TÜBİTAK

Research Article

Turk J Zool
2012; 36(4) 430-446
© TÜBİTAK
doi:10.3906/zoo-1103-15

Distribution of soft-bottom mollusks (Mollusca) in Mersin Bay (eastern Mediterranean Sea)

Erhan MUTLU[1,*], Mehmet Betil ERGEV[2]
[1]Fisheries Faculty, Akdeniz University, 07050 Antalya - TURKEY
[2]Derinsu Underwater Engineering and Consulting Company, Kavaklıdere, 06680 Ankara - TURKEY

Received: 27.03.2011

Abstract: A total of 44 molluscan species belonging to 5 classes were identified in 3 transects (including depths of 10, 25, 50, 75, 100 and 200 m) located in Kumkuyu, Limonlu, and Erdemli. Overall, no significant difference in community parameters such as diversity index, evenness index, and species richness was found among transects. The species abundance showed seasonal and depth-wise variations. The highest species richness (6-16 species) was encountered between depths of 10 and 100 m in winter and spring, whereas the molluscan population increased in warm seasons due to the high abundance of *Corbula gibba* and *Nucula nitidosa*. Bivalves and gastropods were abundantly found at depths of 10-200 m, 10-25 m, and 75-100 m. Two main molluscan assemblages were determined: the first assemblage occurred in the shallow water (10-50 m) and was characterized by high abundances of *C. gibba*, *Abra alba*, and *Tellimya ferruginosa*, and the second occurred in deep waters (75-200 m) and was characterized by the presence of *Falcidens gutturosus*, *N. nitidosa*, and *Astarte fusca*. Depth, the fine-grain size of sediment, and total organic carbon were the main factors governing the distribution of the mollusks in the area. Among the species, only *Conomurex persicus* was an alien species.

Key words: Zoobenthos, Mollusca, Mersin Bay, Levantine Sea, Turkey

Mersin Körfezi (Doğu Akdeniz)'nde yumuşak zemin yumuşakçalarının (Mollusca) dağılımları

Özet: Kumkuyu, Limonlu ve Erdemli'de yer alan 3 ayrı hat üzerinde (10, 25, 50, 75, 100 ve 200 m) beş sınıfa ait toplam 44 yumuşakça türü tanımlanmıştır. Genel olarak, çeşitlilik indeksi, düzenlilik indeksi ve tür zenginliği gibi kommunite parameterlerinde hatlar arasında istatistiki olarak önemli bir fark bulunmamıştır. Mollusk bolluğu derinliğe ve mevsime bağlı varyasyon göstermiştir. Tür zenginliği (6-16 tür) daha çok kış ve ilkbaharda olmak üzere 10 ila 100 metre derinliklerde yüksek bulunmuştur buna mukabil sıcak zamanlarda *Corbula gibba* ve *Nucula nitidosa* türleri bolca bulunarak katkıları yüksek olmuştur. Bivalve ve gastropodlar baskın olan sınıflar iken, 10-200 metre derinlikte, ve 10-25 ve 75-100 metrelerde bolca bulunmuştur. İki yumuşakca topluluğu belirlenmiştir. Sığ su (10-50 m) topluluğu, *C. gibba*, *Abra alba* ve *Tellimya ferruginosa*, türleri ile ve derin su (75-200 m) topluluğu, *Falcidens gutturosus*, *N. nitidosa*, ve *Astarte fusca* türleri ile karakterize olmuşlardır. Su derinliği, ince-sediman danesi ve toplam organik karbon içeriği yumuşakçaların dağılımlarını etkileyen en önemli faktörlerdir. Türler arasında sadece *Conomurex persicus* yabancı bir türdür.

Anahtar sözcükler: Zoobentos, yumuşakçalar, Mersin Körfezi, Levantin Denizi, Türkiye

---

* E-mail: emutlu@akdeniz.edu.tr

Introduction

The phylum Mollusca is one of the most highly diversified phyla among marine animals, occurring in many habitat types; therefore, it is used as an indicator to compare and contrast the differences between ecosystems (Zenetos, 1996). In the Mediterranean Sea, benthic mollusks have been used as descriptors of the sublittoral soft-bottom benthic communities in association with their ecological relevance to water quality variations from unpolluted to moderately and grossly polluted bays with the impact of hypoxia and sedimentation linked to river discharges (Zenetos, 1996; Rueda et al., 2001). They also play important roles in the ecosystem structure and biodiversity maintenance (Zenetos, 1996). Furthermore, some mollusks have been widely used in monitoring studies of various contaminants worldwide because of their economic and ecological importance.

Depth and geographic location are known to influence marine benthic communities spatially (Gray, 1981; Karakassis and Eleftheriou, 1997). The growth, reproduction, and abundance of soft-bottom marine fauna are greatly influenced by environmental variability in littoral ecosystems (Rhoads and Young, 1970). Depth-related sedimentary, hydrographical, and biological variables are most likely to be temporal controlling factors in shallow-water benthic communities (Gray, 1981; Karakassis and Eleftheriou, 1997). In marine soft sediments, information on the spatial and temporal distribution of species is important for understanding biotic and abiotic interactions (Dauvin et al., 2004).

In the eastern Mediterranean Sea, zoobenthic studies are generally restricted to particular regions: Greek, Turkish, and Israeli waters (i.e. Kocataş, 1978; Galil and Lewinsohn, 1981; Karakassis and Eleftheriou, 1997; Conides et al., 1999; Tselepides et al., 2000; Çinar et al., 2006, 2008; Ergen et al., 2006; Koulouri et al., 2006; Öztürk and Can, 2006; Açık, 2011). Knowledge of molluscan diversity has increased with new records of alien species, in particular in the Levantine Sea (Koutsoubas et al., 2000; Çevik and Öztürk, 2001; Önen and Doğan, 2007; Çinar et al., 2011). In Mersin Bay, Mutlu and Ergev (2008) studied the spatiotemporal distribution of epifaunal mollusks. The spatiotemporal distribution of benthic mollusks along the coast has not been a subject of study until now.

The objectives of this study were to investigate molluscan diversity in the area and to assess the factors governing the spatiotemporal distributions of mollusks in Mersin Bay.

Materials and methods

Benthic samples were collected by RV *Erdemli* of the Institute of Marine Sciences-Middle East Technical University (IMS-METU) at 3 north-south orientated transects (Kumkuyu, Limonlu, and Erdemli) in Mersin Bay in February, May, August, and November 2000 (Figure 1). Each transect was designed to consist of 7 depths (10, 25, 50, 75, 100, 150, and 200 m), and 3 replicates were taken at each depth using a Van Veen grab (surface area: 0.10 m^2). Approximately 0.25 L of sediment from a depth of 10 cm, taken from the bottom surface of each station, was put in a nylon bag and then kept in a deep-freezer for geophysicochemical analyses.

Water temperature, salinity, and density were measured along the water column by means of a Sea-Bird conductivity, temperature, and depth probe (SBE 19*plus* SEACAT profiler; Sea-Bird Electronics, Inc., Bellevue, WA, USA). The benthic material was sieved through a set of sieves with mesh sizes of 0.5, 1 and 2 mm. Samples on each sieve were treated with a 5% $MgCl_2$ solution for relaxing of the animals and then fixed with 10% formalin-sea water solution buffered with borax.

In the laboratory, zoobenthic organisms were sorted according to major groups and preserved in 70% alcohol. Molluscan specimens were identified to the lowest possible taxonomic level and counted. Species names were updated according to the checklist of species-group taxa of the Taxonomic Database on European Marine Mollusca (CLEMAM, 2011). The total wet weights of specimens of each species from each sample were measured with a digital scale to the nearest 0.0001 g. Gravel (>2 mm) and sand (2.0-0.063 mm) size fractions of surface sediment samples were separated using standard dry sieving. The silt (0.063-0.0039 mm) and clay (<0.0039 mm) were determined using the standard pipette technique proposed by Folk (1974), who made the grain-size classification according to the Udden-Wentworth scale. The mud was composed of clay and silt. The $CaCO_3$ content of

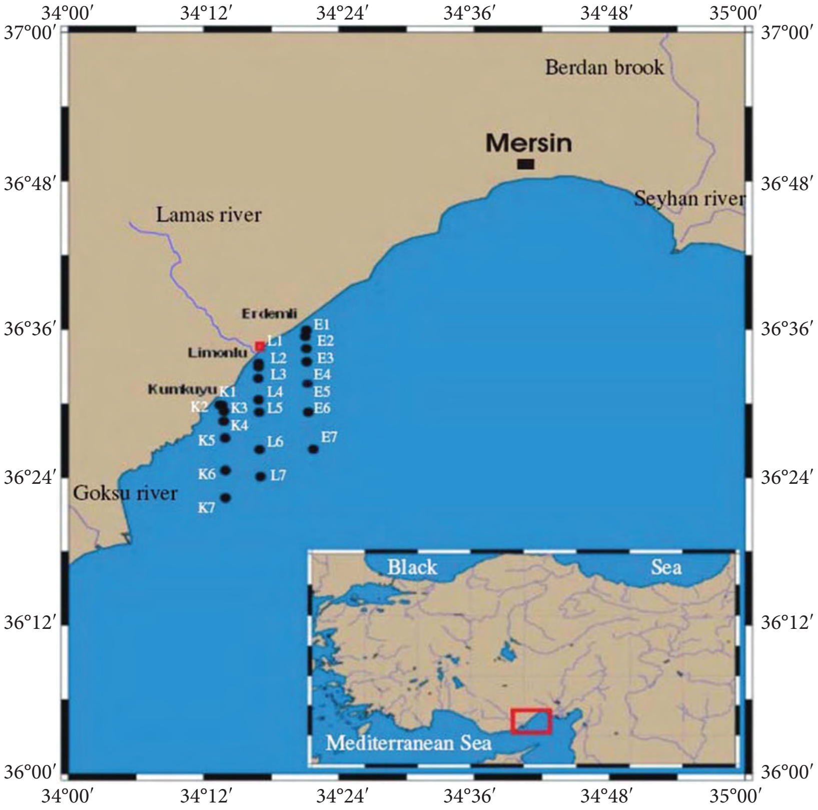

Figure 1. Map of the investigated area with the locations of stations (1: 10 m, 2: 25 m, 3: 50 m, 4: 75 m, 5: 100 m, 6: 150 m, and 7: 200 m).

sediments was determined by measuring the volume of CO_2 produced upon treating a known weight of sediment with excess HCl (Müller, 1967). Total organic carbon (TOC) was determined titrimetrically according to the method of Gaudette et al. (1974).

