MCCIP Marine Climate Change Impacts Partnership

Climate change and marine conservation

Supporting management in a changing environment

Maerl beds

- Maerl beds are formed by calcareous red seaweeds and support diverse communities of plants and animals.
- Three species are most abundant in the UK and their relative composition varies with latitude, salinity and wave exposure.
- Maerl beds are listed as a Priority Marine Feature (PMF) in Scotland, as a Habitat of Principal Importance in England, a Section 7 priority habitat in Wales, and are included as a feature of Marine Protected Areas (MPA) throughout the UK. They are also on the OSPAR list of threatened and/or declining species and habitats.
- Potential impacts of climate change include reductions in pH affecting skeleton formation, changes in sea temperature affecting growth and reproduction, and changes in storminess and run-off causing physical damage.
- Reducing pressures associated with human activities remains the most effective method of increasing resilience of maerl beds to climate change.
- Improved consideration in river and marine planning of the need to reduce impacts from freshwater inputs and terrestrial run-off, will help improve their resilience.

2018

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Maerl beds

Maerl beds are formed by calcareous red seaweeds that grow as small rounded nodules, short branched twig-like shapes, or ball-like shapes. The loosely interlocking beds support diverse communities of plants and animals such as seaweeds, sea firs, sea urchins, brittlestars, starfish, sea anemones, bivalve molluscs, scallops, algal flora and burrowing species. Extensive maerl beds can provide nursery grounds for fish and shellfish, such as scallops and razor clams.

Living maerl is restricted to the surface of the beds overlying the chalky skeletons of dead maerl at depths of up to around 20 m, but they can be found at twice this depth in clear water.

Three species are most abundant in the UK and the relative composition and the proportion of living/dead maerl within a bed varies with factors such as salinity and wave exposure. The majority of maerl propagation is through *in situ* vegetative reproduction and they are extremely slow growing and fragile. Extensive beds may be 1000s of years old.

Maerl is potentially vulnerable to a wide range of climate change impacts, most notably the effects of pH changes on their skeletons[1]. Other climate-related pressures that can impact maerl growth and reproduction include sea temperature increases, physical damage and smothering from wave action and increased turbidity from storms and run-off. Maerl beds are also vulnerable to other pressures related to human activities, such as bottom trawling and dredging, which may reduce their resilience to climate change impacts.

A queen scallop on a maerl bed.
Ben James © SNH

Map of current known feature distribution

Maerl beds have a widespread but fragmented distribution around the UK and are only found in abundance in south-west England and in the north and west of Scotland. They can be found on the open coast or in tide-swept channels in brackish or marine conditions to around 20 m in depth.

Figure 1. UK map showing the distribution of maerl beds (EMODnet), and the distribution of Marine Protected Areas (MPAs) (JNCC) including those which are designated to protect maerl. © Crown copyright. All rights reserved. This map reflects the best available information in 2018.

Scientific evidence for climate change impacts

Maerl is likely to be affected by a number of climate drivers, most notably pH changes, temperature, increased run-off and wave action.

Some species may be more tolerant than others to environmental variations, but the projected rates of change may be too rapid to allow maerl species to adapt. Maerl beds at higher latitudes in the north-east Atlantic are considered to be more vulnerable because pH changes are projected to be particularly large in this area[2].

Coralline algae such as maerl are expected to be highly sensitive to reductions in pH (i.e. increasing acidification) because they have high concentrations of magnesium-calcite in their skeletons[1]. Experiments carried out at realistic projected future pH conditions show that maerl growth may decrease and its structural integrity may weaken, although this may be mediated by the rate at which ocean acidication occurs. If it is slower than projected, maerl may be able to acclimate. It is expected that maerl will decline in higher latitudes where aragonite saturation decreases with climate change.

Dead maerl is expected to degrade more quickly because it doesn't have the ability to regenerate like live maerl. This has implications for the habitat and the species that rely on it, as it may be lost completely.

Research shows that it is likely that long term increases in temperature may inhibit sexual and asexual reproduction, because reproductive conceptacles are only produced at certain, cooler temperatures and higher temperatures are not optimum for vegetative growth[1,3,4]. For maerl beds, which have been in some places for hundreds, even thousands of years, acclimatising to increases in temperature over a short time period may be challenging, giving less potential for adaptation.

Any increase in run-off and wave action due to climate change may cause degradation of maerl beds, especially those found in shallow inshore waters[5]. *Lithothamnion glaciale* and *Phymatolithon calcareum* are highly intolerant of smothering and only recover slowly, and so could be sensitive to decreased water clarity after storms and high levels of terrestrial run-off.

Long-term changes to salinity are also likely to cause a decline in *P. calcareum* abundance and richness associated with maerl beds[1]. Figure 2 shows an impression of what a degraded maerl bed may look like in contrast to a healthy bed.

What is already being done to support management of maerl beds in a changing climate?

Maerl beds are listed under the OSPAR Convention and are also protected as an Annex V species as well as part of other habitats listed under the EC Habitats Directive.

