef, within the natural range of each reef-forming species, is required for future maintenance of biological diversity and variation in biogenic reef habitat sub-types. This is particularly important for reefs formed by *Modiolus modiolus* as they can be particularly biodiverse and sensitive to damage (Holt and others 1998). It is not currently possible to quantify what a favourable range and distribution should be so an arbitrary increase of 10% to the current distribution is proposed.

Confidence: Moderate

Area

Geogenic reefs

Each of the CP2 regions should include sufficient areas of both littoral and sublittoral geogenic reef sub-habitat types to maintain biological diversity and variation in the habitat. It is not possible to quantify the required area of reef, but the sub-type areas should be sufficiently large to protect from damaging activities and enable maintenance of biotopes through species recruitment (see Ecological Network Guidance, NE & JNCC 2010).

Favourable status, therefore, requires the maintenance of the current area of geogenic reef - 4,794 km^2.

Biogenic reefs

An increase from the current area of biogenic reef, within the natural range of each reef-forming species, is required for future maintenance of biological diversity and variation in biogenic reef habitat sub-types and to support an expansion in the distribution of biogenic reef. There is no evidence available to indicate the favourable area required to ensure that biogenic reef is able to form and be maintained throughout its natural range. Therefore, an arbitrary increase of 10% in the area of biogenic reef is proposed to 426 km^2.

Sources: *NE & JNCC 2010; Holt and others 1998*

Confidence*:* Low

Quality of habitat

The attributes below are required for future maintenance of biological diversity and variation in the habitat.

Table 9: Favourable structure and function attributes

Attribute name	Favourable state
Structure: presence and spatial distribution of biological communities	Maintenance of the full natural zonation of biological communities.
Structure: species composition of component communities	Maintenance of the natural species composition of component communities.
Structure: physical structure of rocky substrate	Maintenance of the natural surface and structural complexity provided by geogenic structures (that is, cobbles, boulders), the structural organisation of the substrate and the stability of the reef structure.
Structure: population density for biogenic reef.	Natural density of biogenic reef-forming species.
Structure: non-native species and pathogens	Negligible presence and impact of non-native species and pathogens.
Structure: age / size frequency	A balanced age / size frequency and distribution within species populations across the extent of the habitat, to provide a healthy, productive population.
Structure and function: presence and abundance of key structural and influential species	Natural abundance of key species, to enable each of them to be a viable component of the habitat.
Supporting processes: areas with conditions suitable for biogenic reef formation	Suitable environmental conditions in those locations that are known, or which become known, to be important for biogenic reef formation.
Supporting processes: energy / exposure	Natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes and stability, across the habitat.
Supporting processes: physico-chemical properties	Natural physico-chemical properties of the water.
Supporting processes: sedimentation rate	A natural rate of sediment deposition.

Supporting processes: water movement and energy	Natural water flow velocities to biogenic reefs, to provide high levels of oxygen, sediment supply and food.
Supporting processes: water quality - contaminants	Aqueous contaminants restricted to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.
Supporting processes: water quality - dissolved oxygen	Dissolved oxygen (DO) concentration at levels equating to Good or High Ecological Status according to the Water Framework Directive for 95% of the year, avoiding deterioration from existing levels.
Supporting processes: water quality - nutrients	Water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the features, avoiding deterioration from existing levels.
Supporting processes: water quality - turbidity	Natural levels of turbidity (for example, concentrations of suspended sediment, plankton and other material) across the habitat.

The indicators developed to implement the Marine Strategy Framework Directive can be applied to assess the above attributes at a national level. Some of those indicators are currently operational (for example, for intertidal rocky habitats), whilst others, particularly those relevant to subtidal habitats, require further development.

Sources: *JNCC 2004; NE 2017*
Confidence: Moderate

5.4 Constraints to expansion or restoration

Recovery or restoration success depends on how extensive damage was, and the sensitivity of the individual habitat, sub-habitat or biotope. Habitat sensitivity, resilience and resistance to a wide range of natural and anthropogenic pressures has been assessed and published (Tyler-Walters & Hiscock 2017). For marine habitats, restoration is generally achieved through removal of pressures to which the habitat is sensitive, allowing natural recovery.

Geogenic reefs

As it was formed by geological processes, it is not possible to expand the range, distribution and area of geogenic reef.

There is considerable evidence worldwide that the communities of geogenic reef habitats can demonstrate signs of recovery and potentially be considered to be restored towards a natural state if pressures are removed for a sufficient period of time. (Ballantine 2014; Lester and others 2009). However, restoration to a viable community of similar functionality may occur, but the community might not support the same species assemblages as present prior to damage, and particularly rare or sensitive species may not return.

