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Summary of Japan-Russia-Canada Cooperative Juvenile Salmon Research aboard the Research Vessel *Kaiyo maru* in 1993

by

Yasuhiro Ueno, Tero Azuma, Miki Ogura
Jiro Seki*, Ikutaro Shimizu*
Yasuhiro Kawasaki** and Tokihiro Kono**
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424, Japan
*Hokkaido Salmon Hatchery
2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan
**Hokkaido National Fisheries Research Institute
116 Katsurakoi, Kushiro, Hokkaido085, Japan

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National Research Institute of Far Seas Fisheries
***Hokkaido Salmon Hatchery**
****Hokkaido National Fisheries Research Institute**

Abstract

To elucidate the migration routes of Japanese origin chum juvenile salmon, we conducted fishing operations using a large surface trawl in the central and southern parts of the Sea of Okhotsk and the Pacific coastal waters off the Kuril Islands. A total of 24,642 salmonids were collected and about 99.4% of them were the juvenile stage (first year in ocean age). Pink salmon *Oncorhynchus gorbuscha* were the most abundant species (20,280), followed by chum (*O. keta*, 4,133), sockeye (*O.nerka*, 87), coho (*O. kisutch*, 54), masu (*O. masou*, 49), and chinook salmon (*O. tschawytscha*, 39). In October, pink and chum juveniles were mainly distributed in the central and southern Okhotsk Sea. In November juveniles moved to southern part of the Okhotsk Sea and the Pacific coastal waters off the Kuril Islands. We considered that this southward migration of the juveniles was for getting out of seasonal cooling of the surface water temperatures of the central part of the Okhotsk Sea. It is estimated that about 518-882 million juvenile pink and 102-170 million juvenile chum have been distributed in the survey areas, assuming the catching efficiency of the surface trawl to be 0.3. The stock identification of the juvenile is under way.

Introduction

The purpose of this research is to make clear the migration routes of juvenile chum salmon *Oncorhynchus keta* originating from Japanese rivers. Juvenile chum are believed to migrate northwards along the coastal belt of northern Japan from spring to early summer (Irie, 1990). Juvenile chum a known to arrive in the southeastern part of Hokkaido in early summer. However, it is unknown where juveniles migrate after leaving Hokkaido. Although some surveys on the migration routes were conducted in the Pacific coastal waters off Hokkaido and the Kuril Islands, only a few juveniles were collected and reported in mid-summer (Ueno and Ishida, 1994). On the other hand, it was confirmed that a lot of juvenile salmon are distributed in the central and northern parts of Okhotsk Sea in late summer and autumn (Birman, 1969; Shimazaki, 1977). However, the origins of these juveniles in the Okhotsk Sea have never been identified and vaguely thought to be the Far East Russia.

To arrange a cruise plan on this survey, considering the previous reports, we set up the following assumption; 1) Japanese origin juvenile chum migrate from coastal waters off the southeastern coast of Hokkaido to the central and northern parts of the Okhotsk Sea during early and mid-summer; 2) juvenile chum live and grow there in late summer and early autumn; 3) after mid-autumn, juvenile chum migrate from the Okhotsk Sea to the Northwestern Pacific Ocean for getting out of seasonal cooling of the Okhotsk Sea.

Based on this assumption, we conducted two research cruises for juveniles using a surface trawl in October and November, 1993 and could confirm that enormous numbers of juvenile salmon were distributed in the southern and central parts of the Okhotsk Sea in mid and late autumn.

Methods

The 5 fixed research lines with 20 sampling stations in the central and southern Okhotsk Sea and the 4 fixed research lines with 11 sampling stations in the Pacific coastal waters off the Kuril Islands were set up. A large surface trawl (the width and depth; 60 m x 60 m) was used for collecting salmon. We towed the surface trawl for 60 minutes and conducted oceanographic observations (0-1500m) using CTD, and Plankton samplings using some kinds of nets at each sampling station.

The survey consisted of a first half research and a second half research. All research stations were surveyed one time each half research for investigating the seasonal variation of the distribution of juvenile salmon. The first half research was done in October (from October 15 to November 2) and the second half research in November (from November 8 to November 26).

All of animals collected were identified into species and body lengths and weights of them were measured. The area method was applied for the stock abundance estimation of juvenile salmon. The survey area was divided into 4 strata for estimating the numbers of juvenile salmon distributed using the stratified method after the end of the research.

Results

Sea Surface Water Temperature (SST) Distribution (Fig.1)

October (the first half); SSTs in the Okhotsk Sea were ranged from 5° C to 11° C and that of the Pacific waters from 4° to 9° C. The Oyashio waters of low temperature were distributed along the Kuril Islands. Warm waters originating in the Soya Warm Current (9-11° C) existed off the northwest of the southern Kuril Islands, and waters of more than 7° C, which were affected by the warm waters, widely extended to the central part of the Okhotsk Sea.

November (the second half); compared with SSTs in October, SSTs of November fell 2-4° C to 3-9° C in the Okhotsk Sea and 3-5° C in the Pacific waters. In the central waters of Okhotsk Sea, cold waters (less than 5° C) were mainly distributed. A basic water mass distribution of November was similar to that in October.

Catches of Juvenile Salmonids

A total of 24,642 salmonids were collected (Table 1). About 99.4% of the salmonids collected were the juvenile stage (first year in ocean age). In October (the first half), pink salmon *Oncorhynchus gorbuscha* were the most abundant species (7,565 individuals), nd following by chum salmon (*O. keta*; 2,590), coho salmon (*O. kisutch* ;51), sockeye salmon (*O. nerka*;38), masu salmon (*O. masou*;33), and chinook salmon (*O. tschawytscha*;11). In November (the second half), pink salmon were the most abundant species (12,715), followed by chum (1543), sockeye (49), chinook (28), masu (16), and coho salmon (3).

Distribution and Fork Length Frequencies of Juvenile Salmonids

Sockeye salmon (Fig.2): A few juvenile which ranged from 210mm to 340mm with a mode of 250mm in fork length (FL) were collected in coastal waters of the northern Kuril Islands.

