SOME CONSIDERATIONS ON THE POPULATIONS OF ATKA FISH, *PLEUROGRAMMUS AZONUS*, CAUGHT BY DRAG NET IN THE WEST COASTAL WATERS OF HOKKAIDO IN SPRING

Ken-ichiro KYUSHIN and Tetsuichiro KINOSHITA
Faculty of Fisheries, Hokkaido University

Introduction

The drag net fishery for Atka fish in spring in the Tsugaru Strait and in the west coastal waters of Hokkaido, first begins at the west mouth of the strait early in April. Then, with the passage of days, the fishing grounds move eastward in the strait, and, on the other hand, northward in the west coastal waters. The fishing season closes early in June near Rishiri and Rebun Islands for the latter area.

These Atka fish shoals, called the "haru-hokke" commonly, are feeding groups which rise to near the sea-surface from the bottom to take *Themisto sp.*, *Euphausia spp.*, *Calanus spp.* etc. gathering there.[1)2)3)] They are mainly formed by 1-year-old fish, about 25 cm in body length.[4)5)] The movements of the grounds suggest, at a glance, the migration or movements of the shoals, but because these shoals, from the results of the tagging experiments, are not seen to migrate widely,[6)7)] the fishery biologists have doubted whether the shifting of the grounds really represent actual migrations of the shoals.

In order to make clear this problem, the present authors examined the measurement data on 1-year-old fish of the "haru-hokke" caught in the various areas of the west coastal waters of Hokkaido from April to June, 1956. But, no consideration was made for the Tsugaru Strait, since the materials collected in this area were not sufficient to treat the problem.

Before going further, the authors wish to express sincere gratitude to Dr. Hiroaki Aikawa, professor of the Faculty of Agriculture, Kyushu University, for his valuable advices and review of this manuscript. Thanks are offered to Mrs. Toshiko Maruta for her help in arranging the data.

The present study was carried out as a part of the researches of the bottom fish populations which have been executing by some members of the Hokkaido Regional Fisheries Research Laboratory, the Hokkaido Fisheries Experimental Station and the Faculty of Fisheries, Hokkaido University.

Materials and Methods

The materials used in this study were sampled from the catches taken by drag net from the middle of April to early in June, 1956 (Table 1). Arranging in order the fishing grounds from south to north, they were taken in the area from the west mouth of the Tsugaru Strait to off Hakodate (landed at Hakodate), around Okushiri Island (Aonai),

Table 1. Materials

Sampling station	Date			Number of specimen
Hakodate	Apr.	26,	1956	25
	Apr.	27,	〃	25
	Apr.	29,	〃	25
	May	10,	〃	25
	May	14,	〃	25
	May	24,	〃	25
	Total			150
Aonai	Apr.	15,	1956	20
	Apr.	20,	〃	21
	Apr.	25,	〃	20
	May	2,	〃	20
	May	27,	〃	20
	Total			101
Suttsu	Apr.	25,	1956	50
	Apr.	27,	〃	50
	May	6,	〃	50
	Total			150
Kutsugata and Oniwaki	May	4,	1956	50
	May	7,	〃	50
	May	9,	〃	50
	May	9,	〃	50
	May	20,	〃	50
	May	21,	〃	50
	May	21,	〃	50
	June	6,	〃	50
	June	6,	〃	50
	Total			450

