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COMPARATIVE STUDY OF THE TROPHIC STRUCTURE OF SOFT-BOTTOM ASSEMBLAGES IN THE BAY OF BLANES (WESTERN MEDITERRANEAN SEA)

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ABSTRACT

This study describes the trophic structure and dynamics of the soft-bottom macroinfauna inhabiting shallow sublittoral zones off the Bay of Blanes. The area is influenced by the inputs of the Tordera River, the activity of Blanes Harbor, and the effluent of domestic sewage. Five assemblages were studied from March 1992 to March 1993. Biomass data have been used for the analysis. Coarse sand sediments with low organic matter content were dominated by filter feeders and carnivores. The mixed group (filter and surface-deposit feeders) was the dominant one in fine sand sediments at the opening of the harbor. Subsurface-deposit feeders became more abundant in silty-sand sediments with the highest percentage of organic matter. Water depth, granulometry and organic matter content were correlated to the observed spatial distribution. Rainfall, chlorophyll-*a* concentration in the water column, and organic matter content in the sediment were used to explain the seasonal variability. Annual dominance of trophic groups among sampled sites showed higher differences than the seasonal variability within sites. Comparisons of the trophic structure among stations were carried out using a trophic group importance index. The use of the traditional trophic indexes was discussed.

Trophic organization in soft-bottom environments has usually been related to the particle size of substrata and the organic matter content in sediments (Sanders, 1958; Gray, 1974; Snelgrove and Butman, 1994). However, the distribution patterns of trophic groups have proved to be sensitive to several other factors including environmental disturbance, stress conditions, or food availability (Maurer and Leathem, 1981; Probert, 1984; Gaston and Nasci, 1988).

One common generalization dealing with the trophic organization of communities is that deposit-feeders are more abundant in muddy habitats and suspension-feeders dominate in sandy habitats. Nevertheless, besides the frequent coexistence of both groups, a number of species alter their trophic mode in response to flow and food conditions, and many species are not always associated with a single sediment type (Snelgrove and Butman, 1994). Therefore, this traditional pattern seems not to be so consistent and may be highly dependent on each particular habitat condition.

Macrobenthic studies usually produce large data sets including high number of species, but with poor information about functional organization of communities (Warwick, 1988). Since benthic organisms are distributed in the sediment according to their trophic-functional type, feeding guilds have been used as biological variables to investigate and predict functional interactions (Sanders, 1958; Levinton, 1972; Whitlatch, 1977), to reduce long data sets (Dauer, 1984), and to replace the concept of species (Paiva, 1993). Other benthic studies have searched for an index that integrates macrobenthic community structure as a response to habitat characteristics (Curtis and MacIntosh, 1951; Bouchet et al., 1983; Wildish, 1984; Paiva, 1993; Engle et al., 1994), but how those indexes correctly reflect variation in trophic structure or in the source of stress over time, have seldom been demonstrated.

Environmental variables modulate temporal changes influencing the community organization of benthic ecosystems. The response of macrobenthic organisms to seasonal changes in environmental conditions has been examined using trophic groups (Whitlatch, 1977; Bachelet, 1981; Desrosiers et al., 1986; Paiva, 1993). Although the analysis of trophic guilds reveal some problems derived from the ability of organisms to alternate their feeding mechanisms (Fauchald, 1992), enough information about feeding behavior is available to perform analysis of community trophic structure using almost all the macrobenthic species in the assemblages (Gaston and Nasci, 1988). Most studies on trophic structure of communities are based on densities, but the use of biomass emerged as a more coherent approach to work on the distribution and seasonality of feeding guilds. Density may be the result of recruitment events which produce large numbers of small organisms with little biomass, and patchy distribution.

In this paper, we examine the trophic structure of five soft-bottom macrobenthic assemblages off the Bay of Blanes (northwestern Mediterranean Sea) submitted to different environmental conditions. We investigate whether seasonal dynamics of these assemblages can obscure the spatial structure over time, and whether the differences in the source of environmental variations may affect both the spatial distribution and the seasonal variability of the trophic groups. To meet our objectives, the following variables have been analyzed: rainfall data, hydrographic parameters (i.e., salinity, temperature, wave height), chlorophyll-*a* concentration in the water column, granulometry, and organic matter content in the sediment. The use of trophic indexes to qualify habitats is also discussed.

MATERIAL AND METHODS

Study Site.—Blanes Bay is located in the northwestern Mediterranean Sea (41°40′N, 2°48′E) (Fig. 1). The area is characterized by the presence of a harbor (fishing port and recreational marina), the effluents of domestic sewage, the inputs of the Tordera River, and the combined action of the dominant east (winter) and south (summer) winds.

Five macroinfaunal assemblages were examined in the bay (Fig. 1). Mean benthic parameters are shown in Table 1. The seasonal pattern in macroinfaunal abundance was characterized by a peak during spring (recruitment period), a sharp decrease through summer and lower values in autumn and winter. The biomass followed roughly the abundance pattern. The assemblages were dominated by polychaetes and bivalves. Echinoderms and crustaceans, as other less represented groups, showed lower densities. The number of species was similar among sites (Pinedo et al., 1996).

Sampling Procedure.—Two replicate grab samples were obtained fortnightly at stations 1 and 2, and monthly at stations 3, 4 and 5, from March 1992 to March 1993. A Van Veen grab of 600 cm^2 area was used. Samples were sieved through a 0.5-mm screen and preserved in a 10% formalin sea-water solution stained with Rose Bengal.

