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BLACK SEA WATER SETTING IN FRONT OF CAPE GALATA

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Abstract: Spatiotemporal hydrological and hydrochemical characteristics of the Black Sea in the Cape Galata region (Western Black Sea) bring out the dynamics of living marine conditions and causality during 2005-2006. The western periphery of the Black Sea is unlike eastern owing mainly to strong penetration of waters by river origin therefore a focus was given on Danube River stream through the Cape Galata region and its affect on the variability of salinity, oxygen concentrations, and nutrients. This subject is important as the frontal interface separating river waters and open-sea waters in the Black Sea is a boundary between the eutrophic waters and the less productive open-sea waters.

Keywords: Black Sea, Hydrology, Hydrochemistry, Danube River stream

Introduction

The western periphery of the Black Sea is unlike eastern owing mainly to penetration of Danube Transformed Waters [16] and waters by river origin of north-western part of the sea. The total river discharge coming from the north-western part of the Black Sea represents about 300 km^3 of water annually [13]. The Danube's discharge into the sea amounts to approximately 200 m^3 yearly [11]; [2]; [18]; [14]; [15]; [1]; [19]. With this volume, the Danube contributes with approximately 70 % of the total river discharge coming from the north-western part of the Black Sea and about 56 % of the total river discharge of the Black Sea. Danube Transformed Waters, passing along the Bulgarian coast, strongly influence on the seasonal and inter-annual variability of the salinity - mainly in the surface layers [3]; [5], the oxygen concentrations, and the nutrients, as well. The Danube's very high nutrient content results from run-off from agriculture (about half of the load), industry and households (about a quarter each).

With aim to expand the knowledge for principal characteristics of the Black Sea in the Cape Galata region (Western Black Sea), hydrological and hydrochemical research was carried out during 2005-2006. The study is a continuation of the investigations related to changing Black Sea water environment [3]; [4]; [5]; [6]; [7]; [8]; [9].

Material and Methods

The 20-mile Black Sea zone in front of Cape Galata was studied during 2005-2006. Observations were performed aboard the IFR R/V Prof. A. Valkanov. Research was done with sampling at 1, 3, 5, 10, 15, and 20 miles offshore. Study of the Varna Bay was performed at Control Station (St.) B5 in the central area, as well.

Measurements of temperature, salinity, oxygen, and oxygen saturation were done by CTD 60 [17]. Study of nitrite and nitrate nitrogen concentrations was carried out. Samples were collected at standard depths [10]. Processing of samples was performed via unified methods for marine waters. Nutrient concentrations were established by Spectrophotometer HITACHI-U 2001 UV/Vis [12].

Results and Discussion

Results of the research about sea temperature, sea salinity, and dissolved oxygen are presented in Figure 1, Figure 2, Figure 3, and Figure 4 at standard depths in order to be formed a clear view and to be comparable with other parameters for study of the Black Sea ecosystem.

Sea surface temperature (SST) in front of Cape Galata has ranged from 6.38˚C at 1 mile offshore to 5.50˚C at 20 miles offshore in March 2005, with small drop towards open-sea. The stream of Danube Transformed Waters was at 20 miles offshore, with sea surface salinity (SSS) 16.82 psu. During 2005-2006, in the 20-mile zone, sea bottom salinity maximum of 19.96 psu was ascertained at 20 miles offshore (65 m depth). Oxygen super-saturation was up to 131.48 % at 3 miles in front of

Cape Galata although the salinity was high -18 psu. Nutrient concentrations have varied in broad bounds (Figure 5).

