

Polychaete assemblages of rocky shore along the South Adriatic coast (Mediterranean Sea)

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Abstract: The present study deals with the distribution of hard substratum polychaete assemblages under different environmental conditions. Samples were collected along a stretch of coast from Torre Guaceto to Otranto (Southern Adriatic Sea, Italy), in three transects perpendicular to the coast from 5 to 25 m in July 2000, by scraping off 400 cm². A total of 3188 specimens, belonging to 118 taxa were collected. Multivariate analysis showed that polychaete assemblages differed among depths with a clear difference between the shallowest sites (5 m) and the deeper ones (15-25 m). A variation among sites was also observed, with highest differences among sites within samples collected at 5 m depth, and with a sharp separation of some samples relative to Torre Guaceto from the remaining ones. Some potential causes for the observed differences both within and among sites were hypothesized and discussed, as well as the usefulness of polychaete assemblage analysis as descriptor of different environmental situations.

Résumé: *Assemblage de Polychètes des substrats rocheux de la côte sud de l'Adriatique (Méditerranée).* La distribution des assemblages de polychètes de substrat dur est étudiée dans différentes conditions d'environnement. Les échantillons ont été recueillis le long des côtes de la Mer Adriatique méridionale (Italie), dans trois secteurs perpendiculaires à la côte, de 5 à 25 m de profondeur (Torre Guaceto, Cerano, Otranto) en Juillet 2000, par un grattage de 400 cm². Un total de 3188 spécimens appartenant à 118 taxa ont été recueillis. L'analyse multivariante indique que les assemblages de polychètes varient avec la profondeur avec une différence marquée entre les localisations de faible profondeur (5) et celles plus profondes (15-25 m). Des différences ont été notées en fonction de la localisation, avec les plus grands écarts pour celles situées à une profondeur de 5 m et avec une séparation très marquée de certains échantillons de Torre Guaceto. Les raisons possibles des différences constatées entre les sites et à l'intérieur d'un même site, font l'objet d'hypothèses et sont débattues, de même que l'utilité de l'analyse du groupement de polychètes comme marqueur des différentes conditions d'environnement.

Keywords: Polychaetes, Rocky shores, Mediterranean Sea, Monitoring.

Introduction

The present paper is part of a larger work performed along the Apulian coast in order to increase the knowledge on polychaete diversity of this area.

The area considered here, the south Adriatic coast from Torre Guaceto to Otranto (Salento), results up to now scarcely studied as far as polychaetes inhabiting hard bottom. Information concerning this group is dated (Sarà 1968; Parenzan, 1983; Damiani et al., 1988), and the only recent works carried out within this area come from our laboratory: Fraschetti et al. (2002) Musco et al. (in press), and Giangrande et al. (in press).

The paucity of the studies on hard bottom polychaetes is in contrast with the particular importance that this area has from a biogeographical point of view (Sarà, 1967), and with the presence of a large variety of different and interesting habitats (Sarà, 1969; Damiani et al., 1988), including the coralligenous formations, a relatively poor studied biocoenosis in the whole Mediterranean area as far as the polychaete syntaxon. Most of the studies on Mediterranean polychaetes are in fact relative to the infralittoral superficial fringe (Bellan, 1969; 1971; Katzmann, 1971; Fresi et al., 1984; Cantone, 1985; Acero & San Martin, 1986; Abbiati et al., 1987; Sardá, 1987; Giangrande, 1988; Somaschini, 1988; Alós, 1999; Badalamenti et al., 1999; Lopez & Vietez, 1999; Tena et al., 2000), while data on deeper communities are very scant (Bellan, 1961; Laubier, 1966; Sarà, 1968; Sardá, 1991).

Notwithstanding the aim of the paper was mainly to realize an inventory of the polychaetes fauna of the Apulian coast, the examination of areas submitted to different human impact gave also the chance to observe polychaete assemblages under different environmental conditions, thus providing a preliminary evaluation of the usefulness of this group in hard bottom monitoring works.

Polychaete assemblages have been widely utilized within monitoring studies especially concerning soft-bottom environments (Bellan, 1980; Diaz-Castaneda, 1987; Nicolaidou et al., 1987; Oyarzún et al., 1987; Bellan et al., 1988; Amaral et al., 1998; Samuelson, 2001), whilst their use in hard bottom monitoring is less common (Bellan, 1980). This is probably due to the difficulty in quantitative sampling, extraction and comparison among different substrata, coupled with the lack of specialists for their identification (Giangrande, 2003). Moreover, the application of a correct experimental design with a great number of replicates (Underwood, 1993; Chapman et al., 1995; Underwood et al., 1996) becomes difficult considering taxa at specific level, especially within sublittoral rocky bottom environments, and considering the mat-like habitats with the extremely diverse assemblage of small cryptic invertebrates (Kelaher et al., 2001). For this reason, in this environment, monitoring is often carried out considering only macroscopic encrusting organisms, and involving non-destructive sampling by permanently marked quadrats or transects resurveyed visually or photographically (Fraschetti et al., 2001), and the response of vagile invertebrates to the environmental changes remains largely unknown (Moore, 1972). By contrast, these organisms, on account of their short lifespan, can respond faster to disturbance than encrusting macrobenthos. Among the vagile invertebrates inhabiting mat-like habitats, polychaetes are one of the best represented group (Bellan-Santini, 1969), and their abundance and their diversified feeding types make them suitable organisms for

investigating biological processes and physical factors responsible for structuring patterns of biodiversity.

Materials and methods

Study area and sampling

The three examined sites, Otranto, Cerano and Torre Guaceto (Fig. 1), are located about 80 km apart along the Adriatic coast of Apulia, and provide comparable habitats in terms of type of substratum. The choice of the sampling sites was made in order to examine a large array of environmental situations. Otranto is an area recently included in a list of European Marine Biodiversity Research Sites selected because of its pristine status (BIOMARE, www.pml.ac.uk/biomare/site.htm). Cerano is instead an area largely influenced by the presence of industries; lastly Torre Guaceto is an already functioning protected area.

Samples were collected during July 2000, by SCUBA divers through scraping off the rocky substratum on a surface of 20 x 20 cm. At each site, samplings were collected at three depths (5, 15, and 25 metres) with a similar vertical substratum orientation for each sample. However, at Otranto, the 25 m depth is located closer to the coastline, this means that the slope of the coast is higher in this site compared to the other two sites. After collection, samples were fixed in 8% formaldehyde solution. Polychaetes were sorted under a binocular microscope, preserved in 70% ethanol and taxonomically identified and counted. Nomenclature followed San Martin (1984), Castelli et al. (1995) and Licher (1999). After polychaete extraction the substratum was analysed and encrusting organisms were identified for the substratum characterization. Due to the difficulty in identification, some organisms were grouped within morphological and/or ecological categories.

Data analysis

Shannon Weaver Diversity index and Pielou Evenness were calculated for polychaetes assemblages. Species were also classified within trophic categories according to Fauchald & Jumars, 1979, revised by Giangrande et al., 2000 as far as the family Syllidae is concerned, integrated with some personal observations (Unpublished data).

