

Total and size fractionated phytoplankton biomass off Karataş, north-eastern Mediterranean coast of Turkey

Türkiye'nin kuzeydoğu Akdeniz kıyıları, Karataş açıkları toplam ve boy gruplarına ayrılmış fitoplankton biyomasi

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Abstract

The biomass of phytoplankton in terms of chlorophyll *a* was investigated in an Mediterranean coastal area, off Karataş. Data were obtained during four cruises conducted in July 2003, November 2003, February and May 2004. In addition to total chlorophyll *a* determination, chlorophyll *a* was fractionated into size classes as: <20 µm and >20 µm fractions. Inorganic nutrients were also determined. Total chlorophyll *a* values ranged from 0.10 to 7.43 µg l⁻¹. The contributions of the <20 µm and >20 µm fractions to the total chlorophyll *a* were similar. The proportion of <20 µm fraction to total chlorophyll *a* ranged between 9% and 96%. On the other hand, the lowest proportion of >20 fraction to total chlorophyll *a* was 4 %, and the highest one was 91 %. Despite the dominance of small sizes in the oligotrophic seas such as Mediterranean, the biomass of small size fraction was not higher than large size in the present study.

Keywords: Chlorophyll *a*, phytoplankton, size fraction, northeastern Mediterranean.

Introduction

Small sized phytoplankton such as picoplankton and nanoplankton are the major contributors of biomass and primary productivity in oligotrophic marine environments. Small size fractions appear to be an important component of microbial food web and carbon flow of such environments

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(Berman *et al.*, 1986; Azov, 1991). Recent studies made by epifluorescence methods reveal that the phytoplankton smaller than $<3 \mu\text{m}$ (picoplankton) are ubiquitous and very common and this size fraction accounts for about 80-90% of the total primary productivity in some waters (Harris, 1986). Due to its small size, picophytoplankton has advantage to acquire nutrients in oligotrophic environments. However, under nutrient rich conditions, phytoplankton populations dominated by large cells (Jiao and Ni, 1997).

There are many methods to determine phytoplankton biomass. Of these, the analyse of chlorophyll pigments to characterize phytoplankton biomass is widely used. Since chlorophyll is an unique component of plant matter and essential for photosynthesis, the determination of chlorophyll *a* concentration has been recognized as one of the most useful methods of estimating the algal biomass (Jasprica and Caric, 1997). For this reason, the contribution of different size classes to total biomass is determined by pigment analyses as well as microscopic methods.

A number of studies on phytoplankton communities including their spatial and temporal variations have been conducted in the eastern Mediterranean (Lakkis and Lakkis, 1980; Azov, 1986; Polat *et al.*, 2000). However, size fractionated biomass measurements are still very scarce in the Mediterranean coast of Turkey (Polat, 2006). In this study, the dynamic of phytoplankton biomass in terms of chlorophyll *a* was investigated. The aims of this study were: (1) to determine temporal and spatial variations of chlorophyll *a* biomass, (2) to describe the relative contribution of different size classes to total chlorophyll *a* by means of size fractionation, and (3) to investigate processes affecting the size distribution, especially related to physico-chemical parameters.

Material and Methods

Study area

The research was carried out at the North-eastern Mediterranean coast of Turkey, off Karataş. A seaside town, Karataş is located at the northern entrance of İskenderun Bay. The Ceyhan River which is one of the most important river of the region drain into the sea near Karataş with an average discharge rate of $180 \text{ m}^3 \text{ s}^{-1}$. Nine sampling stations were selected. Sampling stations were located in an area between Karataş and Ceyhan River mouth (lat. $36^\circ 31' \text{ N}$, $36^\circ 33' \text{ N}$; long. $35^\circ 20' \text{ E}$, $35^\circ 33' \text{ E}$) (Figure 1).

Sampling procedures and physico-chemical analyses

The sampling was performed four times from July 2003 to May 2004, at the nine stations, off Karataş, North-eastern Mediterranean Sea. Water samples

were collected from surface at all stations for chlorophyll *a* (chl *a*) and nutrient analyses. At the stations 7 and 8, samples were also taken at depths of 5, 10, 20, 30, 40, 50 m using a Hydro-bios water sampler. Sea water temperature and salinity were measured using a YSI SCT meter. Inorganic nutrients (phosphate, nitrate+nitrite and silicate) were measured spectrophotometrically according to methods described by Strickland and Parsons (1972).

