Variability in Distribution of Macrobenthos on Rocky Shores at Elba Island

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The Sixth International Conference on the Mediterranean Coastal Environment
7-11 October 2003, Ravenna (Italy)

Fig. 1. Bay of Fetovaia (Elba Island, Tyrrhenian Sea).

Fig. 3. Visual estimates of percentage cover using quadrates (0.25 m^2).

Introduction

Several biotic and abiotic factors affect the distribution of macrobenthic organisms on the subtidal rocky shores. Biotic factors include the inter- and intraspecific interactions acting at different spatial scales (Hughes, 1990). Among abiotic factors geographic orientation, with related physical features, and substratum composition play a major role (Breitburg, 1987; Blanchard and Bourget, 1999; Bavestrello *et al*., 2000). In the present work the distribution of the macrobenthic assemblages on the rocky subtidal shore of Fetovaia Bay (Elba Island, Tyrrhenian Sea; Fig. 1) in relation to geographic orientation and substratum mineralogy are discussed.

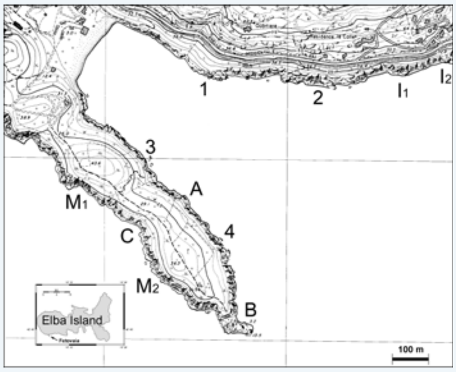

Fig. 2. Sampling sites investigated during the 1st (A, B, C), 2nd (1, 2, 3, 4) and 3rd study (M_1, M_2 on metamorphic rocks; I_1, I_2 on igneous rocks).

Materials and methods

Bay of Fetovaia is located on the southwestern coast of Elba Island. A promontory of metamorphic rocks (amphibolites) delimits the southern side of the bay, while the north side of the bay and the surrounding shores are made by igneous rocks (granodiorites) (Bouillin *et al*., 1993).

Macrobenthic assemblages on the subtidal hard bottoms of the Fetovaia bay were investigated during three surveys carried out in September 1999, June 2000 and June 2002, respectively. Multifactorial sampling designs were applied to investigate: 1) the distribution of macrobenthic assemblages around the promontory; 2) the assemblages on the two shores insides the bay; 3) the influence of substratum mineralogy (i.e. metamorphic *vs*. igneous rocks) on species distribution. In the first two studies sampling was done between 3 and 5 metres in depth. Two spatial scales were investigated: sites, separated by hundreds metres, and areas, separate by tens of metres (Fig.2). At each site 4 areas were randomly chosen and in each area 3 replicate samples were taken (Dethier *et al*., 1993). In the third study, for each substratum two sites with comparable orientation were randomly chosen. At each site fourteen replicate samples were collected at 3 and 10 metres in depth. Abundances of conspicuous taxa were quantified by visual estimates of percentage cover using quadrates of 0.25 m^2 (Benedetti-Cecchi *et al*., 1996; Fig. 3). Patterns of species distribution were analysed by ANOVA and post hoc SNK test (Underwood, 1997). Species assemblages were compared, after square root transformation of data, by non-metric MDS (Clarke, 1993) and NPMANOVA based on the Bray-Curtis similarity index (Anderson, 2001).

Taxa distribution

During the first and second survey 15 main taxa were identified. Algae (i.e. *Peyssonnellia* spp., branched coralline and *Padina pavonica*) dominated the epibenthic assemblages both in September and June. Some species showed a clear temporal trends: hydroids were present in September with an average covering of 4.7% but they were nearly absent in June, while *Acetabularia acetabulum* dominated the assemblages in June with an average covering of 31%. Filamentous algae showed on average cover of 2.8% in September and of 53.2% in June.

In September 1999 distribution of branched coralline algae, *Codium bursa*, *Halimeda tuna*, *Padina pavonica*, and massive sponges, didn't show any difference in abundance at different sites and areas (Table 1). *Peyssonnellia* spp., encrusting coralline algae, *Flabellia petiolata*, filamentous algae, hydroids, encrusting sponges, serpulids, and bryozoans showed a significant heterogeneity of abundance among areas. Only *Dasycladus vermicularis* showed significant difference in abundance among the three sites around the promontory and a homogeneous distribution among areas. In particular *D. vermicularis* was more abundant at site C (SNK site A=B<C).

