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AGE, GROWTH, AND CONDITION OF PERCH IN THE SZCZECIN LAGOON

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ABSTRACT

The study involved analysis, performed with standard methods, of length and weight growth of 202 perch individuals caught in November 1999 from the Szczecin Lagoon. The verge coefficient was factored in both when determining the age distribution and when analysing length and weight growth by calculating mean values in age groups (when Kr > 0.50, the number of annual rings was increased by 1).

The perch length growth was rather similar to that emerging from earlier studies in the Pomeranian Bay, Szczecin Lagoon, and Lake Dąbie. A slightly slower growth rate was recorded during the final years of life. On the other hand, the weight growth rate was much slower; the condition coefficient proved clearly lower as well.

Key words: perch, growth, mathematical growth models, condition coefficient.

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INTRODUCTION

The present study on growth and condition of perch in the Szczecin Lagoon terminates the preliminary stage of analysing the problem in the River Odra estuary. Earlier, studies had been carried out in the Szczecin Lagoon and Lake Dąbie (data collected in 1991 and 1992) as well as in the Pomeranian Bay (1995, 1996, and 1998). When supplemented by the 1999 data on the Szczecin Lagoon perch, discussed in this paper, the study on age, growth rate, and condition of perch will have covered almost the entire last decade (1991–2000). In the future, the data will be subjected to a further processing and analysis so that carried a detailed synthesis can be produced.

The perch, due to its tasty meat, is a favourite target species, sought after by anglers. It is also a very interesting object of study due to its relatively slow growth and a high pressure it exerts on other fish species (particularly their larvae and juveniles). As environmental conditions in the River Odra estuary are highly variable, the species requires a continuous scientific monitoring. The present study is a part of a larger project, entitled "The fish growth rate in the unstable environment of the Odra estuary system", carried out by the Department of Fish Biology, Agricultural University of Szczecin.

MATERIALS AND METHODS

The present study involved a total of 202 perch individuals caught in November 1999 from the Szczecin Lagoon. The fish measured 14.5–21.2 cm l.c. (17.0–23.3 cm l.t.) and weighed, prior to gutting, 46 – 125 g. For a possible conversion of the l.c. length into l.t. (for comparison with literature data), the relationship between the two lengths was determined as:

l.t. = 3.9249 + 0.9292 l.c. (r = 0.9882)

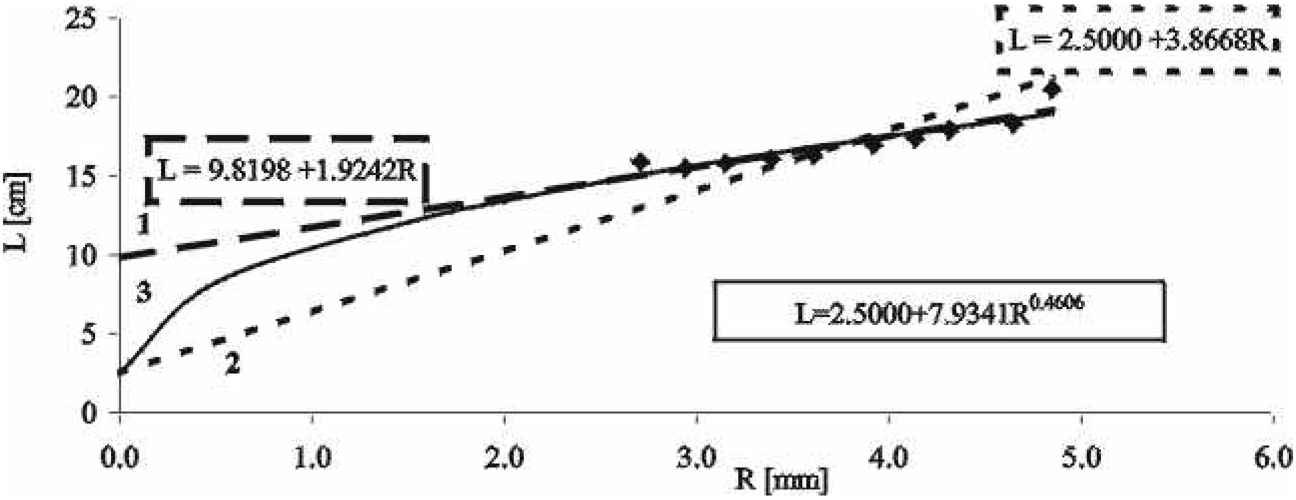
To identify the hypothetical time when the first annual ring started forming on the scales, and also to reduce the uncertainty in length and weight growth rate determination by calculating mean values in age groups, the so–called verge coefficient (Kr) was computed, using the generally accepted formula, for each individual. In addition, Kr was taken into account when ascribing the individuals examined to age groups (when Kr > 0.5, the age calculated from the number of annual rings was increased by 1).