Chlorophyll *a* analysis and size fractionation

Chlorophyll *a* concentrations were measured spectrophotometrically according to method given by Parson et al. (1984). From each station and depth, 2 l of seawater were filtered separately through 20 μm pore size filters and GF/F filters (47 mm diameter). The filters were put into glass tubes containing 10 ml of 90% acetone, and stored in the dark at 4°C for 24 h. In this study, size range was based on presented by Boney (1989), in which picoplankton size range is <2 μm , that of nanoplankton is 5-20 μm , and that of microplankton is 20 μm -200 μm . Since a 20 μm filter was used in this study, picoplankton and nanoplankton fractions were evaluated together as <20 μm fraction.

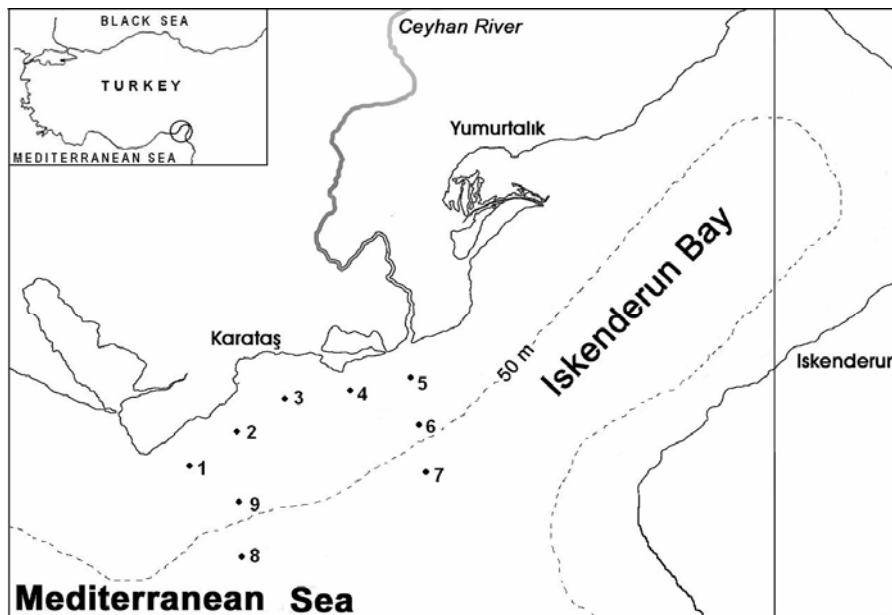


Figure 1. Location of sampling stations.

The chlorophyll *a* retained with GF/F filter is referred as total chlorophyll *a*. The pico+nanoplankton (<20 µm) size fraction is defined as that retained on GF/F filter after filtration the seawater sample through 20µm filter. Finally, the chlorophyll *a* content of larger fraction (>20 µm) was calculated by subtracting the <20 µm size fraction from total chlorophyll *a*.

Results

The minimum, maximum and mean values of temperature and salinity are presented in Table1. The lowest sea water temperature was measured in February 2004 (11.9 °C) and the highest (29.8 °C) in July 2003. Salinity varied between 12.3 and 38.6 ‰. The lowest salinity was recorded in February 2004 at station 6, which was close to the river discharge area.

Table 1. The minimum, maximum and mean values of physico-chemical data during the sampling periods.

	July 2003	November 2003	February 2004	May 2004
Temperature (°C)	28.7-29.8 29.2±0.10	24.5-26.4 25.6±0.20	11.9-16.10 14.4±0.49	15.6-21.8 20.5±0.56
Salinity (‰)	13.8-38.6 31.3±2.40	30.6-35.6 34.3±0.52	12.3-36.4 30.5±3.30	32.9-34.7 33.8±0.20

Seasonal variations of surface water nutrient concentrations are shown in Figure 2. Phosphate concentrations ranged from 0.05 to 1.42 µM. The highest value was determined at the station 4 in February. Phosphate concentrations were usually between 0.1-0.4 µM in water column. However, phosphate values showed significant fluctuation at water column of station 8 (Figure 3). Significant seasonal and spatial variations was observed in the nitrate+nitrite concentrations, with lowest value (0.19 µM) in October 2003, and the highest value (64.4 µM) in July 2003. The highest values were observed at the surface in terms of nitrate+nitrite concentrations (Figure 3). Silicate ranged from 1.93 to 95.8 µM, with the lowest value in February 2004 and highest value in July 2003 (Figure 2). Generally higher values were recorded at the stations near the river discharge area. Silicate values were higher at surface water in most of the sampling periods (Figure 3).

