

JEM 01115

## Polychaete zonation and its relation to algal distribution down a vertical cliff in the western Mediterranean (Italy): a structural analysis

A. Giangrande

*Dipartimento di Scienze dell'Ambiente e del Territorio, Università di Pisa, Pisa, Italy*

(Received 10 April 1987; revision received 11 May 1988; accepted 23 May 1988)

**Abstract:** The zonation of polychaetes down a vertical cliff (0–5 m in depth) at Cape Romito, Leghorn, Italy, was investigated. The structural organization of the community changed with depth. A community typical of photophilic environments was found in the superficial zone (0–2 m), while in the deeper zone (3–5 m), a more diversified community characterized by species typical of sciaphilic environments was present. At the surface (0 m) the community was very poor in species and individuals and thus probably corresponds to the midlittoral fringe. In fact, some species typical of the midlittoral zone were found. This distribution pattern was constant for samples taken in February and August 1985. The distribution of polychaetes was closely related to that found for macroalgae. It is hypothesized that algae condition the substratum and that this is the main factor responsible for the zonation of polychaetes.

**Key words:** Algal cover; Benthos; Polychaete zonation; Rocky bottom; Western Mediterranean

### INTRODUCTION

Although numerous studies (Pérès, 1952; Cognetti, 1957; Bellan, 1965, 1968, 1969, 1971; Amoureux & Katzmann, 1971; Katzmann, 1971; Ben-Eliahu, 1977a,b; Bianchi, 1979; Cantone & Fassari, 1980; Bellan & Marinopoulos, 1981; San Martin *et al.*, 1981, 1982; Alos *et al.*, 1982; Belloni & Bianchi, 1982; Fresi *et al.*, 1983, 1984; Cantone, 1985; Acero & San Martin, 1986) have been performed on hard bottom polychaetes in the Mediterranean Sea, vertical zonation has only been studied by Abbiati *et al.* (1987). These authors put forward the hypothesis that polychaete zonation may be an expression of the biological conditioning of the substratum by algae rather than of the direct influence of physical factors. The importance of algal cover to polychaete distribution has also been observed by Bellan & Marinopoulos (1981).

In order to test the above hypothesis, the present work analyses the zonation of polychaetes and compares it with that of the algae. It also takes into account the variations in light and water movement which are considered to be the main abiotic factors influencing the vertical zonation of macrobenthic communities, as presented in the models of Pérès & Picard (1964) and Riedl (1964), respectively.

Correspondence address: A Giangrande, Dipartimento di Scienze dell'Ambiente e del Territorio, Università di Pisa, Via Volta 6, Pisa, Italy.

## MATERIALS AND METHODS

The study area was situated on a cliff with a northern exposure, terminating in a bottom of coarse sand at a depth of  $\approx 6$  m, at Cape Romito, south of Livorno, Italy (Fig. 1). In this zone tidal amplitude is very low ( $\approx 20$  cm), as is common in the Mediterranean Sea.

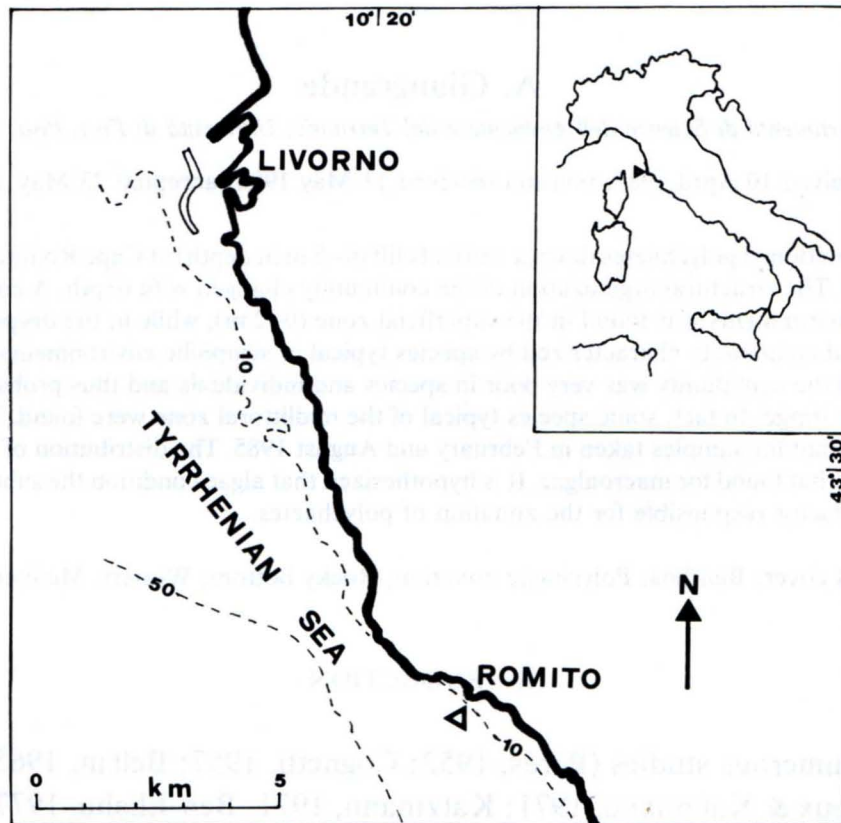


Fig. 1. Map of the study area. The arrow shows the sampling site.

Twelve samples were collected, six in February and six in August 1985. The samples were taken by SCUBA divers who scraped off an area of  $400 \text{ cm}^2$  ( $20 \times 20 \text{ cm}$ ), in accordance with the procedure outlined by Bellan-Santini (1969) and subsequently widely adopted throughout the Mediterranean. The samples were taken at 1-m depth intervals between 0 and 5 m (Fig. 2). The first samples at the surface (0 m) were taken according to Boudouresque & Cinelli (1976), who identified the separation point between the midlittoral and infralittoral zones for the Mediterranean coasts.

At these same depth intervals, measurements of physical factors were taken in August. Light intensity was measured in  $\text{mw} \cdot \text{cm}^{-2}$ , using an Ocean System irradiator OIM 1 Ws. Water movement was measured by recording the dissolution of plaster balls, a method first described by Muus (1968) and later used successfully in the Mediterranean Sea.

Each sample was passed through a 400- $\mu\text{m}$  sieve and the number of individuals from each species, the number of species present, the total abundance, and the Shannon–Weaver diversity index ( $H'$ ) were computed for each station.