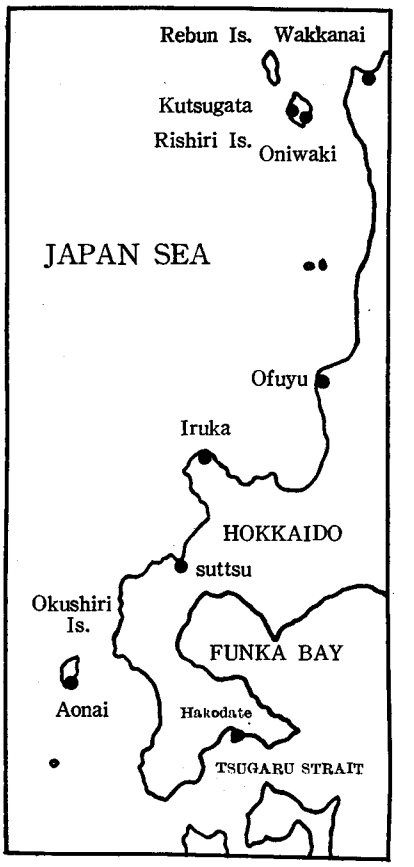

Fig. 1. Map of the west coastal waters of Hokkaido, showing localities mentioned

off the coast from Suttsu to Iruka (Suttsu) and around Rishiri and Rebun Islands (Kutsugata and Oniwaki); the areas and the localities are shown by the map in Fig. 1.

The items of measurement and count of the specimens were: body length, body weight, sex, number of vertebrae (urostyle included), number of dorsal and anal fin rays, scale length and scale diameter at the time of the first ring formation. However, the number of vertebrae and dorsal fin rays of the specimens collected in Aonai and Kutsugata-Oniwaki was not counted.

The scales were taken from portion III of the fish-body.[8] The scales were magnified 50 times by the projector for measnrement of the overall scale length and scale diameter

at the time of the first ring formation; the measurements were recorded in mm along the antero-lateral line of the scale.

Results

1) Length composition

The length compositions of fish from the various areas which are gathered up through

