

Zooplankton composition and distribution across coastal and offshore waters off Albania (Southern Adriatic) in late spring

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We present for the first time composition, numerical abundance and vertical structure of micro- and mesozooplankton in the Albanian coastal and open sea region. Zooplankton was sampled at six stations on the 75-km long continental shelf slope transect in May 2009. The most numerous microzooplankton were copepod nauplii (maximum: 39 ind. L⁻¹), followed by calanoid and cyclopoid copepodites (maxima: 5 and 4 ind. L⁻¹, respectively). The most abundant of fourteen tintinnid species was Tintinnopsis radix, found in the surface to 50 m layer. The species composition of the coastal and open sea mesozooplankton was similar to that previously reported for the south Adriatic Sea. The copepod Oithona similis was the dominant species at all stations, followed by Oithona plumifera, Acartia clausi, Paracalanus parvus, Oithona nana and cyclopoida-oncaeiids at the shallower coastal stations, and Clausocalanus pergens, Oithona plumifera and Oithona nana offshore. Mesozooplankton diversity rose considerably from the coast to the open sea. Mesozooplankton abundance exhibited the opposite trend, with the maximum (2286 ind. m⁻³) noted at the shallowest station. Findings of typically open sea tintinnid and copepod species at the coastal station indicate the high influence of currents from the open sea area during our investigation. Our results suggest the low influence of fresh water on zooplankton population densities, even at the shallow stations where penetration of fresh water in the surface layers was notable.

Key words: microzooplankton, mesozooplankton, species diversity, Mediterranean Sea

INTRODUCTION

The Adriatic Sea is a semi-enclosed sea, forming a separate sub-region within the Mediterranean Sea. The Southern Adriatic region is deep and oligotrophic (FAGANELI *et al.*, 1989). Nutrients are supplied mainly via intrusions of the Ionian Surface Water and Levantine Intermediate Water, which periodically stimulate intense phytoplankton bloom episodes in the centre of the Southern Adriatic cyclonic gyre (GAČIĆ *et al.*, 2002; MOROVIĆ *et al.*, 2004). The dynamics of both the Southern Adriatic and Ionian Sea are intimately linked by means of the Bimodal Oscillating System mechanism that changes the circulation of the North Ionian Gyre from cyclonic to anticyclonic and *vice versa*, on decadal time scales (CIVITARESE *et al.*, 2010).

In contrast to other areas of the Adriatic Sea, there is still poor knowledge of the hydrographic conditions, plankton production and distributions in waters off Albania. Albanian rivers have not been seriously considered as a physical force or a nutrient source, although these rivers have an average discharge of $1\,308\text{ m}^3\text{ s}^{-1}$ (CULLAJ *et al.*, 2005) and thus could greatly influence the south-eastern coastal area. The first data on the distribution of nutrients, picoplankton and phytoplankton community in the southern Adriatic off Albania are presented by ŠILOVIĆ *et al.* (2011) and VILIČIĆ *et al.* (2010). These studies give the first insight into the fine scale oceanography of the area in which Albanian shelf riverine waters come into contact with the Eastern Adriatic Current. Knowledge of zooplankton is also weak and restricted to the two bays: MIGLIETTA *et al.* (1997) investigated protist and metazoans resting stages of the Butrinto Bay; MOSCATELLO & BELMONTE (2006) presented mesozooplankton species composition and abundance in the Gulf of Vlorë; and MOSCATELLO *et al.* (2011) describe space distribution of microzooplankton in the same bay. SHMELEVA (1964, 1965, 1969) collected some zooplankton samples in the border area of Albanian open sea waters, focused mostly on the qualitative composition and description of the small copepod species of the genera *Calocalanus* and *Oncaea*.

The aim of this study is to present for the first time information on (1) microzooplankton and (2) mesozooplankton communities along the coastal-open sea transect of the waters off Albania. For provide this aims, we selected 6 stations along transect from the coastal area to the deep open sea Albanian waters. Although short time sampling (May 2009), we hypothesized that we could recognize the influence of the river plume and/or the open sea on the zooplankton community.

MATERIAL AND METHODS

Study area

The Albanian coastal zone is a narrow shelf area smoothly sloping into the Southern Adriatic Pit. Circulation of this area is greatly influenced by the inflowing Eastern Adriatic Current (Ionian Surface Water and Levantine Intermediate Water), relatively large amounts of riverine inflow, and wind action (GAČIĆ *et al.*, 2001). In May 2009, increasing sea surface temperature were noted, together with the development of warm patches in response to calm and sunny weather, and the average temperature values appeared generally higher than the average of the six previous years, in particular in the middle of the southern Adriatic basin (VILIČIĆ *et al.*, 2010). Detailed description of hydrography conditions over the same period and at the same stations is presented in ŠILOVIĆ *et al.* (2011) and VILIČIĆ *et al.* (2010). According to the above authors, water temperature ranged from 13.3°C (A900, 200 m) to 20.9°C (A200, surface), with thermal stratification in the first 40 m. Salinity varied between 33.8 (A50, surface) and 38.8 (A300, 280 m). Average surface layer salinity gradually decreased from station A900 to the coast, indicating the plume from the Albanian rivers. The 0-150 m layer of stations A50 to A150, as well as the 0-100 m layer of the stations A200 to A1000 was covered by the Ionian surface water, while the core of the Levantine Intermediate Water (Eastern Adriatic Current) ingression was indicated in the layer below 100 m, westward of the A200 station.