Data for polychaetes and encrusting organisms were arranged in two taxon/sample matrices and analysed separately by multivariate techniques. A matrix of abundance was analysed for polychaetes, after square root transformation of data, to give rise to rarer taxa and prevent few abundant species from dominating the analyses. A semi quantitative matrix was instead computed in the case of substratum matrix (very abundant, abundant, scarce). Bray-Curtis similarity values (S_{BC}) were calculated (PRIMER, Clarke, 1993). Polychaete ranks of similarity were

represented in a dendrogram plot (CLUSTER ANALYSIS). Similarity values were also represented by non-metric multidimensional scaling ordinations (MDS Clarke, 1993) for both groups, polychaetes and encrusting organisms. Stress values were also shown to indicate the goodness of representation of differences among samples.

Results

Polychaetes

A total of 3188 specimens belonging to 118 taxa were collected, of which, 114 identified at species level (Table I). On the whole, 18 families were recorded. Among them, Syllidae was the family characterized by the higher richness (55 taxa), followed by Serpulidae (15 taxa), Sabellidae (12), Eunicidae (10) and Nereididae (6).

Qualitative, but mostly quantitative changes were observed in all sites along the depth gradient, with increasing abundance of some species such as *Eusyllis lamelligera*, *Kefersteinia cirrata*, *Nereis rava*, *Syllis pulvinata*, and *S. garciai*, and a decrease of some others, such as *Lysidice ninetta*, and *Nereis zonata*, whilst other species such as *Eunice vittata*, and *Syllis gerundensis* were completely absent at the shallowest depth (5 m). Most of the species, however, seemed to be linked to the intermediate depth (15 m).

Differences in species composition among the three sites were not high. A pool of abundant species was common to all sites: *Lysidice ninetta*, *L. collaris*, *Amphiglena mediterranea*, *Nereis rava*, *Eurysyllis tuberculata*, *Grubeosyllis clavata*, *Sphaerosyllis hystrix*, *S. pirifera*, *Syllis gerlachi*, and *S. prolifera*. All these species increased in number of individuals at Torre Guaceto, with the exception of the two *Lysidice* species. Quantitative difference among sites were also found within less abundant species belonging to the genus *Syllis*, which increased in abundance at Torre Guaceto as well, with exception of *S. pulvinata* decreasing in abundance in this site. Finally, some small Exogoninae were completely absent at Cerano site.

These patterns are well described by the trends of abundance and number of species relative to each site at each investigated depth (Fig. 2a). As a whole lower values for abundance and number of species were recorded at 5 m depth, with the lowest recorded at Cerano, while the maximum at 15 m depth, with the exception of Cerano site, where the maximum of number of species was recorded at 25 m depth. The highest values for both number of individuals and species were recorded at Torre Guaceto site at all the examined depths, while the lowest densities were observed at Cerano, together with the lowest number of species. Species number trend was instead quite similar both at Torre Guaceto and Otranto sites. A similar pattern could be observed considering Syllidae family alone (Fig. 2b).

Despite the difference recorded, especially in the abundance, the Diversity index did not show high differences among sites (Fig. 2c). Otranto and Torre Guaceto showed respectively the highest and the lowest Evenness values. As far as the depth gradient is concerned (Fig. 2d), Diversity and Evenness increased with depth, with the highest values recorded at the deepest samples. The lowest value for Diversity was recorded at Cerano 5 m depth and for Evenness at Torre Guaceto 5 m depth. In all samples located at 15 m depth, where abundance and species richness resulted higher, the Evenness had always low values.

Distribution of feeding groups is shown in Fig. 3. Trophic structure of the three sites, expressed as relative percentage of the categories for all the depths at each site, revealed as Filter-feeders and Carnivores were always poorly represented. Otranto was the site where the remaining groups (Herbivores, Deposit-feeders and Omnivores) were more equally represented (Fig. 3a), by contrast, Deposit-feeders were more abundant at Cerano (Fig. 3b), and Herbivores dominated at Torre Guaceto (Fig. 3c). This trend was also enhanced when the categories were analysed along the depth gradient within each site (Fig. 3d, e, f). Less differences among pattern of trophic categories of each depth, were found at Otranto, excluding a slight decrease of Herbivores. By contrast, at Cerano, Herbivores increased with depth, especially from 5 to 15 m depth, and Deposit feeders decreased, showing a high dominance at 5 m depth. An opposite trend was observed at Torre Guaceto where Deposit-feeders increased and Herbivores decreased along the deep gradient. In this last site, Herbivores dominate the community until 15 m depth. Comparing the three sites and examining category distributions at each depth, the higher differences in percentages were enhanced at 5 m where Deposit-feeders were dominant at Cerano and Herbivores at Torre Guaceto. By contrast, the patterns appeared more homogeneous among sites when category distribution at 25 m depth were considered.

In Fig. 4, the dendrogram relative to the polychaetes assemblages is shown. Similarity is always under the 50%. The shallowest samples relative to Cerano and Otranto were firstly separated from the remaining ones, which in turn were splitted between two clusters, a first containing Torre Guaceto samples relative to 5 and 15 m depths, a second containing the 15 and 25 m depths of the all sites, clearly excluding 15 m relative to Torre Guaceto.

The MDS model relative to the polychaetes is shown in Fig. 5a. Samples were scattered according with depth with the superficial ones on the right and the deeper ones located at the bottom on the left of the model. The samples relative to Torre Guaceto, however, were separately located on the left of the model, with the exception of the deeper sample (25 m), which resulted close to the samples collected at the same depth in the other sites.

Table 1. List of the polychaete species collected. F: Filter feeders; H: Herbivores; C: Carnivores; D: Deposit feeders; O: Omnivores.
Tableau 1. Liste des polychètes récoltés. F : Filtreurs ; H : Herbivores ; C : Carnivores ; D : Dépositivores ; O : Omnivores.

