

Distribution patterns of the sublittoral epibenthic assemblages on a rocky shoal in the Ligurian Sea (NW Mediterranean)*

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SUMMARY: Acquiring baseline data on highly diverse communities such as coralligenous ones is very valuable in order to determine possible shifts in communities and define strategies for their preservation. Distribution of sciaphilic epibenthic communities belonging to the 'coralligène de la roche littorale' was investigated at 30 photostations from 17 to 24 m depth on a rocky shoal off the island complex in the Gulf of La Spezia (Ligurian Sea, NW Mediterranean). Four communities displayed a sharp zonation: *Paramuricea clavata* characterised deeper, vertical surfaces, whereas on horizontal and medium inclination, sediment-covered substrata, *Leptogorgia sarmentosa*, together with *Eunicella singularis* and *Eunicella verrucosa*, characterised the upper stratum of the deeper community. Shallow vertical walls were characterised by a facies with sponges and zoantharians, whereas community dominated by large, massive colonies of *Pentapora fascialis* with a basal stratum of sciaphilic algal species patched with sediment on shallow rocky slopes of medium inclination. Bathymetric distribution of assemblages is influenced by high seawater turbidity (mean annual transparency: 11.9 ± 5.7 m at the western site, 6.2 ± 1.6 m at the eastern site), which induces a shift of the upper limit of distribution of these facies to unusually shallow depths. Quantitative data provide a baseline on the study site that will be useful to understand the influence of not only biotic and abiotic factors, but also mass-mortality events, particularly on these communities characterised by high resilience.

Key words: hard substrate epibenthos, communities zonation, coralligenous, northwestern Mediterranean.

INTRODUCTION

In their classical work on vertical zonation of Mediterranean benthos, Pérès and Picard (1964) described the complex of communities thriving on hard substrates characterised by the presence of sciaphilic organisms, which they named 'coralligenous biocenosis'. The diversity and richness of the Mediterranean coralligenous communities have been compared to those of tropical coral reefs (Ros *et al.*, 1985) and their scientific importance has been stressed

(Sarà, 1969; Laborel, 1987). At present, the work of Pérès and Picard (1964), mainly based on northern part of the western Mediterranean basin, is the basis for knowledge on coralligenous communities, together with studies on distribution and abundance of the most representative species (Laborel, 1961; Laubier, 1966; Sarà, 1969; True, 1970; Augier, 1982; Hong, 1982). However, there are very few quantitative studies describing these communities (Gili and Ros, 1985a; Gili and Ballestreros, 1991; Abbiati *et al.*, 1996; Garrabou *et al.*, 1998; Ferdeghini *et al.*, 2000).

Acquiring baseline data on highly diverse communities such as coralligenous ones is very valuable

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in order to determine possible shifts in communities and define strategies for their preservation. Furthermore, a renewed interest in coralligenous communities has resulted from the extensive mass mortality of gorgonians and other sessile epibenthic invertebrates which occurred in the area in the summer of 1999 (Cerrano *et al.*, 2000).

Apart from studies on the biology of one of the typical species, the octocoral gorgonian *Leptogorgia sarmentosa* (Mistri and Ceccherelli, 1993; Mistri, 1995a), and on the species composition and abundance of bioconstructor organisms (Morganti *et al.*, 2000), the presence and distribution of sciaphilic epibenthic assemblages in the Gulf of La Spezia (Ligurian Sea, Italy) has remained largely unstudied. The area shows some peculiarities which influence the bathymetric distribution of assemblages: the highest seawater turbidity in the Ligurian Sea (mean value of transparency 11.4 m, Della Croce *et al.*, 1992), and the deposition of a large amount of sediment (Morganti *et al.*, 2000) shift the upper limit of distribution of sciaphilic assemblages to shallower depths than those usually reported (Gili and Ros, 1985b).

The aim of the study was to investigate the species composition and percent cover of sciaphilic epibenthic assemblages belonging to the 'coralligène de la roche littorale' (*sensu* Pérès and Picard, 1964) on a sublittoral shoal off Tinetto Rock in the Gulf of La Spezia, to describe their spatial distribution, and to determine whether the scale of observation reveals community-related spatial patterns conventionally described for the north-western Mediterranean. Quantitative data provide a baseline on the study site that will be useful for temporal change detection.

