Spatial and temporal variations in the hydro-chemical properties of the Black Sea upper layer

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Abstract- Hydrochemical data obtained during the May-June 2001 Knorr cruise indicate that the euphotic zone waters were depleted in nitrate and phosphate over western Black Sea, including northern shelf. Moreover, the nitracline onset and the oxycline boundary were locally modified in the central and norther self break regions due to insufficient ventilation of the upper pycnocline. However, the Bosphorus underflow is a natural means for the ventialtion of SW Black Sea. Nevertheless, the main chemical features of the transition zone have not been modified in the deep basin since late 80's.

Key words- Black Sea, nutrients, upper layer, oxic/anoxic transition zone

Introduction

The Black Sea is a land-locked basin having distinctly different biochemical properties due to the presence of sulphide-bearing waters below 100-175 m depths from the sea surface (Basturk et al., 1998; Konovalov et al, 2001; Tuğrul et al., 1992). This unique marine ecosystem has been changed drastically by both anthropogenic and natural pressures during the last 30 years (Tuğrul et al., 1992; Konovalov et al. 2001). Such alterations have principally occurred in both living and non-living resourses of the Black Sea upper layer whilst the boundary of the anoxic layer has almost remained unchanged during the same period due to as yet clarified natural bio-mediated hydro-chemical processes over the basin. Large loads of nutrients and other chemicals from the major rivers to NE shelf waters have altered the natural marine community structures in both coastal and open seas (Cociasu et al. 1996; Kıdeys, 2002; Yunev et al., 2002) as well as the princial hydro-chemical properties of the entire basin with more pronounced changes in the NW shelf region. The present report aims to assess and discuss spatial and temporal variability in the principal hydro-chemical properties (dissolved oxygen, nitrate, phosphate, silicate, disolved ammonia and manganese) of the Black Sea upper layer extending down to the sulphide-bearing anoxic waters, based on data obtained during the Knorr Black Sea surveys conducted in May-June 2001 and previous measurements in the basin.

Results and Discussion

Vertical profiles of nutrients and dissolved manganase measured at hydro-chemically different sites of the western Black Sea by using a 6-channel Technicon AII Model auto-analyzer are displayed in Fig.s 1-2. All data plotted against to water density, rather than water depth, permit us to examine spatial and temporal variability in the principal chemical structure of the water column in the oxic/anoxic transtion layer coinciding strickly with the permanent pycnocline.

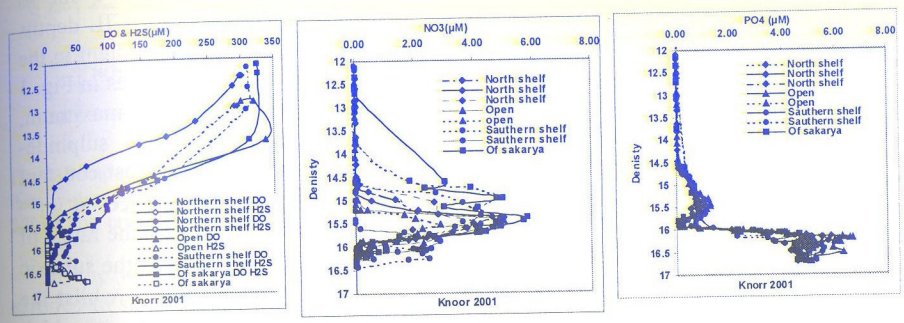

Fig. 1a. Density-dependent chemical profiles obtained in different regions of the Black Sea during the May-June 2001 Knorr cruise.

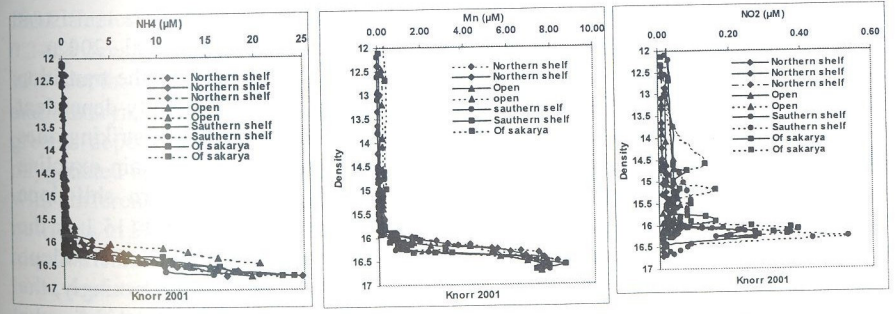

Fig. 1b. Denisty-dependent chemical profiles obtained in different regions of the Black Sea during the 2001 Knorr cruise.

