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SPECIES COMPOSITION, DENSITY AND BIOMASS OF COCCOLITHOPHORIDS IN THE ISTANBUL STRAIT, TURKEY

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Summary

A first report of the coccolithophorid flora in the phytoplankton of the Istanbul Strait is presented in this paper. Samples were taken with a Nansen bottle at three depths (surface, -5 m, -10 m), on the coast of Istanbul Strait, considering four different areas: Üsküdar, Çengelköy, Kanlıca and Beykoz during May 97 and August 1998. Density, biomass and total phytoplankton chlorophyll *a* content were calculated. During the study period, some physical and chemical parameters were measured. A total of five species of coccolithophorids were observed at sites, however considerable differences were observed in the seasonal fluctuations of density and biomass. A bloom was observed during May 1997. *Calyptrosphaera* species was the most dominated species followed by *Anacanthoica acanthos* (Shiller) Deflandre. Biomass, quantified as biovolume, showed a well-defined seasonal pattern.

Introduction

Marine plankton mostly consists of unicellular, loading cells belonging to different classes of algae and bacteria, motile flagellates and ciliates. These cells range from less than 1 μm to greater than 1 mm in size and can attain population abundances exceeding a million cells per liter during bloom periods.

The coccolithophorids form a very important group of marine phytoplankton. They play an important role in the formation of calcareous deposits (Tomas, 1993). At present 200 living species of coccolithophorids belonging to nearly 70 genera have been described. They often form the dominant constituent of the nannoplankton (the fraction of less 20 μm), because their longest dimensions rarely exceed 30 μm (Heimdal, 1999). Because of their abundance they also play a major role in the cycling of organic matter within the oceanic microbial food web. They occupy the ecological niches of both primary producers and grazers. As grazers of bacteria they are vital components of the microbial loop but also serve as food for ciliates and larvae (Thomsen *et al.*, 1994).

Coccolithophorid belong to the Haptophyte algae and bear ornamented calcified plates or coccoliths on the cell (or coccosphere) surface. The coccoliths consist of calcium carbonate, primarily in the crystalline form of calcite and the morphology and arrangement is used together with cell shape to identify the species (Heimdal, 1997; Hernandez-Becerril, 2001).

Many studies have been carried out on phytoplankton ecology in Turkish seas but very few on nannoplankton including coccolithophorids (Polat *et al.*, 2000; Eker Kıdeyş, 2000; Koray, 1995; Uysal, 1987; Uysal, 1996; Uysal, Ünsal, 1996; Tüfekçi & Okuş, 1998; Balkıs, 2000).

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During a study of the phytoplankton of the Istanbul Strait (Turkey), which was carried out from May 1997 to 1998 extensive occurrence and abundance of Haptophytes (coccolithophorids) have been observed. The present paper describes the composition and seasonal variations of coccolithophore density and biomass in phytoplankton of Istanbul Strait and physico-chemical factors affecting them.

Materials and Methods

Study area

The Istanbul Strait is an important canal located at 28^{0}58' 00" E - 29^{0}10'00" E and 41^{0}00'00" N - 41^{0}15'00" N. The Istanbul Strait links the Black Sea and is characterised by a salinity of about 17 ‰ due to the inflows of the rivers Danube, Dnieper and Dniester with the Marmara Sea, which is directly connected with the Mediterranean Sea by the Dardanelles Strait. The Istanbul Strait has been threatened by domestic and industrial outputs of Istanbul city of about 12 millions of inhabitants extended along its shores. The Istanbul Strait is characterised by a well definite current system consisting of two layers: a surface one, from the Black Sea to the Marmara Sea, which has waters less saline than the deep one, from the Marmara Sea to the Black Sea. Several urban and industrial untreated wastes pour in the Istanbul Strait in addition to the freshwaters coming from the great rivers that flow into the Black Sea (Samsunlu *et al.*,1991; Polat & Tuğrul, 1996). Main morphometric characteristics of the Istanbul Strait are given in Table 1.