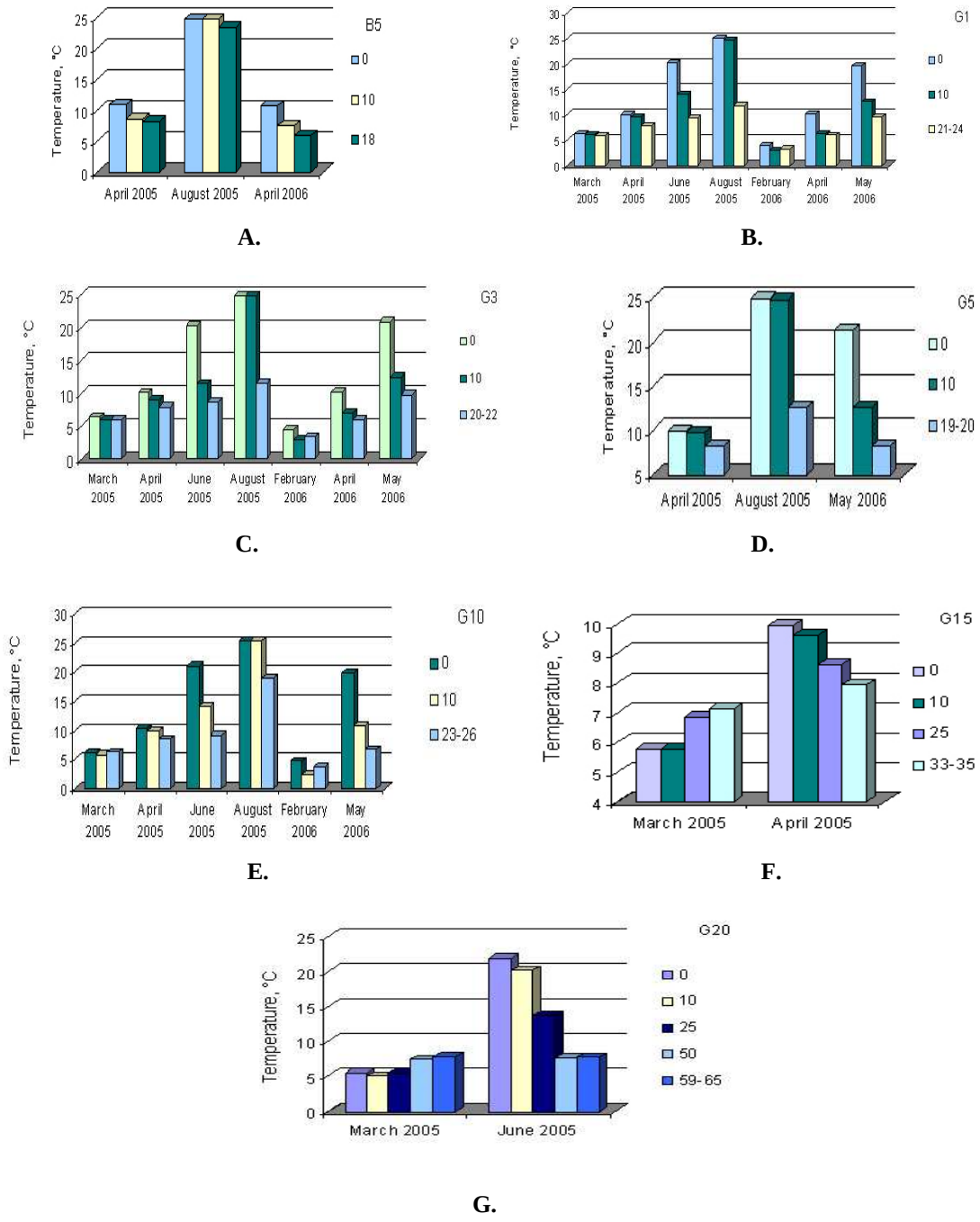
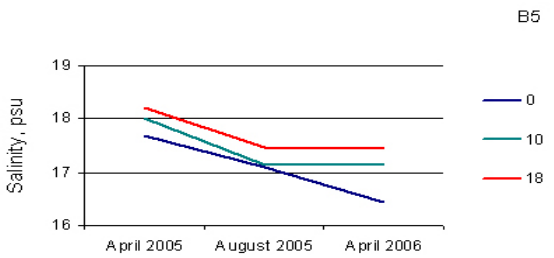


Figure 1. Black Sea temperatures in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay during 2005-2006

In April 2005, SST was 10.07˚C in the 15-mile zone and 10.87˚C at St. B5. Owing to reduced Danube River discharge, salinity was high. Drop in oxygen saturation at 3 and 15 miles offshore was

ascertained as oxygen deficit was significant even in the surface waters - 84.68 % saturation at 3 miles and 72.04 % saturation at 15 miles. Nutrient load was strongest in the Varna Bay, with 0.58 µM nitrite nitrogen concentration and 2.58 µM nitrate nitrogen concentration in the surface - bottom layer.

