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Macrobenthic assemblage structure associated with a *Caulerpa prolifera* meadow in the eastern Mediterranean Sea (Elounda Bay, Crete Island)

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HIGHLIGHTS

- Macrofaunal assemblages in a shallow semi-enclosed marine ecosystem.
- Macrobenthic assemblages associated with a green alga *Caulerpa prolifera* meadow.
- High abundances of benthic macrofauna associated with a *Caulerpa prolifera* meadow.
- Benthic macrofauna important as food source for demersal and cephalopod populations.

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ABSTRACT

The present study investigates the structure and intra-annual variation of the benthic macrofaunal community associated with a monospecific *C. prolifera* meadow in a shallow semi-enclosed coastal marine ecosystem of the eastern Mediterranean Sea (Elounda Bay, Crete Island). The samples were collected on five occasions (May, September and November 2006, February and April 2007) by using an epibenthic sledge (0.5 mm mesh size). The analysis of the macrofauna revealed 319 taxa with densities ranging from 71 to 410 individuals m^{-2}. The most diversified animal groups were polychaetes, gastropods and amphipods. Crustaceans were by far the most abundant group with densities exceeding 50% of the total macrofauna during the study period. The dominant species were the amphipods *Caprella acanthifera acanthifera*, *C. rapax* and *Microdeutopus stationis*, the gastropod *Pusillina lineolata*, the tanaid *Leptochelia* sp. and the bivalve *Abra alba*. The results of the present study revealed a relatively high diversified and abundant benthic macrofauna, which is supported by the presence of the dense and continuous canopy of *C. prolifera* in this shallow wave-sheltered area characterized by high organic matter input.

1. Introduction

Submerged aquatic vegetation constitutes a functionally important component of many soft-sediment marine communities (e.g. Everett, 1994; Boström et al., 2006). These vegetated habitats can influence associated animal assemblages via a complex suite of physical and biotic processes. The structural complexity of these habitats provides protection against predators, availability of food resources, deposition of organic matter, stabilization of sediments, low hydrodynamic stress and erosion (Orth et al., 1984; Everett, 1994; Boström et al., 2006). Many authors have emphasized the influence of each one of these factors as being the main cause of the importance of the vegetated systems which support high species diversity and abundance of benthos; most agree that it is the structural complexity rather than a particular type of habitat that is the most important factor, although this leads to different interpretations (Heck et al., 2003; Sánchez-Moyano et al., 2001a; and references therein).

Seagrass beds of coastal marine ecosystems are a good example of shaping an optimal habitat for benthic fauna (Orth et al., 1984; Boström et al., 2006). Many studies have demonstrated the facilitative role of the most common and widespread seagrass

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species meadows in the Mediterranean Sea, *Posidonia oceanica* and *Cymodocea nodosa*, in terms of colonization and increased diversity of benthic assemblages (e.g. Gambi et al., 1995; Buia et al., 2000; Tuya et al., 2001; Sfriso et al., 2001; Brito et al., 2005). Macroalgae are also common components in coastal marine environments and can have important physical and biological effects on benthic faunal assemblages (e.g. Everett, 1994; Pereira et al., 2006; Guerra-García et al., 2011). However, the influence of these habitats on the structure and dynamics of macrobenthic faunal soft-sediment assemblages has received little consideration, with attention being focused mostly on comparisons with seagrass habitats (Pérez-Ruzafa et al., 2012; Png-González et al., 2014; Tuya et al., 2014).

Caulerpa prolifera (Forsskål) J.V. Lamouroux is a subtropical green macroalga which forms permanent dense meadows usually extending on muddy sands in sheltered waters at depths from 1 to 40 m (Davies et al., 2004). Although *C. prolifera* beds have been recorded in many coastal areas of the Mediterranean Sea, there are a few studies dealing with the associated macrofaunal assemblages (Sánchez-Moyano et al., 2001a,b, 2007; Rueda et al., 2001; Rueda and Salas, 2003; De la Rosa et al., 2006).

Elounda Bay is a semi-enclosed area, situated in the north-eastern part of the island of Crete (south Aegean Sea, eastern Mediterranean), the seafloor being covered by a monospecific *C. prolifera* meadow. This shallow embayment is regarded as an important nursery for the development of fish and cephalopod species, thus contributing to the conservation and maintenance of the local marine biological resources (Koulouri et al., 2016). The objectives of the present study were: (a) to describe the structure and dynamics of the benthic macrofaunal assemblage associated with *C. prolifera* meadow for the first time in the eastern basin of the Mediterranean Sea in relation to the environmental factors examined, and (b) to compare the results with those available from similar studies carried out in the western Mediterranean Sea.

