Quantitative changes in the Baltic mesozooplankton on the basis of monitoring within the 1979–1983 period

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Quantitative changes
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Southern Baltic
Seasonal variability

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Abstract

The paper consitutes a summary of a 5-years monitoring of the Southern Baltic with respect to mesozooplankton. The investigations revealed the occurrence of a significant quantitative variability in occurrence of zooplankton in the particular years, its range being much greater in spring and summer seasons. A more abundant occurrence of zooplankton was observed in 1981 and 1983. The smallest amount of zooplankton occurred in 1979. Moreover, it has been observed that a larger amount of mesozooplankton occurs in spring in the eastern part, while in summer in the western part of the Southern Baltic.

1. Introduction

Zooplankton of the Southern Baltic has been an object of interest to the biologists since the beginning of the present century. Particularly intensive investigations on zooplankton of the open waters of the Southern Baltic have been carried out in the second half of the recent century (Ackefors and Hernroth, 1972; Chojnacki and Dworczak, 1979; Ciszewski, 1972; Drzycimski *et al.*, 1973; Hernroth and Ackefors, 1977; Mańkowski, 1972, 1976; Schulz *et al.*, 1982). The results of these investigations, in many cases carried out systematically for several years, constitute a very valuable comparative material for the determination of the direction and the kind of changes taking place in the Baltic. However. due to application of different research methods (various kinds of nets for sampling, differen methods of laboratory processing and paying attention to diffe-

[1]The investigations were carried out under the research programme R-6.

rent systematic groups of zooplankton), the complete utilization of this material is not always possible.

Monitoring of the Baltic, carried out systematically from 1979, created the possibility of collecting comparable data owing to international unification of the research methods (Baltic Marine Environment, 1980). Monitoring of the biocenosis of the Baltic Sea can constitute a basis for the investigations on the kind and direction of changes taking place within its particular components.

This paper constitutes a summary of a 5-years period of zooplankton monitoring, and an attempt of evaluation whether such a period is sufficiently long for drawing general conclusions on the type and direction of changes taking place in the mesozooplankton of the Southern Baltic. Due to the primary goal of this research and to a large variability of the results obtained at particular, even adjacent stations, data averaged either for the entire region, or for several years have been considered in spatial and time aspects.

2. Materials and methods

The basic material has been collected during the investigation period at five stations representing five basic regions of the Southern Baltic (Fig. 1.), comprising both open waters: the Bornholm Deep (Station P5), the Gdańsk Deep (Station P1), as well as the Gotland Deep (Station P40), and bay waters: the Gulf of Gdańsk (Station P110) and the Pomeranian Bay (Station B12). According to the agreements to the Helsinki Convention, the material was collected four times a year, *viz.* in spring (May), summer (August), autumn (November) and winter (February).

The samples were preserved with 4% formaline. Using a Folsom splitter (McEven *et al.*, 1954), two subsamples ca 500 individuals each were drawn from each sample. Copepoda and Cladocera were identified down to the level of species. Earlier and later growth phases, as well as the sex of the grown up individuals, were additionally determined in the case of Copepoda. Due to difficulties related to the manner of sample preservation, Rotatoria were identifies to the level of genus only. Individuals belonging to other taxonomic groups, except Fritillaria borealis, were identified only to the level of phylum or class.

The analysis of mesozooplankton occurrence calculated per 1 m^3 of water was carried out on the basis of results averaged for the entire water

