

**CLIMATIC WARMING AND ACCOMPANYING CHANGES  
IN THE ECOLOGICAL REGIME OF THE BLACK SEA DURING 1990S**

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**ABSTRACT**

The Black Sea ecosystem is shown to experience abrupt shifts in its all trophic levels from primary producers to apex predators in 1995-1996. It arises as a manifestation of concurrent changes in its physical climate introduced by intensive warming of its surface waters as well as abrupt increases in the mean sea level and the net annual mean fresh water flux. The warming is evident in the annual-mean sea surface temperature (SST) data by a continuous rise at a rate of  $\sim 0.25^{\circ}\text{C}$  per year, following a strong cooling phase in 1991-1993. The most intense warming event with  $\sim 2^{\circ}\text{C}$  increase in the SST took place during winters of the 1994-1996 period. It also coincides with  $4\text{ cm yr}^{-1}$  net sea level rise in the basin, and substantial change in the annual mean net fresh water flux from  $150\text{ km}^3\text{ yr}^{-1}$  in 1993 to  $420\text{ km}^3\text{ yr}^{-1}$  in 1997. The subsurface signature of warming is marked by a gradual depletion of the Cold Intermediate Layer (characterized by  $T < 8^{\circ}\text{C}$ ) throughout the basin during the same period. Winters of the warming phase are characterized by weaker vertical turbulent mixing and upwelling velocity, stronger stratification and, subsequently, reduced upward nutrient supply from the nutricline. From 1996 onwards, the major late winter-early spring peak of the classical annual phytoplankton biomass structure observed prior to mid-90s was, therefore, either weakened or disappeared all together depending on local meteorological and oceanographic conditions during each of these years. The effect of bottom-up limited unfavorable phytoplankton growth is reflected at higher trophic levels (e.g., mesozooplankton, gelatinous macrozooplankton and pelagic fishes) in the form of their reduced stocks after 1995.