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THE VARIABILITY OF DISTRIBUTION AND DENSITY OF PELAGIC FISHES IN THE ROŻNOWSKI DAM RESERVOIR

Andrzej Świerzowski

The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, Poland

ABSTRACT. The distribution, density, species and size structures of the fish in the waters of the Rożnowski Dam Reservoir (area - 1100 ha; average depth - 12 m) were studied and their numbers and biomass were estimated. Hydroacoustic methods were applied and supplemented and verified with the results of control fishing. A SIMRAD EY-500 (split beam) 120 kHz, 7x7 deg echosounder was used. Maps of the spatial distribution and density of fish were prepared and the number of fish were determined in various areas and at various depths. The data indicate that there were significant differences in the number of fish in particular areas and at various times of day or night. At night fish density was over 6.3 times higher in the near-surface water layer in the backwater area than near the dam. The average fish density was 5.8 times lower during the day than at night; this is attributable to diurnal feeding and predator-avoidance migrations. The analyses of the nighttime acoustic data reveal that there are 13.5 million fish specimens in the pelagic zone of the Rożnowski Dam Reservoir. The total fish biomass was estimated based on the average unit weight of the fish caught (81.5 g) and was 1102.4 tons, or 1234.3 kg ha^{-1}. This is 30-times greater per hectare than the estimates for the Solina and Klimkówka reservoirs. Two cyprinid fishes, bleak and roach, constitute 85.8% of the number of fish and 66.3% of the biomass – for a total of 818.1 kg ha^{-1} in the Rożnowski Dam Reservoir. Stocking only predatory fish (pike, pikeperch, wells) in this reservoir must be supported. It is recommended that net catches be intensified in the backwater area, especially those of bleak.

Key words: DAM RESERVOIR, HYDROACOUSTIC, FISH DISTRIBUTION, DENSITY, CONTROL FISHING

INTRODUCTION

Accelerated water eutrophication is harmful to the environment, fisheries and angling. Changes in fish assemblages often indicate permanent and directed environmental changes. Steering the ichthyofauna composition and structure, a process known as biomanipulation, can decelerate eutrophication and the destruction of aquatic ecosystems. Biomaniupulation must be preceded by detailed studies of fish resources and dependencies at the lowest trophic levels (Colby et al. 1972, Jachner 1988, Zalewski et al. 1990, Frankiewicz 1998, Mazurkiewicz-Boroń 2000, Starmach and Jelonek 2000).

The species composition and age structure of dam reservoir ichthyofauna changes at the beginning of hydrotechnical works in the river bed and influence water quality and all the organisms in the water. The rate of change of the

ichthyofauna is the most rapid in the first three years after the reservoir has been filled. The character and rate of changes depend on the degree of eutrophication in the reservoir and the character of the fisheries and angling conducted in it (Mastyński 1985, Jelonek and Godlewska 2000, Klich 2002).

Hydroacoustic measurements combined with unselective control fishing is a fast and effective method for evaluating the structure and resources of the ichthyofauna (Świerzowski 1996, 1998, 1999a, b, 2000a, b, c, Stepnowski 2001).

The aim of the studies was to determine the state, distribution, species composition and size distribution of the ichthyofauna as well as to estimate the numbers and biomass of the fish in the Rożnowski Dam Reservoir using hydroacoustic methods verified by control fishing. The results of the studies can be used to shape the desired ichthyofauna composition and structure in this reservoir in order to halt destructive processes and to implement the rational management of both fisheries and angling. The results of this study should simplify updating the program for the rational management of the natural resources of this ecosystem and the region. This, in turn, should ensure that the biodiversity of the reservoir is appropriate, that development is sustainable and that the ecosystem is protected from ecological degradation.

STUDY AREA

The Rożnowski Dam Reservoir (Fig. 1) was built in 1942 in the valley of the Dunajec River near the town of Rożnów. The usable area of the reservoir was originally 1200 – 1500 ha, but after 60 years of exploitation it has decreased as a result of silting to about 1100 ha. Its shoreline is about 56 km long and the average depth is 12 m (Jelonek and Amirowicz 1987, Bieniarz et al. 1990, Augustyn 2001a,b,c). The reservoir is multi-functional and is used to produce electricity in the 50 MW power plant, control floods, supply potable water when deficits occur and provide opportunities for the recreational and economic development of the region.

The reservoir was stocked initially with vimba bream *Vimba vimba* (L.), carp *Cyprinus carpio* L., common bream *Abramis brama* (L.), tench *Tinca tinca* (L.), pike *Esox lucius* L., pikeperch *Sander lucioperca* (L.) and rainbow trout *Oncorhynchus mykiss* (Walb.), and then with crucian carp *Carassius carassius* (L.), roach *Rutilus rutilus* (L.) and eel *Anguilla anguilla* (L.). Since 1986 the reservoir has been stocked only with predatory fish, such as pike and pikeperch, and, from 1996, also with wells *Silurus glanis* L. Fishery was begun in the reservoir in 1944, and at that time 88.5% of the catch comprised sneep *Chondrostoma nasus* (L.)