Monitoring following the closure of Lyme Bay to bottom towed fishing gear in 2008 recorded positive responses within assemblage composition for species richness and total abundance. Evidence of recovery was considered to be definitive for species richness measures and for three of the selected indicator taxa (Sheehan and others 2013). More recent work also showed increased resilience to, and recovery from, natural perturbations (R. Covey pers. comm.).

Biogenic reefs

There is potential for restoration of reef structures within the natural range of the species concerned, depending on the removal of the pressures affecting reefs, availability of suitable substratum on which the organisms can settle, on the supply of larvae (and sand particles in the case of *Sabellaria* spp.), and maintaining suitable environmental conditions for reef formation.

Sabellaria spp. and *Mytilus edulis* are relatively short-lived species with rapid and widespread larval recruitment, so reefs are likely to recover quickly under suitable conditions. *Modiolus modiolus* is slow growing with poor larval recruitment and therefore new reef is less likely to form (Holt and others 1998). Many reef building species are slow growing and recovery of reefs is expected to take many decades or centuries.

Studies have indicated that successful re-generation of biogenic reef communities is achievable (Cook 2016). Crusts of *Sabellaria spinulosa* are likely to re-form after damage within 1-3 years, although settlement is thought to be strongly influenced by the presence of existing *Sabellaria*. The epibiotic species typically associated with the special features of *Sabellaria* reef are likely to take longer to develop (MarLin 2016). Full regeneration of damaged mature *Sabellaria* reef has not been recorded, due to challenges in establishing suitable areas where pressures are excluded and reef recovery monitored.

The potential for expansion of *Modiolus* reefs is likely to be poor, due to the effects of climate change. *Modiolus* reefs have a predominantly northern distribution, reaching their southerly limit in the Irish Sea. Modelling predicts that the range of *Modiolus* reef will retreat northwards as sea temperatures increase, with 100% loss of most suitable habitat in most English waters by 2030, and complete loss by 2050 (Gormley and others 2013).

Other sources: *Cook and others 2013; Dolmer 2013; Hunter & Sayer 2009; Jensen, Collins & Lockwood 2000; Roberts and others 2011; Tyler-Walters and others 2017*

Confidence: *Moderate*

6. Conclusions

6.1 Favourable range and distribution

Geogenic reefs

The natural range for geogenic reef is favourable when the full zonation of reef biotopes or biological communities is able to develop and be maintained on naturally occurring geogenic structures. The current range (519 10 km squares across all CP2 regions) of geogenic reef represents its maximum potential range overall and should be considered as the favourable range.

Biogenic reefs

The natural range is favourable when reef structures of sufficient area are able to naturally form and be maintained in all CP2 regions where environmental conditions are suitable for that particular reef-forming species. Evidence indicates that the current range of biogenic reef is likely to be less than favourable due to human pressures, but it is not currently possible to quantify what a favourable range should be. An arbitrary increase of 10% to the current distribution is proposed for favourable status.

Favourable range within English inshore waters for biogenic reef of different types is:

CP2 region/No. of 10 km squares	*Sabellaria alveolata*	*Sabellaria spinulosa*	*Mytilus edulis*
1 – Northern North Sea	0	8	9
2 – Southern North Sea	21	70	33
3 – Eastern Channel	7	19	35
4 – Western Channel & Celtic Sea	27	3	12
5 – Irish Sea	20	1	31
Increase	8	10	12
Total number of 10 km squares	83	111	132

6.2 Favourable area

The natural area is favourable when the full zonation of reef biotopes or biological communities is able to develop and be maintained on naturally occurring geogenic structures.

The current area of geogenic reef (4,794 km^2) represents its favourable area.

For biogenic reef, the natural area is favourable when reef structures of sufficient area are able to naturally form and be maintained in all CP2 regions where environmental conditions are suitable for that particular reef-forming species. Evidence indicates that the current area of biogenic reef is likely to be less than favourable, but it is not possible to quantify the favourable area. An arbitrary increase of 10% from the current area (387 km^2), pro-rata within the range of each reef-forming species, is suggested for future maintenance of biological diversity and variation in biogenic reef habitat sub-types to give a favourable area of 426 km^2.

