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Spatial distribution of copepod abundance in the epipelagic layer of the south Adriatic Sea

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An investigation into the spatial distribution of copepod abundance, using an "Adriatic Trap", in the epipelagic layer of the south Adriatic Sea, was performed during 4 cruises at 5 stations from April 1993 to June 1994. Samples were collected at 1, 5, 10, 20, 50, 75, and 100 meter depths. Nauplii were the most abundant identified at all stations and depths, corresponding to an average of 69-81% of all copepod individuals. With respect to the total number of postnaupliar copepods, the 0-50 m layer was dominated by specimens of calanoids (49.7%), while in the 50-100 m layer, the most abundant taxa were cyclopoida-oncaeids (31.5%), cyclopoida-oithonids (23.5%) and harpacticoids (6.7%). Our research also clearly indicates that copepodites and small adult copepods, such as calanoids, Paracalanus parvus, Clausocalanus paululus, oithonids Oithona similis, Paroithona parvula, oncaeids Monothula subtilis, Oncaea zernovi, Spinoncaea ivlevi and harpacticoids Microsetella norvegica, M. rosea, were particularly dominant in the euphotic zone. Consequently, the problem of loss of small and undeveloped copepods through standard plankton nets requires that other quantitative methods must be utilised for an objective evaluation of total copepod population.

Key words: zooplankton, copepods, distribution, sampling methodology, Adriatic Trap, Adriatic Sea

INTRODUCTION

Zooplankton has a non-random distribution in the pelagic community and exhibits various levels of patchiness (HAURY *et al*., 1978). Recently, particular attention has been focused on investigating the small-scale vertical and horizontal distribution of zooplankton assemblages which are important for monitoring marine processes and disturbances to marine ecosystems (PAFFENHÖFER & MAZZOCCHI, 2003; FERNÁNDEZ *et al*., 2004; ISLA *et al*., 2004; LEE *et al*., 2005; KIMMEL *et al*., 2006; ALBAINA & IRIGOIEN, 2007).

Currently, more research exists on the qualitative-quantitative composition of zooplankton than on their horizontal distribution. Research on vertical distribution is also rare, and has only occasionally been reported for both shallow and open marine waters. This is due to various difficulties arising from inadequate research using standard plankton nets. One of the main problems associated with investigating the small-scale vertical distribution of zooplankton stems from choosing the appropriate sampling method which, ideally, would enable analysis of the actual qualitative content and population density. In spite of many reports concerning sampling methodology, a universal method for all regions, various production situations and different zooplankton assemblages, has not yet been defined (FRASER, 1968; HARRIS *et al.*, 2000; WIEBE & BENFIELD, 2003).

In the open waters of the south Adriatic Sea, the vertical distribution of copepod assemblages was previously investigated using plankton nets equipped with a closing system, at depths from 100 m to the surface, usually in one or two hauls. Various mesh sizes were used for this purpose: 53 µm for small copepods (KRŠINIĆ, 1998; KRŠINIĆ & GRBEC, 2002), and 200 or 250 µm for other copepods (HURE *et al.*, 1980). However, population densities could not be determined for any of the above-mentioned assemblages using variously sized plankton nets and mesh size, and in particular the relationship between ecological factors at precise depths could not be analysed. A major problem is the loss of juvenile and undeveloped copepods through larger mesh sizes, while plankton nets made with fine mesh show poor filtering in euphotic layers due to phytoplankton densities. In addition, the selectivity of each net does not permit a thorough analysis of the entire copepod community, and the recommendations of UNESCO (1968) were not applied in the investigations.

A simple plankton trap was constructed to address the problems associated with zooplankton sampling, primarily in coastal waters (KRŠINIĆ, 1990). Preliminary investigations were performed (KRŠINIĆ & LUČIĆ, 1994), including an analysis of the annual variability of mesozooplankton assemblages in a bay in the eastern Adriatic (LUČIĆ & KRŠINIĆ, 1998). This paper presents the first dataset on the fine vertical distribution of copepod assemblages utilising the "Adriatic Trap" in the open waters of the south Adriatic Sea.

MATERIAL AND METHODS

Samplings were performed during 4 cruises (20-21 April, 1993; 16-17 September, 1993; 26-27 February, 1994 and 17-18 June, 1994), aboard the R/V "Bios" of the Institute of Oceanography and Fisheries, Split, Croatia (Fig.1). Five main stations were sampled along the transect from Dubrovnik (S-100) to the deepest part of the South Adriatic (S-1000), and the lighthouse Glavat, positioned between

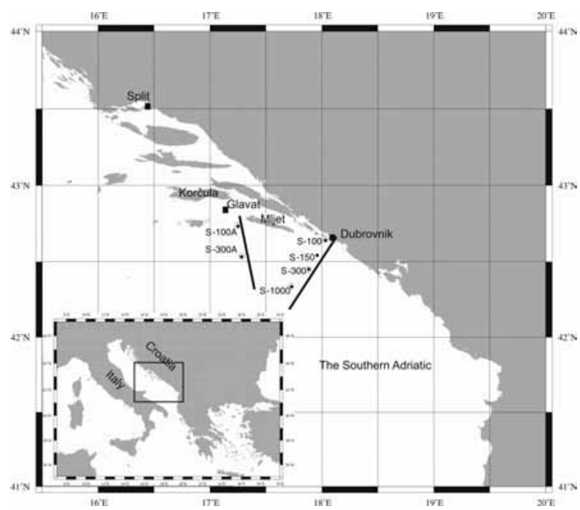

Fig. 1. Research area and sampling stations

the islands of Mljet and Korčula (S-100A), and Station S-150 (only hydrographical parameters). Depths of stations were: S-100 above 100 m; S-150, 150 m; S-300, 300 m; S-1000, 1000 m; S-300A, 300 m and S-100A above 100 m depth. Copepods were sampled using a 250 L volume "Adriatic Trap" (KRŠINIĆ, 1990), equipped with a 20 µm-mesh netting gauze cylinder. Sampling series were taken at 1, 5, 10, 20, 50, 75, and 100 m depths. Times of sampling are listed in Figures 4-7. Our study focused on nauplii (NAU), calanoids (CAL), cyclopoida-oithonids (OIT), cyclopoida-oncaeids (ONC) Poecilostomatoids and harpacticoids (HAR). Samples were preserved in a 2.5% formaldehyde-seawater solution neutralised with calcium carbonate buffer. Counting and species identification were performed using an Olympus inverted microscope at magnifications of x100 and x400.

