# Spatial and temporal variation of soft-bottom peracarid (Crustacea: Peracarida) infauna in the Canakkale Strait (Turkey)

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#### **Abstract**

The biodiversity and distribution of soft-bottom peracarid crustaceans were analyzed in the southern part of the Canakkale Strait, a very important biological corridor between the Mediterranean and the Black Sea. Samples were collected seasonally from 11 coastal stations at depths ranging from 10 to 22 m. Moreover, qualitative samples were collected in summer from 7 stations (40 - 83 m depth) located in the middle part of the Strait. A total of 110 species were identified. Amphipods were the dominant group both in terms of species richness and abundance. *Apocorophium acutum, Phtisica marina* and *Microdeutopus versiculatus* were the most abundant species. A large number of rare species was recorded, leading to very low similarity values among stations. Six different feeding types were detected, with surface deposit feeders being the dominant ones in the area. Significant differences in abundances and assemblage structure were detected along the eastern and western coasts of the Strait that could be attributed to food supply and sediment composition, depending on bottom current velocities. Possible relations of peracarids with the hydrological regime of the area are also discussed.

Keywords: Peracarida; Crustacea; Canakkale Strait; Distribution; Diversity.

#### Introduction

Coastal soft bottom benthos is subjected to different sources of disturbance, both from natural and human origin (OCCHIPINTI-AMBROGI et. al., 2005). Peracarids (Amphipoda, Cumacea, Isopoda, Mysidacea and Tanaidacea) are, in general, common elements of soft bottom mac-

robenthos (MOREIRA et al., 2008; LOURIDO et al., 2008) from shallow habitats to the abyssal plains of the world oceans, often presenting high abundance and diversity (BRANDT, 1995). They are considered good indicators of water and sediment quality (CORBERA & CARDELL, 1995; ALFONSO et al., 1998; GÓMEZ GESTEIRA & DAUVIN, 2000) and it has

been repeatedly pointed out that the knowledge of their assemblages may be useful to interpret changes in benthic communities for environmental management purposes (MOREIRA *et al.*, 2008; CONLAN, 1994; BIERNBAUM, 1979).

The Canakkale Strait, one of the two straits in the Turkish Straits System, constitutes a pathway between the Aegean basin of the Mediterranean Sea and the Marmara Sea. The dense maritime traffic in the strait affects the environment, due to maritime accidents, garbage and used oil dumping, ballast water and waste water discharging (Undersecretariat for Maritime Affairs, www.denizcilik.gov.tr) The Strait also plays an important role as a biological corridor between the Mediterranean and the Black Sea, and acts as an acclimatization zone for the Mediterranean species (OZTURK & OZTURK, 1996).

Studies on peracarid fauna of the Canakkale Strait are scant or deal only with peracarid faunal composition, without any investigation into their ecological requirements and/or adaptations to the peculiar environmental conditions of the Strait (KOCATAS & KATAGAN, 1978; MULLER, 1985, ERKAN-YURDABAK, 2004, KIRKIM et al., 2005, ASLAN-CIHANGIR et al., 2008, 2009).

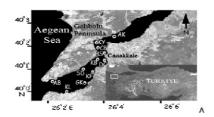
The objectives of the present study were

1) to investigate the biodiversity of soft bottom benthic peracarid communities, and 2) to assess the seasonal dynamics of peracarid fauna also relating its temporal variation with abiotic parameters, such as hydrodynamism and water masses circulation.

### **Materials and Methods**

## Study area

Fieldwork was carried out along the southern part of the Canakkale Strait, connecting the Sea of Marmara to the Aegean Sea (Fig. 1). It has an approximate length of 70 km and an average width and depth of 3.5 km and 55 m, respectively. The Strait has a well-defined two-layer stratification associated with a two-layer pattern of water exchange. A prominent southward flow, at velocities of 50-200 cm s<sup>-1</sup> (ERGIN et al., 1991), is driven by sea level difference, with the Sea of Marmara being at a higher level than the Aegean Sea. The sea level difference follows a seasonal pattern, ranging at the extremes from 12 cm during summer to 18 cm during winter. The northward flow, with velocities ranging from 20-40 cm s<sup>-1</sup> (ERGIN et al., 1991), is driven by the different salinity between the Sea of Marmara and the Aegean Sea. Consequently, brackish Black Sea waters flow southward through the Canakkale Strait at the surface layer,



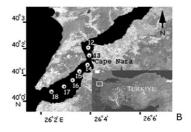


Fig. 1: Map of the Canakkale Strait showing A) coastal sampling stations B) qualitative sampling stations at the mid-line area.

while the more saline and denser waters of the Aegean Sea flow deeper in the opposite direction (OĞUZ & SUR, 1989; STASHCHUK & HUTTER, 2001). Black Sea water salinity increases by about 4 ppt crossing the Canakkale Strait, reaching values of 29.6 ppt. Aegean waters, with a salinity of 38.9 ppt when entering the Canakkale Strait, flow through the strait with little change in their salt content (STASHCHUK & HUTTER, 2001). Inevitably, the surface water outflow and bottom water inflow fluxes vary seasonally, as they depend upon wind stress and density differences above and below the pycnocline (POULOS, et. al., 1997).

## Sampling

Soft bottom samples were obtained seasonally during 2006 by means of a 0.1 m<sup>2</sup> van Veen grab at 11 stations; six of them were located along the European shelf and the remaining five stations were located on the Asian shelf. Samples were collected from depths between 10-22 m from R/V Bilim 1. At each station, three replicates were taken for faunistic analysis and an additional one was collected for chemical and granulometric sediment analyses. Seven more stations located in the mid-line of the Canakkale Strait were sampled using a van Veen grab, dredge and box-corer from R/V K. Piri Reis in June 2007 at depths between 40-83 m. Due to technical difficulties (high hydrodynamism reducing the sampling gear's capacity, maritime traffic, etc) different gears were used and only twelve samples containing peracarids were collected from the mid-line, here used only for qualitative analyses. Coordinates, depth, sampling gear, and sediment types for all stations are given in Table 1.

All benthic samples were sieved (mesh opening 0.5 mm) and the retained fauna was fixed with 4% formaldehyde-sea water solution. In the laboratory, the peracarids

were separated under a stereomicroscope, preserved in 70% ethanol, identified at the species level and counted.

Water samples for hydrographic data were collected with Nansen bottles at two layers (surface and bottom) of the water column. Temperature, salinity, dissolved oxygen, pH, TDS (Total Dissolved Solid) and conductivity were thereafter measured on board using a YSI 556 Multiprobe System. Water clarity was also determined at each station using a Secchi disc. Granulometric analyses were performed following LEWIS, 1984. The percentage of organic carbon (TOC) was determined spectrophotometrically in sediment samples following the sulphochromic oxidation method (HACH Publication, 1988). The amount of total nitrogen (TN) was measured applying the Kjeldahl method. Unfortunately, due to several problems with equipment, some parameters are missing (bottom water parameters at all stations in summer, all parameters at stations KL, GK, DC HS in winter, DO values at all stations in winter).

#### Data analysis

Univariate analyses were applied to characterise the community in terms of relative abundance and diversity. The Margalef richness index (d), Pielou evenness index (J') and Shannon-Wiener diversity index (log2 base) (H') were calculated at each station and season. The frequency of species occurrence (Ci) was calculated to identify the most representative species; accordingly, each species was evaluated either as constant  $(1 \ge \text{Ci} \ge 0.5)$ , common  $(0.5 > \text{Ci} \ge$ 0.25) and rare (Ci < 0.25) (SOYER, 1970). Dominance index (Di, relative total abundance in percentage) and the hierarchical importance of each species (given by the product Ci x Di) were also calculated (LOPEZ DE LA ROSA et al., 2002).

