Proc. Zool. Inst. Russ. Acad. Sci, 299, 2003: 181-186

The winter zooplankton of the Chupa Inlet (the White Sea)

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There have been conducted only a few investigations of winter zooplankton dynamics in the White Sea. The short-term observations (which were not repeated for more than two seasons) were conducted by M.M. Kamshilov in 1951-1952 (Kamshilov, 1952), N.M. Pertsova in 1961 (Pertsova, 1963). P.P. Voronkov and G.V. Krechman worked before the II World War near Research Station of the State Hydrological Institute in Umba (Voronkov & Krechman, 1939). R.V. Prygunkova has covered winter period in her long-term investigations (Prygunkova, 1974, 1979, 1985, etc.). But all these works covered rather short period, not more than two seasons. In some cases only total biomass of zooplankton was considered (Voronkov & Krechman, 1939). No one differentiated between major ecological groups (cryophiles and thermophiles, holo- and meroplankton, herbivorous and carnivorous). Besides that zooplankton was not explored in years with temperature or salinity anomalies in winter. But this is very important for the White Sea, because of great year-to-year fluctuations of hydrological parameters here. The goal of this work is to explore dynamics of abundance of total zooplankton and major ecological groups in winter period and to consider dynamics of zooplankton in years with temperature and salinity anomalies.

Materials and methods

The work is based upon data of yearly winter zooplankton sampling (January-April) from 1963 to 2001 in the mouth of the Chupa Inlet (the Kandalaksha Bay of the White Sea) near cape Kartesh - so-called "Decade station". Samples were taken monthly by vertical hauls in standard layers: 0-10, 10-25, 25 m to bottom (depth ca. 65 m). Water temperature and salinity is determined simultaneously. Number of mesoplanktonic animals in m^3 is determined. Biomass of zooplankton was calculated using data on average weights of different species (Pertsova, 1967). Samples were taken on different dates during winter months, so the analysis was done using average values for each 10-day period.

Results and discussion

The scheme of dynamics of temperature and salinity from January to April is normal for northern seas (Fig. 1). Salinity of surface layer decreases, and the most prominent decline takes place in April, probably because of spring melting of ice. The temperature in bottom and intermediate layers decreases, but near surface it does not change, so by April temperature equals -0.7 °C from surface to bottom. Average temperature and salinity show the tendency to decline during winter.

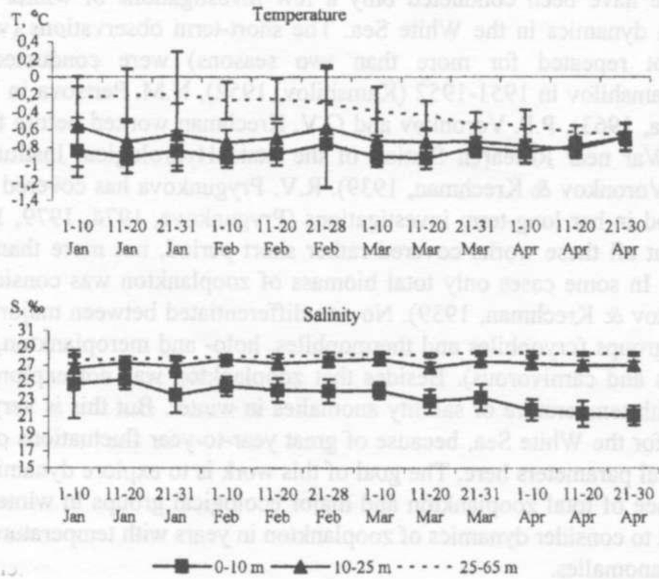

Fig. 1. Temperature and salinity at the "Decade station" in winter. Values averaged for 10-day periods and confidence intervals (95%) are shown

The total density of zooplankton in January and February is the lowest in the year cycle. The increase of density and biomass begins in March (Fig. 2). The growth of abundance slows down in April due to fluctuations of *Pseudocalanus minutus* (one of the most abundant species in region) density. The number of late copepodit stages of *P. minutus* declines and adults mature in this period.

