A categorisation system for maerl bed habitats in England

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Executive summary

This Natural England research report introduces a new national categorisation system for maerl habitats in England.

Maerl is the common and collective term used for several free-living, unattached coralline red algae species (Riosmena-Rodriguez *et al*., 2016) including *Phymatolithon calcareum*, *Lithothamnion corallioides, Lithothamnion glaciale* and *Lithophyllum fasciculatum*

Whilst there are several definitions of maerl beds and habitats (e.g. Marine Habitat Classification system, MHC), there is currently no categorisation system and some records of maerl may therefore be lost during the survey and analysis stages, or not recorded at all.

A maerl habitat categorisation system will help classifying different maerl bed habitats, better inform analysts of habitat maps, aid assessments during field work (for Seasearch, commercial entities and government agency scientists) and improve the analysis and reporting processes.

A categorisation system is particularly important to identify the various maerl bed habitats to improve distribution and mapping data but also allow further consideration around the differing sensitivities and therefore levels of protection and management needed by different maerl habitats along the English coastline.

The main factors being considered when developing a categorising system include physical size, percentage cover, the live versus dead maerl ratio and the physical structure (3D versus 2D).

Considering the large variation in condition and size of maerl bed habitats in England, five main categories have been created with specific terms for each: Dense Maerl, Maerl Sediment, Sparse Maerl, Maerl Veneer and Potential Maerl. Within these five categories, one, two or three groups have also been created for each category.

Contents

1. Background

Over recent years, it has become apparent that a national categorisation system for maerl bed habitats in England is needed. A categorisation system is particularly important to identify the various maerl bed habitats to improve distribution and mapping data but also allow further consideration around the differing sensitivities and therefore levels of protection and management needed by different maerl habitats along the English coastline.

A new habitat and biotope designation system (current maerl biotopes and sub-biotopes given in section 2.5) with new biotope descriptions should also be considered as new information about maerl DNA, maerl community eDNA, the variety of maerl habitats and new records become available. This document aims to discuss and suggest a new categorisation system for different maerl bed habitats in English inshore waters, with potential for wider application around the UK.

2. Maerl

Maerl is the common and collective term used for several free-living, unattached coralline red algae species (Riosmena-Rodriguez et al., 2016) including *Phymatolithon calcareum*, *Lithothamnion corallioides, Lithothamnion glaciale* and *Lithophyllum fasciculatum* (OSPAR, 2008). These are unattached nodules, or ‘rhodoliths’, which literally means “red stone” (Bosence, 1983) based on the ancient Greek words for roselike (ῥόδειος) and stone (λίθoϚ) and occur on open coasts and marine inlets (OSPAR, 2008).

Maerl rhodoliths are substrate specific in the UK and in the North-East Atlantic and known to develop around a nucleus of mud (in some areas of Scotland for example), sand, gravel, rock, coral, shell, or similar, which serves as substrate for development and growth. Some are found without any material at the centre, instead consisting of a number of concentric thallus layers (Riosmena-Rodriguez *et al.*, 2016).

The reproduction of maerl is not fully understood but sexual and asexual reproduction are known to occur (Figure 1). For maerl-forming species to reproduce sexually there must be hard (usually rock) substrate for the encrusting forms to develop. Carpospores are released into the water column and grow into attached sphorophytes on the hard substrate. These then produce tetraspores, through meiosis, which develop further into gametophytes (see sexual reproduction schematic in Figure 1). Male gametophytes produce gametes by mitosis. These are released and fertilize the female gametophytes to produce uniporate conceptacles which then results in carposphorophytes and eventually sporophytes which completes the sexual cycle.

The asexual reproductive stages given in Figure 1 occur when branches from free-living maerl thalli develop through fragmentation. These fragments grow into unattached sporophytes that become part of the sexual stages through bispore release or meiosis to produce multiporate conceptacles.

