Seasonal changes of nutrients and oxygen in the Bulgarian Black Sea coastal area

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Abstract The paper discusses the seasonal dynamics of nutrients and oxygen during the period 1995–1998 in comparison to the previous periods. This study is based on monthly and seasonally monitoring in the 3–20 n.m. zone along the Bulgarian Black Sea area. The investigation reveals certain shifting of seasonal maximums (minimums) and a trend of decreasing oxygen saturation, phosphorus and silicon in the last few years.
Keywords Black Sea; DO; eutrophication; nutrients; OS; seasonal changes

Introduction

The western Black sea area and its Bulgarian section in particular, are subjected to the influence of the Danube River and to the lesser influence of the local freshwater outflow in the north-western part of the Black sea. The influence of the industrial and sewage input is localised in specific areas (mostly in the bays). Increased input has been reported for the Danube delta for the period 1960–1990: total phosphorus from 14 to 40 kt/y, total nitrogen from 50 to 450 kt/y (Volenbroek, 1995). The influence of the anthropogenic factor has been considerably expressed after 1970 when dramatic changes in the Black Sea ecosystem occurred as a result of eutrophication (Moncheva *et al.*, 1995).

The economic changes of 1990–1992 and the decreased industrial and agricultural production caused a decrease of the anthropogenic impact. Such a trend is being noticed in the north-western part of the region, and especially in the nutrients input of the Danube River (Cociasu *et al.*, 1997). Aiming to define the trends in the changes of chemical parameters within the coastal area, a comparison has been made with previous periods. The comparative analysis uses data from seasonal expeditions organised through 1985–1992 in the studied area (Rozhdestvensky, 1986, 1992; Stoyanov, 1995).

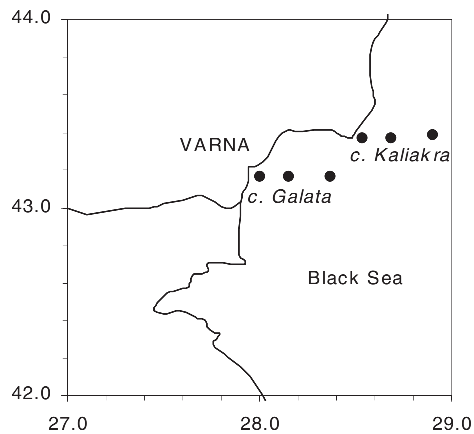

Figure 1 Map of the sampling stations

Water Science and Technology **Vol 46 No 8 pp 137–143**

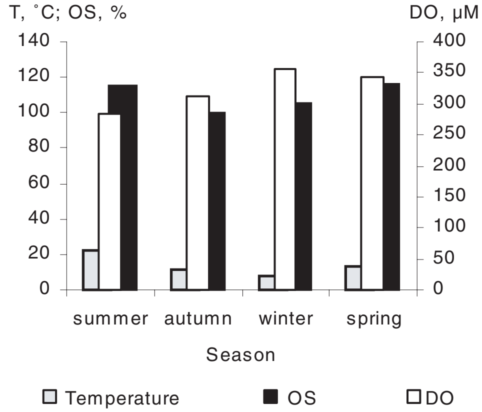

Figure 2 Seasonal dynamics of T, DO and OS

Material and methods

The study is based on monthly monitoring in the 3 n.m. area and on seasonal monitoring (spring and summer) of two transects (10 and 20 n.m.) during 1995–1998 (Figure 1). The following parameters were measured: temperature, salinity (S), dissolved oxygen (DO), and nutrients (phosphate phosphorus (P), nitrate, nitrite and ammonia nitrogen (N) and silicon (Si) (Methods . . ., 1978; Methods . . ., 1983)). Historical data for these parameters have been used for comparison.

