Structural and Trophic Variations in a Bathyal Community in the Ligurian Sea

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ABSTRACT

The structure of a Mediterranean bathyal community living between 400 and 700 m depth in front of Portofino Promontory (Ligurian Sea) has been investigated, using sets of data collected in 1981 and 1996 respectively. Percent community composition, total density and biomass don't show any significant change, at least on the whole. Although total species number found in the two considered years is comparable, as well as diversity and evenness values, the specific composition shows an almost complete substitution. In particular, the disappearance of epifaunal species, mainly of large size, is outstanding. A real biocoenotical change did not occur, as evidenced by the qualitative (species dominance) and quantitative (numerical dominance) analyses of biocoenotical stocks, which show only a light increase in abundance of limicolous species and species linked to deep muds (VP) *versus* coastal terrigenous muds (VTC). Conversely, multivariate analysis evidences a clear clustering of 1996 and 1981 data due to presence/absence or different abundance of some key species: *Amphilepis norvegica, Spiophanes kroyeri rejssi* and *Amphiura filiformis* are present only in 1981, *Aricidea quadrilobata* and *Paradoneis lyra* appear in 1996. The analysis of community trophic structure highlights a significant increase of carnivorous species (mainly scavengers), mostly in terms of numerical dominance, opposed to a strong decrease of deposit-feeders.

The traditional use of descriptive tools, such as species number, total density and biomass lead to the classic hypothesis of general stability of bathyal communities. Conversely, changes in faunal composition of the bathyal benthic community of the Portofino Promontory were stressed only through the coupling of uni- and multi-variate approaches, suggesting that deep-sea benthic assemblages are not so stable as usually considered, probably partly because of small-scale changes in sedimentary regime (natural and anthropogenic) and heavy fishing trawling activities, both affecting the surface sediments, determining unfavourable conditions for the epifauna and favouring, instead, omnivorous and scavenger species.

Introduction

Deep-sea communities are considered to be characterised by a high degree of stability, due to the widespread uniformity of environmental parameters and food availability: increasing stability is correlated with increasing depth, as changes in the environment are decreased (Hessler and Sanders 1967; Rex 1981).

The *stability-time hypothesis* (Margalef, 1968; Sanders 1969; Slobodkin and Sanders, 1969) relates low diversity (= low degree of organisation) with severe and/or unpredictable hydrochemical environmental conditions. On the contrary, low variations of environmental parameters allow the stabilisation of biotic interactions which lead to high degree of specialisation. While there have been a great number of studies dealing with deep-sea benthic community structure from a static point of view, data on its persistence are still scarce (Bernstein and Meador 1979; Josefson 1981).

Lack of variation in the water column and in benthic environment below the thermocline have been a basic tenet of physico-chemical and ecological studies in the deep-sea. Whilst the

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concept of temporal stability is valid for much of the world oceans and over mesoscale terms, on a short basis periodic variability appears to be more common in certain areas of the deep-sea than originally supposed (Tyler 1988). Predictable and unpredictable processes may be responsible of variations in the deep-sea environment (Tyler 1988): physical features and seasonality in vertical flux are usually of a short time scale and predictable, while unpredictable events may be considered turbidity currents, sediment slides and benthic storms. The most considerable and predictable fraction of the vertical flux is constituted by the rain of small particles derived from surface primary and secondary production (organic and inorganic particles, macrophyte detritus, faecal pellets and large food falls of moults), while deadfall of carcasses and river run-off are unpredictable. Seasonal processes are mainly responsible for growth, spawning and recruitment of deep-sea benthic organisms (Gage and Tyler 1981; Tyler 1988), while unpredictable events can play a relevant role in determining small scale patchiness in mega-, macro- and meiobenthic organism distribution and relevant abundance of scavenger species (Dayton and Hessler 1972).

In order to evaluate deep-sea community structure and its stability, a comparison between present and past data sets was carried out off the Portofino Promontory (Eastern Ligurian Sea, Mediterranean Sea), comparing data recorded in 1981 and 1996. The investigated area (between 400 and 700 m depth) is located on a very steep continental slope, characterised by the presence of drainage lines, river run-off from the Entella river and strongly affected by anthropogenic activities (fishery and dumping).

