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**BIOCOENOTIC CHANGES  
IN DEEP WATER AREAS OF THE SOUTHERN PART OF  
THE BALTIC PROPER IN 1979–1988**

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Based on results of 10 years (1979–1988) of biological monitoring activities carried out by Polish scientists at 3 open-sea stations, the biocoenotic changes in the Southern Baltic open waters are evaluated. The analysis reveals considerable temporal variations of all biological parameters, macrobenthos disappearing temporarily at the stations visited. Phytoplankton densities were found to increase, the phytoplanktonic community being dominated by flagellates. The increase in phytoplankton densities was not, however, reflected in zooplankton abundances.

**INTRODUCTION**

Monitoring activities in the southern part of the Baltic Proper have been carried out by Poland since 1979 within the framework of the Helsinki Commission's Biological Monitoring Programme (BMP). Monitoring was conducted at the following three stations (Fig. 1): BMP K2 (BY-5) in the central part of the Bornholm Deep; BMP K1 (BSC-III-10) in the southern part of the Gotland Deep; and BMP L1 (BSC-III-15) in the central part of the Gdańsk Deep.

Monitoring was conducted by the Gdańsk Branch of the Institute of Environment Protection in cooperation with the Academy of Agriculture in Szczecin and the Sea Fisheries Institute in Gdynia. Hydrochemical data were provided by the Marine Section of the Institute of Meteorology and Water Management in Gdynia.

Biological monitoring was performed according to the Helsinki Commission guidelines (Anonymus 1984).

The present paper attempts to analyse biological data collected at the three stations monitored by Poland in 1979–1988. More detailed descriptions of different compart-

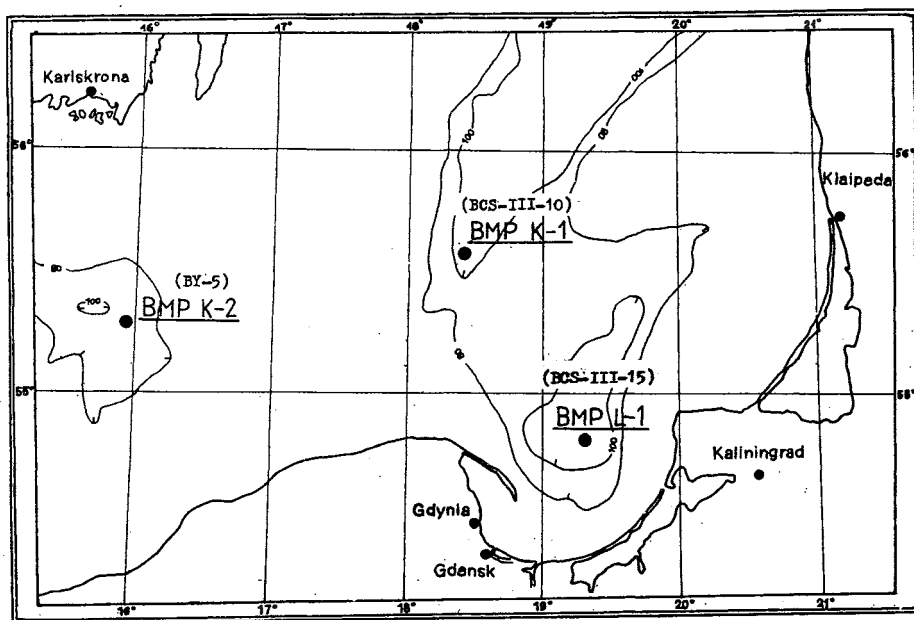


Fig. 1. Location of the monitoring stations in the Southern Baltic

ments of the ecosystem studied are presented in Rybicka et al. (1991), Wolska-Pyś and Ciszewska (1991), and Osowiecki (1991).

BMP has been so far conducted in three, gradually improved, 5-year stages. According to the international agreement, sampling for the first stage (1979–1983) was carried out seasonally, i.e. at the end of each season. At the second stage (1984–1988) and during the growth season, two additional sampling times (early spring and early summer) were recommended. These additional sampling occasions provided a better picture of seasonal changes in biological parameters and facilitated the analysis of interannual variability. During the first stage, phytoplankton biomass was not covered by the Polish monitoring activities, zooplankton biomass (volumetric method), chlorophyll *a*, and primary production being only occasionally determined.