Fig. 1 illustrates the relationship between the fish length (L) and the total scale oral radius (R). When approximating the arrangement of the empirical data points, the following three initial assumptions were put forth: 1) line 1 was determined exclusively from the real data points; 2) the equation describing line 2 was derived with an additional prerequisite requiring the intersection of the y axis (L) at 2.5 cm on the x axis; and 3) the power curve 3 was determined by introducing an additional prerequisite, which was analogous to that applied to line 2. As seen in the plot, line 1 and curve 3 are almost overlapping within the empirical range and nearly follow the empirical data points. However, application of the back reading procedure, apparently necessitated by the character of the line, would require the standard length (*c*) of 9.8 cm, a value greatly deviating from that given by Heese [1] (2.5 cm), derived from a very abundant and representative sample of fish of highly variable length (1059 individuals measuring 2.2 – 35.7 cm l.c.). Heese's work [1] as well as the present author's earlier papers on the perch growth rate in the Odra estuary [5, 6, 7] provide no grounds for basing length growth back calculations on a non–linear relationship, either. Eventually, the Rosa Lee procedure was used, with the standard length *c* equal to 2.5 cm (as in line 2). This choice is additionally justified by a high similarity between the line 2 equation and that given by Heese [1]:

$$L = 2.5000 + 3.8668\ R \text{ (line 2)}$$

$$L = 2.5600 + 4.0200\ R \text{ (the L–R relationship as given by Heese [1])}$$

Fig. 1. Relationship between the perch body length (L) and scale oral radius (R)



The final choice of methodology was further supported by the fact that the back reading method selected had been used in the author's earlier studies on perch growth, already referred to. In this way, the comparability of the results obtained was ensured.

The back–calculated data served as a basis for calculating parameters of two mathematical length growth models: the von Bertalanffy equation and the modified power function. In addition, the length growth was determined by calculating mean lengths in age groups.

The weight growth rate was determined with three methods: by calculating mean weights in age groups, by converting back–calculated lengths to weights using the length–weight relationship, and by applying the modified von Bertalanffy equation [4].

The length (L)–weight (W) relationship was studied, as is a generally accepted practice, with the power function. The fish condition was determined by calculating the Fulton coefficient and by applying two additional methods proposed by Le Cren [2, 3]:

$$K' = \frac{W \cdot 100}{L^n}$$

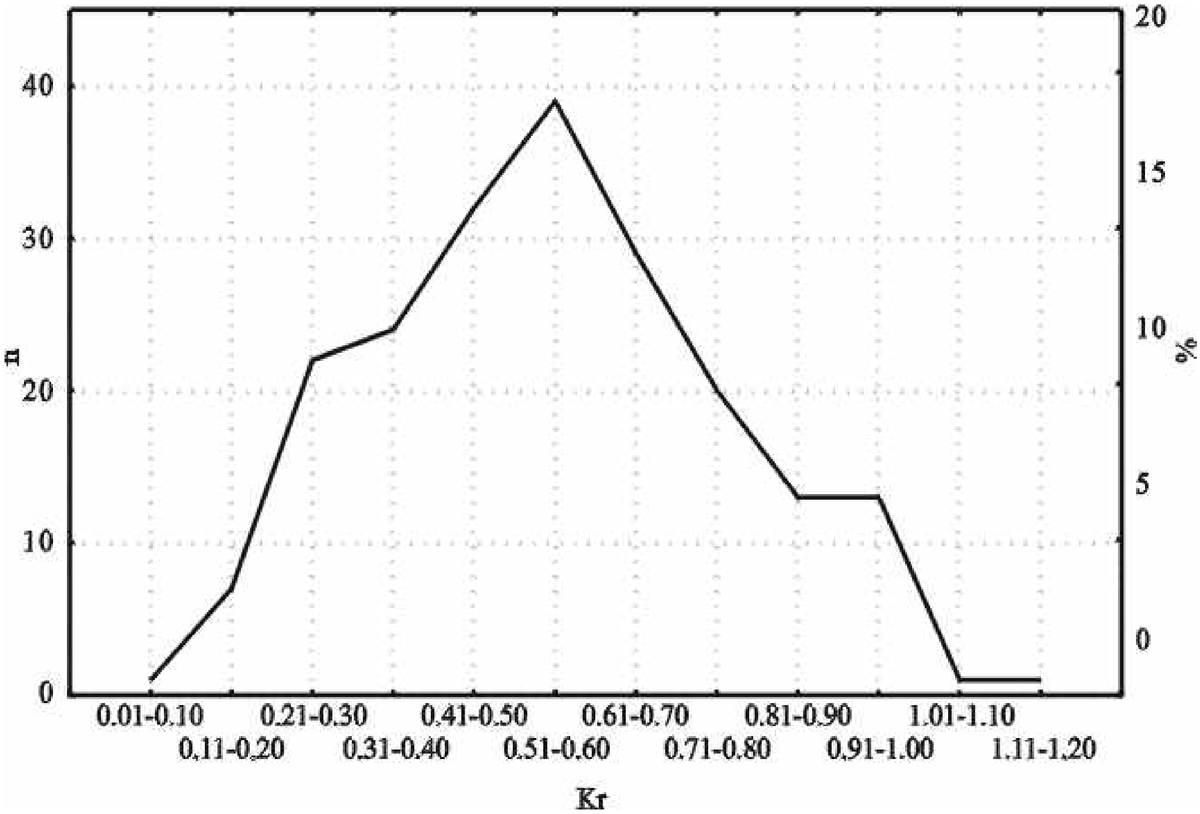
$$K'' = \frac{W}{\hat{W}}$$

In the first case (*K*'), the fish weight (g) multiplied by 100 is related to the power of length, the exponent of which is identical to that in the L–W relationship. In the second case (*K*''), the empirically determined fish weight (*W*) is related to the weight ($\hat{W}$) derived from the L–W relationship, determined earlier, valid for the fish of the given length.

RESULTS

Distribution of the verge coefficient (Kr) is illustrated in Fig. 2. As seen in the plot, the distribution is unimodal, the maximum frequency being found in the Kr class of 0.51–0.60 (n = 39, equivalent to 19.3%). The overall mean Kr was 0.55, which was taken as an evidence that the perch individuals examined were at a mid–point of a period necessary for the next annual ring to appear. A total of 116 individuals (57.4%) showed "large" scale verge increments (Kr>0.50), which was interpreted as a situation temporally closer to the formation of the next annual ring. The Kr values in the remaining 86 individuals (42.6%) were lower than 0.50, i.e., closer, temporally, to the already existing ring. Mean values of Kr determined for "large" and "small" verge increments were 0.70 and 0.35, respectively.

Fig. 2. Distribution of the verge coefficient (Kr) in the perch studied



The length and age distributions of the perch examined are summarised in Table 1. Clearly dominant were two length classes: 16.1–17.0 cm (45.0%) and 15.1–16.0 cm (33.1%). The 17.1–18.0 cm class was the third and the last class contributing more than 10% (13.9%) of all the individuals examined. Together, the three classes contributed 92% (186 individuals). It can be concluded that the sample examined was characterised by rather low length variability (92.0% of the individuals measured 15.1–18.0 cm!).

Similar was the situation with respect to the age distribution in the sample analysed. Clearly dominant were individuals aged 6 (37.1%) and 5 years (36.6%), those aged 7 years contributing fairly many individuals as well (22.3%). Together, the three age classes contributed as many as 96.0% (194 individuals).