MATERIALS AND METHODS

The study site is a shoal (44°01'N, 9°51'E) located off Tinetto Rock, at the western border of La Spezia Gulf, Italy (Fig. 1a). The study area receives a great input of terrigenous material from the Magra River, the biggest in the region, and is subjected to the influence of the town of La Spezia. The shoal consists of carbonate outcrops with vertical walls at the northern and western side, whereas eastern and

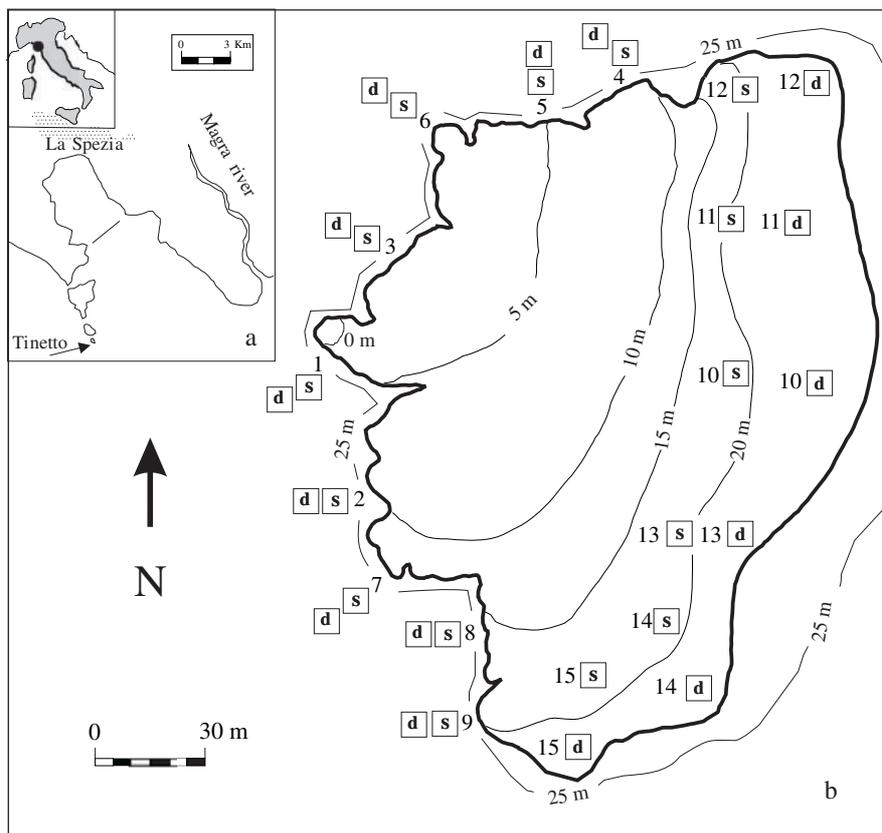


FIG. 1. – a) Geographic layout of the study area; b) bathymetry of Tinetto shoal and location of the 30 photostations (s: shallow, d: deep). The bold line represents the rocky outcrop limit.

southeastern sides are constituted of rocky slopes of medium inclination with boulders covered by fine sediment. The shoal is surrounded by a flat, muddy bottom with an average depth of about 26 m. The topography of the shoal was determined during a preliminary survey in spring 1997 (Fig. 1b).

Monthly measurements of seawater transparency were taken with a Secchi disk, as suggested for turbid water (English *et al.*, 1997), during 1997-98 at two sites on the western and eastern sides respectively of the islands complex. Seawater transparency measurements showed very low values (annual medium value \pm S.D.: 11.9 ± 5.7 m at the western site, 6.2 ± 1.6 m at the eastern site) (Bassano *et al.*, 2000), indicating the influence of the harbour of La Spezia, especially on the eastern site.

Photographic samples were made in May-June 1997 at 15 sites at 2 depths - 17 and 24 m - for a total of 30 photostations around the rocky shoal. At each photostation six replicated areas (600 cm²) were photographed using a Nikonos V camera with a 35 mm lens fitted with a 4 diopter correction close-up lens (produced by CentroFotoSub) and a fixed frame. The frame ensured the accurate positioning of the camera over the scene and kept the distance from the scene fixed to 49 cm and thus the sampling area to 600 cm². A total of 180 photographs were obtained.

Species unknown or difficult to identify during the dive were sampled, preserved in 5% formaline seawater, and identified in the laboratory by specialists.

The taxonomic identification of conspicuous species (as defined by Hiscock, 1987) from images was performed by placing the slides under a binocular microscope. The software Nih Image® was used to calculate the cover of species. Both branches and base of gorgonians were included in the counts. Area measurements were performed by outlining the contour of species by hand. The cover of each species was expressed as a percentage of the total area sampled. Average percent cover values for each species at each photostation were obtained from the six replicated areas.