APHRODITIDAE	POLYNOIDAE	<i>Exogone dispar</i> Webster, 1879 H
<i>Pontogenia chrysozona</i> (Baird, 1865) C	<i>Harmothoe spinifera</i> (Ehlers, 1864) C	<i>Exogone naidina</i> Oersted, 1845 H
CHRYSOPETALIDAE	SABELLIDAE	<i>Exogone rostrata</i> Naville, 1933 H
<i>Chrysopetalum debile</i> (Grube, 1855) C	<i>Amphicorina armandi</i> (Claparède, 1864) F	<i>Exogone verugeta</i> (Claparède, 1868) H
CIRRATULIDAE	<i>Amphiglena mediterranea</i> (Leydig, 1851) F	<i>Grubeosyllis clavata</i> (Claparède, 1863) H
<i>Caulerliella bioculata</i> (Keferstein, 1862) D	<i>Branchiomma lucullanum</i> (Delle Chiaje, 1828) F	<i>Grubeosyllis limbata</i> (Claparède, 1868) H
DORVILLEIDAE	<i>Chone collaris</i> Langerhans, 1880 F	<i>Grubeosyllis vieitezi</i> (San Martin, 1984) H
<i>Dorvillea rubrovittata</i> (Grube, 1855) H	<i>Demonax langerhansi</i> Knight-Jones, 1983 F	<i>Grubeosyllis yraidae</i> (San Martin, 1984) H
EUNICIDAE	<i>Demonax tenuicollaris</i> Grube, 1870 F	<i>Haplosyllis spongicola</i> (Grube, 1855) C
<i>Eunice harassii</i> Audouin & M. Edwards, 1834 C	<i>Fabricia stellaris</i> (Müller, 1774) F	<i>Odontosyllis fulgurans</i> (Audouin & M. Edwards, 1833) H
<i>Eunice oerstedii</i> Stimpson, 1854 C	<i>Hypsicomus stichophthalmos</i> (Grube, 1863) F	<i>Odontosyllis gibba</i> Claparède, 1863 H
<i>Eunice pennata</i> (Müller, 1776) C	<i>Jasmineira elegans</i> Saint-Joseph, 1884 F	<i>Parapionosyllis brevicirra</i> Day, 1954 D
<i>Eunice torquata</i> Quatrefages, 1865 C	<i>Megalomma vesiculosum</i> (Montegu, 1815) F	<i>Parapionosyllis minuta</i> (Pierantoni, 1903) D
<i>Eunice vittata</i> Delle Chiaje, 1889 C	<i>Perkinsiana rubra</i> (Langerhans, 1880) F	<i>Pionosyllis lamelligera</i> Saint-Joseph, 1887 D
<i>Lysibranhia paucibranchiata</i> Cantone, 1983 O	<i>Pseudopotamilla reniformis</i> (Bruguiere, 1789) F	<i>Pionosyllis morenoe</i> San Martin, 1984 D
<i>Lysidice collaris</i> Grube, 1870 D	SERPULIDAE	<i>Pseudosyllis brevipennis</i> Grube, 1863 D
<i>Lysidice ninetta</i> Audouin & M. Edwards, 1833 D	<i>Filograna</i> sp F	<i>Sphaerosyllis cryptica</i> Ben-Ehliou, 1977 H
<i>Nematonereis unicornis</i> (Grube, 1840) D	<i>Hydroides elegans</i> (Haswell, 1883) F	<i>Sphaerosyllis hystrix</i> Claparède, 1863 H
<i>Palola siciliensis</i> (Grube, 1840) C	<i>Hydroides helmatus</i> (Iroso, 1921) F	<i>Sphaerosyllis pirifera</i> Claparède, 1868 H
GLYCERIDAE	<i>Hydroides niger</i> Zibrowius, 1971 F	<i>Sphaerosyllis taylori</i> Perkins, 1981 H
<i>Glycera tessellata</i> Grube, 1863 C	<i>Hydroides pseudouncinatus</i> Zibrowius, 1968 F	<i>Sphaerosyllis xarifae</i> Hartmann-Schröder, 1960 H
GONIADIDAE	<i>Pomatoceros triquetra</i> (Linnaeus, 1767) F	<i>Syllides fulvus</i> Marion & Bobretzky, 1875 D
<i>Goniada maculata</i> Oersted, 1843 C	<i>Protula</i> sp. F	<i>Syllis compacta</i> Gravier, 1900 D
HESIONIDAE	<i>Semivermilia pomatostegoides</i> (Zibrowius, 1969) F	<i>Syllis armillaris</i> Müller, 1771 H
<i>Kefersteinia cirrata</i> (Keferstein, 1862) H	<i>Serpula concharum</i> Langerhans, 1880 F	<i>Syllis beneliahuae</i> Campoy & Alquezar, 1982 O
LUMBRINERIDAE	<i>Serpula vermicularis</i> Linnaeus, 1767 F	<i>Syllis bouvieri</i> Gravier, 1900 D
<i>Lumbrinereis coccinea</i> (Renier, 1804) C	<i>Spirobranchus polytrema</i> (Philippi, 1884) F	<i>Syllis columbretensis</i> (Campoy, 1982) H
<i>Lumbrinereis fragilis</i> (Müller, 1776) O	<i>Vermiliopsis infundibulum</i> (Linnaeus, 1788) F	<i>Syllis ferrani</i> Alòs & San Martin, 1987 O
<i>Lumbrinereis funchalensis</i> (Kinberg, 1865) O	<i>Vermiliopsis labiata</i> (Costa, 1861) F	<i>Syllis garciai</i> Campoy, 1982 O
<i>Lumbrinereis gracilis</i> (Ehlers, 1868) O	<i>Vermiliopsis monodiscus</i> Zibrowius, 1968 F	<i>Syllis gerlachi</i> Hartmann-Schröder, 1960 O
<i>Lumbrinereis tetraura</i> (Schmarda, 1861) O	<i>Vermiliopsis striaticeps</i> (Grube, 1862) F	<i>Syllis gerundensis</i> (Alòs & Campoy, 1981) D
NEREIDIDAE	SYLLIDAE	<i>Syllis hyalina</i> Grube, 1863 O
<i>Ceratonereis costae</i> (Grube, 1840) H	<i>Autolytus benazzi</i> Cognetti, 1853 C	<i>Syllis krohni</i> Ehlers, 1864 O
<i>Nereis rava</i> Ehlers, 1868 E	<i>Autolytus brachycephalus</i> (Marenzeller, 1874) C	<i>Syllis prolifera</i> Krohn, 1852 H
<i>Nereis</i> sp.	<i>Autolytus convolutus</i> Cognetti, 1953 C	<i>Syllis pulvinata</i> Langerhans, 1881 O
<i>Nereis zonata</i> Malmgren, 1867 H	<i>Autolytus edwardsi</i> Saint-Joseph, 1887 C	<i>Syllis rosea</i> (Langerhans, 1879) H
<i>Perinereis cultrifera</i> (Grube, 1840) C	<i>Autolytus prolifer</i> (Müller, 1788) C	<i>Syllis variegata</i> Grube, 1860 D
<i>Platynereis dumerilii</i> (Audouin & M. Edw., 1833) H	<i>Autolytus quindecimdentatus</i> Langerhans, 1884 C	<i>Syllis westheidei</i> San Martin, 1984 O
OENONIDAE	<i>Branchiosyllis exilis</i> (Gravier, 1900) C	<i>Trypanosyllis coeliaca</i> Claparède, 1868 D
<i>Arabella iricolor</i> (Montagu, 1804) C	<i>Brania arminii</i> Langerhans, 1880 H	<i>Trypanosyllis zebra</i> (Grube, 1860) D
OPHELIDAE	<i>Brania pusilla</i> Dujardin, 1839 H	<i>Xenosyllis scabra</i> (Ehlers, 1864) D
<i>Polyophthalmus pictus</i> (Dujardin, 1839) H	<i>Ehlersia ferrugina</i> (Langerhans, 1881) D	TEREBELLIDAE
PHYLLODOCIDAE	<i>Eurysyllis tuberculata</i> Ehlers, 1864 O	<i>Pista cristata</i> (Müller, 1776) D
<i>Notophyllum foliosum</i> (Sars, 1835) H	<i>Eusyllis assimilis</i> Marenzeller, 1865 D	<i>Streblosoma hesslei</i> (Day, 1955) D
<i>Phyllococe pusilla</i> (Claparède, 1868) H	<i>Eusyllis lamelligera</i> Marion & Bobretzky, 1875 D	
<i>Pterocirrus macroceros</i> (Grube, 1860) H	<i>Eusyllis</i> sp.	

Substratum characterization

In this area, the coast is mainly rocky, abruptly extending from the surface to about 30 metres. A dense fringe of the brown algae *Cystoseira amentacea* characterizes the shallow infralittoral zone. From the surface to 5-7 m depth, the rocky substratum is characterized by patches of hydroids and photophilic algae, and by less colonised patches of encrusting calcified red algae, encrusting and globose sponges. At 12-15 m, the assemblage is mainly characterized by both erected and encrusting algae, and by different species of sponges. Below 20 m, the substratum is constituted by the so-called "coralligenous formations", a

term broadly defining the secondary hard-substratum formed by encrusting calcified algae, Bryozoans, Serpulids and a complex biota inhabiting them (Sarà, 1969; Ros et al., 1985).

