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SAMPLE SIZE IN THE STUDIES OF POPULATION AGE STRUCTURE OF SOME FISH SPECIES

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ABSTRACT. Minimum size of a representative sample collected for age structure analysis of fish populations: roach, bream, tench, whitefish, and pike ranges from 150 to 300 individuals. In case of stratified samples it is about 200, and for random samples –250 individuals on the average. Due to more laborious collection of stratified samples, for age structure analysis random samples are more appropriate. They are also representative for size structure analysis.

Key words: SAMPLE, POPULATION, AGE STRUCTURE, RANDOM SAMPLING

INTRODUCTION

The issue of representative samples for population age structure analysis seems still not definitely resolved. Each scientist dealing with this subject has to chose the sampling method and sample size by himself to obtain accurate estimate of population age structure.

Age structure of population may be analysed using modified random sampling:

- Fridriksson's method (1934) involving additional measurements of fish body length in order to reduce the size of sample used for age analysis.
- Ketchen's method (1950) – further modification of the previous one, involving „stratified" sampling – the same number of fish of each size class is randomly taken (Fig. 1). According to Ketchen, stratification allows for better representation of the youngest and the oldest, less numerous age groups, which results in more accurate data on their contribution to the population.

The aim of these modifications of random sampling method was to reduce sample size and effort used for sample collection and their laboratory analysis.

Ricker (1975), who dealt with sample representativeness in age structure analysis, accepted Ketchen's method and rejected Fridriksson's as less useful. Kimura (1977) concluded based on mathematical analysis that both methods produced accurate results, but from a statistical point of view Fridriksson's method was more correct and accurate. According to Kimura, use of numerous samples for age evalu-

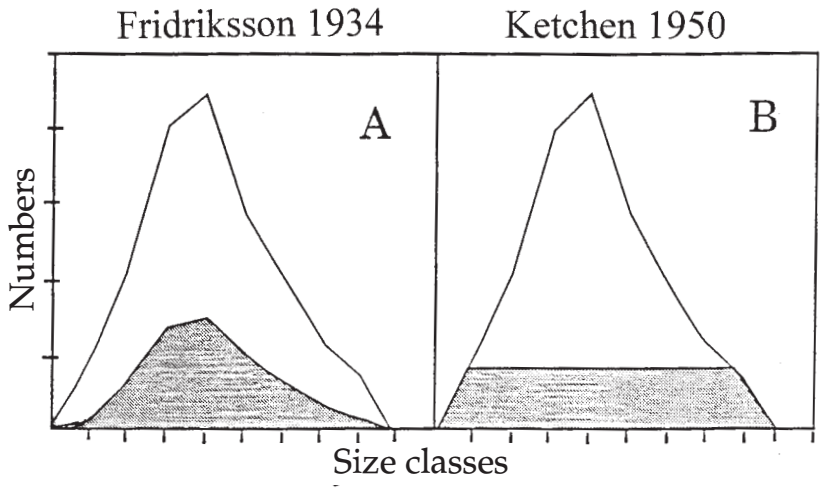

Fig. 1. Length class distribution for two sampling methods. A – Fridriksson's method, B – Ketchen's method. Large polygon – general population, small (filled) – sample (Ketchen 1950).

ation results in higher sample representativeness than high number of fish measurements.

In the present study both sampling methods and representative sample size are analysed and evaluated.

MATERIAL AND METHODS

Several species of freshwater fish caught using gill nets and drag nets: pike, bream, roach, and vendace were used for the analysis. The fish were measured (l. c.) with 1-2 mm accuracy. Scales for age determination were collected from all harvested fish, or from subsamples if the fish were sized. In such cases all individuals in a box were measured to avoid any selection e.g. of smaller fish (Gulland 1966).

Randomly collected (from all harvested fish) samples of about 500 – 1000 or more individuals were used as „general" populations of known size distribution and age structure, representative for the whole fish catch.

From „general" populations, random and „stratified" (according to Ketchen) samples were taken. In both cases dependent selection was used – selected individuals did not return to the general population.

In case of random sampling, samples of 100, 200, or 300 individuals were taken from the general population data file using a computer. Then, age structure of each

sample was calculated, and number of each age group in general population was estimated. Such theoretical age distribution was then compared with the real data using Chi-square test. If no statistically significant differences occurred (at the level P= 0.5, and at n-1 degrees of freedom), sample size was assumed sufficient for age structure analysis.

In case of Ketchen's method total sample number is unknown, contrary to the random sampling method. The same number of fish of each size class is randomly collected. Ketchen presented three levels of stratification – 5, 10, and 15 individuals at 1 cm length intervals, for one species of Pacific flounder, *Parophrys vetulus*.

In the present study, the same and higher levels of stratification, and the same length interval (1 cm) were applied. Such interval was proved appropriate for all analysed fish species by Andersen (1965), who suggested that no higher interval should be used if $h \geq \frac{1}{2}$ SD, because the lower the interval, the higher the accuracy of age structure calculations.

The samples taken using Ketchen's method were obtained from the same general populations as the random samples. Respectively to the level of stratification, randomly selected number of fish of each length class was collected, using the table of random numbers (Zieliński 1972). It should be mentioned that in „stratified" sampling, all individuals of size classes less numerous than the applied stratification level were included into the sample, without selection.

Further data processing was the same as in case of random sampling.

RESULTS

Size structure of typical bream catch (unsized, and sized) are shown in Fig. 2. It should be explained that harvested fish are sized according to size groups established for each species. For example, large bream (L_D) are over 1 kg fish, medium bream (L_S) – 0.5-1 kg, and small bream (L_M) – 0.25-0.5 kg. Such size classes result from consumers' demand. Usually prices of 1 kg of larger fish are higher.

Length class distribution for particular weight groups overlap (Fig. 2). This was observed for all fish species sized according to body weight. In the inland fishery practice in Poland, only vendace is not sorted into size groups due to low and fairly even body weight.

General population of large and medium bream in Pomeranian lakes consisted of samples collected in autumn 1998.