Chum salmon (Fig. 3): A large number of juveniles which ranged from 180mm to 310mm with a mode of 230mm in FL were collected in October (the first half) in almost all the survey areas of the Okhotsk Sea. In the Pacific Ocean, no juveniles were collected except for only one station near the central Kuril Islands. Juveniles were found in the southern part of the Okhotsk Sea and the Pacific coastal waters off the central Kuril Islands in November (the second half). The FLs of the juveniles ranged from 160mm to 280mm with a mode of 230mm. Chum salmon hardly showed any changes in their body size through these two months.

Pink salmon (Fig. 4): The distribution of juvenile pink was similar to that of juvenile chum. The FLs of juveniles collected in October ranged from 130mm to 310mm with a mode of 230mm and that in November from 190-330mm with a mode of 240mm. A difference in the modes of FLs between October and November was comparatively small.

Coho salmon (Fig. 5): A few juveniles were collected in all over the survey area in October. In November only three juveniles were caught. The FLs of the juveniles ranged from 220mm to 390mm.

Chinook salmon (Fig. 6): A few juvenile were collected in the Pacific coastal waters off the northern Kuril Islands in both the months (Fig. 5). The FLs of the juveniles ranged from 230mm to 310mm.

Masu salmon (Fig. 7): A few juvuvenile were collected in the southern and western parts of the Okhotsk Sea in both the months. The FLs of juveniles ranged from 210mm to 460mm. Three tagged fish were found. Two of them were missing adipose fin and one was attached a ribbon tag which marked "Kumaishi". This fish was confirmed to be tagged and released in this summer (1993) from the hatchery of the southern Hokkaido.

Estimates of the Number of Juvenile Salmonids in the Survey Area

We divided the survey area into four strata (subregions) for estimating the numbers of juvenile salmonids distributed using the area and stratified method. Because it is difficult to exactly determine the catching efficiency of the surface trawl, we estimated the numbers of juvenile salmonids assuming that the catching efficiency of the trawl was 0.3, 0.5, and 1.0. The results of estimation are shown in Table 2.

The estimates indicates that a large number of juvenile pink and chum salmon were distributed in the survey area. Assuming that the catching efficiency of the trawl was 0.3, about 518-882 millions juvenile pink and 102-170 millions juvenile chum were estimated to be distributed in the survey areas.

We also calculated the proportion of the estimated number of the juvenile by the stratum (Table 3). In October more than 99% of chum and pink salmon juvenile were estimated to stay in the Okhotsk Sea. In November about 10% of pink juvenile and 40% of chum juvenile were estimated to migrate from the Okhotsk Sea to the Pacific coastal waters off the central Kuril Islands.

Discussion

The estimation of the numbers of juvenile salmonids indicates that a great many juvenile pink and chum were distributed in the Okhotsk Sea. This suggests that the Okhotsk Sea is very important for juvenile pink and chum as their habitats.

In contrast to the Okhotsk Sea, few juvenile pink and chum were confirmed to be distributed off the Pacific coastal waters off the Kuril Islands in October. In November, juvenile pink and chum appeared in Pacific coastal waters off the central Kuril Islands and disappeared the central part of the Okhotsk Sea. We considered that these juveniles migrate southeastwards from the central part to the southern part of the Okhotsk Sea and the Pacific waters off the central Kuril Islands for getting out of seasonal cooling of the surface water temperatures of the Okhotsk Sea.

The estimation by the stratum (subregion) suggests that about 40% of juvenile chum and 10% of juvenile pink migrated to the Pacific waters (Table 3). It is likely that juvenile chum proceeded juvenile pink in the seasonal migration.

There is little difference between the FLs of juvenile chum collected between October and November. The mode of FLs of juvenile pink in November was also near that in October. These indicate that juvenile chum and pink grew a little in late autumn.

We are trying to identify stocks of chum juvenile collected using the scale pattern analysis, electrophoresis analysis, and other methods. These analyses are under way at present. We entrusted that scale pattern analysis of juvenile pink for stock identification to Russian scientists of TINRO, who took part in this survey.

Juvenile sockeye and chinook were collected in only coastal waters off the northern Kuril Islands. This suggests that sockeye and chinook juvenile may come from rivers of the Peninsula of Kamchatka, because the peninsula is near the northern Kuril Islands and has many natal rivers of sockeye and chinook salmon. It is obvious that a part of juvenile masu come from Hokkaido based on the recovery of a tagged fish.