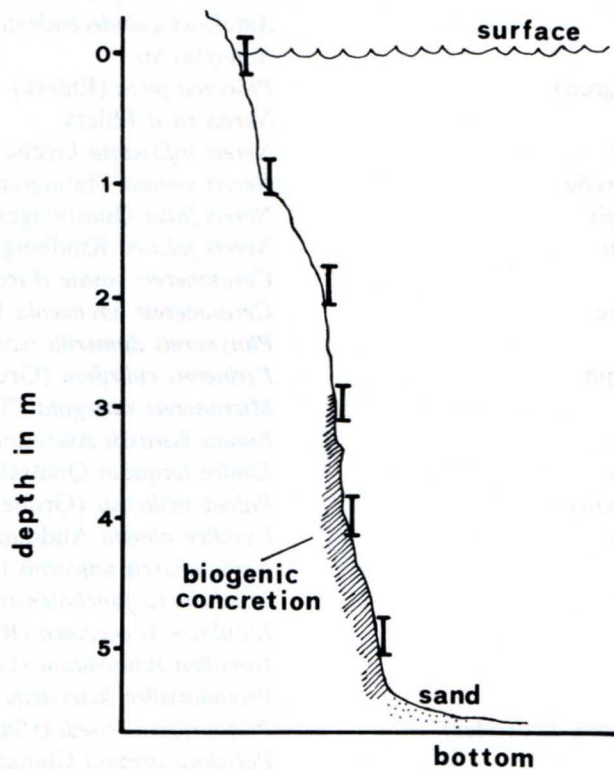


Fig. 2. Profile of the cliff studied. The vertical lines indicate the sites sampled along the transect.

Polychaetes were identified according to Fauvel (1923, 1927), complemented by monographs on particular families (Day, 1967; San Martin, 1984).

Numerical data were analysed using multivariate ordination and classification techniques (Zurlini, 1983). Ordination was performed using the factorial analysis of correspondence (Benzecri, 1982), the significance of the axes were evaluated using the table of Lebart (1975).

## RESULTS

### POLYCHAETES: DISTRIBUTION OF SPECIES AND STRUCTURAL PARAMETERS

A total of 4873 polychaetes belonging to 119 species was found (Table I). The dominant family was Syllidae, with 45 species and 2863 individuals (58% of the total). Other well-represented families were Nereidae, Eunicidae, Sabellidae and Serpulidae. Certain species new to the Mediterranean fauna were found, such as *Sphaerosyllis longicauda* (see Table I for all taxonomic authorities) and *Nereis trifasciata*, as well as others never before documented from Italy, such as *Syllis bouvieri*, *Sphaerosyllis austriaca* and *Syllis golfonovoensis*.

TABLE I

The polychaetes found during the investigation.

---

<i>Pontogenia chrysocoma</i> (Baird)	<i>Autolytus convolutus</i> Cognetti
<i>Lepidonotus clava</i> (Montagu)	<i>Autolytus prolifer</i> (Muller)
<i>Harmotöe spinifera</i> Ehlers	<i>Autolytus quindecidentatus</i> Langerhans
<i>Harmotöe areolata</i> Grube	<i>Autolytus</i> sp.
<i>Harmotöe ljugmanni</i> (Malmgren)	<i>Procerea picta</i> (Ehlers)
<i>Harmotöe</i> sp.	<i>Nereis rava</i> Ehlers
<i>Chrysopetalum debile</i> Grube	<i>Nereis trifasciata</i> Grube
<i>Pholöe synophtalmica</i> Claparède	<i>Nereis zonata</i> Malmgren
<i>Phyllodoce nana</i> Saint-Joseph	<i>Nereis falsa</i> Quatrefages
<i>Eulalia tripunctata</i> McIntosh	<i>Nereis jaksoni</i> Kindberg
<i>Eulalia sanguinea</i> Oersted	<i>Ceratonereis costae</i> (Grube)
<i>Pterocirrus macroceros</i> Grube	<i>Ceratonereis hircinicola</i> Eisig
<i>Notophyllum foliosum</i> Sars	<i>Platynereis dumerilii</i> Audouin & M. Edwards
<i>Mystides limbata</i> Saint-Joseph	<i>Perinereis cultrifera</i> (Grube)
Phyllodocidae n.c.	<i>Micronereis variegata</i> Claparède
<i>Ephesia peripatus</i> Claparède	<i>Eunice harassii</i> Audouin & M. Edwards
<i>Syllidia armata</i> Quatrefages	<i>Eunice torquata</i> Quatrefages
<i>Kefersteinia cirrata</i> (Keferstein)	<i>Palola siciliensis</i> (Grube)
<i>Haplosyllis spongicola</i> Grube	<i>Lysidice ninetta</i> Audouin & M. Edwards
<i>Syllis armillaris</i> Malmgren	<i>Nematonereis unicornis</i> (Grube)
<i>Syllis amica</i> Quatrefages	<i>Lumbrineris funchalensis</i> (Kinberg)
<i>Syllis gracilis</i> Grube	<i>Lumbrineris coccinea</i> (Renieri)
<i>Syllis prolifera</i> Krhon	<i>Dorvillea rubrovittata</i> (Grube)
<i>Syllis variegata</i> Grube	<i>Protodorvillea kefersteini</i> (McIntosh)
<i>Syllis golfonovoensis</i> (Hartmann-Schroder)	<i>Protoaricia oerstedii</i> (Claparède)
<i>Syllis vittata</i> Grube	<i>Polydora armata</i> Claparède
<i>Syllis garciae</i> (Campoy)	<i>Polydora caeca</i> (Oersted)
<i>Syllis truncata criptica</i> Ben-Ehliou	<i>Prionospio cirrifera</i> Wiren
<i>Syllis krohni</i> Ehlers	<i>Prionospio</i> sp.
<i>Syllis zonata</i> Haswell	<i>Cirriformia filigera</i> (Delle Chiaje)
<i>Syllis bouvieri</i> Gravier	<i>Cirratulus chrysoderma</i> Oersted
<i>Syllis hyalina</i> Grube	<i>Dodecaceria concharum</i> Oersted
<i>Xenosyllis scabra</i> Marion & Bobretzky	<i>Caulleriella bioculata</i> (Keferstein)
<i>Branchiosyllis exilis</i> Westeide	<i>Caulleriella alata</i> (Southern)
<i>Ehlersia ferruginea</i> (Langerhans)	<i>Polyopthalmus pictus</i> (Dujardin)
<i>Trypanosyllis zebra</i> Grube	<i>Micromaldane ornitochaeta</i> Mesnil
<i>Eurysyllis tuberculata</i> Ehlers	<i>Nicolea venustula</i> (Montagu)
<i>Pseudosyllis brevipennis</i> Grube	<i>Thelepus cincinnatus</i> (Fabricius)
<i>Odontosyllis gibba</i> Claparède	<i>Parathelepus collaris</i> (Southern)
<i>Odontosyllis ctenostoma</i> Claparède	<i>Streblosoma</i> sp.
<i>Odontosyllis fulgurans</i> Claparède	<i>Polycirrus</i> sp.
<i>Pterosyllis formosa</i> Claparède	Terebellidae n.c.
<i>Syllides fulva</i> Marion & Bobretzky	<i>Branchiomma bombyx</i> (Dalyell)
<i>Pionosyllis lamelligera</i> Saint-Joseph	<i>Branchiomma lucullanum</i> (Delle Chiaje)
<i>Pionosyllis morenoe</i> San Martin	<i>Pseudopotamilla reniformis</i> (Muller)
<i>Eusyllis assimilis</i> Marenzeller	<i>Amphiglena mediterranea</i> (Leydig)
<i>Eusyllis lamelligera</i> Marion & Bobretzky	<i>Oriopsis armandi</i> (Claparède)
<i>Parapionosyllis minuta</i> (Pierantoni)	<i>Oriopsis eimeri</i> Langerhans
<i>Pseudobrania clavata</i> (Claparède)	<i>Oriopsis</i> sp.
<i>Pseudobrania vieitezi</i> San Martin	<i>Fabricia sabella</i> (Ehrenberg)
<i>Pseudobrania limbata</i> (Claparède)	<i>Fabriciola tonerella</i> Banse
<i>Brania pusilla</i> (Dujardin)	<i>Chone collaris</i> Langerhans

