Structural changes and distribution of the mesozooplankton in the Gulf of Gdańsk in an annual cycle

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Mesozooplankton
Structural changes
Gulf of Gdańsk

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Abstract

The present work is based on materials collected every day at the turn of March and April, in June, July, November and December 1980, from one station in the Gulf of Gdańsk.
Species composition, abundancy and vertical distribution of the mesozooplankton in particular months are presented in relation to thermal conditions and water salinity. An attempt has been made to follow up seasonal changes in the domination structure and percentages of the three basic trophic groups of the mesozooplankton: filtrators, euryphagous organisms and zophagous organisms.

1. Introduction

Annual cycle of the hydrological regime, especially of temperature, constitutes a basic factor determining the dynamics of biological processes taking place in pelagic waters of the Baltic Sea. As a result, more or less pronounced seasonal differences are observed as regards the species composition and quantitative relations in the Baltic flora and fauna. These differences are noted also with respect to vertical distribution of the hydrobionts, and especially of the mesozooplankton (Ackefors and Hernroth 1975; Chojnacki 1973a, b, 1975; Ciszewski 1974, Hernroth, Ackefors 1979; Mańkowski, Ciszewski 1961; Nikołajew 1957; Sidrewic 1979; Siudziński 1977; Żmijewska 1974). Obviously, these phenomena cannot be viewed as resulting from the hydrological regime only, as they are affected also by variable intensity of insolation, and most of all by a complex of biotic factors, mainly by the availability and composition of the food resources (Beklemiszew 1954; Bougis 1976; Gliwicz 1974; Hernroth, Ackefors 1979; Nichols 1933; Nikołajew 1957; Sidrewic 1979; Timonin 1976).

The present work has been based on materials collected during daily studies, carried out at the turn of March and April, and in June, July, November and December 1980. Samples were collected from one station situated in the Gulf of Gdańsk (54°36′ N, 19°06′ E). Systematic hydrobiological studies have been carried out since many years upon this station. Thus, comprehensive scientific data made the interpreting of biocenotic phenomena much more easier.

The objective of this paper is to present qualitative and quantitative composition and vertical distribution of the mesozooplankton in selected months. An attempt has also been made to follow up changes taking place in the predominance of basic trophic groups of the mesozooplankton. The results are discussed basing on hydrological data, with reference to the literature.

2. Material and methods

Materials were collected with a Nansen net (202 μm), from particular water layers, upon one station in the Gulf of Gdańsk (54°36′ N, 19°06′ E). Sampling dates and water layers were as follows:

30 March - 2 April 1980	0 - 20, 20 - 60, 60 - 80 m,
24 June - 27 June 1980 17 July - 20 July 1980 12 November - 13 December 1980	0 - 30, 30 - 60, 60 - 80 m.

Samples were collected six times every day (at $0^{\circ\circ}$, $4^{\circ\circ}$, $8^{\circ\circ}$, $12^{\circ\circ}$, $16^{\circ\circ}$ and $20^{\circ\circ}$ h.) and preserved in 4% solution of formalin. Water temperature and salinity were measured at the same time. In most cases the mesozooplankton organisms were determined to species or genus, with the exception of nauplii forms of Copepoda and Cirripedia, and juvenile forms of Polychaeta and Lammelibranchiata.

In order to determine the balancing of the structure of predominating mesozooplankton community advantage was taken of a new method proposed by Cieślak (1980). Curves of the domination structure were drawn, representing cumulative value of the domination of species or zooplankton groups, arranged on the abscissa according to decreasing domination value. Along with increasing disproportion of domination between particular components, bending of the curve also increases. Balancing of the domination in a community is estimated on the basis of a domination index E_c, obtained from the equation:

$$E_c = \frac{(d_1 + 2d_2 + 3d_3 + \ldots + nd_n) - 50}{N \cdot 50},$$

where:

$d_1, d_2 \ldots d_n$ – domination of particular components expressed in %,

2, 3 ... n – consecutive figure of particular components arranged according to decreasing domination,

N – number of components in a community (N=n).

Value of the E_c index remains within a range of 0.0 - 1.0, being directly proportional to an increasing balance of the domination. For a community with equal share of all components, value of the E- index is 1.0.

3. Vertical distribution of temperature and salinity

At the turn of March and April 1980, vertical distribution of water temperature and salinity was typical of a winter season (Fig. 1). An isothermal and isohaline layer extended down to the depth of 40 m. Water temperature in this layer did not exceed 1°C, being 0.85°C on the average. Water temperature in March was by over 1°C lower than a multi-year average for this month*. Water salinity remained within a range of 8.01°/$_{oo}$ at the surface and 8.14°/$_{oo}$ at the depth of 40 m. Below this layer both water temperature and salinity increased rapidly, reaching 4.97°C and 11.1°/$_{oo}$ at the bottom respectively.

In June the situation was characteristic of a summer stratification (Fig. 2). The highest temperature was recorded at the surface (11.01°C on the average); it decreased rapidly along with depth, reaching 2.44°C at 50 m. Below the depth of 50 m water temperature increased slightly, reaching on the average 3.52°C at the bottom. Surface water temperature in June 1980 was lower than the multi-year average, the latter being 12.17°C. Vertical distribution of water salinity remained within a range of

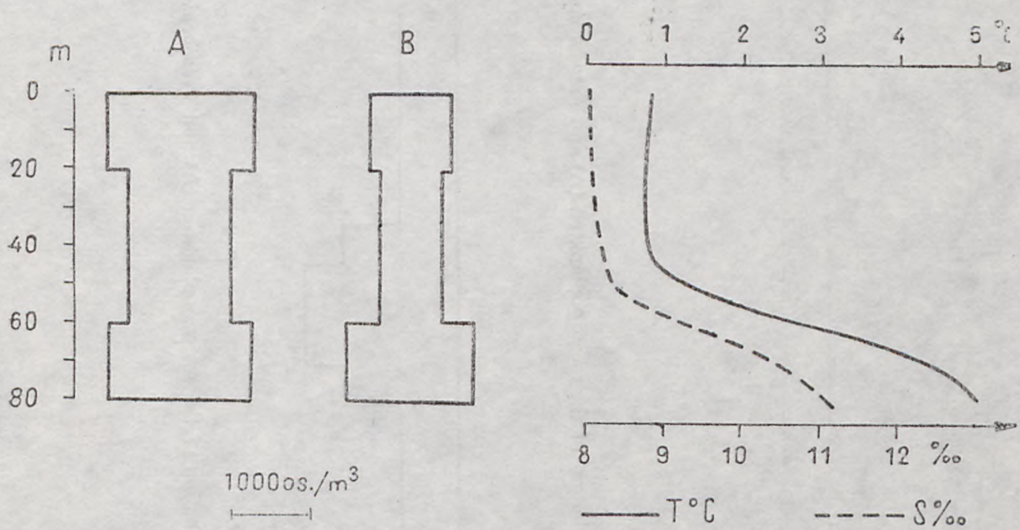

Fig. 1. Vertical distribution of the mesozooplankton (A) and *Pseudocalanus elongatus* (B) in relation to water temperature and salinity at the turn of March and April 1980

* Data on average temperatures in particular months, calculated for surface waters of the Gdańsk Bay, were based on unpublished long-term materials of the Laboratory of Baltic Hydrology.