Results

The content variations of DO are connected to the temperature changes. Seasonal minimum is in summer, when the temperature (T) is the highest (Figure 2). During the period of anthropogenic eutrophication (after 1980) the average seasonal values (summer and autumn) were close and maximum DO content was established in spring (Rozhdestvensky, 1986, 1992). In the last few years the DO winter maximum has recovered. The typical winter minimum for the 1981–1985 period of OS has not been observed recently either. Along with the winter maximum high values in spring were recorded. OS seasonal amplitudes are lower than the 1981–1985 period, but are still higher than before 1970. This fact correlates to the active spring and even winter DO production as evident from bloom data for these seasons (Velikova *et al.*, 1999). DO summer and OS autumn values decrease due to oxygen consumption for organic matter oxidation. In general the seasonal dynamic of OS correlates well with the seasonal dynamic of total phytoplankton

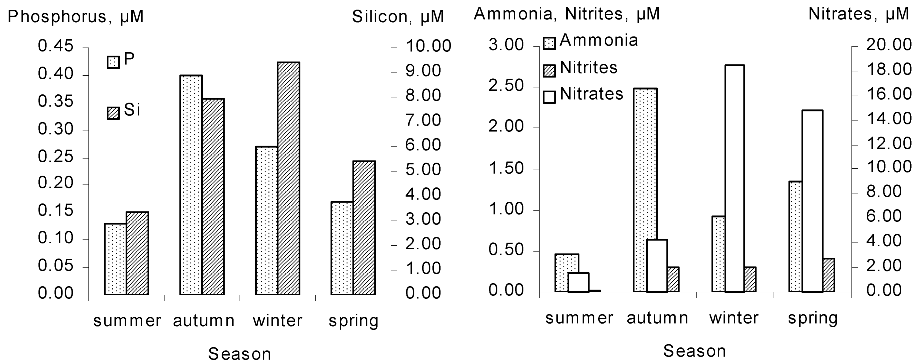

Figure 3 Seasonal dynamics of nutrients

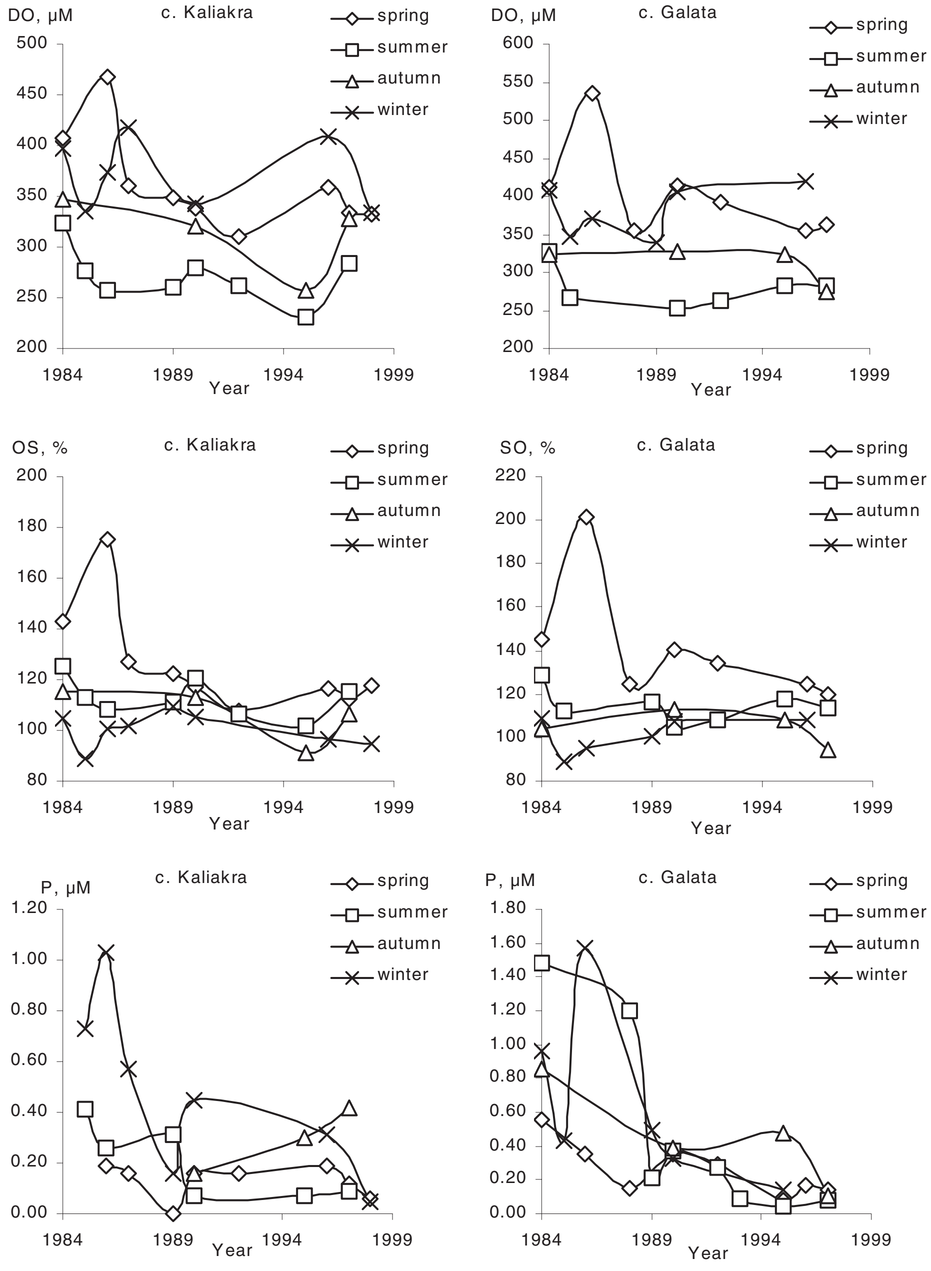

Figure 4 Long-term changes for DO, OS and P at transect c. Kaliakra and c. Galata

biomass, the highest being in spring (Report . . ., Ch II , 1998; Shtereva *et al*., 1999). Peculiarities of the 1981–1985 period are characterised by autumn DO and winter OS minima but are not observed during 1995–1998.

