THE ICHTHYOFAUNA OF THE DEGRADED VENDACE LAKES MIELNO AND MARÓZ STUDIED WITH HYDROACOUSTIC AND MONITORING CATCH METHODS

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In 2005, the distribution, density, and structure of pelagic fish resources was studied in lakes Mielno (363 ha) and Maróz (332 ha) located in the Łyna catchment basin through which the Marózka River flows. The studies were conducted with a Simrad EY-500 echosounder (120 kHz, 7x7 deg, 0.3 ms, split beam version) and a pelagic trawl for monitoring catches. At the outset of the 1990s, vendace dominated the commercial catches of both lakes reaching about fifteen kg·ha^{-1}. Significant changes have occurred in the structure of the pelagic ichthyofauna in recent years in the studied lakes; the disappearance of vendace and the dominance of bleak and roach in the catches indicates that the tempo of eutrophication has increased.

INTRODUCTION

The EU Water Framework Directive (WFD) stipulates achieving its environmental objectives in all aquatic ecosystems by the year 2015 [2]. This requires knowledge of the current state of each hydrological region. The tools and methods used to this end are in constant need of improvement, and acoustic and monitoring catch methods are being applied more and more frequently [5, 11, 14, 17, 18,19, 21, 22]. The lack of comparable data obtained within designed standards is an impediment to using fish an environmental quality indicator.

In 2005, hydroacoustic and monitoring catch methods were used to study the distribution and structure of pelagic fish resources in lakes Mielno (363 ha) and Maróz (332 ha) located in the Łyna catchment basin through which the Marózka River flows. In the early 1990s, the decisive dominant in both of these lakes was vendace (*Coregonus albula* L.) and commercial catches of it were as high as fifteen kg·ha^{-1}; however, in recent years catches of this species have fallen to just a fraction of this (Fig. 1). Vendace is typically planktivorous and due to its habitat requirements and behavior, it can be used as a bioindicator of the quality of aquatic ecosystems [21, 22, 23].

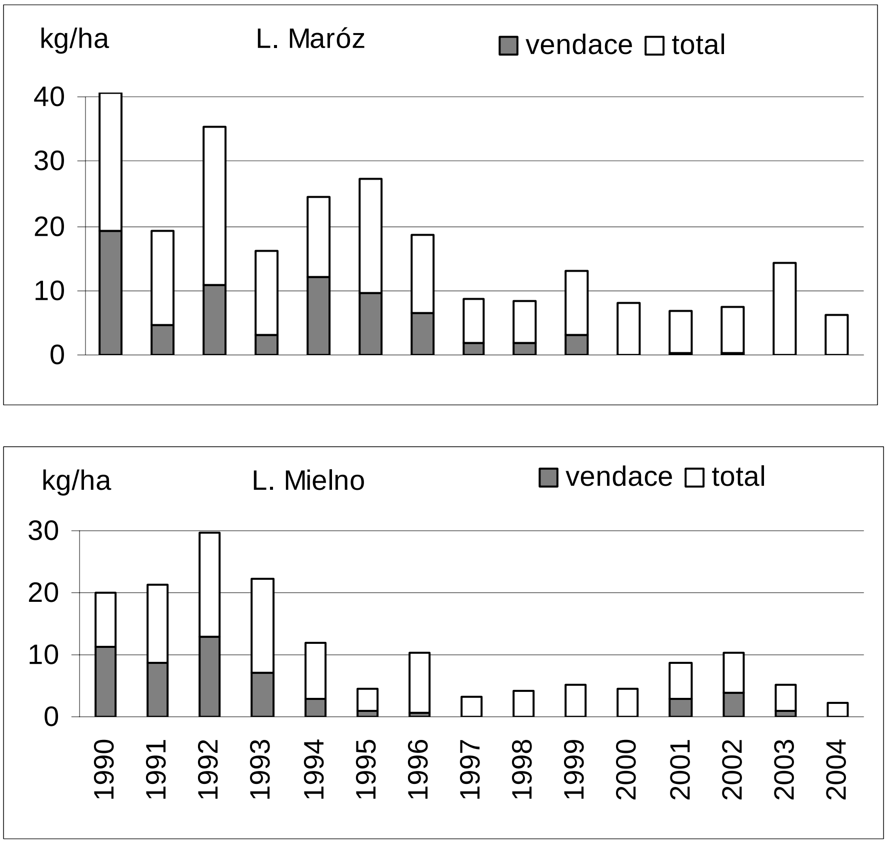


Fig.1 Commercial catches of vendace and total fishes in Lake Maróz and Lake Mielno in 1990-2004 year

