脊椎骨数によるスケトウダラ地方群の分離

誌名	日本水産學會誌
ISSN	00215392
著者	岩田, 宗彦 浜井, 生三
巻/号	38巻10号
掲載ページ	p. 1129-1142
発行年月	1972年10月

Bulletin of the Japanese Society of Scientific Fisheries 38(10), 1129–1142, (1972)

Local Forms of Walleye Pollock, *Theragra chalcogramma* (PALLAS), Classified by Number of Vertebrae*

Munehico IWATA and Ikusô HAMAI**

(Received June 29, 1972)

Geographical variation in mean counts of vertebrae of the walleye pollock were statistically analyzed in relation to its distribution in the regions of the Sea of Japan, the Okhotsk Sea and the Pacific Ocean adjacent to Hokkaido, the northern island of Japan. The frequency distribution of the numbers of vertebrae is normal in an area. Significance tests indicated that there may have been eight local forms with distinctive means in the investigated regions. The means of all samples were concentrated on four clumps in Cartesian co-ordinates crossing at an angle of 60° between co-ordinates of abdominal and caudal vertebrae. Mean vertebral counts increased with an increase in latitude.

These results indicate that there are at least eight local forms in the sea regions surrounding Hokkaido, but it is also possible that some local forms migrate to other habitats from their spawning ground after their period of reproduction. The term "local form" is a reasonable proposition for geographical variations instead of "population" when the phenotypic characteristics are used for classification.

The walleye pollock, *Theragra chalcogramma,* is now one of the largest fish resources, in yield of weight, in Japan, and the pollock landings continue to increase. However very little information is available on the stocks or their fluctuations.

Several workers have described some characteristics of the walleye pollock in the sea near Japan. ISHIDA[1] pointed out morphometric differences of otoliths from different areas. With tagging experiments, the Korea Fisheries Experimental Station investigated the migration of the walleye pollock in the Sea of Japan during 1931–35. The results suggested migration routes between the southwestern coast of Hokkaido, Vladivostok and Hugnam (*vide* OGATA[2]). KYUSHIN *et al*[3] and ISHIDA[4] described the transition of two different populations in Uchiura Bay. A morphological study was carried out on the populations from many areas in the North Pacific[5]. According to the data of body length, modal number of vertebrae and tagging experiments[6], only one population was suggested in the northern Sea of Japan.

Although these studies have suggested the presence of several populations in the seas around Hokkaido, there was little relationship among these studies, and the evidences were insufficient to define those populations. It is well known that the diagnostic features of living organisms are growth and reproduction, and populations should be defined by

* Contribution No. 61 from the Research Institute of North Pacific Fisheries, Faculty of Fisheries, Hokkaido University.

** Faculty of Fisheries, Hokkaido University, Hakodate, Japan (岩田宗彦・浜井生三: 北海道大学水産学部)

these features[7]. A group of homo-phenotypic individuals that participate in the process of reproduction and growth in the same environment is not always a group which comprises homogenetic individuals. Accordingly this homo-phenotypic group is provisionally termed "local form" here.

In a population study of the walleye pollack, the present paper deals with the number of vertebrae as a phenotypic character.

Materials and Methods

1856 specimens of the walleye pollock were collected from 41 stations in three regions around Hokkaido: 15 samples is the Sea of Japan; 15 samples in the Okhotsk Sea; and 11 samples in the Pacific Ocean (Fig. 1). Most samples were collected during the spawning season, from late autumn to spring, with gill-nets, trawls and long-lines. The collecting period was from November 1968 to September 1970 (Table 1).

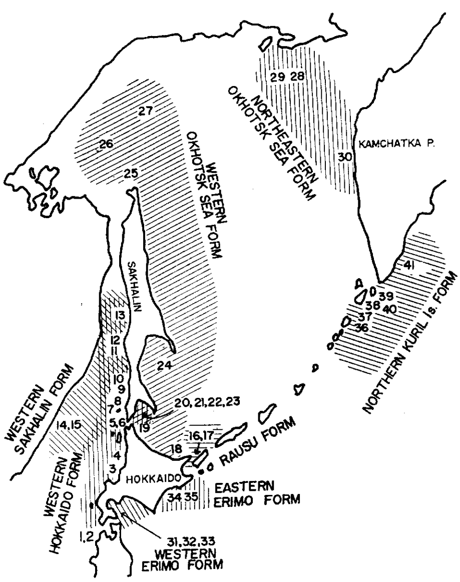

Fig. 1. Map showing the sampling stations and the estimated distribution of local forms defined by numbers of vertebrae of the walleye pollock.

The samples, except for Mashike (S. 3), consisted of several age groups of adults, 37 to 60 cm long, that would contribute to reproduction. However, the year classes could not be classified because of the uncertainty of age determination.

