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LONG-TERM CHANGES OF ZOOBENTHOS BIOMASS IN THE BARENTS SEA

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Long-term variability of marine ecosystems has recently become one of the most topical hydrobiological study subjects. Such an interest in the problem can be explained by the lack of strict interpretation of global climatic fluctuations and other related phenomena. It is still not clear what the causes of the local and global ecosystem fluctuations are and whether the influence of the natural factors on biota prevails over the influence of the human factors.

Marine macrozoobenthos indicates and integrates long-term environmental changes very well. Most benthic organisms are slow moving and their life cycles are long in comparison to e.g. pelagic organisms. The temperature dependence of the Barents Sea zoobenthos was shown by many researches (Galkin, 1998), but human influence on bottom fauna was considered only as a hypothesis (Denisenko & Denisenko, 1998).

The aim of our study was to reveal the long-term temperature and fishery dependence of zoobenthos biomass in the Barents Sea.

MATERIALS AND METHODS

Zoobenthos. A lot of local studies were carried out in the Barents Sea, but only two extensive quantitative zooobenthos surveys have taken place there (in 1926-1935 and 1968-1970). The sampling networks and the schedules of these extensive surveys were not identical (Fig. 1A, 1B). The most extensive sampling program was performed in 1968-1970. However, the data on the southern and central parts of the Barents Sea for the year 1968 are lacking because the materials of the 1st cruise of R/V "Maslov" (1968) have been lost. The sampling network in the period 1924-1932 was very irregular. Most of the sampling in the open sea area was carried out in 1927-1932. In the southeastern part of the Barents Sea, the Pechora Sea, 4 detailed benthic surveys have been carried out during the last 60 years.

For our researches we used all the materials, which had been kept in archives and were accessible.

The biomass mapping and the computation of average biomass values for the whole Barents Sea in different periods of benthic surveys were based on the

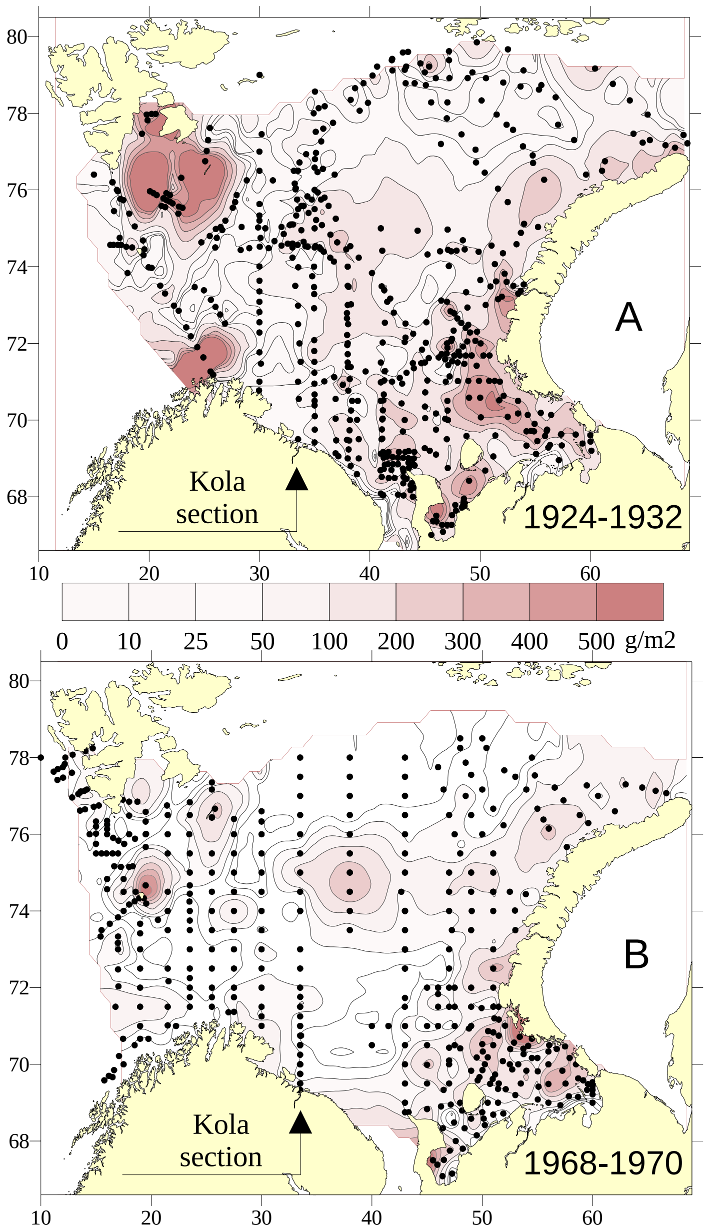


Fig. 1. Station network of quantitative zoobenthos sampling and distribution of zoobenthos biomass (g/m^2 of wet weight) in 1924-1932 (A) and 1968-1970 (B).

estimated values. Estimated biomass values have been calculated by Kriging method (Cressie, 1991) for the fixed vertexes of interpolation grid on the basis of the real biomass values and geographical positions of corresponding stations.

