

TITLE: BIOMAERL: maerl biodiversity, functional structure and anthropogenic impacts.
(project **BIOMAERL**)

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MAERL GROUNDS: HABITATS OF HIGH BIODIVERSITY IN EUROPEAN SEAS

By
BIOMAERL team¹

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SUMMARY

The BIOMAERL programme is a 3-year collaborative programme between laboratories in UK, Spain, France and Malta which began in February 1996. Its main aims are described in the Workplan. A full inventory of the biological composition (biodiversity) of maerl bed assemblages in these regions therefore has yet to be completed, but progress is outlined below.

1. INTRODUCTION

Maerl beds are characterized by accumulations of unattached thalli of calcareous rhodophytes. They occur worldwide (Bosence, 1983; Carannante *et al.*, 1988; Steller and Foster, 1995), yet few have been studied ecologically in any detail. Many such beds are under immediate threat from human impacts: most notably, in Europe, from direct exploitation (Cabioch *et al.*, 1997), towed demersal fishing gear (Hall-Spencer, 1995, 1998) and eutrophication effects (Grall and Glémarec, 1997, in press).

The EC-funded BIOMAERL project, linking laboratories in the United Kingdom, France, Spain and Malta, has set out: a) to examine W.European maerl-bed biodiversity, b) to establish the functional roles played by key elements of the biota, c) to assess the impacts of a variety of anthropogenic assaults on representative grounds, and d) to compile an inventory of NE Atlantic and Mediterranean maerl-bed biota.

In many ways maerl beds are analogous to sea-grass beds or kelp forests. All are structurally complex, perennial habitats formed by marine plants that support a high associated biodiversity. Maerl beds especially form isolated, fragile habitats supporting many rare, unusual or endemic species and, as such, they are of particular international conservation interest (Bosence, 1976, 1979; Blunden *et al.*, 1981; Nunn, 1993; Bellan-Santini *et al.*, 1994; Hall-Spencer, 1998). They may also be of significance as nursery grounds for commercial species of fish and shellfish, e.g. scallops (Thouzeau, 1991; G.A.Fisher, unpubl.).

Large maerl thalli are among the oldest marine plants in the N. Atlantic and contribute deposits that take hundreds, perhaps thousands, of years to accumulate, since even optimal growth rates are extremely slow (Potin *et al.*, 1990; Littler *et al.*, 1991). For this reason, management of the exploitation of maerl-forming *Lithothamnion corallioides* (P. & H.Crouan) P. & H.Crouan and *Phymatolithon calcareum* (Pallas) Adey & McKibben is obligatory under the EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (1992).

2. WORKPLAN

Pairs of maerl grounds have been identified for study by participants in the Clyde Sea area (Scotland), Galicia (Spain), Brittany (France), Alicante (Spain) and Malta (Fig. 1). Pairs of maerl grounds have been identified for study. Each pair represents a ground that has been impacted anthropogenically and a relatively pristine control ground. In Scotland, Alicante and Malta impacts to maerl habitats derive mainly from the use of towed demersal fishing gears. In the Ria de Vigo (Galicia), the major impacts derive from organic matter falling from moored rafts used in the culture of the edible mussel (*Mytilus edulis* L.). Mussel faeces and pseudofaeces from the extensive culture rafts moored above maerl beds rain down onto the maerl surface, altering sediment structure and compromising the ability of maerl thalli to photosynthesize and grow. In the Bay of Brest (Brittany), maerl beds are also affected by high nutrient and sediment loadings due to eutrophication, with nutrient inputs there deriving both from the industrialized estuary and run-off from surrounding agricultural land. Another major way in which European maerl habitats are impacted by Man is through direct extraction. Maerl is valued commercially as a soil conditioner. So, another pair of sites in Brittany (in the Glenan archipelago) are being compared to assess the impact of maerl extraction practices.

