SPATIAL VARIATION IN THE OCCURRENCE AND DENSITY OF PELAGIC FISH IN LAKE LANSK: MONITORING WITH HYDROACOUSTIC AND CATCH METHODS

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The study was conducted in Lake Lansk (surface area - 1042 ha, maximum depth - 53 m), in which the former dominant was vendace. Commercial catch results from the past decade indicate that there has been a seventy-two-fold decreased in vendace stocks. Hydroacoustic estimates indicate that there are 7.9 million fish in the pelagic zone. Approximately 93% of these inhabit the epilimnion (6.8 thousand fish·ha^{-1}), which is 7.6 times larger than that in the hypolimnion. There were 2.5 times fewer fish in a similarly sized southern region of the lake in 2004 than in 2001. Using the numbers, species structure, and individual weight, the biomass of the fish inhabiting the pelagic zone was calculated at 194.7 kg·ha-^{1}. The largest share was of vendace at 45.7% (89.0 kg·ha-^{1}), followed by roach at 18% (35.0 kg·ha-^{1}) and bleak at 13.1% (25.5 kg·ha-^{1}). The share of 0^{+} age group vendace was determined to be 70%. This might explain the decrease in commercial vendace catches caused by poor environmental conditions and overfishing. It also forecasts an improvement in resources of this species in the coming years.

INTRODUCTION

The investigation was conducted in the mesotrophic Lake Lansk (surface area - 1042 ha; maximum depth - 53 m; Figure 1) located in the Warminski Lake District in eastern Poland. The decided ichthyofauna dominant ten to fifteen years ago was the planktivorous vendace (*Coregonus albula* L.). The results of commercial catches over the past decade indicate that resources of vendace have decreased drastically from 28.8 kg·ha^{-1} in 1991 to 0.4 kg·ha^{-1} in 2001, which is a decline of more than seventy-two fold despite annual stocking at a similar level (Figure 2).

The aim of the investigation was to estimate current pelagic fish resources, their numbers, species structure, and biomass and to determine the vertical and horizontal distribution and density of fish in the lake's northern and southern basins. Vendace was also

evaluated as a bioindicator of aquatic quality, as has been suggested by investigations in other vendace-type lakes [1, 2, 3, 7, 9].

