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Biological diversity of plankton communities in the south-east of the Baltic Sea

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ABSTRACT. In this investigation, we used the data on hydrobiological and hydrochemical observations (phyto- and zooplankton, nutrients), which were obtained from the monthly (April–October) research cruises in the Baltic Sea and its lagoons (Curonian and Vistula) in 2002–2010. For the analysis of species diversity, Shannon index (*H*) and its relation to different abiotic characteristics of the aquatic environment was used. The obtained results have shown that many factors influence the formation of biological diversity, which manifest themselves in different ways at different times. The *H* Index is apparently not related to the level of the trophy of a water body. A decrease and increase in ecosystem diversity occur under the influence of abiotic factors and through trophic relationships, and it is an adaptive characteristic of the ecosystems. This is what ensures the stability of the ecosystems in the seasonal and interannual aspects at the existing level of trophies. These results also clearly indicate that during analysis it is very important to consider the time scale of the processes for a selected period of averaged data and, as a rule, the nonlinear feature of correlative dependences.

Keywords: Curonian and Vistula Lagoons, Shannon index, plankton communities

1. Introduction

The south-eastern part of the Baltic Sea and its lagoons (Curonian and Vistula) are located in areas with developed economical infrastructure of Kaliningrad as well as towns and settlements of Poland and Lithuania. In a changing environment, the biodiversity is the mechanism for stabilizing the function of the natural, non-polluted as well as anthropogenically changed and possibly disturbed aquatic ecosystems (Jactel et al., 2005). For this reason, a study of the species diversity of the plankton communities in the Baltic Sea is especially relevant under conditions of the anthropogenic eutrophication, aquatic ecosystem contamination and alien species invasion. The aim of this investigation was to apply some approaches to study the relationship between the productivity of plankton communities and species diversity.

2. Materials and methods

In this paper, we used the data on hydrobiological and hydrochemical observations (phyto- and zooplankton, nutrients), which were obtained from the monthly (April–October) research cruises in the Baltic Sea and its lagoons (Curonian and Vistula) in 2002–2010. For the analysis of species diversity, Shannon index and its relation to different abiotic characteristics of the aquatic environment was used.

3. Results and Discussion

The studies revealed that the highest phytoplankton species diversity was observed in the meso-eutrophic Vistula Lagoon (H = 3.0 bit/g on average). In hypertrophic Curonian Lagoon, the average long-term H value was 2.7 bit/g. In the oligo-mesotrophic coastal zone of the Baltic Sea *H* value was below 2.3 bit/g, and in the open Baltic Sea 2.6 bit/g. The obtained average long-term data generally support the idea existing in hydrobiology that the maximum species diversity of phytoplankton is typical for water bodies with average productivity (Gilyarov, 2001).

Statistical relations have been obtained in the study between the Shannon index and a row of abiotic indicators of an aquatic environment. We have found that the role of any of the considered hydrological indicators in the formation of phytoplankton species diversity can be rather important. During the growing season, the average value of determination coefficient (R^2) for dependences of Shannon index and the water temperature was 0.43, water transparency – 0.24, salinity – 0.38, pH of water – 0.30, and the concentration of dissolved oxygen in the water – 0.28. At the same

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time, the role of any of these factors taken separately can significantly change in time: both during the season and in the interannual aspect. The high values of root-mean-square deviations of R^2 value indicate this. Therefore, the formation of species structure of a phytoplankton community is affected by a complex combination of hydrological factors, whose intensity and influence direction are continuously changed.

In the study of the relationship of productivity of plankton communities and species diversity based on the analysis of mean monthly values, we obtained a negative linear correlation between phytoplankton biomass (B) and the H index. With increasing B in the community, fewer and fewer species dominate the composition. The reason for reduction of diversity is that, depending on the concentration of nutrients, abiotic environmental factors and the concentration of cells, significant differences occur in the growth rate of cells in different species of phytoplankton, which lead to the dominance of one species over other species. For example, at a cell concentration equal to 109 cells/l, which is possible in some eutrophic estuarine and other areas, there is a possibility that the vital functions of the dominant species will lead to the elimination of other species, and, thus, to a reduction of diversity (Hulburt and Corwin, 1970).

A more detailed analysis of the whole range of data without the monthly averaging showed that despite the significant differences in the biomass of phytoplankton and levels of productivity in the surveyed area the correlation between Shannon index and phytoplankton biomass was nonlinear. Until the biomass of phytoplankton reached a "critical value" B_{cr}, the Shannon index increased. The "critical value" of biomass in the Vistula Lagoon was $B_{cr} = 8 – 9$ g/m^3, in the Curonian Lagoon $B_{cr} = 30$ g/m^3 and in the coastal and open areas of the Baltic Sea $B_{cr} = 1.6 – 1.9$ g/m^3. When the $B > B_{cr}$, the correlation between the Shannon index and phytoplankton biomass was different: with the growth of phytoplankton biomass, the Shannon index decreased. The reason for decreasing biodiversity of the community is the development of the particular community structure with the appearance of dominant and subdominant species at the time when the biomass of phytoplankton in the water ecosystems had a "critical value". Thus, the minimum of biodiversity in the course of the trophy growth can be achieved both in the "weak" and high-trophy waters, and the maximum of biodiversity can be observed at high as well as at low phytoplankton biomass.

It was found that changes in the Curonian Lagoon H index calculated from the biomass of zooplankton and phytoplankton during the growing seasons are in an anti-phase. This indicates the presence in the ecosystem of the regulatory mechanism formed by "predator–prey" type. A long-term coexistence of predators and preys is known to lead to the formation of the system of interactions, in which both groups have a stable coexistence in the study area.

4. Conclusions

The obtained results show that the ecosystem biodiversity growth and weakening occur under the influence of abiotic factors and through trophic relationships. It is an adaptive characteristic of the ecosystems. This ensures the stability of the ecosystems functioning in the seasonal and interannual aspects at the existing level of trophies.

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