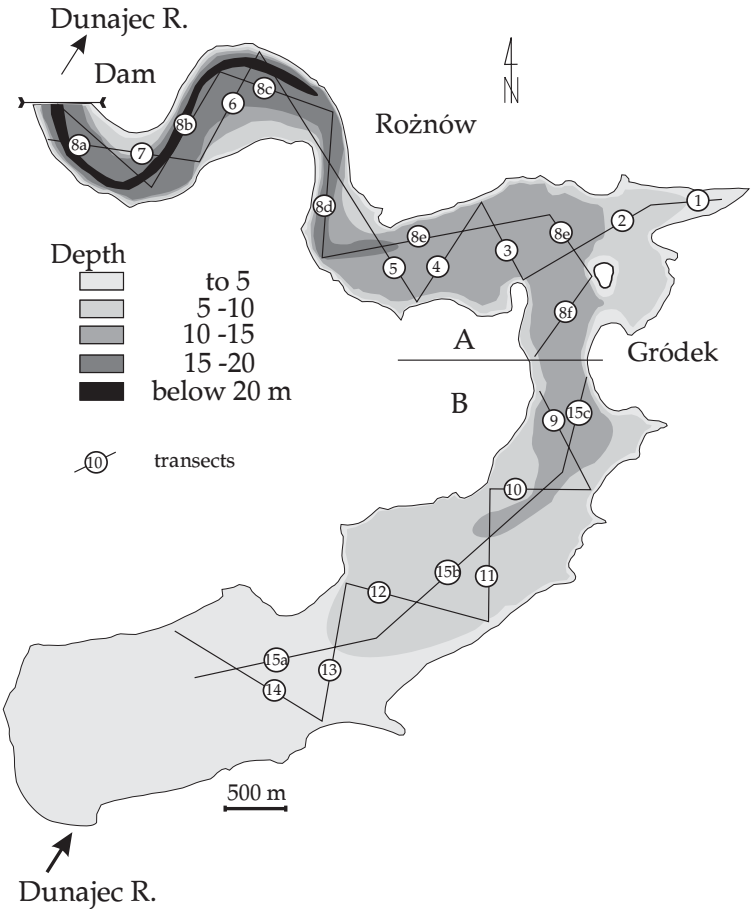

Fig. 1. Rożnowski Dam Reservoir. Bathymetry and subsequent acoustic transects near the dam (A) and backwater (B).

and 10.1% - vimba bream. Common bream quickly started to dominate the catch structure and in 1985 it accounted for 94.4% of the catches. The initial reservoir fisheries yield of 7.2 kg ha^{-1} increased to 78.2 kg ha^{-1} in the 1980s, but by 1999 it had decreased to 22.5 kg ha^{-1}. Excessive exploitation and accelerated eutrophication caused by anthropogenic, communal and agricultural factors have most likely resulted in changes in the magnitude and structure of fisheries production in recent years (Jelonek and Amirowicz 1987, Bieniarz at al. 1990, Augustyn 2001a,b,c). Currently, angling is the primary form of fishery exploitation in the Rożnowski Dam Reservoir.

MEDHODS

The study of environmental conditions was limited to measurements of water temperature and oxygen content in the water from the surface to the bottom at one station near the dam and another in the backwater. Since the spatial distribution of fish resources in aquatic ecosystems may depend largely on thermal-oxygen stratification (Świerzowski 1996, Godlewska et al. 2000b, Świerzowski 2000a,b, Świerzowski et al. 2000), temperature and oxygen content measurements were made at 1 m increments from the surface to the bottom using an EO96 sounder and an OXI 196 WTW a microprocessor oxygen meter.

The acoustic surveys were conducted in a "zigzag" pattern both during the day and at night along previously determined routes (Fig. 1). The boat ECHO was used, which is specially equipped with a log, GPS, a navigation echosounder and an engine powerful enough to haul a pelagic trawl in various water layers during control fishing. The acoustic surveys were conducted with a SIMRAD EY-500 (split beam), 120 kHz, 7x7 deg echosounder. The boat traveled at a constant speed of 5 knots during the acoustic surveys. The acoustic data set was registered on a computer in real time.

Fish density was calculated in the number of methodologically-justified water layers and segments along 23 acoustic transects (Fig. 1) using EP-500 computer data analysis software (Simrad 1999). The system of counting individual fish identified by the acoustic system was applied. The data obtained were interpolated (using the Krigingu method and the computer software SURFER Gold. Soft. Inc. 4.04.1989), and then spatial distribution and fish density maps were prepared. The number of fish in various depth layers and areas of the Rożnowski Dam Reservoir was also calculated. Detailed information regarding the methodology applied can be found in the work of MacLennan and Simmonds (1992), Stepnowski (2001) and Simrad (1999) - EP 500 Echo Processing System (1999). The results of the acoustic surveys were used to make bathymetric maps of the Rożnowski Dam Reservoir (Fig. 1) which are necessary for the proper presentation and description of the results obtained.

In order to identify the species and determine the fish size structure as well as verify the acoustic data regarding fish density, control fishing was conducted using a pelagic trawl and two, unselective sets of gill-nets. The pelagic trawl was made of netting with a mesh size of 80 mm at the inlet and 5 mm in the codend. The area of the trawl inlet was S = 11 m^2, and water filtration was F = 849.2 m^3 min^{-1} at a trawling speed of V = 77.2 m min^{-1}. Trawling was conducted near the dam at various depths. Catch per unit effort (CPUE) of the calibrated pelagic haul was calculated based on

the number and biomass of fish caught in one minute. Additionally, two 16-panel gill-net sets with a mesh bar length from 10 to 65 mm were used. The height of the gill-nets was 6 m. The caught fish were identified and measured (Lt) to the nearest 0.1 cm and weighed to the nearest 0.1 g.

The acoustic determination of fish numbers, the percentage structure of species in catches and the average unit weight facilitated evaluating biomass, both total and for particular fish species; this cannot be done on the basis of catches made with selective fishing gear.

