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Interdecadal variations in the inorganic phosphorus content in the Atlantic Water and their possible impact on commercial resources of the Barents Sea

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Since the second half of the last century interdecadal variations in the content of inorganic phosphorus in the southern Barents Sea waters occurred quasi-synchronously with similar variations in the active layer of the Atlantic Water over a large area from the Irminger Sea to the Baltic Sea and from the Porcupine Plateau to the Norwegian Sea. Interdecadal structural changes in the Barents Sea ecosystem, manifested as variations in the total biomass and catches of some fish species, are caused by changes in the "cumulative" properties of seawater, in particular, stratification and inorganic phosphorus content. In line with general eutrophication-related trends, an increased content of phosphates in the Barents Sea and adjacent areas of the Atlantic coincided with a decrease in biomass and catches of relatively long-lived species (cod and herring) and a simultaneous increase in those for capelin, a short-lived plankton-eater. So, in the periods of low inorganic phosphorus content in seawater, the Barents Sea ecosystem can be classified as a continental shelf temperate marine ecosystem. When the total level of inorganic phosphorus in the environment was high, the food chain structure was closer to that typical of biological communities inhabiting the Arctic seas and upwelling areas.

Introduction

A specific character of sea biogeochemical processes requires their study as a natural factor regulating the functioning of marine ecosystems. The content of mineral phosphorus in the Barents Sea has been measured annually since the late 1950s till now. The most stable measurements are made along the Kola Section, in the southern sea part. This paper is a continuation of studies initiated earlier (Titov, 2001) of variations in the content of mineral phosphorus in sea water and their effect on fish resources in the Barents Sea.

Materials and methods

Data from observations in the near-bottom layer at about 250 m depth on the Kola Section at 70°30'-72°30'N, 33°30'E are regarded as characteristic of year-to-year variability of the phosphate content in the Barents Sea water. The sea water was analyzed by the Deniges-Atkins method in the vessel laboratory immediately after sampling. Based on the long-term (1957-2013), more than 250 times completed series of observations on the section, the continuous series of hydrochemical parameters were reconstructed. The following analysis used information, comparable in respect of the timeframe, on the basic parameters characterizing the long-term variations in the Barents Sea ecosystem (the content of mineral phosphorus in the sea water, climate parameters, data on stocks and catches of the main commercial fish species), data for the Norwegian Sea and other areas of the Northeast Atlantic.

Results and Discussion

Year-to-year variability of phosphate concentrations in the Barents Sea is characterized by the existence of a long-term time trend. Its primary feature is a significant growth of the mineral phosphorus reserve

from the early 1960s to the mid-1980s. In the period from the late 1980s to the early 1990s, the content of phosphates declined and then stabilized at the level close to the long-term mean. The main specific feature of the year-to-year variability of the phosphate content was that the variability in the Barents Sea, on the sections in the Norwegian Sea and other areas of the Northeast Atlantic was close to synchronous.

Changes of analytic methods applied in observations in the Baltic Sea and areas of investigations by PINRO took place in different time. In other cases, there is no information available about the time when methods of analysis changed. Taking this into consideration, it is unlikely that the revealed synchronism of the long-term variability in the content of mineral phosphorus in the investigated areas was a result of systematic analytic errors during hydrochemical studies.

Hence, the background content of the mineral phosphorus in the Barents Sea varied, apparently, as a result of similar variations in more southern areas (the Norwegian Sea and the Northeast Atlantic). According to one of the scenarios, the rise in the phosphate concentration in the 1970s-1980s was caused by general cooling of climate in the Barents and Norwegian Seas and in the Northeast Atlantic and, as a consequence, by reduced stratification, stronger vertical mixing in the water column and reduced intensity of the Atlantic waters advection. Another possible reason could be a transatlantic transport of water masses enriched by phosphates as in the case of distribution of the "Great salinity anomalies". It is, probably, sufficient that there is an impact of phosphorus flow having antropogenic origin, however, it is difficult at present to ascertain the scale and relative contribution of such an impact.

Long-term variations in the year-class strength of main commercial fish species in the Barents Sea (capelin, cod, herring) may be interpreted as a feature of ecological succession (Odum, 1953). According to classical concepts of the modern ecology when climate is cooling, biogenous pressure is increasing and stagnation phenomena are developing, the productivity of community grows at early stages of seasonal succession and then, as a rule, strong year-classes of arctoboreal species and r-strategist such as the Barents Sea capelin, appear. Under warming climate, declining biogenous pressure and the inflow of "fresh" Atlantic waters the productivity of community increases at the late stages of seasonal succession, and these conditions are favourable for appearance of strong year-classes of northern boreal species and K-strategists, such as the Northeast Arctic cod and Atlantic herring.

So, in the periods of low inorganic phosphorus content in seawater, the Barents Sea ecosystem can be classified as a continental shelf temperate marine ecosystem. When the total level of inorganic phosphorus in the environment is high, the food chain structure is closer to that typical of biological communities inhabiting the Arctic seas and upwelling areas.

References

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