Shannon-Wiener diversity (H′, $\log_2$base), Margalef's species richness (d), and Pielou's evenness (J′) indices were calculated as community parameters for each sample. Nonparametric Spearman's rank correlation analysis was used to determine the correlation between the community parameters (diversity index, evenness index, species richness, number of species, and number of individuals) and environmental variables. Three-way ANOVA was undertaken to test for differences in each community parameter among seasons, depths, and transects by using MATLAB (version 7.0; The MathWorks, Inc., Natick, MA, USA). A post hoc test, Tukey's least significant difference (LDS), was applied to determine which factors were responsible for the differences. Prior to the analysis, data were tested for normality with the Kolmogorov-Smirnov test (K-S test). As all data did not show normal distribution, the log-transformed data were used for the analysis. Levene's test (STATISTICA 5; StatSoft Inc., Tulsa, OK, USA) was then applied to the log-transformed data for the homogeneity of the variance for each variable. Of the variables, only variances of evenness and abundance were found to be heterogeneous. By means of rarefaction curves, the identified diversity at depths of each station was compared using Biodiversity Pro software (version 2). This method has the advantage of being independent of sample size and density (Sanders, 1968) to provide here an indication of the diversity in terms of species richness in the different depth strata.

The Bray-Curtis dissimilarity matrix, based on the log10-transformed molluscan abundance, was tested by 3-way orthogonal nonparametric (permutation-based) MANOVA (PERMANOVA) (Anderson,

2001) for assessing differences in the molluscan communities at stations, under a model in which depth is fixed and season and transect are random using a MATLAB program, FATHOM (Jones, 2002).

A canonical extension of principal component analysis (CCA) (teer Braak and Smilauer, 2002) was performed to analyze the relationship between the molluscan assemblages and environmental variables (CANOCO 4.5 for Windows). All molluscan abundances were $\log_{10}(N+1)$-transformed prior to the analysis and were set as objective variables. Specifically, a matrix of predictor variables (physical and sedimentary variables) was used to quantify variation in a matrix of response variables (benthic community matrix). Monte Carlo permutations were used to test the significance of the ordination axes.

Results

Environmental variables

At shallow-water stations (<25 m), sea surface water temperatures varied between 16 and approximately 30 °C. The temperature was below 20 °C from November to May and then increased abruptly to approximately 30 °C in August 2000. At deeper stations (>25 m), the temperature varied between 15.5 °C (February) and 29.3 °C (August), and the salinity varied between 38.08 psu (May) and 39.95 psu (August).

The composition of surface sediments was not considerably variable over time. At depths between 75 and 100 m, there were aggregations (12%-20%) of gravel. Overall, the sand content varied between 30% (deep water) and 100% (shallow water) in contrast to the mud (silt + clay) distribution: silt content varied between 0% and 75%. Clay was the dominant component of the sediment at depths below 100 m. The percentage distribution of the total carbonate in bottom sediments ranged from 16% to 55%. Overall, the total organic carbon (TOC) increased with depth, from 0.1% to 0.40%.

Distribution of mollusks

A total of 44 mollusk species belonging to 5 classes (Polyplacophora, Gastropoda, Bivalvia, Caudofoveata, and Scaphopoda) were identified (Table 1). Bivalvia (30 species) and Gastropoda (8 species) were represented by the highest number of species. The species with the highest dominance values were *Nucula nitidosa* (51% of total number of specimens) and *Falcidens gutturosus* (25%).

Spatial and temporal distributions

Almost 99% of the total species had dominance values of less than 50%. As for the most dominant species at the stations, *Falcidens gutturosus* had a maximum density of 60 ind m^{-2} at 175 m in November. *Nucula nitidosa* attained its maximum density (50 ind m^{-2}) at 100-180 m in August-November and *Corbula gibba* (60 ind m^{-2}) at 55-58 m in May and August (Table 1). The number of species was high in February and May (22 species in each month). In February-May, *N. nitidosa* and *F. gutturosus* were the most common and frequent species, followed by *Astarte fusca* and *C. gibba*, respectively. In August and November, the most common species were *N. nitidosa* and *C. gibba* (Table 1). However, *Tellimya ferruginosa* formed a relatively dense population (160 ind m^{-2}) in May, *Abra alba* (150 ind m^{-2}) in August, and *Thracia pubescens* (120 ind m^{-2}) in May.

Three-way ANOVA showed that there was no significant effect of transect on community parameters such as diversity index (H′), evenness index (J′) and species richness (d), except for biomass (Table 2). The abundances of the mollusks did not vary significantly among depths (Table 2). The biomass of the mollusks varied significantly among the transects. The source of this variation was the biomass of transect Kumkuyu (Figure 2). The community indices were not significantly correlated with transects, seasons, or depths. Overall, the number of species was not significantly different among depths, seasons, or transects (Table 2).

The number of species at a depth of 10 m was higher than that at 25-75 m (Figure 2). The gastropod (at 10-25 and 75-100 m) and bivalve (at 10-200 m) species dominated the area (Figure 3). The number of species peaked at a depth of 10 m and was more stable at deeper stations among seasons (Figures 2 and 4).

The total abundance of mollusks was 4724 individuals in the area, and the averaged density value was calculated as 21.1 ind m^{-2}. The mean density of mollusks at Limonlu station (27 ind m^{-2}) was higher than that at Erdemli (19 ind m^{-2}) and

Table 1. Mollusk species with their dominance (D%) and maximum densities (ind m^{-2}) in samples. F: February, M: May, A: August, and N: November. The number given after the slash represents the depth (m) where the species occurred. *Alien species.

Species/**Classes**	D (%)	F	M	A	N
Caudofoveata					
Falcidens gutturosus (Kowalewsky, 1901)	24.69	40/145	30/145	50/151	60/175
Prochaetoderma raduliferum (Kowalewsky, 1901)	1.23	-	-	-	10/28
Polyplacophora					
Leptochiton cancellatus Sowerby G.B. II 1840	1.23	-	-	10/76-79	-
Chiton sp.	1.23	-	-	-	10/77
Ischnochitonidae sp.	1.23	10/50	-	-	-
Gastropoda					
Eulima bilineata Alder, 1848	2.47	10/90-100	-	-	-
Nassarius mutabilis (Linné 1758)	1.23	20/5.5	-	-	-
Natica stercusmuscarum (Gmelin, 1791)	1.23	-	-	-	10/105
Neverita josephinia Risso, 1826	2.47	10/10	10/8	-	-
Philine aperta (Linné, 1767)	1.23	-	10/8	-	-
Propebela turricula (Montagu, 1803)	1.23	10/82	-	-	-
Smaragdia viridis (Linné 1758)	2.47	10/5	-	-	10/8
**Conomurex persicus* (Swainson, 1821)	4.94	20/5	10/7-13	-	20/8
Bivalvia					
Abra alba (Wood W., 1802)	11.11	10/10, 82	21/8	150/9	10/10, 146-175
Abra nitida (Müller O.F., 1776)	1.23	10/198	-	-	-
Abra sp.	1.23	-	-	10/55	-
Acanthocardia tuberculata (Linné 1758)	1.23	-	-	-	20/105
Astarte fusca (Poli, 1791)	11.11	10/82-146	10/11, 78	10/104	20/99
Astarte sulcata (da Costa, 1778)	1.23	10/4.5	-	-	-
Callista chione (Linné 1758)	2.47	10/50, 95	-	-	-
Corbula gibba (Olivi, 1792)	20.99	10/33-56	60/58	60/55	20/10
Cuspidaria cuspidata (Olivi, 1792)	2.47	-	10/77	-	10/146
Donax venustus Poli, 1795	2.47	10/5.5	10/8	-	-
Donax vittatus (da Costa, 1778)	1.23	-	10/8	-	-
Gastrochaena dubia (Pennant, 1777)	1.23	-	-	-	10/56
Kurtiella bidentata (Montagu, 1803)	1.23	-	20/11	-	-
Lutraria angustior Philippi, 1844	1.23	-	10/59	-	-
Mactra stultorum (Linné 1758)	1.23	-	50/8	-	-
Modiolula phaseolina (Philippi, 1844)	1.23	-	-	10/98	-
Mysia undata (Pennant, 1777)	17.28	-	10/14	50/145	20/8, 153
Nucula nitidosa Winckworth, 1930	50.62	30/100	30/91, 198	50/180	50/100
Nuculana pella (Linné, 1767)	1.23	-	10/100	-	-
Phaxas pellucidus (Pennant, 1777)	2.47	10/82	-	10/90	-
Saccella commutata (Philippi 1844)	3.70	-	-	10/59	40/90
Tellimya ferruginosa (Montagu, 1808)	9.88	20/36	160/8	10/9, 48	20/59
Tellina albicans Gmelin, 1791	2.47	10/100	-	-	10/99
Tellina donacina Linné 1758	2.47	-	10/8	10/9	-
Tellina pulchella Lamarck, 1818	7.41	10/10	30/8	-	10/10-21
Tellina pygmaea Lovén, 1846	1.23	-	-	-	10/56
Tellina tenuis da Costa, 1778	1.23	10/198	-	-	-
Thracia pubescens (Pulteney, 1799)	2.47	-	120/21	-	-
Thracia sp.	1.23	-	-	10/194-199	-
Thyasira flexuosa (Montagu, 1803)	2.47	10/150	-	10/87	-
Scaphopoda					
Dentaliidae (sp.)	1.23	-	-	-	10/100