RESULTS AND DISCUSSION

THERMAL AND OXYGEN STRATIFICATION

Measurements of temperature and oxygen content in the water from the surface to the bottom were taken on 3-4 September 2002 at one station near the dam and another in the backwater. Thermal and oxygen stratification, which is typical for lakes without an outlet at this time of the year, was not observed, and there was no thermocline. The content of dissolved oxygen in water near the backwater was high from the surface to the bottom (5 m) at 10.3 mg dm^{-3} and was 2.8 mg dm^{-3} higher than at the same depth near the dam. Oxygen content near the dam decreased significantly with depth. At 16 m it was 1.3 mg dm^{-3} and a meter below - only 0.6 mg dm^{-3}. A total lack of oxygen was observed beginning at 19 m. The Dunajec River water supplied to the reservoir near the backwater was slightly colder, by 0.9°C, than near the dam and it was well oxygenated, which may have influenced the spatial distribution of the fish (Fig. 2).

FISH DISTRIBUTION AND DENSITY

The results of acoustic and control fishing refer to the pelagic zone of the Rożnowski Dam Reservoir and thus exclude the coastal area to a depth of 3 m, the near surface layer to a depth of 1 m and the area directly above the bottom. The acoustic data were analyzed separately for the 1-4 m and 4-22 m (bottom) water layers in order to illustrate the importance of the near-surface layer in the evaluation of the distribution, density, numbers and fish biomass.

Dam reservoirs are usually characterized by significant diversity of abiotic and biotic conditions along their longitudinal axis. This variability influences the diurnal and seasonal variations of fish distribution and density and may have an influence on the paths and speed of matter circulation in the reservoir (Mastyński 1985, Zalewski et al. 1990, Frankiewicz 1998). Therefore, the whole reservoir was also divided into

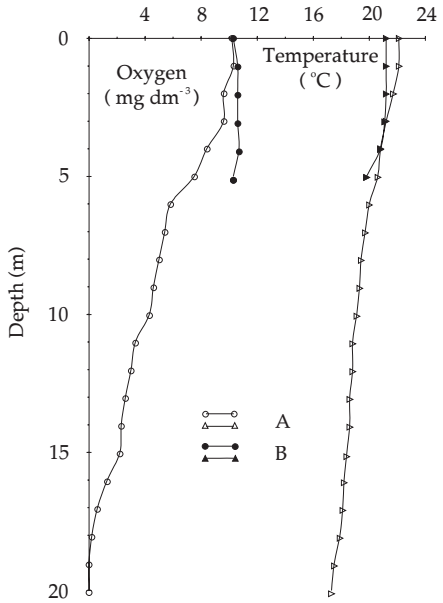

Fig. 2. Thermal and oxygen stratification near the dam (A) and backwater (B) in the Rożnowski Dam Reservoir.

dam (A) and backwater (B) regions (Fig. 1). All of the acoustic and catch data were analyzed separately for these two regions.

Table 1 and Figure 3 present the average day- and nighttime fish densities in both regions and in particular water layers. The data presented indicate that there were significant differences in fish numbers both regions and at different times. Especially significant differences between the day- and nighttime densities were observed in the near-surface water layer in the backwater region. The average nighttime fish density in the 1-4 m water layer in the backwater region was 22.6 thousand fish per ha, which was 8.5 times greater than during the daytime - 2.6 thousand fish per ha. The differences between the day- and nighttime fish densities in water layers deeper than 4 m were insignificant. In the backwater region it was 2.8 thousand fish per ha at night, i.e. only 1.2 times greater than during the day - 2.3 thousand fish per ha. The echograms in Figure 4 illustrate this phenomenon. The analysis of surface (fish per ha) and volumetric (fish per 1000 m^3) densities are also presented.

The day- and nighttime spatial distribution of fish and the density from the surface to the bottom in both of the analyzed water layers (1-4 m and 4-22 m) are presented in Figures 5 and 6. The data presented indicate that the nighttime location and density of the fish in this reservoir are determined by the upper water layer from 1-4 m. The nighttime

TABLE 1

Fish numbers and average density in the day and at night near the dam (A) and backwater (B) and in water depth layers

	Region	Depth (m)	Numbers (1000 fish)	Surface (ha)	Mean density (1000 fish ha^{-1})
Day	A	1-4	118.7	470	0.3
		4-22	251.8	463	0.5
		1-22	370.5	470	0.8
	B	1-4	1120.7	423	2.6
		4-22	857.8	373	2.3
		1-22	1978.5	423	4.7
	A+B	1-4	1239.4	893	1.4
		4-22	1109.6	836	1.3
		1-22	2349.0	893	2.6
Night	A	1-4	1702.2	470	3.6
		4-22	1200.2	463	2.6
		1-22	2902.4	470	6.2
	B	1-4	9577.8	423	22.6
		4-22	1050.2	373	2.8
		1-22	10628.0	423	25.1
	A+B	1-4	11280.0	893	12.6
		4-22	2250.4	836	2.7
		1-22	13530.4	893	15.2

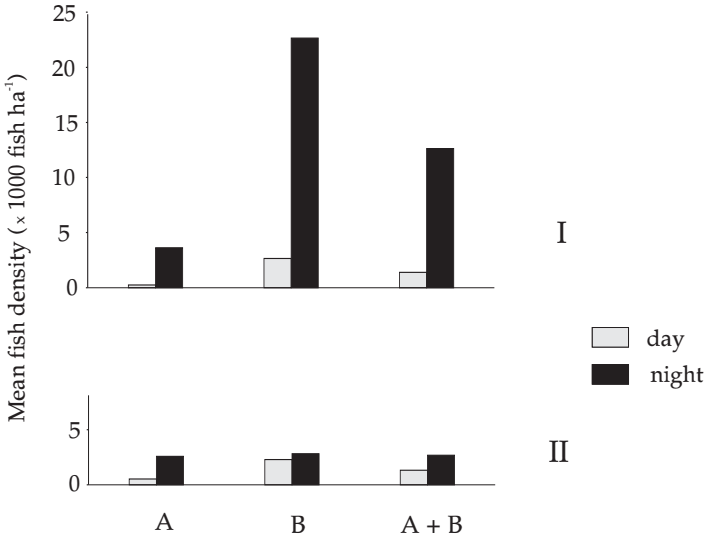

Fig. 3. Daytime and nighttime average fish densities near the dam (A) and backwater (B) in the 1-4 m (I) and 4-22 m (II) water layers of the Rożnowski Dam Reservoir.

