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Research Article

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 macrobenthos (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^{-1} (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^{-1} (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,

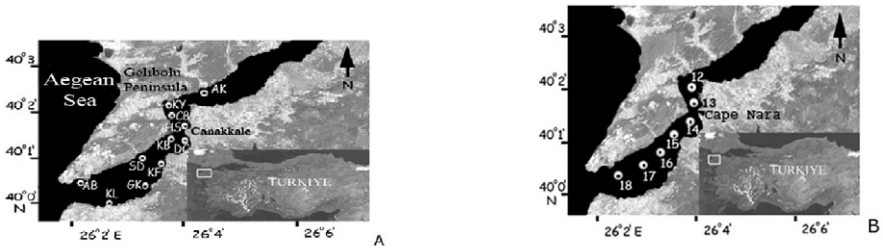


Fig. 1: Map of the Canakkale Strait showing A) coastal sampling stations B) qualitative sampling stations at the mid-line area.

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^2 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 ($1 \geq Ci \geq 0.5$), common ($0.5 > Ci \geq 0.25$) 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 (LÓPEZ 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)
CB	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 $\log_{10}(x+1)$ 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 situation 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

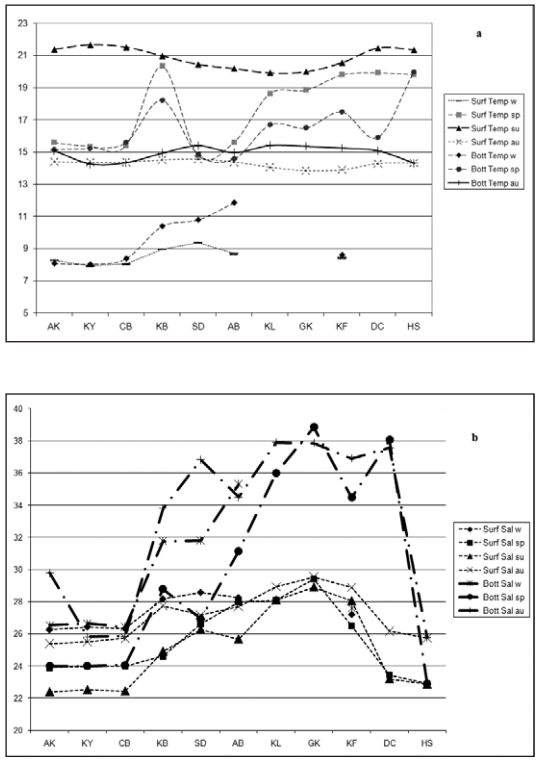


Fig. 2: Seasonal fluctuation of temperature (a) and salinity (b) at sampling sites.

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-

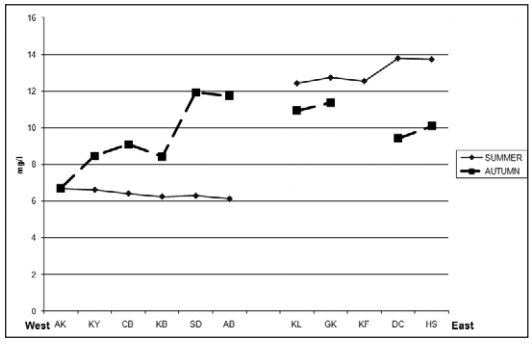


Fig. 3: Surface DO during summer and autumn.

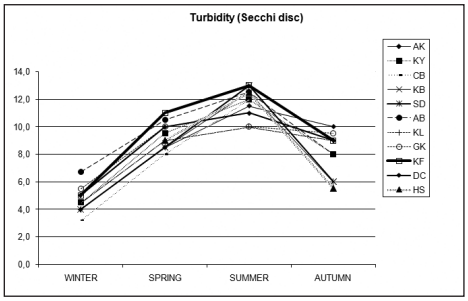


Fig. 4: Secchi disc depth (m) by season.