Table 2. The results of 3-way analysis of variance for the number of species (S), abundance (N), biomass (B), and community indices (d: species richness, J´: evenness index, and H´: Shannon-Wiener diversity index). Depth is fixed or random; transect and season are random. Bold number shows that the P-value is less than 0.05.

Source		**S**		**N**		**B**		**d**		**J´**		**H´**	
	d.f.	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**
Transect	2	0.69	0.51	0.64	0.54	4.32	**0.02**	1.90	0.17	0.11	0.90	1.85	0.17
Season	3	1.41	0.26	2.57	0.07	0.84	0.48	0.60	0.62	1.50	0.29	0.92	0.44
Depth	6	1.11	0.38	1.92	0.11	1.84	0.12	1.22	0.33	1.20	0.39	0.96	0.47
Transect × season	6	1.40	0.25	0.95	0.47	1.22	0.32	2.26	0.07	1.24	0.38	1.67	0.16
Transect × depth	12	1.48	0.18	0.82	0.63	1.75	0.10	1.18	0.35	1.40	0.32	1.41	0.21
Season × depth	18	1.43	0.18	0.93	0.55	1.24	0.29	1.82	0.08	2.10	0.14	1.55	0.13

Kumkuyu (21 ind m^{-2}, Figure 2). The Erdemli station was dominated by *N. nitidosa* (average: 5 ind m^{-2}), *T. pubescens* (average: 4 ind m^{-2}), and *C. gibba* (average: 4 ind m^{-2}). At the Erdemli station, the highest density found in August (30 ind m^{-2}) was 2-fold higher than that in February. Mean mollusk abundance in the study area showed significant variations among the depths ($P < 0.05$, Figures 2 and 4). The abundances found at depths of 10 m and 150 m were significantly higher than those at 25-100 m (Figure 2).

Mollusk abundances between 10 and 25 m and between 100 and 200 m showed great seasonal fluctuation at the stations (Figure 4). The density of mollusks ranged from 12 ind m^{-2} to 17 ind m^{-2} between 10 m and 100 m, and decreased to 7-8 ind m^{-2} in deep waters (Figure 4). The abundance of mollusks decreased with increasing near-bottom surface temperature (NBT; $r = -0.34$, $P < 0.05$) and near bottom salinity (NBS; $r = -0.32$, $P < 0.05$).

The mean biomass value in the study area was measured as 5.1 g m^{-2}. *Conomurex persicus* had the highest biomass value, accounting for up to 71% of the total biomass. Overall, the mollusk biomass values were significantly different only among transects, being highest in Kumkuyu and lowest in Limonlu and Erdemli (Table 2, Figure 2). The mean biomass value decreased from 13-14 g m^{-2} at 10-25 m to 1-4 g m^{-2} in the deeper zone (Figures 2-4). Significant correlations were found between biomass and NBT ($r = -0.39$, $P = 0.01$), NBS ($r = -0.41$, $P = 0.01$), and bottom water density (NBD; $r = 0.40$, $P = 0.01$).

Community indices such as d, J´, and H´ were not significantly different among depths, transects, and seasons (Table 2, Figure 2). The community index values were higher in February (d = 8.4, J´ = 0.76, H´ = 2.34) and May (d = 6.45, J´ = 0.77, H´ = 2.37) than in August and November (d = ~5.0, J´ = 0.70, H´ = 2.00). Species richness values calculated at 10 m were significantly higher than those calculated at 75 m (Figures 2 and 4). Evenness values varied between 0.57 (200 m) and 0.83 (25 m) (Figure 3). Diversity index values found at 10-100 m (H´ = 1.7-2.2) were higher than those calculated in deep waters (H´ = 1.2; Figure 4).

The rarefaction method was only applied to depth groups of mollusks in the area (Figure 5). The analysis of the mollusk diversity showed that there was a definite linear bathymetric pattern. Individual rarefaction curves (Figure 5) separated into 2 distinct groups: the depths of 10-25 m and of 50-200 m. In general, diversity decreased with depth.

Multivariate analyses

Three-way PERMANOVA showed that there was only a significant difference in the mollusk community among depths ($P < 0.05$) (Table 3a). The pairwise test indicated that the difference was mainly attributed to a large difference between shallow-water (0-25 m) and deep-water (150-200 m) mollusk communities (Table 3b).

In general, mollusk assemblages were oriented in association with the bottom depth in a direction from

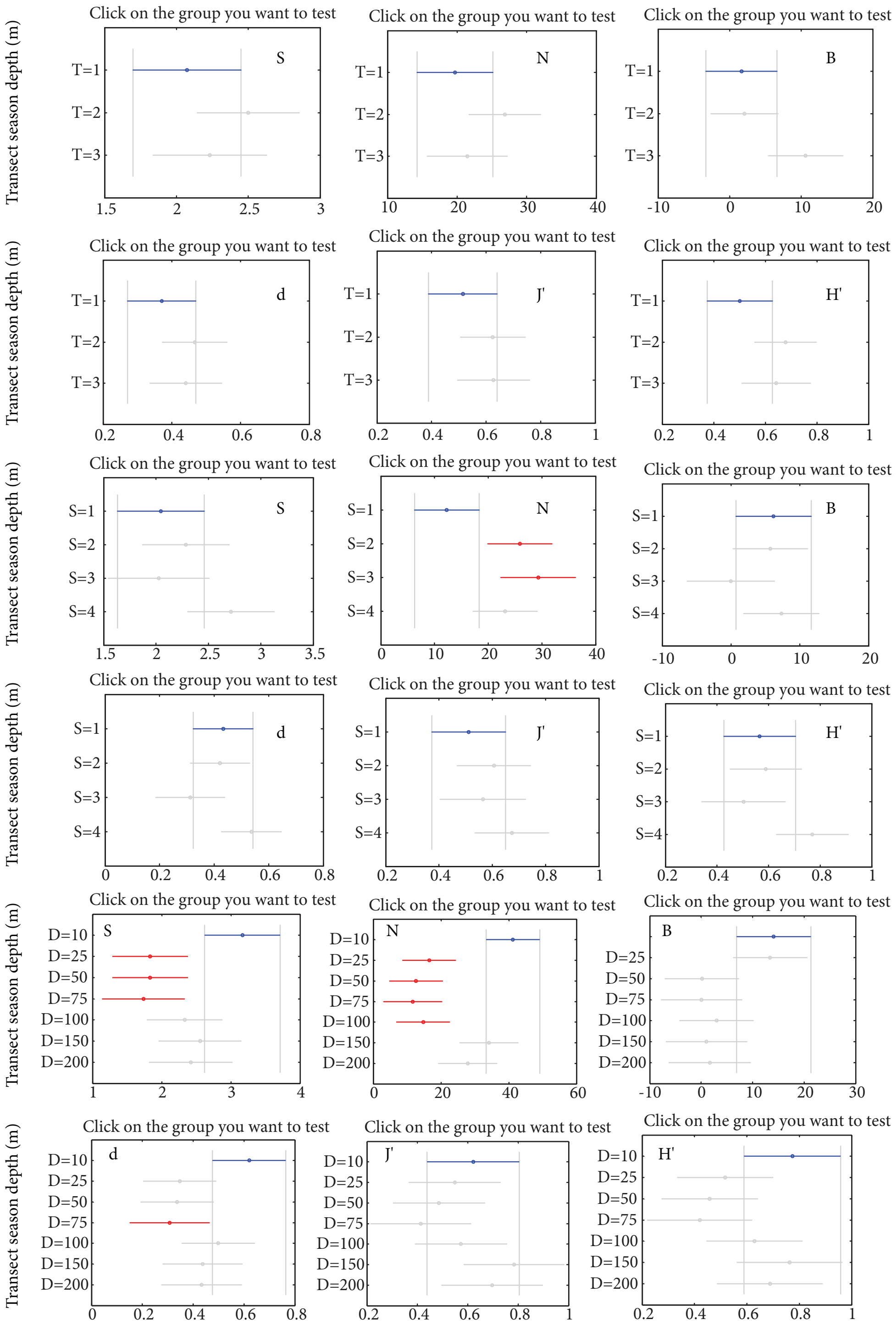

Figure 2. Comparisons of mean values of the community parameters of the mollusks among transects (1 = Erdemli, 2 = Limonlu, and 3 = Kumkuyu), seasons (1 = February, 2 = May, 3 = August, and 4 = November), and depth with 95% confidence limits (S: number of species; N: density, ind m^{-2}; B: biomass, g m^{-2}; d: species richness; J´: evenness index; H´: Shannon-Wiener diversity index).