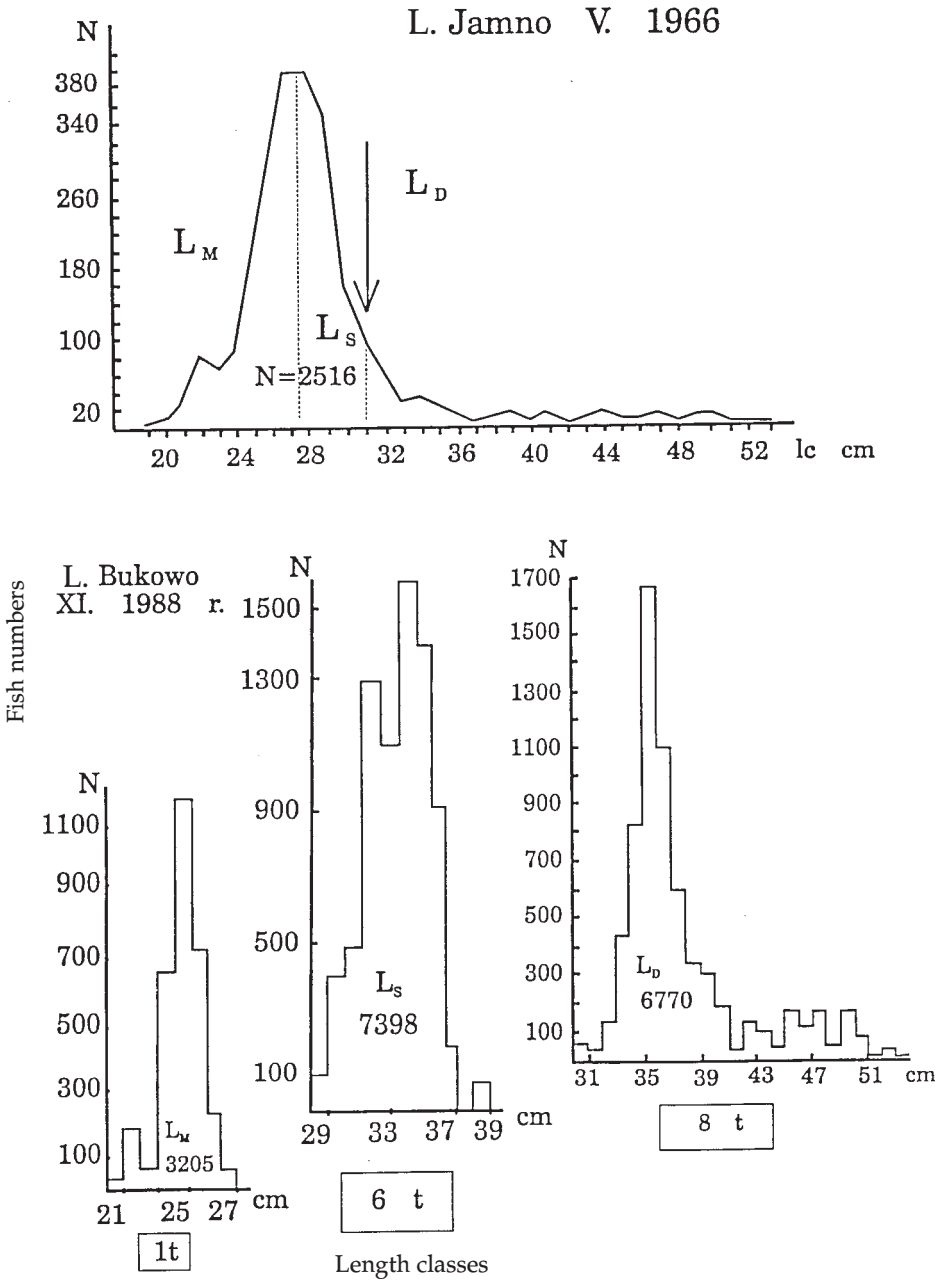

Fig. 2. Size structure of non-sized bream from Jamno Lake, and sized from Bukowo Lake. Fish obtained from 1 drag-net haul were measured.

TABLE 1

Comparison of theoretical distributions (N'_p) obtained from random samples with actual distribution (N_p) of age groups in general population of large bream (L_D).

Sampling levels	Age groups											Σ	χ^2	P
	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+			
N_p	25	155	216	233	154	78	46	25	9	4	2	947		
N_{100}	5	13	24	24	15	9	3	5	1	1		100		
N'_p	47	123	227	227	142	85	28	47	9	9		947	56,5	< 0,05
N_{200}	4	35	41	51	33	16	9	5	2	3	1	200		
N'_p	19	166	194	241	156	76	43	24	9	14	5	947	33,2	< 0,05
N_{250}	7	46	53	62	35	23	12	7	4	1		250		
N'_p	27	174	201	235	133	87	45	27	15	4		947	8,7	0,36

Attention - general population consists of fish harvested in Łebsko , Gardno , Bukowo , Jamno lakes in autumn 1988

The data in Tab. 1 indicate that age structure of bream (L_D) calculated from the sample of 200-250 individuals was representative for general population (Fig. 3). Sample of similar size was taken from population of medium bream (Tab. 2, Fig. 3). More numerous (about 300 individuals) was the sample of large bream harvested at the same time from two Mazurian lakes (Tab. 3).

TABLE 2

Comparison of theoretical distributions (N'_p) obtained from random samples with actual distribution (N_p) of age groups in general population of medium bream (L_S).

Sampling levels	Age groups						Σ	χ^2	P
	4+	5+	6+	7+	8+	9+			
N_p	170	601	346	67	7	1	1192		
N_{100}	10	46	36	4	4		100		
N'_p	119	548	429	48	48		1192		
N_{200}	30	100	54	15	1		200		
N'_p	179	596	322	89	6		1192	9,9	0,04
N_{250}	31	129	76	13	1		250		
N'_p	148	615	362	62	5		1192	5,4	0,25

General populations of pike obtained from small (38.4 ha) eutrophic Lake Warniak show different size and age structures (Fig. 4). The numbers of representative samples are, however, similar – about 250 individuals.