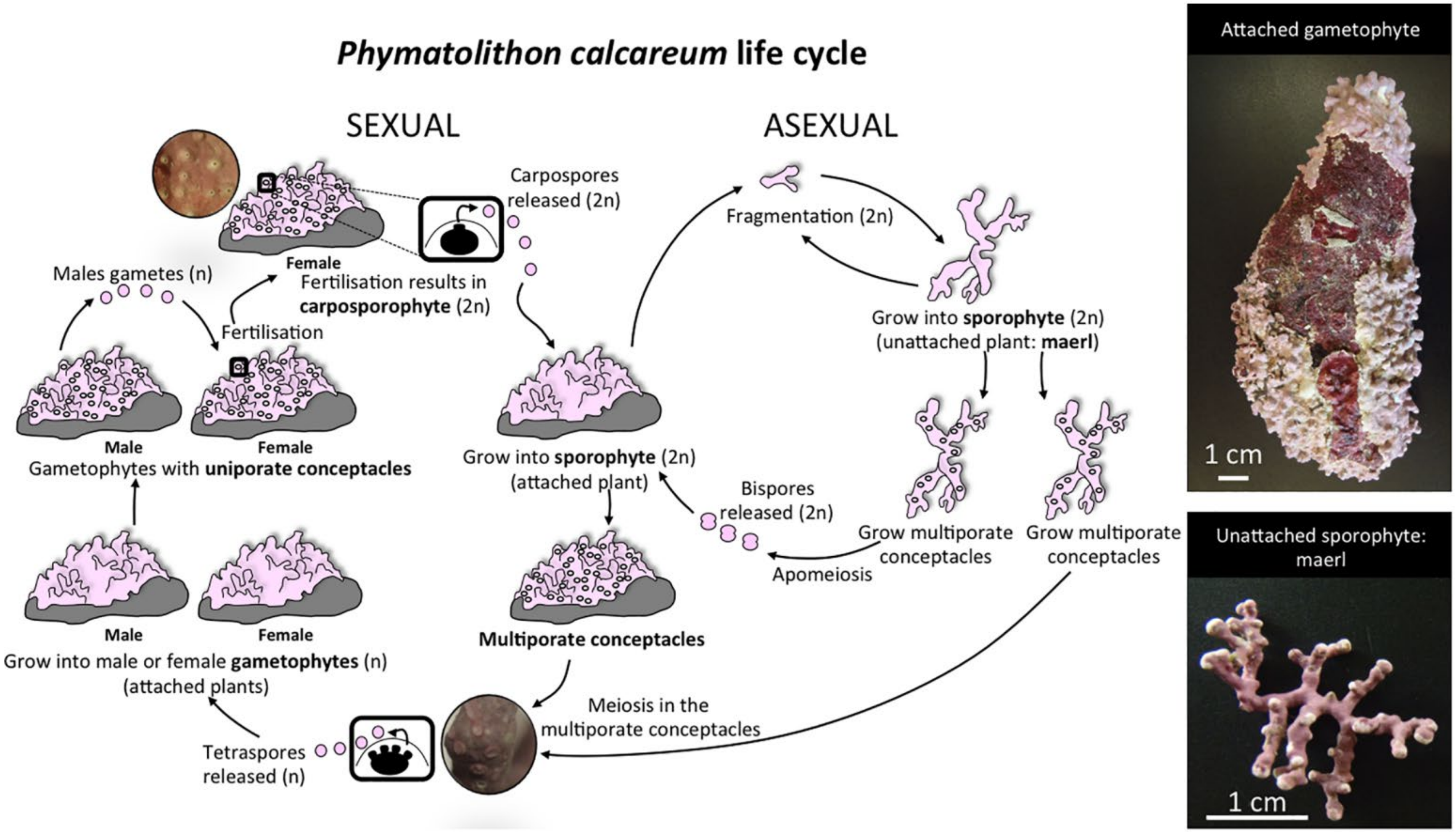


Figure 1The life cycle of Phymatolithon calcareum (from Pardo et al., 2019) © 2019 Pardo, Guillemin, Peña, Bárbara, Valero and Barreiro. Reproduced under Creative Commons license (CC BY 4.0).

Identification of maerl species in the field, or on video still photographs, is notoriously difficult and typically requires access to a microscope but even then, virtually impossible. Unless the reproductive structures can be observed. Natural England have recently changed the rationale to emphasise the importance of the maerl habitat rather than the specific species (Selley, 2016), but for any restoration project it will be important to know the dominant maerl-forming species (the number and abundance of species comprising a particular maerl habitat). This is now possible using relatively cheap and straightforward DNA barcoding techniques (Jenkins *et al.,* 2021; Melbourne *et al.*, 2017; Pardo *et al.*, 2014).

A recent DNA-based study (Jenkins *et al*., 2021) sequenced whole genomes of the maerl-forming species *P. calcareum* and revealed distinct genetic structuring between maerl beds across the UK and western Europe. Many of the maerl beds included in the study were composed of more than one species (e.g., the Fal Estuary contains both *P. calcareum* and *L. corallioides*). Unlike *P. calcareum*, it is unknown if there is distinct genetic diversity in the *L. corallioides* population in the Fal Estuary maerl bed.

There is currently no clear evidence that a particular maerl-forming species supports more or less biodiversity or any evidence that aggregations of one species builds a better 3D habitat than another. However, it is the importance of maerl as a habitat rather than a particular species that has implications on how maerl is managed in a conservation setting.