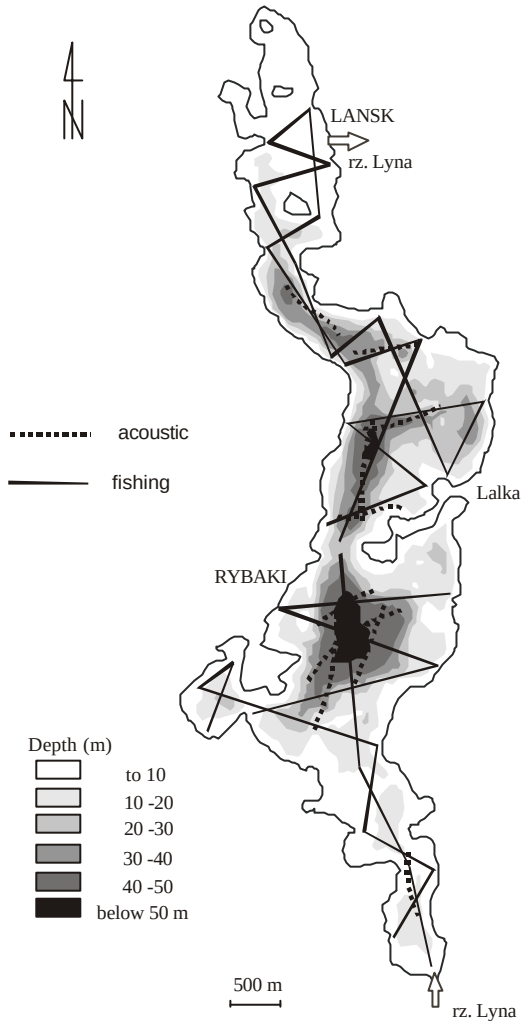

Fig.1. Lake Lansk – bathymetry and acoustic survey and trawl catch routes

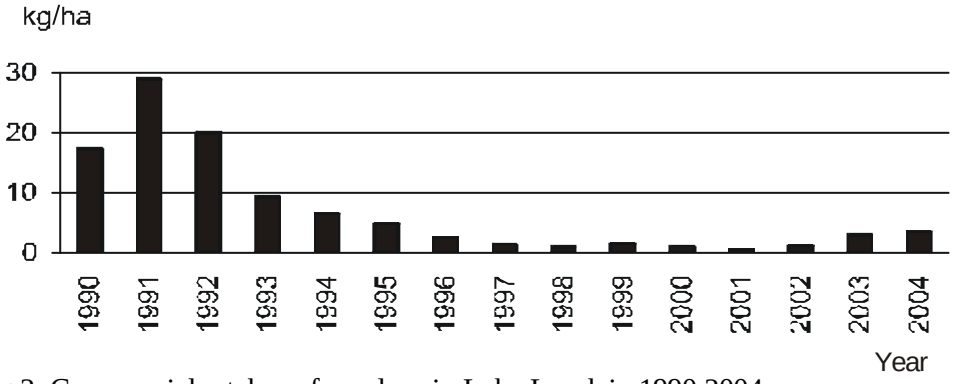

Fig.2. Commercial catches of vendace in Lake Lansk in 1990-2004

1. METHODS

The acoustic surveys were conducted in a zig-zag pattern at night, when fish dispersion and layering were simultaneously the most pronounced, along previously determined SIMRAD EY-500 (120kHz, 7x7 deg, 0.3 ms – split beam version) echosound routes. The EP-500 and SURFER programs were used to develop distribution and density maps in various water layers, and also to calculate fish numbers in the investigated area. In order to identify species and describe the size structure of the fish, control catches were made with a pelagic trawl in depths ranging from 2.5 to 37.8 m at four water depth layers. The surface area of the trawl inlet was $11m^2$ and filtration was 850 $m^3 \cdot min^{-1}$ at a trawling speed of $77m \cdot min^{-1}$. A total of 1,111 fish were caught in ten night hauls. Each fish was measured for TL (cm) and weighed (g). This, in addition to the acoustic determinations of number, the species structure percentages of the catches, and the determination of mean individual weight, permitted estimating the total biomass of all the fish and that of the various species

2. RESULTS AND DISCUSSION

The acoustic surveys indicated that the average total density throughout the lake was 7.9 thousand $fish \cdot ha^{-1}$. The majority (93%) inhabited the epilimnion, with 1.25 times more fish in the southern part of the lake than in the northern part. The density of fish in the shallower, warmer, more oxygenated epilimnion was 6.2 times higher than in the deeper hypolimnion. This difference was especially pronounced in the southern part of the lake, which is enriched with nutrients from the inflow of the Lyna River. In this case, the average density of fish in the epilimnion was ten times higher than in the hypolimnion thanks to the exceptionally large share of cyprinid fishes. The distribution and density of pelagic fish in the hypolimnion was similar in both distinct parts of the lake (Table 1, 3; Figure 4).

Tab.1. Number (N) and density of pelagic fish ($fish \cdot ha^{-1}$) in the epilimnion and hypolimnion of the northern (A) and southern (B) parts of Lake Lansk

Parts	Epilimnion				Hypolimnion				Total			
	N x 1000	%	Area (ha)	fish $\cdot ha^{-1}$	N x 1000	%	Area (ha)	fish $\cdot ha^{-1}$	N x 1000	%	Area (ha)	fish $\cdot ha^{-1}$
North (A)	2 977	89,4	516	5 769	353	10,6	380	929	3 330	100,0	516	6 453
South (B)	4 390	95,1	571	7 688	224	4,9	291	770	4 614	100,0	571	8 081
Total	**7 367**	**92,7**	**1 087**	**6 784**	**577**	**7,3**	**671**	**860**	**7 944**	**100,0**	**1 087**	**7 308**

Estimates from hydroacoustic surveys indicated that there were 2.5 times more fish in comparable parts of the southern basin of the lake in 2004 than in 2001, when commercial catches were exceptionally low at the lowest recorded levels in a fifteen-year period (Figures 2 and 5).