The fish were boiled to separate the flesh from the vertebral column, and then the number of abdominal and caudal vertebrae were counted separately. The caudal vertebrae counts began with the centrum having the first closed haemal arch. The urostyle was excluded from the caudal vertebrae. The total number of vertebrae included the number of abdominal and caudal vertebrae.

Fisher's F-test and Student's *t*-test were used for determining significant differences among variances and means. When the variance test showed a significant difference, the method of Cochran & Cox[8] was employed in place of the *t*-test for the difference of mean.

Table 1. Number of observed fish (n), mean number of centra of abdominal, caudal and total vertebrae, and the variance in 41 samples of the walleye pollock in 1968–70.

Region	Sample number and area*	Date of collection	Abdominal			Caudal			Total		
			n	mean	variance	n	mean	variance	n	mean	variance
Sea of Japan	1 Kumaishi	5 II '70	47	18.04	0.1285	47	30.94	0.4089	47	48.98	0.4996
	2 Kudô	23 I '70	49	18.02	0.2704	49	31.16	0.3894	49	49.18	0.4052
	3 Mashike	29 III '69	49	18.00	0.1667	46	31.00	0.5333	46	49.02	0.5996
	4 Teuri Yagishiri Is.	29–30 XII '69							25	48.96	0.7900
	5 Northwest Wakkanai	6 XII '69							29	49.07	0.4950
	6 North Wakkanai	17 I '69	65	18.09	0.1789	65	31.14	0.3711	65	49.23	0.3991
	7 Moneron Is.	7 XII '69							30	49.03	0.3093
	8 Moneron Is.	29 III '69							30	49.20	0.3034
	9 Kholmsk	25 XII '69	83	17.98	0.1945	83	31.34	0.4945	83	49.33	0.5393
	10 Kholmsk	26–27 III '69							30	49.23	0.5310
	11 Il'inskiy	27–29 III '69							30	49.20	0.3584
	12 Il'inskiy	23–25 V '69	40	18.28	0.3582	40	31.38	0.5992	40	49.65	0.6505
	13 Staritsa	24–29 III '69							28	49.29	0.7300
	14 Belkina	4 XII '69	73	18.19	0.1572	73	31.42	0.6089	73	49.62	0.6564
	15 Belkina	18 XII '69	100	18.26	0.2347	100	31.21	0.4908	100	49.48	0.6360
Okhotsk Sea	16 Rausu	8 IV '69							48	49.19	0.6662
	17 Rausu	21 IV '79	96	18.07	0.1736	96	31.16	0.3648	96	49.23	0.3891
	18 Abashiri	10–11 IV '69							66	49.89	0.6809
	19 East from Sôya	21 X '69	29	18.52	0.4729	29	31.79	0.2414	29	50.31	0.6896
	20 Aniva Bay	23 X '69	48	18.73	0.2868	48	31.67	0.9504	48	50.40	0.7974
	21 Aniva Bay	19 XII '69	63	18.60	0.2677	62	31.79	0.5946	62	50.44	0.6433
	22 Aniva Bay	24 V '69	50	18.36	0.2759	50	31.22	0.6649	50	49.58	0.6371
	23 Aniva Bay	20 VII '69	39	18.38	0.3482	38	31.47	1.1749	38	49.87	1.6371
	24 Terpeniya	24 V '69	26	18.58	0.2140	26	31.54	0.4984	26	50.12	0.5060
	25 Northern Sakhalin	30 VIII '70	26	19.04	0.4824	26	31.19	0.8816	26	50.23	0.5846
	26 Northern Sakhalin	2 IX '70	31	18.65	0.4366	31	31.52	0.5247	31	50.16	0.8731
	27 Northern Sakhalin	3 IX '70	37	18.76	0.3281	37	31.52	0.7808	37	50.43	0.8078
	28 Magadan	9 IX '70	29	18.86	0.1946	29	31.83	0.5746	30	50.73	0.4784
	29 Magadan	21 XI–2 XII '70							18	50.83	0.9706
	30 Western Kamchatka	2 I '70	87	18.91	0.2240	87	31.99	0.6627	87	50.90	0.7683

Table. 1. (Continued)

