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The Black Sea coastal ecosystem is very dynamic. Last two decades, fisheries were affected by regime shift, changing ecosystem structure and overfishing. The phytoplankton is also important phenomena in the Black Sea as in all aquatic ecosystems. Monitoring program on phytoplankton biomass help us understanding the ecosystem dynamic by using bottom up control models. In the present study we try to understand and compare the phytoplankton biomass dynamics and the response to the environmental parameter during the period of 1993-1994 and 2001-2002. For this aim, the station was fixed in 5 miles far from coastline and water samples were collected at monthly periods. According to our results, secchi disk depth increased in 2001-2003 sampling period when compared with the 1993-1994 sampling period. This increment showed that light penetration increased but attenuation of light decreased. Chlorophyll-a values, used as an indicator of phytoplankton biomass were higher in 1993-1994 and it decreased after 2001-2002 samples. Diatom biomass decreased and species composition also changed after the 2001-2002. On a contrary, diversity of dinoflagellat species increased.

Keywords: Phytoplankton, Chlorophyll-a, Black Sea,

Introduction

Enclosed or semi-enclosed sea means a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas. The European continent has tree large semi enclosed seas. The Black Sea is one of the enclosed seas in European continent and beside this largest anoxic basin in the world (Mee, 1992; Turgut et al 1992).

Enclosed basin can be divided in two main categories according to water exchange processes. First category includes seas having a negative water balance, where the evaporation exceeds the total input of fresh water. Mediterranean Sea provides a classical example of negative water balance. Second category includes seas having positive water balance, where the inflow of fresh water from precipitation and from surrounding drainage area exceeds the evaporation. Black Sea is example of the sea which have positive water balance. This can lead, as in the case of the Black Sea, to a permanent stratification between low saline surface layers and more saline deep water (Barale and Murray, 1995). This two layer stratified system is accompanied by a distinct biochemical structure characterized by complete anoxia of sub-pynocline waters and their separation from the oxygenated surface
waters though a transition zone called the Suboxic Layer. The oxygenated surface layer comprises an euphotic zone of about 40-50 m (Oguz et al., 1999).

Euphotic zone can be described as upper layers of water body which have sufficient light for photosynthesis (Parson et al., 1990). Pigment contain plants by making use of light energy are able to combine simple substance to synthesize complex organic molecules by means of photosynthesis. Phytoplankton which contains chlorophyll and carotenoids as pigment material is an important component of pelagic system. By far the greater part of primary production in the sea is performed by the phytoplankton (Tait and Dipper, 2001). Structure and functional characteristics of the phytoplankton are closely related to the ecological stage of environment and can be used as indices for determining the ecological stage coastal ecosystem in the Black Sea (Yunev et al., 2002).

There are several ways in which estimation of amount of organic production, phytoplankton community structures and biomass in the Black Sea. The most common techniques for estimation of productivity and biomass are periodic measurement of the phytoplanktonic organisms. For this purpose, it is possible to count the number of plant cell in the measurement volume of sea water. The other way is estimation of pigment concentrations in the sea water. The well known pigments in the sea water are chlorophyll (a, b, c), xanthophylls and carotenoid pigments. Chlorophyll-a presents in all planktonic algae and constitutes almost 1-2 % of total dry weight of them. The quantity of chlorophyll that extracted from unit volume of sea water depends upon the number of algae cell present, and it is possible to use as an indicator for designation of algae biomass (Okuş and Uysal, 1988; Jeffrey et al., 1997; Tait and Dipper, 2001). Chlorophyll content is an important indicator of water quality too. Estimating chlorophyll concentrations in estuaries would be an asset in the study and management of coastal ecosystem (Stumpf and Tyler, 1988).

In the resent years the problem called global warming has an effects on the black sea ecosystem by means of temperature variation, anomalies in precipitation, nutrient input from run off to the coastal ecosystem lead to changes of nutrient cycling, primary production and prey predator interaction

Black Sea coastal ecosystem has very dynamic planktonic structure in the last decay because of new coastal structure such as filling area for new Black Sea Highway after 2000 years. Majority of study have focused on comparison the chlorophyll-a content of phytoplankton cells, nutrient concentrations and CTD parameter in Surmene Bay at South-eastern Black Sea coast during the periods of 1993-1994 and 2001-2002 in photic zone above 25 meter.
Material and Methods

