

Broad-scale ecological distribution of dominant macrozoobenthic taxa of the northern Cilician shelf, eastern Mediterranean Sea: crustaceans*

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Abstract: The distribution of crustaceans in 3 transects (İskenderun, Mersin, and Anamur bays, including depths of 10, 25, 50, 75, 100, and 200 m) located within Turkish coastal borders of the Cilician shelf was studied between 2005 and 2007 to show the association with habitat types, eutrophication level, and depth-dependent environmental parameters in representative months of each season (winter, spring, summer, and autumn). A total of 153 crustacean taxa were found. Of the specimens identified at species level, 93 species were distributed in the Mediterranean Sea and Atlantic Ocean, 12 in the Indian Ocean and the Red Sea, and 4 in the cosmopolitan waters of the oceans. Three crustacean assemblages were distinguished according to the habitat types and eutrophication levels of the study sites: 1) the crustacean community of the eutrophic regions was dominated by decapods and characterized by high biomass, low faunistic characters, and high nutrient concentrations; 2) the assemblage of the bottom, vegetated with a meadow, exhibited well-diversified assemblages mainly composed of amphipod species with high faunistic characters, low biomass, and dissolved oxygen content; and 3) the assemblage of the nonvegetated undisturbed soft bottom was associated with the sedimentary parameters along the bottom depths (10–25 m, 50–100 m, and 150–200 m).

Key words: Zoobenthos, Crustacea, Cilician shelf, Turkey

1. Introduction

The Cilician Basin contains a unique wide continent shelf, excluding the Nile Delta in the eastern Mediterranean Sea, which is ultra-oligotrophic with primary productivity (Krom et al., 2004). The determinant that makes the Cilician Basin important is the occurrence of riparian rivers discharging into the region (Figure 1). Nevertheless, the Nile River influences the Cilician Basin via rim currents of the eastern Mediterranean (Uysal et al., 2008). The Cilician shelf has not been well documented in terms of the biophysicochemical properties of its pelagic waters, although basin-wise the oceanography of the eastern Mediterranean, including the Cilician Basin, has been well studied. Geological characteristics of the shelf were published by Ergin (1996) and Ediger et al. (1997), and a few national projects have focused recently on the oceanography of the shelf, including the present study area (POEM, 1986a, 1986b; Salihoğlu and Mutlu, 2000; Uysal et al., 2008; SINHA, 2010). The present study was carried out as a subtask of the project context (Uysal et al., 2008).

Coastal ecosystems of the North Levantine Basin have undergone permanent changes due to increasing anthropogenic inputs, resulting in elevated eutrophication, mainly in İskenderun and Mersin bays. Domestic industrial and agricultural residues resulting from excessive nutrient inputs cause intense outbursts of monospecific phytoplankton (Uysal et al., 2003), which cause a negative impact on water quality, evident in the process of decomposition, reduction of the concentration of dissolved oxygen, and light penetration. In the 1970s, the intensive destruction of algal communities in the Mersin port and coastal areas was observed for a few years. The inner Gulf of İskenderun, the Mersin inner bay, and the western coastal area were rich in terms of population density of phytoplankton. In these areas, the current regime is generally from east to west, and inputs of the Seyhan and Ceyhan rivers contribute to the form of the eutrophic region. The port of Mersin has a sewage-water treatment system, which is one of the factors causing eutrophication of the region. *Chl-a* concentration in the

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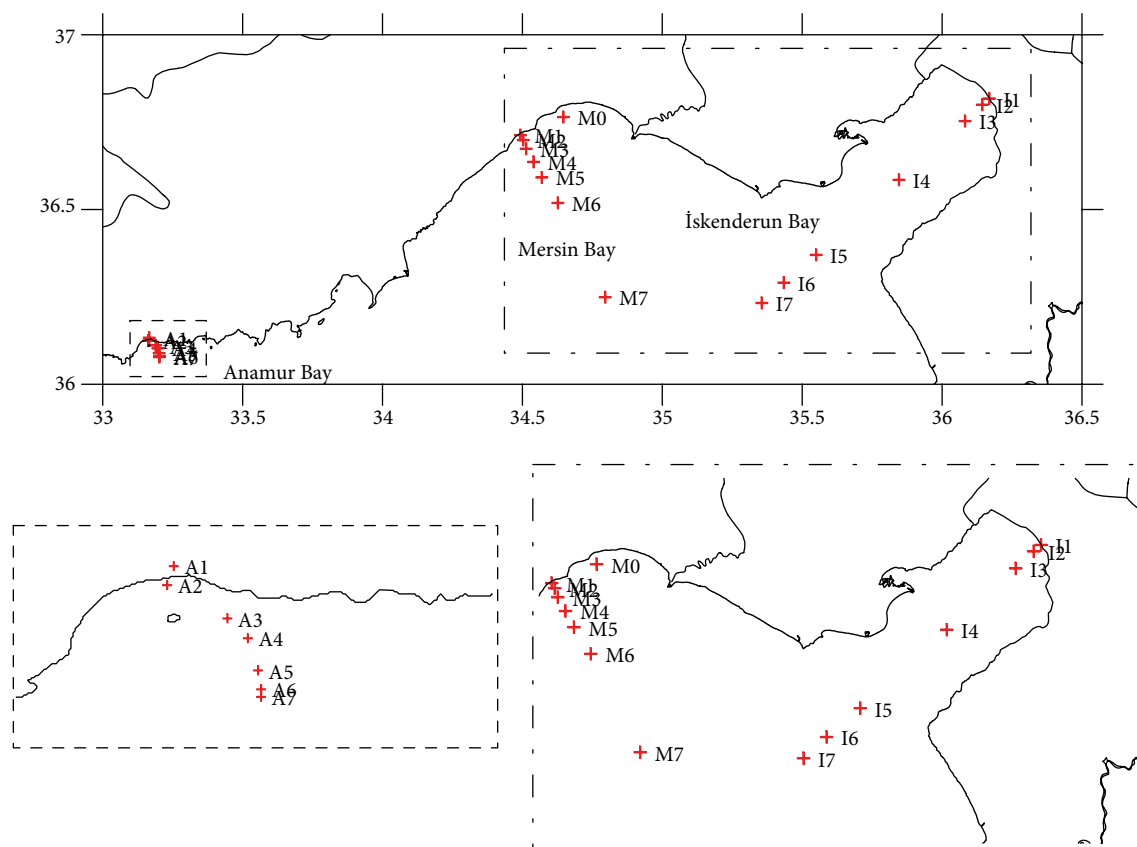


Figure 1. Study area and Turkish part of the Cilician Basin (transects: M: Mersin, I: İskenderun, A: Anamur) and location of the sampling stations (depth code: 1: 10 m, 2: 25 m, 3: 50 m, 4: 75 m, 5: 100 m, 6: 150 m, and 7: 200 m) visited in November 2005, March 2006, July 2006, and January 2007.

inner Gulf of Mersin, İskenderun, and the Göksu and Seyhan rivers is higher than in other open waters. Warmer surface waters from the west to the east have been getting colder, and deep, cold waters with rich nutritive salts are pumped up to the surface waters towards the end of the continental shelf waters of the Gulf of Mersin. Therefore, a high concentration of *chl-a* occurs. The Gulf of İskenderun is higher in nutrients than Cape Akıncı off the Gulf of İskenderun (Uysal et al., 2008).

A current system that could derive variable measurement values of the environmental parameters, and therefore change the response of the benthic community, prevails toward the west along the Turkish area of the Cilician Basin. In İskenderun Bay, station I7 is located on the westward rim current, whereas the rest of the stations are located in a constant water system. The stations of Mersin Bay are located at a meso-scaled cyclonic eddy. The stations at Cape Anamur are located in a very constant current system, as all stations are very close to the shore (Uysal et al., 2008).

A variety of environmental gradients affect the biodiversity pattern of benthic organisms. The effects of those gradients occur in different ways, resourced

by induced variables (chemicals, nutrients, and energy consumption), direct variables (grain size of sediment and temperature), and indirect variables (depth and latitude) (Meynard and Quinn, 2007). Substrates and habitat, such as hard and soft bottoms and vegetative marine beds, play an important role in biodiversity patterns (Williams and Bax, 2001; Beaman et al., 2005; Beaman and Harris, 2007). There is richer biodiversity in seagrass beds than in sandy and muddy soft bottoms, and this diversity drives the increase of biodiversity in adjacent regions. Nevertheless, seagrasses that host many epiphytes along their leaves are not a favored food source for grazing taxa (Jenkins and Wheatley, 1998; Fry, 2006). Other sources that have altered the biodiversity and richness are eutrophication and nutrient enrichment, followed by high primary productivity, which reduce the species richness and increase the evenness of the benthos in near-shore waters (Snelgrove, 2001; Hillebrand et al., 2007), in contrast to oligotrophic waters (Poore et al., 2008). After detritus forms as a consequence of primary production and waste of zooplankton, the deposited particulate organic carbon (POC) drives the biodiversity of the benthos (Seiter et al., 2005). One of POC's fluxes, total organic carbon

(TOC), is a powerful variable explaining the community structure within an ecological framework of tolerant and intolerant species to pollution and opportunistic species (Gogina et al., 2010). TOC alone sometimes does not show good correlation with faunistic characters of the benthos because of the effect of bacterial degradation in sediments overstocked with TOC (Danovaro et al., 1995; Cartes et al., 2002).

Benthic crustaceans can potentially be consumed by humans and other organisms inhabiting the sea, and they are also tools for monitoring the ecological status and water quality in bioassay experiments (Cockroft et al., 1988). Particular to the Levantine Sea, alien benthic crustaceans establishing and succeeding in the sea replace or fill the gaps in ecological niches left by native benthic crustacean species. Prior to the 2000s, the last decadal benthic ecological and distributional research of the eastern Mediterranean Sea was performed only for the waters of Greece and Israel (Galil and Lewinsohn, 1981; Karakassis and Eleftheriou, 1997; Tom and Galil, 1991; Papazacharias et al., 1998; Conides et al., 1999; Tselepides et al., 2000). Thereafter, alien species, new records, and new species of crustaceans were studied in the Turkish waters of the Levantine Sea (Çinar et al., 2006; Özcan et al., 2006; Ateş et al., 2007a; Bakır et al., 2007; Yokes et al., 2007; Çinar et al., 2008; Doğan et al., 2008; Ateş et al., 2009; Çinar et al., 2011; Çinar et al., 2012a, 2012b; Bakır and Katağan, 2014; Bakır et al., 2014). Recently, ecological and distributional studies of macrozoobenthos have explained the benthic faunal assemblages with bottom depth and sedimentary factors over time and space for the Levantine Sea (Mutlu and Ergev, 2008; Mutlu et al., 2010; Çinar et al., 2012a, 2012b; Mutlu and Ergev, 2012; Mutlu and Ergev, 2013). A variety of factors composed of depth-related ecological factors such as habitats (the nonvegetative and vegetative soft-bottom) and nutritional levels (soft bottoms of eutrophic and noneutrophic pelagic zones) were studied in a limited manner to show association with spatial and temporal distribution of the macrobenthic crustaceans in the Turkish Levantine Sea shelf, as each dominant taxa of the macrozoobenthos showed a different response to a variety of ecological parameters in a small area of the Levantine Sea, Mersin Bay (Mutlu et al, 2010; Mutlu and Ergev, 2012; Mutlu and Ergev, 2013).

