ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XVIII Fasc. 1 Szczecin 1988

Andrzej KOMPOWSKI

GROWTH RATE OF BREAM, *ABRAMIS BRAMA* (L., 1758), IN LAKE DĄBIE AND THE SZCZECIN LAGOON

SZYBKOŚĆ WZROSTU LESZCZA, *ABRAMIS BRAMA* (L., 1758), Z JEZIORA DĄBIE I ZALEWU SZCZECIŃSKIEGO

Institute of Fishery Oceanography and Sea Protection

Back-calculation of scales with the method by Vovk was used to determine the growth rate of bream. A comparison with the data given in the literature revealed that dramatic changes in bream biomass in Lake Dąbie and the Szczecin Lagoon, which took place in the last twenty five years, were accompanied by an only slight (though noticeable) increase of the growth rate of fishes 3–8 years of age.

INTRODUCTION

Considerable changes have been observed in the past 25 years of the fish catch levels and its species structure in Polish part of the Szczecin Lagoon and the neighbouring waters. (Fig. 1) Undoubtedly, these changes reflect changes in the biomass of particular species caused by rapid eutrophication (Kompowski and Pieńkowski unpubl. data). The eutrophication process is more intensive in the Szczecin Lagoon and Odra River Mouth than in Lake Dąbie, mostly due to the effect of industrial wastes and domestic sewage discharged from Szczecin town to Odra River and, thus, also to the Szczecin Lagoon. These changes were noticed also in bream stocks, the fish of uppermost importance for the fishery in the Szczecin Lagoon. In 1960–1967 bream predominated the fish catch. In 1960 it constituted almost 50% of total fish landings. Peak of bream catch was observed in 1961 (1011.7 t). Another peak was noted in 1972 (922.2 t). Since then, bream catches tended to decrease, to only 302.5 t in 1985. At the same time its percentage in total fish

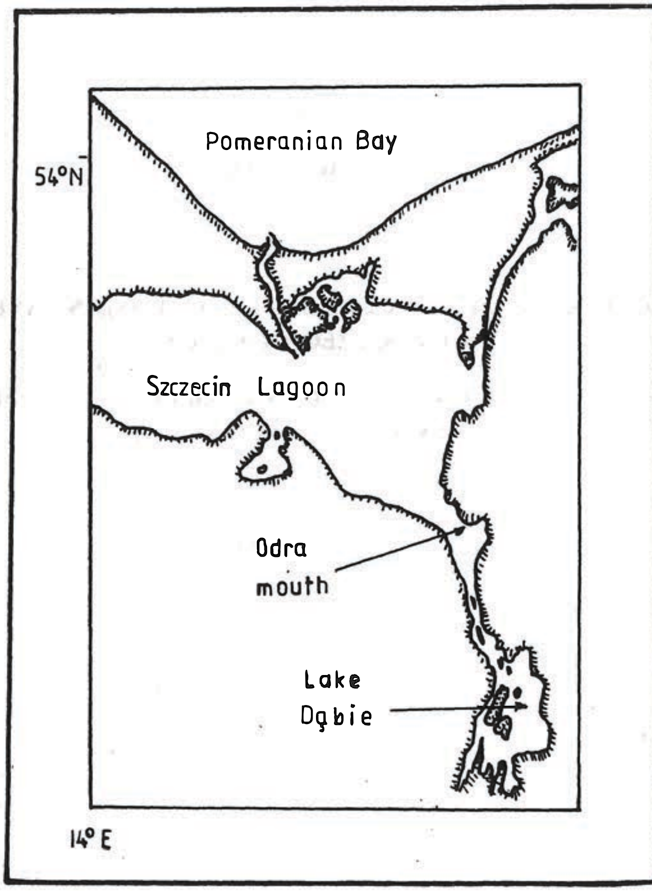

Fig. 1. Schematic map of the Szczecin Lagoon and Lake Dąbie.

landings also decreased. In 1960 bream represented 44.8% of total catch weight, in 1965 – 27.4%, in 1970 – 22.9%, in 1975 – 17,4%, in 1980 – 14,9% and in 1985 only 12,5%.

In view of this, a question arose whether these changes were accompanied by changes in the growth rate, This problem constituted an objective of my studies. In addition to this, an attempt was made to assess basic parameters of the fish stock.