	Sample number and area*	Date of collection	Abdominal			Caudal			Total		
			n	mean	variance	*n*	mean	variance	*n*	mean	variance
Pacific Ocean	31 Uchiura Bay	18 I '69	26	18.27	0.2844	26	31.23	0.5844	26	49.50	0.3400
	32 Uchiura Bay	18 I '69	25	18.20	0.1667	25	31.25	0.5233	25	49.44	0.5900
	33 Uchiura Bay	30 I '70	83	18.28	0.2516	83	31.20	0.4088	83	49.48	0.4960
	34 Kushiro	8 IV '69	24	18.50	0.3478	24	31.79	0.6070	27	50.26	1.1996
	35 Kushiro	18 IV '70	60	18.35	0.3161	60	31.52	0.4235	60	49.87	0.6430
	36 Northern Kuril Is.	10–17 X '69	40	18.85	0.2846	40	32.13	0.3679	40	50.98	0.4351
	37 Northern Kuril Is.	16–23 XI '68							29	51.31	0.5789
	38 Northern Kuril Is.	23–27 XI '68							28	50.89	0.5437
	39 Northern Kuril Is.	19–21 VII '69	29	19.00	0.3571	29	31.69	0.8646	29	50.69	0.7932
	40 Northern Kuril Is.	21–28 XI '69	87	18.86	0.2830	87	32.20	0.7172	87	51.06	0.8423
	41 Inkanyush Cape	14 IV '70							29	51.10	0.8103
	Total number		1441			1436			1856		

* See the numbered localities in Fig. 1.

Results

The caudal vertebrae counts of the walleye pollock ranged from 29 to 34, the abdominal vertebrae counts, from 17 to 20, and the total vertebrae counts, from 47 to 54. Usually, the range of vertebral counts in a sample was three centra for abdominal vertebrae, and three to five for caudal and total vertebrae.

To certify, whether or not, these variations of vertebral counts occur in a local form, the distribution curve and the statistical difference between male and female were examined in the combined samples from Mashike (S. 3) to Kholmsk (S. 9) in the northern Sea of Japan. These spawning shoals in this area apparently belong to a single local form[9]. Figure 2 illustrates the results of the normal probability paper method[10] applied to the frequency distributions of each sex. They seem to be normal, and no significant difference between sexes is indicated in the variances except a case of the means (Table 2). Therefore, the sexes were combined for the following analyses.

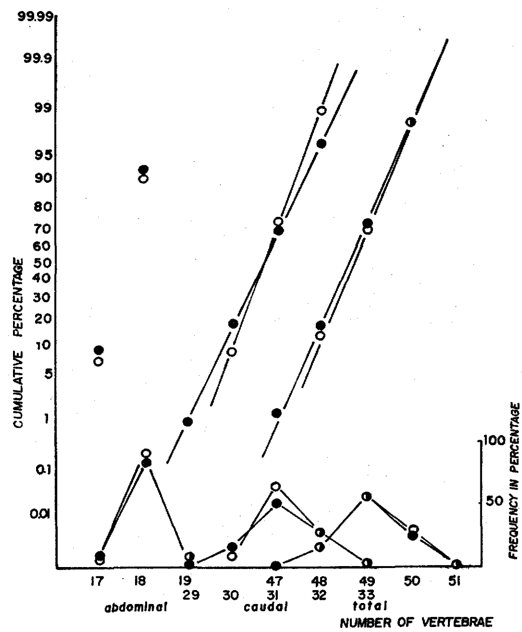

Fig. 2. Frequency distributions of abdominal, caudal and total vertebrae numbers for the walleye pollock in the Sea of Japan; and the cumultive percentage plotted in the normal probability paper.
○: female, ●: male

Table 2. Significance test for the difference of mean number of vertebral centra between male and female.

section	sex	mean	s^2	n	F	t
abdominal	male	17.98	0.1721	117	1.1807	0.8351
	female	18.03	0.1708	100		
caudal	male	31.15	0.6059	114	1.9753*	$t'=0.38$
	female	31.18	0.3610	97		
total	male	49.10	0.5206	182	1.0983	1.1474
	female	49.18	0.4637	186		

Asterisk shows the significant difference at the 5% level.

1. Differences among mean vertebral counts

Japan Sea Based upon the above results, the geographical variations of the number of vertebrae were compared among 41 samples. As seen in Fig. 3–i, the means of total vertebrae from four samples, i.e. Kholmsk (S. 9), Il'inskiy (S. 12) and Belkina (S. 14, 15), in the northern area of the Sea of Japan showed higher values than all samples (S. 1–8) in the southern area with statistical significance at the 1 or 5% significance level. That is, the northern Sea of Japan can be separated into two areas, i.e. a southern area adjacent to Hokkaido, and a northern area off Sakhaline Island and Primorskaya Province. However, the means of three samples (S. 10, 11, 13) in March were more similar to the samples of the southern area than those of the northern area. Also the samples from the southern area showed no statistical difference from the samples of Rausu (S. 16, 17), in the Okhotsk Sea.

The means of the abdominal vertebrae for three samples (S. 12, 14, 17), in the northern area were clearly different from those of the samples in the southern area, as illustrated in Fig. 3–ii. Sample 9 was included in the group from the southern area in this comparison. Further, in case of caudal vertebrae, it was demonstrated that those four samples (S. 9, 12, 14, 15) were separable from sample 1 in the southern area.