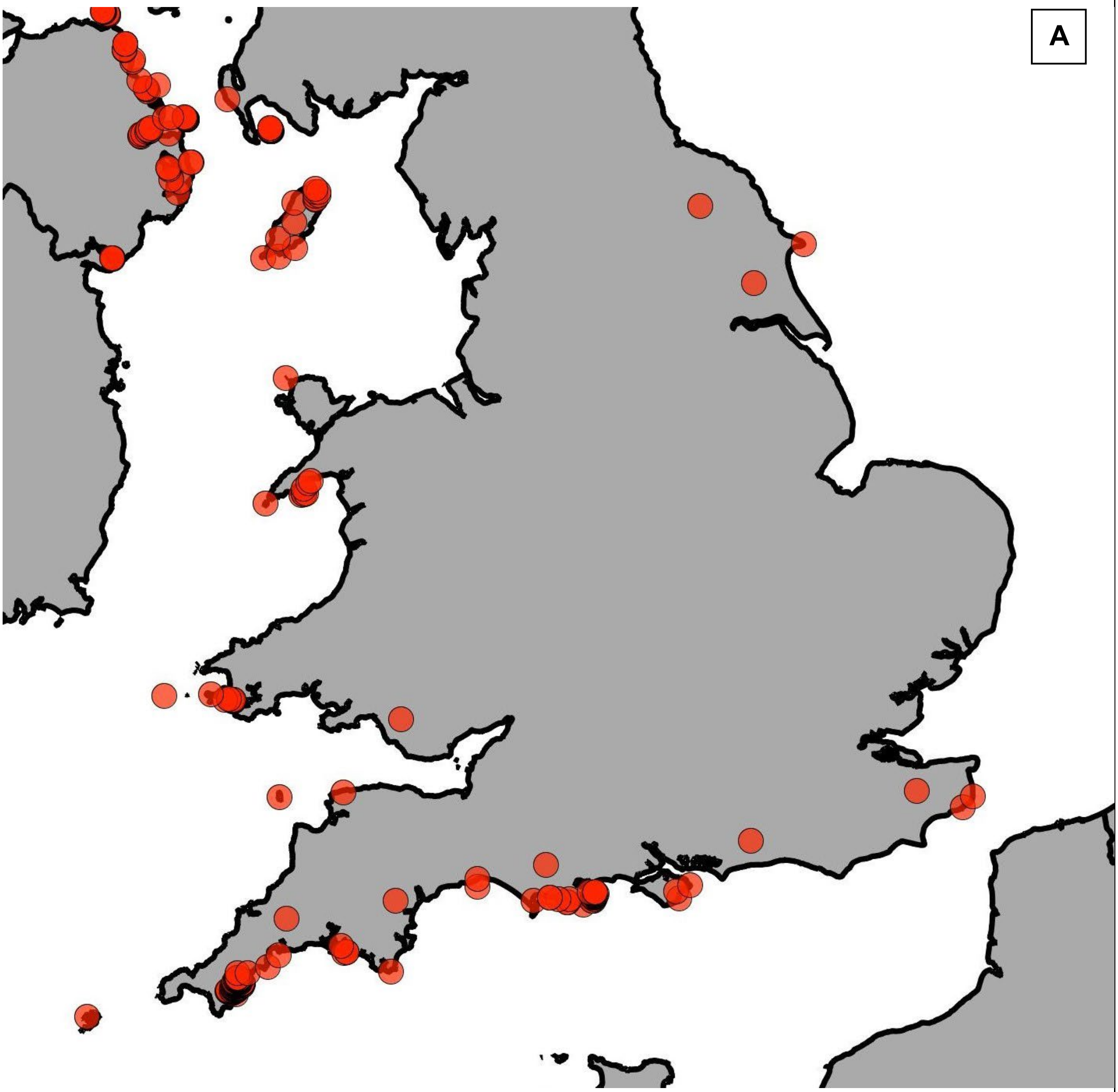
2.1 Distribution

2.1.1 Europe

Maerl is found along most of the Western Atlantic coast from Norway and Denmark in the north, to Spain and Portugal in the south but also in the Mediterranean Sea, although maerl is rare in the English Channel, North Sea and Baltic Sea (OSPAR, 2008; Barbera et al., 2003; Irvine and Chamberlain, 1994). The most widely distributed and common maerl-forming species across Europe is *P. calcareum*, with *L. corallioides* and *L. glaciale* being second and third respectively (Pardo et al., 2014).

