ANALYSIS OF THE LOCATION OF UPPER BOUNDARY OF THE H2S-ZONE FROM MULTIANNUAL DATA

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The problem of the hydrogen sulphide contamination of the Black sea is in the focus of attention of oceanologists and ecologists in view of the existing assumptions and some data on the rise of the anoxic water boundary to the sea surface and on possible catastrophic effect of hydrogen sulphide on human activity in the coastal zone. The estimates of dynamic of the upper boundary on the H_2S zone (UB of the H_2S zone) obtained up to present were based on the limited data array which did cover the whole population of measuring results accumulated. The work on mobilization and rescue of all accessible data has been done by us.

The correlation between the location of the UB of the H_2S zone and some physical surfaces in the Black sea was noted in a series of papers published in recent years. According to the opinions of many researchers (BEZBORODOV, 1989; VINOGRADOV, 1991) the correspondence of the UB of the H_2S zone to the certain, rather narrow isopycnic layer ($\sigma_{s,\,t,\,o}$ -16.20) is most demonstrative. However such a correspondence was observed, as a rule, within rather short time interval, most often during one voyage and over the limited areas. Research carried out by academic institutions of the Ukraine showed that in the Black sea there exists a relationship between the location of the definite isopycnic surface and the UB of the H_2S zone not only on meso-scales but also on climatic scales when computation is done using the multiannual averaged data. In computations averaged data over the period 1921-1993 years was used.

The coefficent of correlation between the location of the UB of the H_2S zone and the depth of the 16.2 isopycnal has been computed from the averaged data. The value of this coefficent was obtained to be equal to 0.71. It is noteworthy that the best correspondence between the location of the UB of the H_2S zone and the depth of the isopycnal is observed in the deep-sea region where the correlation coefficient reaches 0.88.

Thus the results obtained permit a conclusion that an interplay between location of the UB of the H_2S zone and the depth of isopycnal 16.20 can be traced not only witihin rather short time intervals (as noted previously) but also on the climatic time scales when using the averaged observation data for the entire basin.

On the basis of the studies implemented, the linear regression equations was deduced relating the location of the UB of the H_2S zone with the depth of the 16.20 isopycnal, which allows us to specify the depth of the upper bounday of the hydrogen sulphide zone in the squares in poor data coverage or in the periods when observations of the hydrogen sulphide concentration vertical distribution was absent.

Figure 1 shows the multiannual average variability of the depths of the UB of the H_2S zone (solid line) and of isopycnal with conventional density 6-16.2 (dashed line) for the Black sea basin. One can assume that these curves describe some global climatic process which has no constant trend. Apparently, the UB of the H_2S zone produces oscillatory movements in time with approximately century period. Comparing curves, one can conclude that the diagrams showing the location of the UB of the H_2S zone and the depth of the isopycnal agree well, which supports a corollary about the oscillatory character of variability of the UB of the H_2S zone.

The high correlation level between the location of the H_2S zone boundary and the elements of the density structure od seawater points to the dominant role of hydrophysical and hydrological factors in a totality of processes which govern its multiannual variability.

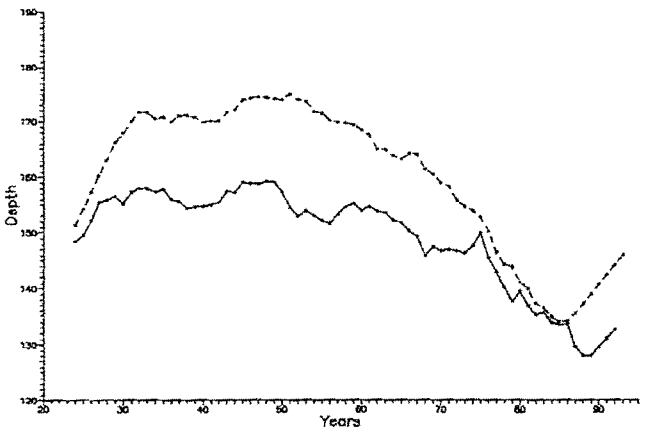

Figure 1. The multiannual average variability of the depths of the UB of the H23-zone (solid line) and of isopycnal 16,20 (dashed line).