Table 1. Main morphometric characteristics of the Istanbul strait.

Mean depth (m)	36
Maximum depth (m)	110
Length (km)	31
Minimum width (m)	700
Maximum width (m)	3500
Water flow in the upper layer ($m^{-3}s^{-1}$)	20000

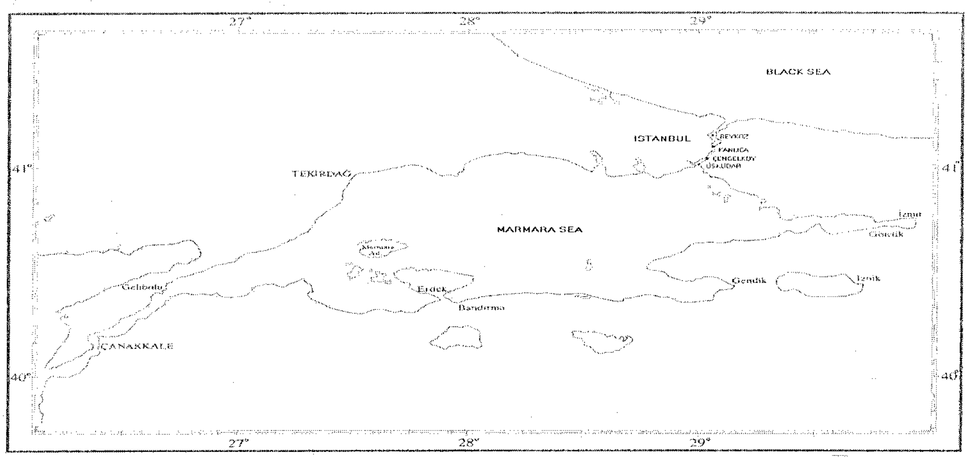

Fig. 1. The sampling stations of the Istanbul Strait

Water samples were collected with a Nansen bottle bimonthly from May 1997 to August 1998 from 4 sampling sites at three depths from surface, -5 m and –10 m, corresponding to the euphotic zone (Fig. 1). In the laboratory, the samples were placed in 1liter jars and then fixed with formaldehyde solution (4% final concentration) for counting of phytoplankton. Phytoplanktonic density was calculated as cells/L. Cells counts were performed with an inverted Zeiss microscope by the Utermöhl method. Biomass was estimated from biovolumes according to Findenegg (1974). The cell volume of each algal species was calculated based on cell shape and size (Hillebrand, 1999), and chlorophyll *a* was determined by adjusting the final acidification concentration to $3x10^{-3}$ HCl (Anon., 1966).

For physical and chemical characteristics, water transparency was measured with a Secchi disk and the temperature at each depth measured with a thermometer. pH, conductivity, dissolved oxygen (Winkler method) and dissolved inorganic nutrients (posphorus, nitrogen and silica) all were determined according to Strickland & Parsons, 1968) and the average was calculated to represent the euphotic zone

Results

Physical and chemical parameters

During the research period, the water temperature showed a well-defined seasonal pattern, ranging from 25^0C in July 1997 (Beykoz) to 3.8^0C in January 1998. There were no remarkable temperature differences between depths. The yearly mean value for Secchi disc depth was determined as 5,4 m. The highest value was recorded as 8 m in August 1998 and the lowest was recorded as 3 m in Çengelköy, Kanlıca and Beykoz (in May). In the annual cycle of dissolved oxygen, maximum value (116.5% sat.) was measured in Üsküdar (July 1997), while minimum value (57% sat.) was measured in Beykoz (November 1997 and August 1998). pH of the bay water did not change very much and ranged between 8.3-8.5 with an average being 8.4. There were no marked changes in conductivity between stations and depths, except in November 1997 (23 mS cm^{-1} in surface of Kanlıca) with an average of 28 mS cm^{-1}.