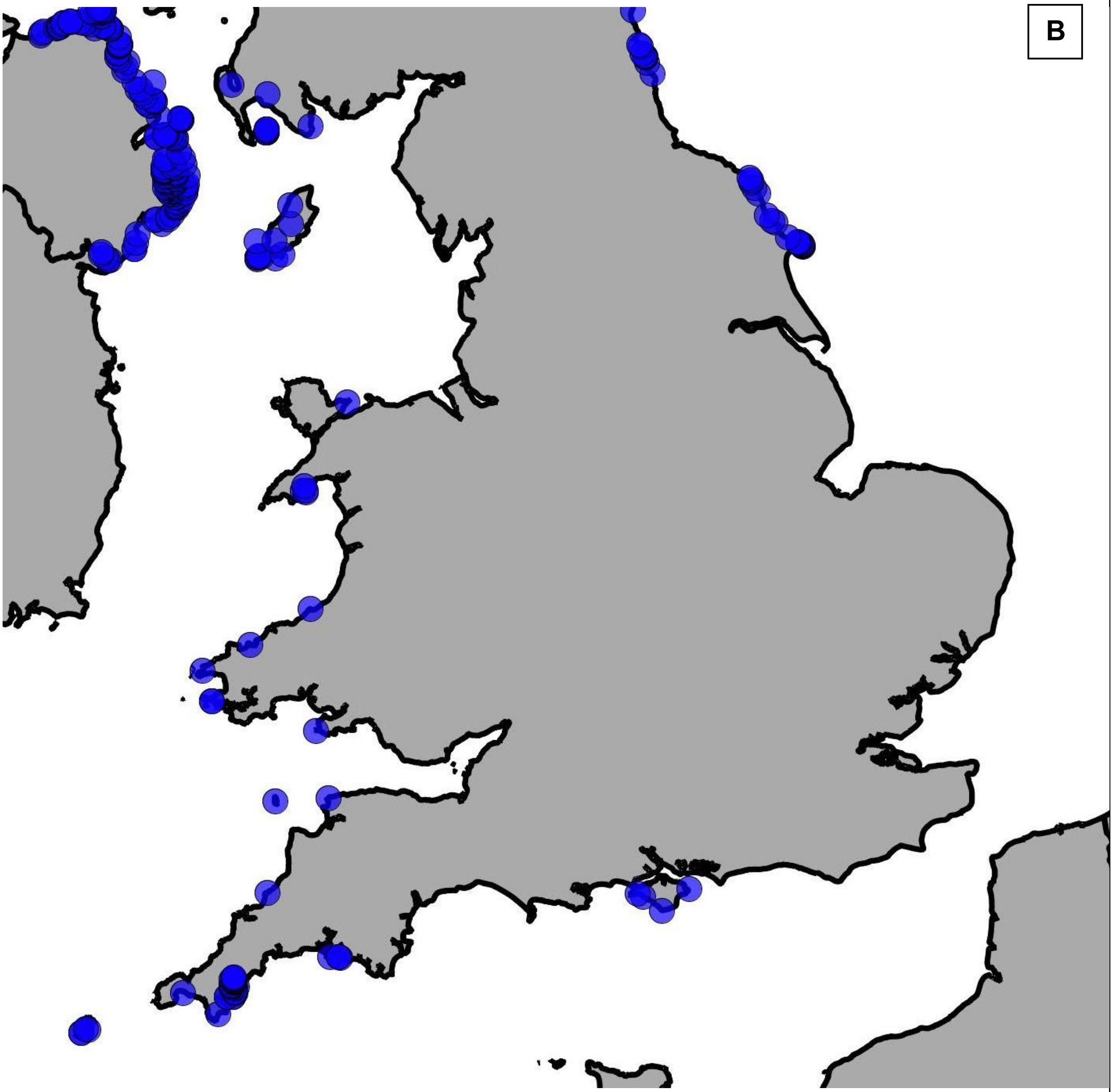
2.1.2 England

In England, maerl and maerl bed habitats are found on the open coast, in bays and estuaries, often where there is a significant tidal effect. The three most commonly recorded maerl species in England are *Phymatolithon calcareum, Lithothamnion coralloides* and *Lithothamnion glaciale* (Figure 2; NBN, 2023; JNCC, 2015), with the former two taxa predominantly recorded in the south and southwest of the country (Figure 2). *Lithothamnion glaciale* and *Lithothamnion erinaceum* also occur in England but are predominantly found in northern waters, although *L. glaciale* has recently been recorded along the south coast westwards from the Isle of Wight (NBN, 2023; MCCIP, 2018; Birkett *et al*., 1998).



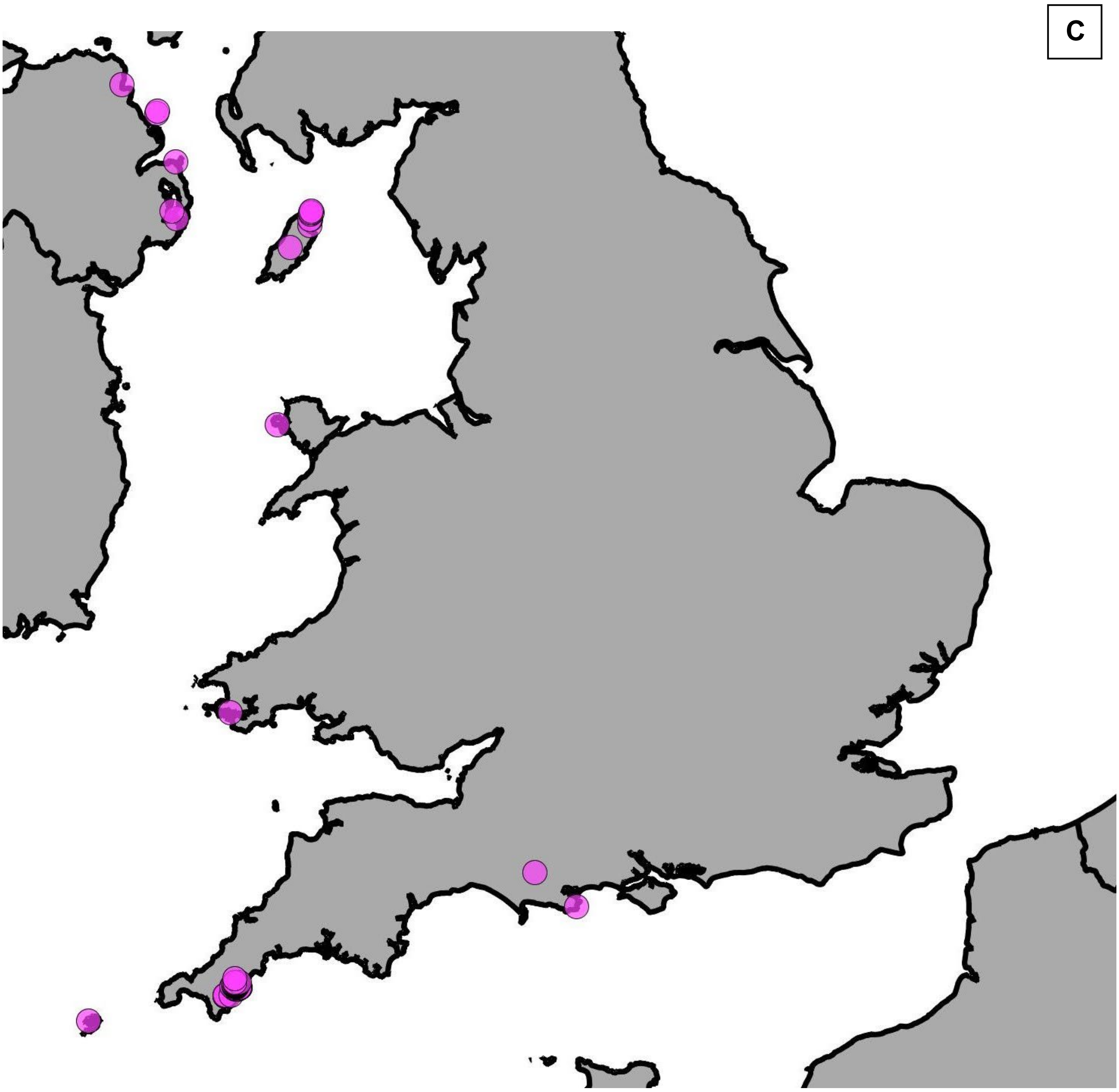
Phymatolithon calcareum

Figure 2A: The distribution of *P. calcareum* in England is given in Figure 2A illustrating records along the entire south coast of England from the Isles of Scilly to Dover. There are additional records along the northern coastline of Cornwall and Devon as well as in Yorkshire.



