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Contribution to the study of deep coastal detritic bottoms: the algal communities of the continental shelf off the Balearic Islands, Western Mediterranean

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Abstract

Three main algal-dominated coastal detritic communities from the continental shelf off Mallorca and Menorca (Balearic Islands, Western Mediterranean) are described herein: maërl beds dominated by Spongites fruticulosus and forests of Laminaria rodriguezii located in the Menorca channel, and Peyssonnelia inamoena beds found along the Southern coast of Menorca. There seems to be a gradient of disturbance from the highly disturbed Peyssonnelia beds to the almost undisturbed L. rodriguezii forests. Whether this gradient is the result of current and past anthropogenic pressure (e.g. trawling intensity) or is driven by natural environmental factors needs further assessment. Finally, the location of the target communities by means of ROV dives combined with the use of a Box-Corer dredge and beam trawl proved to be a good methodology in the study of the composition and structure of these deep water detritic communities.

Keywords: detritic bottoms, Laminaria rodriguezii, macroalgae, sampling methods, Mediterranean Sea, Peyssonnelia inamoena, Spongites fruticulosus.

Introduction

Mediterranean algal-dominated coastal detritic bottoms usually develop at depths between 25 and 130 m (Pèrès, 1985; Giaccone et al., 1994). They are composed of silt, sand, gravels, and calcareous skeletons of benthic organisms such as molluscs, bryozoans, cnidarians, echinoderms and macroalgae. Free-living members of the orders Corallinales and Peyssonneliales (Pèrès, 1985; Klein & Verlaque, 2009) are usually the major components of these bottoms. Both the skeletons and the calcareous algae allow the settlement and growth of organisms usually found on rocky bottoms (Bianchi, 2001), creating a special habitat harbouring animals and plants of both soft and hard bottoms (Laborel, 1987).

Different assemblages have been recognized in Mediterranean algal-dominated coastal detritic bottoms, each one characterized by either one or a reduced number of more or less exclusive species (e.g. see Dieudede, 1940; Huvè, 1954, 1956; Jacquotte, 1962; Pèrès & Picard, 1964; Picard, 1965; Giaccone, 1967; Bourcier, 1968; Augier & Boudouresque, 1978; Ballesteros, 1988, 1994; Giaccone et al., 1994). The Balearic Islands harbour extensive areas of these kinds of bottoms and different seascapes have been described between 52 and 93 m, using bottom trawls (Joher et al., 2012): maërl beds dominated by Spongites fruticulosus, deep water forests of Laminaria rodriguezii, two types of Peyssonnelia beds (one dominated by P. inamoena and the other one by P. rubra, both species presenting hypobasal calcification, and the last one presenting some cystoliths too), and red algae meadows dominated by Osmundaria volubilis and Phyllophora crispa.

However, although bottom trawling was effective for the characterization of underwater landscapes, descriptions at community level require the use of smaller sampling areas. Several ROV dives were performed in 2009 in the Menorca channel and along the Southern coast of Menorca (Barberá et al., 2009, 2012) in order to locate certain homogeneous areas harbouring the communities that characterized the seascapes found by Joher et al. (2012). Three of these areas were located: one with maërl beds of S. fruticulosus, another with forests of L. rodriguezii, and a last one with P. inamoena beds. In contrast, extensive areas covered by the assemblage dominated by Osmundaria volubilis and Phyllophora crispa were found, with a patchy distribution.

Maërl beds dominated by S. fruticulosus have seldom been reported from the Balearic Islands (Barberá et al., 2012), and their composition and structure have only been studied from Tossa de Mar (Northwestern Mediterranean, Spain) (Ballesteros, 1988), where the maërl bed...
grows in reduced light levels (around 0.3 % of surface PAR irradiance) and moderate temperature range conditions (12.5 to 21.5°C). Forests of *L. rodriguezii* develop under low light intensities (usually at depths between 50 and 120 m, being more abundant below 70 m), low temperature (less than 14°C), and unidirectional current conditions (Feldmann, 1934; Huvé, 1955; Molinier, 1960; Pérès & Picard, 1964; Giaccone, 1967, 1971; Lüning, 1990; Giaccone & Di Martino, 1997). Most information available about these rarefied kelp forests focuses on species composition although there are no quantified lists of species (Huvé, 1955; Molinier, 1956; Gautier & Picard, 1957). Finally, several authors have reported *Peyssonnelia* beds developing on circalittoral bottoms, mainly along the coasts of Marseille, the Tyrrhenian Sea and the Baltic Islands (e.g. Huvé, 1954; Carpine, 1958; Parenzan, 1960; Augier & Boudouresque, 1978; Basso, 1990; Ballesteros, 1994; Joher et al., 2012), highlighting the variety of the dominant *Peyssonnelia* species. These beds also develop under low light conditions but they seem to need pulsing current conditions, which prevent the burial of living *Peyssonnelia* spp. (Bourcier, 1968; Basso, 1990).

Two kinds of *Peyssonnelia* beds, one dominated by *P. rosa-marina* and the other by an unidentified *Peyssonnelia* have been reported previously from the Balearic Islands (Ballesteros, 1994), but there is no published information on the beds dominated by *P. inamoena*.

The purpose of this paper is to describe the species composition and abundance of three specific communities from the detritic bottoms off the Balearic Islands (*S. fruticulosus*, *L. rodriguezii* and *P. inamoena*), which characterized three of the landscapes described previously in Joher et al. (2012). Another objective was to check whether Box-Corer dredging and beam trawling, combined with ROV images, are suitable methodologies to characterize deep-water coastal detritic communities.

**Materials and Methods**

The sampling area was located in the Menorca channel and along the Southern coast of Menorca (the Balearic Islands, Western Mediterranean; Fig. 1). The continental shelf bottoms of this area are characterized by sediments of biogenic origin (Canals & Ballesteros, 1997; Fornós & Ahr, 1997) with a high percentage of carbonates (Acosta et al., 2002), and the water column presents a high light transmittance (Ballesteros & Zabala, 1993; Canals & Ballesteros, 1997).

Sampling was performed in May 2009, during the MEDITES ES05_09 campaign organized by the Centre Oceanogràfic de Balears (Instituto Español de Oceanografía). Target communities had been located previously by ROV during the CANAL0209 research survey (February-March 2009): large areas were occupied by the communities with *Spongites fruticulosus* and *Laminaria rodriguezii* in the Menorca channel at depths between 50 and 62 m, while the community dominated by *Peyssonnelia inamoena* was found on the Southern coast of Menorca, at depths of around 65 m.

Because of the deep-water distribution of these communities, we did not sample them by SCUBA diving but used other sampling methods: dredges (e.g. see Dieuzede, 1940; Huvé, 1956; Costa, 1960; Bourcier, 1968; Blunden et al., 1977; Bordehore et al., 2003; Peña, 2010) and beam trawls (Barberá et al., 2012; Ellis et al., 2013). Images obtained by ROV, together with previous results (Joher et al., 2012), showed that the community dominated by *S. fruticulosus* was very homogeneous, and composed mainly of small maërl-forming species (*S. fruticulosus* and *Phymatolithon calcareum*). There, samples were collected using a Box-Corer dredge (sampling area: 200 cm²). In contrast, communities with *L. rodriguezii* and *P. inamoena* were more heterogenous because of the size of the algae and the aggregation in clusters of the thalli of the characteristic species. There, the use of a Box-Core was disregarded, and samples were collected using a beam trawl (horizontal and vertical openings: 1.30 and 0.88 m, respectively; mesh size: 10 mm), at speeds of 2.5-3.0 knots. Trawling time ranged from 5 to 12 seconds and was controlled by a SCANMAR system (Scanmar Maritime Services Inc., Makati City, Philippines) in order to calculate the trawled area, which ranged from 6 to 16 m².

