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Density and biomass of fish in the Rożnów Reservoir (Southern Poland)*

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Abstract — The investigations of the ichthyofauna of the Rożnów Reservoir were carried out at 5 stations, using a beach seine, a fry trawl, a set of gill nets, and trammel nets. The biomass and density of the particular species of fish were estimated using the Zippin triple catch removal method. The total biomass and density of the ichthyofauna was 162.75 10^8g ha^{-1} and 4475 indiv. ha^{-1}. 18 species of fish were found to occur, the bream, roach, pikeperch, and perch being the dominant species.

Key words: man-made reservoirs, fish density, estimation, catchability, Zippin equation.

1. Introduction

The Rożnów Reservoir was constructed in 1942 by erecting a dam across the valley of the River Dunajec near the village of Rożnów. It is a trough-type reservoir as encountered in submontane regions (Wajdowicz 1961) with a productive area of about 1500 ha and mean depth of about 12 m. Fishery exploitation of the reservoir is carried out by the Polish Anglers Association, mainly by means of angling and commercial fishing using gill nets with a mesh size greater than 60 mm. Owing to limitation of the size of permitted catches and temporary prohibition of commercial fishing it is impossible to estimate the biomass of fish on the basis of catch effort (CPUE) (Robson, Regier 1968, Leopold et al. 1975a, 1975b) or by the method of mark and recepture (Robson, Regier 1968, Stott 1968).

The aim of the investigations carried out in the period 1981—1984 was to estimate the density and biomass of fish in the Rożnów reservoir in order to determine its production possibilities.

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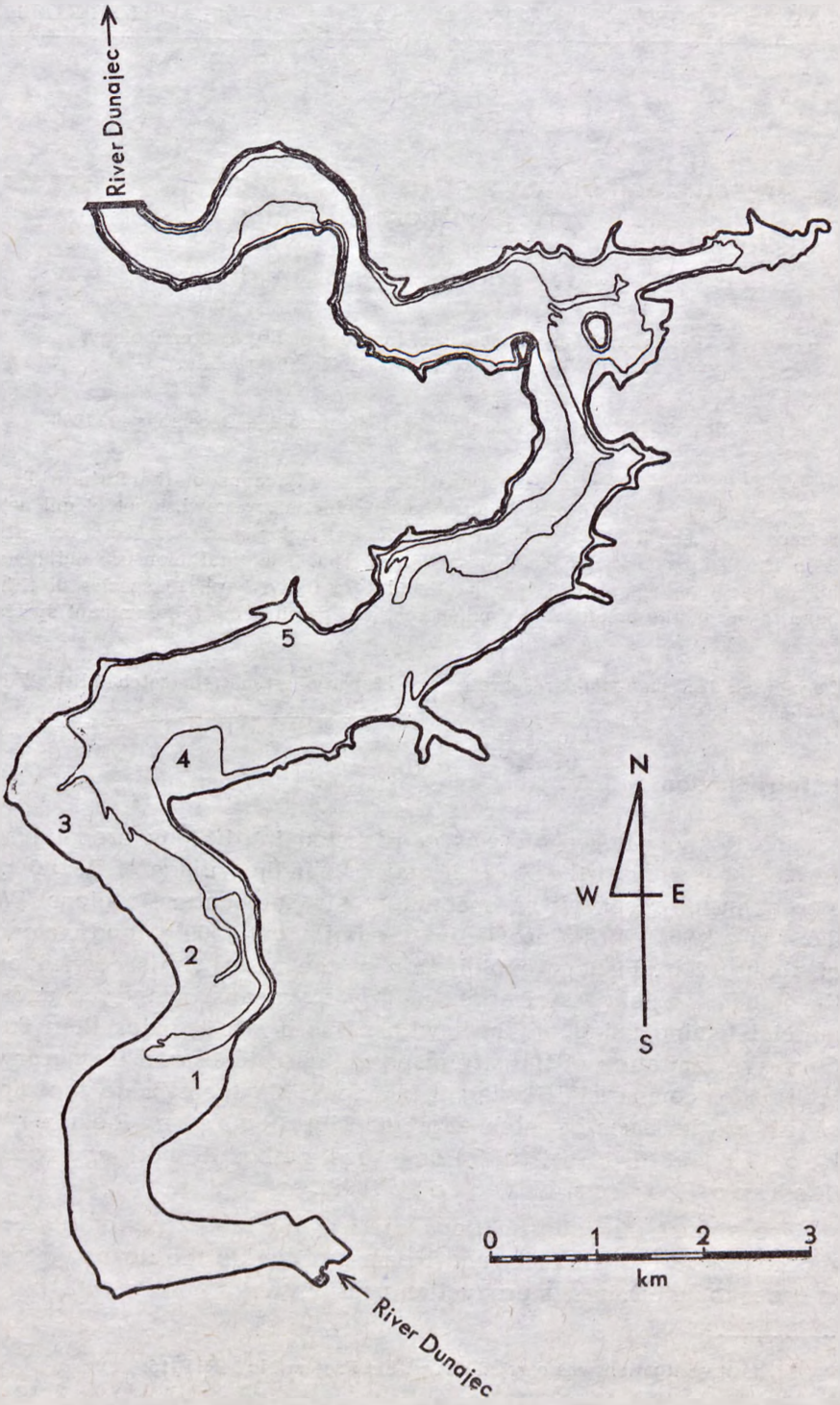

