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FISH ABUNDANCES AND SIZE STRUCTURE DISTRIBUTIONS IN RESERVOIRS WITH DIFFERENT TROPHY LEVEL.

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Hydroacoustical estimation of fish abundance and distribution was performed in three reservoirs with different levels of eutrophication. To analyse TS distribution the echo counting method was applied with TVG set to 40 logR. The Biosonics 101 dual beam echosounder, frequency of 420 KHz, was used for measurements and the ESP software for acoustical data analyses. In the mesotrophic Solina reservoir fish abundance was an order of magnitude lower than in the other two eutrophic reservoirs. Also the fish length distributions had different shapes in all three reservoirs indicating the changes in fish size structure due to eutrophication. Comparison of the above results shows that hydroacoustically collected data may help to assess the ecological state of inland waters and be used together with other methods in monitoring the water quality.

INTRODUCTION

Eutrophication of inland waters is the world wide problem which leads to fast deterioration of the water quality. If sustainable management and restoration of aquatic ecosystems is to be succcesful, it is important to have cost effective methods for reliable, large scale monitoring of water quality to in order to assess the current trends and patterns, and to evaluate the effectivness of the undertaken restoration. At the moment there exist many different measures of the ecosystem healthy state. based on chemical, physical and biological parameters [Kudelska et al. 1983]. Most of them are determined from point measurements not necessarly representative for the whole ecosystem. The main advantage of the hydroacoustical methods is that they cover large areas within a short time, are continuous, non selective, non invasive (do not affect the environment), easily automated and they are cost effective. It is well known that eutrophication leads to undesirable changes in fish species composition, size distribution and abundance. Salmonids characteristic for oligotrophic conditions are replaced by cyprynids with rapidly decreasing share of predatory fish. Density of fish at the beginning increases, than drops dramatically with the number of species and their body lengths continuously decreasing [Opuszyñski 1997]. Apart from species composition other changes in fish populations such as abundance and length distribution can be measured acoustically.

The aim of this work was to check if any and which of the parameters derived from hydroacoustical monitoring of aquatic ecosystem can be used as indices of its health y state. For this purpose the hydroacoustical data concerning fish were compared with the environmental parameters for three aquatic bodies which differed substantially as regarding the water quality.

1. MATERIALS AND METHODS

1.1 Study sites

The principal morphometric parameters of three studied reservoirs are summarized in Table 1.

Table 1. Principal morphometric parameters of reservoirs under study.

Parameter Reservoir	Area ha	Volume 10^6 m^3	h_{max} m	h_{mean} m
Solina	2105	472	65	22
Dobczyce	1120	127	35	11
Miko³ajki	498	55	26	11

The largest Solina reservoir comprises about 15 % of the total water storage in Poland. Due to a power station activity the fluctuation of the water level is up to 10 m which leads to the absence of littoral. The total water volume is exchanged about twice a year. Concentrations of phosphorus and nitrogen compounds in the reservoir correspond to mesotrophy. The most frequent fish species are: *Abramis brama* 57.8 %, *Carassius carassius* 16.1%, *Rutilus rutilus* 9.2%, *Stizostedion lucioperca* 4.5% and *Perca fluviatilis* 4.8% [Bieniarz and Epler, 1993]. Information on the physical, chemical and biological characteristics of the reservoir may be found in publications by P³u¿añski et al (1990) and Godlewska et al. (2000).

The Dobczyce reservoir is the main source of drinking water for Kraków. No fish angling is allowed in the reservoir and its management aims at increasing share of predatory fish (by introduction) and decreasing the number of planktivores (by catch). The most frequent species are: *Abramis brama* 57.8 %, *Carassius carassius* 16.1%, *Rutilus rutilus* 9.2%, *Stizostedion lucioperca* 4.5% and *Perca fluviatilis* 4.8% [Jelonek and Godlewska 2000]. More information about the Dobczyce reservoir can be found in a monography [Starmach and Mazurkiewicz-Boroń 2000].

Miko³ajskie lake belongs to the system of natural Mazurian lakes, situated in north-eastern Poland. It has been included into eutrophicated lakes over 30 years ago, with annual blooms and subsequent changes to fish population structure which is dominated by smelt (90%).

1.2 Field measurements

Hydroacoustical records of fish distribution were obtained along zig-zag transects covering the whole area of the reservoirs. Surveys were performed in June and July 2000 on day and night bases. The echo sounder used was a Biosonic 101 dual beam, 420 kHz, with a beam width of 6° and 15°. The acoustical system was routinely calibrated with a -43.2 dB copper sphere. To estimate fish size distribution the echo counting method was applied with the TVG set to 40 logR. The echo sounding results were analysed using the ESP software system supplied by the manufacturer.

