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ORAL PRESENTATION

Abundance and Distribution of Picoplankton in the Northeastern Mediterranean Sea

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Pelagic microscopic flora is consisted mainly of picoplanktonic fraction of phytoplankton in the oligotrophic offshore waters of northeastern Mediterranean Sea lacking sufficient amount of dissolved nutrients in euphotic layer. Present study aimed to investigate temporal and spatial heterogeneity in eukaryotic picoplankton (small eukaryotes) as well as in marine cyanobacteria *Synechococcus* and *Prochlorococcus* in different sectors of the basin. Samples were collected from 50 different stations including eutrophic Mersin Bay, Göksu River discharge area and oligotrophic offshore waters during October 2017 and February 2018. Flowcytometric cell counts clearly indicated dominancy of P*rochlorococcus* over *Synechococcus* and small eukaryotes in the study area. At surface, abundance of small eukaryotes, *Synechococcus* and *Prochlorococcus* varied in the range >1084; 11059 – 53842; 51661 – 29975 cells/ml in October 2017 and in the range 186 – 8122; 1835 – 77334; 261 - 77535 cells/ml in February 2018. Small eukaryotes have been found to be most numerous near Göksu discharge area and could not compete with marine cyanobacteria in offshore waters. *Synechococcus* and *Prochlorococcus* profiles have displayed similar patterns with subsurface peaks observed at around 50-75 m depths in October 2017. Conversely to maximal abundance was reached at surface in February 2018 where abundance decreased with depth. It is concluded that *Prochlorococcus* is the most abundant group in the study area compared to small eukaryotes and *Synechococcus*.

Keywords: picoplankton, *Synechococcus, Prochlorococcus*, abundance, northeastern Mediterranean

Introduction

Nutrient and chlorophly-*a* content of Mediterranean decrease from west to east and south to north depending upon major current systems and decreasing riverine nutrient inputs, respectively. (Krom et al., 1991, Moutin and Raimbault, 2002; Ortenzio and Alcal, 2009). As a result, Northeastern Mediterranean is known as the most oligotrophic sea in the world (Yılmaz and Tuğrul, 1998; Krom et al., 1991). Because of this oligotrophic nature, primary productivity relies mostly on smaller forms of phytoplankton (picoplankton) in this basin (Yücel, 2013; Uysal and Köksalan, 2017). Therefore, knowing the picoplankton abundance is crucial to understand microbial food web dynamics in the system. The aim of the present study is to investigate spatial and temporal heterogeneity in small

eukaryotes as well as in marine cyanobacteria *Synechococcus* and *Prochlorococcus* in areas with varying trophic capacity.

Material and Methods

In the present study, vertical and horizontal distribution of small eukaryotes and marine cyanobacteria *Synechococcus* and *Prochlorococcus* have been investigated in the northeastern Mediterranean. Sample collection was carried out at 50 different stations all covering partly the eutrophic Mersin Bay, Göksu River discharge area and oligotrophic offshore waters during October 2017 and February 2018 (Fig. 1).

