Long-term trends in mesozooplankton biomass development in the southern Baltic

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Biomass of mesozooplancton
Dynamics of mesozooplancton

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Abstract

The dynamics of the southern Baltic mesozooplankton biomass in the years 1951–1974 is presented with a consideration of the whole 24-year period and, separately, three shorter periods of 6–8 years. A distinct increasing trend of biomass was observed. On the basis of the results of investigations carried out in 1981–1983, this trend may be expected to continue in the coming years.

1. Introduction

This paper presents changes in the southern Baltic mesozooplankton biomass in the period between 1951 and 1974. The whole 24-year period is considered and, separately, shorter periods of 6–8 years. The paper is based primarily on the materials of Mańkowski (1971), collected systematically over many years at a large number of stations. The investigations of other authors (Ackefors 1969, 1972, 1978; Hernroth 1978, 1979; Eriksson 1973; Lindahl 1977; Eerola 1979; Wiktor 1963; Różańska 1976; Siudziński 1977; Chojnacki 1974; and others) conducted for many years in various parts of the Baltic, despite their merits, were disregarded here since they either covered much shorter periods or referred to small areas, and were often based on a small number of stations or else concerned the ecology and biology of selected species.

It should be noted that in the years 1975–1981 there were no representative collections of the southern Baltic mesozooplankton biomass. Some investigations connected with zooplankton biomass stock estimations, carried out by Polish and foreign scientists, did not correspond with the long-term investigations of Mańkowski and Ciszewski – as regards the number and frequency of sampling. That is why it was impossible to include that period in this study. It was only in 1982 (Wolska) and 1983 (Beil) that – during the Baltic monitoring programme – the sampling was representative and similar to that made during the investigations of Mańkowski and Ciszewski. The results of these investigations are treated only tentatively, as an indication of the regularity of the prognosis concerning the line of increase of zooplankton biomass with respect to the results obtained in the early 1980s. The author hopes that the results presented in this paper will help to explain the course of the eutrophication process taking place in the Baltic marine environment in the last quarter of a century.

2. Material and method

The present paper is based on the results of investigations of Władysław Mańkowski, conducted in the years 1951 – 1969, and those carried out by the author in the years 1970 – 1974.

Although in the years 1971 – 1974, zooplankton was collected both with a Hensen net (Mańkowski 1978) and a Nansen net (Ciszewski 1977), only the materials collected with a Nansen net were used in this paper. There were two reasons for that:

(i) the differences in the biomass caught with Hensen and Nansen nets were negligible,

(ii) the use of the materials collected with a Nansen net in 1971 – 1974 made it possible to compare them directly with the materials collected with a WP-2 net in the 1980s by the states participating in the Baltic monitoring programme.

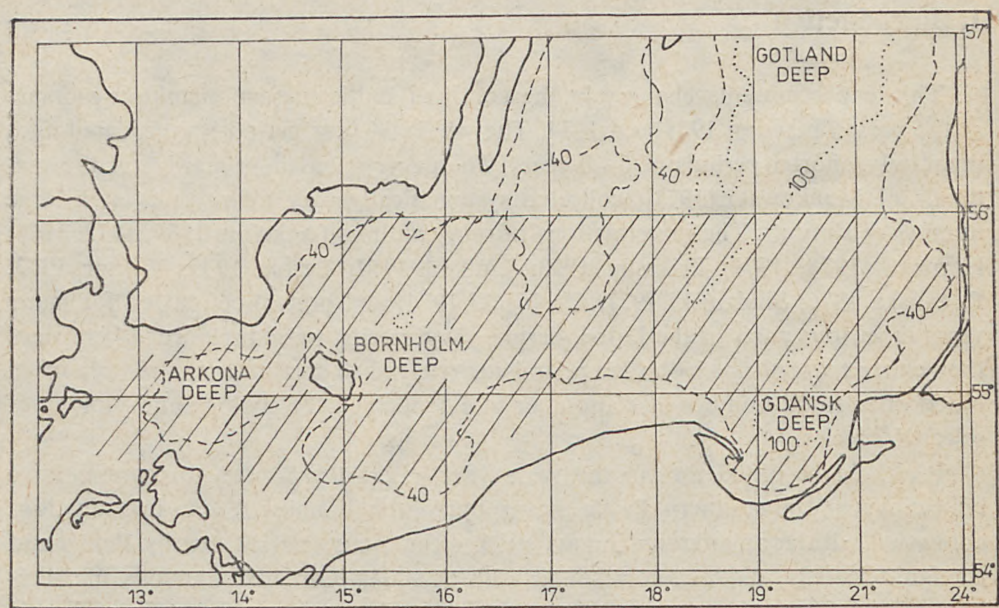

Fig. 1. Sectors of the southern Baltic (the hatched area) covered by long-term investigations of zooplankton biomass distribution

It should be noted that both types of nets (Nansen and WP-2) are of similar construction (same mesh size, similar opening and length). In the first period, *ie* until 1969, zooplankton was collected with a Hensen net with a mesh size of 330 μm.