2. Materials and methods

2.1. Study area and sampling design

Elounda Bay has a surface area of 6.5 km^2, while its inner part, sheltered from waves and currents, occupies an area of 4.7 km^2 (Fig. 1). The study was conducted in the inner part of the Bay which is shallow with a maximum depth of 8.8 m and covered by a monospecific *C. prolifera* meadow, which appeared almost homogenous throughout the study period based on visual observations made by scuba diving. This shallow part of the Bay (∼2–9 m depth) is considered to be an important habitat for the growth of juvenile fish species, thus contributing to the conservation and maintenance of the local marine biological resources (Koulouri et al., 2016). The sampling design included regular surveys carried out every two to three months for a year (2006–2007) by using a local fishing boat: May 2006 (end of May-beginning of June, early summer); September 2006 (early autumn); November 2006 (end of November-beginning of December, early winter); February 2007 (end of February-beginning of March, early spring) and April 2007 (spring).

2.2. Environmental variables

Measurements and sampling for the environmental variables was performed at six stations in order to cover most of the surface of the Bay and the maximum variability in the estimated values (Fig. 1, Table 1). Measurements of the vertical distribution of temperature, salinity and photosynthetically active radiation (PAR) were carried out using a Seabird SBE-25 CTD. For the analysis of the water column chemical variables, samples were collected one metre below the water surface using 5 L Niskin bottles. For the estimation of chloroplastic pigments (chlorophyll-*a* and phaeopigments) and particulate organic carbon (POC), water samples were filtered through Whatman GF/F glass fibre filters. Sub-samples (200 ml) were collected from the filtrate for nutrient analysis (PO_4, SiO_2, NH_4, NO_2, NO_3). All samples were frozen immediately and stored at −20 °C until analysis on return to the laboratory. Surficial sediment samples (0–0.01 m depth) were collected using a Ponar grab sampler (sampling surface of 0.229 × 0.229 m) for the estimation of chloroplastic pigments, POC concentrations and grain-size analysis, also stored at −20 °C until subsequent laboratory analysis. Grain size analysis was performed according to Buchanan (1984). Chloroplastic pigments concentrations in water and sediment samples were estimated according to the fluorometric method of Yentsch and Menzel (1963) using a Turner 112 fluorometer, while POC was measured using a CHN elemental analyzer Perkin Elmer model 2400 according to Hedges and Stern (1984). Concentrations of nutrients in seawater samples were estimated using a Beckmann DU65 spectrophotometer and standard manual oceanographic colorimetric methods (Strickland and Parsons, 1972).

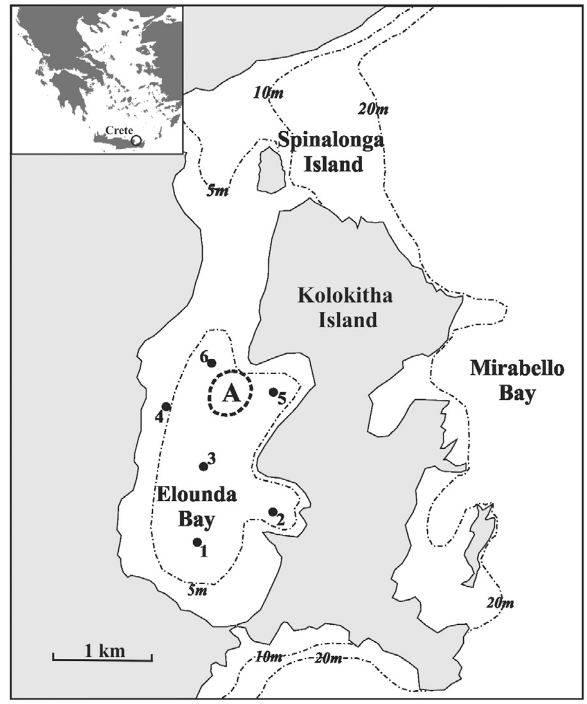

Fig. 1. Map showing the localities of the sampling stations of Elounda Bay.

2.3. Macrozoobenthos

For the study of macrozoobenthos, daylight sampling was carried out on the five occasions (May 2006; September 2006; November 2006; February 2007; April 2007) at site A of the study area (Fig. 1). The final selection of the sampling site, representative of the *C. prolifera* meadow density, was made based on visual observations by SCUBA diving. This site was initially selected for describing the structure of the fish assemblage associated to *C. prolifera* meadow in the area (see Koulouri et al., 2016) as it has traditionally been the only boat seine fishing ground in the Bay. Macrofauna was sampled using an epibenthic sledge equipped with a net of 0.5 mm mesh size. The surface area of the aperture of the net was 0.15 m^2 (1 m width × 0.25 m height). A tickler chain was adjusted in front of the net specially designed to disrupt the surface of the seabed. Three random tows (replicate samples) of approximately 30 m length were performed along site A of the