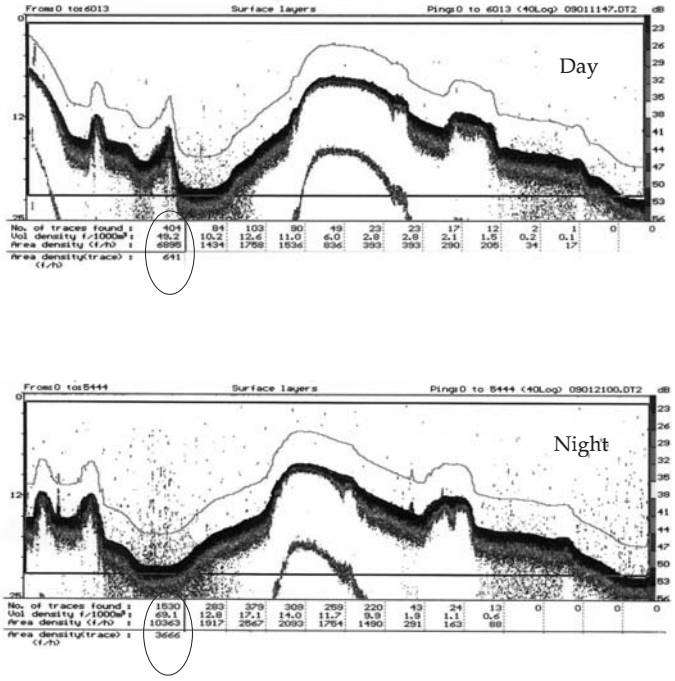

Fig. 4. Daytime and nighttime echograms and the analysis of fish density in transect No. 7 near the dam (see Fig. 1).

fish density in this water layer in the backwater region was 6.3 times higher than near the dam. During the day, the fish density near the backwater, about 2.6 thousand ha^{-1}, was 10.5 times higher than that near the dam - 0.25 thousand ha^{-1} (Table 1). This higher density of fish resulted from the better environmental and trophic conditions which are associated with the inflow of communal waters and sewage and the use of angling baits. Similar dependencies were also observed in Lake Żarnowiec, the heated Konin lakes and in dam reservoirs such as the Solina and Klimkówka (Świerzowski 1996, 1998, Godlewska et al. 2000a,b. Godlewska and Świerzowski 2001).

Hydroacoustic surveying has detected diurnal fish migrations in many lakes, including dam reservoirs such as the Solina, Klimkówka and Dobczyce (Świerzowski 1996, 1998, 1999a,b, Jelonek and Godlewska 2000). During the day, the average fish density in the pelagic zone of the Rożnowski Dam Reservoir was 5.8 times lower than at night (Table 1), which is the result of diurnal feeding and predator-avoidance migrations. Such a significant difference is related to the fact that during the day fish

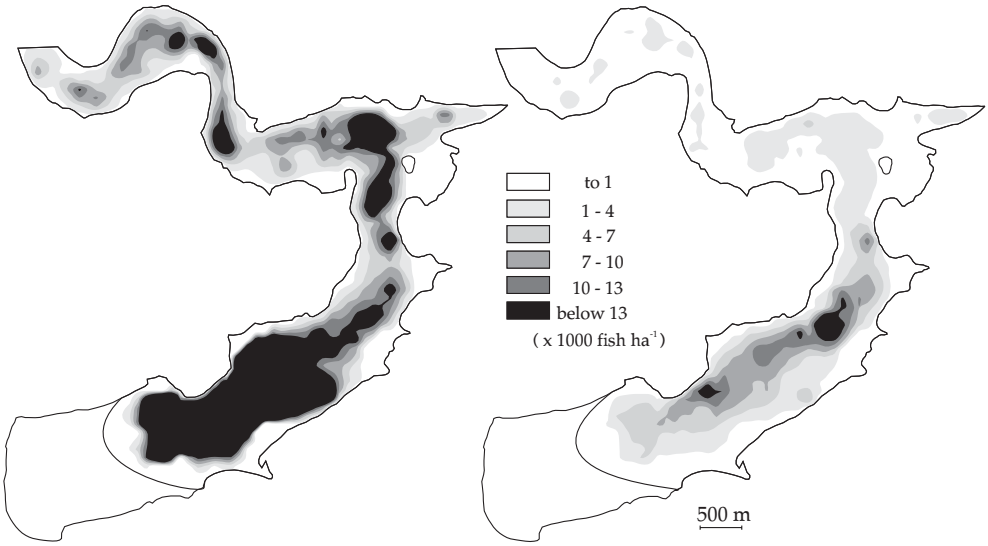

Fig. 5. Daytime and nighttime fish distribution and density throughout the water column of Rożnowski.