The 43 identified groups are reported in Table 2. In Fig. 5b the MDS relative to these data is shown. As in the case of polychaetes analysis, samples were scattered according to their depth with superficial ones on the left and deeper ones on the right. The only exception was the point relative to Otranto 15 m, which appeared closer to the points relative to 25 m depth of the other sites.

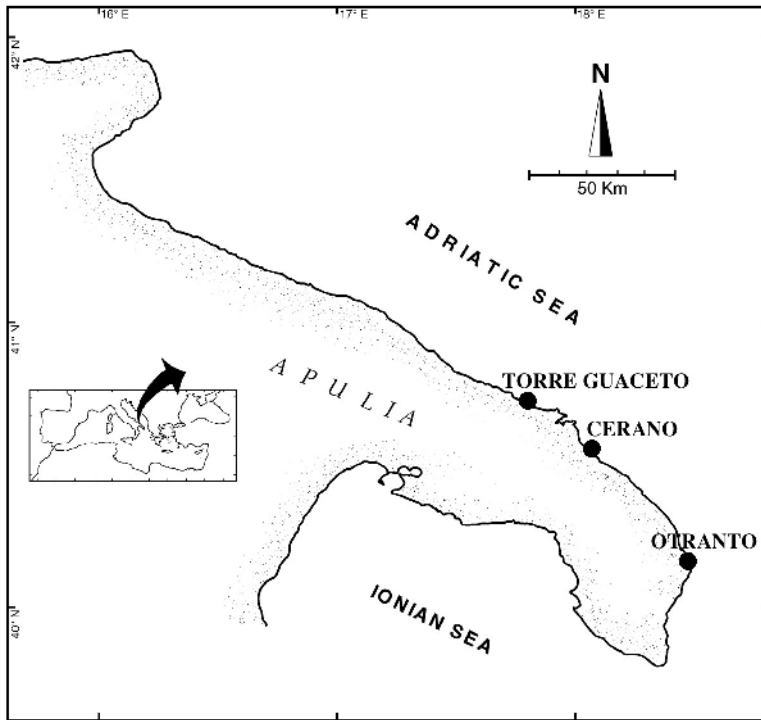


Figure 1. Map of the study area and location of sampling sites.
Figure 1. Carte de la zone d'étude et des sites de prélèvement.

Discussion

The high biodiversity shown by the polychaetes in the studied area is probably due to the variety of the examined habitats. Polychaete assemblages differed among depths, with a pattern of zonation from the shallower to the deepest stations. Changes in polychaete assemblages with depth were mainly quantitative along the vertical gradient, with most of the species linked to 15 m depth. A similar zonation pattern was already described in the Porto Cesareo area, along the Ionian Sea, where similar depths were analysed, even though with some differences in species composition (Corriero et al., in press).

Overall, the majority of the species collected below 5 m are known as typical of sciaphilous environments (Giangrande, 1988; Sardá, 1991). The knowledge of Mediterranean polychaete assemblages of sciaphilous environments, including coralligenous formations, is very scant and mainly limited to qualitative studies (Bellan, 1961; Laubier, 1966; Sarà, 1968; Sardá, 1991). As a consequence, there is no available information from previous studies allowing comparisons with present results.

A possible explanation for vertical gradient is the change in the features of substratum covering with depth. The architectural complexity of algal assemblage has been demonstrated to influence the structure of invertebrate

vagile assemblages (Abbiati et al., 1987; Giangrande, 1988; Chemello & Milazzo, 2002). In the studied area, a shift from photophilic algal assemblages, dominated by erected and fleshy species, towards sciaphilous algal assemblages, dominated by encrusting calcified algae, is present at about 15 m depth. Such differences in substratum complexity can be hypothesized as responsible for the differences observed and could justify the higher affinities between 15 m and 25 m assemblages.

The most suitable environment for polychaete colonization seems to be the intermediate depths where frondose and calcareous algae, producing a series of different microhabitats, constitute a conspicuous vegetal cover. This environment could be interpreted as an ecotone area where both photophilous and sciaphilous conditions are present. An increasing in abundance, number of species and diversity at intermediate depth, is also commonly observed in polychaete assemblage from soft-bottom environments, where mixed sedimentary conditions are present (Gambi & Giangrande, 1986).

In addition to changes occurring along the depth gradient, differences among sites at each depth were also observed. Once again differences were mostly quantitative, with an increase of density and number of species at Torre Guaceto. The most variable area resulted the 5 m depth, with the less richness recorded at Cerano and the less Evenness at Torre Guaceto, whilst more homogeneous seems to be the deep area (coralligenous), probably reflecting a more stable environmental situation.

This pattern is enhanced by multivariate analyses indicating that besides differences along the depth gradient, a horizontal variability in the structure of the polychaete assemblages also exists. Changes in substratum composition can be taken into consideration also to explain differences among sites within each depth. Patchiness in sessile assemblages has been recently quantified and demonstrated to be higher at 5 m than below (Terlizzi et al., unpublished data), and this could explain the higher differences observed at 5 m depth among sites.

The correspondence between substratum feature and polychaete assemblage is well illustrated by Otranto 15 m sample that in both models (polychaetes and substratum) is located close to the deepest samples, probably indicating a more sciaphilous component of the substratum at 15 m in this site. However, results arising from substratum model analysis are not completely overlapping with that from polychaetes. In the MDS analyses, depth gradient is enhanced for all the substratum samples, while 5 and 15 m