The present study aimed to investigate the ecological distribution of the macrobenthic crustaceans on a broad scale and their response to the environmental factors of sedimentary (texture and biochemical contents) and hydrophysicochemical parameters in a bottom environment at different nutritional levels and habitats of the most oligotrophic basin of the Levantine Sea, the Cilician Basin.

2. Materials and methods

The area of the basin is nourished by the Seyhan, Ceyhan, and Göksu rivers. Mersin and İskenderun bays are considered to having nonvegetated bottoms, while the bottoms of the shallow stations (A1 and A2) off Cape Anamur are covered by *Posidonia* beds. The inner part (I1 and I2) of the Gulf of İskenderun is generally disturbed by its own nutritional dynamics derived from enclosed eddies and anthropogenic activities. The benthic samples of the study for the Levantine Sea were collected at 7 separate depths (10, 25, 50, 75, 100, 150, and 200 m) on 3 transects, each located in İskenderun, Mersin, and Anamur bays of the Cilician continental shelf in November 2005, March and July 2006, and January 2007 by R/V Bilim-2 (Figure 1). Even though the continuity of the subsequent sampling seasons under the trended atmospheric and sea condition events could have been optimized for a better understanding of the crustacean community, the samplings were performed well enough for the ecological parameters to explain the crustacean community structure. A Van Veen grab (0.10 m² surface area) was used to take one sample from each station. However, some stations (I5 in November, I5–I7 in March, and the last few deep stations off Anamur) could not be sampled due to the bad weather and close depth contours of the bay in the March–January sampling only (Figure 1). Approximately 0.25 L of sediment taken by the grab was reserved in a nylon bag and preserved in a deep-freezer for geochemical analyses (grain size, TOC, and carbonate contents).

During the onboard sampling, the sediment was sifted with a set of sieves (0.5, 1, and 2 mm mesh sizes in square); the benthic materials were then put into a 5% MgCl₂ solution to anesthetize the organisms, and then transferred into a 10% formalin solution.

Hydrographical parameters of the water column were profiled by casting a SeaBird CTD probe (SBE 19plus profiler) from the sea surface to the bottom. In the laboratory, nutrient salts (PO₄, NO₂ + NO₃, and Si) and dissolved oxygen of the sea surface (SSx) and near-bottom (NBx and/or Nx) water put into Niskin bottles with a rosette water sampler were read using an autoanalyzer and following the Winkler method, respectively (Table 1). Grain-size analyses of the sediment were carried out with a standard technique described by Folk (1974). The titrimetrical method standardized by Gaudette et al. (1974) was applied to read the TOC of the sediment, and the CaCO₃ content was measured applying the method determined by Müller (1967) (Table 1).

The laboratory studies were performed to determine abundance and biomass, with identification of the crustacean species following the checklist of the World Register of Marine Species, WoRMS (<http://www.marinespecies.org/>) (Appendix; on the journal's website).

Principle component analysis (PCA in PRIMER 6) was used with the normalized data of each group set of physical, chemical, and sedimentary parameters to determine explanatory variables and components for the spatiotemporal description of the studied bays (Table 1). Tukey's least significant difference was used to evaluate the sources of variation for the explanatory variables in time and space using the MATLAB statistical tool (version 7.0, MathWorks, Inc.).

As an indication of crustacean faunistic characters, a set of variables was formed composed of Shannon–Wiener diversity (H' , \log_2 base), Margalef's species richness (d) and Pielou's evenness (J') indices, percent dominance ($D\%$), and numerical occurrence ($NO\%$). Differences in the crustacean community among the seasons, transects, and depths were tested statistically by PERMANOVA (Anderson, 2001). The Bray–Curtis dissimilarity matrix of the \log_{10} -transformed abundance data was applied to the nonparametric PERMANOVA in a three-way model with fixed transect, random season, and depth (FATHOM; Jones, 2002). Canonical correspondence analysis (CCA) was applied to determine the crustacean assemblages and then to show their relationships with the spatiotemporal bathymetrical, physical, and sedimentary variables (CANOCO 4.5; ter Braak and Šmilauer, 2002). Choice of CCA for usage was determined by applying the $\log_{10}(N + 1)$ -transformed abundance data to detrended correspondence analysis; it was concluded that the maximum gradient exceeded 3 standard deviations (SDs; Hill and Gauch, 1980) among the calculated SDs (0.000, 0.000, 10.309, and 8.025 for the first 4 axes, respectively). A similarity of percentage analysis (SIMPER, PRIMER 6) was used to determine the contribution of discriminator and contributor species among the station groups classified as having nonvegetated soft bottoms, vegetated soft bottoms with *Posidonia* beds, and nonvegetated soft bottoms of the nutrient salts–eutrophic water column.

3. Results

3.1. Environmental structure

Annual sea surface water temperatures (SSTs) were found to be $0.3\text{ }^\circ\text{C}$ warmer in Mersin and İskenderun bays (20.46 ± 0.067 and $20.61 \pm 0.09\text{ }^\circ\text{C}$, respectively) than those in Anamur Bay. The sea surface salinity (SSS) and density (SSD) of the bays varied between 39.21 and 39.24 PSU and between 27.78 and 27.87 PSU, respectively. Near-bottom water temperature (NBT; $18.04\text{--}18.38\text{ }^\circ\text{C}$), salinity (NBS; 39.21–39.23 PSU), and density (NBD; 28.36–28.45) were not found to be significantly different among the bays. Sea surface oxygen (SSOx) was significantly higher in Mersin Bay ($6.99 \pm 0.03\text{ mg L}^{-1}$), being in the same range in Anamur Bay (6.92 ± 0.04), followed by İskenderun (6.85 ± 0.04). Overall, SST, SSD, and NBD were significantly different among the transects. Annual average SST of the study area did not vary significantly by bottom depth, with the exception of warmer water at 150 m than at 200 m. The sea surface at 10 and 25 m was significantly less salty than that at the greater depths of the Cilician shelf. Near-bottom water was significantly warmer at 10–50 m than at 75–200 m in depth, and it was significantly denser at 10–25 m than at greater depths. Overall, SSS, SSD, NBT, NBS, and NBD were significantly different at the bottom depth. Physical measurements of both the sea surface and near-bottom waters differed significantly among the seasons. SST was warmer in November than in March and January, but cooler than in July. The physical characters of the study area changed in association with the season–bottom depth interaction, rather than with the sites. Sea surface temperature along the shelf of Mersin and İskenderun bays was warmer by $2\text{ }^\circ\text{C}$ and $1\text{ }^\circ\text{C}$ than that of Anamur Bay in July and November, respectively. The temperature remained in a similar range in all the bays in January and March. SSS was found to be in a similar range of 39.3–39.4 PSU along the shelves of Mersin and

Table 1. Environmental characters as physical, chemical, and sedimentary parameters measured at the sampling stations and abbreviations of the parameters used in the analyses.

Physical parameters	Chemical parameters in μM	Sedimentary parameters
Surface (SSx) and near-bottom water (NBx)	Surface (SSx) and near-bottom water (NBx)	Superficial sediment
Temperature ($^\circ\text{C}$); SST and NBT	Dissolved oxygen (Winkler); SSO and NBO	Gr; gravel (%)
Salinity (PSU); SSS and NBS	PO_4 ; SSPO_4 and NBPO_4	Snd; sand (%)
Density, sigma-t; SSD and NBD	$\text{NO}_2 + \text{NO}_3$; $\text{SSNO}_2 + \text{NO}_3$ and $\text{NBNO}_2 + \text{NO}_3$	Mud (%)
Oxygen (mg L^{-1}); SSOx and NBOx	Si; SSSi and NBSi	Slt; silt (%)
		Cly; clay (%)
		CaCO_3 ; total carbonate (%)
		TOC; total organic carbon (%)

Anamur bays in January, July, and November. The SSS was variable seasonally at a depth zone of 10–75 m in the inner part of İskenderun Bay. The SSS was less salty in March in all the bays. This less salty water appeared particularly between depths of 10 and 25 m. The PCA showed that an explained variation of 57.8% resulted from a set of seasonal parameters such as SST and NBT in increasing trend and SSD, NBD, SSOx, and NBOx in decreasing trend on PCA1. The other component, PCA2, was explained with a variation of 19.4% and was based mainly on the less salty shallow waters (<25 m) in a period (May) of high spring freshwater inputs.

The chemical hydrograph of the pelagic zone in the study area was mainly structured on 2 depth zones: very shallow water (10 m) and deeper water (25–200 m). Nevertheless, such zonal regions of the shallow water occurred in certain seasons (January and March) and where the riverine inputs existed for the bays of Mersin and İskenderun. At greater depths, seasonality of the chemical variables appeared clearly and was scattered in the shape of an X on the PCA analyses, regardless of the locality. The source of this variability was primarily explained by silicate content. Near-bottom silicate concentration of the bays was significantly higher than that of Anamur Bay. More than 50% of the total variability in the chemical characters of the area was explained by the first 2 axes on the PCA. The PCA1 had an explained variance of 35.6% in association with such parameters as NSi (–0.521), SSi (–0.450), $\text{NNO}_2 + \text{NO}_3$ (–0.413), and $\text{SNO}_2 + \text{NO}_3$ (–0.445). The PCA2 where the seasonality appeared was accompanied by the dissolved oxygen NDOW (0.661) and SDOW (0.670), with a variation of 22.5%. Overall, each of SDOW, SPO_4 , SSi, NPO_4 , and NSi were significantly different among the transects. Mersin Bay was generally richer in SDOW ($231.28 \pm 0.77 \mu\text{M}$), SPO_4 ($0.026 \pm 0.001 \mu\text{M}$), NPO_4 ($0.0357 \pm 0.002 \mu\text{M}$), and NSi ($1.723 \pm 0.088 \mu\text{M}$) than Anamur Bay ($227.33 \pm 0.10 \mu\text{M}$, $0.020 \pm 0.001 \mu\text{M}$, $0.022 \pm 0.003 \mu\text{M}$, and $1.390 \pm 0.114 \mu\text{M}$, respectively), where all the parameters were at low concentrations. İskenderun Bay was significantly richer in SSi ($1.808 \pm 0.063 \mu\text{M}$) and NSi ($1.841 \pm 0.121 \mu\text{M}$) than Anamur Bay. The concentrations of $\text{SNO}_2 + \text{NO}_3$ and $\text{NNO}_2 + \text{NO}_3$ in all the bays were in the same range. The average of annual values of the SDOW, $\text{SNO}_2 + \text{NO}_3$, SSi, NDOW, NPO_4 , and $\text{NNO}_2 + \text{NO}_3$ differed significantly at the bottom depths. In general, concentrations of sea surface parameters at 10 m were significantly higher than at greater depths. NPO_4 of near-coastal water (10 m) was higher than that of greater depths, with the exception of 200 m. The near-bottom depth–intermediate waters (25–150 m depths) of the shelf were poorer in nutrients as contrasted to the NDOW than the other depths. Concentrations of all the chemical parameters with the exception of PO_4 ($0.0222\text{--}0.0238 \mu\text{M}$

in the surface waters and $0.0246\text{--}0.0294 \mu\text{M}$ in the near-bottom waters) were seasonally different at a significance level of $P < 0.05$. In general, densities of the remaining nutrients in both surface and near-bottom waters were significantly higher in November than in other months. Both SDOW and NDOW were significantly higher in March (253.42 ± 1.47 and $249.92 \pm 3.46 \mu\text{M}$, respectively) than in other months ($202\text{--}234 \mu\text{M}$ and $220\text{--}225 \mu\text{M}$, respectively). SSi was significantly higher in November ($1.79 \pm 0.06 \mu\text{M}$) and lower in July ($1.04 \pm 0.06 \mu\text{M}$) than in March ($1.40 \pm 0.09 \mu\text{M}$) and January ($1.56 \pm 0.06 \mu\text{M}$). NSi was significantly higher in November ($2.20 \pm 0.11 \mu\text{M}$) and January ($1.78 \pm 0.12 \mu\text{M}$) than in March ($1.31 \pm 0.17 \mu\text{M}$) and July ($1.32 \pm 0.11 \mu\text{M}$). $\text{SNO}_2 + \text{NO}_3$ and $\text{NNO}_2 + \text{NO}_3$ were higher in November than in the other months.