The goals of the study were as follows: estimating current resources of pelagic fish and their abundance, species structure, and biomass; determining the vertical and horizontal distribution and density of the fish in these basins; attempting to identify the causes of the significant changes that have occurred in the resources and structure of the pelagic ichthyofauna of these lakes.

1. METHODS

In comparison to studies in other vendace lakes, the study period was brought forward to late June/early July due to the exceptionally early occurrence in these lakes of thermal-oxygen stagnation and oxygen deficit in the hypolimnion. The acoustic surveys were conducted at night using the zigzag system along predetermined transects (Fig. 2) with a Simrad EY-500 research echosounder (120 kHz; 7x7 deg; 0.3 ms; split beam version). Fish density was calculated for a methodologically justified number of water layers and segments along each transect. The EP-500 and Surfer computer software packages were used to produce fish distribution and density maps in various water layers and also to count the abundance of fish in the studied regions. Due to the presence of a large quantity of small organisms, zooplankton, and *Chaoborus* larvae that migrated vertically at night, only single specimens identified by the acoustic system were used to estimate fish density with the EP

500 software [18]. Although this provided more certainty that the identified target was indeed a fish, it could have resulted in a certain degree of underestimation.

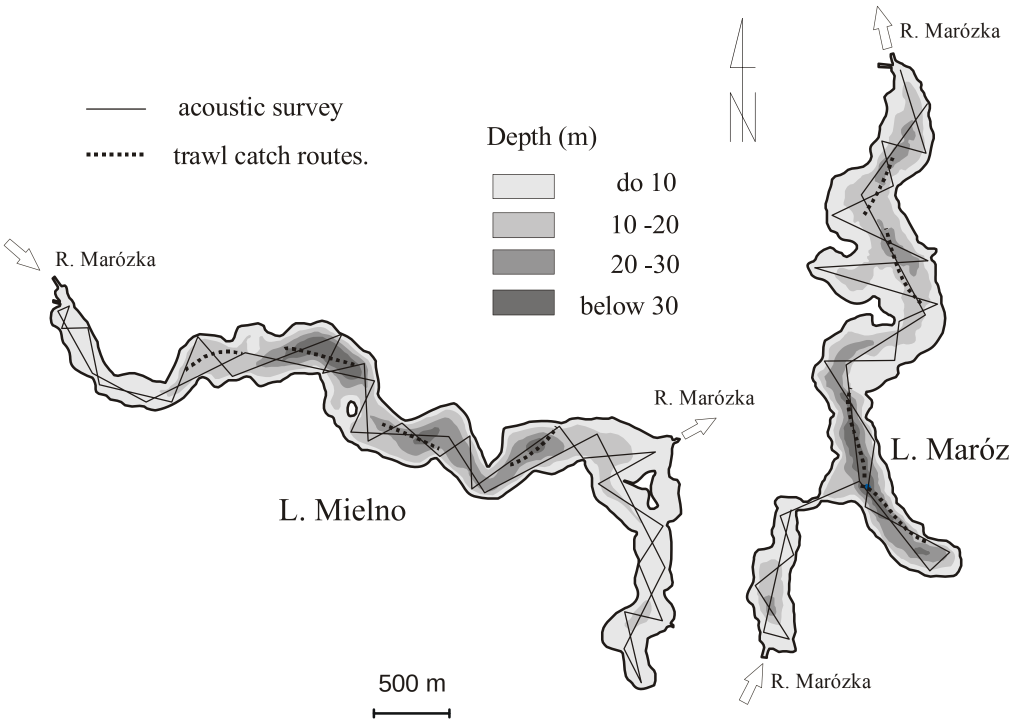


Fig.2 Bathymetry and acoustic survey and trawl catch routes in Lakes Mielno and Maróz

Since the distribution of pelagic fish resources (especially vendace) is significantly dependent on thermal-oxygen stratification, water temperature and oxygen content were measured at 1m intervals from the surface to the bottom in the deepest parts of the lakes with an OXI 196 WTW microprocessor oximeter.

