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MORPHOMETRY AND GROWTH OF GREENLAND HALIBUT *REINHARDTIUS HIPPOGLOSSOIDES* (WALBAUM, 1792) OFF LABRADOR

MORFOMETRIA ORAZ WZROST HALIBUTA NIEBIESKIEGO *REINHARDTIUS HIPPOGLOSSOIDES* (WALBAUM, 1792) Z REJONU LABRADORU

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The paper presents the morphometric characteristics as well as results of study on length and age distributions, length and weight growth rates and length-weight relationships of the Greenland halibut population inhabiting the region off Labrador.

INTRODUCTION

Knowledge on variability of biometric features is necessary for the description of a species. The variability of characters is observed not only among different species or populations belonging to a single species, but in the internal structure of a population as well. Specimens from a geographically widely distributed species and coming from different areas of its distribution differ, as a rule, from one another in their morphology. According to Johnson (1983), the intraspecific morphological variability if fish of different widely distributed species is evident and every effort should be made to estimate the range of these differences. Estimation of differences is important from the taxonomic point of view, because it makes it possible to assess the range of variations in characters of a species studied as a whole. The present study was aimed at determining variability of meristic and metric characters of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum, 1792), caught off Labrador. Materials collected allowed to determine some biological properties of the species. Length and age distributions, length and growth rates and the length-weight relationships were examined.

MATERIALS AND METHODS

The materials under study consisted of 154 specimens of Greenland halibut (121 males and 33 females) caught off Labrador (53°20'N; 52°20'W) on 26 June 1976.

The biometric analysis was made involving 22 measurements and determination of 11 meristic features made on each fish. The measurements of all metric features were taken with a ruler or callipers to 0.1 cm. Fish weight was determined to 1 g.

The measurements were carried out according to a scheme of Vernidub (Pravdin, 1966), generally adopted for flatfish. The measurement design shown in Fig. 1, while Table 1 presents symbols used for different features.

The metric characters were studied with two methods: the classic one involving point comparisons with the use of per cent indices, and by correlation coefficients and linear regression analysis. The latter has been recently introduced and has not been widely applied yet, particularly for marine fishes. The method checks for association between the metric character studied and the body or head length, the association being expressed as a linear regression equation

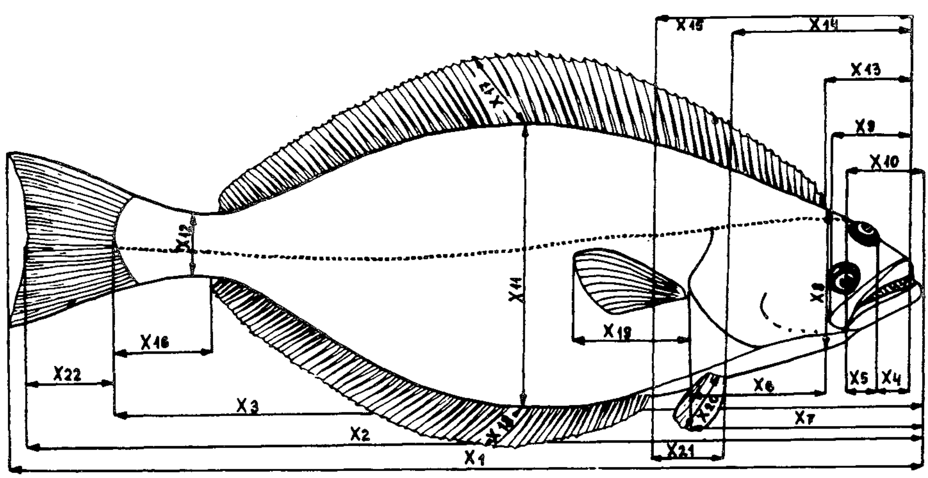

Fig. 1. Diagram of metric character measurements

Table 1

Symbols used to denote metric characters studied

Character	Latin name
x_1	logitudo totalis
x_2	longitudo caudalis
x_3	longitudo corporis
x_4	longitudo praeorbitale
x_5	diameter oculi
x_6	longitudo postorbitale
x_7	longitudo capitis lateralis
x_8	altitudo capitis
x_9	longitudo ossis maxillare
x_{10}	longitudo ossis dentale
x_{11}	altitudo corporis maxima
x_{12}	altitudo corporis minima
x_{13}	longitudo praedorsale
x_{14}	longitudo praeventrale
x_{15}	longitudo praeanale
x_{16}	longitudo pedunculi caudae
x_{17}	altitudo pinnae D
x_{18}	altitudo pinnae A
x_{19}	longitudo pinnae P
x_{20}	longitudo pinnae V
x_{21}	distantia V–A
x_{22}	longitudo mediale radiorum pinnae C

$$y = a + bx$$

where y is the character studied used here as a dependent variable, and x is an independent variable (body or head length).

Correlation coefficient (v) is a measure of closeness of the relationship. The method was used by i.a. Tadajewska (1980a, 1980b), Kopiejewska (1980), Terlecki and Martyniak (1989). The authors referred to, however, expressed the characters they studied as absolute values (cm) and not as % of body length, hence as a rule they obtained very high, close to 1, corelation coefficients. Such results are to be expected as different parts of fish body grow with fish growth.

