A C T A I C H T H Y O L O G I C A E T P I S C A T O R I A
Vol. XXIV, Fasc. 1 Szczecin 1994

Stanisław *KRZYKAWSKI*, Andrzej *JELEŃSKI*, Beata *WIĘCASZEK*

Fish systematics

BIOMETRIC CHARACTERS OF WALLEYE POLLOCK *THERAGRA CHALCOGRAMMA* (PALLAS, 1811) (*GADIDAE*) FROM THE SEA OF OKHOTSK

CECHY BIOMETRYCZNE MINTAJA *THERAGRA CHALCOGRAMMA* (PALLAS, 1811) (*GADIDAE*) Z MORZA OCHOCKIEGO

Department of Fish Systematics, University of Agriculture, Szczecin, Poland

In the present paper the detailed biometric characteristics of walleye pollock (involving 25 metric and 12 meristic features) is demonstrated, with regard to both sexes. In addition, the comparison is made between the population studied and population of walleye pollock from the Bering Sea (concerning data available in literature) in order to find out if any differences statistically significant exist.

INTRODUCTION

In recent years the walleye pollock has played a very important role in the world fishery, with the largest contribution in catch, amounting to circa 6 million tons a year. Such results presumably are caused first of all by simple exploitation of this fish (the walleye pollock exists in huge shoals, often migrating over the shelf), as well as by high demand for fish possessing lean flesh.

However the walleye pollock is quite well known as a species, hitherto published Polish papers have mostly dealt with *Theragra chalcogramma* from the Bering Sea. Therefore the present work is aimed at describing the biometric features of the walleye pollock inhabiting the Sea of Okhotsk. Estimation of range of variability of characters mentioned is motivated by infraspecies differentiation, being characteristic for fish of wide distribution.

BIOLOGY OF WALLEYE POLLOCK FROM THE SEA OF OKHOTSK

According to Temnyh (1990) and Balanov and Ilinsky (1992) the walleye pollock belongs to mesopelagic and pelagic fish, existing at depth from 50 to 1000 m, in dependence on day–time, season of the year, as well as on character of fish concentration.

Spawning of the walleye pollock in the Sea of Okhotsk takes place in its north–east part, off Kamchatka's coast and offshore Kuril Islands, in the period of March–May (Fadeev, 1987; Smirnov, 1987). Roe is pelagic. The walleye pollock is a predator, feeding on crustaceans, fish and molluscs (Wyszyński and Draganik, 1993).

GEOGRAPHICAL DISTRIBUTION

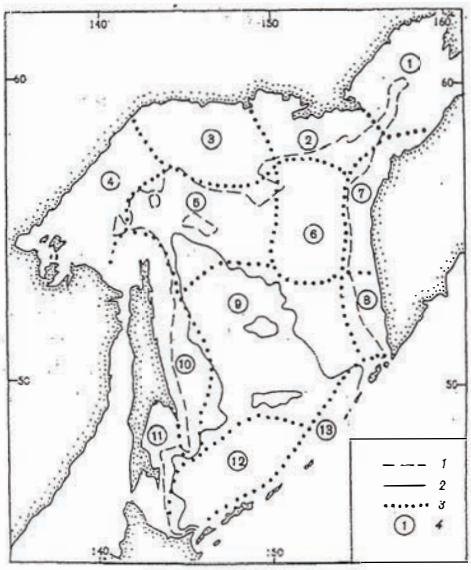

Fig. 1. Repartition of the Sea of Okhotsk into 13 regions (according to Šuntov et al., 1990) 1 – isobath of 200 m; 2 – isobath of 1000 m; 3 – regions' boundaries; 4 – number of region.

Fishes of this species inhabit two sides of Pacific Ocean. At Asian side they are distributed from the Japanese Sea to Kamchatka, while at American one from middle California to the Bering Sea. In the Sea of Okhotsk *Theragra chalcogramma* inhabits the whole area. The sea is being divided by Russians into 13 regions (Fig.1), in order to make more detailed observations on the walleye pollock.

The biggest concentrations of the walleye pollock are found in the central part of sea (zone number 9 – central–deepwater and 6 – depth of TINRO). These regions constitute the international fishing ground called Free Zone of the Sea of Okhotsk.

BIOMASS OF WALLEYE POLLOCK

Russian biologists Temnyh (1990), Balanov and Ilinsky (1992) estimated the biomass of fish in the Sea of Okhotsk as amounting to 34 million tons, with respect to both epi- and mesopelagial fish. Resourses of the walleye pollock was estimated to 16 mln tons. Investigation carried out in summer by Šuntov et al. (1990) showed that the biggest part of this mass occurs in epipelagial (11.4 mln t). According to authors citied above, the second place when regarding biomass takes family *Bathylagidae* – cá 13 mln t, with species *Leuroglossus schmidti* (11 mln t). This fish is not a fishing object due to its small size, however being of big importance as main item of the walleye pollock food. The remaining resourses of fish in the Sea of Okhotsk are as follows: *Clupeidae* – cá 3 mln t, *Zoarcidae* – 1 mln t, and *Myctophidae* – 1 mln t.

MATERIAL AND METHODS

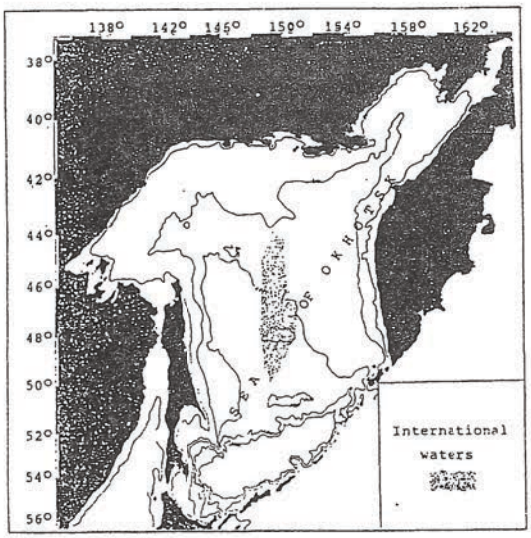

Fig. 2. Map of the Sea of Okhotsk showing the situation of the interantional waters (Wyszyński and Draganik, 1993)

Fish studied were collected during the cruise F/V "Aquarius" from the Fishery and Fishing Services Company in Szczecin, in the Free Zone of the Sea of Okhotsk (Fig.2).