MATERIAL AND METHODS

Bream were collected in 1984–1986 from the fishery cooperative "Certa". Almost all fishes were of legal size, over 28 cm in length (l.c.). A few samples were also collected of non-sorted fishes, containing some undersized specimens. These were used to check the reliability of age determination as well as to establih the dependence between scale radius

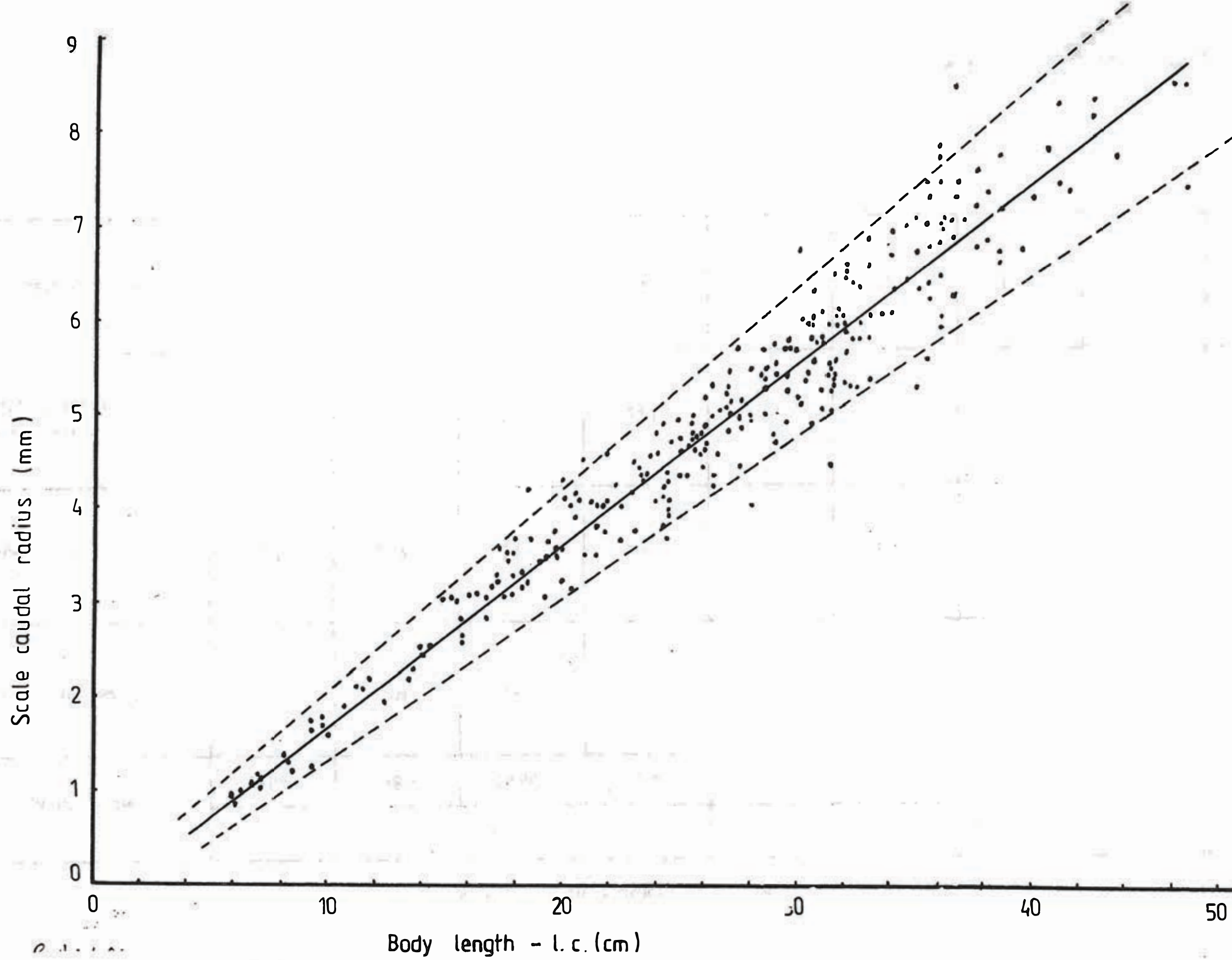

Fig. 2. Dependence between body length (l.c.) and length of the scale caudal radius in bream from the Szczecin Lagoon n = 240.