In this paper the relationship between the characters examined and of body or head length expressed with linear regression, is presented in terms of relative values expressed as per cent of the basic dimension.

The test in the form of:

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$ (Parker, 1978)

where r = the sample correlation coefficient

n = the sample size

was used to test for significance of the correlation coefficient.

Metric features analysed with the methods described above are in relation to the whole sample and for both sexes separately. Student's test was used to compare results obtained for the two sexes.

Seven meristic characters were determined from every fish examined. They are, together with their symbols, summarised in Table 2.

Table 2

Symbols used to denote meristic characters studied

Character	Nazwa łacińska
D	Numerus radiorum pinnae dorsalis
A	Numerus radiorum pinnae analis
C	Numerus radiorum pinnae caudalis
V	Numerus radiorum pinnae ventralis
P	Numerus radorium pinnae pectroalis
sp. br.	Numerus spinarum ad arcum branchiorum
vt.	Numerus vertebrarum

All fins of Greenland halibut, are supported by soft rays. The last soft ray in the dorsal and anal fin is double, but it was counted as one (as suggested by Gąsowska (1962)) because it is based, like the other rays, on a single basal ray hidden within the muscles.

In all the remaining fins all rays were counted.

The vertebrae count and number of caudal fin rays were estimated using the X-ray radiograms made specifically for this purpose. All vertebrae were counted, including the first one connected with the occiput and the terminal one, considering the urostyl as an integral part of the terminal vertebra.

Gill rakers were always counted on the first gill arch, collected from the right, eyed, side of the head. Despite their different size and thickness, all gill rakers were counted, including the smallest ones.

Snedecor's F test was used to test for significance of differences between generations of the population studied. Tabulated values were those for the $\alpha = 0.05$ significance level.

The coefficient of variation is of importance for the analysis of the characters examined. Ruszczyc (1981) states that coefficients of variation are statistically significant when they amount to 8–10% only. Thus characters yielding coefficients of variation below 10% were considered to be of low plasticity.

Age was determined from scales collected from the caudal part of the body above the lateral line on the eyed side. As shown by Krzykawski (1976a), scales from this area show a clearer pattern of annuli than do other anatomical elements.

Relationship between the total fish length (l.t.) and the scale oral radius from the caudal part as estimated for the entire material, can be described by the following regression equation:

$$y = 0.05\,x + 0.013$$

where:

x – total length of fish (cm)
y – scale oral radius (mm)

The correlation coefficient of these variables amounted to $r = 0.941$, Krzykawski (1976a) estimated similar relation on the much more representative sample (430 individuals), derived from the New Foundland fishing grounds with the fish length ranging from 13 to 81 cm (i.e. a range wider than that in the sample analysed here) and obtained the following linear regression equation: $y = 0.057x - 0.20$, the correlation coefficient amounting to $r = 0.986$. This equation was adopted as a bassis for growth rate back calculations performed with the Rosa-Lee formula (Krzykawski, 1976a).

The length values obtained with this method were presenting growth rate with the following five models: those of v. Bertalanffy, Gompertz, Ford-Walford equations, binomial and power function.

The power function was used also to determine the length-weight relationship (Lagler, 1959), while the weight growth rate was presented with the modified v. Bertalanffy equation.

RESULTS

Biometric characters

Measurable features of the Greenland halibut, expressed in relative units for the entire material are presented in Table 3.

Table 3

Metric characters of Labrador Greenland halibut in % of l. corporis and % of l. capitis lateralis

Character	n	% longitudo corporis				
		Range	$\overline{x}$	S	m	V
x_1	153	110.8 – 117.3	114.0	1.09	0.09	0.96
x_2	153	109.6 – 115.6	112.5	1.04	0.08	0.93
x_7	148	22.0 – 27.7	24.2	0.87	0.07	3.61
x_4	150	4.4 – 7.4	5.3	0.49	0.04	9.28
x_5	153	3.1 – 5.1	4.0	0.41	0.03	10.28
x_6	151	11.8 – 15.3	14.0	0.64	0.05	4.59
x_8	153	12.7 – 17.1	14.7	0.72	0.06	4.87
x_9	151	9.7 – 12.5	11.2	0.49	0.04	4.41
x_{10}	150	11.6 – 15.7	14.1	0.63	0.05	4.48
x_{11}	154	28.1 – 36.2	32.4	1.55	0.12	4.78
x_{12}	154	6.7 – 9.6	8.2	0.53	0.04	6.37
x_{13}	150	8.5 – 12.1	10.4	0.57	0.05	5.54
x_{14}	148	23.3 – 31.1	26.3	1.36	0.11	5.17
x_{15}	149	32.3 – 50.0	37.9	2.28	0.19	6.01
x_{16}	153	8.4 – 13.6	11.6	0.84	0.07	7.23
x_{17}	151	7.1 – 11.3	9.3	0.70	0.06	7.55
x_{18}	151	6.6 – 12.5	10.3	0.91	0.07	8.87
x_{19}	142	7.6 – 12.6	10.3	0.81	0.07	7.82
x_{20}	149	4.4 – 7.8	6.6	0.68	0.06	10.27
x_{21}	151	9.7 – 17.9	13.4	1.44	0.12	10.67
x_{22}	153	11.3 – 14.4	12.8	0.66	0.05	5.15
		% longitudo capitis lateralis				
x_4	148	18.7 – 30.0	22.0	1.96	0.16	8.88
x_5	148	13.1 – 22.4	16.5	1.72	0.14	10.43
x_6	147	49.4 – 63.5	57.8	2.03	0.17	3.52
x_8	147	53.2 – 69.6	60.8	2.88	0.24	4.73
x_9	147	41.8 – 51.5	46.4	1.52	0.13	3.28
x_{10}	146	52.8 – 63.2	58.2	1.85	0.15	3.17