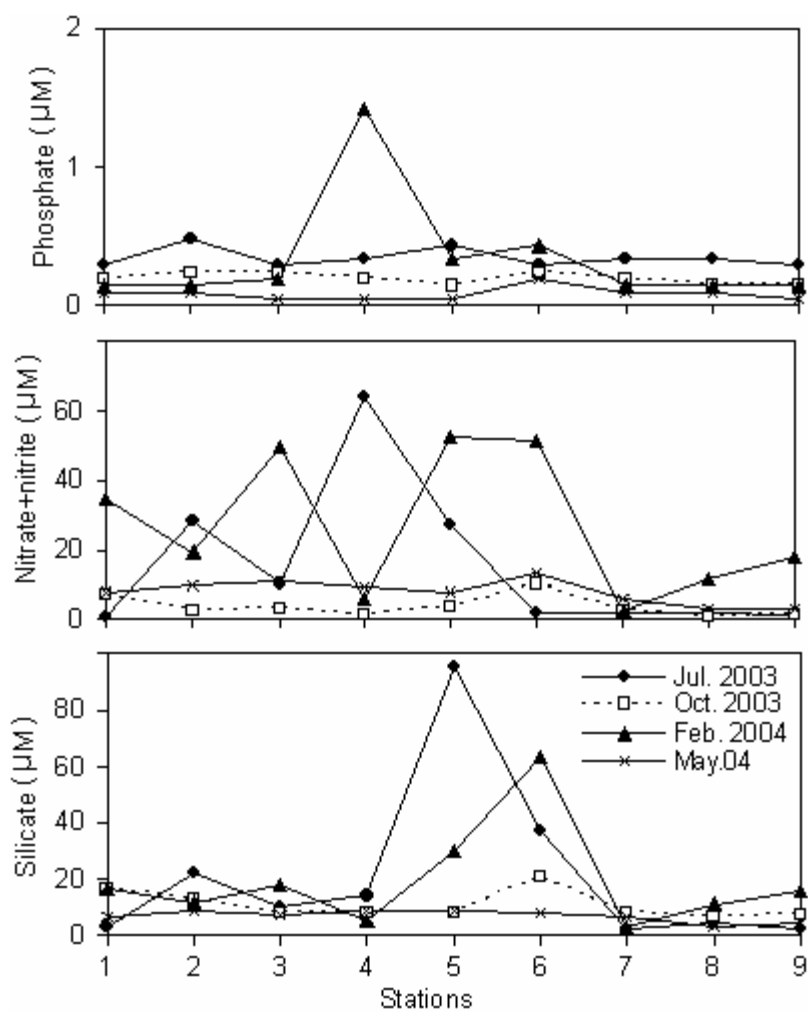


Figure 2. Surface water nutrient concentrations at the sampling stations.