We collected seven samples of the *S. fruticulosus* community, which were integrally quantified, and two from the *L. rodriguezii* and *P. inamoena* communities. All samples were preserved on board in 4% formalin:seawater. Samples of *L. rodriguezii* and *P. inamoena* were homogeneously extended occupying the corresponding sampled surface, and we took two replicates of 1.2x1.2 m² per sample. Samples and replicates were named *C*s-*r*, where *C* corresponds to each community, s to each sample, and *r* to each replicate. Then, they were sorted and identified to the minimum taxonomic level, and each taxon was quantified measuring its algal surface (*Sₐ*, in cm²) and biomass (*Bₜ*, as dry weight in g) (Ballesteros, 1992). Skeletons of dead Corallinales were rejected because we only wanted to quantify live specimens.

Several synthetic parameters were calculated for each sample/replicate: a) the number of species, total algal surface (*Sₐ*) and total biomass (*Bₜ*); b) the Index of Floral Originality (IFO = (∑1/Mₙ)/n), where Mₙ is the number of samples in which the species i occurred and n the number of species in the sample; c) the total algal surface and biomass of the maërl-forming species (*MFSₐ*, *MFSₜ*); d) Shannon’s diversity index (H’ = -∑p(log₂p)), where pᵢ corresponds to the proportion of the measured parameter (*Sₐ*/*Sₜ*, or *Bₜ*/Bₜ) for each species; and e) Pielou’s evenness index (*J’* = H’/log₂S), where H’ was based both on algal surface and biomass.

In order to verify the grouping of the samples, cluster analysis accompanied by the SIMPROF test (Clarke et
al., 2008) adjusted to 9999 permutations and a 0.1% significance level according to Potter et al. (2001), based on Sørensen and Bray-Curtis similarity matrices, were performed for each community. Finally, SIMPER tests were used to calculate species contribution to the similarities within each of the three studied communities and their characteristic species. These analyses were performed with PRIMER version 6 software (Clarke & Warwick, 2001).

Results

We identified up to 143 algal taxa at specific and infraspecific level (below named species for convenience) (Table 1), although some of them could not be identified to species level because either we had only small fragments of the specimens, they were sterile (e.g. Aglaophamnion sp., Peyssonnelia sp., Polysiphonia sp., unidentified Rhodophyta), or they are probably undescribed species (e.g. Halymenia sp., Rhodymenia sp.).

A total of 57 algal species were identified on the Spongites fruticulosus beds (Table 2), with a dominance (84.2%) of Rhodophyta (Fig. 2). The number of species per sample was 16±5; the SaT per sample 3965±2838 cm² m⁻²; and the BT per sample 351±270 g dw m⁻². Maërl-forming species represented 76.8±21.5% of total SaT per sample, and 94.5±3.7% of BT (Fig. 3). The characteristic species of these maërl beds were S. fruticulosus and Phymatolithon calcareum (SIMPER test, Fig. 4), which accounted for 80% of SaT and 82.6% of BT. It should be noted that despite statistical analyses (cluster + SIMPROF), based both on qualitative and algal surface data, indicated that the samples belonged to a single significant group;

![Fig. 1: Sampling locations of the three communities studied in the Menorca Channel and the Southern coast of Menorca. Isobaths of -50, -100 and -200 m are shown. Abbreviations: Spo, Spongites fruticulosus beds; Lam, forests of Laminaria rodriguezii; Pey, Peyssonnelia inamoena beds.](image)

![Fig. 2: Number of species (n) per community showing Rhodophyta, Phaeophyceae and Chlorophyta, and number of species and Index of Floral Originality (IFO) per sample (mean and standard deviation). Abbreviations: Spo, Spongites fruticulosus beds; Lam, Laminaria rodriguezii forests; Pey, Peyssonnelia inamoena beds.](image)
Table 1. Species composition of the collected samples/replicates. For each taxon, the upper value corresponds to the algal surface (Sa, in cm² m⁻²) in the sample or replicate, and the lower value, the biomass as dry weight (B, in g dw m⁻²). The introduced species are marked with an asterisk (*), and the maërl-forming species, with a hashtag (#). Abbreviations: Spo, *Spongites fruticulosus* beds; Lam, *Laminaria rodriguezii* forests; Pey, *Peyssonnelia inamoena* beds; MC, Menorca Channel; SM, Southern Menorca.

| Location               | Date of collection | Rhodophyta | Acrochaetium sp. | Acrochaetium elongatum (Harvey) Kylin | Acrochaetium sp. | Acrochaetium sp. | Acrosorium ciliolatum (Harvey) Kylin | 'Acrosymphytonema breemaniae' (stadium) Boudouresque, Perret-Boudouresque & Knoepffler-Peguy nom. inval. | Acrothamnion preissii (Sonder) E.M. Wollaston* | Aglaothamnion tenuissimum (Bonnemaison) Feldmann-Mazoyer | Aglaothamnion tripinnatum (C. Agardh) Feldmann-Mazoyer | Aglaothamnion sp. | Algyroides (Turner) J. Agardh | Botryocladia botryoides (Wulfen) Feldmann |
|------------------------|--------------------|------------|------------------|--------------------------------------|------------------|------------------|--------------------------------------|------------------------------------------------|---------------------------------|--------------------------|---------------------------|-----------------|----------------|--------------------------|
| Spo I                  | 13/05/09           | 10.0       | 5.0              | 0.4                                  | 2.8              | 10.0             | 0.1                                 | 2.8                                | 0.22               | 0.050                    | 5.0                       | 0.050          | 5.0                       | 0.050                      |
| Spo II                 | 13/05/09           | 0.4        | 0.1              | 0.4                                  | 0.2              | 0.001            | 0.001                               | 0.001                             | 0.001              | 0.001                    | 0.001                     | 0.001          | 0.001                    | 0.001                      |
| Spo III                | 13/05/09           | 0.04       | 0.01             | 0.01                                 | 0.001            | 0.001            | 0.001                               | 0.001                             | 0.001              | 0.001                    | 0.001                     | 0.001          | 0.001                    | 0.001                      |
| Spo IV                 | 13/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Spo V                  | 13/05/09           | 0.04       | 0.001            | 0.001                                | 0.001            | 0.001            | 0.001                               | 0.001                             | 0.001              | 0.001                    | 0.001                     | 0.001          | 0.001                    | 0.001                      |
| Spo VI                 | 13/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Spo VII                | 13/05/09           | 0.04       | 0.001            | 0.001                                | 0.001            | 0.001            | 0.001                               | 0.001                             | 0.001              | 0.001                    | 0.001                     | 0.001          | 0.001                    | 0.001                      |
| Lam I-1                | 15/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Lam I-2                | 15/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Lam II-1               | 15/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Lam II-2               | 15/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Pey I-1                | 19/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Pey I-2                | 19/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Pey II-1               | 19/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| Pey II-2               | 19/05/09           | 0.1        | 0.1              | 0.1                                  | 0.1              | 0.1              | 0.1                                 | 0.1                               | 0.1                | 0.1                      | 0.1                       | 0.1            | 0.1                      | 0.1                        |
| MC                     | 13/05/09           | 13.05/09   | 13.05/09         | 13.05/09                             | 13.05/09         | 13.05/09         | 13.05/09                             | 13.05/09                          | 13.05/09                       | 13.05/09                  | 13.05/09                  | 13.05/09            | 13.05/09                   | 13.05/09                    |
| SM                     | 19/05/09           | 19/05/09   | 19/05/09         | 19/05/09                             | 19/05/09         | 19/05/09         | 19/05/09                             | 19/05/09                          | 19/05/09                       | 19/05/09                  | 19/05/09                  | 19/05/09            | 19/05/09                   | 19/05/09                    |