n – number of individuals;
$\overline{x}$ – arithmetic mean;
S – standard deviation;
m – standard error;
V – coefficient of variation;

Table 4

Analysis of significance of differences (Student's t test) in biometric characters between Greenland halibut males and females from off Labrador ($t_{0.05} = 1.96$)

Character	Males n	Males $\bar{x}$	Males S	Females n	Females $\bar{x}$	Females S	$t_{obl.}$
			Metric characters – % longitudo corporis				
x_1	120	114.0	1.10	33	113.8	1.03	1.02
x_2	120	112.5	1.05	33	112.5	1.04	0.00
x_7	116	24.3	0.86	32	23.9	0.88	2.13*
x_4	118	5.3	0.48	32	5.4	0.56	0.50
x_5	121	4.0	0.40	32	3.9	0.43	0.61
x_6	118	14.0	0.65	33	13.9	0.61	1.26
x_8	120	14.8	0.71	33	14.6	0.71	1.22
x_9	119	11.3	0.50	32	11.0	0.43	2.78 *
x_{10}	118	14.1	0.65	32	13.8	0.52	2.24 *
x_{11}	121	32.4	1.52	33	32.3	1.68	0.46
x_{12}	121	8.2	0.53	33	8.3	0.51	0.77
x_{13}	119	10.4	0.54	31	10.2	0.69	1.20
x_{14}	116	26.4	1.36	32	25.7	1.21	2.73*
x_{15}	117	38.1	2.32	32	37.4	2.08	1.42
x_{16}	120	11.6	0.91	33	11.5	0.51	0.24
x_{17}	118	9.3	0.66	33	9.3	0.83	0.22
x_{18}	118	10.3	0.93	33	10.1	0.84	1.28
x_{19}	112	10.4	0.81	30	10.1	0.71	1.34
x_{20}	117	6.6	0.71	32	6.6	0.55	0.00
x_{21}	119	13.4	1.49	32	13.7	1.27	1.00
x_{22}	120	12.9	0.65	32	12.6	0.64	2.57 *
			Metric characters – % longitudo capitis lateralis				
x_4	116	21.9	1.85	32	22.5	2.30	1.38
x_5	116	16.5	1.70	32	16.5	1.80	0.03
x_6	115	57.8	1.85	32	57.9	2.64	0.32
x_8	115	60.8	2.73	32	61.1	3.41	0.50
x_9	115	46.5	1.42	32	46.0	1.80	1.64
x_{10}	114	58.3	1.83	32	58.0	1.91	0.78
			Meristic characters				
D	117	95.73	4.02	31	95.45	4.72	0.33
A	118	71.41	2.91	31	71.32	4.52	0.13
C	118	19.02	0.13	31	19.03	0.18	0.35
V	118	5.95	0.26	33	5.94	0.24	0.20
P	114	13.67	0.73	31	13.65	0.91	0.13
sp. br.	121	15.96	1.37	33	15.64	1.27	1.20
vt.	121	61.55	0.75	33	61.67	0.65	0.83

* Difference statistically significant

As seen from the table, the coefficient of variation estimated for percentages in terms of both the body and head length was statistically significant (over 10%) for three characters only: the ventral fin length, distance between the ventral and anal fins (V–A), and eye diameter. The last one varies significantly when expressed both as a ratio relative to the body length and to the head length. Thus the three above mentioned characters should be considered as plastic in the population studied.

Comparison of the values of per cent indices estimated for males and females (Table 4) metric characters shows negligible (below 1%) differences between the sexes. Females show a slighty larger distance between the ventral and anal fins and somewhat larger preorbital distance and dorsal fin height, and a slightly higher caudal peduncle. The remaining characters were somewhat larger in males.

Student's t test revealed (at the 0.05 level) statistically significant differences for following characters (Table 4): the head length, length of upper and lower jaws, preventral length and length of caudal fin middle rays. The mean per cent indices of the above characters were higher in males.

The metric features of the population examined were presented also by means of linear regression equations and corelation coefficient, estimated from the partial means in 1 cm length classes. In most hitherto-published papers on fish morphometry, relationships between metric characters and body length were calculated only from absolute values (cm). Corelation coefficients of the relationships estimated in such way are, as a rule, statistically significant, their values being close to 1.