Nitrate concentrations were usually below 15 mg N m^{-3}, with isolated peaks in late spring (May 1997 and May 1998) and autumn (November 1997). The pattern of seasonal variation was irregular with high low values occurring at any time, depth or stations.

Phosphate concentrations also varied irregularly throughout the period. Peak concentrations were found as average of 19 mg P m^{-3} (November, 1997) in Çengelköy where waste-water enters directly. The lower values were found in November 1997. Lower silicate concentrations were found at the autumn and winter period of the study cycle, while higher silicate concentrations were found in July 1997 and January1998.

The chlorophyll *a* of phytoplankton concentrations in the water varied from 0.1 mg m^{-3} to 2.1 mg m^{-3}. Higher chlorophyll *a* values were found at the beginning of the study period in Beykoz particularly because of coccolithophorids developing and between October 1997 and January 1998 in all stations because of developing of diatoms eg., *Pseudosolenia calcar-avis* (Schultze) Sundstörm.

The results of some physical and chemical analysis are summarised in Table 2.

Table 2. The results of the some physical and chemical analysis (March 1999-September 2000).

	min	max	average
Temperature (^{0}C)	4	26	13
Secchi disc (m)	3	8	5,4
Dissolved oxygen (%)	54	119	85
PH	8,3	8,6	8,4
Conductivity (mS cm^{-1})	23,2	33,2	27,8
Alkalinity (meq l^{-1})	2,4	3,5	3,2
Nitrate (mg N m^{-3})	0	48	14,6
Reactive posphorus (mg P m^{-3})	0	44	2,4
Reactive silica mg Si L^{-1}	0,02	0,34	0,14
Total density of coccolithophores (cells L^{-1})	0	2339265	315492
Total biomass of coccolithophores (mg L^{-1})	0	0,5	0,07
Chlorophyll *a* of phytoplankton (mg m^{-3})	0,1	2,1	0,7

Composition and seasonal variation in Coccolithophore abundance, biomass and bloom (peak) timing

During the research period, member of the algal classes viz., Bacillariophyceae, Dinophyceae, Crysophyceae, Dictyochophyceae, Haptophyceae, Prasinophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, Ebriidea were recorded. A total of 5 taxa of coccolithophorids were found during the annual cycle (Table 3).

Table 3. Coccolithophorids observed at several sites in the Istanbul Strait. [a] Cell Volume (μm^3) calculated based on cell shape and size; [b]Occurence of coccolithophorids.

	Volume [a]	Stations [b]			
		Üsküdar	Çengelköy	Kanlica	Beykoz
Anacanthoica acanthos	231	+	+	+	+
Anacanthoica sp.	513	+	+	+	+
Calyptrosphaera sp.	215	+	+	+	+
Rhabdosphera sp.	2142	+	+		
Syracosphera sp.	624		+	+	+
Unidentified *Coccolithophores*	1170	+	+	+	+

The most abundant species at all stations and depths was mostly *Calyptosphaera* species, followed by *Anacanthoica acanthos* (Schiller) Deflandre. Biomass, quantified as biovolume, showed a well-defined seasonal pattern (Fig. 2 and Fig. 3). Positive correlation was observed between seasonal variation in density and biovolume expressed as cells L^{-1} and mg L^{-1} (R^2= 0,99). Correlation of chlorophyll *a* was found not significant (R^2=0,1) because of developing of diatoms and dinoflagellates which contributed higher chlorophyll *a* in some period.

One peak was distinguished at the beginning of the study cycle during May 1997 (Fig. 2). Seasonal changes of density and biomass did not show remarkable differences between stations. In May 1997, the highest density 2,340,000 cells L^{-1}and biomass of 0.5 mg L^{-1}were recorded in Beykoz at surface.