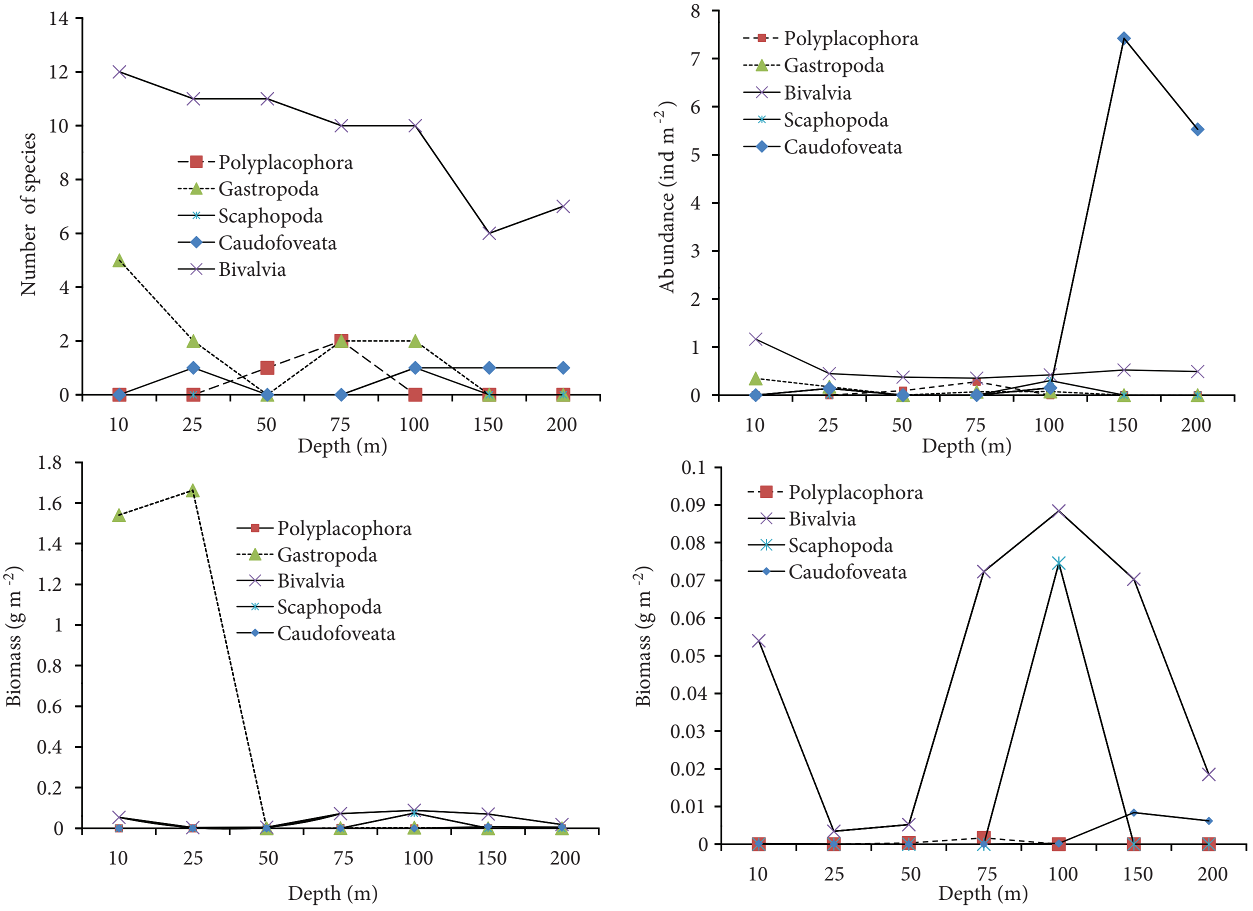

Figure 3. Changes in the number of species, number of individuals, and biomass of classes of Mollusca according to depth. The distributions were obtained from the values averaged over the pooled transects and season. Two biomass graphics were drawn: with Gastropoda (bottom left) and without Gastropoda (bottom right).

the left lower quadrant to the right upper quadrant of the CCA ordination (Figures 6 and 7). Two main groups occurring at the shallow-water (10-50 m) and deep-water (75-200 m) stations were clearly clustered in all sampling periods (Figure 7).

Two subentities occurred in the shallow water depending on a slight difference in the total organic carbon (TOC) in the sediment (Figure 7). No seasonal difference was observed for the assemblages on the ordination of CCA (Figure 6).

Multivariate CCA revealed the relative importance of various environmental factors (Table 4). Both canonical axes together explained 34.2% of the variability, but the first axis contributed 20.1%. Eight of the 15 environmental parameters explained the major part of 34.2% of the total variation associated with the benthic community variables on the first 2 CCA axes (Table 4; Figure 7). Four of these environmental parameters (depth, TOC, mud percentage, and silt percentage in sediment) had the strongest correlations with the first CCA axis (Table 4; Figure 7). The physical parameters of the water had no strong correlation with the second CCA axis, whereas the inorganic carbon (IngC), sand, and total carbonate contents of the sediment explained most of the variation with a moderate correlation with the mollusk assemblages (Table 4). Together, these 2 axes explained the spatiotemporal variation in the relation between the species and the environmental factors (Table 4, Figure 7). However, neither the first canonical axis (Table 3, F = 2.605, P = 0.2160) nor all of the axes (F = 1.208, P = 0.0720) explained the variance significantly by the Monte Carlo test.

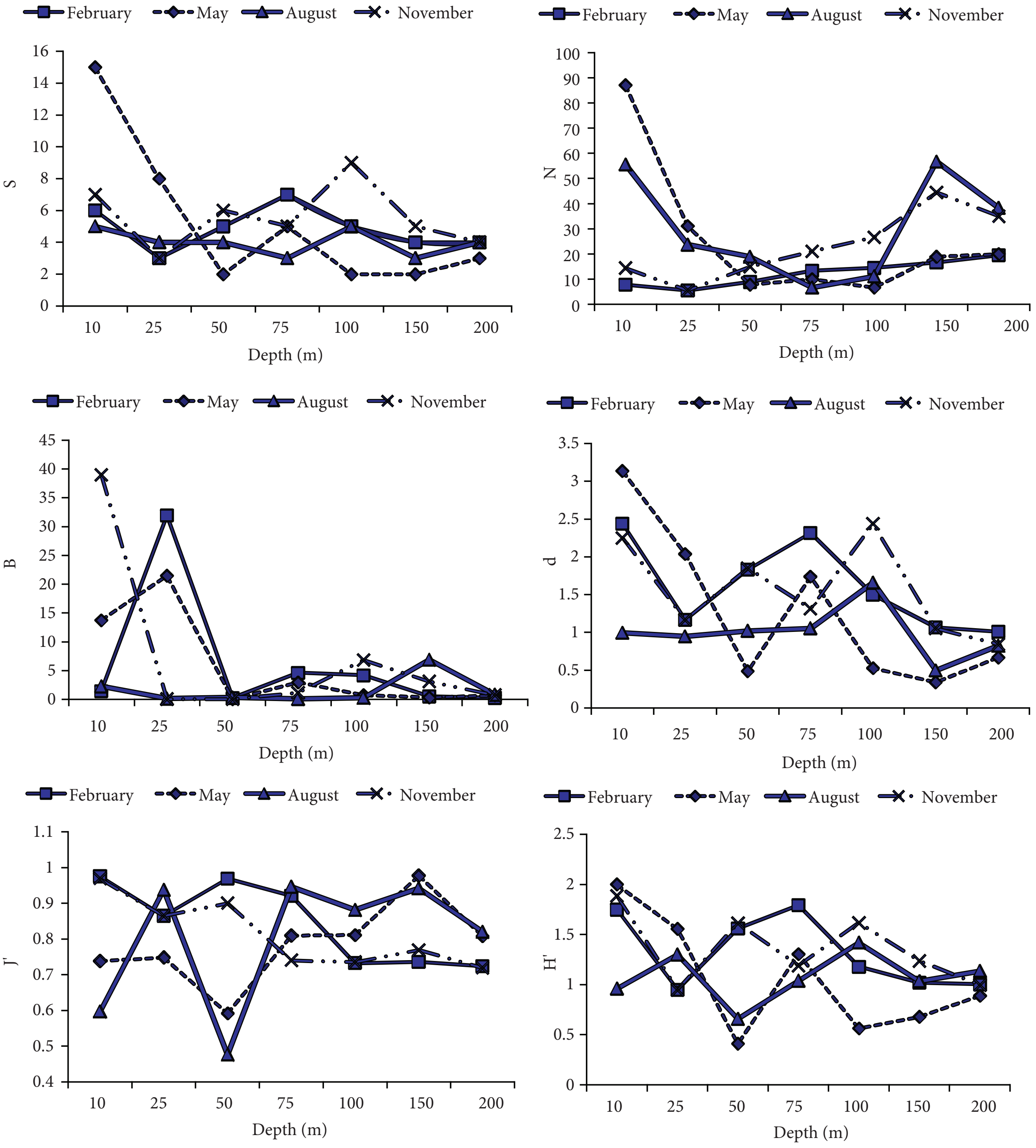

Figure 4. Seasonal distributions of the community parameters (S: number of species; N: density, ind m^{-2}; B: biomass, g m^{-2}; d: species richness; J´: evenness index; H´: Shannon-Wiener Diversity index) of mollusks along the standard depth gradients of the shelf.