Table 1

A review of the studies made on bream

Type of studies	Lake Dąbie				Szczecin Lagoon				Overall
	1984	1985	1986	Total	1984	1985	1986	Total	
Length measurement	25	204	141	370	40	165	104	309	679
Body weight	25	124	141	290	40	165	103	308	598
Scale radius measurements	–	138	133	271	37	153	87	277	548
sex determination	25	124	141	290	40	159	104	303	593

and fish body length. Length (l.c.) of 679 fishes was measured up to 1 mm, and individual weight up to 1 g established for 598 fishes as ungutted and gutted. Sex was established from fish gonads. If the sex could not have been established by eye, the fishes were classified as immature (I stage of gonad development according to Maier's scale). Scales used for back-calculation of the growth rate and for age determination were collected under the latteral line, in place directly beneath the front of the dorsal fin. Caudal radius of the scales was measured up to 0.01 mm, using a microscope with moving board and micrometric screw. Radii of 548 scales were measured. Back-calculation of the growth rate was based on the method of Vovk. Rate of bream growth in Lake Dąbie was determined using an empirical curve of Kompowski (1982). Back-calculations of bream growth rate in Szczecin Lagoon were made using an empirical curve presented in Fig. 2. The curve was obtained from the measurements of 277 scales collected from bream of body length (l.c.) 5.9–46.5 cm. Whenever necessary, body length (l.c.) was recalculated to total length (l.t.) using the equation from Kompowski (1982):

$$\text{l.c.} = 0.3845 + 0.7253\ \text{l.t.} + 0.00177\ \text{l.t.}^2$$

Dependence between fish length and weight was presented according to the equation:

$$w = a \cdot \text{l.c.}^n$$

where: w – fish weight (g)
l.c. – fish body length (cm)
a and n – coefficients of proportionality.

Coefficients "a" and "n" were found with the least square method. Rate of growth was presented in form of von Bertalanffy's equation:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}]$$

where: L_t – length of the fish at age t
L_∞ – asymptotic length which the growth curve approaches
K – catabolic coefficient
t_0 – arbitrary outset of the growth curve

Parameters of this equation were found with the method of Beverton and Holt (1957). They were then used to assess natural mortality (M) of bream in the Szczecin Lagoon, taking advantage of the empirical regression equations given by Pauly (1980)

$$\log M = -0.2107 - 0.0824 \log W_\infty + 0.6757 \log K + 0.4627 \log T$$

and

$$\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where: L_∞ – and K – as before
W_∞ – weight of the first at L length
T – multi-year average water temperature

A summary of all studies made is given in Table 1.

Table 2

Average length of bream in Lake Dąbie and the Lagoon of Szczecin in consecutive years of the fish life. Estimated with the method of back-calculation from scales. Theoretical length calculated using von Bertalanffy equation is also given (l.c. in cm)

Age (years)	Lake Dąbie				Szczecin Lagoon			
	$\bar{x}$ length	$\pm\sigma$	n	theoretical length	$\bar{x}$ length	$\pm\sigma$	n	theoretical length
1	5.46	1.0011	271	5.63	5.71	0.9692	166	5.59
2	10.68	1.9084	233	11.89	11.32	2.0401	165	11.76
3	15.85	2.3361	173	17.14	16.80	2.5495	159	17.16
4	21.36	2.5904	127	21.55	21.86	2.6584	142	21.86
5	25.88	2.8098	102	25.26	26.38	2.6392	126	25.97
6	29.12	2.7652	76	28.37	30.11	2.2894	95	29.55
7	31.58	3.0586	50	30.97	33.00	2.2475	70	32.68
8	33.70	3.2240	28	33.17	35.08	2.4907	41	35.41
9	35.30	2.8539	22	35.00	36.86	–	19	37.80
10	36.36	–	19	36.65	40.16	–	11	39.88
11	37.24	–	12	37.84	41.63	–	10	41.69
12					43.55	–	6	43.28
13					44.47	–	3	44.66

RESULTS AND DISCUSSION

a) Growth

Table 2 present average bream length in Lake Dąbie and the Szczecin Lagoon in consecutive years of the fish life. Fig. 3 presents annual length increments. As results from these data, bream is characterized by uniform growth in both water bodies. Inhibition of growth with fish age is very slow. Length increments in the sixth year of life are almost the same as in the first three years. 1982 and 1983 were characterized by an exceptionally high growth rate.

Data presented in Table 2 were used to assess the parameters of von Bertalanffy's equation. These parameters were: $L_\infty = 44.62$ cm, $K = 0.175$ and $t_o = 0.23$ years for bream in Lake Dąbie, and $L_\infty = 54.14$, $K = 0.136$ and $t_o = 0.20$ years for bream in the Szczecin Lagoon.