Species/Area (km^2)	*Sabellaria alveolata*	*Sabellaria spinulosa*	*Mytilus edulis*
Current area	11	307	68
Favourable area	12	338	75

6.3 Favourable structure and function attributes

For Favourable Status a percentage of the favourable area for each type of reef would need to meet the structure and function requirements. The percentage is higher for those reef habitats that have been identified as a Habitat of Conservation Interest (HOCI) (NE & JNCC 2010).

Reef type	Percentage of favourable area needing to meet the structure and function requirements
Geogenic reef within Protected Sites not identified as a Habitat of Conservation Interest (HOCI) or particularly rare or sensitive to damage	95%
Geogenic reef outside Protected Sites not identified as a Habitat of Conservation Interest (HOCI) or particularly rare or sensitive to damage	75%
Geogenic reef identified as a Habitat of Conservation Interest (HOCI)	100%
Biogenic reef	100%

Threatened species

All species that are Features of Conservation Interest (FOCI) partially or wholly dependent on this habitat should be Least Concern, when assessed using IUCN criteria (or considered to be Least Concern if not formally assessed), as regards to this habitat.

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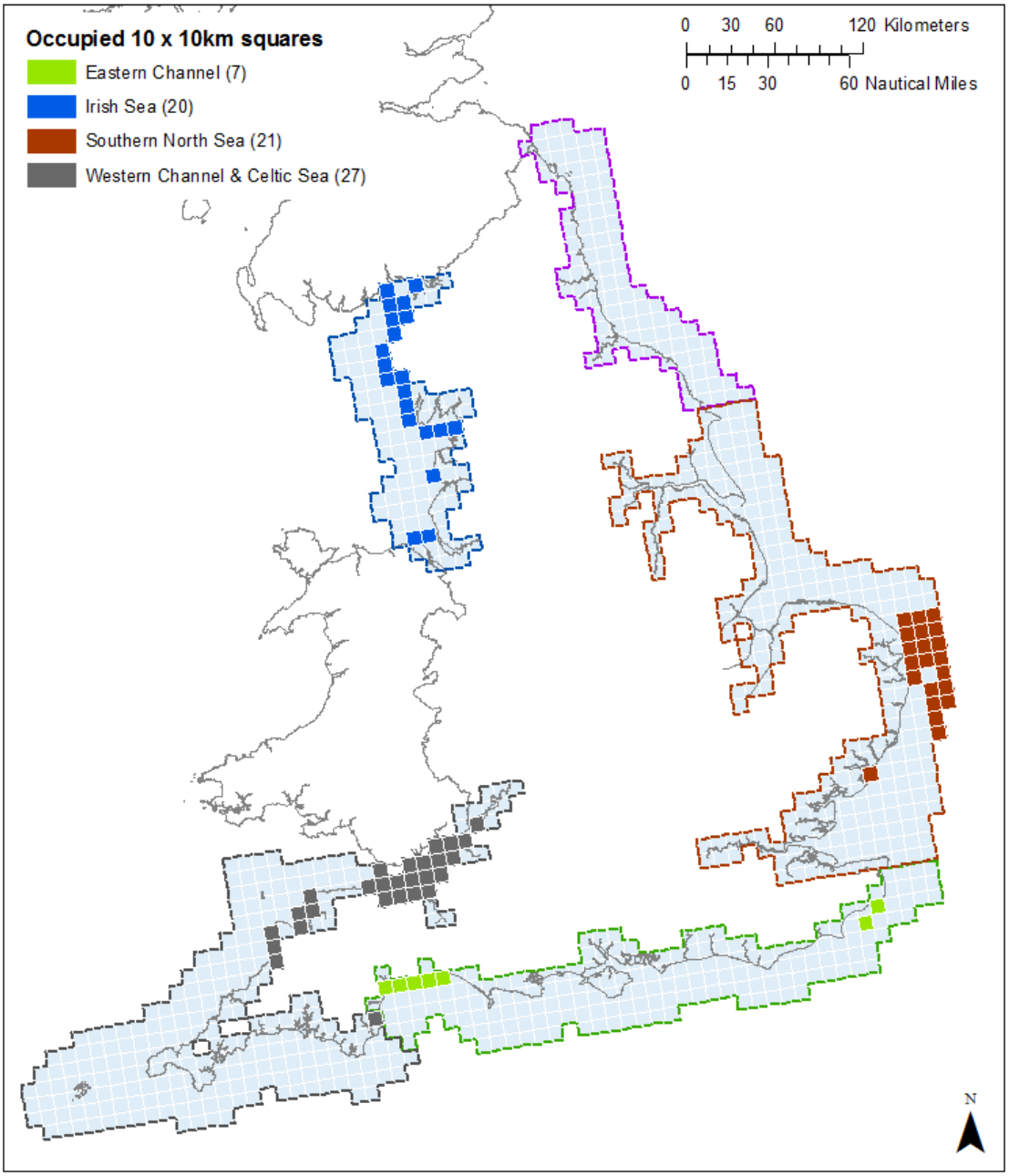
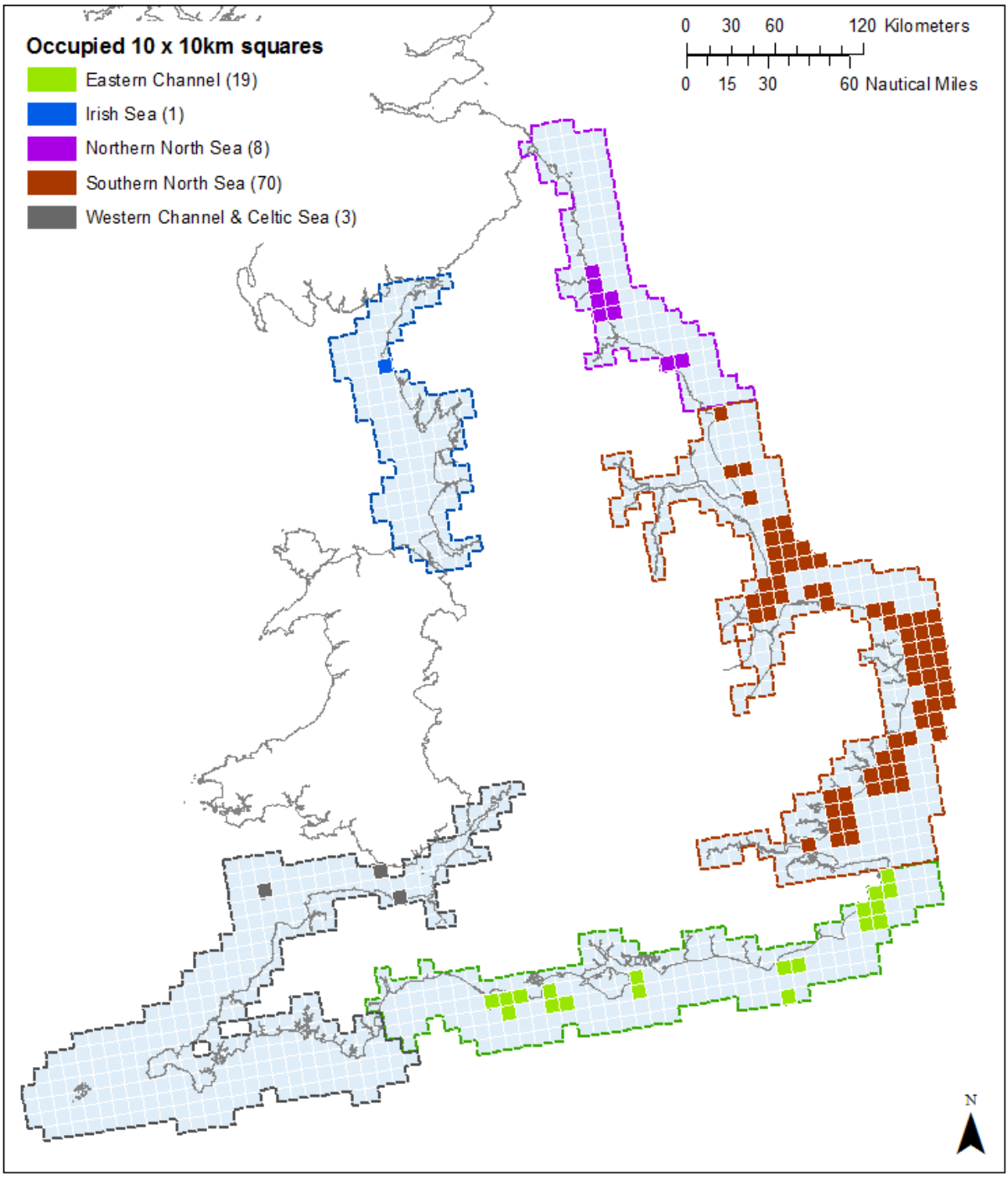
Annex 2: Presence of biogenic reefs by charting progress 2 regions

Presence of *Sabellaria alveolata* by charting progress regions in English waters.



Presence of *Sabellaria spinulosa* by charting progress regions in English waters.