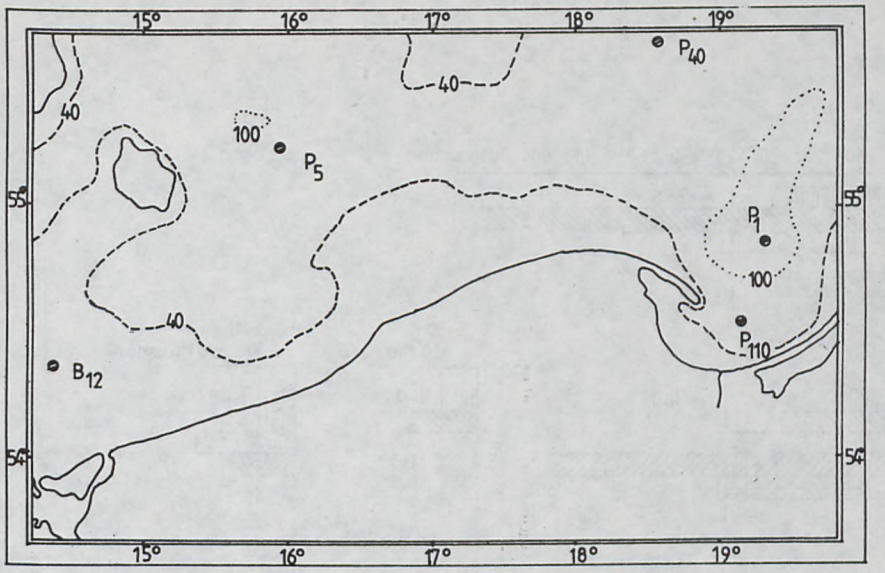

Figure 1: Localization of stations monitored in 1979–1983

column in the aspects of spatial distribution, seasonal and long-term variability. Spring and summer seasons were chosen for the evaluation of the spatial distribution and long-term variability of mesozooplankton, since these seasons are characterized by the most complete species composition of plankton animals and the highest number of them.

3. Results

3.1. Spatial distribution of mesozooplankton

Spatial distribution of mesozooplankton at the investigated stations in 1979–1983 revealed large variability, yet different for various systematic groups.

Copepoda were generally distributed relatively uniformly (Figs. 2, 3). The only exception was the Pomeranian Bay during summer seasons, when the number of Copepoda largely exceeded that in the remaining regions (Fig. 3).

The number of Cladocera was diversified both in spring and in summer, being much greater in summer (Fig. 4). Occurrence of a greater number of Cladocera in the eastern part of the Southern Baltic in spring has been established on the basis of a mean number of individuals for the entire