Table 1 Physical description of the sampling stations.

Station	Coordinates	Depth (m)	Gear	Sediment type
AK	40°13'605"N, 26°25'735"E	19	grab	sand+mud+stones
KY	40°12'094"N, 26°22'005"E	12	grab	sand + detritus (shell)
СВ	40°10'395"N, 26°22'082"E	15	grab	sand + Mytilus galloprovincialis
KB	40°08'296"N, 26°22'436"E	10	grab	sand + detritus (shell)
SD	40°05'923"N, 26°19'004"E	15	grab	sand + Posidonia oceanica
AB	40°02'960"N, 26°12'544"E	13	grab	sand + P. oceanica
KL	40°00'252"N, 26°14'884"E	22	grab	mud + Caulerpa racemosa
GK	40°02'409"N, 26°20'011"E	20	grab	mud
KF	40°04'988"N, 26°21'490"E	18	grab	mud
DC	40°07'783"N, 26°23'786"E	19	grab	sand
HS	40°09'500"N, 26°24'000"E	21	grab	sand+ stones
12	40°11'603"N, 26°23'366"E	60	grab, dredge	stones
13	40°10'026"N, 26°23'548"E	83	grab	gravel
14	40°07'663"N, 26°23'145"E	81	grab	sand
15	40°06'065"N, 26°20'000"E	40	dredge, box-corer	sand
16	40°04'333"N, 26°18'668"E	60	box-corer	mud
17	40°03'593"N, 26°16'614"E	69	box-corer	mud
18	40°01'749"N, 26°13'342"E	83	box-corer	mud

Spearman's rank correlation coefficient was used in order to determine correlation between biotic (number of species, individuals of species, diversity, richness, and evenness) and all abiotic measured parameters. The temporal trends at each station were tested using one-way ANOVA, based on seasonal abundance values and all abiotic factors. In addition, spatial and temporal trends of the three most abundant species were tested using two-way ANOVA.

The PCA analysis was performed for each survey to ordinate samples both according to their physico-chemical (water column) and sedimentological characteristics, using four matrices (one per season) based on 'environmental variable x sampling sites' (standardized values, 25 parameters x 11 stations).

The numerical abundance data were analyzed using cluster and multidimensional

scaling (MDS) techniques, based on Bray Curtis similarity, using the PRIMER package ver. 5.0 (CLARKE & WARWICK, 2001). The cluster analysis was based on log<sub>10</sub>(x+1) transformation with the 'Taylor's Power Law' method concepts (TAYLOR, 1961). The one-way ANOSIM permutation test was used to assess if significant differences exist among groups of sample sites as pre-defined by the cluster analysis. SIMPER analysis was performed to identify the percentage contribution of each species to the overall similarity/dissimilarity within each group as identified from cluster analysis.

#### Results

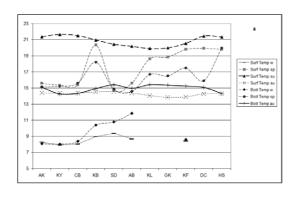
#### Abiotic parameters

Figure 2a shows the seasonal fluctuation of temperature values for surface and bottom. The maximum and minimum values of surface water temperature were measured at station KY, in the innermost part of the strait, ranging from 7.92°C (winter) to 21.66°C (summer). Minimum bottom temperature was observed at the same station (winter, KY, 8.03°C), while maximum bottom temperature (in spring, as summer values are missing) was observed at station HS (19.97°C), on the opposite side of the Strait.

As it be observed, in winter and spring, both surface and bottom temperatures were lower at the three innermost stations, followed by the western outer stations (with the exception of station KB, which presents a peak during spring). In summer, the situ-

ation is totally inverted, with higher values of surface temperature at the innermost stations, decreasing at the outer stations following a cyclonic behavior. In autumn, lower values were confined to the outermost stations at the strait entrance, followed by a slight increase along eastern coasts towards the inner part of the strait. Inversely, bottom temperature was higher at the eastern outer stations when compared to the inner ones. It can be also observed that at each station surface temperature was higher than bottom in spring, but lower during autumn and winter.

The minimum value of surface-water salinity (Fig. 2b) was 22.39 psu (summer, station AK, in the innermost part of the



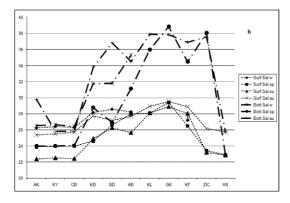


Fig. 2: Seasonal fluctuation of temperature (a) and salinity (b) at sampling sites.

Strait), while the maximum reached 29.54 psu (autumn, station GK, in the outer part of the Strait). Bottom-water salinity ranged between 22.88 psu (spring, station HS) and 38.85 psu (spring, station GK).

It must be noticed that winter salinity follows the same trend as temperature both for surface and bottom, increasing from the inner to the outer part. A sharp increase was observed in bottom salinity of outer stations during spring, followed by a sharp decrease at station HS. The same trend was observed for autumn, while, at all stations, bottom salinity was significantly higher than that of the surface at the outer stations.

Surface-water pH was rather homogeneous and ranged between 8.2- 8.91 according to the season. In addition, pH of surface waters was higher than that of the bottom layer.

TDS of surface water showed a minimum (23.04 mg/l) at KY (summer) and a maximum 29.54 mg/l at GK (autumn). Additionally, TDS of surface water was lower than that of the bottom layer, like conductivity.

Dissolved oxygen content of surface water showed its minimum at KF during spring (4.58 mg/l) and maximum at DC during summer (13.78 mg/l). Generally, higher values

were observed at the eastern-coast stations during summer, with a strong difference between eastern and western coasts (Fig. 3). A similar trend was observed during autumn, with slighter differences among stations, higher values at the western stations and lower at the eastern (Fig. 1). In winter and spring values were more homogenous (data not shown), ranging between 4.58 mg/l (station KF) and 7.95 mg/l (station AK).

Regarding bottom DO, the only available data comes from spring and autumn measurements, showing the same geographical trend (higher values at the western stations and lower at the eastern). At all stations spring values were lower than summer and autumn, and bottom values generally lower than surface ones.

According to Secchi disc depth (Fig. 4) the highest turbidity was measured in winter (minimum value 3.2 m, station CB) and the lowest during summer (maximum value 12.5 m, stations SD, DC, HS). Turbidity showed a seasonal trend, decreasing from winter to spring and summer, increasing again from summer to autumn.

TOC and TN contents in the sediment varied between 0.536 and 22.01 mg/g, and 0.01 and 1.01 mg/g, respectively. Their val-

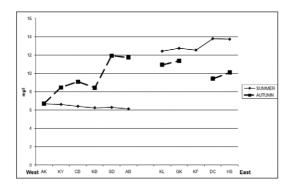


Fig. 3: Surface DO during summer and autumn.

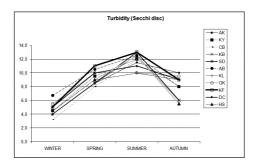


Fig. 4: Secchi disc depth (m) by season.

ues increased through summer and autumn (Fig. 5 a, b).

