

**THE EFFECT OF THE SEASONAL CHANGES OF ENVIRONMENT
ON THE HYDROACOUSTICALLY MONITORED SPATIAL
DISTRIBUTION AND DENSITY OF VENDACE (*Coregonus albula* L.) IN
PLUSZNE LAKE**

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Vendace (Coregonus albula L.) is an ecologically important element in the ecosystem of low trophy deep lakes. Investigations were carried out in Pluszne lake (surface area 900 ha, maximal depth 51 m) using Simrad EY-M (70 kHz) and EY 500 split beam (120 kHz) echosounder. Fish species identification was based on pelagic trawling. Water temperature and dissolved oxygen content were measured at 1 meter depth intervals. In June oxygen saturation of the upper hypolimnion reached nearly 100% while in October it dropped to 8% and approached the sublethal level for fish. The autumnal thermal and oxygen stratification caused that 80% of the fish became trapped in 10 m water stratum. The 20-fold decrease in the living and feeding space area for coregonids in autumn was the likely cause of their weakened condition and low reproduction. This happens directly preceding spawning and is the probable cause of decreased occurrence, or even disappearance of coregonids from many lakes.

INTRODUCTION

Accelerated eutrophication of waters threatens both the environment and fish husbandry. Changes in the composition of fish communities are indicators of environmental changes. Appropriate control of the structure and density of ichthyofauna might bring about the slowing down of eutrophication [5].

Vendace (*Coregonus albula* L.) is an ecologically important element in the ecosystem of deep oligotrophic lakes, where it inhabits colder water of the hypolimnion. The densities of vendace fluctuate considerably and are determined by the success of natural spawning, by the level and frequency of stocking with fry, and by the trophic conditions during the early stages of development [1, 3]. It is supposed, that drastic or long lasting changes in environmental

conditions cause evident changes in the fish behaviour, which might be considered as an early warning system for destruction of the aquatic ecosystem.

The purpose of the study has been an attempt to find the relationship between the physical-chemical conditions of the environment and the distribution, density, and population dynamics of vendace. This would allow to determine the role, importance, and behaviour of a typical plankton feeding fish in the process of lake eutrophication. Quick and effective method of estimation of fish resources and population dynamics are the hydroacoustic measurements performed together with the control net catchment of fish [4,6,10,11].

1. STUDY AREA AND METHODS

Investigations were done in June and October 2000 in the major part (600 ha) of lake Pluszne having the total surface area of 900 ha and maximal depth of 51 m. Acoustic survey was done at night along the „zyg-zag” transects (Fig.1).

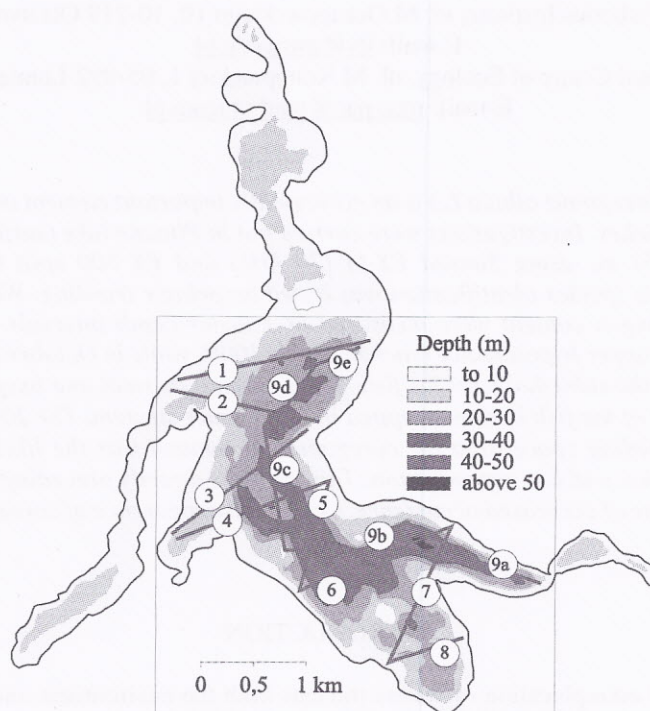


Fig.1 Bathymetric map and position of the acoustic transects in Lake Pluszne.

Two echsounders were used simultaneously: Simrad EY-M with a single beam 70 kHz and Simrad EY-500 split beam 120 kHz at TVG 40 log R. The registered fish signals were analysed using the HADAS [7] and EP-500 programmes. Fish densities were calculated in the several water strata and water segments along the investigated route. Interpolation of data allowed to draw the fish density distribution charts. The methods applied are described in [6,7,8,10]

In order to identify the species and size structure of fish, the control pelagic catchments were made at different depths. The fish were measured and weighed individually. Water temperature and dissolved oxygen content were determined at 1 m intervals between the surface and bottom using the OXI 196 (WTW).