Theoretical fish length in consevutive years of age, calculated using the above equation parameters, is presented in Table 2. As can be seen from this table, they fit the empirical data quite well.

Dependence between total body weight (w_1) and body length (l.c.) for bream in Lake Dąbie was expressed by the equation:

$$w_1 = 0.01424 \text{ l.c.}^{3.1177}$$

and for bream in the Szczecin Lagoon by the equation:

$$w_1 = 0.01346 \text{ l.c.}^{3.1614}$$

Dependence was also calculated between weight of gutted fish (w_2) and body length:

Lake Dąbie: $w_2 = 0.01511 \text{ l.c.}^{3.0576}$

Szczecin Lagoon: $w_2 = 0.01438 \text{ l.c.}^{3.1096}$

Bream weight in consecutive years of life was calculated from the dependence between w_1 and l.c., taking advantage of the theoretical lengths obtained from von Bertalanffy's equation. The results are presented in Table 4. Asymptotic weight (W_∞) was also calculated. It amounted to $W_\infty = 1978.2$ g in Lake Dąbie, and $W_\infty = 3429.3$ g in the Szczecin Lagoon.

Tables 3 and 4 presented overall results on the growth rate, length and weight attained by bream in various coastal lakes of Poland. Comparison of fish length data was difficult due to the differences in the methods used by various authors. Zawisza (1970) used scale back-calculation to determine the growth rate of bream in lakes Jamno, Gardno and Łeba. Data on the growth rate of bream in the Vistula Lagoon (Filuk 1963) and the Szczecin Lagoon (Pęczalska and Kraczkiewicz 1272, Pęczalska unpubl. data) were obtained from direct measurements. Pęczalska and Kraczkiewicz measured the fishes in November. According to Wojno (1964) bream should at that time fully attain its annual length increment. Thus, length of the 1 + fishes would in reality represent length of the two-years old specimens, length of the 2+ fishes that of the three – years ones etc. Filuk