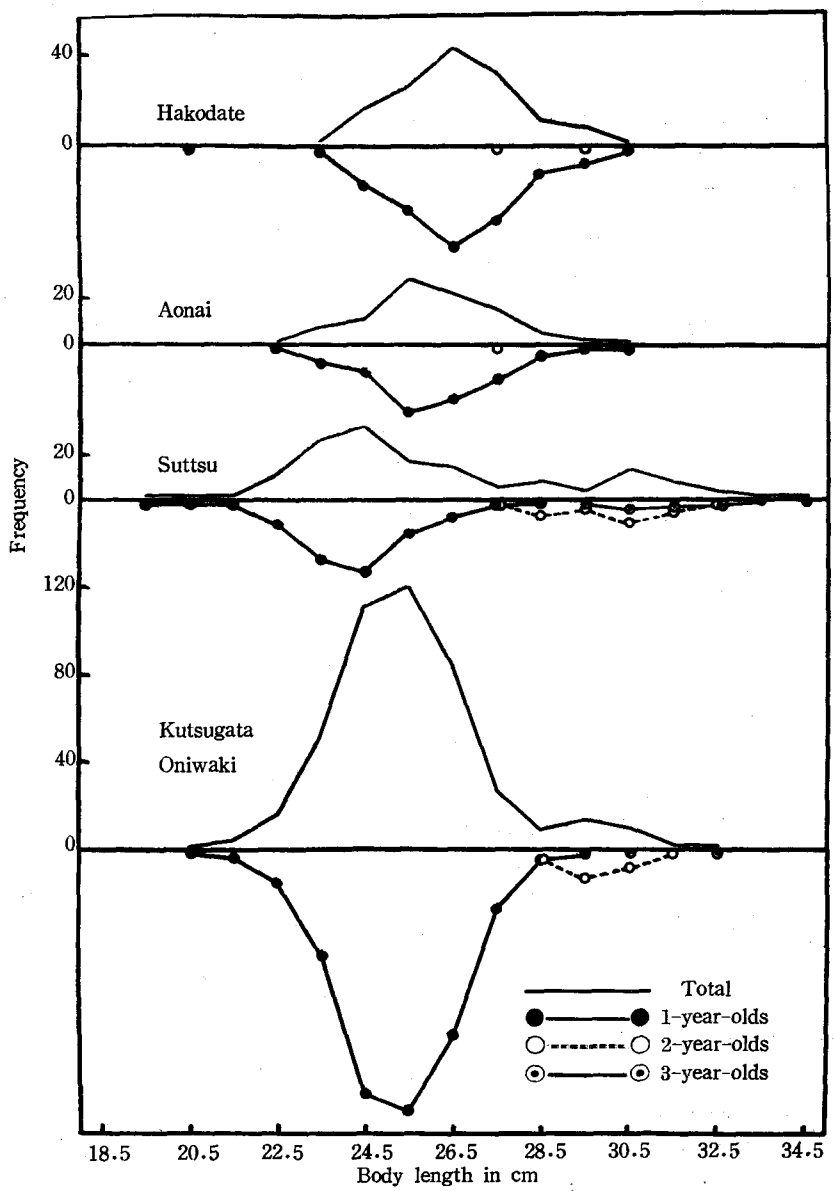

Fig. 2. Length compositions of samples from various areas gathered up through the saeson

the season are shown in Fig. 2. The data of Hakodate and Aonai represent the normal form of distribution with the respective modes at 26.5 and 25.5 cm. Otherwise, the data of Suttsu and Kutsugata-Oniwaki show polymodality with the maximum frequency in 24.5 cm for the former and in 25.5 cm for the latter.

Analyzing the length composition into age groups, one finds that the main mode is supplied by 1-year-old fish in all cases, whilst other modes seen in Suttsu and Kutsugata-Oniwaki are furnished by 2- and 3-year-old fish chiefly. In total data, 1-year-old fish account for 91 percent and the rest are 2- and 3-year-old fish.

Comparing the length compositions of 1-year-old fish by areas, the data of Suttsu and Kutsugata-Oniwaki show smaller size than others. The mean values of body length are 26.5, 26.0, 24.2 and 25.2 cm for Hakodate, Aonai, Suttsu and Kutsugata-Oniwaki respectively. The values of the data from Hakodate and Aonai on the fish taken in April and May are somewhat larger than those from Kutsugata-Oniwaki derived from the fish caught in May and June; the values from Suttsu which is situated geographically between the other two grounds are the smallest.

The seasonal changes of body length of 1-year-old fish are shown in Fig. 3. The data are separated into two groups — one is the large size group, developing from about 25 cm at the middle of April to about 27.5 cm late in May, which is composed of the data from Hakodate and Aonai; the other is the small one, increasing from about 24 cm late in April to about 26 cm early in June, composed of fish from Suttsu and Kutsugata-Oniwaki. There is about 2 cm difference between them through the whole season.

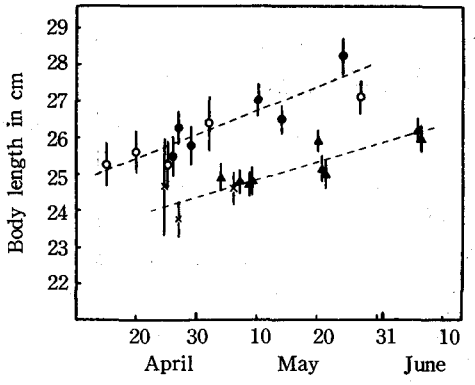

Fig. 3. Seasonal changes in length of samples from various areas

Dots and longitudinal lines show the position of the mean values and confidence intervals for $P_{0.05}$ respectively. ●: Hakodate ○: Aonai ×: Suttsu ▲: Kutsugata-Oniwaki

Thus, for the reason that the data of Hakodate and Aonai were collected from the large size group, while those of Suttsu and Kutsugata-Oniwaki, from the small one, the length compositions of the former lay considerably on the larger size than those of the latter. Especially, that the length composition for Suttsu showed the smallest size among the data was due to the fact that the data were collected from the small group only in the early fishing season.