According to the grain size analysis, sandy bottoms were dominant among the stations all year (Fig. 6). However, the granulometric composition of the sediments displayed considerable seasonal variations for each station, with coarser sediment in winter and spring and finer in summer and autumn. Gravely bottom was dominant only at KY in winter (45% medium gravel, 35% fine gravel). The highest percentages of fine sediments (mostly silt) were measured in autumn from station HS (70%) and in summer from station KF (80%). Clay was present at very low levels, between 1 and 5%, only in summer and autumn.

The result of PCA (Fig. 7a) applied to the surface water physico-chemical properties, Secchi disc and depth parameters, confirms seasonal changes. The first two PC axes together explained 64.9% of the variability, but the first axis contributed 45.1%. Whereas surface TDS had the strongest positive correlation with the PC1 axis (0.51), surface temperature had the strongest negative correlation with the PC1 axis (-0.43). Turbidity showed the strongest correlation with the second PC axis (0.62).

Sedimentary structure and TOC and TN value did not show a seasonal and spa-

tial linearization with variables as results of PCA (Fig. 7B). Cumulative variation explained by both axes was 63.7%, whereas the first axis explained 34.5%. Sand had the strongest correlations with PC1 axis, gravel had the strongest correlation with PC2 axis. Station KY was isolated because of its different sediment composition (80% and 34% gravel in winter and spring, respectively).

### Biotic analyses

#### Structure of peracarid assemblages

A total of 7,988 specimens (including qualitative samples from the mid-line) were collected from the study area (Annex 1, expressed as ind/m<sup>2</sup>) belonging to 110 species; 78 species were new records for the Canakkale Strait. Amphipods were the dominant group both in terms of species richness (95 species) and abundance (93.7% of the total), followed by isopods (9 species, 4.7% of abundance). Tanaids and cumaceans were both represented by three species (with 30 and only 3 specimens respectively), whereas only one mysid species was collected. Seven peracarid species were obtained from the mid-line of the Canakkale Strait, three of them (namely Ampelisca planierensis, Ampelisca sp. and Gammarus aequicauda)

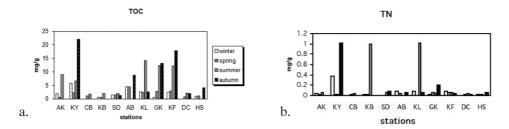


Fig. 5: Seasonal fluctuation of A) Total Organic Carbon (TOC, mg/g) and B) Total Nitrogen (TN, mg/g).

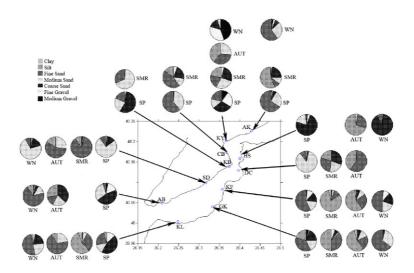


Fig. 6: Seasonal grain size analysis at sampling sites (SP: spring, SMR: summer, AUT: autumn, WN: winter).

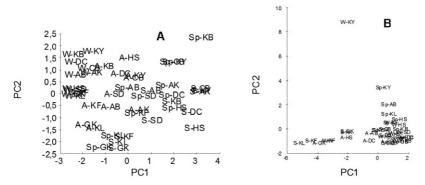


Fig. 7: PCA analysis applied on surface water parameters (A) and sediment data (B). Sp: spring, S: summer, A: autumn, W: winter.

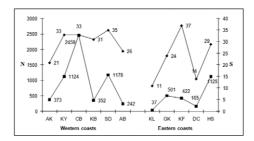


Fig. 8: Total number of species (S) and abundance  $(N/m^2)$  at sampling sites.

absent from the coastal stations. Figure 8 shows total number of species (S) and abundance (N/m²) for each sampling station. Minimum abundance values were observed at the entrance of the Strait (stations AB and KL), while maximum abundance was recorded at station CB, in the northern, narrower part. The lowest number of species was also observed at station KL, while the highest was at station KF, on the eastern coast.

Of the total 107 identified species from coastal stations, 88 were found along western coasts and 73 along the eastern coasts of the Canakkale Strait. Only 52 were present on both coasts, while 20 species were present only at stations located on the eastern coast and 35 were present only on the western coast. High abundance of several species was observed mainly in the innermost part of the Strait (stations AK, KY, CB, HS), while almost exclusively rare species (Ci < 0.02) were observed in the outer part (stations DC, KB and KF) as well as at the entrance of the Strait (stations AB and KL).

Rare species, present only in one station, showed a very high percentage (40 vs 110, or 36.4%). Of them, only two species had a percentage higher than 3%, while the remaining had percentages ranging between 0.1 and 2.6%.

Temporal variations in number of species (S), abundance (N), richness (d), diversity

(H') and evenness (J) values at all stations are presented in Table 2. Total abundance increased from winter (875 ind/m<sup>2</sup>) to spring (2,527 ind/m<sup>2</sup>) and the highest values were recorded in summer (2,758 ind/m<sup>2</sup>), decreasing again in autumn (1846 ind/m<sup>2</sup>). The highest number of species was found in spring and the lowest in winter. The highest diversity (H') values were observed at spring and summer. The highest evenness (J) values (1) were shown in winter at stations KF and DC, due to their paucity in abundance and species number. In addition, peracarida were not found at stations KL and GK, located in the eastern outer part of the Strait during winter nor at stations KB and DC, located in the narrowest part of the strait, during autumn.

The results of one-way ANOVA, including temporal and spatial changes in abundance, richness, evenness and diversity index values were not statistically significant (p > 0.05). Only species number showed significant differences between stations (F = 0.23, p < 0.05).

Calculation of Spearman's rank correlation coefficient (rs) between biotic (S, N, H', d, J) and abiotic (depth, surface and bottom physico-chemical parameters, turbidity, grain size, TOC and TN) parameters (Table 3) revealed a statistically significant negative correlation (p < 0.05) between depth and all biotic parameters except evenness (J), which

 $Table\ 2$  Number of species (S), abundance (N/m²), richness index (d), evenness (J') and diversity index (H') for each station and season.

		AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS
S	W	3	19	6	10	8	8	0	0	2	4	5
	Sp	12	6	21	17	18	10	1	6	15	8	15
	S	8	11	16	14	17	8	9	10	18	5	9
	A	3	15	0	0	17	7	1	15	16	0	11
N	W	13	470	143	50	100	33	0	0	7	13	43
	Sp	300	110	567	243	640	60	3	27.	123	127	327
	S	47	103	1750	60	270	43	33	77	173	27	175
	A	17	443	0	0	170	107	3	400	123	0	583
d	W	0.8	2.9	1.0	2.3	1.5	2	0	0	0.5	1.2	1.1
	Sp	1.9	1.1	3.2	2.9	2.6	2.2	0	1.5	2.9	1.5	2.4
	S	1.8	2.2	2.0	3.2	2.9	1.9	2.3	2.1	3.3	1.2	1.6
	A	0.7	2.3	0	0	3.1	1.3	0	2.3	3.1	0	1.6
J	W	1	0.7	0.6	0.9	0.8	1	0	0	1	1	0.8
	Sp	0.7	1	0.7	0.8	0.8	1	0	1	0.9	0.8	0.7
	S	0.9	0.9	0.6	1	0.8	0.9	1	0.9	0.9	0.9	0.7
	A	0.9	0.4	0	0	0.9	0.9	0	0.7	0.8	0	0.6
H'	W	0.5	0.9	0.4	0.9	0.8	0.9	0	0	0.3	0.6	0.6
	Sp	0.7	0.7	0.9	1	1.0	1	0	0.8	1.1	0.7	0.8
	S	0.8	0.9	1	1.1	1	0.8	0.9	0.9	1.1	0.6	0.6
	A	0.4	0.5	0	0	1.1	0.8	0	0.8	1	0	0.6

Table 3
Spearman's rank-correlation coefficients between biotic and some abiotic parameters.
Statistically significant correlations in bold.