The organisms retained by the sieve were classified to the lowest possible taxonomic level for polychaetes, bivalves, large nematodes and echinoderms. Remaining taxa were classified only to major groups. Biomass was determined as dry weight (24 h at 70°C), except for calcified species where it was obtained by the loss of weight after ashing (5 h at 450°C). Regressions were used to convert measured lengths to biomass for the polychaete *Owenia fusiformis* and the different species of bivalves.

Small sediment subsamples were collected from the grab for organic content and mechanical granulometric analysis. Organic content of dry sediment was estimated as the loss of weight after ashing. Sediment was submitted to the standard dry-sieved procedure (Wentworth, 1972) for granulometric analysis. Six size classes were used in this study: silt (<63 μm), very fine sand (63 to 120 μm), fine sand (120 to 250 μm), medium sand (250 to 500 μm), coarse sand (500 to 750 μm), and very coarse sand (750 to 1,000 μm). Meteorological and hydrographical data came from a previous work on the physical environment of the bay (Cebrián et al., 1996). Rainfall data ($1\ m^{-2}{\cdot}d^{-1}$) were provided by the meteorological station located in the town of Blanes. Surface sea-water temperature (°C) and salinity (%) at about −0.5 m depth were recorded outside the harbor with an Aanderaa model 3210 salinity-temperature probe (sampling frequencies ranging from 0.3 and $12{\cdot}day^{-1}$). Data of wave height (m) off Blanes was acquired from a monitoring mooring of the Generalitat de Catalunya with a sampling frequency of $12{\cdot}day^{-1}$. Water column samples were taken weekly to measure chlorophyll-a concentration ($mg{\cdot}m^{-3}$) by fluorometric analysis (Mura et al., 1996).

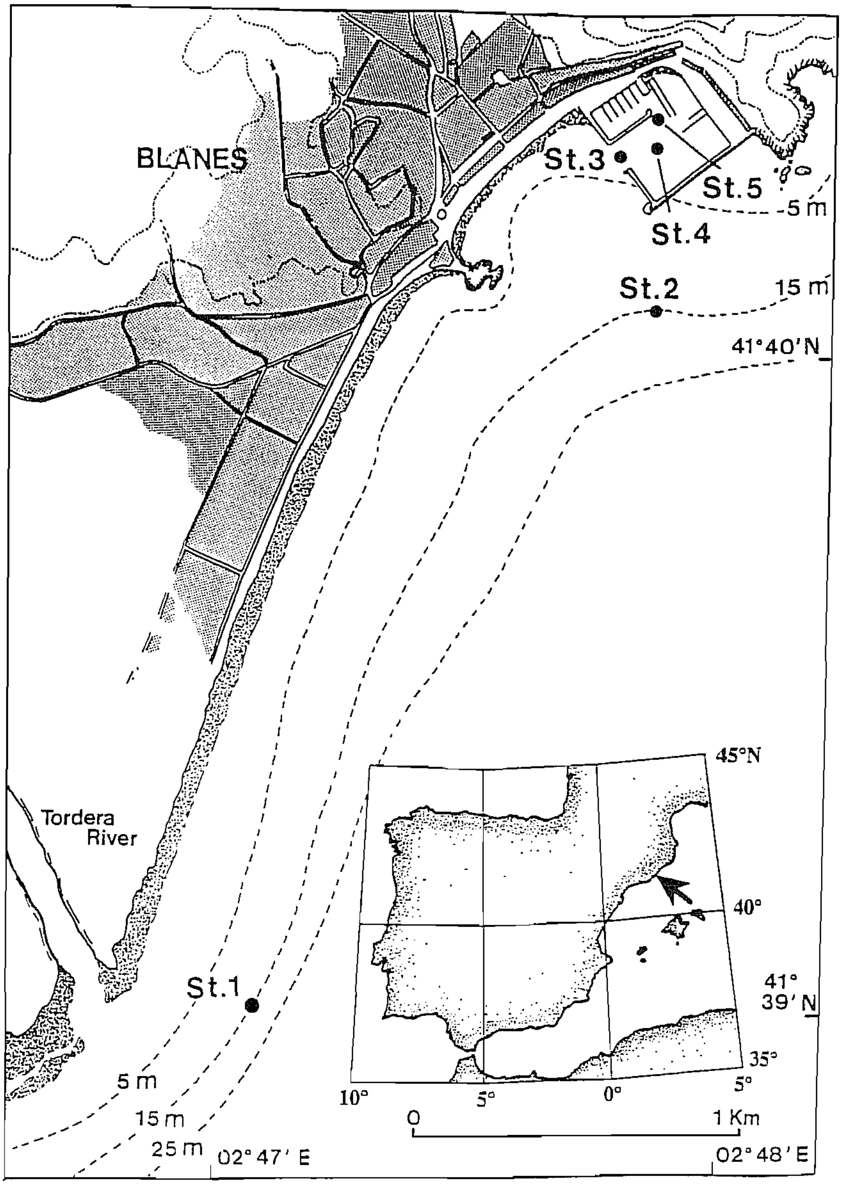

Figure 1. Studied stations in Blanes Bay.

