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PROCEEDINGS OF THE 1ST MEDITERRANEAN SYMPOSIUM ON THE CONSERVATION OF THE CORALLIGENOUS AND OTHER CALCAREOUS BIO-CONCRETIONS

15 - 16 January 2009 – Tabarka

ACTES DU 1ER SYMPOSIUM MEDITERRANEEN SUR LA CONSERVATION DU CORALLIGENE ET AUTRES BIOCONCRETIONS CALCAIRES

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SPATIAL AND TEMPORAL VARIATION OF ASSEMBLAGES IN MEDITERRANEAN CORALLIGENOUS REEFS

ABSTRACT
The structure, distribution and temporal changes of epibenthic assemblages of Mediterranean coralligenous reef in the Ligurian and Adriatic Sea were investigated by using a multifactorial sampling design. The distribution of taxa were analysed at scales ranging form hundred of meters to tens of kilometres. Temporal variations were analysed among different years. Percentage cover of conspicuous species have been analysed by means of photographic sampling. Strong spatial patterns of taxa distribution were found among coralligenous outcrops in the Adriatic, while in the Ligurian Sea a strong small scale pattern related to habitat orientation was found. There was some temporal fluctuation in abundance of taxa, but no clear patterns were observed. These results suggest that coralligenous assemblages are a patchy habitat where changes in species composition and abundance can occur at a range of spatial scales, down to few meters, moreover, validate the assumption of the limited temporal variability in Mediterranean coralligenous reefs, possibly related to the slow growth rates of the most abundant taxa and the reduced seasonality of physical conditions.

KEY-WORDS**:** coralligenous reefs, spatial patterns, temporal variation, Northern Adriatic Sea, Ligurian Sea.

INTRODUCTION

The Mediterranean Sea has been recognised as a hot-spot for marine biodiversity (Bianchi & Morri, 2000). Several Mediterranean habitats and ecosystems, including the coralligenous subtidal biogenic rocky reefs, are unique, extremely reach in species and complex in structure. Biogenic subtidal rocky bottoms also include some of the most economically valuable assemblages of the world (UNEP, 1995). These habitats play a relevant role in terms of carbonate production in the marine coastal environment. Moreover, they host a number of species that have been extensively exploited since very long time (e.g. red coral), and are playing a key nursery role for commercially valuable fish species (sea bas, sea breams, various grouper species, etc.). however, only minor shifts have been observed among seasons. As most coastal habitats (Airoldi & Beck, 2007) coralligenous reefs (Ballestreros, 2006) are impacted by human activities and disturbances. Important causes of threats to coralligenous habitats are represented by harvesting and fishing activities, particularly trawling and the highly destructive ‘St. Andrew Cross’, used to harvest precious red coral and sponge, which can physically destroy the biogenic structures and alter the quality of the surrounding water masses by increasing turbidity and sediment deposition rates. The state of the knowledge on coralligenuos reefs has been provided in a recent review (Ballestreros, 2006). From the analyses clearly emerged that these reefs are intrinsically valuable for their biological diversity and for the ecological processes that they are supporting. Since the ’60 a bulk of data on species composition of the assemblages dwelling on these biogenic reefs has been collected, while much limited is the knowledge on scales and patterns of species distributions and on their trends of seasonal/temporal variability. The need to quantify patterns of variability in benthic assemblages at a range of spatial and temporal scales is nowadays generally accepted (e.g. Fraschetti *et al.*, 2001; Benedetti-Cecchi *et al.*, 2003). Understanding of natural patterns of distribution is a crucial basic need for any conservation or management initiatives. Drivers of species diversity patterns change with the spatial scales considered, going from species interactions and substrata morphology at the small scale, to changes in species pools and oceanography features at the regional scale. Indeed, for long time coralligenous reefs have been associated to the idea of stability in space and time due to the slow growth rate of the reef building species, as well as to the relatively steady environmental conditions associated with the deeper rocky subtidal. A few quantitative studies have recently investigated patterns of spatial distribution and temporal changes (Garrabou *et al.*, 1998; Ferdeghini *et al.*, 2000; Piazzi *et al.*, 2002; Balata *et al.*, 2005; Garrabou *et al.*, 2002; Balata *et al.*, 2006; Virgilio *et al.*, 2006; Ponti *et al.*, 2007). These studies revealed an unexpected complexity in pattern of spatial variation, with most of the variation at the smallest investigated scales, while at the scale of habitats; assemblages appeared to be more homogeneous. Similarly, temporal dynamics of the whole assemblages have been only rarely investigated. Same seasonal patterns of single or groups of algal and animal species have been described,