Similar minimum representative sample size (200-300 individuals) was obtained for vendace harvested in two Mazurian lakes (Fig. 5, Tab. 4-5). Minimum stratifica-

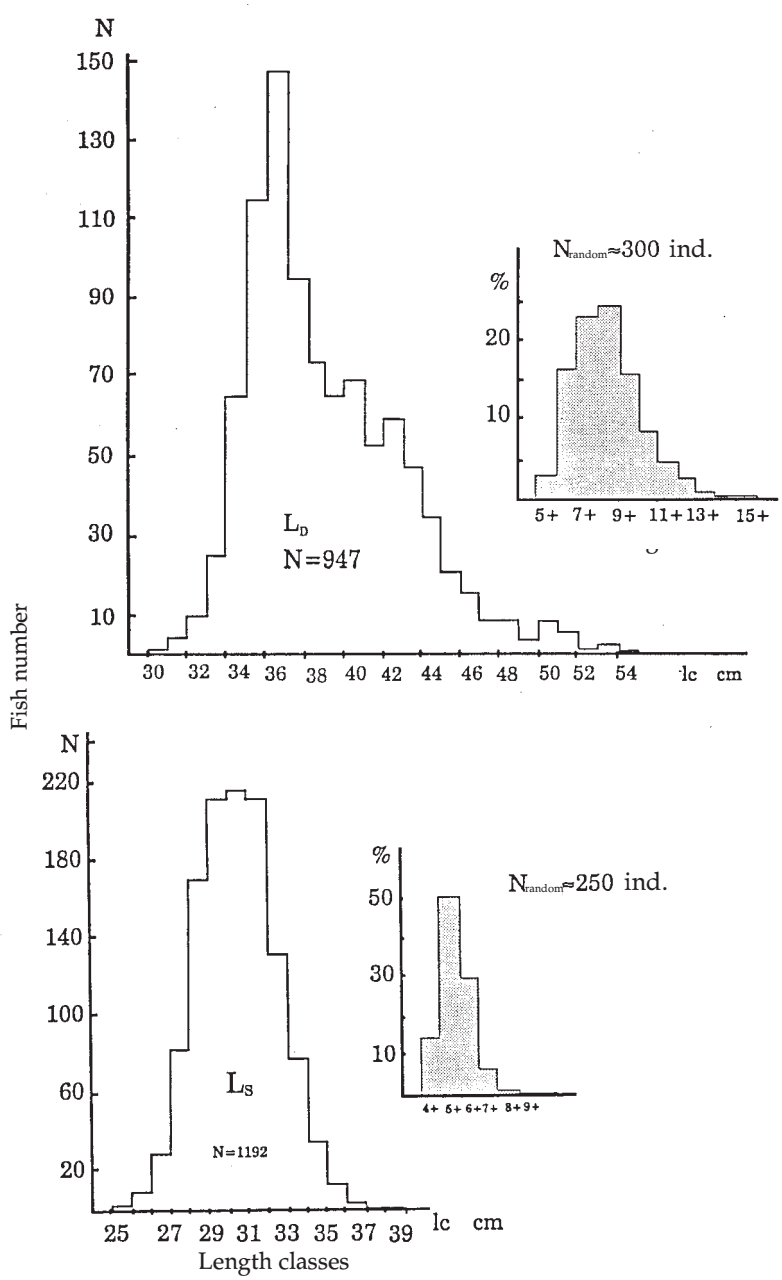

Fig. 3. Size and age structures of large (L_D), and medium (L_s) bream general populations harvested from Łebsko, Gardno, Bukowo, and Jamno lakes in autumn 1988. N – general population size, N_{random} – minimum size of representative sample for age structure analysis.

TABLE 3

Comparison of theoretical distributions (N'_p) and actual distribution (N_p) in general population of large bream (L_D) consisting of fish harvested in Mamry and Śniardwy lakes in autumn 1988

Sampling levels	Age groups										Σ	χ^2	P
	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+			
N_p	27	145	185	184	130	78	29	10	1	2	791		
N_{100}	5	29	24	21	11	8	2				100		
N'_p	40	229	190	166	87	63	16				791	90	
N_{200}	3	32	53	49	34	21	5	3			200		
N'_p	12	126	210	194	134	83	20	12			791	18 ,0	0 ,01
N_{300}	11	53	70	77	46	28	11	3		1	300		
N'_p	29	140	185	203	121	74	29	8		2	791	3 ,8	0 ,8

TABLE 4

Comparison of theoretical distributions (N'_p) and actual distribution (N_p) in general population of vendace in Maróz Lake.

Sampling levels	Age groups								Σ	χ^2	P
	1+	2+	3+	4+	5+	6+	7+	10+			
N_p	425	629	83	25	22	5	1	2	1192		
N_{100}	38	48	8	3	3				100		
N'_p	453	572	95	36	36				1192	14,7	< 0 ,05
N_{200}	67	109	16	5	1	1	1		200		
N'_p	399	650	95	30	6	6	6		1192	18,6	< 0 ,05
N_{300}	101	170	17	6	6				300		
N'_p	401	675	68	24	24				1192	8,3	0,08

Attention - general population obtained from gill net harvest at spawning grounds in Nov. 1977

TABLE 5

Comparison of theoretical distributions (N'_p) and actual distribution (N_p) in general population of vendace in Pluszne Lake.

Sampling levels	Age groups									Σ	χ^2	P
	1+	2+	3+	4+	5+	6+	7+	8+	9+			
N_p	111	363	334	39	55	62	13	4	2	993		
N_{100}	9	38	33	7	4	8	1			100		
N'_p	89	377	328	70	40	79	10			993	45 ,3	< 0 ,05
N_{200}	20	77	64	9	7	14	7	2		200		
N'_p	99	382	318	45	35	70	35	90		993	51,0	< 0 ,05
N_{300}	33	115	101	14	14	15	7	1		300		
N'_p	109	382	334	46	46	50	23	3		993	8,6	0 ,20

Attention - general population obtained using seine on July 19-20 1978 r.