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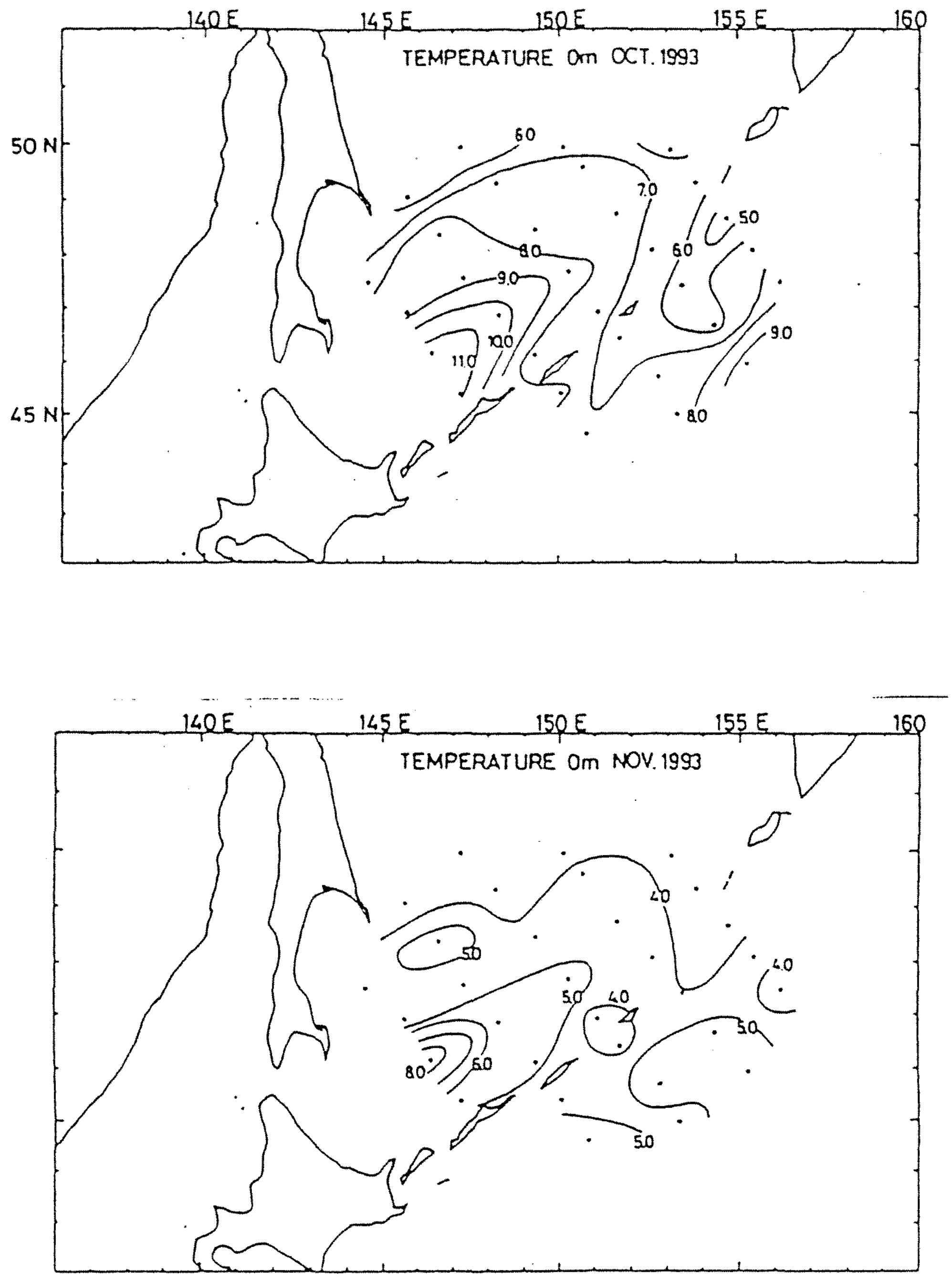

Fig. 1 Distribution of Surface temperatures

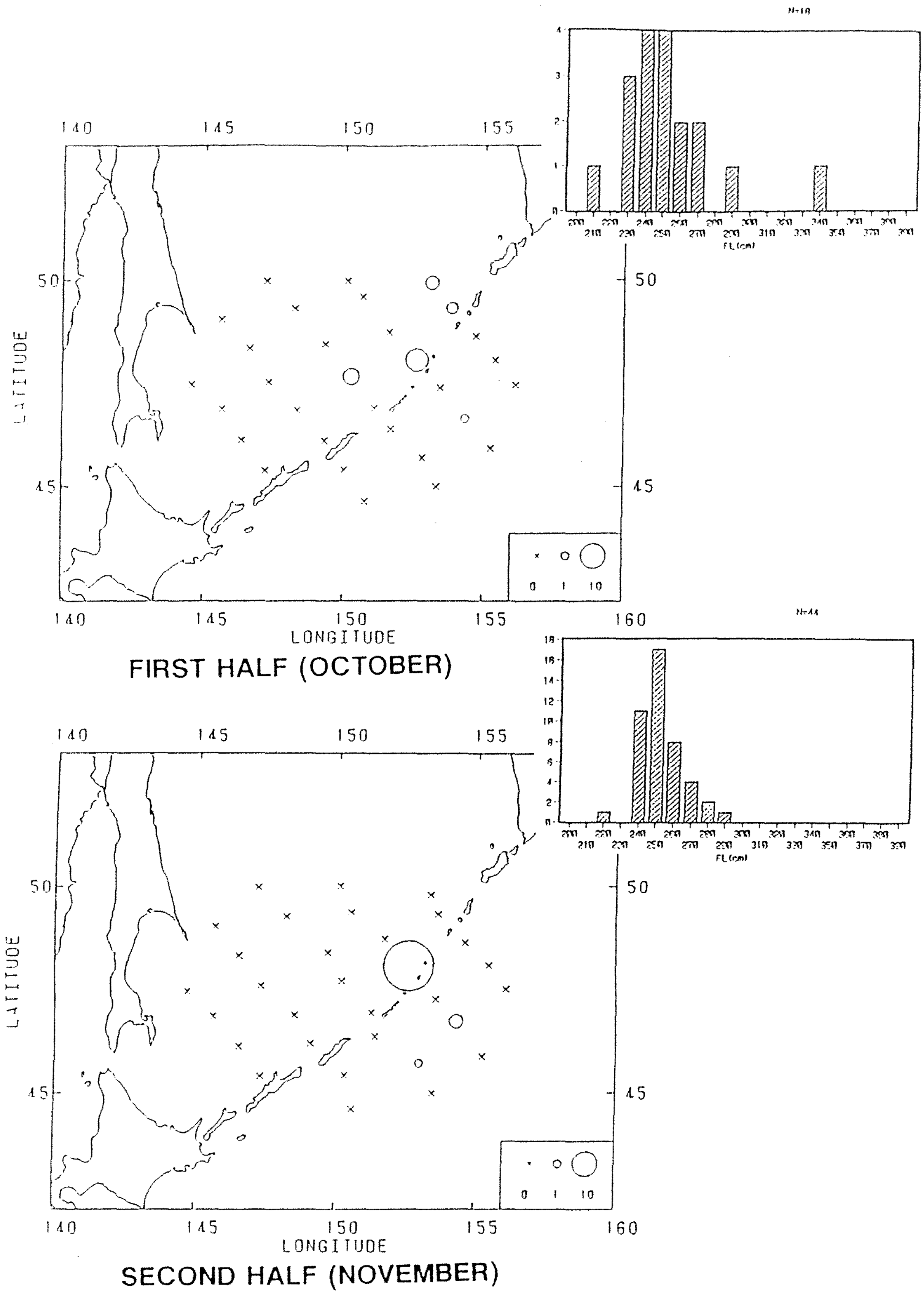

Fig. 2 Distribution and fork length frequencies of juvenile sockeye salmon.