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 spatial 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^2) 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*)

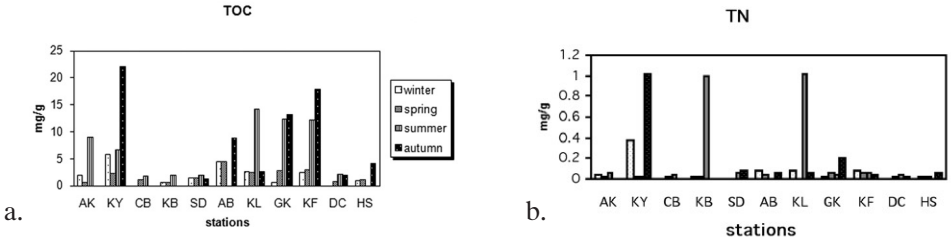


Fig. 5: Seasonal fluctuation of A) Total Organic Carbon (TOC, mg/g) and B) Total Nitrogen (TN, mg/g).

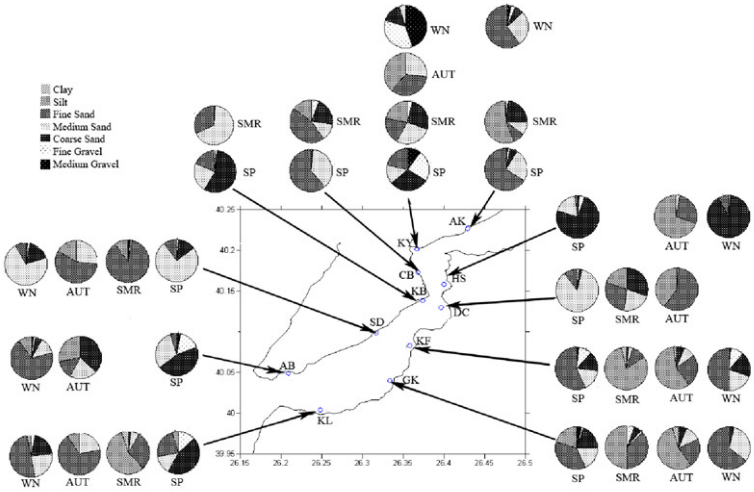


Fig. 6: Seasonal grain size analysis at sampling sites (SP: spring, SMR: summer, AUT: autumn, WN: winter).

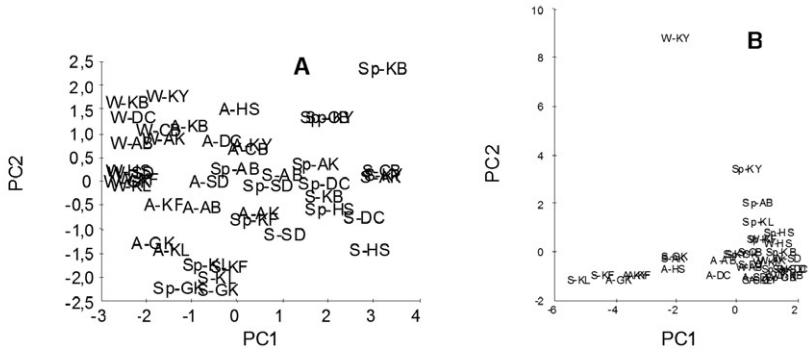


Fig. 7: PCA analysis applied on surface water parameters (A) and sediment data (B). Sp: spring, S: summer, A: autumn, W: winter.

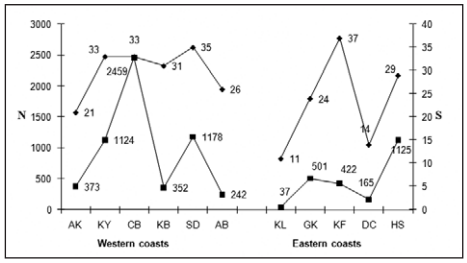


Fig. 8: Total number of species (S) and abundance (N/m^2) at sampling sites.

absent from the coastal stations. Figure 8 shows total number of species (S) and abundance (N/m^2) 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^2) to spring (2,527 ind/m^2) and the highest values were recorded in summer (2,758 ind/m^2), decreasing again in autumn (1846 ind/m^2). 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/m^2), richness index (d), evenness (J') and diversity index (H') for each station and season.