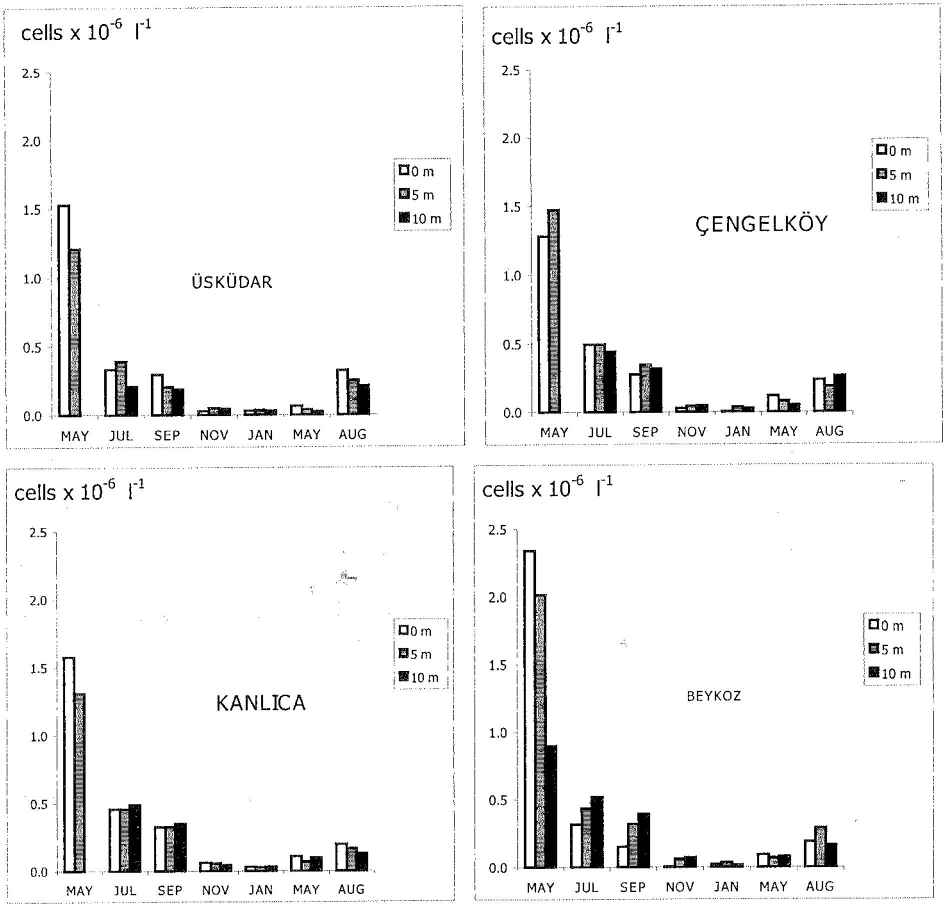

Fig. 2. Seasonal changes of coccolithophore density at different stations in the Istanbul Strait

In all stations a sharp decrease less than 521,000 cells L^{-1} in density and 0.1 mg L^{-1} in biomass was observed after May 1997. Decreasing gradually toward the autumn periods, the lowest density and biomass were recorded in November 1997 and January 1998. A small increase was recorded in May 1998 with no remarkable growth. The highest values recorded was 325,523 cells L^{-1} and 0.07 mg L^{-1} in August 1998.

Discussion

Several species of marine phytoplankton frequently form huge blooms and disturb natural ecosystems in coastal areas around the world. Coccolithophorids are often more abundant than other phytoplankton groups in warm, oligotrophics water and may occasionally bloom (Thomsen *et al.*, 1994; Hernandez-Becerril, 2001). Data from remote sensing revealed that such blooms cover many thousands of square kilometers, but few attempts have been made to investigate their dynamics or determine their importance with respect to carbon removal from surface waters and their influence on the air-sea exchange of carbon dioxide (Tomas, 1999).