The sample investigated consisted of 108 individuals including 62 females and 46 males. Fish were chosen at random, from one houl on April 12th, 1992 (53°52' N; 149°33' E). The trawl was at depth of cá 500 m, in the afternoon time. The material was frozen, then studied during the cruise time. On each fish measurements were performed, involving 12 meristic characters (symbols of them are presented in Table 1, according to Brylińska et al., 1991) and 25 metric characters (on the basis of scheme given by Pravdin, 1966 and modified by Grzelakowski and Hrehorowicz, 1982 – Fig.3). Measurements were made with accuracy to 0.1 cm with the aid of ruler and calliper. Symbols of metric characters are presented in Table 2.

Table 1

Symbols of meristic characters studied

Symbol of character	Latin name
D_1	Numerus radiorum pinnae dorsalis I
D_2	Numerus radiorum pinnae dorsalis II
D_3	Numerus radiorum pinnae dorsalis III
A_1	Numerus radiorum pinnae analis I
A_2	Numerus radiorum pinnae analis II
P	Numerus radiorum pinnae pectoralis
V	Numerus radiorum pinnae ventralis
C	Numerus radiorum pinnae caudalis
sp.br.$_1$	Numerus spinarum ad arcum branchiorum I
sp.br.$_2$	Numerus spinarum ad arcum branchiorum II
vt.	Numerus vertebratum
r.branch.	Numerus radiorum branchialis

Table 2

Symbols of metric characters studied

Symbol of character	Latin name
ab	longitudo totalis
ad	longitudo corporis
o_1d	longitudo caudalis
an	spatium praeorbitale
np	diameter oculi
po	spatium postorbitale
ao	longitudo capitis
lm	latitudo capitis
aa_1	longitudo ossis maxillare
k_1l_1	longitudo ossis dentale
qh	altitudo corporis maxima
ik	altitudo corporis minima
aq	distantia praedorsale
ay	longitudo praeanale
fd	longitudo pedunculi caudae
qa	longitudo basis (D_1)
q_1s_1	longitudo basis (D_2)
q_2s_2	longitudo basis (D_3)
tu	summa altitudo (D_1)
yy_1	longitudo basis (A_1)
y_2y_3	longitudo basis (A_2)
ej	summa altitudo (A_1)
vx	longitudo basis (P)
zz_1	longitudo basis (V)
zy	distantia V – A_1

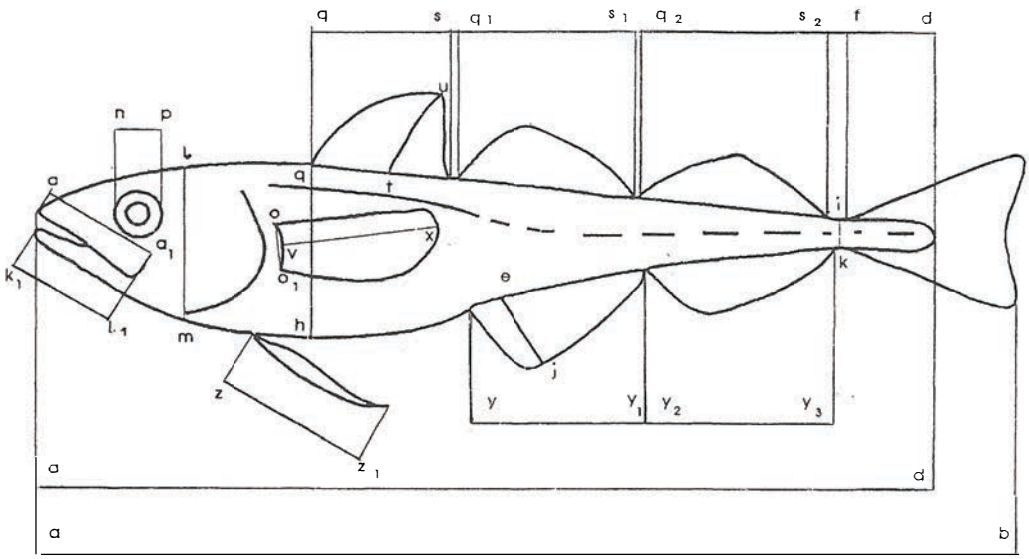

Fig. 3. Diagram of measurements made on walleye pollock *Theragra chalcogramma* (Pallas, 1811)

In order to analyse particular biometric features of fish investigated with respect to both sexes, data were treated statistically. Following statistical parameters were established: standard deviation (S), mean error (m) and coefficient of variation (v). According to Ruszczyc (1981) the coefficient of variation is significant statistically, when its value exceeding 10%. To find a significance of differences between females and males in biometric characters in the sample investigated, as well as when comparing the populations from the Sea of Okhotsk and Bering Sea, Student's t test was applied for a big sample ($n > 30$). The comparison was performed at the level of significance $\alpha = 0.05$. When $t_{calc.} > t_{0.05}$, the difference is statistically significant. The results were given with the accuracy to 0.01.

RESULTS

Length distribution

In the population studied total length (l.t.) of fish ranged from 30.1 to 57.0 cm. Fourteen 2–cm classes of length were performed, from 30.1 to 58.0. Fig. 4 presents the length distribution in particular classes in the sample studied, both for the whole group and both sexes separately.

As can be seen from the curve, classes 40.1 – 50.0 were the most numerous for all fish and both sexes, with 81 individuals out of 108 (75%). Length class 46.1 – 48.0 was the most numerous for whole sample including 21 specimens; in males this group was prevailing, too (12 fish), when in females 44.1 – 46.0 cm class contained the largest number of individuals (12). Females were found in all 14 classes, while males only in 9, namely from 34.1 to 52.0 cm. The smallest and largest length were found in females only.

