www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 18: 577-584 (2018) DOI: 10.4194/1303-2712-v18_4_09

RESEARCH PAPER

Coastal Plankton Assemblages in the Vicinity of Galindez Island and Neumayer Channel (Western Antarctic Peninsula) during the First Joint Turkish -Ukrainian Antarctic Research Expedition

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Received 09 May 2017
Accepted 14 August 2017

Abstract

Western Antarctic Peninsula is one of the fastest warming areas on Earth and coastal areas of the region are foremost affected. Here we present the state of coastal plankton assemblages of the Galindez Island and Neumayer Channel, Western Antarctic Peninsula in austral autumn (April 2016). Surface water temperatures were ranged between −0.12 °C and −0.97 °C and average chlorophyll-*a* concentrations were 0.65 µg/l. A total of 50 phytoplankton and 24 zooplankton taxa (15 copepods and 9 meroplanktonic species) were identified during the sampling period. Diatom species (78%) predominated phytoplankton and the highest abundance was 820 cells l^{-1}, while the highest number of phytoplankton species was 42. Zooplankton was prevailed by the dominance of copepods, except contribution of meroplankton at the Neumayer channel. Highest zooplankton abundance was 101 ind.m^{-3}. The sampling season was the transition period from the productive spring-summer to dormant winter conditions, which explains the low abundances registered, however, on contrary to low cell abundances, diversity was high within plankton.

Keywords: Antarctica, Galindez Island, Vernadsky Research Base, phytoplankton, zooplankton, hydrography.

Introduction

The average temperature of the earth has increased by 0.85°C in the last century due to climate change and oceans absorbed over 80% of the added heat to the global climate system (IPCC, 2013). The increase in stratification and ocean acidification and mismatch due to shifts in phenological events threatens the base of oceanic food webs that will have global implications (Doney *et al*., 2012). Planktonic food web constitutes the base of life in ocean and phytoplankton has significant impact on the global climate by equivalent CO_2 absorption to land (Chavez, Messie, & Pennington, 2011) and through their high thermal adaptability (Padfield, Yvon-Durocher, Buckling, Jennings, & Yvon-Durocher, 2015). Phytoplankton and zooplankton drives the biological pump which is of great importance in the transportation of surface organic carbon to deeper layers, where they are either consumed by detrital feeders or deposited and stored in the sediment (Longhurst, 1991). Long-term plankton data might act as sentinels of climate induced changes in marine ecosystems due to the facts that; i) few species of plankton are commercially harvested (e.g. krill), therefore any long-term change can be attributed to climate change, ii) the poikilothermic physiology and short life span of plankton makes the group a prompt indicator of changing environmental conditions due to the tight coupling between plankton dynamics and environmental variability and finally iii) plankton are dispersed in the water column and they can adopt their biogeographic distribution to changing conditions by expanding and contracting their ranges (Hays, Richardson, & Robinson, 2005).

Western Antarctic Peninsula is one of the fastest warming areas on Earth and coastal areas of the region are foremost affected and polar oceans and their ice cover play a crucial role in global carbon cycle (Arrigo, 2003). Therefore, more information is needed on the state and fate of plankton in the polar seas. Although some Long-term Ecological Research (e.g. Palmer LTER initiated in 1990) exists for the Southern Ocean and Antarctica, there is still a great need for continuous efforts in documenting biological and physicochemical structure in Antarctica.

Even though Turkey signed Antarctic Treaty in 1995, there have been very limited contributions from Turkish scientists (Öztürk, 2015). Turkish Antarctic Science Programme, aiming to increase and

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in cooperation with Japan International Cooperation Agency (JICA), Japan

coordinate Turkey's scientific contribution to Antarctic research, has been initiated in 2014 (Öztürk *et al*., 2014). In the austral autumn of 2016 the first Turkish–Ukranian Expedition to Antarctica had been held. One of the main aims of the Turkish Polar Program is to contribute data for a better understanding of these important ecosystems. This study provides first contribution on plankton assemblages in the vicinity of Galindez Island.