In June 2000 most of the analysed taxa showed a significant heterogeneity of abundance among areas (Table 1). Abundance of both encrusting and massive sponges was homogeneous among areas but differ significantly among sites, being more abundant on the southern side of the bay. *A. acetabulum* and filamentous algae were more abundant on the northern side of the bay (sites 1 and 2), while *F. petiolata* was more abundant on the southern side of the bay (sites 3 and 4).

In third study the analysis of epibenthic assemblages occurring on the two different typologies of rock was extended to 20 taxa (Table 2). Most of the analysed taxa (branched coralline algae, *Laurencia* sp., *Dasycladus vermicularis*, other erected algae, algal turf, serpulids, barnacle, and bryozoans) showed a heterogeneous distribution of abundance between sites within each combination of depth and substratum. These results are in agreement with the small-scale heterogeneity observed in the previous studies. The distribution of some erected algae (e.g. *Laurencia* sp., Dictyotaceae) and of the encrusting sponges was affected by depth. The abundance of *Acetabularia acetabulum* was homogeneous among sites but varied between the different combination of depth and substratum: it was more abundant at 3 metre in depth on the igneous rocks. *D. vermicularis* was more abundant on the igneous rocks than on the metamorphic, at both depth.

Tab. 1. Summary of the ANOVA on percent covers data of all analysed taxa found in first and second study analysing different spatial scales in the Fetovaia bay (*: $p < 0.05$; **: $p<0.01$; ns: not significant, -: not analysable).

Taxa	September 1999 Area(Site)	September 1999 Site	June 2000 Area(Site)	June 2000 Site
Peyssonnellia spp.	*	ns	**	ns
Branched coralline algae	ns	ns	**	ns
Encrusting coralline algae	*	ns	**	ns
Acetabularia acetabulum	-	-	**	**
Codium bursa	ns	ns	*	ns
Halimeda tuna	ns	ns	**	ns
Flabellia petiolata	**	ns	*	*
Dasycladus vermicularis	ns	*	**	ns
Padina pavonica	ns	ns	*	ns
Filamentous algae	**	ns	**	**
Hydroids	**	ns	-	-
Encrusting sponges	*	ns	ns	**
Massive sponges	ns	ns	ns	**
Serpulids	*	ns	*	ns
Bryozoans	**	ns	ns	ns

Tab. 2. Summary of the ANOVA on percent covers data of all taxa found in third study analysing species distribution in relation to substratum type and depth.

	Site(SxD)	SxD	Depth (D)	Substratum (S)
Bacterial film	-	-	-	-
Peyssonnellia spp.	ns	ns	ns	ns
Branched coralline algae	**	ns	ns	ns
Encrusting coralline algae	ns	ns	ns	ns
Acetabularia acetabulum	ns	*	**	*
Laurencia sp.	**	ns	*	ns
Codium bursa	ns	ns	ns	ns
Halimeda tuna	ns	ns	ns	ns
Flabellia petiolata	ns	ns	ns	ns
Dasycladus vermicularis	**	ns	ns	*
Dictyotaceae	ns	ns	*	ns
Padina pavonica	ns	ns	ns	ns
Other erected algae	*	ns	*	ns
Algal turf	*	ns	ns	ns
Hydroids	-	-	-	-
Encrusting sponges	ns	ns	*	ns
Massive sponges	ns	ns	ns	ns
Serpulids	**	ns	ns	ns
Barnacle	**	ns	ns	ns
Bryozoans	*	ns	ns	ns

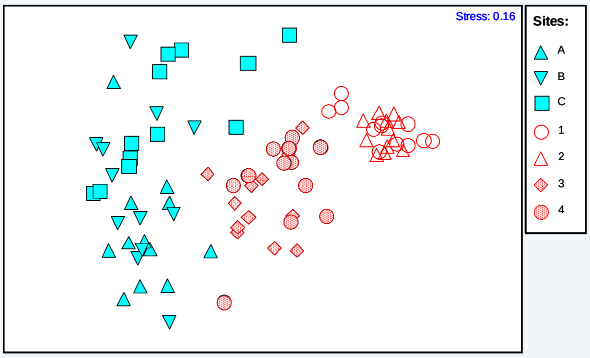

Fig. 4. MDS plot on percent cover data of epibenthic assemblages observed in the first (sites A, B, and C) and second survey (sites 1, 2, 3, and 4) comparing different spatial scales in the Fetovaia bay.