(continued)
| Location | MC | MC | MC | MC | MC | MC | MC | MC | SM | SM | SM | SM | SM |
| Location | MC | MC | MC | MC | MC | MC | MC | MC | MC | MC | MC | MC | MC |
| Date of collection | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 |
| Botryocladia chiajeana (Meneghini) Kylin | 0.4 | 0.6 | 0.3 | 0.3 | 0.5 | 0.014 | 0.007 | 0.007 | 0.001 | 0.005 | 0.1 | 0.1 | 0.001 | 0.001 | 0.2 | 0.8 | 5.3 | 0.002 | 0.004 | 0.023 |
| Chlrophyllis laciniata (Hudson) Kützing | 0.2 | 0.8 | 5.3 | 0.002 | 0.004 | 0.023 |
| Ceramium bertholdii Funk | 5.0 | 0.1 | 0.1 | 0.050 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Cryptopleura ramosa (Hudson) L. Newton | 9.0 | 40.0 | 120.0 | 48.0 | 5.0 | 15.0 | 8.4 | 0.5 | 0.6 | 1.6 | 26.1 | 25.0 | 2.5 | 0.5 | 0.050 | 0.245 | 1.075 | 0.410 | 0.043 | 0.007 | 0.028 | 0.007 | 0.127 | 0.136 | 0.015 | 0.003 |
| Cryptopleura ramosa (Hudson) L. Newton | 5.0 | 2.4 | 0.1 | 4.7 | 6.6 | 6.7 | 4.1 |
| Dasya corymbifera J. Agardh | 10.0 | 0.050 | 0.014 | 0.001 | 0.023 | 0.027 | 0.021 | 0.020 |
| Dasya corymbifera J. Agardh | 0.100 |

Table 1 (continued)
| Location | Depth (m) | Date of collection | Dasya penicillata | Zanardini | Dermatolithon sp. | Erythroglossum balearicum J. Agardh ex Kylin | Erythroglossum sandrianum (Kützing) Kylin | Erythrotrichia carnea (Dillwyn) J. Agardh | Eupogodon planus (C. Agardh) Kützing | Felicinia marginata (Roussel) Manghisi, Le Gall, Ribera, Gargiulo et M. Monabito | Gloiocladiad furcata (C. Agardh) J. Agardh | Gloiocladiad microspora (Bomet ex J.J. Rodríguez y Femenías) Berecibar, M.J. Wynne, Barbara & R.Santos | Gracilaria corallicola Zanardini | Halymenia sp. | Haraldia lenormandii (Derbès & Solier) Feldmann |
|----------|----------|-------------------|------------------|----------|------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|----------------|----------------|
| Spo I    | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 1.3                           | 0.5                            | 0.1                            | 0.1                            | 13.0                          | 0.100                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo II   | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.050                         | 0.007                          | 0.007                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo III  | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo IV   | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo V    | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo VI   | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Spo VII  | MC       | 13/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 5.0                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Lam I-1  | MC       | 15/05/09          | 5.0              | 0.1      | 0.1              | 1.5                           | 0.9                            | 0.4                            | 0.1                            | 1.3                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Lam I-2  | MC       | 15/05/09          | 5.0              | 0.1      | 0.1              | 0.050                         | 0.007                          | 0.007                          | 0.001                          | 0.001                        | 0.069                          | 0.781                          | 0.014                          | 0.008                          | 0.014                          | 0.008 |
| Lam II-1 | MC       | 15/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 0.001                        | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Lam II-2 | MC       | 15/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 0.001                        | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Pey I-1  | SM       | 15/05/09          | 5.0              | 0.1      | 0.1              | 1.5                           | 0.9                            | 0.4                            | 0.1                            | 1.3                           | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Pey I-2  | SM       | 15/05/09          | 5.0              | 0.1      | 0.1              | 0.050                         | 0.007                          | 0.007                          | 0.001                          | 0.001                        | 0.069                          | 0.781                          | 0.014                          | 0.008                          | 0.014                          | 0.008 |
| Pey II-1 | SM       | 19/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 0.001                        | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |
| Pey II-2 | SM       | 19/05/09          | 5.0              | 0.1      | 0.1              | 0.001                         | 0.001                          | 0.001                          | 0.001                          | 0.001                        | 0.001                          | 0.001                          | 0.001                          | 0.001                          | 0.001 |

(continued)
| Location          | MC | MC | MC | MC | MC | MC | MC | SM | SM | SM | SM | SM | SM |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Depth (m)         | -50-60 | -50-60 | -50-60 | -50-60 | -50-60 | -61 | -61 | -62 | -62 | -64 | -64 | -65 | -65 |
| Date of collection| 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 |
| *Hydnolithon farinosum* (J.V. Lamouroux) D. Penrose & Y.M. Chamberlain | 7.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.699 | 0.003 | 0.001 | 0.006 | 0.001 |
| *Hypoglossum* hypoglossoides (Stackhouse) F.S. Collins & Hervey | 9.0 | 5.0 | 56.0 | 154.0 | 5.0 | 1.8 | 0.8 | 0.1 | 0.5 | 0.0 | 0.2 | 0.1 |
| *Irvinea boergesenii* (Feldmann) R.J. Wilkes, L.M. McIvor & Guiry | 5.0 | 5.0 | 6.0 | 5.0 | 5.0 | 0.4 | 0.6 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.3 |
| *Jania virgata* (Zanardini) Montagne | 0.1 |
| *Kallymenia feldmannii* Codomier | 0.7 | 5.9 | 0.7 | 0.1 | 0.014 | 0.015 | 0.003 | 0.001 |
| *Kallymenia patens* (J. Agardh) Codomier ex P.G. Parkinson | 588.3 | 31.5 | 67.4 | 46.7 | 2.4 | 3.3 | 0.1 | 0.6 |
| *Kallymenia requienii* (J. Agardh) J. Agardh | 20.0 | 130.0 | 14.0 | 19.5 | 14.0 | 30.0 | 5.0 | 18.0 | 8.4 | 9.9 | 27.3 | 4.0 | 2.2 | 4.4 | 0.3 |
| *Kallymenia sp.* | 0.200 | 0.710 | 0.050 | 0.095 | 0.050 | 0.135 | 0.050 | 0.050 | 0.014 | 0.007 | 0.001 | 0.007 | 0.002 | 0.002 | 0.002 | 0.001 |
| *Lejolisia mediterranea* Bornet | 5.6 | 1.2 | 8.1 | 1.7 | 0.028 | 0.007 | 0.042 | 0.009 |

(continued)