Partly as a result of these listings, maerl beds are included within a network of MPAs across the UK. Within MPAs, activities that are considered damaging to the feature are excluded or regulated. Such activities include certain types of fishing with mobile gear, and marine and coastal development, e.g. aquaculture, moorings[6]. Potential impacts on maerl beds protected through the subtidal sandbanks habitat of SACs (under the Habitats Directive) are considered through Habitats Regulations Appraisals, in Nature Conservation MPAs (NCMPA) in Scotland through a Section 83 assessment (under the Marine (Scotland) Act 2010), and in Marine Conservation Zones (MCZ) in England through an MCZ assessment. Through these processes the regulator must confirm that the proposals will not affect the integrity of the SAC, or pose no significant risk of hindering the achievement of the conservation objectives of the NC MPA or MCZ. Monitoring of the maerl beds within MPAs takes place, to better understand their status and to fulfil reporting requirements under the Habitats Directive and OSPAR. The Scottish MPA Monitoring Strategies take a risk-based approach to prioritising monitoring to enable the effectiveness of protection to be monitored and to inform adaptive management based on the findings.

The inclusion of maerl beds in the Marine Strategy Framework Directive provides further protection from extraction. Environmental Impact Assessments take into account whether activities will impact on the feature. Also, in Scotland it is a Priority Marine Feature (PMF)[7], and as such has protection from uses of the marine environment that would result in a significant impact on their national status (Scotland's National Marine Plan). Specific policies are included in some regional management plans, e.g. Shetland Marine Spatial Plan, to guide development and damaging activities away from sensitive areas.

Work is ongoing to define what is included under the term 'maerl beds', their function and supporting processes, and to research the blue carbon contribution of maerl beds to climate change mitigation through carbon sequestration and storage.

What management measures for maerl beds could also increase resilience to climate change and what wider management options could feasibly be considered?

Marine and River Basin Planning

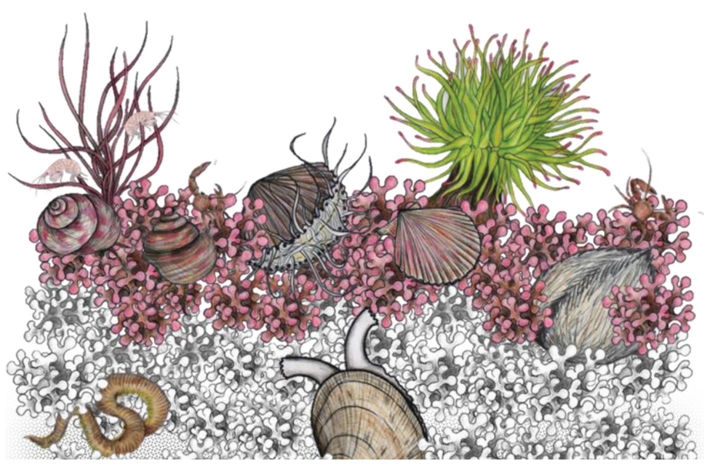
Owing to their exceptionally slow to non-existent recovery after impacts, reducing or avoiding pressures associated with human activities remains the most effective method of increasing resilience of maerl beds to climate change. The inclusion of policies on maerl beds in Regional Marine Management Plans in Scotland and England, and the Pembrokeshire Marine SAC Agreed Management Scheme in Wales, will ensure that potential impacts are considered when planning marine developments and activities outside MPAs as well as within them. Additionally, improved consideration in river basin planning and integration with marine planning to reduce impacts from freshwater inputs and terrestrial run off, will help improve their resilience. The level of management could be based on current understanding of the vulnerability of the habitat and modified over time, dependent on monitoring outcomes.

Highlighting the ecosystem services and natural capital value of maerl beds in marine planning, e.g. Regional Marine Plans, could help to highlight the utility of both live and dead maerl beds (e.g. as nursery grounds) for other species including those of commercial value[8], and their function as carbon sequestration sites (blue carbon stores[9]). Plans could also include a requirement that developments take into account potential impacts on the functions of habitats like maerl beds.

Invasive non-native species

Elevated temperatures associated with climate change may result in an increase in the abundance and distribution of invasive non-native species[10], which in turn could threaten habitats like maerl beds. These species can grow and reproduce quickly, resulting in native species being smothered and outcompeted. The invasive non-native mollusc, the American slipper limpet *Crepidula fornicata* is known to cause substantial smothering of subtidal habitats in western Europe, and is currently known to be of concern on maerl beds in Brittany, Pembrokeshire and Falmouth[11,12,13]. The density of shells, as well as their fine silt pseudofaeces cause smothering, changing the capacity for the maerl to photosynthesise, filling the crevices within the maerl and changing the infaunal composition into a deposit feeding community. It is important that new records of non-native species gathered from existing monitoring and the general public continue to be captured and investigated.