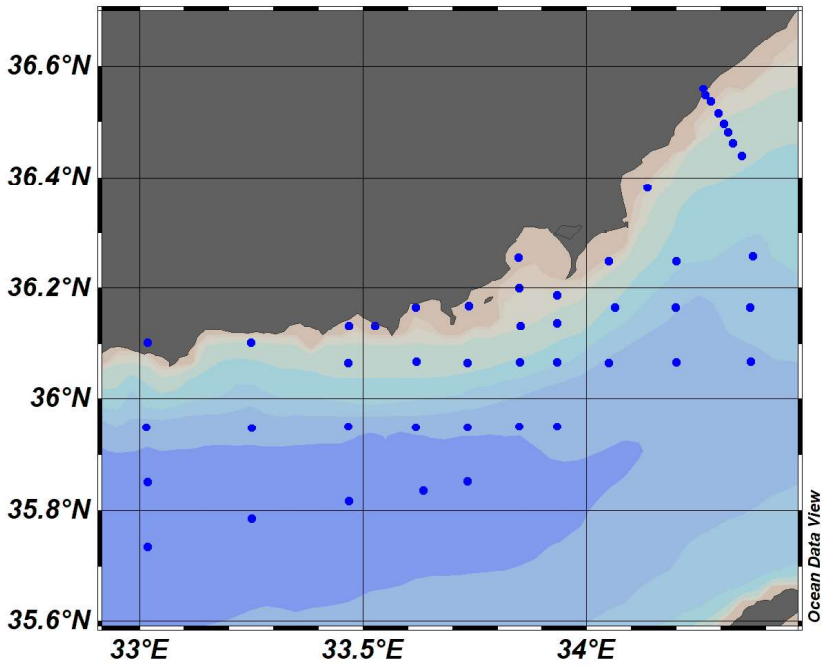

Fig. 1. Location of the sampling stations

Two cruises were undertaken on board R/V Bilim-2 of the Institute of Marine Sciences, Middle East Technical University in October 2017 and February 2018. Water samples from surface and various depths up to 200 meters were collected using 5 liters capacity Nansen closing bottles attached to a rosette sampler housing a Sea-bird Electronics-911 plus CTD probe. Samples taken from Nansen bottles were transferred into 50 ml dark glass bottles. Thereafter, 1.25 ml of 25% glutaraldehyde was added to provide a final concentration of 0.625%. Cell-counts were carried out using an Apogee brand flow-cytometry device.

Results and Discussion

Minimum and maximum abundance of small eukaryotes were found as 0-1084 cells/mL with an average of 160 cell/mL in October 2017 and 186-8.122 cells/mL with an average of 1.737 cells/mL in February 2018 (at surface). Results clearly showed that abundance of small eukaryotes increased in February as a result of winter conventional mixing. Profiles (not given here) indicated that abundance of small eukaryotes decreased with depth within the euphotic layer due to deficiency in dissolved nutrients. Eukaryotic microorganisms were found more abundant in coastal areas than offshore areas. However, they could not compete with cyanobacteria even in Göksu discharge area (Figure 2, Figure 3).

Surface minimum and maximum abundances of marine cyanobacteria, *Synechococcus,* were found as 11.059-53.842 cells/mL with an average of 11.059 cells/mL in October 2017 and 1.835-

77.334 cells/mL with an average of 17.963 cells/mL in February 2018. Similar to small eukaryotes, *Synechococcus* abundance was found greater in February. *Synechococcus* abundances observed recently have been found to be relatively less compared to the previous studies conducted in the same area (Uysal ve Koksalan, 2006; 2017; Uysal, 2006; Bayındırlı, 2007). Surface distribution of *Synechococcus* showed heterogenous distribution and dense populations were observed in both coastal and offshore waters in October 2017. However, in February 2008, *Synechococcus* population was only dense in coastal regions (Figure 4). Deep chlorophyll maximum (DCM) was observed at 50-75 meter depth range depending on station during October 2017 stratification period.