Control catches were conducted with a pelagic trawl for species identification and to verify the acoustic data (Fig. 2). The fish caught were identified, weighed, and measured. Along with determining the abundance acoustically and the percentages of the species structure of the catches and the mean individual weight, this permitted estimating the overall fish biomass as well as that of individual species. The methodological details of the study can be found in numerous publications [15, 18, 19, 21, 22].

2. RESULTS AND DISCUSSION

The horizontal distribution and density of fish in the epilimnion and hypolimnion of the studied lakes are presented in Figures 3 and 4. These indicate that the decided majority of the fish inhabit the epilimnion. As in other basins [20], the highest fish density (cyprinid) was registered in the region of the inflow of the Marózka River, which supplies waters enriched with oxygen and nutrients.

The vertical layers of fish density in lakes Mielno and Maróz in relation to the distribution of temperature and oxygen concentrations in the water column are presented in Figure 5. The layers of vertical fish density were similar in both lakes and were primarily limited to the epilimnion. At this time, the oxygen saturation in the hypolimnion of Lake Maróz was good at 8 mg $O^2 \cdot dm^{-3}$. In this instance, the migration of fish from the hypolimnion to the epilimnion was not dictated as observed at other times [20, 21, 22] due to oxygen depletion but by the migration of its food – zooplankton and *Chaoborus* larvae. The phenomenon of plankton and *Chaoborus* larvae migrating towards the surface with fish at dusk and the problems this poses for identifying fish and estimating their abundance is presented in Figure 5.