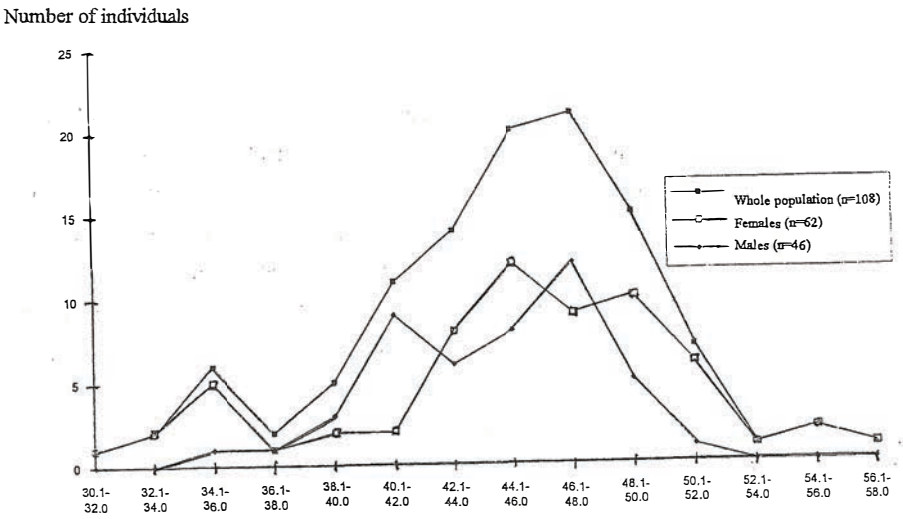

Fig. 4. Length distribution of walleye pollock from the Sea of Okhotsk

Table 3

Meristic characters of whole sample of walleye pollack from the Sea of Okhotsk (n = 108)

Symbol of character	Number of fish with estimated value of the character																														Range	$\bar{x}$	S	m	V
Value of character	6	7	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	32	33	34	35	36	37	38	39	40	41	50	51	52	53					
D_1			34	44	23	7																										11-14	12.1	0.24	0.02	1.96
D_2						7	12	45	28	12	2	2																				14-20	16.4	0.57	0.05	3.48
D_3									7	31	40	25	5																			17-21	18.8	0.30	0.03	1.61
A_1										6	13	31	38	17	3																	18-23	20.5	0.42	0.04	2.04
A_2										12	30	47	16	3																		18-22	19.6	0.30	0.03	1.54
P								3	9	59	30	7																				16-20	18.3	0.30	0.03	1.67
V	99	9																														6-7	6.1	0.10	0.01	1.58
C																								4	18	61	25					38-41	40.0	0.24	0.02	0.59
sp.br.$_1$												6	9	14	17	56	6															20-25	23.1	0.42	0.04	1.81
sp.br.$_2$																		3	5	7	13	38	20	12	4	2	4					32-41	36.3	0.89	0.09	2.45
vt.																												4	12	61	31	50-53	52.2	0.24	0.02	0.45
r.branch.		108																														7	7.0	0.00	0.00	0.00

Legend of statistical symbols used: n - number; $\bar{x}$ - arithmetic mean; S - standard deviation; m - standard error; V - coefficient of variation.

Table 4

Meristic characters of females of walleye pollack from the Sea of Okhotsk (n = 62)

Symbol of character	Number of fish with estimated value of the character																													Range	$\bar{x}$	S	m	V
Value of character	6	7	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	32	33	34	35	36	37	38	39	40	41	50	51	52	53					
D_1			16	26	15	5																										11-14	12.1	0.31	0.04	2.56
D_2						5	7	24	17	6	2	1																				14-20	16.4	0.75	0.10	4.59
D_3									6	22	17	13	4																			17-21	18.8	0.40	0.05	2.14
A_1										3	6	19	24	8	2																	18-23	20.5	0.55	0.07	2.69
A_2										6	22	25	8	1																		18-22	19.6	0.40	0.05	2.06
P								1	7	30	19	5																				16-20	18.3	0.40	0.05	2.21
V	56	6																														6-7	6.1	0.13	0.02	2.10
C																									13	35	14					39-41	40.0	0.18	0.02	0.45
sp.br.$_1$												4	7	5	13	30	3															20-25	23.1	0.55	0.07	2.40
sp.br.$_2$																		2	5	7	13	38	20	12	4	2	4					32-41	36.3	1.18	0.15	3.26
vt.																												4	12	61	31	50-53	52.2	0.31	0.04	0.60
r.branch.		62																														7	7.0	0.00	0.00	0.00

Legend of statistical symbols - beneath table 3.

Table 5

Meristic characters of males of walleye pollack from the Sea of Okhotsk (n = 46)

Symbol of character	Number of fish with estimated value of the character																																Range	$\bar{x}$	S	m	V
Value of character	6	7	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	32	33	34	35	36	37	38	39	40	41	50	51	52	53						
D_1			18	18	8	2																											11-14	11.9	0.36	0.05	3.04
D_2						2	5	21	11	6		1																					14-20	16.4	0.75	0.11	4.59
D_3									1	9	23	12	1																				17-21	19.1	0.47	0.07	2.45
A_1										3	7	12	14	9	1																		18-23	20.5	0.64	0.09	3.14
A_2										6	8	22	8	2																			18-22	19.8	0.47	0.07	2.35
P								2	2	29	11	2																					16-20	18.2	0.47	0.07	2.56
V	43	3																															6-7	6.1	0.15	0.02	2.43
C																								4	5	26	11						38-41	40.0	0.36	0.05	0.90
sp.br.$_1$												2	2	9	4	26	3																20-25	23.3	0.64	0.09	2.76
sp.br.$_2$																		1	2	5	2	17	11	4	1	1	2						32-41	36.3	1.36	0.20	3.74
vt.																												3	6	25	12		50-53	52.0	0.36	0.05	0.69
r.branch.		46																															7	7.0	0.00	0.00	0.00

Legend of statistical symbols - beneath table 3.

Meristic features

Meristic features are demonstrated in Tables 3, 4 and 5 (for whole sample, females and males respectively).

All fins of the walleye pollock are supported by soft rays. In the first dorsal fin (D_1) the range of rays count was identical for whole sample and both sexes, amounting to 11–14. Individuals with 12 rays prevailed, in all fish as well as in males and females. The mean value (12.1) was the same for whole sample and females, exceeding that in males (11.9).