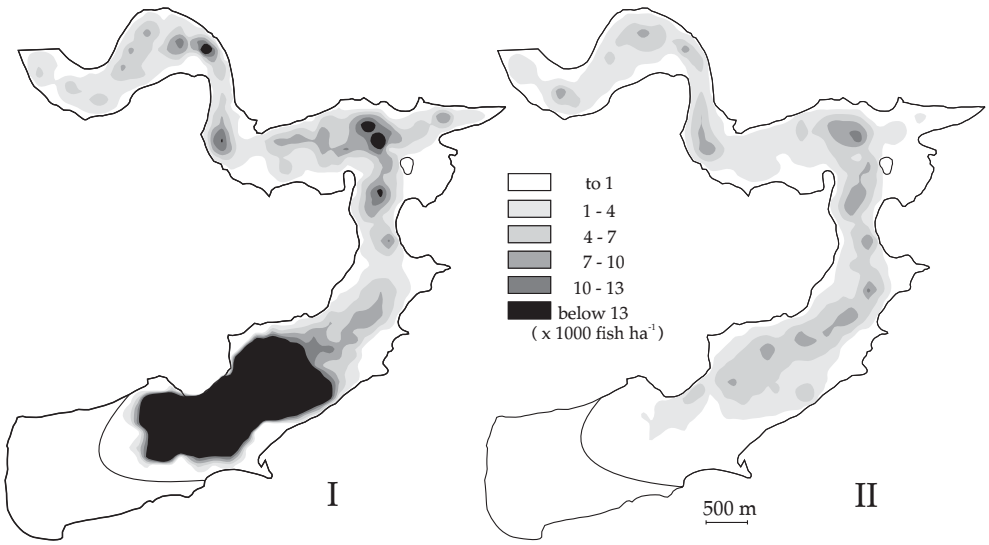

Fig. 6. Nighttime fish distribution and density in 1-4 m (I) and 4 m - bottom (II) water layers in the Rożnowski Dam Reservoir.

migrate to the coastal (too shallow) and bottom (resolution to low) zones which are outside of the range of fish echo registration by the echosounder acoustic system.

Figure 7 presents the vertical distribution and density of fish in 2 m water layers during the day and at night in both regions of the reservoir. This figure shows a typical situation – higher fish densities occur in the upper water layers, especially at night. Fish migrate at nighttime from the littoral to the pelagic zone and from deeper layers towards the surface to feed when there is less internal and external pressure from predacious fish and water birds, respectively (Jachner 1988, Gliwicz and Jachner 1992, Świerzowski 1998, 2000c, Jelonek and Godlewska 2000). Similar vertical fish distribution was observed in the Solina, Dobczycki and Klimkówka reservoirs (Amirowicz 2000, Jelonek and Godlewska 2000, Świerzowski 2003).

The average daily fish density for the entire reservoir was 2.6 thousand ha^{-1} and at night - 1.5 thousand ha^{-1} and it was much greater than in other reservoirs, i.e. 34 times higher than in the Solina and 24 times higher than in the Klimkówka. It was even higher than in over a dozen lakes investigated, with the exception of Lake Czerwonka Wlk., where it was 46.0 thousand ha^{-1} (Table 2).

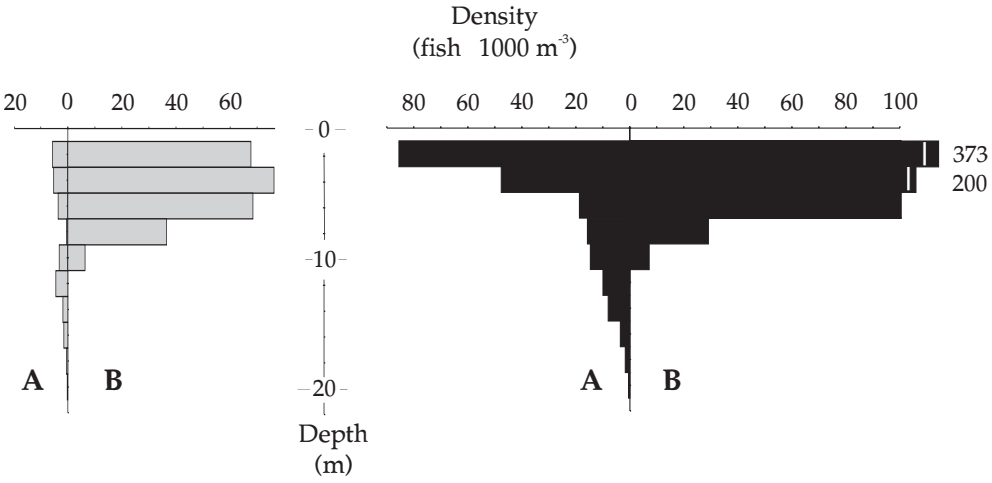

Fig. 7. Daytime and nighttime fish density in layers near the dam (A) and backwater (B) in the Rożnowski Dam Reservoir.

TABLE 2

Average surface fish density in lakes and dam reservoirs monitored with hydroacoustic methods (Świerzowski 1996, 1998, 1999ab, 2000ab, 2003)

Lake or reservoir	Surface (ha)	Date (mm-yy)	Density (1000 fish ha^{-1})
L. Pluszne	580	08.94	2.3
		06.00	3.5
		07.01	12.9
		09.01	5.9
		07.02	9.8
L. Żarnowieckie	920	06.94	0.8
	1220	09.94	2.3
L. Licheńskie	154180	06.95	5.3
		10.95	1.6
		10.97	3.1
L. Ślesińskie	148162	06.95	3.4
		10.95	1.3
		10.97	1.1
L. Wąsowskie	245264	06.95	2.4
		10.95	1.2
		10.97	3.4
L. Wulpińskie O	356	09.95	7.9
L. Wulpińskie W	295	09.95	5.3
L. Wigry N	655	08.96	6.3
L. Wigry S	1047	08.96	2.2
L. Białe Wigierskie	98	08.96	4.2
	98	09.97	6.7
L. Mamry N-O	1500	06.97	10.9
L. Mamry S-W	1000	06.97	3.5
L. Święcajty	651	06.97	2.8
L. Czerwonka Wlk.	29	06.01	46.0
R. Soliński	1554	09.99	0.4
R. Klimkówka	260	09.01	0.6
R. Rożnowski	893	09.02	15.2

ANALYSIS OF CONTROL FISHING

A total of 149 fish, 59.7% of roach and 30.9% of bleak *Alburnus alburnus* (L.), were caught using pelagic trawls at different depths. Catches were made along the axis of the reservoir in the 4-8 m and 12-16 m water layers at a total time of 38 minutes. During this time 32 thousand m^3 of water were "filtered", so the catch effort was 4.6 fish per 1000 m^3, and the CPUE - 3.9 fish per minute. Assuming that under such conditions trawl catch effectiveness was 33%, then the fish density in the area was about 13.9 fish per 1000 m^3.