Trophic Groups and Related Indexes.—Organisms were ranked into five trophic groups adapted from Fauchald and Jumars (1979) and Dauvin and Ibanez (1986): F, filter feeders; M, mixed (filter and surface-deposit feeders); S, surface-deposit feeders; SS, subsurface-deposit feeders; C, carnivores/ omnivores. The bivalve species of the Subfamilies Tellinoidea and Nuculoidea were included in the mixed group according to Levinton (1982). The remaining bivalve species were classified as filter feeders. Each species was classified into a single trophic group.

To test the capacity to describe the trophic structure of the area under study, several indexes related to trophic groups were used: Bouchet et al. (1983): abundance of surface-deposit feeders/abundance of filter feeders plus carnivores; Wildish (1984): abundance of surface-deposit feeders/abundance of filter feeders plus surface-deposit feeders. Other trophic indexes based on different combinations of the observed contribution to biomass of trophic groups have been also examined. To evaluate the

Table 1. Mean benthic parameters for the studied assemblages

	Station 1	Station 2	Station 3	Station 4	Station 5
Environmental data					
Water depth (m)	15	15	8	6.5	3
Sediment type (Wentworth's)	coarse	fine	fine	very fine	medium
Medium grain size (μm)	575	148	179	85	235
Silt-clay (%)	0.245	2.185	3.575	32.860	2.375
Sorting index	1.43	1.39	1.32	1.49	1.42
Sediment organic matter (% dw)					
annual mean	0.706	1.077	1.629	3.986	1.153
range	(0.313–1.110)	(0.675–1.441)	(1.115–2.790)	(2.370–4.955)	(0.675–2.060)
Biological data					
Abundance ($ind{\cdot}m^{-2}$)					
annual mean	4712	10122	23489	63609	13189
range	(398–21106)	(1382–46400)	(5442–51600)	(31558–91383)	(2450–36458)
Biomass (dry weight $g{\cdot}m^{-2}$)					
annual mean	3.410	1.690	4.484	8.045	2.577
range	(1.389–6.109)	(0.130–4.050)	(0.838–9.278)	(3.699–11.811)	(0.619–7.472)

ecological importance of trophic groups at stations, the importance index (Ti) adapted from Paiva (1993) was used:

$$Ti = \sum_{i=1}^{s} \ln ni \text{ (Paiva, 1993)}$$

s = number of taxa [species in Paiva, 1993] of the trophic group in the sample.
ni = (% biomass) + 1[abundance values in Paiva, 1993] of the i^{th} taxa groups [species in Paiva, 1993] in the sample.
ln = natural logarithm.

Statistical Analysis.—A factorial analysis of correspondence was performed on a non-transformed biomass of trophic guilds-per-sample matrix to investigate the relationships between guild distribution and seasonal and spatial variability. These relationships were graphically illustrated by representing each sample by a label including specifications of sampling site (1–5) and date (1(January)–12(December)); e.g., 2–8 refers to station 2 and the August sampling.

Since the assumptions of normality and homoscedasticity (as tested by Kolmogorov-Smirnov and Bartlett test, respectively) were not meet, non-parametric analysis were used to test: (1) the biomass variation among the different trophic groups at each station (Kruskal-Wallis test), and (2) the influence of the habitat on the biomass contribution of each trophic group (Mann-Whitney test).

Parametric one-way analysis of variance (ANOVA) was used to test the seasonal variation of the trophic group biomass at each station. The ANOVA was performed using the time as a factor. Data were transformed to meet the assumptions of normality and homoscedasticity. When the assumptions were not meet, non-parametric analysis was used (Kruskal-Wallis test). Multiple comparisons among time units were carried out by Tukey test.

Pearson correlation analysis was used to asses the relationships between environmental parameters (water depth, granulometric variables, organic matter content), trophic indexes, and mean annual biomass of the different guilds at each station. Cross-correlation analysis were used to examine the strength of the association (given by Pearson correlation coefficients, r) between the seasonality of environmental variables (organic matter content, rainfall and hydrographic data, and chlorophyll-*a* concentration in the water column), and the seasonal changes of trophic groups biomass. Environmental data used in the analysis were obtained integrating the values recorded between sampling dates. The coupling between two variables may involve a time lag, which is estimated as the time lag to obtain maximal Pearson's correlation index in the cross-correlation analysis. The lag is the time delay in the relation of the values of the first data series (environmental variable) to values in the second one (trophic group biomass). The same analysis was applied to compare the seasonal trends of the trophic groups.