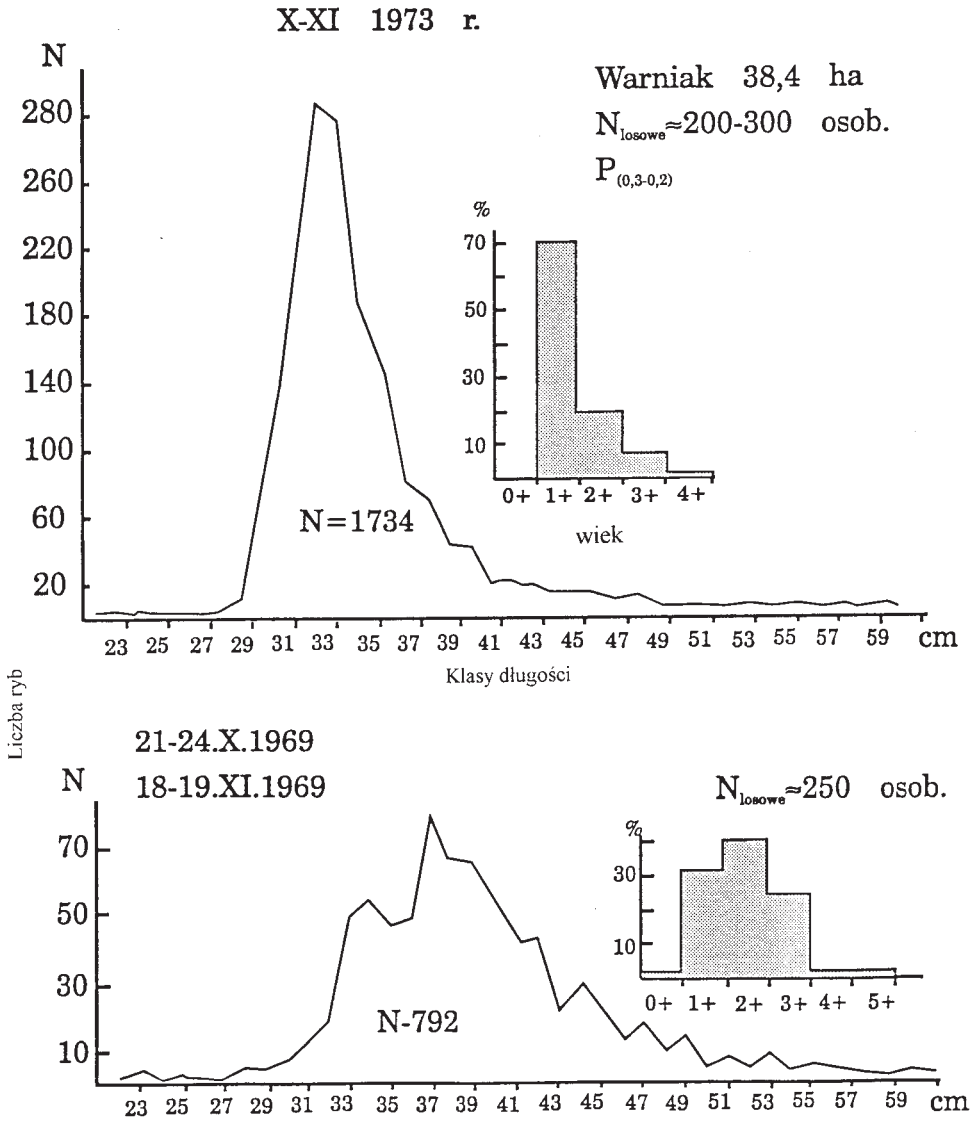

Fig. 4. Size and age structures of Warniak Lake pike general populations. N – general population size, N_{random} – sample size, P – probability.