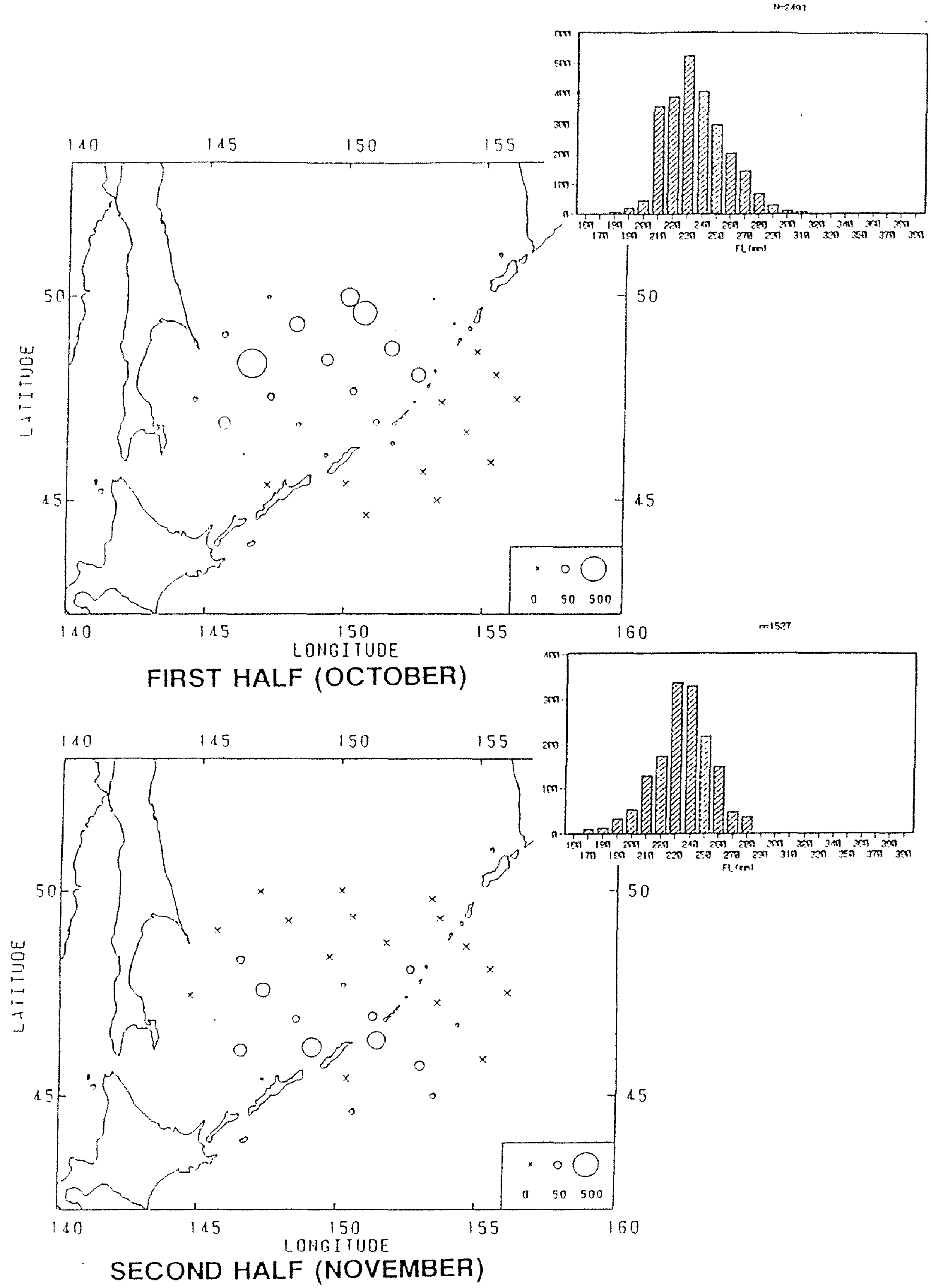

Fig. 3 Distribution and fork length frequencies of juvenile chum salmon.