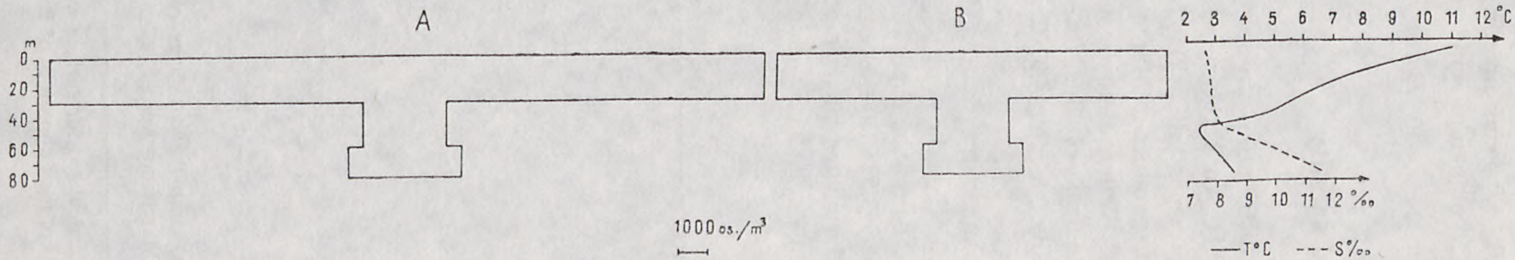

Fig. 2. Vertical distribution of the mesozooplankton (A) and *Pseudocalanus elongatus* (B) in relation to water temperature and salinity in June 1980

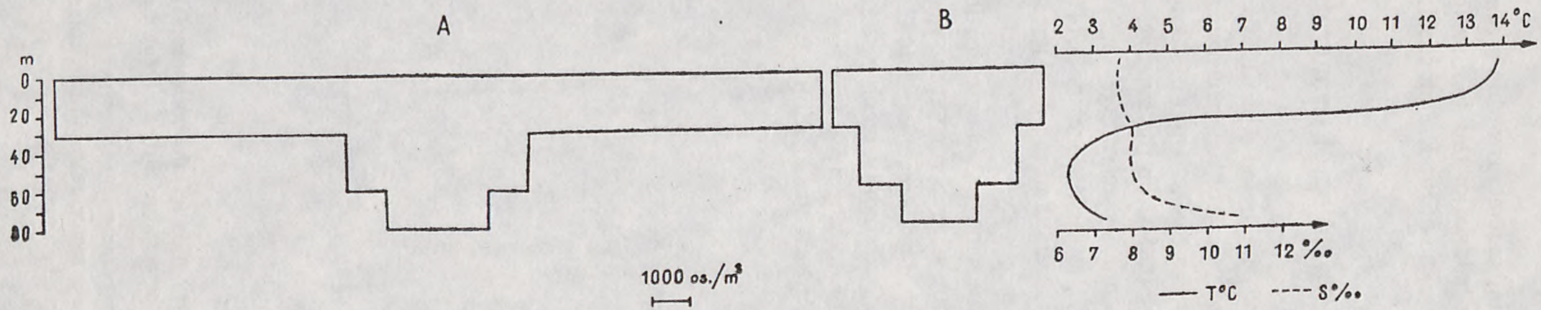

Fig. 3. Vertical distribution of the mesozooplankton (A) and *Pseudocalanus elongatus* (B) in relation to water temperature and salinity in July 1980

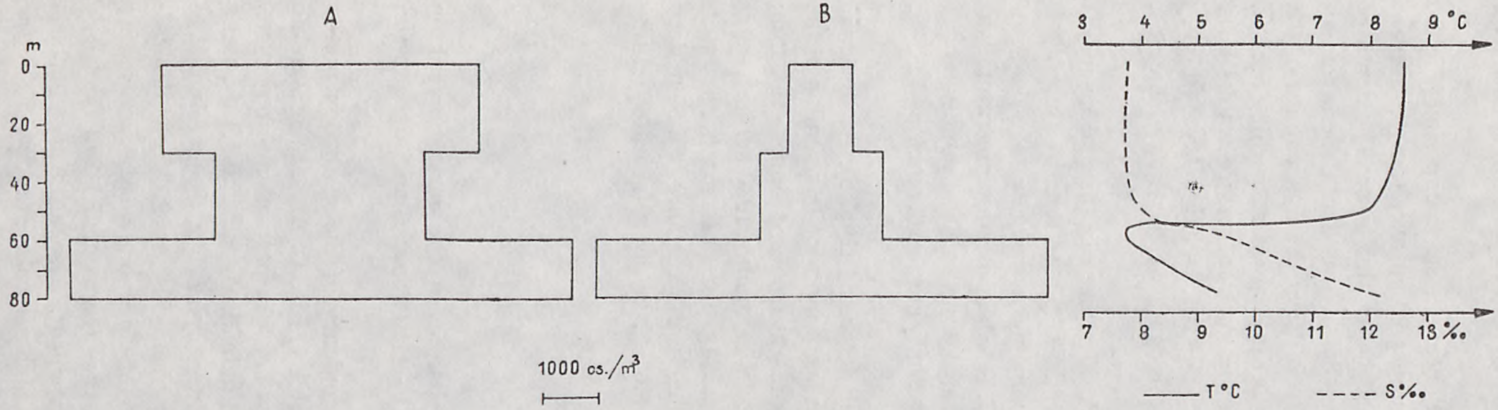

Fig. 4. Vertical distribution of the mesozooplankton (A) and *Pseudocalanus elongatus* (B) in relation to water temperature and salinity in November 1980

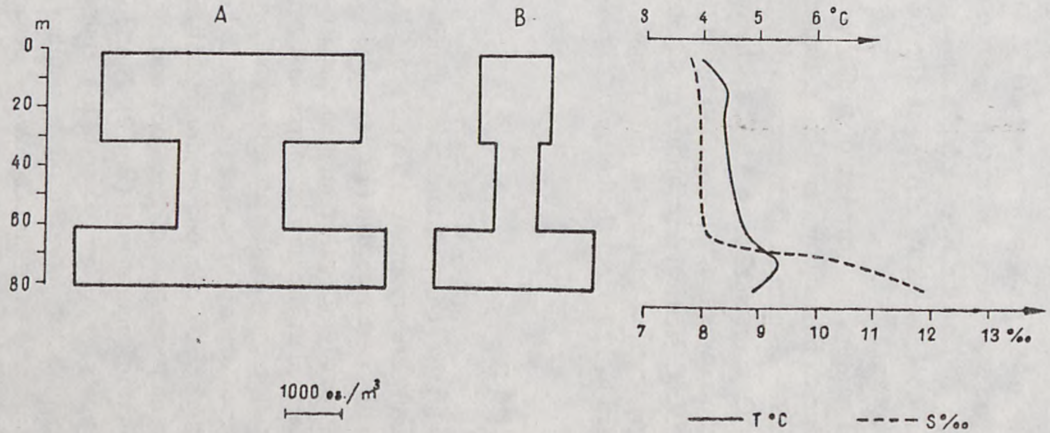

Fig. 5. Vertical distribution of the mesozooplankton (A) and *Pseudocalanus elongatus* (B) in relation to water temperature and salinity in December 1980

7.65 - 7.87‰ in the 50 m deep isohaline layer. Below this depth salinity increased reaching 11.45‰ at the bottom.