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Table 1. Length and age distribution of the perch studied

Length class (cm l.c.)	Age group							
	IV	V	VI	VII	VIII	IX	pieces	%
14.1–15.0	–	6	–	–	–	–	6	3.0
15.1–16.0	1	43	23	–	–	–	67	33.1
16.1–17.0	–	25	51	15	–	–	91	45.0
17.1–18.0	–	–	–	27	1	–	28	13.9
18.1–19.0	–	–	1	2	–	–	3	1.5
19.1–20.0	–	–	–	1	2	–	3	1.5
20.1–21.0	–	–	–	–	–	3	3	1.5
21.1–22.0	–	–	–	–	–	1	1	0.5
No. of individuals	1	74	75	45	3	4	202	
%	0.5	36.6	37.1	22.3	1.5	2.0		100.0

NB: verge coefficient was taken into account when classifying individuals examined to age groups (when Kr>0.5, the age resulting from the number of annual rings was increased by adding 1).

Table 2 summarises back–read data on the perch length growth rate. The results point to relatively small differences in the length growth rate between various age groups. Although a slight tendency towards reduction of mean length (in identical years of life) can be observed with age during the first 5 years of life, the trend was reversed in those fish aged 6 and 7 years. Generally, the comparison of length growth rate in different age groups showed no indication of the so–called Rosa Lee phenomenon, which is an indirect proof that the methodology used was correct.

Table 2. Back–calculated perch length growth rate

Age group	n	Length (cm l.c.)							
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
IV	16	6.6	9.5	11.8	13.8	–	–	–	–
V	112	6.6	9.2	11.4	13.4	15.2	–	–	–
VI	63	6.2	8.7	10.7	12.6	14.4	16.0	–	–
VII	7	6.2	8.6	10.6	12.6	14.5	16.3	17.8	–
VIII	4	6.2	8.8	10.9	12.9	14.8	16.5	18.2	19.6
$\bar{x}$		6.5	9.0	11.2	13.1	14.9	16.1	18.0	19.6
SD		0.36	0.51	0.58	0.60	0.61	0.41	0.60	0.38
v		5.5	5.7	5.2	4.6	4.1	2.5	3.3	1.9
Δ l		6.5	2.5	2.2	1.9	1.8	1.2	1.9	1.6
n		202	202	202	202	186	74	11	4

NB: Age groups were determined exclusively from the number of annual rings

Length increments in the consecutive years of life produced a characteristic pattern. The increment recorded in the first year of life was more than 2.5 times that in the second year. Subsequently, a gradual, slight reduction in length increments was observed. That trend was disturbed only in the sixth (a clear reduction) and in the seventh (increased length increments) years of life. Noteworthy is also a relatively limited scatter of data: the maximum coefficient of variation (v = 5.7%) was recorded in the second year of life, while the minimum variation (v = 1.9%) was typical of the eighth year.

The back–calculated results served as a basis for calculating parameters of the two mathematical growth models: the von Bertalanffy equation and the modified power function. The respective models can be presented as:

$$L_t = 35.8\ [1 - e^{-0.0827(t+1.4692)}]$$

$$L_t = 4.5887\ t^{0.6455} + 1.8557$$

Table 3 compares the back–calculated length data, the results obtained with the above growth models, and mean lengths in individual age groups. As shown by the table, the two models work very well in reflecting the nature of the perch length growth. An average absolute difference between lengths calculated with a model and the back–read ones was as low as 0.16 cm for the von Bertalanffy equation. The modified power function was still more precise and yielded the average absolute difference of 0.09 cm. Larger differences (averaging 0.96 cm) were recorded when using mean lengths in age groups.