Materials and Methods

Samplings were performed at 6 stations; one located at the Neumayer Channel and five located in the vicinity of Vernadsky Research Base (Galindez Island) (Table 1, Figure 1). Temperature, salinity, pH, chlorophyll *a* and dissolved oxygen profiles were recorded by a Hydrolab DS5 CTD profiler.

For phytoplankton identification and enumeration, water samples were collected from the surface (5 m) and lower layer (Table 1) by using a Niskin bottle. Samples were fixed by addition of Lugol's solution (2%) and kept in dark amber bottles (250 ml). In the laboratory, subsamples (100 ml) were left to settle in Utehmohl sedimentation chambers for at least 48 hours. Phytoplankton cells were counted using inverted light microscope equipped with phase contrast optics at 100× or 200× magnification. All of the phytoplankton cells in the settling chamber were counted and abundances were calculated as cells per liter.

For phytoplankton species richness, net samples

Table 1. Station coordinates, sampling dates, station depths and phytoplankton and zooplankton sampling depths

Station	Date	Latitude (N)	Longitude (E)	Depth	Phytoplankton sampling depths	Zooplankton sampling depth
1	06.04.2016	-64.80360	-63.49273	71.5	5-25	69.3
2	07.04.2016	-65.24662	-64.25208	17.5	5	15.3
3	07.04.2016	-65.24720	-64.25703	21.1	5-15	18.9
4	07.04.2016	-65.24907	-64.26940	31.0	5-20	28.8
5	07.04.2016	-65.24297	-64.25917	34.0	5-13	31.8
6	07.04.2016	-65.24430	-64.25382	26.2	5-15	24.0