---

TABLE I (continued)

<i>Sphaerosyllis pirifera</i> Claparède	<i>Serpula concharum</i> Langerhans
<i>Sphaerosyllis hystrix</i> Claparède	<i>Serpula vermicularis</i> L
<i>Sphaerosyllis austriaca</i> Banse	<i>Spirobranchus polytrema</i> (Philippi)
<i>Sphaerosyllis longicauda</i> Webster & Benedict	<i>Hydroides pseudouncinata</i> Zibrowius
<i>Exogone verugera</i> (Claparède)	<i>Hydroides nigra</i> Zibrowius
<i>Exogone naidina</i> Oersted	<i>Vermiliopsis striaticeps</i> (Grube)
<i>Exogone rostrata</i> Naville	<i>Pomatoceros triqueter</i> L.

An analysis of the vertical distribution of all the species showed a zonation which proceeded along the bathymetric gradient from 0 to 5 m. Certain species were associated with the superficial samples (levels 0–1–2). These species are typical of semi-exposed biotopes with a photophilic algal cover (*Platynereis dumerilii*, *Syllis prolifera*, *Eunice harassii*, *Spirobranchus polytrema*). In particular, the species *Syllis amica* was found only at the surface (0 m), together with abundant numbers of *Protoarcia oerstedii*, *Platynereis dumerilii*, and *Syllis prolifera*. These species have been recorded in midlittoral zones (Abbiati *et al.*, 1987) as well as in stressed environments such as harbours (Bellan, 1980).

Other species such as *Lysidice ninetta*, *Lumbrineris funchalensis*, *Kefersteinia cirrata*, *Nereis rava* and most of the Syllidae, which are typical of a sciaphilic algal cover or coralligenous formations, were found in the deeper samples (levels 3–4–5).

Most of the remaining species were irregularly distributed along the transect and tended to obscure the observed zonation somewhat. In fact, the overall change in the distribution of the polychaete assemblage, proceeding from the surface to the bottom, was rather gradual.

The distribution of species described above was the same in February and August; much of the variation observed was due to the occurrence of rare species.

In general, a greater total abundance was found in August, due mainly to the increased presence of the Syllidae. The greatest seasonal variation in species composition was observed at the surface.

Species number (Fig. 3A) and diversity ( $H'$ ) (Fig. 3B) increased with increasing depth, with a maximum at 4 m, while the trend in total abundance was for peaks at depths of 2 and 4 m, especially in February (Fig. 3C).

#### POLYCHAETES: STATISTICAL ANALYSIS

Only the first two axes of the factorial analysis of correspondence were significant ( $P < 0.05$ ), accounting for 27.35 and 15.79% of the total variance. The model obtained (Fig. 4A) shows a parabolic distribution of the stations along the bathymetric gradient. This conformation is typical of situations where there is a single strong polarizing factor, represented by the first axis. The second axis has a squared relationship with the first and represents an intensity factor (Fresi & Gambi, 1983).