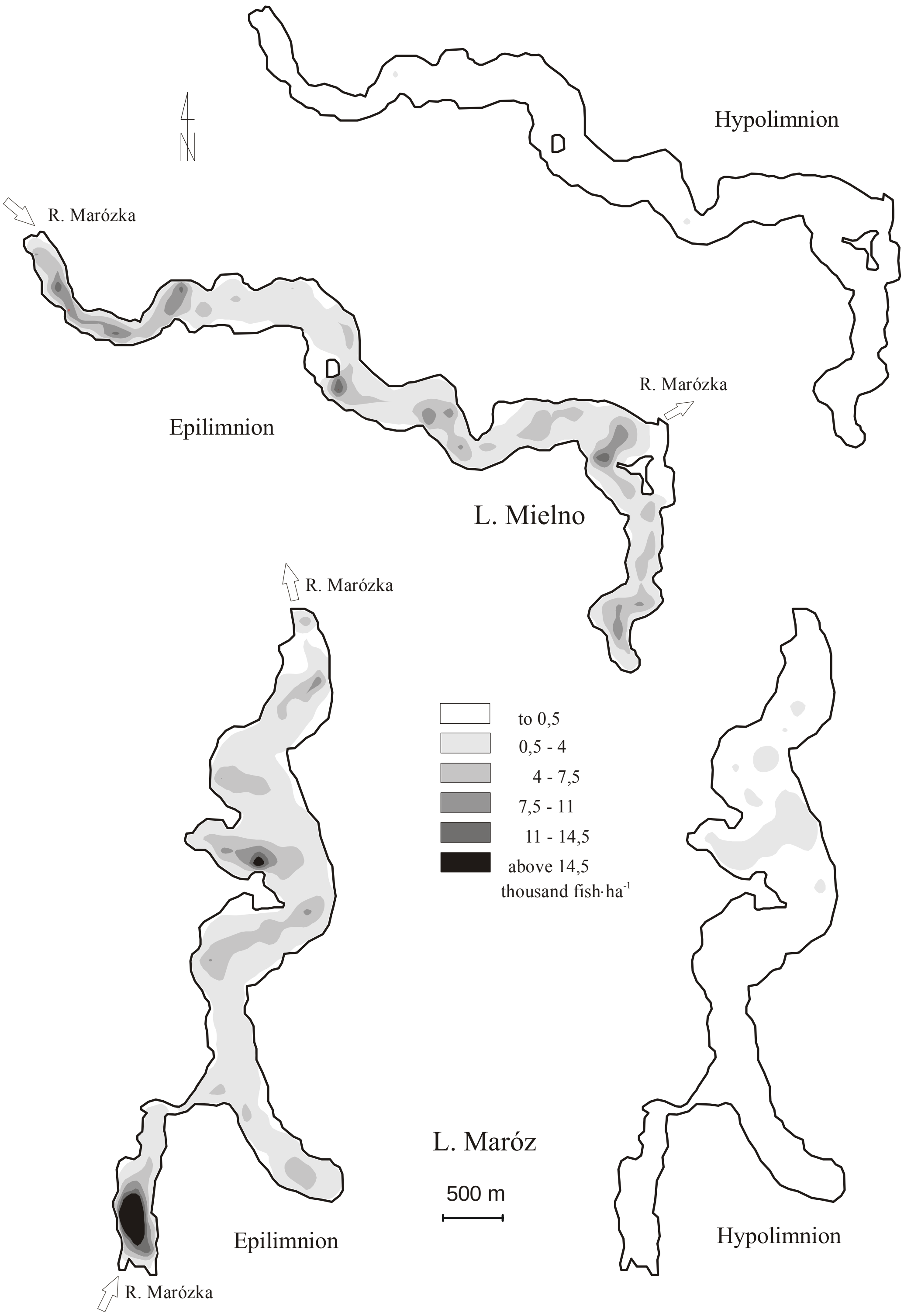


Fig.3 Distribution and density of fish in the epilimnion and hypolimnion of Lakes Mielno and Maróz