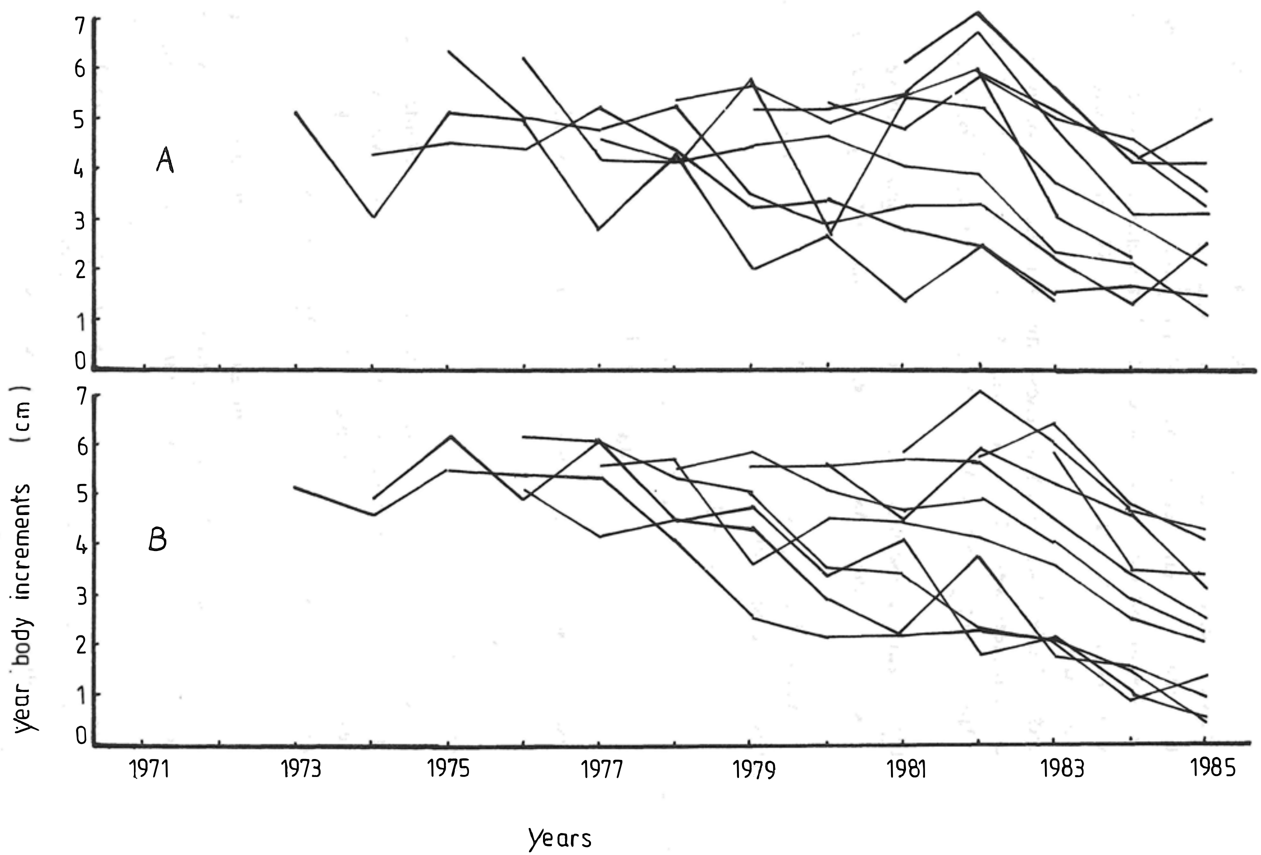

Fig. 3. Average annual increments of body length for various bream generations in particular years. A – Lake Dąbie, B – Szczecin Lagoon

Table 3

Comparison of the growth rate of bream in various coastal waters of Poland (length, l.c. in cm)

Water, body, period, method used	Age (years)																Source
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Regalica, 1974–77, back-calculation	5.4	9.3	13.5	17.6	21.6	24.5	27.3	29.6	32.0	33.9	35.2	37.3	39.4	40.3	40.7	43.1	Kompowski, 1982
Lake Dąbie, 1972, direct measurements	–	–	–	–	–	–	25.8	29.1	32.0	36.3	38.7	41.0	–	–	–	–	Pęczalska* unpublished
Lake Dąbie, 1974–77, back-calculation	5.7	10.4	15.2	19.7	23.8	26.7	30.0	32.7	34.7	36.6	38.5	39.8	42.4	43.1	46.6	44.4	Kompowski, 1982
Lake Dąbie, 1985–86, back-calculation	5.5	10.7	15.9	21.4	25.9	29.1	31.6	33.7	35.3	36.4	37.2	–	–	–	–	–	this paper
Szcz. Lagoon, 1956–58, direct measurements	–	–	16.6	19.7	22.4	26.4	29.9	33.0	36.2	37.1	40.2	43.1	44.0	44.3	46.6	48.3	Pęczalska i Kraczkiewicz, 1972*
Szcz. Lagoon, 1968–71, direct measurements	–	11.9	14.6	16.9	21.4	25.2	27.9	30.5	34.5	36.5	38.7	42.0	43.4	44.9	46.7	–	Pęczalska i Kraczkiewicz, 1972*
Szcz. Lagoon, 1985–86, back-calculation	5.7	11.3	16.8	21.9	26.4	30.1	33.0	35.1	36.9	40.2	41.6	43.6	44.5	–	–	–	this paper
Lake Jamno, 1966, back-calculation	6.2	11.2	15.7	19.5	23.2	26.3	30.8	35.0	37.9	39.8	42.1	43.6	45.2	46.8	48.3	–	Zawisza, 1970
Lake Gardno, 1962, back-calculation	5.7	9.0	13.2	15.6	19.0	22.4	24.9	27.8	31.0	34.2	36.0	38.0	–	–	–	–	Zawisza, 1970
Lake Łeba, 1963, back-calculation	6.3	10.5	14.1	17.5	21.2	24.2	28.2	31.8	35.5	38.2	–	–	–	–	–	–	Zawisza, 1970
Vistula Lagoon, 1960, direct measurements	–	–	19.0	23.3	27.8	31.1	34.3	36.6	38.8	41.5	42.6	43.8	45.7	46.6	47.9	–	Filuk, 1963*
Average bream growth rate in Polish waters	4.9	8.9	12.7	16.7	20.6	24.5	28.0	31.0	33.5	34.8	36.9	38.6	39.0	–	–	–	Marciak, 1974

* originally total length (l.t.), here recalculated to body length (l.c.)