		Depth	Surface	Turbidity	% medium	% fine sand	% clay
			temperature		gravel		
Number of	r <sub>s</sub>	-0.4515	0.188	0.1465	-0.006	-0.3685	0.2407
species (S)	p-level	0,0119	ns	ns	ns	0.0402	ns
A hum dom oo (NI)	r <sub>s</sub>	-0.4424	-0.0732	0.0347	0.0238	-0.4293	0.1058
Abundance (N)	p-level	0.0138	ns	ns	ns	0.0168	ns
Divorcity (II')	r <sub>s</sub>	-0.3765	0.4738	0.3212	0.0092	-0.3216	0.3911
Diversity (H')	p-level	0.0361	0.0178	ns	ns	ns	0.0294
Diahnass (d)	r <sub>s</sub>	-0.4238	0.3308	0.3117	0.4223	-0.3294	0.3475
Richness (d)	p-level	0.0183	ns	ns	ns	ns	ns
Evenness (I)	r <sub>s</sub>	-0.1055	0.495	0.5107	0.4223	-0.1196	0.161
Evenness (J)	p-level	ns	0.0133	0.0303	0.0187	ns	ns

was positively correlated with surface temperature, turbidity and medium gravel per-

centage. There were positive relationships between species diversity (H') and surface temperature as well as clay percentage (p < 0.05). In addition, fine sand percentage was negatively correlated with species number (S) and abundance (N) (p < 0.05).

#### **Dominant species**

The most important and characteristic species in the taxocoenosis were *Apocorophium acutum*, *Phtisica marina* and *Microdeutopus versiculatus*, which represented 40% of the total number of specimens. Only *Phtisica marina* and *Microdeutopus versiculatus* were common species  $(0.50 > \text{Ci} \ge 0.25)$  for the studied area, while no constant species  $(\ge 0.50)$  was found.

According to the Spearman rank correlation, the abundance of *P. marina* was negatively correlated to bottom salinity (r = -0.479, p = 0.013), bottom TDS (r = -0.548, p = 0.006) and bottom conductivity (r = -0.549, p = 0.005). Density of M. versiculatus was also negatively correlated to bottom salinity (r = -0.434, p = 0.027), bottom TDS (r = -0.481, p = 0.017), bottom conductivity (r = -0.475, p = 0.019), and percent of sand (r = -0.428, p = 0.011) but showed positive correlation only with the percent of gravel (r = 0.650, p = 0.000). The abundance of Apocorophium acutum had a positive correlation with TN (r = 0.380, p = 0.027), TOC (r = 0.470, p = 0.004), percent of silt (r = 0.410, p = 0.016) and a negative correlation with sand (r = -0.419, p = 0.014).

Results of 2-way ANOVA, based on the abundance of each of the three most abundant species for each station and season, showed interactions between factors to be statistically significant (stations and seasons, p=0.033). However, statistically significant differences were found only among stations (p=0.0015), but not among seasons (p=0.14). According to the LSD analysis, stations AK, CB, KY, HS (in the innermost part of the Strait) and SD (western coasts)

were totally different from the rest, while stations DC, KB and KF (in the central part of the Strait) did not show any difference among them, based on the abundance of dominant species. Moreover, different spatial and temporal patterns were followed by each species, as one-way ANOVA revealed that P. marina and A. acutum showed statistically significant differences among seasons (p = 0.045 and 0.030, respectively), while M. versiculatus did not show any statistically significant (p = 0.667) seasonal difference. Comparing spatial and temporal patterns, all the three species were absent from the eastern coast during winter, when M. versiculatus had its maximum contribution along the western coast. During spring P. marina was equally dominant all over the sampling area, while in summer A. acutum dominated along the western coast and P. marina increased its abundance at the eastern stations. In autumn A. acutum dominated in the whole Strait.

In terms of total spatial abundance (Fig. 9), stations where P. marina reached higher values were poorly populated by the other two species, especially at station AK, in the innermost part of the Strait. On the contrary, where A. acutum and/or M. versiculatus had their maximum contribution P. marina was present in low percentages. Only two stations presented a different pattern, namely station KL from where all the three species were totally absent and station HS where percentages of the three species were similar. It is worth mentioning that M. versiculatus and A. acutum are surface deposit feeders, thus requiring similar ecological conditions for their survival, while P. marina is a predator.

#### Multivariate analysis of assemblage structure

No patterns of seasonal grouping of stations were obtained by applying numerical classification, which revealed a very low Bray-Curtis similarity among stations (< 50 %).

When considering the total species abundance for each station, cluster analysis based on the  $\log_{10}(x+1)$  revealed two main groups in the area (Fig. 10). Group I includes all stations located in the upper and western side of the strait (except KB), as well as station HS, on the opposite coast. However, inside Group I two subgroups are delineated, one including stations KY and HS (52.53%) and one including Stations SD and AB (47.7%). Stations CB and AK are joined to them at similarity levels of 37.09% and 33.02% respectively. Similarity values were 38% within group I and 36% within

Group II. The species much contributing to the similarity between group I and group II according to the SIMPER analysis was Phtisica marina (contribution: 13%, 14% respectively). Apocorophium acutum (contribution: 11 %) and Microdeutopus versiculatus (10.5%) were the other important species for Group I. Dexamine spinosa (11%) and Microdeutopus versiculatus (10%) contributed as second and third range to Group II, including stations KB and KF. Dissimilarity between these two groups reached 72%. Stations KL, GK and DC, all located along the eastern coast, remained separated, due to their extreme faunistic paucity (KL) or high abundance of a single species

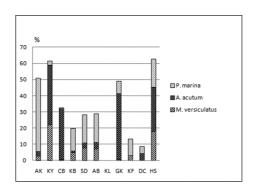


Fig. 9: Spatial distribution of the three most important peracarid species.

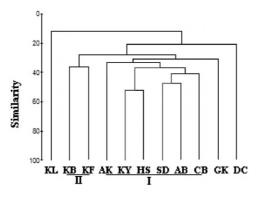


Fig. 10: Cluster analysis applied to total abundance of peracarids.

(40.5% A. acutum at GK, and 46.7% Urothoe intermedia at DC). The geographical separation among stations was ulteriorly testified, as according to the ANOSIM this dissimilarity is statistically significant (R = 0.667, p = 0.036).

Performing the same analyses after omitting the rare species, two major groups were observed at about 45% similarity level (Fig. 11); the first one comprises all western stations, again together with station HS, forming a subgroup (similarity level >60%) with station KY, due to the high abundance of A. acutum, M. versiculatus, Microdeutopus anomalus, Gammarella fucicula, as well as the common presence of Leptocheirus pectinatus, Leptochelia savignyi. Station AK, in the innermost part of the strait, even though separated, links to this group at similarity level of about 40%, due to the presence of high values of P. marina and M. anomalus. Group II, consisting of stations CB and GK, showed 60 % similarity due to the common presence of Microdeutopus gryllotalpa, Erichthonius punctatus, Janira maculosa, and Melita palmata, absent or with very low abundance in the other stations. The three remaining stations, all of them located on the eastern coast, were not grouped. KL owes its lowest level of similarity to its paucity both in number of species (11) and specimens (37), while DC and KF were characterized by rare species and very low abundance or absence of the most dominant species characterizing the remaining stations.

