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The ecosystem service value of living versus dead biogenic reef

E.V. Sheehan*, D. Bridger, M.J. Attrill

Plymouth University Marine Institute, Drake Circus, Plymouth PL4 8AA, United Kingdom

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ABSTRACT

Mixed maerl beds (coralline red algae) comprise dead thalli with varying amounts of live maerl fragments, but previously it was not known whether the presence of the live maerl increases the ecosystem service ‘habitat provision’ of the dead maerl for the associated epibenthos. A ‘flying array’ towed sled with high definition video was used to film transects of the epibenthos in dead maerl and mixed maerl beds in two locations to the north and south of the English Channel (Falmouth and Jersey). Mixed maerl beds supported greater number of taxa and abundance than dead beds in Falmouth, while in Jersey, mixed and dead beds supported similar number of taxa and dead beds had a greater abundance of epifauna. Scallops tended to be more abundant on mixed beds than dead beds. Tube worms were more abundant on mixed beds in Falmouth and dead beds in Jersey. An increasing percentage occurrence of live maerl thalli correlated with increasing number of taxa in Falmouth but not Jersey. It was concluded that while live thalli can increase the functional role of dead maerl beds for the epibenthos, this is dependent on location and response variable. As a result of this work, maerl habitat in SE Jersey has been protected from towed demersal fishing gear.

1. Introduction

Biogenic reefs provide an ecosystem service ‘habitat provision’ for benthic fauna and are formed by organisms such as corals, seagrasses, polychaetes and bivalves (Commito and Rusignuolo, 2000). These ecosystem engineers provide the foundation for many other ecosystem processes, making them pivotal for conservation (Crain and Bertness, 2006). For example, complex biogenic habitats formed by tube dwelling polychaetes such as *Lanice conchilega* act as refuges for juveniles of commercial species, including hake and plaice (Auster et al., 1997; Rabaut et al., 2010). Structurally complex habitats created by biogenic reefs generally have higher densities and greater species richness of macroinvertebrates than less complex sediment habitats (Crowder and Cooper, 1982; Lenihan and Peterson, 1998). Due to their ecological importance, biogenic reefs such as those made by *Sabellaria alveolata*, *Modiolus modiolus* and maerl species, *Phymatolithon calcareum* and *Lithothamnion corallioides*, are included under Annex 1 reefs protected by the European Habitats Directive (Council Directive 92/43/EEC). The quality of such reef habitats is often judged based on whether the reef forming organisms are alive or dead (Irving, 2009); dead biogenic reef is often considered to be degraded and therefore has a low conservation value (Borg et al., 2006). Borg et al. (2006), however, found that the dead matte of *Posidonia* seagrass beds supported greater species diversity and abundance than live beds.

Maerl beds comprise unattached coralline red algae that can form extensive beds at water depths up to 40 m (OSPAR, 2010). Maerl beds are analogous to seagrass beds or kelp forests (BOMAERL, 1999) due to their three-dimensional, structurally complex habitat supporting biodiverse assemblages (Hall-Spencer, 1998; Barbera et al., 2003; Steller et al., 2003) including molluscs (Hall-Spencer, 1998), and crustaceans and annelids (Bosence, 1979; Barbera et al., 2003). Maerl beds act as nursery grounds for commercially important species of crabs, fishes and scallops (Kamenos et al., 2004 a & b) including king scallops *Pecten maximus* and queen scallops *Aequipecten opercularis* (Hall-Spencer, 1998). Live and dead maerl beds are also a UKBAP Priority Habitat (UK Biodiversity Group, 1999). Yet despite legal protection, maerl beds, particularly those considered to be ‘dead’ are under threat from anthropogenic impacts, including land claim, extraction and offshore spoil dumping (Barbera et al., 2003).

While live maerl can cope with extreme ranges of temperature, salinity or metal pollution (Wilson et al., 2004), it is fragile, slow-growing and can be easily broken and killed by demersal towed fishing gear (Hall-Spencer and Moore, 2000) and smothered by sediment (Wilson et al., 2004). Live maerl has greater heterogeneity

* Corresponding author.
E-mail address: emma.sheehan@plymouth.ac.uk (E.V. Sheehan).

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than dead maerl (Kamenos et al., 2003). For example, the matrix of spaces between the maerl thalli provide refuge from predation for post-settled juvenile queen scallops (Kamenos et al., 2004 a). Kamenos et al. (2004 c) found that juvenile queen scallop densities were significantly greater in live maerl beds than on the other substrata surveyed, including dead maerl beds, gravel, rock and sand. Studies have focused on the biodiversity associated with live or dead maerl beds (Kamenos et al., 2004b,c); however, maerl beds can also occur in a range of states comprising different proportions of live and dead thalli, where dead maerl is covered by a varying amount of live maerl fragments (OSPAR, 2010). This study focuses on these “Mixed” maerl beds.