Similar results for both abdominal and caudal vertebrae counts supported the possibility of separation between the northern area and the southern area in the Sea of Japan. On the basis of the above results, the walleye pollock stock in the northeastern Sea of Japan can be segregated into the *Western Sakhalin form* and the *Western Hokkaido form*, as schematically demonstrated in Fig. 1.

Although the Western Hokkaido form is separated from the Western Sakhalin form, some samples of these forms are close to the samples from Rausu (S. 16, 17) or the samples in May and July from Aniva Bay (S. 22, 23). Aniva Bay lies near the habitat of the Western Sakhalin form (Fig. 1), and a sample (S. 23) from this bay in July showed a significantly larger variation in total vertebral counts (Table 1). These results suggest that there are two local forms deduced from the numbers of vertebrae, and the possibility of mixing between the Western Sakhalin form and the fish of Aniva Bay during their feeding period.

Okhotsk Sea Fifteen samples (S. 16–30) were collected in this sea during all seasons except winter, when the fishing was closed by ice. Out of them, twelve samples were collected from the western continental shelf and three from the northeastern area of this sea (Fig. 1).

From the results of *t*-test (Fig. 3–i), four remarkable groups on means were identified. Two samples from Rausu (S. 16, 17) formed the first group with significantly lower means than those of the other samples. As described previously this Rausu group had similar values to the Western Hokkaido form. The second group is composed of eight samples (S. 18–21, 24–27) which are indicated by the thick lined triangle in Fig. 3–i. The means of total vertebral counts of this group all fell within the range of 50.12–50.43. All of these samples were collected within a narrow band on the continental shelf along the western Okhotsk Sea from north to south ends (Fig. 1). The third group from the same

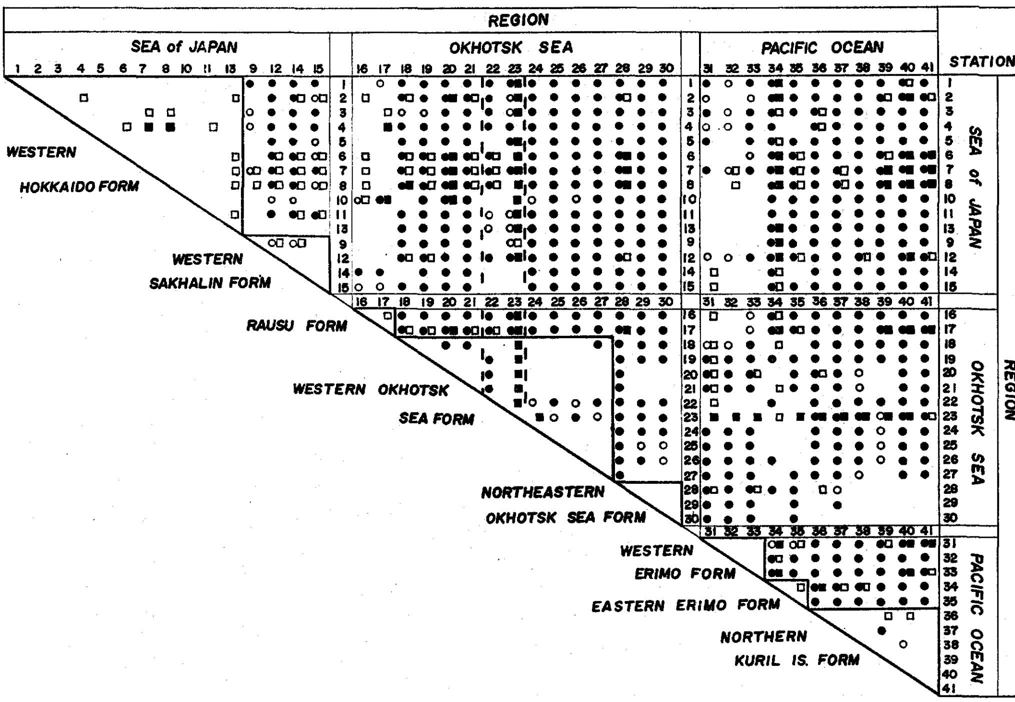

Fig. 3-i. Significance of differences between the mean total numbers of vertebrae and their variances in various stations, and the estimated groups of stations showing a local form with a thick lined triangle.

○: significant at the 5% level of significance in the mean
●: significant at the 1% level of significance in the mean
□: Significant at the 5% level of significance in the variance
■: Significant at the 1% level of significance in the variance

region consisted of two samples (S. 22, 23) from Aniva Bay. These did not correspond to the second group, but showed similar mean values to the Western Sakhalin form. These two samples were collected in May and July, when the feeding migration had begun following spawning. The fourth group included three samples from the northeastern Okhotsk Sea (Fig. 1). They showed significantly higher values than all others in this sea.