SST was 20.87˚C in the 20-mile zone in June. Danube River current was ascertained at 10 miles offshore, with increase in the east and the SSS minimum was at 20 miles offshore - 15.14 psu. Oxygen consumption has exceeded oxygen production at 1 mile in front of Cape Galata and oxygen concentration was in the range 404.47 µM - 517.86 µM in the surface - bottom layer. Nutrient concentrations were higher in the 3-mile zone - 0.72 µM nitrite nitrogen and 2.25 µM nitrate nitrogen in the surface - bottom layer.



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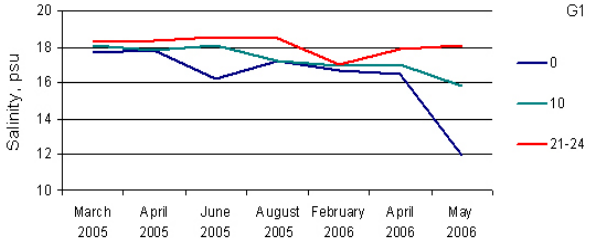

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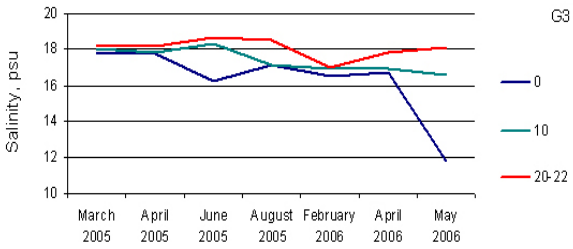

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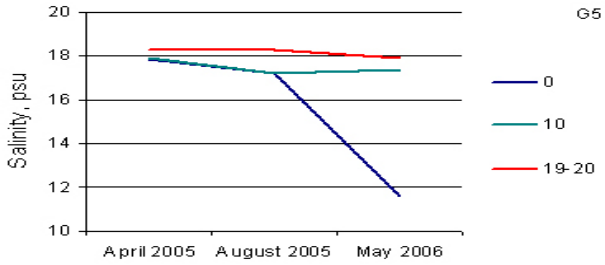

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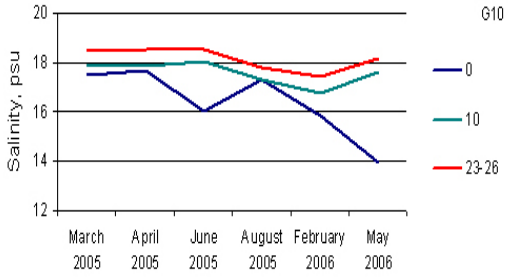

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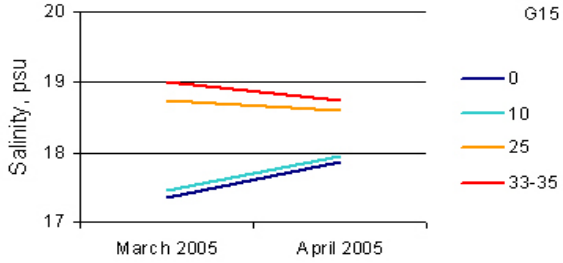

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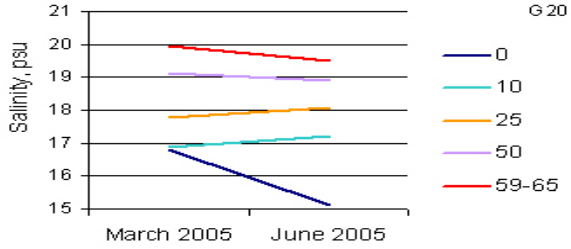

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Figure 2. Black Sea salinity in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay during 2005-2006