In the second dorsal fin (D_2) the rays count was ranging from 14 to 20 in the whole sample and both sexes separately. Specimens with 16 rays predominated. The mean value amounted to 16.4.

In the third dorsal fin (D_3) number of rays covered the range 17–21. Individuals possessing 19 rays prevailed, in females 18 being the most often found rays count. The mean number of rays was 18.8, in males being slightly larger – 19.1.

The range of rays in the first anal fin (A_1) was identical for all fish, females and males. 21 rays was found most often, with the mean value of 20.5.

In the second anal fin (A_2) the range of rays was from 18 to 22. Specimens with 20 rays predominated. The mean value was amounted to 19.6, in males being feebly higher (19.8).

The count of rays in the pectoral fin (P) covered the range from 16 to 20, with predominating number of 18 rays. Mean value (18.3) exceeded that in males (18.2).

Ventral fin demonstrated the shortest rays range, varying from 6 to 7, with the considerably prevailing number of specimens possessing 6 rays. The mean value for whole sample studied, as well as in females and males was 6.1.

The count of rays in the caudal fin was ranging from 38 to 41 in all fish and males, while in females the lowest count was 39. Mean value amounted to 40.0 rays.

In the fish investigated, gill rakers were found arranging in two rows on the gill arch. In the first row of the first gill arch (sp. $br._1$) the gill rakers count covered the range from 20 to 25, 24 being the most often found. The mean value amounted to 23.1, and in males – 23.3. The count of gill rakers in the second row on the first gill arch (sp. $br._2$) ranged within 32–41. The number of 36 gill rakers was prevailing. Mean value was 36.3.

Count of vertebrae (vt.) was ranging from 50 to 53, specimens with 52 ones predominated. The mean value amounted to 52.2, exceeding that in males (52.0).

Number of rays in the suboperculum membrane was constant for all fish being 7.

Differences in meristic characters between females and males are shown in Table 6.

The statistically significant differences were demonstrated in following features (α =0.05):

- count of rays in the first dorsal fin (D_1)
- count of rays in the third dorsal fin (D_3)
- count of rays in the second anal fin (A_2)
- vertebrae count (vt).

Table 6

Analysis of significance of differences (Student's t test) in meristic characters between females (n = 62) and males (n = 46) of walleye pollock from the Sea of Okhotsk ($t_{0.05}$ = 1.98)

Symbol of character	Females		Males		$t_{calc.}$
	$\bar{x}$	S	$\bar{x}$	S	
D_1	12.1	0.31	11.9	0.36	3.17*
D_2	16.4	0.75	16.4	0.75	0.00
D_3	18.8	0.40	19.1	0.47	3.54*
A_1	20.5	0.55	20.5	0.64	0.00
A_2	19.6	0.40	19.8	0.47	2.36*
P	18.3	0.40	18.2	0.47	1.18
V	6.1	0.13	6.1	0.15	0.00
C	40.0	0.18	40.0	0.36	0.00
$sp.br._1$	23.1	0.55	23.3	0.64	1.74
$sp.br._2$	36.3	1.18	36.3	1.36	0.00
vt.	52.2	0.31	52.0	0.36	3.06*
r.branch.	7.0	0.00	7.0	0.00	0.00

* differences significant statistically

Legend of statistical symbols – beneath Table 3.

Metric characters

The characteristics of metric features was presented by estimation the percent value of particular characters in relation to the body length (ad) and lateral head length (ao), with the aid of formula given by Pravdin (1966). The statistical treatment for whole sample, females and males separately is demonstrated in Table 7, 8 and 9 respectively.

According to Ruszczyc (1981), only in one case value of coefficient of variation exceeded 10%, namely in length of ventral fins (zz_1) in the whole population studied. That is the only character very plastic in the material investigated of the walleye pollock from the Sea of Okhotsk.

Table 7

Metric characters of whole sample of walleye pollock from the Sea of Okhotsk in % of longitudo corporis and in % of longitudo capitis lateralis

Symbol of character	Range	$\bar{x}$	S	m	v
% longitudo corporis (n = 108)					
ad	–	–	–	–	–
ab	108.0 – 111.8	109.9	0.58	0.06	0.53
o_1d	73.6 – 77.8	75.7	0.78	0.07	1.03
an	6.5 – 8.9	7.8	0.41	0.04	5.26
np	4.5 – 6.2	5.2	0.31	0.03	5.96
po	9.6 – 12.7	11.2	0.59	0.06	5.27
ao	22.0 – 26.4	24.3	0.83	0.08	3.42
lm	13.2 – 16.6	15.0	0.69	0.07	4.60
aa_1	9.1 – 11.3	10.0	0.44	0.04	4.40
k_1l_1	12.4 – 14.9	13.7	0.52	0.05	3.80
qh	15.0 – 19.3	17.0	1.11	0.10	6.53
ik	3.3 – 4.4	3.9	0.25	0.02	6.41
aq	28.0 – 33.7	30.7	1.19	0.11	3.88
ay	41.5 – 47.9	44.6	1.26	0.12	2.82
fd	9.1 – 12.9	10.6	0.64	0.06	6.04
qa	9.5 – 14.1	11.4	0.88	0.08	7.72
q_1s_1	15.3 – 19.8	17.6	1.09	0.10	6.19
q_2s_2	13.6 – 19.4	16.1	0.96	0.09	5.96
tu	10.9 – 16.5	13.7	1.16	0.11	8.47
yy_1	17.6 – 24.9	20.9	1.06	0.10	5.07
y_2y_3	14.8 – 19.8	17.0	1.05	0.10	6.18
ej	8.7 – 15.9	10.9	1.08	0.10	9.90
vx	16.3 – 23.2	19.1	1.17	0.11	6.13
zz_1	12.7 – 24.2	16.1	2.06	0.20	12.80
zy	22.2 – 29.9	25.2	1.59	0.15	5.31
% longitudo capitis lateralis (n = 108)					
ao	–	–	–	–	–
an	28.7 – 35.8	32.4	1.52	0.15	4.70
np	18.9 – 25.0	21.4	1.08	0.10	5.05
po	42.7 – 52.0	46.1	1.73	0.17	3.75
lm	54.7 – 71.3	61.9	3.28	0.32	5.30
aa_1	37.3 – 46.5	41.3	1.69	0.16	4.09
k_1l_1	47.2 – 63.8	56.2	2.18	0.21	3.88

Legend of statistical symbols – beneath Table 3.