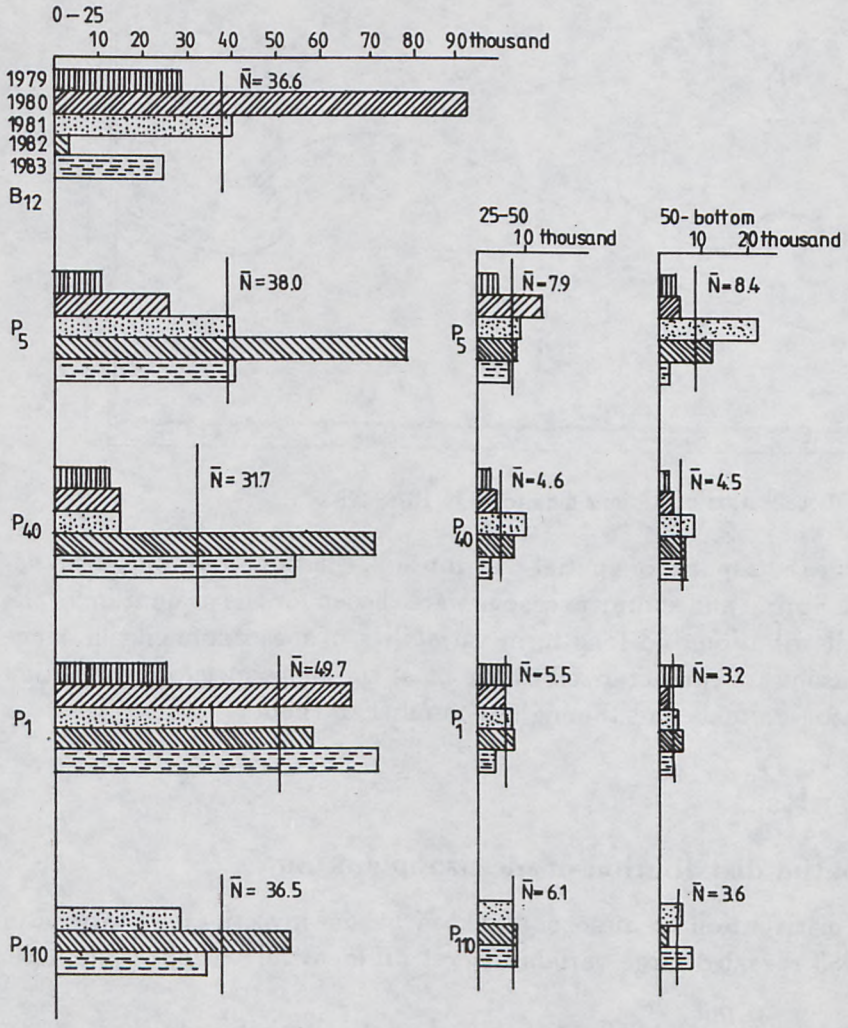

Figure 2: Amount (in thousands of individuals per m^3) of Copepoda (Copepodit I–V and adult) and nauplii in the particular layers of sea at five stations controlled in springs 1979–1983

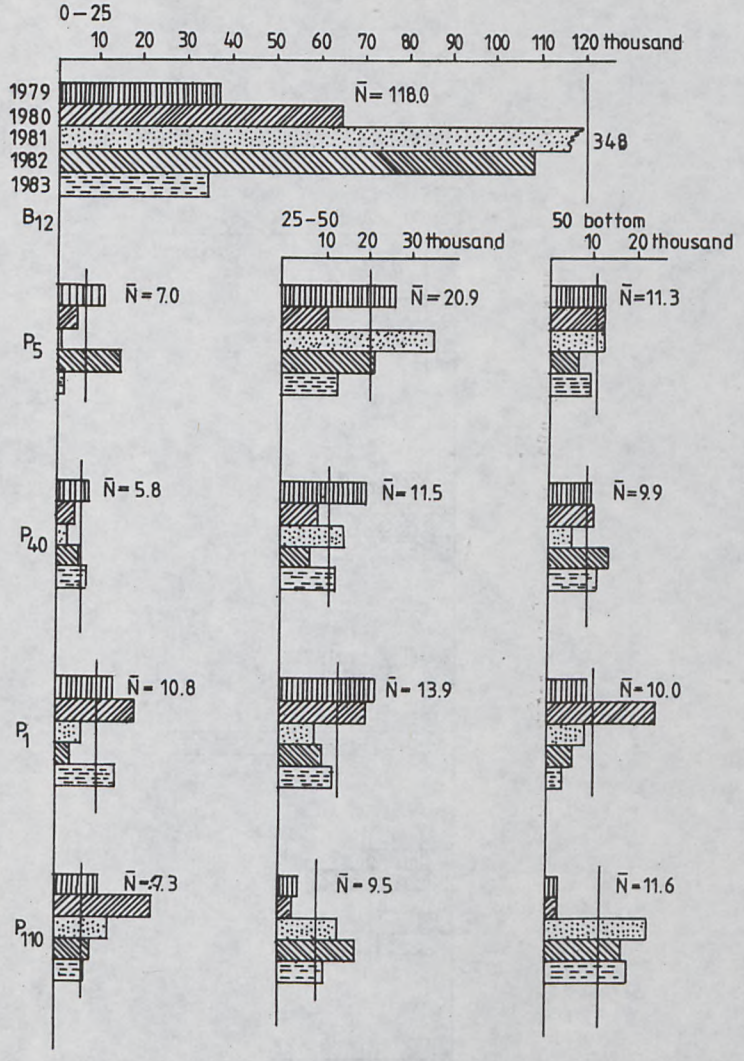

Figure 3: Amount (in thousands of individuals per m^3) of Copepoda (Copepodit I–V and adult) and nauplii in the particullar layers of sea at five stations controlled in summers 1979–1983