Therefore this paper analyses relations between relative values of measurable characters (per cent indices) and body length; relations between the characters pertinent to the cephalicpart and the lateral head length are analysed in the same manner, too.

Tables 5 and 6 give relationships between these features and the body or head length for all fish and for the sexes separately. As seen from the tables, correlation coefficients for a few characters only, at the $\alpha = 0.05$ are statistically significant. Their values as a rule differ widely from 1 and are positive and negative. In the whole sample from the region of study the following features correlate with the body length: the eye diameter, postorbital length (both correlate with the lateral head length as well), minimal body height, antedorsal length, height of dorsal and anal fins, length of ventral fin and length of caudal fin middle rays. The correlation between the characters mentioned and the body or head length (except for the height of dorsal fin) was found in males from the region, too. On the other hand, only 2 features (i.e. the total length and eye diameter) in females show significant relationships with the body length. The eye diameter correlates with the head length as well; additionally, the length of lower jaw revealed a significant relationship with the head length.

It is worth noticing that a single character only, namely teh eye diameter, displays significant relationships with the body and head length both throughout the entire

Table 5

Correlation coefficients and regression equations for relationships between metric characters and body length (l.c.) of Greenland halibut off Labrador

Character	Males (n = 121)		Females (n = 33)		Males and females (n = 154)	
	Correlation coefficient $r_{0.05} = 0.381$ *	Regression equation	Correlation coefficient $r_{0.05} = 0.497$ *	Regression equation	Correlation coefficient $r_{0.05} = 0.381$ *	Regression equation
x_1	−0.376	y = 115.828 − 0.047x	− 0.567	y = 117.823 − 0.111x	−0.343	y = 115.086 − 0.032x
x_2	−0.192	y = 113.374 − 0.021x	−0.366	y = 114.756 − 0.059x	−0.065	y = 112.682 − 0.005x
x_4	0.262	y = 4.841 + 0.016x	−0.236	y = 6.415 − 0.028x	0.191	y = 5.055 + 0.011x
x_5	−0.630	y = 4.817 − 0.025 x	−0.917	y = 6.303 − 0.070x	−0.703	y = 5.037 − 0.031x
x_6	0.620	y = 12.940 + 0.035x	−0.024	y = 13.946 − 0.002x	0.639	y = 12.888 + 0.035x
x_7	0.051	y = 24.317 + 0.004x	−0.261	y = 24.822 − 0.027x	0.250	y = 23.604 + 0.019x
x_8	0.067	y = 14.727 + 0.003x	−0.348	y = 15.671 − 0.031x	0.145	y = 14.547 + 0.007x
x_9	0.170	y = 11.152 + 0.006x	−0.100	y = 11.209 − 0.007x	0.252	y = 10.939 + 0.009x
x_{10}	−0.066	y = 14.428 − 0.004x	0.383	y = 12.898 + 0.029x	0.136	y = 13.894 + 0.008x
x_{11}	0.293	y = 30.808 + 0.042x	0.110	y = 31.650 + 0.027x	0.295	y = 31.381 + 0.030x
x_{12}	0.530	y = 7.355 + 0.026x	0.381	y = 7.183 + 0.034x	0.710	y = 7.186 + 0.031x
x_{13}	−0.755	y = 11.743 − 0.038x	−0.496	y = 12.166 − 0.055x	−0.714	y = 11.501 − 0.033x
x_{14}	0.238	y = 25.818 + 0.025x	−0.196	y = 27.118 − 0.036x	0.310	y = 25.368 + 0.032x
x_{15}	0.189	y = 37.186 + 0.027x	−0.353	y = 40.972 − 0.103x	0.106	y = 37.542 + 0.015x
x_{16}	−0.152	y = 11.949 − 0.012x	0.193	y = 10.997 + 0.015x	−0.162	y = 11.951 − 0.012x
x_{17}	−0.319	y = 9.984 − 0.021x	−0.145	y = 9.899 − 0.016x	−0.407	y = 10.163 − 0.024x
x_{18}	−0.792	y = 12.548 − 0.066x	−0.199	y = 10.678 − 0.017x	−0.811	y = 12.386 − 0.061x
x_{19}	0.720	y = 8.579 + 0.055x	0.349	y = 8.564 + 0.048x	0.718	y = 8.614 + 0.053x
x_{20}	0.147	y = 6.206 + 0.009x	0.302	y = 5.633 + 0.027x	0.126	y = 6.313 + 0.006x
x_{21}	−0.066	y = 13.644 − 0.009x	−0.490	y = 17.735 − 0.112x	−0.222	y = 14.298 − 0.025x
x_{22}	−0.628	y = 14.075 − 0.036x	−0.330	y = 14.022 − 0.040x	−0.661	y = 13.769 − 0.030x

* Correlation significance limit

Table 6

Correlation coefficients and regression equations for relationships between metric characters and head lengths (x_7) of Greenland halibut off Labrador