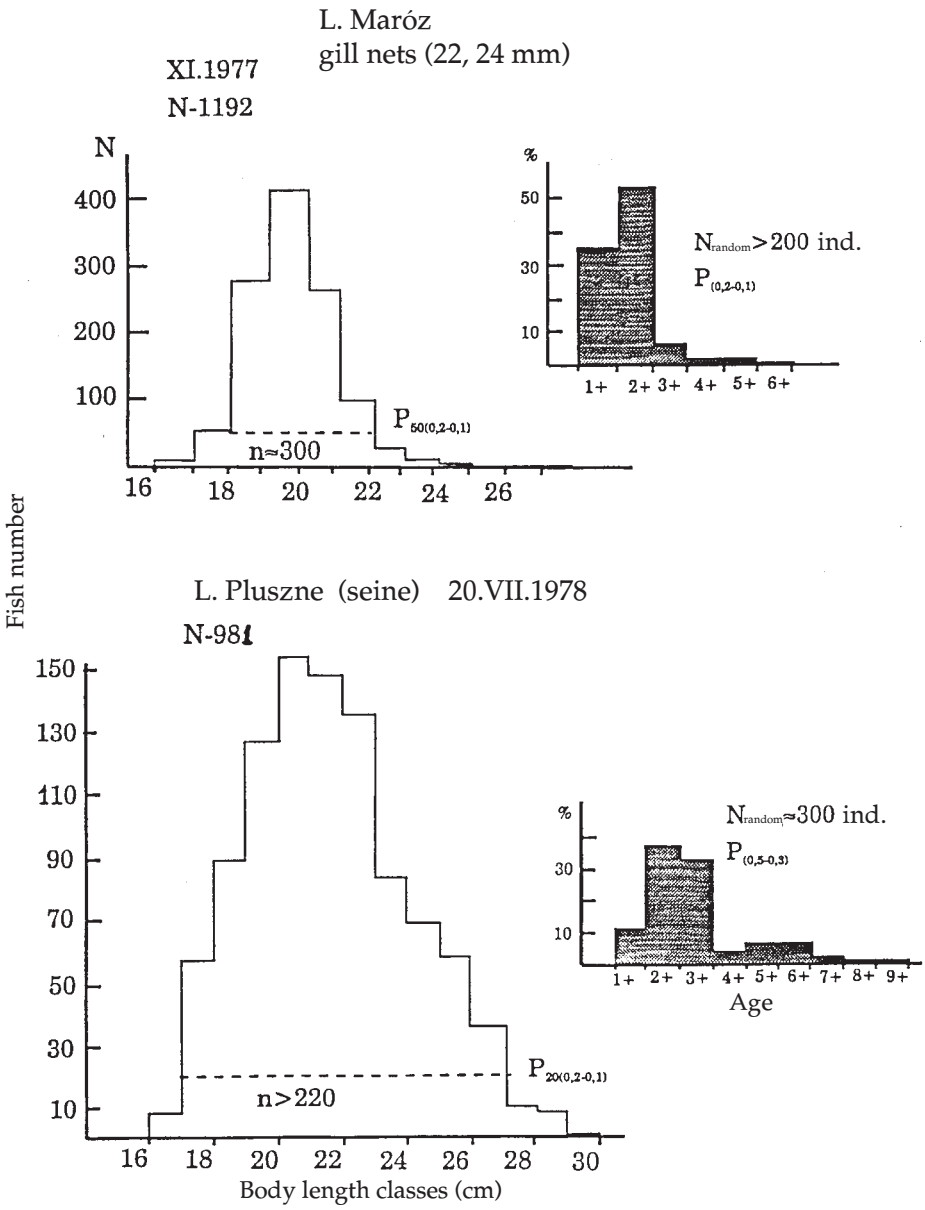

Fig. 5. Size and age structures of vendace general populations in two Mazurian lakes. N – general population size, N_{random} – random sample size, n – stratified sample size, P – probability with stratification level.

TABLE 6

Representative sample size (n), stratification levels (N_x), chi-square, and probability (P) of similarity of age distributions obtained from stratified samples, and general populations of vendace

Lake/Date	Numbers of the general population N	Stratification level N_x	χ^2	P	Sample size n
Łańskie VII. 1997	648	N_{10}	28,85	< 0 ,01	200
		N_{20}	10 ,15	0 ,05-0 ,025	
		N_{30}	5 ,86	0 ,3-0 ,2	
		N_{40}	3 ,69	0 ,5-0 ,4	
		N_{50}	2 ,61	0 ,7-0 ,6	
Bełdany VII. 1978	916	N_{10}	3 ,89	0 ,3-0 ,2	200
		N_{20}	6 ,94	0 ,1-0 ,05	
		N_{30}	2 ,38	0 ,5-0 ,4	
		N_{50}	2 ,14	0 ,6-0 ,5	
Mamry Płn. VII. 1977	913	N_{10}	42 ,83	< 0 ,01	200
		N_{15}	23 ,25	< 0 ,01	
		N_{30}	1 ,61	0 ,7-0 ,6	

tion level necessary for representative sampling of these populations of different size and age structures is shown with dashed line. The figure also shows that, for both lakes, representative stratified sample size is similar to that for random sample despite different stratification levels – higher for lower number of size classes. It should be mentioned that both examples of age structure of the population fraction under fishery exploitation are typical for Polish vendace lakes – 2-3 age-classes predominate, with little addition of older fish (Ciepielewski 1987). Other data show that, similarly as for random samples, minimum representative stratified sample size are similar for various lakes, despite different stratification levels (Tab. 6).

Tab. 7 shows calculated minimum size of representative samples for pike. The results confirm earlier suggestions that the size of stratified samples taken from populations of different age structures is similar. In case of pike, 5 individuals of each 1 cm length class is sufficient for a representative sample. In such cases, total sample size is equal to 150-200 individuals.

Similar evaluation of sample representativeness performed for large bream (L_D) from Łebsko and Bukowo lakes showed that stratification level N_{10} (10 individuals of each length class) is sufficient for a representative sample. Total sample size is thus about 150 fish. In case of medium bream, representative sample size is about 200 indi-

TABLE 7

Comparison of theoretical age class distribution in stratified samples, and in general population (N_p) of Warniak Lake pike.

Date of obtainings the general sample	Stratification level	Age groups								Σ	χ^2	P	Sample size n^x
		0+	1+	2+	3+	4+	5+	6+	8+				
X-XI 1969	N_p	5	272	288	199	14	8	5	1	792			
	N_5	5	283,5	277,5	200	13	7	5	1	792	1,07	0,98	150
	N_{10}	5	262,5	302,5	194,5	13,5	8	5	1	792	1,18	0,98	250
	N_{15}	5	274	282,5	202,5	14,5	8	5	1	792	0,20	0,99	300
XI 1972	N_p	116	115	352	17					600			
	N_5	110,5	115	358,5	16					600	0,44	0,93	200
	N_{10}	115	119	347,5	18,5					600	0,34	0,95	300
	N_{15}	117,5	110	355	17,5					600	0,28	0,96	350
X-XI 1973	N_p	4	539	158	64	4	1			770			
	N_5	4	561,5	130	69,5	4	1			770	6,37	0,04	150
	N_{10}	4	548,5	149,5	63	4	1			770	0,64	0,83	200
	N_{15}	4	519,5	182	59,5	4	1			770	4,64	0,20	250
X-XI 1974	N_p		14	164	94	20	2			294			
	N_5		14,5	153	106	18,5	2			294	2,39	0,50	150
	N_{10}		14,5	157	101,5	19	2			294	0,96	0,82	200
	N_{15}		14	163,5	91,5	17	2			294	0,66	0,88	250
X 1975	N_p		78	352	111	21	4			566			
	N_5		83,5	365,5	99	14	4			566	4,16	0,25	150
	N_{10}		81,5	357	98	25,5	4			566	2,56	0,60	200
	N_{15}		80,5	348	110,5	23	4			566	0,29	0,99	250
X-XII 1976	N_p		288	326	97	10	4			725			
	N_5		319	306	89	7	4			725	5,87	0,11	150
	N_{10}		280,5	329,5	95,5	5,5	4			725	1,53	0,67	200
	N_{15}		304,5	315	95,5	6	4			725	2,48	0,48	250

X – Sample size (n) rounded up to 50 fish

viduals, at stratification level 25 fish, and for small bream – about 250 individuals, at stratification level 30 fish (Tab. 8).