The analysis of community structure was carried out taking into account biocoenotical and trophic features, evidencing analogies and discrepancies between recent and past data.

Materials and Methods

Samples were collected in April 1981 (Cattaneo and Albertelli 1983), on board of the H/V *L.F. Marsili* and in April 1996, on board of the H/V *Ammiraglio Magnaghi*, in an area off the Portofino Promontory around 44°14.2 N and 09°08.5 E (0.5 nautical mile radius; Fig. 1).

Sampling was performed using a Van Veen grab (0.1 m^2): 36 samples were collected in 1981, ranging in depth between 428 and 760 m, while 24 were collected in 1996, between 438 and 690 m depth.

Samples were sieved using a 1 mm mesh sieve, preserved in 10% formaline and sorted in the laboratory, using a stereomicroscope.

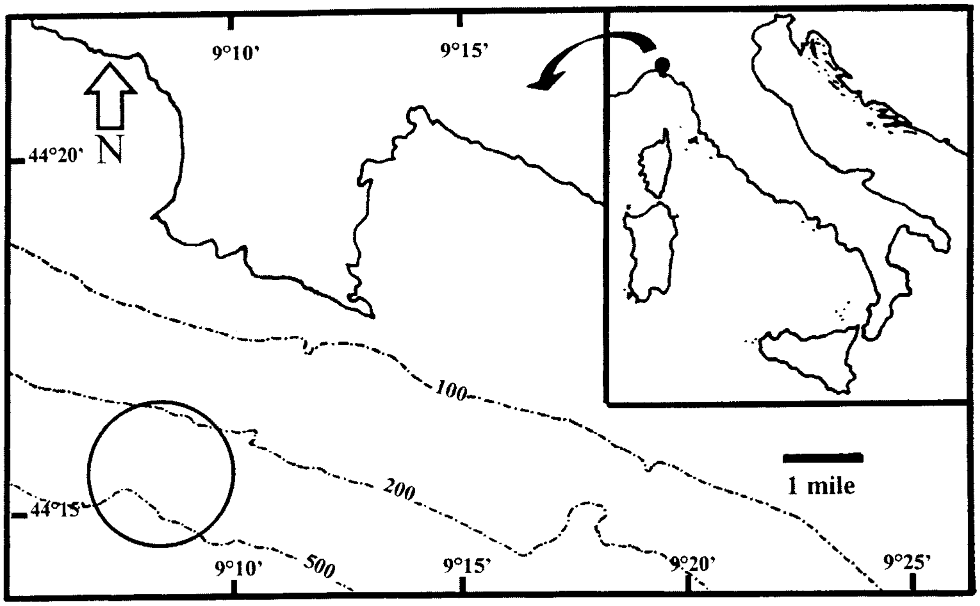

Fig. 1. Location of sampling area

Macrobenthic specimens were counted and identified at species level. Biomass values of different phyla were assessed in terms of wet weight (gWW).

The following Cabioch index (Cabioch et al. 1980) was applied:

$$Ci = (q-p) / (q+p)$$

where: p = frequency of species i in 1981 data set
q = frequency of species i in 1996 data set

The Cabioch index ranges between −1 (species disappearance) and +1 (species appearance).

Margalef species richness (Margalef 1958), Shannon-Weaver diversity (Shannon and Weaver 1963) and Pielou evenness (Pielou 1966) indexes were evaluated.

Table 1. Total density, biomass and species numbers in 1981 and 1996 samplings

		1981	1996
Total macrobenthic density (ind./m^2)		126.4	101.6
Total macrobenthic biomass (gWW/m^2)		6.6	6.3
Species number:	Polychaetes	46	38
	Crustaceans	16	22
	Molluscs	7	8
	Echinoderms	6	1
	Other taxa	6	6
	Total	81	75

Classification (cluster analysis) and ordination (MDS) of data were performed on square root transformed density data (1981 + 1996 data), grouping stations according to bathymetric levels (400-500 m, 500-600 m and > 600 m), using the Bray-Curtis similarity index (Bray-Curtis 1957). The contribution of species to groups dissimilarity was assessed through R-mode analysis. Classification, ordination and R-mode analysis were performed using the software PRIMER of the Plymouth Marine Laboratory.