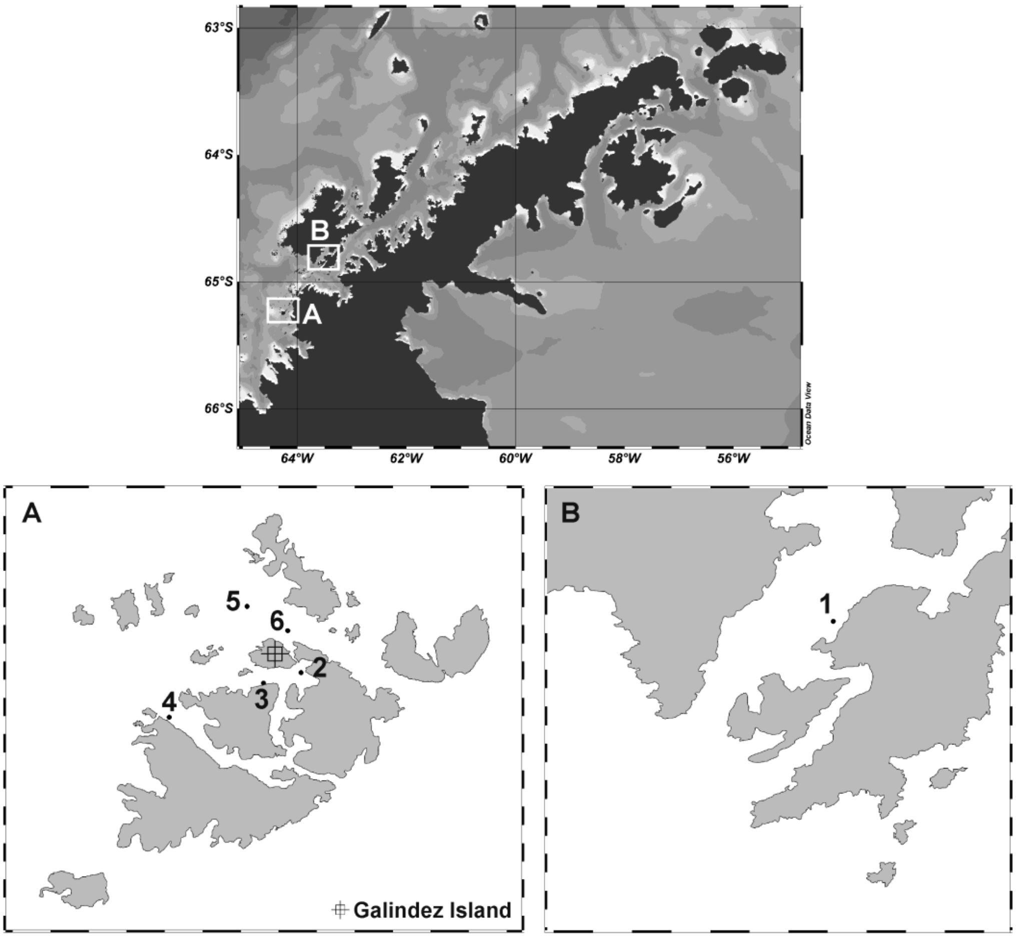

Figure 1. Maps of the study area and sampling locations.

were collected using an Apstein plankton net with 30µ mesh size by vertical tows from ~20 m to surface. Net samples were preserved by addition of borax buffered formaldehyde solution to a final concentration of 4%. ~50 ml sample volume has been concentrated to 5 ml prior to microscopic examinations.

Zooplankton samples were collected using a modified WP2 net with 30 cm diameter and 200 µm mesh from the bottom to the surface. The volume filtered was calculated with the aid of a vertical flowmeter located at the mouth of the net. At station 1 and 5 horizontal tows were also performed for qualitative purposes. Samples were preserved by addition of borax buffered formaldehyde solution to a final concentration of 4%. Due to the scarcity of zooplankton, all sample content has been enumerated.

Results

Hydrography

The CTD profiles recorded at Neumayer Channel (St.1) and Galindez Island (St.3) indicates differences in salinity and temperature between these stations, located 34 nm apart (Figure 1 and Figure 2). The surface water temperatures were recorded as −0.12°C and −0.97°C in St. 1 and St. 3, respectively while average temperatures were −0.01°C and −0.68°C in the water column of the stations, respectively. Similar difference in minor scale was observed in salinity, fluctuating between ‰30-31. Low temperatures were accompanied with high dissolved oxygen concentrations, St.3 once again having higher values as 11.35 mg/l in the water column (through 20 m depth) while it was measured as10.44 mg/l in the water column of St. 1 (through 30 m depth). Chlorophyll *a* profiles had a similar distribution pattern, while concentrations were ~0.2 µg/l higher at St.3.

Phytoplankton

A total of 50 phytoplankton taxa belonging to 3 taxonomic classes were enlisted of which 78% were diatoms (39 taxa; 16 centrics and 23 pennates), 14% were dinoflagellates (7 taxa) and 7% were silicoflagellates (4 taxa) (Table 2). Although majority of species are adapted to colder environment, some cosmopolite species also existed. Some of the cold-