In July water temperature and salinity became typical of a summer period (Fig. 3). The highest temperatures were recorded for the upper 20 m layer (on the average 13.87°C at the surface). A thermocline was formed below this layer. The depth of 30 m constituted lower range of the thermocline. Below this depth there was an intermediate layer, with temperatures decreasing to 2.3°C at the upper range of the halocline, *i.e.* at 60 m. Below the halocline water became warmer, reaching 3.21°C.

Similarly as in earlier months, also July temperatures in surface waters were lower than the multi-year average, the latter being 17.75°C. Isohaline layer (salinity of 7.68 - 8.16‰) extended down to 60 m; below this depth water salinity increased, reaching 10.66‰ at the bottom.

In November surface waters became cooler. A 50 m deep isothermal layer was formed; average temperature at the surface fell to 8.56°C, *viz.* to level by almost 1°C lower than the multi-year average (Fig. 4). Thermocline occurred at the depth of 50 - 60 m. Water temperature dropped to 3.71°C. At the bottom temperature was higher, 5.25°C on the average. Isohaline layer extended down to 50 m; salinity ranged between 7.8‰ and 8.0‰. Below this depth water salinity increased, reaching 12.2‰ at the bottom.

In December temperature of surface waters still decreased (Fig. 5). At the same time, due to intensive water mixing, temperatures were more or less similar in the whole water column. A slight increase of temperature was recorded along with depth: from 4°C at the surface to 4.9°C at the bottom. In December 1980 surface water temperature was much lower than a multi-year average for this month, the latter being 5.92°C. Vertical distribution of salinity pointed to the existance of a 60 m deep isohaline layer, of salinity within a range of 7.7 - 8.0‰. Below 60 m water salinity increased to 12.1‰ at the bottom.

4. Results

Qualitative composition and quantitative relations in the mesozooplankton community are presented in Table 1 and Figures 1 - 11. 19 species and higher systematic units were recorded (Table 2).

Compared with other months, the lowest abundancy of the mesozooplankton was observed at the turn of March and April (Table 1, Fig. 1). Also, there were no drastic differences in the abundancy of organisms between particular water layers. Number of organisms ranged between 2 thousand individuals /m^3 and 1.1 thousand individuals/m^3. Copepoda predominated in all water layers (Fig. 6), mainly due to significant percentage of *Pseudocalanus elongatus* (from 50% to 90% of all mesozooplankton components) (Fig. 7). Nauplii stages of Copepoda were found mostly in the upper 20 m layer. Despite low abundancy, they represented 1/5 of the whole mesozooplankton, constituting a significant component. Also an Appendicularia representative — *Fritillaria borealis* — occurred at high percentage (about 15% in the

Table 1. Average values and abundancy of mesozooplankton components (individuals /m³) in particular months and water layers in 1980

Date of sampling	Mesozooplankton components (individuals/m³)	Water layer (m)		
		0–20	20–60	60–80
30 March–2 April	*Pseudocalanus elongatus*	1022	870	1655
	Acartia spp.	79	16	5
	Temora longicornis	138	112	9
	Centropages hamatus	2	3	–
	Oithona similis	–	1	4
	Nauplii Copepoda	447	49	1
	Evadne nordmanni	1	–	–
	Podon intermedius	1	–	–
	Fritillaria borealis	268	112	102
	Oikopleura dioica	1	1	1
	Total:	1959	1164	1777
		0–30	30–60	60–80
24–27 June	*Pseudocalanus elongatus*	13169	2441	3396
	Acartia spp.	268	–	2
	Temora longicornis	727	–	11
	Nauplii Copepoda	3011	156	61
	Evadne nordmanni	2089	63	85
	Podon intermedius	791	3	9
	Fritillaria borealis	266	91	7
	Oikopleura dioica	–	10	–
	Synchaeta spp.	3907	73	120
	Keratella spp.	10	1	–
	Polychaeta larvae	10	20	90
	Total:	24247	2858	3781
17–20 July	*Pseudocalanus elongutus*	5681	4325	2003
	Acartia spp.	1065	7	20
	Temora longicornis	2467	59	104
	Eurytemora sp.	30	–	1
	Centropages hamatus	5	–	–
	Nauplii Copepoda	4003	94	114
	Nauplii Cirripedia	6	–	–
	Evadne nordmanni	3616	182	216
	Podon intermedius	1257	56	69
	Bosmina coregoni	107	6	8
	Fritillaria borealis	134	19	–
	Synchaeta spp.	1879	88	70
	Keratella spp.	63	–	–
	Polychaeta larvae	2	19	69
	Bivalvia larvae	282	6	17
	Total:	20597	4861	2681
12–13 November	*Psudocalanus elongatus*	1157	2110	7964
	Acartia spp.	1053	483	230
	Temora longicornis	1147	647	407
	Centropages hamatus	67	123	44
	Oithona similis	–	–	47

cont. Table 1.

Date of sampling	Mesozooplankton components (individuals/m³)	Water layer (m) 0–20	20–60	60–80
	Nauplii Copepoda	2040	350	78
	Fritillaria borealis	–	7	–
	Total:	5464	3720	8770
20–21 December	*Pseudocalanus elongatus*	1276	796	2793
	Acartia spp.	1392	144	557
	Temora longicornis	428	496	1310
	Centropages hamatus	208	322	623
	Limnocalanus grimaldi	108	20	7
	Oithona similis	–	–	73
	Nauplii Copepoda	1140	176	83
	Fritillaria borealis	4	–	–
	Total:	4556	1954	5446

Table 2. List of species and higher systematic units in the mesozooplankton samples

Rotatoria
- *Synchaeta* spp. – A
- *Keratella quadrata* (Müller)
- *Keratella cruiciformis* (Thomson)

Polychaeta
- larval stages

Cladocera
- *Bosmina coregoni-maritima* (Müller) – A
- *Podon intermedius* (Lilljeborg) – A
- *Evadne nordmanni* (Loven) – B

Copepoda
- *Pseudocalanus elongatus* (Boeck) – A
- *Centropages hamatus* (Lilljeborg) – B
- *Temora longicornis* (Müller) – A
- *Eurytemora* sp. – B
- *Acartia longiremis* (Lilljeborg) – B
- *Acartia bifilosa* (Giesbrecht) – B
- *Oithona similis* (Claus) – C
- *Limnocalanus grimaldi* (De Guerne) – A

Cirripedia
- nauplii stages – A

Bivalvia
- larval stages – A

Appendicularia
- *Fritillaria borealis* Lohm – A
- *Oikopleura dioica* Fol.

A – filtrators; B – euryphagous forms; C – zoophagous forms

0 - 20 m layer). Cladocera were scarce, represented mainly by *Evadne nordmanii* and *Podon intermedius.*

In June there was a noticeable disproportion in the abundancy of mesozooplankton in particular water layers. Mesozooplankton organisms were most numerous down to the depth of 30 m – over 24 thousand individuals/m³ (Table 1, Fig. 2). *Pseudocalanus elongatus* was predominating; it constituted 65% to 90% of all mesozooplankton components (Fig. 8). Numbers of nauplii stages of Copepoda visibly increased, most of all in the 0 - 30 m layer. Cladocera and Rotatoria were also more numerous, and especially *Synchaeta* spp. (over 15% in the 0 - 30 m layer).