Table 3. Perch length growth (cm l.c.) as determined with different methods

Age group	Back readings	Mean lengths in age groups	von Bertalanffy model	Modified power function	[1–2]	[1–3]	[1–4]
	[1]	[2]	[3]	[4]			
I	6.5	–	6.6	6.4	–	0.1	0.1
II	9.0	–	8.9	9.0	–	0.1	0.0
III	11.2	–	11.1	11.2	–	0.1	0.0
IV	13.1	15.3	13.0	13.1	2.2	0.1	0.0
V	14.9	15.9	14.8	14.8	1.0	0.1	0.1
VI	16.1	16.3	16.5	16.4	0.2	0.4	0.3
VII	18.0	17.3	18.0	18.0	0.7	0.0	0.0
VIII	19.6	18.9	19.4	19.4	0.7	0.2	0.2
IX	–	20.7	–	–	–	–	–
Average absolute difference				cm	0.96	0.14	0.09
				%	5.9	1.0	0.7

NB: % expresses a ratio of average absolute difference and mean back–calculated length at the age range compared.

Fig. 3 shows the length–weight relationship of the perch studied. The power function used to express the relationship assumed the mathematical form of

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$$W = 0.0403\ L^{2.6336}$$

The above relationship was used to determine the weight growth rate by converting the back–read lengths to weights. In addition, mean weights in age groups and the modified von Bertalanffy equation in the form of

$$W_t = 498\ [1 - e^{-0.0827(t+1.4692)}]^{2.6336}$$

were used.

Fig. 3. The length (L) - weight (W) relationship in the perch studied

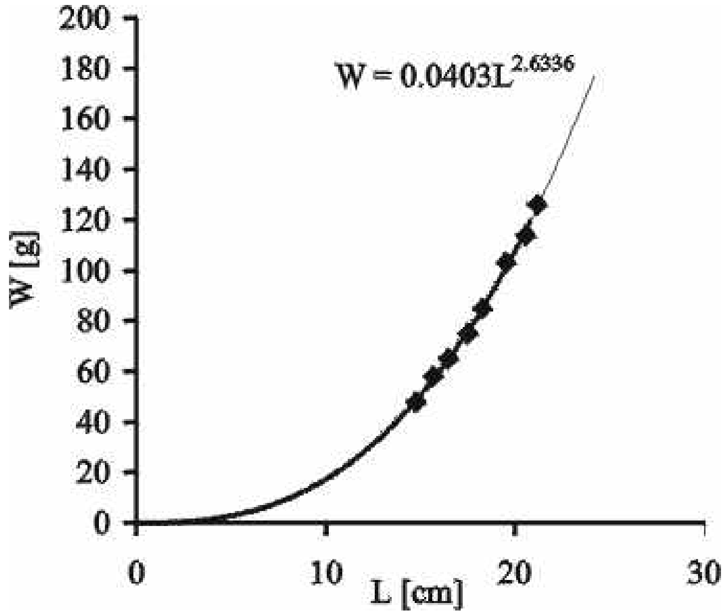

Table 4 summarises and compares results obtained when determining the perch weight growth rate with the three methods discussed above. As showed by the results, the weight growth rate accelerated with age. Such a trend was most pronounced in the data obtained with the modified von Bertalanffy equation, whereby a weight increment in a given year was higher than that in the preceding year. Similar results were produced by the remaining two methods, but the weight increment in the sixth year was lower than that in the fifth year, while the mean weight in age groups showed the weight increase in the ninth year to be slightly lower than that in the eighth year.

Table 4. Perch weight growth (g.) as determined with different methods

Age group	Back–calculated length converted into weight	Mean weights in age groups	Modified von Bertalanffy equation	[1–2]	[1–3]
	[1]	[2]	[3]		
I	6	–	6	–	0
II	13	–	13	–	0
III	23	–	23	–	0
IV	35	53	35	18	0

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V	50	59	49	9	1
VI	61	63	65	2	4
VII	82	74	82	8	0
VIII	102	96	100	6	2
IX	–	117	–	–	–
Average absolute difference			g	8.6	0.9
			%	13.0	1.9