Only the sedimentary structures (grain size) were significant among the bottom depths, while the sedimentary structures and the contents were different significantly in space (the transects). The finest grains were significantly different among the seasons. The source for differentiating the sedimentary characters in the study area was formed by an interaction due mainly to both the transect and bottom depth. Sediment structure and grain size of the sediments explained 59.9% of variation on PCA1. The first component was associated with sand (–0.462), clay (0.375), silt (0.387), CaCO_3 (–0.386), and mud (0.478). PCA2 varied with the sediment contents such as gravel (–0.510), that originating from gravel (–0.603), CaCO_3 (–0.298), and TOC (–0.707). Nevertheless, regional differences with respect to sedimentary characters were observed, being due mainly to the sediments at a site in Anamur. Bottoms of the deeper waters in Anamur Bay were composed primarily of sandy (47.68 ± 3.67) and secondarily of gravel (5.92 ± 1.69) sediments. İskenderun and Mersin bays possessed a similar sedimentary structure and a lower content (19%–22%) of the coarse materials, but a higher content (76%–77%) of fine materials in the sediments than Anamur. Additionally, TOC was not significant among the transects (0.48%–0.62%). Seasonal variation in the sedimentary characters was observed for the sand and clay contents. The sand content was significantly higher in November ($34.00 \pm 2.63\%$) than in January ($25.12 \pm 3.15\%$). The clay content was found to be significantly higher in January ($37.36 \pm 3.84\%$) than in March ($21.54 \pm 4.48\%$).

3.2. Community structure

A total of 153 crustacean species belonging to 6 orders were recorded. Five species were alien decapods that have been recorded in the Mediterranean Sea previously (Appendix). Amphipoda (84 benthic and 1 pelagic species) and Decapoda (36 species) orders were represented by the highest number of species. The species with the highest

dominance index values ($D\% > 10\%$) were *Ampelisca diadema* (33%), *Apseudopsis latreillii* (28%), *Harpinia antennaria* (20%), *Eriopisa elongata* (16%), *Leptochela* (*Leptochela*) *pugnax* (13%), and *Paraphoxus oculatus* (11%). *Ampelisca diadema* (240 ind m^{-2} with $NO\% = 14\%$ at 10 m of the Mersin site in January), *Apseudopsis latreillii* (80 ind m^{-2} with $NO\% = 9\%$ at 10 m of the Mersin site in January), and *Ampelisca brevicornis* (420 ind m^{-2} with $NO\% = 8\%$ at 10 m of the Mersin site in January) were the most abundant species at the sampling sites (Appendix). The number of species was found to be highest in January and March (23 and 21 spp. at 25 m and 10 m on the Anamur transect, respectively, Figures 2a–2c). Number of species (S) was significantly different only among the transects (Table 2).

The highest numbers of crustacean individuals in November were 170 ind m^{-2} at 10 m and 110 ind m^{-2} at 75 m on the Mersin transect, 110 ind m^{-2} at 75 on the İskenderun transect, and 100 ind m^{-2} at 75 m on the Anamur transect (Figures 2d–2f). Peak abundances in March were 630 ind m^{-2} at 10 on the Mersin transect, 40 ind m^{-2} at 75 on the İskenderun transect, and 430 ind m^{-2} at 25 m on the Anamur transect. *Apseudopsis latreillii* (average abundance: 11 ind m^{-2}) was the most abundant species in November. The most abundant species in other months were *Ampelisca diadema* (average abundance: 25 ind m^{-2}) and *Medicorophium runcicorne* (average abundance: 15 ind m^{-2}) in March; *Ampelisca diadema* (average abundance: 10 ind m^{-2}), *Ampelisca brevicornis* (average abundance: 8 ind m^{-2}), *Harpinia antennaria* (average abundance: 7 ind m^{-2}), and *Eriopisa elongata* (average abundance: 6 ind m^{-2}) in July; and *Ampelisca brevicornis* (average abundance: 23 ind m^{-2}), *Ampelisca diadema* (average abundance: 17 ind m^{-2}), and *Apseudopsis latreillii* (average abundance: 14 ind m^{-2}) in January. Abundance was found to be significantly different among the transects and depths (Table 2).

A total of 175.57 g m^{-2} biomass and an average biomass value of 1.15 g m^{-2} were measured in the study area. *Macrophthalmus graeffei* was the dominant species in biomass, amounting to up to 14.64% of the total biomass. *Inachus* sp. (4.89%), *Pagurus forbesii* (1.86%), *Upogebia stellata* (1.24%), and *Alpheus glaber* (1.02%) were other species contributing significant percentages with their wet weights to the total biomass. The dominant species in the biomass during different seasons were as follows: *Alpheus glaber* (0.107 g m^{-2}), *Processa edulis* (0.063 g m^{-2}), and *Eurydice pulchra* (0.051 g m^{-2}) in November; *Macrophthalmus graeffei* (0.793 g m^{-2}), *Upogebia stellata* (0.472 g m^{-2}), and *Pilumnus spinifer* (0.126 g m^{-2}) in March; *Macrophthalmus graeffei* (2.133 g m^{-2}) and *Alpheus glaber* (0.219 g m^{-2}) in July; and *Macrophthalmus graeffei* (2.033 g m^{-2}), *Inachus* sp. (1.665 g m^{-2}), *Pagurus forbesii* (0.623 g m^{-2}), and *Ethusa mascarone* (0.270 g m^{-2}) in January.

Spatiotemporal differences were observed in the maximum biomass with depths, seasons, and transects (Figures 2g–2i). Maximum biomass was measured to be 2.86 g m^{-2} at 75 m in Mersin, 1.90 g m^{-2} at 50 m in İskenderun, and 0.25 g m^{-2} at both 25 m and 100 m in Anamur in November (Figures 2g–2i). In March, it was 8.11 g m^{-2} at 10 m in Mersin, 14.12 g m^{-2} at 25 m in İskenderun, and 2.5 g m^{-2} at 25 m in Anamur. The biomass peaked at 100 m (4.51 g m^{-2}) in Mersin, at 25 m (32.20 g m^{-2}) in İskenderun, and at 50 m and 100 m (0.41 and 0.52 g m^{-2} , respectively) in Anamur in July. The highest biomasses measured in January were 5.53 g m^{-2} at 75 m in Mersin, 38.63 g m^{-2} at 10 m in İskenderun, and 31.65 g m^{-2} at 100 m in Anamur (Figures 2g–2i). No significant differences were found in the biomass among transects, depths, and seasons (Table 2).

Three-way ANOVA showed that transects had a significant effect on community indices (the diversity (H') and species richness (d) values, $P < 0.05$; Table 2). The species richness (d) and diversity (H') values had a normal Gaussian distribution across the depth gradient on the shelf. Evenness (J') increased with the bottom depth and showed a seasonal fluctuation in the bottoms between 10 and 50 m (Figures 2j–2r). There were distributional differences in the richness and diversity values along the bottom depth among the transects. The highest values were found between 75 and 100 m in cold seasons (January and March) but between 50 and 150 m in warmer seasons (July and November) for the Gulf of İskenderun (Figures 2m–2r). In Mersin Bay, those values were found to be the highest at 10 m, and between 75 and 150 m through the year (Figures 2m–2r). Anamur Bay exhibited the highest values between 25 and 100 m, being more pronounced in spring and summer months (Figures 2m–2r).

Three-way PERMANOVA showed that there was significant difference in the crustacean distribution with relation only to transect (the site) ($P < 0.05$; Table 3).

In general, crustacean assemblages along the gradient of the shelf were, in order of importance, oriented in association with habitat types (sea grasses and soft bottom) and ecological status (eutrophication, dissolved nutrients), and then bottom depths and depth-related sediment structure and contents (Figure 3a). With a cumulative percentage variance of 6% for the species data and 15.6% for the species–environment relation on the first 2 axes (Table 4), *Posidonia* beds and eutrophic regions were located at the opposite corners of the CCA ordination, while the sedimentary bottom was centered (Figure 3a). The first CCA with an eigenvalue of 0.703 (Table 4) had no significant validity ($F = 1.487$, $P = 0.3760$), but the validity of the significance of 4 axes (27.6%) was proved by the Monte Carlo test ($F = 1.237$, $P = 0.0140$). Crustacean communities in the *Posidonia* beds, eutrophic region, and sedimentary bottom were correlated