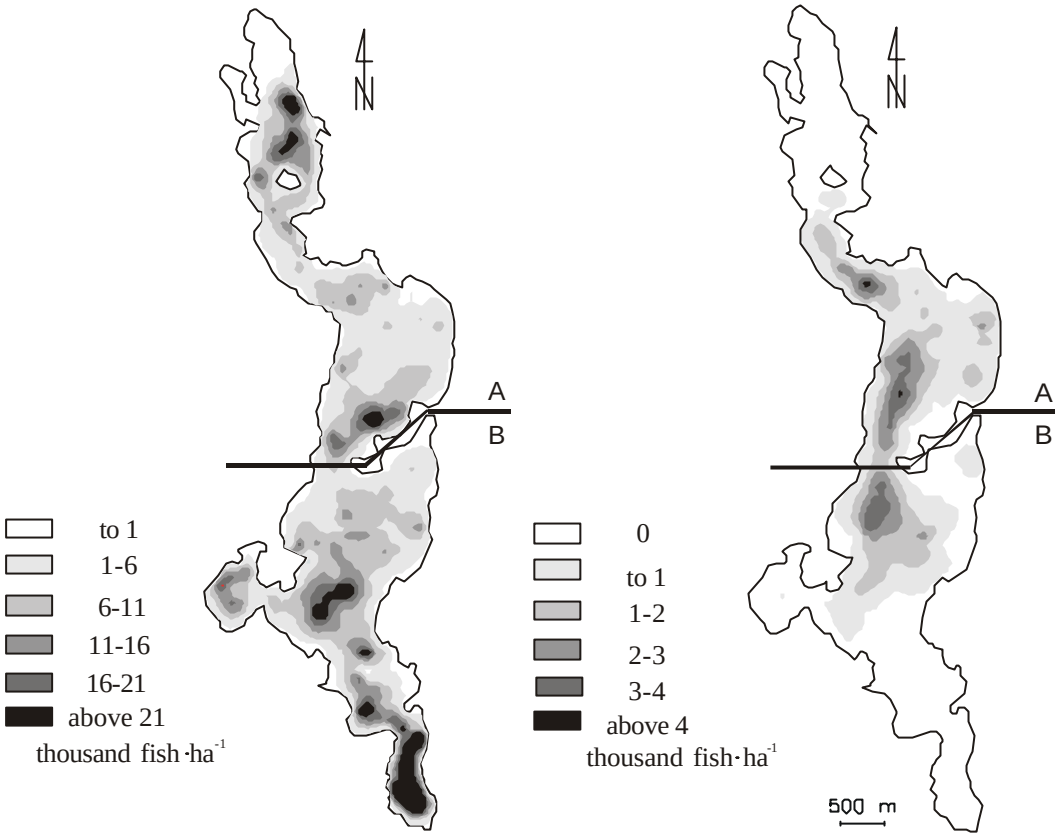

Fig.3. Distribution and density of fish in the epilimnion and hypolimnion of the northern (A) and southern (B) parts of Lake Lansk.

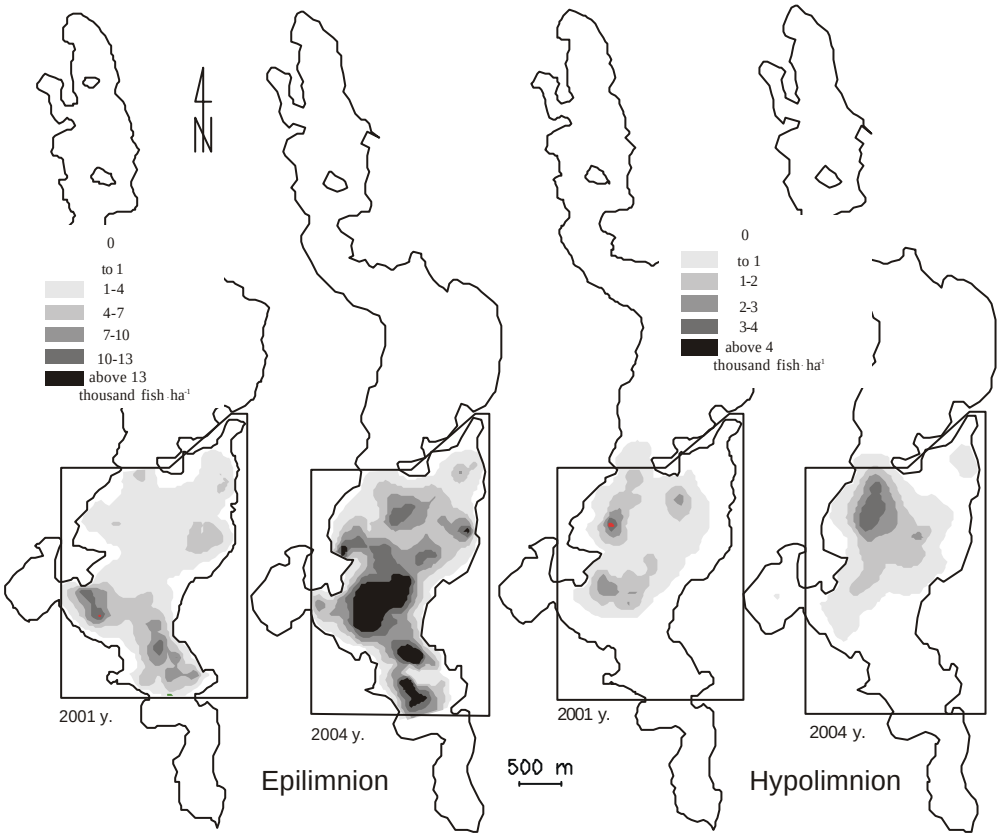

Fig.4. Distribution of pelagic fish stocks in 2001 and 2004 in the epilimnion and hypolimnion of comparable areas of Lake Lansk.

