Fifty-year changes of phytoplankton in the deep-water basin of the Black Sea

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During the period from 1970s to 1980s the Black Sea has been affected by intensive eutrophication, which led to drastic changes and regime shifts in ecosystems on the shelf and in the open waters. They were manifested in elevated values of chlorophyll a, biomass of phytoplankton, primary production, etc. The goal of the current research was to trace the long-term (1968–2017) dynamics of phytoplankton biomass and taxonomic composition in connection with changes of physical and chemical properties of environment.

Prominent changes occurred in the species composition of phytoplankton. During 50-year period the following taxons showed the decreasing trend: dinoflagellates *Protoperidinium spp.*, *Prorocentrum spp.*, *Gyrodinium spp.*, *Gymnodinium spp.*, *Ceratium fusus*, *C. tripos*, *Gonyalax spp.* and diatoms *Chaetoceros spp.*, *Thalassiosira anguste-lineata*, *Coscinodiscus spp.*, *Thalassionema frauenfeldii*. At the same time, coccolithophores *Emiliania huxleyi* and *Acanthoica quattrospina*, diatoms *Proboscia alata* and *Pseudo-nitzschia spp.* showed an increasing trend.

The annual (average for warm part of year from May to October) depth integrated biomass has varied over a wide range from 1 to 46 g m-2. Eutrophication of the deep-water basin in the 1970-1980s created the favourable conditions for phytoplankton growth. The concentration of inorganic nitrogen in the deep cold intermediate layer (CIL) increased from 1.2 to 3.3 μM during the period from 1970s to mid-1980s. However, most of this nutrient stock was locked in the deep layers due to high stratification of the Black Sea waters. This potential for phytoplankton development was actualized during the cold climatic period from 1984 to 1996. The deep winter convection occurred during this period intensified the upward flow of biogenic elements into the photosynthetic zone. Thus, the cold climatic period acted as the immediate driver of a sharp increase of the total phytoplankton biomass and amount of diatoms and dinoflagellates by a factor of 6. Simultaneously the nitrogen-to-phosphorus ratio (N:P) in the CIL increased from 6:1 to 11:1 mitigating the limitation of the growth of phytoplankton by nitrogen. After 1996 the falling of concentration of inorganic nitrogen by 1.5 times and reduction of N:P to 9:1 led to decrease in the biomass of the both groups by 1.5-2 times. During the 50-year period a fourfold reduction in biomass of silicoflagellates was associated with a 30% decrease of the concentration of silicon. The increase in quantity of coccolithophores by 2 orders of magnitude was caused by 50% increase in concentration of phosphate. As a result, the taxonomic composition of phytoplankton changed. Before 1984, diatoms and dinoflagellates prevailed in the phytoplankton biomass, making 54% and 40%, respectively. After 1996, the corresponding contribution of diatoms, coccolithophores and dinoflagellates was 40%, 23% and 20%.

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