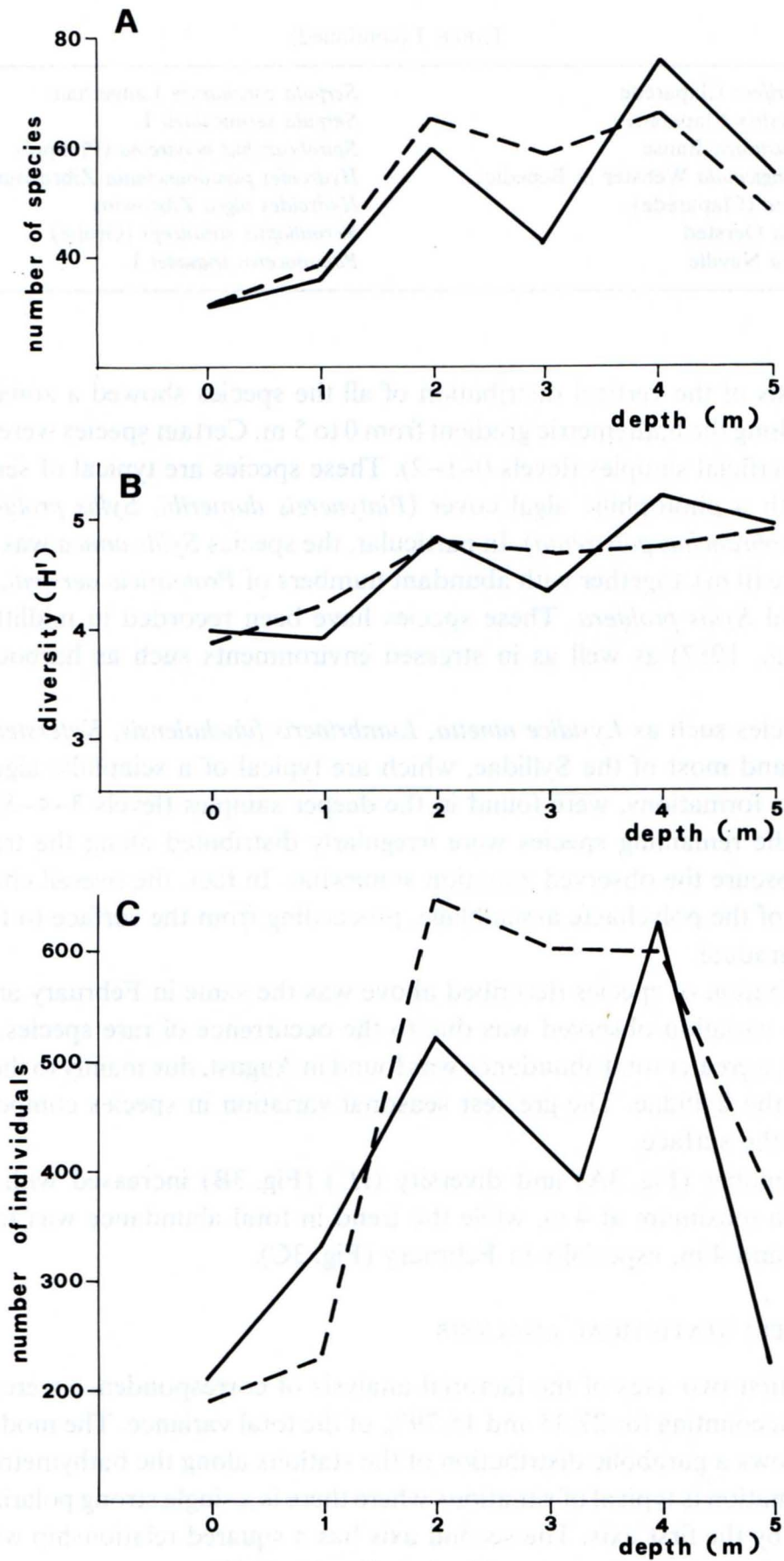


Fig. 3. Trend of some structural parameters along the transect. A, number of species. B, diversity index ( $H'$ ). C, abundance (number of individuals). The solid lines indicate the February samples, the broken lines indicate the August samples.

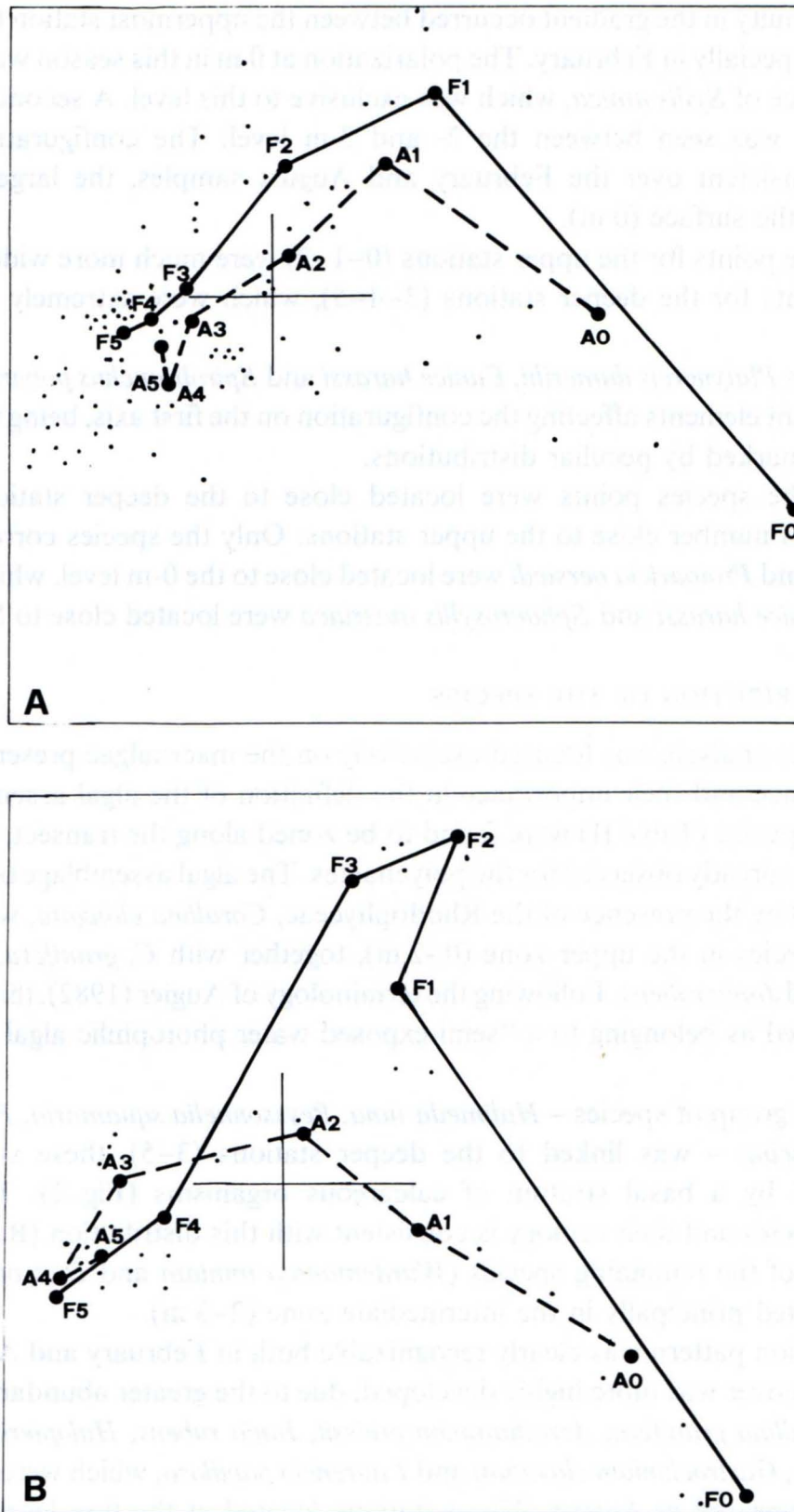


Fig. 4. Factorial analysis of correspondence. The ordination models are shown on the plane of the first two axes. Large dots with numbers are station points and relative depth (F = February, A = August), small dots are species points. A, polychaetes; analysis performed on quantitative data. B, algae; analysis performed on qualitative data.

A discontinuity in the gradient occurred between the uppermost station (0 m) and the remainder, especially in February. The polarization at 0 m in this season was due mainly to the presence of *Syllis amica*, which was exclusive to this level. A second and weaker discontinuity was seen between the 2- and 3-m level. The configuration observed remained consistent over the February and August samples, the largest difference occurring at the surface (0 m).

The sample points for the upper stations (0–1–2) were much more widely dispersed than the points for the deeper stations (3–4–5), which were extremely close to one another.

The species *Platynereis dumerilii*, *Eunice harassi* and *Spirobranchus polytrema* were the most important elements affecting the configuration on the first axis, being those species which were marked by peculiar distributions.