Results

The comparison between present and past data sets has evidenced large discrepancies according to the different community descriptor parameters considered.

In fact, the macrobenthic community living off the Portofino Promontory in the last 15 years did not show any relevant variation in terms of density, biomass as well as total species number (Table 1; t-test, P>5 %).

Quite similar values of Margalef species richness, Shannon-Weaver diversity and Pielou evenness were also found comparing 1981 and 1996 data: 3.42 versus 3.46, 1.90 versus 2.07 and 0.98 versus 0.96, respectively.

Comparable results were also observed in terms of numerical dominance of the main different phyla (Fig. 2), except for the disappearance of ophiuroids, mainly *Amphilepis norvegica*, an exclusive species of Mediterranean deep muds

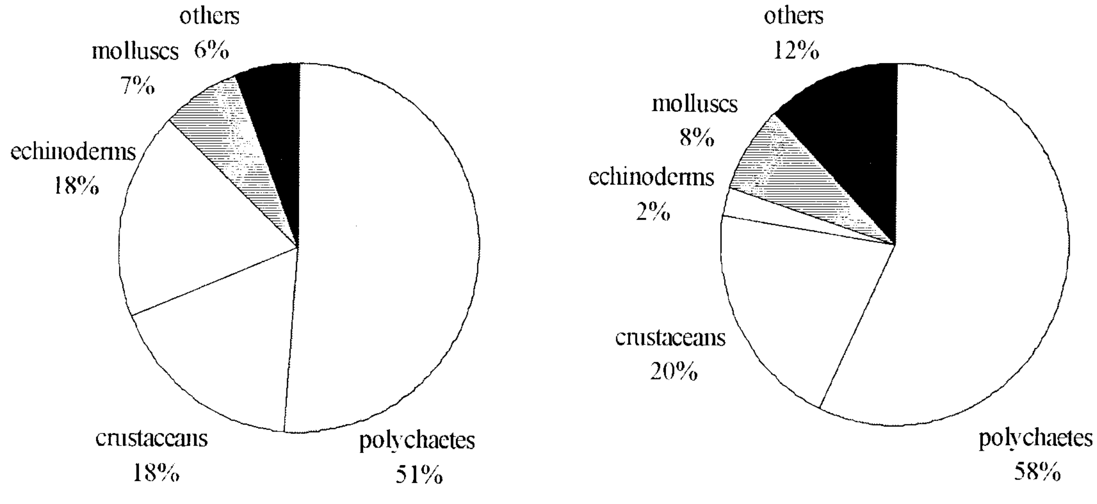

Fig. 2. Percent dominance of different taxa to total density in 1981 (*left*) and 1996 (*right*)

(VP: Peres and Picard 1964) (Carpine 1970; Picard 1972; Chardy et al. 1973).

Differently, significant variations were observed taking into account the contribution of the different phyla to total biomass (Fig. 3): in particular polychaetes showed a marked decrease in biomass values, dropping from 2.1 to 0.1 gWW/m^2.

Moreover, taking into account the species composition of the whole two data sets, large variations may be stressed. A total of 156 species was found on the whole, only 25 of which were recorded both in 1981 and 1996 cruises. These species showed quite different dominance values, as evidenced by the Cabioch index (Fig. 4).

In Table 2a,b the characterising species of the two data sets are reported with their numerical dominance values in respect of the whole community and of the phylum, to which they belong.

Trophic structure stressed an increase of carnivorous and scavenging species in 1996 (grouped together in Fig. 5) at despite of typical deposit-feeding species.