The Study was carried out at Sürmene Bay at four stations Figure 1. Samples were collected at monthly intervals during the April 1993- May 1994 and April 2001-May 2002 on board R/V Yakamoz and R/V DENAR

Figure 1. Sampling location

Continuous profiles of salinity temperature and Sigma-t were also obtained at all station using YSI model 3800 and AANDERA RCM 9 CTD prop. Water samples for nutrient and pigment analysis were collected at surface, 10 and 25 m depth with 9 liter capacity Teflon Van dorn bottles (Sournia, 1981). Nitrate, nitrite and phosphate concentrations were measured by using standard spectrophotometric methods. For chlorophyll-a analysis, 2 l of sea water was immediately filtered through 0.45 μm por size GF_F glass fiber filters. The filters were homogenized in 90 % acetone, kept in refrigerator for 24 hours for extraction. Spectrophotometer was used to measure chlorophyll-a (Parsons at al,1984). Light Extinction Coefficient (LEC) calculated using data obtained from Li-Cor LI-193SA Spherical Quantum Sensor. Light penetration was also measured by using 30 cm diameter black-with painted secchi disk.

Results and Discussion

Seasonal temperature, salinity and density obtained during the sampling period were shown in figure 2. No pronounced difference in CTD profiles were observed between the sampling stations. Water column temperature of the area was changed seasonally and seasonal
stratification was occurred as generally seen in the Black Sea. The average water temperature at spring was 8°C (in March). In Spring period CIL (cold intermediate layer), which is characterized 7.5°C, was seen between 50-100m. As seen from Figure 2, water column salinity and density changed with depth, and seasonal picnocline and halocline were seen between surface and 100m depths.

Figure 2. Seasonal CTD profile in study area
In summer (July), temperature values in surface layer (between 5-40m) decreased from 18 °C to 8°C (Figure 2). Thermocline (40-120m) and deep sea water (below 120m) temperatures were 7.5-8 °C. In these periods, temperature stratification is very strong in the summer; in seasonal mixing zone salinity decreased to ‰ 17 at low temperate waters (5-40 m) and increased to ‰ 18 at high temperate surface water due to high evaporation. Salinity increased to ‰ 22 in halocline (below 80m) waters. Water column density was increased surface to picnocline (60m) sharply (sigma-t 9.5 to 16), also increased at deeper waters.

In autumn (September) stratification of the water column was clear. Surface temperature mixing zone was established between surface-20m, blow these zone, seasonal thermocline occurred (20-40m) with dramatically temperature changes from 16°C to 8°C. Thermocline was same as summer period. In these seasons, seasonal halocline and picnocline were lower than summer (90-100m)

In the area, lower temperature values were observed in from winter (November) to early spring. In these periods, temperatures of the water column were stagnant, these situation established by effective winter winds and lower air temperatures (beloved 10°C). At these periods permanent thermocline layer deeper than other seasons (beloved 140m). In these periods salinity and density has stagnation at seasonal mixing zone. Water density has highest values (sigma-t =13) in surface zone due to lower temperatures.

The secchi disk measures the transparency of the water. Transparency can be affected by the color of the water, algae, and suspended sediments. Transparency decreases as color, suspended sediments, or algal abundance increases. Secchi depth results were given in figure 3 for the whole sampling period. Although the secchi depth was deeper in 2001-2002 than the 1993-1994, it showed similar seasonal structure. During the late spring secchi depth was closer to surface but it was the deepest in winter

![Sampling period](image)

**Figure 3.** Annual secchi depth changes
Nitrite + nitrite concentrations as well as changes in phosphate with depth are given in figure 4 and figure 5 respectively. Nitrate + nitrite concentrations in sampling stations were ranged from 0.55 µg-al l⁻¹ (in May 1993) to 1.27 µg-al l⁻¹ (in March 1994) at 1993-1994 sampling period and from 0.05 µg-al l⁻¹ (in August 2001) to 8.87 µg-al l⁻¹ (in December 2001) at 2001-2002 sampling period. Although sudden increase were observer in Nitrite + nitrate concentrations at whole water column at December 2001 and January 2002 sampling period, no significant difference were observed between the sampling period. But significant differences were observed between the sampling months (p<0.05) and sampling depths. (p<0.01).

![Figure 4](image1.png)

**Figure 4.** Seasonal and depth variation of nitrite + nitrate concentrations (µg-at l⁻¹) in sampling station at 1993-1994 and 2001-2002 sampling period.