The limited sampling frequency in different years forced the authors to introduce some simplification in their analysis of seasonal changes. It is particularly evident in graphs presenting seasonal changes in primary production (shown as average values calculated for different quarters of the year) and phytoplankton abundance. The curves representing average values lack the spring peaks, the peaks being observed in single cases only.

## RESULTS

The 10-year period of study showed, first of all, a substantial year-to-year variations in all the parameters measured at the three stations visited, which makes the evaluation of long-term variability rather difficult. An additional difficulty in detecting long-term changes was introduced by fixing the time of cruises in advance. This latter fact prevented detection of the spring primary production peak during the monitoring programme at some stations, at least.

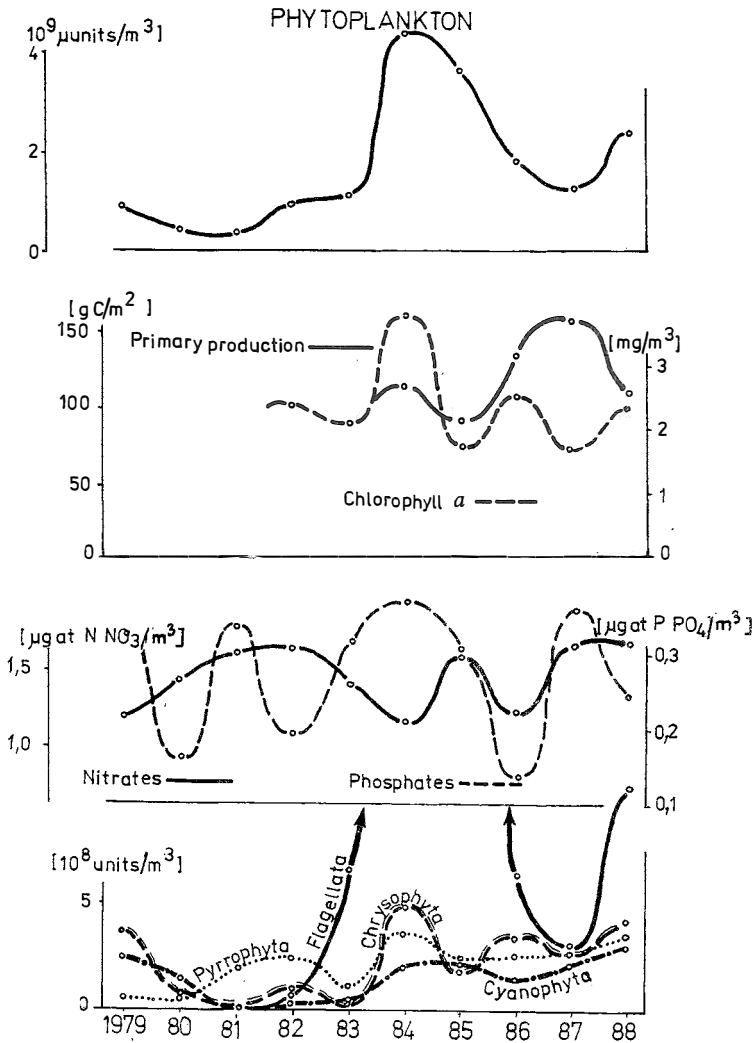


Fig. 2. Average annual abundances of phytoplankton and its major taxa in the euphotic layer (0–10 m) against the background of changes in major environmental parameters

The substantial temporal variability of the biological and environmental parameters monitored prompted the authors to pool the monitoring data obtained from the three stations to arrive at an average description of the entire region. The analysis could have been done in this way because average values calculated for the 10-year period did not differ very much from station to station. In particular, the average values obtained for the Bornholm Deep and the southern part of the Gotland Deep were similar, which points to a similarity in the environmental conditions in the two areas. These values differed somewhat from average found for the more eutrophic Gdańsk Deep area.