		AK	KY	CB	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 temperature	Turbidity	% medium gravel	% fine sand	% clay
Number of species (S)	r_s p-level	**-0.4515** 0,0119	0.188 ns	0.1465 ns	-0.006 ns	**-0.3685** 0.0402	0.2407 ns
Abundance (N)	r_s p-level	**-0.4424** 0.0138	-0.0732 ns	0.0347 ns	0.0238 ns	**-0.4293** 0.0168	0.1058 ns
Diversity (H')	r_s p-level	**-0.3765** 0.0361	**0.4738** 0.0178	0.3212 ns	0.0092 ns	-0.3216 ns	**0.3911** 0.0294
Richness (d)	r_s p-level	**-0.4238** 0.0183	0.3308 ns	0.3117 ns	0.4223 ns	-0.3294 ns	0.3475 ns
Evenness (J)	r_s p-level	-0.1055 ns	**0.495** 0.0133	**0.5107** 0.0303	**0.4223** 0.0187	-0.1196 ns	0.161 ns

was positively correlated with surface temperature, turbidity and medium gravel percentage. 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 ($0.50 > Ci \geq 0.25$) for the studied area, while no constant species (≥ 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

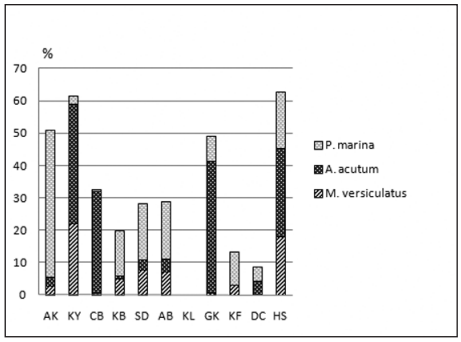


Fig. 9: Spatial distribution of the three most important peracarid species.

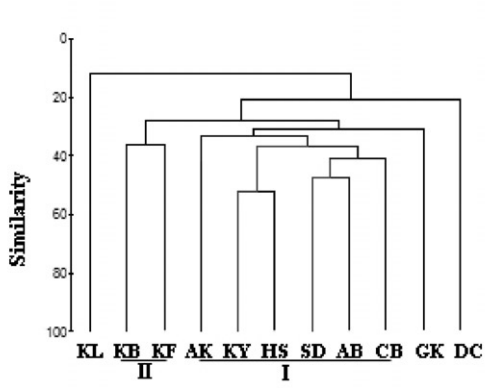


Fig. 10: Cluster analysis applied to total abundance of peracarids.

(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-

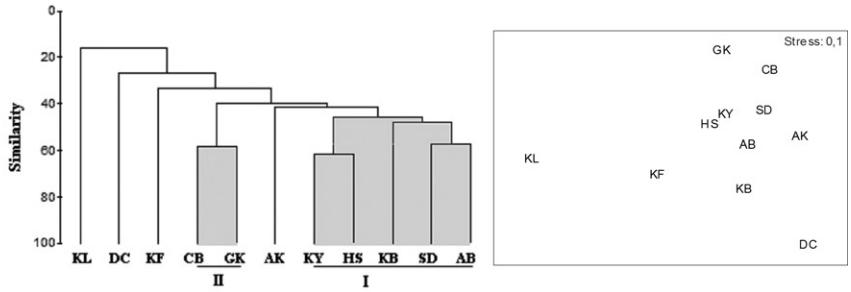


Fig. 11: Cluster analysis and MDS applied to species with >3% contribution.

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.

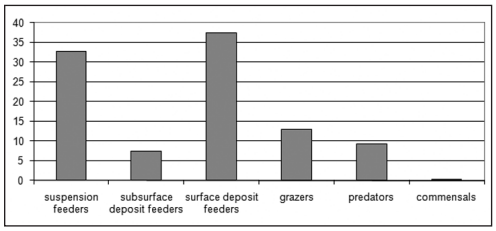


Fig. 12: Feeding types of peracarid fauna (expressed as %).