In the second period, the same Hensen net was used in addition to a Nansen net with a mesh size of 210 μm. After 1980, samples were collected only by means of a WP-2 net with a mesh size of 200 μm. Nansen and WP-2 nets had smaller meshes so slightly higher biomasses were taken with their help than with a Nansen net (the difference being 5–10% according to Ciszewski's calculations). Zooplankton was collected with all three nets within the whole column of water, *ie* from the bottom to the surface, and the results were converted into biomass under 1 m^2 of the sea surface. The biomass volume was determined by the displacement method.

Mesozooplankton (Dybern *et al* 1976) – copepods and cladocerans – was mostly caught; their share in the general zooplankton biomass is usually 90–95%. The remaining zooplankton included sporadically encountered medusae, *Ctenophora*, *Mysidacea*, *Sagitta*, and other taxonomic groups. The zooplankton was usually caught in the deepest areas of the southern Baltic, especially in the Gdańsk Deep, the southern part of the Gotland Deep, the Słupsk Furrow, the Bornholm Deep, and the Arkona Deep (Fig. 1).

Since Mańkowski (1971) did not give the mean annual value of zooplankton biomasses for individual years but only the results of samples collected at differen times throughout the year, the calculations of the mean annual zooplankton biomas were made according to the formula given below:

$$B=\frac{\frac{a+b}{2}\cdot t_1+\frac{b+c}{2}\cdot t_2+\frac{c+d}{2}\cdot t_3\ldots\text{etc}}{T}$$

where:

B – mean annual biomass,

a, b, c, d – values of biomass taken in a given period,

t_1, t_2, t_3 – time intervals between sample collections,

T – one-year period.

This formula took into account all values of the biomass collected (ordinate) and different time intervals (abscissa) throughout the year. The same calculations were used for the results obtained in the years 1970–1974 from Nansen and WP-2 nets. Since there was no biomass collection in 1981 (only zooplankton abundance was calculated), the biomass result for this year (Fig. 3) was calculated on the basis of an approximate calculation of the zooplankton abundance ratio to its biomass in the years 1982 and 1983. The results for 1981–1982 were not taken into account in the calculations of the proper regression line, calculated by least squares. In the graphic presentation (Fig. 2) on an A-4 sized sheet, Y-axis scale was reduced by half with respect to X-axis scale. Therefore, coefficient $b = \text{tg}\,\alpha$ is also two times smaller in Figure 2. For the general trend, an equation of the exponential curve and the correlation coefficient were additionally given.

The non-unifrm methods of plankton collection, the different location of sampling stations, and especially the considerable spread (Tabl. 1) of their number in indvidual years (from 42 to 331), as well as the different number of months covered