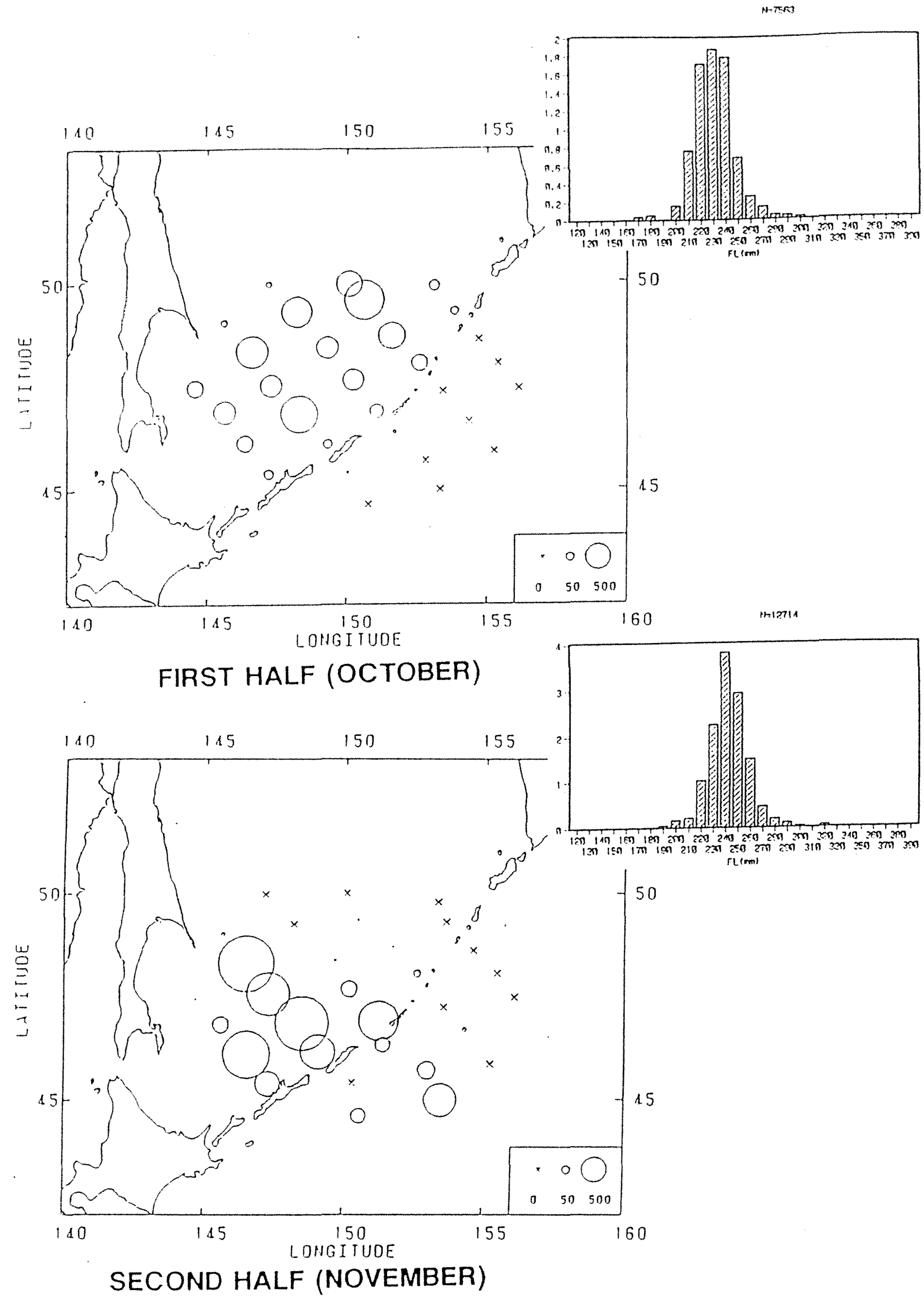

Fig. 4 Distribution and fork length frequencies of juvenile pink salmon.

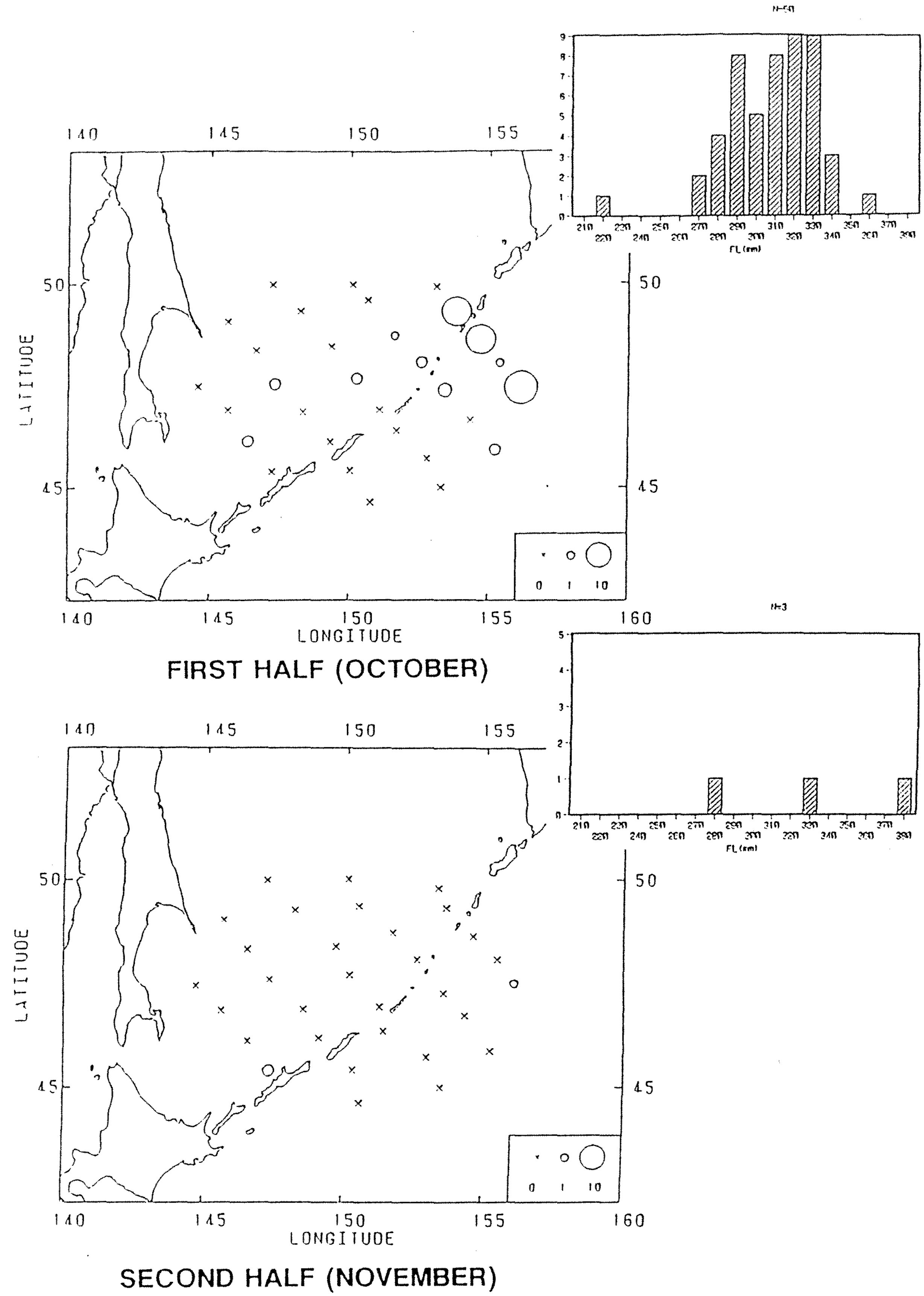

Fig. 5 Distribution and fork length frequencies of juvenile coho salmon.