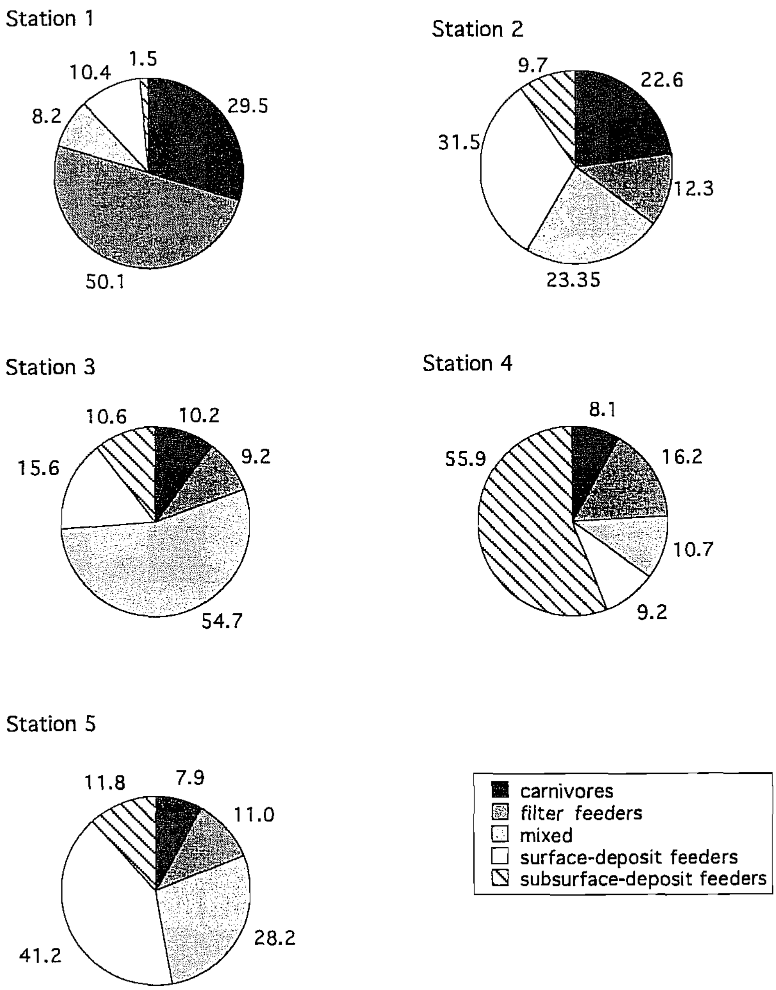

Figure 2. Dominance (based on mean annual biomass) of the trophic groups at the five studied assemblages (values are expressed as percent).

RESULTS

Trophic Structure and Indexes.—The composition of the mean annual biomass for the five trophic group assemblages (Fig. 2, Table 2) showed significant differences (Kruskal-Wallis test) at all the stations (Table 3). Filter feeders and carnivores were the most representative groups at station 1 (Fig. 2). The bivalves *Callista chione* and *Spisula subtruncata*, and the polychaete *Ditrupa arietina* accounted for 86% of the mean annual biomass of filter feeders. The polychaetes

Table 2. Mean annual biomass (g dw m^{-2}) of the trophic groups at the five studied assemblages

Station	Carnivores	Filter feeders	Mixed	S-deposit feeders	SS-deposit feeders	Total biomass
1	1.006	1.709	0.280	0.354	0.051	3.410
2	0.382	0.208	0.393	0.533	0.164	1.690
3	0.458	0.411	2.452	0.699	0.474	4.484
4	0.649	1.301	0.857	0.743	4.495	8.045
5	0.204	0.284	0.726	1.061	0.303	2.577

Table 3. Summary of the Kruskal-Wallis test showing the variation among the different trophics groups at the five assemblages

Station	df	H	*P*
1	4	94.0389	<0.001
2	4	21.8664	<0.001
3	4	42.2336	<0.001
4	4	59.4977	<0.001
5	4	19.5352	<0.001

Glycera cf. *capitata, Sigalion squamatum, Goniada emerita* and *Nephthys cirrosa* made up 47% of the total biomass of carnivores. The Echinodermata *Echinocardium mediterraneum* was the most important surface-deposit feeder with 0.15 $g{\cdot}m^{-2}$ of mean annual biomass.

Surface-deposit feeders was the dominant group at station 2, followed by the mixed and carnivore groups (Fig. 2). The detritivore species, *E. mediterraneum* and the polychaete *Paradoneis armata* accounted for almost 60% of the mean annual biomass of the group at this assemblage. The polychaetes *Spiochaetopterus typicus* and *Owenia fusiformis* contributed 76% of the biomass in the mixed group. Carnivore biomass was widely distributed into several species and taxa. The most representative species were the polychaete worms *Sigalion squamatum* (0.06 $g{\cdot}m^{-2}$) and *Nephthys hombergii* (0.02 $g{\cdot}m^{-2}$).

The mixed group accounted for over 50% of the mean annual biomass at station 3 (Fig. 2). *Owenia fusiformis* (2.03 $g{\cdot}m^{-2}$) was the main contributor with 45% of the total biomass in the assemblage. *Spiochaetopterus typicus* and the bivalves *Abra* sp. and *Tellina pulchella* also were important biomass contributors. The rest of the trophic groups were similarly represented, although the variation among them is still significant (Table 3).

Subsurface-deposit feeders predominated at the most organically enriched station in the harbor (station 4). The large nematode *Pontonema* cf. *vulgare* (3.26 $g{\cdot}m^{-2}$) accounted for 72% of mean annual biomass in this group. The remaining trophic groups ranged from 8 to 16% in importance (Fig. 2).

The surface-deposit feeders were dominant at station 5 as station 2. The spionid *Pseudopolydora antennata* was the main contributor (0.67 $g{\cdot}m^{-2}$) to biomass, whereas other worms such as *P. armata, Cirriformia* sp. and *Spio decoratus* were also important. Another spionid, *Polydora* cf. *caeca,* was the dominant species in the mixed group. Carnivores, filter feeders and subsurface-deposit feeders were less dominant (Fig. 2).

The values of the ecological importance index of each trophic group showed the predominance of one or two groups at each station (Fig. 3). No trophic groups seemed to dominate at station 5. Carnivores and filter-feeders prevailed at station 1, surface deposit-feeders and carnivores at station 2, mixed at station 3, and subsurface deposit-feeders at station 4. The results of Mann-Whitney test showed significant differences in the biomass of each trophic group at the five studied assemblages (Table 4).