Calculated representative sample size for S roach (fish over 200 g) from Warnołty Lake was about 180 individuals, at stratification level 20 fish (Tab. 9).

TABLE 8

Comparison of theoretical and actual (N_p) bream age class distributions, and representative sample size (n)

Lake/Size	Stratification level	Age groups														Σ	χ^2	P	Sample size n
		2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+				
Bukowo L_D	N_p				14	64	123	136	65	26	13	12	8	4	2	467			
	N_{10}				9	75	140	111	63	30	13	12	8	4	2	467	11,27	0,2-0,1	150
	N_{20}				11	68	139	114	63	33	13	12	8	4	2	467	7,87	0,5-0,4	200
Łebsko L_D	N_p				11	80	93	98	88	51	33	12	1			477			
	N_{10}				13	89	93	91	94	60	23	14				477	5,95	0,7-0,5	150
	N_{15}				11	98	84	99	90	56	26	13				477	3,21	0,9-0,8	200
	N_{20}				12	99	83	90	93	54	28	12				477	3,09	0,9-0,8	250
Łebsko L_S	N_p			41	218	128	28	3	1							419			
	N_{25}			51	217	118	28	2	3							419	3,2	0,5-0,3	200
Łebsko Jamno	N_p	1	119	143	230	64	8									565			
Bukowo L_M	N_{30}	1	101	158	241	55	9									565	5,7	0,2-0,1	250

TABLE 9

Comparison of theoretical and actual age class distributions in Warnołty Lake roach population (VII 1978), and representative sample size (n).

Stratification level	Age groups								Σ	χ^2	P	Sample size n^x
	4+	5+	6+	7+	8+	9+	10+	11+				
N_p	9	68	146	167	114	26	8	1	539			
N_{10}	19	65.5	150.5	144.5	120	23.5	15	1	539	20.37	< 0.01	
N_{20}	10.5	59	131.5	167	134.5	28	7.5	1	539	6.51	0.5-0.3	180
N_{30}	10	61.5	161.5	150.5	122	24.5	8	1	539	4.64	0.7-0.5	220
N_{40}	8	66	135	169.5	123.5	27	8	1	539	1.73	0.95-0.9	300

X – Sample size (n) rounded up to 20 fish

TABLE 10

Comparison of vendace length class distribution in general population(N_p), and in the samples (N_x) in various lakes.

Lake	Sample size N	Length classes															Σ	λ	P(λ)
		15-16	-17	-18	-19	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30			
Pluszne VII. 1978	N_p		8	57	88	125	155	148	135	83	68	58	35	11	8	2	981		
	N_{300}		1	22	28	36	52	39	39	27	18	18	12	3	3	2	300	0,33	0,99
	N_{150}			10	15	22	23	17	17	18	11	7	4	2	3	1	150	0,42	0,99
	N_{150}		1	12	13	14	29	22	22	9	7	11	8	1		1	150	0,27	1,00
Maróz XI. 1977	N_p	6	57	282	420	267	99	33	13	7	4	3	1				1192		
	N_{210}		11	54	66	48	21	10									210	0,27	1,00

DISCUSSION

Minimum representative sample size estimated for several fish species ranged from 150 to 300 individuals. In case of stratified samples it was equal to about 200, and for random samples – about 250 individuals on the average. Representative stratified samples are slightly less numerous comparing to random ones. However, stratified sampling is more labour-consuming (it involves fish sizing), thus random samples are more convenient for age structure analysis.

Such samples are probably representative also for size structure analysis. To test this hypothesis, random samples of certain minimum number (n) were taken from general population of vendace. Distribution of length classes in the sample was compared with size distribution in the population using Kolmogorov-Smirnov test (Tab. 10).

Both distributions - for sample of 300 individuals, and for 150 individuals show high $P\lambda$ (>0.99) which indicates that minimum representative sample size for size structure analysis is lower than for age structure analysis.

Similar analysis for other fish species (pike, roach, bream) showed similar trends – representative samples taken for age structure analysis were also sufficient for size structure analysis. Thus, no additional laborious measurements are needed in such analyses.

The hypothesis was also verified using another method. It was assumed that length class distributions of the individuals in general populations are normal. Then, random samples of ($\hat{n}$) size were taken.

Sample size was estimated using the formula:

$$\hat{n} \quad U_{\frac{\alpha}{2}} \quad U \quad \frac{\sigma}{} \quad ^2 \quad ^2 \text{, (Platt, Bochno 1967)}$$

where:

σ – standard deviation of fish length in general population,

Δ – average accuracy of fish length in the sample versus average in general population

α – probability of type I error

β – probability of type II error.

In the present study type I error - probability of rejecting a true hypothesis that the difference between average fish length in the sample and average in the entire popu-

lation was under Δ – was 1 : 200 ($\alpha/2 = 0.005$). $U_{\alpha/2}$ taken from the tables for normal distribution is equal to 2.58. Probability of type II error – accepting a false hypothesis – that the difference between average fish length in the sample and average in general population was over Δ was evaluated as1:20 (β=0.005, $U_\beta = 1.64$). For ($\hat{n}$) calculation two Δ values were used: 0.5, and 1 cm.

Estimated sample size values are shown in Fig. 6. The curves show that for Δ = 0.5 sample number is several fold higher than for Δ – 1.0, at the same values of standard deviation (σ).

Estimated number of individuals was randomly taken from the same general populations as used for age structure analysis. Some populations were sampled and analysed for the first time. Usually the same number ($\hat{n}$) of fish were taken twice. Length class distributions were compared with distributions of general populations, using Kolmogorov-Smirnov test.