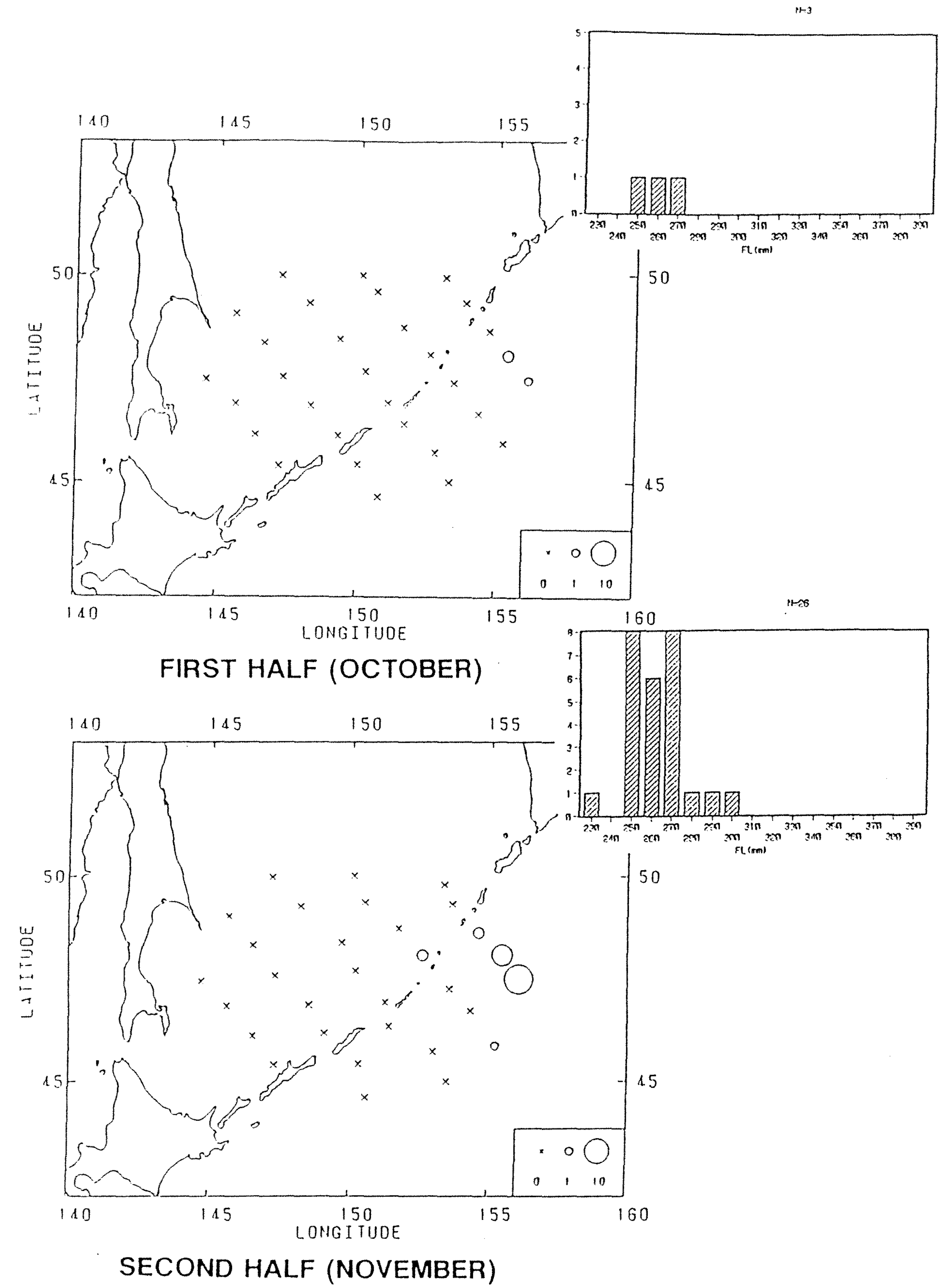

Fig. 6 Distribution and fork length frequencies of juvenile chinook salmon.