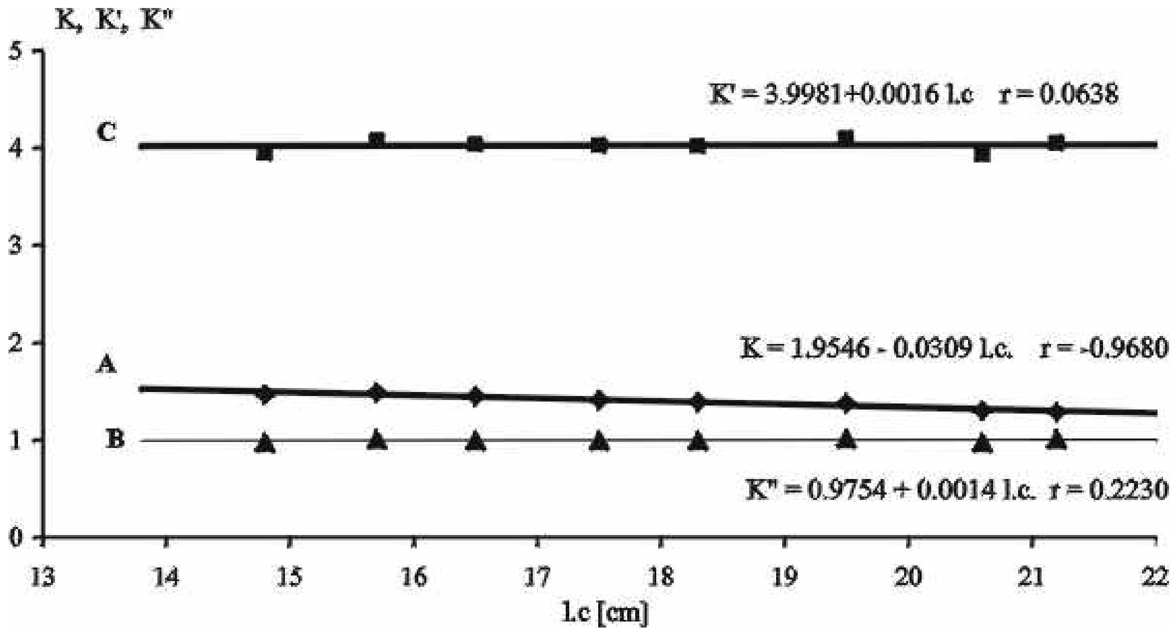
NB: % expresses a ratio of average absolute difference and mean weight determined from the length–weight relationship for age range compared.

Comparison of the weight growth rates determined by calculating mean weights in age groups and by applying the modified von Bertalanffy equation with those obtained with the length–weight relationship demonstrated a high accuracy of the mathematical weight growth model (the average difference amounted to as little as 0.9 g, i.e., 1.9%). Mean weights in age groups produced a clearly larger average difference (8.6 g, i.e., 13.0%).

The Szczecin Lagoon perch condition was the last of the problems analysed. The average condition coefficient, calculated as the Fulton coefficient (K), was 1.45. The average values of K’ and K’’, as calculated following Le Cren [2, 3] (see Materials and methods), were 4.05 and 1.00, respectively.

Length–dependent changes in condition coefficients are shown in Fig. 4. Statistically significant (at the 0.99 confidence level), with a negative slope (r = –0.9680), was only the regression calculated for the Fulton coefficient (K). The remaining two forms of the condition coefficient, K’ and K”, remained virtually at an unchanged level within the range of empirical data, as shown both by low, statistically non–significant, correlation coefficients (0.0638 and 0.2230, respectively) and by negligibly low regression coefficients (0.0016 and 0.0014, respectively). K’ showed a slightly wider variability of its absolute values (from 3.94 to 4.10), compared to K” with its range of 0.98–1.02. The relevant variability ranges expressed as percentages of the mean value of K’ and K” amounted to 3.95 and 4.00%, respectively.

Fig. 4. Relationships between condition coefficients (K, K', K") and length in the perch studied



DISCUSSION

When compared to earlier data from the Szczecin Lagoon [5], the length variability of the perch studied proved clearly lower (14.5–21.2 cm l.c. versus 13.5–29.5 cm). Data on perch caught from Lake Dąbie [5] and from the Pomeranian Bay [6, 7], too, showed a markedly higher variability in the fish length. On the other hand, age distribution can be compared only with respect to those age groups which could be established exclusively from the annual ring count, as the verge coefficient (Kr) was disregarded in paper [4]. In any case, the comparison shows, again, a clearly higher variability in the fish age to be typical of the earlier data sets (age groups III–XII versus IV–VIII in 1999). However, the dominant (exceeding 10% of the number of individuals examined) age groups were similar in both cases: the dominants in 1994 belonged to age groups IV, V, and VI, whereas age groups V and VI dominated in 1999. The Lake Dąbie perch age distribution was somewhat different: the dominants belonged to age groups IV, V, VIII, and IX.