Samples collection and analysis

The research was carried out in May 2009 at six stations (A50, A150, A200, A300, A900 and A1000) on a 75-km long transect in a SW (230°) direction from the Drini Bay shelf, passing over its edge and along the continental slope (Fig. 1).

Microzooplankton samples were taken using 5-l Niskin bottles at four to eight depths (0, 5, 20, 50, 75, 100, 200 and 300 m), depending on the station depth. Samples were filtered through 53 µm mesh and preserved with 2.5% neutralized formaldehyde. Tintinnids, nauplii, copepodites and small adult copepods were analysed, only. In the laboratory, the samples were counted in a glass cell of dimensions 7 x 4.5 x 0.5 cm, using an Olympus inverted microscope at magnifications of 100x and 400x. Abundance was expressed as ind. L⁻¹.

Mesozooplankton samples were collected using a Nansen plankton net equipped with a closing system. The average hauling speed of all tows was 0.5 m s⁻¹. Two mesh sizes were used: 125-µm mesh size (40 cm opening) for coastal stations A50 and A150, and 200-µm mesh size (57 cm opening) for offshore stations

A200, A300 and A900. Except for station A50, where samples were taken from the bottom to the surface, vertical tows were taken in two oceanographic layers (50–0 m, and from the bottom (or 300 m for stations A300 and A900), to 50 m). Samples were preserved with buffered formaldehyde (2.5% final concentration) until laboratory analysis. Whole samples were analyzed under the Olympus stereomicroscope. Taxonomic determination was performed at the lowest possible taxonomic level. Mesozooplankton abundance was expressed as ind.m⁻³.

Data were contoured with the graphical program Surfer 7 for Windows (Golden Software). Mann-Whitney's nonparametric test was used to compare the abundances between stations. Diversity was estimated, at species or genus level, from each station, calculating the Shannon–Weaver diversity index (H' ; SHANNON & WEAVER, 1949), using the PRIMER 5 software (CLARKE & WARWICK, 2001).

RESULTS

Microzooplankton

The highest total microzooplankton abundance of 63 ind. L⁻¹ was noted at the surface at A50 (Fig. 2). Abundances decreased with depth, and towards the open sea. However, according to a Mann–Whitney test, there was no significant difference in abundance between stations.

The most abundant of fourteen tintinnid species (Table 1) was *Tintinnopsis radix*, with a maximum of 36 ind. L⁻¹ at A300. This species was found from the coastal stations to A300, with a considerable range of vertical distribution from surface to 200 m depth. Other tintinnids were less numerous. The highest abundance of 4 ind. L⁻¹ was recorded for *Tintinnopsis nana* only at the surface of station A50. Vertical distributions of most of other tintinnids were restricted to the zone above 50 m depth (Fig. 3). *Xystonella lohmanni* and *Dadayiella ganymedes* were recorded between 50 and 100 m, and *Salpingella glockentoegei* below 100 m depth. Species found only in the open sea (A300–A1000) were: *Protorhabdonella curta*, *Xystonella lohmanni*, *Dictyocista muelleri*, *Dadayiella ganymedes* and *Salpingella glockentoegei*.

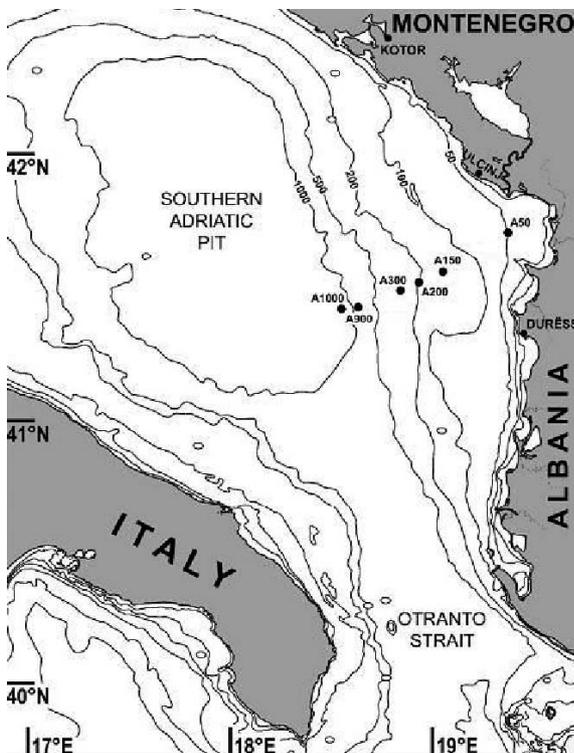


Fig. 1. Study area with the sampling stations

Table 1. Distribution of tintinnid species according to the depth range (m) and maximum abundance (ind. L⁻¹)