Therefore, it would appear that in the Okhotsk Sea there are three indigenous groups called the *Rausu form,* the *Western Okhotsk Sea form* and *Northeastern Okhotsk Sea form.* The fishes from the Western Hokkaido form seem to appear in this region during the feeding season.

Pacific Ocean Eleven samples (S. 31–41) were collected from three areas in the Pacific region (Fig. 1). These areas are distant from each other. The samples from Uchiura Bay and Kushiro were collected during the spawning season (from winter to spring) in 1969 and 1970, while those from the north Kuril Is. area were caught during

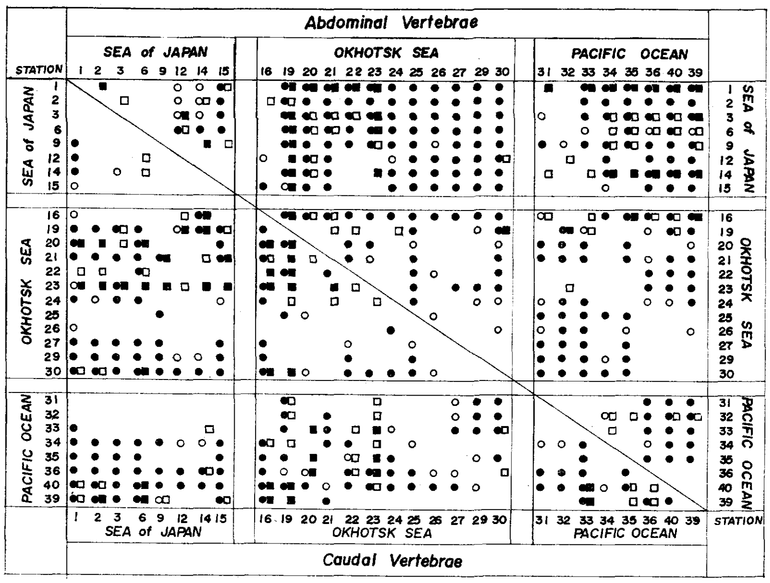

Fig. 3–ii. Significance of differences among means and variances of abdominal and caudal vertebral numbers in various stations. Notations are the same as those in Fig. 3–i.

the prespawning stage.

The habitat of each walleye pollock group might differ seasonally due to migration, but the statistical tests successfully detected local forms. The samples from Uchiura Bay possessed the lowest counts of abdominal, caudal and total vertebrae compared with those from the other two areas, and conversely, the counts for the northern Kuril Is. samples were highest. In every case, the differences of vertebral counts among three areas were statistically significant for all three counts (Fig. 3–i, ii).

Accordingly, in the Pacific region, three geographical groups of walleye pollock were designated: the *Western Erimo form, viz.* Uchiura Bay group; the *Eastern Erimo form, viz.* Kushiro group; and the *Northern Kuril Is. form.*

2. Correlative variation of abdominal and caudal vertebrae

Since the total number of vertebrae is the sum of abdominal and caudal vertebrae, these values are not independent from each other (Table 3). Each frequency distribution was normal, and the variance of caudal vertebrae was approximately twice as large as that of abdominal vertebrae (Table 1). Therefore, if the abdominal and caudal vertebral numbers are plotted on rectangular co-ordinates, the points are expected to be distributed in an ellipse whose long axis corresponds to the count of caudal vertebrae. In the same manner, sets of these means of samples extracted from a definite local form are also expected to be distributed in an ellipse which represents a probability density of the normal bivariate population. Hereupon, in order to make the relation of these variates to the total number of vertebrae clear, the means of abdominal and caudal vertebrae were

Table 3. Correlation coefficients among abdominal, caudal and total vertebral counts in the walleye pollock sampled from Western Hokkaido form.

section	r	P (H_0: $\rho=0$)
abdominal–caudal	0.705 (0.613–0.779)	<0.01
caudal–total	0.359 (0.192–0.526)	<0.01
total–abdominal	0.816 (0.753–0.864	<0.01

d.f.=139 Figures in parenthesis show the confidence interval of *r*.

plotted on Cartesian co-ordinates intersecting at an angle of 60° (Fig. 4). The origin was fixed conveniently at the point, 18.5 and 31.5 respectively on the abdominal and caudal axis to scatter uniformly all the points about the origin. Accordingly, values for the total vertebrae can be read rectangularly on the bisector of the two axes.