Correspondence Analysis.—Correspondence analysis indicated two associations, between carnivores and filter-feeders and between surface deposit-feeders and the mixed group, which were separated along axis 2 (Fig. 4). Subsurface deposit-feeders appeared isolated and showed higher scores on axis 1 (Fig. 4). This clustering of trophic groups corroborated the ecological importance index results and has been taken into account to further define trophic indexes, adapted to the particular environmental conditions of the studied assemblages.

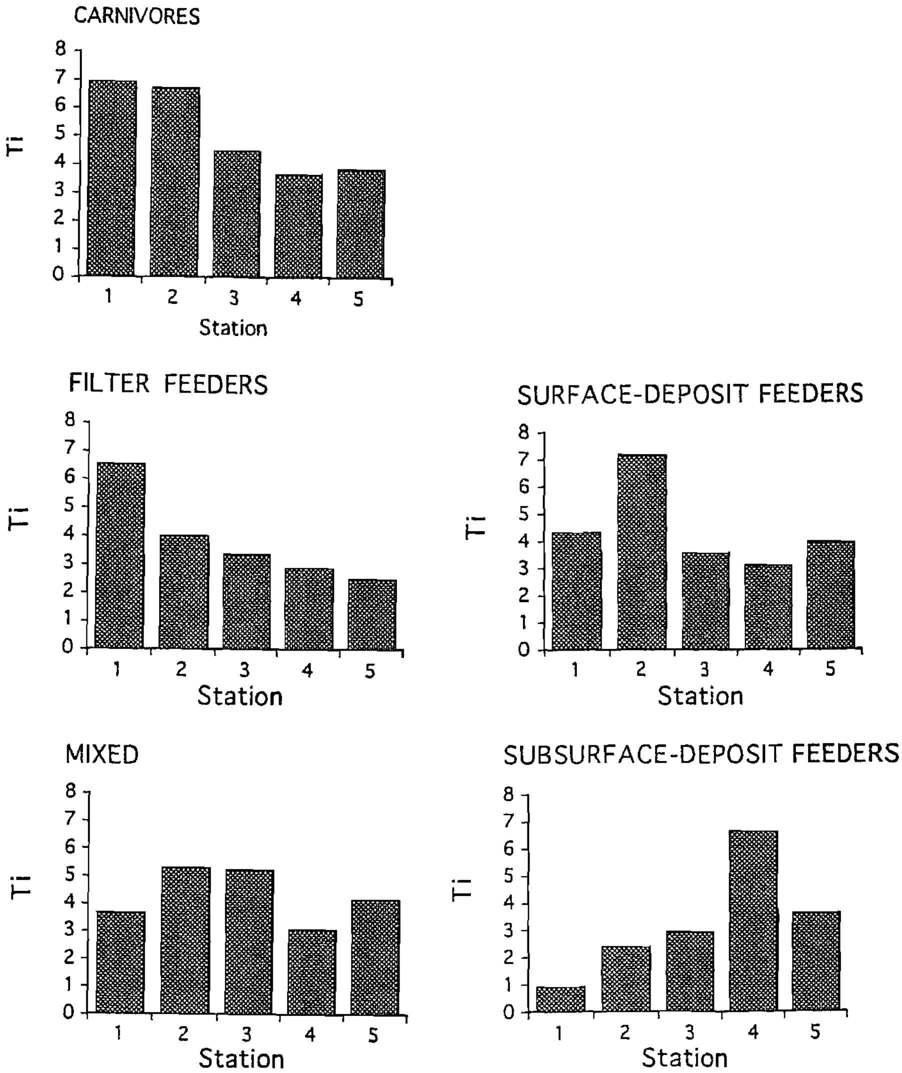

Figure 3. Trophic Importance Index adapted from Paiva (1993) of each trophic group at the five studied assemblages.

A similar segregation was observed among sampling sites. Samples from station 4 (with the lower grain size and higher organic matter content) and from station 1 (with the opposite sedimentological characteristics) appeared isolated from the others. The axis 1 was associated to the segregation based on the sediment organic content while the granulometric composition of sediment was shown by the axis 2. Station 1 was placed in relation to carnivores/filter feeders, station 3 was mainly the mixed trophic group, and subsurface-deposit feeders characterized station 4. Station 2 and 5 exhibited less fidelity with regards to trophic groups over time.

Trophic Dynamics.—The results of the analysis of variance on seasonal variation of trophic group biomass are shown in Table 5. Post hoc test showed that the significant differences were related to the tendency of biomass to increase from

Table 4. Summary of Mann-Whitney U-tests (H values) performed for the biomass composition of the five trophic groups at each station (*: $P < 0.05$, **: $P < 0.001$, ***: $P < 0.001$, n.s.: no significant differences)