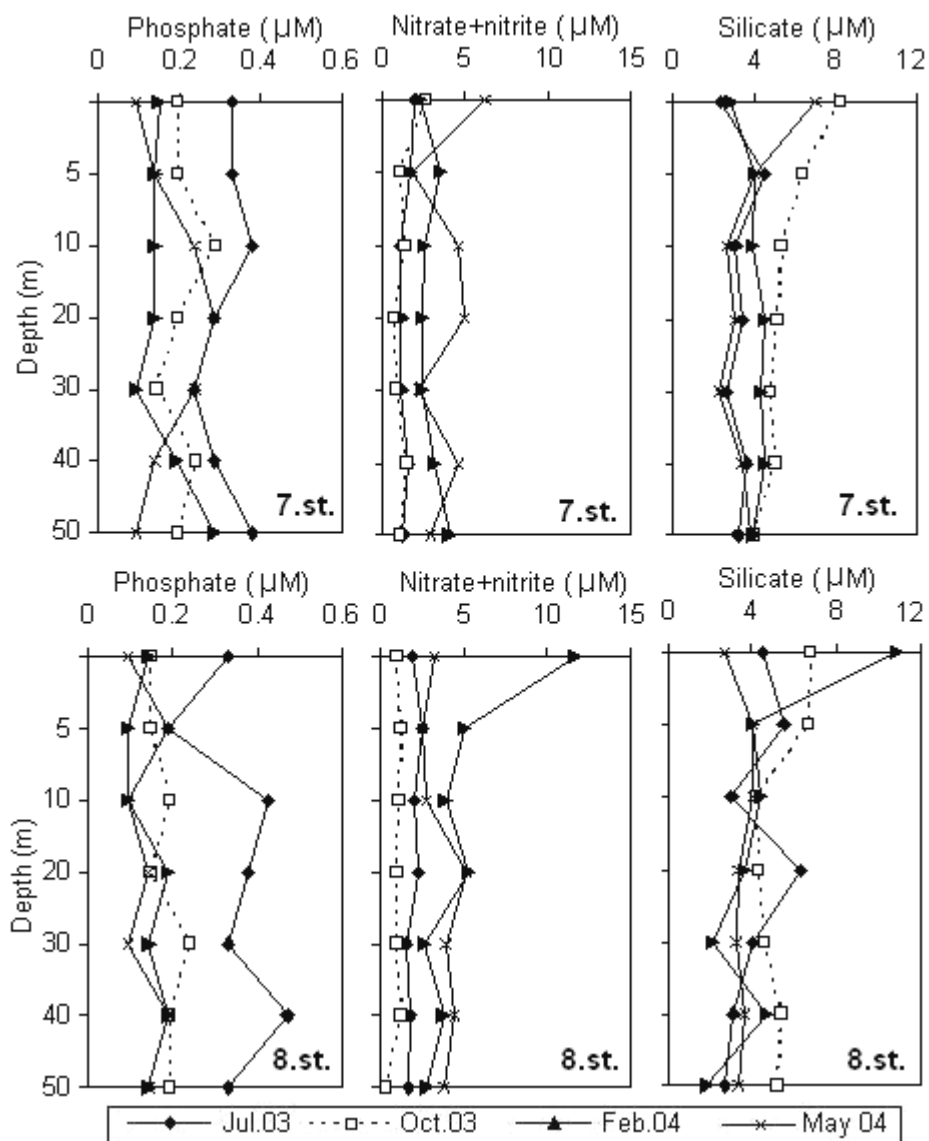


Figure 3. Vertical distribution of nutrients in water column.

The total chlorophyll *a* concentrations ranged from 0.10 to 7.43 $\mu\text{g l}^{-1}$. The lowest value was recorded at station 8, and the highest one at the station 5 which was closest station to the river discharge (Figure 4).