Comprehensive samples have been taken not only of the benthic environment of each maerl ground (including bathymetry, macro- and micro-architecture of the maerl surface, granulometry, calcimetry, organic matter content, pH and Eh profile), but also of the water column overlying the BIOMAERL study sites (including measurements of seawater temperature, salinity, Secchi disc transparency, seston content, current speed as well as chlorophyll and photosynthetically active radiation on occasion). Edaphic measurements have been collected seasonally over one to two years.

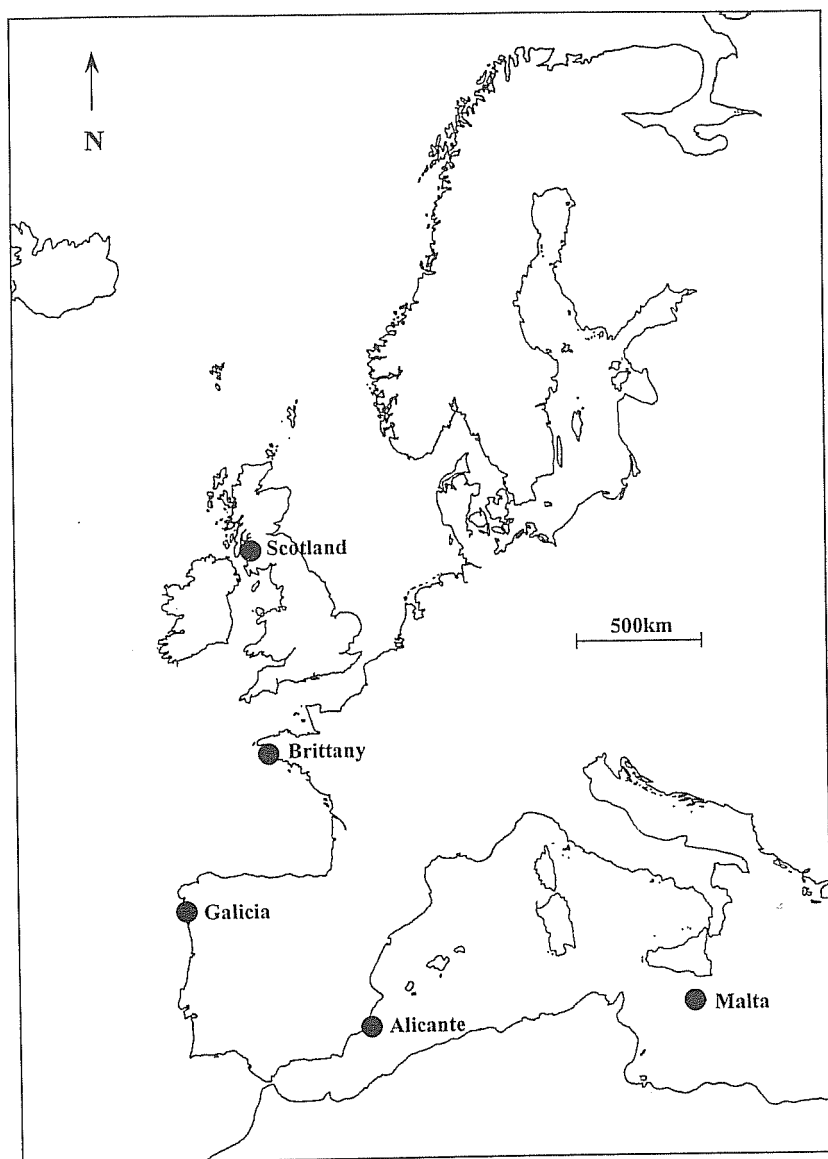


Fig.1. Map of BIOMAERL study sites.

Biological samples of the maerl biota have been taken quantitatively over a two year period, either directly by divers using quadrats and/or cores *in situ*, or by deployment of a variety of indirect sampling gears from ships (grabs, box corers). Megafauna and macrofauna have been compared; infaunal samples being sieved through a 1mm screen as standard. Detailed data on population structure, biomass and population density are being generated for the commonest and/or structurally most important key species from each ground. In addition, semi-quantitative and qualitative faunistic/ floristic data have been gathered using towed dredges and trawls and by direct diver observation. In these ways we are gradually accumulating a comprehensive inventory of the biota at the study sites.