The analysis of percent cover data to investigate patterns in assemblages distribution was performed through multivariate analysis. The matrix of cover values, after arcsin transformation, was first subjected to cluster analysis by the Bray-Curtis similarity matrix to delineate groups of photostations. The calculated similarity matrix was also used to produce a 2-dimensional MDS (multidimensional scaling)

TABLE 1. – List of the species identified on rocky bottom at Tinetto shoal. Species contributing for more than 10% to similarity in SIMPER analysis are indicated (*).

Phylum Chlorophyta
* <i>Flabellia petiolata</i> (Turra) Nizamuddin
<i>Pseudoclorodesmis furcellata</i> (Zanardini) Børgesen
Phylum Phaeophyta
<i>Cystoseira zosteroides</i> (Turner) C. Agardh
<i>Dictyopteris membranacea</i> (Stackhouse) Batters
<i>Dictyota dichotoma</i> (Hudson) Lamouroux
<i>Halopteris filicina</i> (Grateloup) Kützing
Phylum Rhodophyta
* Unidentified encrusting corallinaceae
<i>Fauchea repens</i> (C. Agardh) Montagne
* <i>Peyssonnelia squamaria</i> (Gmelin) Decaisne
<i>Sphaerococcus coronopifolius</i> (Goodenough et Woodward) C. Agardh
Phylum Porifera
<i>Aaptos aaptos</i> Schmidt
<i>Acanthella acuta</i> Schmidt
<i>Aplysina cavernicola</i> (Vacelet)
<i>Axinella damicornis</i> (Esper)
<i>Cacospongia</i> cfr. <i>mollior</i> (Schmidt)
<i>Cacospongia scalaris</i> (Schmidt)
* <i>Chondrosia reniformis</i> Nardo
<i>Clathrina clathrus</i> (Schmidt)
<i>Clathrina coriacea</i> (Montagu)
Clionidae spp.
<i>Crambe crambe</i> (Schmidt)
<i>Dysidea avara</i> (Schmidt)
<i>Dysidea fragilis</i> (Montagu)
<i>Eurypon major</i> Sarà and Siribelli
<i>Haliclona mediterranea</i> Griessinger
<i>Ircinia variabilis</i> (Schmidt)
<i>Oscarella lobularis</i> (Schmidt)
<i>Petrosia ficiformis</i> (Poiret)
<i>Pleraplysilla spinifera</i> (Schulze)
<i>Scopalina lophyropoda</i> (Schmidt)
<i>Spirastrella cunctatrix</i> Schmidt
<i>Spongia agaricina</i> Pallas
<i>Spongia officinalis</i> Linnè
Phylum Cnidaria
<i>Caryophyllia smithii</i> Stokes and Broderip
<i>Cladocora caespitosa</i> (Linnaeus)
<i>Corynactis viridis</i> Allman
* <i>Eunicella singularis</i> (Esper)
<i>Eunicella verrucosa</i> (Pallas)
Unidentified hydroids
* <i>Leptogorgia sarmentosa</i> (Linnaeus)
<i>Leptopsammia pruvoti</i> Lacaze-Duthiers
* <i>Paramuricea clavata</i> (Risso)
* <i>Parazoanthus axinellae</i> (Schmidt)
<i>Parerythropodium coralloides</i> (Pallas)
<i>Polycyathus muelleriae</i> (Abel)
<i>Sertularella crassicaulis</i> (Heller)
Phylum Annelida
<i>Filograna implexa</i> Berkeley
<i>Serpula vermicularis</i> Linnaeus
Unidentified serpulids
Phylum Bryozoa
<i>Chartella papyrea</i> (Pallas)
<i>Fron dipora verrucosa</i> (Lamouroux)
<i>Margaretta cereoides</i> (Ellis et Solander)
* <i>Pentapora fascialis</i> (Pallas)
<i>Schizomavella cuspidata</i> (Hincks)
<i>Scrupocellaria reptans</i> (Linnaeus)
<i>Sertella septentrionalis</i> Harmer
<i>Smitina cervicornis</i> (Pallas)
<i>Turbicellepora avicularis</i> (Hincks)
Phylum Chordata
<i>Halocynthia papillosa</i> (Linnaeus)

plot. After identification of the main groups of photostations, similarity percentage analysis (SIMPER from the PRIMER - Plymouth Routines In Multivariate Ecological Research) was used to determine the taxa most responsible for any significant multivariate differences detected among groups of photostations (Clark, 1993). Taxa that made percentage contributions higher than 10% to similarity were identified as being more important components of the assemblages.