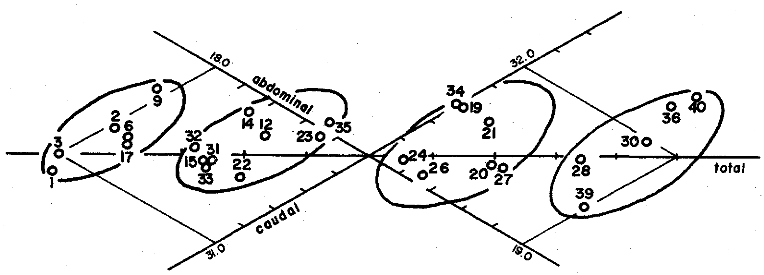

Fig. 4. The means of abdominal and caudal vertebral counts plotted on Cartesian co-ordinates of 60°. The figures show the stations.

The points of 27 samples are distributed in four clumps which are in rows like stairs along the total-vertebrae axis. On the abdominal axis, the points concentrate on four levels—18.0, 18.3, 18.65, and 18.95. These clumps may be enclosed with respective probability ellipses. The Western Hokkaido form and the Rausu form are contained in the first clump; the Western Sakhalin form, the May and July samples of Aniva Bay, and the Western Erimo form are in the second group; in the third clump are included the Western Okhotsk Sea form and the Northern Kuril Is. form; and the Northeastern Okhotsk Sea form are in the fourth clump. But the Eastern Erimo form is divided into the second and the third clumps.

3. Inclination of means of the vertebral number to latitude

In general, it is known that fish from higher latitudes tend to have a larger number of vertebrae than the fish from lower latitudes. So the relationship between the means of vertebral number and the degree of latitude were analyzed for the three regions (Fig. 5). In order to extend the range of latitude, fifteen means of the total vertebrae in nine coastal area of Honshû, published by OGATA (1959) and HASHIMOTO and KO-

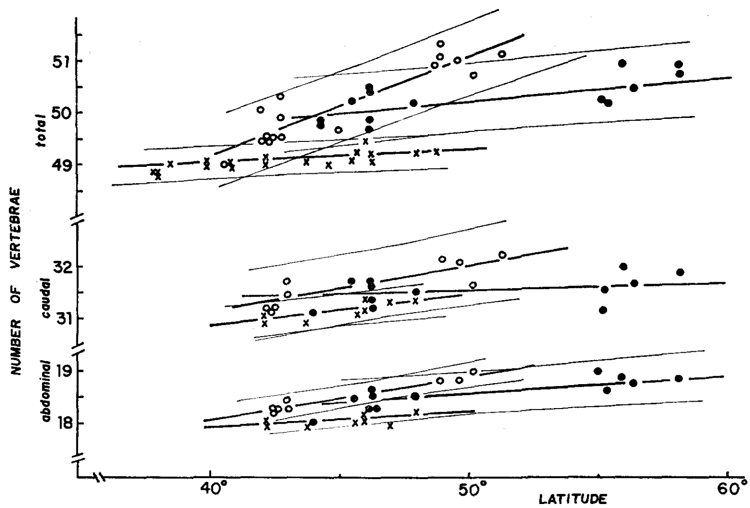

Fig. 5. Regression lines and their rejection limits of the means for abdominal, caudal and total vertebrae in the walleye pollock with regard to latitudes in three regions. ○: Pacific region, ●: Okhotsk Sea region, ×: Japan Sea region

YACHI (1969), were added to the present data.

The regression lines were calculated for three counts of vertebral numbers, i.e. total, abdominal, and caudal, in each region, and the significance test for the slopes of these lines were also performed (Table 4). The results of the tests showed that the slopes were significantly positive at the 5% level of significance, exclusive of the caudal vertebrae in the Okhotsk Sea and the abdominal vertebrae in the Sea of Japan. Then the significance of difference of the adjusted means and the regression coefficients between the regions were tested by the covariance analysis.

The adjusted mean of total vertebrae of the Sea of Japan was significantly lower than those of two other regions. In the caudal vertebrae the adjusted mean of the Pacific region is higher than that of the Sea of Japan at the 1% level of significance. The adjusted means of abdominal vertebrae are significantly different at the 1% level of significance between the Seas of Okhotsk and Japan, and between the Sea of Japan and the Pacific. Consequently the regression lines of the Pacific region generally show the highest position in each count of vertebrae and those of the Okhotsk Sea follow after. In the regression coefficients significant differences were noted for the total vertebrae between the Pacific region and the Sea of Okhotsk or the Sea of Japan.

These results suggest that there is a positive linear relationship between the latitude and the numbers of total, abdominal and caudal vertebrae, also the inclination was steeper and the vertebral counts higher in the Pacific region.

Table 4. Constants a and b in the regression equation ($V=a+bL$, where V means the number of vertebrae and L the degree of latitude) and comparison of b and the adjusted means between regions.