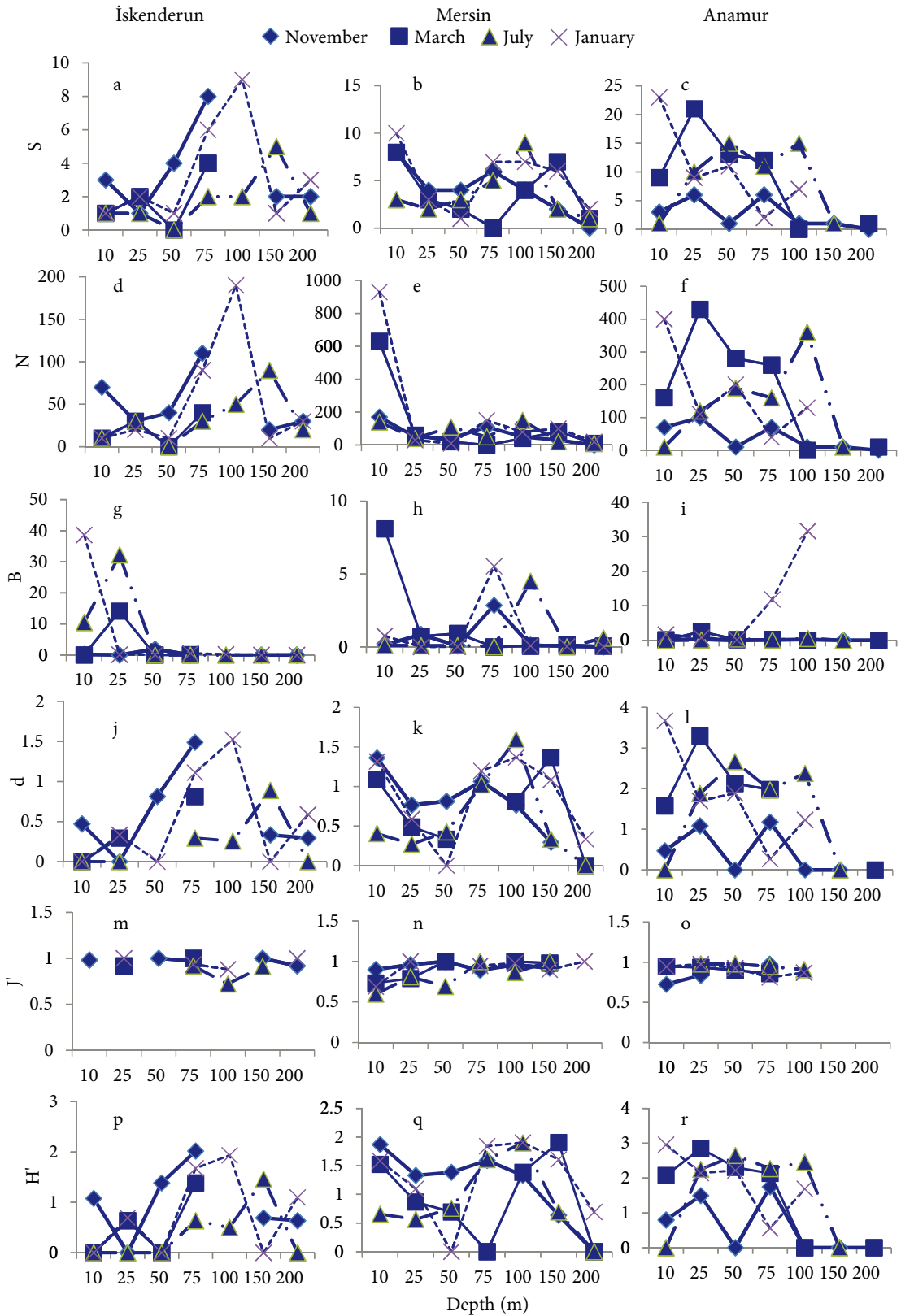


Figure 2. Spatiotemporal (depths and months) and annual (average) changes of crustacean faunistic parameters at each season and transect of the Cilician shelf. Number of crustacean species (S; a-c), density (N; ind m⁻²; d-f), biomass (B; g m⁻²; g-i), species richness (d; j-l), evenness (J'; m-o), and Shannon-Wiener's diversity (H'; p-r) indices.

Table 2. Calculated P-values from three-way analysis of variance for the faunistic characters. Bold numbers show that P-values are significantly different at $P < 0.05$.

Source	d.f.	S	N	B	d	J'	H'
Transect	2	0.000	0.012	0.340	0.002	0.760	0.007
Season	3	0.410	0.171	0.255	0.353	0.668	0.669
Depth	6	0.305	0.011	0.554	0.219	0.341	0.070
Transect × season	6	0.204	0.389	0.458	0.210	0.547	0.234
Transect × depth	12	0.387	0.015	0.229	0.437	0.925	0.180
Season × depth	18	0.468	0.184	0.720	0.764	0.919	0.641

Table 3. Nonparametric (permutation-based) MANOVA. Transect is fixed, and depth and season are random. Bold number shows $P < 0.05$.

Source	df	SS	MS	F	p
Transect	2	1.6283	0.8141	1.3382	0.0166
Depth	6	3.2701	0.5450	0.9586	0.1452
Season	3	1.6812	0.5604	1.0621	0.0956
Transect × Depth	12	5.7938	0.4828	1.5262	0.0500
Transect × Season	6	2.6515	0.4419	1.3970	0.2584
Depth × Season	18	7.2372	0.4021	1.2710	0.5434
Residual	36	11.3884	0.3163		
Total	75	33.6504			

with dissolved oxygen content of sea surface and near-bottom waters, nutrients, and sedimentary variables such as sand, mud, and TOC and CaCO_3 contents, respectively (Table 4; Figure 3a). *Apseudopsis latreillii*, *Atylus guttatus*, *Phtisica marina*, *Microdeutopus obtusatus*, *Apseudopsis mediterraneus*, *Metaphoxus fultoni*, and *Lysianassa costae* were dominant and abundant and contributor species in the *Posidonia* beds (Figures 4a–4g; Table 5; Appendix). In the CCA plot with exclusion of the community in the *Posidonia* beds, the crustacean communities of the noneutrophic and eutrophic soft bottoms were oriented separately, with a cumulative percentage of explained variance of 6.2% for the species data and 15.9% for the species–environment relation on the first 2 axes (Table 4; Figure 3b). Significance of both the first canonical axis (Table 4; $F = 1.394$, $P = 0.5880$) and all the axes ($F = 1.216$, $P = 0.0160$) were tested with the Monte Carlo test. The distance between the communities of noneutrophic and eutrophic soft-bottoms on CCA1 was correlated with only sea surface nutrients, and the bottom depth effect on the orientation appeared regardless of habitat type (Figure 3b; Table 4). The contributor species of each soft-

bottom type were *Macrophthalmus graeffei* and *Ampelisca diadema*, respectively (Figures 4a and 4g; Table 5). In the eutrophic soft bottom alone, 4 quadrates of the CCA were discriminated depending on particular environmental parameter groups (Figure 3b). One crustacean assemblage was affected by loading the nutrient enrichments with dissolved nutrients (PO_4 , $\text{NO}_2 + \text{NO}_3$, and Si) of the waters and TOC and CaCO_3 on the right half, one with loading fine grain size of the sediment on the up-and-down direction of the ordination along axis CCA2, left-bottom with the bottom depth, and the last one by increasing SST (Figure 3b; Table 4). The explained variance of 7.9% on CCA1 was not significant ($F = 1.234$, $P = 0.8500$), but the validity of significance of 4 of the axes (28.7%) was proved by the Monte Carlo test ($F = 1.167$, $P = 0.0360$). *Ampelisca diadema* (percent similarity: 32.36%) and *Eriopisa elongata* (percent similarity: 14.29%) contributed half of the total average similarity (7.72%) in the noneutrophic soft bottoms (Table 5). In general, bottom depth affected the assemblages of the crustacean community in each case, while none of the physical parameters governed the formation of the assemblages (Figure 3; Table 4).

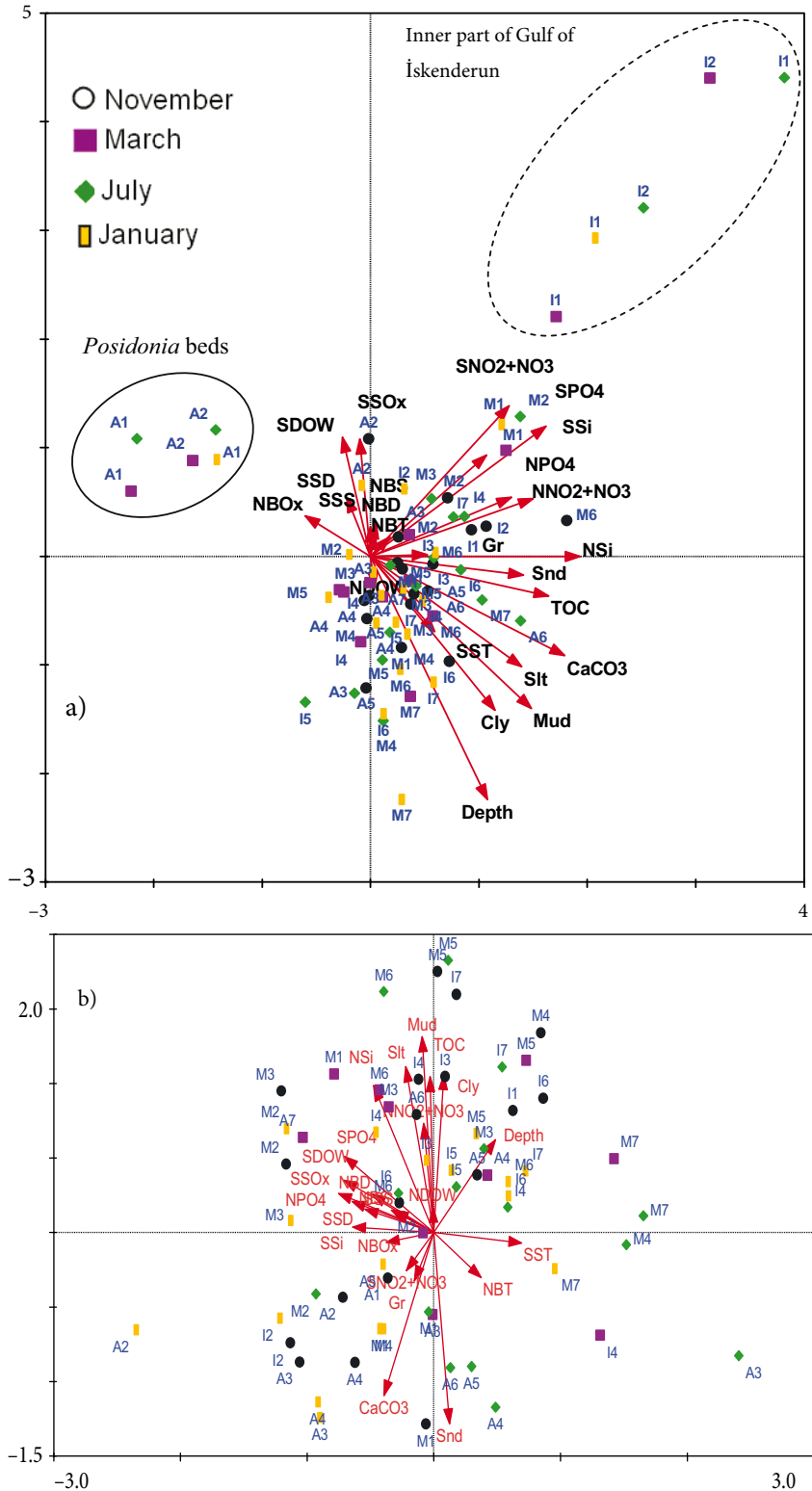


Figure 3. Biplot of CCA performed on log-transformed ($\log_{10}[N + 1]$) density values (N) of the crustaceans and environmental variables (arrows) at 7 depth samples of 3 transects (M, I, and A) (1–7; see Figure 1 for position and depth, and Table 1 for codes of the environmental variables) in 4 sampling months. a) CCA included with crustacean species on the *Posidonia oceanica* beds, and b) with those eutrophic and *Posidonia* beds excluded. Arrows refer to the direction and relative importance of environmental variables in the ordination.

Table 4. Summary of statistical measures of crustacean species' characteristics and environmental variables for All: CCA included with crustacean species on the *Posidonia* beds; NP: CCA excluded with crustacean species on the *Posidonia* bed; and NP + NN: CCA excluded with crustacean species on the *Posidonia* bed and eutrophic region (see Table 1 for abbreviations of the parameters).