2. Study area

The investigation of the ichthyofauna of the Rożnów Reservoir was carried out at 5 stations (fig. 1). Station 1 was situated in the backwaters of the reservoir, where a slight current can still be seen. Stations 2 and 3 were situated below the backwaters in places where the suspended matter carried by freshets of the Dunajec settles. The thickness of the silt in these parts of the reservoir is about 60—70 cm. Stations 4 and 5 were situated in the central part of the reservoir. They are characterized by a smaller amount of silt on the bottom and a relatively rapid increase in depth in the littoral zone.

3. Material and methods

Catches were made in the period 1981—1984 in the spring and summer. Altogether 5 catches, each repeated 3 times (at Stations 1 and 2) and 10 single catches (at Stations 3—5) were made.

The following fishing gear was used:

a) a beach seine with wing length 75 m, height 6 m, and bag with 25 mm mesh,
b) a fry trawl with the wing length 5 m, height 1.2 m and 8 mm mesh,
c) trammel nets, 2.2 m in height and 24 mm mesh in webbing,
d) a set of gill nets, 3.5 m in height and 20, 24, 30, 35, 40, 50, 60 mm mesh,
e) 8 mm mesh netting spread on piles driven into the bottom.

Hauls repeated three times using the beach seine and fry trawl were made in areas of about 6500 m² and 500 m² enclosed with trammel nets (beach seine) or netting (fry trawl). Individual fishes caught with trammel nets were added in proportion to the successive catches made using the beach seine. The results obtained were re-counted per area of 1 ha and calculated applying the Zippin equation (1956):

$$\hat{N} = (C_1 + C_2 + C_3) / \hat{p}_s \qquad (1)$$

where: C_1, C_2, C_3 — fish density in successive hauls.

The applicability of Zippin's method for estimation of the density of the particular species of fish was tested when calculating the value R (Zippin 1956):

$$R = (C_2 + 2C_3) / (C_1 + C_2 + C_3) \qquad (2)$$

since for R = 0 or R = 1, equation (1) cannot be applied. Capture efficiency $\hat{p} = 1 - \hat{q}$ was read from the graph R and $\hat{p}_s$ for the number s = = 3 of repetitions, published in Zippin's study (1956). As an addi-

Fig. 1. Plan of the Rożnów Reservoir. Stations: 1 — Kurów; 2 — Tęgoborza I; 3 — Tęgoborza II; 4 — Zbyszyce; 5 — Znamirowice

tional investigation method, a single catch using a beach seine was applied, calculating the population of individuals $\hat{N}$ according to the equation:

$$\hat{N} = C_1 / \hat{p}_1 \tag{3}$$

where $\hat{p}_1$ — catchability of the beach seine in one haul.