SPATIAL ISOPYCNAL ANALYSIS OF SOME PROCESSES RESPONSIBLE FOR THE HYDROCHEMICAL STRUCTURE OF THE BLACK SEA WATERS

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Scientific discussion on shoaling of the upper boundary of hydrogen sulfide zone and catastrophic degradation of the Black Sea environment is the reason of intensive investigation of the surface and undersurface Black Sea waters during the last ten years. Obviously, that scientists need some new methods to collect and to analyze samples of water, but more over they have to use new methods to analyze obtained chemical data.

Before the nearest time investigators usually analyzed the data on the hydrochemical structure of the Black Sea waters versus depth. In this way they could only conclude that intensity of the main cyclonic and anticyclonic gyres determine the main features of the chemical vertical structure. But it is very difficult to eliminate the influence of different gyres on a shape of the isopycnal surfaces, so this is extremely difficult to analyze the influence of chemical and biochemical processes, to analyze the real (cross-isopycnal) vertical fluxes of any chemical substances in this way.

Hydrochemists started to use intensively one-dimensional isopycnal analysis for investigation of the Black Sea chemical structure after American-Turkish cruise on R/V "KNORR" in 1988. The sigma-t scale rather then depth is used in this method. This one-dimensional method is very useful, but one needs to suggest that the intensity of different biochemical processes and crossisopycnal fluxes are equal for entire basin.

When some large data sets for entire Black Sea (obtained, for example, during "CoMSBlack" experiments) were analyzed, scattering of some hydrochemical parameters for equal values of density has been observed. This scattering was much higher then any possible analytical errors.

Spatial isopycnal analysis is very useful method for investigation of variations of hydrochemical structure. The most advantages will be received, if to use this method for investigation of highly stratified marine basins. In this way the influence of different hydrophysical and chemical or biochemical processes on the hydrochemical structure can be divided effectively.

We have used 2D-isopycnal analysis to understand and to investigate the main features of the spatial distribution of oxygen and hydrogen sulfide in different layers of water (on different isopycnal surfaces) and the main processes responsible for it. The significance of the winter ventilation processes over the main cyclonic gyres in the central part of the Black Sea for transfer of oxygen downward to the upper boundary of hydrogen sulfide has been indicated.

It has been confirmed, that sub-oxygen zone ("SO"), where concentrations of oxygen and hydrogen sulfide are less then 3 - 5mcM/l, with the thickness of 14 - 51 meters or 0.2 - 0.6 units of sigma-t is the permanent feature of the Black Sea hydrochemical structure. Analysis of spatial variations of the structure of "SO" zone has been carried out and some mechanisms responsible for it have been suggested. Spatial enter and interannual variations of hydrogen sulfide distribution versus sigma-t have been investigated on the basis of "CoMSBlack-91", "CoMSBlack-92", "CoMSBlack-93" data sets.

It has been shown that convectional ventilation over the main cyclonic gyres in winter time is responsible for destruction of the layer of nitrates' maximum (sigma-t ~15.4) and the upper phosphates' maximum (sigma-t ~15.6). This process can transfer a lot of nutrients into euphotic zone. It has been estimated for nitrates by value as much as ~200 000 tuns, what is equal to annual riverine inflow.

These winter ventilation processes can be the reason of intensification of oxygen - hydrogen sulfide interaction and, as a result, decreasing of phosphates in the layer of their minimum (sigma-t ~15.95) and increasing of phosphates in the layer of their down maximum (sigma-t ~16.20-16.30). The area of the sea, where all three extremes of phosphates can be observed in winter-spring period of the year is bounded by the Main Black Sea Flow.

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