The shallow waters (10-50 m) were dominated by *C. gibba* and *A. alba* in August and by *T. ferruginosa* in February-May, whereas the deep waters were characterized by the presence of *N. nitidosa* in all seasons (Figure 8). *Falcidens gutturosus* dominated the deep waters (150-200 m) of the shelf (Figure 8). The gravelly zone (50-100 m) was characterized by *A. fusca* and *N. nitidosa* (Figures 7 and 8). *Corbula gibba* and *Tellimya ferruginosa* appeared in shallow waters.

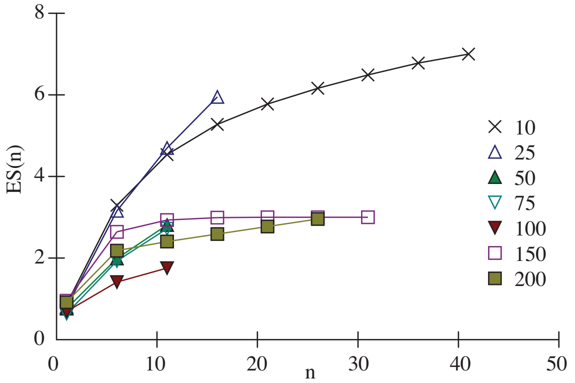

Figure 5. Rarefaction curves obtained according to the mollusk assemblages identified at depths of Mersin Bay.

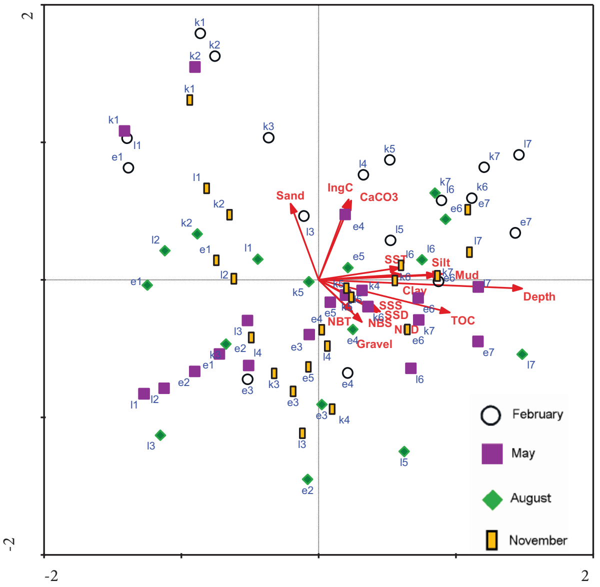

Figure 6. Biplot of CCA (plane 1-2) performed on log-transformed [$\log_{10}(N+1)$] density values (N) of the mollusks and environmental variables (arrows) at 7 depth samples (see Figure 1 for depth and transect codes around the symbols) of the seasons. Arrows refer to the direction and relative importance of environmental variables in the ordination.

Discussion

In this study, a total of 44 species belonging to the phylum Mollusca were identified. The number of soft-bottom molluscan species found in this study is far below the number of species given in the previous studies performed in the eastern Mediterranean Sea and adjacent regions of the study area (Galil and Lewinsohn, 1981; Aartsen et al., 1989; Tom and Galil, 1991; Zenetos, 1996; Grémare et al., 1998; Conides et al., 1999; Koutsoubas et al., 2000; Tselepides et al., 2000; Doğan et al., 2005; Çinar et al., 2006). The reasons for this difference could be attributed to different hydrodynamic and eutrophication levels (more oligotrophic) among the areas. The study area was nutritionally fed by very small brooks (Figure 1) and the content of the TOC was well below the lower critical limit (<10 mg g^{-1}) corresponding to the coastal areas without organic loading (Hyland et al., 2005). In addition, high salinity and temperature

Table 3. Results of PERMANOVA: a) bold number shows that P-value is less than 0.05 (df: degrees of freedom, SS: sum of squares, MS: mean square, F: F-value, P(perm): calculated probability value; number of iterations = 5000); b) pairwise test of PERMANOVA among the depths; c) pairwise test of PERMANOVA among the transects; d) pairwise test of PERMANOVA among the seasons.

a) Source	**df**	**SS**	**MS**	**F**	**P(perm)**	**P(MC)**
Transect	2	11,793.3	5896.65	1.19	0.33	0.31
Season	3	34,686.1	11562.1	2.32	0.05	0.02
Depth	6	162,073	27012.1	4.63	**0.00**	0.00
Transect × season	6	29,840.8	4973.47	2.03	**0.00**	0.00
Depth × transect	12	53,123.7	4426.97	0.93	0.60	0.60
Depth × season	18	105,063	5836.81	1.23	0.15	0.13
Transect × season × depth	36	170,992	4749.79	1.94	**0.00**	0.00
Residual	168	410,960	2446.19			
Total	251	978,532				

Table 3. (Continued).

b) Groups (depths)	**t**	**P(perm)**	**P(MC)**	**#unique values**
10-25	1.17	0.20	0.26	35
10-50	1.17	0.33	0.29	35
10-75	1.52	0.16	0.11	35
10-100	1.58	0.11	0.11	35
10-150	3.01	**0.03**	0.00	35
10-200	2.68	**0.03**	0.01	35
25-50	0.96	0.31	0.43	35
25-75	1.50	0.06	0.09	35
25-100	1.43	0.15	0.16	35
25-150	3.96	**0.03**	0.00	35
25-200	3.26	**0.03**	0.00	35
50-75	1.39	0.13	0.13	35
50-100	1.43	0.17	0.18	35
50-150	3.51	**0.02**	0.00	35
50-200	2.96	**0.03**	0.01	35
75-100	0.65	0.82	0.68	35
75-150	3.04	**0.04**	0.01	35
75-200	2.37	**0.03**	0.02	35
100-150	1.80	**0.03**	0.07	35
100-200	1.51	0.07	0.15	35
150-200	0.55	0.70	0.67	35

c) Groups (transects)	**t**	**P(perm)**	**P(MC)**	**#unique values**
Erdemli-Limonlu	0.73	0.83	0.72	35
Erdemli-Kumkuyu	1.12	0.33	0.30	35
Limonlu-Kumkuyu	0.81	0.55	0.58	35

d) Groups (seasons)	**t**	**P(perm)**	**P(MC)**	**#unique values**
February-May	1.39	0.09	0.16	10
February-August	2.08	0.11	0.03	10
February-November	1.40	0.11	0.18	10
May-August	1.66	0.10	0.08	10
May-November	1.45	0.10	0.15	10
August-November	0.87	0.59	0.52	10

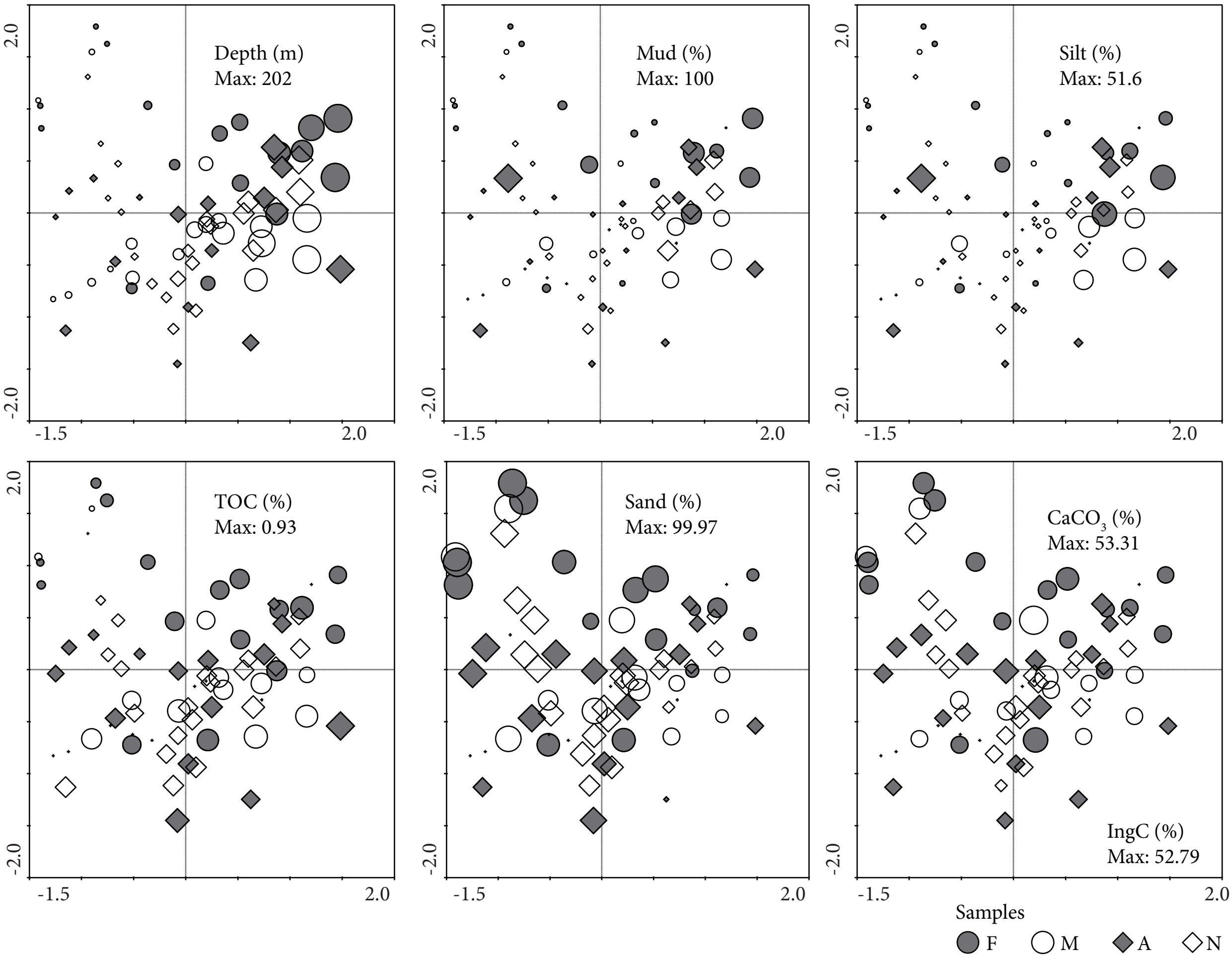

Figure 7. CCA ordination of species abundance with superimposed symbols representing bottom depth and sedimentary parameters of the sampling locations in February, May, August, and November. Symbol size is proportional to the value of each variable. The largest symbol corresponds to the maximum value.