2. RESULTS AND DISCUSSION

During the last 10 years the annual stocking of Pluszne lake with vendace fry varied from 7 to 32 million hatch with the average of 10.5 million. Catchments in this period ranged between 4.8 and 24.2 kg ha⁻¹, with the annual average of 10.7 kg ha⁻¹. Fluctuations in vendace catchments result from differences in the success of natural spawning and fry stockings, and also from differences in the richness of feeding grounds during the period of the hatch growth and development [1,2,3,10]. For this reason the catchment fluctuation can not be considered as a direct warning of the intensification of eutrophication processes in the lake ecosystem. On the other hand, essential changes in vendace behaviour, its allocation, dispersion, aggregation, and related migrations might be considered as warning signals.

As shown by the control trawl fishing, the hypolimnion of lake Pluszne is inhabited by one year old, or older *Coregonus albula*. Its contribution in the spring was 82.0 %, and in autumn 99.3 %. Additionally, the lake's pelagial was inhabited by smelt (*Osmerus eperlanus* L.) and roach (*Rutilus rutilus* L.), Tab.1.

Table 1 Seasonal changes of control fishing in Lake Pluszne. (N – numbers, W±SD – average individual weight, M – young-of-year, D – two-year-old and older)

Species	Spring			Autumn		
	N	%	W±SD (g)	N	%	W±SD (g)
Vendace M	15	2,8	3,6± 1,1	-	-	-
Vendace D	433	82,0	56,8±10,2	1023	99,3	56,4±22,9
Smelt M	50	9,5	0,3± 0,0	-	-	-
Smelt D	3	0,6	21,2± 4,4	3	0,3	24,5± 2,6
Roach	23	4,4	29,3± 8,3	4	0,4	40,0± 4,7
Others	4	0,7	9,2± 7,9	-	-	-
Total	528	100,0	-	1030	100,0	-

Seasonal variation in the vertical distribution of fish in the water column resulted from distinct differences in the distribution of temperature and dissolved oxygen. In June the oxygen content in the hypolimnion, at 20 m was 12 mg dm⁻³, at oxygen saturation of 100 %, while in October it was scarcely 1 mg dm⁻³, less than 8 % saturation and close to the sublethal saturation for these species (Fig. 2). A similar phenomenon was observed in 1999 [11]. Respiration difficulties for the fishes of the genus *Coregonus* are known to occur at the dissolved oxygen content of 3.5 - 4.5 mg dm⁻³, and death may result at 1.0-2.0 mg O₂ dm⁻³[9].

In the spring in conditions of full oxygen saturation vendace were dispersed over the entire hypolimnion. During the autumnal oxygen deficiency they were forced to aggregate in the upper hypolimnion. Thus the density of vendace in autumn resulted from environmental conditions and it was 20-fold greater as compared with the spring period (Tab. 2). The autumnal oxygen-thermal stratification caused, that 80 % of vendace resources became trapped within 10 m water stratum, between 14 m and 24 m (Fig. 2 and 3).

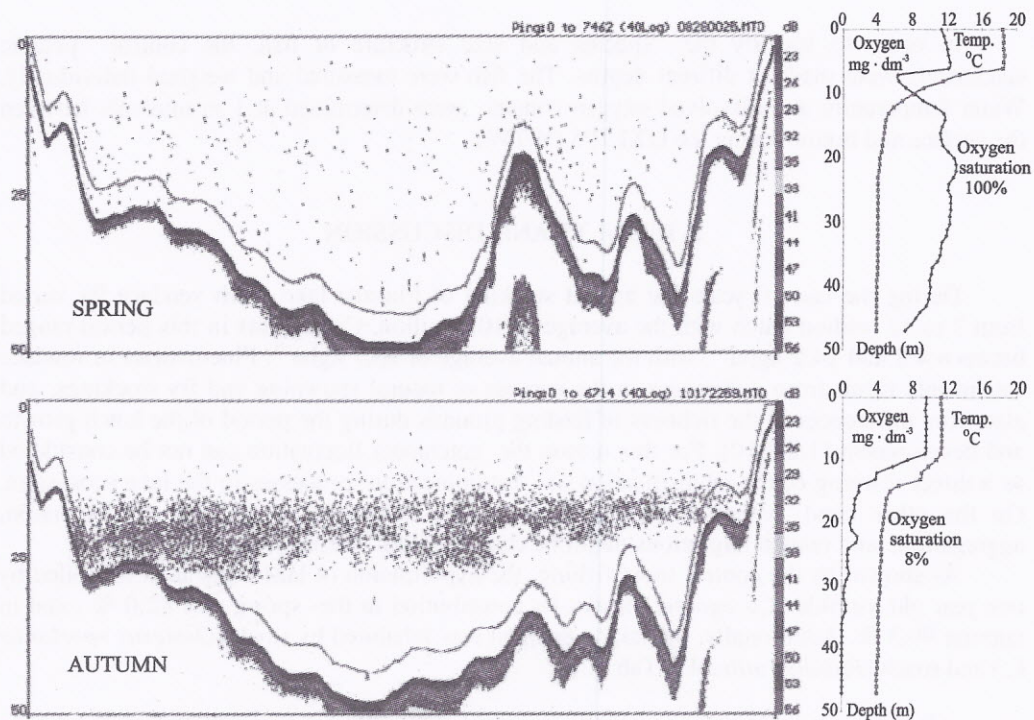


Fig. 2 Seasonal changes in vertical distribution of vendace and oxygen content and temperature in Lake Pluszne