Present



Future

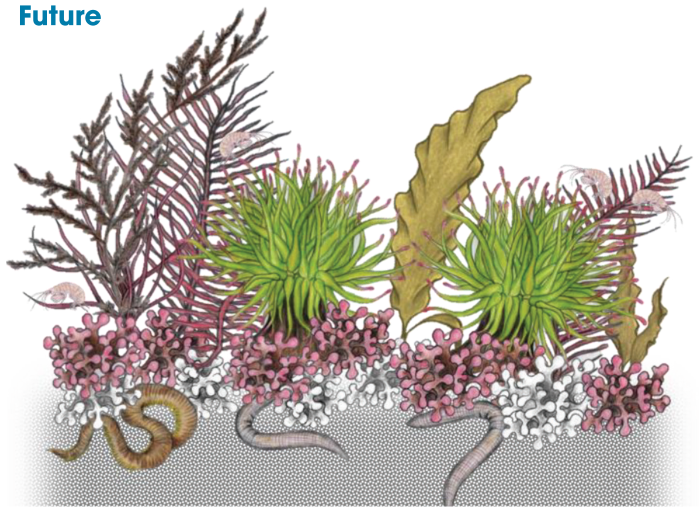


Figure 2. Projected changes to a typical maerl bed with rising temperature and CO_2 levels. Figure reproduced with permission from Sophie Martin[1].

Practical actions that could support management of maerl beds in a changing climate

The process outlined in Table 1 below could be carried out for an individual site, for the maerl beds within the MPA network (country or UK) or across wider seas. The most realistic management for maerl beds in a changing climate is focused on managing pressures rather than managing the species or habitat. Management should focus on reducing current and future human pressures that will in turn help to improve the habitat's resilience and to ensure it has the best chance of future adaptation.

Table 1. Process to integrate climate change into management of maerl beds

Stage	Process and Questions
1.Background Define the feature	a. Define the feature (including both live and dead maerl beds). Its role and function. b. Identify the management objective. Maintaining overall ecosystem structure and function. c. Identify the spatial/temporal scale being considered. Extent of management area and time-scale of management.
2. Vulnerability assessment Identify the existing non-climate change threats to the feature	a. Determine the feature condition, and any trends identified from monitoring. Favourable/declining. b. For the pressures to which maerl beds are sensitive (see FEAST/MarESA), determine exposure to these at the locations considered. c. Determine the vulnerability based on the above sensitivity and exposure (vulnerability assessment). d. Determine any known synergistic effects between pressures e.g. temperature, hypoxia, etc.
3. Increasing resilience to climate change by reducing vulnerability to current pressures	a. Determine whether the pressures to which the maerl bed is vulnerable are currently managed adequately. b. For those that aren't, determine which should be prioritised. c. Identify mechanisms and requirements to address these. For maerl beds this could include: • Outside MPAs, incorporation into Regional Marine Management Plans to protect maerl beds from activities and to enhance connectivity where known. Statutory/voluntary measures could be used until these plans are developed. • Improved integration with river basin planning to reduce issues associated with increased pollution from runoff and freshwater input e.g. nitrification, sedimentation. • Non-native species monitoring and subsequent management/control.
4. Identification of MPAs and locations more vulnerable to climate change pressures	• Assess level of vulnerability, based on maerl sensitivity to climate change pressures and likelihood of exposure at specified locations. To encompass sea temperature, pH changes and wave exposure projections in particular.
5. Monitoring	Any monitoring strategies established should take into account the following: • A geographic spread of monitoring sites from the south of England to the west of Scotland and in the north, ideally both inside and outside MPAs. • Encompass a variety of maerl bed types – different maerl species and varying proportions of live and dead maerl in different physical settings (exposure, etc.). • Prioritisation of monitoring locations should consider the level of risk from pressures i.e. development, fishing and climate change associated pressures, as informed by steps 3 and 4 above. Variation in the level of pressure should be incorporated where practicable. • Monitoring should, where possible, make connections between cause and effect by incorporating measurement of environmental parameters and pressures from activities. This will assist in detecting trends and enable the effectiveness of protection to be assessed to support adaptive management.

Further research

Priorities for research to inform the management of maerl beds in a changing climate should be focused around the following areas:

- What are the effects of multiple stressors, including climate change pressures on maerl beds?
- Are there any differences in the effects of climate change on the various species of maerl and live verus dead maerl beds?
- Assessments of the role of maerl beds in wider ecosystem service provision and the impact of climate change on this.
- Agreement on appropriate methods for monitoring the effects of climate change on maerl beds, that can effectively link changes in human pressures and climate change effects to trends observed in maerl bed condition (i.e. extent, distribution, function, structure etc.).
- Determine the extent of maerl bed decline that is due to invasive non-native species e.g. the American slipper limpet *Crepidula fornicata*, and other native species e.g. *Limaria hians*.
- With appropriate monitoring of suitable parameters can MPAs act as sentinel sites for earlier detection of change?
- Apply genetic studies and hydrodynamics to help determine if there are any links between beds and if additional protection or management is needed to maintain this connectivity.

Survey diver on the Caol Scotnish rapids maerl bed at Loch Sween MPA. Graham Saunders © Marine Scotland

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Maerl bed in Caol Scotnish rapids with common brittlestars at Loch Sween MPA. Graham Saunders. © Marine Scotland

Front page image: Edible crab on a maerl bed in Loch Gairloch. Graham Saunders © SNH