values in Mersin Bay create unsuitable conditions for many Mediterranean mollusk species.

The most dominant mollusk species in the area were *N. nitidosa* (51%), *F. gutturosus* (25%), and *C. gibba* (24%). *Nucula nitidosa* was found on the gravelly muddy bottom with relatively high TOC. This species was found to be the characteristic species of the fine or mixed sediments (Zarkanellas and Kattoulas, 1982; Albayrak et al., 2007) and it forms scarce populations in undisturbed environmental conditions (Occhipinti-Ambrogi et al., 2005). *Corbula gibba* was found in sandy muddy bottoms from 10 m to 60 m, but it was absent at 10 m with relatively less TOC. The maximum densities of this species were recorded in the sandy muddy bottoms at around 50 m in depth. This species was distributed at depths greater than 20 m in the Strait of Messina (Cosentino and Giacobbe, 2006) and on the coast of Crete (Koutsoubas et al., 2000). Hrs-Brenko (2006) reported that *C. gibba* forms dense populations in organically polluted bottoms. This occurrence was linked to feeding plasticity as an adaptation to switch between suspension and deposit feeding (Yonge, 1946). This species usually lives on muddy bottoms rich in organic matter (Mastrototaro et al., 2008). Therefore, *C. gibba* was reported to be abundant in eutrophic seas and polluted areas: the Sea of Marmara and the Black Sea (Uysal et al., 2002), and İzmir Bay (Doğan et al., 2005; Çinar et al., 2006). *Falcidens gutturosus*, which occurred in deep waters (150-200 m) in Mersin Bay, indeed exhibited a wide bathymetric distribution extending from

Table 4. Summary of statistical measures of abundance of mollusk species and environmental variables for CCA (SST: sea surface temperature, NBT: near-bottom temperature; SSS: sea surface salinity; NBS: near-bottom salinity; SSD: sea surface density; NBD: near-bottom density; $CaCO_3$: total carbonate content in sediment; TOC: total organic carbon content in sediment; IngC: Inorganic Carbon (%)).

Environmental variables	Species axis 1	Species axis 2
Depth	**0.8842**	−0.0402
SST	0.3509	0.0563
NBT	0.1468	−0.1484
SSS	0.2532	−0.1497
NBS	0.2499	−0.1483
SSD	0.2504	−0.1437
NBD	0.2673	−0.1476
Gravel (%)	0.1882	**−0.1952**
Sand (%)	−0.1213	**0.3530**
Silt (%)	**0.5099**	0.0225
Clay (%)	0.3591	0.0247
Mud (%)	**0.5367**	0.0272
CaCO3 (%)	0.1415	**0.3675**
TOC (%)	**0.5696**	−0.1517
IngC (%)	0.1308	**0.3738**
Eigenvalues	0.675	0.471
Species-environment correlations	0.934	0.835
Cumulative percentage variance		
of species data	4.2	7.2
of species-environment relation	20.1	34.2

the continental shelf region (100 m) to the bathyal slope (700 m) (Koutsoubas et al., 2000). It was fairly common at depths of 40-866 m in the Sea of Marmara and the Aegean Sea (Salvini-Plawen and Öztürk, 2006). The recruitment of the dominant species affects the species abundance and the diversity and evenness values in time (Koutsoubas et al., 2000). The mean mollusk abundance in the area was found to be 22 ind m^{-2}. *Nucula nitidosa* (25% of total individuals) was the most abundant species, followed by *F. gutturosus* (16%) and *C. gibba* (12%). *Corbula gibba* reached a maximum density of 70-83 ind m^{-2} in Edremit Bay in the Aegean Sea (Albayrak et al., 2007), 16 ind m^{-2} in Augusta Harbor of Sicily (Giacobbe and Rinelli, 2002) and 15,860 ind m^{-2} in the polluted part of İzmir Bay (Çinar et al., 2006). *Nucula nitidosa* had lower abundance in the muddy bottom than in sandy mud in a macrotidal bay of Marennes-Oléron, France (de Montaudouin and Sauriau, 1999). In Edremit Bay, *N. nitidosa* was reported with a maximum abundance of 13-40 ind m^{-2} (Albayrak et al., 2007). The abundance in the study area of *T. ferruginosa*, a suspension feeder that dominated the North Sea during cold weather periods (Kronche et al., 2001; Reiss et al., 2006), peaked in May when the water temperature was still cold. The abundance of mollusks decreased from 41 ind m^{-2} at a depth of 10 m to 13-16 ind m^{-2} at 25-100 m and then increased abruptly to 27-32 ind m^{-2} at depths of 150-200 m. Tselepides et al. (2000) found that molluscan abundance ranged from 107 to 648 ind m^{-2} between the depths of 40 and 200 m, with the maximum at 100 m, whereas the abundance of mollusks decreased with depth on the Cretan shelf (Karakassis and Eleftheriou, 1997).

The number of mollusk species decreased sharply from shallow-water (12-17 species) to deeper zones (7-8 species). Tselepides et al. (2000) found the total number of molluscan species to be relatively stable (19.38%-24.27%) between depths of 40 and 200 m on the continental shelf of Crete, whereas Karakassis and Eleftheriou (1997) and Koulouri et al. (2006) showed that the diversity of mollusks remained stable (13.2% to 14.4 %) in benthic communities at any depth. Similar findings have also been reported in the western Mediterranean Sea (Grémare et al., 1998; Chimenz Gusso et al., 2001).

The mean biomass value of mollusks was 5 g m^{-2}, which was 4 times lower than that found by Zarkanellas and Kattoulas (1982). The biomass of mollusks decreased sharply from depths of 10-25 m (~14 g m^{-2}) to 50-200 m (1-3 g m^{-2}). Koulouri et al. (2006) found high mollusk biomass at the intermediate depth (20-35 m) on the Cretan coast. Tselepides et al. (2000) reported that the dry-weight biomass of mollusks decreased with increasing depth from 40-100 m (0.7-1.17 g m^{-2}) to 200 m (0.008 g