One-sixteenth of each sample was analysed for common species, and the entire sample was analysed for rare species. Samples were counted in a glass cell with dimensions 7 x 4.5 x 0.5 cm.

Vertical temperature and salinity profiles were measured using an SBE (Sea Bird Electronic). The accuracy of the SBE measurements was at least 0.002°C for temperature, 0.0003 S/m for conductivity and 0.1% of the full-scale pressure range. The data were pre-processed and averaged vertically every 1 m.

The distribution of various water masses during the different cruises was obtained using collected CTD data and was presented on a standard TS diagram, with the mean values and standard deviations of each previously defined water mass noted (VILIBIĆ & ORLIĆ, 2001). This analysis was used to document the presence of different water masses during the different cruises, as a result of different atmospheric-oceanographic conditions.

The non-parametric Spearman's correlation coefficient (Rs) was used to test for correlations between copepod assemblages. In order to identify layers and assemblages with similar behaviours (in terms of variability within the copepod population) Principal Component Analysis (PCA) (PREISENDORFER, 1982) was performed to analyse: 1) the depth distribution of all copepod populations (for each depth n=83), and 2) copepod assemblages in the water column (for each assemblage n=141). PCA was applied following the procedure briefly explained in KRŠINIĆ & GRBEC (KRŠINIĆ & GRBEC, 2002). Variance analysis (one-way ANOVA) and Student-Newman-Keuls (SNK) multiple-range tests were used to determine statistical differences between seasonal means.

RESULTS

Thermohaline properties

In the study area, 4 water masses were identified: MAdDW (Middle Adriatic Deep water), SAdDW (South Adriatic Deep Water), LIW (Levantine Intermediate Water), and SW (Surface Water). The relative distribution and presence of these water masses during the cruises in this study are denoted in Fig. 2. In cruises from April 1993 and September 1993, the presence of LIW and SAdDW may be due to a barocline situation which occurs during the relatively warmer parts of the year (Fig. 2A). During the cruise in February 1994 (Fig. 2B), the water masses recognised in the region were MAdDW, LIW and SadDW. These water

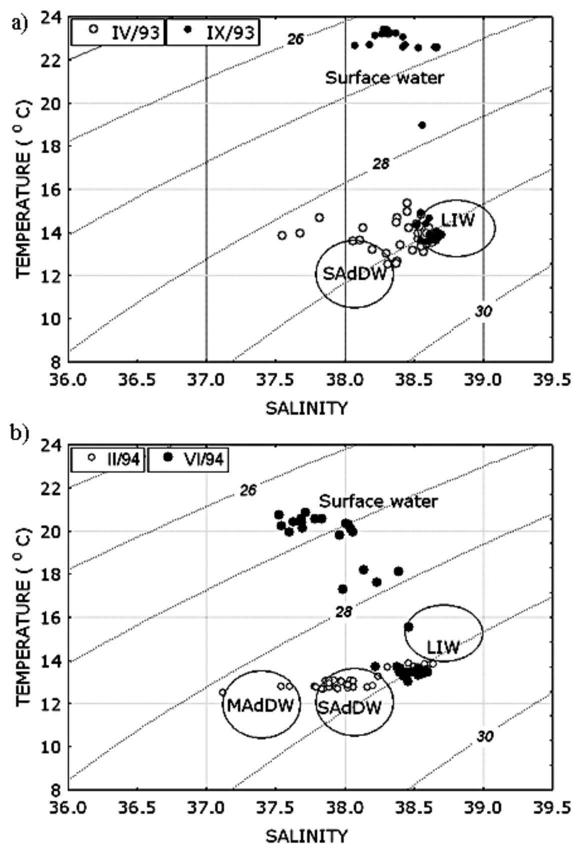

Fig. 2. T-S diagram obtained for all CTD cruises. Characteristic values of deep Adriatic water masses (MAdW-Middle Adriatic Deep Water, SAdW-South Adriatic Deep Water, and LIW –Levantine Intermediate Water) are denoted

masses were present throughout the water column, but at different stations. The surface layer was under atmospheric influence, but homogeneous conditions prevailed due to strong vertical mixing. During the summer cruise of June 1994, the intermediate layer was highly marked by the presence of LIW while thermohaline properties were undergoing heat and water flux exchanges at the surface.

Variability on the basis of depth layers

Copepod assemblages collected during the 4 cruises were decomposed using Principal Component Analysis in order to identify layers with similar copepod patterns. Three layers were distinguishable in the water column, representing 61% of the total variability of the copepod community. The first three extracted components were able to account for the variability observed in the lower layers (20, 50, 75, and 100 m; denoted PC1), surface layers (1 and 5 m; denoted PC2), and at a depth of 10 m (denoted PC3) (Fig. 3A). The PC1 layer encompassed a depth of 20-100 m, with the extracted factor accounting for 33% of the total variability in the copepod community. The second PC factor had significant surface loadings, and accounted for 17% of the total variability. The last extracted factor had significant loadings at the sub-surface, accounting for 11% of the variance.