A total of 253 fish were caught using gill-nets, including 53% roach and 42.6% bleak near the dam. A total of 1486 fish were caught in the central area using gill-nets, which included 70.4% bleak and 21.9% roach. A total of 2147 fish were caught in the central area and near the backwater using gill-nets, including 56.4% bleak, 27.8% roach, 6.3% common bream and 6.2% pikeperch.

A total of 2549 fish were caught throughout the Rożnowski Dam Reservoir using both methods – bleak comprised 53.6% of the numbers and 19.7% of the weight, roach - 32.2% and 46.2%, pikeperch - 5.7 and 14.7%, common bream - 5.5 and 16.8%, respectively. A total of 8 fish species (209 kg) were caught during control fishing (Table 3).

TABLE 3

Description of fish control fishing in the Rożnowski Dam Reservoir

Species	Numbers		Biomass		Mean body Lt (SD) cm	Mean indiv. weight (SD) g
	specimens	%	g	%		
Bleak	1365	53.6	41065.7	19.7	14.7 (2.9)	30.1 (16.4)
Roach	821	32.2	96544.6	46.2	15.8 (9.6)	117.6 (162.1)
Pikeperch	145	5.7	30680.9	14.7	20.5 (14.6)	211.6 (418.6)
Bream	141	5.5	35113.4	16.8	25.2 (9.8)	249.0 (245.3)
Ruffe *Gymnocephalus cernuus* (L.)	56	2.2	409.1	0.2	8.2 (1.8)	7.3 (6.6)
Perch	12	0.5	989.7	0.4	18.3 (3.4)	82.5 (28.9)
Rapfen *Aspius aspius* (L.)	8	0.3	3054.8	1.5	34.8 (4.4)	381.9 (117.0)
Eel	1	0.04	1085.0	0.5	-	-
Total	2549	100.0	208943.2	100.0	15.9 (7.9)	82.0 (164.7)

Fish species such as chub *Leuciscus cephalus* (L.) and pike were not present in the catches, although they were reported in catches in the Solina and Klimkówka reservoirs. During control fishing in 1999 in the Solina Reservoir with gill-nets and trawls, a total of 9 fish species were reported, with bleak constituting 44.5%, roach 23.7%, and common bream - 15.0%. In 2001 nine fish species were reported in the Klimkówka Reservoir, including 45.7% of perch *Perca fluviatilis* L., 26.2% chub and 18.4% gudgeon *Gobio gobio* (L.).

Control fishing confirmed the hydroacoustic survey data regarding vertical fish distribution and density in the waters of the Rożnowski Dam Reservoir. Table 4 shows that of a total of 2534 fish specimens, 76% were caught in the water layer to 6 m, and 24% between 6 m and the bottom. In the water layer to 6 m bleak constituted 57.6%, roach 29.3%, common bream 6.8% and pikeperch 4.4%. In the catches in the layer from 6 m to the bottom both bleak and roach constituted a similar amount at 40.9 and 40.5%, respectively, while the figures for common bream - 2.1% and pikeperch - 9.7% were much lower (Table 4, Fig. 8).

TABLE 4

Structure of control fishing in the Rożnowski Dam Reservoir in water layers to 6 m and from 6 m to the bottom

Species	Depth				Total	
	To 6 m		From 6 m to bottom			
	specimens	%	specimens	%	specimens	%
Bleak	1109	57.6	249	40.9	1358	53.6
Roach	564	29.3	247	40.5	811	32.0
Bream	131	6.8	13	2.1	144	5.7
Pikeperch	85	4.4	59	9.7	144	5.7
Ruffe	19	1.0	37	6.1	56	2.2
Perch	9	0.5	3	0.5	12	0.5
Rapfen	7	0.3	1	0.2	8	0.3
Eel	1	0.1	-	-	1	0.04
Total	925	100.0	609	100.0	2534	100.0

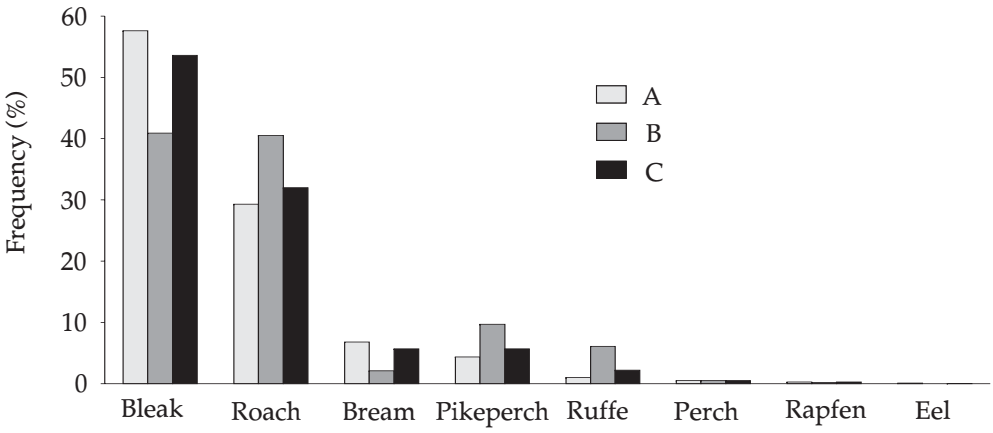

Fig. 8. Structure of fish in control fishing in the Rożnowski Dam Reservoir: A – to 6 m, B – from 6 m to the bottom, C – throughout the water column.