Lithothamnion glaciale

Figure 2B: The distribution of *L. glaciale* in England is given in Figure 2B illustrating records along the entire south coast of England from the Isles of Scilly to the Isle of Wight. There are additional records along the northern coastline of Cornwall and Devon as well as in Yorkshire and Northumberland.



Lithothamnion corallioides

Figure 2C: The distribution of *L. corallioides* in England is given in Figure 2C illustrating records predominantly in the southwest coast of England from the Isles of Scilly to Swanage.

Figure 2. Distributions of three maerl species (A: *Phymatolithon calcareum,* B: *Lithothamnion glaciale* and C: *Lithothamnion corallioides*) in England and parts of the UK (NBN, 2023;[1] N.B. some records appear to be on land, positions only indicative of actual locations); These figures are published under CC-BY-NC licence

[1] The Data Provider, Original Recorder (where identified), and the NBN Trust bear no responsibility for any further analysis or interpretation of the material, data and/or information

The largest maerl habitats in England are found in and around the Fal Estuary (NE, 2000) with a particularly important maerl habitat found at St. Mawes. Other significant beds are found at The Manacles and in Falmouth Bay. Recent surveys have also preliminary recorded some significant beds in Veryan Bay, Gerrans Bay and St. Austell Bay (Crosby et al., 2023).

2.2 Current definition systems

There are a number of proposed and currently used maerl bed habitat definition systems but there is no categorisation system in England. A system is under review in Scotland expected to largely be in line with the Marine Habitat Classification system (JNCC, 2015), also referred to as the biotope classification system (more information about the biotope classification system below). A maerl biotope or sub-biotope is designated where there is 20% of maerl (dead or live), the habitat is $25m^2$ in size, the habitat has a 3D structure and the maerl thalli are >1cm in size (shapes described as twiglets, medallions or hedgehog stones).

Maerl beds are protected under Annex I (habitat) and Annex V (species) under the European Commission’s Habitats Directive (OSPAR, 2008) but there are no specifications on physical size or quality of the habitat.

The OSPAR Commission has no specified habitat physical size, any requirement for a certain percentage of live or dead maerl thalli or 3D structure (OSPAR, 2008, 2010) but refer to all maerl habitats as declining and requiring some level of protection to recover.

2.3 Threats

Maerl is highly sensitive to any form of abrasion, bottom-towed fishing activity, and the active extraction of maerl itself (Jenkins et al., 2021; Perry & Tyler-Walters, 2018; Grall and Halll-Spencer, 2003; Hall-Spencer et al., 2003; Hall-Spencer and Moore, 2000). Maerl is also highly sensitive to sedimentation (particularly smothering and light level changes) caused by, for example, sediment disposal, sediment extraction and fishing (Perry & Tyler-Walters, 2018; Grall and Halll-Spencer, 2003; Hall-Spencer et al., 2003; Barbera et al., 2003).

Maerl beds are also under threat from land reclamation (e.g. artificial beaches), coastal developments (e.g. breakwaters, harbours and marinas), aquaculture (e.g. fish cages), recreation and invasive species (e.g some macroalgae and slipper limpet *Crepidula fornicata*), where the faeces can cause smothering (Barbera et al., 2003).

Maerl is also sensitive to changes in water quality (e.g. seawater chemistry, temperature and ocean acidification) and light attenuation caused by eutrophication, sewage discharge, aquaculture, industrial waste and construction activities (OSPAR, 2008, 2010; Barbera et al., 2003; Birkett et al., 1998).

2.4 Current protection

The sensitivity, slow recovery rates and the decline in maerl habitats extent have resulted in a number of international and national pieces of legislation (Table 1). Both maerl habitats and species have some level of protection and maerl habitats are listed as ‘vulnerable’ on the European Red List of habitats as well as being recorded in the OSPAR list of threatened and/or declining habitats (OSPAR, 2008, 2010). Protection of the maerl habitat (regardless of species) was the accepted rationale by Natural England in 2016 (Selley, 2016).

Maerl is not included in the Wildlife and Countryside Act 1981 but there might be a need to reassess the importance of some maerl community taxa as there are potential interstitial species (e.g. Leptognathis paramanca; Tannaidae) endemic to maerl habitats (Bamber pers. comms; Barbera et al., 2003) but these are smaller than 1mm which might explain why these have not been widely recorded as many studies tend to use sieve mesh sizes of 1mm for the retention of infaunal invertebrates in benthic macrofaunal analyses (Bamber pers. comms). With the recent developments in eDNA, it may be possible to explore the prevalence of these interstitial / endemic species (sizes < 1mm) without the need for invasive sampling (e.g. core sampling).

Table 1. Maerl has protection under the following national and international legislation (*previously UK BAP list of priority species and habitats; FOCI = Features of Conservation Interest).

MCZ FOCI	OSPAR Threatened and/ or Declining Species and Habitats	Wildlife & Countryside Act 1981 Sch. 5 and 8 protected species	UK Post-2010 Biodiversity Framework*	EU Habitats Directive Annex I & V	NERC Act 2006 Habitats & Species of Principal Importance
Maerl beds	Yes	Not applicable	Yes	Yes (Annex I)	Yes
Coral maerl (*Lithothamnion corallioides*)	No	No	Yes	Yes (Annex V)	Yes
Common maerl (*Phymatolithon calcareum*)	No	No	Yes	Yes (Annex V)	Yes

2.5 Current Marine Habitat Classification system

Maerl is included in the Marine Habitat Classification system (MHC; JNCC, 2015) under a number of biotopes. There are 6 main biotopes and sub-biotopes described as maerl beds and characterised by the presence of maerl-forming species (see Table 2 for biotope descriptions).