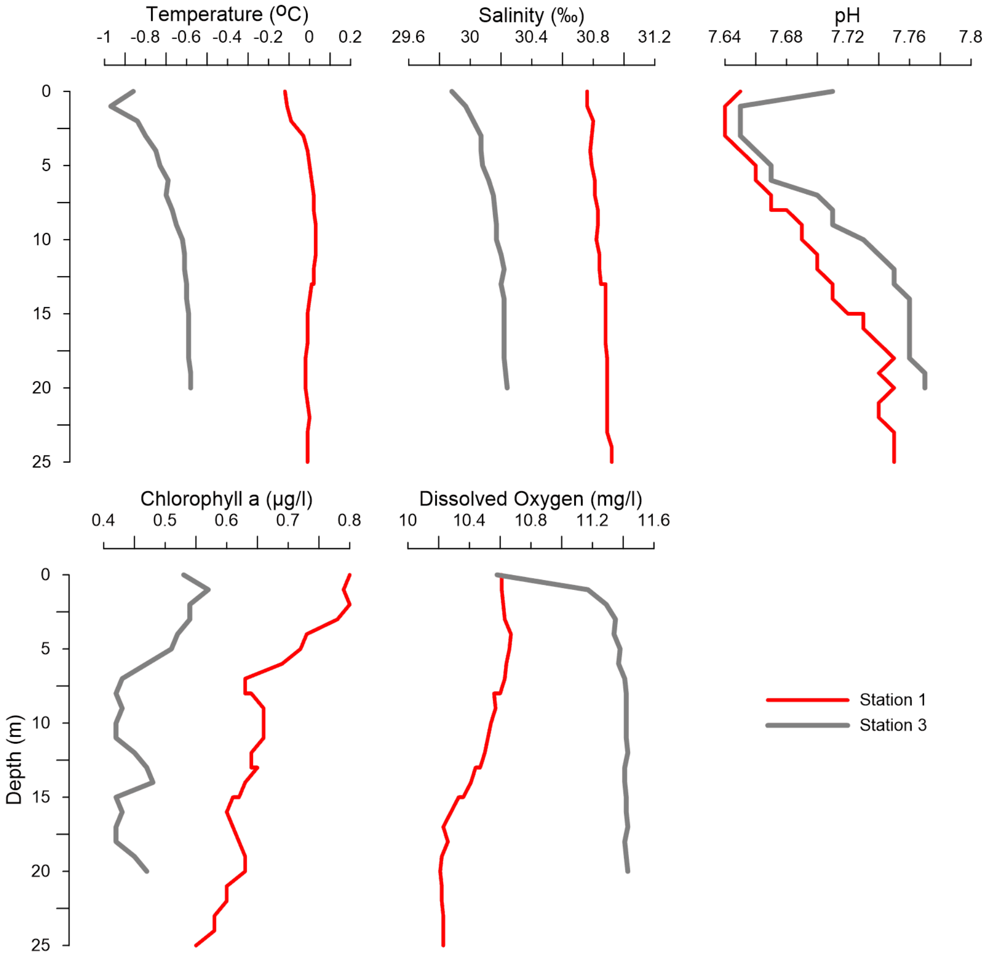

Figure 2. Temperature, salinity, pH, chlorophyll a and dissolved oxygen profiles at selected stations.

Table 2. A check-list of phytoplankton identified in water and net samples and their occurrences in the sampling stations in the vicinity of Galindez Island and Neumayer Channel, Western Antarctic Peninsula

BACILLARIOPHYCEAE	St.1	St.2	St.3	St.4	St.5	St.6
Centrics						
Asteromphalus hookeri	+		+	+		
Chaetoceros atlanticus	+	+	+	+	+	+
Chaetoceros convolutus	+	+	+	+		+
Chatoceros concavicornis	+			+	+	+
Chaetoceros sp.	+		+	+	+	
Corethron pennatum	+	+	+	+	+	+
Coscinodiscus concinnus	+			+		
Coscinodiscus radiatus	+	+	+	+	+	+
Cyclotella sp.	+	+	+	+	+	+
Odontella aurita	+	+	+	+	+	+
Odontella weissflogii	+	+	+	+	+	+
Proboscia alata	+	+	+	+		+
Proboscia indica	+	+	+	+	+	
Rhizosolenia castracanei	+	+	+	+	+	
Rhizosolenia curvata	+	+		+		
Rhizosolenia sp.						
Pennates	+					
Achnanthes longipes			+	+	+	+
Cocconeis britannica	+	+	+	+	+	+
Cocconeis scutellum		+	+	+		
*Diploneis*sp.		+	+	+	+	+
Entomoneis alata	+	+	+	+	+	+
Fragilaria islandica	+	+		+	+	+
Fragilaria capuciana						
Fragilaria striatula	+	+	+	+	+	+
Fragilaria sp.	+		+			+
Gyrosigma acuminatum				+	+	
Gyrosigma fasciola	+	+			+	+
Gyrosigma sp.			+	+	+	+
Licmophora abbreviata	+		+	+	+	+
Membraneis challengeri	+	+	+	+	+	+
Navicula sp.	+	+	+	+	+	+
Nitzschia bilobata	+	+	+	+	+	+
Nitzschia longissima	+	+	+	+	+	
Nitzschia sp.	+	+	+	+		
Plagiotropis gaussii	+	+	+	+	+	+
Pleurosigma sp.	+	+	+	+	+	
Pseudo-nitzschia sp.	+	+	+	+	+	+
Stauroneis sp.				+		
Thalassiothrix frauenfeldii				+	+	
DINOPHYCEAE						
Gyrodinium lachryma	+	+		+	+	+
Gyrodinium spirale	+					
Oxytoxum scolopax	+			+	+	+
Phalacroma oxytoxoides		+				
Prorocentrun micans	+	+	+	+	+	+
Prorocentrun scutellum	+	+			+	+
Protoperidinium sp.	+	+	+	+	+	+
DICTYOCHOPHYCEAE						
Dictyocha antarctica	+	+	+	+	+	+
Dictyocha fibula		+	+			
Dictyocha speculum	+	+	+	+	+	+
Octactis octonaria	+		+	+		