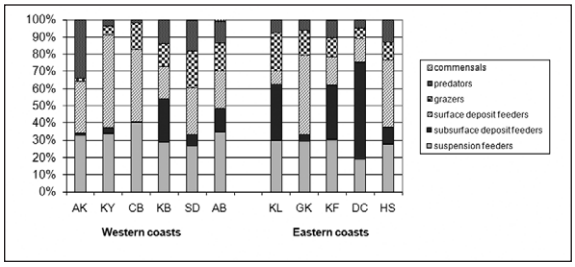


Fig. 13: Relative contribution of each feeding type at the sampling stations.

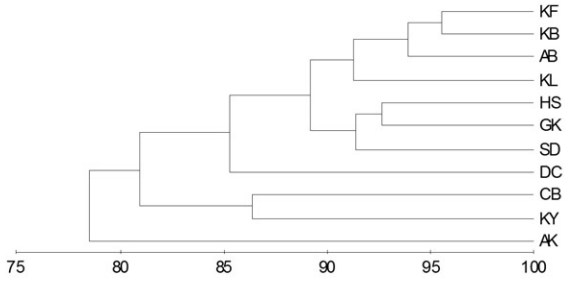


Fig. 14: Cluster analysis according to the feeding type.

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^2). 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^2). 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 (CHINTIROGLOU *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^2). 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 somehow in disagreement with the known literature data; according to GUERRA-GARCIA & GARCIA-GÓMEZ (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 decrease of 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^2) and *Atylus guttatus* was obtained in autumn (2 specimens/0.1 m^2). 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-GARCÍA & 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).

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Amphipoda																
Iphimedia minuta G.O. Sars, 1882*											3	3	0.01	0.05	0.0005	
Ampelisca diadema (A. Costa, 1853)		38			27		3		27		5	100	0.11	1.35	0.1485	
Ampelisca gibba G.O. Sars, 1882*						3		20				23	0.03	0.33	0.0099	
Ampelisca ledoyeri Bellan-Santini & Kaim-Malka, 1977*											3	3	0.01	0.05	0.0005	
Ampelisca pseudosarsi Bellan-Santini & Kaim-Malka, 1977*	3	20						3	10			36	0.05	0.51	0.0255	
Ampelisca pseudospinimana Bellan-Santini & Kaim –Malka, 1977				3					3			6	0.02	0.09	0.0018	
Ampelisca ruffoi Bellan-Santini & Kaim-Malka 1977*					10							10	0.01	0.14	0.0014	
Ampelisca sarsi Chevreux, 1888		5					3		30		3	41	0.03	0.56	0.0168	
Ampelisca typica (Bate, 1856)*				3				10				13	0.03	0.19	0.0057	+
Ampelisca planierensis Bellan-Santini & Kaim –Malka, 1977*												0	0	0	0	+
Ampelisca sp.												0	0	0	0	+
Ampelisca brevicornis (A. Costa 1853)*	7											7	0.02	0.09	0.0018	
Amphilochus neapolitanus Della Valle, 1893*				3								3	0.01	0.05	0.0005	
Amphilochus picadurus J.L. Barnard, 1962*		20		10	3					13		46	0.04	0.56	0.0224	

(continued)

Annex I (continued)