The fish density in vertical layers in both parts of the lake was similar; however, in the south (B), the oxygen content in the hypolimnion was 33% higher. The oxygenation of the hypolimnion in both parts of the lake was sufficient and higher than in the neighboring Lake Pluszne [4, 7, 8, 10, 11].

The overall size structure of vendace individuals in Lake Lansk was characterized by a 70% share of 0+ age group fish measuring TL = 10-14 cm. In the northern part of the lake these fish comprised 55%, while in the southern part - as much as 80%. In other vendace lakes these fish usually comprise approximately 30% [1, 2, 3, 4, 6, 11]. The relatively small share of older age groups in the vendace population might stem from poor environmental conditions caused by anthropogenic pollution from recreational facilities, or trout cultivation in the upper reaches of the Lyna combined with the pressure of commercial catches. The large share of 0+ age group vendace forecasts an improved situation in the coming years (Figure 6).

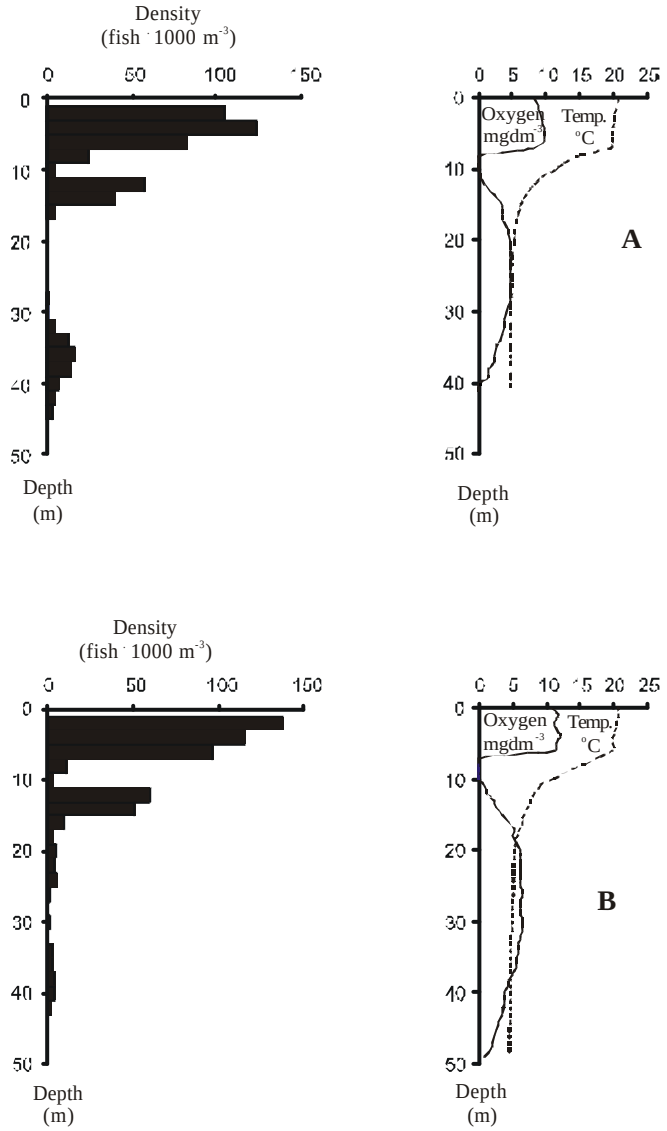

Fig.5. Vertical layering of fish density in the northern (A) and southern (B) parts of Lake Lansk in relation to the temperature distribution and oxygenation of the water column.