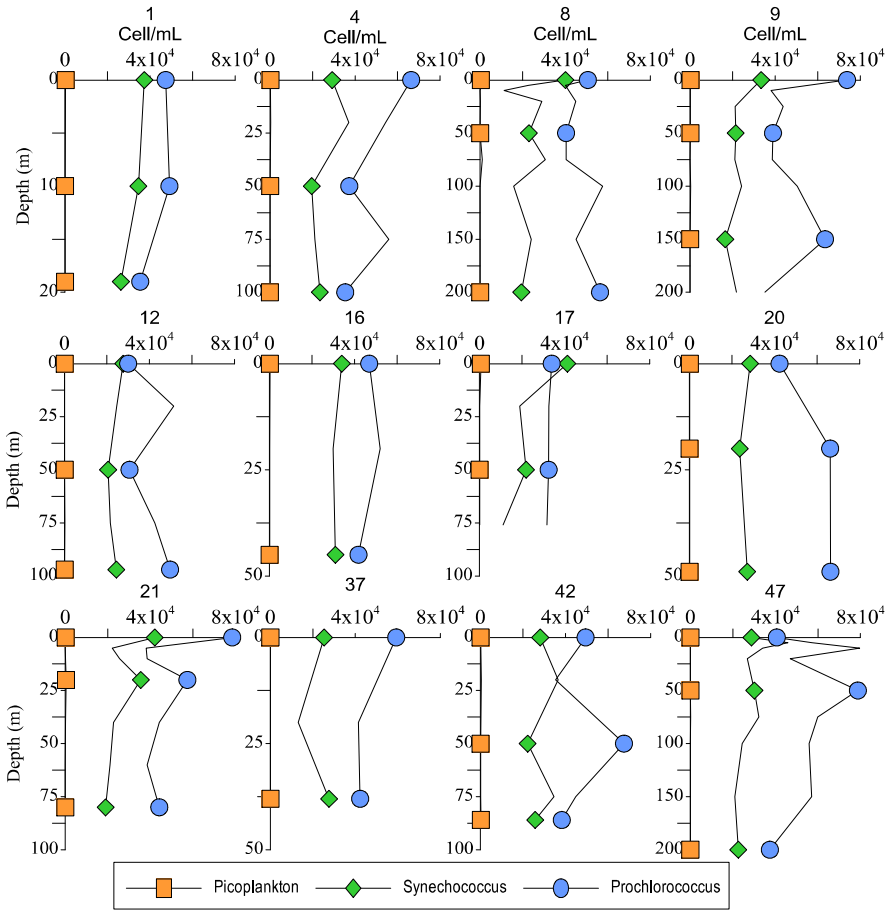

Figure 2. Vertical distribution of picoplankton (small eukaryotes), *Synechococcus* and *Prochlorococcus* in October 2017