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Amphithoe ramondi Audouin, 1826			87	10	130	17		17		3	3	267	0.12	3.44	0.4128	
Peramphitoe spuria (Krapp-Schieckel, 1978)*			7									7	0.02	0.09	0.0018	
Sunamphithoe pelagica (Milne-Edwards, 1830)*			7									7	0.01	0.09	0.0009	
Aora gracilis (Bate, 1857)*	3											3	0.01	0.05	0.0005	
Leptocheirus mariae G. Karaman, 1973*						3			20			23	0.03	0.33	0.0099	
Leptocheirus pectinatus (Norman, 1869)*		47		3							20	70	0.03	0.98	0.0294	
Leptocheirus pilosus Zaddach, 1844*				7				3				10	0.02	0.14	0.0028	
Microdeutopus algicola Dellavalle, 1893*	3	3	115						7	20		148	0.06	1.53	0.0918	
Microdeutopus anomalus (Rathke, 1843)	70	50	143	3	53			3			27	349	0.13	4.70	0.611	
Microdeutopus bifidus Myers, 1977*	27		3			17						47	0.03	0.65	0.0195	
Microdeutopus chelifer (Bate, 1862)*	23				27							50	0.02	0.70	0.014	
Microdeutopus gryllotalpa A. Costa, 1853			247		13	3		37				300	0.06	4.09	0.2454	
Microdeutopus obtusatus Myers, 1973*			30									30	0.01	0.42	0.0042	
Microdeutopus stationis Della Valle, 1893*			40					10				50	0.02	0.70	0.014	
Microdeutopus versiculatus (Bate, 1856)*	10	247	13	17	90	17		3	13		200	610	0.26	7.44	1.9344	
Microdeutopus sp.				7								7	0.02	0.09	0.0018	
Apocorophium acutum (Chevreux, 1908)*	10	417	773	3	37	10		203		7	310	1770	0.28	20.73	3.7314	
Monocorophium insidiosum (Crawford, 1937)*								13				13	0.01	0.19	0.0019	
Monocorophium sextonae (Crawford, 1937)**		8		3							23	34	0.05	0.46	0.023	

(continued)

Annex I (continued)

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Atylus guttatus (A. Costa, 1851)*		20	10				3	3			7	43	0.05	0.51	0.0255	
Atylus massiliensis Bellan-Santini, 1975*			3								3	6	0.02	0.09	0.0018	
Tritaeta gibbosa (Bate, 1862)*			3									3	0.01	0.05	0.0005	
Dexamine spiniventris (A. Costa, 1853)		5		3							13	21	0.03	0.28	0.0084	
Dexamine spinosa (Montagu, 1813)		47	23	17	67	17		3	17		10	201	0.16	2.60	0.416	
Dexamine thea Boeck, 1861*	13	3	25		17	17						75	0.04	0.93	0.0372	
Apherusa chiereghinii Giordani-Soika, 1950									3			3	0.01	0.05	0.0005	
Apherusa alacris Krapp-Schickel, 1969*					3							3	0.01	0.05	0.0005	
Gammaropsis maculata (Johnston, 1827)*				20	97	10					135	262	0.07	3.21	0.2247	
Gammaropsis palmata (Stebbing & Robertson, 1891)*										3	3	6	0.02	0.09	0.0018	+
Gammaropsis ostroumowi (Sowinsky, 1898)*	3	5			33						30	71	0.06	0.98	0.0588	
Megamphopus brevidactylus Myers, 1976*				83		3				3	3	92	0.06	1.30	0.078	
Photis longicaudata Bate & Westwood, 1862)*				23					3			26	0.03	0.37	0.0111	
Cerapopsis longipes Della Valle, 1893				7				3	3			13	0.02	0.19	0.0038	
Erichthonius brasiliensis (Dana, 1855)*			3		10	3			7		5	28	0.04	0.37	0.0148	
Erichthonius punctatus (Bate, 1857)		7	240					17	3			267	0.06	2.60	0.156	
Jassa marmorata Holmes, 1903			5		3							8	0.02	0.09	0.0018	
Jassa ocia (Bate, 1862)*	3		5									8	0.02	0.09	0.0018	

(continued)

Annex I (continued)