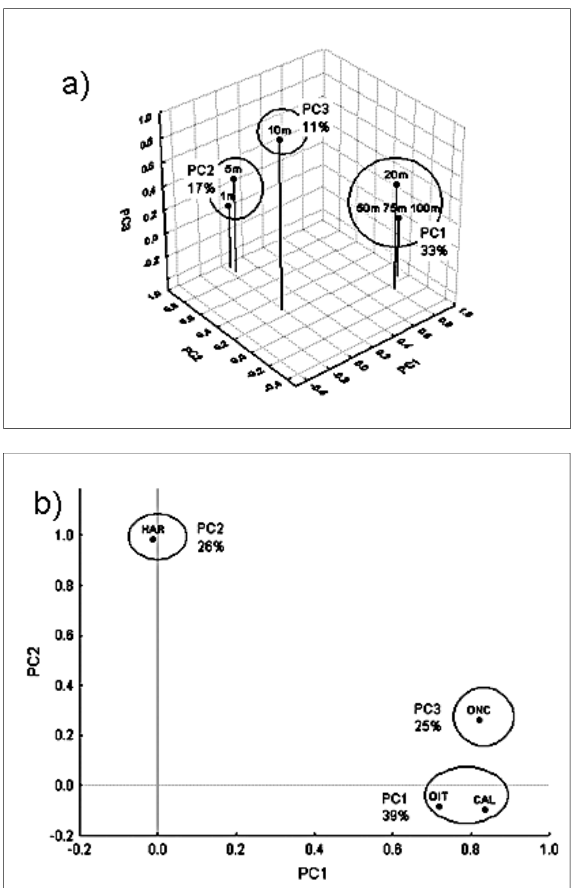

Fig. 3. a. Spatial representation (in PC-coordinate frame) of factor loadings extracted from the depth distribution of all copepod populations. The number above the circles indicates the depth layers; b. Spatial representation (in PC-coordinate frame) of factor loadings for the species distribution of copepod assemblages in the water column. The text above the circles indicates the copepod assemblages

Variability of assemblages

The same decomposition method was applied to the distribution of copepod populations, in order to identify group assemblages with similar behaviours. Eigenvalues for the first three extracted components accounted for 90% of the total variability of the assemblage community in the water column to a depth of 100 m. The first component, PC1, accounted for 39% of the total variability (CAL and CYC-OIT), PC2 accounted for 26% (HAR) and PC3 accounted for 25% (CYC-ONC), suggesting that the same conditions control the variability of these assemblages in the water column (Fig. 3B).

Copepod assemblages
Nauplii

Nauplii were the most abundant at all stations and during all seasons (Figs. 4A-7A). The highest percentage (81%) of nauplii were sampled in June 1994, concurrently with the lowest average nauplii abundance recorded (8141 ind. m^{-3}). Nauplii comprised 69% of the total sample during the February 1994 cruise, and made up 78% of the total sample collected during the April 1993 cruise when the highest average abundance (14912 ind. m^{-3}) was recorded. Maximum nauplii abundance values were recorded in April 1993 (72310 ind. m^{-3} at 5 m depth at station S-300 and 69160 ind. m^{-3} at 50 m depth at station S-100) (Fig. 4A). During all cruises, a significant correlation between nauplii abundance and the abundance of calanoids (CAL), oncaeids (CYC-ONC) and oithonids (CYC-OIT) was noted, except during the September 1993 cruise. Harpacticoid abundance did not correlate with nauplii