Station	2	3	4	5
Carnivores				
1	524.0***	516.0***	424.0**	572.0***
2		280.0 n.s	168.0*	388.5*
3			212.0 n.s.	451.5***
4				500.0***
Filter feeder				
1	528.0***	556.0***	384.0*	576.0***
2		148.0*	40.0***	196.5 n.s.
3			96.0***	356.0 n.s.
4				512.0***
Mixed				
1	174.5*	24.0***	105.0***	180.0 n.s.
2		24.0***	175.5*	232.0 n.s.
3			476.0***	488.0***
4				352.0 n.s.
Surface-deposit feeders				
1	251.5 n.s.	224.0 n.s.	144.0**	184.0*
2		242.0 n.s.	204.0 n.s.	214.0 n.s.
3			244.0 n.s.	244.0 n.s.
4				263.0 n.s.
Subsurface-deposit feeders				
1	230.5 n.s.	27.5***	0.0***	53.0***
2		128.0***	0.0***	148.0**
3			0.0***	356.0 n.s.
4				576.0***

winter to late spring, and to decrease through summer. This seasonal pattern was nearly the same for most trophic groups at the five assemblages (Fig. 5). However, carnivores peaked in March at stations 2 and 3 and subsurface-deposit feeders had the highest biomass values after summer (September–October) at station 5. Although non significant, a tendency to peak in winter was also observed at the stations 3, 4, and 5 (Fig. 5).

Relationships with Environmental Variables.—The mean annual biomass of the station assemblages was correlated with the organic matter content (Pearson correlation analysis, $r = 0.93$, $P < 0.05$) and percentage of silt-clay ($r = 0.91$, $P < 0.05$). These two environmental variables were significantly and positively correlated ($r = 0.99$, $P < 0.01$). No relationships were found between mean annual biomass and water depth and the other sedimentological variables. When the analysis was applied to each trophic groups biomass, few significant responses were detected. Subsurface-deposit feeders was the single group positively correlated with the percentage of silt-clay ($r = 0.99$, $P < 0.001$) and organic matter content ($r = 0.99$, $P < 0.01$). The surface-deposit feeder group was negatively correlated with water depth ($r = -0.94$, $P < 0.05$).

Positive correlations were obtained between medium grain size and the following trophic indexes: (C + F)/(M + S + SS) ($r = 0.95$, $P < 0.05$), and (C + F)/(all five groups) ($r = 0.90$, $P < 0.05$). Negative correlation was observed between the sorting index and a combination based on the contribution of the mixed group: (M)/(F + C + S + SS) ($r = -0.88$, $P < 0.05$). Negative regression was

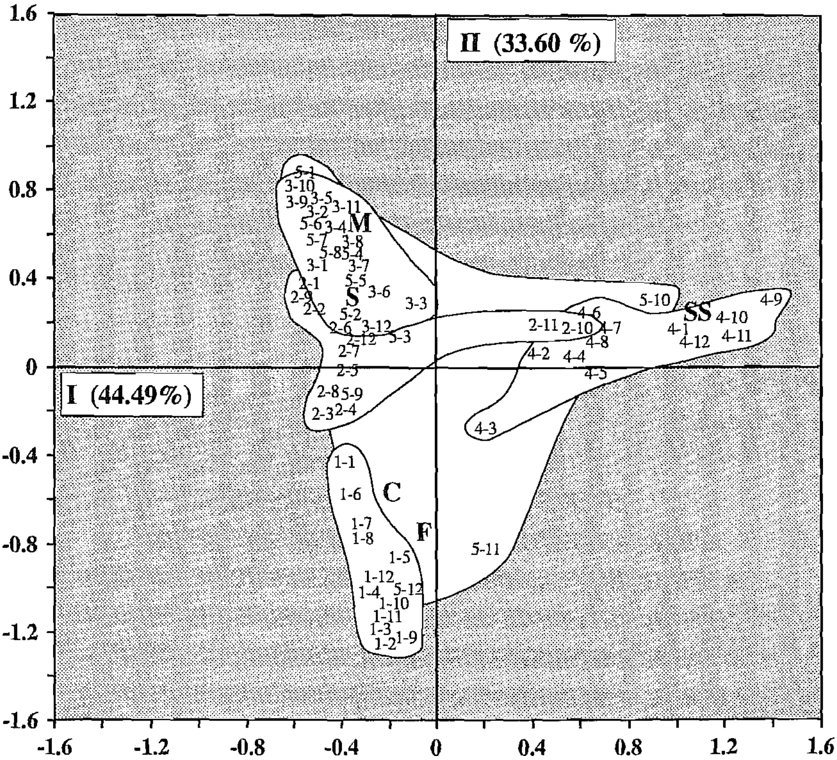

Figure 4. Correspondece analysis performed with the station samples and the trophic groups (the first two axes, I and II, account for 78% of the variance). Sample codes (x-y) indicate the number of station (x, from 1 to 5) followed by sampled month (y, from January (1) to December (12)). Trophic groups are: F, filter feeders; M, mixed; S, surface-deposit feeders; SS, subsurface-deposit feeders and C, carnivores/omnivores.

obtained between water depth and an adapted coefficient from the Bouchet index: (S + SS)/(C + F) ($r = -0.88$, $P < 0.05$).