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Leucothoe lilljeborgi Boeck, 1861*				3					7			10	0.02	0.14	0.0028	
Leucothoe spinicarpa (Abildgaard, 1789)*			5		10	3			3			21	0.03	0.28	0.0084	
Liljeborgia psaltrica Krapp-Schickel, 1975*									3			3	0.01	0.05	0.0005	
Hippomedon massiliensis Bellan-Santini, 1965*						3				3		6	0.02	0.09	0.0018	
Orchomene grimaldii Cheveux, 1890*		10										10	0.01	0.09	0.0009	
Orchomene humilis (A. Costa, 1853)*					7							7	0.02	0.09	0.0018	
Orchomenella nana ((Kroyer, 1846)*	7			17			3					27	0.04	0.37	0.0148	
Paracentromedon crenulatum (Chevreux, 1900)*									3			3	0.01	0.05	0.0005	
Cheirocratus sundevallii (Rathke, 1843)*									7			7	0.01	0.09	0.0009	
Elasmopus rapax A. Costa, 1853*	3		40									43	0.02	0.42	0.0084	
Elasmopus brasiliensis (Dana, 1855)		5						3			7	15	0.02	0.19	0.0038	
Gammarella fucicola (Leach. 1814)	3	50	10		3	7					23	96	0.08	1.26	0.1008	
Gammarus aequicauda (Martyinov, 1931)																+
Maera grossimana (Montagu, 1808)			7	7	90	3	3		10		38	158	0.09	2.19	0.1971	
Melita palmata (Montagu, 1804)			132	3				20				155	0.04	2.00	0.08	
Melphidipella macra (Norman, 1869)**									3			3	0.01	0.05	0.0005	
Monoculodes subnudus Norman, 1889*						3						3	0.01	0.05	0.0005	
Monoculodes acutipes Ledoyer, 1983*	3											3	0.01	0.05	0.0005	

(continued)

Annex I (continued)

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

(continued)

Annex I (continued)

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Urothoe pulchella (A. Costa, 1853)*					3							3	0.01	0.05	0.0005	
Caprella acanthifera Leach, 1814					7	7		7	3		3	27	0.05	0.37	0.0185	
Caprella danilewskii Czerniavski, 1868*				7					7			14	0.02	0.19	0.0038	
Caprella lilliput Krapp-Schickel & Ruffo, 1987*									13			13	0.01	0.19	0.0019	
Caprella mitis Mayeri, 1890*								3	3			6	0.02	0.09	0.0018	
Caprella rapax Mayer, 1890					103					3		106	0.02	1.49	0.0298	
Pseudolirius kroyerii (Haller, 1879)*									33			33	0.02	0.46	0.0092	
Pseudoprotella phasma (Montagu, 1804)									10			10	0.02	0.14	0.0028	
Phtisica marina Slabber, 1769	170	25	17	50	203	43		40	43	7	195	793	0.26	10.79	2.8054	+
Cumacea																
Iphinoe tenella Sars, 1878*		5										5	0.01	0.05	0.0005	
Iphinoe douniae Ledoyer, 1965*		5										5	0.01	0.05	0.0005	
Campylaspis macrophthalma Sars, 1878		3										3	0.01	0.05	0.0005	
Mysidacea																
Gastrosaccus normani G.O. Sars, 1877*	3						3				3	9	0.02	0.14	0.0028	
Tanaidacea																
Apseudes latreillii (Milne-Edwards, 1828)*	3	10	7		3							23	0.03	0.28	0.0084	
Apseudes intermedius Hansen, 1985*				7					7			14	0.03	0.19	0.0057	
Leptochelia savigny (Kroyer, 1842)		23	15		3					3	32	76	0.09	0.93	0.0837	

(continued)

Annex I (continued)

	Western coasts						Eastern coasts									
	North			South			South		North							
Species	**AK**	**KY**	**CB**	**KB**	**SD**	**AB**	**KL**	**GK**	**KF**	**DC**	**HS**	**Ni**	**Ci**	**Di**	**CixDi**	**Mid line**
Isopoda																
Jaeropsis brevicornis Koehler, 1885	3											3	0.01	0.05	0.0005	
Gnathia oxyuraea (Lilljeborg, 1855)*											5	5	0.01	0.05	0.0005	
Gnathia sp.		5			7			3				15	0.03	0.19	0.0057	
Janira maculosa Leach, 1814*			348		3		3	53				407	0.05	4.09	0.2045	+
Cymodoce tuberculata Costa in Hope, 1851*							3					3	0.01	0.05	0.0005	
Eurydice spinigera Hansen, 1890*										3		3	0.01	0.05	0.0005	
Paragnathia formica (Hesse, 1862)*		3										3	0.01	0.05	0.0005	
Anthura gracilis (Montagu, 1808)*					3							3	0.01	0.05	0.0005	
Synisoma capito (Rathke, 1837)		3										3	0.01	0.05	0.0005	
No. of individuals/m^2	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					