Several examples of the calculations are discussed. In general population of whitefish in Maróz Lake at the time of 1977 spawning (N = 1192 individuals) average fish body length was equal to 18.7 cm, and standard deviation 1.3. Size of the sample, evaluated using the formula:

$$\hat{n} \quad U_{\frac{\alpha}{2}} \quad U \quad \frac{\sigma}{} \quad ^2 \quad ^2$$

in which average fish length did not differ from the average in general population more than 0.5 cm was about 120 individuals ($\hat{n}_{0.5} = 120$). Distribution of length classes of the individuals in randomly taken samples (from two samplings) was very similar to that of general population – calculated λ was equal to 0.24 for the first distribution, and 0.36 for the second. Probability (P_λ) of similarity of these distributions with the general population distribution was about 1.0.

In other general populations of vendace, of about 1000 individuals collected in various lakes, average body length of an individual usually ranged from 18 to 20 cm, and standard deviation – 1.1-1.6. Sample size ($\hat{n}_{0.5}$) estimated for such populations ranged from 86 to 180 individuals respectively. Length class distributions were very similar to general population distributions ($P_\lambda \approx 1.0$). The samples were over twice less numerous comparing to those required for age structure analysis.

In the general population of S roach in Warnołty Lake (N = 539), average fish body length was 23.6 cm, and σ = 1.9. Estimated sample size ($\hat{n}_{0.5}$) was about 257 indivi-

duals, and for $\hat{n}_{1.0}$ – about 65 individuals. In other S roach population, in Gosławskie Lake (N = 535, $\bar{x}$ = 21.1 cm, and σ = 2.1). Sample size ($\hat{n}_{0.5}$) was about 314, and $\hat{n}_{1.0}$ – about 78.

In case of Warniak Lake, tench population (N = 395, $\bar{x}$ = 26.7 cm, σ = 2.45), $\hat{n}_{0.5}$ was about 428, and $\hat{n}_{1.0}$ – about 107.

For S bream from Pomeranian lakes (N = 1192, $\bar{x}$ = 30.8 cm, σ = 2.05), $\hat{n}_{0.5}$ was about 300, and $\hat{n}_{1.0}$ – about 75.

For the general population of D bream from Pomeranian lakes (N = 945, $\bar{x}$ = 38.4 cm, σ = 4.1), $\hat{n}_{0.5}$ was about 1197, and $\hat{n}_{1.0}$ – about 300.

The results for roach, bream, and tench – distributions of size classes in randomly taken samples were very similar to general population distributions ($P_\lambda \approx$ 0.8 - 1.0).

General population of pike in Warniak Lake in autumn 1969 consisted of N = 998 individuals of average body length $\bar{x}$ = 38.1 cm, with σ = 5.08. Estimated sample size $\hat{n}_{0.5}$ was about 1838, and $\hat{n}_{1.0}$ – about 460 individuals. General population in autumn 1973 was equal to 1734 fish of average body length $\bar{x}$ = 34.4 cm, and σ = 4.4. Estimated sample size $\hat{n}_{0.5}$ was about 1739, and $\hat{n}_{1.0}$ – about 345 fish.

Population of young eel (under 200 g per individual) migrating from Maróz and Mielno lakes consisted of N = 2240 fish, $\bar{x}$ = 40 cm, and s = 2.7. Estimated $\hat{n}_{0.5}$ was 519, and $\hat{n}_{1.0}$ – about 130 individuals. For large eel population (N = 4500, $\bar{x}$ = 62.5 cm, σ = 8.3) from the same lakes (Ciepielewski 1976) estimated $\hat{n}_{1.0}$ was 1227 individuals, and $\hat{n}_{0.5}$ was four fold higher.

Analysed length class distributions of pike and eel populations of ($\hat{n}_{1.0}$) were very similar to general population distributions ($P_\lambda \approx$ 0.9 - 1.0). Sample sizes, however, are about 50% higher comparing to representative sample sizes for age structure analyses.

Sample size $\hat{n}$ may be reduced even below the number needed for age structure analysis by increasing Δ. But in such cases, especially for general populations of σ > 4.0, average fish length in the samples would differ by 2 or more cm from the average in general population despite high similarity of size class distributions in samples and in general populations.

The curves (Fig. 6), and the data mentioned above show that for populations of some fish species (vendace, roach, tench, and S bream), of σ values ranging from 1.1 to 2.5, size of representative samples for length structure analysis are lower or equal to those for age structure analysis.

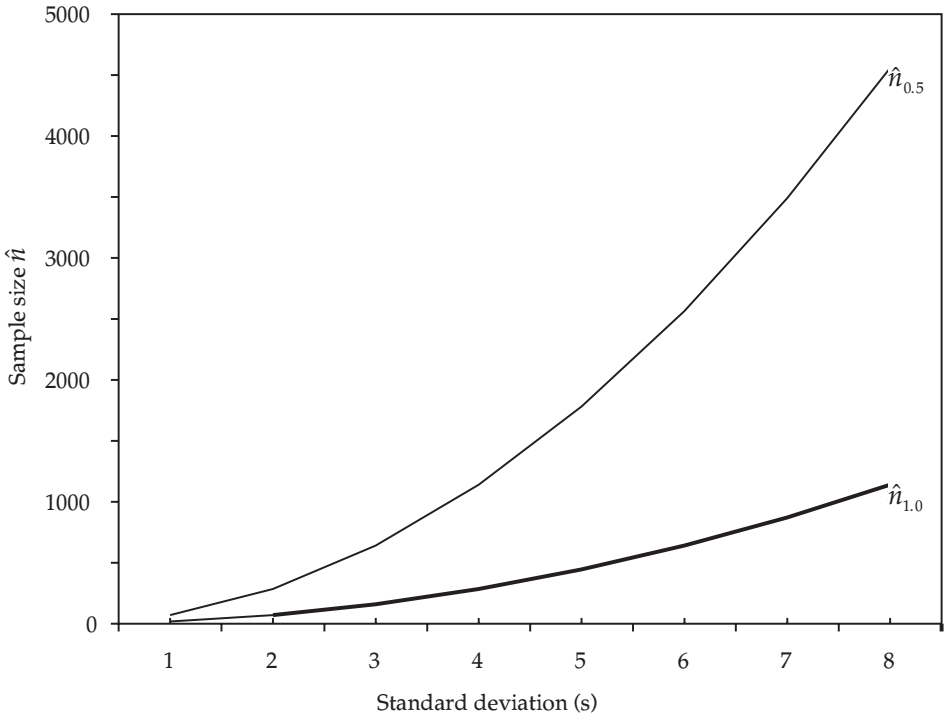

Fig. 6. Sample size (n) versus standard deviation (σ) in general population. $n_{0.5}$ and $n_{1.0}$ calculated from the formula $\hat{n} \approx U_{\frac{\alpha}{2}}^2 \frac{\sigma^2}{U}$, for Δ = 0.5, and 1.0, respectively.