Table 1 (continued)

| Location          | Lam I-1 | Lam I-2 | Lam II-1 | Lam II-2 | Pey I-1 | Pey I-2 | Pey II-1 | Pey II-2 |
|-------------------|---------|---------|----------|----------|---------|---------|----------|----------|
| Depth (m)         | -50-60 | -50-60 | -50-60 | -50-60 | -61 | -61 | -62 | -62 |
| Date of collection| 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 |
| *Hydnolithon farinosum* (J.V. Lamouroux) D. Penrose & Y.M. Chamberlain | 7.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.699 | 0.003 | 0.001 | 0.006 | 0.001 |
| *Hypoglossum* hypoglossoides (Stackhouse) F.S. Collins & Hervey | 9.0 | 5.0 | 56.0 | 154.0 | 5.0 | 1.8 | 0.8 | 0.1 | 0.5 | 0.0 | 0.2 | 0.1 |
| *Irvinea boergesenii* (Feldmann) R.J. Wilkes, L.M. McIvor & Guiry | 5.0 | 5.0 | 6.0 | 5.0 | 5.0 | 0.4 | 0.6 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.3 |
| *Jania virgata* (Zanardini) Montagne | 0.1 |
| *Kallymenia feldmannii* Codomier | 0.7 | 5.9 | 0.7 | 0.1 | 0.014 | 0.015 | 0.003 | 0.001 |
| *Kallymenia patens* (J. Agardh) Codomier ex P.G. Parkinson | 588.3 | 31.5 | 67.4 | 46.7 | 2.4 | 3.3 | 0.1 | 0.6 |
| *Kallymenia requienii* (J. Agardh) J. Agardh | 20.0 | 130.0 | 14.0 | 19.5 | 14.0 | 30.0 | 5.0 | 18.0 | 8.4 | 9.9 | 27.3 | 4.0 | 2.2 | 4.4 | 0.3 |
| *Kallymenia sp.* | 0.200 | 0.710 | 0.050 | 0.095 | 0.050 | 0.135 | 0.050 | 0.050 | 0.014 | 0.007 | 0.001 | 0.007 | 0.002 | 0.002 | 0.002 | 0.001 |
| *Lejolisia mediterranea* Bornet | 5.6 | 1.2 | 8.1 | 1.7 | 0.028 | 0.007 | 0.042 | 0.009 |

(continued)

Table 1 (continued)
| Location         | Spo I       | Spo II      | Spo III     | Spo IV      | Spo V       | Spo VI      | Lam I-1     | Lam I-2     | Lam II-1    | Lam II-2    | Pey I-1     | Pey I-2     | Pey II-1    | Pey II-2    |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Depth (m)        | MC          | MC          | MC          | MC          | MC          | MC          | MC          | MC          | MC          | MC          | SM          | SM          | SM          | SM          |
| Date of collection | 13/05/09   | 13/05/09   | 13/05/09   | 13/05/09   | 13/05/09   | 15/05/09   | 15/05/09   | 15/05/09   | 15/05/09   | 15/05/09   | 19/05/09   | 19/05/09   | 19/05/09   | 19/05/09   |
| Lithothamnion valens | 375.0       | 900.0       | 1300.0      | 250.0       | 250.0       | 200.0       | 196.4       | 190.3       | 24.8        | 2.1         | 5.2         | 2.8         |            |            |
| Foslie          | 37.500      | 90.000      | 130.000     | 25.000      | 25.000      | 20.000      | 19.462      | 19.028      | 2.483       | 0.208       | 0.521       | 0.278       |            |            |
| Lomentaria clavellosa | (Lightfoot ex Turner) | Gaillon | | | | | | | | | | | | | |
| Lomentaria ercegovicii | Verlaque, Boudouresque, Meinesz, Giraud & Marcot-Coqueugniot | | | | | | | | | | | | | |
| Lomentaria subdichotoma | Erogovic | | | | | | | | | | | | | |
| Erosovica | | | | | | | | | | | | | |
| Lophosiphonia obscura | (C. Agardh) Falkenberg | | | | | | | | | | | | | |
| Melobesia membranacea | (Esper) J.V. Lamouroux | | | | | | | | | | | | | |
| Meredithia microphylia | Mer (J. Agardh) J. Agardh | | | | | | | | | | | | | |
| Mesophyllum alternans | Mesosp. Cabioch & M.L. Mendoza | | | | | | | | | | | | | |
| (Foslie) | 25.0       | 0.1         | 0.1         | 0.1         | 0.1         | 0.1         | 0.001       | 0.002       | 0.001       | 0.001       | 0.001       | 0.001       | 0.001       | 0.001       |
| Mesophyllum expansum | Mesopol. Cabioch & M.L. Mendoza | | | | | | | | | | | | | |
| (Philippi) | 2.500      | 0.2         | 0.2         | 0.2         | 0.2         | 0.2         | 0.243       | 1.381       | 0.243       | 0.243       | 0.243       | 0.243       | 0.243       | 0.243       |
| Monosporus palicellatus | Monospor. Solier | | | | | | | | | | | | | |
| Myriogramme carnea | Myriog. y Femenías | | | | | | | | | | | | | |
| (J.J. Rodríguez y Femenías) | Kylin | | | | | | | | | | | | | |
| Myriogramme tristromatica | Myriog. y Femenías | | | | | | | | | | | | | |
| (J.J. Rodríguez y Femenías) | Boudouresque | | | | | | | | | | | | | |
| Neogoniolithon mamillatus | Neogoniol. Hauck | | | | | | | | | | | | | |
| (Hauck) | 30.000      | 32.2        | 2.8         | 0.3         | 3.5         | 0.2         | 0.004       | 0.031       | 0.004       | 0.004       | 0.004       | 0.004       | 0.004       | 0.004       |

Table 1 (continued)
Table 1 (continued)

| Location          | Spo I | Spo II | Spo III | Spo IV | Spo V | Spo VI | Spo VII | Lam I-1 | Lam I-2 | Lam II-1 | Lam II-2 | Pey I-1 | Pey I-2 | Pey II-1 | Pey II-2 |
|-------------------|-------|--------|---------|--------|-------|--------|---------|---------|---------|----------|-----------|---------|---------|----------|---------|
| Depth (m)         | MC    | MC     | MC      | MC     | MC    | MC     | MC      | MC      | MC      | MC       | MC        | SM      | SM      | SM       | SM      |
| Date of collection| 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 |