Table 4

Comparison of the growth rate of bream (weight, in g) in various coastal waters of Poland

Water body, period	Age (years)																Source
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Regalica, 1974–77	2.2	10.3	55.3	117.6	213.1	321.3	451.6	582.4	737.0	892.3	1050.0	1205.2	1364.3	1513.3	1647.8	1790.2	Kompowski, 1982
Lake Dąbie, 1972	–	–	–	–	–	–	411.0	604.0	785.0	1170.0	1371.0	1630.0	–	–	–	–	Pęczalska, unpublished
Lake Dąbie, 1974–77	3.9	29.3	84.8	174.9	294.2	438.2	604.4	786.1	967.0	1154.7	1344.4	1530.8	1709.0	1874.2	2035.9	2192.1	Kompowski, 1982
Lake Dąbie, 1985–86	3.1	32.0	100.2	204.6	335.6	482.1	633.6	784.8	927.8	1062.0	1183.3	–	–	–	–	–	this paper
Szcz. Lagoon, 1956–58	–	–	111.0	178.0	263.0	430.0	615.0	851.0	1136.0	1306.0	1494.0	1690.0	1935.0	1950.0	2030.0	2435.0	Pęczalska i Kraczkie-wicz, 1972
Szcz. Lagoon, 1960–64	–	21.0	82.0	148.0	264.0	409.0	618.0	930.0	1074.0	1255.0	1386.0	1620.0	1840.0	2148.0	2330.0	2875.0	Pęczalska i Kraczkie-wicz, 1972
Szcz. Lagoon, 1968–71	–	40.0	66.0	117.0	242.0	371.0	543.0	725.0	1105.0	1195.0	1297.0	1970.0	2111,0	2238.0	2600.0	–	Pęczalska i Kracz-kiewicz, 1972
Szcz. Lagoon, 1985–86	3.1	32.6	107.6	231.3	398.8	599.9	824.7	1062.8	1306.6	1547.7	1780.0	2004.5	2213.6	–	–	–	this paper
Lake Jamno, 1966	–	–	76.0	150.0	285.0	420.0	670.0	1020.0	1280.0	1560.0	1790.0	2010.0	2300.0	2490.0	2600.0	–	Zawisza, 1970
Lake Gardno, 1962	–	–	40.0	85.0	135.0	230.0	325.0	450.0	660.0	860.0	1000.0	1185.0	–	–	–	–	Zawisza, 1970
Lake Łeba, 1963	–	20.0	60.0	125.0	225.0	330.0	525.0	720.0	1005.0	1285.0	–	–	–	–	–	–	Zawisza, 1970
Vistula Lagoon, 1951–60	–	–	184.0	337.0	541.0	731.0	936.0	1134.0	1339.0	1549.0	1783.0	1929.0	2043.0	2095.0	2348.0	–	Filuk, 1963