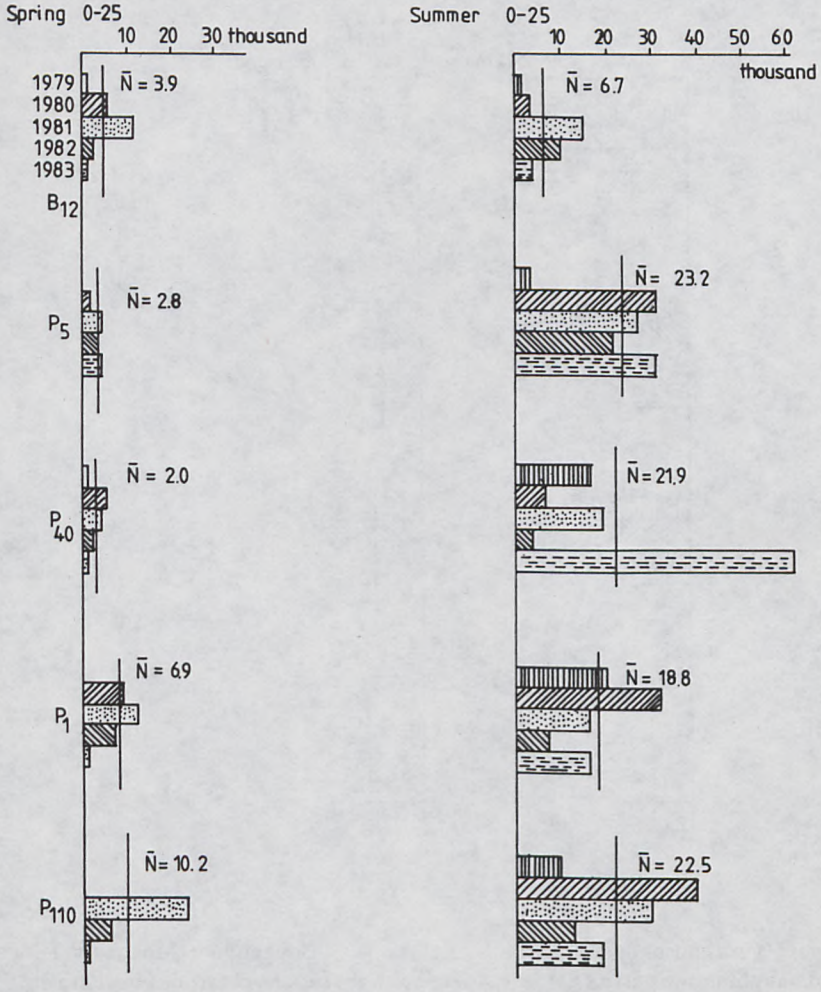

Figure 4: Amount (in thousands of individuals per m^3) of Cladocera in the upper sea layer (0–25 m) at five stations controlled in springs and summers 1979–1983