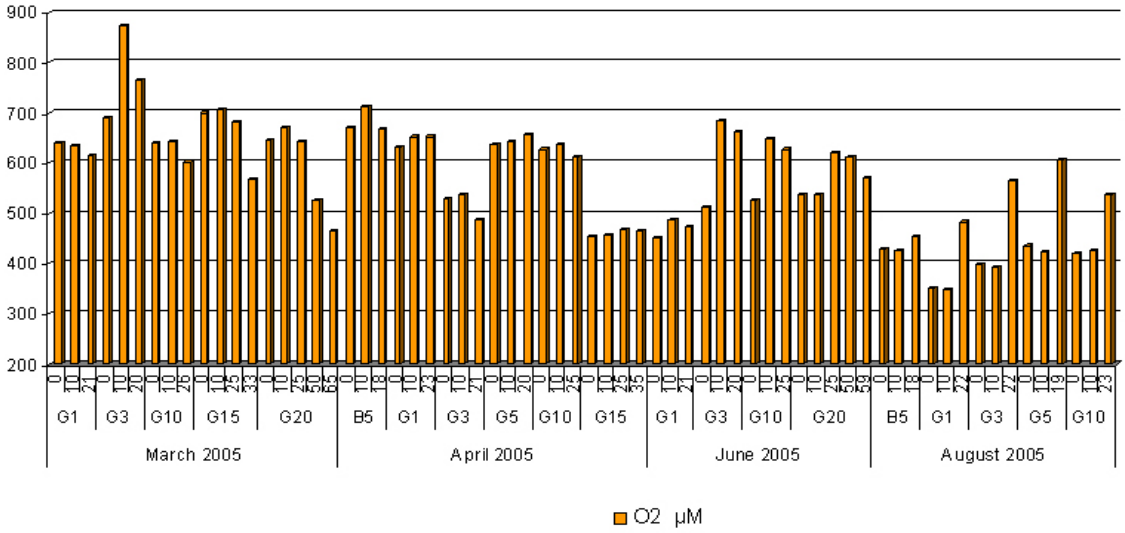

Figure 3. Dissolved oxygen concentrations in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay during 2005

Varna Bay waters were warmed throughout the surface - bottom layer in August, with temperature range 24.69˚C - 23.21˚C. SST was 25.05˚C in the 10-mile zone in front of Cape Galata, while sea bottom temperature range was 11.58˚C - 18.99˚C. Due to reduced Danube's discharge, salinity was above 17 psu. Oxygen consumption has exceeded oxygen production throughout the 10-mile zone and surface-bottom layer of St. B5 as drop in oxygen saturation has reached 75.33 % even in the surface waters at 1mile offshore. Drop in nutrient fund has approached 0.17 µM nitrite nitrogen and 0.58 µM nitrate nitrogen in the surface - bottom layer of 10-mile zone. Similar nutrient concentrations - 0.18 µM nitrite nitrogen and 0.63 µM nitrate nitrogen in the surface - bottom layer were found out in the Varna Bay.

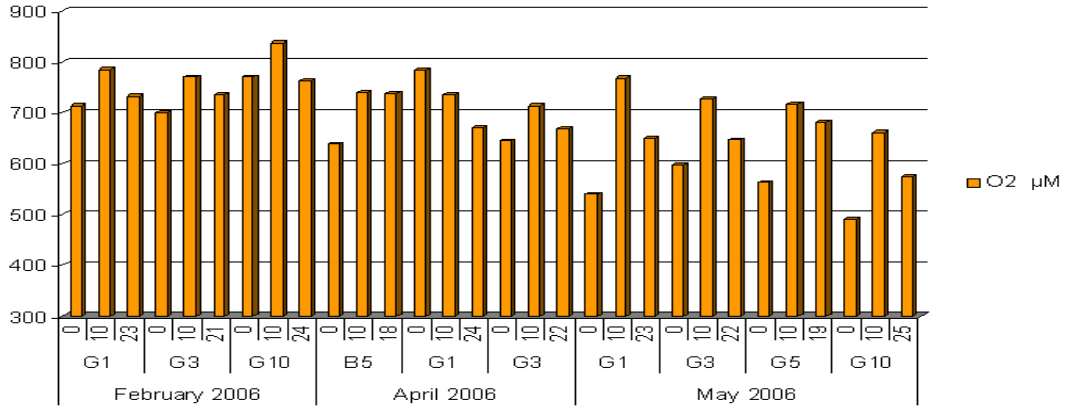

Figure 4. Dissolved oxygen concentrations in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay during 2006

SST has increased from 4.02˚C at 1 mile offshore to 4.78˚C at 10 miles offshore, with small drop into the bottom in February 2006. SSS minimum was at 10 miles in front of Cape Galata - 15.84 psu. During 2005-20006, sea bottom salinity minimum of 17.02 psu in the 20-mile zone was ascertained at 1 mile offshore (23 m depth). Dissolved oxygen concentrations were comparatively near to the norm. Nitrite nitrogen concentration was 0.32 µM and nitrate nitrogen concentration - 1.22 µM in the surface - bottom layer of 10-mile zone (Figure 6).