3. RESULTS

1) Sampling

In order to achieve as comprehensive coverage of the biota as possible, it has been necessary: a) to utilize as many methods of sampling as possible; and b) for sampling to take place over all seasons of the year. This was because not every organism present on the ground was captured in any one type of gear, and there were strong seasonal influences at work both in terms of species occurrences (migrations), and/or population fluctuations (both real and apparent). To illustrate this latter point, Fig. 2 shows the seasonal pattern of population densities recorded by divers for a species of infaunal holothurian (*Neopentadactyla mixta* (Ostergren)) from site UKI (Stravanan Bay, Bute, Scotland).

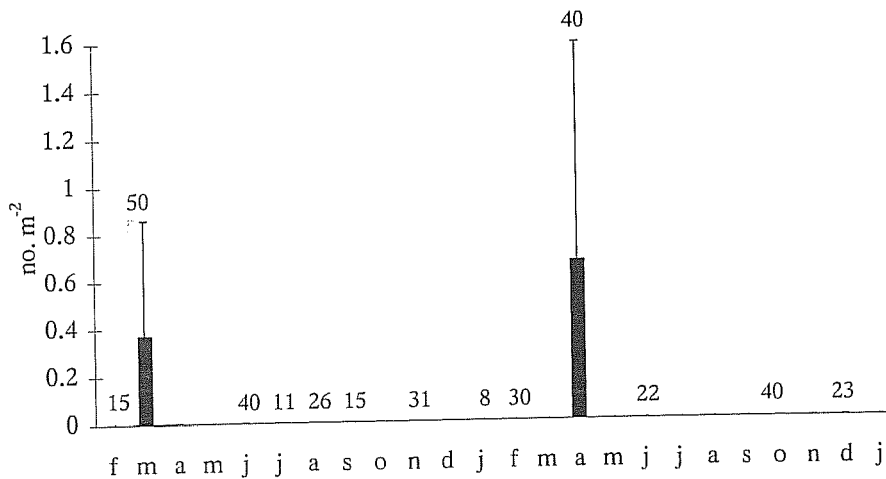


Fig. 2. Mean numbers of the holothurian *Neopentadactyla mixta* counted by divers in replicate 1m² quadrats at UKI from February 1996 - January 1998. Error bars are + one standard deviation, *n* values are indicated above each month sampled.

It would be easy to misinterpret such data as showing this species to be absent for most of the year. Use of an airlift to excavate sediment to a depth of 1m (following methods in Keegan and Könnecker, 1973), however, showed that this sea cucumber was present year-round, but was only seen by divers (by virtue of its feeding crown being extended into the water column) at the time of year that planktonic food was available in abundance, i.e. during the spring phytoplankton bloom. The rest of the time it was invisible to divers, at any rate during the day (no night-time observations available). Contemporaneously with these diving observations, routine Van Veen grab sampling (10 replicates on each sampling occasion) failed to reveal this organism, as it retracts into the sediment beyond the penetration depth of the grab (ca 20cm).

So, despite its large size and abundance ($>4 \text{ m}^{-2}$), it could easily be overlooked, even by intensive sampling with an inappropriate gear.

It is important for the sampling of rare or highly dispersed biota also that maerl grounds are investigated using towed sampling gears. These gears have therefore been used (*inter alia*), but with care to minimize damage to the ground. Thus in the Bay of Brest, species like the sponge *Tethya aurantium* (Pallas), the cnidarian *Aureliania heterocera* (Thompson), the polychaetes *Hermonia hystrix* (Savigny in Lamarck) and *Psammolyce arenosa* (Chiaje), the decapod crustaceans *Thia scutellata* (Fabricius), *Pirimela denticulata* (Montagu), *Maja squinado* (Herbst), *Pisa armata* (Latreille) (to name but a few) have been captured only using an AQUAREVE dredge. Highly mobile species, like mysid crustaceans and most epibenthic fish are capable of avoiding grab samplers. They have been sampled using towed sledges, dredges and trawls and, in Malta, using bottom-set gillnets.