The density of species to which Zippin's equation could not be applied was estimated on the basis of a formula proposed by Mahon et al. (1979):

$$\hat{N} = (N \Sigma \hat{N}_z) / \Sigma N_z \tag{4}$$

where: $N = C_1 + C_2 + C_3$

$\Sigma \hat{N}_z$ — total catch of all species using Zippin's equation,

ΣN_z — total number of fish of all Zippin population estimates.

The biomass $\hat{B}$ was calculated as the product of the density $\hat{N}$ and the mean weight of the individuals. Considering that in the Rożnów reservoir the density and biomass of fish in the littoral zone differ greatly from those in the deep water zone, in order to estimate the mean density and biomass of fish the proportionally coefficient w_p was introduced. It was calculated from the formula:

$$w_p = 0.72\ b / 0.28\ a \tag{5}$$

where: a — biomass of fish caught with gill nets in the littoral zone,

b — biomass of fish caught with gill nets in the deep water zone,

0.28, 0.72 — numerical values illustrating the percentage proportion of littoral (28%) and pelagic (72%) zones in the total area of the reservoir, respectively.

The variance for Eq. (1) was calculated from the dependence:

$$V\ [\hat{N}] = \hat{N}\ (1 - q^s)\hat{q}^s / [(1 - q^s)^2 - (\hat{p}\ s)^2\ q^{s-1}] \tag{6}$$

where: $q^{s-1} = 1 - (1 - \hat{q}^s) / \hat{q}$.

95% confidence levels for Eq. (1) are: $\bar{x} \pm t \sqrt{\mathrm{Var}\ [\hat{N}]}$, and for Eq. (3): $\bar{x} \pm t$ SE, where t — value read off from Student's "t" — tables for the confidence level $p = 0.05$ and $n - 1$ degrees of freedom.

4. Results

The mean density of the particular fish species caught by applying the method of three successive catches and that of a single catch, and the catchability of the beach seine used are listed in Tables I and II. The highest values of the catchability factors were recorded for roach, pike, and bream. The calculated mean density of the adult part of the population (mean value for the data from Tables I and II) was 745 individuals and biomass 207.11 10^3 g ha^{-1}.

Table I. Mean catch data obtained from Stations 1 and 2 of the Rożnów reservoir by the removal method utilizing three beach seine successive catches. C_1 – C_3 – catches from successive fishing; N – total number individuals collected; R – coefficient of Zippin method; $\hat{p}$ – capture efficiency; $\hat{p}_1$ – catchability of the beach seine in one haul; $\hat{\theta}$ – estimated density (N ha^{-1}) ; $\hat{B}$– estimated biomass (10^3 g ha^{-1}) ; n – number of experiments; CL – confidence level. * – values estimated from equation (4)

Species	n	C_1	C_2	C_3	N	R	$\hat{p}$	$\hat{p}_1$	$\hat{\theta}$	95% CL	$\hat{B}$
Abramis brama (L.)	5	88.0	30.8	15.0	133.8	0.45	0.61	0.401	219	4.1	104.8
Rutilus rutilus (L.)	5	106.8	37.0	10.2	154.0	0.37	0.68	0.471	226	2.4	36.5
Perca fluviatilis L.	5	36.0	17.6	6.6	60.2	0.51	0.56	0.335	107	3.8	18.8
Stizostedion lucioperca	5	56.2	28.0	10.6	94.8	0.52	0.57	0.338	166	4.7	56.8
Tinca tinca (L.)	5	14.6	7.4	4.0	26.0	0.59	0.47	0.264	55	5.2	14.0
Esox lucius (L.)	5	7.4	2.2	1.4	11 .0	0.44	0.62	0.418	18	1.1	5.6
Other+	1-3	14.0	20.0	11.0	45.0	-	-	-	74*	-	11.3*
Total		323.0	143.0	58.8	524.8				865		247.8

+ Cyprinus carpio L., Aspius aspius (L.), Scardinus erythrophthalmus (L.) , Blicca bjoerkna (L.) , Vimba vimba (L.) , Ctenopharyngodon idella Val., Alburnus alburnus (L.), Leucaspius delineatus (Heckel) , Gymnocephalus cernua (L.) , Lota lota (L.) , Anquilla anquilla (L.) , Carassius carassius (L.) .