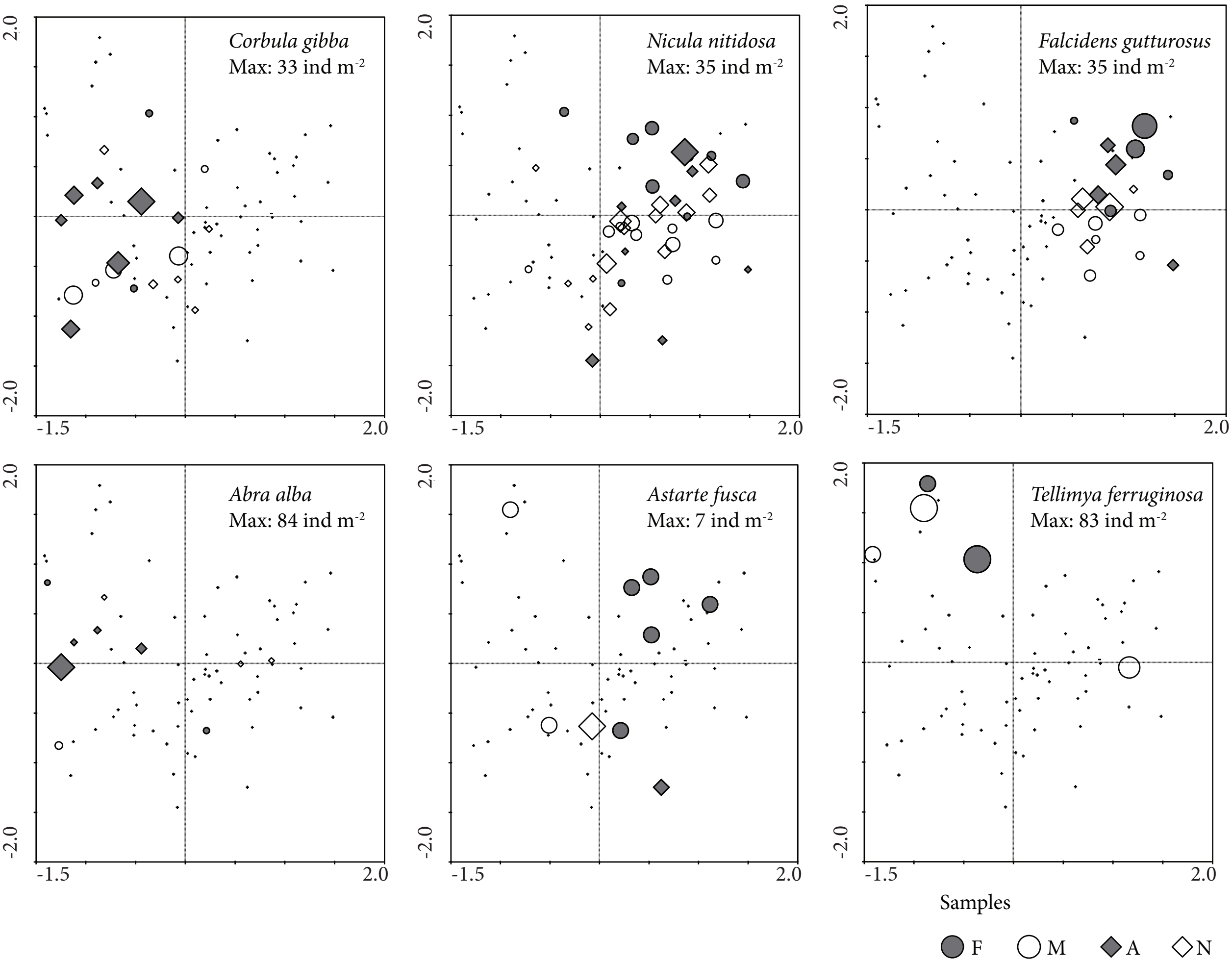

Figure 8. Abundance distribution of dominant species in each depth zone identified by CCA. Symbol size is proportional to abundance. The largest symbol corresponds to the maximum abundance of each species (see Figures 6 and 7 for the bottom depths).

m^{-2}). Karakassis and Eleftheriou (1997) also reported that mollusks exhibited larger dry-weight biomass at the nearshore stations (0.15 g m^{-2}) and decreased with depth (0.0025 g m^{-2} at 190 m) on the Cretan shelf. In the study area, the biomass of the shallow-water stations was dominated by *Conomurex persicus*, contributing up to 97% to the total biomass (Mutlu and Ergev, 2006, 2008).

Mollusk communities, which largely depend on the input of organic matter, which determines the species composition and abundance of populations in space and time (Gage 2003), did not show any significant seasonal differences in the study area. The study area is oligotrophic (Yılmaz and Tuğrul, 1998) and therefore, with an insufficient amount of organic carbon (maximum TOC: 0.98%), it did not show significant seasonal changes in the mollusk community. Koulouri et al. (2006) stated that low TOC (<10 mg g^{-1}; Hyland et al., 2005) did not seem to influence the molluscan species richness in the eastern Mediterranean Sea. Evagelopoulos and Koutsoubas (2008) determined that the pattern of the spatial organization of the molluscan fauna did not appear to change seasonally, although seasonal shifts of the zones did occur in other coastal areas of the eastern Mediterranean Sea.

The present study showed that a strong correlation exists between the abundance of mollusks and the depth and sediment features (mud, silt contents, and TOC of the sediment). Tselepides et al. (2000)

found similar results on the continental margin of Crete. They emphasized that species groupings are associated with depth, but not with season. The study by Albayrak et al. (2007) also indicated that depth is the main factor affecting the distribution of benthic species. A moderate correlation was found between the distribution of mollusks and TOC in the study area. This could be due to the oligotrophic pelagic system (Maynou and Cartes, 2000) and low annual primary production (Berman et al., 1984). Karakassis and Eleftheriou (1997) indicated that the depth gradient is even more important in an oligotrophic system where the flux of organic material toward the sea bed is more limited. Tselepides and Eleftheriou (1992) found significant correlations between the macrofauna and sediment parameters, leading to the conclusion that food availability (especially with chlorophyll *a*) is the principal regulating factor in the system. Therefore, depth as a factor influenced the species number, species abundance, and biomass in different ways. Tselepides et al. (2000) indicated that macrofauna abundance decreases with increasing depth. Kroncke et al. (2003) found that the mean abundance and number of species were negatively correlated with depth, but positively correlated with the TOC content in the sediment. The quantity of organic matter present in sediments and differences in its quality, bioavailability, fluxes, and utilization as a food source can have strong effects on patterns of distribution (Hyland et al., 2005). For instance, Reiss and Kroncke (2006) found a relatively low abundance of *T. ferruginosa* in shallow waters with high TOC in the German depositional Bight, the same pattern that was found in the present work.

In conclusion, mollusk diversity was very poor (44 species) in an oligotrophic region of the Cilician basin. The average and biomass were also very low as compared with those found in other regions of the Mediterranean Sea. The mollusk communities in the area varied primarily according to depth and sediment structure. Two major molluscan assemblages occurred, the first in shallow water (10-50 m) and the second in deep water (75-200 m).

Acknowledgements

The present study was carried out within the framework of a project (YDABCAG-100Y015) funded by the Scientific and Technological Research Council of Turkey (TÜBİTAK) and a part of an MSc thesis by Mehmet Betil Ergev (2002, IMS-METU, Turkey). We thank Elif Özgür, Evrim Kalkan, and 2 anonymous referees for reviewing the English of the text and for their constructive comments.

References

Aartsen, J.J. van; Barash, A. and Carrozza, F. 1989. Addition to the knowledge of the Mediterranean Mollusca of Israel and Sinai. Boll. Malacol. 25: 63-76.

Açık, S. 2011. Sipuncula from the southern coast of Turkey (eastern Mediterranean), with a new report for the Mediterranean Sea. Cah. Biol. Mar. 52: 313-329.

Albayrak, S., Balkıs, H. and Çınar, M.E. 2007. Shallow-water soft bottom macrozoobenthic communities from Edremit Bay (NE Aegean Sea). Belg. J. Zool. 137: 127-132.

Anderson, M.J. 2001. A new method for non-parametric multivariate analysis of variance. Austral. Ecol. 26: 32-46.

Berman, T., Townsend, D.W., Elsayed, S.Z., Trees, C.C. and Azov, Y. 1984. Optical transparency, chlorophyll and primary productivity in the Eastern Mediterranean near the Israeli coast. Oceanol. Acta 7: 367-372.

Çevik, C. and Öztürk, B. 2001. A new Lessepsian mollusc *Hypselodoris infucata* (Ruppell and Leuckart, 1828) (Gastropoda: Nudibranchia) for the coasts of Turkey. Turk J. Zool. 25: 27-30.

Chimenz Gusso, C., Gravina, M.F. and Maggiore, F.R. 2001. Temporal variations in soft bottom benthic communities in central Tyrrhenian Sea (Italy). Arch. Oceanogr. Limnol. 22: 175-182.

Çinar, M.E., Bilecenoğlu, M., Öztürk, B., Katağan, T., Yokeş, M.B., Aysel, V., Dağlı, E., Açık, S., Özcan, T. and Erdoğan, H. 2011. An updated review of alien species on the coasts of Turkey. Medit. Mar. Sci. 12: 257-315.

Çinar, M.E., Katağan, T., Koçak, F., Öztürk, B., Ergen, Z., Kocatas, A., Önen, M., Kırkım, F., Bakir, K., Kurt, G., Dağli, E., Açik, S., Doğan, A. and Özcan, T. 2008. Faunal assemblages of the mussel *Mytilus galloprovincialis* in and around Alsancak Harbour (Izmir Bay, eastern Mediterranean) with special emphasis on alien species. J. Mar. Syst. 71: 1–17.

Çinar, M. E., Katagan, T., Öztürk, B., Egemen, Ö., Ergen, Z., Kocatas, A., Önen, M., Kirkim, F., Bakir, K., Kurt, G., Dagli, E., Kaymakçi, A., Açik, S., Dogan, A. and Özcan, T. 2006. Temporal changes of soft bottom zoobenthic communities in and around Alsancak Harbor (Izmir Bay, Aegean Sea), with special attention to the autoecology of exotic species. Marine Ecology 27: 229-246.

CLEMAM. 2011. Taxonomic Database on European Marine Mollusca. http://www.somali.asso.fr/clemam/biotaxis.php. Accessed on January 2011.

Conides, A., Bogdanos, C. and Diapoulis, A. 1999. Seasonal ecological variations of phyto- and zoobenthic communities in the south of Nisyros Island, Greece. The Environmentalist 19: 109-127.

Cosentino, A. and Giacobbe, S. 2006. A case study of mollusc and polychaete soft-bottom assemblages submitted to sedimentary instability in the Mediterranean Sea. Mar. Ecol. 27: 170-183.

Dauvin, J.C., Thiebaut, E., Gomez Gesteira, J.L., Ghertsos, K., Gentil, F., Ropert, M. and Sylvand, B. 2004. Spatial structure of a subtidal macrobenthic community in the Bay of Veys (western Bay of Seine, English Channel). J. Exp. Mar. Biol. Ecol. 307: 217-235.

De Montaudouin, X. and Sauriau, P.G. 1999. The proliferating Gastropoda *Crepidula fornicata* may stimulate macrozoobenthic diversity. J. Mar. Biol. Assoc. U.K. 79: 1069-1077.