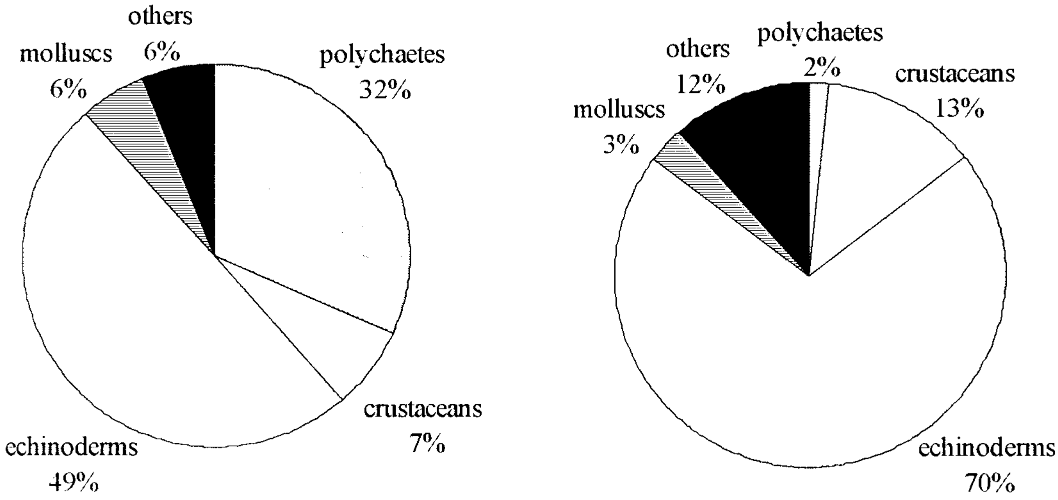

Fig. 3. Percent dominance of different taxa to total biomass in 1981 (*left*) and 1996 (*right*)

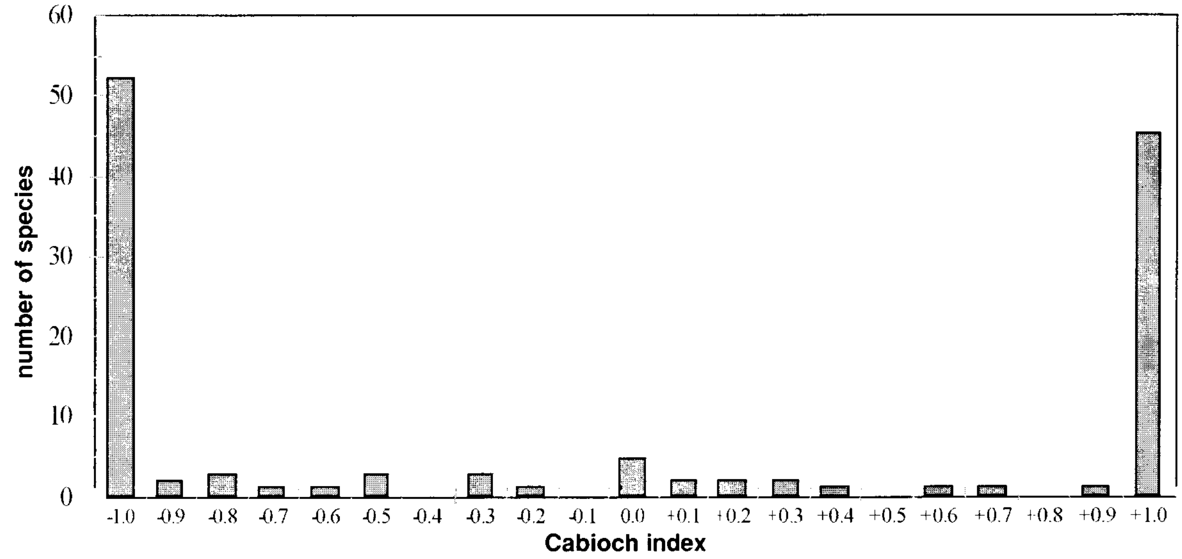

Fig. 4. Frequency distribution of Cabioch index

Table 2a,b. a 1981, and b 1996, characterising species: numerical dominance in respect of the phylum to which they belong and of the whole community