Maerl can also be found in other biotopes, including SS.SMX.CMx.MysThyMx and SS.SCS.CCS.Nmix, but if present, maerl only occur at very low abundances and do not form maerl beds.

The results from a recent study (Jackson, 2021) comparing the MHC and this current categorisation system suggest the categorisation system allows all types of maerl habitat to be recorded, allows more detailed distribution maps to be created and highlights areas of potential maerl, providing information for future confirmation studies.

Table 2. JNCC Marine Habitat Classification maerl biotopes applicable in England (and the UK; Connor et al., 2004; public access through Open Government Licence v3.0)

Maerl biotope/sub-biotope	Description
SS.SMp.Mrl.Pcal	Maerl beds characterised by *Phymatolithon calcareum* in gravels and sands in the infralittoral zone. Associated epiphytes anchored to the maerl or to dead bivalve shells may include *Dictyota dichotoma, Halarachnion ligulatum, Callophyllis laciniata*, *Cryptopleura ramosa*, *Brongniartella byssoides* and *Plocamium cartilagineum*.
SS.SMp.Mrl.Pcal.R	Upper infralittoral maerl beds characterised by *Phymatolithon calcareum* in gravels and sand with a wide variety of associated red seaweeds. These algae typically include *Dictyota dichotoma*, *Plocamium cartilagineum*, *Phycodrys rubens* and *Chondrus crispus.*
SS.SMp.Mrl.Pcal.Nmix	Lower infralittoral maerl beds characterised by *Phymatolithon calcareum* in gravels and sand with a variety of associated echinoderms. The echinoderm *Neopentadactyla mixta* is frequently observed.
SS.SMp.Mrl.Lgla	Upper infralittoral tide-swept channels of coarse sediment in full or variable salinity conditions support distinctive beds of *Lithothamnion glaciale* maerl 'rhodoliths'. *Phymatolithon calcareum* may also be present as a more minor maerl component. Associated fauna and flora may include species found in other types of maerl beds (and elsewhere), e.g. *Pomatoceros triqueter*, *Cerianthus lloydii*, *Sabella pavonina*,

Maerl biotope/sub-biotope	Description
	Chaetopterus variopedatus, *Lanice conchilega*, *Mya truncata*, *Plocamium cartilagineum* and *Phycodrys rubens.*
SS.SMp.Mrl.Lcor	Live maerl beds in sheltered, silty conditions which are dominated by *Lithothamnion corallioides* with a variety of foliose and filamentous seaweeds. Live maerl is at least common but there may be noticeable amounts of dead maerl gravel and pebbles. Other species of maerl, such as *Phymatolithon calcareum* and *Phymatolithon purpureum*, may also occur as a less abundant component. Species of seaweed such as *Dictyota dichotoma*, *Halarachnion ligulatum.* and *Ulva* spp. are often present.
SS.SMp.Mrl.Lfas	Shallow, sheltered infralittoral muddy plains with *Lithophyllum fasciculatum* maerl. This rarely recorded maerl species forms flattened masses or balls several centimetres in diameter (Irvine & Chamberlain 1994). Lfas may be found on mud and muddy gravel mixed with shell. Species of anemone typical of sheltered conditions may be found in association, for example, *Anthopleura ballii*, *Cereus pedunculatus* and *Sagartiogeton undatus*. Polychaetes such as *Myxicola infundibulum* and terebellids, also characteristic of sheltered conditions.

2.6 Maerl tolerances and sensitivities

As outlined above, there are a number of maerl habitats and biotopes. In all cases, the dominant maerl species forms a unique habitat that supports a diverse assemblage of associated species (Perry and Tyler-Walters, 2018). However, as all maerl habitat forming species are ecologically fragile due to slow growing rates (Wilson et al., 2004), the loss of the maerl taxa would result in loss of the habitat. Therefore, the sensitivity of maerl habitat is dependent on the sensitivity of the specific maerl species (Perry and Tyler-Walters, 2018).

The sensitivities, resistance and resilience of live maerl-forming taxa was reviewed by (Perry and Tyler-Walters, 2018) and summary is given in Table 3. Live maerl has been shown to be particularly sensitive to abrasion, extraction and smothering but several other factors too.

Table 3. Sensitivities, resistance and resilience of live maerl-forming taxa (scale 5-1 added where 5 is highest impact and 1 is lowest impact on maerl in the respective column).

Hydrological Pressures	Resistance	Resilience	Sensitivity
Temperature increase	Medium (3)	Very low (5)	Medium (3)
Temperature decrease	Medium (3)	Very low (5)	Medium (3)
Salinity decrease	Low (4)	Very low (5)	Low (4)
Water flow (tidal) changes	Low (4)	Very low (5)	Low (4)
Wave exposure changes	High (1)	High (1)	Not sensitive (1)
Chemical pressures	**Resistance**	**Resilience**	**Sensitivity**
De-oxygenation	Low (4)	Very low (5)	High (4)
Organic enrichment	None	Very low (5)	High (4)
Physical pressures	**Resistance**	**Resilience**	**Sensitivity**
Physical loss to habitat	None (5)	Very low (5)	High (4)
Physical change to seabed type	None (5)	Very low (5)	High (4)
Habitat structure changes	None (5)	Very low (5)	High (4)
Abrasion/disturbance of substratum surface	None (5)	Very low (5)	High (4)
Penetration/disturbance of seabed subsurface	None (5)	Very low (5)	High (4)
Changes in suspended solids (water clarity)	Medium (3)	Very low (5)	Medium (3)
Smothering and siltation rate (light)	None (5)	Very low (5)	High (4)
Smothering and siltation rate (heavy)	None (5)	Very low (5)	High (4)
Biological pressures	**Resistance**	**Resilience**	**Sensitivity**
Invasive non-indigenous taxa	None (5)	Very low (5)	High (4)
Removal of target species	None (5)	Very low (5)	High (4)
Removal of non-target taxa	Low (4)	Very low (5)	High (4)