In the present study we compare species assemblages in two different types of coralligenous habitats: Ligurian rocky cliffs and Adriatic bottom outcrops. In each region structured multi-scale sampling designs have been used to detect shifts and patterns in species distributions. Moreover, in both regions observed patterns of variability have been compared in time over several years.

MATERIALS AND METHODS

The researches were carried out in the Ligurian Sea and the northern Adriatic Sea. In the Ligurian Sea the study location was a wave-exposed reef, south of Livorno, Italy (Ligurian Sea, 43°30'N, 10°20'E, locality Calafuria). The general environmental characteristics of the study area are described in Piazzi et al. (2002), and the references therein. The sea-bottom consists of a gently sloping sandstone platform extending 200–300 m from the coastline to a depth of about 20 m. The platform is dominated by turf-forming seaweeds (Airoldi & Virgilio, 1998) and is characterised by high rates of sediment deposition and movement (Airoldi *et al.*, 1996). At the platform edge, there is a steep cliff, with the depth dropping from 20 m to about 45 m. For over 10 km in length, the cliff consists of nearly vertical walls scattered with crevices and overhangs, which host a rich coralligenous assemblage. The area is a popular site for scuba divers and commercial fishermen of *Corallium rubrum* (Santangelo & Abbiati, 2001). Epibenthic assemblages on ten randomly selected sampling sites hundreds of metres apart along 2 km of the reef were investigated. Samples have been collected both on vertical and down-facing surfaces of crevices and overhang, at 25 m approximate depth. Sampling was done in two periods 1) April 1995 to March 1996 (hereafter 1995–1996) and 2) April 1997 to March 1998 (hereafter 1997–1998); 4 four sampling dates where randomly extracted for each period (Fig.1a) and 9 replicated samples have been collected in combination sampling date per site.