Distribution of macrobenthic assemblages

The MDS plot (Fig. 4) showed a clear separation among the epibenthic assemblages sampled in the first and second study. In the first survey there were significant differences among the assemblages of the areas within each site but there were no differences among sites, as indicated by NPMANOVA.

In the second survey the assemblages of the northern side of the bay (sites 1 and 2) were well distinct from those present in the southern side (sites 2 and 3; Fig. 4). This was confirmed by NPMANOVA, which detect high significant difference at both spatial scales (among areas within sites, and among sites), and by the pair-wise post hoc comparisons, which clearly separate the assemblages of the two different sides of the bay (1 = 2 ≠ 3 = 4). Overall, the assemblages found in the second survey on the northern side of the bay appear more homogeneous than those present on the promontory in both seasons.

In the third study, the MDS showed some separation between the assemblages found at the two different depths (-3 metres *vs*. -10 metres; Fig. 5). Moreover, at the shallowest depth it is possible to see some separation between the assemblages colonising different substrata (igneous *vs*. metamorphic). These patterns were not confirmed by NPMANOVA, which detect high heterogeneity among sites within each combination of depth and substratum.

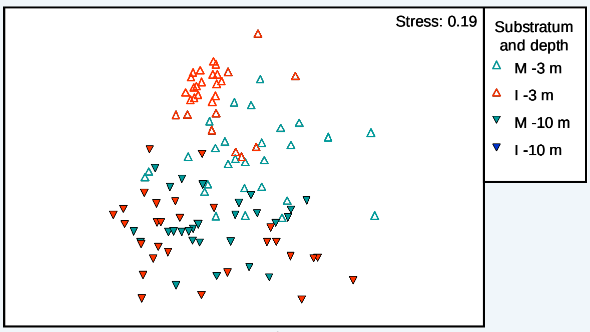

Fig. 5. MDS plot on percent cover data of epibenthic assemblages in June 2002. Symbols indicate the combinations of different substrata (black: igneous rocks; grey: metamorphic rocks) and depths (triangle toward up: 3 metre in depth; triangle toward down: 10 metres in depth).

Conclusions

The results of the first two surveys showed a high heterogeneity of the epibenthic assemblages colonising the rocky subtidal shores of the promontory and bay of Fetovaia at both the investigated dates. Heterogeneities observed among areas, at a scale of tens of metres, were comparable to those observed between sites, separate by hundreds of metres and with different geographic orientation. The distributions of several species and of the overall assemblages showed clear differences between the two inner sides of the bay. Furthermore assemblages found on the promontory were more variable than those of the shores of the bay. The high level of heterogeneity observed among areas could be probably related to biotic and abiotic factors, like recruitment processes, inter- and intraspecific competition and predation, and substratum heterogeneity (Blanchard and Bourget, 1999). The observed difference between the assemblages of the two sides of the bay could be related to differencies in geographic orientations, which involve different irradiation and hydrodynamic conditions.

The distribution of most taxa did not appear to be related to differences in substratum mineralogy. Only *Acetabularia acetabulum* and *Dasycladus vermicularis* appear to be affected by substratum mineralogy beeing more abundant on the igneous rocks. The possible effects of substratum mineralogy on the overall assemblage are probably hidden by the high variability among areas, that increases with depth.

Acknowledgements

We thank C. Barbanti, A. Bonazzi, C. Cagliola, D. Cagnazzi, E. Camorani, A. Cariani, M. Carrera, L. Caruso, F. Colosio, E. Cortesi, F. Costantini, R. Di Placido, L. Di Totto, S. Errani, M. L. Felloni, F. Foschini, B. Leonzio, N. Liverani, L. Massardi, D. Pacchioli, C. Ragazzini, F. Roncarati, and F. Virdis for their assistance during field work.

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