The inter-annual changes of nutrients were discussed in detail earlier by Shtereva *et al*. (2001). Our results show a highest average concentration of phosphates in autumn and lowest in summer (Figure 3).

Between 1981 and 1985 the variations in the seasonal means of P were significantly different. The seasonal maximum was shifted from spring to summer and minimum respectively from summer to spring. During 1995 – 1998 a winter maximum and spring minimum for Si are registered. The low spring content correlates to the intensive growth of diatom species such as *Sceletonema costatum* (Report . . ., Ch II , 1998). Duration and intensity of the blooms define seasonal minimum and maximum positions.

The seasonal distribution of nitrate N is not different from the natural, reaching highest concentration in winter and lowest in summer. The ammonia seasonal changes differ from the ones recorded by Rozhdestvensky (1986) for the three-mile zone, where he points out the winter concentration as the highest one. As the data for the ammonia N are collected and processed only for the period 1997–1998, to clear up the origin of the changes we need further investigations.

The analysis of seasonal monitoring data shows a certain trend of decrease or keeping the same level of eutrophication indices (OS, P) in most seasons, best expressed after 1990 (Figure 4). A similar trend was established in the 10–20 n.m. zone also (Figure 5). Two of the seasons were selected as representative for the 10–20 n.m. region: spring and summer. The average values of OS and DO are higher in spring.

