UNUSUAL WINTER ZOOPLANKTON BLOOM IN THE OPEN SOUTHERN ADRIATIC SEA

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INTRODUCTION

The Southern Adriatic (SA) is oligitrophic basin and the deepest part of the Adriatic Sea to about 1200 m (Fig. 1). This paper focuses on the unusually high microzooplankton abundance and an unexpected change in community composition in the SA during the winter of 2015. It addresses the link between zooplankton density and primary production using winter hydrographic, optical, and water-mass observations.

METHODS

Data collection was between 28 February and 2 March 2015 in the South Adriatic Sea along transects P and M (Fig.ure 1).

MODIS Aqua ocean color products accessed (NASA Goddard Space Flight Center, 2016) extended the spatio-temporal scale of at-sea observations in the study area. An SBE25 CTD probe (SEA-Bird Electronics Inc) was used for collection of basic water-quality data .

Microzooplankton was collected by vertical hauls of opening-closing Nansen nets (0.57 - m diameter, 53 - µm mesh configuration). Sample depths (as allowed by each station's maximum depth) were: 0 - 50, 50 - 100, 100 - 150, 100 - 300, 300 - 600, and 600 - 1000 m. Microzooplankton was analyzed with an inverted microscope at 100 x and 400 x.

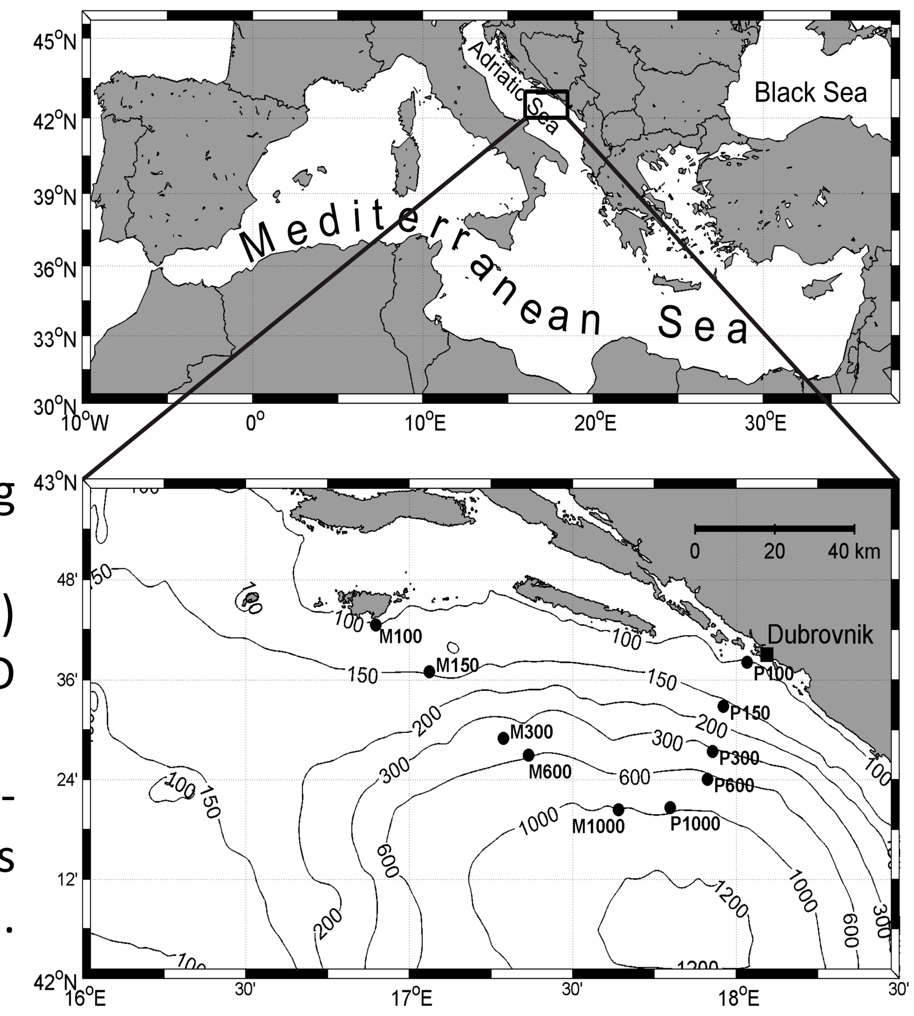

Figure 1. Map of investigated area with noted stations over two investigated transects.