Character	Males (n = 121)		Females (n = 33)		Males and females (n = 154)	
	Correlation coefficient $r_{0.05} = 0.381$ *	Regression equation	Correlation coefficient $r_{0.05} = 0.497$ *	Regression equation	Correlation coefficient $r_{0.05} = 0.381$ *	Regression equation
x_4	0.221	y = 20.250 + 0.223x	−0.176	y = 25.693 − 0.341x	0.159	y = 21.218 + 0.147x
x_5	−0.668	y = 19.825 − 0.424x	−0.928	y = 26.436 − 1.229x	−0.739	y = 20.648 − 0.508x
x_6	0.681	y = 53.455 + 0.524x	0.418	y = 54.776 + 0.392x	0.659	y = 53.732 + 0.508x
x_8	0.049	y = 60.432 + 0.032x	−0.126	y = 62.637 − 0.190x	0.085	y = 60.310 + 0.053x
x_9	0.219	y = 45.892 + 0.065x	0.055	y = 45.574 + 0.053x	0.207	y = 45.750 + 0.065x
x_{10}	−0.075	y = 58.707 − 0.041x	0.784	y = 51.695 + 0.786x	0.097	y = 57.812 + 0.052x

* Correlation significance limit

Table 7

Meristic characters of Greenlwand halibut off Labrador

Character	Males						Females						Males and females					
	n	Range	$\bar{x}$	S	m	V	n	Range	$\bar{x}$	S	m	V	n	Range	$\bar{x}$	S	m	V
D	117	82-106	95.73	4.02	0.37	4.20	31	82-102	95.45	4.72	0.85	4.95	148	82-106	95.67	4.16	0.34	4.35
A	118	63-82	71.41	2.91	0.27	4.07	31	66-89	71.32	4.52	0.81	6.34	149	63-89	71.39	3.29	0.27	4.61
C	118	19--20	19.02	0.13	0.01	0.68	31	19—20	19.03	0.18	0.03	0.94	149	19-20	19.02	0.14	0.01	0.74
V	118	5-7	5.95	0.26	0.02	4.29	33	5-6	5.94	0.24	0.04	4.08	151	5-7	5.95	0.25	0.02	4.23
P	114	12-16	13.67	0.73	0.07	5.37	31	12-17	13.65	0.91	0.16	6.70	145	12-17	13.66	0.77	0.06	5.65
sp. br.	121	12-19	15.96	1.37	0.12	8.58	33	13-19	15.64	1.27	0.22	8.12	154	12-19	15.89	1.35	0.11	8.50
vt.	121	60-63	61.55	0.75	0.07	1.22	33	60-63	61.67	0.65	0.11	1.05	154	60-63	61.58	0.73	0.06	1.18

sample and in each sex separately. As, however, the numbers of males and females in the sample differ considerably, data on the differences between the sexes should be treated with caution.

Table 7 summarises metric features of the Greenland halibut from the region of study. As seen from the table the range of variability in the number of soft rays in the dorsal fin was 82–106 both for the whole sample and for males. while the maximum value in females was lower (102). Most individuals, both wirth respect to the entire sample and within each sex showed 96 rays. The mean value for the sample was 95.67, the mean for males exceeding that for females. Females showed wider range of variability. Most frequent were individuals with 71 rays (70 among females). The overall mean was 71.39. In this character, too, mean in males was slightly higher.

The range of variations in the caudal fin was at its narrowest and amounted 19–20 rays, individuals with 19 rays predominating in the sample. The overall mean 19.02; the means for each sex were close to each other.

The ventral fin number of rays in the whole sample and in males ranged from 5 to 7, while the range found in females was 5 to 6 only. In this case, too, the mean value (5.95) is almost identical for both sexes.

The number rays found in the pectoral fin was 12–17 in all the fish and in females, 12–16 being found in males. Most individuals had 14 rays and the mean value for the whole sample and for both sexes amounted to 13.66.

The number of gill rakers on the first gill arch ranged within 12–19, the range in females being 13–19. Most individuals showed 15 and 16 rakers. The mean count for all the fish examined was 15.89, males showing a somewhat higher value.

The vertebral count ranged from 60 to 63, 61 and 62 vertebrae being found in most fish. The mean value of this character for the whole sample amounted to 61.58, the mean in females being slightly higher than that in males.

The coefficients of variation estimated for the meristic features discussed above (Table 7) are neither high nor significant. The lowest variation is found in the caudal fin ray count, the number of gill rakers being the most variable character.

The between sexes differences between ranges of the meristic features were not statistically significant (Tab. 4).

Since the fish examined were caught during one calendar year, they were divided into different age groups coming from different generations, which allowed to analyse significance of differences among generations occurring in several succeeding years (1969–74). Such analysis, involving meristic characters, was run with Snedecor's F test and is summarised for the entire sample in Table 8.

As can be seen, the significant differences among generations examined appeared only in the dorsal and anal fins ray number.