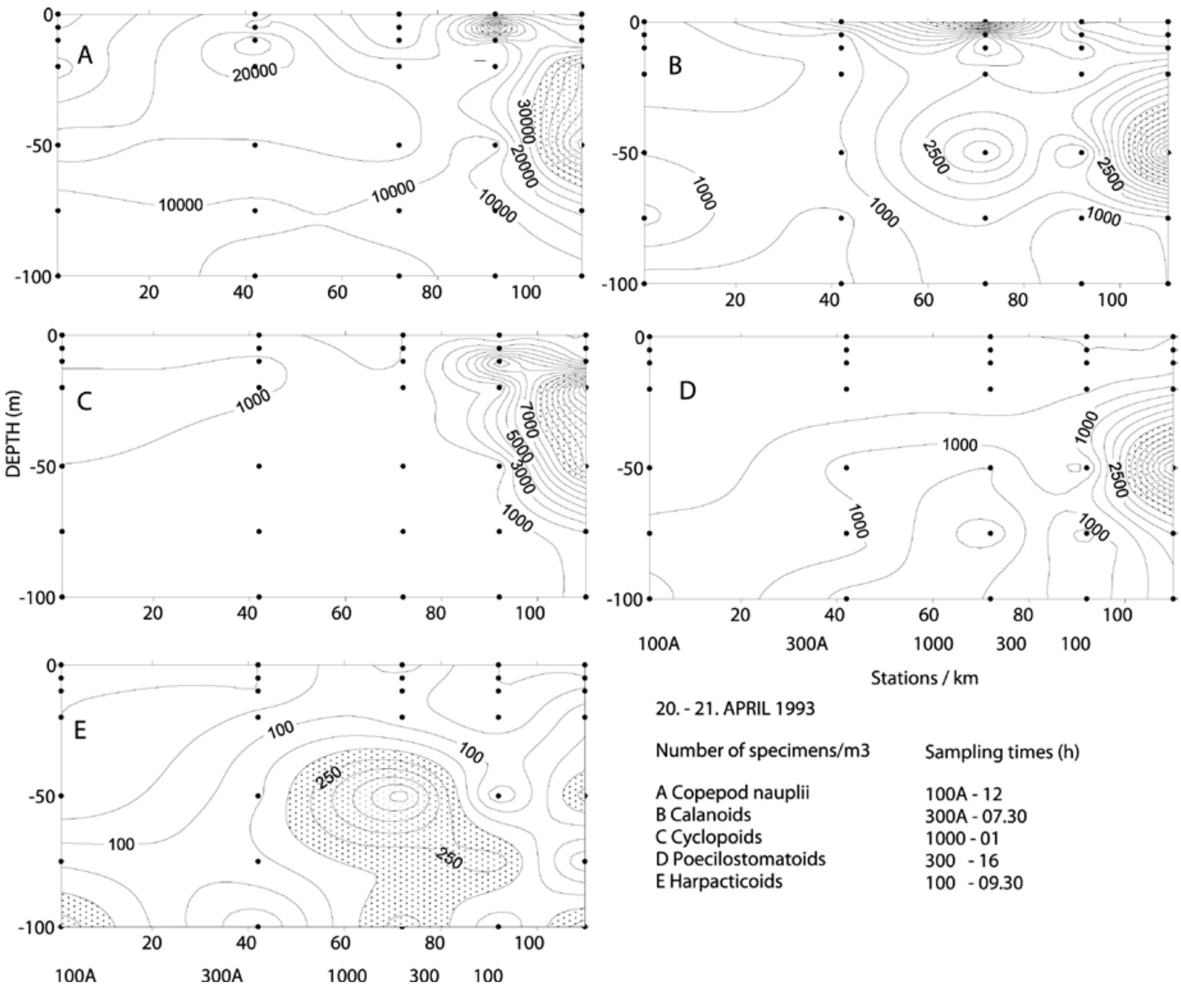

Fig. 4. Isopleth diagram for copepod population abundance along the S-100A - S-1000 and S-1000 - S-100 profiles, during the April 1993 cruise in the southern Adriatic

abundance, and no significant differences were found between seasons (Table 1).

Calanoids

Calanoids were the most numerous, comprising on average 49.7% of the total number of copepodites and adult copepods in the 50 m layer, while only 38.2% were noted in the 50-100 m layer (Figs. 4B-7B). The lowest average calanoid abundance was recorded in June 1994 (476 ind. m^{-3}) and the highest spatial densities were recorded at station S-300A, with a predominance of calanoid copepodites. The highest average abundance (2687 ind. m^{-3}) was recorded in February 1994, with a pronounced abundance of copepodites and adult *Clausocalanus arcuicornis*, particularly at stations S-100 and S-1000 (Fig. 6B). In addition, a maximum calanoid abundance value was recorded in April 1993 at station S-100 (10080 ind. m^{-3}, 50 m depth), where total number of copepodites and adults of *Paracalanus parvus*, *Ctenocalanus vanus, Acartia clausi* and *Centropages typicus* were the most frequently recorded species, and at station S-1000 (10752

Table 1. Spearman's correlation coefficient (R_s) between copepod assemblages during 4 cruises

April 1993 (n=35)				
	NAU	CAL	CYC.OIT	CYC.ONC
NAU				
CAL	**0.392; p=0.020**			
CYC.OIT	**0.624; p=0.000**	**0.421; p=0.012**		
CYC.ONC	**0.511; p=0.002**	**0.565; p=0.000**	**0.474; p=0.004**	
HAR	0.092; p=0.596	**0.371; p=0.028**	0.129; p=0.458	**0.473; p=0.004**
September 1993 (n=32)				
NAU				
CAL	**0.615; p=0.000**			
CYC.OIT	0.288; p=0.109	0.253; p=0.162		
CYC.ONC	**0.439: p=0.012**	0.001; p=0.995	0.162; p=0.375	
HAR	0.222; p=0.237	0.083; p=0.662	0.177; p=0.349	0.802; p=0.637
February 1994 (n=34)				
NAU				
CAL	**0.657; p=0.000**			
CYC.OIT	**0.707; p=0.000**	**0.761; p=0.000**		
CYC.ONC	**0.563; p=0.001**	**0.654; p=0.000**	**0.504; p=0.003**	
HAR	**0.341; p=0.048**	**0.430; p=0.011**	0.279; p=0.116	**0.693; p=0.000**
June 1994 (n=35)				
NAU				
CAL	**0.658; p=0.000**			
CYC.OIT	**0.717; p=0.000**	**0.383; p=0.023**		
CYC.ONC	**0.648; p=0.000**	**0.523; p=0.001**	**0.670; p=0.000**	
HAR	0.156; p=0.370	0.144; p=0.409	0.156; p=0.369	0.211; p=0.223

ind. m^{-3}, 0 m depth) where *C. arcuicornis* predominated (Fig. 4B). A significant difference was noted between calanoid population abundance recorded in February 1994 and June 1994 (one-way ANOVA; SNK test, p<0.001). Calanoid abundance was also significantly correlated with CYC-OIT and CYC-ONC, except during September 1993 (Table 1).

Cyclopoida-oithonids

Oithonids represented 29.5% of the total number of copepodites and adult copepods in the 50 m layer and 23.5% in the 50-100 m layer (Figs. 4C-7C). A significant difference was found between oithonid abundances recorded in April 1993 and February 1995 (one-way ANOVA; SNK test, p<0.001), when the highest average abundance of 1735 ind. m^{-3} in April 1993 and only 499 ind. m^{-3} in February 1995 were recorded. A maximum oithonid abundance of 18780 ind. m^{-3} was noted at a depth of 20 m at the S-100 coastal station in April 1993 (Fig. 4C), and predominated by copepodites and adult specimens of the species *Oithona nana*. The higher oithonid values observed at station S-1000 during other seasons were due to copepodites and adult specimens of *O. similis* and *Paroithona parvula.*