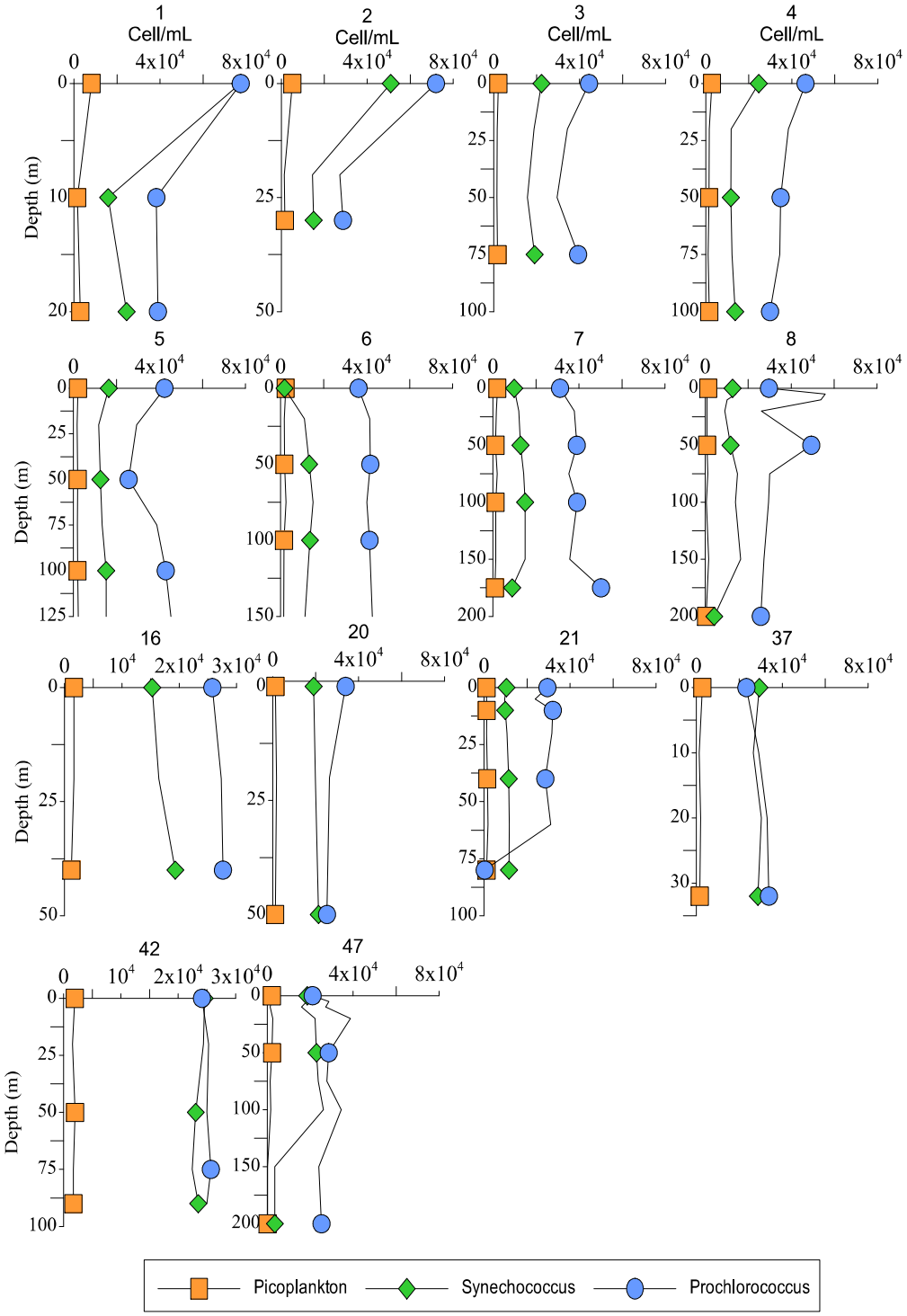

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Figure 3. Vertical distribution of picoplankton (small eukaryotes), *Synechococcus* and *Prochlorococcus* in February 2018.

Minimum and maximum abundance of *Prochlorococcus,* were found as 29.975 – 100.911 cells/mL with an average of 51.661 cells/mL in October 2017 and 261 – 77.535 cells/mL with an average of 31.134 cells/mL in February 2018 (at surface). Even though, average *Synechococcus* abundance was closer to the *Prochlorococcus* in February 2018, they could not compete with

Prochlorococcus in both offshore and coastal regions (Figure 3-4). Therefore, it could be said that *Prochlorococcus* was the most dominant group at all stations and at all depths sampled in the study area during both sampling periods (Figure 2 and 3). These results indicate that *Prochlorococus* is more tolerant to varying ambient conditions (from highly oligotrophic to eutrophic) than *Synechococcus* and small eukaryotes. Similar to *Synechococcus,* surface distribution of *Prochlorococcus* was more homogenous in February 2018 than October 2017.

Results showed that among the present groups studied *Prochlorococcus* is the most abundant microorganism in the study area. However, their contribution to the total phytoplankton biomass could be different depending on season and/or station. Li et al. (1993) found that *Prochlorococcus* pigment-biomass constitutes only 30 % of total in Sargossa Sea. Charles et al. (2005) found that contribution of marine cyanobacteria to the total picophytoplankton biomass is insignificant during December and January in the NW Mediterranean. Similarly, Buitenhuis et al. (2012), found that *Prochlorococcus*, *Synechococcu*s and picoeukaryotes accounts for 17-39%, 12-15% and 49-69% of total biomass in the global ocean, respectively.

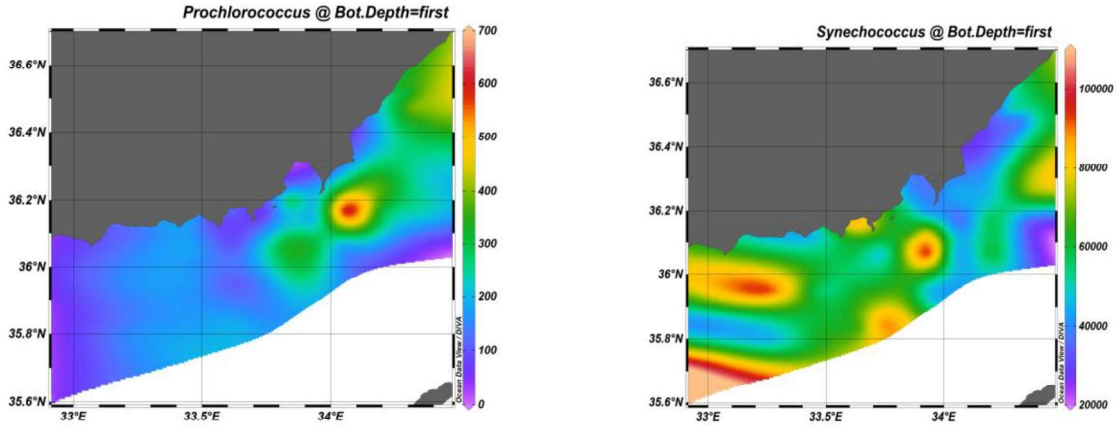

Figure 4. Surface distribution of *Prochlorococcus* and *Synechococcus* in October 2017