By comparing the CPUE (fish per minute) of pelagic trawls, the differences in fish density in studied lakes and reservoirs can be estimated (Table 5).

TABLE 5

Comparison of catches and CPUE of the pelagic trawl used in control fishing in acoustic-fishing monitoring of fish resources in lakes and dam reservoirs

Lake or reservoir	Date mm-yy	Tow number	Time (min)	Fishing		CPUE	
				specimens	biomass (g)	(fish min^{-1})	(g min^{-1})
L. Wigry S	08.96	4	47	980	19524.4	20.9	415.4
L. Wigry N	08.96	3	31	1208	49294.8	39.0	1590.1
L. Pierty	08.96	3	41	1596	19414.4	38.9	473.5
L. Białe	08.96	4	52	1162	31886.4	22.3	613.2
L. Czerwonka Wlk.	06.01	1	18	1421	26400.0	78.9	1467.0
L. Pluszne	06.01	4	32	1055	6249.9	33.0	195.3
L. Łańsk	07.01	3	18	134	1492.5	7.4	82.9
L. Pluszne	08.01	8	70	2144	55884.6	30.6	798.4
L. Pluszne	10.01	4	32	996	10605.1	31.1	331.4
L. Łańsk	10.01	4	31	65	2805.4	2.1	90.5
R. Soliński	09.99	12	254	30	7990.0	0.1	31.5
R. Klimkówka	09.01	2	60	30	1853.1	0.5	30.9
R. Rożnowski	09.02	5	38	149	2614.3	3.9	68.8

ESTIMATION OF FISH NUMBERS AND BIOMASS

The analysis of the nighttime acoustic surveys indicate that the number of fish in the pelagic zone of the Rożnowski Dam Reservoir was 13.5 million specimens at an average density of 15.1 thousand fish per ha. Using the average unit weight of the fish caught - 81.5 g, the total fish biomass was estimated to be 1102.4 tons, i.e. 1234.3 kg ha^{-1} (Table 6). This biomass figure is 30-times greater per 1 hectare than in the Solina and Klimkówka reservoirs (Świerzowski 2000a,b, 2003). The fish biomass in the Rożnowski Dam Reservoir is several times higher in comparison with the majority of the lakes studied with the same method in past decade and two times higher than in the dystrophic Lake Czerwonka Wlk. where the fish biomass in the 4 m epilimnion layer was estimated to be 605 kg ha^{-1} (Świerzowski, unpublished data). The characteristics of fish resources estimated from acoustic-fishing data in the Rożnowski Dam Reservoir are presented in Table 6. The data presented in the table indicate that in terms of biomass roach dominated - 573.7 kg ha^{-1} (46.5%), followed by bleak - 244.4 kg ha^{-1} (19.8%), common bream - 207.5 kg ha^{-1} (16.8%), pikeperch - 182.7 kg ha^{-1} (14.8%) and all other species combined - 26.0 kg ha^{-1} (2.1%).

TABLE 6

Characteristics of fish resources estimated from acoustic-fishing data in the Rożnowski Dam Reservoir

Species	Numbers			Biomass			
	specimens	(%)	Density (1000 fish ha^{-1})	mean indiv. (g)	total (kg)	(%)	(kg ha^{-1})
Bleak	7252294	53.6	8121	30.1	218294	19.8	244.4
Roach	4356789	32.2	4879	117.6	512358	46.5	573.7
Pike perch	771233	5.7	864	211.6	163193	14.8	182.7
Bream	744172	5.5	833	249.0	185299	16.8	207.5
Ruffe	297669	2.2	333	7.3	2173	0.2	2.4
Perch	67652	0.5	76	82.5	5581	0.5	6.2
Rapfen	40591	0.5	45	381.9	15502	1.4	17.4
Total	13530400	100.0	15152	81.5	1102400	100	1234.3

In order to verify the density, numbers and fish biomass which were estimated acoustically, the CPUE was compared with those attained with the same calibrated pelagic trawl in the Solina and Klimkówka reservoirs. The data presented in Table 5 indicate that the CPUE in the Rożnowski Dam Reservoir, expressed as numbers (3.9 fish per min) was 39 times higher, and expressed as biomass (68.8 g min^{-1}) was 2.2 times higher than in the Solina Dam Reservoir. In the Klimkówka Dam Reservoir the CPUE expressed as numbers (0.5 fish per min) was 7.8 times lower and expressed as biomass (30.9 g min^{-1}) was similar to that of the Solina Dam Reservoir at 2.2 times higher. Similar relations were observed for the acoustic evaluations of fish densities, numbers and biomass in many lakes (Świerzowski 1999, 2000a,b). This confirms the reliability of the evaluations, provided that the proper methods and hydroacoustic systems are used.

Based on the results of analyses of angling catches which were conducted in previous years, it was anticipated that there would be a greater contribution of common bream and perch. Once again, it was confirmed that evaluations of the structure of fish resources in reservoirs based unselective control fishing and selective angling and commercial (nets) catches differ significantly. For example, bleak dominated (44.5%) in control fishing in the Solina Dam Reservoir and gudgeon (18.4%) played an important role in the Klimkówka Reservoir; neither of these species are caught by anglers or fishermen.

