Belg. J. Zool., 137 (2) : 127-132 July 2007

Shallow-water soft bottom macrozoobenthic communities from Edremit Bay (NE Aegean Sea)

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ABSTRACT. Qualitative and quantitative aspects of macrozoobenthic fauna in Edremit Bay were studied. Benthic samples were collected from 20 stations at depths ranging from 1 to 30m in October 2002. Salinity of sea water varied between 35.3 and 38.6psu, temperature between 18.8 and 21.6ºC, dissolved oxygen between 2.6 and 8.9mg/l, and silt-clay percentage of sediment between 1.6 and 94.1. A total of 139 macrozoobenthic taxa were identified, of which Polychaeta was the dominant group (44.6% of species, 42.7% of specimens). Shannon-Weaver's Diversity Index (H'), Pielou's Evenness Index (J'), Soyer's Frequency Index (F), Bray-Curtis similarity measure and Spearman's rank correlation coefficient were applied to the presence and abundance of the benthic fauna. Medium diversity index values (between 2.7 and 4.8) but high evenness index values (between 0.75 and 0.98) were determined in the area. The cluster and nMDS analysis showed that there were 6 distinct species assemblages in the area. A positive correlation was determined between silt-clay percentage, and number of individuals, number of species and diversity index value. The number of specimen is also positively correlated with depth.

KEY WORDS : Zoobenthos, environmental variables, Edremit Bay, Aegean Sea.

INTRODUCTION

Benthic organisms including a variety of feeding modes can provide a link between substratum and water column predators. They are important food resources especially for demersal fishes. Since most benthic organisms are sessile or sedentary, the analysis of benthic communities gives a tool to determine the dimension of environmental stresses and if those stresses are natural or due to pollutants (POCKLINGTON & WELLS, 1992; PANCUCCI-PAPADOPOULOU et al., 1999).

Macrobenthic communities inhabiting the Greek coasts of the Aegean Sea were intensively studied (ZARKANELLAS & KATTOULAS, 1982; KISELEVA, 1983; ZENETOS et al., 1991; SIMBOURA et al., 1998; PANCUCCI-PAPADOPOULOU et al., 1999). Researches at the Turkish coasts were mainly focused in İzmir Bay (ÖNEN, 1983; ERGEN et al., 1994; ERGEN & ÇİNAR, 1994; ÇİNAR et al., 1998).

Edremit Bay is one of the most important fishery regions of the Aegean Sea. It is located between the longitudes E26º34'34"-E26º56'44" and latitudes N39º18'41"-N39º34'45". This region supports dense populations of many demersal fishes and is also suitable for trawling (KOCATAŞ & BILECIK, 1992). However, increasing number of summer houses, light food industry and fisherman ports are major factors threatening the ecosystem of the bay.

The aim of this study is to assess macrozoobenthic species inhabiting different depths of Edremit Bay and their distributional patterns according to major environmental variables. The present study also analyzed the structure and ecological features of macrobenthic communities prevailing in the area where no detailed study has been previously performed on this subject.

MATERIALS AND METHODS

This study was conducted in Edremit Bay in October 2002 (Fig. 1). Macrobenthic samples were obtained by means of a $0.1m^2$ Van Veen grab from four transects, namely A, B, C and D, perpendicular to the coast line. The bottom was sampled at five stations corresponding to 1, 5, 10, 20 and 30m depths at each transects. These four transects and five depths at the shores of different human population densities were chosen as representatives of the ecological situation of the bay. Transect A is located at the shore of most dense population throughout the year, transects B and C are at the shores of summer houses and transect D is at the shore of non-settled area. Three replicates were collected at each depth.

All benthic samples were sieved through a 0.5mm mesh sized sieve and then the retained material was fixed with 4% formaldehyde-sea water solution. In the laboratory, macrobenthic organisms were sorted into main taxonomic groups, and then identified to species level and counted.