Table 2 Seasonal changes of vendace density in the 14-24 m depth layer in Lake Pluszne

Transects No (see Fig. 1)	Pings N	Spring		Autumn		Proportion (B/A)
		fish · ha ⁻¹ (A)	fish · 1000 m ⁻³	fish · ha ⁻¹ (B)	fish · 1000 m ⁻³	
5	1000	290	2,9	5595	56,0	19,3
9b	1200	545	6,1	11026	110,3	20,2

The thermocline with the temperature difference of 6.5 C , as well as probable defence reactions against predators [3,5] must have prevented the migration of vendace either to the oxygenated epilimnion, or into deeper strata devoid of oxygen. Acoustic data on the vertical distribution of fish were verified by the results of control catchments with the use of trawl done within 5 m water strata between surface and bottom.

The more than 20-fold decrease in the living and feeding space of vendace in autumn had diminished its access to oxygen and food and caused stress that lowered the fish physiological condition and reproduction ability. These adverse conditions occurred in the period preceding the fish spawning. This explanation is the most probable when comparison is made between summer increases of individual body weight of vendace in the years 1991 and 1993 with those observed in 1999 and 2000. In the former period (1991 and 1993) in autumn two years old and older vendace had obtained the respective individual body weights of 98.6 g and 59,9 g, and its summer increases were 24,3 and 28.0 %. In 1999 the average

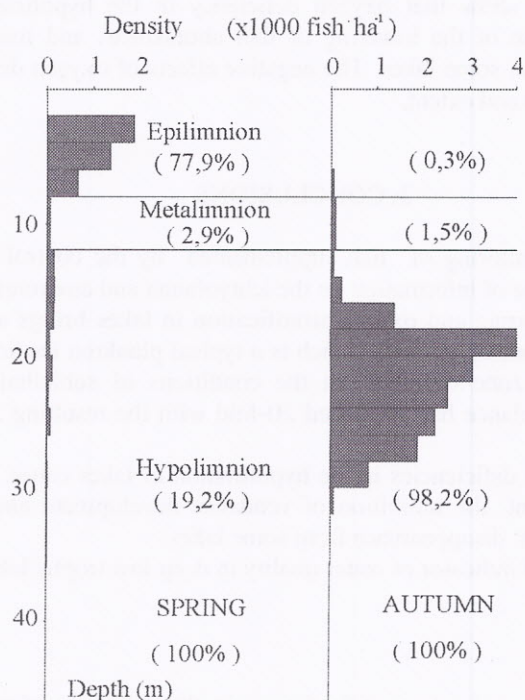


Fig.3 Seasonal changes in vertical distribution and density of pelagic fish in Lake Pluszr

Table 3 Seasonal growth of individual weight of vendace in Lake Pluszne. (N – number, $W \pm SD$ – average individual weight, M – young-of-year, D – two-year-old and older)

Date (mm –yy)	Vendace M		Vendace D		
	N	$W \pm SD$ (g)	N	$W \pm SD$ (g)	Growth (%)
08-91	21	$9,4 \pm 2,9$	28	$79,3 \pm 17,3$	
10-91	11	$14,2 \pm 4,9$	96	$98,6 \pm 29,3$	+24,3
07-93	-	-	369	$46,8 \pm 21,2$	
09-93	-	-	366	$59,9 \pm 29,9$	+28,0
07-99	291	$2,2 \pm 0,8$	428	$52,3 \pm 9,9$	
09-99	32	$4,8 \pm 1,5$	867	$52,6 \pm 11,5$	+0,6
06-00	15	$3,6 \pm 1,1$	433	$56,8 \pm 10,2$	
10-00	-	-	1023	$56,4 \pm 22,9$	-0,7

body weights of two years old and older vendace were lower, and the average summer increase of weight was small 0.6 %. In 2000 during four summer months the average body weight of the fish had decreased (Table3) contrary to the expected increases in weight. Investigations conducted during different years and lakes showed, that during summer the increase of individual body weight of vendace may amount to as much as 80 % of its total annual growth [2,3].

The presented data show that oxygen deficiency in the hypolimnion might be the probable and direct cause of the lowering of fish abundances and may even lead to the disappearance of vendace in some lakes. The negative effects of oxygen deficiency in the lake will depend on its duration and extent.

3. CONCLUSIONS

1/ Hydroacoustic monitoring of fish supplemented by the control catchments of fish provides an essential source of information on the ichthyofauna and environment.

2/ The autumnal thermic and oxygen stratification in lakes brings about differences in the expected usual behaviour of vendace, which is a typical plankton feeding fish that inhabits the pelagic hypolimnion zone of lakes. In the conditions of sublethal dissolved oxygen content the density of vendace had increased 20-fold with the resulting 20-fold decrease of the fish living space.

3/ Periodical oxygen deficiencies in the hypolimnion of lakes cause, depending on their timing, duration and extent, the inhibition of vendace development and growth, and may consequently cause the fish' disappearance from some lakes.

4/ Vendace is a good indicator of water quality in deep low trophy lakes

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