Environmental variables	Species axis 1			Species axis 2		
	All	NP	NP + NN	All	NP	NP + NN
Depth	0.2702	-0.3873	-0.3614	-0.557	0.1537	-0.573
Physical parameters						
SST	0.1483	-0.1588	-0.2815	-0.1721	0.2226	0.0511
SSS	0.0113	0.0591	0.1102	0.0493	-0.0667	-0.0556
SSD	-0.0553	0.1371	0.2477	0.1344	-0.1736	-0.088
SSOx	-0.0253	0.2702	0.3259	0.2683	-0.1396	-0.0191
NBT	0.0443	-0.0078	-0.1265	0.0441	0.1274	0.2059
NBS	0.0133	0.0824	0.1255	0.0744	-0.0656	-0.0464
NBD	0	0.0933	0.1783	0.0668	-0.113	-0.1118
NBOx	-0.1518	0.0405	0.1111	0.0921	-0.0642	0.0339
Sedimentary parameters						
Gr	0.131	0.0779	0.0224	0.004	0.0218	0.0957
Snd	0.3543	0.0978	0.0088	-0.0434	0.1052	0.8001
Mud	0.3721	-0.11	-0.0127	-0.3483	-0.1066	-0.7992
Slt	0.3502	-0.0066	0.1219	-0.253	-0.203	-0.6341
Cly	0.2882	-0.1811	-0.1517	-0.3525	0.034	-0.6907
CaCO ₃	0.4495	0.0659	0.0764	-0.2276	-0.0661	0.3577
TOC	0.4126	0.2105	0.5214	-0.0907	-0.4714	-0.2435
Chemical parameters						
SDOW	-0.065	0.2659	0.3234	0.2724	-0.1451	-0.0456
SPO4	0.2685	0.348	0.4273	0.2312	-0.1494	0.07
SNO2 + NO3	0.3209	0.4084	0.1072	0.3444	0.2194	0.3202
SSi	0.4062	0.4577	0.2514	0.2975	0.0425	0.059
NDOW	0.0099	-0.0464	-0.0038	-0.07	-0.0367	-0.1226
NPO4	0.3265	0.2752	0.2973	0.1345	-0.0294	0.2146
NNO2 + NO3	0.3768	0.2746	0.1426	0.1318	0.0655	-0.138
NSi	0.4858	0.2595	0.2437	-0.0009	-0.0745	-0.3515
Eigenvalues	0.703	0.670	0.637	0.636	0.618	0.587
Species–environment correlations	0.964	0.935	0.938	0.932	0.915	0.958
Cumulative percentage variance						
of species data	3.1	3.2	3.2	6.0	6.2	6.2
of species–environment relation	8.2	8.3	7.9	15.6	15.9	15.2

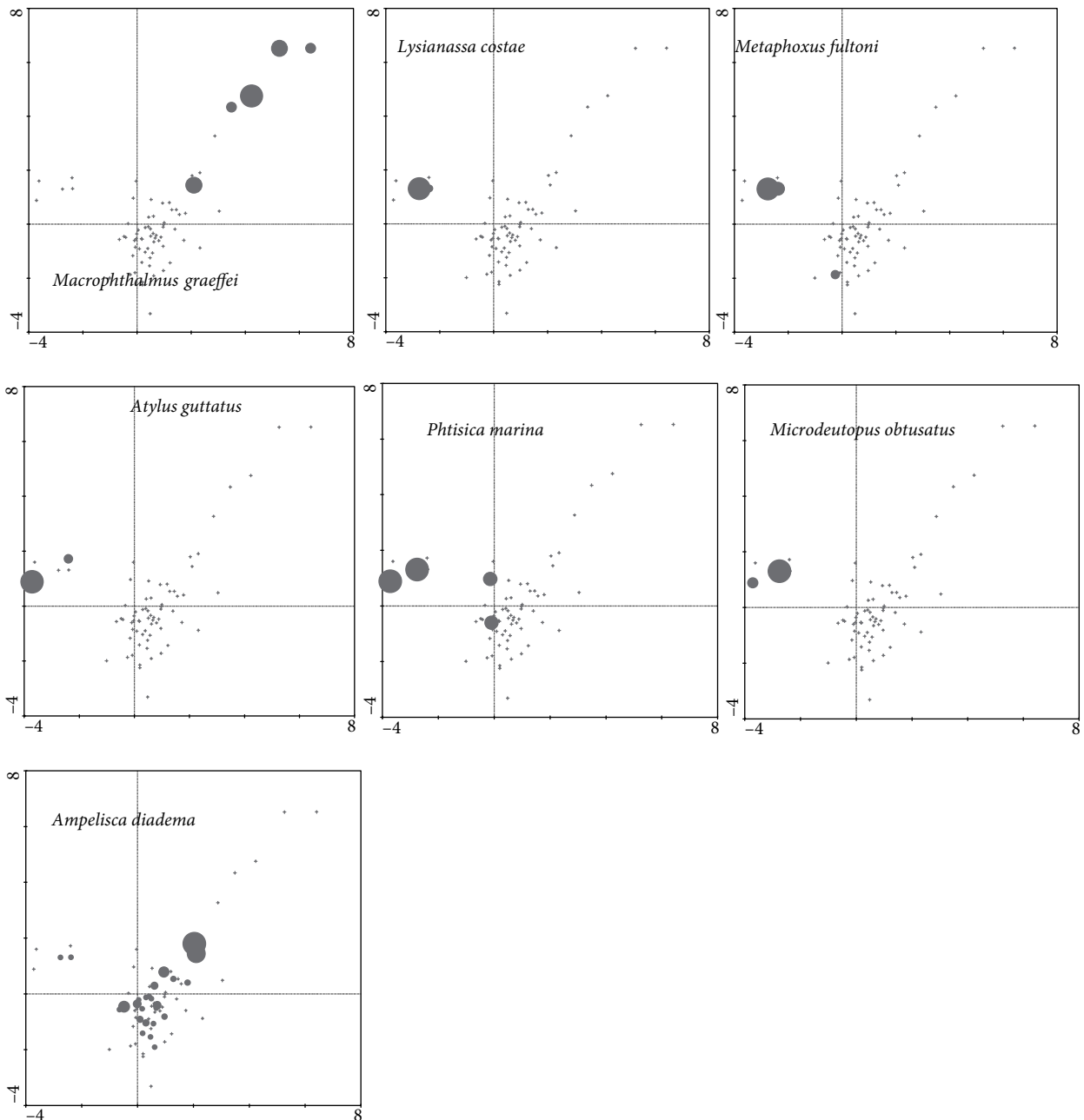


Figure 4. Abundance distribution of dominant species in each crustacean assemblage identified by CCA. Circle diameter is proportional to the abundance. The largest circle corresponds to the maximum abundance (see Appendix on the journal's website for the maximum abundance observed) of each species.

4. Discussion

At least 3 replications are highly recommended (Stirn, 1981) for the statistical analyses of macrozoobenthic studies, and the statistically sufficient number of replications differs with different methods (FAO, 1991; Gotelli and Ellison, 2004). The replicated sampling that is considered necessary for a better study of many of the other taxa such as plankton, nekton, etc. was not applied, however. Indeed,

onboard and laboratory work for macrobenthic studies is complicated and highly time-consuming, and significance of the sufficient number of replications can only be tested after all measurements (mainly species, abundance, or biomass) are obtained even to test the 3 replications that are highly recommended during sampling (Stirn, 1981; FAO, 1991; Gotelli and Ellison, 2004). Therefore, all measurements necessary for making the statistical decision

Table 5. Dissimilarity result table of SIMPER analyses between pairwise crustacean communities in *Posidonia* beds (Group p), eutrophic sedimentary bottom (Group e), and noneutrophic undisturbed sedimentary bottom (Group s). *: Contributor species within the group; bold: discriminator species among the groups; N: abundance; δ : dissimilarity.

Species	N	N	δ	δ / SD	Contrib. %
Average dissimilarity = 98.96					
	Group s	Group e			
<i>Macrophthalmus graeffei</i>	0.05	2.25*	24.6	0.99	24.86
<i>Eurydice pulchra</i>	0.19	0.48	7.34	0.42	7.42
<i>Ampelisca diadema</i>	1.11*	0	6.61	0.58	6.68
<i>Harpinia antennaria</i>	0.59	0	4.73	0.45	4.77
<i>Apseudopsis latreillii</i>	0.91	0	4.62	0.48	4.67
<i>Alpheus migrans</i>	0	0.48	3.93	0.42	3.97
Average dissimilarity = 96.36					
	Group s	Group p			
<i>Metaphoxus pectinatus</i>	0.07	0.48	6.22	0.37	6.45
<i>Apseudopsis latreillii</i>	0.91	1.75*	4	0.75	4.15
<i>Atylus guttatus</i>	0	1.22*	3.52	0.75	3.65
<i>Ampelisca diadema</i>	1.11*	0.96	3.47	0.55	3.6
<i>Phtisica marina</i>	0.07	1.22*	2.67	0.73	2.77
<i>Harpinia antennaria</i>	0.59	0.48	2.36	0.41	2.45
<i>Microdeutopus obtusatus</i>	0	1.17*	2.34	0.77	2.43
<i>Iphinoe elisae</i>	0.16	0.96*	2.33	0.57	2.42
<i>Apseudopsis mediterraneus</i>	0.1	0.96*	2.11	0.73	2.18
<i>Pagurus cuanensis</i>	0.15	0.61*	2.01	0.52	2.08
<i>Metaphoxus fultoni</i>	0.04	1.35*	1.89	0.8	1.96
<i>Lysianassa costae</i>	0	1.3*	1.8	0.76	1.86
Average dissimilarity = 100.00					
	Group e	Group p			
<i>Macrophthalmus graeffei</i>	2.25*	0	12.4	0.72	12.4
<i>Metaphoxus pectinatus</i>	0	0.48	8.87	0.48	8.87
<i>Atylus guttatus</i>	0	1.22*	4.28	0.77	4.28
<i>Apseudopsis latreillii</i>	0	1.75*	3.61	1.07	3.61
<i>Phtisica marina</i>	0	1.22*	3.08	0.72	3.08

of the number of replications to perform are impossible to complete onboard during sampling.

4.1. Environmental structure

Sea temperature at the 10 m depth of the Cilician Basin varied between 18.5 and 21.5 °C in November 2005; SST was warmer in İskenderun Bay (21.5–23 °C) than in Mersin Bay (cyclonic region; 19–21 °C) and Anamur Bay (20–20.5 °C). The cyclonic region was characterized with relatively cold, less salty, and dense waters, which originate in the

jet stream of mid-Atlantic water in the Mediterranean Sea (POEM, 1986a, 1986b; Salihoğlu and Mutlu, 2000; Uysal et al., 2008). SST in March 2006 ranged from 16.5 to 19.5 °C in the basin, 18 to 19.5 °C in İskenderun Bay, 17 to 18 °C in Mersin Bay, and 17.5 to 18.5 °C in Anamur Bay. In March 2006, the Cyprus–İskenderun section of the temperature distribution indicated a cold body of water close to the bottom in İskenderun Bay and cold water that propagated toward the gulf disclosure. As a consequence of severe

winter conditions, a formation of less salty sea surface waters and more salty near-bottom waters spreading out of the gulf led to the thermocline/halocline rising toward the coast. Such a physical process proved the contribution of the gulf in the formation of the Levantine intermediate water (LIW) propagating toward Mersin Bay in the basin (Uysal et al., 2008). Uysal et al. (2008) pointed out the existence of a strong westerly rim current transporting high *chl-a* associated with 3 rivers (Seyhan, Ceyhan, and Göksu) in July 2006, where the small-scale Asian Rim current along the coast of the basin was observed over the LIW. SST ranged from 26.5 °C in offshore waters to 28 °C in inshore waters. In January 2007, Mersin and İskenderun bays were influenced by the anticyclonic eddies. SSTs of inshore waters of the 3 bays were 2–3 °C colder than those of the offshore waters (18.5 °C). The thermocline was shoaled toward the coast in Anamur Bay, unlike in Mersin and İskenderun bays, as a consequence of the occurrence of cold water causing convection and dense water in the winter months (Uysal et al., 2008).