adapted species also show a boreal distribution. In general, the phytoplankton species composition showed no considerable differences among stations except for St. 1 which included the highest diversity of dinoflagellates. The highest number of species number was 42 (St.4), and the lowest one was 31 (St.6) (Figure 3). The most common species were *Chaetoceros atlanticus, Corethron pennatum, Coscinodiscus radiatus, Odontella aurita, O. weissflogii, Cocconeis britannica, Entemoneis alata,* *Membraneis challengeri*, *Nitzschia bilobata*, *Plagiotropis gaussii* from diatoms; *Prorocentrum micans* from dinoflagellates; *Dictyocha antarctica* and *D. speculum* from silicoflagellates (Table 2).

Phytoplankton abundance was very low throughout the study area (Figure 4). The highest abundance was registered as 820 cells l^{-1} in St. 3, of which diatoms were remarkably dominant (98%). The lowest phytoplankton abundance (250 cells l^{-1}) was observed in St. 1 at Neumayer Channel and also the most different group composition; with fewer contribution of diatoms when compared to Galindez stations. Ssmall diatom species (<20 µm), including *Chaetoceros*, had very low contribution to total cell abundance. Conversely, large diatom species (>50-100 µm) such as *Cocconeis britannica*, *Fragilaria* spp., *Navicula* sp., *Odontella weissflogii and Probosca indica* constituted the majör fraction of total abundance. Dinoflagellates were seldom detected and their highest abundance was 90 cells l^{-1} (St. 1). Lower layer and surface communities did not show a remarkable difference except for St. 5, thus might be attributed to the almost homogeneous vertical structure as depicted by the CTD casts.

Zooplankton

Zooplankton species composition was dominated by copepods, similar to all oceans. 15 copepod species were registered, together with