![Figure 5](image2.png)

**Figure 5.** Mean nitrite and nitrate concentration both sampling period.
Figure 6. Seasonal and depth variation of Phosphate concentrations (µg-at l⁻¹) in sampling station at 1993-1994 and 2001-2002 sampling period.

Figure 7. Phosphate concentration both sampling period

Phosphate concentrations in sampling stations were ranged from 0.11 µg-at l⁻¹ (in February 1994) to 1.62 µg-al l⁻¹ (in December 1994) at 1993-1994 sampling period and from 0.047 µg-al l⁻¹ (in April 2001) to 0.60 µg-al l⁻¹ (in November 2001) at 2001-2002 sampling period. Statistical differences in phosphate concentrations were observed between first and second sampling period (1993-1994 and 2001-2002) (p<0.01). Decrease in mean phosphate
values were determined at 2001-2002 sampling period. But no pronounced difference in phosphate values was observed between sampling months.

Figures 6 shows species the percentage distribution of 1993-1994 and 2001-2002 sampling periods. According to the observations 102 and 68 species were noticed in 1993-1994 and 2001-2002 respectively. Diatom has decreased from 53.78 % (in 1993-1994) to 44.12 % (in 2001-2002) while an increase (from 33.65 to 41.18 %) was noticed in dinoflageltates in the same period.

**Figure 8.** Species percentage of main phytoplankton groups in A 1993-1994 and B 2001-2002 sampling period

Mean chlorophyll-a concentrations were 0.60 µg l⁻¹ and 0.46 µg l⁻¹ for 1993-1994 and 2001-2002 sampling periods respectively. Although mean chlorophyll-a concentrations degreased in 2001-2002 sampling period compared to 1993-1994 sampling period, no pronounced difference in chlorophyll-a concentrations were observed. Vertical distribution of mean chlorophyll-a are given in Figure 9. Although the surface and 10 m chlorophyll-a values had a similar pattern in the whole sampling period, samples taken from 25 m depth were statistically different then others (p<0.05).
Figure 9. Mean vertical distribution of chlorophyll-a at the sampling period

Monthly changes in chlorophyll-a concentrations in 1993-1994 and 2001-2002 sampling periods at the study station are shown in figure 10 and figure 11 respectively. The highest chlorophyll-a concentration in first sampling period (1993-1994) was 3.4 µg l⁻¹ at 10 m depth in June 1993. In the second sampling period (2001-2002) the highest chlorophyll-a concentration was found as 1.54 µg l⁻¹ at 10 m depth in May 2001.

Figure 10. Seasonal variation of chlorophyll-a concentrations in 1993-1994 sampling period
Figure 11 Seasonal variation of chlorophyll-a concentrations in 2001-2002 sampling period

Chlorophyll-a value, as an indicator of phytoplankton biomass, reached the highest level in June 1993 and in May 2001 during the spring bloom. After summer low Ch-a biomass, second weaker picks were observed in November and October for 1993-1994 and 2001-2002 sampling period respectively. There is no statistical difference between 1993-1994 and 2001-2002 (Figure 12). However annual mean chlorophyll-a concentration decreased. But any seasonal anomalies were not observed during whole sampling period. Negative correlation were observed between chlorophyll a and secchi disk (p< 0.05, $r^2=0.43$, n=144). Our results indicate that first phytoplankton bloom occurs late spring and sec blooms late autumn in whole year period.

Figure 12. Mean chlorophyll a concentration both sampling period.
Throughout water column chlorophyll-a values range was larger in 1993-1994 than 2001-2002 due to the light limitation of high turbidity chlorophyll-a concentration in deep water was lower along 1993-1994 sampling period (Figure 12). But the reduction of the light limitation in the deep water due to the low turbidity condition, chlorophyll-a value were more homogeneous in the water column along 2001-2002 sampling period.

Light extinction coefficient (LEC) and chlorophyll-a relations were shown in figure 13. Their correlations were not strong but statistically important (p< 0.05). LEC values were higher in 2001-2002 sampling period than 1993-1994. This means the light penetrations is deeper in 2001-2002. But mean chlorophyll-a concentrations were lower in the photic zone. Lower chlorophyll-a concentration under available light condition may be explained by decrement in nutrient concentration due to Black Sea High way which is restricted sea land interaction. Recently, hydro-Electric Power Plants on the coastal river system also will effects the run-off quality and present status of the coastal ecosystem at the future.

References