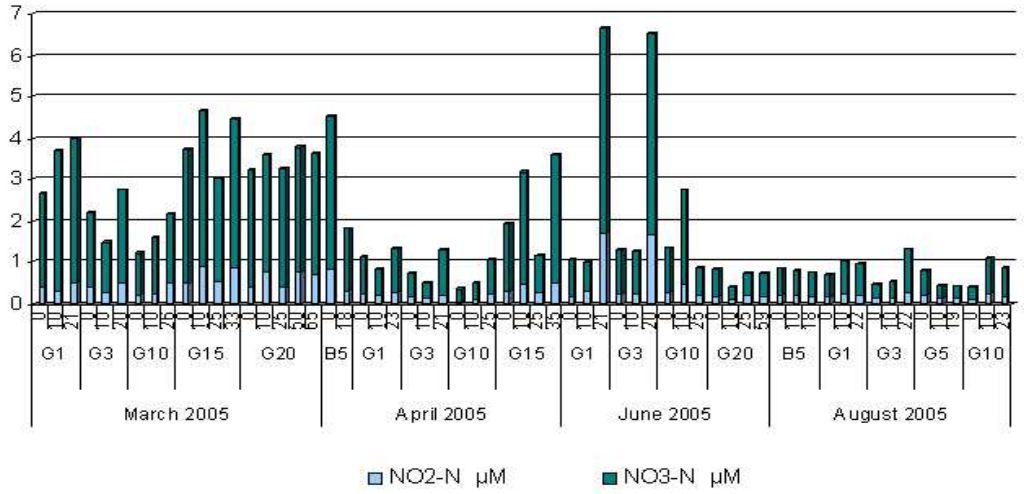

Figure 5. Concentrations of NO_2-N and NO_3-N in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay in 2005

Like 2005, SST in the coastal and bay waters was above 10˚C in April 2006, whereas drop in salinity was ascertained. Surface waters of nearest coastal zone at 1 mile offshore were most oxygen super-saturated - 124.19 %. Drop in nitrite nitrogen has reached 0.03 µM at 3 miles offshore, 10 m depth and 0.05 µM in the bottom waters of St. B5.

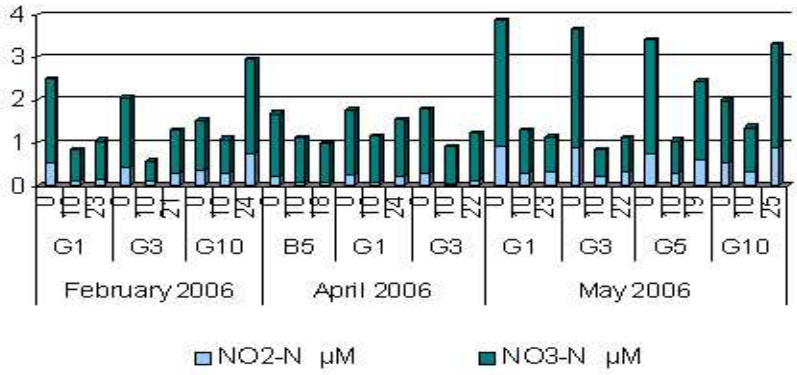

Figure 6. Concentrations of NO_2-N and NO_3-N in the 20-mile zone in front of Cape Galata and at the Control St. B5 in the Varna Bay in 2006

In May 2006, SST was in the range 19.63 - 21.33˚C in the littoral waters. Strong drop in SSS in the coastal zone reached 11.56 psu at 5 miles offshore. High horizontal salinity gradient of 0.5 psu $mile^{-1}$ was established in the 5-10-mile zone in front of Cape Galata. Oxygen super-saturation approached 131.71 % at 1 mile offshore, 7 m depth. Increase in nutrient concentrations has reached

0.51µM nitrite nitrogen and 1.61µM nitrate nitrogen in the surface - bottom layer of 10-mile coastal zone.