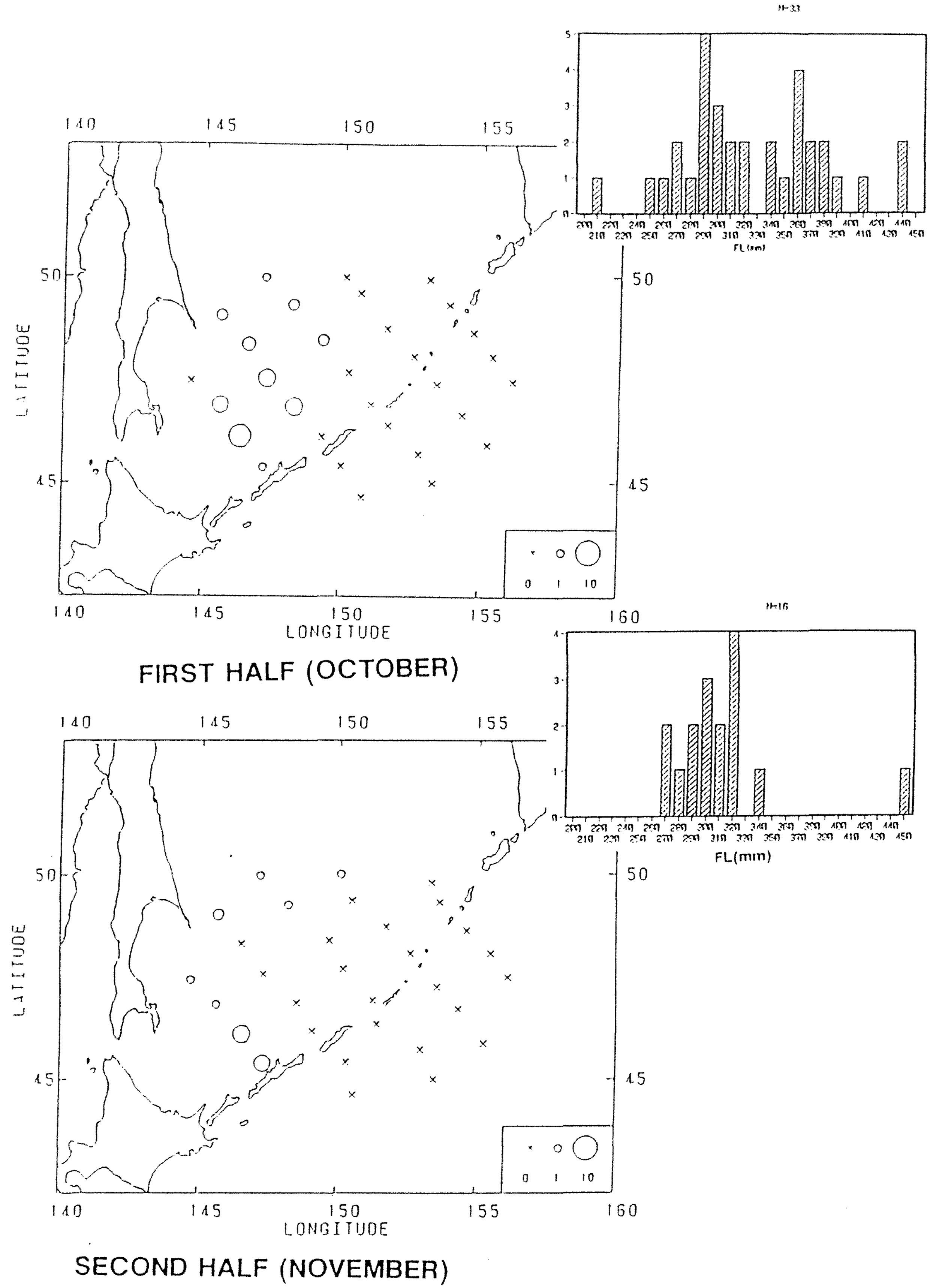

Fig. 7 Distribution and fork length frequencies of juvenile masu salmon.

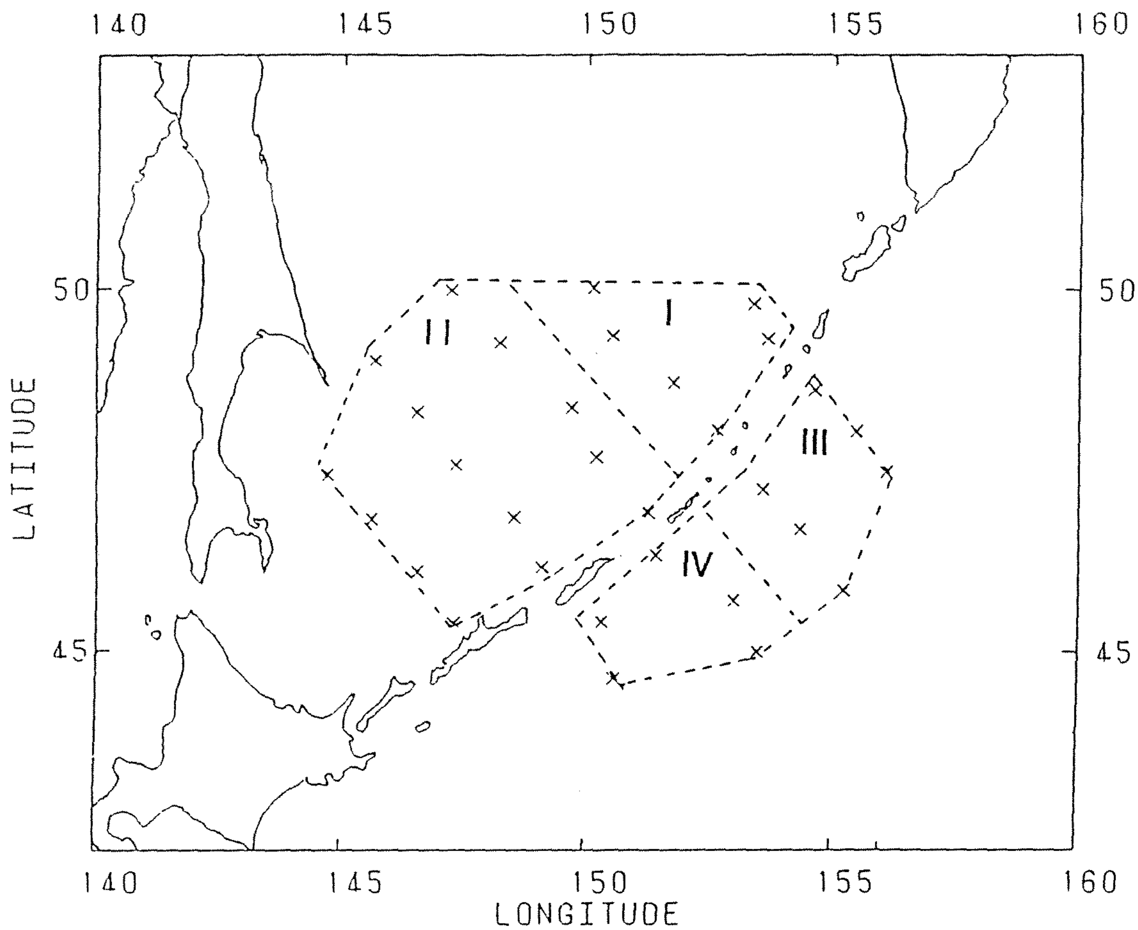

Fig. 8 The sub-regions (strata) for estimating the number of salmonids distributed.

Table 1-1. Numbers of juvenile salmon caught by the surface trawl during the 1995 *Kaiyo-maru* survey (the first half)