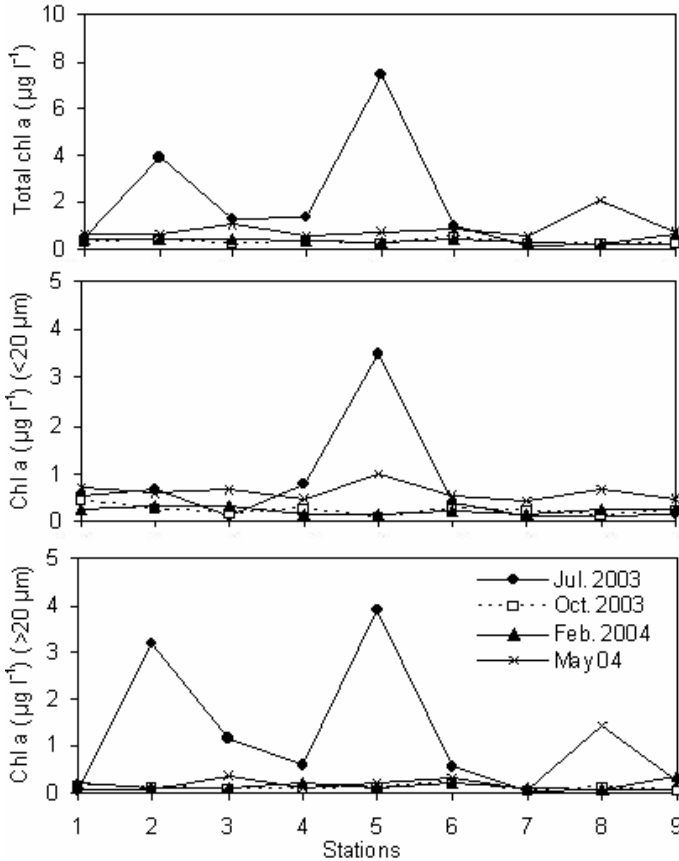


Figure 4. Total and size fractionated chlorophyll *a* concentrations at the sampling stations.

In summer, chlorophyll *a* was much higher than other seasons. The lowest values were observed in October 2003 and February 2004.

Figure 5 shows the vertical distribution of total chlorophyll *a*. The distribution of chlorophyll *a* showed fluctuations through the water column. In February and May, it increased at 40m depth of station 7.

Chlorophyll *a* peaked at surface with a highest value of 1.09 $\mu\text{g l}^{-1}$, and then decreased toward the lower depths at the station 8, in May 2004.

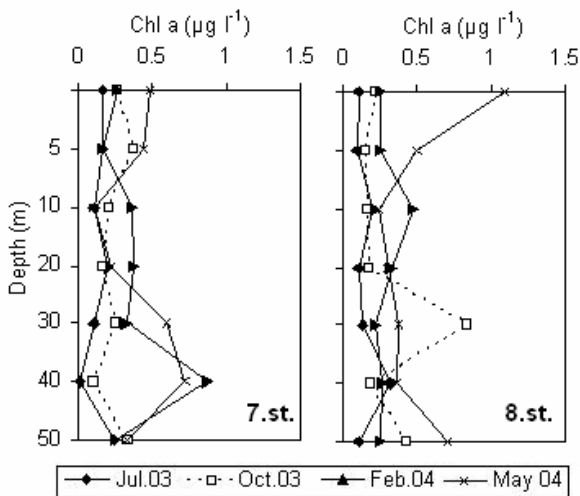


Figure 5. Vertical distribution of total chlorophyll *a*.

The relative distribution of chlorophyll *a* between size fractions at the stations was similar (Figure 4). The $<20\mu\text{m}$ fraction ranged between 0.09 and $3.50 \mu\text{g l}^{-1}$. The highest value of this fraction was found at station 5, in July. The distribution of $<20\mu\text{m}$ fraction across the stations 1-9 showed little variation with the exception of the station 5. In other sampling periods and stations chlorophyll *a* values of this fraction were lower than $1 \mu\text{g l}^{-1}$. Regarding to contribution of different fractions to the total chlorophyll *a*, the lowest proportion of $<20\mu\text{m}$ fraction was 9 %, and the highest one was 96% of the total.

The chlorophyll *a* concentrations of microplankton fraction ($>20\mu\text{m}$) varied between 0.01 and $3.93 \mu\text{g l}^{-1}$. The spatial distribution of this fraction showed that it was higher at the stations 2 and station 5, in July. The lowest proportion of $>20\mu\text{m}$ fraction to total chlorophyll *a* was 4 %, and the highest one was 91 % in July. Total chlorophyll *a* concentrations negatively correlated with salinity ($r = -0.532$, $p < 0.01$) but not with temperature. Of the nutrients, only silicate was significantly correlated to total chlorophyll *a*

($r = 0.697$, $p < 0.01$). Furthermore, significant positive correlation ($r = 0.744$, $p < 0.01$) was found between $<20\mu\text{m}$ and $>20\mu\text{m}$ fractions.

Discussion

The biomass and size distribution of the phytoplankton community play an important role in the energy flow and food web dynamics of marine

ecosystems. In general, it is accepted that, the larger phytoplankton species are associated with nutrient rich waters, whereas smaller microorganisms are dominant in the oligotrophic waters (Bec *et al.*, 2005). However, the physical and chemical properties of a given environment are very important factors controlling the size distribution.