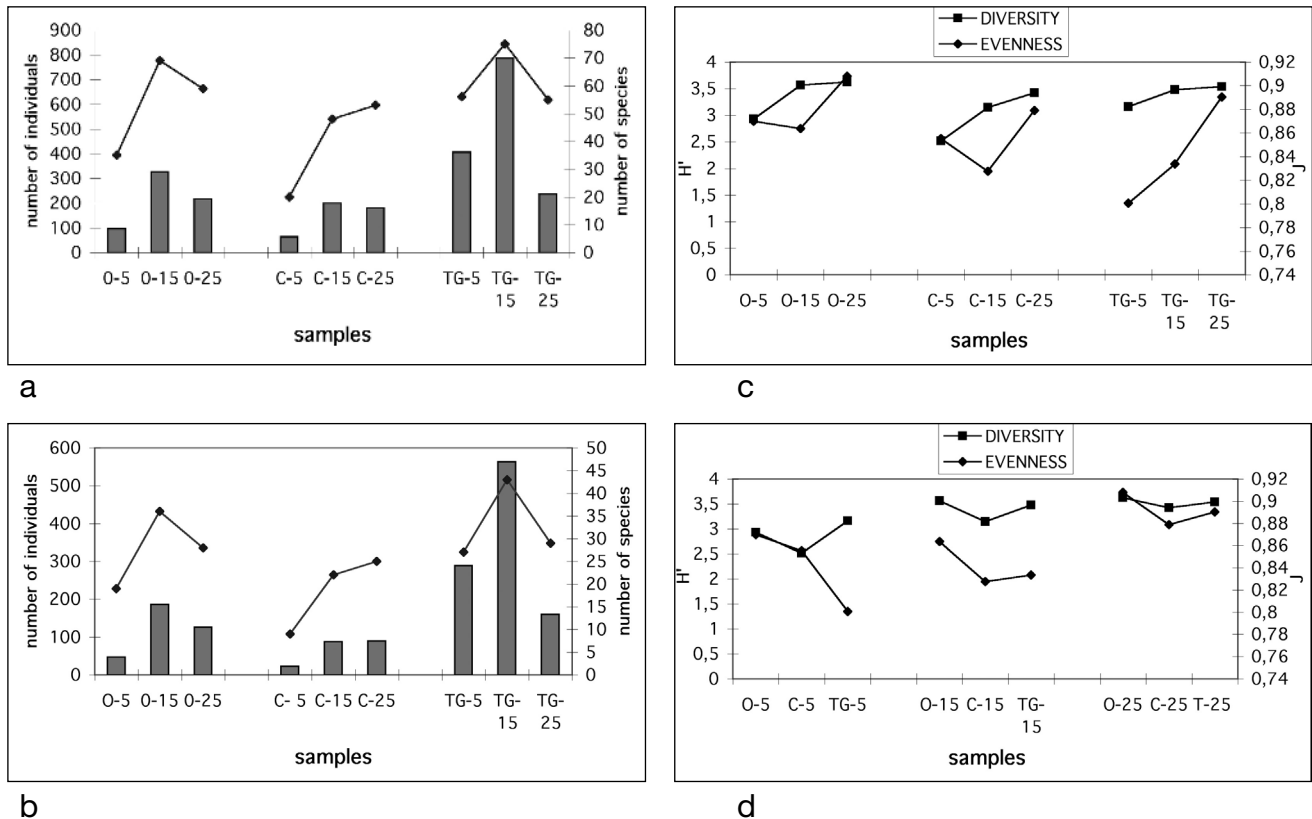


Figure 2. Trend of structural parameters in the three sites: a) Trend of abundance and species number relative to the whole polychaete assemblage; b) abundance and species number trend for the Syllidae only; c) Diversity and Evenness trend relative to the whole assemblage; d) The same of figure c, arranged to show the variation of the two parameters with depth. (O= Otranto; C= Cerano; TG= Torre Guaceto).

Figure 2. Tendances des paramètres structurels sur les trois sites : a) Tendance concernant l'abondance du groupe des Polychètes et la variété des espèces de l'ensemble ; b) Tendance concernant l'abondance et la variété des espèces pour la seule Syllidae ; c) Tendance de l'index de Diversité H' et de l'Evenness de l'ensemble ; d) Le même que figure c, corrigé pour montrer la variation des deux paramètres avec la profondeur. (O = Otranto ; C = Cerano ; TG = Torre Guaceto).

depths relative to polychaetes assemblage of Torre Guaceto are located outside this depth gradient, thus suggesting as the differences in polychaete assemblage relative to Torre Guaceto are not completely controlled by "abiotic factors" (e.g. the substratum). The same samples were also separated in the cluster analysis. The separation of these samples is probably due to a "density effect", coupled with a worst repartition of individuals among species, clearly illustrated by the analysis of variables such as Density, Diversity, and Evenness.

Notwithstanding present work was drawn as an inventory of polychaetes along the Apulian coast, data can be useful to evaluate hard bottom polychaetes as descriptors of different environmental situations. The Otranto site, which could be considered less influenced by human impact, among the examined site, shows intermediate values of density and number of species. In this site, the pattern relative to

abundance and species number resulted quantitatively similar to that observed at comparable depths in Porto Cesareo area, located along the Ionian coast (Corriero et al., in press), and characterized by low human impact as well.

The Cerano area, submitted to "negative impact", showed the lower number of species and Diversity. The decrease of this last variable, therefore, seems to remain a good indicator of presence of negative impact. In this area the Exogoninae, among Syllidae, seem to suffer from this kind of impact, probably on account of the high sedimentation rate here existing. Syllids are particularly good indicators of negative impact, suddenly disappearing with bad water quality, even when the macrobenthic organisms (substratum) are apparently not influenced (Musco et al, in press). As shown by the comparison between trends from the whole polychaetes and that relative to the Syllidae, this family seems to be highly indicative of the environmental conditions.

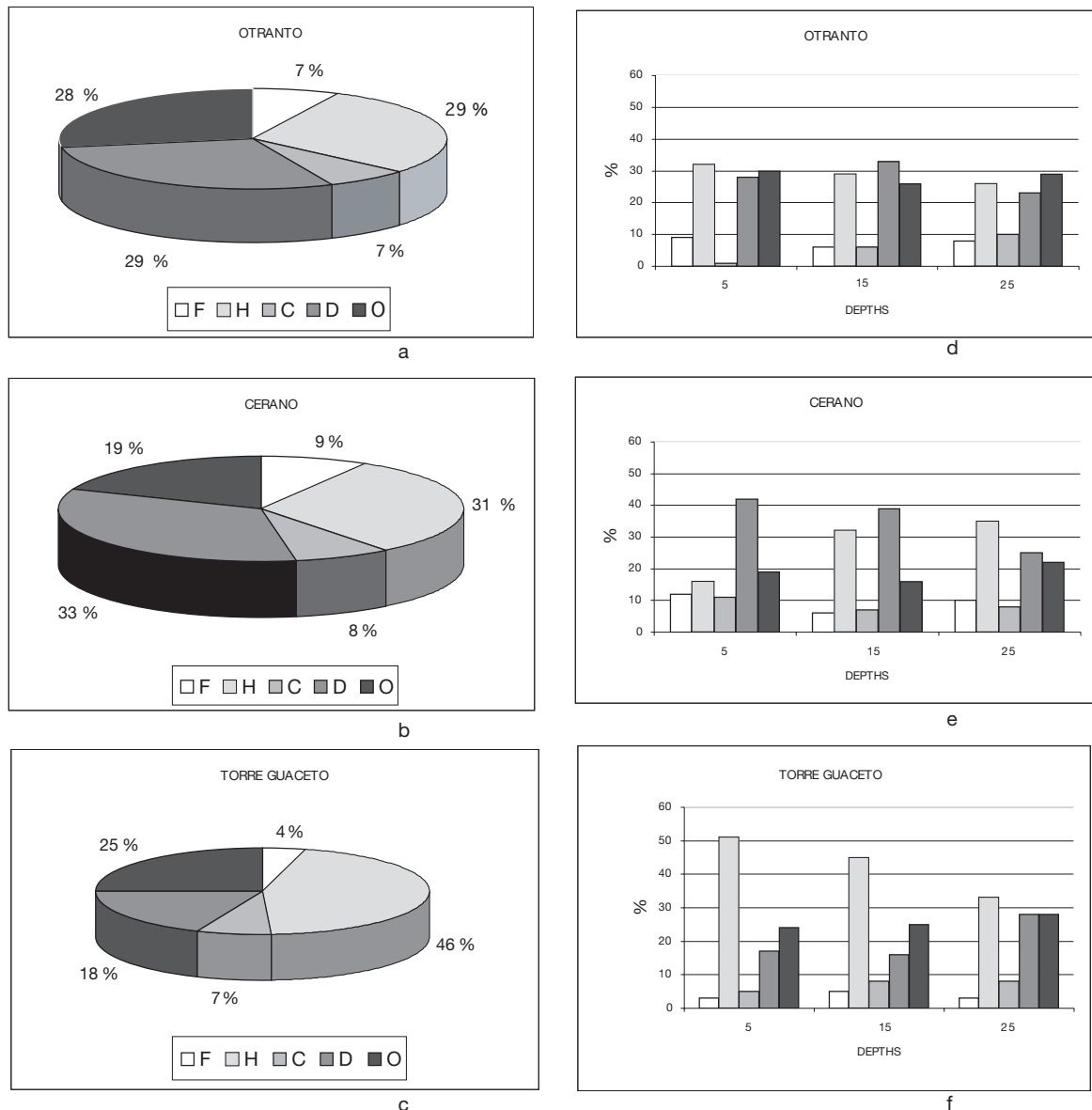


Figure 3. Comparison among trophic structure of the polychaete assemblages. The trophic structure of the sites considering all the depth in each site is showed on the left (a, b, c). The trend of category percentages with depth in each site is showed on the right.