Temperature regime. It is generally accepted, that observations in the 0-200 m layer of the Kola transect reflects the interannual changes in the heat content of the Coastal, Murman and Central Branch of the Nordcap currents and characterise the thermal regime of the whole Barents Sea. The Kola meridians transect has been studied for 98 years starting in 1900. For our study we used all this series of observations.

Bottom trawling. More than 600 monthly fish-trawling maps for the Barents Sea in 1946-1997, kindly placed at our disposal by "Sevrybpromrazvedka" (Murmansk Service of Fish Stocks Searching), were digitised and processed by computer. For the period before WWII trawling activity was quite precisely restored on the basis of literature sources (Shorygin, 1933; Maslov, 1939; 1944).

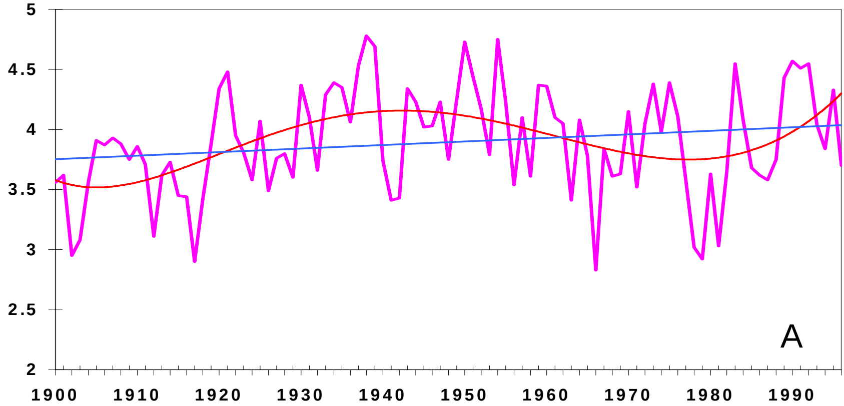
RESULTS AND DISCUSSION

Previous analysis of species composition and spatial distribution of zoobenthos communities during the different research periods along the Kola transect has not shown any clear connection of biomass changes with the temperature variations. The values of zoobenthos biomass in the coastal areas (up to 72^o N) were approximately the same during all periods, except the late 1940s, when the biomass reached its maximum values along the whole transect. Maximal range of the values variations was registered in the late 1960s (Fig. 2). In general, the similarity of biomass distribution near the shore was the greatest in the middle 1930s and 1990s and in the offshore area of transect - in the late 1940s and in the middle 1990s.

In the Pechora Sea area the calculated average zoobenthos biomass during 1924, 1959 and 1992-1993 was 251, 220 and 258 g/m^2 respectively. After strong lowering of the temperature in 1969, the value of biomass was by one third lower (176 g/m^2) than in other three periods. This fact can be completely explained by primary production variations in the Barents Sea caused by temperature changes in the same periods (Slagstad and Stokke, 1994).

The main conclusion, made by Antipova (1975) on the basis of the results analysis of two extensive benthic surveys, was that the decrease of zoobenthos biomass in the Barents Sea in 1968-1970 in comparison with 1924-1932, was probably caused by the previous cold period. Our attempts to compare an average zoobenthos biomass for the whole Barents Sea in 1926-1935 and in 1968-1970 have shown that the simple comparison of statistically average values is not correct, because the spatial distribution of stations at the first period was far from regular.

The results of analysis based on the estimated values have shown that the decrease of zoobenthos biomass in the whole Barents Sea in the late 1960s was about 60% in contrast to 20%, shown by Antipova (1975). The variability in the primary production values during the warm and cold years in the Barents Sea