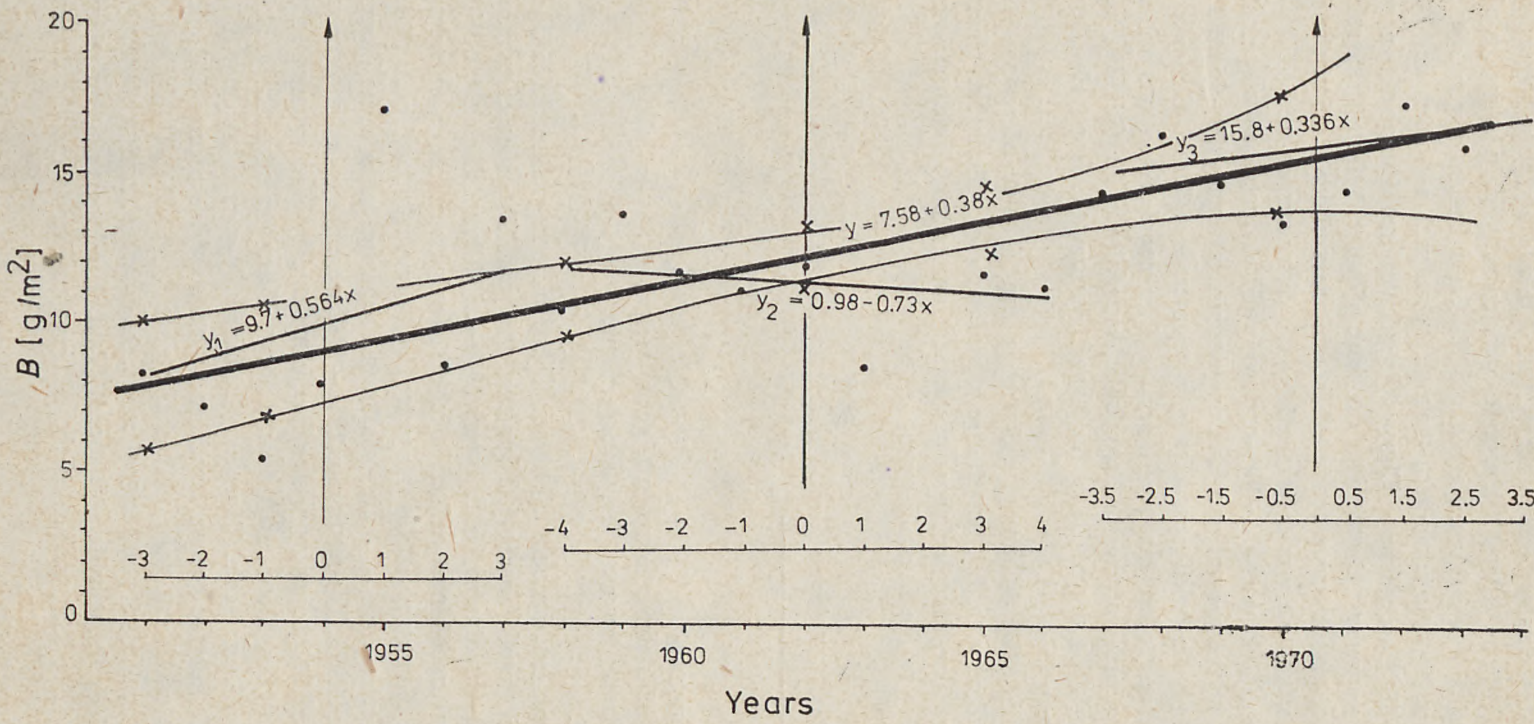

Fig. 2. Long- and short-term trends in mesozooplankton biomass development in the southern Baltic

Table 1. Mean annual mesozooplankton biomass and a list of stations and months covered by annual investigations in the southern Baltic waters.

Year	Mean annual biomass [g/m²]	Number of months	Number of stations
1951	8.1	9	115
1952	7.1	5	53
1953	5.4	7	58
1954	7.9	4	42
1955	17.0	5	55
1956	8.7	6	218
1957	13.7	6	138
1958	10.4	6	67
1959	13.5	10	102
1960	11.4	5	48
1961	10.8	5	192
1962	11.9	8	65
1963	8.3	6	127
1964	10.2	5	150
1965	11.4	5	47
1966	11.0	8	139
1967	14.1	7	331
1968	16.1	7	253
1969	14.6	7	165
1970	13.3	—	—
1971	14.2	6	60
1972	17.1	10	100
1973	15.8	5	50
1974	21.2	5	50

by the investigations in those years (from 4 to 10) and the mitigating influence of the climate in that period (Ciszewski 1975) are not without effect on the comparability of the results obtained. Still, they constitute valuable material which points out the characteristic long-term trends in the zooplankton biomass development in the southern Baltic (See Table 1).

3. Results

3.1. Main trend

Despite the considerable spread of the annual results of mesozooplankton biomass for individual years, a relatively high correlation coefficient (in the order of 0.68) was obtained indicating a significant dependence. It was enough to justify the drawing of a regression line $y=7.58+0.38x$, contained within confidence limits $0-.132<\alpha<0.191$ for the regression coefficient (Fig. 2). In addition, a formula for the exponential curve $y = 7.63 \cdot 1.03^x$ was calculated. This line informs us that during the period between 1951 and 1974, the mesozooplankton biomass increased 2.2 times and its mean annual increase was 0.38 g/m^2.

3.2. Short - term trends

In order to determine short-term changes in the zooplankton biomass, calculations were made for 6–8-year time intervals. The regression line $y_1 = 9.7 + 0.564x$ for the years 1951–1957 shows a slightly higher upward trend of biomass in this time interval (annual increases of 0.569 g/m^2) as compared with the whole 24-year period.

In the years 1958–1966, a slight drop in the zooplankton biomass was observed, as can be seen from the sec ond regression line $y_2 = 10.98 - 0.07x$ (annual drop of 0.07 g/m^2).