Most of the species points were located close to the deeper stations (3–4–5), diminishing in number close to the upper stations. Only the species corresponding to *Syllis amica* and *Protoaricia oerstedii* were located close to the 0-m level, while *Platynereis dumerilii*, *Eunice harassi* and *Sphaerosyllis austriaca* were located close to Stations 1–2.

#### ALGAE: DISTRIBUTION OF THE SPECIES

The floristic analysis was focused exclusively on the macroalgae present because of their abundance and their importance in the definition of the algal assemblage.

In all, 29 species (Table II) were found to be zoned along the transect, the zonation reflecting that already observed for the polychaetes. The algal assemblage of the cliff was characterized by the presence of the Rhodophyceae, *Corallina elongata*, which was the dominant species in the upper zone (0–2 m), together with *C. granifera*, *Stypocaulon scoparium* and *Jania rubens*. Following the terminology of Augier (1982), this assemblage may be defined as belonging to a “semi-exposed water photophilic algal community” (ESEPA).

A different group of species – *Halimeda tuna*, *Peyssonnelia squamaria*, *P. borneti* and *Halopteris filicina* – was linked to the deeper stations (3–5), these stations being characterized by a basal stratum of calcareous organisms (Fig. 2). These are all sciaphilic species and their ecology is consistent with this distribution (Boudouresque, 1984). Most of the remaining species (*Wurdemannia miniata* and *Dictyota dichotoma*) were distributed principally in the intermediate zone (2–3 m).

This zonation pattern was clearly recognizable both in February and August, but in August algal cover was more highly developed, due to the greater abundance of certain species (*Corallina granifera*, *Acrothamnion preissii*, *Jania rubens*, *Halopteris filicina*).

In contrast, *Gastroclonium clavatum* and *Laurencia papillosa*, which were linked to the surface, disappeared in August. These stations located at the 0-m level showed the greatest variation in species composition for the two seasonal samples, as already seen in the polychaetes.



TABLE II

The macroalgae found during the investigation.

---

<i>Corallina elongata</i> Ellis & Solander
<i>Corallina granifera</i> Ellis & Solander
Corallinaceae n.c.
<i>Jania rubens</i> (L.) Lamouroux
<i>Jania longifurca</i> Zanardini
<i>Dictyota dichotoma</i> (Hudson) Lamouroux
<i>Dictyota linearis</i> (C. Agardh) Greville
<i>Dictyopteris membranacea</i> (Stackhouse) Batters
<i>Laurencia obtusa</i> (Hudson) Lamouroux
<i>Laurencia papillosa</i> (C. Agardh) Greville
<i>Herposiphonia tenella</i> (C. Agardh) Ambronn
<i>Gelidium latifolium</i> var. <i>hystrix</i> (C. Agardh) H. Auck
<i>Gracilaria</i> sp.
<i>Feldmannophycus rayssiae</i> (Feldmann & Feldmann) Augier et Boudouresque
<i>Wundermannia miniata</i> (Lamouroux) Feldmann & Hamel
<i>Sphaerococcus coronopifolius</i> Stackhouse
<i>Dasyopsis spinella</i> (C. Agardh) Zanardini
<i>Gastroclonium clavatum</i> (Röth) Ardissonne
<i>Acrothamnion preissii</i> (Sander) Wallaston
<i>Amphiora</i> sp.
<i>Nitophyllum punctatum</i> (Stackhouse) Greville
<i>Hypoglossum woodwardii</i> Kützing
Ceramiales n.c.
<i>Halimeda tuna</i> (Ellis & Solander) Lamouroux
<i>Stypocaulon scoparium</i> (L.) Kützing
<i>Halopteris filicina</i> (Grateloup) Kützing
<i>Padinia pavonica</i> (L.) Thivy
<i>Peyssonnelia squamaria</i> (Glemlin) Decaisne
<i>Peyssonnelia borneti</i> Boudouresque & Denizot

---

## ALGAE: STATISTICAL ANALYSIS

The model obtained by factorial analysis is shown in Fig. 4B. Only the first axis was significant, explaining 25.75% of the total variance. Its configuration is very similar to that obtained in the analysis of the polychaete distribution.

In the algal assemblage, again reflecting the polychaete situation, there is a discontinuity between the samples located at the surface (0 m) and the remaining stations, especially in February, and a second, weak discontinuity may be noted between the upper samples (0-1-2) and the deeper ones (3-4-5).

The species *Corallina elongata*, *Gastroclonium clavatum*, *Laurencia papillosa* and *Dictyota dichotoma* were linked to the superficial level, while the species *Halopteris filicina*, *Acrothamnion preissii*, *Peyssonnelia borneti* and *P. squamaria* were close to the deeper samples.

## POLYCHAETES AND ALGAE: A COMPARISON OF THEIR ORDINATION MODELS

In both of the ordination models (algae and polychaetes), the stations were ordinated with a parabolic configuration along the first axis proceeding from 0 to 5 m. The first

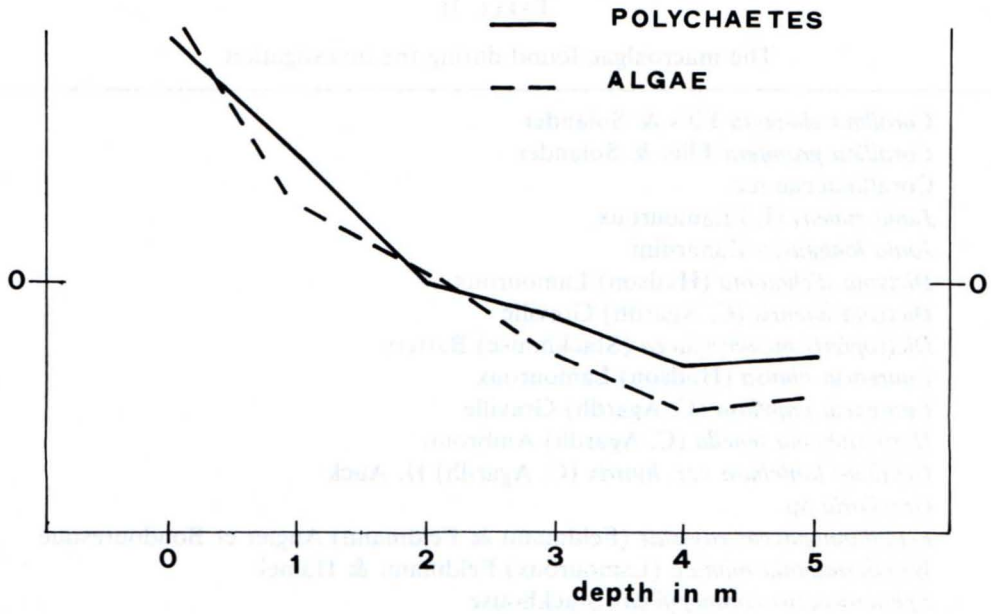


Fig. 5. Graphic representation of the first axis of the factorial analysis for the August samples of polychaetes and algae.