| Species                        | MC   | 13/05/09 | 5.0  | 0.001 | 0.1  | 0.007 | 0.7   | 0.004 | 3.0  | 0.050 | 0.003 | 2.0   | 83.3  | 0.100 |
|--------------------------------|------|----------|------|------|------|------|-------|-------|------|------|------|------|------|------|
| Nitophyllum micropunctatum Funk|      |          | 0.1  |      |      |      |       |       |      |      |      |      |      |      |
| Nitophyllum punctatum F(Stockhouse) Greville | | | | | | | | | | | | | |
| Osmundaria volubilis (Linnaeus) R.E. Norris | 720.0 | 137.8 | 166.7 | 40.1 | 30.6 | 0.6 | 0.8 | 0.7 | | | | | |
| Osmundea pelagica (Schiffn) K.W. Nam | 5.245 | 1.107 | 1.385 | 0.333 | 0.194 | 0.005 | 0.009 | | | | | | |
| Peyssonnelia armorica (P.L. Crouan & H.M. Crouan) Weber-van Bosse | | | | | | | | | | | | | |
| Peyssonnelia bornetii Boudouresque & Denizot | 81.8 | 111.6 | 2.6 | | | | | | | | | | |
| Peyssonnelia coriacea Feldmann | 427.4 | 477.5 | 62.0 | 346.4 | 1.2 | 0.1 | | | | | | | |
| Peyssonnelia dubyi P.L. Crouan & H.M. Crouan | 3.0 | 6.6 | 8.5 | 2.8 | 0.7 | 177.4 | 760.4 | 60.5 | 6.9 | 0.050 | 0.001 | 0.007 | 0.001 |
| Peyssonnelia harveyana P.L. Crouan & H.M. Crouan ex J. Agardh | 0.050 | 0.165 | 0.213 | 0.070 | 0.018 | 4.435 | 19.010 | 1.513 | 0.173 | | | | |
| Peyssonnelia inamoena Filger | 94.0 | 17.5 | 0.150 | 1.444 | 0.177 | 1.485 | 3.535 | 14.653 | 8.392 | 3.366 | 2.339 | | | |
| Peyssonnelia rosa-marina Boudouresque & Denizot | 2.3 | 0.725 | 0.113 | 0.105 | 1.270 | 0.205 | 1.485 | 3.535 | 14.653 | 8.392 | 3.366 | 2.339 | | |
| Peyssonnelia rubra Greville J. Agardh | 458.2 | 458.2 | | | | | | | | | | | | |
| Peyssonnelia squamaria (S.G. Gmelin) Decaisne | 5.6 | 3.431 | | | | | | | | | | | | |
| Peyssonnelia stoechas Boudouresque & Denizot | 0.012 | 2.3 | | | | | | | | | | | | |
| Peyssonnelia sp. | 5.0 | 0.050 | 0.4 | 9.6 | 0.2 | | | | | | | | |
| Phyllophora crispa (Hudson) P.S. Dixon | 337.5 | 486.1 | 569.3 | 758.3 | 433.9 | 24.8 | 42.3 | 34.7 | 20.2 | 4.321 | 4.867 | 6.507 | 3.354 | 0.149 | 0.285 | 0.232 | 0.150 | (continued)
| Location | MC | MC | MC | MC | MC | MC | SM | SM | SM | SM |
|----------|----|----|----|----|----|----|----|----|----|----|
| Depth (m) | -50-60 | -50-60 | -50-60 | -50-60 | -61 | -61 | -62 | -62 | -64 | -64 |
| Date of collection | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 | 19/05/09 |
| Phyllophora herediae | 0.3 | 0.6 | 1.1 | 0.004 | 0.006 | 0.010 |
| (Clemente) J. Agardh | | | | | | |
| Phymatolithon calcaratum | 210.0 | 247.5 | 50.0 | 55.0 | 155.0 | 207.5 | 70.0 | 35.9 | 219.2 | 55.4 | 99.3 | 4.5 |
| (Pallas) W.H. Adey & D.L. McKibbin' | | | | | | |
| Plocamium cartilagineum | 1.4 | 0.3 | 1.4 | 0.8 | 0.9 | 0.4 | 0.021 | 0.014 | 0.009 | 0.007 | 0.004 | 0.002 |
| (Linnaeus) P.S. Dixon | | | | | | |
| Polysiphonia ornata J. Agardh | 5.0 | 0.1 | 0.050 | 0.001 |
| P. ornata | | | | | |
| Agardh | | | | | |
| Polysiphonia perforans | 2.9 | | | | |
| Cormaci, G. Fumari, Pizzuto & Serio | | | | | |
| Polysiphonia subulifera | 46.0 | 0.1 | 2.4 | 3.2 | 0.2 | 0.7 | 0.1 | 0.1 |
| (C. Agardh) Harvey | 0.220 | 0.001 | 0.024 | 0.032 | 0.001 | 0.006 | 0.001 | 0.001 |
| Polysiphonia sp. | 5.0 | 262.0 | 7.1 | 0.1 | 8.5 | 1.6 | 0.050 | 2.618 | 0.072 | 0.001 | 0.085 | 0.016 |
| Pterothamnium crispum | 5.0 | | 0.1 | 0.1 | 0.1 | 0.050 | 0.001 | 0.001 | 0.001 |
| (Ducluzeau) Nägeli | | | | | | |
| Pterothamnium plumula (J. Ellis) Nägeli | 5.0 | 0.050 |
| Politochloropsis horrida | 0.1 | 0.1 | 0.1 |
| Berthold | 0.001 | 0.001 | 0.001 |
| Politochloropsis plumula (Dillwyn) Thuret | 5.0 | 5.0 | 13.8 | 8.5 | 0.1 | 0.050 | 0.050 | 0.138 | 0.085 | 0.001 |
| Politochloropsis sp. | | | | | | |
| Radicilingua thysanorhizans (Holmes) Papenfuss | 0.1 | 2.1 | 1.7 | 0.1 | 0.014 | 0.007 | 0.007 | 0.007 |
| Papenfuss | | | | | | |
| Radicilingua sp. | 0.7 | | | | 0.007 |
| Rhodophyllis divaricata | 0.5 | | | | |
| (Stackhouse) Papenfuss | 0.005 |
| Rhodophyllis strafforelloi Ardissone | 4.5 | 1.6 | 1.4 | 9.9 | 0.1 | 0.9 | 0.7 | 0.050 | 0.008 | 0.011 | 0.047 | 0.001 | 0.007 | 0.007 |

(continued)
## Table 1 (continued)

| Location | Spo I | Spo II | Spo III | Spo IV | Spo V | Spo VI | Spo VII | Lam I-1 | Lam I-2 | Lam II-1 | Lam II-2 | Pey I-1 | Pey I-2 | Pey II-1 | Pey II-2 |
|----------|-------|--------|---------|--------|-------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Depth (m) | MC    | MC     | MC      | MC     | MC    | MC     | MC      | MC      | MC      | MC      | MC      | SM      | SM      | SM      | SM      |
|          | -50-60| -50-60 | -50-60  | -50-60 | -50-60| -50-60 | -61     | -61     | -62     | -62     | -64     | -64     | -64     | -64     | -65     | -65     |
| Date of collection | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 |
| Rhodymenia sp. | 0.5    | 0.4    | 10.8    | 0.2    | 30.7   | 1.2    | 2.0      | 0.001   | 0.004   | 0.108   | 0.002   | 0.104   | 0.007   | 0.010   | 0.010   |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Rodriguezella bornetii (J.J. Rodriguez y Femenías) F. Schmitz ex J.J. Rodriguez y Femenías | 2.3    | 0.014  | 0.009  | 0.003  | 0.001  | 0.001  | 0.001    | 6.9     | 0.026   |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Rodrigueza pinnata (Kützing) F. Schmitz ex Falkenberg | 0.001  | 0.001  | 0.001  | 0.001  | 0.001  | 0.001  | 0.001    | 0.001   | 0.001   |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Rodrigueza strafforelloi F. Schmitz ex J.J. Rodriguez y Femenías | 6.9    | 0.026  | 0.001  | 0.001  | 0.001  | 0.001  | 0.001    | 0.001   | 0.001   |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Rhytiphaeae tinctoria (Clemente) C. Agardh | 0.2    | 0.003  | 0.003  | 0.003  | 0.003  | 0.003  | 0.003    | 0.003   | 0.003   |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Sahlingia subintegra (Rosenvinge) Komnmmann | 0.6    | 0.4    | 0.3    | 0.1    | 0.1    | 0.1    | 0.1      | 0.1     | 0.1     |
|         |        |        |        |        |        |        |          |         |         |         |         |         |         |         |         |
| Seddenia rodriqueziana (Feldmann) Athanasiadis | 0.015  | 0.004  | 0.003  | 0.001  | 0.001  | 0.001  | 0.001    | 0.001   | 0.001   |
| Sphaerococcus connopifolius Stackhouse | 14.2   | 8.9    | 4.0    | 2.6    | 2.6    | 2.6    | 2.6      | 2.6     | 2.6     |
| Sphaerococcus rhizophylloides J.J. Rodriguez y Femenías | 0.022  | 0.064  | 0.048  | 0.017  | 0.017  | 0.017  | 0.017    | 0.017   | 0.017   |
| Spongites fruticulosus Kützing | 4.7    | 14.2   | 8.9    | 4.0    | 2.6    | 2.6    | 2.6      | 2.6     | 2.6     |
|         | 0.022  | 0.064  | 0.048  | 0.017  | 0.017  | 0.017  | 0.017    | 0.017   | 0.017   |
|         | 0.022  | 0.064  | 0.048  | 0.017  | 0.017  | 0.017  | 0.017    | 0.017   | 0.017   |
| Stylonema alsidii (Zanardini) K.M. Drew | 0.1    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1      | 0.1     | 0.1     |
|         | 0.1    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1      | 0.1     | 0.1     |
| Titanoderma pustulatum (J.V. Lamouroux) Nägeli | 0.2    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1    | 0.1      | 0.1     | 0.1     |
| Titanoderma sp. | 5.0    | 0.3    | 0.2    | 0.1    | 0.1    | 0.1    | 0.1      | 0.1     | 0.1     |
| Womersleyella setacea (Hollenberg) R.E. Norris* | 5.0    | 0.050  | 0.022  | 0.002  | 0.001  | 0.001  | 0.001    | 0.001   | 0.001   |

