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Living coccolithophores at an anthropogenically impacted neritic site of Thermaikos Gulf, NW Aegean Sea

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Background

Coccolithophores constitute a significant component of the phytoplankton communities in the oligotrophic environments of the Aegean Sea, especially in the south Aegean (Ignatiades *et al.*, 2002; Triantaphyllou *et al.*, 2004). In particular, *Emiliania huxleyi* is a key taxon for the coccolithophore productivity in the marine environment of Aegean Sea, but also numerous species of *Syracosphaera* spp., Rhabdosphaeraceae and holococcolithophores show significant contributions mainly in relatively diverse summer assemblages (e.g., Triantaphyllou *et al.*, 2004; Malinverno *et al.*, 2009; Dimiza *et al.*, 2015; Karatsolis *et al.*, 2017; Skampa *et al.*, 2019). These studies showed that coccolithophore dynamics display a highly seasonal variability primarily driven by the local water circulation pattern, changes in temperature and nutrient availability. Despite the well-studied coccolithophore assemblages in various marine ecosystems of the Aegean Sea, little is known about the coccolithophore species composition and variability in anthropogenically impacted neritic regions. In a recent study on the late-winter coccolithophore assemblages from the industrial zone of Elefsis-Saronikos Gulf, Dimiza *et al.* (2014) reported significantly lower abundance and species diversity compared with off-shore assemblages of the Aegean Sea, with nearly monospecific assemblages of *Helicosphaera carteri*, which behaved like an opportunistic taxon.

Objectives

In the present study, we investigated the living coccolithophore abundance, community structure and key species of coccolithophores from a 12 monthly time series in the Thessaloniki Bay, a polluted bay located in the inner part of Thermaikos Gulf (Northwestern Aegean Sea). The aims of this research were to examine the seasonal variation of coccolithophorres and determine the effects of environmental factors on their abundance, species composition and distribution in a restricted environment with intense anthropogenic activity.

Materials and methods

The monitoring site is located near the outer edge of the Thessaloniki Bay (Inner Thermaikos Gulf), about 7 km south of the Thessaloniki city (station SP1: 40°35'11.72" N and 22°55'1.20" E) and is approximately 22 m in depth. Water samples have been collected by pumping, on a monthly basis between January and December 2016. During each sampling campaign, water temperature and salinity measurements were obtained with a CTD device. Monthly-averaged data for satellite chlorophyll a (Chl-*a*) concentration from MODIS-Aqua (MODerate resolution imaging spectroradiometer) were obtained from the National Aeronautic and Space Administration (NASA) Giovanni website (http://disc.sci.gsfc.nasa.gov/techlab/giovanni/).

Phytoplankton counts (cells, colonies, and filaments) were performed on subsample volume of 25 ml of seawater per sample using a Zeiss inverted light microscope (LM) following the sedimentation method described by Utermohöl (1958).

The coccolithophore composition and community structure was evaluated through Scanning Electron Microscopy. The samples were examined in a Jeol JSM 6360 Scanning Electron Microscope (SEM) (University of Athens, Faculty of Geology and Geoenvironment) and the coccospheres per liter was calculated following the methodology of Jordan and Winter (2000).

Results and Discussion

The sea surface temperatures exhibited a seasonal cycle with low values ~11°C in wintertime and maxima of approximately 26°C during the summer months. Sea surface salinity values (< 22.5) were low from January through to May indicating significant freshwater supply and increased gradually to 34.7 in the following months. Satellite measurements of Chl-*a* concentrations in this area were quite high (> 2.5 mg m^{-3}) throughout the year with a spring peak reaching 33 mg m^{-3}.

The phytoplankton community was composed mainly of diatoms, dinoflagellates, coccolithophores, cryptophytes, silicoflagellates and euglenophytes. The total phytoplankton abundance ranged from 2×10^4 cells l^{-1} to 1.5×10^6 cells l^{-1} and averaging 3.5×10^5 cells l^{-1}. The seasonal pattern showed a main peak in April-May and a secondary increase in October. Diatoms were the most abundant component of the phytoplankton community, whereas coccolithophores were the second significant element of the community. Dinoflagellates were abundant mostly in July.

Coccolithophore assemblages were dominated mostly by *Emiliania huxleyi*, a typical opportunistic species; well known for its quick response to nutrient enrichment, even in oligotrophic areas (e.g., Dimiza *et al.*, 2015). This species displayed

concentrations of up to 24 × 10^3 coccospheres l^{-1} during winter-early spring, similar to the typical *E. huxleyi* Aegean values. However, extremely high cell densities of *E. huxleyi* (420 × 10^3 coccospheres l^{-1}) were observed in April, following Chl-*a* maxima. *Gephyrocapsa oceanica*, a well-known species for its preference for warm, high-nutrient, less saline waters (e.g., Andruleit and Rogalla, 2002), represented a major component (210 × 10^3 coccospheres l^{-1}) to coccolithophore abundance in July. Its abundance is unusually high for the coccolithophore assemblages of the Aegean Sea, where this species has been rarely reported. *Helicosphaera carteri*, and various species of *Syracosphaera*, such as *S. protrudens*, *S. molischii* represented minor components of the coccolithophore assemblages.