Table II. Catch data obtained from Stations 3, 4, and 5 of the Rożnów reservoir by a single beach seine catch. Numerator – number of individuals collected; denominator – estimated density. N – mean density; B – mean biomass in 10^3 g ha^{-1}. *-values estimated from equation (4)

Species \ No of haul	Station 3			Station 4				Station 5			N	95%CL	B
	1	2	3	4	5	6	7	8	9	10			
Abramis brama (L.)	80 / 199	35 / 87	64 / 160	51 / 127	101 / 252	85 / 212	115 / 287	71 / 177	53 / 132	47 / 117	70 / 175	18.0 / 45.1	27.96 / 69.71
Rutilus rutilus (L.)	64 / 136	91 / 193	32 / 68	78 / 166	43 / 91	95 / 202	74 / 157	80 / 170	101 / 214	85 / 180	74 / 158	15.9 / 33.7	9.23 / 19.58
Perca fluviatilis L.	46 / 137	21 / 63	30 / 89	43 / 128	56 / 167	47 / 140	52 / 155	58 / 173	29 / 87	18 / 1.43	43 / 128	8.8 / 26.3	9.49 / 28.28
Stizostedion lucioperca (L.)	32 / 95	41 / 121	23 / 68	47 / 139	18 / 53	36 / 106	48 / 145	26 / 77	40 / 118	27 / 80	34 / 100	7.4 / 22.0	8.15 / 24.09
Tinca tinca (L.)	- / -	3 / 11	6 / 23	7 / 26	4 / 15	3 / 11	5 / 19	5 / 15	7 / 26	6 / 23	5 / 17	1.5 / 5.9	1.23 / 4.50
Esox lucius L.	14 / 33	6 / 14	7 / 17	8 / 19	5 / 12	10 / 24	13 / 31	12 / 29	3 / 7	7 / 17	8 / 20	2.5 / 6.2	2.82 / 6.97
Other (as in Table I)	20 / 51*	17 / 42*	7 / 19*	10 / 26*	7 / 18*	4 / 10*	8 / 21*	14 / 36*	5 / 12*	13 / 33*	10 / 27*	3.8 / 9.6	4.97 / 13.41*
Total	256 / 651	214 / 532	169 / 444	244 / 631	234 / 608	280 / 705	316 / 815	266 / 681	238 / 596	213 / 543	244 / 625	28.1 / 71.5	61.85 / 166.54

These values show the number and weight of the older age groups of fish and the recruitment in the littoral zones of the reservoir without providing information about the values of these parameters with respect to the entire production area of the reservoir. In order to calculate the mean density and biomass of the particular fish species, comparative method were used. The application of the proportionality coefficient w_p (Table III) enabled the obtained values (Tables I, II) to be verified and the actual density and biomass of the adult part of the fish population (Table IV) to be obtained. Subsequently the density and the biomass of individuals which on account of their small size were not caught with the beach seine were estimated. The catches of this part of the popula-

Table III. Mean biomass of fish caught using a set of gill nets ($\bar{x}$) in the littoral zone (a) and deep water zone (b) in 10^3 g catch^{-1} and the values of the proportionality coefficient w_p. Values estimated from equation (5). No - number of catches

Station \ Zone	a			b			w_p
	No	$\bar{x}$	95% CL	No	$\bar{x}$	95% CL	
1	12	74.93	± 24.62	7	12.06	± 5.10	0.414
2	10	63.85	± 26.80	11	12.32	± 5.80	0.496
3	13	84.64	± 34.24	6	13.97	± 4.75	0.424
4	9	61.05	± 19.67	8	9.28	± 4.91	0.391
5	11	62.44	± 18.07	9	13.36	± 6.77	0.549
Mean		69.38			12.28		0.455