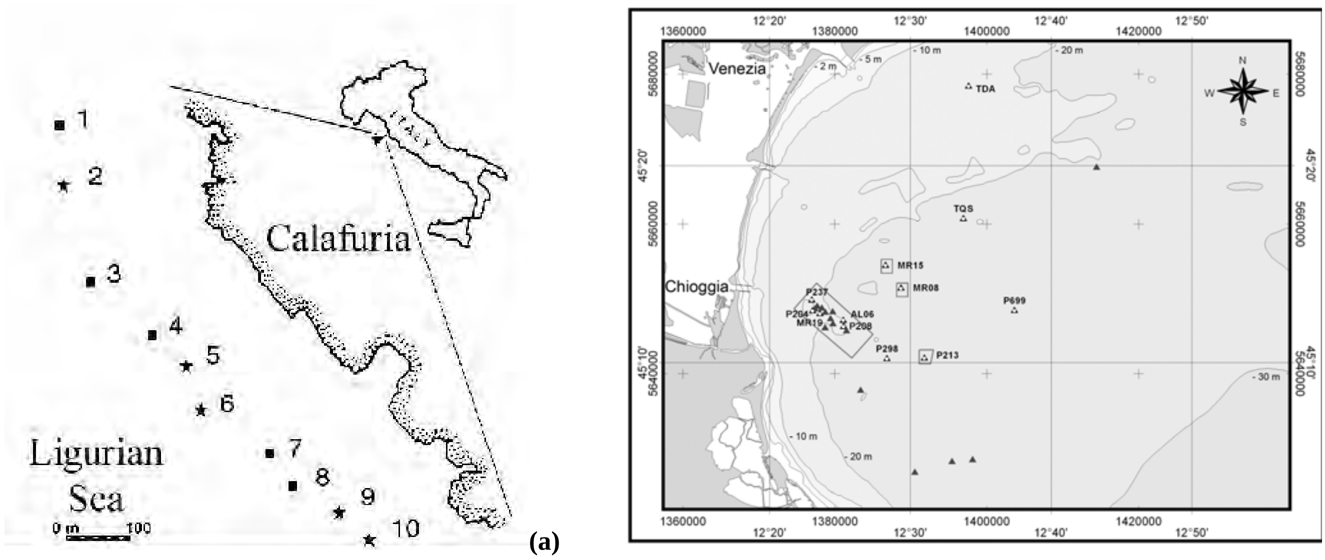

Fig. 1: Maps of the study sites: a) ten sampling sites along the Tyrrhenian coast; b) twelve investigated outcrops scattered in the Northern Adriatic Sea. **(b)**

In the northern Adriatic Sea the study area covers approximately 500 km^2 of the continental shelf offshore Chioggia and Venice (Lat. 45° 24' - 45° 04' N; Lon. 12° 23' - 12° 43' E). In the area numerous coralligenous rocky outcrops 1 to 4 meters high emerge form a silty/sandy bottom, between 10 and 40 m in depth. These rocky outcrops, ranging in size from few to several thousands of square metres, are biogenic reef made predominantly by calcareous algae and characterized by very diverse epibenthic assemblages. Epibenthic assemblages have been quantitatively studied on twelve randomly selected outcrops, at a depth ranging between 19.4 and 27.0 m and a distance from the coast ranging between 6.6 and 23.9 km. From 2003 until 2006, on each outcrop, 10 replicated samples have been collected during annual field trips in month of August (Fig. 1b).

In both regions sampling was done using a non-destructive photographic method (Roberts *et al.*, 1994). Underwater images have been collected using a frame of 0,04 m^2. Images have been analysed by projecting them on a grid of 100 quadrates to estimate the relative percentage cover of the most abundant taxa using the visual method (Benedetti-Cecchi *et al.*, 1996). Taxa were identified to the lowest possible taxonomic level. During sampling voucher specimens were collected to help identification. The filamentous turf-forming seaweeds (mainly red seaweeds belonging to the order Ceramiales), that could not be consistently identified from the photographs, were grouped as "algal turf"' (Airoldi & Virgilio, 1998).

Multivariate procedures were used to analyse the spatial and temporal variability in the distribution of taxa. The data were fourth-root transformed, in order to reduce differences in scale among variables, while preserving information about the relative abundance of taxa among replicates. Non-metric multi-dimensional scaling (MDS) and clustering techniques were used to produce an ordination replicates.

RESULTS

Epibenthic assemblages developing on the Tyrrhenian coralligenous reefs were characterised by 18 conspicuous taxa that could be identified. These included turf-forming seaweeds, three prostrate seaweeds, nine sponges, the cnidarian *C. rubrum*, and four bryozoans. Three were the most abundant taxa: turf-forming algae, *Peyssonnelia rubra*, and *Corallium rubrum*. The remaining 15 taxa identified, showed relatively low average percentage cover, ranging from <0.1 to 5.5% on vertical surfaces and from 0.3 to 2.6% on down-facing surfaces. All taxa were found on both vertical and down-facing surfaces, but were generally abundant at one orientation only. Clear differences between assemblages living on vertical and down-facing surfaces were observed (Fig. 2). In particular, seaweeds were most abundant on vertical surfaces, with turf-forming seaweeds and *P. rubra* as the dominating taxa, while invertebrates were generally most abundant on down-facing surfaces.