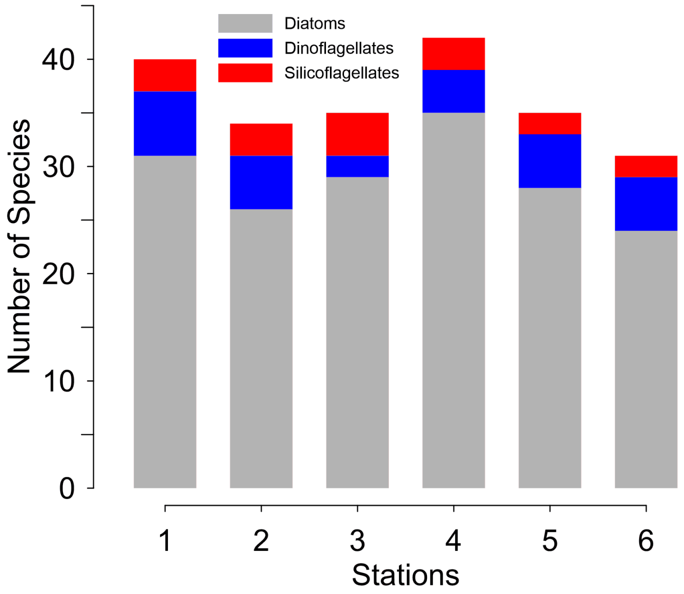

Figure 3. Distribution of phytoplankton species among stations based on water and net samples.

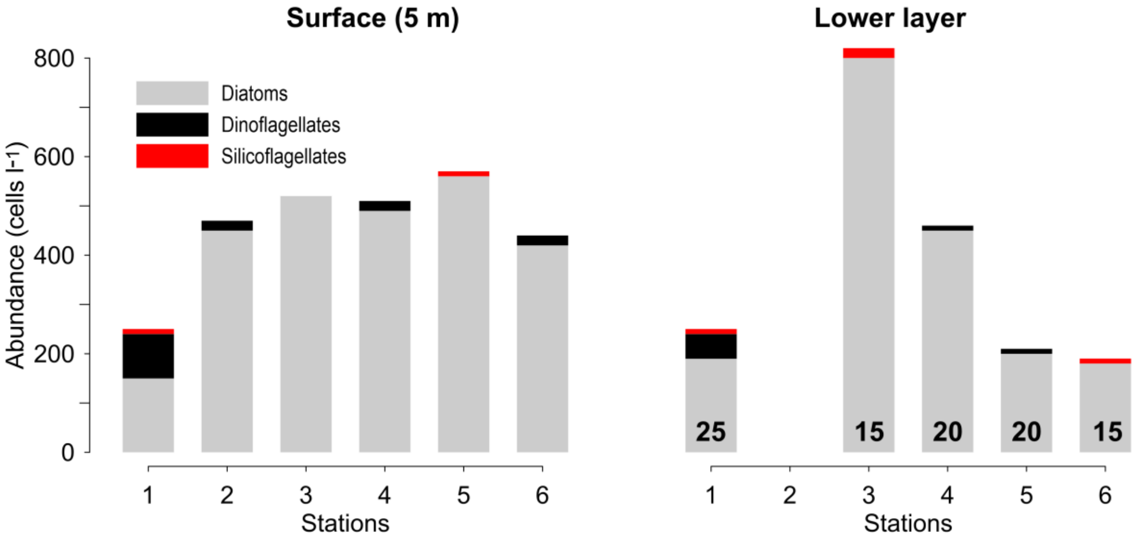

Figure 4. Group composition and abundance of phytoplankton at surface and lower layer. (Numbers within columns indicate sampling depth).

copepodites and naupli of a number of species (Table 3). In addition 9 meroplanktonic species were encountered, particularly at the Neumayer Channel Station. Cosmopolite *Oithona*, had the highest abundance. A Southern Ocean species, *Metridia gerlachei*, was the second most abundant species in terms of copepodit and nauplier stages. St. 1 once again had a different structure than Galindez stations (Figure 5). In addition to highest zooplankton abundance attained, contribution of meroplankton and a larvacean (*Fritillaria haplostoma*) were significantly higher.

Discussions

Global warming drives changes in the marine life as an outcome of the shift in the physicochemical context of the oceans (Boyd, Lennartz, Glover, & Doney, 2015). The species adapted to colder or warmer environments fluctuate their ranges in