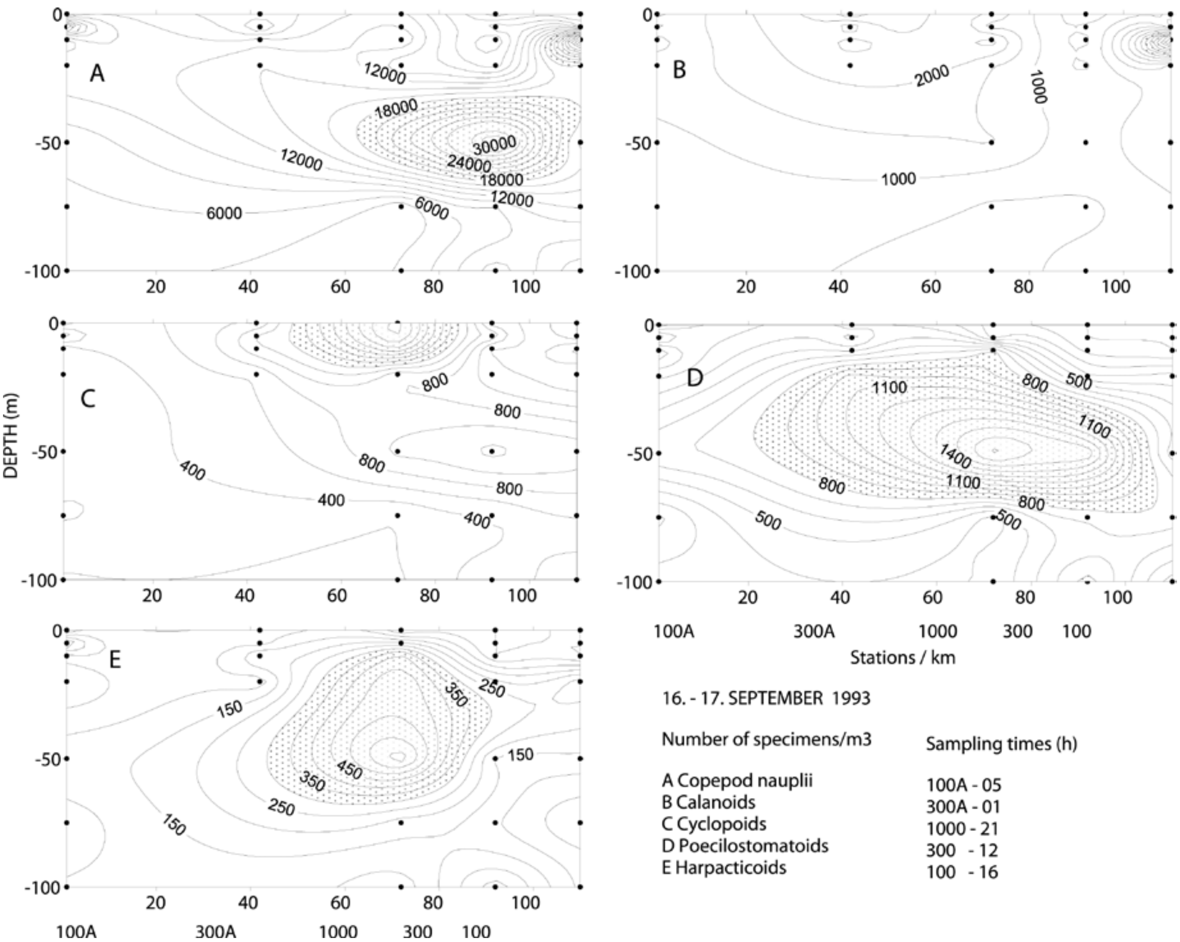

Fig. 5. Isopleth diagram for copepod population abundance along the S-100A - S-1000 and S-1000 - S-100 profiles, during the September 1993 cruise in the southern Adriatic

Cyclopoida-oncaeids

Oncaeids comprised 16% of the total number of copepodites and adult copepods found from the surface to a depth of 50 m, and 31.5% in the 50-100 m layer. No significant differences were found between seasons. The abundance distribution for oncaeids is shown in Figs. 4D-7D. The highest abundance of oncaeids was most frequently recorded at the neritic station, S-100. Oncaeids were the most abundant at deep sea stations in September 1993 and at station S-100A in June 1994. At typical open sea stations, at depths from 75 to 100 m, the small species *Oncaea zernovi* markedly predominated, along with *Monothula subtilis* and *Spinoncaea ivlevi*. The abundance of *O. zernovi* reached values of 520 ind. m^{-3} in February 1994 (at a depth of 20 m at station S-100). The highest average oncaeid abundance values were recorded in February 1994 (1143 ind. m^{-3}) when a maximum value of 8080 ind. m^{-3} was recorded at a depth of 20 m at station S-100 (Fig. 6D). These samples were dominated by copepodites and adult specimens of *M. subtilis* and *Oncaea waldemari*. Oncaead abundance significantly correlated with oithonid abundance, except during September 1993 (Table 1).

Harpacticoids

Harpacticoids represented an average of 4.4% of the total number of copepods and adult copepods from the surface to a depth of 50 m, and 6.7% between 50 and 100 m