A comparison of our results to previous period data (1981–1985 and 1986–1990) reveals a more remarkable variability in the 3 mile zone. Current concentrations of phos-

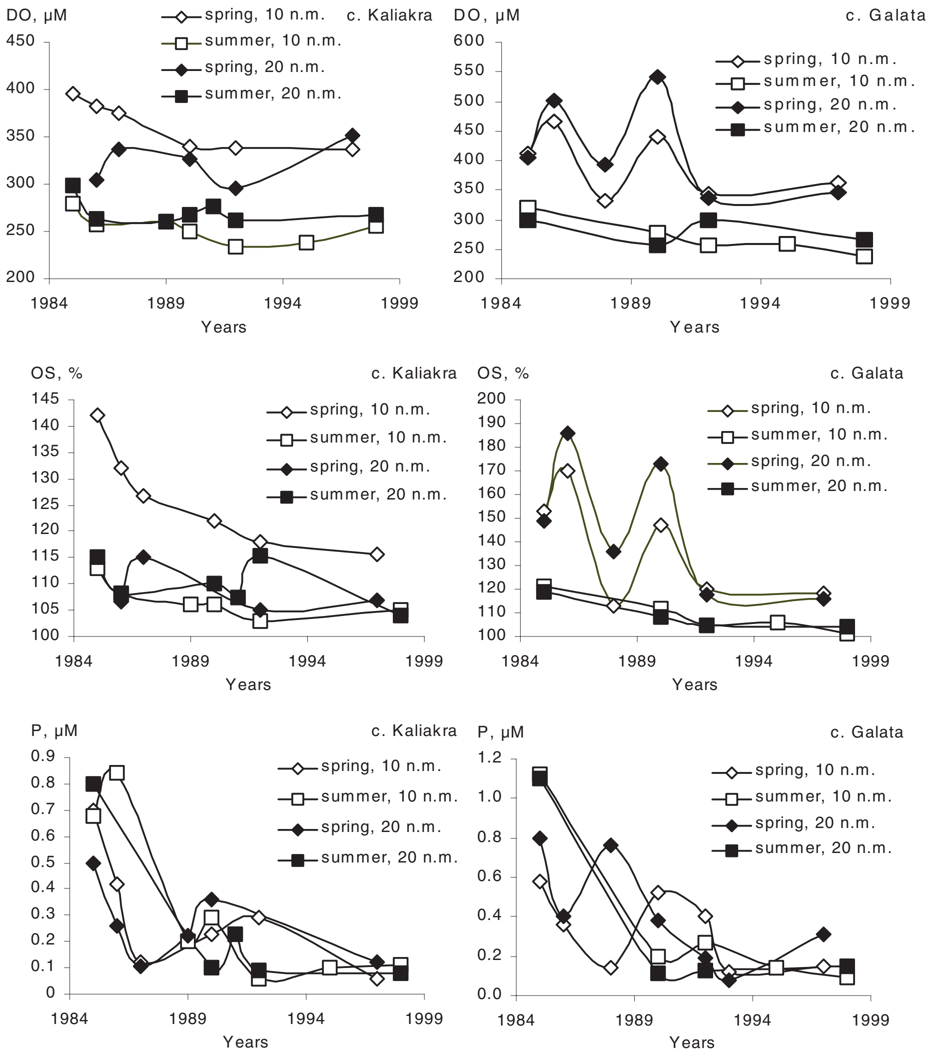

Figure 5 Long-term changes for DO, OS and P at c. Kaliakra and c. Galata

phate seem to be similar to those measured before eutrophication was recorded. A trend of decrease of chemical parameters is more significant in the 20 n.m. zone (Figures 6–8).

The decreased content of these nutrients is probably related to their altered input within the freshwater inflow in the north-western Black Sea area (Cociasu *et al.*, 1997). The highest stocks of nutrients on the Romanian shelf were recorded in the 1970s. These values decreased considerably during the 80's and slightly during the 90's (see Table 1).