Table 8

Analysis of variability in meristic characters by age groups of Greenland halibut off Labrador

Age	n		D	A	C	V	P	sp. br.	vt.
II	1	$\bar{x}$	93.00	74.00	19.00	6.00	14.00	15.00	62.00
		S	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		m	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		V	0.00	0.00	0.00	0.00	0.00	0.00	0.00
III	49	$\bar{x}$	95.89	70.36	19.04	5.96	13.49	15.69	61.59
		S	3.67	2.32	0.20	0.20	0.55	1.43	0.64
		m	0.54	0.34	0.03	0.03	0.08	0.20	0.09
		V	3.83	3.30	1.06	3.39	4.07	9.13	1.04
IV	58	$\bar{x}$	94.59	71.05	19.02	5.95	13.61	15.93	61.53
		S	3.69	3.77	0.14	0.22	0.88	1.35	0.78
		m	0.49	0.50	0.02	0.03	0.12	0.18	0.10
		V	3.90	5.30	0.72	3.76	6.45	8.47	1.26
V	24	$\bar{x}$	96.26	72.13	19.00	5.91	13.83	15.92	61.58
		S	3.92	2.93	0.00	0.29	0.49	1.18	0.78
		m	0.82	0.61	0.00	0.06	0.10	0.24	0.16
		V	4.07	4.06	0.00	4.87	3.55	7.39	1.26
VI	17	$\bar{x}$	96.24	73.65	19.00	5.94	14.00	15.94	61.59
		S	5.77	3.26	0.00	0.43	0.79	1.39	0.87
		m	1.40	0.79	0.00	0.10	0.19	0.34	0.21
		V	6.00	4.42	0.00	7.22	5.65	8.72	1.41
VII	5	$\bar{x}$	103.00	73.20	19.00	6.00	13.80	17.20	61.80
		S	2.45	3.35	0.00	0.00	1.79	1.10	0.45
		m	1.22	1.50	0.00	0.00	0.80	0.49	0.20
		V	2.38	4.57	0.00	0.00	12.96	6.37	0.72
		$F_{obl.}$	3.81 *	3.57 *	0.37	0.17	1.45	1.26	0.21
		$F_{0.05}$	2.27	2.27	2.27	2.27	2.27	2.27	2.27

* Difference statistically significant

GROWTH RATE

The analysis of length and age distribution for the entire sample and by sex is presented graphically in Fig. 2.