3. Maerl bed habitat categories

Maerl beds occur from the tropics to the poles (Foster, 2001; Hinojosa-Arango & Riosmena- Rodriquez, 2004; Barbera et al., 2003). Fundamentally, natural conditions and processes need to be favourable to allow a maerl bed habitat to develop in the first instance but also limits how large and complex a particular maerl bed habitat develops, the scale of which will be driven by coastal topography, local hydrodynamics (waves, tides, and currents), depth and other environmental conditions (irrespective of human impacts).

This can be exemplified by the maerl communities at The Manacles (an architecturally complex maerl bed (3D) but with no live maerl) and in the Fal Estuary (architecturally complex maerl bed (3D) with dense live and dead maerl), which experience different tidal regimes, affecting the degree of sedimentation which in turn influences the rate of photosynthesis and growth / survival of maerl. Therefore, the true natural capacity of The Manacles as a site for maerl bed establishment (in the absence of human impacts) may still be less than the Fal Estuary.

Of note is also that maerl beds appear to be quite patchy, but rhodolith dominated benthic communities have reached much more extensive development in the past, colonising most of the temperate platforms (e.g., during late Miocene; Halfar and Mutti, 2005). The current maerl patchiness has, at the large European scale, been shown to result in a significant pattern of isolation by distance in, for example, *P. calcareum*, confirming the limited dispersal capacity of spores and gametes observed in various sexually reproducing macroalgae (Durrant et al., 2014).

For the reasons given above, any designations and levels of protection will have to allow for both natural processes and habitat development limitations as well as any human interaction. A maerl habitat categorisation system will help classifying different maerl bed habitats, better inform analysts of habitat maps, aid assessments during field work (for Seasearch, commercial entities and government agency scientists) and improve the analysis and reporting processes.

3.1 Main factors for consideration for maerl habitat categorisation

In addition to the above, the main factors being considered when developing a categorising system include physical size, percentage cover, the live versus dead maerl ratio and the physical structure (3D versus 2D) but other factors including epi- and infauna, should also be considered.

3.1.1 Physical size

The OSPAR definition of a maerl bed does not include a minimum physical size but the guidance for assigning MNCR benthic biotopes (MHC) states that a biotope should cover at least 25m^2 to qualify (Parry, 2015). For consistency, a physical size of 25m^2 to qualify as a maerl bed would therefore arguably be practical and appropriate as both systems are likely to be used in conjunction during marine survey work, environmental assessments, mapping and designations.

A smaller minimum physical size of $5m^2$ has been considered for designations and protection after advice from academic sources (Selley, 2016). This needs to be taken into consideration when establishing the new categories but to help end-users of a categorisation system and relate this system to the biotope classification system (using $25m^2$), the smaller maerl bed sizes could be applied to specific sites with additional guidance.

3.1.2 Percentage cover

As with physical size, there is no defined percentage cover requirement within OSPAR for a site to qualify as a maerl bed (Selley, 2016; OSPAR, 2008) but consistent with the MNCR biotope classification, 20% is used (equivalent to Common (C) on the SACFOR abundance scale) in the UK biotope classification system (Connor *et al*., 2004) and could therefore be applied to a categorised maerl habitat system.

Various methods of quantification of benthic fauna and flora are currently being discussed widely. The SACFOR scale has been discussed in the Big Picture Group (Quantification Project Working Group). A log transformed system, SACFOR is applicable to robust statistical analysis and covers crust/meadow/turf fauna as well as counts. It is widely used and understood by surveyors, scientists and others.

3.1.3 Percentage cover of live vs. dead maerl

Neither OSPAR or the MNCR biotope classification system (MHC) specify percentage cover for live or dead maerl habitats (OSPAR, 2008, 2010; Connor *et al*., 2004). It has also been argued that defining maerl habitats based on the percentage cover of live versus dead maerl is scientifically unjustified (Selley, 2016) but categorising maerl habitats based on different percentages would be beneficial in terms of describing, mapping and assessing habitats in different regions as well as allowing further consideration as to how these should be protected and designated.

3.1.4 Three-dimensional (3D) structure

A full range of thalli sizes should be present in a site to ensure a healthy, productive population. As thalli size increases, the three-dimensional complexity increases leading to a higher diversity of associated species (Nelson, 2009). It can therefore be argued that the structure of a maerl habitat should be considered when categorising these into separate groups.

The draft maerl bed classification in Scotland (SNH, 2017) states that for practical conservation purposes, a habitat is considered a ‘maerl bed’ when based on a complex 3D structure. The rhodoliths should be at least 1cm in size but whether these are dead or alive is irrelevant. In fact, the architectural complexity of a 3D maerl bed has been shown to significantly enhance biodiversity compared to surrounding soft sediment habitats whether the maerl is dead or live (Jackson et al., 2004) but the relative importance of dead and live maerl can vary with location (Sheehan et al., 2015).

3.1.5 Particle size

Particle Size Analysis (PSA) is typically based on the Wentworth Scale (Leeder,1982). When referring to maerl gravel, maerl sediments and various sediment particle sizes, it should also be described according to the sediment sizes for the gravel, sand and mud size fractions of the Wentworth scale.