When comparing mean values expressed as percent indices between males and females (Table 8 and 9), it was found that they did not vary in large range. The differences reach to 1.0 %, except of 3 characters:

- length of ventral fins (zz_1) – with the difference amounting to 3.3 % in favour of males (in relation to the body length); this feature is very distinct and discernible, indicating for the sexual dimorphism existing in the species examined;
- height of head (lm) – with the difference 3.2 % in favour of females;
- length of upper jaw (aa_1), with the difference 1.7 % in favour of females, too.

Table 8

Metric characters of females of walleye pollock from the Sea of Okhotsk in % of longitudo corporis and in % of longitudo capitis lateralis

Symbol of character	Range	$\bar{x}$	S	m	v
% longitudo corporis (n = 62)					
ad	–	–	–	–	–
ab	108.0 – 111.8	109.8	0.61	0.08	0.55
o_1d	73.6 – 77.8	75.7	0.89	0.11	1.17
an	6.5 – 8.9	7.8	0.43	0.05	5.51
np	4.7 – 6.2	5.2	0.35	0.04	6.73
po	9.6 – 12.7	11.2	0.59	0.07	5.27
ao	22.0 – 26.4	24.2	0.91	0.08	3.76
lm	13.2 – 16.4	15.1	0.62	0.08	4.10
aa_1	9.1 – 11.0	10.0	0.44	0.05	4.40
k_1l_1	12.4 – 14.9	13.5	0.52	0.07	3.85
qh	15.0 – 19.3	17.0	1.06	0.13	6.23
ik	3.3 – 4.4	3.9	0.23	0.03	5.90
aq	28.0 – 33.7	30.8	1.19	0.15	3.86
ay	41.6 – 47.9	45.0	1.26	0.16	2.80
fd	9.1 – 12.0	10.5	0.65	0.08	6.19
qa	9.9 – 13.8	11.4	0.84	0.10	7.37
q_1s_1	15.4 – 19.7	17.5	1.09	0.14	6.23
q_2s_2	13.6 – 18.9	15.8	1.02	0.13	6.45
tu	10.9 – 16.2	13.5	1.11	0.14	8.22
yy_1	17.6 – 24.9	20.8	1.18	0.15	5.67
y_2y_3	14.9 – 19.2	17.0	0.99	0.13	5.82
ej	8.7 – 13.4	10.5	0.98	0.12	9.33
vx	16.4 – 21.1	18.8	1.08	0.14	5.74
zz_1	12.7 – 16.7	14.7	0.94	0.12	6.39
zy	23.1 – 28.9	25.5	1.46	0.18	5.72
% longitudo capitis lateralis (n = 62)					
ao	–	–	–	–	–
an	28.7 – 35.1	32.2	1.38	0.17	4.28
np	18.9 – 26.4	21.3	1.49	0.19	6.99
po	43.0 – 50.0	46.0	1.49	0.19	3.24
lm	54.7 – 71.3	62.2	3.38	0.43	5.43
aa_1	37.3 – 46.5	41.1	1.81	0.23	4.40
k_1l_1	47.2 – 63.8	55.8	2.43	0.31	4.35

Legend of statistical symbols – beneath Table 3.

Table 9

Metric characters of males of walleye pollock from the Sea of Okhotsk in % of longitudo corporis and in % of longitudo capitis lateralis

Symbol of character	Range	$\bar{x}$	S	m	v
% longitudo corporis (n = 46)					
ad	–	–	–	–	–
ab	108.0 – 111.8	110.0	0.61	0.09	0.55
o_1d	63.7 – 77.5	75.4	1.88	0.28	2.49
an	7.0 – 8.8	7.9	0.44	0.06	5.57
np	4.5 – 5.6	5.2	0.23	0.03	4.42
po	10.4 – 12.4	11.3	0.52	0.08	4.60
ao	23.2 – 25.7	24.4	0.59	0.09	2.42
lm	13.5 – 16.6	14.9	0.73	0.11	4.90
aa_1	9.3 – 11.3	10.1	0.44	0.06	4.36
k_1l_1	13.0 – 14.8	13.8	0.39	0.06	2.83
qh	15.0 – 19.3	17.0	0.92	0.14	5.41
ik	3.3 – 4.4	3.9	0.22	0.03	5.64
aq	28.1 – 33.4	30.7	1.26	0.19	4.10
ay	41.5 – 46.8	44.2	1.16	0.17	2.62
fd	9.4 – 12.9	10.8	0.74	0.11	6.85
qa	9.5 – 14.1	11.4	1.01	0.15	8.86
q_1s_1	15.3 – 19.8	17.8	1.09	0.16	6.12
q_2s_2	14.7 – 19.4	16.4	1.03	0.15	6.28
tu	11.1 – 16.5	13.9	1.31	0.19	9.42
yy_1	18.7 – 22.8	21.0	0.93	0.14	4.43
y_2y_3	14.8 – 19.8	17.0	0.96	0.14	5.65
ej	9.2 – 15.9	11.5	1.08	0.16	9.39
vx	16.3 – 23.2	19.5	1.32	0.19	6.77
zz_1	14.6 – 24.2	18.0	1.77	0.26	9.83
zy	22.2 – 29.9	24.8	1.63	0.24	6.57
% longitudo capitis lateralis (n = 46)					
ao	–	–	–	–	–
an	29.0 – 35.8	32.1	2.30	0.34	7.16
np	19.4 – 23.1	21.8	0.79	0.12	3.62
po	42.7 – 52.0	45.6	1.99	0.29	4.36
lm	54.9 – 68.2	59.0	3.05	0.50	5.17
aa_1	38.7 – 45.6	39.4	1.52	0.22	3.86
k_1l_1	53.7 – 60.2	56.1	1.61	0.09	2.87

Legend of statistical symbols – beneath Table 3.

Values of the two characters mentioned above were calculated in relation to the lateral length of head – longitudo capitis lateralis.