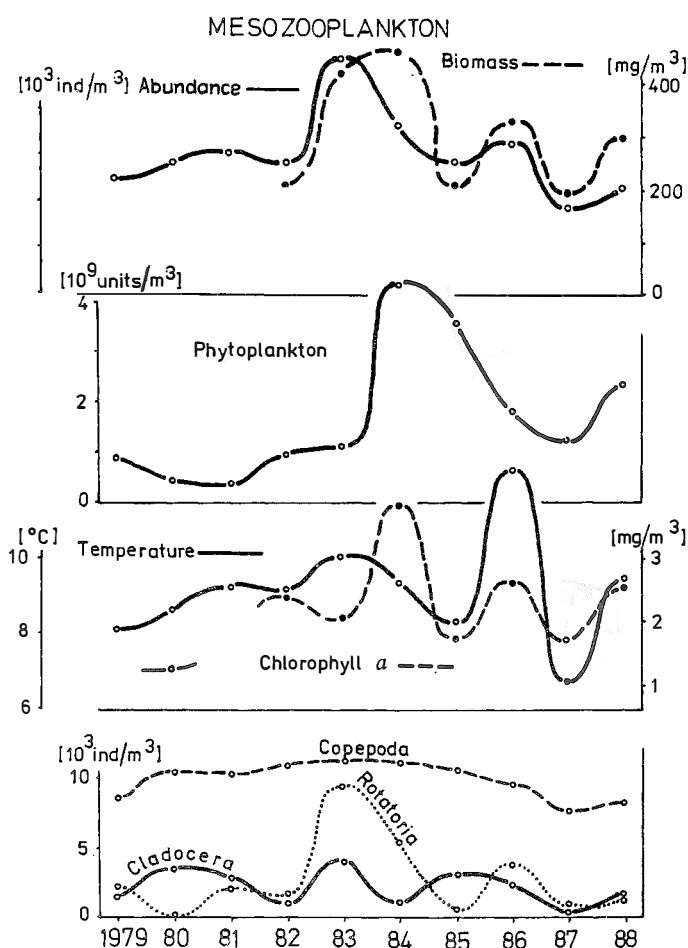


Fig. 3. Average annual abundances and biomass of mesozooplankton and its major taxa in the euphotic layer (0–10 m) against the background of changes in major environmental parameters

## Phytoplankton

During the first five years of the decade analysed, phytoplankton occurred in smaller densities than in the second half. Phytoplankton was most abundant within 1984–1985, the abundances being caused by the luxuriant growth of the Flagellata at that time (Fig. 2). It is interesting to note that during the first 3 years, flagellates were only a minor component of the phytoplankton. In the years of abundant flagellate occurrence, other phytoplankton taxa (Chrysophyta, Pyrrophyta, and Cyanophyta) were abundant as well. Fluctuations in abundances of the Pyrrophyta and Cyanophyta were irregular, while the curve representing the Chrysophyta is quite regular, the regularity arising from the fact that years of high abundances are followed by years of low abundances of those algae. Long-term variations in the total phytoplankton abundance show no correlation with basic environmental factors. Nevertheless, in some years the concurrence of both curves can be seen, as for instance in the case of phytoplankton and chlorophyll *a* and nitrates (except for 1985).

Generally, higher values of phytoplankton abundance coincided with higher chlorophyll *a* concentrations and lower nitrate contents. Long-term changes in temperature and phosphate content showed no relationship to the long-term variability of phytoplankton abundance.

## Zooplankton

Results of the 10-yr studies on mesozooplankton in open waters of the southern part of the Baltic Proper show a rather stable level of zooplankton abundances in different years. A clearly higher abundance was observed in 1983 only; the increase was caused by high densities of the Rotatoria (Fig. 3).

Abundances of the Copepoda, the major component of the mesozooplankton, remained generally at the same level. Abundances of the Cladocera showed some fluctuations with 2- to 3-yr periods. Analysis of long-term variations in abundances of the total mesozooplankton and its basic groups did not show any clear relationship between these parameters and environmental factors. Curves representing the average zooplankton abundance have shapes similar to those of curves describing average annual temperatures.