Table 3. Registered zooplankton species and abundances

	St.1	St.2	St.3	St.4	St.5	St.6	St.1 Hor.	St. 5 Hor.
Calanoides acutus (Giesbrecht, 1902)	0.4	1.9	0.0	2.5	3.2	2.4		+
Calanus propinquus Brady, 1883	0.0	0.0	0.0	0.0	0.0	0.6	+	
Calanus sp. Copepodit	0.0	0.0	0.0	0.5	0.0	0.0		
Ctenocalanus citer Heron & Bowman, 1971	0.8	7.7	5.4	6.1	23.5	21.9	+	+
Unidentified Harpacticoid	0.4	2.9	3.9	2.5	0.9	1.2		+
Heterorhabdus sp. Copepodit	0.2	0.0	0.0	0.0	0.0	0.0		
Metridia gerlachei Giesbrecht, 1902	0.2	1.0	2.3	11.7	2.3	1.2	+	+
M. gerlachei Copepodit	15.2	2.9	1.5	0.5	0.5	0.0		
M.gerlachei Nauplius	28.3	0.0	0.0	0.0	0.0	0.0	+	+
Microcalanus pygmaeus (Sars, 1900)	0.4	0.0	0.0	0.0	0.0	0.0	+	
Oithona pseudofrigida Rosendorn, 1917	0.4	0.0	0.0	0.0	0.0	0.0	+	
Oithona similis Claus, 1866	22.6	27.7	11.6	30.5	55.7	49.4	+	+
Oncaea curvata Giesbrecht, 1902	9.1	2.9	3.9	4.1	3.2	2.4	+	+
Pareuchaeta sp. Copepodit	0.2	0.0	0.0	0.0	0.0	0.0	+	+
Rhincalanus gigas Brady, 1883	0.2	0.0	0.0	0.0	0.0	0.0		
Stephos longipes Giesbrecht, 1902	9.7	20.1	7.0	10.2	0.9	0.0	+	+
Triconia c.f. antarctica (Heron, 1977)	0.4	0.0	0.0	0.0	0.0	0.0		
Fritillaria haplostoma Fol, 1872	11.0	0.0	0.0	0.0	0.0	0.0	+	+
Calyptopis larvae	0.2	0.0	0.0	0.0	0.0	0.0	+	
Furcilia euphausiid larvae	0.4	0.0	0.0	0.0	0.0	0.0	+	+
Actinula larvae	0.2	0.0	0.0	0.0	0.0	0.0		
Polychaeta larvae	0.4	0.0	0.0	0.0	0.0	0.0		
Echinodermata Bipinnaria larvae	0.2	0.0	0.0	0.0	0.0	0.0	+	
Ecnidermata Brachiolaria larvae	0.0	0.0	0.0	0.0	0.5	0.0		
Ascidiacea larvae	0.2	0.0	0.0	0.5	0.0	0.0		+
Pilidium larvae	0.0	0.0	0.0	0.0	0.0	0.6		+

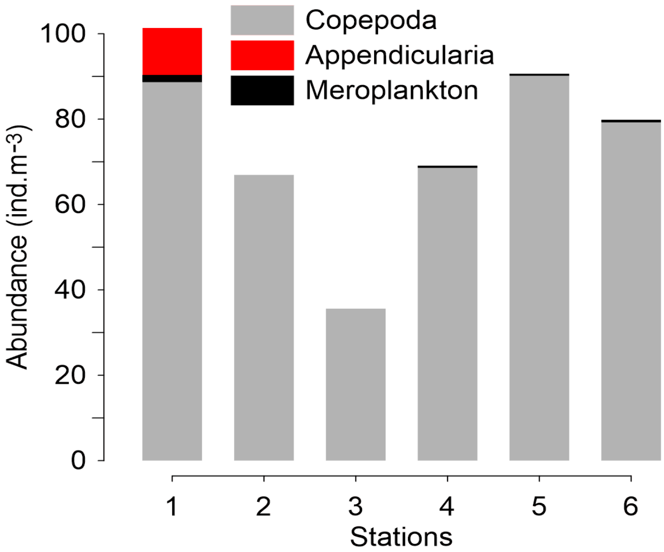

Figure 5. Copepod, meroplankton and total zooplankton abundance.