## Feeding types

The most important feeding types in the area were surface deposit feeders (37.4%) and suspension feeders (32.7%), followed by grazers (13%), predators (9.2%) and subsurface deposit feeders (7.4%), whereas commensalism was negligible (Fig. 12).

The contribution of each feeding type at each station (Fig. 13) showed that suspension feeders had a more homogenous distribution among stations (27 to 40%), with the exception of station DC (only 19%). Deposit feeders (both surface and subsurface) showed their minimum at station AK, in the innermost part of the strait; their abundance peaked at station DC, and, in general, it was lower at the western than at the eastern stations. Grazers had their lowest values at the innermost stations. AK and KY, which increased at the outer stations of the strait. Predators, on the contrary, were dominant at station AK (33%), showing low values at stations KY and CB (up to 3.5%); their values were higher along the western coast than the eastern (less than 10%) with the exception of HS (13%).

Cluster analysis applied to the relative abundance of feeding type grouped all sta-

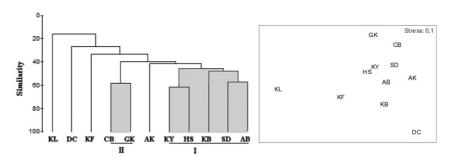
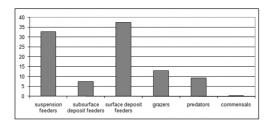


Fig. 11: Cluster analysis and MDS applied to species with >3% contribution.

tions at similarity level higher than 75% (Fig. 14). Increasing similarity level, a group including all stations southward of Canakkale harbour (Fig. 1) can be detected, which is further subdivided into 2 subgroups. The 'joining ring' is here considered to be the suspension feeders' percentage, ranging between 29 and 34%. The second subgroup includes stations HS, GK and SD, with higher percentages of deposit feeders. Station

DC, with the highest percentage of deposit feeders, is isolated but near to the previous subgroup at similarity levels of about 85%. Stations KY and CB, located in the northern part of the strait, formed a single group due to their common low percentage of predators, while station AK, in the innermost part of the strait, was completely isolated because of the high presence of predators and the lowest contribution of grazers.



*Fig. 12:* Feeding types of peracarid fauna (expressed as %).

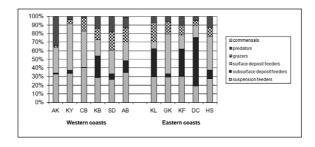


Fig. 13: Relative contribution of each feeding type at the sampling stations.

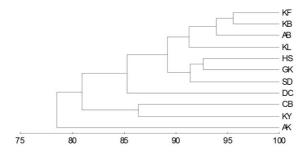


Fig. 14: Cluster analysis according to the feeding type.

#### **Discussion**

Faunistic analyses of the soft bottom peracarid assemblage of the Canakkale Strait revealed a rich species composition (110 species), with amphipods as the dominant group both in diversity and abundance (95 species, mean number of individuals 673/m<sup>2</sup>). SCIPIONE et al. (2005) reported that among peracarids, amphipods confirm their important leading role in defining the structure of assemblages; they dominate in species richness along environmental gradients and may play a key-role in coastal benthos due to their wide ecological and functional properties (BELLAN-SANTINI, 1998). Isopods were the second peracarid group in species richness (9 species, mean number of individuals 37/m<sup>2</sup>). Among them, Janira maculosa peaked in abundance at station CB in summer, even though it was rarely encountered during the whole study. This species lives among shells and was found associated to a Mytilus galloprovincialis facies, with low TOC and TN concentrations According to HALL-SPENCER et al. (2006) the abundance of J. maculosa decreases near fish farm cage sites with high TOC and TN values. CINAR et al. (2008) reported this species also from the harbour of Izmir, associated with M. galloprovincialis, but only during spring. Probably, its presence in the polluted Izmir harbour (KUCUKSEZGİN et al. 2005) could be sustained by the filtering action of M. galloprovincialis. Cumaceans were recorded only at station KY. CORBERA & CARDELL (1995) suggested that cumaceans may be used to determine high eutrofication levels, like polychaetes and molluscs, because their abundance increases with higher organic matter content and higher silt/clay proportion in sediments. For about a decade (1994-2005) aquaculture activities (M. galloprovincilis, trout and sea bass) were operating in the area of station KY. As a probable consequence, TOC and TN values remain high in the area, justifying the presence of cumaceans. Tanaidacea were represented by three species. One of them, Apseudes latreilli has been reported as preferring organic enrichment by GRALL & GLEMAREC (1997), whereas LOURIDO et al. (2008) observed an opposite behaviour. Nevertheless, the latter authors obtained the highest number of A. latreilli from muddy sand habitats, while in our study it was encountered on fine sand and medium gravel. Only nine specimens, belonging to one mysid species, were obtained in our samples. An explanation could be that mysids, which are not burrowers or tubicolous (SHILLAKER & MOORE, 1978), are sampled more efficiently by epibenthic trawling (BRANDT, 1995; MUNILLA & VINCENTE, 2005) rather than grabs (LOURIDO et al., 2008).

Two species were newly recorded for the Turkish Seas (ASLAN-CIHANGIR et al., 2009) and 78 for the Canakkale Strait. The most important and characteristic species in the taxocoenosis were the amphipods Apocorophium acutum, Phtisica marina and Microdeutopus versiculatus, which were responsible for the structure of the peracarid community and represented 40 % of the total number of specimens. PEARSON & ROSENBERG (1978) reported Corophium species as favored by organically rich sediments but also by the presence of Caulerpa racemosa (VÁZQUEZ-LUIS et al., 2008, 2009). Corophium is a scrape deposit feeder (CIARELLI et al., 1997) by means of its antennae (PARKER, 1984) and selects bacteria, algae and diatoms from the surface of sediment particles (MEADOWS & REID, 1966). The highest abundance of A. acutum was observed in summer at station CB, occupied by a Mytilus galloprovincialis facies. High abundance values of the species were also encountered in autumn at stations KY, HS, and GK, with the highest TOC values. In addition, statistical analyses showed that the species is positively correlated to TOC, TN and silty sediments. Thus, it seems that the abundance of A. acutum is correlated with high TOC, except in summer at CB (TOC = 1.08 mg/g). However, in this case A. acutum may feed on the feces of Mytilus galloprovincilis present at this station, which is also characterized by high hydrodynamism. Apocorophium is tube-dwelling and inhabits small U tubes (CHINTI-ROGLOU et al., 2004). It has also been reported that tube-builders, like Corophiidae, are not easily sighted (thus consumed) by benthic feeders (WAKABARA et al., 1982). This could be an additional reason for such a high abundance of A. acutum in the study area. The other important species, Microdeutopus versiculatus, flourishes in areas of relatively high detritus accumulation (BELLAN-SANTINI, 1982). This is consistent with the observed positive correlation of the species with coarser sediments (gravel) content and its negative correlation with sand percentages, according to the Spearman rank correlation. Phtisica marina was the second most important species in the study area (793 ind/m<sup>2</sup>). According to GUERRA-GARCIA et al. (2000), the abundance of the species during winter and spring is more than 10 times higher than during summer and autumn, suggesting as a cause the life cycles of algae. In the study area, P. marina followed a decreasing trend from spring to winter, showing the same seasonal pattern both for western and eastern coasts. It is worth noticing that the species was absent only from station KL, at the outermost eastern coast. Furthermore, of the 12 samples taken from the mid-line of the Canakkale Strait only four specimens of P. marina were found at stations 12 and 13, located in the north of the Strait. This is some-

how in disagreement with the known literature data; according to GUERRA-GARCIA & GARCIA-GOMEZ (2001), P. marina is characteristic of areas with low hydrodynamism, high silting, high values of suspended organic matter and suspended solids, as this species attaches to the substrate in the 'upright' position (GUERRA- GARCIA et al., 2002). In the study area no correlation was observed between P. marina abundance and silt, while its highest abundance values were obtained during spring at stations HS and AK, in absence of silt and in the presence of high hydrodynamism. Moreover, on the whole abundance (Annex 1) maximum values were observed at stations SD and HS, where algal coverage was not very high.