Regarding Si, a decreasing trend was observed after the construction of Iron Gate dam on the Danube (Humborg *et al.*, 1997). But the decrease of Si content is due not only

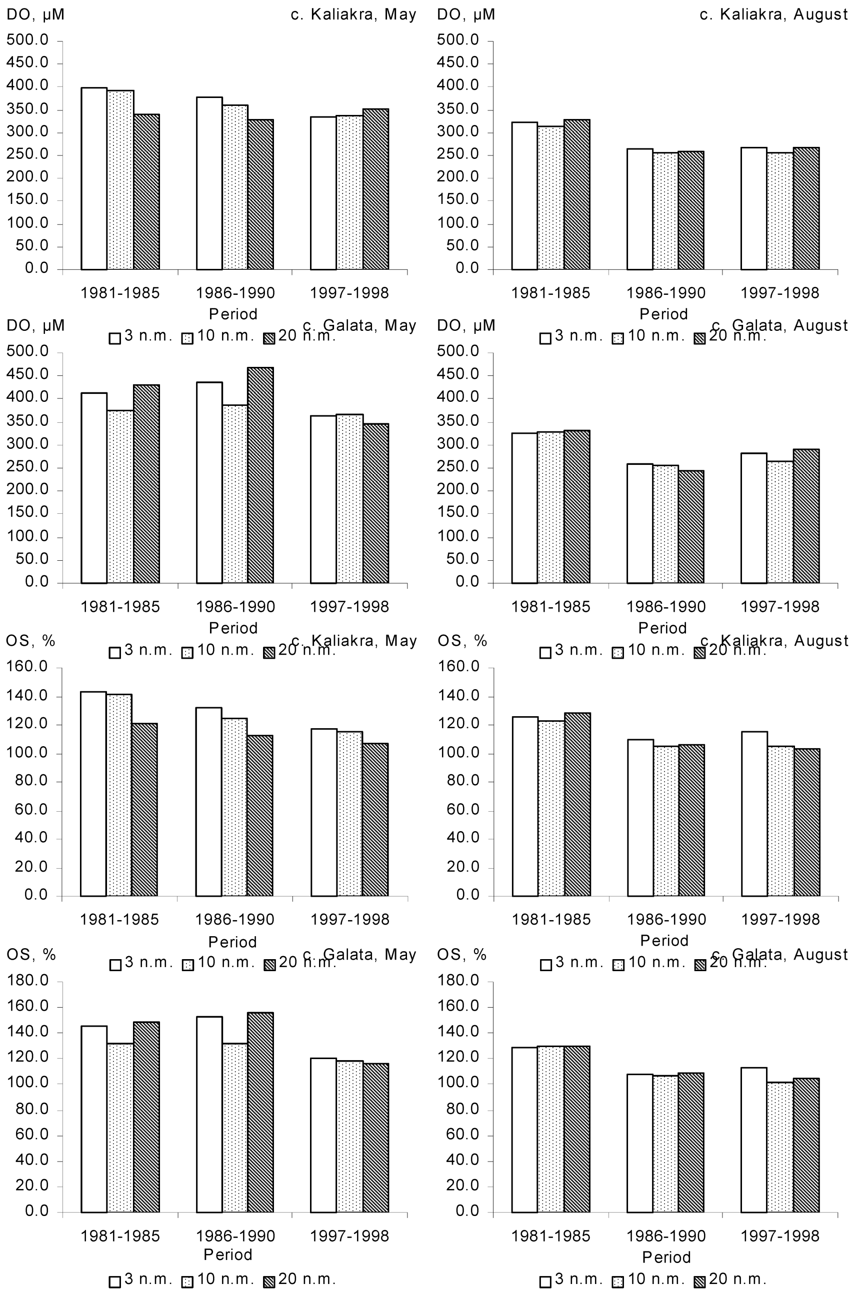

Figure 6 Trends of mean values of Dissolved Oxygen (DO, µM) and Oxygen Saturation (OS, %) by periods