Figure 3. Comparaison entre les structures trophiques des assemblages de Polychètes. La structure trophique des sites toutes profondeurs confondues est montrée à gauche (a, b, c). Les proportions des groupes trophiques pour chaque profondeur dans chaque site est montrée à droite.

Finally, the Torre Guaceto area, submitted to some “positive impact” (protection) showed no high variation in Diversity index and number of species, but high differences in Density and Evenness values, except for the deepest samples, which appear more homogeneous in all the sites.

The underlined variability existing mostly among 5 m samples, could also be due to the fact that this depth is most influenced by human activities.

The analysis of trophic structure seems to corroborate this pattern. The highest difference among sites is found at

5 m as well, while the deepest samples appear less variable between sites. Otranto is the site where all groups seems to be more equally represented, while the highest abundance of Deposit-Feeders at Cerano can account for the high sedimentation here existing. Finally, protection at Torre Guaceto, producing an increase in abundance, seems mainly to act on the Herbivore category here highly dominant.

As far as the modifications of structural and functional variables such as dominance of some taxa (high density and low Evenness), and dominance of Herbivores, occurring at

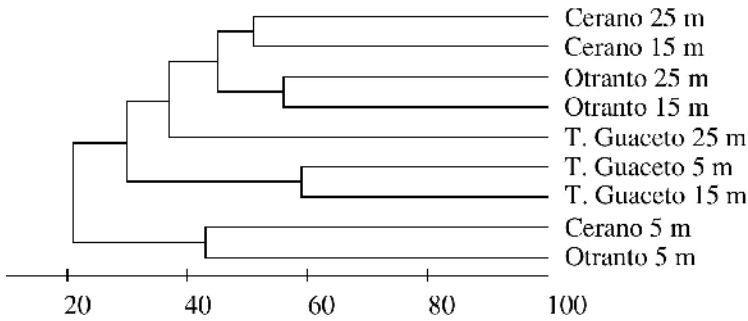
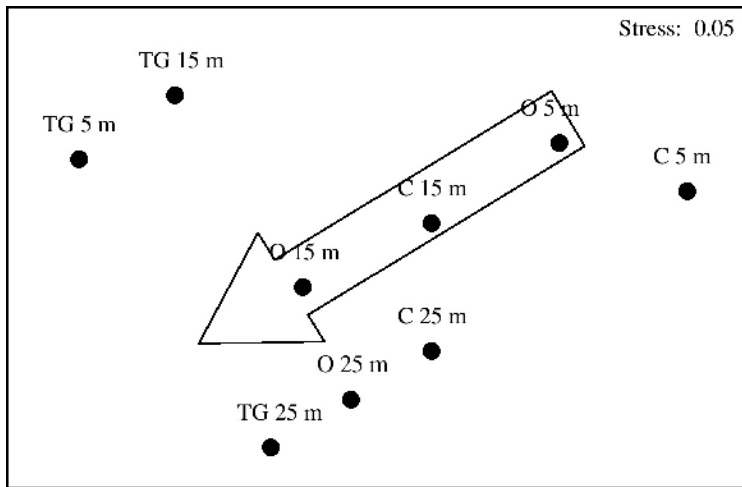
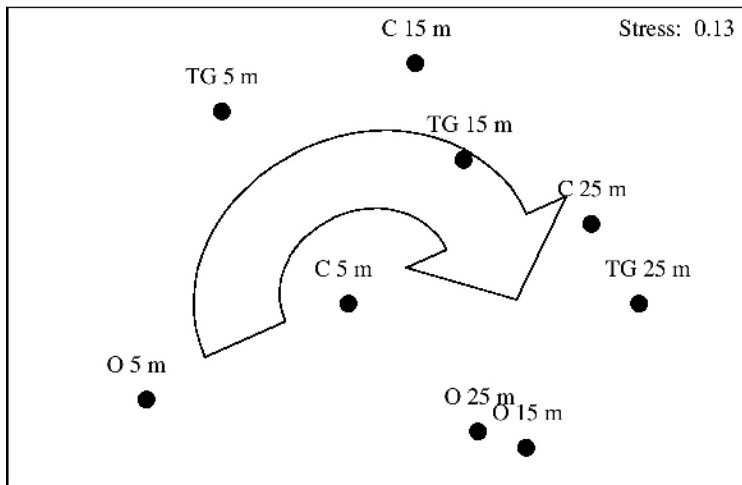


Figure 4. Dendrogram relative to polychaetes analysis

Figure 4. Dendrogramme relatif à l'analyse des Polychètes



a



b

Figure 5. MDS analyses: a) polychaetes; b) substratum

Figure 5. Analyses MDS a) Polychètes; b) substrat

Torre Guaceto, a possible explanation could be a decrease in abundance of polychaete predators as a consequence of protection. A lower predation rate was also invoked by Badalamenti et al. (1999) and Milazzo et al. (2000), to explain the increase of abundance of polychaetes and molluscs found studying an area submitted to protection as well. These authors suggested that the increase in abundance of these vagile invertebrates could be linked to the increasing abundance of piscivore species preying on small fishes, which in turn feed on small invertebrates (trophic cascade, Pinnegar et al., 2000). The same authors hypothesized that abundance and not diversity could be an indicator of protection, and this is in accordance to present observations. However, our data also indicated that the increasing in abundance is accompanied by a decrease in Evenness values.

In the present paper, the hypothesis of low predation rate can be corroborated by the observation that the high species increase in number of individuals at Torre Guaceto are that already more abundant in the other sites, which is more probable affected by a non-selective predation. Moreover this effect does not seem to be present in the endolithic species of the genus *Lysidice*.

High predation rate was already hypothesized by Gambi et al. (1995) as a factor explaining the assemblage structure of polychaete inhabiting *Posidonia* bed. In this environment, characterized by the presence of a large number of large sized Crustacea, polychaete assemblage is often characterized by a high number of species with very few individuals, especially compared to the abundance existing on hard bottom. Once again, the species mostly suffering from this "factor" controlling abundance are the more commonly abundant within hard bottom polychaete assemblages.