Small portions of surface sediment were removed from grab samples for analysis of silt-clay percentage (FOLK, 1974). The bottoms of stations are sand or silty-clay, except for B2 and D2, where the bottom was covered with the phanerogames *Cymodocea nodosa* (Ucria) Ascherson and *Posidonia oceanica* (Linnaeus) Delile, respectively.

For the determination of temperature, salinity and dissolved oxygen of sea water, water samples were taken by means of a 3 liter water sampler just above the sea bottom. The temperature was measured by thermometer on the water sampler, salinity by Mohr-Knudsen method (IVANOFF, 1972) and dissolved oxygen by Winkler method (WINKLER, 1888).

SHANNON-WEAVER's (1949) Diversity Index (H') (log base 2) and PIELOU's (1975) Evenness Index (J') were calculated on the basis of the qualitative and quantitative composition of the macrobenthic fauna.

SOYER's (1970) Frequency Index (F) was used to determine the frequencies of species in the study area and results were evaluated as constant (F≥50%), common (50%>F≥25%) and rare (F<25%).

The numerical abundance data obtained per sampling station were analyzed using cluster and non-metric multidimensional scaling (nMDS) techniques, based on the Bray-Curtis similarity (CLARKE & WARWICK, 2001). Prior to the analysis, the raw data expressed as number of individuals in each sample were transformed using the fourth root transformation. The cluster and nMDS analysis were performed on a previously reduced set of species in order to limit the noise caused by the very rare species (with only one specimen). SIMPER analysis was performed to identify the percentage contribution of each species to the overall similarity within each group that was assessed according to results of the cluster analysis.

In order to determine the correlation between the biotic (species number, specimen number, community diversity, evenness) and abiotic (depth, dissolved oxygen, silt-clay%) parameters, Spearman's rank correlation coefficient was used (SIEGEL, 1956).