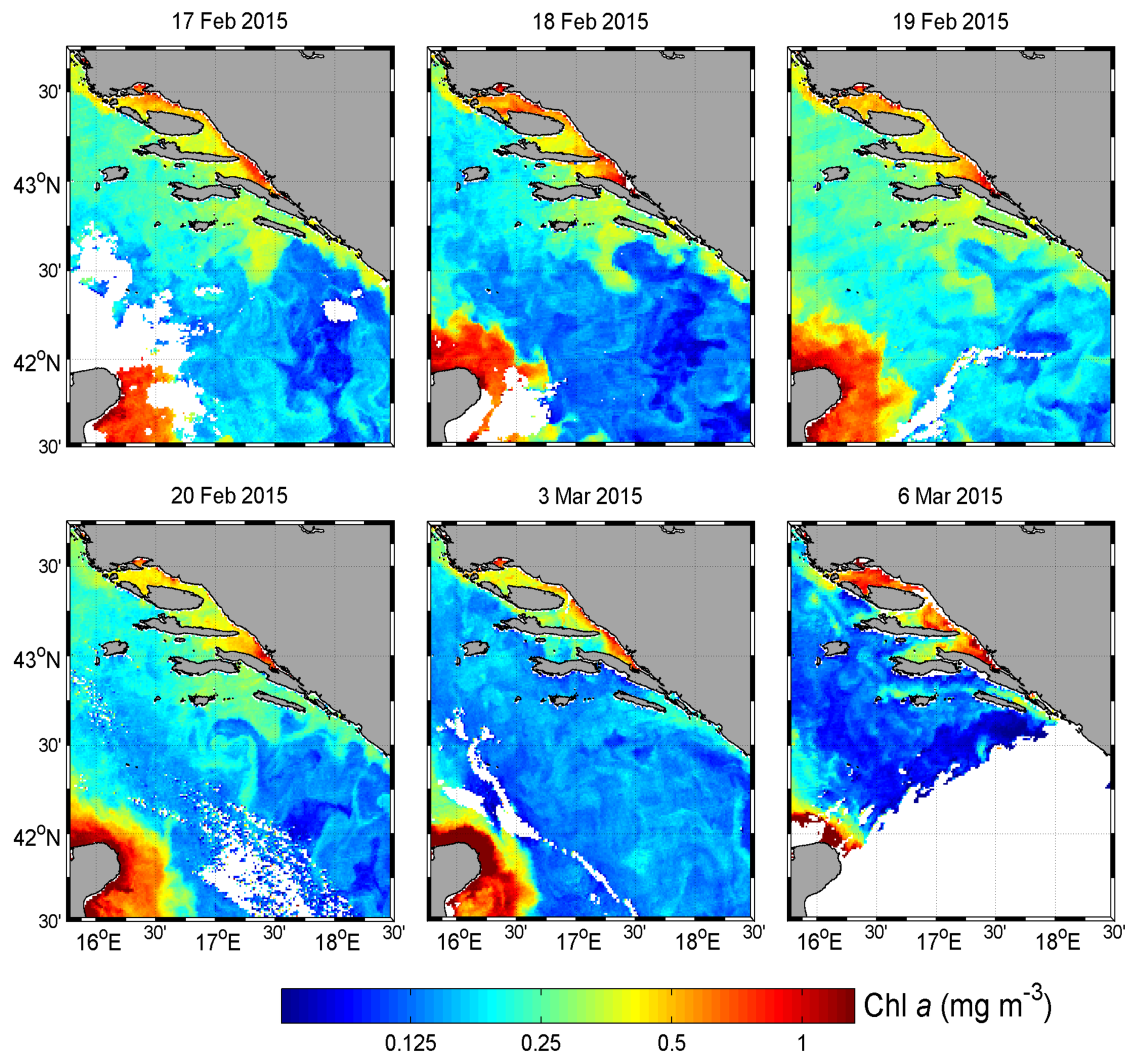

Figure 2. Maps of Chl concentrations retrieved from MODIS Aqua17 February 2015; 18 February 2015; 19 February 2015; 20 February 2015; 03 March 2015; and 06 March 2015