## Macrozoobenthos

The occurrence of bottom macrofauna at the three stations visited showed significant fluctuations from year to year (Figs. 4–6). The recurrent disappearance of the benthos at all the stations evidences adverse effects of progressing eutrophication. Even on the southern slope of the Gotland Deep, an area formerly always inhabited by the bottom macrofauna, a complete absence of macrozoobenthos was observed in 1981 (Fig. 6). The total absence of the benthos was recorded in 50% of cases in the

## MACROZOOBENTHOS

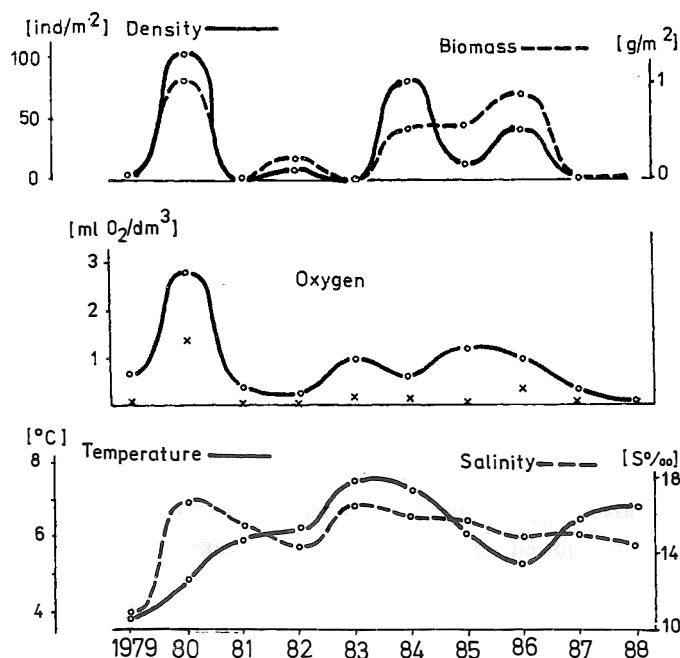


Fig. 4. Average annual densities and biomasses of macrozoobenthos in the central part of Gdańsk Deep against the background of changes in major environmental parameters and minimum oxygen contents in the near-bottom water layer

central part of the Bornholm and Gdańsk Deeps (Figs 4 and 5). Whenever the oxygen content in the near-bottom layer increased temporarily, strongly impoverished bottom macrofauna communities, consisting often of only one semipelagic species (the polychaete *Harmothoe sarsi*), were observed. It should be stressed here that some dozens of years ago the same three stations showed the presence of macrobenthic communities consisting of 5–8 species (Żmudziński 1989).

### Seasonal variability

Results of monitoring the southern part of the Baltic Proper, collected over 10 years, allowed to detect a pattern of seasonal changes in biological and environmental parameters in the euphotic layer (Fig. 7). The pattern is based on average seasonal values calculated for different cruises. The pattern can be a valuable reference material for the future monitoring activities conducted in the southern part of the Baltic Proper.

The data obtained showed that the maximum of chlorophyll *a* concentration occurred in spring, while the maxima of phytoplankton abundance (Fig. 7) and primary

## MACROZOOBENTHOS

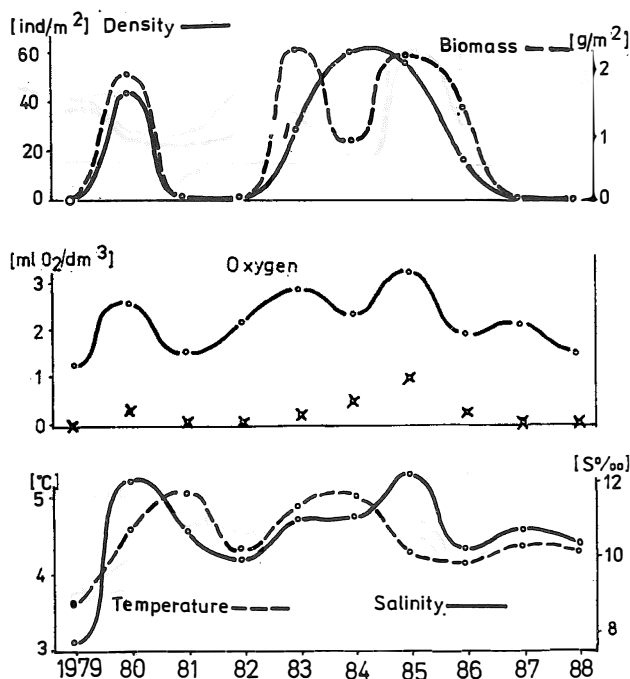


Fig. 5. Average annual densities and biomasses of macrozoobenthos in the central part of the Bornholm Deep against the background of changes in major environmental parameters and minimum oxygen contents in the near-bottom water layer

production were recorded in summer. The peak development of phytoplankton was not followed by a total depletion of nutrients (Fig. 7), which is one of the symptoms of the progressing eutrophication in the Baltic Sea.