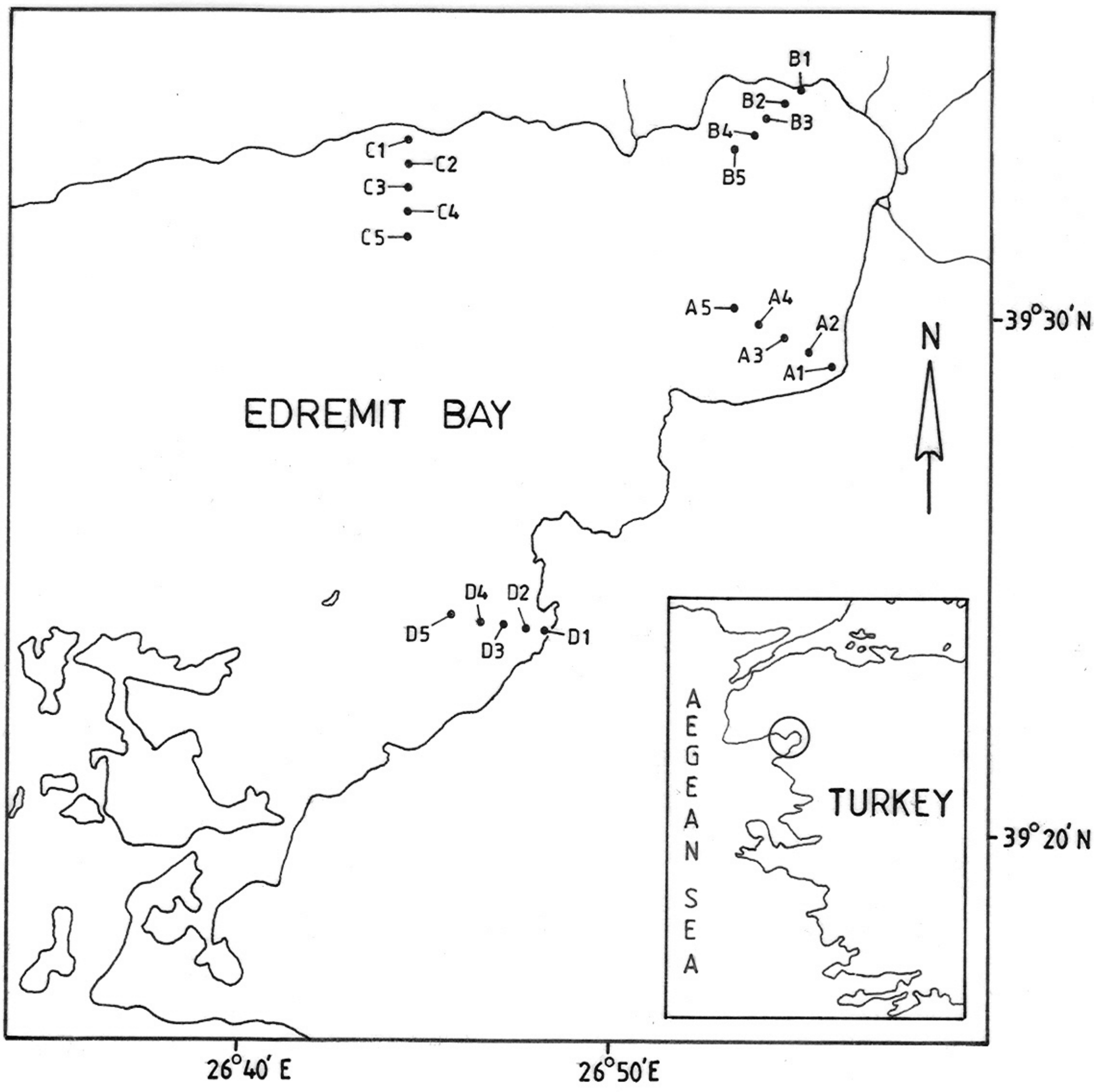

Fig. 1. – Positions of the sampling stations in Edremit Bay.

RESULTS

The difference in sea water salinity values of depths was statistically significant ($p<0.05$). Salinity values differed from 38.2 to 38.6psu at all transects between 1 and 20m depths except C1 (37.7psu), from 37.5 to 37.9psu at 30m depth at all transects except D5 (35.3psu). Temperature values did not vary among depths ($p>0.05$). It varied between 18.8 (B1) and 21.6 (C2) ºC in the area. Dissolved oxygen values of depths differed from 2.6 (B5) to 8.9 (B1) mg/L and did not show a significant statistical difference among depths ($p>0.05$). Depth greater than 20m had lesser dissolved oxygen values than shallower waters except transect C. Silt-clay percentage of sediment varied between 1.6 (D1) and 94.1 (B4) and did show a significant difference among depths ($p<0.05$). It had its minimum values at 1m depth of each station (1.6-3.6%) and extremely increased after 5m depth downward, except station C2 (2.5%).

TABLE 1

Some abiotic and community parameters at each sampling site (S: Salinity, T: Temperature, dO: Dissolved oxygen mg/l, S: Species number, N: Abundance per 1m2, H': Diversity index value, J': Evenness index value)