SPECIES	A50		A150		A200		A300		A900		A1000	
	depth range (m)	max. abund. (ind. L ⁻¹)	depth range (m)	max. abund. (ind. L ⁻¹)	depth range (m)	max. abund. (ind. L ⁻¹)	depth range (m)	max. abund. (ind. L ⁻¹)	depth range (m)	max. abund. (ind. L ⁻¹)	depth range (m)	max. abund. (ind. L ⁻¹)
<i>Codonella aspera</i>			5-20	1	5-75	1	100	1	5	1		
<i>Tintinnopsis levigata</i>	surface	1										
<i>Tintinnopsis nana</i>	surface	4										
<i>Tintinnopsis radix</i>	0-20	3	surface	1	0-200	1	0-50	36				
<i>Epiplocytilis undella</i>			20	1			20	1				
<i>Protorhabdonella curta</i>							50	1				
<i>Rhabdonella spiralis</i>	20	1			20	1					0-20	2
<i>Xystonella lohmanni</i>									75	1		
<i>Dictyocysta elegans</i>			20	1								
<i>Dictyocysta muelleri</i>											100	1
<i>Dictyocysta mitra</i>			20	1					surface	1		
<i>Dadaviella ganymedes</i>												
<i>Eutintinnus fraknoi</i>	surface	1					50	1	75	1		
<i>Salpingella glockentoegei</i>					50-100	1			200	1		

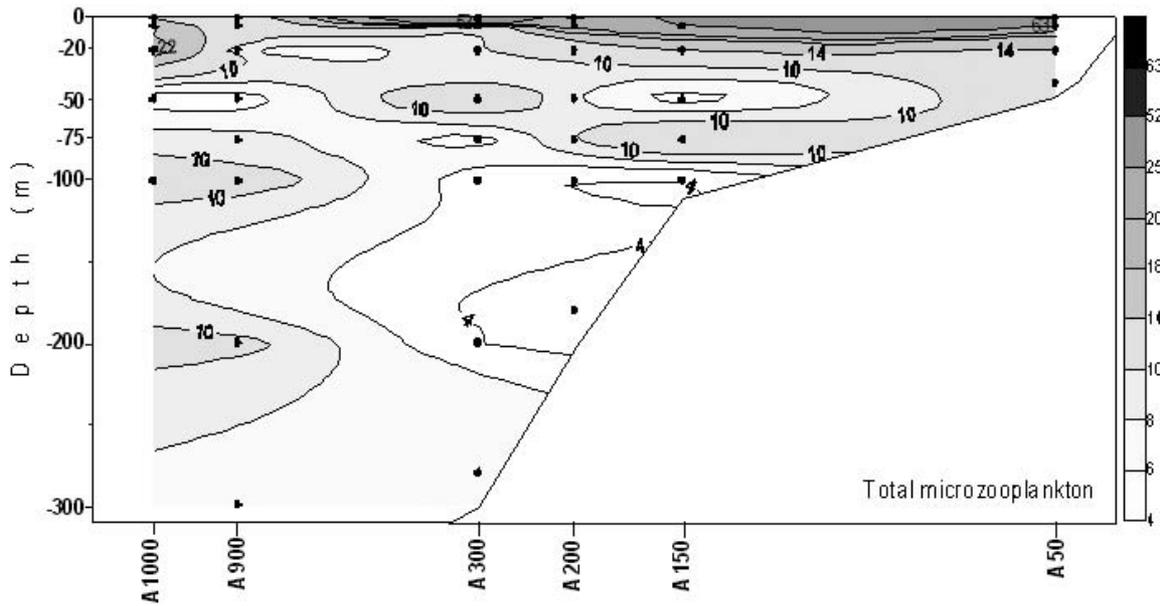


Fig. 2. Distribution of total microzooplankton along the profile (ind.L⁻¹)

The most numerous microzooplankton metazoans were copepod nauplii with a maximum of 39 ind. L⁻¹ at A50. Abundance decreased from the coastal stations toward open sea stations, and from the surface to deeper layers (Fig. 3). Abun-

dance of the other microzooplankton metazoans (copepodites and small adult copepods) was lower than nauplii densities, with maximum of 10 ind. L⁻¹ recorded at 20 m at A1000 station. We recorded five small copepod species: *Oithona nana*, *Oithona similis*, *Monothula subtilis*, *Oncaea waldemari* and *Microsetella norvegica*.

Mesozooplankton

We identified a total of 97 mesozooplankton taxa (Table 2). Species numbers were lowest in the coastal region (A50 and A150), where 35 taxa were noted. The highest species richness was found in the deep layer of station A900, where we found a total of 51 taxa (26 Copepoda, five Hydromedusae, six Calycophorae, five Euphausiacea, three Appendicularia, three Chaetognatha, two Pteropoda and one Hyperiidea). The Shannon–Wiener diversity index ranged from 1.6 to 2.9, with generally lower values at the coastal region and in the upper layers of the open sea stations (Fig. 4).