Table 10

Analysis of significance of differences (Student's t test) in metric characters between females (n = 62) and males (n = 46) of walleye pollock from the Sea of Okhotsk ($t_{0.05} = 1.88$)

Symbol of character	Females		Males		$t_{calc.}$
	$\bar{x}$	S	$\bar{x}$	S	
% longitudo corporis					
ab	109.8	0.61	110.0	0.61	1.66
o_1d	75.7	0.89	75.4	1.88	1.13
an	7.8	0.43	7.9	0.44	1.16
np	5.2	0.35	5.2	0.23	0.00
po	11.2	0.59	11.3	0.52	0.90
ao	24.2	0.91	24.4	0.59	1.28
lm	15.1	0.62	14.9	0.73	1.53
aa_1	10.0	0.44	10.1	0.44	1.17
k_1l_1	13.5	0.52	13.8	0.39	3.28*
qh	17.0	1.06	17.0	0.92	0.00
ik	3.9	0.23	3.9	0.22	0.00
aq	30.8	1.19	30.7	1.26	0.34
ay	45.0	1.26	44.2	1.16	3.34*
fd	10.5	0.65	10.8	0.74	2.20*
qa	11.4	0.84	11.4	1.01	0.00
q_1s_1	17.5	1.09	17.8	1.09	1.40
q_2s_2	15.8	1.02	16.4	1.03	3.05*
tu	13.5	1.11	13.9	1.31	1.70
yy_1	20.8	1.18	21.0	0.93	0.94
y_2y_3	17.0	0.99	17.0	0.96	0.00
ej	10.5	0.98	11.5	1.08	4.99*
vx	18.8	1.08	19.5	1.32	2.30*
zz_1	14.7	0.94	18.0	1.77	12.38*
zy	25.5	1.46	24.8	1.63	2.32*
% longitudo capitis lateralis					
an	32.2	1.38	32.1	2.30	0.28
np	21.3	1.49	21.8	0.79	2.06*
po	46.0	1.49	45.6	1.99	1.18
lm	62.2	3.38	59.0	3.05	0.47
aa_1	41.1	1.81	39.4	1.52	5.14*
k_1l_1	55.8	2.43	56.1	1.61	0.72

* differences significant statistically

Legend of statistical symbols – beneath Table 3.

Table 10 presents the results of Student's t test ($\alpha = 0.05$) applied in order to establish the significance of differences in metric features between females and males. The statistical significance was found:

– for metric features in relation to the body length:
- length of lower jaw (k_1l_1)
- preanal distance (ay)
- length of caudal peduncle (fd)
- length of the third dorsal fin base (q_2s_2)
- maximum height of the first anal fin (ej)
- length of pectoral fins (vx)
- length of ventral fins (zz_1)
- distance between the base of pectoral fin and base of anal fin (zy);

– for metric characters in relation to the lateral head length:
- horizontal eye diameter (np)
- length of upper jaw (aa_1).

DISCUSSION

In order to identify already known or to distinguish new taxons many kinds of comparative analyses should be performed. To obtain credible results, representative samples must be comparing, concerning as large as possible number of morphological characters.

In the sample investigated the individuals of the walleye pollock were found with total length ranging from 30.1 to 57.0 cm, the most numerous range being 40.1 to 50.0 (70 %) (Fig. 4). The mean length in the sample examined amounted to 44.6 cm. The similar length distribution of the walleye pollock is reported by Temnyh (1990), who carried out his investigation in the central part of Sea of Okhotsk. By this author, over 50 % of the population examined by him, constitutes specimens of length from 40.1 to 50 cm, with the mean length of 45.3 cm. Grzelakowski and Hrehorowicz (1982) investigated the population of the walleye pollock from Bering Sea, where fish length covered the range 25.5 – 70.5 cm. In the sample studied by these authors only 40 % of all fish were included in the range from 40.1 to 50.0 cm, with mean length amounting to 42.3 cm.

Table 11 demonstrates the comparison of meristic features of the walleye pollock sample from the Sea of Okhotsk, with the avalaible data in the literature. Mean values of particular biometric characters are presented in Table 12.

The ranges of rays count in three dorsal fins, as a rule are close to those recorded in other works. However in a case of second fin in the material studied, the maximum rays count (20) was by 1 higher , when comparing to data given by Lipka (1989) – 19. It is worth mentioning, that the mean value of rays count in this fin (16.4) exceeds that reported

by author citied above. However mean counts of the first and third fins rays numbers are higher in Lipka's paper, when comparing to our own results (D_1 – 13.4, D_3 – 19.7 and D_1 – 12.1, D_3 – 18.8, respectively).

Table 11

Comparison of range of variability of meristic characters of walleye pollock sample from the Sea of Okhotsk with the data obtained from literature

Region of study	Sea of Bering	Sea of Bering	Sea of Bering	Sea of Okhotsk
Authors / Symbol of character	Grzelakowski and Hrehorowicz (1982)	Rutkowicz (1982)	Lipka (1989)	Own data (1994)
D_1	11 – 15	10 – 13	12 – 16	11 – 14
D_2	14 – 18	13 – 16	12 – 19	14 – 20
D_3	16 – 20	15 – 19	16 – 23	17 – 21
A_1	18 – 22	17 – 21	19 – 26	18 – 23
A_2	18 – 22	16 – 21	18 – 24	18 – 22
P	16 – 20	18 – 21	17 – 21	16 – 20
V	6 – 7	6 – 7	6	6 – 7
C	33 – 47		30 – 35	38 – 41
sp.br.$_1$				20 – 25
sp.br.$_2$	31 – 42		21 – 28	32 – 41
vt.	49 – 53	48 – 50	49 – 52	50 – 53
r.branch.			12 – 16	7

Ranges of counts of rays in anal fins according to data obtained in the sample investigated (A_1 – 18–23, A_2 – 18–22) are almost identical with those found by Grzelakowski and Hrehorowicz (1982), namely A_1 – 18–22, A_2 – 18–22. Lipka (1989) stated higher ranges of rays count in these fins (A_1 – 19–26, A_2 – 18–24), what is reflected in high mean counts (A_1 – 21.5; A_2 – 20.7). According to data in this paper, the average counts of fins mentioned are as following: A_1 – 20.5 and A_2 – 19.6.