a	Phylum	1981	% on phylum	% on whole community
	Polychaetes	*Anobothrus gracilis*	12.9	6.6
		Melinna monoceroides	10.3	5.3
		Spiophanes kroyeri rejssi	10.3	5.3
	Crustaceans	*Calocaris macandreae*	27.2	4.8
		Eriopisa elongata	19.8	3.5
	Molluscs	*Abra longicallus*	42.4	3.1
		Lionucula tenuis aegeensis	18.2	1.3
		Thracia papyracea	15.2	1.1
	Echinoderms	*Amphilepis norvegica*	57.3	10.3
		Amphiura filiformis	24.4	4.4
	Other taxa	*Aspidosiphon mulleri*	53.8	3.1

b	Phylum	1996	% on phylum	% on whole community
	Polychaetes	*Aricidea quadrilobata*	11.5	3.5
		Onuphis lepta	11.5	3.5
		Prionospio cirrifera	10.8	3.3
	Crustaceans	*Anthelura fresi*	14.0	1.5
		Calocaris macandreae	12.0	1.3
		Eriopisa elongata	20.0	2.2
	Molluscs	*Abra longicallus*	36.8	1.5
		Dentalium agilis	15.8	0.7
	Echinoderms	*Molpadia musculus*	100	1.3
	Other taxa	*Onchnesoma steenstrupi*	20.0	1.3

The analysis of biocoenotical assemblages dominance evidenced only a slight increase of VP characteristic species, although remarkable absences may be stressed, such as the ophiuroid *Amphilepis norvegica*. Most remarkable differences were stressed about *habitus* of dominant species. In 1996 a decrease of tube-building (sediment stabilisers) species occurred, balanced by

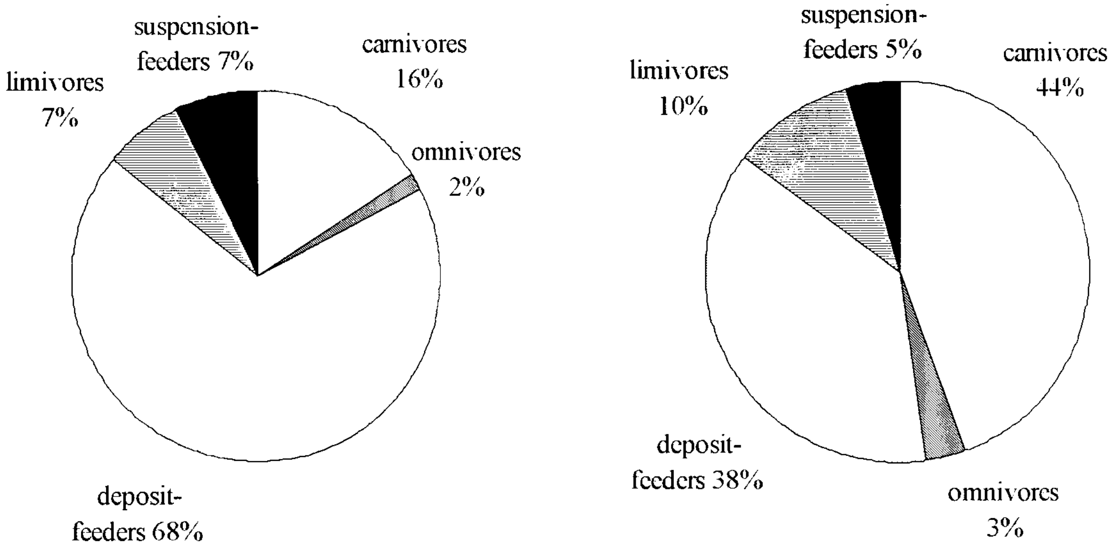

Fig. 5. Percent dominance of different trophic groups in 1981 (*left*) and 1996 (*right*)