On the whole sampled area, abundance increased from winter to summer, decreasing again in autumn, except for station KY, where abundance increased from winter to spring. The high abundance observed at station KY, rich in detritus, could be related to relatively high TOC values, justifying eutrophication conditions. It is worth noticing that station KY is located in a small bay, characterized by low hydrodynamism. Similarly, a high abundance of amphipods was observed during winter in the Mar Piccolo Lagoon, and was attributed to poor hydrodynamism, high sedimentation and evolvement of reduction reactions in sediments (PRATO et al., 2000).

The community's composition showed a considerable number of rare species, represented by few individuals. Rare species can play a significant role in the description of communities (BOERO, 1994). These species can in fact represent an important source of diversity within the community itself, thus allowing a certain number of adjustments in the community composition in response to biotic and/or abiotic disturbance.

In the study area, rare species were found mostly at the entrance of the Strait and in its outer part, probably linked to water mass movement and consequent sediment instability. It could be stressed that seasonal changes of sediment structure could permit settlement and survival of different species throughout the year, while in stations with more stable sediment we observed dominance of some species.

Whereas 107 peracarid species (except Ampelisca planierensis, Ampelisca sp., Gammarus aequicauda) were encountered from shallow waters, up to 22 m depth, only seven species were detected from deeper stations (40-83 m depth). Depth and substrate are the most important factors influencing the structure of the benthic fauna (MUTLU & ERGEV, 2008), and it is well known that meiofauna and macrofauna abundance decrease with increasing depth in the eastern Mediterranean (TSELEPIDES et al., 2000; KRÖNCKE et al., 2003). According to SCIPIONE et al. (2005) the number of crustacean species, individuals and diversity (H') diminish towards depth, while evenness (J) increases. Other authors have also reported that depth is an important factor in peracarid distribution patterns (ROBERTSON et al., 1989; CORBERA & CARDELL, 1995; LOURIDO et al., 2008). Indeed, in the study area species number (S), density values (N), diversity (H') and richness (d) decreased with depth. In soft bottoms, the increase of the finest fractions in the sediment (KARAKASSIS & ELEFTHERIOU, 1997) results in the deof habitat heterogeneity (BIERNBAUM 1979; SCIPIONE et al., 2005); thus, the number of microhabitats, which favor a greater biodiversity than homogeneous sediment, decrease (GRAY, 1974; LOURIDO et al., 2008). As a consequence, a negative correlation between

biotic factors and clay-fraction and a positive correlation between biotic and fine sand bottoms has to be expected. Many authors report (BIERNBAUM, 1979; MARQUES & BELLAN-SANTINI, 1993; DAUVIN et al., 1994; LOURIDO et al., 2008) the highest number of peracarid species and abundance in fine sand bottoms. However, in this study it has been found that both number of species and abundance tended to be lower in fine sand; diversity (H') tended to be higher in clay, and evenness is getting higher in medium gravel sediments. Reduced diversity of benthic assemblages in sandy substrata has been reported in stressed conditions (VANOSMAEL et al., 1982). The hydrodynamic conditions of the Canakkale Strait could be the major factor acting on peracarida assemblage, as currents have been indicated as the most important factor determining sediment grain size (GRAY, 1974; BIERNBAUM, 1979). Seasonal grain size analyses in the study area showed significant fluctuation at each station, with coarser sediments during winter and spring, due to sediment instability caused by winter winds, and the finest sediments in summer and autumn, as a result of lower wind and lower currents. In this case, it is obvious that individual settlement was favoured in periods and areas with milder conditions, resulting in higher diversity values in finer sediments. This is to some degree opposed to the generally observed situation, with no changes during winter in finer sediment, but substantial faunal changes in the coarser sediments (BIERNBAUM, 1979).

From the result of cluster analysis on peracarid abundance, station KL was completely separated from the other stations, due to the total absence of peracarids in winter, as well as to its paucity in spring and autumn. It is remarkable that only the am-

phipod Orchomenella nana, a scavenger, was obtained in spring (1 specimen/0.1 m<sup>2</sup>) and Atylus guttatus was obtained in autumn (2 specimens/0.1 m<sup>2</sup>). It is also worth mentioning the presence in the area of the invasive alga Caulerpa racemosa showing its maximum abundance during the warm season. C. racemosa is one of the fastest spreading algae across the Mediterranean and it has been recorded on soft bottoms in rather deep waters (15-20 m) (VERLAQUE et al., 2004) and on dead matte of Posidonia oceanica (VAZQUEZ-LUIS et al., 2008). It has also been reported that the effects of this invasive alga on habitat structure, resulting in changing the native algal composition and increasing the detritus stock, were more important during warm periods, when detritus values were 2-6 times higher than those recorded from native seaweeds (VAZQUEZ-LUIS et al., 2008). Consequently, both qualitative and quantitative composition of amphipods changed (VÁZQUEZ-LUIS et al., 2008). In the study area, although C. racemosa presented slight seasonal changes, peracarids were substantially present only during summer, due to the peculiar hydrological features of the Strait. Thus, it seems that the presence of C. racemosa and hydrodynamism play a complementary role in the observed assemblage structure.

In terms of trophodynamic groups, peracarid species obtained from the Canakkale Strait showed a very high diversity in their trophic status, involving a wide range of ecological behaviours: suspension feeders, predators, scavengers, surface deposit feeders, subsurface deposit feeders, grazers and commensals. Moreover, the assemblage was strongly dominated by amphipods, many of which are thought to be opportunistic scavengers or predators (BARNARD & KARAMANN, 1991). In addition, most of the sampled species can adopt different

feeding types, leading to a great advantage for survival in such a hard environment. This is the case of *P. marina*, one of the dominant species in the area, which can be considered as opportunistic (GUERRA-GARCÍ A & TIERNO DE FIGUEROA, 2009), because it can feed on a very large variety of preys (small crustaceans, macroalgae, diatoms and dinoflagellates), adopting different trophic preferences according to prey availability and local conditions. According to RHOADS & YOUNG (1970) suspension feeders are dominant in sandy and firm muddy bottoms (under high currents) and deposit feeders are dominant in soft muddy bottoms (under low currents). The contribution of each feeding type at each station showed that suspension feeders had a more homogeneous distribution among stations, while deposit feeders (both surface and subsurface) showed lower abundance in the western than in the eastern stations. Grazers had their lowest values in the innermost stations, and increased in the outer stations of the strait. Predators, on the contrary, were dominant in the innermost station AK, and their values were generally higher along the western coast than the eastern. Spatial patterns of feeding types distribution were also detected by cluster analysis, where all stations southward of Canakkale harbour were separated from the northern part of the strait, while station AK, in the innermost part of the strait, was completely isolated because of the high presence of predators and the lowest contribution of grazers.