(continued)
Table 1 (continued)

| Location | Spo I | Spo II | Spo III | Spo IV | Spo V | Spo VI | Spo VII | Lam I-1 | Lam I-2 | Lam II-1 | Lam II-2 | Pey I-1 | Pey I-2 | Pey II-1 | Pey II-2 |
|----------|-------|--------|---------|--------|-------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Depth (m) | MC | MC | MC | MC | MC | MC | MC | MC | MC | SM | SM | SM | SM | SM |
| -50-60 | -50-60 | -50-60 | -50-60 | -50-60 | -50-60 | -61 | -61 | -62 | -62 | -64 | -64 | -65 | -65 |
| Date of collection | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 13/05/09 | 15/05/09 | 15/05/09 | 15/05/09 | 19/05/09 | 19/05/09 | 19/05/09 | 19/05/09 |
| Unidentified Ceramiaceae | 0.5 | | | | | | | | | | | | | |
| Unidentified Corallinaceae | 400.0 | 250.0 | 205.0 | 5.0 | 150.0 | 29.1 | 86.3 | 64.8 | 18.4 | 9.6 | 10.2 | 5.3 | 3.0 | |
| Unidentified Delesseriaceae | 40.000 | 25.000 | 20.500 | 0.050 | 15.000 | 0.991 | 7.010 | 1.106 | 1.840 | 0.924 | 1.006 | 0.522 | 0.299 |
| Unidentified Halymeniaceae | 0.2 | | | | | | | | | | | | | |
| Unidentified Rhodomelaceae | 5.0 | | | | | | | | | | | | | |
| Unidentified Rhodophyta 1 | 0.050 | | | | | | | | | | | | | |
| Unidentified Rhodophyta 2 | 0.2 | | | | | | | | | | | | | |

Phaeophyceae (Ochrophyta)

| Asperococcus bullosus J.V. Lamouroux | 0.3 | | | | | | | | | | | | | |
| Carpomitra costata (Stackhouse) Batters | 0.015 | | | | | | | | | | | | | |
| Cutleria chilosa (Falkenberg) P.C. Silva | 1.4 | 0.3 | 0.1 | 0.4 | 0.001 | 0.003 | 0.007 | 0.004 | 0.014 | 0.017 | 0.005 |
| Dictyopteris lucida M.A. Ribera Siguán, A. Gómez Garreta, Pérez Ruzafa, Barceló Marií & Rull Lluch | 10.0 | 0.050 | | | 0.2 | 3.5 | 0.1 | 0.6 | 0.001 | 0.011 | 0.001 | 0.002 |
| Dictyoïda dichotoma (Hudson) J.V. Lamouroux | 3.5 | 14.0 | 98.0 | 12.5 | 5.0 | 47.2 | 15.8 | 21.5 | 8.7 | 0.1 | 2.7 | 0.5 | 0.6 |
| Halopteris filicina (Grateloup) Kützing | 5.0 | 8.0 | 4.0 | 4.0 | 2.8 | 3.0 | 9.3 | 3.1 | 11.0 | 5.6 | 4.5 | 3.0 |
| Laminaria rodriguezii Bornet | 121.5 | 88.0 | 593.2 | 359.0 | 0.826 | 0.472 | 3.285 | 2.368 | 0.002 | 0.006 |

(continued)
| Location | Depth (m) | Date of collection | Sphacelaria plumula | Zanardinia typus (Nardo) | Zonaria tournefortii (J.V. Lamouroux) Montagne | Unidentified encrusting Phaeophyceae | Chlorophyta | Cladophora sp. | Derbesia tenuissima (Moris & De Notaris) P.C. Silva | Flabellia petiolata (Turra) | Nizamaddin | Halimeda tuna (J. Ellis & Solander) J.V. Lamouroux | Microdictyon umbilicatum (Velley) Zanardini | Palmophyllum crassum (Naccari) Rabenhorst | Pseudochlorodesmis furcellata (Zanardini) | Uronema marina (Zanardini) | Valonia macrophysa | Kützing |
|----------|----------|-------------------|--------------------|------------------------|-----------------------------------------------|-------------------------------------|------------|----------------|-----------------------------------------------|--------------------------|----------|-----------------------------------------------|------------------------------------------|-----------------------------------------------|--------------------------------------------|----------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Spo I    | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo II   | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo III  | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo IV   | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo V    | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo VI   | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Spo VII  | -50-60   | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Lam I-1  | -61      | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Lam I-2  | -61      | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Lam II-1 | -62      | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |
| Lam II-2 | -64      | 13/05/09          | 13/05/09           | 13/05/09               | 13/05/09                                      | 15/05/09                            | 15/05/09   | 15/05/09       | 15/05/09                                      | 19/05/09                              | 19/05/09 | 19/05/09                                      | 19/05/09                                 | 19/05/09                                      | 19/05/09                                    | 19/05/09                               | 19/05/09                                      | 19/05/09                                      | 19/05/09                                    |

Table 1 (continued)
sample Spo III grouped separately from the other samples in the analysis based on biomass because it presented an extremely low biomass compared to the rest of the samples.

A total of 104 species were identified in samples collected from Laminaria rodriguezii forests (Table 2), with Rhodophyta accounting for 85.6% of the species (Fig. 2). This community presented a mean of 64±8 species per replicate, a Sa of 3653±817 cm^2 m^-2 and a Bb of 106±42 g dw m^-2 (Fig. 3). The species Phyllophora crispa, Spongites fruticulosus, Peyssonnia coriacea, Laminaria rodriguezii, Flabellia petiolarata and Peyssonnia rubra, in this order, were found to be the main characterizing species in terms of algal surface, according to the SIMPER test (Fig. 4). Maërl-forming species represented 21.8±5.7% of Sa, but 76.3±5.0% of Bb, and consequently, as regards biomass, the SIMPER test indicated that the main species were the Corallinales Spongites fruticulosus, Phymatolithon calcareaum and Litothamnion valens (Fig. 4). Statistical analyses based on both qualitative and quantitative data showed no significant differences between replicates of both samples.