Table IV. Mean stock density and harvest obtained from all stations of Rożnów reservoir using the proportionality coefficient w_p. $\hat{N}$ - estimated density in N ha^{-1} (N - total number of individuals collected); $\hat{B}$ - estimated biomass in 10^3 g ha^{-1}

Species	Adult fishes		Juvenile fishes		Total		%	
	$\hat{N}$	$\hat{B}$	$\hat{N}$	$\hat{B}$	$\hat{N}$	$\hat{B}$	$\hat{N}$	$\hat{B}$
Abramis brama (L.)	83	39.70	454	7.57	537	42.27	12.0	29.0
Rutilus rutilus (L.)	79	12.76	648	9.40	727	22.16	16.2	13.6
Stizostedion lucioperca (L.)	54	18.40	381	6.72	435	25.12	9.7	15.4
Perca fluviatilis L.	61	10.71	506	11.01	567	21.72	12.9	13.3
Tinca tinca (L.)	16	4.21	23	0.28	39	4.49	0.9	2.7
Esox lucius L.	9	2.86	36	0.49	45	3.35	1.0	2.0
Alburnus alburnus (L.)	4	0.06	828	10.41	832	10.47	18.6	6.4
Blicca bjoerkna (L.)	2	0.05	317	6.60	319	6.65	7.1	4.1
Leucaspius delineatus (Heck.)	-	-	474	6.54	474	6.54	10.6	4.0
Other fishes +	31	5.51	469	9.47	500	14.98	11.2	9.2
Total	339	94.26	4136	68.49	4475	162.75	100.0	100.0

+ Cyprinus carpio L., Carassius carassius(L.), Vimba vimba(L.), Scardinius erythrophthalmus(L.), Lota lota(L.), Ctenopharyngodon idella Val., Aspius aspius(L.), Anguilla anguilla(L.)

Table V. Mean catch results obtained from Stations 1, 2, and 3 of the Rożnów reservoir by removal method utilizing three fry trawl successive catches. C_1-C_3 - catches from successive fishing; N - total number of individuals collected; R - coefficient of Zippin method; p - capture efficiency; $\hat{N}$ - estimated density N ha^{-1}; $\hat{B}$ - estimated biomass 10^3g ha^{-1}; n - number of experiments; * - values estimated from equation (4)

Species	n	C_1	C_2	C_3	N	R	p	$\hat{N}$	95% CL	$\hat{B}$
Alburnus alburnus (L.)	7	896	238	104	1238	0.36	0.68	1820	5.9	4.74
Rutilus rutilus (L.)	7	835	197	66	1098	0.30	0.73	1504	3.5	4.28
Perca fluviatilis L.	7	518	139	77	734	0.40	0.66	1112	5.5	5.01
Abramis brama (L.)	7	345	123	81	549	0.52	0.55	998	14.7	3.44
Blicca bjoerkna (L.)	7	237	107	46	390	0.51	0.56	696	9.1	3.00
Leucaspius delineatus(Heck.)	7	572	92	76	740	0.33	0.71	1042	3.5	2.93
Stizostedion lucioperca (L.)	7	334	88	72	494	0.47	0.59	837	8.1	3.06
Other+	1-5	286	231	243	760	-	-	1161*		4.66*
Total		4023	1215	765	6003	-	-	9170		31.12

+ Tinca tinca (L.), Esox lucius L., Cyprinus carpio L., Aspius aspius(L.), Scardinius erythrophthalmus (L.), Vimba vimba(L.), Gymnocephalus cernua(L.), Carassius carassius (L.)

tion, carried out using a fry trawl (Table V), revealed that the structure of the density and thus the percentage proportion of the particular fish species differ from those in the population of adult individuals. It was found that 47% of individuals in the samples caught belonged to species defined in Table I as "Others". Within this conventional group, besides juvenile individuals with a long life cycle, were found fry and adult fish species of little commercial value, which because of their slow growth rate were not caught with the beach seine. Assuming that the rations of the number of individuals caught using the fry trawl and the number of the adult part of the fish population in the littoral zone and the pelagic zones of the reservoir are similar (high percentage proportion of fish of little commercial value penetrating the entire area of the reservoir), the mean density and biomass of fish were calculated applying the coefficient w_p (Table III). They were: 4475 indiv. ha^{-1} and 162.75 10^3 g ha^{-1} (Table IV). In the Rożnów reservoir 18 fish species were found to occur, among which bream, roach, pikeperch, and perch constituted 50.8% of the population and 71.3% of the biomass.