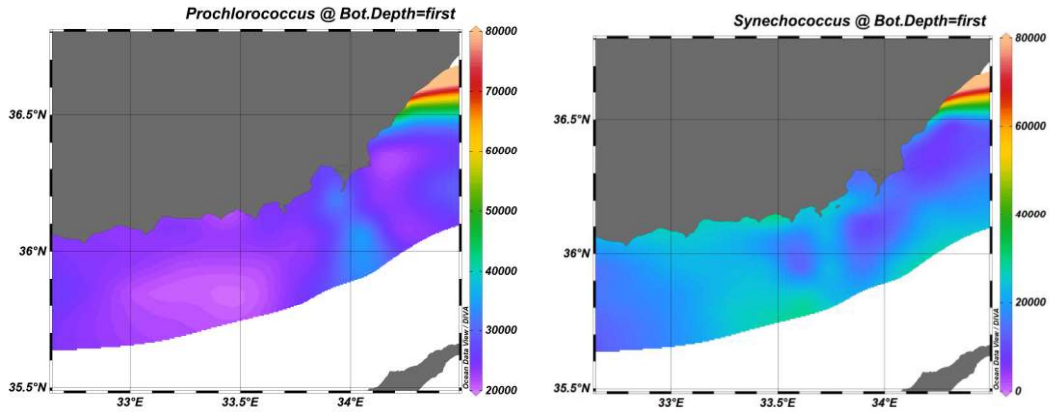

Figure 5. Surface distribution of *Prochlorococcus* and *Synechococcus* in February 2018

Relationships between small eukaryotes & marine cyanobacteria with ambient physical parameters (temperature, salinity, density, pH) were determined using Spearman rank corelation. Results showed that abundance of small eukaryotes depended on depth (negatively) and salinity (positively) for both seasons ($p<0.05$). On the other hand, temperature and density were only effective in October 2017 due to stratification period ($p<0.01$). Marine cyanobacteria *Synechococcus* abundance was strongly correlated with depth (negatively), temperature (positively) and salinity (positively) for both seasons

($p<0.01$). Additionally, there was a positive relationship between pH and density in February 2018. Lastly, even though *Prochlorococcus* abundance was only depended on depth in October 2017 ($p<0.05$), it is strongly posively depended on depth, temperature, pH and density on February 2018.

Table 1. Relationships between physical parameters and pikoplankton abundance based on Spearman's rank correlation coefficient

Abundance			Depth	Temprature	Salinity	pH	Density
October 2017	Small eukaryotes	Coefficient	-0.543	0.512	0.279	0.054	-0.509
		Significance	0.000	0.000	0.006	0.606	0.000
	Synechococcus	Coefficient	-0.720	0.334	0.507	-0.15	-0.325
		Significance	0.000	0.001	0.000	0.885	0.001
	Prochlorococcus	Coefficient	-0.238	-0.114	0.126	0.122	0.101
		Significance	0.020	0.272	0.225	0.239	0.328
February 2018	Small eukaryotes	Coefficient	-0.310	0,158	0,267	0,231	-0,188
		Significance	0.001	0.100	0.05	0.016	0.050
	Synechococcus	Coefficient	-0.329	-0.507	-0.339	0.440	0.342
		Significance	0.000	0.000	0.000	0.000	0.000
	Prochlorococcus	Coefficient	0.415	0.312	0.162	-0.518	-0.373
		Significance	0.000	0.001	0.093	0.000	0.000

Conclusion

This study is conducted to evaluate vertical and horizontal distribution of eukaryotic picoplankton, marine cyanobacterium *Synechococcus* and *Prochlorococcus* in contrasting regions. Flowcytometric cell counts showed that *Prochlorococcus* was most abundant than *Synechococcus* in offshore waters. While higher abundances of eukaryotic picoplankton and *Synechococcus* was found in winter, higher *Prochlorococcus* abundance was observed in fall. This study revealed that *Prochlorococcus* numerically is the major contributor to bulk phytoplankton in the northeastern Mediterranean which further needs to be studied in detail spatially and temporally.

Acknowledgment

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