2) Components of maerl-bed biodiversity

European maerl-bed biodiversity has components on widely different scales. The overarching consideration, in such an Atlantic-Mediterranean comparison as ours, is biogeographical. The BIOMAERL partnership covers the whole temperate province from Galicia to Scotland, and encompasses a latitudinal cline from the western Mediterranean to Malta. A few species, e.g. the sea urchin *Echinocyamus pusillus* (O.F.Müller), the amphipods *Leptocheirus hirsutimanus* (Bate) and the crab *Liocarcinus corrugatus* (Pennant), occurred in all (or nearly all) of the BIOMAERL study sites, but the majority of species have geographical limits between different regions considered. The polychaete *Hesione pantherina* (Risso), for instance, reaches its northern limits of distribution in the Bay of Brest area. Some species are Mediterranean endemics, like the amphipod *Urothoe hesperiae* Conradi, Lòpez-González and Bellan-Santini (our record of which off Alicante represents only the second since its description in 1995), others like the anemone *Bolocera tuediae* (Johnston) are northern species, not occurring in BIOMAERL sites further south than Scotland.

The maerl beds investigated have proved to be remarkably heterogeneous in terms of their sediment composition. Some contain deep unstratified maerl, others are made up of a shallow veneer of maerl over mud, sandy mud or coarse sand. Some grounds have a complete cover of living maerl, some are made up of patches (or strips) of maerl and rhodoliths between shelly sands, while others again may be composed exclusively of dead maerl. Some grounds, notably those from open-water sites, have a megarippled surface that is reorientated periodically by storm activity. Some grounds have the maerl thalli bound together by other organisms (e.g. holdfasts of the kelp *Laminaria saccharina* (L.) Lam., and the nests of the bivalve *Limaria hians* (Gmelin) in Scotland; rhizoids of the chlorophyte *Flabellia petiolata* (Turra) Nizamuddin and the rhodophyte *Polysiphonia setacea* Hollenberg off Malta), stabilizing the surface. The activities of deep-burrowing bioturbatory invertebrates (e.g. *Upogebia*, *Cerianthus*, *Chaetopterus*) will also modify the properties of maerl sediments.

An understanding of the role and dynamics of habitat structural complexity and three-dimensional heterogeneity will clearly be central to any explanation of maerl bed biodiversity. The high biodiversity of European maerl grounds can be judged from the fact that, to date, over

460 spp of animals and 63 spp. of algae have been recorded from our most northerly (Scottish) sites.

A functional analysis of the maerl bed biota is currently being undertaken, in which the trophic composition of the biota at all BIOMAERL sites will be related to natural hydrodynamism and, subsequently, to the various anthropogenic impacts described in the Workplan. Fig. 3 shows the seasonal variability in population density of one polychaete species in the Bay of Brest maerl grounds investigated, and reveals significant differences in density between the control and impacted sites. This species would seem to be especially sensitive to eutrophication, its density being considerably reduced on the impacted ground. It is often the case that species at their geographical limits prove to be especially sensitive to environmental perturbation.

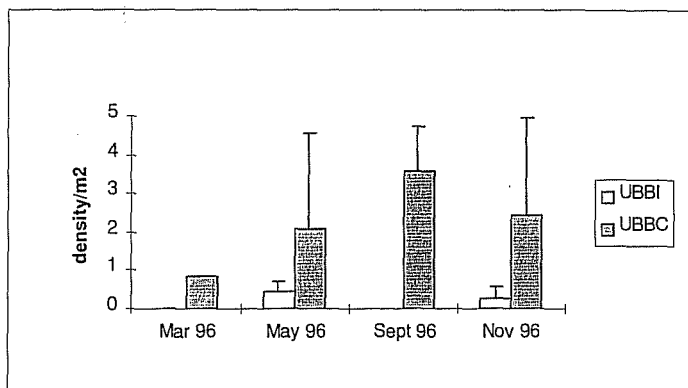


Fig.3. Seasonal variation in the population density of the polychaete *Hesione pantherina* at two sites (UBBI = impacted ground, UBBC = control ground) in the Bay of Brest, Brittany as derived from grab samples. Error bars are +1SD.