2) The scale diameter at the time of the first ring formation and the marginal increment of the scale from the first ring

The 1-year-old fish have one ring on their scales, as they hatched out in the period

from January to April of the previous year and rings are formed in winter. The mean values of the scale diameter and the calculated body length from various areas at the time first ring is formed are shown in Table 2. Here, use was made of standardized first ring diameter.[8] The frequency distributions of the first ring diameter represent the normal form in all cases and the mean values differ among areas. The value of 1.61 mm for Suttsu is the minimum value and 1.70 mm for Kutsugata-Oniwaki the maximum one.

Table 2. Scale diameter and calculated body length at the time of the first ring formation

Sampling station	Mean value of first ring diameter (mm)	Calculated body length (cm)
Hakodate	1.63	21.3
Aonai	1.66	21.8
Suttsu	1.61	21.1
Kutsugata and Oniwaki	1.70	22.5

The seasonal changes of the marginal increments of scales from the first ring, that is $R-r_1$, — here, R is the scale length and r_1 is the first ring diameter — are shown in Fig. 4. The development of $R-r_1$ differs among the areas remarkably; values are separated into three groups — the data of Hakodate and Aonai which develop from about 0.16 mm at the middle of April to about 0.36 mm late in May, those of Kutsugata-Oniwaki which increase from about 0.12 mm early in May to about 0.14 mm early in June and those of Suttsu which lie between the other two groups and increase from about 0.13 mm late in April to about 0.17 mm early in May.

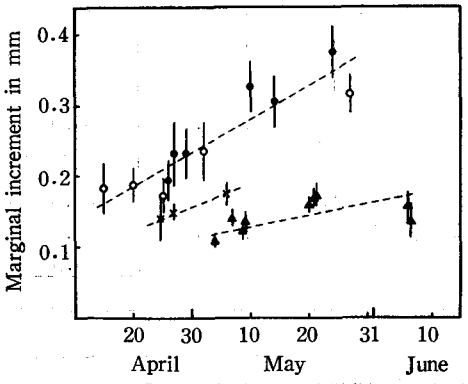

Fig. 4. Seasonal changes in the marginal increments of scales from the first ring

Dots and longitudinal lines show the position of the mean values and confidence intervals for $P_{0.05}$ respectively. ●: Hakodate ○: Aonai ×: Suttsu ▲: Kutsugata-Oniwaki

3) The counts of vertebrae, dorsal fin rays and anal fin rays

For a preliminary examination, differences between means by sex of individual samples from various areas were examined for statistical significance using the t-test. In all samples there was no one in which significant differences were recognized as to vertebrae; in only one from Hakodate out of 9 cases for dorsal fin rays and each one from Hakodate and Kutsugata-Oniwaki out of 23 cases for anal fin rays were there significant differences. From the above examination, it may be acceptable that differences of mean between sex are not recognized in the three meristic characters examined.

The next step was to compare the mean counts of the combined data by sex for these

characters within each area by means of an analysis of variance (Table 3). There were no significant differences by the areas, Hakodate ($F = 0.80$) and Suttsu ($F = 2.27$) in vertebrae nor also by the areas, Hakodate ($F = 0.59$), Aonai ($F = 1.95$), Suttsu ($F = 0.06$) and Kutsugata-Oniwaki ($F = 1.79$) in anal fin rays. In respect of dorsal fin rays, significant differences were not recognized for the samples of Hakodate ($F = 1.77$) but 4.97 of F value for Suttsu was significant for $P_{0.01}$. Hence, the samples from each area except Suttsu may have been drawn from a single population. Table 4 shows the results of examinations for three mean values of the dorsal fin ray counts from Suttsu by t-test.