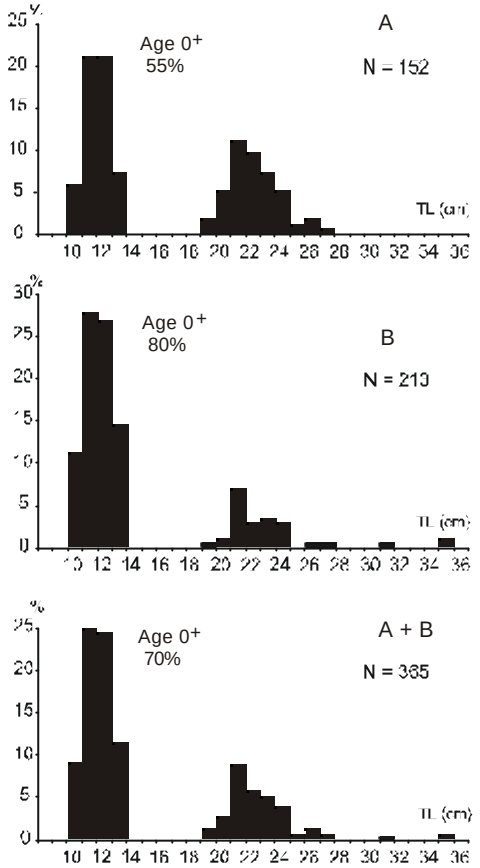

Fig.6. Size structure of vendace TL (cm) caught with a pelagic trawl in the northern (A), southern (B), and combined (A+B) areas of Lake Lansk.

The calculated CPUE indicated that the numerical dominants in the epilimnion were roach (40.4%), bleak (24.7%), and bream+silver bream (19.6%), while the share of vendace was 6.4%. In the hypolimnion, however, the dominants were vendace (60.3%), bleak (16.3%), and roach (13.3%). Overall, in the epilimnion the CPUE was 2.4 times higher (23.5 ind.·min^{-1}) than in the hypolimnion (9.8 ind.·min^{-1}) (Table 2).

Tab.2. CPUE of control catches made with a pelagic trawl in Lake Lansk

Species	**Epilimnion**		**Hypolimnion**		**Total**	
	ind.·min^{-1}	**%**	**ind.·min^{-1}**	**%**	**ind.·min^{-1}**	**%**
Vendace	1,5	6,4	5,9	60,3	4,6	33,1
Smelt	-	-	0,2	2,0	0,2	1,4
Bleak	5,8	24,7	1,6	16,3	2,9	20,9
Perch	2,0	8,5	0,2	2,0	0,7	5,0
Roach	9,5	40,4	1,3	13,3	3,7	26,7
Bream	4,6	19,6	0,4	4,1	1,6	11,5
Other	0,1	0,4	0,2	2,0	0,2	1,4
Total	**23,5**	**100,0**	**9,8**	**100,0**	**13,9**	**100,0**

The results of control catches made with a pelagic trawl confirmed the trend detected in the data from the hydroacoustic surveys of the lake. Simultaneously, a certain degree of overestimation of fish resources with acoustic methods was detected in comparison with the results of control catches made with the pelagic trawl, assuming an effectivity rate of 50%) (Tables 1 and 2).

Based on the number, species structure, and individual weight, the biomass of fish inhabiting the pelagic zone was estimated. The highest shares were of vendace 45.7% (89.0 kg·ha-^{1}), roach 18% (35.0 kg·ha-^{1}), and bleak 13.1% (25.5 kg·ha-^{1}). The total fish biomass for the pelagic zone was estimated at 194.7 kg·ha-^{1}(Table 3).

Tab.3. Fish number and biomass in the pelagic zone of Lake Lansk estimated with the acoustic-catch method

Species	Numbers x 1000	%	Mean ind. weight (g)	Biomass		
				kg	%	kg·ha^{-1}
Vendace	2 629,5	33,1	35,3	92 821,3	45,7	89,0
Smelt	111,2	1,4	12,9	1 434,5	0,7	1,4
Bleak	1 660,3	20,9	16,0	26 564,8	13,1	25,5
Perch	397,3	5,0	14,1	5 600,5	2,8	5,4
Roach	2 121,0	26,7	17,2	36 481,2	18,0	35,0
Bream	913,6	11,5	12,9	11 785,4	5,8	11,3
Other	111,2	1,4	254,1	28 255,9	13,9	27,1
Total	**7 944,0**	**100,0**	**25,5**	**202 943,6**	**100,0**	**194,7**

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3. CONCLUSIONS

Controlling pollution sources and maintaining appropriate stocking programs will allow numbers of this valuable species to increase in Lake Lansk. This prognosis is based on the current 70% share of 0+ age group vendace and, presently, that there is no indication the environmental quality of the lake will decline; this refers primarily oxygen deficits in the hypolimnion. This investigation confirmed, yet again, that the environmental behavior of the vendace is a reliable indicator of the quality of this type of lacustrine ecosystem.

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