In July vertical distribution of the mesozooplankton was similar to June (Fig. 3). Most organisms gathered in the 0 - 30 m layer (about 20 thousand individuals/m³). In the water layer 30 - 60 m abundancy of the mesozooplankton also increased, from 2.8 thousand individuals/m³ in June to about 5 thousand individuals/m³ in July (Table 1). *Pseudocalanus elongatus* predominated, although its percentage in

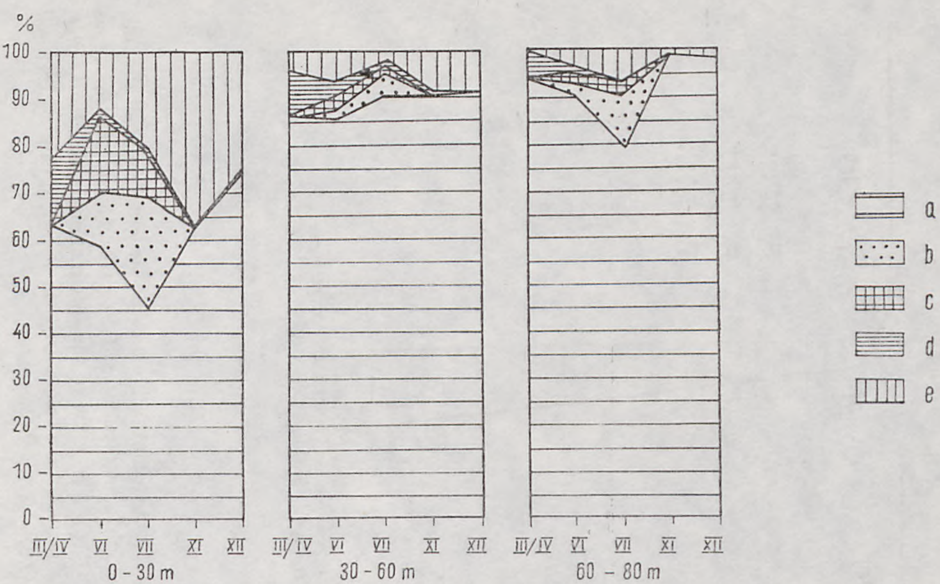

Fig. 6. Percentages of essential mesozooplankton groups in particular months and water layers
a – Copepoda; b – Cladocera; c – Rotatoria; d – Appendicularia; e – other

the upper 30 m layer decreased compared with June – from 65% to 25% (Fig. 9). Nevertheless, it constituted main zooplankton component below the depth of 30 m (75% - 90%). Percentage and abundancy of nauplii forms of Copepoda increased (mainly in the 0 - 30 m water layer), and so did Cladocera and Rotatoria.

In November mesozooplankton abundancy in the 0 - 30 m layer decreased to 5.5 thousand individuals/m^3 on the average (Fig. 4, Table 1). Mesozooplankton organisms gathered in deeper waters (60 - 80 m), reaching the level of 9 thousand individuals/m^3. Below 30 m *Pseudocalanus elongatus* predominated; it constituted 55% to 90% of all components (Fig. 10). On the other hand, it represented only 20% in the upper layer (down to 30 m). *Acartia* spp. and *Temora longicornis* occurred at similar percentages. Abundancy of Copepoda nauplii decreased compared with the two preceeding months, but their percentage increased, especially in the surface (0 - 30 m) layer, reaching almost 40%. No representatives of Cladocera and Rotatoria were recorded in this month.

In December, the mesozooplankton still gathered in the 60 - 80 m layer, but the differences in the abundancy of organisms in the 0 - 30 m and 30 - 60 m layers were not so drastic – 4.5 thousand individuals/m^3 and 5.4 thousand individuals/m^3 respectively (Table 1, Fig. 5). Compared with November, abundancy of the hydrobionts decreased in the whole column of water. *Pseudocalanus elongatus* predominated in the water layer below 30 m, but in the 0 - 30 m layer it was represented by a similar percentage as *Acartia* spp. (Fig. 11). Nauplii stages of Copepoda occurred mostly in the surface layer; their abundancy decreased compared with November. Nevertheless, they still constituted an important component of the mesozooplankton, being present at a level of 25%.