Table 3. Frequencies of meristic characters of each sample from various ares

1. Number of vertebrae

Sampling station	Date	Vertebrae								Mean	s.s.
		57	58	59	60	61	62	63	Total		
Hakodate	Apr. 26				5	13	5	1	24	61.083	13.9
	Apr. 27			1	5	11	8		25	61.040	17.0
	Apr. 29				3	10	9	3	25	61.480	18.3
	May 10				2	16	6	1	25	61.240	10.6
	May 14			1	6	6	9	1	23	61.130	22.7
	May 24				5	11	6	1	23	61.130	14.7
											97.2
	Total			2	26	67	43	7	145	61.186	100.0
Suttsu	Apr. 25				2	4	1		7	60.857	2.9
	Apr. 27			3	16	21	6	4	50	60.840	49.0
	May 6	1	2	7	13	21	4	1	49	60.367	64.0
											115.9
	Total	1	2	10	31	46	11	5	106	60.623	121.0

2. Number of dorsal fin rays

Sampling station	Date	Dosal fin rays								Mean	s.s.
		47	48	49	50	51	52	53	Total		
Hakodate	Apr. 26			8	13	3			24	49.729	10.0
	Apr. 27			9	12	3	1		25	49.840	15.4
	Apr. 29			10	11	4			25	49.760	12.6
	May 10			8	11	6			25	49.920	13.9
	May 14			6	11	5	1		23	50.043	15.0
	May 24			3	12	6	2		23	50.304	14.9
											81.8
	Total			44	70	27	4		145	49.938	87.0
Suttsu	Apr. 25			1		5	1		7	50.857	4.9
	Apr. 27	1		9	19	12	7	2	50	50.400	68.0
	May 6			1	11	25	8	4	49	51.061	39.0
											111.9
	Total	1		11	30	42	16	6	106	50.736	122.7

3. Number of anal fin rays

Sampling station	Date	Anal fin rays 26	27	28	29	30	31	33	Total	Mean	s.s.
Hakodate	Apr. 26		3	10	10	1			24	28.375	13.4
	Apr. 27	1	2	12	10				25	28.375	14.6
	Apr. 29	1		13	10	1			25	28.400	14.0
	May 10		1	10	12	2			25	28.600	12.0
	May 14		4	6	11	2			23	28.478	17.8
	May 24		4	6	11	2			23	28.478	17.8
											89.6
	Total	2	14	57	64	8			145	28.428	91.5
Aonai	Apr. 15		4	13	3				20	27.950	7.0
	Apr. 20		5	11	3	2			21	28.095	16.0
	Apr. 25		2	10	5	2			19	28.368	12.5
	May 2		1	7	12				20	28.550	7.0
	May 27		4	10	6				20	28.100	9.8
											52.3
	Total		16	51	29	4			100	28.210	56.6
Suttsu	Apr. 25				4	3			7	29.428	1.7
	Apr. 27			8	17	22	1	2	50	29.440	42.4
	May 6		2	2	20	21	4		49	29.469	41.3
											85.4
	Total		2	10	41	46	5	2	106	29.453	85.5
Kutsugata and Oniwaki	May 4		2	12	29	4	2		49	28.837	30.7
	May 7		4	18	20	5	3		50	28.700	46.5
	May 9	1	2	19	25	2			49	28.510	26.3
	May 9		2	19	18	9	1		49	28.755	37.1
	May 20		4	11	23	12			50	28.860	38.1
	May 21			17	26	7			50	28.800	22.0
	May 21		3	15	27	5			50	28.680	26.9
	June 6			18	20	2			40	28.600	13.6
	June 6		6	12	13	2			33	28.333	23.4
											264.6
	Total	1	23	141	201	48	6		420	28.690	273.8

Table 4. Tests of significancy of mean dorsal fin ray counts between samples from Suttsu

Sample	n		d.f.	t
Apr. 25	7		55	0.983
Apr. 27	50		54	0.557
May 6	49		97	3.117**

** Significant for $p_{0.01}$

Differences between the samples collected on 27th April, showing the lowest mean value, and those on 6th May, the highest one, are significant. However, those three samples may be considered together for the following procedure, since the lowest mean value, 50.400, of Suttsu samples is considerably larger than any mean value from Hakodate, and further-

more no significant differences have been recognized among samples from this area as regards the mean vertebral and anal fin ray counts.