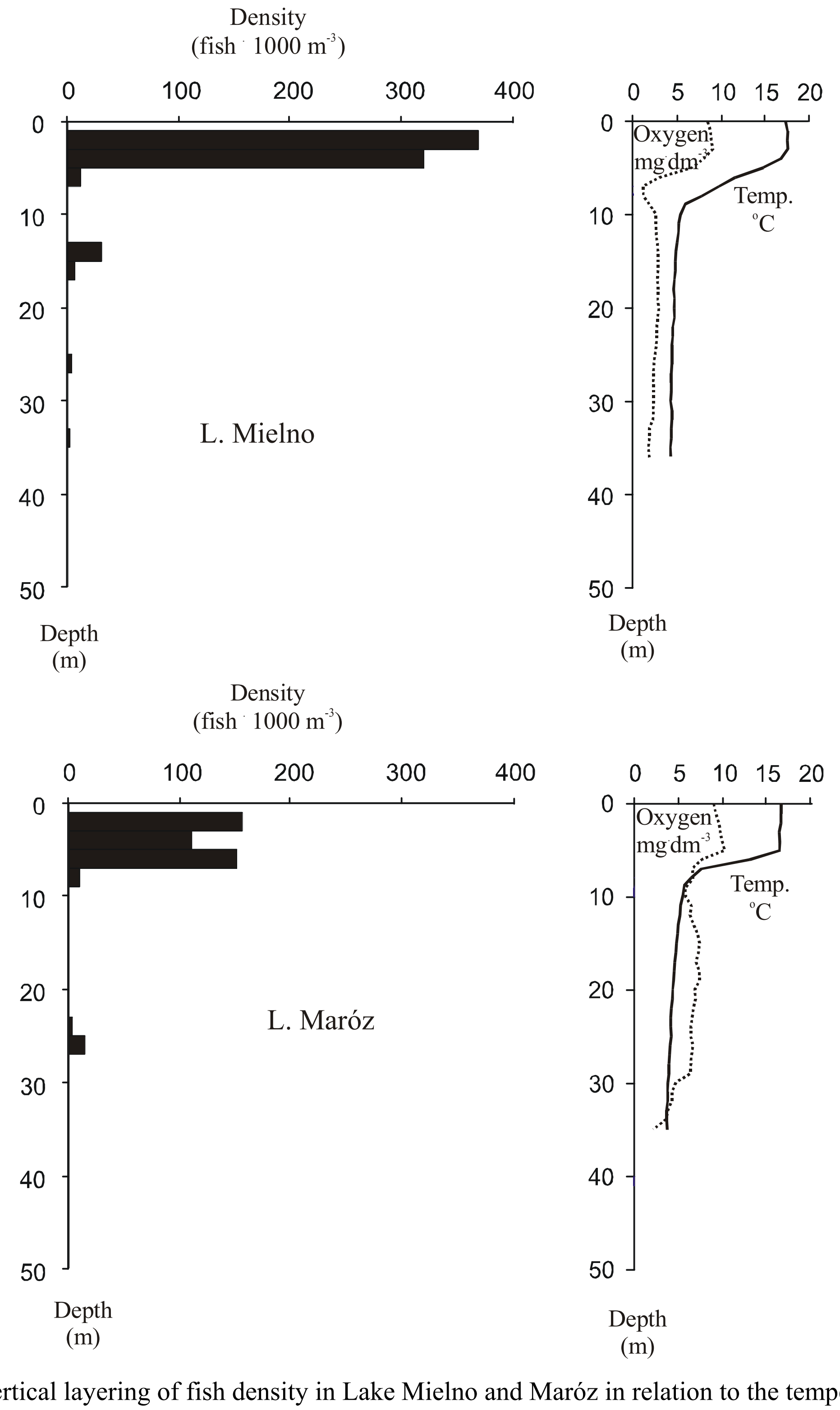
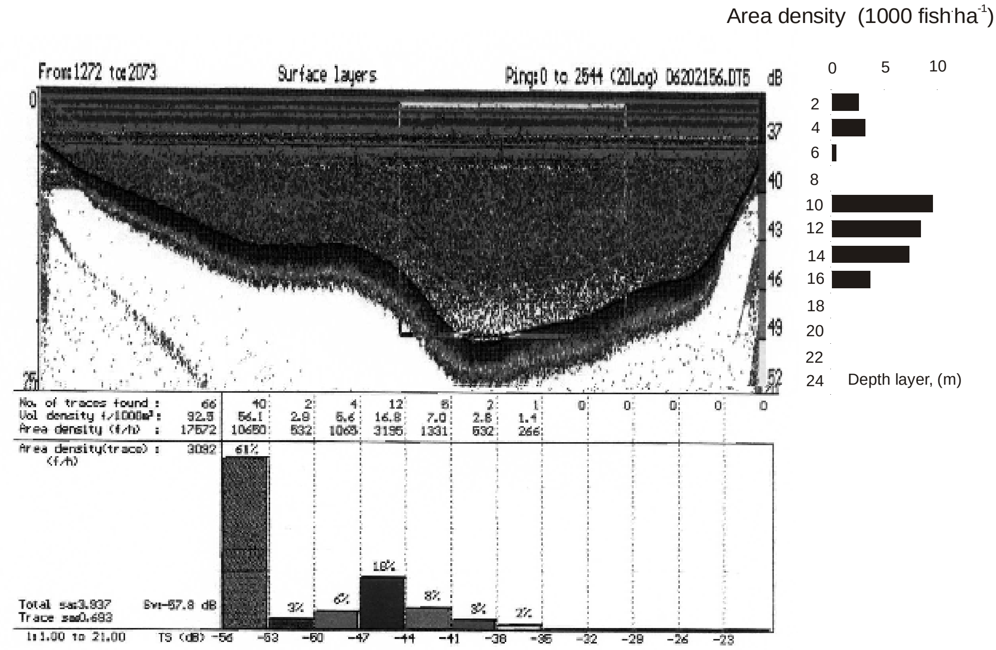


Fig.4 Vertical layering of fish density in Lake Mielno and Maróz in relation to the temperature distribution and oxygenation of the water column

The analysis of the echogram from the same area of Lake Maróz indicates that during a period of about two hours (from 21:56 to 23:47 CET) a migration of organisms to the surface was recorded as was an approximate two-fold increase in their density. The share of this agglomeration comprised of the smallest organisms (zooplankton and *Chaoborus*) with a target-strength (TS) of up to -53 dB was 60%.