A two-way crossed analysis of similarities (ANOSIM) without replication was applied to the similarity matrix in order to test differences among transects (Clark and Warwick, 1994).

RESULTS

A total of 59 species (or major taxonomic ranks) were identified (Table 1). They belonged to six main groups: Algae (10), Porifera (23), Cnidaria (13), Hydrozoa and Anthozoa, Serpulidea (3), Bryozoa (9) and Ascidiacea (1).

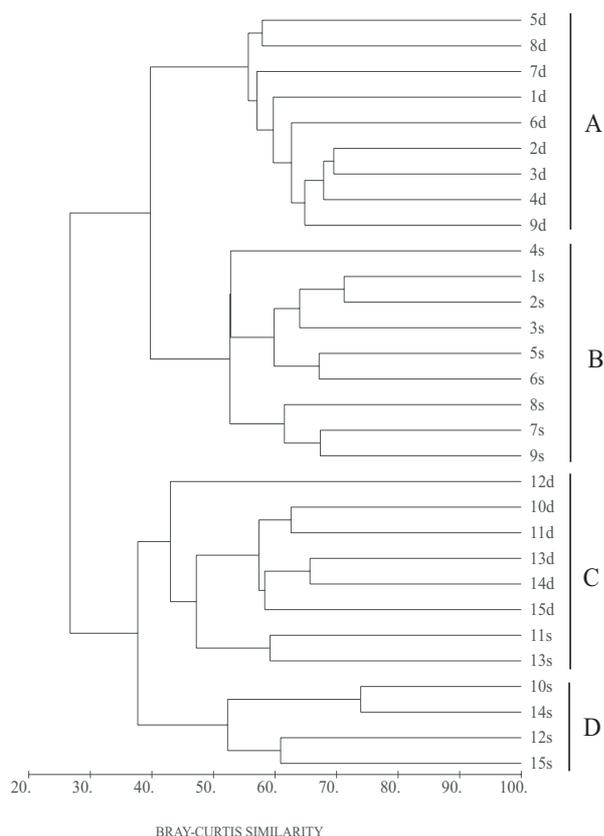


FIG. 2. – Bray-Curtis similarity plot following arcsin data transformation (based on species cover values) analysing similarity among photostations.

Cnidarians, mainly represented by erect species, showed the highest cover values (52%), due particularly to the gorgonians *Paramuricea clavata* which reached up to 69% on deeper vertical walls and *Lepetogorgia sarmentosa*, *Eunicella singularis* and to a lesser extent *Eunicella verrucosa* which altogether covered up to 89% of substratum on muddy bottom. Hydroids were generally epibionts on sponges or gorgonians, whereas *Sertularella crassicaulis* belonged to the higher stratum. The carpeting madreporarians *Leptopsammia pruvoti* and *Polycyathus muelleriae* grew on vertical substrate and *Parazoanthus axinellae* was also present as epibiont on the sponge *Axinella damicornis*.

Algae, the second major taxon (20% cover), were represented by encrusting corallinaceae, mainly belonging to genus *Mesophyllum* and *Pseudolithophyllum*, and the foliose *Peyssonnelia squamaria*, typical components of coralligenous communities; the sciaphilic, arborescent rhodophyte *Sphaerococcus coronopifolius*, the chlorophyte *Flabellia petiolata* and the phaeophyte *Cystoseira zosteroides* were also present.

Poriferans (16.5% cover) thrived both in the lower stratum with the encrusting *Scopalina lophyropoda*, *Oscarella lobularis*, *Dysidea avara* and with the massive *Chondrosia reniformis*, *Petrosia ficiformis*, *Aplysina cavernicola*, *Cacospongia scalaris*.

Large, massive colonies of the bryozoan *Pentapora fascialis* contributed greatly to the total percent cover of the taxon (10.4%), together with the erect *Smittina cervicornis* and the encrusting *Schizomavella cuspidata*.

The other taxa contributed poorly to cover values (1.1%).

The cluster analysis based on cover values of conspicuous species showed four clear groups of photostations with about 40% similarity between them (groups A to D in Fig. 2). Groups A and B separated precisely deep and shallow photostations on the western and northern vertical walls of the shoal. Group C contained deep photostations on the eastern and southeastern side plus two shallow photostations of the same area, whereas Group D comprised one small outlying cluster consisting of four shallow photostations.