The next procedure was to compare the mean values of these characters between and among the areas on the basis of the the data gathered in each area. F values for each of the vertebrae, dorsal fin rays and anal fin rays were 21.89, 46.31 and 47.67 respectively; they are highly significant. The comparisons of mean values by t-test, shown in Table 5, reveal recognizable differences between Hakodate and Suttsu in cases of both vertebrae and dorsal fin rays. In the case of anal fin rays, differences exist between areas for $P_{0.01}$ except in the comparison between Hakodate and Aonai, which shows significant differences for $P_{0.05}$.

Table 5. Tests of significancy of means of meristic characters between areas

1. Number of vertebrae

Sampling station	n	d.f.	t
Hakodate	145	249	4.762**
Suttsu	106		

2. Number of dorsal fin rays

Sampling station	n	d.f.	t
Hakodate	145	249	7.078**
Suttsu	106		

3. Number of anal fin rays

Sampling station	n	d.f.	t
Hakodate	145	243	2.196*
		249	9.569**
Aonai	100	563	3.429**
Snttsu	106	204	9.662**
Kutsugata and Oniwaki	420	518	5.681**
		524	8.593**

* Significant for $P_{0.05}$
** Significant for $P_{0.01}$

Discussion and Conclusion

Investigations on the seasonal movement of adult Atka fish in Hokkaido waters have been made by the Hokkaido Regional Fisheries Research Laboratory continuously, and much has been done for population analysis. On the basis of tagging experiments,[7] and studies of the length composition[7] and growth type of the fish,[8] it has been pointed out that there exist pretty distinct groups at the main spawning grounds, namely in the coastal areas of the Shiretoko peninsula, Rishiri and Rebun Islands and the coastal waters from the southwestern region of Hokkaido to about the west side of the entrance to Funka Bay. The fishes concentrate to the grounds at the spawning season and move somewhat dispersedly about the ground after the end of the season. On the other hand, only limited information is available about the migration or movement of immature fish and that has been an obstacle to analysis of the population of Atka fish.

In this paper is presented the author's examination of the various data on 1-year-old fish collected from the west coastal waters of Hokkaido. Data were classified into two

groups on the basis of the seasonal increases of body length, one including the data of Hakodate and Aonai and the other those of Suttsu and Kutsugata-Oniwaki, though all specimens examined here were 1-year-old fish. The mean values of the scale diameter and the calculated body length at the time of the first ring formation differed among the areas. Furthermore the seasonal changes of the marginal increments of scales from the first ring represented different tendencies of increase as evidenced by the data from Hakodate and Aonai, Suttsu and Kutsugata-Oniwaki.

It is certain that the seasonal increase of body length represents the growth of the fish. Furthermore, the rings observed on scales are formed in winter season, a slow growing period for the fish; the values of scale diameter and calculated body length at the time of the ring formation from the data of the southern grounds, Hakodate, Aonai and Suttsu, are less than the values based on the data from the northern ground, Kutsugata-Oniwaki. Then, differences of growth seen among areas are probably due to some discrepancy of the time when the fishes start growing in early spring. One of the authors has estimated that the hatching season throughout the Hokkaido waters extends from January to April and that the high season of ring formation in the west coastal waters of Hokkaido is in January and February,[8] but the discrepancy of these seasons for more subdivided localities has not been studied sufficiently. Hence, it is not conceivable that the values of scale diameter and calculated body length at the ring formation time are fixed only by the rapid or slow growth, although they represent the growth of the first year of the fish within the period from hatching to formation of the first ring.

As regards the counts of vertebrae, dorsal fin rays and anal fin rays, the characteristic mean values were calculated for the data from each area. It may be suggested that the shoals examined here did not intermingle with each another during the life stages previous to that of "haru-hokke".

Judging from the above considerations, one may conclude that the Atka fish shoals caught in spring by means of drag net from all the west coastal waters of Hokkaido do not belong to a single population. Thus the northward movement of the fishing ground does not reflect the movement of the fish themselves, but is probably due to the fact that the local groups are caught from south to north in sequence as the season goes by.