In the fall season (November 2005), a period of water cooling, the dissolved oxygen (DO) concentration ranged from 213 and 234 µM before the coldest period when the DO reached up to 243–288 µM. The profile of the DO as a function of the depth was associated with vertical distribution of the nutrients in a trend of coincidence of nutricline and oxycline (190 µM), and then reduced concentration of the DO (180–185 µM) in the greater depths of the coastal area. In the open waters of the Cilician Basin, the top layer of the waters was characterized with a very noticeable seasonal oxygen exchange. The DO decreased in summer and increased significantly during the winter, and the maximum DO occurred below the thermocline (depth of 25–50 m). No statistically significant change was observed in the oxygen between 100 and 200 m in depth. The rapid decline of oxygen yielded the “oxycline layer” at 300 m. However, in surface waters of the coastal area of the Gulf of İskenderun, decreased oxygen concentration occurred during the summer and the highest concentration was reached at a depth of 100 m, and then it decreased (200 µM) toward the bottom at about 200 m. The shallow waters of İskenderun and Mersin bays were homogeneous in DO from the surface to the bottom during the winter as a result of the homogeneous distribution of the salinity profiles due to the vertical mixture between coastal and open waters (Uysal et al., 2008). The deep water was mainly poor in DO because of the scarcity of oxygen from the surface, the lack of vertical mixture, and the deposition of particulate organic matter and hence the start of bacterial activities (Riley and Skirrow, 1975). Production of organic matter in surface waters of the eastern Mediterranean and deep water transport of organic matter were low and therefore oxygen consumption was lower compared to the

ecosystem of the western Mediterranean (Copin-Montégut and Copin-Montégut, 1983; Béthoux et al., 1998; Yılmaz and Tuğrul, 1998; Béthoux et al., 2002; Tuğrul et al., 2004; Kress et al., 2005). The main sources of inorganic nutrients (nitrate + nitrite, ammonia nitrogen-orthophosphate, and reactive silicate) are surface waters of the Mediterranean, especially during rainy periods, and high activity of rivers that are rich in nitrate and nitrite, dissolved silicate, and rainwater, and an atmosphere rich in ammonium ion powders (Martin et al., 1989; Justic et al., 1995; Herut et al., 1999; Migon et al., 1999; Herut et al., 2002; Markaki et al., 2003). Nutrients in the basin were found to be in high concentrations, particularly in parts under the influence of the river and the inner part of İskenderun Gulf. This trended seasonally along the coast, which is under the influence of river inputs, primary production and degradation, and mixing of the upper layer of water (Uysal et al., 2008). Higher values of organic, inorganic, and particulate matters were observed in open waters and the Gulf of İskenderun.

In terms of geological and geochemical structures, the deep bottoms of the Cilician–Adana Basin were composed primarily of clay (Buchanan et al., 1978). A high percentage of sand occurred in the Gulf of İskenderun due to the presence of the Ceyhan River, in contrast to gravel content. The central part of the bay was relatively rich in clay. In bottoms of some areas in the Gulf of Mersin, not only the percentages of sand but also in general the percentages of mud were high. The Göksu River delta and the Gulf of Taşucu were characterized by bottoms of muddy-gravelly sandy sediment. The bottom around Cape İnce near the Göksu River was composed of sand mainly transported by a rim current along the coast (Uysal et al., 2008). Surface sediments of the Cilician Basin contained a minimum value of 20% calcium carbonate and a maximum value of 70% with an average value of 35%. In front of Seyhan and Ceyhan rivers inputting glacial sediments, there was low content of CaCO₃, whereas its concentration was high in front of the Göksu River. Therefore, maximum carbonate composed mainly of shells of organisms was observed between the offshore waters of the Gulf of İskenderun and southern parts of Mersin Bay. According to Ediger et al. (1997), the gravel percentage of the sediment in Mersin Bay was generally less than 1.5% and the coarse fractions (gravel) occurred in high amounts on the inner shelf (<50 m). Sand and finer grains were regularly variable in depth, whereas carbon contents and gravel contents were locally variable due to occurrence of a carbonate zone composed of shell fragments between 50 and 100 m in the study area (Ergin, 1996; Ediger et al., 1997). TOC in the sediment of the Cilician Basin varied between 0.01% and 12%, with an average value of 1.5%. The highest TOC was observed in the coastal area between Mersin Bay and the Ceyhan River

delta. The amount of organic carbon in surface sediments of the Cilician Basin changed with the composition of the lithogenic and biogenic materials. The distribution of organic carbon content correlated with grain size of the sediment; high TOC in the mud (silt and clay) and low TOC in CaCO₃-sediments was formed by coarse-grained biogenic and terrestrial compounds. TOC reached the minimum concentrations in some parts of the Seyhan and Göksu deltas and the deep parts of the basin. TOC distribution was derived by factors of hydrodynamic, biogenic, and terrestrial origin and anthropogenic activities. The İskenderun Gulf off the Ceyhan River and the Gulf of Mersin were enriched with TOC higher than 3%. Nevertheless, another riverine region, the Göksu River, was poor in TOC.

4.2. Community structure

The species composition, faunistic characters, and density distribution of the macrobenthic crustaceans in the Cilician shelf were structured by habitat type (vegetated and nonvegetated bottom) on the first component of CCA and the hydrochemistry of the pelagic environment and sedimentary parameters on the second component of CCA.

Prior to ecological discrimination of the crustacean community by the nutritionally enriched area (stations I1–I2 and M1–M2) of the Cilician shelf, the habitat type was also a significant factor in the distribution of the benthic crustaceans. Çınar et al. (2012b) found 59 crustacean species on the nonvegetated soft bottom of Mersin Bay and 70 species in İzmir Bay (Çınar et al., 2012a). Distinguishing faunistic characters for the crustacean community on the Cilician shallow water soft bottom then occurred between bottom predominantly vegetated mainly by *Posidonia oceanica* (stations A1 and A2) and nonvegetated bottom (stations I3–I7, M2–M7, and A3–A7). Vegetated bottom was well diversified with higher values for the faunistic characters than nonvegetated sandy bottom, with the exception of the biomass of the crustacean community. Ergen et al. (1994) described the vegetated bottom as having a more diverse benthic fauna as compared with the very coastal bottoms of Gencelli Bay in the Aegean Sea, which resulted in a distinguished benthic community (Ergen et al., 2006). Colonization of numerous species from different substrates was achieved by living seagrasses (Como et al., 2008) playing a role in the dynamic parameters of populations such as recruitment, predation, and mortality of the different species (Tuya et al., 2010; Mateo and García Raso, 2012). Of the 153 crustacean species found in the present study, 57 species were found on the meadow-covered bottom and 116 species on the sedimentary soft bottom composed of sand to mud. Nevertheless, Bakır and Katağan (2014) found the highest number of amphipod species in muddy and sandy

bottoms in comparison with the other biotopes along the Turkish coast of the Levantine Sea. Amphipod species such as *Metaphoxus pectinatus*, *Atylus guttatus*, *Phtisica marina*, and *Microdeutopus obtusatus* and one tanacaid (*Apeudopsis latreillii*) and one decapod species (*Pagurus cuanensis*) formed the mainly crustacean assemblage of the meadow. A similar assemblage was observed during a study on the restructuring of crustacean assemblages on meadow beds modified by bottom trawling (Sanchez-Jerez et al., 2000). One amphipod species, *Ampelisca diadema*, was found to be a discriminator species between nonvegetative and vegetative soft bottoms.

Eutrophic and TOC-loaded regions in the inner part of İskenderun Bay and the shallowest water of Mersin Bay, respectively, were distinguished in terms of the macrobenthic crustacean community. Both regions were typified with faunistic characters as the ecological response of the macrobenthic crustacean community on the nonvegetated soft-bottom. In contrast with the region with high TOC, the eutrophic region was characterized by low species richness, abundance, and diversity, but high evenness and biomass values for macrobenthic crustaceans. Such faunistic characters were classified as a normal ecological status regarding the disturbance level to the sediment environment with an indication of slight increases in biomass and few species, according to the Pearson–Rosenberg model (Pearson and Rosenberg, 1978). An exotic crab species, *Macrophthalmus graeffei*, previously recorded in İskenderun Bay (Enzenross and Enzenross, 1995) and the Levantine Sea (Ksiunin and Galil, 2004; Lakkis and Novel-Lakkis, 2005; Ateş et al., 2007b; Pancucci-Papadopoulou et al., 2010), was the only discriminator species of the eutrophic regions of İskenderun and Mersin bays. Few species contributing a high amount to the total biomass were found throughout the year in İskenderun Bay. With increasing organic matter in the sediment, an increase in biomass and then shifts in the assemblages towards the dominance of r-selected species occurred (Paerl et al., 1998; Grall and Chauvaud, 2002) as the result of a bottom-up food transfer of high primary production to higher trophic levels (Elmgren, 1989; Herman et al., 1999). High nutrient concentrations in surface and near-bottom waters were measured in the inner parts of İskenderun Bay. Furthermore, an isopod and a decapod species (*Eurydice pulchra* and *Alpheus migrans*) had increased the crustacean biomass of the bays, followed by a few amphipods, particularly in the shallow waters of Mersin Bay (stations M1 and M2). Çınar et al. (2012b) found that the benthic infauna in shallow waters had high density and low diversity index values in Mersin Bay, and that the shallow water infauna assemblages were correlated with dissolved nutrients and *chl-a* concentrations. The semienclosed shallow region

of İskenderun Bay with an inner water current dynamic (stations I1 and I2) was dominated by decapod species but none of the amphipods in all seasons (Appendix) where DO contents of the near-bottom waters varied between 5 mg/L in July and 7.5 mg/L in January. These values are not at the critical level for the vitality of benthic organisms and habitat degradation (DO < 2–3 mg/L; Zimmerman and Canuel, 2000; Hagy et al., 2004; Vaquer-Sunyer and Duarte, 2008). Seitz et al. (2009) outlined a sigmoid curve of the relationship between changes in biomass and DO and concluded that the biomass of the benthic community was 4 times higher at the oxygen threshold value (DO > 4.5 mg/L) than at the lower DO. Many amphipod species were eliminated with the beginning of hypoxia (Bishop et al., 2006). The eutrophic areas of the present work were classified as slightly or moderately polluted, which was verified by applications of the ABC (abundance/biomass curve), rarefaction curves and AMBI indices (Uysal et al., 2008).