Cross-correlation analysis between seasonal changes of environmental variables and seasonality of trophic groups biomass pointed out several differences among stations. The significant relationships of trophic groups and environmental variables are summarized in Table 6. Chlorophyll-*a* concentration and organic matter

Table 5. Summary table of the Kruskal-Wallis test (H, df, P) and one-way parametric ANOVA (F, df, P) testing the seasonality of the trophic groups at the five studied assemblages (*: $P < 0.05$, **: $P < 0.001$, ***: $P < 0.001$, —: absence of seasonality)

Station	Carnivores	Filter feeders	Mixed	S-deposit feeders	SS-deposit feeders
1	H = 32.53, 20, *	H = 35.43, 20, *	H = 31.97, 20, *	—	—
2	F = 3.04, 16, *	—	F = 11.14, 16, ***	H = 28.72, 16, *	H = 26.37, 16, *
3	F = 11.36, 10, ***	F = 8.20, 10, ***	F = 4.74, 10, **	F = 8.02, 10, ***	F = 7.30, 10, **
4	—	—	F = 5.26, 10, **	F = 6.67, 10, **	—
5	—	—	F = 3.21, 10, *	F = 14.50, 10, ***	F = 4.31, 10, *

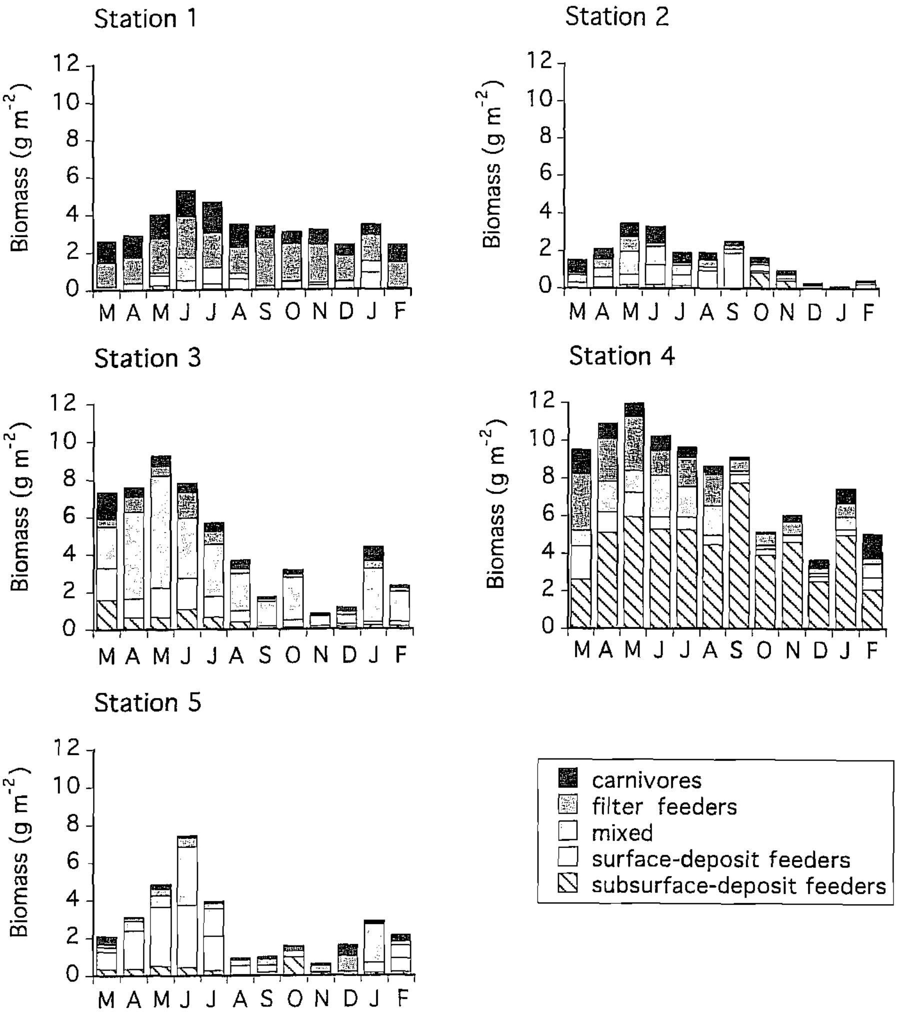

Figure 5. Seasonal variation of the different trophic groups at the five studied assemblages.

content appeared to be the most explanatory environmental variables, whereas rainfall affected only the mixed group at station 2. No significant relationships were found for temperature, salinity, and wave height. Carnivores and subsurface-deposit feeders did not show significant responses to the remaining variables. Nevertheless, a significant response ($P < 0.05$) of the seasonal trend of carnivores with respect to the biomass peaks of the remaining groups was noted at most of the stations (all except station 1).

Discussion

The study of trophic structure provide evidence of a clear spatial distribution at Blanes Bay. The trophic structure of the benthic assemblages at each sampling site seems to be defined by each particular set of local environmental constraints. Seasonal variation in the trophic structure could not obscure the spatial distribution over time.

Table 6. Summary table of the Cross-correlation analysis among the environmental variables (rain: $1\ m^{-2} \cdot d^{-1}$, chlorophyll-*a*: $mg \cdot m^{-3}$, and organic matter: % dw) and the trophic groups seasonality at the five different sampling stations ($P < 0.05$; *r*: correlation value; lag: time (months) delay in the relation of the values of the first series—variable—to values in the second series—trophic group biomass-; —: non explainable seasonality; empty cells: absence of seasonality).