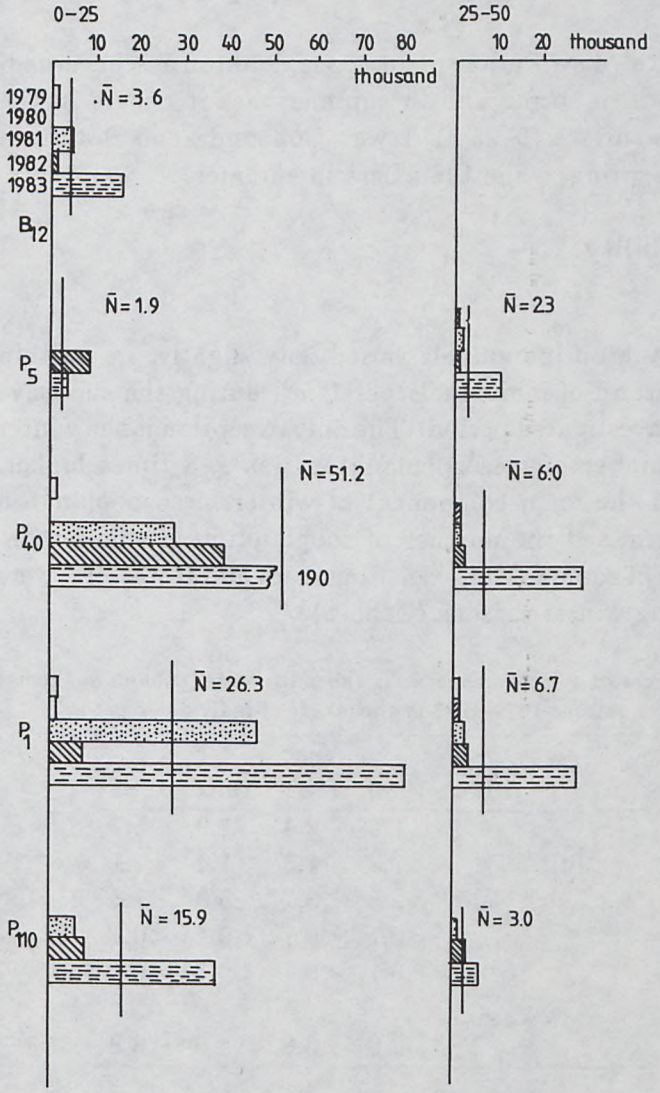

Figure 5: Amount (in thousands of individuals per m^3) of Rotatoria in 0–25 m and 25–50 m layers at five stations controlled in springs 1979–1983

investigation period. In summer Cladocera distinctly avoided the Pomeranian Bay.

Rotatoria occurred mainly during spring (Fig. 5). Similarly to Cladocera they were more numerous in the eastern part of the Southern Baltic.

As far as the vertical distribution of mesozooplankton is concerned, it is characteristic both in spring and in summer that it occurs in the greates number in the surface (0–25 m) layer. Copepoda and Rotatoria gather in this layer in spring, while Cladocera in summer.

3.2. Seasonal variability

3.2.1. Winter

The number of zooplankton individuals varied only slightly, *i.e.* within the limits of 3–4 thousand of individuals per 1 m^3, during the succesive winter seasons of the investigated period. The only exception is the winter of 1983, when the number of mesozooplankton was 2–3 times higher. Copepoda constituted the main component of winter mesozooplankton and mainly they determined the number of zooplankton in this season. The remaining groups of zooplankton, *viz.* Cladocera and Rotatoria, were seldom recorded during winter seasons (Tabl. 1).

Table 1: Mean number of mesozooplankton species in the entire water column at the five measuring stations in winter seasons 1979–1983 in thousands of individuals per m^3

	Year				
Taxonomic group	1979	1980	1981	1982	1983
Copepoda–nauplii		1.5	2.4	1.9	5.7
Copepoda–copepodit + adult		1.3	1.3	1.4	2.1
Σ Copepoda		2.8	3.7	3.3	7.8
Σ Cladocera		<0.1	<0.1	<0.1	<0.1
Σ Rotatoria		<0.1	<0.1	<0.1	<0.1
Σ Mesozooplankton (Varia included)		2.9	3.9	4.0	8.8

3.2.2. Spring

The amount of mesozooplankton in spring seasons was very diversified and generally large, much greater than in winter seasons. Particularly high values were recorded in the spring of 1983. On the other hand, in

Table 2: Mean number of mesozooplankton species in the entire water column at the five measuring stations in spring seasons 1979–1983 in thousands of individuals per m^3

	Year				
Taxonomic group	1979	1980	1981	1982	1983
Copepoda–nauplii	7.5	9.9	8.2	13.0	9.7
Copepoda–copepodit + adult	1.6	12.4	8.5	10.6	9.7
Σ Copepoda	9.1	22.3	16.7	23.6	19.4
Σ Cladocera	<0.1	2.0	4.3	1.4	<0.1
Σ Rotatoria	<0.1	<0.1	6.5	5.2	30.8
Σ Mesozooplankton (Varia included)	9.7	25.5	35.2	32.7	53.8

1979 an exceptionally low number of zooplankton individuals was recorded (Tabl. 2).