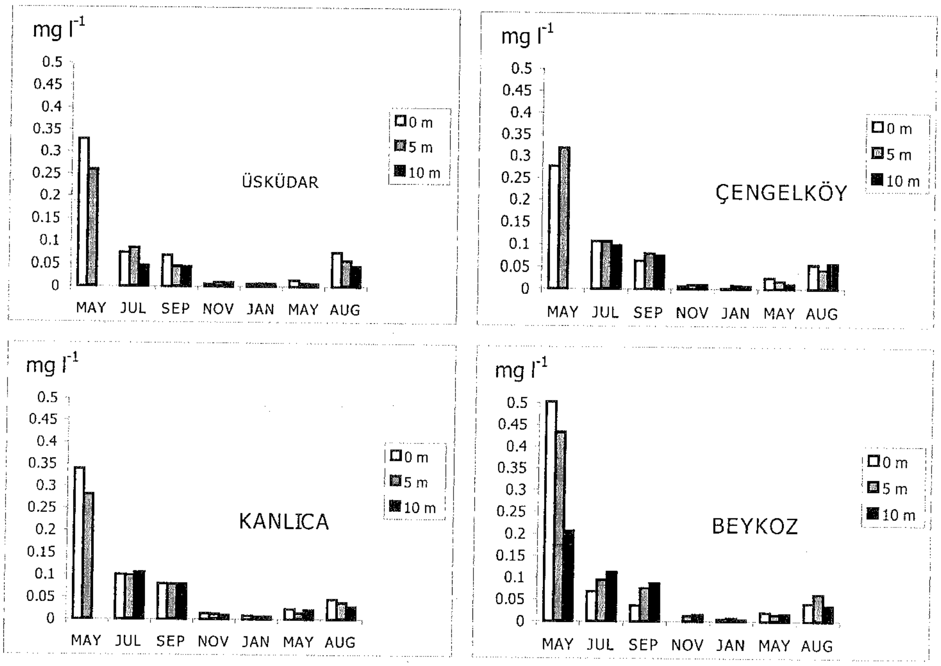

Fig. 3. Seasonal changes of coccolithophore biomass for stations in the Istanbul Strait

In many studies bloom of the Haptophytes, which have a cosmopolitan distribution, were recorded (Hernandez-Beceril, 2001). Tomas (1999) suggested that most living coccolithophorids inhabit tropical or sub tropical waters, predominantly oceanic ones, although other species are rather neritic or found indifferently in both regions.

Coccolithophorids blooms (>10^6 cells l^{-1}) are persistent features in certain regions of the Atlantic. In Norwegian coastal waters, the North Sea, and the Skagerrak conspicuous blooms of *Emiliania huxleyi* appear to be an almost annual phenomenon with cell numbers up to 115 x 10^6 cells l^{-1} (Thomsen *et al.*, 1994). *E.huxleyi* also was recorded in Mersin Bay at the end of winter and spring, which constituted 37% of total phytoplankton (Eker & Kıdeyş, 2000).

In the present study, 5 coccolithophorid taxa have been observed with a bloom in May 1997 whilst at other times quite considerable growth were recorded. Relative low number of taxa were found in this study in comparison with the other algal groups. However, density and biomass were important and haptophytes were recorded as a significant component.

Bloom of coccolithophorids was recorded in May in the Istanbul Strait, when temperature was increasing. pH values did not show sharp difference. Values of nutrients were not stable. It is probably because of the hydrodynamics of the Istanbul Strait and entry of intensive sources of nutrients from rivers, sewage, industry, heavy marine traffic and their importance varied from place to place on the coasts of the Istanbul Strait.

Detailed studies on coccolithophorids have been neglected in Turkish seas, despite their great importance. Possible causes for the lack of information for this the group may be problems in collecting coccolithophorids, which involve sampling with large bottles or very fine-meshed plankton nets, and the analysis that requires certain experience in recognizing very small forms (many species may be easily ignored or identified as nanoplankton in routine phytoplankton examinations). This study is an attempt to gain more knowledge on this group in waters of the Istanbul Strait, Istanbul. However light, transmission and scanning electron and epifluorescence microscopy will contribute to identifications of this group.

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