It is now possible, when comparing results on the Pomeranian Bay perch, to use syntheses of the age composition data in which the respective Kr values were factored in. Such comparisons show the Pomeranian Bay perch to consist of individuals classified to age groups IV–XIV [6] and V–XVIII [7], whereas the 1999 Szczecin Lagoon sample analysed consisted of individuals classified as belonging to age groups IV–IX. Thus the earlier results, again, demonstrate much higher age variability. However, in all the three cases, the same (or close) age groups supplied more than 10% of all the individuals: age groups V, VI, and VII as well as VII, VIII, and IX were dominants in the Pomeranian Bay, while groups V, VI, and VII dominated in the Szczecin Lagoon.

In 1999, the length growth rate of the Szczecin Lagoon perch was slightly lower than that recorded in 1994 (the maximum differences, observed in the sixth, seventh, and eighth years of life amounted to 1.3 cm). Somewhat larger differences (1.6 cm) were observed with respect to the results obtained in Lake Dąbie, while the data from the Pomeranian Bay were closest to those reported on in the present paper (maximum differences of 0.9 and 0.7 cm). On the other hand, the weight growth rate of the Szczecin Lagoon perch, as recorded in 1999, was clearly lower than that emerging from earlier studies. In its eighth year of life, the Lagoon perch studied in 1994 weighed 204 g, i.e., twice as much as in 1999 (102 g). The difference with respect to the Lake Dąbie perch was somewhat lower (176 g in the eighth year of life). Similarly large weight differences were revealed by comparison of the present data with those collected in the Pomeranian Bay in 1998 (208 g in the eighth year of life) and 1999 (183 g).

The situation described could have resulted from a much narrower range of the Szczecin Lagoon perch size in 1999, compared to the earlier data. The absence of large individuals (there were just a few individuals longer than 18 cm) might have caused the L–W relationship, vital for weight growth rate determination, to be derived from data not fully representative of the stock studied. In all the earlier studies, the exponent n in the length–weight relationship exceeded 3 (3.2775 in the Pomeranian Bay in 1999). In contrast, the exponent was as low as 2.6336 in the present study. Consequently, the condition coefficient K (1.45) was clearly lower than that determined in the Szczecin Lagoon in 1994 (2.24), Lake Dąbie (1.84), and the Pomeranian Bay (2.39 and 2.20).

The results reported by Żuromska [8] for perch inhabiting the Węgorzewo District lakes indicated still higher length and weight growth rates. The perch studied by her measured, in

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its eighth year of life, 26.1–31.5 cm and weighed 272–495 g. Thus the differences with respect to the values determined in this study amounted to 6.5–11.9 cm and 170–393 g.

CONCLUSIONS

The length growth of the perch studied was only slightly lower than that observed in earlier studies in the Odra estuary. The largest and the smallest differences were shown by the Lake Dąbie and the Pomeranian Bay perch, respectively, the respective differences in the eighth year of life amounting to1.3 and 0.7 cm. On the other hand, the perch studied in the 1950's in the Węgorzewo District lakes grew markedly faster (the differences in the eighth year of life ranging within 6.5–11.9 cm).

The 1999 data demonstrated a markedly lower weight growth rate of the Szczecin Lagoon perch. Earlier studies in the Lagoon (1994) and in the Pomeranian Bay (1998) showed the perch aged 8 years to weigh twice as much; slightly smaller differences were shown the Lake Dąbie perch studied in 1994 and the Pomeranian Bay stock studied in 1999.

The L–W relationship exponent was relatively low (2.6336), compared to earlier data (3.0906–3.2775). The Fulton condition coefficient K, too, was markedly lower (1.45 on the average), compared to the earlier data (1.84–2.39).

The much narrower size range of the fish examined in 1999, compared to the materials collected and analysed earlier, could be one of the causes of such pronounced differences in the perch weight and length growth rates.

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