More of the comparatively younger fishes, about 21 cm in body length, which are just in the life stage previous to "haru-hokke" have been called "rōsoku-hokke" commonly. They are caught in great quantity by the Danish seine from the north area in the west coastal waters of Hokkaido in winter. On the other hand, they are caught in small qnantity in the south area by line fishery prepared for adult Atka fish in the same season. Up to the present, it has been an open question whether the yield of "rōsoku-hokke" from the south ground is insignificant compared with that from the north, even supposing that a considerable population is there originally, owing to the fact that the operation of the

Danish seine fishery is entirely prohibited in the south area, or whether "haru-hokke" caught all over the west coastal area are supplied from the dense population of "rōsoku-hokke" which appears in the northern area, considering that the Danish seine grouud for "rōsoku-hokke" moves southwards from the north-western area off of Wakkanai in January to the area off Ofuyu in March.

To solve the problem, it seems essential either to search for some unknown population of "rōsoku-hokke" in the south area or to make the tagging experiments for "rōsoku-hokke" appearing in the north area. At the same time, the characters examined here, such as the scale diameter at the ring formation time and the counts of vertebrae, dorsal fin rays and anal fin rays, must be useful indicators to assist in an analysis of the population of immature stages of the Atka fish.

Summary

By examination of the several characters of 1-year-old Atka fish, *Pleurogrammus azonus* JORDAN et METZ, the authors have considered the movement of the fish, based upon materials collected by drag net from the west coastal waters of Hokkaido in spring, 1956. The sampling stations were Hakodate, Aonai, Suttsu, Kutsugata and Oniwaki.

The results obtained here are summarized as follows:

1) Two groups, differing in growth type, are recognized on the basis of seasonal increases of body length. One group is based on data from Hakodate and Aonai and the other on those from Suttsu and Kutsugata-Oniwaki.

2) Differences are recognized among the values of the scale diameter and the calculated body length at the time of the first ring formation from various areas.

3) The seasonal changes of the marginal increments of scales from the first ring represent the different tendencies of increase as shown by the data from Hakodate and Aonai, Suttsu and Kutsugata-Oniwaki.

4) As to the counts of vertebrae, dorsal fin rays and anal fin rays, there are obvious differences among the areas.

5) From the above results, it may be deduced that the shoals of "haru-hokke" appearing in various areas do not belong to a single population and therefore the northward movement of the drag net fishing ground with the lapse of days, from April to June, in the west coastal waters of Hokkaido does not reflect any migratory movement of the fish.

Peferences

1) Tsujisaki, H. & Ishigaki, T. (1957). Studies on "Hokke", *P. azonus* JORDAN et METZ. (V). The stage of development and its habit. *Jour. Hokkaido Fish. Exper. Stat.* 14 (12), 8-9.

2) Ishigaki, T. & Nakamichi, K. (1958). Ditto (VI). Behaviour, feeding habit and environmental condition. *Ibid.* 15 (1), 4-13.

3) Motoda, S. & Sato, S. (1949). The food of the spring Atka-fish (*Pleurogrammus azonus*) with

its hydrographic bearing. *Bull. Jap. Soc. Sci. Fish.* 15 (7), 344-346.

4) Report of the survey of fisheries resources from the Hokkaido Regional Fisherheries Research Laboratory (1954). (9) 29.

5) *Ibid.* (1957). (14), 37.

6) Hokkaido Fisheries Experimetal Station (1953). "Hokke-to-sono-Gyogyō". 21-22, 49-82.

7) Tsujisaki, H. & Kanbara, H. (1958). Studies on "Hokke", *P. azonus* JORDAN et METZ. (VII). Migration. *Jour. Hokkaido Fish. Exper. Stat.* 15 (2), 3-18.

8) Kyushin, K. (1959). On the age of "Hokke". *P. azonus* JORDAN et METZ, by scale. *Bull. Fac. Fish., Hokkaido Univ.* 10, (1), 1-14.