5. Discussion

The density and biomass of fish in dam reservoirs and lakes are usually estimated:

— by indirect methods based on the concentrations of nutrient substances in the water or the production of lower trophic layers, the numerical determination of which is easier;

— by direct methods among which net fishing deserves notice. One of the best methods appears to be that of Zippin, whereas that of three successive catches (Penczak, O'Hara 1983) is a compromise permiting reliable results to be obtained with relatively little effort. In order to estimate the density and biomass of fish in dam reservoirs the method of draining the reservoir can also be used (Wajdowicz 1961, Epler, Bieniarz 1977, Mastyński 1984). Its great disadvantage, however, is that it supplies "historical results" and excludes the possibility of utilizing the gathered observations for the management of fish populations.

The biomass of the ichthyofauna of the Rożnów Reservoir is greater than the mean biomass of fish estimated on the basis of the size of the primary production of dam reservoirs under similar climatic conditions. In the opinion of Wróbel (1968), its amounts to from 96.0 to 120.0 10^3 g ha^{-1}. The ichthyofauna estimated by Mastyński (1984) by the method of draining the lowland Malta reservoirs with an area of 64.3 ha amounted to $\bar{B} = 438.1$ 10^3 g ha^{-1} and that of the Gołuchów Reservoir with an area of 35 ha to $\bar{B} = 507.3$ 10^3 g ha^{-1}. These values are much higher than those obtained by Epler and Bieniarz (1977) for the

drained Tresna Reservoir ($\bar{B} = 119.4\ 10^3$ g ha^{-1}) and by the authors for the Rożnów Reservoir ($\bar{B} = 162.75\ 10^3$ g ha^{-1}).

It appears that the actual biomass of the Rożnów Reservoir is not much higher than that estimated in the present paper because:
— the reservoir is of submontane type, thus its productivity is lower than that of reservoirs of lowland type (W a j d o w i c z 1961);
— it has a small mean retention period (S t a r m a c h 1958), the circulation of matter being similar to that in a large river, hence its fish production cannot be high;
— during the operation of the turbines of the power station in summer the bottom feeding ground is diminished as a result of the reduction in oxygen content in the water layers below the offset of the water intake of the power station.

6. Polish summary

Liczebność i biomasa ryb w zbiorniku Rożnowskim (Polska Południowa)

Celem prac, prowadzonych w latach 1981—1984, było określenie liczebności i biomasy ichtiofauny zbiornika Rożnowskiego (ryc. 1). Posługując się zależnością podaną przez Z i p p i n a, obliczono łowność użytych narzędzi połowu oraz średnią liczebność i biomasę łownej części populacji ryb, które wynosiły odpowiednio: 745 osobników ha^{-1} i 207,17 10^3 g ha^{-1} (tabele I, II). Oszacowano również liczebność i biomasę młodocianych stadiów ryb i gatunków małocennych (9170 osobników ha^{-1} i 31,12 10^3 g ha^{-1} (tabela V). Wprowadzono współczynnik proporcjonalności w_p (tabela III), umożliwiający porównanie biomasy ryb w strefie przybrzeżnej i strefie pełnej wody. Po wprowadzeniu współczynnika w_p liczebność i biomasa całej populacji ryb w zbiorniku wynosiła średnio 4475 osobników ha^{-1} i 162,75 10^3 ha^{-1} (tabela IV).

W zbiorniku Rożnowskim stwierdzono 18 gatunków ryb, z których leszcz, płoć, sandacz i okoń stanowiły 50,8% liczebności i 71,3% biomasy (tabela IV).

7. References

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