Coastal stations

At the coastal area the highest abundance of 2286 ind. m⁻³ was found at station A50 (Fig. 5). Copepods distinctly dominated and contributed 92-99% to total mesozooplankton abundance.

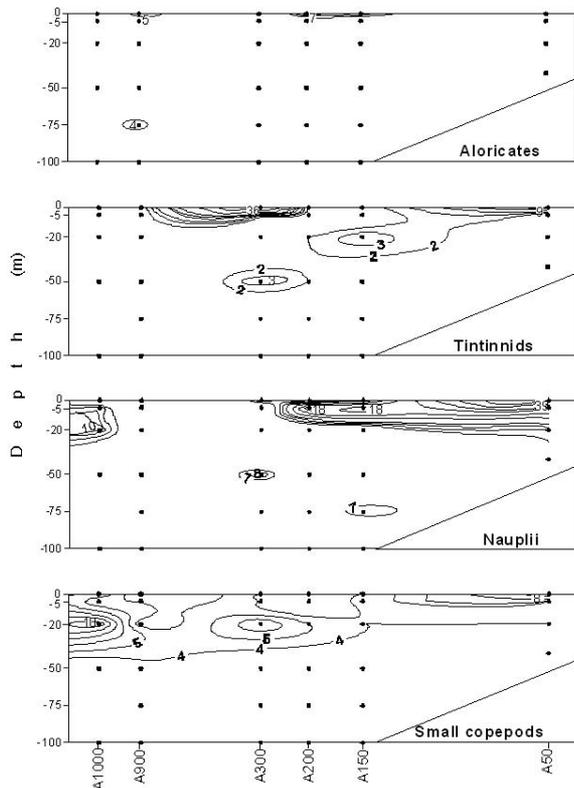


Fig. 3. Distribution of microzooplankton groups along the profile (ind.L⁻¹)

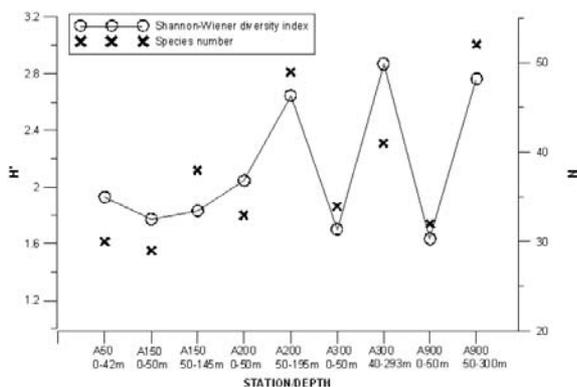


Fig. 4. Shannon–Wiener diversity index (H') and number of species (N) at the investigated stations in the upper and bottom layer

The average contribution of the copepodite stages in the total copepod numbers was 40%. *Oithona similis* was by far the most abundant species (22% of the total mesozooplankton abundance), followed by *Oithona plumifera* (8,1%), *Acartia clausi* (4,63%), *Paracalanus parvus* (3,95%), *Oithona nana* (3,84%) and cyclopoida-oncaeids (2,77%). Among the other groups, higher values of doliolids and pteropod *Limacina trochiformis* were recorded (Table 2). Here we also found higher abundance of some typical open sea species such as hydromedusae *Aglaura haemistoma* and copepods *Paraeucha-*

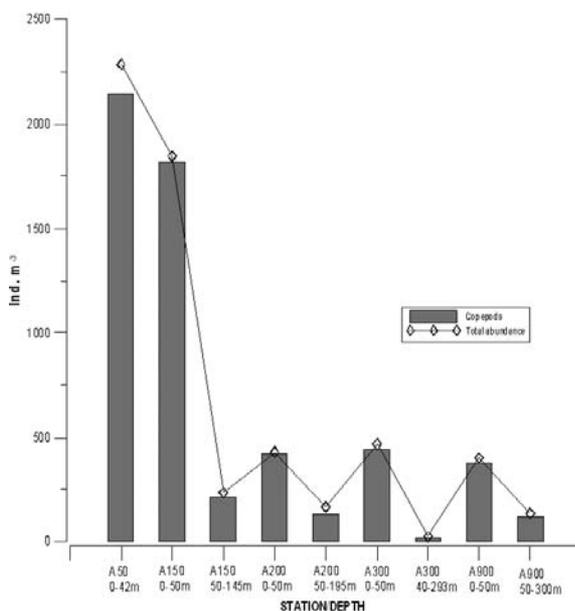


Fig. 5. Total abundances and copepod abundances at the investigated stations in the upper and bottom layer

eta hebes, *Candacia giesbrechti*, *Scolecithrix bradyi* and *Lucicutia flavicornis*.