A total of 106 species were identified in the community with Peyssonnia inamoena (Table 2), with Rhodophyta accounting for 85.8% of the species (Fig. 2). The number of species per replicate was 62±14; Sa was 1661±1118 cm^2 m^-2; and Bb was 34±29 g dw m^-2 (Fig. 3). While the SIMPER test for algal surface indicated that P. inamoena and P. rubra were the most characteristic species, the analysis performed with the biomass data revealed four Peyssonnia species: P. inamoena, P. rosa-marina, P. harveyana and P. rubra (Fig. 4). In this community, maërl-forming species accounted for 6.3±3.6% of Sa and 30.6±15.0% of Bb (Fig. 3). According to the statistical analyses, replicates of both samples did not present significant differences in qualitative and quantitative species composition.

Discussion

Spongites fruticulosus beds presented a very low number of species, H’ and J’, which could also be a sampling artifact due to the small sampling areas. Besides, our results show that they were mostly characterized by the calcareous species of the basal stratum (mainly Spongites fruticulosus and Phymatolithon calcareaum), which accounted for 76.8±21.5% of Sa and 94.5±3.3% of Bb, erect algae being irrelevant. This relatively low development of fleshy species was also observed previously in Tossa de Mar (Spain, Northwestern Mediterranean) and although it might be caused by low irradiance levels (Ballesteros, 1988), we still do not have the clues to explain this situation as the other communities studied here thrive at the same irradiance levels.

A contrasting case is displayed by the kelp forest of Laminaria rodriguezii, which showed a well-developed erect stratum, composed of dispersed clusters of thalli of L. rodriguezii, interspersed with free-living corallines and sand patches. Free-living corallines S. fruticulosus and P. calcareaum were far less abundant (21.8±5.7% of Sa, and 76.3±4.9% of Bb) than on Spongites fruticulosus beds. As expected, the forest presented higher values of H’ and J’ when compared to Spongites fruticulosus beds (Table 2), due to higher complexity. Diversity values based on algal surface are amongst the highest in Mediterranean algal communities, and similar to those found on free-living Peyssonnia beds (Ballesteros, 1994) or other deep-water communities along the Northeastern coast of Spain (Cystoseira zosteroides, Halimeda tuna, Lithophyllum stictaefolium and Phymatolithon calcareaum) (Ballesteros, 1988, 1992). The kelp forest of L. rodriguezii studied here was very similar in species composition to that found in Hyères Islands (France, Northwestern Mediterranean) (Gautier & Picard, 1957), and even to that found growing over coralligenous concretions at Ustica (Tyrrhenian Sea, Italy) (Giaccone, 1967), suggesting a high homogeneity of these forests in the Western Mediterranean Sea.

Peyssonnia inamoena beds were quite diverse because soft erect algae and prostrate species were relatively abundant. These beds were as rich in species as the L. rodriguezii forests but showed lower values of H’ and J’ (Table 2). They displayed the lowest percentage of free living corallines of the three communities (6.3±3.6% of Sa and 30.6±15.0% of Bb) and, in addition, 45% of MFSsa and 41% of MFSsb belonged to the calcified species Peyssonnia rosa-marina. Similar low abundances of members of the order Corallinales (<2%) have been found on other Peyssonnia beds dominated by P. rosa-marina or Peyssonnia sp. in the Balearic Islands (Ballesteros, 1994), which has been explained by the burial of corallines in bottoms with a high sedimentation rate, while Peyssonnia and other fleshy species accumulate in ripple mark depressions (Ballesteros, 1994; Bordehore et al., 2003). Values of H’ and J’ in relation to algal surface were similar to values found on S. fruticulosus beds, but in relation to biomass, the P. inamoena community presented higher values of H’n and J’n (Fig. 3). Peyssonnia beds seem to be abundant and diverse on the continental shelf of the Balearic Islands. In this regard, besides the P. inamoena and P. rubra identified here and in a previous work (Joher et al., 2012), some bottoms dominated by different Peyssonnia species have been identified previously in the Balearic Islands (Ballesteros, 1994) as well as in other areas of the Western Mediterranean Sea (Huvé, 1954; Carpine, 1958; Parenzan, 1960; Bourcier, 1968; Augier & Boudouresque, 1978; Basso, 1990). In addition, the P. inamoena beds studied here also show a great abundance of other congeneric species (P. rosa-marina, P. harveyana, P. rubra), suggesting that all Peyssonnia beds could constitute a single habitat, where the different species could become dominant as a response to slightly different environmental conditions. However, further studies are required on this issue.
**Fig. 3:** Characteristics of the three studied communities (mean and standard deviation). A) Total algal surface ($S_a$) and total biomass ($B_t$). The percentage of the maërl-forming species is given for both parameters. B) Shannon’s diversity ($H'$) and Pielou’s evenness ($J'$) both based on algal surface ($S_a$) and biomass ($B_t$). Abbreviations: Spo, *Spongites fruticulosus* beds; Lam, *Laminaria rodriguezii* forests; Pey, *Peyssonnelia inamoena* beds.

**Fig. 4:** Results of the SIMPER test based on algal surface ($S_a$) and biomass ($B_t$) for the three communities. The species summarizing 70% of total contribution to the similarity of the samples are given. Abbreviations: Spo, *Spongites fruticulosus* beds; Lam, *Laminaria rodriguezii* forests; Pey, *Peyssonnelia inamoena* beds.
Table 2. Main characteristics of the collected samples/replicates. Abbreviations: Spo, Spongites fruticulosus beds; Lam, Laminaria rodriguezii forests; Pey, Peyssonnelia inamoenae beds; MC, Menorca Channel; SM, Southern Menorca; n, number of species; IFO, Index of Floral Originality; Sa, total algal surface; TB, total biomass; MSF, and MSF′, maërl-forming species according to total algal surface and biomass; Jsa and Jri, Pielou’s evenness based on algal surface and biomass; Bsa and Bri, calculated for each of the studied communities (Fig. 1).

Although the spatial structure of the communities studied here was different, differences in species composition were small, as reflected in the low values of IFO calculated for each of the studied communities (Fig. 1). In this sense, previous reports of bottoms dominated by the kelp L. rodriguezii as ‘fonds à prâlines et Laminaria rodriguezii’ (Molinier, 1956; Gautier & Picard, 1957; Pérès & Picard, 1964), together with the high similarities between S. fruticulosus beds and L. rodriguezii forests highlighted in this study, suggest the existence of a gradient moving from the S. fruticulosus beds to the L. rodriguezii forests. Whether this is driven by natural environmental factors or by anthropogenic pressures would require further work. However, in this sense, recent studies pointed out that the abundances of this endemic kelp on detritic bottoms geographically differ depending on commercial trawling pressure, since well-developed L. rodriguezii kelps are only found in specific areas of the Menorcan channel with low trawling pressure (Joher et al., 2012). Finally, the development of Peyssonnelia spp. communities could also be favoured by adverse local environmental conditions for the development of maërl beds. Thus, the natural presence of high sedimentation rates and/or changes induced by trawling, such as turbidity, could enhance the abundance of Peyssonneliaceae over Corallinales, as previously observed in Alicante (Spain) and Malta (Bordehore et al., 2000).