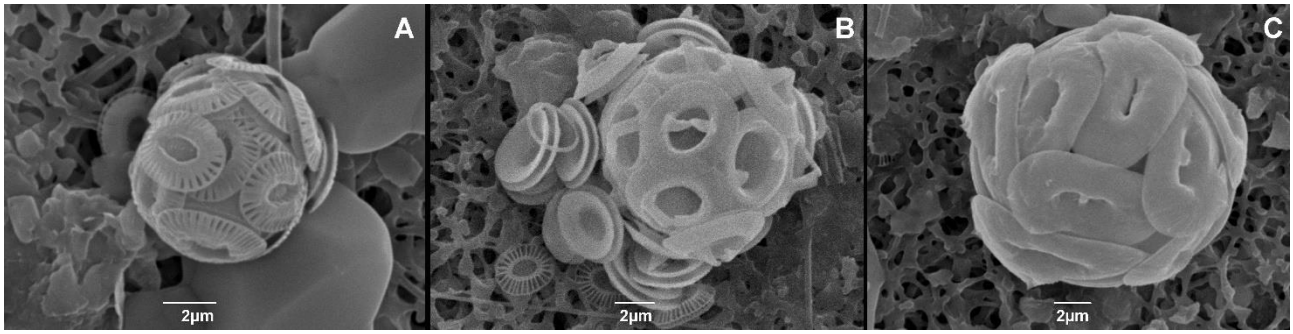

Fig.1 Coccolithophore species A *Emiliania huxleyi* (Lohmann) Hay and Mohler var. *huxleyi*, SP1, February 2016; B *Gephyrocapsa oceanica* Kamptner, SP1, April 2016; C *Helicosphaera carteri* (Wallich) Kamptner, SP1, February 2016.

The seasonal variation of living coccolithophores reflects the exceptional environmental conditions that prevailed in the semi-closed inner Thermaikos Gulf with respect to the open Aegean Sea, thus providing further evidence of the species' biogeography.

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References

Andruleit, H., Rogalla, U., 2002. Coccolithophores in surface sediment of Arabian Sea in relation to environmental gradients in surface waters. Marine Geology, 186, 505–526.

Dimiza M.D., Triantaphyllou M.V., Malinverno E., 2014. New evidence for the ecology of *Helicosphaera carteri* in polluted coastal environments (Elefsis Bay, Saronikos, Greece). Journal of Nannoplankton Research, 34: 37–43.

Dimiza, M., Triantaphyllou, M.V., Malinverno, E., Psarra, S., Karatsolis, BT., Mara, P., Lagaria, A., Gogou, A., 2015. The composition and distribution of living coccolithophores in the Aegean Sea (NE Mediterranean). Micropaleontology 61, 521–540.

Ignatiades, L., Psarra, S., Zervakis, V., Pagou, K., Souvermezoglou, E., Assimakopoulou, G., Gotsis-Skretas, O., 2002. Phytoplank ton size-based dynamics in the Aegean Sea (Eastern Mediterranean). J. Mar. Sys., 36, 11–28.

Jordan, R.W., Winter, A., 2000. Assemblages of coccolithophorids and other living microplankton off the coast of Puerto Rico during January-May 1995. Mar. Micropaleontol. 39, 113–130.

Karatsolis, B.-Th., Triantaphyllou, M.V., Dimiza, M. D., Malinverno, E., Lagaria, A., Mara, P., Archontikis, O., Psarra, S., 2017. Coccolithophore assemblage response to Black Sea Water inflow into the North Aegean Sea (NE Mediterranean). Continental Shelf Research 149, 138–150.

Malinverno, E, Triantaphyllou, M.V., Stavrakakis, S., Ziveri, P., Lykousis, V., 2009. Seasonal and spatial variability of coccolithophore export production at the South-Western margin of Crete (Eastern Mediterranean). Marine Micropaleontology 7, 131–147.

Skampa, E., Triantaphyllou, M.V., Dimiza, M.D., Gogou, A., Malinverno, E., Parinos, C., Panagiotopoulos, I.P., Baumann, K.-H., 2019. Coupling plankton-sediment trap-surface sediment coccolithophore regime in the North Aegean Sea (NE Mediterranean). Marine Micropaleontology, https://doi.org/10.1016/j.marmicro.2019.03.001.

Triantaphyllou, M.V., Ziveri, P., Tselepides, A., 2004. Coccolithophore export production and response to seasonal surface water variability in the oligotrophic Cretan Sea (NE Mediterranean). Micropaleontology 50, 127–144.

Utermöhl, H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton. Methodik. Mit. lnt. Verein. Theor.Angew. Limnology, 9, 1-38.