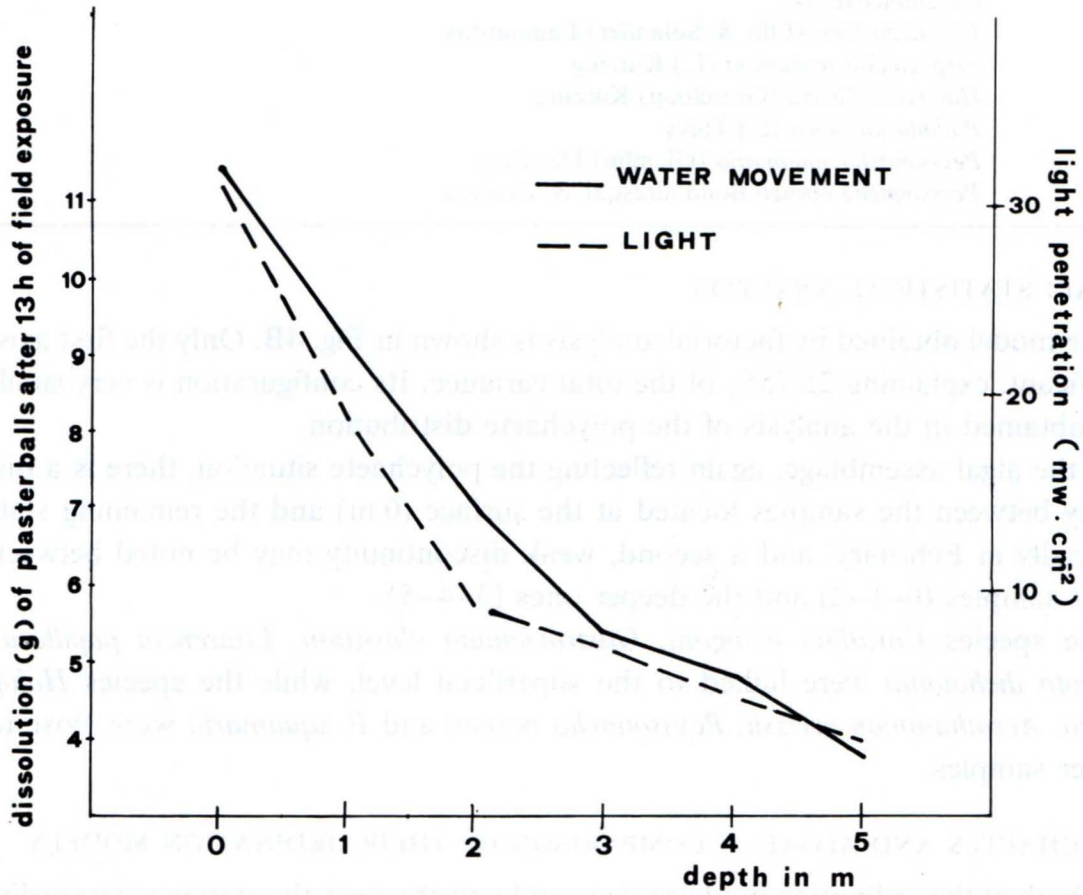


Fig. 6. Trend in the intensity of light and water movement along the transect.

axis is therefore interpreted as being the bathymetric gradient, which reflects the changes in environmental factors occurring down the transect, from 0 to 5 m.

Along this gradient two discontinuities were noted, the first sharply separating the surface (0 m) from the remaining samples, and the second separating the superficial samples (1–2 m) from the deeper ones (3–4–5 m).

The similarity between the models for polychaetes and for algae was evidenced by comparing the first axis of the summer samples (Fig. 5). The trend follows that of the two physical factors (Fig. 6). Light penetration and water movement greatly decreased with depth down the transect, and at the 2–3 m depth both values were reduced to half of their superficial value.

### DISCUSSION

The analysis of the polychaete distribution down to 5 m depth revealed the existence of more than one distinct zone. The first, extending from the surface to  $\approx 2$  m, was a zone characterized by polychaetes typical of the superficial infralittoral zone (*Platynereis dumerilii*, *Syllis prolifera*, *Eunice harassii*, *Spirobranchus polytrema*, *Ceratonereis costae*, *Syllis gracilis*, *S. prolifera* and *Nereis zonata*). In this area a cover of photophilic algae was present (*Corallina elongata*, *Jania rubens*, and *Laurencia obtusa*). This first zone, where the intensity of light and water movement was great, could correspond to the "infralittoral fringe", defined by Stephenson & Stephenson (1949). A second zone, which extended from 2 to 5 m, where light and water movement decreased in intensity, was characterized by a more diverse community, dominated by species typical of sciaphilic environments or coralligenous formations (*Lysidice ninetta*, *Kefersteinia cirrata*, *Amphiglena mediterranea*, *Lumbrinereis funchalensis*, *Oriopsis armandi*, *Nereis rava*, *Eurysyllis tuberculata* and *Syllis truncata criptica*). In this second zone, the algal covering was characterized by the presence of sciaphilic species (*Peyssonnelia squamaria*, *P. borneti* and *Halimeda tuna*).

At the surface (0 m) the lowest values for diversity, number of species and abundance were recorded. This was probably due to the fact that at this level emersion, mainly caused by wave movement, was a negative factor for polychaete colonization. This level probably corresponds to the "midlittoral fringe" (Boudouresque, 1971). In fact, some species typical of the midlittoral zone were present, especially in winter: viz. the polychaetes *Syllis amica* and *Protoaricia oerstedii* and the algae *Gastroclonium clavatum* and *Laurencia papillosa*.

As Abbiati *et al.* (in press) have, however, demonstrated, the discontinuity between the midlittoral and infralittoral zones is not clearly detectable simply from the analysis of the polychaetes. Polychaete species which colonize the transition zone between the midlittoral and infralittoral zones may also be found frequently in stressed environments such as harbours or lagoons (Bellan, 1980) and probably suffer from competition with other species.

In the deeper zone (3–5 m), a higher structural organization of the polychaete community was noted, as demonstrated by the increases in diversity. This is probably due to two factors, the first being changes in the algal cover: in this zone the biogenic concretion generated by Corallinaceae and the presence of species-retaining sediment (*Peyssonnelia* sp.) produce a more diversified microhabitat which can favour polychaete settlement. The second factor may be a decrease in the intensity of environmental factors which favour a higher degree of biotic interaction within the community (Sanders, 1968). From a bionomical standpoint, and following the classical model of Pérès & Picard (1964) for the Mediterranean Sea, the assemblages found would be defined as simple “facies” of a single infralittoral community belonging to the photophilic algae biocoenoses.