In the pectoral fin the shortest range of rays count was found (6 – 7), individuals possessing 6 rays prevailed (mean count – 6.1). The same data were reported by the authors citied (Table 11), except for Lipka (1989), who observed the constant number of rays in this fin amounting to 6.

Table 12

Analysis of significance of differences (Student's t test) in biometric characters between populations of walleye pollock from the Sea of Okhotsk and from Bering Sea ($t_{0.05} = 1.96$)

Symbol of character	Sea of Okhotsk			Sea of Bering			$t_{calc.}$
	n	$\bar{x}$	S	n	$\bar{x}$	S	
Meristic charactwers							
	Own data			According to Lipka (1989)			
D_1	108	12.1	0.24	110	13.4	0.96	13.70*
D_2	108	16.4	0.57	110	16.2	1.37	1.40
D_3	108	18.8	0.30	110	19.7	1.27	7.16*
A_1	108	20.5	0.42	110	21.5	1.48	6.73*
A_2	108	19.6	0.30	110	20.7	1.45	7.68*
P	108	18.3	0.30	110	18.7	0.56	6.57*
V	108	6.1	0.10	110	6.0		10.57*
C	108	40.0	0.24	110	32.7	2.08	36.25*
sp.br.	108	23.1	0.42	110	24.7	2.08	7.84*
vt.	108	52.2	0.24	110	50.7	0.57	25.22*
Metric characters – % longitudo corporis							
	Own data			According to Grzelakowski and Hrehorowicz (1982)			
ab	108	109.9	0.58	200	109.7	1.38	1.43
o_1d	108	75.7	0.78	200	75.3	1.72	2.24*
an	108	7.8	0.41	200	7.7	0.56	1.68
np	108	5.2	0.31	200	5.4	0.48	3.90*
po	108	11.2	0.59	200	11.7	0.73	6.00*
ao	108	24.3	0.83	200	24.5	1.04	1.29
lm	108	15.0	0.69	200	13.3	1.16	12.3*
aa_1	108	10.0	0.44	200	9.6	0.65	5.70*
k_1l_1	108	13.7	0.52	200	12.9	1.30	6.40*
qh	108	17.0	1.11	200	18.3	2.18	5.75*
ik	108	3.9	0.25	200	4.4	0.45	10.77*
aq	108	30.7	1.19	200	30.9	1.22	1.39
ay	108	44.6	1.26	200	47.5	2.27	12.30*
fd	108	10.6	0.64	200	12.9	0.82	23.00*
qa	108	11.4	0.88	200	11.9	1.04	4.20*
q_1s_1	108	17.6	1.09	200	16.4	2.45	4.85*
q_2s_2	108	16.1	0.96	200	15.2	0.92	8.04*
tu	108	13.7	1.16	200	12.9	1.18	5.60*
yy_1	108	20.9	1.06	200	20.7	1.47	1.29
y_2y_3	108	17.0	1.05	200	16.6	1.04	3.20*
ej	108	10.9	1.08	200	11.0	1.47	0.60
vx	108	19.1	1.17	200	18.1	1.34	6.27*
zz_1	108	16.1	2.06	200	15.3	2.26	3.05*
zy	108	25.2	1.59	200	25.1	2.30	0.40

* differences significant statistically

Legend of statistical symbols – beneath Table 3.

Count of rays in the caudal fin covered the range 38 – 41, specimens with 40 rays predominated considerably. Grzelakowski and Hrehorowicz (1982) stated considerable higher range of rays in this fin (33 – 47) what could result from higher number of sample investigated. Quite different data are obtained by Lipka (1989), namely 30 – 35 rays with the mean count amounting to 32.7.

Our own observations resulted in finding 2 rows of gill rakers on the first gill arch. Data avalaible in literature suggest existing of 1 row only. When comparing data obtained in this work with those from other papers it could be stated that Lipka (1989) took into consideration presumably only the count of gill rakers in the first row. The range reported by this author was 21 – 28 being close to our own data (20 – 25) in the first row on the first arch in the present paper.

The gill rakers count in the second row was ranging from 32 to 41, similarly to data obtained by Grzelakowski and Hrehorowicz (1982). Therefore results stated by these authors concerning probably the second row of gill rakers then.

The mean number of vertebrae in the population studied of the walleye pollock from the Sea of Okhotsk amounted to 52.2, ranging from 50 to 53. Considerably shorter range was presented by Rutkowicz (1982) – 48 – 50. However the most similar range was reported by Grzelakowski and Hrehorowicz (1982), estimated as 49 – 53.

The count of rays in the suboperculum membrane in the sample examined appeared to be a constant character of value 7. Rays in the presented work were counted on the left side of fish head. Among authors citied only Lipka (1989) dealt with this character. The range observed by this author was 12 – 16, individuals with 14 rays being predominated. Thus the range of rays indicated for being jointly counted in the suboperculum membrane on both sides of fish head.

Table 12 demonstrates results of the analysis of significance of differences in biometric characters between the population of the walleye pollock from the Sea of Okhotsk and from Bering Sea. Student's t test showed signifcance of differences both in meristic and metric features (in relation to the body length).

In the conclusion we should state, that results obtained in meristic and metric characters indicate for existing statistically significant differences in population of the walleye pollock from the Sea of Okhotsk and from Bering Sea (on the basis of the available literature). However it is difficult to conclude if the differences existing resulted from the systematic separateness of populations compared, or from the distance of the regions inhabited by them (Szarski, 1986).

CONCLUSIONS

1. In the sample under investigation the specimens of total length from 30.1 to 57.0 cm were found out, while the mean length was established to 44.6 cm. 70 % of the sample examined comprised of individuals in the length range 40.1 – 50.0 cm.
2. Meristic characters of the sample studied can be presented as follows: D_1 – 11–14, D_2 - 14–20, D_3 – 17–21, A_1 – 18–23, A_2 – 18–22, P – 16–20, V – 6–7, C – 38–41, sp.br.$_1$ – 20–25, sp.br.$_2$ – 32–41, vt. – 50–53, r. branch. – 7.
3. Statistically significant differences between females and males were found in the following meristic characters:
   - rays count in the first dorsal fin (D_1)
   - rays count in the third dorsal fin (D_3)
   - count of rays in the second anal fin (A_2)
   - count of vertebrae (vt).
4. In the population investigated sexual dimorphism appeared to be in the body proportion. Statistically significant differences were stated in the following metric features (expressed as percent indices):
   - in relation to the body length: preanal distance, distance between the basis of ventral and first anal fins (values in favour of females), length of lower jaw, length of the basis of third dorsal fin, length of pectoral fin and length of ventral fin (values in favour of males);

     in relation to the head length: upper jaw's length (in favour of females), eye diameter (in the favour of males).