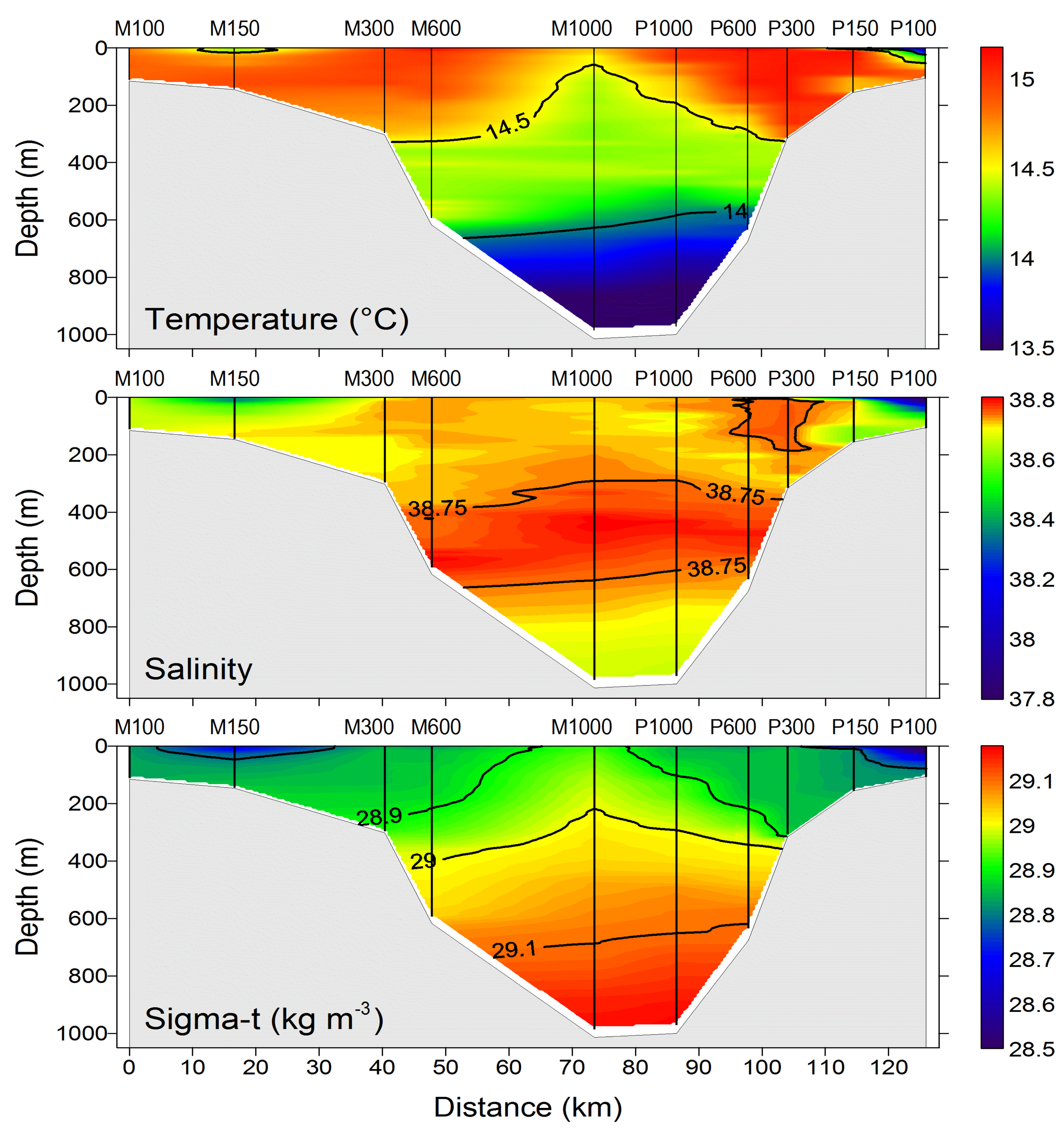

Figure 3. Vertical profiles of temperature, salinity and density (sigma-t).