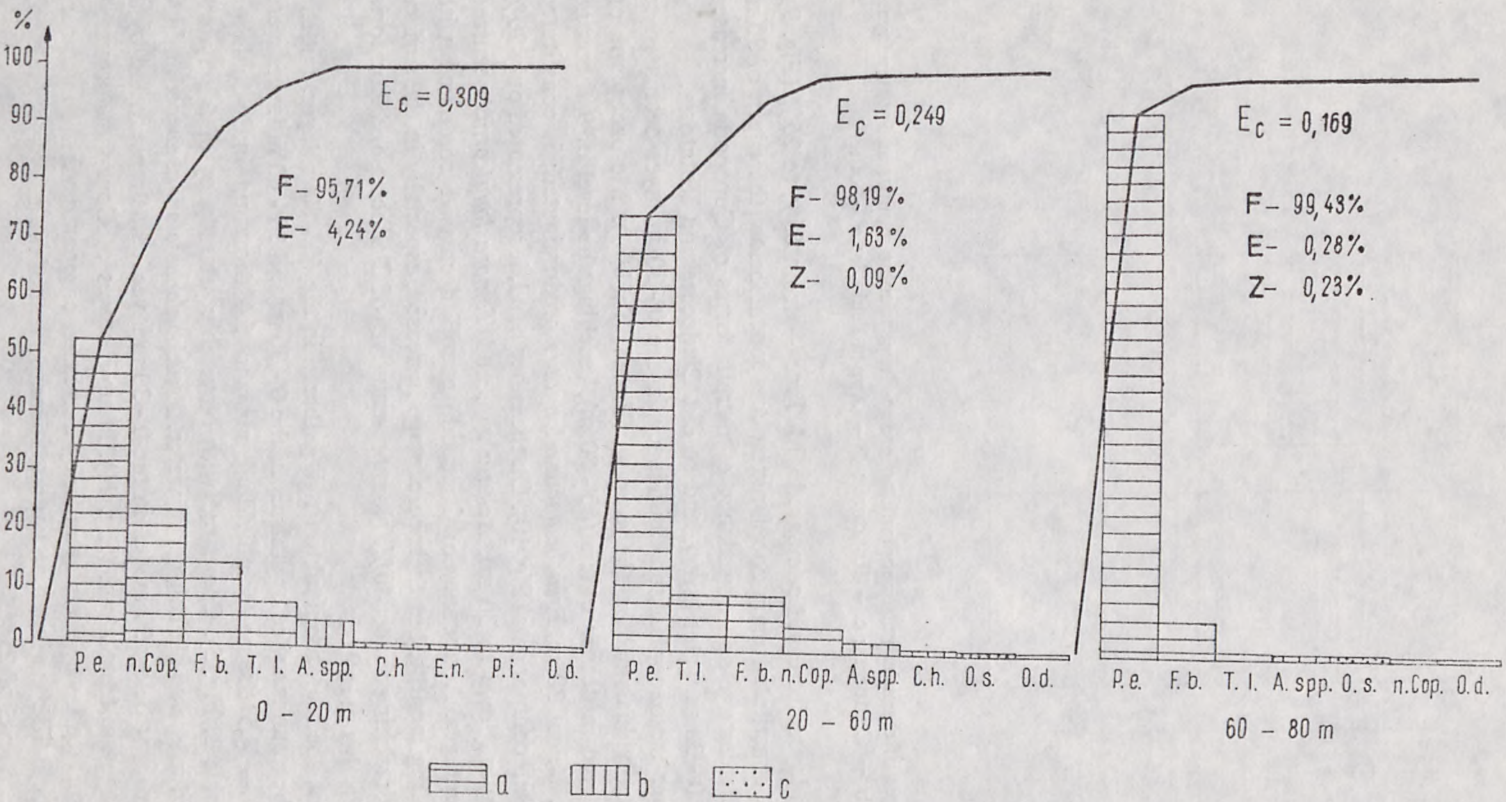

Fig. 7. Percentages of the mesozooplankton components in particular water layers, on the background of domination structure curve at the turn of March and April 1980 a – phytophagous organisms; b – euryphagous organisms; c – zoophagous organisms; F – percentage of phytophagous organisms; E – percentage of euryphagous organisms; Z – percentage of zoophagous organisms; E_c – value of the domination index; P.e. – *Pseudocalanus elongatus*; C.h. – *Centropages hamatus*; A. spp. – *Acartia* spp.; T.l. – *Temora longicornis*; O.s. – *Oithona similis*; n.Cop. – Nauplii Copepoda; E.n. – *Evadne nordmanni*; P.i. – *Podon intermedius*; F.b. – *Fritillaria borealis*; O.d. – *Oikopleura dioica*

5. Discussion

Presented elements of the hydrological regime, vertical distribution and species composition of the mesozooplankton in selected months allow for distinguishing three different hydrobiological situations.

At the turn of March and April the situation was typical of a biological winter, in June and July – of a biological summer, and in November and December – of a biological autumn (Hernroth, Ackefors 1979; Mańkowski, Ciszewski 1961; Nikołajew 1957; Sidrewic 1979; Siudziński 1977; Żmijewska 1974).

Biological winter in the Baltic Sea is characterized by low primary production and low abundancy of the phytoplankton. The phytoplankton is predominated by diatoms (Borysiak 1977; Hernroth, Ackefors 1979; Nikołajew 1957; Renk 1973; Sidrewic 1979). This results in low abundancy and biomass of the mesozooplankton, as stated by Ackefors, Hernroth (1975), Ciszewski (1974, 1977), Hernroth and Ackefors (1979), Nikołajew (1957), Siudziński (1977) and Żmijewska (1974). The same was observed also in March and April 1980 (Table 1, Fig. 1). Mesozooplankton in this period was also characterized by a most even distribution in the vertical profile (Fig. 1).

Species composition was determined by low temperature on the one hand, and restricted food resources on the other. Consequently, cold-water components were most abundant, such as *Pseudocalanus elongatus* and *Fritillaria borealis*, together with temperate-water organisms, as *Temora longicornis*. Percentages of particular

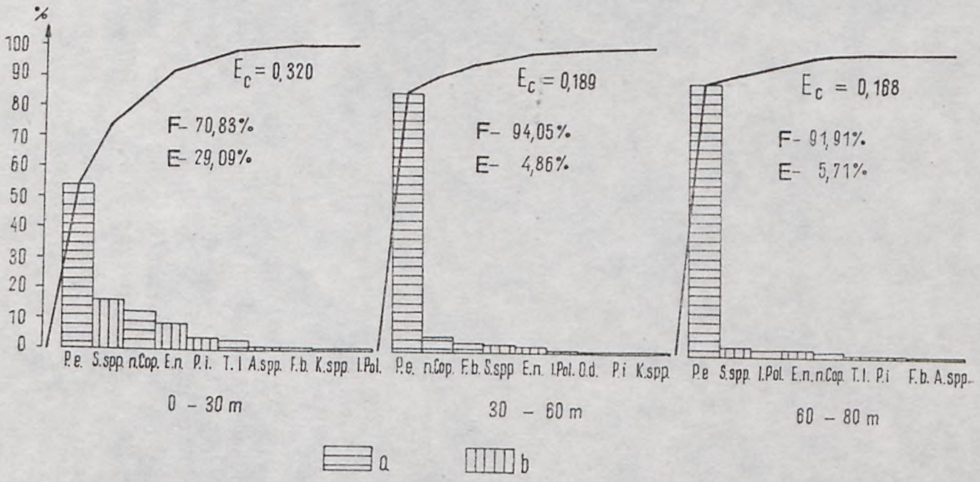

Fig. 8. Percentages of the mesozooplankton components in particular water layers, on the background of domination structure curve in June 1980
a – phytophagous organisms; b – euryphagous organisms; F – percentage of phytophagous organisms; E – percentage of euryphagous organisms; E_c – value of the domination index; P.e. – *Pseudocalanus elongatus*; A.spp. – *Acartia* spp.; T.l. – *Temora longicornis*; n.Cop. – Nauplii Copepoda; E.n. – *Evadne nordmanni*; P.i. – *Podon intermedius*; S.spp. – *Synchaeta* spp.; K. spp. – *Keratella* spp.; F.b. – *Fritillaria borealis*; O.d. – *Oikopleura dioica*; L. Pol. – *Polychaeta larvae*