Statistical analysis shows that parallel configurations exist in the ordination models of polychaetes and algae. In both models, two discontinuities were revealed – the first between 0 and 1 m and the second between 2 and 3 m. As far as the polychaetes are concerned, these discontinuities are principally attributable to changes in the number of species, abundance and diversity with depth. In the algal assemblage, on the other hand, these discontinuities were mainly due to changes in species composition. This zonation pattern was consistent over the 2 months covered in the study. The main differences appeared among the superficial samples, specifically at Station 0. The discontinuity between the 0-m and the 1-m samples was more highly accentuated in February, when the species typical of the midlittoral zone were present.

The observed discontinuities could be explained by the zonation model of Riedl (1964) which emphasized the rôle of water movement in the vertical distribution of the littoral benthos. The first discontinuity can be related to the mean water level, while the second corresponds to a transition zone between two masses of water, each characterized by a different hydrodynamic movement and defined as the “first critical depth”.

The importance of water movement in community zonation has already been demonstrated for several sessile epifauna groups by Sarà *et al.* (1978) and Boero & Fresi (1986).

In the present study, the interpretation of the polychaete assemblages found on the cliff cannot, however, be based solely on the models of Riedl (1964). In fact, it is very difficult to differentiate between the relative importance of the many factors which may have influenced the distribution observed. Both light and water movement, for example, exhibited correlated trends. These two factors then probably play only an indirect rôle, acting synergetically to create qualitative and quantitative modifications of algal cover.

The polychaete zonation, in fact, follows the algae associations on the cliff wall at the same depths; this would suggest that conditioning of the substratum due to the algal cover is the main factor determining polychaete zonation. This conditioning of the substratum by algae is achieved both by the creation of spatial microhabitats and by trophic effects, as has been pointed out by Abbiati *et al.* (1987) and Giangrande (1986).

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Professor Francesco Cinelli and Professor Giuseppe Cognetti, who provided help and encouragement throughout the course of this study, to my colleagues at the Institute, who helped me to collect the samples, and particularly to Dr. Ursula Salghetti-Drioli, who completed the taxonomic classification of the algae. I would also like to thank Dr. C. Nike Bianchi (Centro Enea Crea, La Spezia), Dr. Michele Scardi and Professor Eugenio Fresi (Stazione Zoologica di Napoli), for their help in completing the statistical analysis of the data.

## REFERENCES

- ABBIATI, M., C.N. BIANCHI & A. CASTELLI, 1987. Polychaete vertical zonation along a littoral cliff in the west Mediterranean. *P.S.Z.N.I.: Mar. Ecol.*, Vol. 8, pp. 33–48.
- ABBIATI, M., C.N. BIANCHI, A. CASTELLI, A. GIANGRANDE & C. LARDICCI, in press. Distribution of Polychaetes in hard substrates of the midlittoral-infralittoral transition zone. Western Mediterranean. Presented at the Second International Polychaete Conference, Copenhagen, 1986.
- ACERO, M. & G. SAN MARTIN, 1986. Poliquetos epibiontes del primer horizonte de algas fotofilas en la provincias de Cadiz y Malaga. Estudio faunístico comparado. *Boln. R. Soc. Esp. Hist. Nat. Biol.*, Vol. 82, pp. 5–24.
- ALOS, C., A. CAMPOY & F. PEREIRA, 1982. Contribution al estudio de los anélidos poliquetos endobiontes de esponjas. *Actas II Simp. Ibér. Estud. Benthos Mar.*, Vol. 3, pp. 139–157.
- AMOUREUX, L. & W. KATZMANN, 1971. Note faunistique et écologique sur une collection d'annélides polychètes de substrats rocheux circalittoraux de la région de Rovinj (Yougoslavie). *Zool. Anz.*, Vol. 186, pp. 114–122.
- AUGIER, H., 1982. Inventory and classification of marine benthic biocenoses of the Mediterranean. *Council of Europe, Strasbourg, Nature and Environment*, No. 25, pp. 1–57.
- BELLAN, G., 1965. Contribution à l'étude des polychètes des substrats solides circalittoraux de la région de Marseille. *Recl. Trav. Stn. Mar. Endoume*, Bull. 39, Fasc. 55, pp. 237–252.
- BELLAN, G., 1968. Contribution à l'étude des polychètes des substrats solides circalittoraux des environs de Marseille. II. Polychètes (Serpulidae exclues) des grottes sous-marines. *Recl. Trav. Stn. Mar. Endoume*, Bull. 44, Fasc. 60, pp. 109–123.
- BELLAN, G., 1969. Polychètes des horizons supérieurs de l'étage infralittoral rocheux dans la région provençale. *Téthys*, Vol. 1, pp. 349–366.
- BELLAN, G., 1971. Étude sommaire des polychètes des horizons supérieurs de l'étage infralittoral sur substrat dur dans la région provençale. *Rapp. Comm. Int. Mer. Médit.*, Vol. 20, pp. 217–219.
- BELLAN, G., 1980. Relationship of pollution to rocky substratum polychaetes on the French Mediterranean coast. *Mar. Pollut. Bull.*, Vol. 11, pp. 318–321.
- BELLAN, G. & J. MARINOPOULOS, 1981. Contribution à la connaissance des annélides polychètes des substrats solides de la partie inférieure de l'étage infralittoral dans la région marseillaise. *Rapp. Comm. Int. Mer. Médit.*, Vol. 27, pp. 165–166.
- BELLAN-SANTINI, D., 1969. Contribution à l'étude des peuplements infralittoraux sur substrat rocheux. Étude qualitative et quantitative de la frange supérieure. *Recl. Trav. Stn. Mar. Endoume*, Bull. 47, Fasc. 63, pp. 1–294.
- BELLONI, S. & C.N. BIANCHI, 1982. Policheti di alcune grotte marine della penisola sorrentina (golfo di Napoli). *Boll. Mus. Ist. Biol. Univ. Genova*, Vol. 50, pp. 118–127.
- BEN-ELIAHU, M.N., 1977a. Polychaetes cryptofauna from rims of similar intertidal vermetid reefs on the Mediterranean coast of Israel and in the Gulf of Elat: Syllinae and Eusyllinae (Polychaeta Errantia: Syllidae). *Isr. J. Zool.*, Vol. 26, pp. 1–58.
- BEN-ELIAHU, M.N., 1977b. Polychaetes cryptofauna from rims of similar intertidal vermetid reefs on the Mediterranean coast of Israel and in the Gulf of Elat: Exogoninae and Autolytinae (Polychaeta Errantia: Syllidae). *Isr. J. Zool.*, Vol. 26, pp. 59–99.
- BENZECRI, J.P., 1982. *L'analyse des données. II. L'analyse des correspondances*. Dunod, Paris, third edition, 632 pp.