accordance with the changing physical structure, which are likely to have significant impacts on food web dynamics. One of the best known examples is the decreasing krill abundance and increasing salp biomass in the Southern Ocean (Pakhomov, Froneman, & Perissinotto, 2002). The krill, as one of the most abundant species on earth supports a wide range of organisms, while salps are considered as the trophic dead end (McClintock, Ducklow, & Fraser, 2008). Therefore, changes in the niche of species and mismatch due to phenological changes as an outcome of temperature fluctuations might have significant impacts on marine ecosystems. The continuous monitoring of plankton and physicochemical parameters will provide us a better understanding of the change in oceans and foresee future projections in a warmer ocean.

Our results indicate distribution of cosmopolite and boreal plankton species in the region in addition to Southern Ocean species. High variability in plankton and oceanographic conditions among small scale distances shows the dynamic structure of the basin. Low phytoplankton abundance in the study area could be considered as typical late autumn transition period from productive spring/summer to dormant winter conditions. However, a high diversity must be noted despite of low abundance. Previous studies on phytoplankton blooms at Eastern Antarctic Peninsula have suggested that warmer conditions may have led to stronger sea ice melting thus strengthening the water column stratification and favoring primary productivity (Detoni, de Souza, Garcia, Tavano, & Mata, 2015). The environmental features in the sampling area favoured the dominance of diatoms as the most important contributors to the phytoplankton community. In the present study, phytoplankton species composition showed that large diatom species dominated the total phytoplankton reflecting a much greater biomass. The contribution of small phytoplankton (<20 µm) to total abundance and biomass is reported to be higher than other taxa particularly in warmer years (Detoni *et al*., 2015; Olguín & Alder, 2011) and their importance may be expected to increase under future warming scenarios (Lee *et al.*, 2014). The large cell-sized *Odontella weissflogii* is described as a typical species of mid-season assemblages (Detoni *et al.*, 2015), similar to the present work.

Zooplankton was dominated by two species; the cosmopolite *Oithona similis* and the Southern Ocean species *Metridia gerlachei. Oithona* is argued to be the most important copepod taxa in world oceans (Gallienne & Robins, 2001). The same researchers suggested that the highly preferred 200 µm mesh size samples only 10% of small species such as *Oithona* and *Oncea*. Therefore, considering the tendency to smaller phytoplankton species as stated above, dominant zooplankton in austral autumn might also be dominated by the deficiently sampled smaller copepods. *M. gerlachei* is known to reside in deeper layers in higher densities, displaying strong vertical migration (Huntley & Escritor, 1992). *M. gerlachei* prefers to feed on <10 µm fraction of plankton (Calbet & Irigoien, 1997) while *O. similis* has a tendency to small diatoms and ciliates (Nishibe, Kobari, & Ota, 2010), all indicating the importance of smaller phytoplankton fractions in austral autumn. Therefore, future zooplankton samplings in the region should be conducted by utilizing a standard 200 µm mesh sized net, as well as an Apstein-type 55-63 µm mesh sized net, in order to better sample smaller zooplankton and more accurately estimate secondary production.

The remote location and harsh sea conditions in Antarctica and the Southern Ocean makes even the smallest scientific contribution important for a better understanding of the region. The utilization of these datasets in online GIS databases, such as Coastal & Oceanic Plankton Ecology, Production & Observation Database (http://www.st.nmfs.noaa.gov/plankton/), will enable us to better predict the ongoing changes in polar seas and world oceans through meta-analysis of numerous scientific datasets.

Acknowledgements

This work is supported by the Scientific Research Projects Coordination Unit of Istanbul University (FOA-2016-20530), Scientific Research Projects Coordination Unit of Kocaeli University (KOU-BAPB-2016/026), Scientific Research Projects Coordination Unit of Cukurova University (FBA-2016-6205) and the first joint Turkish-Ukrainian Antarctic Research Expedition. Authors thank the captain and crew of M/V Ushuaia, as well as the Turkish and Ukrainian authorities for their valuable help and support.

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