Site	Depth	S (psu)	T (ºC)	Silt-Clay %	dO	S	N	H'	J'
A1	1	38.6	19.9	3.5	6	9	43	2.9	0.93
A2	5	38.2	19.9	43.5	8	15	250	3.2	0.84
A3	10	38.4	19.5	56.2	6.7	13	260	3.1	0.85
A4	20	38.5	19.1	84.8	5.9	14	160	3.5	0.93
A5	30	37.5	21.2	39.6	4.7	17	270	3.8	0.93
B1	1	38.4	18.8	3.6	8.9	12	63	3.5	0.97
B2	5	38.5	18.9	26	8	43	523	4.7	0.88
B3	10	38.5	19.1	89.4	4.9	21	260	3.3	0.75
B4	20	38.5	21.1	94.1	3.2	17	290	3.8	0.94
B5	30	37.9	21.1	82.6	2.6	13	186	3.6	0.98
C1	1	37.7	21.2	1.8	5.4	9	67	3	0.96
C2	5	38.6	21.6	2.5	4.9	9	80	3	0.97
C3	10	38.5	21.4	56.4	3.2	29	310	4.5	0.92
C4	20	38.4	21.4	76.6	5.6	28	579	4.3	0,90
C5	30	37.9	21.2	41.1	5.6	20	356	4	0.93
D1	1	38.5	20.1	1.6	6.2	12	87	3.2	0.89
D2	5	38.5	19.9	45.7	4.4	39	243	4.8	0.91
D3	10	38.4	19.8	67.4	7.7	21	220	4	0.91
D4	20	38.6	19.9	52.4	4.7	13	167	3.5	0.94
D5	30	35.3	19.9	38.3	4.9	9	127	2.7	0.91

A total of 139 macrozoobenthic taxa were identified during the course of this study. The number of species at stations ranged from 9 to 43 and the number of specimens from 43 to 579 (per $1m^{-2}$). The most abundant taxonomic groups in terms of number of species and number of specimens were Polychaeta (44.6% of species, 42.7% of specimens) and Mollusca (26.6% of species, 37.3% of specimens), respectively.

Half of the total number of taxa (67 species) appeared only once in samples. Among these, Polychaeta was represented by a total of 30 species and was followed by Crustacea (17 species), Mollusca (13 species) and Echinodermata (7 species). Only three species can be classified as constant in the area; *Nephtys hombergii* occurred at 13 stations, *Ampelisca diadema* at 11 stations and *Amphiura chiajei* at 10 stations. Twenty species were common and others rare.

Species represented by high number of individuals in the area were *Nephtys hombergii* (maximum density: $87ind.m^{-2}$), *Corbula gibba* (maximum density: $83ind.m^{-2}$), *Rissoa splendida* (maximum density: $63ind.m^{-2}$), *Notomastus latericeus* (maximum density: $60ind.m^{-2}$), *Nephthys incisa* (maximum density: $57ind.m^{-2}$), *Processa* sp. (maximum density: $50ind.m^{-2}$), *Mellinna palmata* (maximum density: $40ind.m^{-2}$), *Nucula nitidosa* (maximum density: $40ind.m^{-2}$) and *Ampelisca diadema* (maximum density: $37ind.m^{-2}$).

When values of biotic parameters according to depths and transects are examined, it can be seen that the lowest mean value of specimen density per $1m^2$ was found at 1m depth (65±10.4 SE) and transect D (169±32.1 SE), the highest at 20m depth (299±113.1 SE) and transect C (278±106.5 SE). As for the mean number of species the lowest scores were also calculated at 1m depth (11±0.9 SE) and transect A (14±1.5 SE) and the highest at 5m (27±9.8 SE) and transect B (21±6.3 SE). The lowest mean Shannon-Weaver diversity index value was determined at 1m depth (3.1±0.1 SE) and transect A (3.3±0.1 SE), the highest at 5m depth (3.9±0.5 SE) and transects B and C (3.7±0.2 and 0.3 SE). The lowest mean evenness value was calculated at 10m (0.85±0.04 SE) and transect A (0.89±0.02 SE), and the highest at the deepest depth, 30m (0.93±0.01 SE) and transect C (0.93±0.01 SE). The phanerogames *Cymodocea nodosa* and *Posidonia oceanica* found at B2 and D2 (5 m) greatly increased the number of species and diversity index values estimated at 5m. The high values of standard error calculated at this depth were mainly due to the effect of these phanerogames.

The nMDS and cluster analysis (Fig. 2) based on the fourth-root-transformed species abundances in each station revealed six distinct species assemblages in the area.