Doğan, A., Çinar, M.E., Önen, M., Ergen, Z. and Katağan, T. 2005. Seasonal dynamics of soft-bottom zoobenthic communities in polluted and unpolluted areas of Izmir Bay (Aegean Sea). Senckenb. Marit. 35: 133-145.

Ergen, Z., Çınar, M.E., Dağlı, E. and Kurt, G. 2006. Seasonal dynamics of soft-bottom polychaetes in Izmir Bay (Aegean Sea, eastern Mediterranean). Sci. Mar. 70: 197-207.

Evagelopoulos, A. and Koutsoubas, D. 2008. Seasonal community structure of the molluscan macrofauna at the marine-lagoonal environmental transition at Kalloni solar saltworks (Lesvos Island, NE Aegean Sea, Greece). J. Nat. Hist. http://www.informaworld.com/smpp/title~db=all~content=t713192031~tab=issueslist~branches=42 - v4242: 597-618.

Folk, R.L. 1974. Petrology of Sediment Rocks. Hephill Publishing Company, Austin.

Gage, J. 2003. Food inputs, utilisation, carbon flow and energetics. In: Ecosystems of the World (Ecosystems of the Deep Ocean) (Ed. P.A. Tyler), Elsevier, Amsterdam, pp. 313-426.

Galil, B.S. and Lewinsohn, C. 1981. Macrobenthic communities of the Eastern Mediterranean continental shelf. Mar. Ecol. 2: 343-352.

Gaudette, H.E., Flight, W.R., Toner, L. and Folger, D.W. 1974. An inexpensive titration method for determination of organic carbon in recent sediments. J. Sediment. Petrol. 44: 249-253.

Giacobbe, S. and Rinelli, P. 2002. *Corbula gibba* (Mollusca: Bivalvia) death assemblages in Augusta harbour, Mediterranean Sea. J. Mar. Biol. Assoc. U.K. 82: 265-268.

Gray, J.S. 1981. The Ecology of Marine Sediments: An Introduction to the Structure and Function of Benthic Communities. Cambridge University Press, London.

Grémare, A., Amouroux, G. and Vétion, G. 1998. Long-term comparison of macrobenthos within the soft bottoms of the Bay of Banyuls-sur-mer (northwestern Mediterranean Sea). J. Sea Res. 40: 281-302.

Hrs-Brenko, M. 2006. The basket shell, *Corbula gibba* Olivi, 1792 (Bivalve, Mollusks) as a species resistant to environmental disturbances: a review. Acta. Adriat. 47: 49-64.

Hyland, J., Balthis, L.W., Karakassis, I., Magni, P., Petrov, A., Shine, J.R., Vestergaard, O. and Warwick, R. 2005. Organic carbon content of sediments as an indicator of benthic stress. Mar. Ecol. Prog. Ser. 295: 91-103.

Jones, D.L. 2002. Users Manual for FATHOM: A MATLAB Toolbox for Multivariate Ecological and Oceanographic Data Analysis. Cooperative Institute for Marine and Atmospheric Science, University of Miami-RSMAS, Miami.

Karakassis, I. and Eleftheriou, A. 1997. The continental shelf of Crete: structure of macrobenthic communities. Mar. Ecol. Prog. Ser. 160: 185-196.

Kocataş, A. 1978. İzmir Körfezi kayalık sahillerinin bentik formları üzerinde kalitatif ve kantitatif araştırmalar. Ege Üniversitesi Fen Fakültesi İlmi Raporlar Serisi 12: 1-93.

Koulouri, P., Dounas, C., Arvanitidis, C., Koutsoubas, D. and Eleftheriou, A. 2006. Molluscan diversity along a Mediterranean soft bottom sublittoral ecotone. Sci. Mar. 70: 573-583.

Koutsoubas, D., Tselepides, A. and Eleftheriou, A. 2000. Deep sea molluscan fauna of the Cretan Sea (Eastern Mediterranean): faunal, ecological and zoogeographical remarks. Senckenb. Marit. 30: 85-98.

Kroncke, I., Turkay, M. and Fiege, D. 2003. Macrofauna communities in the Eastern Mediterranean deep sea. P.S.Z.N. Mar. Ecol. 24: 193-216.

Kroncke, I., Zeiss, B. and Rensing, C. 2001. Long-term variability in macrofauna species composition off the island of Norderney (East Frisia, Germany) in relation to changes in climatic and environmental conditions. Senckenb. Marit. 31: 65-82.

Mastrototaro, F., Giove, A., D'onghia, G., Tursi, A., Matarrese, A. and Gadaleta, M.V. 2008. Benthic diversity of the soft bottoms in a semi-enclosed basin of the Mediterranean Sea. J. Mar. Biol. Assoc. U.K. 88: 247-252.

Maynou, F. and Cartes, J.E. 2000. Community structure of bathyal decapod crustaceans off south-west Balearic Island (western Mediterranean): seasonality and regional patterns in zonation. J. Mar. Biol. Assoc. U.K. 80: 789-798.

Müller, G. 1967. Methods in Sedimentary Petrology. E. Schweizbart'sche Verlagsbuchhandlung, Stuttgart.

Mutlu, E. and Ergev, M.B. 2006. Dynamics and ecology of an Indo-Pacific gastropod, *Conomurex persicus* in southeastern Turkey. Rev. Biol. Trop. 54: 117-129.

Mutlu, E. and Ergev, M.B. 2008. Spatio-temporal distribution of soft-bottom epibenthic fauna on the Cilician shelf (Turkey), Mediterranean Sea. Rev. Biol. Trop. 56: 1919-1946.

Occhipinti-Ambrogi, A., Savini, D. and Forni, G. 2005. Macrobenthos community structural changes off Cesenatico coast (Emilia Romagna, Northern Adriatic), a six-year monitoring programme. Sci. Total Environ. 353: 317-328.

Önen, M. and Doğan, A. 2007. *Dacrydium hyalinum* (Monterosato, 1875) and *Musculus discors* (Linnaeus, 1767): two new Mytilidae (Bivalvia) species for the Turkish mollusc fauna. Turk J. Zool. 31: 235-239.

Öztürk, B. and Can, A. 2006. Indo-Pacific gastropod species in the Levantine and Aegean Seas. Aquat. Invasions 1: 124-129.

Reiss, H. and Kröncke, I. 2006. Temporal patterns of infaunal communities in the North Sea: interannual vs. intraannual variability. Senckenb. Marit. 36: 11-18.

Reiss, H., Meybohm, K. and Kröncke, I. 2006. Cold winter effects on benthic macrofauna communities in near- and offshore regions of the North Sea. Helgol. Mar. Res. 60: 224-238.

Rhoads, D.C. and Young, D.K. 1970. The influence of deposit-feeding organisms on sediment stability and community trophic structure. J. Mar. Res. 28: 150-178.

Rueda, J.L., Fernandez-Casado, M., Salas, C. and Gofas, S. 2001. Seasonality in a taxocoenosis of molluscs from soft-bottom in the Bay of Cadiz (southern Spain). J. Mar. Biol. Assoc. U.K. 81: 903-912.

Salvini-Plawen, L.V. and Öztürk, B. 2006. New records of Caudofoveata (*Falcidens gutturosus*, *Prochaetoderma raduliferum*) and of Solenogastres (*Eleutheromenia carinata*, spec. nov.) from the eastern Mediterranean Sea. SPIXIANA 29: 217-224.

Sanders, H.L. 1968. Marine benthic diversity: a comparative study. Am. Nat. 102: 243-282.

teer Braak, C.J.F. and Smilauer, P. 2002. Canoco 4.5. Canoco Reference Manual and CanoDraw for Windows User's Guide. Software for Canonical Community Ordination (Version 4.5). Wageningen University and Research Center, Wageningen.

Tom, M. and Galil, B. 1991. The macrobenthic associations of Haifa Bay, Mediterranean coast of Israel. Mar. Ecol. 12: 75-86.

Tselepides, A. and Eleftheriou, A. 1992. South Aegean (eastern Mediterranean) continental slope benthos: macroinfaunal - environmental relationships. In: Deep-Sea Food Chains and the Global Carbon Cycle (Eds. G.T. Rowe and V. Pariente), Kluwer Academic Publishers, Dordrecht, pp. 139-156.

Tselepides, A., Konstantia, N.P., Dimitris, P., Wanda, P. and Drosos, K. 2000. Macrobenthic community structure over the continental margin of Crete (South Aegean Sea, NE Mediterranean). Prog. Oceanogr. 46: 401-428.

Uysal, A., Yüksek, A., Okuş, E. and Yilmaz, N. 2002. Benthic community structure of the Bosphorus and surrounding area. Water Sci. Technol. 46: 37-44.

Yılmaz, A. and Tuğrul, S. 1998. The effect of cold and warm-core eddies and the distribution and stoichiometry of dissolved nutrients in the northeastern Mediterranean. J. Mar. Sys. 1: 253-268.

Yonge, C.M. 1946. On the habits and adaptations of *Aloidis* (*Corbula*) *gibba*. J. Mar. Biol. Assoc. U.K. 26: 358-376.

Zarkanellas, A.J. and Kattoulas, M.E. 1982. The ecology of benthos in the Gulf of Thermaikos, Greece I. Environmental conditions and benthic biotic indices. P.S.Z.N. Mar. Ecol. 3: 21-39.

Zenetos, A. 1996. Classification and interpretation of the established Mediterranean biocoenoses based solely on bivalve molluscs. J. Mar. Biol. Assoc. U.K. 76: 403-416.