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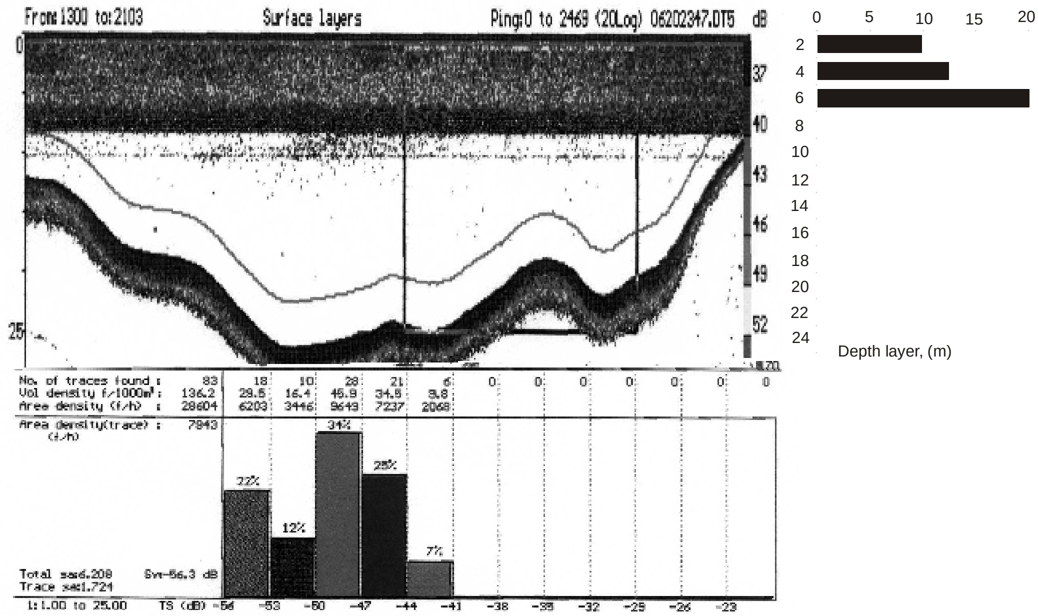

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Fig.5 Illustration of distribution, density and structure of TS (dB) in the same part of Lake Maróz in the CET 21:56 and 23:47

Publications on this topic indicate that the TS of larval insects ranges from -70 dB to -50 dB depending on body length and the applied frequency. Predatory *Chaoborusa* larvae usually settle in the bottom sediments during the day and migrate towards the surface after crustaceous plankton which are both under the same chemical influence [7, 24]. Both of these planktonic forms are feed for planktivorous fish. An especially valuable food are *Chaoborus* stage IV larvae and pupae, which occur at very high densities (at an average of several to 100,000 specimens per m^2) especially in eutrophic and dystrophic lakes [6, 8, 9]. *Chaoborus* and fish, especially their juvenile forms, both consume large quantities of crustaceous plankton that help to prevent phytoplankton blooms that are harmful to the environment [1, 3, 4, 12, 13, 14, 16, 25, 26, 27].

The abundance of pelagic fish in Lake Mielno was estimated to be 1.04 million at a mean density of 2937 fish·ha^{-1} and a biomass of 60.7 kg·ha^{-1}, including vendace at 8.4 kg·ha^{-1}. The monitoring catches were dominated by roach at 56.2% and bleak at 37.5%, while vendace comprised just 4.6%. The mean body length of the 49 vendace caught was TL 19.9 cm (±1.0), and the mean specimen weight was 61.9 g (±10.7). Commercial catches of vendace in 1992 were 12.9 kg·ha^{-1}, and then in 1997-2000 they fell to 0.3 kg·ha^{-1} as they did in 2004 (Tables 1 and 2, Fig. 1).

Tab.1 Characteristics of control catches by pelagic trawl in lakes Maróz and Mielno in 2005 year

Species	**Numbers N**	**CPUE**		**Mean body lenght TL (SD) in cm**	**Mean ind. weight W (SD) in g**
		fish·min^{-1}	**%**		
Lake Maróz					
Vendace	-	-	-	-	-
Roach	445	13,5	44,0	12,7(3,3)	22,1(14,2)
Bleak	543	16,4	53,4	13,2(1,4)	16,9(5,0)
Bream	13	0,4	1,3	12,8(5,2)	32,8(46,1)
Perch	3	0,1	0,3	12,6(2,2)	25,4(11,9)
Other	10	0,3	1,0	-	110,0(101,7)
Total	**1014**	**30,7**	**100,0**	**-**	**20,3(17,9)**
Lake Mielno					
Vendace	49	2,3	4,6	19,9(1,0)	61,9(10,7)
Roach	599	28,5	56,2	11,9(2,8)	17,8(10,4)
Bleak	399	19,0	37,5	12,8(1,6)	15,2(4,5)
Bream	6	0,2	0,6	15,6(7,1)	68,2(97,3)
Perch	7	0,3	0,7	11,8(1,8)	18,8(7,8)
Other	4	0,2	0,4	-	388,7(269,1)
Total	**1064**	**50,5**	**100,0**	**-**	**22,4(69,5)**