Open sea stations

Total mesozooplankton values ranged from 405 ind. m⁻³ to 469 ind. m⁻³ in the 0–50 m layer of the offshore stations (A200–A900), and decreased at the deeper layer, from 170 ind. m⁻³ (A200) to 25 ind. m⁻³ (A300). Copepods were dominant mesozooplankton group with average contribution of 90%. At the offshore stations *O. similis* was still the most abundant species (21.7% of the total mesozooplankton abundance), followed by *Clausocalanus pergens*, *O. plumifera*, *O. nana*, cyclopoida-oncaeids, *Corycaeus spp.* and *Ctenocalanus vanus*. Among other groups, high values were noted for hyperiid *Phronima sp.* (9,71 ind. m⁻³) and appendicularia *Oikopleura longicauda* (6,18 ind. m⁻³) at deeper layer of A200, and chaetognath *Mesosagitta minima* (10,24 ind. m⁻³) at surface layer of A300.

DISCUSSION

In this study, we present for the first time composition, numerical abundance and vertical structure of micro- and mesozooplankton in the Albanian coastal and open sea region. Microzooplankton exhibit diverse diet composition and was able to switch between a preferably herbivorous to an omnivorous diet in response to the seasonal variations of the available food items (ALMEDA *et al.*, 2011). The highest microzooplankton value was found at the surface of A50 station, coinciding with the maximum of chlorophyll *a*, diatoms and heterotrophic nanoplankton (ŠILOVIĆ *et al.*, 2011; VILIČIĆ *et al.*, 2010). Our maximum of microzooplankton was similar to the maximum values found at stations located along the eastern coast of the Adriatic (KRŠINIĆ, 1980), but lower than those detected in the northern Adriatic area (KRŠINIĆ, 1995; FONDA UMANI *et al.*, 2005). However, we found high densities of tintinnids at the offshore station A300, in accordance with the maxima of dinoflagellate and picoheterotroph abundance at the same

Table 2. Mesozooplankton taxa found across the Albanian boundary zone with the abundance values (ind. m⁻³)

Taxa (C=coastal, O=open sea, CO=coastal and open sea species)		Station (A=0-50m, B=below 50m)									
		A 50		A 150		A 200		A 300		A 900	
		A	A	B	A	B	A	B	A	B	
Hydromedusae											
<i>Rhabdoon singulare</i>	O									0,57	
<i>Obelia sp.</i>	C	0,76									
<i>Eirene viridula</i>	CO									0,13	
<i>Liriope tetraphylla</i>	CO							0,03			
<i>Aglaura hemistoma</i>	O	0,76	10,24		0,22		0,16	0,03			
<i>Persa incolorata</i>	O					0,22		0,13			
<i>Rhopalonema velatum</i>	O		0,32	0,08	0,48	0,22	0,08	0,02	0,64	0,51	
<i>Solmundella bitentaculata</i>	O									0,51	
<i>Solmissus albescens</i>	O					0,03				0,18	
Calycophorae											
<i>Lensia conoidea</i>	O					0,06				0,13	
<i>Lensia multicristata</i>	O									0,06	
<i>Lensia subtilis</i>	O		0,64	0,67	0,32	0,88	0,16	0,06	0,32	0,26	
<i>Lensia meteori</i>	O							0,03		0,51	
<i>Muggiaea atlantica</i>	C									0,03	
<i>Eudoxoides spiralis</i>	O		1,28	0,34		0,88	0,32		0,16	0,06	
<i>Sphaeronectes koellikeri</i>	CO	1,52				0,06		0,25			
<i>Sphaeronectes irregularis</i>	O			0,17							
<i>Sphaeronectes fragilis</i>	O					0,06					
Pteropoda											
<i>Limacina inflata</i>	CO	1,52	1,28	0,17	0,64	0,44	0,64	0,03	5,12	0,51	
<i>Limacina trochiformis</i>	CO	24,38							0,32		
<i>Creseis acicula</i>	C	3,05									
<i>Creseis virgula</i>	C					0,03					
<i>Hyalocylix spp.</i>	O									0,03	
Cladocera											
<i>Evadne spinifera</i>	C	1,52									
Copepoda											
<i>Calanus helgolandicus</i>	CO	3,81	5,12	2,02	1,28	0,44	0,16				
<i>Mesocalanus tenuicornis</i>	CO			0,67	0,16	0,88	0,64	0,25	0,32	0,13	
<i>Nannocalanus minor</i>	O		0,16		0,16		2,56				
<i>Pareucalanus attenuatus</i>	O		0,32	2,69	0,08	0,03		0,02	0,24	0,26	
<i>Paracalanus denudatus</i>	CO				0,64						
<i>Paracalanus parvus</i>	CO	60,95	153,60	1,35	3,84		12,8				
<i>Calocalanus spp.</i>	CO		1,28		2,56	4,41	0,24	0,25			
<i>Mecynocera clausi</i>	O	12,19	20,48	2,69	10,24	2,65	5,12	0,51	0,64		
<i>Clausocalanus lividus</i>	O			0,17						0,03	