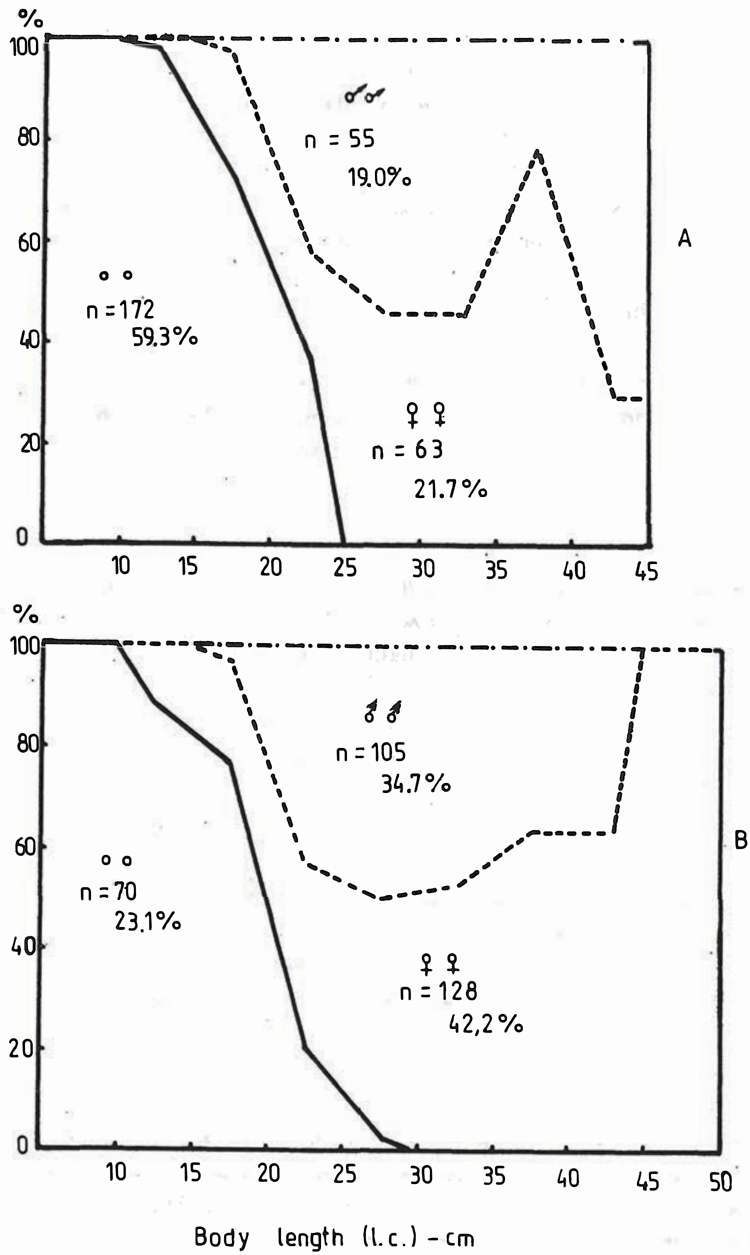

Fig. 4. Share of immature (oo) specimens males (♂♂) and females (♀♀) in particular length-classes of bream. A – Lake Dąbie, B – Szczecin Lagoon.

(1963) collected the samples since April till December, so this data could not have been treated as the data of Pęczalska and Kraczkiewicz. Hence, age of bream in Filuk's studies ranged from 3.5 years to 4.5 years etc., and this must be taken into consideration when comparisons are made. Data of Pęczalska and Kraczkiewicz, and Filuk, refer to total fish length (l.t.). To make them comparable, it was necessary to recalculate these to body length (l.c.), using the equation given in the "Material and methods".

The following conclusions may be formulated comparing the data presented in tables 3 and 4:

1. In the Odra River estuary, the growth rate of bream increseas northward. The slowest growth is observed in Regalica, the most rapid in the Szczecin Lagoon. This refers both to the fish length and weight.

2. In Lake Dąbie, average length of bream 3–8 years old increased in 1985–1986 compared to 1974–1977. Hence, annual increments of the fishes 3–8 years old must have increased. As regards older fish (over 8 years of age) the increments decreased. Thus growth curve became more convex; L_{∞} decreased from 54.4 cm (Kompowski 1982) to 44,6 cm, and catabolitic coefficient increased from 0.113 to 0.175.

3. In the Szczecin Lagoon, average length of bream 4–13 years old was smaller in 1956–1958 and 1968–1971 than in 1985–1986. This was especially noticeable for the fishes 4–8 years old.

4. Growth rate of bream in the water bodies under study was similar to that in coastal lakes of Poland (Jamno, Gardno, Łeba, Vistula Lagoon), but more rapid than in other Polish waters. This refers to both fish length and weight (Tab. 4).

b) Natural mortality

Natural mortality is an important parameter characterizing the fish stock. Pauly's equations (1980) were used to assess this parameter. To assess "M" it is necessary to know "K", L_{∞} (or W_{∞}) and average water temperature.

In case of the Szczecin Lagoon, average water temperature was estimated at 10.2°C, basing on the data from 1950–1972, measurements taken in Trzebież (Majewski 1980). Using the equation with L_{∞} we estimated M = 0.257 while the equation with W_{∞} yielded M value of 0.240. In case of bream from Lake Dąbie M could not have been estimated due to the lack of data on average water temperature.

The author, however, has been able to find out that coefficient of natural mortality for bream in north area of the Caspian Sea was estimated at M = 0.15 (Lukashov, cit. after Backiel and Zawisza 1968).

c) Sex ratio

Sex was identifiable in females earlier than in males. In Lake Dąbie, the smallest identified female was 12.5 cm long (l.c.), and male 19.0 cm long. In the Szczecin Lagoon, the respective fish lengths were 14.0 and 19.5 cm . Sex could have been readily identified in all fishes over 25 cm in Lake Dąbie and 30 cm in the Szczecin Lagoon (Fig. 4). Females predominated in mature fish stocks, especially as regards bigger specimens. From among 290 breams obtained in Lake Dąbie, 172 (59.3%) were immature, 55 (19%) were identified as males, and 63 (21,7%) as females. From among 303 fishes collected in the

Szczecin Lagoon, 70 (23.1%) were immature, 105 (34,7%) were identified as males, and 128 (42.2%) as females. Predamination of females was also observed by Pęczalska (1963) in bream stocks from the Szczecin Lagoon.