In the Solina reservoir water samples for chlorophyll *a* analysis, chemical analyses for nutrients and zooplankton were taken at 9 stations at which temperature, oxygen concentration and Secchi disc visibility were also measured. The stations were situated in the

main basin near the dam as well as in the two branches of the reservoir, the Solinka and San supply rivers, which are characterized by different trophy levels. For the Dobczyce reservoir and Miko³ajskie lake environmental data were taken from literature [Starmach and Mazurkiewicz-Boroń 2000, Karabin et al., 1998, Wilk-Woźniak, personal comm.].

2. RESULTS AND DISCUSSION

Comparison of fish abundances with environmental data shows tendency of increasing fish number with the trophy level (Fig. 1).

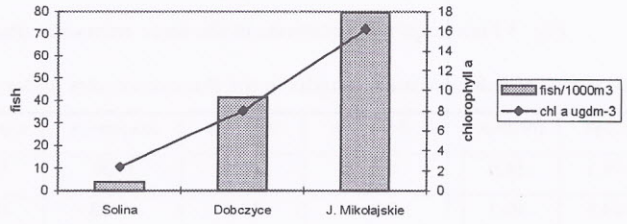

Fig. 1 Fish density in three reservoirs with different trophy level

In the mesotrophic Solina reservoir fish concentrations were an order of magnitude lower than in the other two eutrophic reservoirs.This was true for both day and night estimates, although in the Solina reservoir day estimates were 1.2 higher than the night ones probably due to diurnal vertical migrations of fish [Godlewska et al., 2000], while in Dobczyce reservoir and Miko³ajskie lake night estimates were 1.7 higher than during day probably due to predominance of the horizontal over vertical migrations, from the littoral during the day to open water at night. The same tendency of changes in fish abundance with increasing trophy was observed in one of the branches of the Solina reservoir a year earlier (Fig. 2).

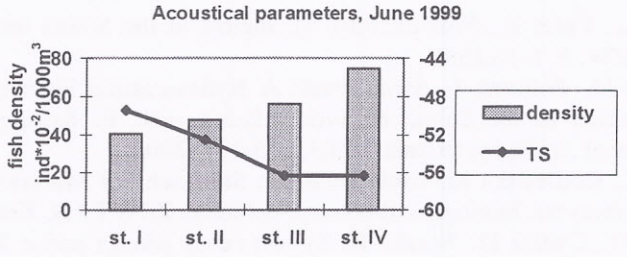

Fig. 2 Fish densities and their mean acoustical size in transects between 4 stations in the Solinka branch along the increasing trophy level.

The fish length distributions differed markedly in all three reservoirs (Fig. 3). In the Dobczyce reservoir pressure of the predatory fish was demonstrated by little contribution of small specimens into the population structure. In Miko³ajskie lake the situation was opposite, the smallest sizes dominated, mainly stynka. In the Solina reservoir all but very large sizes were present in similar proportions with slightly higher share of the smallest and the medium sizes. Inspite of clear differences in the shape of fish length distributions the general statistics of fish acoustical lengths did not differ significantly (Table 2) making it impossible to conclude about the differences in trophy level on the basis of the statistics only.

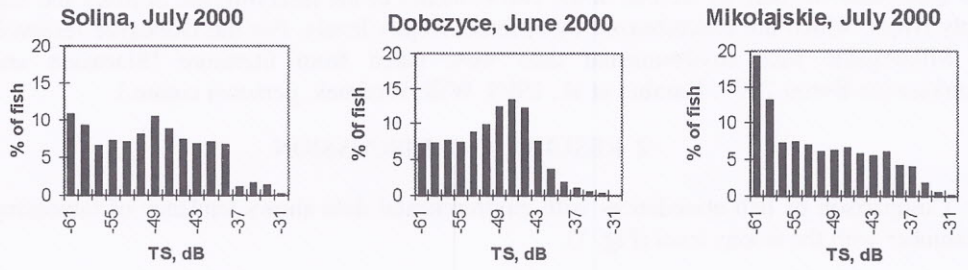

Fig. 3 Fish length distributions in the three reservoirs under study

Table 2. Statistics of fish acoustical lengths in the three reservoirs under study.

Reservoir	mean	median	st. deviation	variance	assymetry	curtosis	number
Solina	-49.2	-49.0	6.9	47.6	0.09	-0.95	509
Dobczyce	-49.8	-49.3	5.8	33.3	-0.03	-0.63	7679
Miko³ajki	-51.0	-52.4	7.6	58.2	0.44	-1.05	1004

3. CONCLUSIONS

The above results suggest that fish abundances and length distributions are good indicators of the trophy level, although it is recognized that the final conclusions about sutibility of acoustical parameters for monitoring water quality should be based on much larger experimental material.

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