Copepoda constituted the main component of spring mesozooplankton and determimed its number. Great differences in the number of Cladocera have been observed. They occurred in the greatest number in 1981, and also quite numerously in 1980 and 1982, although the maximum of their growth occurred mainly in summer. A very intensive growth of Rotatoria occurred in spring. Their greatest number was recorded in 1983, while the lowest in 1979 and 1980 (Tabl. 2).

3.2.3. Summer

The domination of Copepoda is maintained, their number being the greatest in 1981. Also in that year the greates number of nauplii was recorded, idicating very intensive reproduction (Tabl. 3).

Cladocera also occurred in large numbers in summer seasons. Greater numbers were recorded in 1980, 1981 and particularly 1983. In the remaining two years the number was 2–3 times lower.

The amount of Rotatoria in the summer seasons was much lower than in spring, although in 1981 and 1982 their number was similar to that from spring.

Table 3: Mean number of mesozooplankton species in the entire water column at the five measuring stations in summer seasons 1979–1983 in thousands of individuals per m^3

	Year				
Taxonomic group	1979	1980	1981	1982	1983
Copepoda–nauplii	3.1	3.9	11.7	5.0	2.4
Copepoda–copepodit + adult	10.7	14.6	26.2	11.6	9.5
Σ Copepoda	13.8	18.5	37.9	16.6	11.9
Σ Cladocera	4.1	10.4	9.1	4.8	12.4
Σ Rotatoria	<0.1	<0.1	5.6	3.8	<0.1
Σ Mesozooplankton (Varia included)	19.1	33.1	53.7	26.7	25.4

3.2.4. Autumn

The amounts of mesozooplankton in the investigated autumn seasons were uniform (Tabl. 4). Copepoda still prevailed. Cladocera occurred in minimal numbers. Rotatoria were very numerous in autumn of 1979, when their number reached that of summer, and even of spring 1981 and 1982.

Table 4: Mean number of mesozooplankton species in the entire water column at the five measuring stations in autumn seasons 1979–1983 in thousands of individuals per m^3

	Year				
Taxonomic group	1979	1980	1981	1982	1983
Copepoda–nauplii	3.4		4.2	3.2	4.0
Copepoda–copepodit + adult	6.3		8.7	7.5	7.1
Σ Copepoda	9.7		12.9	10.8	11.1
Σ Cladocera	<0.4		<0.1	<0.1	<0.1
Σ Rotatoria	5.3		<0.8	2.4	2.4
Σ Mesozooplankton (Varia included)	15.8		13.8	13.6	14.5

* no data from Station P40

** no data from Stations P1 and P110

3.3. Long-term variability

It has been found that greatest amount of zooplankton occurred in 1981 and 1983 (Tabl. 5). The number of zooplankton individuals in these years

Table 5: Mean number of mesozooplankton species in the entire water column in warm seasons of year (spring, summer) in 1979–1983 at the five measuring stations in thousands of individuals per m^3

	Year				
Taxonomic group	1979	1980	1981	1982	1983
Copepoda–nauplii	5.3	6.9	9.9	9.0	6.1
Copepoda–copepodit + adult	6.1	13.5	17.4	11.1	9.6
Σ Copepoda	11.4	20.4	27.3	20.1	15.7
Σ Cladocera	2.0	6.2	6.7	3.1	6.2
Σ Rotatoria	<0.1	<0.1	6.0	4.5	15.4
Σ Mesozooplankton (Varia included)	14.4	29.2	44.4	29.7	39.6

largely exceeded that in the remaining years. In the 1981 it were the Copepoda that determined this large amount of zooplankton, while in 1983 – Rotatoria.

The year 1979 occurred to be the poorest with respect to the number of zooplankton individuals, mainly due to the very small number of Rotatoria and Cladocera. Also the amount of Copepoda was lower in this year compared to the remaining years. The years 1980 and 1982 were quite similar with respect to the amount of zooplankton. The only differences concerned the occurrence of Cladocera and Rotatoria, the former occurring in bigger number in 1980, while the latter – in 1982.