Cryophiles dominate the zooplankton during the whole winter: copepods *Pseudocalanus minutus, Metridia longa* and chaetognat *Sagitta elegans* constitute ca. 76% of zooplankton biomass; copepods *Pseudocalanus minutus, Oithona similis* and *Oncaea borealis* constitute ca. 90% of total zooplankton density. Biomass of cryophiles increases in March-April. Biomass of thermophiles is lower and its changes are negligible compared to cryophiles. Densities of thermophiles and cryophiles differ from each other less than biomass, only in March and April cryophiles dominate. It may be explained by the abundance of small thermophilic species *Oithona similis.*

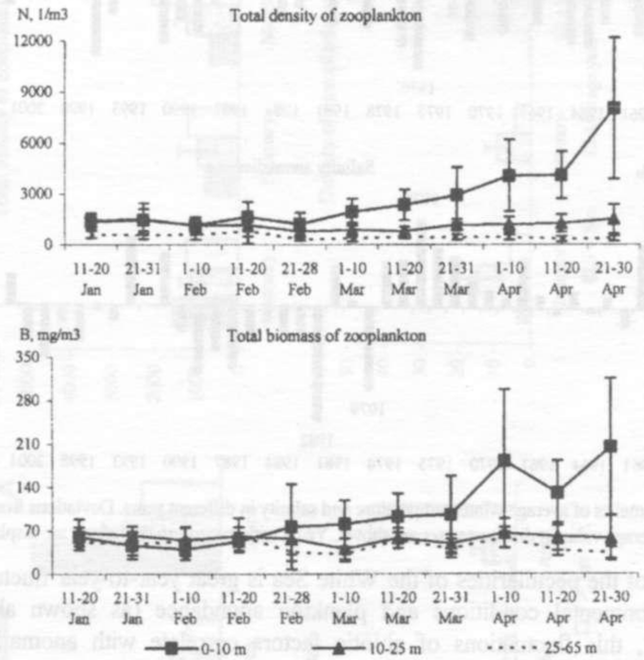

Fig. 2. Density and biomass of total zooplankton in the mouth of the Chupa Inlet in winter. Values averaged for 10-day periods and confidence intervals (95%) are shown

The proportion of meroplankton in total zooplankton number and biomass does not exceed 2%. Its abundance increases by the end of winter; the most intensive growth takes place in April. The maximum density and biomass are concentrated in the surface layer, in spite of even vertical distribution of temperature. Such distribution may be explained by beginning of the spring bloom (Khlebovich, 1974), because phytophagous animals dominate the meroplankton. Abundance of zooplankton and its ecological groups undergoes great variation during period of investigations (see Fig. 2). This may be explained by different environmental influences: currents, patchy distribution of plankton (trophic, breeding aggregations) etc.

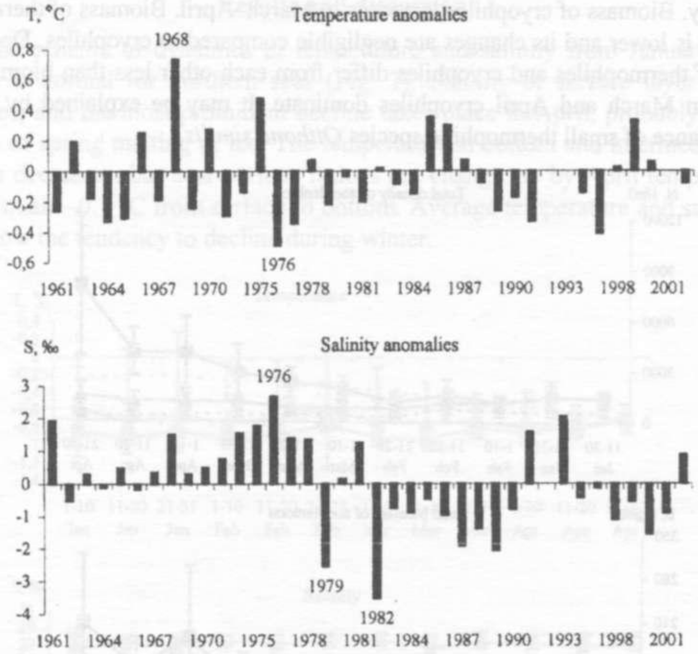

Fig. 3. Anomalies of average winter temperature and salinity in different years. Deviations from long-term average value in different years are shown. Years with maximum deviations are displayed

One of the peculiarities of the White Sea is great year-to-year fluctuation of environmental conditions and plankton abundance (as shown above). Probably, this fluctuations of abiotic factors correlate with anomalies of plankton dynamics. Therefore we decided to study zooplankton dynamics in seasons with anomalies of temperature or salinity. We analyzed: temperature, salinity, total zooplankton density and density of meroplankton.