The high similarity values were estimated within the groups A (64%) and D (64%). The species much contributed to the similarity of the group A according to the SIMPER analysis are *Plagiocardium papillosum* (contribution: 18%), *Gouldia minima* (14%), *Myrtea spinifera* (14%) and *Ampelisca diadema* (13%). The group D including stations A2 and A3 is characterized by high densities of *Corbula gibba* (max. 70ind.m^{-2}), *Nephtys incisa* (max. 57ind.m^{-2}), *Acanthocardia paucicostata* (max. 40ind.m^{-2}) and *Nucula nitidosa* (max. 13ind.m^{-2}). The other associations B, C, E and F as shown on nMDS plot in Fig. 2 have an average similarity of 35%, 46%, 47% and 44%, respectively. The species responsible for the high similarity in the group B are *Lumbrineris gracilis* (% contribution: 11), *Ampelisca diadema* (9%), *Melinna palmata* (9%) and *Corbula gibba* (8%). The group C including the stations A4 and D3 is characterized by the species *Nephtys incisa*, *Gouldia minima*, *Pitar rudis* and *Myrtea spinifera*; the group E including five deepest stations by the species *Nucula nitidosa* (% contribution: 12), *Tellina distorta* (11%) and *Nephtys hombergii* (11%); the group F having four shallow water stations (1m) by *Spisula subtruncata* (26%), *Chamelea gallina* (26%), *Diogenes pugilator* (13%) and *Nephtys hombergii* (11%). There is a high dissimilarity between the groups discerned and the stations C2, C3 and D2. As D2 has a dense *Posidonia oceanica* meadow, a number of species found at this station did not occur at any other stations, resulting in a high dissimilarity between this station and the others. The station C2 had a smaller number of species and some species (*Pelogenia arenosa*, *Caprella acantifera* and *Echinocyamus pusillus*) occurred only at this station. Although C3 possessed relatively high number of species, the high dominance levels of *Processa* sp. (50ind.m^{-2}) and *Microdeutopus stationis* (30ind.m^{-2}) caused dissimilarity between this station and the rest.

According to SIMPER analysis, the average similarity level at each depth was very low, being 44% among samples taken from 1m depth, 15% among samples taken from 5m depth, 24% among samples taken from 10m depth, 28% among samples taken from 20m depth and 31% among samples taken from 30m depth. As it was shown in the dendrogram of Fig. 2, samples taken from 1m has a high faunal affinity. A relatively high similarity (31%) was also calculated among samples collected at 30m. The most contributing species to the similarity of this depth are as follows: *Nephtys hombergii* (22%), *Corbula gibba* (11%), *Processa* sp. (10%) and *Tellina distorta* (10%).

TABLE 2

Spearman rank correlation coefficient (rs) between biotic and abiotic parameters. (dO: dissolved oxygen; NS: Non Significant) n=20

	Number of species	Number of specimens	Community diversity (H')	Evenness (J)
Depth	0.228	0.484	0.257	0.104
	NS	p<0.05	NS	NS
dO	-0.106	-0.172	-0.179	-0.380
	NS	NS	NS	NS
% Silt-Clay	0.529	0.520	0.443	-0.139
	p<0.05	p<0.05	p<0.05	NS