No.	St.	Date	Location		SST	Catch						
			Lat.	Long.	(°C)	Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Total
1	A-5-1	931015	4522.9 N	14714.4 E	11.5			84			1	85
2	A-5-2	931015	4609.3 N	14623.0 E	11.7		3	203	2		8	216
3	A-5-3	931016	4655.6 N	14539.2 E	8.9		126	413			4	543
4	A-5-4	931016	4730.3 N	14434.5 E	7.9		20	203				223
5	A-4-5	931017	4903.9 N	14538.2 E	5.5		37	37			2	76
6	A-4-4	931017	4822.9 N	14638.4 E	8.9		710	815			3	1528
7	A-4-3	931018	4734.1 N	14719.2 E	8.7		49	390	2		5	446
8	A-4-2	931018	4652.3 N	14819.9 E	10.4		20	1067			5	1092
9	A-4-1	931019	4608.2 N	14920.0 E	7.4		16	70				86
10	A-3-1	931019	4655.9 N	15105.4 E	7.1		34	148				182
11	A-3-2	931020	4741.8 N	15016.1 E	8.5	4	45	338	2			389
12	A-3-3	931020	4828.3 N	14919.9 E	7.0		122	385			2	509
13	A-3-4	931021	4919.3 N	14814.0 E	7.6		187	722			2	911
14	A-3-5	931021	4957.6 N	14713.4 E	5.2		13	31			1	45
15	A-2-4	931022	4958.3 N	15006.5 E	6.5		266	517				783
16	A-2-3	931022	4935.6 N	15039.3 E	7.8		462	1201				1663
17	A-2-2	931023	4844.7 N	15137.7 E	7.2		188	573	1			762
18	A-2-1	931023	4805.4 N	15236.6 E	6.8	8	168	208	2			386
19	A-1-1	931024	4919.3 N	15351.9 E	6.8	2	7	50	14			73
20	A-1-2	931026	4955.1 N	15307.8 E	5.8	3	7	95				105
21	A-6-1	931027	4839.4 N	15443.1 E	4.3				14			14
22	A-6-2	931027	4805.2 N	15524.8 E	6.3				1	2		3
23	A-6-3	931028	4728.9 N	15608.8 E	7.8				7	1		8
24	A-7-3	931029	4556.8 N	15515.5 E	9.3				2			2
25	A-7-2	931030	4640.6 N	15422.1 E	5.8	1						1
26	A-7-1	931030	4725.3 N	15327.4 E	5.9				3			3
27	A-8-1	931031	4625.5 N	15142.5 E	5.9		13	8				21
28	A-8-2	931101	4542.9 N	15249.6 E	7.4							0
29	A-8-3	931101	4459.2 N	15321.3 E	7.5							0
30	A-9-2	931102	4437.0 N	15047.5 E	7.1							0
31	A-9-1	931102	4524.7 N	15003.2 E	8.1			5				5
Total						18	2493	7563	50	3	33	10160

Table 1-2. Numbers of juvenile salmon caught by the surface trawl during the 1995 *Kaiyo-maru* survey (the second half)

No.	St.	Date	Location		SST (°C)	Catch						
			Lat.	Long.		Sock-eye	Chum	Pink	Coho	Chi-nook	Masu	Total
1	B-5-1	931108	4524.0 N	14718.4 E	9.1		12	485	2		4	503
2	B-5-2	931108	4608.0 N	14632.4 E	8.9		136	1799			5	1940
3	B-5-3	931109	4652.3 N	14536.6 E	4.5		1	204			1	206
4	B-5-4	931109	4729.0 N	14441.2 E	4.4			1			1	2
5	B-4-5	931110	4903.0 N	14540.5 E	3.7			13			2	15
6	B-4-4	931110	4820.9 N	14630.9 E	5.6		60	2497				2557
7	B-4-3	931110	4737.5 N	14719.5 E	4.7		171	1489				1660
8	B-4-2	931111	4654.0 N	14830.9 E	5.9		49	2284				2333
9	B-4-1	931111	4612.1 N	14905.6 E	5.3		296	950				1246
10	B-3-1	931112	4657.5 N	15115.8 E	3.8		68	1224				1292
11	B-3-2	931112	4744.5 N	15012.4 E	5.1		21	219				240
12	B-3-3	931112	4825.2 N	14942.0 E	4.2			5				5
13	B-3-4	931113	4917.3 N	14813.5 E	3.7						1	1
14	B-3-5	931113	4958.6 N	14712.2 E	3.2						1	1
15	B-2-4	931114	5000.5 N	15007.0 E	3.1						1	1
16	B-2-3	931115	4922.9 N	15031.7 E	4.2			4				4
17	B-2-2	931116	4844.7 N	15145.4 E	4.8			1				1
18	B-2-1	931116	4806.9 N	15236.9 E	4.1	40	53	42		2		137
19	B-1-2	931117	4947.7 N	15322.9 E	3.9							0
20	B-1-1	931117	4920.0 N	15339.9 E	3.3							0
21	B-6-1	931118	4839.0 N	15438.0 E	3.4					2		2
22	B-6-2	931118	4807.0 N	15529.3 E	4.7					7		7
23	B-6-3	931119	4732.1 N	15605.9 E	3.4				1	14		15
24	B-7-3	931120	4552.8 N	15513.8 E	5.5					1		1
25	B-7-2	931121	4644.6 N	15420.0 E	5.1	3	16	16				35
26	B-7-1	931121	4717.4 N	15334.9 E	4.0							0
27	B-8-1	931123	4622.3 N	15124.2 E	3.7		257	179				436
28	B-8-2	931124	4544.3 N	15258.6 E	5.4	1	72	255				328
29	B-8-3	931124	4459.2 N	15328.6 E	4.8		286	879				1165
30	B-9-2	931125	4435.6 N	15035.0 E	5.8		29	168				197
31	B-9-1	931126	4525.5 N	15019.3 E	4.5							0
Total						44	1527	12714	3	26	16	14330

Table 2. Estimates of numbers of juvenile salmonids in the survey areas.

Catching efficiency	Month	Sockeye	Chum	Pink	Coho	Chinook	Masu
		Estimates of numbers by species in thousand fish					
1.0	First	355	51,073	155,454	1,598	16	696
	Second	850	30,552	264,485	58	426	336
0.5	First	710	102,145	310,908	3,196	32	1,391
	Second	1,701	61,103	528,971	117	851	1,119
0.3	First	1,183	170,242	518,180	5,327	54	2,319
	Second	2,835	101,839	881,618	194	1,419	1,119
Coefficient of variation							
	First %	48.7	27.7	20.9	38.3	100.0	27.3
	Second %	92.3	29.3	27.6	77.5	52.2	37.8

Table 3. The proportions (%) of the estimated numbers of the juvenile by the stratum (sub-region)

Species	month	The Sea of Okhotsk I (Central)	The Sea of Okhotsk II (Southern)	Pacific coasts of the Kurils III (Northern)	Pacific coasts of the Kurils IV (Southern)	Total
Chum	Oct.	42.1	57.4	0.0	0.5	100.0
	Nov.	3.4	56.2	0.8	39.6	100.0
Pink	Oct.	33.3	66.5	0.0	0.2	100.0
	Nov.	0.3	89.0	0.1	10.5	100.0