Composite profiles of nutrients demonstrate that the photosynthetic upper layer waters from SW margins to northern shelf/slope of the Black Sea were markedly

depleted in nitrate (0.05-0.1 μM) and phosphate (0.02-0.04 μM) (Fig. 1), limiting algal prduction and thus living biomass, leading to abnormally high POC/Chl-a ratios in the EZ (Çoban-Yıldız et.al, this volume). Relatively low NO_3/PO_4 ratios estimated for the surface waters are realistic because nutrient concentrations meaured were very close the detection limits of the automated methods. In the SW rim current off Bosphorus, the the PO_4-poor CIL formed between $\sigma_t \cong 14.0$-14.3 surfaces (salinity = 18.1-18.3 ppt and depth range:30-60m) were unexpectedly depleted in nitrate ions in May-June 2001 as compared to its values in previous years. It could be due to insufficinet cooling of nitrate-enriched NW shef waters to sink into the CIL depths during the winter 2001. Accordingly, the onset and slope of the nitrate gradient in the region were altered by various processes in 2001. Density-dependent profiles in Fig. 1 exhibit that positions of the principal chemical features, such as nitrate maximum, phospate sub-surface minimum and maxima, onsets of the oxycline and sulphide-bearing water, ammonia and dissolved Mn gradients, have remained almost constant in the western cyclone since late 80's. Specifically, the oxycline commences at σ_t = 14.5 - 14.60 depths whereas the the nitrate maximum has been formed in the range of σ_t = 15.30 - 15.50 surfaces. Similarly, the charactersitic PO_4 minimum in the suboxic zone has been consistently formed between σ_t = 15.85 – 15.95 surfaces whilst the deeper PO_4 maximum always appears between σ_t = 16.15 - 16.20 surfaces, which perfectly coincides with the boundary of sulphide-bearing (H_2S >0.2 μM) water layer. On the other hand, the NH_4 profile commences at σ_t = 16.0 - 16.10 in the central cyclonic region, which is consistently deeper by about 0.1-0.2 density units than the onset of Mn (>0.2 μM) profiles in the same region. These findings are consistent with previous studies (Başturk et al., 1997; Murray et al, 2001; Tuğrul et al., 2002).

Though the main chemical features have not changed apparently in the transition zone of the Black Sea cyclonic region, the boundaries of some density-dependent chemical profiles display remarkable variations in space and time. Most striking ones were the local shifts in the boundaries of oxycine and nitracline. The main oxycline was apparently shifted upward from SW rim cuurent to the northern shlf-slope margins. In May-June 2001, the DO = 10 μM boundary, located at $\sigma_t \cong 15.1$ in the western cyclone, moved upward to $\sigma_t \cong 14.65$ density surface in the northern slope (Figs. 1, 2), due to limited ventilation of the CIL in the later region. Interesingly, the DO = 10 μM density surface reached in the northern region nearly standed for the onsets of the nutricline and oxycline in the SW Black Sea, indicating more effective ventiation of CIL in southern coastal regions.

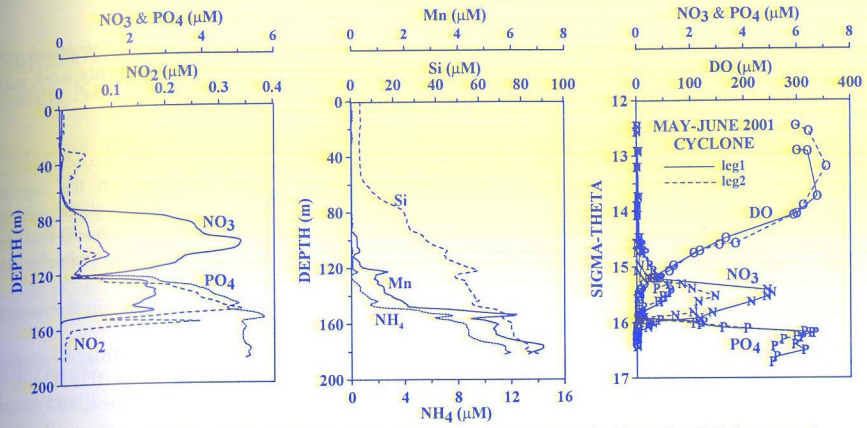

Fig. 2. Pump-cast continuous depth profiles of nutrients and Mn on the shelf break off Sakarya and density-dependent profiles of DO, nitrate and phosphate in the western cyclone during the May-June 2001 Knorr cruise.

In the western cyclone visited in May-June 2001, the steep oxycline was locally erroded to some extent by biochemical processes during the late spring bloom. It may occur in the cyclone provied that POM export from the productive upper layer to the aphotic zone exceeds DO supply into the pre-formed oxycline. This shift natuarally causes to the enlargement of the suboxic zone by some metres towards the surface as experienced in the 2001 summer. Similar alterations were previously recorded in July 1992, September 2000, and the DO = 10 μM boundary was shifted upward by about 0.3-0.4 density units, from $\sigma_t \cong 15.6$-15.7 in other seasons and years to the $\sigma_t \cong 15.2$-15.3 depths in the summer of 1992 ans 2000. On SW rim current between Bosphorus and Sakarya, however, DO = 10 μM have been consistently reached at $\sigma_t \cong 16.0$ or greater depths (Fig. 1) , due to the ventilation of the intermediate waters by the oxygenated and diluted Mediterranean waters. The intrusion of the Bosphorus plume with different chemical properties can also be realized from continuous profiles of nutrients in Fig. 2. Depth-integrated concentrations of both nitrate and phosphate and also N/P ratios in the water column from the surface to phosphate minimum zone have been depleted in 2000 and 2001, indicating less nutrient input to the Black Sea upper layer during the last two years. Nevertheless, the sulphide-bearing waters have reamined almost at the same density surface for years, suggesting that some chemicals recycling in the interface, such as manganese, prevent the shoaling of the anoxic layer although the suboxic zone have enlarged some metres with concurrent modifications in nutrient profiles in the transition zone during recent decades.

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Concentration
Black Sea

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