4. Recapitulation and discussion

The analysis of mesozooplankton occurrence in time and space revealed a great variability of its amount, not allowing the determination of significant trends. On the basis of results averaged for the entire investigation period one can cautiously point out the regions of higher zooplankton density. Unfortunately, this concerns only certain seasons. Thus, in spring zooplankton occurred in greater amount in the eastern part of the Southern Baltic, while in summer – in the western part, particularly in the Pomeranian Bay. Large number of zooplankton individuals in the eastern part of Southern Baltic in spring seasons was mainly due to the occurrence of Rotatoria and Cladocera in the surface water layer, while in summer in the Pomeranian Bay it were the Copepoda that constituted the predominat mass of zooplankton. Taking into account the

vertical distribution, the greatest amount of mesozooplankton occurred in the upper layer (0–25 m), in spring Copepoda and Rotatoria prevailing, while in summer – Copepoda and Cladocera.

Seasonal variability concerned mainly the vegetative period (spring and summer), hence the period of intensive growth of zooplankton. The greatest diversification of the number of individuals was observed in spring seasons, the amount being very high at the same time (except 1979, when the amount was generally exceptionally low). No such great diversification was observed in autumn and winter seasons, except for a few cases when for unknown reasons very huge amounts of zooplankton were observed, *e.g.* in winter 1983 or autumn 1979 (Rotatoria).

The observed regularities are confirmed by the investigations of Schulz *et al.* (1985) on diversification of pelagic forms in the Arkona Deep. These investigations revealed the existence of a very high coefficient of variation (CV%) for the zooplankton biomass in spring and summer seasons (30% and 20%). The value of this coefficient was much lower in autumn equalling 16%. Such diversification is due to physical processes taking place in sea. In seasons of higher water temperature the mixing of water is limited, which promotes diversification of pelagic forms (Evans and Sell, 1983).

Large variability was also observed within the compass of the 5 years of investigations. Therefore it is difficult to give evidence of any long-term trends. On the background of the five years' investigation period the year 1979, when the amount of mesozooplanton was exceptionally low, and the years 1981 and 1983 characterized by an occurrence of great numbers of zooplankton species, are particularly distinct (Tabl. 5). Long-term variability is probably due to varying climatic conditions, and – according to opinions of some authors – to methods of investigations. The former statement is evidenced by long-term investigations on the variations of biomass conditions as a function of temperature (Ciszewski, 1975). Twice as much biomass was observed in the annual profile in the years when the mean temperature of surface waters was high compared to cool years.

Schulz *et al.* (1982) came to a similar conclusion on a basis of long-term investigations. He points out meteorological and hydrological factors as one of the reasons for the variability observed during the years of investigations. On the other hand, he indicates another reason, *viz.* carrying out observations in different periods in the particular years and different frequency of observations.

However, it seems unprobable that increasing the frequency of sampling can significantly decrease the observed variability. Investigations of Wiktor *et al.* (1982) on zooplankton of the region of the Gulf of Gdańsk carried out mainly in monthly intervals also indicate large variability of the intensity of zooplankton growth in spite of the high frequency of sampling. The authors point out climatic and hydrologic conditions as the reasons for this variability. It follows from the above statements that reckoning or determination of trends in zooplankton occurrence during only few years' periods is dangerous. Ciszewski (1985) indicates the occurrence of opposite trends concerning the zooplankton biomass of the Southern Baltic in particular, short time intervals (6–8 years), which only on the background of a long time gave evidence of a distinct of biomass increase (about 2.5 times) within the 1951–1983 period.

Data characterizing the 5-years period can therefore be only one of the reference points for observations of long-term changes.

5. Conclusions

1. Five years monitoring revealed large variability in quantitative occurrence of mesozooplankton at various stations and in the particular years. It is particularly distinct in spring and summer seasons.

2. In spite of the observed variability it has been established that in spring mesozooplankton occurred in bigger amounts in the eastern part, while in summer – in the western part of the Southern Baltic.

3. Five years observation periods are too short for determining long-term trends.

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