ROV dives have been extremely useful for finding extensive beds of the three targeted communities and, in fact, this is the most advisable method to localize specific communities in deep-water, highly patchy detritic landscapes, rather than using destructive dredges or Scuba-diving. Regarding the sampling method, the number of species reported for each community in this work is significantly higher than the values found in corresponding assemblages sampled by bottom trawling (Fig. 5) (Joher et al., 2012). This was unexpected since the sampled surface was much larger in the collections made by bottom trawling. Bottom trawls have a larger mesh size than beam trawls (20 mm vs 10 mm), which could explain this increase in the L. rodriguezii and P. inamoenae communities, even when sampling much smaller surfaces. In the case of the S. fruticulosus community, Box-Corer dredges completely prevented any loss of sample and probably this is the reason explaining the increase. Thus, Box-Corer dredges or beam trawls seem to be good sampling methods for studying the composition and structure of deep-water detritic communities, although bottom trawls are equally effective if the main assemblages have to be identified in large areas.

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References

Acosta, J., Canals, M., López-Martinez, J., Muñoz A., Herranz, P. et al., 2002. The Balearic promontory geomorphology (Western Mediterranean): morphostructure and active processes. Geomorphology, 49, 177-204.

Augier, H., Bouduresque, C.F., 1978. Végétation marine de l’Ille de Port-Cros (Parc National) XVI: Contribution à l’étude de l’épiﬂore du détritique côtier. Travaux Scientiﬁques du Parc national de Port-Cros, 4, 101-125.

Ballesteros, E., 1988. Composición y estructura de los fondos de maërl de Tossa de Mar (Girona, España). Collectanea Botanica, 17, 161-182.

Ballesteros, E., 1992. Els vegetals i la zonació litoral: espècies, comunitats i factors que influeixen en la seva distribució. Arxiu de la Secció de Ciències 101. Institut d’Estudis Catalans, Barcelona, 616 pp.

Ballesteros, E., 1994. The deep-water Peyssonnelia beds from the Balearic Islands (Western Mediterranean). Marine Ecology, 15, 233-253.

Ballesteros, E., Zabala, M., 1993. El bentos: el marc físic. p. 663-685. In: Història Natural de l’Arxipèlag de Cabrera. Monografies de la Societat d’Història Natural de les Bal-ears 2. Alcover, J.A., Ballesteros, E., Fornós, J.J. (Eds). Editorial Moll, Palma.

Barberá, C., de Mesa, A., Ordines, F., Moranta, J., Ramón, M. et al., 2009. Informe campaña CANAL: ‘Caracterización del ecosistema demersal y bentónico del canal de Menorca (Islas Balaures) y su explotación pesquera’. Centre Oceanogràfic de Balears, Instituto Español de Oceanografía, 220 pp.

Barberá, C., Moranta, J., Ordines, F., Ramón, M., de Mesa, A. et al., 2012. Biodiversity and habitat mapping of Menorca Channel (western Mediterranean): implications for conservation. Biodiversity and Conservation, 21, 701-728.

Basso, D., 1990. The calcareous alga Peyssonnelia rosa-marina Bouduresque and Denizot, 1973 (Rhodophyceae, Peyssonniaceae) in circalittoral soft bottoms of Tyrren-nesian Sea. Quaderni della Civica Stazione Idrobiologica di Milano, 17, 89-106.

Bianchi, C.N., 2001. La biocostruzione negli ecosistemi marini e la biologia marina italiana. Biologia Marina Mediterranea, 8, 112-130.

Blunden, G., Farnham, W.F., Jephson, N., Fenn, R.H., Plunkett, B.A., 1977. The composition of maërl from the Glenan Islands of Southern Brittany. Botanica Marina, 20, 121-125.

Bordehore, C., Borg, J.A., Lanfranco, E., Ramos-Esplá, A., Rizzo, M. et al., 2000. Trawling as a major threat to Mediterranean maërl beds. p. 105-109. In: Proceedings of the First Mediterranean Symposium on Marine Vegetation, Ajaccio (France), 3-4 October 2000. RAC/SPA, Tunis.

Bordehore, C., Ramos-Esplá, A.A., Riosmena-Rodríguez, R., 2003. Comparative study of two maërl beds with different otter trawling history, southeast Iberian Peninsula. Aquatic Conservation: Marine and Freshwater Ecosystems, 13, 43-54.

Bourcier, M., 1968. Étude du benthos du plateau continental de la Baie de Cassis. Recueil des Travaux de la Station Marine d’Endoume, France, 44, 63-108.

Canals, M., Ballesteros, E., 1997. Production of carbonate particles by phytobenthic communities on the Mallorca-Menorca shelf, northwestern Mediterranean Sea. Deep-Sea Research II, 44, 611-629.

Carpine, C., 1958. Recherches sur les fonds à Peyssonnelia polymorpha (Zan.) Schmitz de la région de Marseille. Bulletin de l’Institut Océanographique de Monaco, 1125, 1-25.

Clarke, K.R., Warwick, R.M., 2001. Change in marine communities: an approach to statistical analysis and interpretation. 2nd edition. Plymouth Marine Laboratory, U.K., 172 pp.

Clarke, K.R., Somerfield, P.J., Gorley, R.N., 2008. Testing of null hypotheses in exploratory community analyses: simi-
larity profiles and biota-environment linkage. *Journal of Experimental Marine Biology and Ecology*, 366, 56-69.
Costa, S., 1960. Le peuplement des fonds à *Halarachnion spathulatum*. *Vie et Milieu*, 11 (1), 8-68.
Dieuze de, R., 1940. Étude d’un fond de pêche d’Algérie: la “gravelle de Castiglione”. *Bulletin des Travaux publiés par la Station D’Aquiculture et de Pêche de Castiglione, Algérie*, 1, 33-57.
Ellis, J.R., Martinez, I., Burt, G.J., Scott, B.E., 2013. Epibenthic assemblages in the Celtic Sea and associated with the Jones Bank. *Progress in Oceanography*, 117, 76-88.
Feldmann, J. 1934. Les Laminariacées de la Méditerranée et leur répartition géographique. *Bulletin des Travaux publiés par la Station D’Aquiculture et de Pêche de Castiglione, Algérie*, 2, 143-184.
Fornós, J.J., Ahr, W.M., 1997. Temperate carbonates on a modern, low-energy, isolated ramp; the Balearic platform. *Spain. Journal of Sedimentary Research*, 67, 364-373.
Gautier, Y., Picard, J., 1957. Bionomie du banc de Magaud.
Recueil des Travaux de la Station Marine d’Endoume, France, 12, 28-40.
Giaccone, G., 1967. Popolamenti a *Laminaria* *rodriguezii* Bor-Rett sul Banco Apollo dell’isola di Ustica (Mar Tirreno). *Novia Thalassia*, 3, 1-9.
Giaccone, G., Alongi, G., Pizzuto, F., Cossu, A., 1994. La vegetazione marina bentonica sciafila del Mediterraneo: III. Infralitorale e circalitorale. Proposte di aggiornamento. *Bolletino dell’Accademia Gioenia di Scienze Naturali Catania*, 27, 201-227.
Huvé, H., 1954. Contribution à l’étude des fonds à *Peyssonnelia polymorpha* (Zan.) Schmitz de la région de Marseille. *Recueil des Travaux de la Station Marine d’Endoume, France*, 12, 119-136.
Huvé, H., 1955. Présence de *Laminaria* *rodriguezii* Bornet sur les côtes françaises de Méditerranée. *Recueil des Travaux de la Station Marine d’Endoume, France*, 15, 73-91.
Huvé, H., 1956. Contribution à l’étude des fonds à *Lithothamnium (?)* *solutum* Foslie (= *Lithophyllum solutum* (Foslie) Lemoine) de la région de Marseille. *Recueil des Travaux