		Filter feeders		Mixed		S-deposit feeders	
Station	Variable	*r*	lag	*r*	lag	*r*	lag
1	Rain	—		—			
	Chlorophyll-*a*	—		—			
	Organic matter	—		—			
2	Rain			0.726	1	—	
	Chlorophyll-*a*			—		—	
	Organic matter			−0.785	2	—	
3	Rain	—		—		—	
	Chlorophyll-*a*	0.747	2	0.814	1	0.728	1
	Organic matter	0.856	0	0.843	−1	0.788	−1
4	Rain			—		—	
	Chlorophyll-*a*			0.847	2	0.769	−1
	Organic matter			—		—	
5	Rain			—		—	
	Chlorophyll-*a*			—		0.888	1
	Organic matter			0.631	0	0.640	−1

Environmental parameters set the framework for trophic group combinations at Blanes Bay. The presence of the harbor modify habitat characteristics allowing the inner harbor (stations 3, 4, and 5) to be distinguishable from the open bay (stations 1 and 2). The trophic structure of the area is consistent with the pattern of benthic distribution proposed by Sanders (1958), with filter-feeders and carnivores predominating in coarse, organically poor sediments. In the bay, both groups could be dependent on the continuous inputs of suspended matter from the Tordera River. However, only the extremely different environmental conditions (muddy, organically enriched vs. coarse, non-enriched sediments) can be clearly separated. Trophic group complexity is higher at station 2 than at station 1. Habitat complexity is associated with the increment of trophic groups (Gambi and Giangrande, 1985 a, b) and to a more important role of carnivorous and filter feeder species (Bianchi and Morri, 1985).

Trophic complexity decreases at harbor stations. Surface and subsurface-deposit feeders, together with the mixed group, become dominant when sedimentation rates increase the accumulation of detritus at the bottom. The main contributor at station 3, *Owenia fusiformis,* is a surface-deposit feeder (Fauchald and Jumars, 1979; Gambi, 1989) that alternates its feeding mechanism in relation with the environmental conditions. When high planktonic inputs are produced and flow conditions change, *O. fusiformis* can behave as a filter feeder (Gambi, 1989). The presence of a stable population of *O. fusiformis* is supported by the increased possibilities of flow changes at the mouth of the harbor.

The dominance of subsurface deposit feeders, mainly the nematode *Pontonema* cf. *vulgare,* at the most enriched station agrees with the accepted idea that deposit feeders are related to the presence of very fine, organically rich sediments (Lana, 1981; Maurer and Leathem, 1981; Gaston, 1987; Morgado et al., 1994). The decrease of filter feeder biomass when detritivores are dominant supports the idea that sediment stability is biogenically altered (Rhoads and Young, 1970). Moreover, the decrease of surface-deposit feeders in the area is consistent with the functional-group theory predicting mobile burrowing forms to have negative effects on more stationary forms (McCann and Levin, 1989). In general, the environmental conditions at the habitats under study tend to favor the dominance in biomass of a single species, as it usually occurs in organically polluted or stressed areas (Pearson and Rosenberg, 1978).

The results of the correspondence analysis allow us to presuppose the existence of clear relationships between the trophic structure of the assemblages and the environmental variables. Although we could expect carnivores and filter feeders to be negatively correlated to the organic matter and silt-clay content in sediments as a pattern of the trophic distribution, no relationships have been found. This could be related to the tight range of variation of these groups at the habitats. Two possible explanations can be proposed: 1) western Mediterranean populations of commercial bivalves (filter feeders organisms) have been overexploited in the past and mean annual biomass could have been depleted at the open bay stations; 2) the marina could maintain high values of filter feeder biomass due to an increase of food availability. The low affinities of the mixed group and the surface-deposit feeders for the extreme conditions support the result that no correlations are obtained.

The use of the trophic indexes must be viewed with care. Few correlations were obtained by the Pearson analysis when we attempted to describe the trophic structure of the area using trophic indexes and environmental conditions. Trophic group indexes applied to specific sites do not show coherent results in other places. Then, it would be better to work with ranked trophic groups than with another highest grouping level such as indexes. The adaptation of the Paiva's importance index seems to be the simplest way to compare trophic groups at any studied site, as the index works for every trophic group separately and integrates the diversity of zoological taxa presented at one particular station and the biomass contribution of each taxa.

The control of trophic group biomass at Blanes Bay does not depend on the measured environmental parameters. Only the organic matter content in sediments and the chlorophyll-*a* concentration in the water column could explain some of the observed seasonal variation of trophic group biomass. However, the responses are very different and highly dependent on the studied sites. The lack of influence of chlorophyll-*a* concentration at the open bay could be explained either by the low values recorded throughout the year (Mura et al., 1996) or by the high dispersion effect due to hydrodynamic conditions. In the harbor, sedimentation rates increase as water renewal is lowered, and the responses to chlorophyll-*a* concentration are enhanced. The response of filter feeder, surface-deposit feeder and the mixed groups can be attributed to the short term sedimentation/resuspension processes.

The influence of the organic matter content on the spatial heterogeneity of trophic groups is more relevant than its influence in the temporal variability. Continuous inputs entering the assemblages (either low or high) result in the absence of seasonality in biomass, whereas short-time accumulations appear to give rise to inappropriate conditions for maintaining macroinfaunal biomass. The increase of organic matter after the spring biomass peak could be associated to two combining biogenic origins: mortality of organisms after settlement, and the accumulation of chlorophyll-*a* from phytoplankton sedimentation and phytobenthos production. The relationships among these three variables are being currently studied.

No environmental variables provide a direct explanation of the seasonal variation of trophic-functional groups at Blanes Bay. Although environmental variables can contribute to modulate seasonal changes influencing the community organization, seasonality is mainly related to recruitment events (high increase of density, followed by high mortality affecting most of recruits). Therefore, seasonal processes of benthic organisms are controlled by intrinsic mechanisms, whereas environmental parameters determine the variability of the assemblages at the bay.

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