In general, bottoms that are deeper than 25 m on the Cilician shelf showed similar faunistic characters of the crustacean community depth-wise among the transects. Overall, there were 3 crustacean communities depth-wise (the shelf: shallow waters, 10–25 m; the intermediate zone, 50–100 m; and the deep zone, 150–200 m). Mutlu and Ergev (2013) determined 2 main crustacean assemblages; one was formed in depth zones of shallow bottoms (10 m,

25–100 m) and another in deeper bottoms (150–200 m). Nutritional level of the water columns and bottom habitat types were primary factors for structuring the crustacean communities and differed significantly among the transects for a broad-scale area of the Cilician shelf. For a restricted small area in the Cilician shelf, the environmental factors structuring these spatial crustacean assemblages were, in order of importance, bottom depth, grain size, and TOC content of the sediment and water temperature governing the temporal assemblages, particularly in the deep waters (Mutlu and Ergev 2013). Çinar et al. (2012b) found similar spatiotemporal macrozoobenthic infaunal assemblages on the shelf of Mersin Bay.

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Appendix. Maximum abundance (N/bottom depth m) with spatial (transects: M: Mersin, I: İskenderun, A: Anamur Bay) and temporal (months: N: November, M: May, J: July, Ja: January) distribution of the crustacean species in the Cilician shelf of the Levantine Sea. The species were documented in a research project funded by TÜBİTAK (Project No.: 104Y277; Uysal et al., 2008). Distribution: M, Mediterranean Sea; A, Atlantic Ocean; H: Indian Ocean or South Africa; P, Pacific Ocean; R, Red Sea. *: Pelagic amphipod species.

ORDER/Species/Distribution	Transects			Months			
	M	I	A	N	M	J	Ja
TANAIDACEA							
<i>Apseudes</i> sp.	ND	ND	10/64,	ND	10/64,	ND	ND
<i>Apseudes talpa</i> (Montagu, 1808)/MA	ND	ND	20/12,	ND	ND	ND	20/12,
<i>Apseudopsis latreillii</i> (Milne-Edwards, 1828)/MA	80/10,	30/27,	60/64,	50/11,13,31,	60/64,	50/95,	80/10,
<i>Apseudopsis mediterraneus</i> (Bacescu, 1961)/MA	ND	ND	30/64,	ND	30/64,	20/46,	10/12,
<i>Leptochelia savignyi</i> (Kroyer, 1842)/MA	ND	ND	10/26,32,	ND	ND	10/26,	10/32,
<i>Tanaissus liljeborgi</i> (Stebbing, 1891)/MA	ND	ND	10/95,	ND	ND	10/95,	ND
CU/MACEA							
<i>Bodotria arenosa mediterranea</i> (Steuer, 1938)/M	ND	ND	20/8,	ND	20/8,	ND	ND
<i>Bodotria</i> sp.	ND	ND	10/64,	ND	10/64,	ND	ND
<i>Campylaspis glabra</i> Sars, 1878/MA	ND	10/101,	10/64,	ND	10/64,	ND	10/101,
<i>Campylaspis legendrei</i> Fage, 1951/MA	ND	ND	20/95,	ND	ND	20/95,	ND
<i>Campylaspis</i> sp.	ND	ND	10/75,	ND	ND	10/75,	ND
<i>Cumella</i> (<i>Cumella</i>) <i>pygmaea</i> G.O. Sars, 1865/MA	ND	10/71,	20/12,	10/31,	10/71,	10/95,	20/12,
<i>Diastylis rugosa</i> Sars, 1865/MA	10/11,	ND	ND	10/11,	ND	ND	ND
<i>Diastylis</i> sp.	10/153,216,	ND	ND	ND	ND	ND	10/153,216,
<i>Eudorella truncatula</i> (Bate, 1856)/MA	10/54,	10/77,	10/83,	10/77,	10/54,83,	ND	ND
<i>Iphinoe</i> sp1.	ND	ND	30/75,	ND	ND	30/75,	ND
<i>Iphinoe</i> sp2.	10/25,51,	ND	30/64,	ND	30/64,	10/75,	10/51,
<i>Iphinoe maeotica</i> Sowinskyi, 1893/MA	20/10,	ND	ND	ND	ND	ND	20/10,
<i>Iphinoe serrata</i> Norman, 1867/MA	ND	ND	70/95,	ND	ND	70/95,	ND
<i>Iphinoe tenella</i> Sars, 1878/MA	ND	ND	30/83,	ND	30/83,	ND	ND
<i>Pseudocuma</i> sp.	ND	ND	10/75,	ND	ND	10/75,	ND
<i>Pseudocuma</i> (<i>Pseudocuma</i>) <i>longicorne</i> (Bate, 1858)/MARH	ND	ND	10/83,	ND	10/83,	ND	ND
AMPHIPODA							
<i>Abludomelita aculeata</i> (Chevreux, 1911)/MA	ND	ND	20/83,	ND	20/83,	ND	ND
<i>Ampelisca brevicornis</i> (Costa, 1853)/MA	420/10,	ND	10/95,119,	20/11,	ND	110/13,	420/10,
<i>Ampelisca</i> sp1.	ND	ND	30/64,	ND	30/64,	ND	ND
<i>Ampelisca</i> sp2.	10/29,	ND	ND	ND	ND	ND	10/29,
<i>Ampelisca diadema</i> (Costa, 1853)/MA	240/10,	20/11,207	90/83,	20/11,	180/12,	80/49,	240/10,
<i>Ampelisca gibba</i> Sars, 1883/MA	20/11,	ND	30/95,	20/11,	ND	30/95,	ND
<i>Ampelisca massiliensis</i> Bellan-Santini & Kaim-Malka, 1977/MA	ND	10/101,	ND	ND	ND	ND	10/101,
<i>Ampelisca ruffoi</i> Bellan-Santini & Kaim-Malka, 1977/MA	10/75,	10/71,	20/46,	ND	10/71,64,	20/46,	ND
<i>Ampelisca sarsi</i> Chevreux, 1888/MA	10/11,	ND	ND	10/11,	ND	ND	ND
<i>Ampelisca spinifer</i> Reid, 1951/MA	10/150,	ND	ND	10/150,	ND	ND	ND
<i>Ampelisca tenuicornis</i> Liljeborg, 1855/MA	ND	ND	10/119,	ND	ND	ND	10/119,
<i>Amphilochus</i> sp.	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Ampithoe</i> sp.	ND	ND	10/73,	10/73,	ND	ND	ND

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ORDER/Species/Distribution	Transects			Months			
	M	I	A	N	M	J	Ja
<i>Atylus guttatus</i> (Costa, 1851)/MA	ND	ND	40/8,	ND	40/8,	10/26,	ND
<i>Autonoe spiniventris</i> Della Valle, 1893/MA	10/49,	ND	ND	ND	ND	10/49,	ND
<i>Bathyporeia guilliamsoniana</i> (Bate, 1857)/MA	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Ceradocus</i> sp1.	10/103,	ND	20/21,	ND	20/21,	ND	10/103,
<i>Ceradocus</i> sp2.	ND	ND	10/26,	ND	ND	10/26,	ND
<i>Cheirocratus</i> sp.	ND	10/153,	ND	10/153,	ND	ND	ND
<i>Cheirocratus sundevalli</i> (Rathke, 1843)/MA	ND	ND	30/54,	ND	10/8,	ND	30/54,
<i>Cheirophotis mediterranea</i> Myers 1985/MA	80/10,	ND	ND	ND	30/12,	ND	80/10,
<i>Dexamine thea</i> Boeck, 1861/MA	ND	ND	20/8,	ND	20/8,	ND	ND
<i>Erichthonius punctatus</i> (Bate, 1857)/MA	40/11,	ND	ND	40/11,	ND	ND	ND
<i>Eriopisa elongata</i> (Bruzelius, 1859)/MA	10/97,103,15,	70/101,	30/95,	20/77,	10/97,71	40/98,	70/101,
* <i>Hyperia galba</i> (Montagu, 1815)	ND	ND	10/64,	ND	10/64,	ND	ND
<i>Gammarella fucicola</i> (Leach, 1814)/MA	ND	ND	10/26,	ND	ND	10/26,	ND
<i>Halice</i> sp.	ND	ND	10/83,	ND	10/83,	ND	ND
<i>Haploops nirae</i> Kaim-Malka, 1976/MA	10/75,	ND	ND	ND	ND	10/75,	ND
<i>Harpinia ala</i> Karaman, 1987/MA	40/79,	ND	ND	ND	ND	ND	40/79,
<i>Harpinia antennaria</i> Meinert, 1890/MA	60/100,	30/136	10/73,119, 21,64,83	20/150,77,203,	10/21,64,83,	60/100,	10/207,
<i>Harpinia crenulata</i> (Boeck, 1871)/MA	30/79,	10/75,	ND	ND	ND	ND	30/79,
<i>Harpinia dellavallei</i> Chevreux, 1910/MA	20/103,	20/101,	20/12,	ND	ND	10/75,	20/103,101,12,
<i>Harpinia</i> sp1.	ND	ND	10/26,	ND	ND	10/26,	ND
<i>Harpinia</i> sp2.	10/75,	ND	ND	ND	ND	10/75,	ND
<i>Harpinia pectinata</i> Sars, 1891/MA	ND	10/77,207,	10/119,	10/77,	ND	ND	10/207,119,
<i>Hippomedon</i> sp.	ND	ND	10/75,	ND	ND	10/75,	ND
<i>Hippomedon massiliensis</i> Bellan-Santini, 1965/MA	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Hippomedon oculatus</i> Chevreux & Fage, 1925/MA	ND	ND	10/75,	ND	ND	10/75,	ND
<i>Leptocheirus bispinosus</i> Norman, 1908/MA	ND	30/75,	20/12,	ND	ND	ND	30/75,
<i>Leptocheirus guttatus</i> (Grube, 1864)/MA	ND	ND	50/12,	ND	ND	ND	50/12,
<i>Leptocheirus hirsutimanus</i> (Bate, 1862)/MA	ND	ND	20/73,	20/73,	10/64,	ND	ND
<i>Leptocheirus mariae</i> Karaman, 1973/MA	10/97,156,	ND	10/12,	ND	10/97,156,	ND	10/12,
<i>Leptocheirus pectinatus</i> (Norman, 1869)/MA	ND	ND	30/21,	ND	30/21,	ND	ND
<i>Leptocheirus pilosus</i> Zaddach, 1844/MA	ND	ND	10/12,	ND	ND	ND	10/12,
<i>Leptocheirus</i> sp.	ND	ND	50/21,	ND	50/21,	ND	ND
<i>Leucothoe oboa</i> Karaman, 1971 /MA	10/27,	ND	ND	10/27,	ND	ND	ND
<i>Leucothoe lilljeborgi</i> Boeck, 1861/MA	10/74,	ND	10/46,	10/74,	ND	10/46,	ND
<i>Leucothoe richiardii</i> Lesson, 1865/MAH	110/12,	10/136,	20/83,	ND	110/12,	10/136,	ND
<i>Liljeborgia dellavallei</i> Stebbing, 1906/MA	ND	ND	20/21,	ND	20/21,	ND	ND
<i>Lysianassa costae</i> (Milne-Edwards, 1830)/MA	ND	ND	60/21,	ND	60/21,	ND	10/12,
<i>Lysianassa insperata</i> (Lincoln, 1979)/MA	ND	ND	20/95,	ND	ND	20/95,	ND
<i>Lysianassa</i> sp.	ND	ND	10/159,	ND	ND	10/159,	ND
<i>Maera grossimana</i> (Montagu, 1808)/MA	ND	ND	20/12,	10/31,	ND	ND	20/12,
<i>Maera hironellei</i> Chevreux, 1900/MA	ND	ND	10/12,	ND	ND	ND	10/12,
<i>Maera inaequipes</i> (Costa, 1857)/MA	ND	ND	20/12,	ND	ND	ND	20/12,