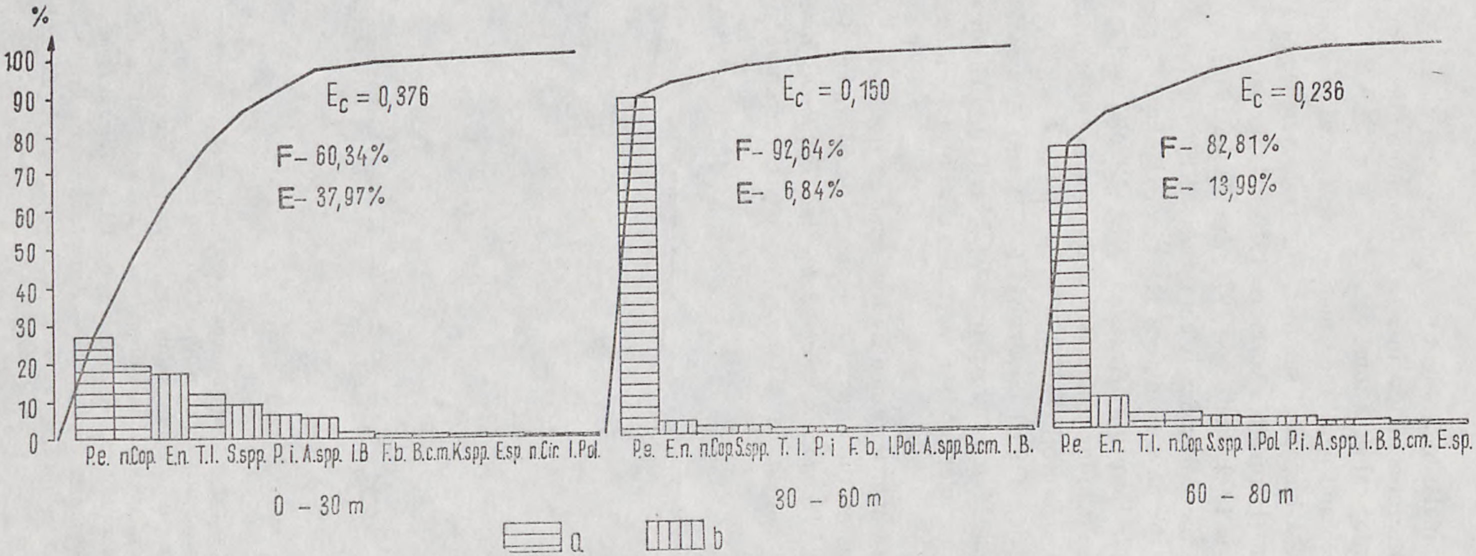

Fig. 9. Percentages of the mesozooplankton components in particular water layers, on the background of domination structure curve in July 1980 a – phytophagous organism; b – euryphagous organisms; F – percentage of phytophagous organisms; E – percentage of euryphagous organisms; E_c -- value of the domination index; P.e. – *Pseudocalanus elongatus*; A. spp. – *Acartia* spp.; T.l. – *Temora longicornis*; E.sp. – *Eurytemora* sp.; n.Cop. – nauplii Copepoda; n.Cir. – nauplii Cirripedia; E.n. – *Evadne nordmanni*; P.i. – *Podon intermedius*; B.c.m. – *Bosmina coregoni maritima*; S. spp. – *Synchaeta* spp.; K. spp. – *Keratella* spp.; F.b. – *Fritillaria borealis*; l.Pol. – *Polychaeta larvae*; l.B. – *Bivalvia larvae*

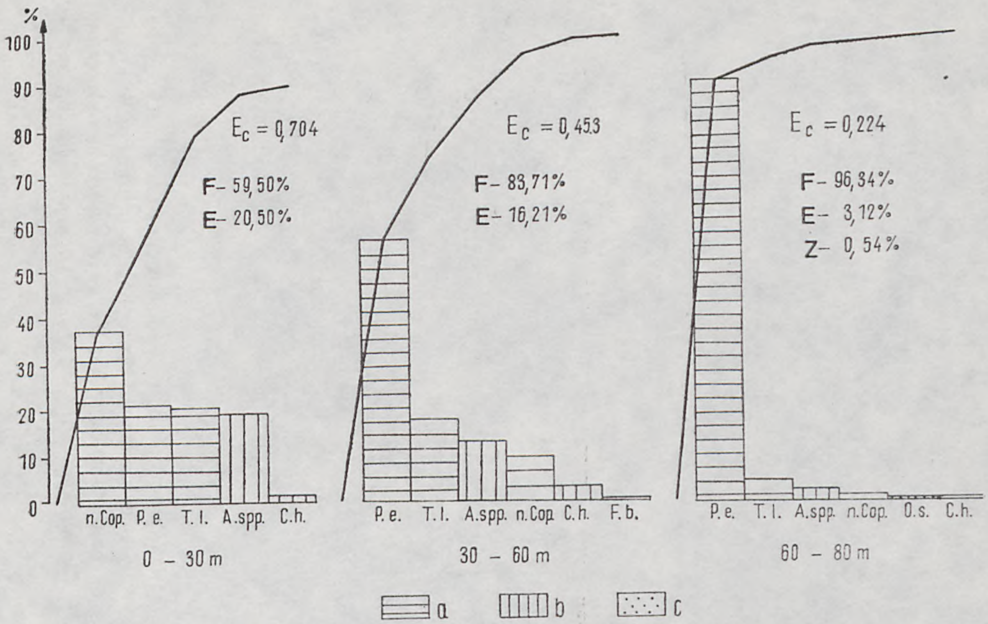

Fig. 10. Percentages of the mesozooplankton components in particular water layers, on the background of domination structure curve in November 1980
a – phytophagous organisms; b – euryphagous organisms; c – zoophagous organisms; F – percentage of phytophagous organisms; E – percentage of euryphagous organisms; Z – percentage of zoophagous organisms; E_c – value of the domination index; P.e. – *Pseudocalanus elongatus*; A. spp. – *Acartia* spp.; T.l. – *Temora longicornis*; C.h. – *Centropages hamatus*; O.s. – *Oithona similis*; n.Cop. – nauplii Copepoda; F.b. – *Fritillaria borealis*

trophic groups were also variable (the trophic groups were distinguished basing on the classification by Petipa (1974) for copepods of the Black Sea, adapted and supplemented for other zooplankton components in the Baltic Sea by Kastriczkina (1979)). Figure 7 shows that winter mesozooplankton was predominated by the filtrators, which constituted from 95% to over 99% of all components, depending on the water layer. In the upper 20 m layer, in which the phytoplankton was most abundant, the mesozooplankton was predominated by *Pseudocalanus elongatus*, but other phytophagous organisms were also abundant, such as *Fritillaria borealis*, *Temora longicornis*, and nauplii stages of Copepoda. As a result, conditions became favourable for scarce euryphagous organisms (represented mainly by *Acartia* spp.) which constituted about 4% of all components (Fig. 7). Below the depth of 20 m euryphagous organisms did not exceed 1.6%, whereas zoophagous organisms were represented by *Oithona similis*, a cold-water species requiring high salinity.

The filtrators were decisively predominated by *Pseudocalanus elongatus*; this affected the domination index which amounted to 0.169 only in the 60 - 80 m water layer, while its value in the surface waters (0 - 20 m) reached 0.309.

At this point it would be worth-while to give some attention to the trophic status of the filtrators, and especially to their most abundant representative: *Pseudocalanus elongatus*. This species is considered as a large, filtrating organism (Kostriczkina