	Region	b	F-test for difference of b	a	Adjusted mean (μ)	F-test for difference of μ
Total vertebrae	Pacific Ocean	0.1873**	F=27.841	41.67	50.341	F=4.544
	Okhotsk Sea	0.0476*	df=1, 25	47.84	49.954	df=1, 26
			P<0.001			0.025<P<0.05
	Okhotsk Sea	0.0476*	F=0.423	47.84	50.035	F=95.36
	Sea of Japan	0.0372**	df=1, 30	47.48	49.194	df=1, 31
			P>0.1			P<0.01
	Sea of Japan	0.0372**	F=54.592	47.48	49.194	F=2.041
	Pacific Ocean	0.1873**	df=1, 33	41.67	50.341	df=1, 17
			P<0.01			P<0.01
Caudal vertebrae	Pacific Ocean	0.0841*	F=2.407	27.83	31.726	F=2.041
	Okhotsk Sea	0.0164	df=1, 12	30.75	31.504	df=1, 13
			P>0.1			P>0.1
	Okhotsk Sea	0.0164	F=0.788	30.75	31.726	F=2.041
	Sea of Japan	0.0841*	df=1, 16	28.29	31.265	df=1, 17
			P>0.1			P>0.05
	Sea of Japan	0.0841	F=0.818	29.29	31.201	F=18.21
	Pacific Ocean	0.0841*	df=1, 12	27.83	31.624	df=1, 13
			P>0.1			P<0.01
Abdominal vertebrae	Pacific Ocean	0.0822**	F=3.655	14.83	18.690	F=3.483
	Okhotsk Sea	0.0386**	df=1, 16	16.68	18.614	df=1, 17
			P>0.05			P>0.05
	Okhotsk Sea	0.0386	F=0.050	16.68	18.545	F=15.784
	Sea of Japan	0.0322	df=1, 17	16.65	18.216	df=1, 18
			P>0.1			P<0.01
	Sea of Japan	0.0322	F=3.427	16.65	18.538	F=57.194
	Pacific Ocean	0.0822**	df=1, 12	14.83	18.109	df=1, 13
			P>0.05			P<0.01

The asterisk shows the significance level for the test of H_0: $\beta=0$,
* 0.01<P<0.05, **P<0.01

Discussion

Although the present samples are insufficient to represent all the local forms of the walleye pollock, the statistical comparison of mean number of vertebrae suggests that some local forms occur in geographically restricted waters within the present study area. In the northern region of the Sea of Japan there are two groups of the walleye pollock showing different mean numbers of both abdominal and total vertebrae. One is a group designated as the Western Sakhalin form in the northern area and another is the Western Hokkaido form in the southern area, and these two forms overlap off the southwest coast of Sakhalin Is.. In the Okhotsk Sea, the Western Okhotsk Sea form is distributed from the eastern coast of Hokkaido to the area northward of Sakhalin Is. along the eastern coast of this island, and is readily distinguished from the Rausu form. In this sea there is another group, the Northeastern Okhotsk Sea form, distributed in the northeastern part of the sea. In the Pacific region there are three local forms, *viz.* the Western Erimo form, the Eastern Erimo form and the Northern Kuril Is. form.

In the diagrammatic analysis of correlative variations between the abdominal and caudal vertebrae, four clumps were distinctly found. Although this discontinuity is expected to represent the discontinuity among local forms, some clumps contain together several samples from geographically distant areas, and consequently it is difficult to accept that each clump represents a discriminated local form. Probably these mixtures are due to the geographical inclination of vertebral counts to latitude which is referred to later. Taking separately each region into account, each clump coincides with each local form excluding the samples from Aniva Bay in May and July and a sample of the Eastern Erimo form (S. 35).

It is also indicated that abdominal, caudal and total vertebrae counts show normal distributions, and both the means and variances of samples within an area are about the same. The mean tends to increase with increasing latitude. Thus, the local form classified by phenotype can be defined in a given region showing continuous environment as follows: (1) the vertebral counts are normally distributed with a certain specific hereditary range within each environmentally homogeneous area; (2) the mean vertebral counts have a relative position and a particular regression coefficient within each region in regard to the latitude, and accordingly their variation range are concerned with particular, environmental and geographical factors in each respective region.

So the various studies on fish population are necessary to be reviewed, the phenotypical characteristics so far employed by previous authors and afterwards the validity must be considered for the concept of "local form" proposed here. Earlier, JORDAN's papers drew attention to a correlation between the temperature conditions on the globe and the number of vertebrae in the different groups of fishes, and HEINCKE's investigations on the racial characters of the Atlantic herring aroused great interest in fisheries research, for the use of meristic characters in delimiting the so-called races in many different groups of fishes (*vide* TÅNING[17]). A numerical variation in vertebral counts with respect to latitude has been investigated by SCHMIDT[11] in the cod, by TESTER[12] in the herring, and by KUBOTA and ONO[13] in the loach. These authors concordantly showed an increase of vertebral counts from warmer waters to colder waters or from south to north in the northern hemisphere. In the anchovy, YOKOTA and FURUKAWA[14] reported a negative linear relationship between the vertebral number and water temperature at the hatching period. A temperature sensitive phase was found by TÅNING[15,16,17] during early ontogeny in the sea trout. This phase is regarded to be the same as in the herring[18]. The results of these authors do not contradict the results of the present paper. Considering the circumstances for the reproduction of the walleye pollock, the following conclusions have been attained.