<i>Clausocalanus arcuicornis</i>	CO	0,76	10,24	5,39	3,84	0,33	0,64	0,51	5,12	1,02
<i>Clausocalanus jobei</i>	CO		5,12		5,12	0,88	2,56			
<i>Clausocalanus paululus</i>	O			1,35		8,83	2,56	0,76	2,56	8,7
<i>Clausocalanus pergens</i>	O			2,69	2,56	1,77	1,28	1,77	92,16	6,66
<i>Clausocalanus furcatus</i>	CO	12,19	10,24	0,34	5,12	0,88	2,56	0,06	7,68	0,51
<i>Ctenocalanus vanus</i>	CO	6,1	5,12	1,35	17,92	0,88	7,68	1,26		
<i>Aetideus armatus</i>	O			0,17				0,13		
<i>Euchirella messinensis</i>	O							0,25	0,08	0,03
<i>Euchaeta acuta</i>	O								0,16	
<i>Pareuchaeta hebes</i>	O	12,19	5,12	1,35	2,56	2,65	1,28	0,25	2,56	0,51
<i>Euchaeta marina</i>	O		0,16	0,08		0,03		0,13	0,08	
<i>Scolecithrix bradyi</i>	O			0,34		0,22				0,13
<i>Scolecithricella spp.</i>	O							0,25		0,06
<i>Centropages typicus</i>	CO	12,19	5,12	0,34	1,6					
<i>Centropages kröyeri</i>	C	0,38								

Table 2. Mesozooplankton taxa found across the Albanian boundary zone with the abundance values (ind. m⁻³)

Taxa (C=coastal, O=open sea, CO=coastal and open sea species)		Station (A=0-50m, B=below 50m)									
		A 50		A 150		A 200		A 300		A 900	
		A	B	A	B	A	B	A	B	A	B
<i>Isias clavipes</i>	C	0,19									
<i>Temora stylifera</i>	CO	0,38									
<i>Pleuromamma abdominalis</i>	O						2,56		0,48	1,54	
<i>Lucicutia flavicornis</i>	O			0,67		2,65		0,13	2,56	5,63	
<i>Lucicutia ovalis</i>	O									0,13	
<i>Heterorhabdus papilliger</i>	O			0,17		0,03			2,56		
<i>Haloptilus acutifrons</i>	O			0,17						1,54	
<i>Haloptilus longicornis</i>	O					0,32	0,44	1,28	0,51	0,64	3,07
<i>Candacia giesbrechti</i>	O	3,05		0,08		5,12			0,02		0,06
<i>Candacia tenuimana</i>	O					0,03					
<i>Acartia clausi</i>	C	48,76	61,44	0,67		7,68		0,32			
<i>Oithona atlantica</i>	O					0,16	0,22	0,64			
<i>Oithona nana</i>	CO	109,71	81,92	5,39		23,04	1,77	7,68	0,25	1,28	2,56
<i>Oithona similis</i>	CO	512	430,08	61,98		157,44	31,78	158,72	4,05	79,36	10,75
<i>Oithona plumifera</i>	CO	24,38	30,72	51,2		12,8	23,04	0,51			
<i>Oithona setigera</i>	O					7,68		0,64	1,01	0,64	12,8
<i>Sapphirina spp.</i>	O			0,17					0,09		0,51
Cyclopoida-oncaeids	CO	158,48	20,48	0,67		16,64	7,94	5,12	0,25	0,64	5,12
<i>Corycaeus spp.</i>	CO	73,14	5,12	0,34		11,52	0,88	7,68	1,26	0,16	4,61
<i>Euterpina accutifrons</i>	C	12,19				1,28					13,47
<i>Macrosetella gracilis</i>	CO	3,05	0,32	1,35			0,88	0,32			0,51

<i>Clytemnestra rostrata</i>	CO		0,34		0,22			5,12	
<i>Mormonilla minor</i>	O						0,38	5,12	2,56
Hyperiid	O								
<i>Hyperia glabra</i>	O				0,03				
<i>Phoronima sp.</i>	O				9,71				
<i>Vibilia sp.</i>	O							0,32	
<i>Eupronoe sp.</i>	O								0,13
Euphausiacea larvae									
<i>Stylocheiron abbreviatum</i>	O				0,06	0,32			0,02
<i>Euphausia krohnii</i>	O				0,03			0,64	0,08
<i>Thysanoessa gregania</i>	O								0,06
<i>Thysanopoda aequalis</i>	O								0,02
<i>Stylocheiron longicorne</i>	O								0,05
Chaetognatha									
<i>Sagitta enflata</i>	CO		0,64		0,16		0,16		
<i>Sagitta minima</i>	CO	3,05	2,56		0,96	0,22	10,24	0,13	0,08
<i>Sagitta setosa</i>	C	0,19			1,28				
<i>Sagitta serratodentata</i>	O					0,44		0,03	0,51
<i>Sagitta decipiens</i>	O		0,32						0,06
<i>Sagitta lyra</i>	O			0,17		0,88		0,08	0,26
Appendicularia									
<i>Oikopleura dioica</i>	C		0,64		0,17		0,11		
<i>Oikopleura longicauda</i>	CO			0,34	0,64	6,18	0,16	0,25	
<i>Oikopleura fusiformis</i>	CO	1,52		3,37				0,03	
<i>Oikopleura villafrancae</i>	O					1,77		0,06	
<i>Oikopleura parva</i>	O					0,22			
<i>Oikopleura albicans</i>	O								0,16 0,06
<i>Appendicularia sicula</i>	O							0,02	
<i>Fritillaria aequatorialis</i>	O							0,06	
<i>Fritillaria borealis</i>	CO					1,77		0,25	0,06
<i>Fritillaria pellucida</i>	CO								0,77
Doliolids	CO	36,57		0,34	0,32	0,88	0,64	0,13	0,16 0,02