Winter of 1976 was the coldest in the period of investigations, winter of 1968 - the warmest (Fig. 3). The lowest temperatures in cold winter were observed in January and February. In the same months in warm year temperature was positive and fell below zero only in March. In the cold winter total density of zooplankton is higher, especially in March-April, because of high abundance of *Pseudocalanus minutus* and *Oithona similis.* Holoplankton demonstrated the same dynamics, because of absolute dominance of this group in plankton (see above). In warm winter density of meroplankton increased towards the end of season and became higher than in "average" and cold winters (Fig. 4).

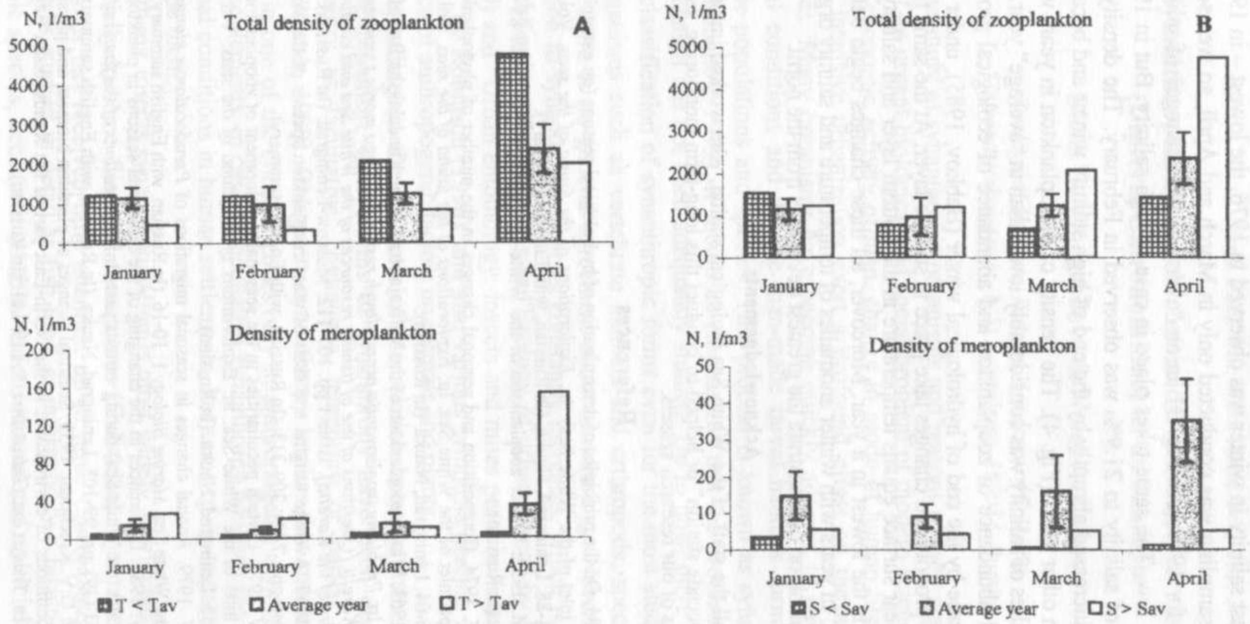

Fig. 4. Dynamics of density of zooplankton and density of meroplankton in average year and in years with temperature (A) and salinity (B) anomalies. Confidence intervals (95%) are shown for average year

The highest salinity in winter was observed in 1976, the lowest - in 1982. But in 1982 sampling was conducted only in March and April, so we use in analysis data for 1979 (see Fig. 3). In an "average" year changes of salinity are relatively low. The same takes place in case of high salinity. But in 1979 the decrease of salinity to 21.9‰ was observed in February. The density of zooplankton increased abruptly by the end of high salinity winter and became higher than in other years (Fig. 4). The density of meroplankton in years with winter anomalies of salinity was considerably lower than in "average" year.

Thus total abundance of zooplankton and abundance of ecological groups begin to increase by the end of hydrological winter (Babkov, 1985), under the ice. The most pronounced changes take place in surface layer. At the same time temperature near surface equals temperature in the bottom layer and salinity in surface layer is the lowest in a year. Moreover, all these changes begin before melting of ice. In years with winter anomalies of temperature and salinity organisms of meroplankton demonstrate the greatest deviations from the norm.

Acknowledgements

Thank to all the staff of the White Sea biological station, who worked immediately at the "Decade station" or helped to conduct this long-term monitoring, especially the crews of our research vessels.

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