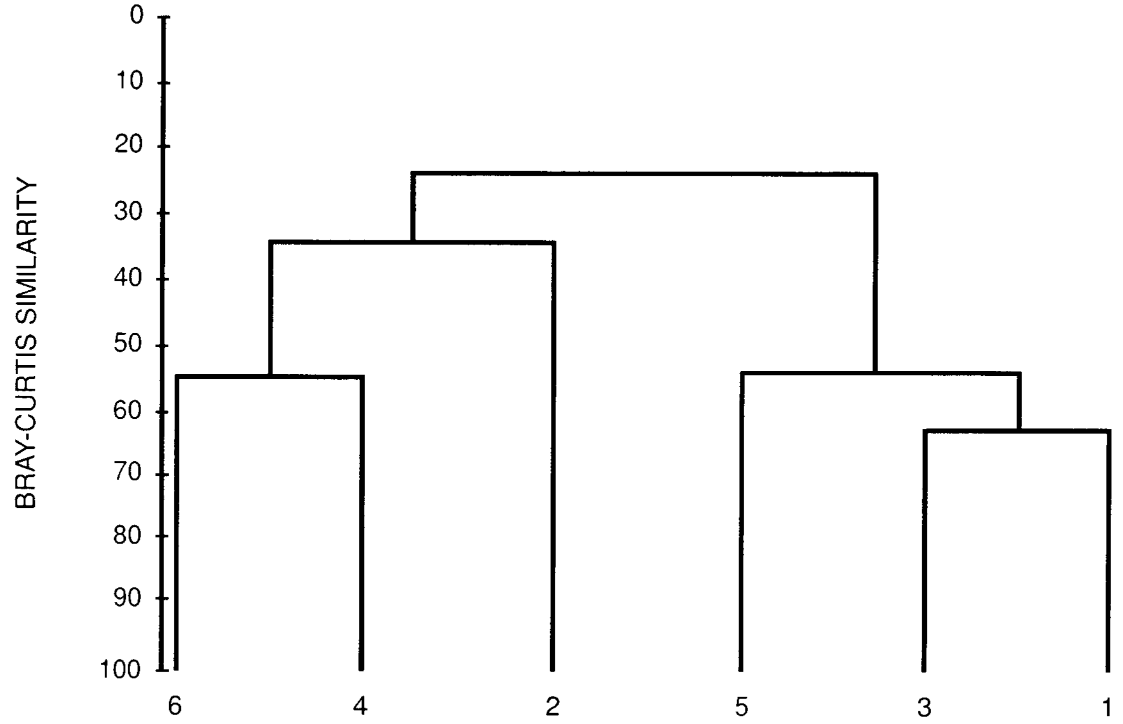

Fig. 6. Classification of density data. Stations grouped according to bathymetric levels [*1*, 400-500 m (1981); *2*, 400-500 m (1996); *3*, 500-600 m (1981); *4*, 500-600 m (1996); *5*, >600 m (1981); *6*, >600 m (1996)]

increase of vagile species (carnivores/scavengers) or sediment-destabilisers.

The differences in community structure were remarkably evidenced through classification (cluster analysis; Fig. 6) and ordination (MDS; Fig. 7) of data, taking into account samples grouped according to bathymetric gradient, showing a complete dichotomy between 1981 and 1996 data. From cluster as well as with *t*-test analyses, the uppermost area (400-500 m) evidenced larger differences between past and present data in terms of total density, biomass and numerical dominance (*t*-test, $P<0.05$), suggesting a more disturbed zone.

The comparison between single stations from the two data sets was also performed, but

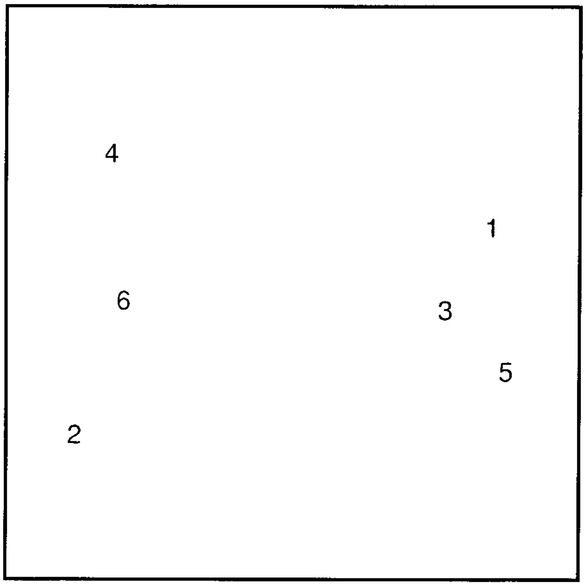

Fig. 7. Ordination of data (MDS). See legend in Fig. 6. 2-dimensional stress < 0.01, excellent representation

