LONG TERM VARIABILITY OF THE PHYSICAL PARAMETERS IN THE BENTHIC BOUNDARY LAYER OVER THE BLACK SEA SHELF

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Abstract
The purpose of this study is to identify long-term changes of hydrological parameters in the benthic boundary layer (BBL) on the Western Black Sea shelf. This is done to provide underpinning information for the study of carbon cycle. Interannual variability and smooth changes in the parameters of the benthic boundary layer which are thought to be related to variation in rates carbon sequestration are assessed.
Keywords: Anoxia, Black Sea, Continental Shelf, Temperature

Introduction The chemical structure of the Black Sea waters is largely determined by the location and the strength of the pycnocline. The oxycline and the chemocline occur at the same depth intervals as the halocline, because of similarity in the mechanisms of vertical exchanges [1]. As the data for Dissolved Organic Carbon (DOC) on the shelf is sparse we test a hypothesis that a similar statement is valid for DOC, so that much abundant data on physical parameters can be used as proxy. We use the near-bottom temperature as indicators for physical conditions in the benthic boundary layer on the shelf. The physical reason for this is that interannual variations in the near-bottom temperature are directly related with the volume of cold waters [2] which are formed on the shelf and then exported into the deep sea. Despite early claims on possible shoaling of the anoxic interface, the vertical position and structure of the chemocline appear reasonably stable within the last few decades [3]. However, seasonal and interannual temperature and salinity variations do exist in the upper layer that are subsequently evidenced in the bottom boundary layer on the Western shelf due to winter convection.

Data and Methods
The majority of the available data suitable for the study of the BBL was taken on the extensive North West shelf, which is the focus of the present report. In this study we identified climatically averaged parameters on a dense horizontal grid of 0.25^{o} as well as monthly anomalies (deviations from the climatology) using over 17,000 stations. Water masses and the chemicals contained therein, which are located in the BBL on the shelf below the upper pycnocline are unlikely to surface due to vertical mixing process. The upper level of the bottom boundary layer was determined by the deepest level to which vertical mixing due to waves and wind can reach if the energy for mixing is limited by a certain threshold, which for this study was taken 10kJ/m^2. We consider here the energy required to completely mix a water column as the difference between the potential energy of the stratified water column and the completely mixed water column. The constant density of the mixed water column can be derived from the original density profile using the principle of the conservation of mass, such that both potential energies can be expressed as a function of the measured density stratification.

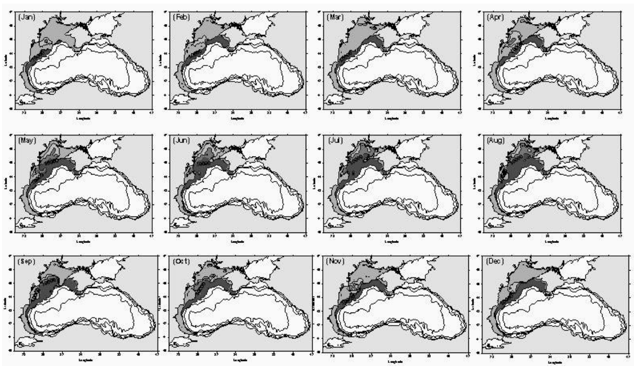

Fig. 1. Climate: shelf areas ($\leqslant$ 200m) covered by waters denser than the mixing depth (W_{mix} = 2,500/5,000/10,000 J m^{-2})

Results and analysis
Comparison of the available vertical profiles of nutrients, DOC and water density has shown that strong density stratification is linked to stratification in nutrients and DOC so that variation in physical parameters can be used as proxies for their biochemical counterparts. The layer below the upper pycnocline forms a 'communication channel' for nutrients and carbon to be removed from the shelf ecosystem. During the winter-early spring month the water masses contained within the 'communication channel' could come into contact with the oxygenated surface waters via isopycnal movement. However, during the summer-autumn month (May to November) these water masses are completely isolated from the surface. The areas on the shelf (depth <200m) which are occupied by the 'locked' BBL waters vary during the year as well as average temperature of these waters. For this study we are using temperature anomalies rather than absolute values to avoid statistical bias when aggregating the data over large geographical areas, such as western Black Sea shelf. The anomalies were calculated for a density range that was fixed for each summer month (May-November) using sigma-theta = 14.2 as a fixed upper limit and a lower limit was the shelf edge (i.e. 200m isobath).

The analysis allowed us to answer the following questions: (i) What are the areas of the Western BS shelf where the near-bottom waters can not be mixed vertically ('locked out water masses')? How these areas change from month to month ? What is the interannual variation of temperature in the locked waters? The intra-annual variability of the 'locked out' areas occupied by bottom waters and the inter-annual variation of the area –aggregated temperature anomaly are shown in Figs 1.and 2.

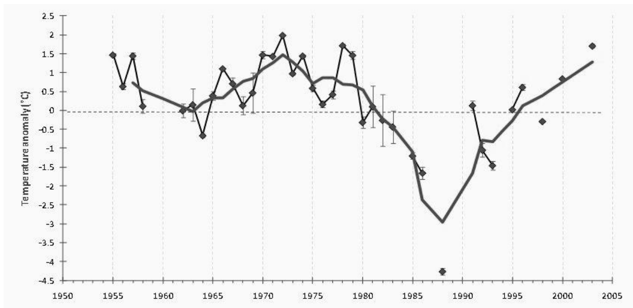

Fig. 2. Temperature anomalies aggregated over the shelf volume of 'locked' waters (as defined by σ_θ=14.2) and averaged over summer months (May-November) shown as function of time + 5yr running mean. Error bars = 1 standard deviation.

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