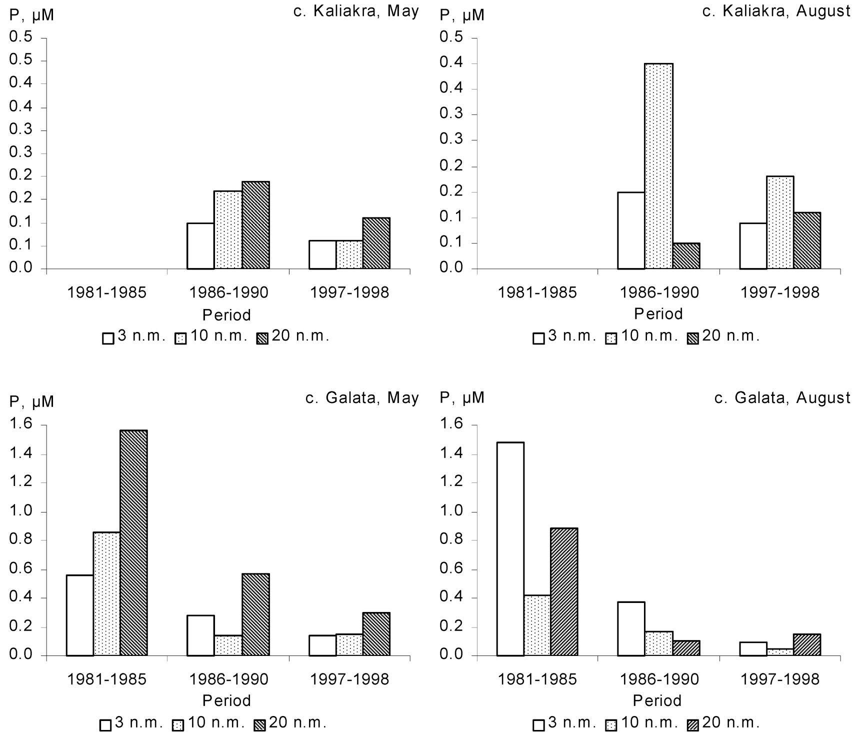

Figure 7 Trends of mean values of phosphorus (P, µM) by periods

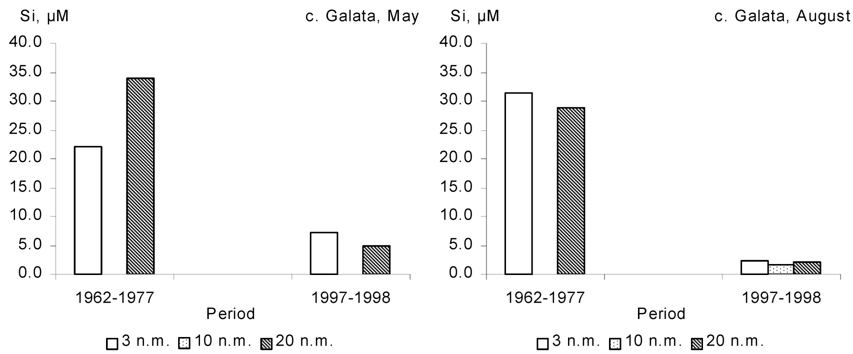

Figure 8 Trends of mean values of silicon (Si, µM) by periods

Table 1 Levels of nutrients on the Romanian shelf.

Parameter	1981–1985	1991–1995
PO_4, 10^3 t	7.0	5.2
SiO_4, 10^3 t	336.9	208.0
DIN, 10^3 t	183.2	83.4

to the reduced river discharge but also to the intensive consumption during algal mass development (Cociasu *et al.*, 1999).

Conclusions

A regular maximum content of DO is established in winter in contrast to the spring maximum concentration throughout the period 1981–1985, which indicates DO recovery to its natural seasonal distribution. The seasonal dynamics of nutrients is characterised by minimum in summer, maximum in autumn for P and N_{NH4}^{+} and respectively in winter for Si and N_{NO3}^{-}. The content of nutrients (P and Si) and OS has decreased in the last few years.

Acknowledgements

The study is financially supported by Projects: EROS 21 IC20-CT96-0065 and NATO SFP Project 971818 ODBMS Black Sea.

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