Table 3. Discriminating species, average abundance in the two data sets and percent contribution to dissimilarity between clusters

Species	1981	1996	%
Amphilepis norvegica	**1.10**	0.00	3.12
Aricidea quadrilobata	0.00	**0.56**	2.50
Paradoneis lyra	0.00	**0.56**	2.49
Spiophanes kroyeri rejssi	**0.61**	0.00	2.49
Amphiura filiformis	**0.51**	0.00	2.34
Prionospio steenstrupi	**0.44**	0.00	2.19
Anobothrus gracilis	**0.77**	0.11	2.09
Syllis cornuta	0.00	**0.35**	1.86
Prionospio cirrifera	0.05	**0.51**	1.86

results were highly contradictory, because of the organism paucity of each sampling station. The analysis of discriminating species through R-mode analysis is reported in Table 3.

Discussion and Conclusions

Comparing data regarding the composition of the bathyal macrobenthic assemblages living between 400 and 700 m depth off the Portofino Promontory (Ligurian Sea), relevant variations between 1981 and 1996 are evident.

No differences arose regarding biomass, density, species number and diversity, but a significant change occurred in the relationships among the trophic groups, with an increment of carnivores and scavengers in despite of deposit-feeders.

The lack of previous long-term data on the structure and dynamics of these deep-sea communities makes it difficult to assess whether these differences are really true or eventually only mirror their diversity due to biocoenoses overlapping (Cattaneo-Vietti 1991) or patchiness, as evidenced in other deep-sea communities (Hessler and Sanders, 1967; Jumars 1975).

This heterogeneity and structural complexity may be the natural result of different stochastic processes such as localised downward organic fluxes (from POM to large carcasses), cropper (*sensu* Dayton and Hessler 1972) and/or tube-builder presence (Gray 1974; Jumars 1975, 1976), allowing coexistence of various microsuccessional stages through contemporaneous disequilibria (Grassle and Sanders 1973).

In the case of real variations, questions arise about which were the main responsible events that affected the stability of benthic communities and influenced the dynamic nature of fine-grained sediments. Are they stochastic, biologically mediated or anthropogenic?

Major changes have been stressed in the uppermost investigated area (400-500 m), suggesting a littoral derived disturbance, probably linked to different and synergic factors. The study area is located close to the *Riviera di Levante* canyon, and it is affected by high density flowing down currents transporting unstable sediments sliding down the submarine slope (Fanucci et al. 1979; Corradi et al. 1980). Moreover these bottoms are influenced by the outflows of the Entella river (Piccazzo 1986) and by its floods.

Besides these natural influences, the area is affected by an intensive trawling activity (Massi et al. 1994), mainly linked to the red shrimp fishing (Relini and Orsi Relini 1987). It is reasonable to suppose that the continuous disturbance of the fishing gears causes a significant reworking of the sediment and difficulties for the bottom-stabilising organisms. Among these, *Funiculina quadrangolaris* and *Isidella elongata* for epifauna (Relini-Orsi 1973; Relini et al. 1986), and different tube-building polychaetes, for endofauna. The continuous fishing activity has caused quali- quantitative changes in the commercial catches (Relini-Orsi 1973; Relini et al. 1986) and an anomalous increase of large organic debris which favours the scavengers (Cattaneo-Vietti et al. 1993).

Besides this permanent impact, it is possible to take into account the authorised dumping of harbour muds that has occurred in the last decades which could have changed the superficial texture of the sediments up to 700 m depth.

A complex of factors favours in this area an environmental instability which influences the community structure, preventing the establishment of sediment-stabilising species (tube-builders, burrow dwellers), whose presence plays an important biological role controlling and maintaining diversity (Rhoads and Young 1970; Young and Rhoads 1971).

In the deep sea, these studies have a significant importance both in the evaluation of the long-term changes and/or of anthropogenic impact, since the only analysis of routine descriptive parameters (density, biomass, species richness and numerical dominance) are not exhaustive, as external factors could radically change the trophic pathways in these food-limited environments and consequently the species composition.

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