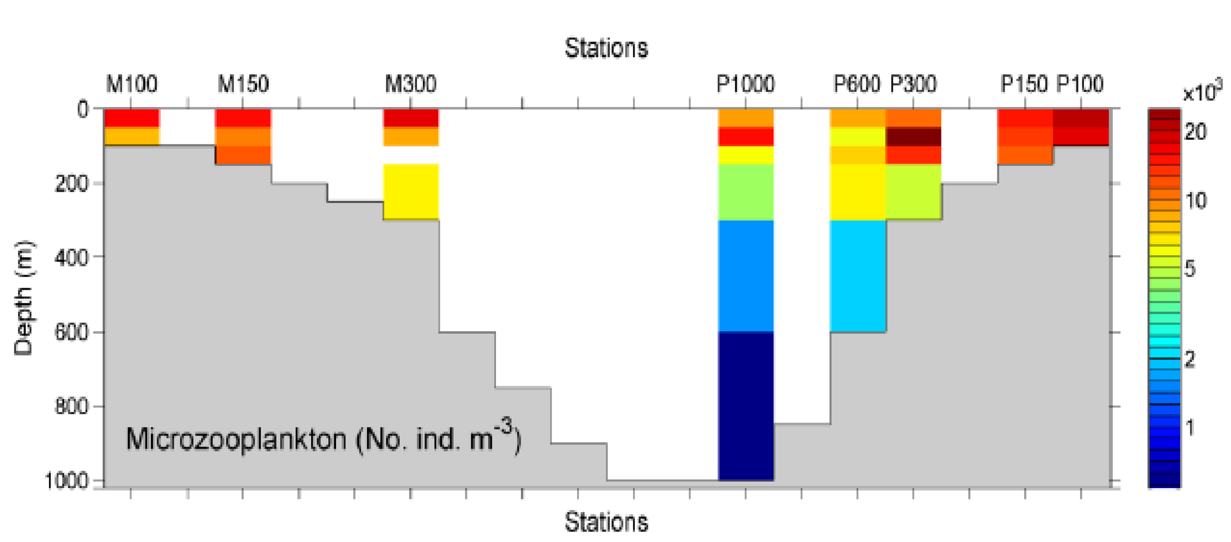

Figure 4. Spatial distribution of total microzooplankton abundance along the investigated profile .

RESULTS

Satellite images in the days following the cruise revealed surface Chl patchiness (Figure 2).

Temperature, salinity, sigma-t, and dissolved oxygen profiles (data not shown) revealed a layered water column over the northern section of the South Adriatic (Figure 3). Warmer-than-usual temperatures (14.5 - 15.0°C) and lower salinity (38.70 - 38.75) characterized most of the surface and upper intermediate layers (Figure 3).

Microzooplankton abundance was high over the entire study area (Figure 4). Mean densities exceeded 10 000 ind. m^{-3} at stations shallower than 300 m. The maximum, 25 094 ind. m^{-3}, was on 28 February within the 50 - 100 m layer at Station P300. Station P1000 had markedly high abundance - 14 760 ind. m^{-3} within the same layer.

Protozoans were abundant from surface to 100 m depth (Figure 5). Tintinnids constituted 68% of total protozoans. The deep protozoan community had higher densities of typically surface species, some of which were found exclusively in the mesopelagic and deeper layers (*Stenosemella nivalis, Tintinnopsis campanula*).

Copepod developmental stages made up 75% of total microzooplankton abundance; of these, 48% were nauplii. Abundance decreased gradually from the surface, but high values were found between 50 and 100 m at P300 (Figure 6) for metazoa (21 082 ind. m^{-3}), nauplii (13 734 ind. m^{-3}), and copepodites (6505 ind. m^{-3}).