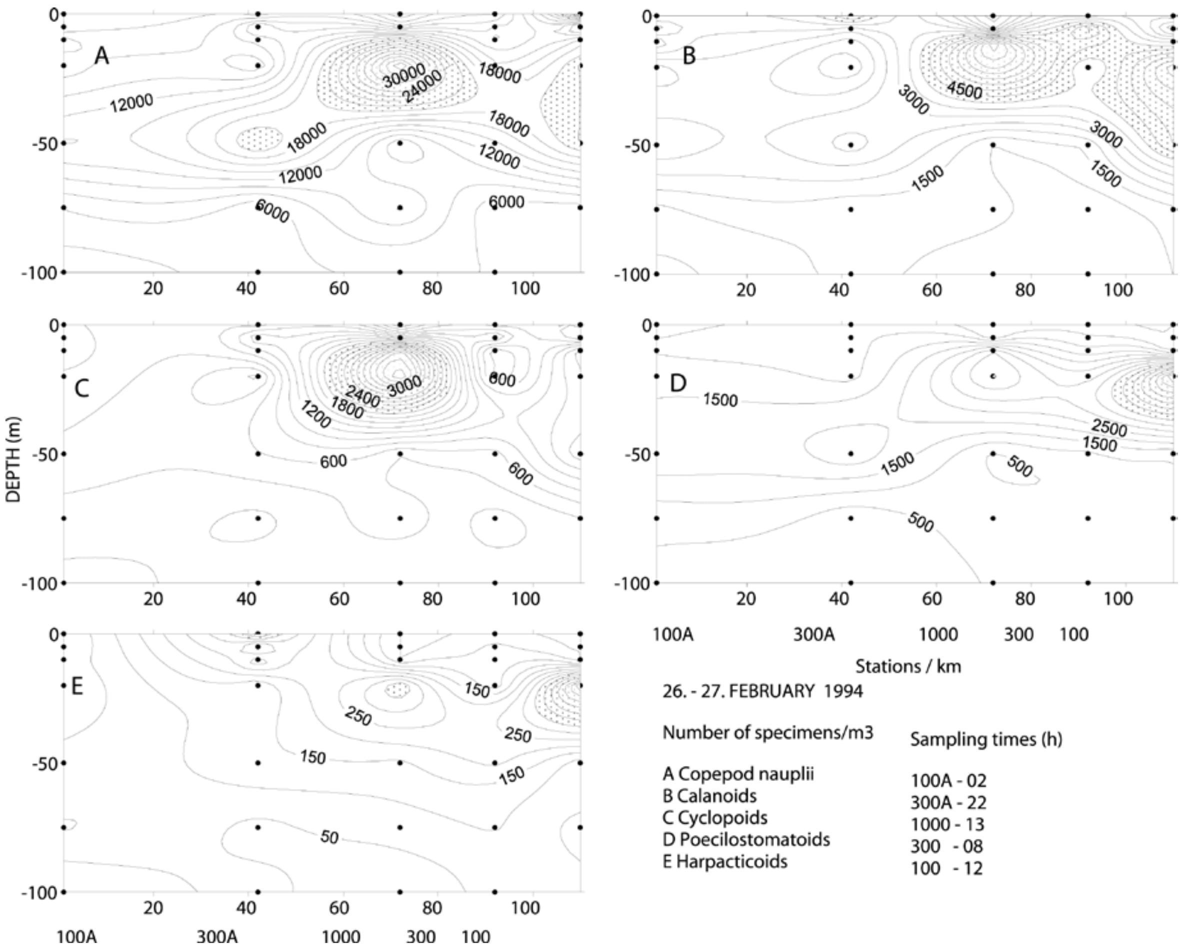

Fig. 6. Isopleth diagram for copepod population abundance along the S-100A - S-1000 and S-1000 - S-100 profiles, during the February 1994 cruise in the southern Adriatic

depths (Figs. 4E-7E). In June 1994, the highest average harpacticoid abundance (450 ind. m^{-3}) was recorded, representing 24% of the total number of copepodites and adult copepods. No significant differences were identified between population abundances recorded in June 1994 and all other seasons (one-way ANOVA; SNK test, $p<0.001$). High harpacticoid abundance values were also recorded at stations S-300 and S-1000, with a maximum of 1800 ind. m^{-3} sampled at a depth of 20 m at station S-300 (Fig. 7E) and dominated by *Microsetella norvegica* and *M. rosea*. No correlation was found between harpacticoid abundance and other groups of copepods during cruises in September 1993 and June 1994 (Table 1).

DISCUSSION

The results presented in the current study demonstrate the efficiency and utility of sample collection using an “Adriatic Trap” for quantitative analysis of copepod assemblages in specific layers of open oligotrophic waters of the Adriatic Sea, in agreement with similar studies focusing on eastern coastal areas (KRŠINIĆ & LUČIĆ, 1994; LUČIĆ & KRŠINIĆ, 1998). The use of this “Adriatic Trap” completely reduces avoidance by all assemblages, which can actively escape the mouth area of nets, extrusion of small organisms through the mesh, and the loss of organisms upon net closing. These problems associated with net samplings have been very well documented by HARRIS *et al*., (2000). Our results confirm earlier investigations, where a