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	M	I	A	N	M	J	Ja
<i>Maera schmidti</i> Stephensen, 1915/MA	ND	10/71,	ND	ND	10/71,	ND	ND
<i>Medicorophium</i> sp1.	10/74,	ND	ND	10/74,	ND	ND	ND
<i>Medicorophium</i> sp2.	30/10,	ND	ND	ND	ND	ND	30/10,
<i>Medicorophium minimum</i> (Schiecke, 1978)/MA	10/100,150,	ND	ND	ND	ND	10/100,150,	ND
<i>Medicorophium rotundirostre</i> (Stephensen, 1915)/MA	20/100,	20/77,	ND	20/77,	10/97,	20/100,	ND
<i>Medicorophium runcicorne</i> (Della Valle, 1893)/MA	250/12,	ND	ND	ND	250/12,	ND	10/29,
<i>Melita</i> sp.	ND	ND	20/21,	ND	20/21,	ND	ND
<i>Metaphoxus fultoni</i> (Scott, 1890)/MA	ND	ND	40/21,	ND	40/21,	10/46,	20/12,
<i>Metaphoxus gruneri</i> Karaman, 1986/MA	ND	ND	20/21,54,	ND	20/21,	ND	20/54,
<i>Metaphoxus</i> sp.	10/100,103,	ND	10/10,	ND	ND	10/100,10,	10/103,
<i>Metaphoxus simplex</i> (Bate, 1857)/MA	20/79,	ND	10/21,	ND	10/21,	ND	20/79,
<i>Microdeutopus armatus</i> Chevreux, 1886/MA	ND	ND	20/21,	ND	20/21,	ND	ND
<i>Microdeutopus obtusatus</i> Myers, 1973/MA	ND	ND	30/21,	ND	30/21,	ND	ND
<i>Microdeutopus</i> sp1.	ND	ND	10/21,46,	ND	10/21,	10/46,	ND
<i>Microdeutopus</i> sp2.	ND	ND	10/21,	ND	10/21,	ND	ND
<i>Monoculodes acutipes</i> Ledoyer, 1983/MA	ND	ND	10/54,	ND	ND	ND	10/54,
<i>Monoculodes subnudus</i> Norman, 1889/MA	ND	ND	10/21,	ND	10/21,	ND	ND
<i>Orchomene grimaldii</i> Chevreux, 1890/MA	ND	ND	10/26,	ND	ND	10/26,	ND
<i>Orchomenella nana</i> (Kroyer, 1846)/MA	ND	10/136,	20/95,	ND	ND	20/95,	ND
<i>Paraphoxus oculatus</i> (Sars, 1879)/MAH	10/156,100,	20/101,	10/53,176,	10/77,153,203,53,	10/156,176,	10/100,	20/101,
<i>Periculodes longimanus</i> (Bate & Westwood, 1868)/MAH	20/10,	ND	20/46,	10/11,	ND	20/46,	20/10,
Phoexidae sp.	40/153,	ND	ND	ND	ND	ND	40/153,
<i>Phtisica marina</i> Slabber, 1769/MAH	ND	ND	20/8,21,	10/73,	20/8,21,	ND	10/32,
<i>Socarnes filicornis</i> (Heller, 1866)/MAH	ND	ND	20/26,	ND	ND	20/26,	ND
<i>Stenothoe marina</i> (Bate, 1856)/MA	10/156,	ND	ND	ND	10/156,	ND	ND
<i>Urothoe elegans</i> (Bate, 1857)/MAH	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Urothoe intermedia</i> Bellan-Santini & Ruffo, 1986/MA	ND	ND	50/54,	ND	10/64,	ND	50/54,
<i>Urothoe poseidonis</i> Reibish, 1905/MA	10/10,	ND	ND	ND	ND	ND	10/10,
<i>Urothoe</i> sp1.	ND	ND	10/8,	ND	10/8,	ND	ND
<i>Urothoe</i> sp2.	10/27,	ND	ND	10/27,	ND	ND	ND
ISOPODA							
Antheluridae sp.	10/156,	ND	10/46,54,	ND	10/156,	10/46,	10/54,
<i>Anthura gracilis</i> (Montagu, 1808)/MA	10/103,	10/77,98,	10/31,12,	10/77,31,	ND	10/98,	10/103,12,
<i>Eurydice pulchra</i> Leach, 1815/MA	20/27,	10/14,26,	10/73,113,	20/27,	10/25,14,	ND	10/26,
<i>Eurydice truncata</i> (Norman, 1868)/MA	10/156,	10/101,	20/54,	ND	10/156,83,	10/95,	20/54,
<i>Gnathia dentata</i> (G. O. Sars, 1872)/MA	10/216,	ND	10/75,	ND	ND	10/75,	10/216,
<i>Gnathia maxillaris</i> (Montagu, 1804)/MA	ND	ND	10/95,	ND	ND	10/95,	ND
<i>Gnathia oxyuraea</i> (Lilljeborg, 1855)/MA	ND	ND	10/12,	ND	ND	ND	10/12,
<i>Joeropsis brevicornis brevicornis</i> Koehler, 1885/A	10/153,	ND	ND	ND	ND	ND	10/153,
<i>Limnoria tripunctata</i> Menzies/MAH	ND	ND	20/8,	ND	20/8,	ND	ND
DECAPODA							
<i>Alpheus</i> sp.	10/79,	10/51,	10/83,	10/51,	10/83,	ND	10/79,

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	M	I	A	N	M	J	Ja
<i>Alpheus glaber</i> (Oliv, 1792)/MA	10/74,100,	ND	10/12,	10/74,	ND	10/100,	10/12,
<i>Alpheus macrocheles</i> (Hailstone, 1835b)/MA	ND	ND	10/12,32,	ND	ND	ND	10/12,32,
<i>Alpheus migrans</i> Lewinsohn & Holthuis, 1978/MAH	ND	10/25,	ND	ND	10/25,	ND	ND
<i>Anapagurus chiroacanthus</i> (Lilljeborg, 1856)/MA	10/100,	ND	ND	ND	ND	10/100,	ND
<i>Anapagurus laevis</i> (Bell, 1845)/MA	ND	20/101,	ND	ND	ND	ND	20/101,
<i>Callinassa subterranea</i> (Montagu, 1808)/MA	10/26,	10/51,75,	10/95,	10/51,	ND	10/26,95,	10/75,
<i>Crangon crangon</i> (Linnaeus, 1758)/MA	10/12,	ND	ND	ND	10/12,	ND	ND
<i>Diogenes pugilator</i> (Roux, 1829)/MAR	20/10,	ND	ND	ND	ND	ND	20/10,
<i>Ebalia cranchii</i> Leach, 1817/MA	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Ebalia granulosa</i> H. Milne Edwards, 1837/MA	ND	ND	10/54,	ND	ND	ND	10/54,
<i>Ebalia nux</i> A. Milne-Edwards, 1883/MA	10/190,	ND	ND	ND	ND	10/190,	ND
<i>Ethusa mascarone</i> (Herbst, 1785)/MA	20/79,	ND	ND	ND	ND	ND	20/79,
<i>Galathea intermedia</i> Lilljeborg, 1851/MA	10/50,	ND	ND	10/50,	ND	ND	ND
<i>Galethea</i> sp.	ND	ND	10/32,	ND	ND	ND	10/32,
<i>Goneplax rhomboides</i> (Linnaeus, 1758)/MAH	ND	ND	10/31,	10/31,	ND	ND	ND
<i>Hippolyte</i> sp.	ND	ND	20/32,	ND	ND	ND	20/32,
<i>Inachus</i> sp.	ND	ND	10/119,	ND	ND	ND	10/119,
<i>Leptochela (Leptochela) pugnax</i> De Man, 1916/MAHP	10/156,	10/77,	ND	10/77,	10/156,	ND	ND
<i>Leptochela</i> sp.	40/74,	20/11,	20/46,	40/74,	10/97,	20/46,	10/26,53,75, 101
<i>Macrophthalmus graeffei</i> A. Milne-Edwards, 1873/MARP	20/12,	30/11,26,	ND	30/11	20/12,25,	30/26,	10/13,
<i>Pagurus cuanensis</i> Bell, 1845/MAH	ND	ND	20/26,	10/13,31,73,	ND	20/26,	10/32,
<i>Pagurus forbesii</i> Bell, 1845/MA	ND	ND	30/78,	ND	ND	10/95,	30/78,
<i>Pagurus</i> sp.	ND	ND	20/32,	ND	ND	ND	20/32,
<i>Palaemon xiphias</i> Risso, 1816/MA	ND	ND	30/12,	ND	10/21,	ND	30/12,
<i>Palaemonella rotumana</i> (Borradaile, 1898)/MHPR	ND	ND	10/12,	ND	ND	ND	10/12,
<i>Pestarella tyrrhena</i> (Petagna, 1792)/MA	ND	ND	10/32,	ND	ND	ND	10/32,
<i>Pilumnus spinifer</i> H. Milne Edwards, 1834/MA	ND	ND	10/21,	ND	10/21,	ND	ND
<i>Plesionika longicauda</i> (Rathbun, 1901)/MA	ND	ND	10/12,	ND	ND	ND	10/12,
<i>Processa canaliculata</i> Leach, 1815/MAR	10/74,	ND	ND	10/74,	ND	ND	ND
<i>Processa edulis</i> (Risso, 1816)/MAR	20/100,12,	10/51,75,	ND	20/100,	20/12,	ND	10/75,
<i>Processa parva</i> Holthuis, 1951a/MA	10/100,	ND	ND	10/100,	ND	ND	ND
<i>Processa robusta</i> Nouvel & Holthuis, 1957/MA	10/10,	ND	ND	ND	ND	ND	10/10,
<i>Thalamita poissonii</i> (Audouin, 1826)/MARHP	ND	ND	10/32,	ND	ND	ND	10/32,
<i>Upogebia pusilla</i> (Petagna, 1792)/MA	ND	ND	10/46,	ND	ND	10/46,	ND
<i>Upogebia stellata</i> (Montagu, 1808)/MA	10/12,54,75, 100	ND	ND	ND	10/12,54,	10/75,100,	ND
OSTRACODA							
<i>Skogsbergia megalops</i> (Sars, 1872)/MA	ND	ND	20/75,	ND	ND	20/75,	10/54,