Clearly, the processes producing changes in polychaete assemblages on subtidal cliffs are likely to be complex and should require detailed experimental inspection. The influence of biotic factors such as predation, competitive interaction among resident species, food resources and recruit supplies, remain to be explored before invoking algal complexities as the only possible factors controlling the structure of polychaete assemblages. Such models must be analysed in detail in future manipulative experiments aimed at highlighting the processes influencing the

Table 2. List of the identified taxa characterizing the substratum
Tableau 2. Liste des taxons identifiés caractérisant le substrat

Algae	TTS Thin Tubular Sheet-like		<i>Chondrosia reniformis</i>
	CB Coarsely branched		<i>Cliona</i> spp.
	GFA - Green Filamentous Algae		ERS - Encrusting Red Sponges
	<i>Amphiroa</i> spp.		<i>Ircinia foetida</i>
	<i>Anadyomene stellata</i>		<i>Ircinia variabilis</i>
	<i>Codium bursa</i>		<i>Phorbas</i> spp.
	<i>Corallina</i> spp.	Antozoa	<i>Balanophyllia europea</i>
	AC - Articulated Corallinaceae-Cutleriales		<i>Caryophyllia</i> spp.
	<i>Dictyopteris polypoides</i>	Briozoa	<i>Cladocora caespitosa</i>
	Dictyotales		EB - Encrusting Bryozoans
	ECR - Encrusting Calcified		TRB - Thin Ramified Bryozoans
	Rodophytes		Celleporidae
	DFA - Dark Filamentous Algae		<i>Margaretta cereoides</i>
	<i>Flabellia petiolata</i>		<i>Myriapora truncata</i>
	Gelidiales		<i>Sertella</i> spp.
<i>Halimeda tuna</i>	Asciadiacea	<i>Pentapora similis</i>	
<i>Padina pavonica</i>		Didemnidae	
<i>Palmophyllum crassum</i>		<i>Diplosoma listerianum</i>	
<i>Peyssonnelia</i> spp.	Mollusca	<i>Halocynthia papillosa</i>	
<i>Tricleocarpa fragilis</i>		<i>Gastrochaena dubia</i>	
<i>Valonia macrophysia</i>		<i>Lithophaga lithophaga</i>	
Porifera	<i>Agelas oroides</i>	Hydrozoa	Vermetidae
	<i>Chondrilla nucula</i>		<i>Aglaophenia</i> spp.
			<i>Eudendrium</i> spp.

structure of invertebrate vagile assemblages on rocky substrata. We are therefore conscious that any consideration arising from present work is only speculative due to the lack of a detailed experimental design including replicates, and that the conclusion arising from present data, even if it gives the indication for a positive use of polychaetes in monitoring of hard substrates, can be considered an hypothesis for future investigations.

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References

- Abbiati M., Bianchi C.N. & Castelli A. 1987.** Polychaete vertical zonation along a littoral cliff in the west Mediterranean. *PSZN: Marine Ecology*, **8**: 33-48.
- Acero I. & San Martin G. 1986.** Poliquetas epibiontes del primer horizonte de algas fotofilas en las provincias de Cadiz y Malaga. Estudio faunístico comparado. *Boletín de la Real Sociedad Española de Historia Natural*, **82**: 5-24.
- Alós C. 1999.** Anelidos poliquetas del Cabo de Creus (NE de Espana). Faces de *Corallina elongata* Ellis and Solander y de *Cystoseira mediterranea* (J. Feldmann). *Miscellanea Zoológica*, **14**:17-27.

- Amaral A.C.Z., Morgado E.H. & Salvador L.B. 1998.** Poliquetas biondicadores de poluição organica em praias paulistas. *Revista Brasileira de Biologia*, **58**: 307-316.
- Badalamenti F., Cantone G., Domina R., Di Pietro N., Catalano D., Mollica E. & D'Anna G. 1999.** Primi dati sulla fauna a policheti di substrato duro dell'infralitorale fotofilo superiore. *Biologia Marina Mediterranea*, **6**: 230-236.
- Bellan G. 1961.** Polychètes de la campagne 1956 du 'Gyf' dans le Nord de la Corse (Corse). *Recueil de Travaux de la Station Marine d'Endoume*, **23**: 71-83.
- Bellan G. 1969.** Polychètes des horizons supérieurs de l'étage infralittoral rocheux dans la région provençale. *Tethys*, **1**: 349-366.
- Bellan G. 1971.** Etude sommaire des polychètes des horizons supérieurs de l'étage infralittoral sur substrat dur dans la région provençale. *Rapport. de la Commission Internationale pour la Mer Méditerranée*, **20**: 217-219.
- Bellan G. 1980.** Annelides Polychètes de substrat solides de trois milieux pollués sur les côtes de Provence (France): Cortiou, Golfe de Fos, Vieux Port de Marseille. *Tethys*, **9**: 267-278.
- Bellan G., Desrosiers G. & Willsie A. 1988.** Use of an annelid pollution index for monitoring a moderately polluted littoral zone. *Marine Pollution Bulletin*, **19**: 662-666.
- Bellan-Santini D. 1969.** Contribution à l'étude des peuplements infralittoraux sur substrat rocheux (étude qualitative et quantitative). *Extrait du recueil des Travaux de la station Marine d'Endoume*, **47**: 1-294.
- Cantone G. 1985.** Variazioni stagionali delle popolazioni a policheti dei fondi duri della rada di Augusta (Sicilia). *Oebalia*, **11 N.S.**: 267-276.
- Castelli A., Abbiati M., Badalamenti F., Bianchi C.N., Cantone G., Gambi M.C., Giangrande A., Gravina M.F., Lanera P., Lardicci C., Somaschini A. & Sordino P. 1995.** Annelida Polychaeta, Pogonophora, Echiura, Sipuncula. In: *Checklist delle specie della fauna italiana* (Minelli A., Ruffo S. & La Posta S. eds.), **19**, Calderini Bologna.
- Chapman M.G., Underwood A.J. & Skilleter G.A. 1995.** Variability at different spatial scales between a subtidal assemblage exposed to the discharge of sewage and two control assemblages. *Journal of Experimental Marine Biology and Ecology*, **189**: 103-12.
- Chemello R. & Milazzo M. 2002.** Effect of algal architecture on associated fauna: some evidence from phytal molluscs. *Marine Biology*, **140**: 981-990.
- Clarke K.R. 1993.** Non-parametric multivariate analysis of changes in community structure. *Australian Journal of Ecology*, **18**: 117-143.
- Corriero G., Gherardi M., Giangrande A., Longo C., Caforio S., Mercurio M. & Nonnis Marzano C. in press.** Inventory