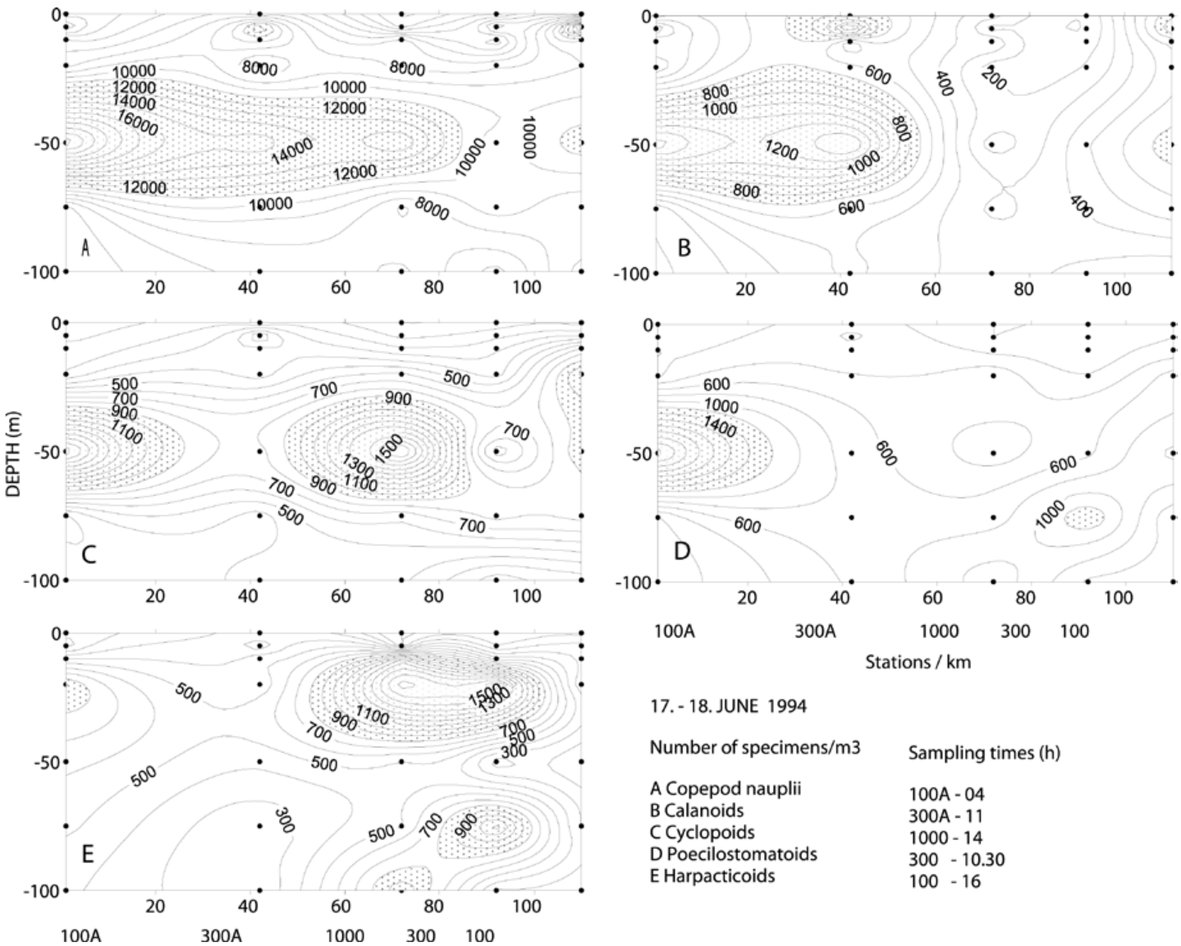

Fig. 7. Isopleth diagram for copepod population abundance along the S-100A - S-1000 and S-1000 - S-100 profiles, during the June 1994 cruise in the southern Adriatic

150 L volume sampler yielded more organisms than a 180 μm fine plankton net in various trophic waters of the Pacific Ocean and Black Sea (VINOGRADOV *et al*., 1987).

With respect to the total number of assemblages, PCA recognised three separate communities in the euphotic surface , layer, (1-5m), 10 m layer, and between 20-100 m depths. Previous studies had investigated the distribution of small copepods in the surface community (0-50 m) and the subsurface community (50-100 m) in the open seas of the southern Adriatic (KRŠINIĆ, 1998). The present study investigated the fine-scale vertical distribution of copepods, and has revealed that they are not proportionately distributed within these communities, in agreement with many investigations (JUDKINS, 1980; NISHIDA & MARUMO, 1982; UEDA, 1987; PAFFENHÖFER & MAZZOCCHI, 2003). However, in order to develop a more complete understanding of the vertical distribution of copepods, samplings were conducted at a greater number of levels in the present study, particularly between depths of 20 to 100 m. In the southern Adriatic, the lowest copepod abundance values are usually recorded at the surface during sunny days. The centre of the copepod population in layers between 5-50 m depths, is specific for each assemblage, and can vary from station to station, the time of day, meteorological conditions, insolation, the sampling season, and production conditions. A copepod community is also typically found between depths of 50-100 m with lower density values, and is predominated by oncaeids and harpacticoids. This research did not include day-night migration effects. However, night-time samplings are obviously richer in species (see Figures 4-7), with the centre of the population occurring at the surface or just below the surface, particularly for calanoids and oithonid copepods (PAFFENHÖFER & MAZZOCCHI, 2003). Moreover, different atmospheric and boundary-layer conditions result in the presence of different water masses at different depths, and each type of water mass is related to the presence of a characteristic species or group of species (KRŠINIĆ & GRBEC, 2002). Many epiplanktonic copepods are always present in populations in the central area of the south Adriatic (Stations S-300, S-300A and S-1000), including *Clausocalanus arcuicornis*, *Paroithona parvula*, *Oncaea zernovi*, *Spinoncaea ivlevi* and *Microsetella rosea.* While low abundant or rare species such as the oncaeids *Triconia dentipes*, *Oncaea minima*, *O. vodjanitskii* and others, regenerate under the influence of LIW water masses in the euphotic layer of the central part of the pit, this was exceptionally pronounced in June 1994. Therefore, their distribution toward the eastern shoreline and the central Adriatic can be related to water masses (ZORE-ARMANDA, 1963) and the main inflowing currents of the Adriatic (ORLIĆ *et al*., 1992). Unfortunately, this research is insufficient to understanding of distribution the low abundant and very rare species.

Copepods are the dominant organisms in any marine habitat, but few open water investigations have taken the entire population into consideration due to limitations in sampling methods. Many authors include nauplii, earlier copepodites and all small copepods in the micro-zooplankton category, which were not considered in the evaluation of total copepod populations presented in this study. A 250 μm net was commonly used for early copepod research in the south Adriatic (HURE *et al*., 1980; HURE & KRŠINIĆ, 1998) and a 53 μm plankton net for small-copepod studies (KRŠINIĆ, 1998). This work presents the first results evaluating realistic quantitative relationships between various copepod groups in the entire copepod population in the open waters of the south Adriatic. It is very important to note that a comparison of sampling methods (net versus "Adriatic Trap") did not reveal significant differences in the relative relationships between copepod groups (KRŠINIĆ, unpublished data). In spite of significant variations in abundance values, a direct comparison was not easy because the net sampling method gives average density values for hauls at 50 m, while the plankton trap yields only a few specific samples at standard hydrographic levels which are not enough for an objective evaluation of the validity of net samplings.