The MDS plot (stress value = 0.13)(Fig. 3) indicated separation between these groups, with a much closer grouping of the eastern and southeastern photostations (groups C and D). A greater variability was evidenced among deep photostations than among shallow ones. Analysis of similarity among

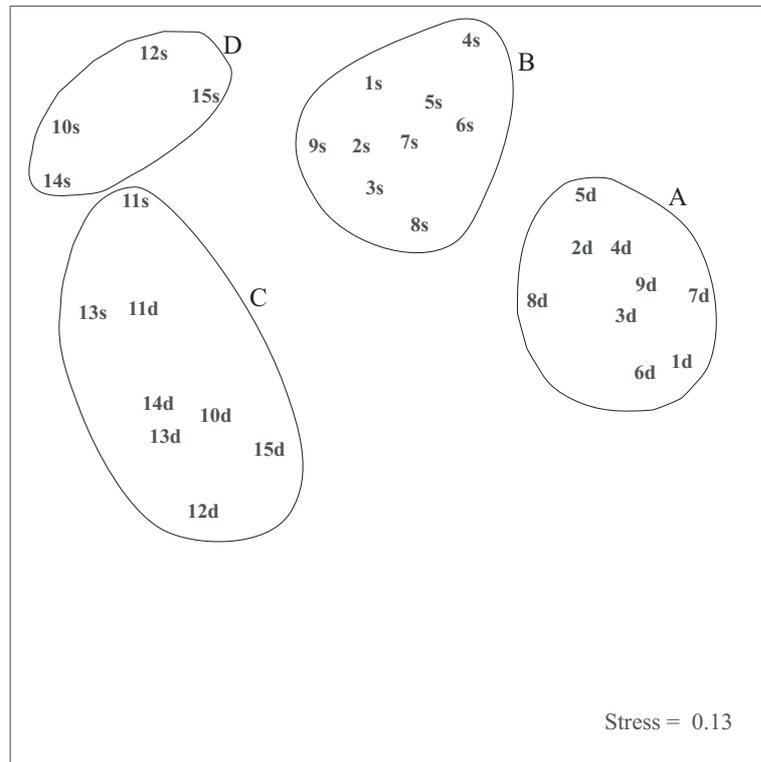


FIG. 3. – MDS plot generated from similarity matrix based on species cover values for the 30 photostations.

transects using ANOSIM showed significant differences (global $R = 0.721$, significant level = 0.0%).

Two to four species characterised each group of photostations, according to SIMPER analysis. Assemblages thriving on deeper, vertical walls, corresponding to group A, were dominated by the gorgonian *Paramuricea clavata* and the sponge *Chondrosia reniformis*, whereas on shallower walls (group B), the encrusting corallines, *Parazoanthus axinellae* and the sponges *Scopalina lophyropoda* were the most important component of the assemblage. On the east side of the shoal, the gorgonians *Leptogorgia sarmentosa* and *Eunicella singularis* were consistently important in deeper bottoms (group D), whereas on shallower bottoms the sciaphilic algae (encrusting corallines, *Peyssonnelia squamaria* and *Flabellia petiolata*) and the bryozoan *Pentapora fascialis* formed the main contribution to the characterisation of the assemblage (group C).

DISCUSSION

The sciaphilic epibenthic communities identified at Tinetto shoal match those conventionally

described for the northwestern Mediterranean under the name of ‘coralligène de la roche littorale’ (Pérès and Picard, 1964) rather well. They develop at nearly the same depth as in the Banyuls-sur-Mer area, which was considered the shallowest record in the northwestern basin.

Notwithstanding the limited extension of the area, distinction between communities is expressed sharply in term of species composition, particularly for deeper communities, as evidenced in the MDS analysis. The community of *Paramuricea clavata* characterises deeper, vertical surfaces; the gorgonian forms dense populations in the upper stratum, which in turn serve as a substrate for other cnidarians (*Parerythropodium coralloides*) and hydroids; a rich and diverse stratum, composed of both massive and encrusting sponges (*Chondrosia reniformis*, *Oscarella lobularis*), carpeting madreporarians (*Leptopsammia pruvoti*) and encrusting bryozoans (*Schizomavella cuspidata*) are present beneath the gorgonians. *Paramuricea clavata* community distribution, common all along northwestern Mediterranean rocky bottoms (Gili *et al.*, 1989), is known to depend upon low irradiance and intense water flow (Riedl, 1966; Weinberg, 1978).