Conclusions

The variation in the Danube's discharge into the Black Sea has strongly affected salinity and has produced significant fluctuations in the distribution of nutrients in the littoral and nearby shelf zone.

The frame of sea temperature fluctuations was given by investigations in August and February. Varna Bay waters in the central deep area were warmed throughout the surface - bottom layer in August 2005, with temperature range 24.69˚C - 23.21˚C. SST was 25.05˚C in the 10-mile zone in front of Cape Galata, while sea bottom temperature range was 11.58˚C - 18.99˚C. SST has increased from 4.02˚C at 1 mile offshore to 4.78˚C at 10 miles offshore, with small drop into the bottom in February 2006.

The stream of Danube Transformed Waters was ascertained at different distance from the shore: in the 10-mile zone in May 2006, 10 miles offshore in February 2006, in the 10-20- mile zone in June 2005, and 20 miles offshore in March 2005, with dominant SSS in the range 15.14 psu (June 2005) - 16.82 psu (March 2005). Only in May 2006, due to spring maximum of Danube's discharge, strong drop in salinity in the 10-mile coastal zone approached 11.56 psu at 5 miles offshore and high horizontal salinity gradient of 0.5 psu $mile^{-1}$ was established in the 5-10-mile zone in front of Cape Galata. Owing to reduced Danube's discharge, salinity was high in April and August in 2005. Sea bottom salinity was in the range 17.02 psu (1 mile offshore, February 2006, 23 m depth) - 19.96 psu (20 miles offshore, March 2005, 65 m depth).

During 2005-2006, oxygen saturation was varyed from 70.49 % (March 2005; 20 miles offshore, 64 m depth) to 131.71 % (May 2006; 1 mile offshore; 7 m depth) throughout the 20-mile zone and surface - bottom layer of St. B5. Oxygen super-saturation was up to 131.48 % in the surface - bottom layer at 3 miles in front of Cape Galata although the salinity was high -18 psu in March 2005. In April 2005, drop in oxygen saturation at 3 and 15 miles offshore was ascertained as oxygen deficit was significant even in the surface waters - 84.68 % at 3 miles offshore and 72.04 % at 15 miles offshore. Oxygen deficit condition was established at 1 mile in front of Cape Galata in June 2005. Oxygen consumption has exceeded oxygen production throughout the 10-mile zone and surface - bottom layer of St. B5 as drop in oxygen saturation has reached 75.33 % even in the surface waters at 1mile offshore in August 2005. Surface waters of nearest coastal zone at 1 mile offshore were most oxygen super-saturated - 124.19 % in April 2006.

Nutrient concentrations have varied in broad bounds, especially in 2005. Due mainly to drop in consumption by phytoplankton, the nutrient fund was high in March 2005. Nutrient load was strongest in the Varna Bay, with 0.58 µM nitrite nitrogen concentration and 2.58 µM nitrate nitrogen concentration in the surface - bottom layer in April 2005. Nutrient concentrations were higher in the 3-mile zone - 0.72 µM nitrite nitrogen and 2.25 µM nitrate nitrogen in the surface - bottom layer in June 2005. Drop in nutrient fund has reached 0.17 µM nitrite nitrogen and 0.58 µM nitrate nitrogen in the surface - bottom layer of 10-mile zone in August 2005. Similar nutrient concentrations - 0.18 µM nitrite nitrogen and 0.63 µM nitrate nitrogen in the surface - bottom layer were found out in the Varna Bay. Drop in nitrite nitrogen has reached 0.03 µM at 3 miles offshore, 10 m depth and 0.05 µM in the bottom waters of St. B5 in April 2006. As in the sea the nutrient concentrations are result of different inputs and consumption by phytoplankton, increase in nitrite and nitrate nitrogen in comparison with the years in the beginning of XXI Century, when the concentrations were extremely low, might be owing to either rich nutrients Danube's water current and coastal sources or decreased consumption.

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