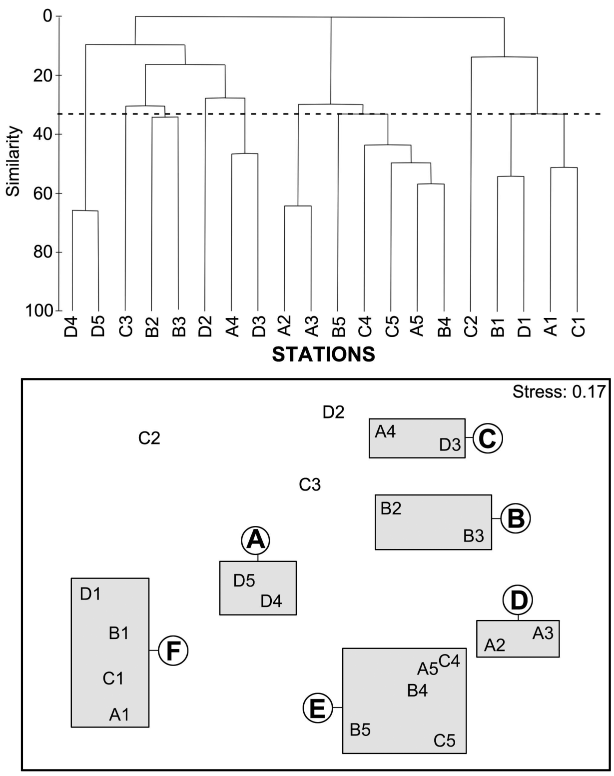

Fig. 2. – Affinity of the sampling sites according to cluster (horizontal line shows 35% similarity level) and non-metric multidimensional sampling analyses.

A positive correlation was determined between silt-clay percentage, and number of individuals, number of species and diversity index value. The number of specimen is also positively correlated with depth (Table 2).

DISCUSSION

Faunistical analyses of macrozoobenthic fauna on the soft substratum of Edremit Bay revealed a rich species composition. The highest numbers of species were encountered at stations B2 (43 species) and D2 (39 species). These stations differed from the others in having phanerogames; *Cymodocea nodosa* formed dense meadows at B2 and *Posidonia oceanica* at D2. These phanerogames are known to provide suitable microhabitats and niches for a variety of organisms in the Mediterranean Sea (Peres, 1967; Mazzella et al., 1989; Çınar et al., 1998; Sánchez-Jerez et al., 1999; Çınar, 2003a). A total of 30 species that occurred in these phanerogames were not found in other stations that possessed sand or silt-clay bottom structure. These species are previously reported from the same habitats in the Mediterranean Sea (Peres, 1967; Mazzella et al., 1989; Çınar et al., 1998).

As seen from cluster analysis, except for samples taken from 1m depth, there was no high similarity among the samples taken from the same depths, showing that the area has a heterogeneous bottom structure and different hydrodynamic conditions that greatly influence the distribution of the species. One-way ANOVA showed that the mean percentage of silt-clay of each assemblage shown in Fig. 2 is statistically significant ($p<0.05$). For example, the group F contained samples taken from 1m, which was characterized by having a low percentage of silt-clay (mean: 2.6±0.54 SE), whereas the group C, which included samples from 10 and 20m, had the highest silt-clay percentage (mean: 76.1±8.7 SE). A high similarity (average score: 44%) calculated among samples collected at 1m depth. The samples were characterized by the presence and low densities of the species *Spisula subtruncata*, *Chamelea gallina*, *Diogenes pugilator* and *Nepthys hombergii*. Having a low silt-clay percentage showed that relatively strong hydrodynamic forces occur at 1m depth and consequently much affect the community structure at this depth than those at the other depths. The substrate characteristics and hydrodynamic forces were considered as one of the principal factors governing the community structures in the shallow water benthic environments of the Aegean Sea (SIMBOURA et al., 1995).

The Aegean Sea is considered as oligotrophic (MIHALATOU & MOUSTAKA-GOUNI, 2002), and such areas have low diversity index but high evenness index values (PANCUCCİ-PAPADOPOULOU et al., 1999). Samples taken in this study presented generally medium community diversity values whereas evenness values were high. Similar results were reported from South Evvoikos Gulf (NW Aegean Sea) by SIMBOURA et al. (1998), but higher diversity index values from Rhodes Island (SE Aegean Sea) by PANCUCCI-PAPADOPOULOU et al. (1999). Moreover, ERGEN & ÇINAR (1994) also determined higher diversity index values at the south-eastern Aegean Sea in comparison to the northern part of the Aegean Sea. PANCUCCI-PAPADOPOULOU et al. (1999) attribute this situation to the prevailing current regime sediment sorting and subtropical character of the southern Aegean Sea.