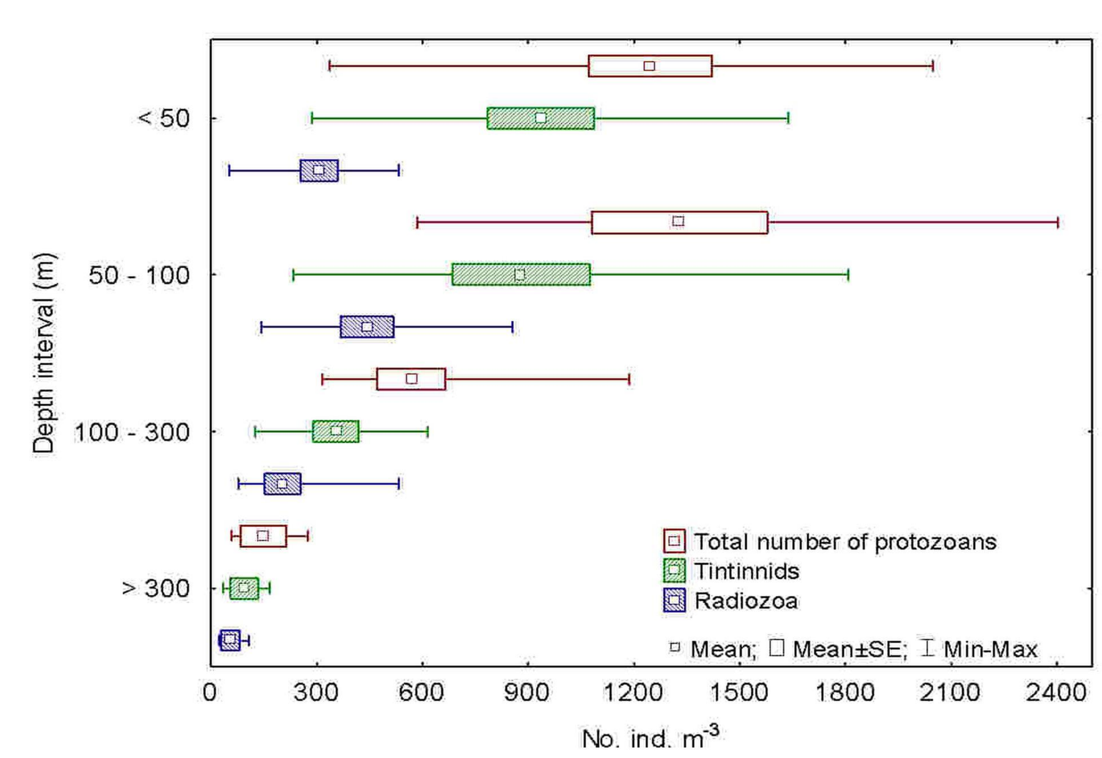

Figure 7. Box-Wiskers plot of the abundance of protozoan shown by depth layers atall investigated stations..