On the contrary, in populations such as D bream, pike, pike-perch, whitefish, or eel – of higher size variability of the individuals (σ = 3-8) – representative sample size for size structure analysis is several times higher comparing to that for age structure analysis.

Thus, it should be taken into consideration that for size, and age structure analyses different sample size should be applied to obtain accurate results.

REFERENCES

Andersen K. P. 1965 – Some notes on the effect of grouping of data with special reference to length measurements. Meddl. Danmarks Fiskeri – og Havund. 4/4:79-92.

Ciepielewski W. 1976 – Rozmiary, płeć i wiek węgorza (Anquilla anquilla L.) spływającego z dwóch jezior mazurskich. Rocz. Nauk Roln. H. 97:7-26.

Ciepielewski W. 1987 – Fluktuacje liczebności roczników sielawy w dwóch jeziorach mazurskich. Rocz. Nauk Roln. H. 101:27-41.

Fridriksson H. 1934 – On the calculation of age distribution within a stock by means of relatively few age dterminations as a key to measurements on a large scale. Rapp. et Proc. – Verb. Const. Int. Explor. Mer, 86, 6:1-14.

Gulland J. A. 1966 – Manual of sampling and statistical methods for fisheries biology. Part I. Sampling methods. (FAO) Food Agric. Organ., United Nations.

Ketchen K. S. 1950 – Stratified subsampling for determining age distributions. Trans. Amer. Fish. Soc. 70:205-212.

Kimura D. K. 1977 – Statistical assessment of the age-length key. J. Fish. Res. Bd. Can. 34:317-324.

Platt Cz., Bochno R. 1967 – Określanie liczebności prób w doświadczeniach rolniczych. Zesz. Nauk. WSR. Olsztyn, 23:875-889.

Ricker W. E. 1975 – Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 191:382p.

Zieliński R. 1972 – Tablice statystyczne. PWN, Warszawa

STRESZCZENIE

LICZEBNOŚĆ PRÓBY W BADANIACH STRUKTURY WIEKOWEJ POPULACJI NIEKTÓRYCH GATUNKÓW RYB

W opracowaniu poddano ocenie dwa sposoby pobierania próby reprezentatywnej z analizowanej pod względem struktury wiekowej populacji (rys. 1). Materiały do analiz uzyskano z połowów rybackich kilku gatunków ryb słodkowodnych: szczupaka, leszcza, płoci, lina i sielawy. Pobrane losowo z połowów rybackich próby o liczebnościach około 500-1000 i więcej osobników potraktowano jako populacje "generalne", o znanych rozkładach liczebności klas długości i znanej strukturze wiekowej, dobrze reprezentujące połów z którego zostały wzięte. Z populacji generalnych pobierano próby losowe i stratyfikowane. W obydwu przypadkach zastosowano losowanie zależne tzn., wylosowane osobniki nie wracały z powrotem do populacji generalnej. Teoretyczne rozkłady grup wieku w populacji generalnej, obliczone na podstawie rozkładów wieku w wylosowanych grupach porównywano z rzeczywistym rozkładem populacji generalnej za pomocą testu Chi-kwadrat – przyjęto poziom istotności α =0.05 i n-1 stopni swobody. Z przedstawionych w tabeli 1 liczb wynika, że struktura wiekowa leszcza dużego (L_D) uzyskana z wylosowanej próby o liczebności 200-300 osobników jest reprezentatywna dla populacji generalnej (rys. 3). Podobną liczebność ma próba reprezentatywna leszcza średniego (L_S) (tab. 2, rys. 3). Nieco więcej osobników (ok. 300) liczy próba reprezentatywna wylosowana z populacji generalnej leszcza dużego odłowionego z dwóch jezior mazurskich (tab. 3). U szczupaka, liczebności wylosowanych prób reprezentatywnych do oceny struktury wiekowej są podobne (rys. 4). Również podobną liczebność minimalną (200-300 osobników) mają reprezentatywne próby losowe a także i stratyfikowane wylosowane z populacji generalnych sielawy (rys. 5, tab. 4-6). Liczebność minimalnej, stratyfikowanej próby reprezentatywnej ocenionej dla różnych populacji szczupaka wynosi około 150-200 osobników (tab. 7). Liczebność próby stratyfikowanej ocenionej dla populacji leszcza dużego, przy poziomie stratyfikacji N_{10} (losowanie dziesięciu osobników z każdej klasy długości) wynosi około 150 osobników. Dla leszcza średniego – 200 osobników, przy poziomie stratyfikacji wynoszącym 25 osobników, a dla leszcza małego – około 250 osobników przy poziomie wynoszącym 30 osobników (tab. 8). Liczebność próby reprezentatywnej oceniona dla płoci sortymentu S wynosi około 180 osobników (tab. 8), przy poziomie stratyfikacji wynoszącym 20 osobników (tab. 9). Mi-

nimalna liczebność prób reprezentatywnych, oceniona dla kilku prezentowanych gatunków waha się od 150 do 300 osobników. W przypadku prób stratyfikowanych wynosi około 200, a dla losowych 250 osobników. Reprezentatywne próby stratyfikowane są nieco mniej liczebne niż losowe. Ze względu na większą pracochłonność pobierania próby stratyfikowanej (konieczność sortowania ryb w procesie pobierania próby) w porównaniu z próbą losową, do oceny struktury powinno się pobierać próby losowe. Próby te są również reprezentatywne dla oceny struktury wielkościowej analizowanej populacji (tab. 10).

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