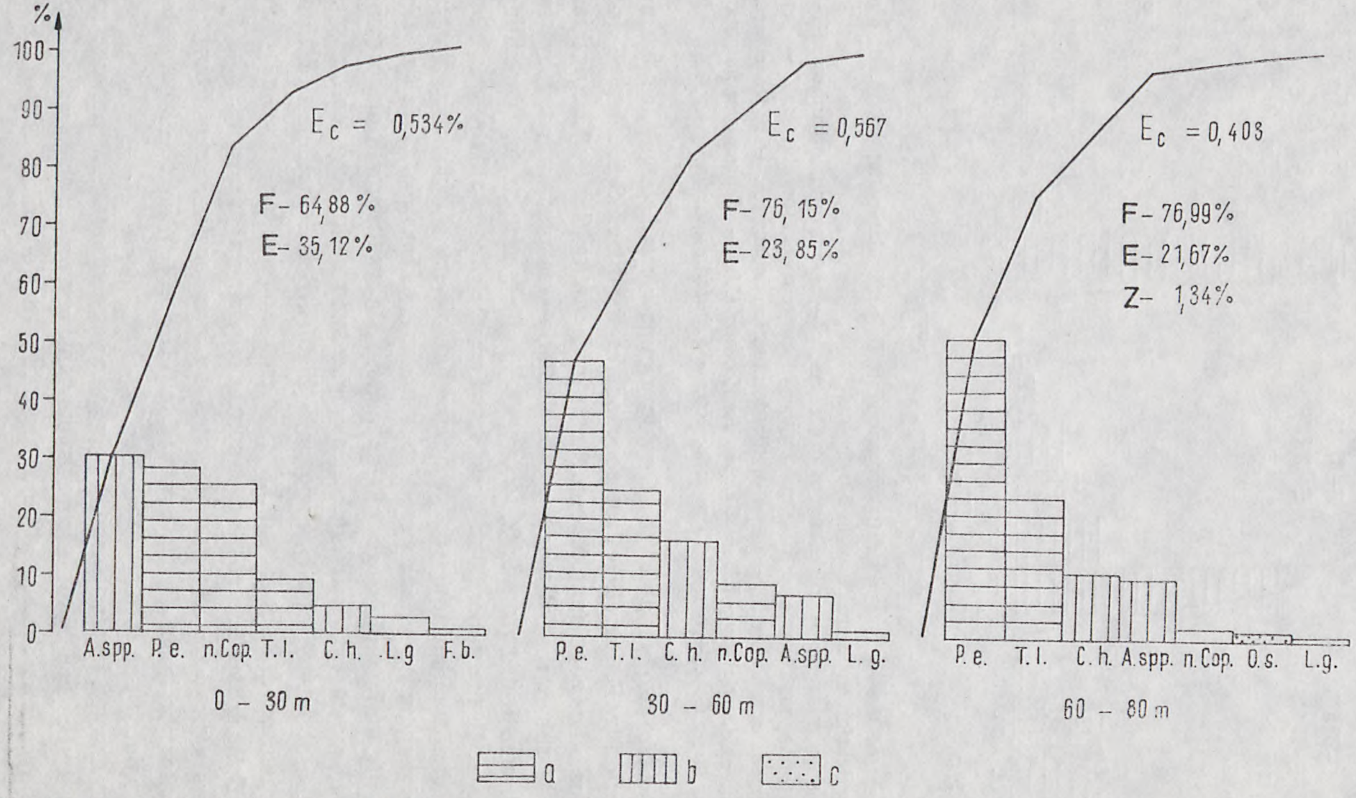

Fig. 11. Percentages of the mesozooplankton components in particular water layers, on the background of domination structure curve in December 1980 a – phytophagous organisms; b – euryphagous organisms; c – zoophagous organisms; F – percentage of phytophagous organisms; E – percentage of euryphagous organisms; Z – percentage of zoophagous organisms; E- – value of the domination index; P.e. – *Pseudocalanus elongatus*; A.spp. – *Acartia* spp.; T.l. – *Temora longicornis*; C.h. – *Centropages hamatus*; L.g. – *Limnocalanus grimaldi*; O.s. – *Oithona similis*; n.Cop. – nauplii Copepoda

1979; Marshall, Orr 1962; Pawłowskaja, Pieczeń-Finienko 1975; Sidrewic 1980; and others).

A comprehensive review of the feeding by the zooplankton, presented by Gliwicz (1969), clearly showed that the filtrators were characterized by passive food selectivity. In other words, food selectivity depends on the size and shape of food particles. As a result, potential diet of these organisms covers a variety of food particles, *i.e.* phytoplankton, protozoans, bacteria, as well as detritus and dissolved organic matter. However, it should be remembered that these sources of food are characterized by different nutritive value, and their assimilation is also different. Algae seem to be the most valuable food resource (mainly Diatomae and Peridineae), together with plant flagellates (Beklemiszew 1954; Marshall, Orr 1962; Wyszkwarcewa 1977; and others). Also bacteria and protozoans may be a valuable food resource, on condition that they form aggregates at the water surface or over the particles of organic suspension (*op. cit.*). On the other hand, detritus and dissolved organic matter (if it does not form coagulates) are characterized by low nutritive value and frequently are unaccessible for the filtrating zooplankton (*op. cit.*).

Hence, it may be said that some components of the net phytoplankton constitute a most valuable food resource; in case of filtrating copepods it is indispensable for proper growth and egg production (Beklemiszew 1954).

In this context, it can be stated that also *P. elongatus* prefers the phytoplankton as its food. Consequently, this species is frequently defined as a phytophagous filtrator (Kostriczkina 1979; Petipa 1974; Sidrewic 1980; and others), or even as a phytophagous organism (Bougis 1976). Nevertheless, if phytoplankton resources are not sufficient (in winter, or in deeper water layers) *P. elongatus* feeds on detritus, bacteria, or coagulates of dissolved organic matter (Bougis 1976; Kostriczkina 1979; Pawłowskaja, Pieczeń-Finienko 1975; Petipa 1974; and others). However, the authors do agree that a change of feeding to detritus can take place only periodically, as full diet of *P. elongatus* must contain plant components. Beklemiszew (1954) is of the opinion that an ability to become a detritusophagous organism represents an adaptation feature, and allows the organism to survive unfavourable trophic conditions.

Very frequently it is also connected with another adaptation, *viz.* resistance to long periods of undernourishment (Beklemiszew 1954). There were no studies on *P. elongatus* that would support this opinion, but it seems most probable that this species can survive certain time without feeding. This suggestion is indirectly confirmed by observations on the daily cycle of vertical migrations and feeding of *P. elongatus* and other copepod species (Marshall, Orr 1962; Nikołajew 1960; Petipa 1965; Sidrewic 1979; Zagorodnaja, Swietlicznyj 1976; and others).

Obviously, these opinions do not exhaust the problems of trophic status of *P. elongatus* and other filtrators. In view of the presented facts and hypotheses many questions and doubts arise, for instance, what is the real role and nutritive value of detritus and dissolved organic matter in *P. elongatus* diet, how significant are various biological, physiological and behavioural adaptations in *P. elongatus* feeding, or what is an explanation for *P. elongatus* occurrance in deeper waters (especially under halocline) during the relatively long winter period.

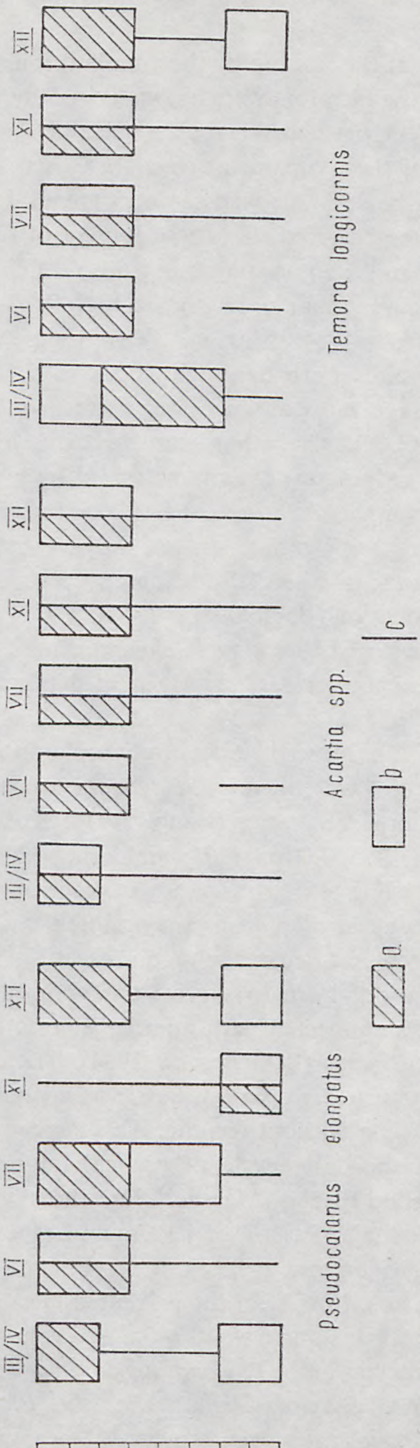

Fig. 12. Water layers with most numerous occurrance of selected Copepoda species in particular months in 1980 a – night (0^{oo}); b – daytime (12^{oo}) c-range of vertical distribution of the species

As regards the situation in the Gulf of Gdańsk at the turn of March and April 1980, it can only be stated that the domination of *P. elongatus* was connected with the fact that this filtrator can feed on dead organic matter. This refers most of all to older copepodits, which constitute the essential part of *P. elongatus* populations in winter (Hernroth and Ackefors 1979, Line 1979, Marshall 1949). Moreover, the species is characterized by considerable vertical migrations (Nikołajew 1960; Sidrewic 1979; Zagorodnaja Swietlicznyj 1976), which were observed also in March and April 1980. Figure 12 shows that at noon *P. elongatus* usually gathered in the 60 - 80 m water layer, while at night it moved upward, to the 0 - 20 m layer. Other components of the mesozooplankton remained in the surface layer both at night and in daytime.