Charting progress regions

- Eastern Channel
- Irish Sea
- Northern North Sea
- Southern North Sea
- Western Channel & Celtic Sea

Map produced on 22/01/2021 by X955392, Natural England

Scale (at A4): 1: 3,500,00

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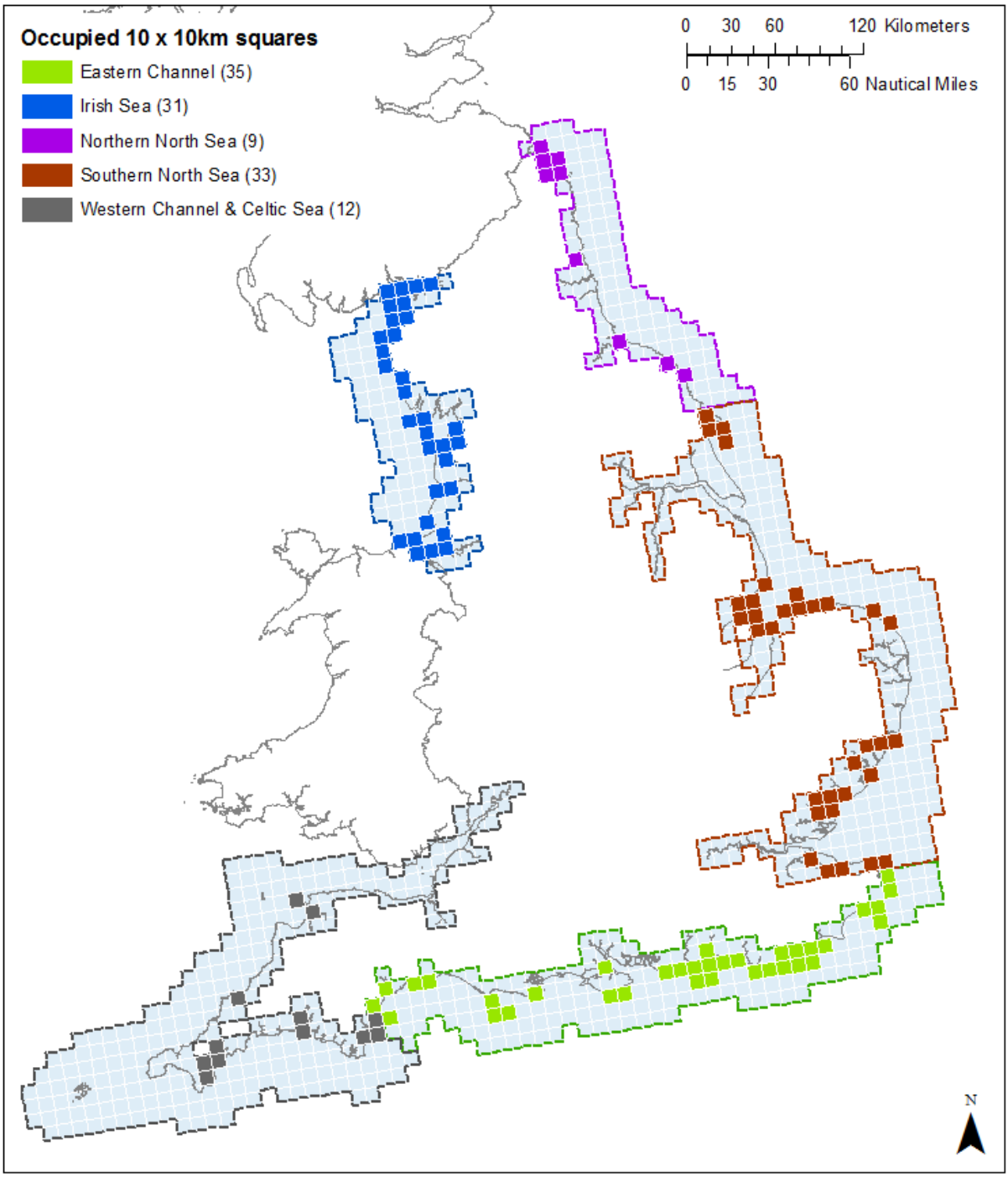
Presence of *Mytilus edulis* by charting progress regions in English waters.



Charting progress regions

- Eastern Channel
- Irish Sea
- Northern North Sea
- Southern North Sea
- Western Channel & Celtic Sea

Map produced on 22/01/2021 by X955392, Natural England

Scale (at A4): 1: 3,500,00

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Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk** .

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Anemones & sponges on highly exposed circalittoral reef, Isles of Scilly
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