3.1.6 Maerl recovery rates

Maerl bed habitat 'recovery' rates, especially if exposed to dredging or similar activities, have variously been described to take 5-50 years (Blake et al., 2007; Cooper et al., 2008) whilst others suggest much longer rates of up 1000 years, if at all (Hall-Spencer, 2009). A recent genetic study suggests that the genetic and species diversity of maerl habitats most likely accumulates over a large temporal scale and that maerl habitats should be considered a non-renewable resource (Jenkins et al., 2021; Barbera et al., 2003). Maerl habitats even in close physical proximity have furthermore been shown to be genetically unique (Jenkins et al., 2021). This has significant ramifications when considering management and enabling the recovery of an impacted maerl bed, a subject beyond the remit of this document.

3.1.7 Fauna and flora

There is limited infaunal and epifaunal data from maerl beds in England, most likely linked to the sensitives of these habitats and the general reluctance to disturb the maerl beds because of the long recovery rates. However, recent developments in eDNA could allow rapid and non-intrusive sampling of these seabed environments in the future to improve the understanding and knowledge of faunal and floral communities of the maerl beds in England.

From the data that are available, it has been established that maerl beds create architecturally complex and heterogenous habitats, which typically exhibit high benthic biodiversity and biomass (Hall-Spencer, 1998; Jackson et al., 2004; Axelsson et al., 2008; Sheehan et al., 2015) and some support rare and endemic species (Hall-Spencer, 1998; Axelsson et al., 2008). Maerl beds can harbour high densities of broodstock bivalves and act as nursery areas for the juvenile stages of commercial species such as cod (*Gadus morhua*), crabs (*Cancer pagurus*) and scallops (*Aequipecten opercularis*), which are attracted to the complex three-dimensional sediment structure (Hall-Spencer et al., 2003, Kamenos et al., 2004a,b).

In terms of recovery rates, ecological studies have estimated the large and long-lived burrowing faunal taxa (e.g. urchins, sessile bivalves and thalassinid shrimps), which are often found deep in maerl deposits, would need 20-50 years to become re-established after disturbances (e.g. bottom-towed fishing; Hall-Spencer et al., 2001; Hall-Spencer, 2009).

3.1.8 Photographic guide to maerl habitat categories

Once the maerl habitat categories have been established and tested (in the field, during analysis and when mapping habitats), a photographic reference catalogue should be produced to ensure end-users can produce consistent and across-agency compatibility in the analysis.

3.2 Maerl bed habitat categories for England

There is currently no standardised system for maerl bed habitat classification or categorisation in England. Various categorisation systems have been designed by contractors, and others, to describe and report the results of the various studies (e.g. Hawes et al., 2014) but these systems were often project (location) specific and not designed or envisaged to become national classification systems.

A categorisation is intended to assist with field work, analysis, reporting and mapping to improve habitat data held nationally, particularly the detailed information held at each site, to aid designations, advice and levels of protection across England.

Considering the large variation in condition and size of maerl bed habitats in England, there is a need for a number of categories to ensure all habitats can be recorded, assessed and considered for protection based on the conditions at a particular site. Five main categories have therefore been created (Table 4) with specific terms for each: Category A is “Dense Maerl”; Category B is “Maerl Sediment”; Category C is “Sparse Maerl”; Category D is ”Maerl Veneer”; and Category E is “Potential Maerl”. Within these five categories one, two or three groups have also been created for each category. Group 1 is the richest, most diverse group within each category, with the subsequent groups becoming less rich and biodiverse with increase in group number. In the future, these categories and groups might need expanding and developing further but the current maerl bed habitat categorisation system is given in Table 4.

Table 4. Categories of maerl bed habitats in England. (*live/dead fraction part of total % cover column; substratum = characterising/dominant substrata.

Category	Group	Maerl bed habitat	Physical size	Structure	% cover	Live/dead*	Substratum
A	1	**Dense Maerl** 'live & dead'	≥25m^2	3D; raised; ≥10cm depth	≥20%	≥5% live	Maerl
	2	**Dense Maerl** 'dead'	≥25m^2	3D; raised; ≥10cm depth	≥20%	0% live ≥20% dead	Maerl
	3	**Dense Maerl** 'live & dead'	<25m^2	3D; raised; ≥10cm depth	≥20%	≥5% live	Maerl
B	1	**Maerl Sediment** 'live and dead'	≥25m^2	3D / 2D	≥5% ≤20%	5% Live and dead	Gravel, sand, mud, mixed
	2	**Maerl Sediment** 'dead'	≥25m^2	2D	≥5% ≤20%	Dead	Gravel, sand, mud, mixed
	3	**Maerl Sediment** 'live and dead'	Patchy	2D	≥5% ≤20%	5% Live and dead	Gravel, sand, mud, mixed
C	1	**Sparse Maerl** 'live and dead'	Sparse	2D	<5% ≥1%	Live and/or dead	Gravel, sand, mud, mixed

Category	Group	Maerl bed habitat	Physical size	Structure	% cover	Live/dead*	Substratum
	2	**Scattered Maerl** 'live and dead'	Scattered	2D	<1%	Live and/or dead	Gravel, sand, mud, mixed
	1	**Maerl Veneer** Live and dead, static	≥25m^2	2D	≥20%	≥5% live	Rock
D	2	**Maerl Veneer** Live and dead, mobile	≥25m^2	2D	≥20%	≥5% live	Rock
	3	**Maerl Veneer** 'live and dead, static'	patchy	2D	≥5% ≤20%	≥5% live	Rock
E	1	**Potential Maerl** *Lithothamnion* sp. or *Phymatolithon* sp.	Lacking detail	Lacking detail	Lacking detail	Live and/or dead	Any suitable, near horizontal

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