The first cluster consisted of calanoids and oithonids (PC1), and the second cluster consisted of harpacticoids (PC2), while oncaeids were included in a separate cluster (PC3). A marked domination by calanoid and oithonid copepodites and adults was uncovered in layers at 5-50 m depths. In contrast, deeper layers had significant increases in the proportion of oncaeids and harpacticoids (KRŠINIĆ, 1998). The smallest difference between nauplii and post-nauplii copepods was a 2.3:1 ratio, recorded in February 1994, when the maximum average abundance values for nauplii and all other groups were recorded (with the exception of harpacticoids). In contrast, the largest difference (4.4:1) was noted in samplings taken in June, coinciding with the lowest average abundance values for nauplii and other groups (with the exception of harpacticoids, for whom maximum abundance values were obtained). During the course of research conducted along the transect of the south Adriatic from 1998 to 2007, maximum abundance samplings of post-nauplii copepods almost always coincided with maximum abundance values for nauplii, where the differences varied from 2.2 to 3.3 times. In the coastal waters of the Adriatic, in the period from 1994 to 2000, 2.5 to 3.5 times more nauplii were detected, on average, for every one postnaupliar copepod (KRŠINIĆ, unpublished data). According to our research, the ratio between nauplii and postnauplii copepods is an important characteristic indicator of a particular area and can be used to monitor disturbances in the pelagic zone. However, such conclusions require additional research in areas with various production conditions.

A deep chlorophyll maximum (DCM) in the open waters of the south Adriatic was discovered in a layer between 50-75 m (JASPRICA *et al*., 2001). Carnivorous copepods are dominant in this layer which is a sign of decomposition and regeneration. In the layer above this DCM, the maximum density values of copepodites and adult calanoid copepods were found which is exceptionally important for regulating phytoplankton production. Specifically, an abundance of herbivore copepods results in substantial grazing pressure, as has been observed in the tropical Pacific (ROMAN *et al*., 1995). The present investigation demonstrates that fine-scale research into the vertical distribution of copepod populations is a very important component to the examination of processes in the euphotic layer of open sea waters. All of the stations used in this study were located in oligotrophic regions of the open sea (VILIČIĆ *et al*., 1989). Only S-100 was occasionally affected by coastal waters, as evidenced by the domination of neritic species for all groups and the relatively higher copepod abundance observed (for example in April 1993). However, according to VILIČIĆ (1998), this station was rich in abundance of such copepod species at the same time that offshore accumulation of microphytoplankton was observed in the south Adriatic gyre interior.

Our research also clearly indicates the dominant abundance of nauplii, copepodites, calanoid copepod species such as *Paracalanus parvus*, *Clausocalanus arcuicornis*, *C. paululus,* and *Ctenocalanus vanus*, copepodites adult specimens of oithonid *Oithona similis*, oncaeids *Monothula subtilis*, and *Oncaea zernovi*, including the harpacticoid *Microsetella norvegica*, in layers from 0-50 m depth. In layers deeper than 50 m, the oithonid *Paroithona parvula*, oncaeid *Spinoncaea ivlevi*, and harpacticoid *Microsetella rosea* were particularly dominant. The average abundances of all post-nauplii copepods in the water column down to 100 m depth ranged from 1840 ind. m^{-3} (June 1994) to 4800 ind. m^{-3} (February 1994) while the average copepod abundance for the same region of the Adriatic was less than 200 ind. m^{-3}, according to HURE *et al*., (1980), on the basis of hauls using a plankton net pulled from the sea bottom (~1000 m depth) to the surface. SHMELEVA (1964) presented quantitative data for some calanoids, with maximum values for *Clausocalanus paululus* determined to be 1000 ind. m^{-3} in autumn at the surface, with an annual mean of 125 ind. m^{-3}.

In conclusion, our results are in agreement with the latest research from various oceanic regions, demonstrating that small copepods and their developmental stages are continuously dominant in the epipelagic zone, and are thus of great significance throughout trophic levels (HOPCROFT *et al*., 2001; UYE *et al*., 2002; PAFFENHÖFER & MAZZOCCHI, 2003; TURNER, 2004, ZERVOUDAKI *et al*., 2007; BÖTTGER-SCHNACK *et al*., 2008). This paper highlights the existence of significant variations in the vertical distribution of copepods, indicating that other quantitative methods must be utilised alongside the standard plankton net, such as plankton pumps, large volume pumps, or the "Adriatic Trap", which was utilised here to analyse fine-scale vertical copepod distributions.

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Prostorna raspodjela brojnosti kopepoda u eufotičnom sloju južnog Jadrana

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SAŽETAK

Istraživanja prostorne raspodjele brojnosti kopepoda (veslonožaca) korištenjem uređaja «Adriatic» u epipelagičnom sloju južnog Jadrana obavljena su za vrijeme 4 krstarenja od travnja 1993 do lipnja 1994 na 5 glavnih postaja. Uzorci su uzeti na 0, 5, 10, 20, 50, 75 i 100 m dubine. Naupliji su bili najbrojniji na svim postajama i dubinama, sudjelujući prosječno od 69 do 81% od brojnosti svih kopepodskih jedinki. S obzirom na ukupne vrijednosti postnauplijarnih kopepoda u sloju 0 do 50 m prevladavaju kalanoidi (49,7%), dok su u sloju od 50 do 100 m dubine najbrojniji primjerci onceidnih ciklopoida (31,5%), oitonidnih ciklopoida (23,5%) i harpaktikoida (6,7%). Naša istraživanja jasno ukazuju da su kopepoditi i odrasli mali kopepodi kao: kalanoidi, *Paracalanus parvus, Clausocalanus paululus,* oitonidi *Oithona similis*, *Paroithona parvula*, onceidi *Monothula subtilis*, *Oncaea zernovi*, *Spinoncaea ivlevi* i harpaktikoidi *Microsetella norvegica*, *M. rosea* osobito brojni u eufotičkom sloju. Stoga problem gubljenja malih i nezrelih kopepoda kroz standardne planktonske mreže mora se rješavati korištenjem drugih kvantitativnih metoda s kojima bi postigli objektivniju procjenu ukupne kopepodske populacije.

Ključne riječi: zooplankton, raspodjela, metodika uzorkovanja, Adriatic Trap, Jadransko more