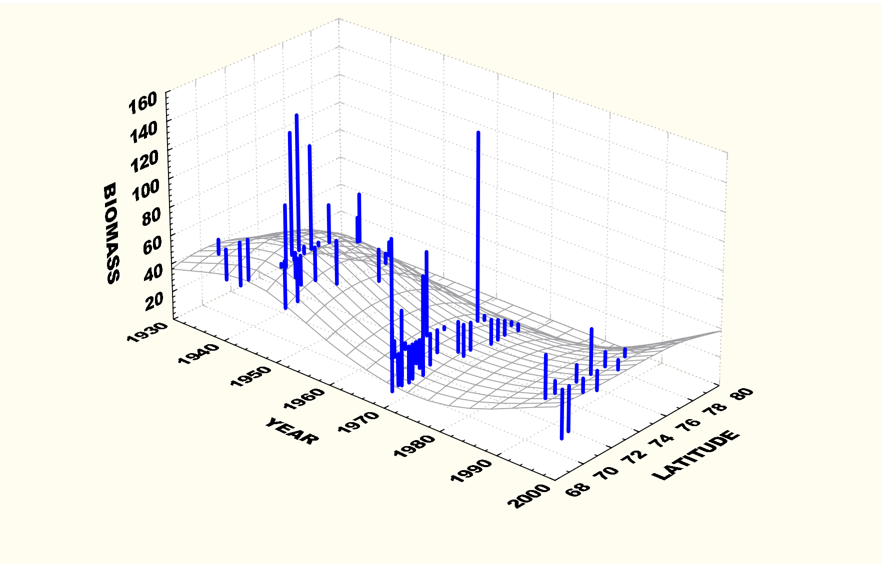


Fig. 2. Average annual water temperature, its linear and spline trends in the layer 0-200 m along the Kola transect (A); trend surface (spline smooth) and absolute values deviations of zoobenthos biomass (g/m^2 of wet weight) at the sampling stations along the Kola transect in different years (B).

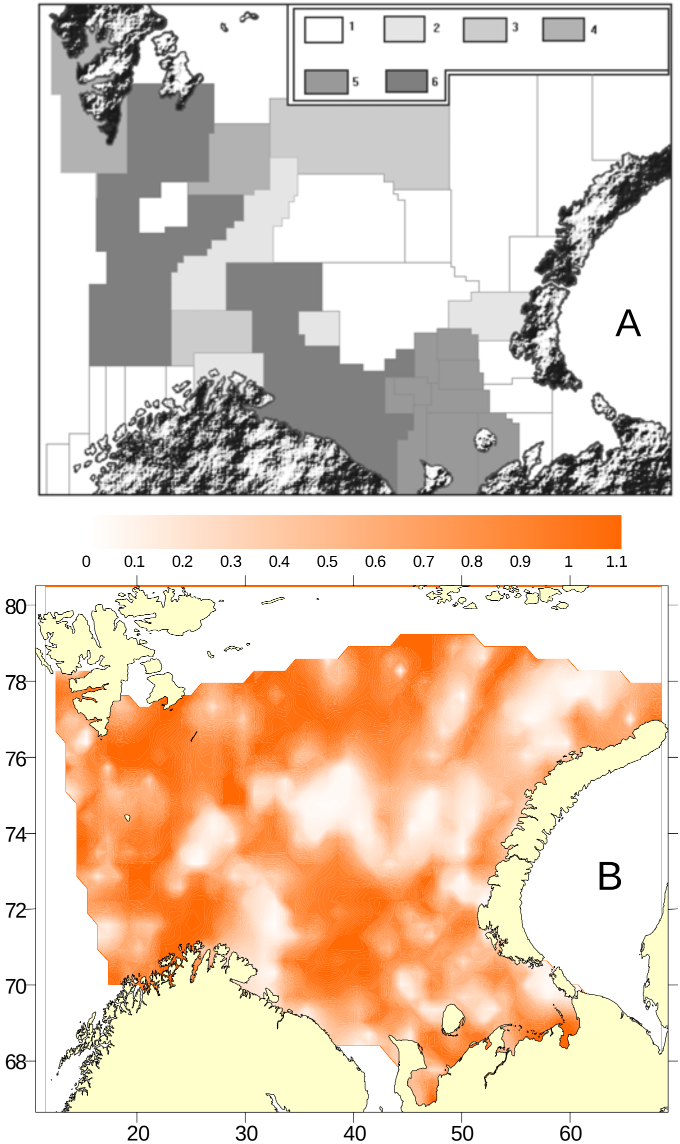


Fig. 3. Number of demersal fishery years in different regions of the Barents Sea in 1956-1985 (A): 1 – 5, 2 – 6-10, 3 – 11-15, 4 – 16-20, 5 – 21-25, 6 – 26-30; decrease (B) of zoobenthos biomass (1 unit = 1 - b_2/b_1) in 1968-1970 (b_2) in comparison to 1926-1932 (b_1).

(Slagstad and Stokke, 1994) explains the changes in zoobenthos biomass only by 30% and only in the unlikely cases of food deficiency for the animals. Differences in sampling methods, according to our calculations, explain in addition not more than 4-5% of the biomass variation.

What was the actual reason of the notable decrease of zoobenthos biomass after the late 1960s? Earlier the bottom trawling activity in different fishing areas of the Barents Sea was mapped (Denisenko & Denisenko, 1991). The similarity of this activity and the decline of zoobenthos biomass, considered in the present paper (Fig. 3A, 3B), gave an idea of possible reasons of this phenomenon.