In general, the fish biomass in the Rożnowski Dam Reservoir was underestimated. Firstly, the echosounder was unable to count the fish near the bottom or, more importantly, those near the shore. Secondly, to evaluate fish density, the individual fish identified by the acoustic system were counted "conservatively".

Initially, the ichthyofauna of the Rożnowski Dam Reservoir was shaped by the naturally occurring fish resources in the Dunajec River as well as numerous attempts to introduce and stock species. Since 1986 the reservoir has been stocked only with the predators pike and pikeperch, and the stocking of wells was begun in 1996 (Augustyn 2001a,b,c, Bieniarz et al. 1990). At the current trophic and eutrophication levels, which are expected to intensify, the role of predacious fish as regulators will only increase as they control the excessive development of cyprinid populations, especially their juvenile forms, which are largely responsible for the rate of eutrophication and the destruction of the reservoir (Jachner 1988, Gliwicz and Jachner 1992, Mazurkiewicz-Boroń 2000).

The studies in the Rożnowski Dam Reservoir showed that the two cyprinids, bleak and roach constitute 85.8% of the fish numbers and 66.3% of the fish biomass – a total of 818.1 kg ha^{-1}. Therefore, it is necessary to support the current stocking strategy of the Regional Branch of the Polish Anglers' Union in Nowy Sącz and to intensify that of predatory fish such as pike, pikeperch and wells. Prior to this, however, it would be advisable to conduct intense net catches, targeted at bleak, especially in the backwater region.

In the future the ichthyofauna of the Rożnowski Dam Reservoir will depend on determining priorities, accepted theories and management strategies, mainly controlled stocking and catches to regulate the ichthyofauna structure. The study results should facilitate updating the management program for the natural resources of this ecosystem and the region and ensure biodiversity, sustainable development and protection from ecological degradation. In a few years it would be advisable to repeat this type of study using the same methods and means. It should be supplemented with environmental studies to allow for a fuller interpretation of the tendencies and dynamics of change.

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STRESZCZENIE

ZMIENNOŚĆ ROZMIESZCZENIA I ZAGĘSZCZENIA RYB PELAGICZNYCH W ROŻNOWSKIM ZBIORNIKU ZAPOROWYM

W rezultacie przeszukiwań akustycznych echosondą Simrad EY-500 i sieciowych (włok pelagiczny i zestawy wontonów) połowów kontrolnych przeprowadzonych w Rożnowskim Zbiorniku Zaporowym (rys. 1), określono przestrzenne rozmieszczenie i zagęszczenie ryb w dzień i w nocy (tab. 1, rys. 3, 4, 5, 6, 7), strukturę gatunkową i rozmiarów ryb (tab.3) oraz oszacowano ich liczebność i biomasę (tab. 6). Wyniki przedstawiono w ujęciu horyzontalnym i pionowym, uwzględniającym różne warstwy wody od powierzchni do dna i oddzielnie dla rejonów zapory i cofki (tab. 1, 4).

Największe zagęszczenie ryb w nocy (średnio 25,1 tys. ryb ha^{-1}) wystąpiło w rejonie cofki w strefie dopływu wód rzeki Dunajec i było czterokrotnie większe niż w rejonie zapory (6,2 tys. ryb ha^{-1}), co należy kojarzyć z lepszymi warunkami środowiskowymi i pokarmowymi kształtowanymi przez dopływ wód Dunajca. Średnie zagęszczenie ryb w całym zbiorniku wynosiło 15,2 ryb ha^{-1} i było 24 razy większe niż w zb. Klimkówka i 34 razy niż w Solińskim, a także większe od szacowanego tą samą metodą zagęszczenia ryb w kilkunastu badanych jeziorach (tab. 5). W dzień średnie zagęszczenie ryb w strefie pelagicznej zbiornika było 5,8 razy mniejsze niż w nocy (tab. 1). Jest to rezultat dobowych migracji pokarmowo-obronnych.

Kontrolne połowy wykazały obecność 8 gatunków ryb. Ogółem złowiono 2 549 osobników, przy czym liczebnie dominowały ukleja 53,6% i płoć 32,2% (tab. 3).Biorąc pod uwagę oszacowaną akustycznie liczebność i określoną w wyniku połowów średnią masę jednostkową, biomasę ryb w strefie pelagicznej zbiornika oszacowano na 1102,4 tony, czyli 1234,3 kg ha^{-1}. Jest to biomasa 30-krotnie większa od oszacowanej tą samą metodą w zb. Solińskim i w zb. Klimkówka, a w porównaniu z kilkunastoma jeziorami, badanymi w okresie ostatnich 10 lat, kilka razy większa.

Jak wykazały badania w zb. Rożnowskim tylko dwa gatunki karpiowatych, ukleja i płoć, stanowią 85,8% liczebności i 66,3% biomasy ryb - łącznie 818,1 kg ha^{-1}. Dlatego należy popierać dotychczasową, praktykę zarybień wyłącznie rybami drapieżnymi (szczupak, sandacz, sum). Wskazane jest przeprowadzenie, szczególnie w rejonie cofki, intensywnych odłowów sieciowych, przede wszystkim uklei. Rezultaty badań powinny ułatwić aktualizację programu gospodarki zasobami przyrodniczymi tego ekosystemu i rejonu zapewniając jednocześnie bioróżnorodność, zrównoważony rozwój i ochronę przed degradacją ekologiczną.

CORESPONDING AUTHOR:

Dr Andrzej Świerzowski
Instytut Rybactwa Śródlądowego
Zakład Techniki Rybackiej
ul. Oczapowskiego 10
10-719 Olsztyn
tel. +48 89 524 10 64, e-mail: a.swierzowski@infish.com.pl