- BIANCHI, C.N., 1979. Ecologia dei Serpuloidea (Annelida, Polychaeta) del piano infralitorale presso Portofino (Genova). *Boll. Mus. Ist. Biol. Univ. Genova*, Vol. 47, pp. 101-115.
- BOERO, N. & E. FRESI, 1986. Zonation and evolution of a rocky bottom hydroid community. *P.S.Z.N.I.: Mar. Ecol.*, Vol. 7, pp. 123-150.
- BOUDOURESQUE, C.F., 1971. Contribution à l'étude phytosociologique des peuplements algaux des cotes varoises. *Vegetatio*, Vol. 22, pp. 83-184.
- BOUDOURESQUE, C.F., 1984. Groupes écologiques d'algues marines et phytocenoses benthiques en Méditerranée nord occidentale: une revue. *G. Bot. Ital.*, Vol. 118, pp. 7-42.
- BOUDOURESQUE, C.F. & F. CINELLI, 1976. Le peuplement algal des biotopes sciaphiles superficiels de mode battu en Méditerranée occidentale. *Pubbl. Stn. Zool. Napoli*, Vol. 40, pp. 433-459.
- CANTONE, G., 1985. Note preliminari sulle variazioni stagionali del popolamento dei policheti nei fondi duri della Rada di Augusta (Sicilia). *Oebalia*, N.S. Vol. 11, pp. 267-276.
- CANTONE, G., & G. FASSARI, 1980. Osservazioni sul popolamento polichetologico della penisola della Maddalena (Siracusa). *Animalia*, Vol. 7, pp. 137-276.
- COGNETTI, G., 1957. I Sillidi del Golfo di Napoli. *Pubbl. Stn. Zool. Napoli*, Vol. 30, pp. 1-100.
- DAY, J.H., 1967. *A monograph on the polychaetes of Southern Africa*. Trustees of British Museum (Nat. Hist.), London, 878 pp.
- FAUVEL, P., 1923. *Faune de France. Polychètes errantes. Vol. 5*. Lechevalier, Paris, 488 pp.
- FAUVEL, P., 1927. *Faune de France. Polychètes sédentaires. Vol. 16*. Lechevalier, Paris, 494 pp.
- FRESI, E. & M.C. GAMBI, 1983. Alcuni aspetti importanti dell'analisi matematica di ecosistemi marini. *Nat. Sicil.*, Vol. 6, Suppl. 3, pp. 449-465.
- FRESI, E., R. COLOGNOLA, M.C. GAMBI, A. GIANGRANDE & M. SCARDI, 1983. Ricerche sui popolamenti bentonici di substrato duro del Porto di Ischia. Infralitorale fotofilo: policheti. *Cah. Biol. Mar.*, Vol. 24, pp. 1-19.
- FRESI, E., R. COLOGNOLA, M.C. GAMBI, A. GIANGRANDE & M. SCARDI, 1984. Ricerche sui popolamenti bentonici di substrato duro del Porto di Ischia. Infralitorale fotofilo: Policheti (II). *Cah. Biol. Mar.*, Vol. 25, pp. 33-47.
- GIANGRANDE, A., 1986. Trophic structure changes of a polychaete community along a vertical cliff. *Rapp. Comm. Int. Mer. Médit.*, Vol. 30, p. 252 only.
- KATZMANN, W., 1971. Polychaeten (Errantier, Sedentariier) aus nordatriatischen *Cystoseira*-Beständen und deren Epiphyten. *Oecologia (Berlin)*, Vol. 8, pp. 31-35.
- LEBART, L., 1975. *Validité des résultats en analyse des données*. Centre de Recherches et de documentation sur la Consommation, Paris, L.L/cd No. 4465, pp. 1-157.
- MUUS, J.B., 1986. A field method for measuring "exposure" by means of plaster balls. A preliminary account. *Sarsia*, Vol. 34, pp. 61-84.
- PÉRÈS, J.M., 1952. Annélides polychètes de la roche littorale de Corse. *Recl. Trav. Stn. Mar. Endoume*, Bull. 2, Fasc. 6, pp. 5-18.
- PÉRÈS, J.M. & J. PICARD, 1964. Nouveau manuel de bionomie benthique de la Mer Méditerranée. *Recl. Trav. Stn. Mar. Endoume*, Bull. 31, Fasc. 47, pp. 1-137.
- RIEDL, R., 1964. Die Erscheinungen der Wasserbewegung und ihre Wirkung auf Sedentariier im mediterranen Felslitoral. *Helgol. Wiss. Meeresunters.*, Vol. 10, pp. 155-186.
- SANDERS, L.H., 1968. Marine benthic community: a comparative study. *Am. Nat.*, Vol. 102, pp. 234-282.
- SAN MARTIN, G., 1984. Estudio biogeográfico, faunístico y sistemático de los poliquetos de la familia Sillidos (Syllidae, Polychaeta) en Baleares. Tesis doctoral, Editorial de la Universidad Complutense de Madrid, 529 pp.
- SAN MARTIN, G., M.I. ACERO, M. CONTONETE & J.J. GOMEZ, 1982. Una colección de anélidos poliquetos de las costas mediterráneas Andaluzas. *Acta II Simp. Ibér. Estud. Benthos Mar.*, Vol. 3, pp. 171-182.
- SAN MARTIN, G., J.M. VIEITEZ & A. CAMPOY, 1981. Contribución al estudio de la fauna de anélidos poliquetos de las costas españolas: poliquetos errantes recolectados en la Bahía de Palma de Mallorca. *Boln. Inst. Esp. Oceanogr.*, Vol. 6, pp. 61-87.
- SARÀ, M., A. BALDUZZI, F. BOERO, M. PANSINI, D. PESSANI & R. PRONZATO, 1978. Analisi di un popolamento bentonico di falesia del promontorio di Portofino. Dati preliminari. *Boll. Mus. Ist. Biol. Univ. Genova*, Vol. 46, pp. 119-137.
- STEPHENSON, T.A. & A. STEPHENSON, 1949. The universal features of zonation between tide-marks on rocky coasts. *J. Ecol.*, Vol. 37, pp. 289-305.
- ZURLINI, G., 1983. Applicazione di metodi multivariati all'analisi ecologica. In, *Un esempio di analisi ecologica del sistema marino costiero de Capa Circeo all'isola di Ischia*, edited by G. Zurlini & V. Damiani, ENEA, Roma, pp. 13-34.