station (VILIČIĆ *et al.*, 2010). Metazoans were more abundant at A1000. Total microzooplankton abundances were higher than previously recorded for the open Adriatic Sea (KRŠINIĆ, 1998; KRŠINIĆ & GRBEC, 2002, 2006). These differences in abundance could be derived from the sampling methods: in previous investigations of the open sea station, samples were taken with 53 µm closing Nansen net for different layers (the minimum layer was 50 m of water column).

Among tintinnids, only 14 species were found in the present study, whereas KRŠINIĆ (2010) encountered 101 species in the Adriatic

Sea. The smaller number of species identified in our study could be due to our methodology (use of smaller volumes) and restricted sampling period (one month). The species *Tintinnopsis radix* was the most numerous with maximum abundance of 36 ind L⁻¹ at the offshore station A300. The highest known abundance of this estuarine tintinnid along Adriatic coast was 34 ind. L⁻¹ (KRŠINIĆ, 2010), and this is the first record of this species in the open southern Adriatic waters. This phenomenon coincides with the higher salinity and temperature, similar to the accumulation of dinoflagelates (VILIČIĆ *et al.*,

2010), whilst increased ammonium concentration in the surface (VILIČIĆ *et al.*, 2010) is interpreted as intensive zooplankton grazing. Other tintinnids were less numerous. The presence of the typically open sea species *Rhabdonella spiralis*, *Codonella aspera*, *Epiplocypris undella*, *Dictyocysta elegans* and *Dictyocysta mitra* at the coastal stations could indicate the influence of currents from the open sea area on the coastal area during our investigation. Vertical distribution of all noted species corresponded with previous descriptions of their bathymetric distribution (KRŠINIĆ, 2010).

Nauplii were the most abundant microzooplankton group and their abundance decreased from the coastal area towards the open sea, and below 20 m depth. In contrary, at the open sea stations high quantitative contribution for small adult copepods was detected. All of these findings are in agreement with previous investigations of the southern Adriatic (KRŠINIĆ, 1998; KRŠINIĆ & GRBEC, 2002). The densities for the whole micrometazoan community were in the same range reported for oligo- and mesotrophic waters (CALBET *et al.*, 2001), but lower than in more productive areas (LUČIĆ *et al.*, 2003).

We found low mesozooplankton values at the coastal stations, despite the fact that we used plankton net with small mesh size (125 μm). The finer net was used due to the nature of the study area and riverine influence on the abundance of coastal species. Therefore, we expected higher values of the small coastal species that pass through the coarser plankton nets, which were documented by KRŠINIĆ & LUČIĆ (1994) and RICCARDI (2010). Compare with the previous results of mesozooplankton sampled with the 125 μm mesh size along the eastern Adriatic coast, our noted maximum of 2286 ind. m^{-3} is several times smaller. VIDJAK *et al.* (2007, 2009) noted range between 3000–7000 ind. m^{-3} of total mesozooplankton at Neretva Channel, and between 5000–45 000 ind. m^{-3} along the Krka river estuary, both during spring. Despite the fact that the amount of fresh water in the Albanian rivers is slightly lower than in the river Po (CULLAJ *et al.*, 2005), mesozooplankton densities between those two regions are incomparable:

in spring, the total mesozooplankton abundance of the northern Adriatic is usually more than 10 000 ind. m^{-3} (FONDA UMANI *et al.*, 2005; KAMBURSKA & FONDA UMANI, 2009; CAMATTI *et al.*, 2008), although samples were taken with 200 μm mesh size. Observed values of the mesozooplankton at the coastal stations A50–A150 correspond with those found in the other oligotrophic coastal regions of the Mediterranean, where zooplankton were taken with the 200 μm mesh size, such as the Patraikos Gulf and Saranikos Gulf in the Aegean Sea (CHRISTOU, 1998; RAMFOS *et al.*, 2006), or Gulf of Naples (RIBERA D'ALCALA *et al.*, 2004; MAZZOCCHI *et al.*, 2011).