Maerl is mostly valued for its structural importance to infauna, but the surface layer of maerl beds also provides a habitat and feeding area for functionally important epifauna and flora (Blunden et al., 1977; Kamenos et al., 2004c). It is not yet known, however, whether maerl habitat quality is improved for epibenthic organisms (epifauna and epiflora) when a higher proportion of live maerl is present. To assess whether these live fragments add ecological value to the dead maerl beds the following response variables for epibenthic assemblages on Mixed or Dead maerl beds were compared: Number of taxa (epiflora and epifauna), Abundance (number of epifaunal organisms) and abundance of four key taxa representative of the functional groups present: Tube-building polychaete worms (ecosystem engineers) (Jones et al., 1994), Scallops (commercial species), Gobies (prey for commercial crustaceans and larger fishes) and Epiflora (primary producers).

Furthermore, the hypothesis was tested that there is a positive correlation between the proportion of live maerl fragments present and the Number of epibenthic (flora and fauna) taxa and Abundance of epifaunal organisms.

2. Methods

2.1. Site location and design

The epibenthic communities associated with maerl beds were surveyed in two separate locations to assess the consistency of trends. Falmouth Harbour, which hosts the largest maerl beds in SW England, was surveyed during November 2011 and February 2012, and the coastal waters of Jersey (Channel Islands) were surveyed during August 2012. The sites in Falmouth were located inside the harbour between 6.3 and 10 m water depth, while the sites off Jersey were located on the island's eastern side between 10 and 25.5 m water depth.

At both locations, the maerl beds surveyed comprised a mosaic of dead maerl (the white calcified skeleton of the alga, termed “Dead” from herein), and dead maerl with live maerl fragments on the surface (termed “Mixed”). To remotely record epifaunal assemblages associated with Dead or Mixed maerl, video transects were filmed across the habitat types. Transects were randomly positioned with the primary purpose of identifying the location of maerl beds where the position was unknown. Transects were approximately 200 m long. 34 transects were recorded in Falmouth and 42 in Jersey.

2.2. Sampling methods

Underwater High Definition (HD) videography mounted on a flying array was used to film transects due to its suitability as a cost-effective and relatively non-destructive method for surveying large areas. The survey employed methods as described in Sheehan et al. (2010) which involved slowly towing the flying array over the seabed (0.2–0.3 knots) sufficiently close to distinguish live from dead maerl (Fig. 1). The HD video system comprised a camera (Surveyor-HD-J12 colour zoom titanium camera, 6000 m depth rated, 720p) that was positioned at an oblique angle to the seabed, three LED lights (Bowtech Products limited, LED-1600-13, 1600 Lumen underwater LED) to provide improved image colour and definition, and two laser pointers (wavelength 532 nm Green) that were set 30 cm apart. Laser scaling was necessary so that the field of view and species densities could be calculated. The umbilical was connected topside to a Bowtech System power supply/control unit which allowed control of the camera, focus, zoom and aperture, and intensity of the lights.

2.3. Frame grab analysis

Frame grabs were extracted at two second intervals from the video (Cybertronix Framegrab Extractor) and a digital grid containing 25 squares (5 x 5) was overlaid on each image. For each transect, frames were analysed every 60 s. If frames were out of focus then the next suitable frame was used. To quantify the amount of live maerl and/or dead maerl present in each frame we calculated % occurrence. This was determined by scoring the number of the 25 squares inside the grid which contained live or dead maerl. Other habitat types were also recorded such as shell or rock. Position of the lasers points on screen were recorded relative to the grid so that the area of the grid could be calculated (see Sheehan et al., 2010). Taxa observed inside the grid were identified to the highest taxonomic separation possible. Values were converted into density m^{-2}. Where species level identification was not possible, some alternative groupings were used. All Hydroid species (Hydroid spp.) and Goby species (Goby spp.) were grouped, and the spider crabs *Inachus* spp. and *Macropodia* spp. were identified to genus level. All algae species were grouped as Rhodophyta, Phaeophyta or Chlorophyta.

2.4. Statistical analysis

Only frames with ≥40% occurrence of maerl (live or dead fragments) were included in the analysis. For the Dead vs Mixed maerl analysis the Dead treatment was made up of frames that had no live maerl present. The Mixed treatment was made up frames that had at least 4% occurrence of live maerl (1 out of the 25 squares in the grid).

1021 frames were analysed from Falmouth, 544 frames were categorised as Dead and 465 as Mixed. 856 frames were analysed from Jersey comprising 480 Dead frames and 197 Mixed frames. Due to the relative lack of Mixed Frames in Jersey, half of the Jersey Dead frames were randomly excluded from analyses so that response variables could be compared. To maintain the number of samples from Falmouth, and not lose half in order to balance the sample size to the Jersey dataset, locations were analysed separately.

To test the hypothesis that mixed maerl beds supported greater biodiversity than dead maerl beds the following response variables were compared between samples with Dead or Mixed maerl habitat: ‘Number of taxa’, ‘Abundance of epifauna’ and ‘Abundance of key taxa’ (Tube worms (*Megalomma* spp. for Falmouth and *Lanice conchilega* for Jersey), Scallops (*Pecten maximus*, *Aequipecten opercularis*, and Scallop spp.) Gobies and Epiflora). For each location (Falmouth and Jersey), values were compared between the treatments ‘Dead’ or ‘Mixed’ using a nonparametric 1-way Kruskal–Wallis test statistic *H-adj* (Kruskal and Wallis, 1952, Minitab 16).

Pearson's correlation coefficient was used to test whether there was a correlation between % occurrence of live maerl and Number