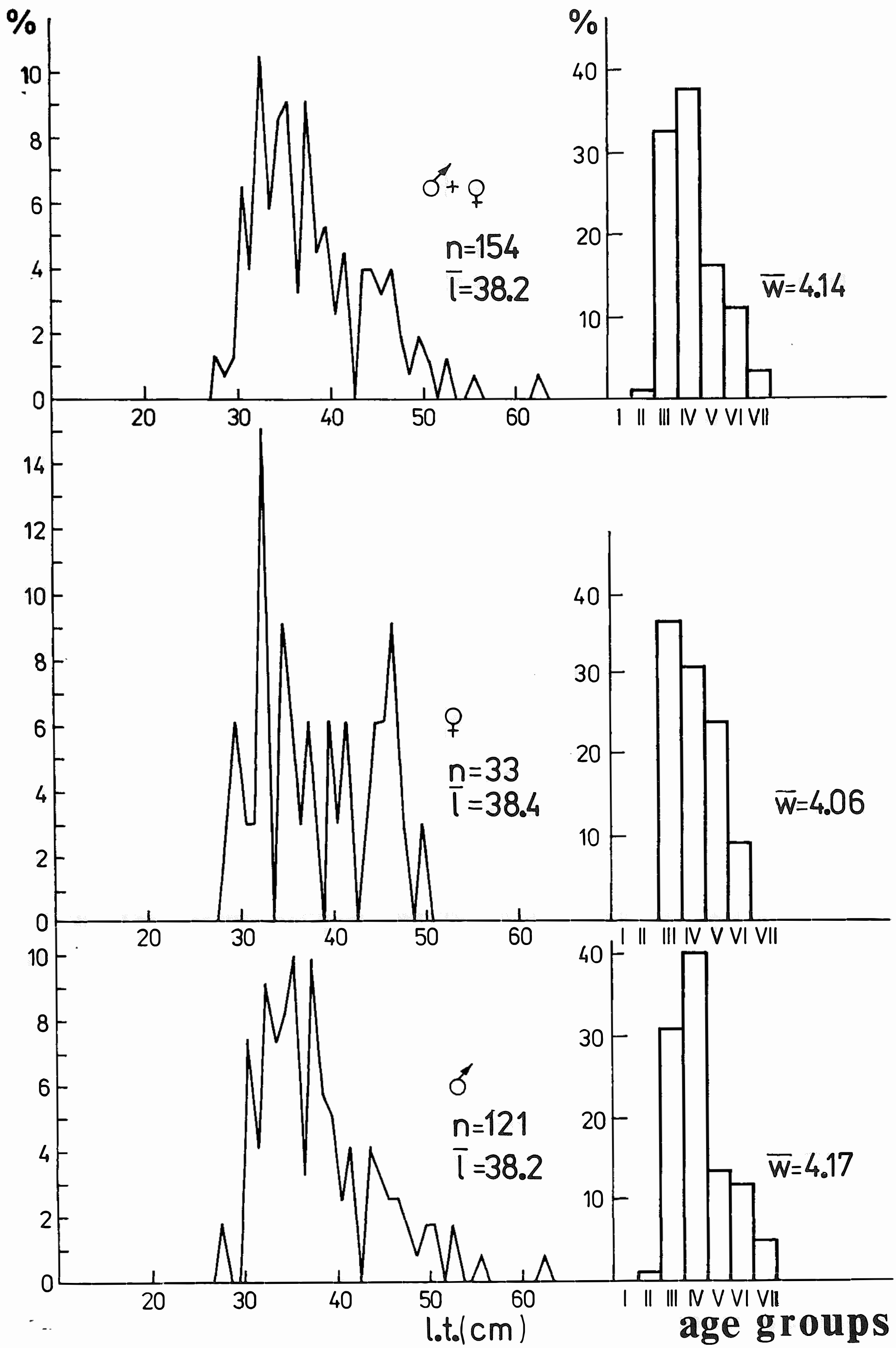

Fig. 2. Length distribution and age structure in the sample studied

Growth equation parameters of Greenland halibut off Labrador

Equation:				
v. Bertalanffy'ego	Gompertza	Forda-Walforda	Binomial	Power function
$L_\infty = 132.0$	$a = 82.7$	$k = 0.936$	$a = 3.211$	$a = 11.075$
$K = 0.068$	$b = 0.076$	$l_1 = 9.5$	b = [illegible]8.293	$b = 0.803$
$t_0 = -0.327$	$c = 0.769$		$c = -0.187$	

General form of growth model:

v. Bertalanffy: $l_t = L_\infty \left[1 - e^{-K(t-t_0)} \right]$

Gompertz: $l_t = ab^{c^t}$

Ford-Walford: $l_t = l_1 + k\,(l_{t-1})$

Binomial: $l_t = a + bt + ct^2$

Power function: $l_t = at^b$

As can be seen from the graph, length of the fish measured ranged within 27.5–63 cm; the mean length amounted to 38.2 cm, the 30–38 cm length classes being the most numerous ones, age groups 3 and 4 being most numerous. The age group 4 contained most fishes, the mean age in the whole sample amounting to 4.14. The number of females in the sample examined is four times lower than that of males. The females belonging to the length class of 32.1–33.0 cm were most numerous, the mean length being slightly higher than that of males. The age range was somewhat narrower (3–4) with age groups 3 prevailing, while group 4 dominated in males. The average females age was slightly lower than that of males.

Mean length of each Greenland halibut age group was obtained by back calculations and used to determine growth rate with an aid of 5 mathematic models: v. Bertallanffy, Ford-Walford, Gompertz equations, binomial, and power function.

Table 9 shows values of the models' parameters. All models proved to be equally adequate in describing growth of the Greenland halibut.

The calculated length (L) – weight (W) relationship for fish studied can be presented as the following equation:

$$W = 0.0049\, L^{3.1557}$$

the modified v. Bertallanffy equation representing weight growth rate is thus:

$$W_t = 24104\,[1-e^{-0.068/t+0.327)}]^{3.1557}$$

DISCUSSION

The Greenland halibut biometric characteristics was dealt with in a few papers only. Moreover, the hitherto published works contain usually analyses of only few chosen features. Most detailed is the paper by Hubbs and Wilimovsky (1964), the authors comparing some morphological features of populations caught in the Antlantic and Pacific.

The available literature, allowed to compare the results obtained on meristic characters and growth rate only. It should be borne in mind, however, that the above mentioned characters are significant for identifying taxa at the species level and within a species. When considering differences in meristic features is ought to be remembered that, although genetically determined, they may be altered to some extent by environmental conditions.

The mean number of dorsal fin rays in the fish examined (95.67) is almost identical with the mean given by Hubbs and Wilomovsky (1964) for somewhat larger areas of Bank and Labrador (95.90). The very wide range of ray numbers in this fin is notewort. In the present study, the range was 82–106, which is almost identical with values recorded by Hubbs and Wilimovsky, both in the Pacific and Atlantic. Mikawa

(1963) reported a slightly narrower range (84–104) for the Pacific halibut.

The same pattern of variation is demonstrated in the anal fin ray count. The mean value for the population examined, amounting to 71.39 is nearly identical to the mean reported by Hubbs and Wilimovsky for the similar region. According to these authors, the population means from the Atlantic are higher by almost one ray than the value found in the Pacific. In this case, too, the ray numbers vary widely from 63 up to 89 in the population examined. Only one fish with 89 rays in this fin was found. The range obtained in this study is higher than those reported by both Hubbs and Wilimovsky and Mikawa.

The range of all caudal fin ray number was narrow: from 19 to 20, fish with 19 rays predominating in the materials examined. According to Hubbs and Wilimovsky, the ray count in this fin should be regarded as a pretty stable character, their value, however, being 17 only. It cannot be ruled out that the discrepancy resulted from different counting techniques (X – raying was applied in the present work).