Mesozooplankton of the Adriatic Sea is characterized by an increase in total number of species from north to south and outwards from the coast (FONDA UMANI, 1996). We also noted high species diversity at the offshore stations. All of species identified at the offshore stations (A200–A900) were previously recorded for the southern Adriatic open sea, with a similar abundance and bathymetric distribution (for gelatinous zooplankton: see BATISTIĆ *et al.*, 2004; BENOVIĆ *et al.*, 2005; LUČIĆ *et al.*, 2011; and for crustaceans and zooplankton: see HURE, 1961; HURE & SCOTTO DI CARLO, 1969; HURE *et al.*, 1980; HURE & KRŠINIĆ, 1998). Mesozooplankton abundances were always between 500–1000 ind. m^{-3} for the spring time (HURE *et al.*, 1980; BENOVIĆ *et al.*, 2005; TURK *et al.*, 2012). These results indicate the stability of zooplankton communities of the open southern Adriatic region.

Epipelagic mesozooplankton communities in the open Adriatic Sea are highly diversified in terms of taxonomic composition, but copepods represent the major group both in terms of abundance and biomass. These bulks are concentrated in the upper 100 m layer and play a major role in biological processes, based on the linkage with phyto- and microzooplankton in the euphotic zone (LONGHURST & HARRISON, 1989). The use of the smaller mesh sizes highlighted the importance of the small-sized copepods in Mediterranean coastal waters. A few small-sized species and species-rich genera of calanoids (*Clausocalanus*, *Calocalanus* and *Ctenocalanus*), cyclopoida-oithonids and cyclo-

poida-oncaeids, together with their copepodites, account for the bulk of copepod abundance and biomass in the epipelagic layers of the Mediterranean Sea (ZERVOUDAKI *et al.*, 2007; SIOKOU-FRANGOU *et al.*, 2010). Our findings confirm previous investigations, with numerical dominance of the copepod coastal form *Oithona similis*, which is considered as the most abundant copepod in the world's oceans (BIGELOW, 1926). However, considering these are the first studies of the mesozooplankton in the open waters off Albania, our intention was to show results that are comparable with the previous investigations of the open waters of the Adriatic Sea (HURE, 1961; HURE & SCOTTO DI CARLO, 1969; HURE *et al.*, 1980; HURE & KRŠINIĆ, 1998). Similarly to some tintinnids, some open sea copepod species were recorded at the shallow stations (e. g. *Euchaeta hebes*, *Candacia giesbrechty*, *Scolecithrix bradyi* and *Lucicutia flavicornis*).

Our study indicate that zooplankton distribution was greatly influenced by the circulation pattern prevailing in the southern Adriatic because of the influence of the Levantine Intermediate Water and East Adriatic Current forcing,

as were documented for picoplankton (ŠILOVIĆ *et al.*, 2011) and phytoplankton (VILIČIĆ *et al.*, 2010). Our results on zooplankton abundance confirmed oligotrophic characteristics of the Albanian coastal and open sea waters, although this area is under the constant influence of significant quantities of fresh water. The observed micro- and mesozooplankton densities coincide with low nutrient and chlorophyll concentrations, as well as with low nanoplankton and bacterial abundance recorded during the same cruise (ŠILOVIĆ *et al.*, 2011; VILIČIĆ *et al.*, 2010).

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Sastav i raspodjela zooplanktona duž obalnih i otvorenih voda Albanije (južni Jadran) u kasno proljeće

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SAŽETAK

Po prvi put su prikazani sastav, abundancija i vertikalna struktura mikro- i mezozooplanktona u albanskim obalnim i otvorenim vodama. Istraživanje je obavljeno na šest postaja duž 75 km dugom transektu od šelfa do kontinentuskog slaza. Najbrojniji predstavnici mikrozooplanktona su bili kopepodni naupliji (maksimum: 39 ind. L⁻¹), iza kojih su slijedili kalanoidni i ciklopoidni kopepoditi. Od 14 zabilježenih vrsta tintinida, najbrojnija je bila vrsta *Tintinnopsis radix*, nađena od površine do 50 m dubine. Sastav zajednice mezozooplanktona obalnog i otvorenog mora u skladu je s prijašnjim istraživanjima južnog Jadrana. Kopepod *Oithona similis* bila je dominantna vrsta na svim istraživanim postajama. Na plićim postajama slijede je vrste *Oithona plumifera*, *Acartia clausi*, *Paracalanus parvus*, *Oithona nana* i cyclopoida-oncaeids, a u otvorenim vodama vrste *Clausocalanus pergens*, *Oithona plumifera* i *Oithona nana*. Bioraznolikost mezozooplanktona značajno raste od obale prema otvorenom moru. Nasuprot tome, najveća gustoća mezozooplanktona (2286 ind. m⁻³) zabilježena je na najplićoj postaji. Prisutnost karakterističnih vrsta tintinida i kopepoda otvorenog mora na obalnim postajama ukazuju na utjecaj struja otvorenog mora za vrijeme ovog istraživanja. Naši rezultati ukazuju da povećani upliv slatke vode nije znatno utjecao na gustoću zooplanktonskih populacija čak i na plitkim postajama gdje je prodor slatke vode u površinskim slojevima osobito izražen.

Ključne riječi: mikrozooplankton, mezozooplankton, bioraznolikost vrsta, Sredozemno more