The third time interval (1967–1974) was again characterized by a slight downward trend of the zooplankton biomass ($y_3 = 15.8 + 0.336x$) as compared with the general trend. The short-term trends (y_1, y_2, y_3) inform us that the zooplankton biomass increase during the whole 24-year period varied from one time interval to another.

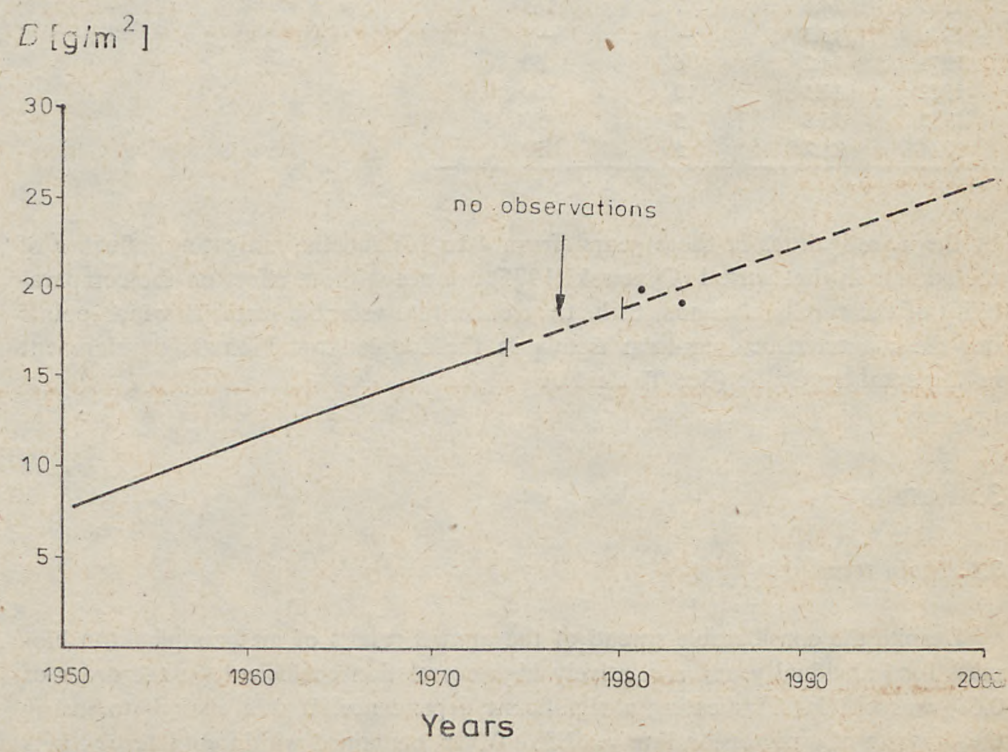

Fig. 3. Prognosis of changes in mesozooplankton biomass in this century

3.3. Prognosis

The presented long-term trend of the biomass increase in the 1950s, 1960s, and the first half of the 1970s allows for a prognosis concerning further quantitative changes in the zooplankton biomass, which may take place in our century. Figure 3 presents a hypothetical prognostic line for the growth rate of the biomass in the last years of this century. The results for 1981 and 1983, shown in Figure 3, oscillate near the prognostic line while the 1982 results are much lower than the remaining two.

4. Discussion and summary

This paper presents quantitative changes in the mesozooplankton biomass in the years 1951–1974. The results of long-term investigations point out to a distinct increase in the zooplankton biomass within this period. Thus, its production also increased since it is to some degree proportional to the biomass. The production intensity coefficient $P : B$ for the southern Baltic zooplankton equals 15 (Ciszewski 1983).

On the basis of the prognostic line and the results assumed for 1981–1983 it may be expected that this process continues in the 1980s; it seems that in the coming years it will correspond to the prognostic line. However, observations made in other strongly eutrophied reservoirs indicate that at some moment the production increase may be hindered and a decrease will follow. It is difficult to foresee now in which time interval such a stop in the increase of zooplankton production in the southern Baltic will really occur since the trend of biomass changes, presented in Figure 2, is of a non-uniform character, exhibiting various degrees of intensity, and even an apparent decrease, which – when observations are made within a short time – may lead to incorrect interpretation of the results of planktonic investigations.

It should be also noted that, alongside this paper, other calculations of the zooplankton biomass increase in the years 1950–1969 were made (Kurzyk *et al* 1983). They may be described with a similar equation, the only difference being that, according to the above authors, the increase in the zooplankton biomass in the 1970s was slower.

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