The peaks of growth of most phytoplankton taxa overlap, the peaks occurring in early summer. The Chrysophyta, represented mainly by diatoms, are the only exception as they occur most abundantly in spring (Fig. 7).

Abundance of the mesozooplankton reaches its maximum in late spring (Fig. 8), which is related to mass development of rotifers and a high abundance of the Copepoda at the same time. The second, less distinct, maximum of rotifer development is observed in autumn. The Copepoda develop most abundantly in early summer, while

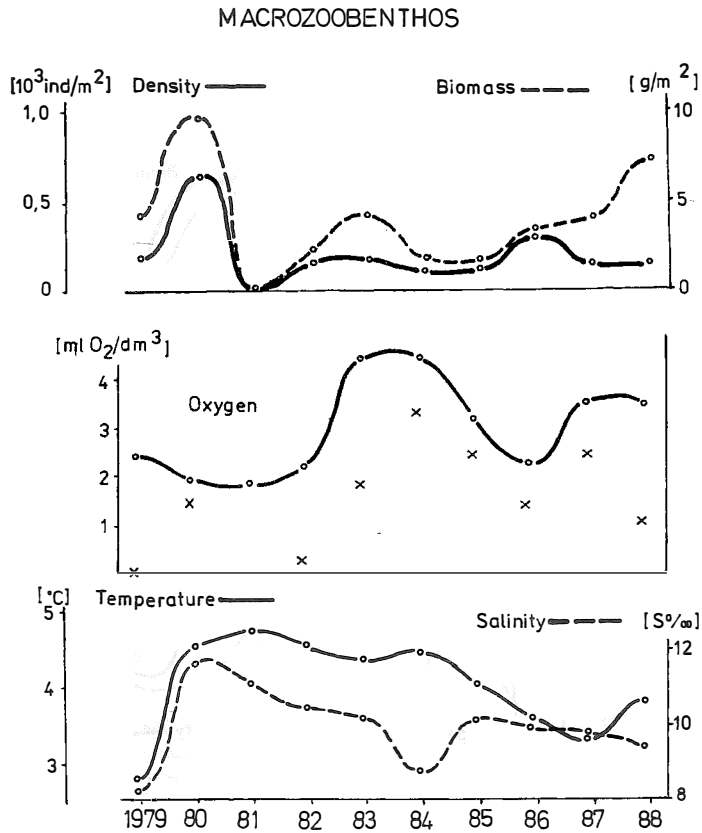


Fig. 6. Average annual densities and biomasses of macrozoobenthos in the southern part of the Gotland Deep against the background of changes in major environmental parameters and minimum oxygen contents in the near-bottom water layer

the Cladocera peak in late summer. The intensive summer increase in copepods, the main component of the mesozooplankton, is of a great importance for developing the maximum zooplankton biomass.

## CONCLUSIONS

Based on the 10-year period of studies conducted within the Biological Monitoring Programme in the southern part of the Baltic Proper, it was found that:

- different biological parameters showed a considerable temporal variability, observed both in the euphotic and near-bottom layers;