Spawning shoals of the walleye pollock migrate on the continental shelf as much as 120 miles or more from south to north along western Hokkaido[6]. These spawning shoals migrate in this area one shoal after another from January to March. The oceanographical environment changes considerably during this period and it must influence the early development of the fish. These evidences will support the above-mentioned hypothetical items (1) and (2) assuming a continuous changing environment in an oceanic region.

It is considered that in the walleye pollock the variation in number of vertebrae occurs through the organogenesis of ontogeny encountered with changeable environmental conditions. It can be reliably stated that fish having similar phenotype, which is aquired by particular external conditions, form a homogeneous group in response to the environment. Their phenotype can be distinguished from that of other groups which developed under different environmental conditions, without the consideration of the innate structures of fish population. However, the population, as a unit of resource, has to be recognized with diagnostic features which reflect the structure of reproduction and growth. It is, therefore, quite proper to call the homogeneous group a "local form" which means the group of identical individuals in respect to phenotypic variation.

On the other hand HEMPEL and BLAXTER[18] suggested that the difference in the mean vertebral counts of Scottish and German spring-spawning herring was genetic, based on experiments involving changing incubation temperature and cross fertilization. But at present nothing is shown to prove the genetic relationship among different groups in the walleye pollock, although it is necessary to define the population which is an infallible unit of fish resource. For this reason the term "local form" is provided to the geographical variations of the phenotypic characteristics, until the system and mechanism which produce the variations are better clarified. After that, the phenotypic characteristics will be recognized as a standard for the classification of populations.

Acknowledgements

The authors wish to express their deepest appreciation to Dr. S. J. WESTRHEIM, Fisheries Research Board of Canada, Mr. T. NISHIYAMA, Research Institute of North Pacific Fisheries, Faculty Fisheries, Hokkaido University, and Mr. R. MEYER, National Marine Fisheries Service, NOAA, for their reading the manuscript and their valuable criticism in this study. Thanks are also due to the research staffs of the Hokkaido Fisheries Experimental Stations, the Hokkaido Regional Fisheries Research Laboratory and the Research Institute of North Pacific Fisheries of Hokkaido University for the supports of the collection of the materials.

References

1) T. Ishida: *Bull. Hokkaido Reg. Fish. Lab.*, **11**, 36–67 (1954).
2) T. Ogata: *Bull. Jap. Sea Reg. Fish. Res. Lab.*, **4**, 93–139 (1956).
3) K. Kyushin, T. Kinoshita, and K. Hayashi: *Monthly Rep. from the Hokkaido Fish. Exp. St.*, **18**, 84–90 (1957).
4) T. Ishida: *Bull. Hokkaido Fish. Res. Lab.*, **16**, 63–69 (1957).
5) R. Hashimoto, and S. Koyachi: *Bull. Tohoku Reg. Fish. Res. Lab.*, **29**, 37–92 (1969).
6) T. Tanaka: *Sci. Rep. Hokkaido Fish. Exp. St.*, **12**, 1–12 (1970).
7) A. S. Boughey: Ecology of Populations, lst ed. 135 pp., Macmillan Company, New York (1968).
8) G. W. Snedecor: Statistical Methods, 5th ed., 478 pp, Iowa State Univ. Press (1956).
9) Hokkaido Fish. Exp. St.: *Monthly Rep. from the Hokkaido Fish. Exp. St.*, **25**, 488–505 (1968).
10) J. P. Harding: *J. Mar. Biol. Asso.* **28**, 141–153 (1949).
11) J. Schmidt: *Comp. rend. Lab. Carlsberg.*, **18** (6), 1–71 (1930)
12) A. L. Tester: *J. Biol. Bd. Canada,* **3** (2), 108–144 (1937).
13) Z. Kubota, and T. Ono: *J. Shimonoseki Univ. Fish.*, **14** (1), 41–52 (1965).
14) T. Yokota, and I. Furukawa: This Bull., **17** (8,9), 60–64 (1952).
15) Å. V. Tåning: *Nature,* **157**, 594–595 (1946).
16) Å. V. Tåning: *ibid.,* **165**, 28 (1950).
17) Å. V. Tåning: *Biol. Rev.,* **27**, 169–193 (1952).
18) G. Hempel, and J. H. S. Blaxter: *J. du Cons.,* **26** (3), 337–346 (1961).