There has been many investigations on the size distribution of phytoplankton in many parts of the Mediterranean Sea and importance of small sized phytoplankton was described in those studies (Delgado and Estrada, 1992; Arin *et al.*, 2002; Ignatiades *et al.*, 2002). The oligotrophy of the Mediterranean Sea supports the contribution of the small size fractions since small cells can use nutrients more effectively than larger ones under nutrient limited conditions (Harris, 1986; Konstantinos *et al.*, 2002). However, the blooms of large sized species are observed in coastal environments of the Mediterranean due to nutrient enrichment. The coastlines between Mersin and İskenderun Bay is intensely industrialized such as fertilizer, iron-steel and petroleum industry. For this reason, much higher nutrient concentrations are recorded in these areas than the open sea (Yılmaz *et al.*, 1992; Yılmaz *et al.*, 1997). In the present study, very high nutrient concentrations were measured due to river discharge near the research area and closeness of the stations to the coast.

There are many studies on the phytoplankton composition and seasonal succession in the northeastern Mediterranean coast of Turkey (Polat *et al.*, 2000; Polat and Işık, 2002; Eker and Kideys, 2000). However, investigation on phytoplankton biomass and size distribution of phytoplankton is very scarce (Polat, 2006). In that study, Polat (2006) reported that pico+ultraplankton (<5 µm) fraction constituted the most important part in the phytoplankton biomass. In the present study, the chlorophyll *a* concentration belonging to the <20 µm and >20 µm fractions were generally similar to each other at the sampling stations and seasons. The highest chlorophyll *a* concentrations were determined in summer in this study. However, in temperate waters, phytoplankton increase occurs in spring due to enrichment of water column with nutrients and optimum levels of temperature and light in this period (Delgado, 1990). Furthermore, unusual increases may be occur in the coastal areas as a result of physical phenomena and land-based effects. In addition to land based effects and deep mixing due to wind in this coastal area under assessment, river discharge was major factor affecting the phytoplankton biomass. It was reported that, the river inflow in coastal areas plays an important role on phytoplankton growth and eutrophic phenomena (Panayotidis *et al.*, 1994; Penna *et al.*, 2003).

Previous researches on phytoplankton size classes in the oligotrophic environments shows high contribution of small sizes to total biomass (Magazzu and Decembrini, 1995; Ignatiades *et al.*, 2002; Polat, 2006). On the contrary, in this study, the contribution of small and large size fractions to the total chlorophyll *a* were found to be similar. This situation most probably due to high nutrient supply in the area since this conditions supports the development of larger species as well as small ones. It can be concluded that phytoplankton biomass levels and size distribution were closely related with influx of Ceyhan River. It was also concluded that, the investigated area showed characteristics of coastal environments instead of oligotroph Mediterranean waters in term of nutrients and biomass dynamics. For a better understanding of the structure of phytoplankton communities in marine environments, more specific studies are required on the temporal and spatial distribution of small size classes.

Özet

Türkiye'nin kuzeydoğu Akdeniz kıyısında Karataş açıklarında fitoplankton biyomasi klorofil *a* düzeyleri yönünden incelenmiştir. Örneklemeler Temmuz 2003, Kasım 2003, Şubat 2004 ve Mayıs 2004'te olmak üzere yılda dört kez yapılmıştır. Toplam klorofil *a* değerlerinin yanısıra, <20 µm ve >20 µm boy gruplarına ait klorofil *a* düzeyleri de incelenmiştir. Toplam klorofil *a* değerleri 0.10 ile 7.43 µg l⁻¹ arasında değişim göstermiştir. <20 µm ve >20 µm boy gruplarına ait klorofil *a* düzeyleri birbirine benzer bulunmuştur. <20 µm boy grubuna ait klorofil *a*'nın toplam klorofil *a*'ya oranı %9 ile %96 arasında değişmiştir. Diğer taraftan, >20 µm boy grubuna ait klorofil *a* miktarının toplam klorofil *a* miktarına oranı ise %4 ile %91 arasında değişim göstermiştir. Akdeniz gibi oligotrof denizlerde küçük boy gruplarının baskınlığına rağmen, bu çalışmada küçük boy gruplarının biyomasi büyük boy gruplarından daha yüksek düzeylere ulaşmamıştır.

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Received: 24.07.2006

Accepted: 15.01.2007