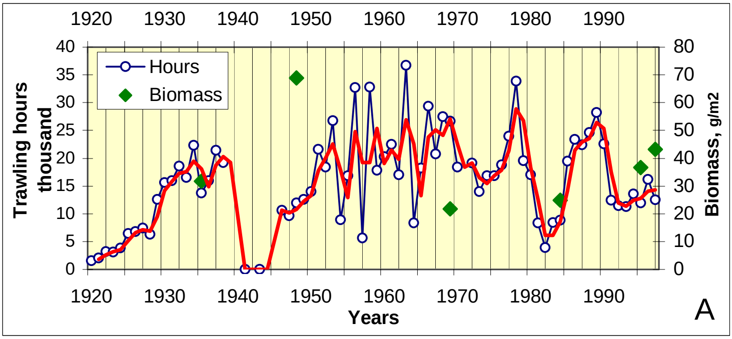
Data available on trawling activity and zoobenthos biomass values disagree in time and space considerably. This restricted, at the present research stage, the analysed area of biomass change to the area of the Kola transect. The results of the analysis performed are shown in Figure 4 and allow formulating the following conclusions. The high correlation (r^2 = 0.987) between biomass values (with a 4-year delay) and intensity of trawling activity along the Kola meridian specifies that this relation can be considered as functional. The calculation of non-linear regression (negative exponent) for the same data gives lower correlation (r^2 = 0.929), but this form of the regression seems more natural and appropriate to reality.

The plotted points of data (Fig. 4B) show that an increase of bottom trawling intensity is accompanied by the declining of zoobenthos biomass almost by 70 %. That estimation is close to that received via comparison of maps illustrating the distribution of zoobenthos biomass in the Barents Sea in 1926-1932 and in 1968-1970.

The obtained results lead to the obvious conclusion that the fish trawling is one of the main causal factors of long-term fluctuations of bottom communities in the Barents Sea. The absence of any significant fishery in the Barents Sea during WWII (Fig. 4A) explains the high values of zoobenthos biomass along the Kola section at the end of the 1940s, when the trawling activity only began its regaining.

The four-year delay in reaction of zoobenthos to the trawling intensity is probably caused by the average life expectancy of bottom organisms. Apparently, it is correct, as P/B (production/biomass) ratio for the whole zoobenthos in the Barents Sea varies within 0,2-0,3 (Brotskaya & Zenkevich, 1939; Zenkevich, 1963). The basic role thus is played not by the destruction of the adult animals, but by destruction of their potential posterity.

These conclusions make doubtful the opinion of some researchers, who interpret moderate bottom trawling as a stimulus for zoobenthos development or as a factor, negative influence of which is short and comparable to seasonal environmental influence (Rijnsdorp & Leeuwen, 1996; Kaiser et al., 1998; Hansson et al., 1998; etc.). This may be true, but only for cases of very low trawling activity, which is not common in traditional fishing areas. Therefore, we share the viewpoint of other researchers, who consider bottom trawling as one of the major impacts on benthic communities in the areas of intensive fishery (e.g. Bergman & Hup 1992, Philippart, 1998).



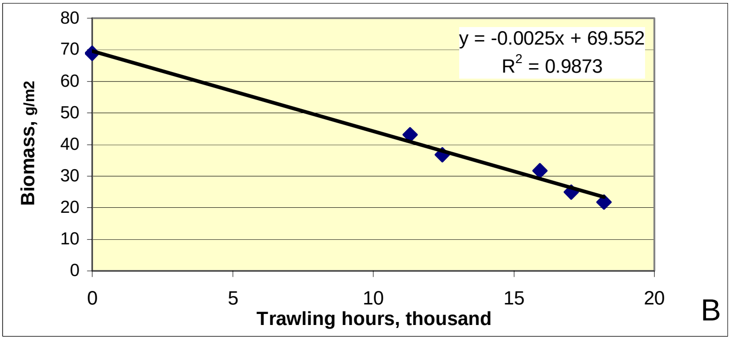


Fig. 4. Annual trawling activity (left axis, hours, solid line – 3-year running average) and zoobenthos biomass (right axis, g/m^2) along the Kola transect during 1920-1997 (A); opposite relation between biomass (4-year delay) and trawling activity (B).

Taking into account the obtained results, it is necessary to point out that more comprehensive programs of marine zoobenthos monitoring, than those now existing, should be done. This is important for recognizing possible influence of fishery on the long-term fluctuations and natural successions of bottom communities.

The number of the Barents Sea regions not used in demersal fishing is relatively low. One of them is the Pechora Sea, where mainly scientific bottom trawling and short-term fishing of the polar cod by the bottom trawls and floating trawls have taken place. The benthic studies carried out there earlier could provide a sound basis for further monitoring of the bottom fauna. Together with the observations along the Kola transect this would be helpful for revealing not only climatic reasons, but also anthropogenic factor responsible for the long-term zoobenthos fluctuations in the Barents Sea.

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