   Sexual dimorphism at the strongest was demonstrated in the length of ventral fins (considerably in favour of males).
5. Statistically significant differences were found in metric and merstic characters of the walleye pollock between populations studied from the Sea of Okhotsk and the Bering Sea (described in the other papers). They could indicate for existing separated stocks. Nevertheless the differences observed should be confirmed by examination made on more representative material.

REFERENCES

Balanov A.A., E.N. Ilinsky, 1992: Vidovoj sostav i biomassa mezopelagičeskih ryb Ohotskogo i Beringova Morej. Voprosy Ihtiologii. Tom 32. Vypusk 1: 56 – 63. (In Russian)

Brylińska M. (ed.), 1991: Ryby słodkowodne Polski. [Freshwater fishes of Poland]. PWN, Warszawa. (In Polish)

Fadeev N.S., 1987: Nerestilišča i sroki razmnoženija mintaja v severnoj časti Ohotskogo morja. Vladivostok: TINRO. 5 – 22. (In Russian)

Grzelakowski M., K. Hreherowicz, 1982: Charakterystyka biometryczna i szybkość wzrostu mintaja – Theragra chalcogramma (Pallas, 1811) pochodzącego z Morza Beringa. [Biometric characteristics and growth rate of walleye pollock Theragra chalcogramma (Pallas, 1811) from the Bering Sea] M.Sc. Thesis, AR Szczecin. (In Polish)

Lipka D., 1989: Cechy merystyczne i wymierzalne mintaja Theragra chalcogramma (Pallas, 1811) z Morza Beringa. [Meristic and metric characters of walleye pollock from the Bering Sea] M.Sc. Thesis, AR Szczecin. (In Polish)

Pravdin L.F., 1966: Rukovodstvo po izučeniju ryb. Izd. Piščevaja promyšlennost. Moskva. (In Russian)

Rutkowicz S., 1982: Encyklopedia ryb morskich. [Encyclopaedia of marine fish]. Wydawnictwo Morskie, Gdańsk. (In Polish)

Ruszczyc Z., 1981: Metodyka doświadczeń zootechnicznych. [Methodology in husbandry] PWRiL, Warszawa. (In Polish)

Smirnov A.V., 1987: Raspredelenie ikry južnokuril'skogo mintaja. Vladivostok: TINRO. 5 – 22. (In Russian)

Szarski H., 1986: Mechanizmy ewolucji. [Mechanisms of evolution] PWN, Warszawa. (In Polish)

Šuntov V.P., A.F. Volkov, A.I. Abakumov, G.V. Šybkij, O. S. Temnyh, A.N. Vbovin, A.N. Starcev, M.A. Šebanova, 1990: Sostav i sovremennoe sostajanie soobščestv ryb epi–pelagiali Ohotskogo Morja. Voprosy ihtiologii. Tom 30. Vypusk 4: 587 – 597. (In Russian)

Temnyh O.S., 1990: Prostranstvienno–razmiernaja struktura mintaja Ohotskogo Morja v letnij period. Voprosy ihtiologii. Tom 30. Vypusk 4: 598 – 608.(In Russian)

Wyszyński M., B. Draganik, 1993: Walleye pollock population supporting the fishery carried out in the international waters of the Sea of Ohkotsk in 1992. Biuletyn MIR. Gdynia.

Stanisław *KRZYKAWSKI*, Andrzej *JELEŃSKI*, Beata *WIĘCASZEK*

CECHY BIOMETRYCZNE MINTAJA *THERAGRA CHALCOGRAMMA* (PALLAS,1811) (*GADIDAE*) Z MORZA OCHOCKIEGO

STRESZCZENIE

Badania miały na celu określenie zmienności cech przeliczalnych i wymierzalnych mintaja złowionego w Wolnej Strefie Morza Ochockiego. Ponadto zebrany materiał posłużył do przedstawienia składu długościowego badanej populacji.

W badanej próbie znajdowały się osobniki o długości całkowitej od 30.1 do 57.0 cm. Średnia długość wynosiła 44.6 cm. Około 70 % badanej próby to ryby o długości od 40.1 do 50.0 cm.

Cechy merystyczne badanej populacji można przedstawić następującą formułą D_1 11–14, D_2 14–20, D_3 17–21, A_1 18–23, A_2 18–22, P 16–20, V 6–7, C 38–41, sp.br.$_1$ 20–25, sp.br.$_2$ 32–41, vt. 50–53, r.branch. 7.

Stwierdzono statystycznie istotne różnice w wartościach cech przeliczalnych między samicami i samcami. Dotyczą one:

- liczby promieni w pierwszej płetwie grzbietowej (D_1),
- liczby promieni w trzeciej płetwie grzbietowej (D_3),
- liczby promieni w drugiej płetwie odbytowej (A_2),
- liczby kręgów (vt.)

W badanej populacji zaznaczył się dymorfizm płciowy w proporcjach ciała. Najwyraźniej uwidocznił się w przypadku długości płetwy brzusznej (u samców była znacznie dłuższa).

Dokonana analiza istotności różnic w zakresie cech biometrycznych pomiędzy badaną populacją pochodzącą z Wolnej Strefy Morza Ochockiego, a populacją z Morza Beringa, wykazała istotne rozbieżności w zakresie porównywanych cech, które mogą świadczyć o przynależności tych populacji do odrębnych stad.

Received: 1993.12.06

Author's address:

Prof. D.Sc. Stanisław Krzykawski,
M.Sc. Andrzej Jeleński,
M.Sc. Beata Więcaszek
Department of Fish Systematics
University of Agriculture in Szczecin
Kazimierza Królewicza 4
71–550 Szczecin
Polska (Poland)