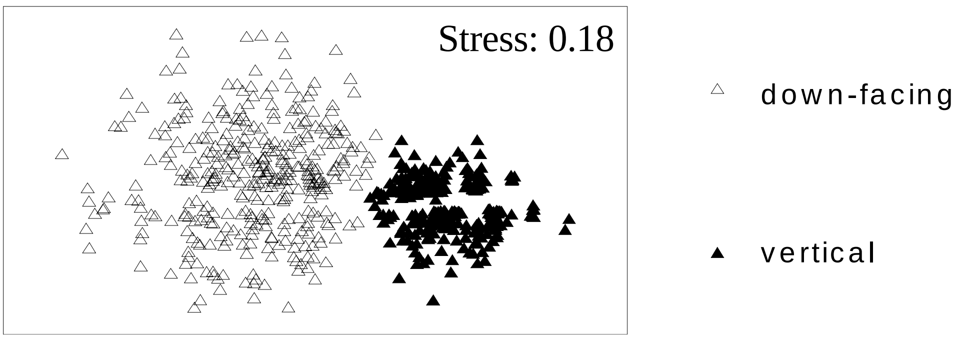

Fig. 2: Non-metric multidimensional scaling ordination of assemblages developing on down-facing (white triangles) and vertical surfaces (black triangles) in the Tyrrhenian Sea. Ordinations were based on the rank orders of similarities among replicate plots (n = 720) sampled at 10 sites (5 sites sampled on vertical surfaces and 5 sites on down-facing surfaces) at 8 times (from 1995 to 1998). The matrix of similarities between each pair of replicate plots was based on the Bray-Curtis similarities after 4th root transformation.

Significant differences in multivariate patterns of distribution of taxa between orientations and periods were found. The significant interaction of these factors suggested that temporal variations were not consistent between vertical and down-facing surfaces (Fig. 3). Furthermore, the significant interaction of time and site showed that the short-term temporal fluctuations varied from site to site.

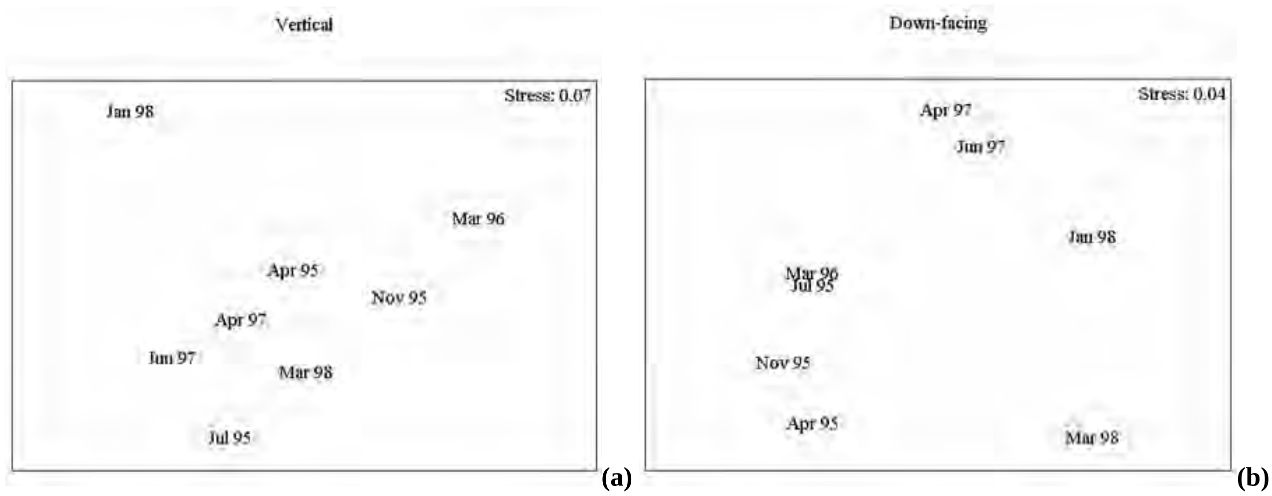

Fig. 3: Non-metric multidimensional scaling ordination of assemblages developing on (a) down-facing and (b) vertical surfaces in the Tyrrhenian Sea. At each orientation, data from April 1995 to March 1998 were averaged across plots in order to obtain a centroid for each of the 8 sampling times (from 1995 to 1998). The matrix of similarities between each pair of centroids was based on the Bray-Curtis similarities after 4th root transformation.