Sediment distributions as well as pattern in benthic food supply via sedimentation events are ultimately linked to the mesoscale hydrography (GRAF, 1992; HEBBELN & WEFER, 1991; WAINWRIGHT, 1990). Thus, the different seasonal sediment compositions of the study area are directly in-

fluenced by the high hydrodynamism of the Canakkale Strait and its two different current systems. To conclude, it could be stressed that differences in abundances and assemblage structures of peracarida along the eastern and western coasts of the Strait can be attributed to food supply and sediment composition, depending on bottom current velocities.

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## Annex I

List of peracaridian crustaceans collected from the Canakkale Strait. Ci: frequency; Di: dominance of species. \*: new record for the Canakkale Strait; \*\*: new record for the Turkish Seas (numbers in bold indicate the most important and characteristic species, Ci >0.25).

+ = presence of the species (qualitative sampling of Canakkale Strait mid-line).

		Wes	tern	coas	sts			East	ern (	coas	ts					
	North				Sout	h	So	uth		Nor	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid
																line
Amphipoda																
Iphimedia minuta G.O.											3	3	0.01	0.05	0.0005	
Sars, 1882*																
Ampelisca diadema		38			27		3		27		5	100	0.11	1.35	0.1485	
(A. Costa, 1853)																
Ampelisca gibba G.O.						3		20				23	0.03	0.33	0.0099	
Sars, 1882*																
Ampelisca ledoyeri											3	3	0.01	0.05	0.0005	
Bellan-Santini &																
Kaim-Malka, 1977*																
Ampelisca pseudosarsi	3	20						3	10			36	0.05	0.51	0.0255	
Bellan-Santini &																
Kaim-Malka, 1977*																
Ampelisca				3					3			6	0.02	0.09	0.0018	
pseudospinimana																
Bellan-Santini & Kaim																
–Malka, 1977																
Ampelisca ruffoi					10							10	0.01	0.14	0.0014	
Bellan-Santini &																
Kaim-Malka 1977*																
Ampelisca sarsi		5					3		30		3	41	0.03	0.56	0.0168	
Chevreux, 1888																
Ampelisca typica				3				10				13	0.03	0.19	0.0057	+
(Bate, 1856)*																
Ampelisca planierensis												0	0	0	0	+
Bellan-Santini &																
Kaim –Malka, 1977*																
Ampelisca sp.												0	0	0	0	+
Ampelisca brevicornis	7											7	0.02	0.09	0.0018	
(A. Costa 1853)*																
Amphilochus neapolitanus				3								3	0.01	0.05	0.0005	
Della Valle, 1893*																
Amphilochus picadurus		20		10	3					13		46	0.04	0.56	0.0224	
J.L. Barnard, 1962*																

		Wes	tern	coas	sts			Easte	ern (	coas	ts					
	North				Soutl	1	So	uth		Nor	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid line
Amphithoe ramondi			87	10	130	17		17		3	3	267	0.12	3.44	0.4128	
Audouin, 1826																
Peramphitoe spuria			7									7	0.02	0.09	0.0018	
(Krapp-Schieckel, 1978)*																
Sunamphithoe pelagica			7									7	0.01	0.09	0.0009	
(Milne-Edwards, 1830)*																
Aora gracilis	3											3	0.01	0.05	0.0005	
(Bate, 1857)*																
Leptocheirus mariae						3			20			23	0.03	0.33	0.0099	
G. Karaman, 1973*																
Leptocheirus pectinatus		47		3							20	70	0.03	0.98	0.0294	
(Norman, 1869)*																
Leptocheirus pilosus				7				3				10	0.02	0.14	0.0028	
Zaddach, 1844*																
Microdeutopus algicola	3	3	115						7	20		148	0.06	1.53	0.0918	
Dellavalle, 1893*																
Microdeutopus anomalus	70	50	143	3	53			3			27	349	0.13	4.70	0.611	
(Rathke, 1843)																
Microdeutopus bifidus	27		3			17						47	0.03	0.65	0.0195	
Myers, 1977*																
Microdeutopus chelifer	23				27							50	0.02	0.70	0.014	
(Bate, 1862)*																
Microdeutopus gryllotalpa			247		13	3		37				300	0.06	4.09	0.2454	
A. Costa, 1853																
Microdeutopus obtusatus			30									30	0.01	0.42	0.0042	
Myers, 1973*																
Microdeutopus stationis			40					10				50	0.02	0.70	0.014	
Della Valle, 1893*																
Microdeutopus	10	247	13	17	90	17		3	13		200	610	0.26	7.44	1.9344	
versiculatus (Bate, 1856)*																
Microdeutopus sp.				7								7	0.02	0.09	0.0018	
Apocorophium acutum	10	417	773	3	37	10		203		7	310	1770	0.28	20.73	3.7314	
(Chevreux, 1908)*			<u> </u>			<u> </u>			<u> </u>	<u> </u>	<u> </u>	<u> </u>				
Monocorophium								13				13	0.01	0.19	0.0019	
insidiosum (Crawford,																
1937)*																
Monocorophium sextonae		8		3							23	34	0.05	0.46	0.023	
(Crawford, 1937)**																

		Wes	stern	coas	sts			East	ern (	coas	ts					
	North				Sout	h	So	outh		Nor	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid
																line
Atylus guttatus		20	10				3	3			7	43	0.05	0.51	0.0255	
(A. Costa, 1851)*																
Atylus massiliensis			3								3	6	0.02	0.09	0.0018	
Bellan-Santini, 1975*																
Tritaeta gibbosa			3									3	0.01	0.05	0.0005	
(Bate, 1862)*																
Dexamine spiniventris		5		3							13	21	0.03	0.28	0.0084	
(A. Costa, 1853)																
Dexamine spinosa		47	23	17	67	17		3	17		10	201	0.16	2.60	0.416	
(Montagu, 1813)																
Dexamine thea	13	3	25		17	17						75	0.04	0.93	0.0372	
Boeck, 1861*																
Apherusa chiereghinii									3			3	0.01	0.05	0.0005	
Giordani-Soika, 1950																
Apherusa alacris					3							3	0.01	0.05	0.0005	
Krapp-Schickel, 1969*																
Gammaropsis maculata				20	97	10					135	262	0.07	3.21	0.2247	
(Johnston, 1827)*																
Gammaropsis palmata										3	3	6	0.02	0.09	0.0018	+
(Stebbing & Robertson,																
1891)*																
Gammaropsis ostroumowi	3	5			33						30	71	0.06	0.98	0.0588	
(Sowinsky, 1898)*																
Megamphopus				83		3				3	3	92	0.06	1.30	0.078	
brevidactylus Myers,																
1976*																
Photis longicaudata				23					3			26	0.03	0.37	0.0111	
Bate & Westwood,																
1862)*																
Cerapopsis longipes				7				3	3			13	0.02	0.19	0.0038	
Della Valle, 1893																
Erichthonius brasiliensis			3		10	3			7		5	28	0.04	0.37	0.0148	
(Dana, 1855)*																
Erichthonius punctatus		7	240					17	3			267	0.06	2.60	0.156	
(Bate, 1857)																
Jassa marmorata			5		3							8	0.02	0.09	0.0018	
Holmes, 1903																
Jassa ocia (Bate, 1862)*	3		5									8	0.02	0.09	0.0018	