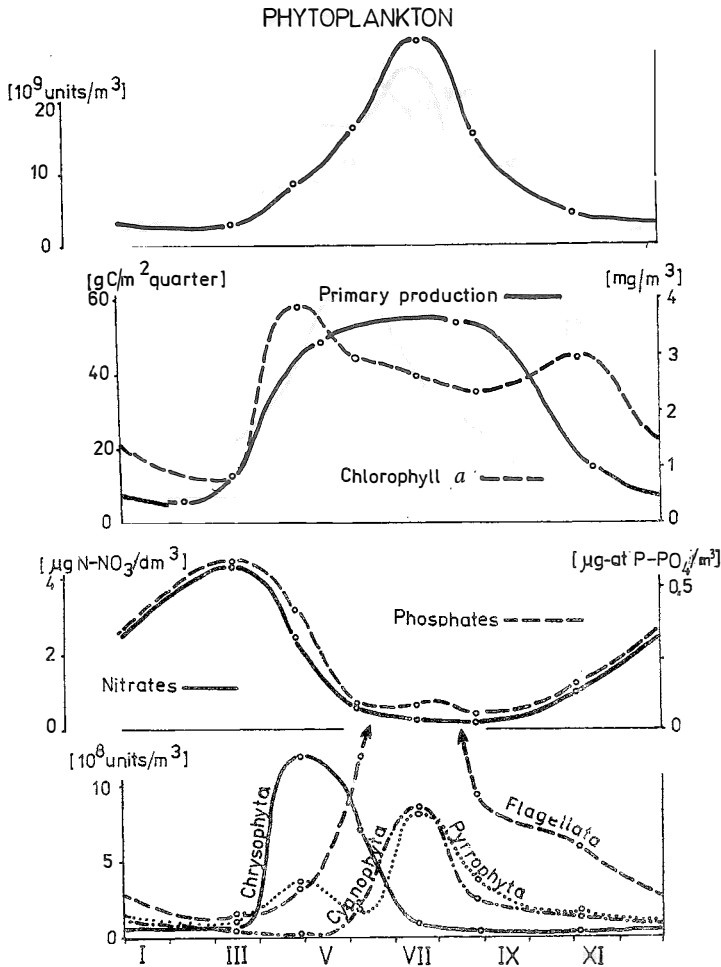


Fig. 7. A model of seasonal changes in phytoplankton against the background of changes in major environmental parameters

- the long-term average values calculated for the biological parameters in the euphotic layer show rather small differences between the three monitoring stations, and may thus indicate similar environmental conditions in the whole of the open Southern Baltic;
- the increased abundance of phytoplankton (dominated by the Flagellata) in 1984–1988, compared with values for 1979–1983, is not reflected in changes of the mesozooplankton abundance;
- the average phytoplankton abundance in different years is related to the average concentration of nitrates and chlorophyll *a*;

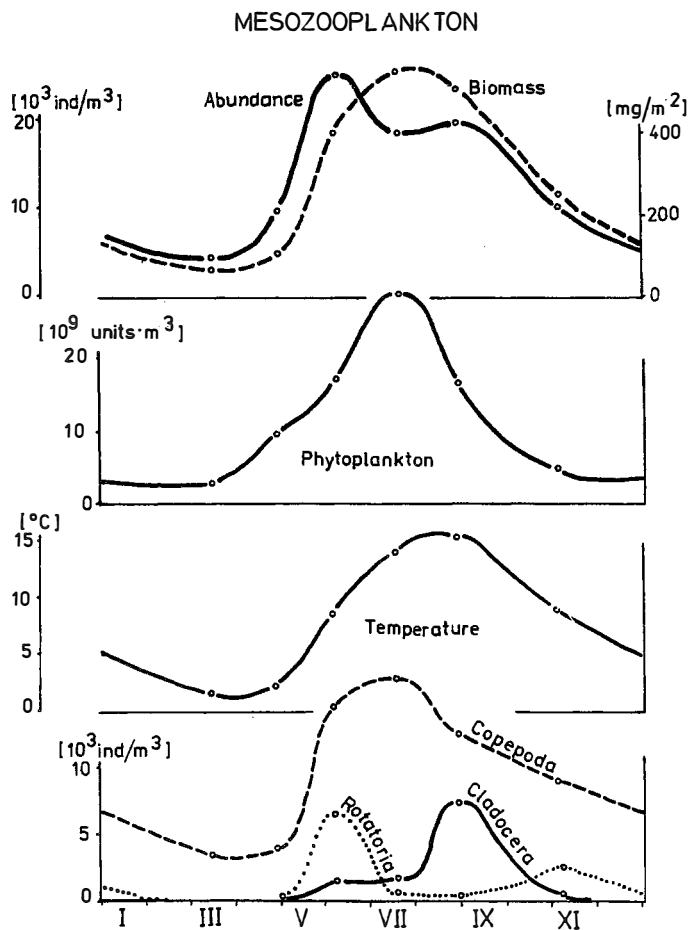


Fig. o. A model of seasonal changes in mesozooplankton against the background of changes in major environmental parameters

- the bottom macrofauna in the Gdańsk and Bornholm Deep, and even in the southern part of the Gotland Deep, disappears periodically.

Additionally, a pattern of seasonal changes in the biological parameters in the euphotic layer of the Southern Baltic was worked out, serving to evaluate results obtained in different cruises in a given year.

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