Epibenthic assemblages developing on the northern Adriatic coralligenous outcrops were characterised by the abundance of algal taxa accounting for about 56% of the total cover (algal turf, calcareous algae: mainly *Lithophyllum stictaeforme*, *Lithothamnion minervae*, *Peyssonnelia polymorpha*). Sponge were the most abundant animal taxa (encrusting: e.g. *Dictyonella incisa* and *Antho incostans*; massive and tubular: e.g. *Geodia cydonium*, *Ircinia variabilis*, *Dysidea avara*, *Chondrosia reniformis*, *Tedania anhelans*, *Ulosa stuposa*, *Axinella damicornis*, *Axinella polypoides*, *Aplysina aerophoba*; boring: e.g. *Cliona* spp), together with anthozoans (*Cereus pedunculatus*, *Cornularia cornucopiae*, *Epizoanthus* spp., *Parazoanthus axinellae*) and colonial ascidians (e.g. *Polycitor adriaticus*, *Aplidium conicum* and *A. tabarquesins*) (Fig. 4).

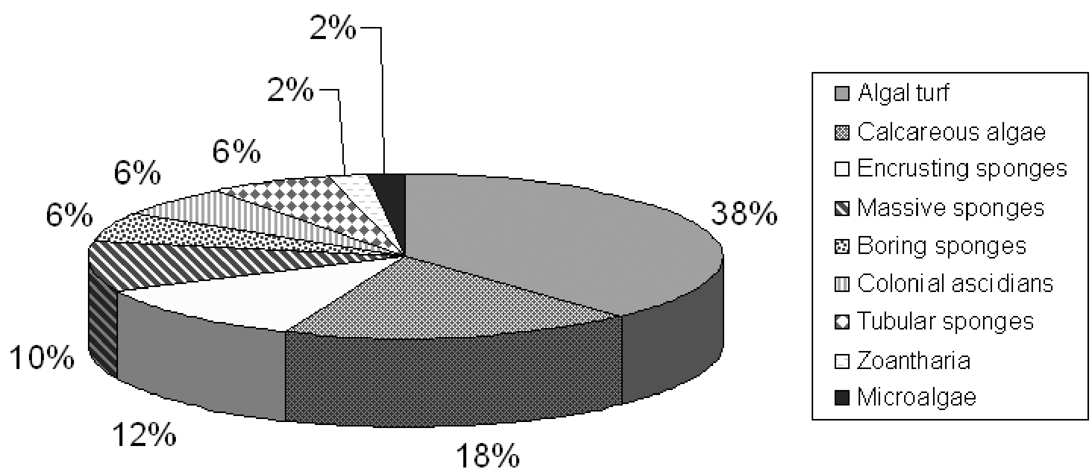

Fig. 4: Relative mean abundance of the main ecological and taxonomical groups developing on the northern Adriatic outcrops.

The species showed a complex distribution patterns. Spatial variation overcame temporal changes in the structure of the assemblages. The cluster analysis clearly separated the epibenthic assemblages in three main spatial groups. These spatial groups of outcrops were persistent in time form 2003 to 2006 (Fig. 5). Species composition of the assemblages characterising the biogenic outcrops in different areas was consistent in time. Observed temporal variation was mostly related to changes in the relative abundance of the most common taxa, rather then to changes in species composition. Variation of assemblages among the areas appeared strongly correlated with the morphological features and geographical location of the outcrops, while hydrological conditions that changed over time seem to be less relevant.