		Wes	tern	coas	sts			East	ern (	coas	ts					
	North				Sout	h	So	uth		Nor	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid line
Leucothoe lilljeborgi				3					7			10	0.02	0.14	0.0028	
Boeck, 1861*																
Leucothoe spinicarpa			5		10	3			3			21	0.03	0.28	0.0084	
(Abildgaard, 1789)*																
Liljeborgia psaltrica									3			3	0.01	0.05	0.0005	
Krapp-Schickel, 1975*																
Hippomedon						3				3		6	0.02	0.09	0.0018	
massiliensis Bellan-																
Santini, 1965*																
Orchomene grimaldii		10										10	0.01	0.09	0.0009	
Cheveux, 1890*																
Orchomene humilis					7							7	0.02	0.09	0.0018	
(A. Costa, 1853)*																
Orchomenella nana	7			17			3					27	0.04	0.37	0.0148	
((Kroyer, 1846)*																
Paracentromedon									3			3	0.01	0.05	0.0005	
crenulatum (Chevreux,																
1900)*																
Cheirocratus sundevallii									7			7	0.01	0.09	0.0009	
(Rathke, 1843)*																
Elasmopus rapax	3		40									43	0.02	0.42	0.0084	
A. Costa, 1853*																
Elasmopus brasiliensis		5						3			7	15	0.02	0.19	0.0038	
(Dana, 1855)																
Gammarella fucicola	3	50	10		3	7					23	96	0.08	1.26	0.1008	
(Leach. 1814)																
Gammarus aequicauda																+
(Martyinov, 1931)																
Maera grossimana			7	7	90	3	3		10		38	158	0.09	2.19	0.1971	
(Montagu, 1808)																
Melita palmata			132	3				20				155	0.04	2.00	0.08	
(Montagu, 1804)																
Melphidipella macra									3			3	0.01	0.05	0.0005	
(Norman, 1869)**																
Monoculodes subnudus						3						3	0.01	0.05	0.0005	
Norman, 1889*																
Monoculodes acutipes	3											3	0.01	0.05	0.0005	
Ledoyer, 1983*																

		Wes	stern	coas	sts			East	ern (	coast	ts					
	North				Sout	h	So	uth		Nort	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid line
Monoculodes gibbosus									3			3	0.01	0.05	0.0005	
Chevreux, 1888*																
Monoculodes carinatus		3							3			6	0.02	0.09	0.0018	
(Bate, 1857)*																
Perioculodes longimanus		18		7					3	17		45	0.06	0.56	0.0336	
longimanus (Bate &																
Westwood, 1868)*																
Perioculodes aequimanus		3	8		3				3			17	0.04	0.23	0.0092	
(Kossmann, 1880)*																
Westwoodilla rectirostris							7		3			10	0.02	0.14	0.0028	
(Della Valle, 1893)*																
Harpinia agna								7	3			10	0.02	0.14	0.0028	
G. Karaman, 1987*																
Harpinia dellavallei						7	3	17	80		8	115	0.12	1.58	0.1896	
Chevreux, 1910*																
Phoxocephalus aquosus				3		13			10			26	0.04	0.37	0.0148	
Karaman, 1985*																
Metaphoxus simplex	3	8		7	10	7	3		13	3		54	0.10	0.74	0.074	
(Bate, 1857)*																
Paraphoxus oculatus						3						3	0.01	0.05	0.0005	
(G.O. Sars, 1879)*																
Bathyporeia		3		3	7							13	0.03	0.19	0.0057	
phaiophthalma Bellan-																
Santini, 1973*																
Stenothoe elachista						3						3	0.01	0.05	0.0005	
Krapp-Schieckel, 1976																
Stenothoe marina											5	5	0.01	0.05	0.0005	
(Bate, 1856)*																
Stenothoe			20		13	10						43	0.05	0.51	0.0255	
monoculoides																
(Montagu, 1813)																
Stenothoe tergestina			65	10								75	0.03	0.74	0.0222	
(Nebeski, 1880)																
Urothoe elegans				3	7							10	0.02	0.14	0.0028	
Bate, 1857*																
Urothoe intermedia			3		73	10				77		163	0.11	2.28	0.2508	
Bellan-Santini &																
Ruffo, 1986*																

		Wes	stern	coas	sts			Easte	ern (	coas	ts					
	North			- ;	Soutl	1	So	uth		Nor	th					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid line
Urothoe pulchella					3							3	0.01	0.05	0.0005	
(A. Costa, 1853)*																
Caprella acanthifera					7	7		7	3		3	27	0.05	0.37	0.0185	
Leach, 1814																
Caprella danilewskii				7					7			14	0.02	0.19	0.0038	
Czerniavski, 1868*																
Caprella lilliput									13			13	0.01	0.19	0.0019	
Krapp-Schickel &																
Ruffo, 1987*																
Caprella mitis								3	3			6	0.02	0.09	0.0018	
Mayeri, 1890*																
Caprella rapax Mayer,					103					3		106	0.02	1.49	0.0298	
1890																
Pseudolirius kroyerii									33			33	0.02	0.46	0.0092	
(Haller, 1879)*																
Pseudoprotella phasma									10			10	0.02	0.14	0.0028	
(Montagu, 1804)																
Phtisica marina	170	25	17	50	203	43		40	43	7	195	793	0.26	10.79	2.8054	+
Slabber, 1769																
Cumacea																
Iphinoe tenella		5										5	0.01	0.05	0.0005	
Sars, 1878*																
Iphinoe douniae		5										5	0.01	0.05	0.0005	
Ledoyer, 1965*																
Campylaspis		3										3	0.01	0.05	0.0005	
macrophthalma Sars,																
1878																
Mysidacea																
Gastrosaccus normani	3						3				3	9	0.02	0.14	0.0028	
G.O. Sars, 1877*																
Tanaidacea																
Apseudes latreillii	3	10	7		3							23	0.03	0.28	0.0084	
(Milne-Edwards,																
1828)*																
Apseudes intermedius				7					7			14	0.03	0.19	0.0057	
Hansen, 1985*																
Leptochelia savigny		23	15		3					3	32	76	0.09	0.93	0.0837	
(Kroyer, 1842)																

			]	Easte	ern c	coast	S									
	North			5	South		So	uth	]	Nort	h					
Species	AK	KY	СВ	KB	SD	AB	KL	GK	KF	DC	HS	Ni	Ci	Di	CixDi	Mid line
Isopoda																
Jaeropsis brevicornis	3											3	0.01	0.05	0.0005	
Koehler, 1885																
Gnathia oxyuraea											5	5	0.01	0.05	0.0005	
(Lilljeborg, 1855)*																
Gnathia sp.		5			7			3				15	0.03	0.19	0.0057	
Janira maculosa Leach,			348		3		3	53				407	0.05	4.09	0.2045	+
1814*																
Cymodoce tuberculata							3					3	0.01	0.05	0.0005	
Costa in Hope, 1851*																
Eurydice spinigera										3		3	0.01	0.05	0.0005	
Hansen, 1890*																
Paragnathia formica		3										3	0.01	0.05	0.0005	
(Hesse, 1862)*																
Anthura gracilis					3							3	0.01	0.05	0.0005	
(Montagu, 1808)*																
Synisoma capito		3										3	0.01	0.05	0.0005	
(Rathke, 1837)																
No. of individuals/m <sup>2</sup>	373	1124	2459	352	1178	242	37	501	422	165	1125					
No. of species	21	33	33	31	35	26	11	24	37	14	29					