- and distribution of hard bottom fauna from the Marine Protected Area of Porto Cesareo (Ionian Sea): Porifera and Polychaeta. *Italian Journal of Zoology*.
- Damiani V., Bianchi C. N., Ferretti O., Bedulli D., Morri C., Viel M. & Zurlini G. 1988.** Risultati di una ricerca ecologica sul sistema marino costiero pugliese. *Thalassia Salentina*, **18**: 153-169.
- Diaz-Castaneda V. 1987.** Recolonisation benthique d'un sédiment dans des enceintes expérimentales replacées dans le milieu naturel (étage infralittoral). *Cahiers de Biologie Marine*, **28**: 551-566.
- Fauchald K. & Jumars P. A. 1979.** The diet of the worms: a study of Polychaete feeding guilds. *Oceanography and Marine Biology: an Annual Review*, **17**: 193-284.
- Fraschetti S., Bianchi C.N., Terlizzi A., Fanelli G., Morri C. & Boero F. 2001.** Spatial variability and human disturbance in shallow subtidal hard substrate assemblages: a regional approach. *Marine Ecology Progress Series*, **212**: 1-12.
- Fraschetti S., Giangrande A., Terlizzi A., Della Tommasa L., Miglietta M.P. & Boero F. 2002.** Spatio-temporal variation of hydroids and polychaetes associated with *Cystoseira amentacea* (Fucales, Phaeophyceae). *Marine Biology*, **140**: 949-957.
- Fresi E., Colognola R., Gambi M.C., Giangrande A. & Scardi M. 1984.** Ricerche sui popolamenti bentonici di substrato duro del Porto di Ischia. Infralitorale fotofilo: Policheti (II). *Cahiers de Biologie Marine*, **25**: 33-47.
- Gambi M.C. & Giangrande A. 1986.** Distribution of soft-bottom Polychaetes in two coastal areas of the Tyrrhenian Sea (Italy): structural analysis. *Estuarine, Coastal and Shelf Science*, **23**: 847-862.
- Gambi M.C., Giangrande A., Martinelli M. & Chessa L.A. 1995.** Polychaetes of a *Posidonia oceanica* bed off Sardinia (Italy): Spatio-temporal distribution and feeding guild analysis. *Scientia Marina*, **59**: 129-141.
- Giangrande A. 1988.** Polychaete zonation and its relation to algal distribution down a vertical cliff in the western Mediterranean (Italy): a structural analysis. *Experimental Journal of Marine Biology and Ecology*, **120**: 263-276.
- Giangrande A., 2003.** Biodiversity, conservation, and the "Taxonomic impediment". *Aquatic Conservation: Marine and Freshwater Ecosystems*, **13**: 451-459.
- Giangrande A., Licciano M. & Pagliara P. 2000.** The diversity of diets in Syllidae (Annelida: Polychaeta). *Cahiers de Biologie Marine*, **41**: 55-65.
- Giangrande A., A.L. Delos, S. Frascchetti, L. Musco, M. Licciano, A. Terlizzi. In press.** Polychaete assemblages of rocky shore along the South Adriatic coast (Mediterranean Sea): pattern of spatial distribution. *Marine Biology*.
- Katzmann W. 1971.** Polychaeten (Errantier, Sedentatier) aus nordadriatischen *Cystoseira*-Beständen und derer Epiphyten. *Oecologia*, **8**: 31-35.
- Kelaker B.P., Chapman M.G. & Underwood A.J. 2001.** Spatial patterns of diverse macrofaunal assemblages in coralline turf and their associations with environmental variables. *Journal of the Marine Biological Association of the United Kingdom*, **81**: 917-930.
- Laubier L. 1966.** Le coralligène des Albères. *Monographie biocénotique Annales de l'Institut océanographique de Paris*, **43**: 137-316.
- Licher F. 1999.** Revision der Gattung *Typosyllis* Langerhans, 1879 (Polychaeta: Syllidae). Morphologie, Taxonomie und Phylogenie. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, **551**: 1-336.
- López E. & Viéitez J.M. 1999.** Polychaete assemblages on non-encrusting infralittoral algae from the Chafarinas Islands (SW Mediterranean). *Cahiers de Biologie Marine*, **40**: 375-384.
- Milazzo M., Chemello R., Badalamenti F. & Riggio S. 2000.** Molluscan assemblages associated with photophilic algae in the Marine Reserve of Ustica Island (Lower Tyrrhenian Sea, Italy). *Italian Journal of Zoology*, **67**: 287-295.
- Moore P.G. 1972.** The kelp fauna of Northeast Britain. II. Multivariate classification. *Experimental Journal of Marine Biology and Ecology*, **13**: 127-63.
- Musco L., Cavallo A. & Giangrande A. In press.** I Sillidi (Annelida, Polychaeta) del litorale brindisino: possibilità di un loro impiego come indicatori di qualità dell'ambiente. *Thalassia Salentina*.
- Nicolaidou A., Zenetos A., Pancucci M.A. & Simboura N. 1987.** Comparing ecological effects fauna of two different types of pollution using multivariate techniques. *PSZN: Marine Ecology*, **14**: 113-128.
- Oyarzún C., Carrasco F.D. & Gallardo V.A. 1987.** Some characteristics of macrobenthic fauna from the organic-enriched sediments of Talcahuano, Chile. *Cahiers de Biologie Marine*, **28**: 429-446.
- Parenzan P. 1983.** *Puglia Marittima* (2 volumi + dieci carte). Congedo editore, Galatina. 688 pp.
- Pinnegar J.K., Polunin N.V.C., Francour P., Badalamenti F., Chemello R., Harmelin-Vivien M.L., Hereu B., Milazzo M., Zabala M., D'anna G. & Pipitone C. 2000.** Trophic cascades in benthic ecosystems: lesson for fisheries and protected-area management. *Environmental Conservation*, **27**: 179-200.
- Ros J.D., Romero J., Ballestreros E. & Gili J.M. 1985.** Diving in Blue Water. The benthos. In: *Western Mediterranean* (Margalef R. ed). Pergamon Press, Oxford: 233-295.
- Samuelson G.M. 2001.** Polychaetes as indicators of environmental disturbance on Subarctic Tidal Flats, Iqaluit, Baffin Island, Nunavut territory. *Marine Pollution Bulletin*, **9**: 773-741.
- San Martín G. 1984.** Estudio biogeográfico, faunístico y sistemático de los poliquetos de la familia Sillidos (Syllidae: Polychaeta) en Baleares. *Publicaciones de la Universidad Complutense de Madrid*, 529 pp.
- Sarà M. 1967.** La zoogeografia marina e il litorale pugliese. *Archivio botanico e biogeografico italiano*, **XLIII**: 327-343.
- Sarà M. 1968.** Research on benthic fauna of Southern Adriatic Italian coast. Final Scientific Report. Washington D.C.
- Sarà M. 1969.** Research on coralligenous formations: problems and perspectives. *PSZN: Marine Ecology*, **37**: 124-134.
- Sardá R. 1987.** Asociaciones de Anelidos Poliquetos sobre substrato duro en la region del estrecho de Gibraltar (S de Espana). *Investigaciones Pesquera*, **51**: 243-262.
- Sardá R. 1988.** Fauna de anélidos poliquetos de la region del estrecho de Gibraltar, II. Datos cualitativos poblacionales de las

- diferentes facies algales. *Bulletin de l'institut Catalan d'Histoire Naturelle*, **55**: 5-15.
- Sardá R. 1991.** Polychaete communities related to plant covering in the mediolittoral and infralittoral zones of the Balearic Islands (Western Mediterranean). *PSZN: Marine Ecology*, **12**: 341-360.
- Somaschini A. 1988.** Policheti della biocenosi ad alghe fotofile (facies a *Corallina elongata*) nel Lazio settentrionale. *Atti Società Toscana di Scienze Naturali, Serie B*, **95**: 83-94.
- Tena J., Capaccioni-Azzati R., Torres-Gavila F.J. & Garcia-Carrascosa A.M. 2000.** Polychaetes associated with different facies of the photophilic algal community in the Chafarinas archipelago (SW Mediterranean). *Bulletin of Marine Science*, **67**: 55-72.
- Underwood A.J. 1993.** The mechanics of spatially replicated sampling programmes to detect environmental impacts in a variable world. *Australian Journal of Ecology* **18**, 99-116
- Underwood A.J. & Chapman M.G. 1996.** Scales of spatial patterns of distribution of intertidal invertebrates. *Oecologia*, **107**: 212-224.