Biological summer in the Baltic Sea is characterized by considerable abundancy and variety of the mesozooplankton community. Temperate- and warm-water species appear along with increasing temperature, most of all representatives of Rotatoria and Cladocera (Ackefors, Hernroth 1975; Chojnacki 1973b; Drzycimski, Siudziński 1977; Hernroth, Ackefors 1979; Nikołajew 1957; Sidrewic 1980; Żmijewska 1974). Upper water layers, well illuminated and rich in phytoplankton, create favourable feeding conditions for various animal organisms (Beklemiszew 1954; Bougis 1976; Jørgensen 1962; Kostriczkina 1979; Marshall, Orr 1962; Pawłowskaja, Pieczeń-Finenko 1975; Petipa 1965; Sidrewic 1980). These general observations were confirmed by qualitative and quantitative relations in the mesozooplankton community in June and July 1980. General picture of these relations (Fig. 8 and 9) was determined by the fact that surface layer of warm water was relatively shallow – from a few meters in June to about 20 m in July (Fig. 2 and 3), and its temperatures were lower than, usually at this time.

Thermal conditions constituted one of the main reasons for considerable abundancy and percentage of *P. elongatus* in the 0 - 30 m layer in summer (Figs. 2, 3, 8, 9). Sidrewic (1980) stated that optimal temperature range for this species was 3.5 - 6°C. Hence, thermal conditions in the 0 - 30 m layer favoured *P. elongatus* development. Differences in the quantitative relations appeared only when samples were collected above and below the thermocline, but unfortunately this procedure was not adopted during our studies. Comparing species composition of the mesozooplankton in June and July, especially in the surface layer (0 - 30 m), it was noted that abundancy and percentage of other mesozooplankton components increased along with increasing temperature (Table 1, Figs. 2, 3, 8, 9). This statement refers most of all to Cladocera and Rotatoria (Fig. 6). Low temperature of surface waters in 1980, and the fact that *Bosmina coregoni maritima* is usually most abundant in August, explain relatively low numbers of this summer cladoceran in July 1980 (thermal optimum for *B. coregoni maritima* is 14.5 - 18°C, Sidrewic 1980). On the other hand, nauplii of Copepoda were numerous, this being probably connected with the reproduction of spring generations of *Acartia* spp., *Temora longicornis* and *Centropages hamatus* (Line 1979).

Apart from the temperature, also other ecological factors and biology of particular species resulted in considerable abundancy of the mesozooplankton in surface water layer (Figs. 2, 3). It should be underlined that abundancy and availability of various food components created favourable conditions for many trophic groups of the mesozooplankton, and decreased competition for food among these groups. Hence, in summer percentage of euryphagous organisms increased considerably (to about 38%), while of filtrators – decreased (Figs. 8, 9).

Waters below 30 m were predominated by filtrators (Figs. 8, 9), although percentage of euryphagous species was higher than in winter. Domination of the filtrators was connected with considerable abundancy of *Pseudocalanus elongatus*. This species was abundant in the whole water column due to its specific trophic status (as discussed above) and vertical migrations. In June, and most of all in July, *P. elongatus* migrated to deeper waters at daytime, and to surface layer at night (Fig. 12).

Autumn plankton in the Baltic Sea is not very specific. Primary production and biomass of the phytoplankton usually decrease compared with summer (Hernroth, Ackefors 1979; Nikołajew 1957). Rotatoria and Cladocera either disappear or become scarce, this being connected with decreasing temperature of surface waters.

In November and December 1980 abundancy of the mesozooplankton decreased in the upper 30 m water layer, and was composed almost exclusively of Copepoda (Figs. 4, 5, Table 1). This phenomenon could not have been explained by low temperature (especially in November) or poor food resources. It is possible that the mesozooplankton was affected by intensive feeding of juvenile fishes, especially herring and sprat (Mańkowski 1947; Nikołajew 1957; Traubierga 1970). In autumn copepod communities are usually composed of older copepodits or mature individuals – maturing autumn generation of *Temora longicornis* and *Acartia* spp. (Line 1979; Sidrewic 1979). These organisms migrate to surface waters (either for nocturnal feeding or for reproduction) and thus become readily available for fishes. This suggestion is supported by November and December data on the abundancy of nauplii stages of Copepoda (Table 1) and vertical distribution of the mesozooplankton (Figs. 4, 5). Mesozooplankton was most abundant and predominated by *Pseudocalanus elongatus* only in the 60 - 80 m water layer (Figs. 10, 11).

Notwithstanding the above, it should be underlined that essential components of autumn mesozooplankton were represented by almost similar percentages, so that the domination index was rather high compared with other months (Figs. 10, 11). Euryphagous organisms still constituted a significant part of the mesozooplankton (up to 35%) in all water layers. In December these organisms exceeded 20% also in water layers below 30 m. This would suggest that feeding conditions were as favourable as in summer, and that intensive water mixing supplied considerable amounts of dead organic matter into deeper waters.

6. Conclusions

Studies on the mesozooplankton, carried out in 1980, supplemented with data on vertical distribution of water temperature and salinity, showed that species composition, quantitative relations and vertical distribution of the organisms were characteristic of biological winter in the Baltic Sea at the turn of March and April, of biological summer in June and July, and of biological autumn in November and December.

In March and April the mesozooplankton was characterized by the lowest abundancy and relatively even distribution of its components in the whole water column; Copepoda predominated, and *Pseudocalanus elongatus* was the dominating species.

In June and July the mesozooplankton gathered in the upper 30 m water layer. Abundancy of organisms in this layer was the highest in an annual cycle; Copepoda predominated but percentage of Cladocera and Rotatoria increased.

In November and December abundancy of the mesozooplankton decreased. Organisms gathered in deeper water layers (60 - 80 m); Copepoda predominated but percentage of *Pseudocalanus elongatus* was noticeably lower in relation to other mesozooplankton components.

Daily vertical migrations were observed most of all as regards *Pseudocalanus elongatus* especially in summer and autumn.

Percentages of particular trophic groups, mainly of filtrators and euryphagous organisms, and balancing of the domination structure changed in particular seasons and water layers, being determined most of all by the abundancy and availability of food components; a) in winter the mesozooplankton was predominated by filtrators, while in summer and autumn percentages of euryphagous organisms were much higher, b) euryphagous organisms were most abundant in the upper, 30 m water layer, c) the domination index reached higher values in summer and autumn in the upper, 30 m water layer.

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