The ventral fin ray count was found to cover a narrow range only (5–7), individuals with 6 rays clearly predominating. Hubbs and Wilimovsky reported a similar range both for the Pacific and Atlantic, one individual with 4 rays being even found in the latter ocean.

The mean pectoral fin ray count (13.66) is in the area of study almost identical with the mean obtained earlier for the area by Hubbs and Wilimovsky. The range of variations in this study, too, is basically convergent with data reported by the two authors, fish with 14 rays predominating markedly.

The summarise characteristics of the fins one should mention that ray count in the dorsal and anal fins are the most variable. Of the paired fins, the pectoral ones were more variable in this respect than the ventral fins. Harrison and Schnakenbeck (quoted after Vladykov, 1934) stated that although the pectoral fin develops much earlier than the ventral ones, they require more time to reach their final form, so effects of the environment on their development is much longer-lasting and thus enhances differentiation.

Although the equestion of taxonomic importance of gill rakers is still debated, the gill raker count on the first gill arch is widely held to be a key systematic character. This point of view assumes the invariant nature of this feature, regardless of fish growth. No relationship between the gill raker count and body length (l.c.) was found in the Greenland halibut. Although the correlation coefficient was positive, it was very low (0.263) and not significant statistically. The gill raker count ranged in the population studied within 12–19 with a mean value of 15.89. Hubbs and Wilimovsky obtained higher values, both for the Pacific (18.03) and Atlantic (17.11). The differences may have stemmed, as the authors quoted admit themselves, from difficulties encountered when counting the gill rakers. In the Greenland halibut, a predator, they are short and barely palpable on the beginning and end part of the gill arch.

The vertebral count in the population discussed was found to range from 60 to 63, with a mean value of 61.58 and fish with 61 and 62 vertebrae predominating. The mean reported by Hubbs and Wilimovsky for the area was 61.27. Comparison between mean age of males and females (Fig. 2) shows a negligible difference being in favour of males, which can be explained by the fact that the sample contained young individuals of both sexes only.

Comparison of the Greenland halibut growth rate in the area of study with data of Krzykawski (1967b) for the region off New Founland shows a considerable similarity in the results, which can presumably be explained by the proximity of the two regions and similar environmental conditions, and probably also by the homogeneity of the population inhabiting the whole area.

CONCLUSIONS

1. The following formula can be applied to the meristic characters of the Greenland halibut population off Labrador: D 82–104 (106), A 63-82(89), C 19–20, V 5–6 (7), P 12–16 (17), sp.br. (12) 13–19, vt. 60–63.

2. No statistically significant differences between male and female mertistic characters were found in the population studied.

3. The fish from region studied showed sexual dimorphism in body proportions. Mean per cent indices of the following metric characters were significantly larger in males: head length, length of upper and lowe jaw, preventral length and length of caudal fin middle rays.

4. Negligible between-generations differences in meristic characters were found to exist in the population studied. They concerned only the ray count in the dorsal and annal fins.

5. The length and weight growth equations for the population under study are as follows:

$$l_t = 132.0\,[1 - e^{-0.068(t+0.327)}]$$

$$W_t = 24104\,[1 - e^{-0.068(t+0.327)}]^{3.1557}$$

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MORFOMETRIA ORAZ WZROST HALIBUTA NIEBIESKIEGO *REINHARDTIUS HIPPOGLOSSOIDES* (WALBAUM, 1792) Z REJONU LABRADORU

STRESZCZENIE

Badania miały na celu określenie zmienności cech przeliczalnych i wymierzalnych halibuta niebieskiego *Reinhardtius hippoglossoides* (Walbaum, 1792) z rejonu Labradoru. Ponadto zebrany materiał posłużył także do ustalenia niektórych właściwości biologicznych badanej populacji. Zbadano skład długościowy i wiekowy, tempo wzrostu długości i masy ciała oraz określono zależność pomiędzy długością a masą ciała.

Cechy merystyczne badanej populacji można określić następującą formułę: D 82–104 (106), A 63–82 (89), C 19–20, V 5–6 (7), P 12–16 (17), sp. br. (12)13–19, vt. 60–63.

Badania nie wykazały statystycznie istotnych różnic w wartościach cech merystycznych między samcami i samicami. Natomiast zaznaczył się dymorfizm płciowy w proporcjach ciała. Dla następujących cech wymierzalnych średnie wskaźniki procentowe były istotnie większe u samców: długość głowy, długość szczęki górnej i dolnej, długość przedbrzuszna oraz długość środkowych promieni w płetwie ogonowej.

Stwierdzono niewielkie różnice w wartościach cech merystycznych między pokoleniami ryb. Dotyczą one tylko liczby promieni w płetwie grzbietowej i odbytowej.

Obliczone równania wzrostu długości i masy dla badanej populacji przedstawiają się następująco:

$$l_t = 132.0\,[1 - e^{-0.068\,(t + 0.327)}]$$

$$W_t = 24104\,[1 - e^{-0.068\,(t + 0.327)}]^{3.1557}$$

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