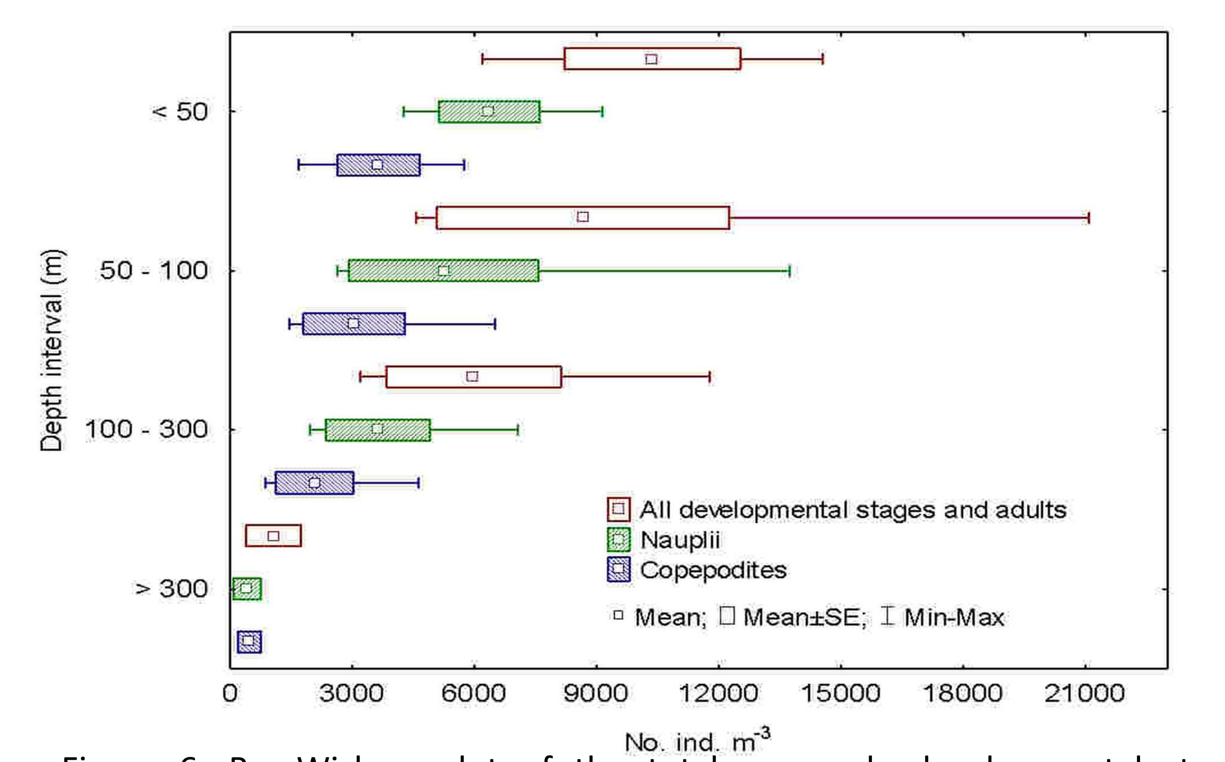

Figure 6. Box-Wiskers plot of the total copepods developmental stages abundance shown by depth layers at all investigated stations.

Table 1. Comparison of maximal microzooplankton winter/ spring abundance noted in this investigation with former records (ind. m^{-3}) at open waters of southern Adriatic Sea.

Data source	Planktonic groups	February/March	April-May	General maximum
	Tintinnids	1807		
This investigations	Nauplii	13 734		
	Calanoid copepodites	3277		
	Tintinnids	133	3778	33 574 (June)
Kršinić (1998)	Nauplii	7936	7820	10 800 (September)
	Calanoid copepodites	1408	1600	2432 (July)
	Tintinnids		>50	1450 (August)
Kršinić and Grbec (2002)	Nauplii		13 625	13 625 (May)
	Calanoid copepodites		819	819 (May)
Kršinić and Grbec (2006)	Tintinnids	185	3778	3914 (October)
	Tintinnids	2304		
Batistić et al. (2012)	Nauplii	5267		
	Calanoid copepodites	810		

DISCUSSION and CONCLUSIONS

Prior to this study, the highest zooplankton concentrations measured in the open South Adriatic were in spring or early summer. During the winter of 2015, all developmental stages were found as deep as 300 m at densities substantially higher than in earlier SAP investigations that used the same sampling methods (Table 1).

The observed zooplankton maximum could have been ascribed to (i) warmer-than-usual surface and intermediate ocean temperatures, (ii) a high excess in precipitation preceding the samplings for a prolonged period, which freshened and widened surface layers and pushed saline Levantine Intermediate Water inflow below 400 m depth, and (iii) strong wind episodes that could transfer nutrients from coastal area to open ocean and induce limited vertical convention. Prior to sampling, MODIS Chl data identified a tongue of high-chlorophyll water that extended from the eastern shore of the Adriatic to the low chlorophyll waters of the study area. Density profiles (Figure 2) confirm that the SAP cyclonic pattern was present during the cruise. Lack of imagery during the cruise owing to thick cloud cover confirm rough weather at this time. Stormy conditions might have been sufficient to mix the high chlorophyll observed in the satellite images to greater depths.

Our results are documenting large and fast variations of production conditions, rarely found to occur in oligotrophic waters such as the South Adriatic Sea. Average seasonal maximum of zooplankton abundance is shifted from spring and early summer towards late winter months. The results presented in this paper are consistent with these recently established trends that the development of planktonic communities is affected to varying degrees by climatic processes.