On horizontal and medium inclination, sediment-covered substrata, on boulders on soft sediment and in areas with turbid water and strong currents, *Lepetogorgia sarmentosa* exhibits dense populations (Mistri and Ceccherelli, 1993). On the eastern and southeastern side of the Tinetto shoal, gorgonians characterise the upper stratum of the deeper community (6.8 ± 3.0 S.D. colonies m^{-2} ; Mistri, 1995a), together with *Eunicella singularis* and *Eunicella verrucosa*. The gorgonians provide substrate for small, slender branched colonies of *Pentapora fascialis*, which display the typical zoarial morphology as an epibiont (Cocito and Ferdeghini, 2000). There is a large number of muddy sediment patches with few encrusting sponges (*Eurypon major* and *Dysidea fragilis*). It is worth mentioning that *L. sarmentosa* was observed up to 17 m depth, thereby confirming earlier data of Weinberg (1976), who found the species in very turbid water at a minimum depth of 18 m.

Cnidarians constitute one of the dominant groups of benthic organisms in sciaphilic communities where algal growth is limited by low light irradiance (Gili and Ballestreros, 1991). In the Tinetto shoal bathymetric distribution of the two communities dominated by cnidarians is likely to be strongly influenced by the low light irradiance, the parameter being controlled by suspended matter. On the eastern side of the Tinetto shoal, the abundance of fine suspended particles, the deposition of a large amount of sediment (Morganti *et al.*, 2000) and the surface sediment composition (more than 80% of silt) (Anselmi, 1983) create environmental conditions suitable for some ecologically adapted species such as *L. sarmentosa* (Weinberg, 1978), which are typical of muddy detritic bottoms (Cocito *et al.*, 1997). A community similar in composition was already described in the neighbouring area, characterised by high turbidity and abundant biodebris on the bottom (Peirano and Sassarini, 1992).

Recently it has been demonstrated that encrusting corallines are able to survive, grow, and reproduce beneath sediment with little adverse effect (Airoldi, 1999). In the study area, corallinaceae algae belonging to bioconstructor species show a low contribution to total cover, in contrast with the literature (Morganti *et al.*, 2000).

Shallower communities display differences from the deeper ones mainly due to the lack of erect stratum. The epibenthic communities are characterised by the presence of sciaphilic species: a community dominated by large, massive colonies of *Pentapora*

fascialis with a basal stratum of sciaphilic algal species such as *Flabellia petiolata* and *Peyssonnelia squamaria* (Boudouresque, 1984) patched with sediment on rocky slopes of medium inclination. Vertical walls, on the other hand, are characterised by a facies of coralligenous communities, as defined by Ros *et al.* (1985), composed of sponges (*Scopalina lophyropoda*, *Chondrosia reniformis*, *Oscarella lobularis*, *Aplysina cavernicola*) and zoantharians (*Parazoanthus axinellae*).

Even if light has been considered the major factor influencing occurrence and depth distribution of coralligenous assemblages in the Mediterranean Sea (Pérès and Picard, 1964; Ros *et al.*, 1985), other spatially different processes that influence distribution should be considered. In a neighbouring shoal Cocito *et al.* (1997) analysed the influence of water current and bottom topography on the distribution of growth forms and trophic guilds of epibenthic communities. In the Tinetto shoal, bottom topography seems to be one of the major structuring parameters responsible for community distribution, as evidenced in the MDS analysis: vertical wall communities are clearly differentiated from medium inclination substrata communities. The interaction between topography and hydrodynamics (Hiscock, 1983), and consequently the different siltation rates experienced by organisms, may be responsible for much of the small-scale spatial distribution in subtidal epibenthic communities (Barry and Dayton, 1991), as observed in the Tinetto shoal. The sharp zonation displayed by the four communities seems not to be a distinctive pattern of the neighbouring island complex in the Gulf of La Spezia (Cocito, unpublished data). Analysis of distribution patterns of coralligenous communities requires extension to the islands complex in the Gulf of La Spezia in order to verify whether different factors may act in neighbouring areas displaying the same topography but on a larger scale.

Moreover, lack or scarcity of baseline data on the density and structure of the coralligenous communities makes it necessary to perform quantitative studies in order to understand the influence not only of biotic and abiotic factors, but also mass-mortality events, particularly on communities characterised by high resilience. Gorgonians and other sessile, dominant species which are typical components of coralligenous communities, grow slowly (Mistri, 1995b), live for many years and have slow population dynamics. Detailed, long-term quantitative studies on sublittoral epibenthic assemblages, par-

ticularly on coralligenous communities, are needed if we are to gain a thorough understanding of the response and direction of change in such communities.

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