REFERENCES

Backiel T., Zawisza J., 1968: Synopsis of biological data on the bream Abramis brama (Linnaeus, 1758). FAO Fisheries synopsis No 36, Roma: 1–16.

Filuk J., 1963: Biological characteristic of bream (Abramis brama L.) catches in Vistula Lagoon. Prace MIR Gdynia, T. **12**/A, Gdynia: 89–116.

Kompowski A., 1982: Remarks on some aspects of bream – Abramis brama (L., 1758) biology in Regalica and Lake Dąbie. Acta Ichth. et Pisc. Vol. XII Fasc. 1 :3–25.

Majewski A. (Ed.), 1980: Szczecin Lagoon – chapter "Variations of water temperature in long-term scale. Wyd. Komunikacji i Łączności, Warszawa :170–172.

Marciak Z., 1974: Characteristics of bream– Abramis brama (Linnaeus, 1758) – growth in Polish lakes. Roczniki Nauk Rolniczych, T. **96**-H-3, :75–95.

Pauly W., 1980: On the interrelationship between natural mortality, growth parameter, mean environmental temperature in 175 fish stocks. J. Cons. Perm. int. Explor. Mer. **39**, 2 :175–192.

Pęczalska A., 1963: On the biology of bream reproduction in the Szczecin Lagoon and the Gulf of Pomerania. Polskie Arch. Hydrob. T. XI, nr 1, Warszawa :109–139.

Pęczalska A., Kraczkiewicz A., 1972: Results of studies on fish resources and fishery management in the Szczecin Lagoon and Gulf of Pomerania. (w) Ekosystemy morskie t. **4**, MIR, Gdynia :133–196.

Zawisza J., 1970: Bream migrations in coastal lakes. Roczniki Nauk Rolniczych, **H.92**,1 :121–142.

Wojno T., 1964: Seasonal changes of the growth of bream (Abramis brama L.) in Lake Wdzydze. Roczniki Nauk Rolniczych. T. **84**-B-2 :493–511.

Andrzej Kompowski

SZYBKOŚĆ WZROSTU LESZCZA, *ABRAMIS BRAMA* (L., 1758), Z JEZIORA DĄBIE I ZALEWU SZCZECIŃSKIEGO

STRESZCZENIE

W pracy podjęto próbę zbadania, czy znacznemu spadkowi biomasy leszcza w ostatnim ćwierćwieczu nie towarzyszą zmiany w szybkości wzrostu. Materiał, pochodzący z połowów gospodarczych, zebrano w latach 1984–1986 (tab. 1). Szybkość wzrostu badano przy pomocy odczytów wstecznych z łusek metodą Wowka (tab. 2). Oszacowano parametry równania wzrostowego von Bertalanffy'ego. Dla leszczy z jez. Dąbie wynoszą one: L_∞ = 44,62 cm; K = 0,175 :, t_o = 0,23 roku, zaś dla leszczy z Zalewu Szczecińskiego: L_∞ = 54,14 cm; K = 0,136:, t_o = 0,20 roku. Zależność między masą całkowitą ciała (w_1) i długością ciała (l.c.) ma dla leszczy z jez. Dąbie postać:

$w_l = 0.01424$ l.c.$^{3.1177}$; zaś dla leszczy z Zalewu Szczecińskiego $w_l = 0{,}001346$ l.c.$^{3.1614}$. Współczynnik śmiertelności naturalnej, M, oszacowany dla leszcza z Zalewu Szczecińskiego metodą Pauly'ego wynosi 0,257 lub 0,240, zależnie od tego, czy do wzoru podstawiono L_∞ czy W_∞. Wśród dojrzałych ryb przeważają w widoczny sposób samice. Porównanie z danymi z literatury (tab. 3 i 4) wykazało, że w obydwu badanych zbiornikach nastąpiło nieznaczne, ale wyraźne zwiększenie się rocznych przyrostów ryb w wieku 3–8 lat badanych w latach 1985–1986 w porównaniu z wcześniejszymi okresami badań. Szybkość wzrostu leszczy w badanych zbiornikach jest większa od przeciętnej szybkości wzrostu tych ryb w wodach Polski i jest podobna jak w innych zbiornikach przymorskich (tab. 3 i 4).

Author's address:

Doc. dr Andrzej Kompowski
Instytut Oceanografii i Ochrony Morza
Zakład Biologicznych Zasobów Morza
ul. Kazimierza Królewicza 4
71–550 Szczecin
Polska (Poland)

Received: 1987.04.27