A positive correlation was determined between the number of individuals and depth ($p<0.05$). ZENETOS et al. (1991) and PANCUCCI-PAPADOPOULOU et al. (1999) reported a negative correlation between depth, and species number and abundance. However, ZENETOS et al. (1991) collected materials from 75-200m depths and indicated that the highest number of species occurred at the shallowest depth (75m) and the lowest at the deepest one (200m), whereas PANCUCCI-PAPADOPOULOU et al. (1999) obtained materials from 30-400m depths and they observed higher values of biotic variables mainly at depths between 30-70m. In addition, MACKIE et al. (1997) and ÇİNAR (2003b) concluded that the nature of substratum (sediment composition) and depth were the major environmental variables influencing the distribution of polychaetes from the southern Irish Sea and northern Cyprus, respectively. ÇİNAR (2003b) studied syllid compositions of habitats from 0 to 600m along the northern Cyprus and stated that the number of syllid species and individuals, and diversity and evenness index values were negatively correlated with depths. In our study, the mean number of species attained its maximum level at 5m because of the presence of the phanerogames and then gradually decreased to 30m depth. However, the mean diversity index values are fairly constant among depths.

Among the species encountered in this study, the polychaetes *Lumbrineris latreilli* and *Notomastus latericeus*, the amphipod *Ampelisca diadema*, and the bivalves *Nucula nitidosa* and *Myrtea spinifera* are known to be typical species of fine or mixed sediments; the polychaete *Melinna palmata*, and the bivalves *Acanthocardia paucicostata* and *Corbula gibba* are characteristic species of muddy bottoms (ZARKANELLAS & KATTOULAS, 1982; POPPE & GOTO, 1993; SIMBOURA et al., 1998). All of these species were generally represented by high number of individuals at the stations.

The macrobenthic community structure identified during this study indicates that a relatively undisturbed condition prevails in the area. A total of four stations had a diversity value between 4.1 and 5, twelve stations between 3.1 and 4, and four stations between 2.7 and 3. Soft bottom benthic habitats can be classified based on community diversity index as bad ($0<H'\leq1.5$), poor ($1.5<H'\leq3$), moderate ($3<H'\leq4$), good ($4<H'\leq5$) and high ($H'>5$) (SIMBOURA & ZENETOS, 2002). According to the above classification, 20% of the stations are in good condition, 60% in moderate and only 20% in poor condition. However, some polychaetes, which are considered as indicator species of semi-polluted or transitional zones of the Mediterranean Sea when they form high-density populations, such as *Lumbrineris gracilis, L. latreilli* and *Monticellina heterochaeta* (PEARSON & ROSENBERG, 1978; SIMBOURA et al., 1998; ERGEN et al. 2002), exist in the area. These species were frequently found at stations but generally no high abundance levels of these species were encountered. The bivalve *Corbula gibba* can attain high abundance at the periphery of the severely polluted environment (PEARSON & ROSENBERG, 1978; ZARKANELLAS & KATTOULAS, 1982). This species was represented by high number of individuals in the study and particularly dominated the stations A2, A3, B3 and B4, together with the other tolerant species *Lumbrineris gracilis*. Diversity index values also were lower than four at these stations. Other stations of transect A were partly dominated by species *Lumbrineris gracilis*, *Notomastus latericeus* and *Abra alba*, which can survive in organically polluted bottoms. Moreover, the lowest mean Shannon-Weaver diversity index value was determined within this transect. The above mentioned stations are located at the innermost region of the bay and seem to be affected by increasing human settlements and the food industry in the area.

ACKNOWLEDGEMENTS

This work was supported by the Research Fund of the Istanbul University, project number: 1614 / 30042001.

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Received: April 22, 2005
Accepted: February 22, 2007