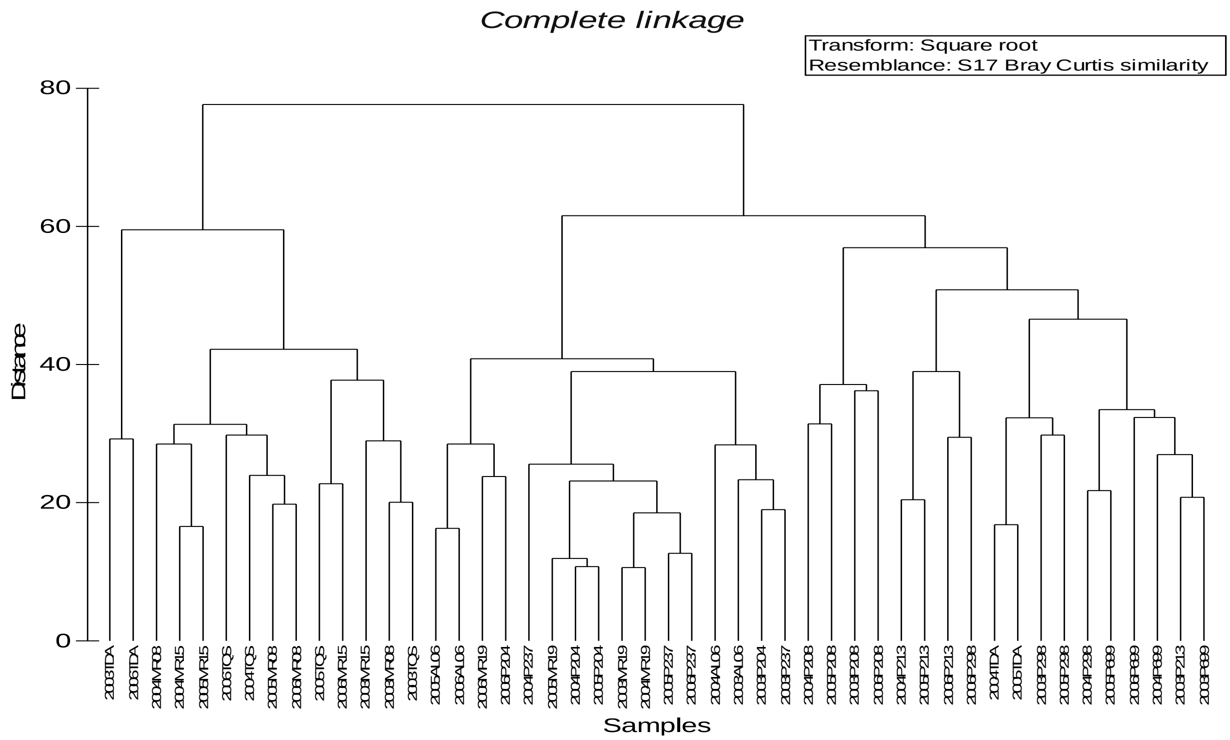

Fig. 5: Cluster analysis of assemblages developing on northern Adriatic coralligenous outcrops. The matrix of similarities between each pair of centroids was based on the Bray-Curtis similarities after 4th root transformation.

DISCUSSION AND CONCLUSIONS

The two types of coralligenous reef that have been investigated (Calafuria, Ligurian Sea, and tegnue, Northern Adriatic Sea) differ in both composition and relative abundances of taxa. Moreover, they noticeably differ also from coralligenous reefs described in other Mediterranean areas (Ros *et al.* 1985; Garrabou *et al.* 1998; Ferdeghini *et al.* 2000). The reef at Calafuria is characterised by high densities of algal turfs, *Peyssonnelia rubra* and *C. rubrum*, while Nothern Adriatic reefs host a very rich and variable assemblage of turf-forming and calcareous algae, sponges and colonial ascidians. Low abundances of calcareous sponges and bryozoans were found in both reefs. These results support the model proposed by Sarà (1969), suggesting that the Mediterranean coralligenous reefs may encompass a number of markedly different biogenic formations.

Scales of spatial structuring of the assemblages differed between the two sites. In Calafuria a very strong gradient of small-scale differentiation was found in relation to the orientation of the substratum, leading to a shift in the abundance of the most common species. In the Northern Adriatic shifts in species composition and in most abundant taxa were found among outcrops in relation to the distance form the coast and to the depth gradient.

Concerning patterns of temporal variation, within Calafuria reefs some fluctuations in the abundance of taxa at both the temporal scales investigated (between- and within-periods) were found. Differences between the orientations were striking and consistent over time, and the assemblages on down-facing surfaces were more heterogeneous than those on vertical surfaces. Some short-term temporal variations (within-periods) arise, but these changes were not consistent across sites and did not suggest the occurrence of clear trends. Temporal variation in the Northern Adriatic outcrops was limited, mainly related to inter-annual fluctuations in abundance of taxa, but no obvious patterns were observed. These results support the model of limited temporal variability in Mediterranean coralligenous reefs, possibly related to the slow growth rates of the most abundant taxa and the reduced seasonality of physical conditions. However, further studies analysing patterns of spatial and temporal variation in coralligenous biogenic reefs are needed to develop a general model for the dynamics of these valuable habitats.

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