DISCUSSION

Maerl beds are unusual benthic habitats, not only because they are derived from living calcareous rhodophytes, but also because they exhibit structural properties that are intermediate between solid and soft sedimentary environments. In some respects (like high permeability, high carbonate content) their structure has resonances with shell-gravel or coral-rubble grounds. In both maerl and shell-gravel habitats, a comparatively open calcareous matrix will facilitate irrigation of interstices (cf. Riedl and Machan, 1972; Webb and Theodor, 1972), promoting a characteristic and diverse infauna. Previous ecological studies on European maerl beds are scant (Cabioch, 1968; Keegan, 1974), most workers have tended to focus on particular elements of the biota, such as the flora (Maggs, 1987) or particular faunal taxa, like the Mollusca (Nunn, 1993; Hall-Spencer, 1998). The present programme is probably unique in attempting to cover such a wide range of sites and inventory the majority of the macrobiota encountered.

Evolutionary and ecological factors determine the origin and maintenance of biodiversity. While the biodiversity of maerl beds cannot compare with tropical calcareous (coral reef)

ecosystems (Reaka-Kudla, 1996), nevertheless, in comparison with other continental shelf habitats in temperate waters, maerl bed biodiversity is impressive. The longevity of maerl thalli, coupled with their complex, open-lattice architecture and need for clean water areas in the euphotic zone with high water exchange rates provides a perennial heterogeneous habitat provide the explanation. Interestingly, that other ecosystem of high biodiversity in European seas, the kelp holdfast, especially that of *Laminaria hyperborea* (Moore, 1973, 1974), is also a long-lived, plant-based habitat in the photic zone. Were data available on the meiofauna of maerl beds (not included in the BIOMAERL programme), then the biodiversity of maerl beds would be even more impressive.

Fortunately, the high fragility and vulnerability of this unique living sediment to human influences (which include direct exploitation for agricultural fertilizer and indirect impacts derived from eutrophication or demersal fishing gear which smashes and erodes maerl beds and increases turbidity) has now been recognized (as witnessed by inclusion of the main maerl-forming algae in the EC Habitats Directive).

Conservation measures need to be established that take cognizance of the role of these grounds: a) as foci for biodiversity (often of specific assemblages of organisms not found elsewhere); and b) as nursery grounds for commercial fish, like juvenile gadoids and shellfish (scallop) species. Maerl grounds are effectively a non-renewable resource, and should be treated as such. The BIOMAERL programme, when complete, will provide the first biogeographical inventory of macrofaunal and floral species in European seas, including identification of key species, their population structure and an analysis of their functional significance in this ecosystem. Assessment of the different anthropogenic threats to this biodiversity experienced over the range of sites considered, will generate recommendations as to the most effective management strategies for this sensitive habitat necessitated by the status of maerl-forming species under the EC Habitats Directive (1992).

We see one way forward as being the establishment of an Environmental Quality Standard for European maerl grounds which is capable of containing, and integrating, all the pertinent structural and functional aspects of the habitat revealed by our studies. Perhaps this might be achievable by allocating a point score to each of the following indicators: edaphic complexity (sediment stratification), basic energy resources (% organic matter, % epifauna / infauna, % macrodetritivores), complex trophic interactions (% predators, % microdetritivores). A summated score would then represent the overall biodiversity status of a particular maerl bed. Such an index would be capable of being monitored over time to provide a check on environmental change, especially any deterioration. It would also supply a mappable, objectively-derived descriptor that, by virtue of being independent of species composition, would be capable of direct comparison at a panEuropean scale. Further funding would be needed, however, to test the validity of these ideas.

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