The characteristics of control catches made with a pelagic trawl are presented in Table 1. Since the length of the monitoring catches varied in the epilimnion and hypolimnion, this data was converted to CPUE (specimen·min^{-1}) and are presented in Table 2. The abundance, species structure, and specimen weight were used to estimate the biomass of the fish species inhabiting the pelagic zone. The largest shares were of roach in Lake Mielno at approximately 48.4% (29.4 kg·ha-^{1}) and in Lake Maróz at 47.8% (29.0 kg·ha-^{1}) and by bleak at 27.6 and 44.3%, respectively.

In both Lake Maróz and Lake Mielno, the abundance of pelagic fish was estimated to be 1.05 million at a mean density of 2982 kg·ha^{-1} and an identical mean biomass of 60.7 kg·ha^{-1}. In monitoring catches (conducted in different water layers at depths ranging from 1.5 to 15.5 m) bleak dominated at 53.4% and roach at 44.0% for a combined total of 97.4%. No vendace were noted in either monitoring or commercial catches. In total, the fish biomass in the pelagic zone was estimated to be 60.7 kg·ha-^{1} in both lakes (Tables 1 and 2, Fig. 1).

Tab.2 Characteristics of fish resources from acoustic – fishing data in lakes Maróz and Mielno in 2005 year

Species	**Numbers**			**Biomass**			
	Ind.x1000	**%**	**Density fish·ha^{-1}**	**Mean ind. weight (g)**	**Total (kg)**	**%**	**kg·ha^{-1}**
Lake Maróz							
Roach	464,4	44,0	1311,9	22,1	10263,2	47,8	29,0
Bleak	563,6	53,4	1592,1	16,9	9524,8	44,3	26,9
Bream	13,7	1,3	38,7	32,8	449,4	2,1	1,3
Perch	3,2	0,3	9,0	25,4	81,3	0,4	0,2
Other	10,6	1,0	29,9	110,0	1166,0	5,4	3,3
Total	**1055,5**	**100,0**	**2981,6**	**-**	**21484,7**	**100,0**	**60,7**
Lake Mielno							
Vendace	47,8	4,6	135,0	61,9	2958,8	13,8	8,4
Roach	584,3	56,2	1650,6	17,8	10400,5	48,4	29,4
Bleak	389,9	37,5	1101,4	15,2	5926,5	27,6	16,7
Bream	6,2	0,6	17,5	68,2	422,8	2,0	1,2
Perch	7,3	0,7	20,6	18,8	137,2	0,6	0,4
Other	4,2	0,4	11,9	388,7	1635,5	7,6	4,6
Total	**1039,7**	**100,0**	**2937,0**	**-**	**21481,3**	**100,0**	**60,7**

3. CONCLUSIONS

In recent years significant changes have occurred in the structure of the pelagic ichthyofauna of the studied lakes; the coregonids (vendace) have disappeared and cyprinids (roach and bleak) have become dominant, which indicates an increased tempo of eutrophication.

The environmental behavior of vendace and the dramatic decline in resources of them can be a reliable index of the declining water quality of this type of lake ecosystem.

Limiting the pollution from resorts and the waters of the Marózka River combined with a stocking program would probably permit increasing the proportion of vendace in these lakes.

The nighttime density of fish in the epilimnion was due to the vertical migration of a large quantity of plankton and *Chaoborus larvae*, and not, as is usual, the higher oxygen content in comparison with the hypolimnion.

The seasonal occurrence of large concentrations of plankton and *Chaoborus* larva sometimes pose a problem, as in the current study, when estimating fish resources, which requires further investigation.

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