NPAFC
Doc. 267
Rev.

Distribution and biological characteristics of juvenile salmon in the Sea of Okhotsk in the early-summer of 1997

by

Yasuhiro Ueno

National Research Institute of Far Seas Fisheries, Japan

Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
by
JAPAN
October 1997

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Ueno, Y., 1997. Distribution and biological characteristics of juvenile salmon in the Sea of Okhotsk in the early-summer. (NPAFC Doc.267). National Research Institute of Far Seas Fisheries, 7-1, Orido 5-chome, Shimizu, Shizoka, 424, Japan. 18 p.

Distribution and biological characteristics of juvenile salmon in the Sea of Okhotsk in the early-summer of 1997

(Cruise report on the 1997 Research Vessel (R/V) Shunyo-maru juvenile salmon research)

Yasuhiro Ueno

(National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan)

Abstract

In order to describe the distribution and migration of juvenile salmon in the early summer, the surface trawl operations for juvenile salmon and oceanographic observations were conducted using the Research Vessel Shunyo-maru (396.85 gross tonnage). Forty-four trawl operations were conducted for collecting juvenile salmon from July 5 to August 4, 1997. Thirty-eight trawl operations of them were conducted in the central and southern Okhotsk Sea. Six trawl operations of them were carried out in the Pacific coasts of Hokkaido and the Kuril Islands. Juvenile chum were distributed in the southern part of the Okhotsk Sea. Especially, they were abundant in offshore waters near the coast of south eastern Sakhalin. Juvenile pink were also found in the southern part of the Okhotsk Sea. Juvenile pink were comparatively abundant in the Okhotsk coasts off the Kuril Islands. Abundance of juvenile pink was poor compared with abundance of juvenile chum. Juvenile masu were also found in the southwestern part of the Okhotsk Sea. In waters north of 50 ° N, no juvenile salmon were collected. However, juvenile Dolly Varden were comparatively abundant in waters off the southwestern Kamchatka Peninsula. I considered that the juvenile salmon collected in this survey were on the way from coastal waters to offshore waters of the Okhotsk Sea. The SST range of juvenile salmon distribution was from 13.1 ℃ to 7.4℃. There are some possibilities that the development of the surface mixing layer facilitated juvenile salmon to move from coastal waters to offshore waters, because the depths of the surface mixing layers at the sites where salmon were caught were often developed to more than 20 m. It is considered that a considerable number of juvenile salmon were still staying in coastal waters that could not be surveyed. Accordingly this season (July to early August) is considered to be too early for estimating stock abundance of juvenile salmon in offshore waters.

Introduction

The Sea of Okhotsk (the Okhotsk Sea) is considered to be a main nursery area for Asian juvenile salmon (for example, Birman, 1969). It is well-known that many juvenile salmon are distributed in the central and southern Okhotsk sea from summer to autumn (Birman, 1969; Shimazaki, 1977; Shuntov, 1989; Shuntov et al., 1995; Lapko and Startev, 1996; Ueno and Ishida, 1996). Juvenile salmon is thought to be migrate offshore waters of the Okhotsk Sea in the early summer because juvenile salmon is generally considered to leave coastal waters to offshore waters in the early summer (for example, Irie,1990). In order to exactly describe the distribution of juvenile salmon in early summer, I conducted the surface trawl operations for juvenile salmon and oceanographic observations in the Okhotsk Sea and the Pacific coasts off the Kuril Islands and Hokkaido. Based on the CPUE distribution and fork length frequencies of juvenile salmon, I discussed about the migration routes of juvenile salmon. I also examined the relationships between sea surface temperatures and distributions of juvenile salmon. Moreover, I examined the possibility that stock abundance of juvenile salmon can be estimated in the Okhotsk Sea in the early summer.

The goal of this research is to establish method for estimating stock abundance of juvenile salmon based on the exact information on distribution and migration of juvenile salmon.

Materials and methods

Oceanographic observation: CTD observations (0-500 m) were conducted at all trawl research stations. Vertical distributions of water temperature were composed along some research lines.

Fishing gear: A large surface rope trawl was used for sampling juvenile salmon. This trawl was designed to be identical to the rope trawl and has a pair of trawl doors (made by NICHIMO CO., LTD). The horizontal opening of the trawl at the mouth was about 30m and the vertical opening was about 30m. The trawl was 86.3 m long and has 1.7 cm mesh liner in the codend. The trawl was towed for 60 minutes at about 5 knots.

Fishing operation: Research Vessel *Shunyo-maru* (396.85 gross tonnage, belonging to the National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan) was used for trawl operations. Forty-four trawl operations were conducted for collecting juvenile salmon from July 5 to August 4, 1997 (Table 1). All the operations were carried out at the sea surface. Thirty-eight trawl operations of them were conducted in the central and southern Okhotsk Sea. Six trawl operations of them were carried out in the Pacific waters off Hokkaido and the Kuril Islands.

Biological measurements: Folk lengths and body weights of juvenile salmon collected by the trawl were measured onboard. Scales of the juveniles were also taken for age determination. The juveniles were frozen and stored for additional examinations in laboratories on land.

Relationships between juvenile salmon distribution and oceanographic conditions: We compared vertical and horizontal distribution of sea waters temperatures with juvenile salmon distributions.

Results

Distribution of juvenile salmon: CPUE distribution of juvenile salmon and Dolly Varden are shown in Fig. 2. Juvenile chum were distributed in the southern part of the Okhotsk Sea. Especially, they were abundant in offshore waters near the coasts of south eastern Sakhalin. Juvenile pink was also found in the southern part of the Okhotsk Sea. Juvenile pink was comparatively abundant in the Okhotsk waters off the mid-Kuril Islands. Abundance of juvenile pink was poor compared with abundance of juvenile chum. Juvenile masu were found in the southwestern part of the Okhotsk Sea. In waters north of 50 ° N, no juvenile salmon were collected. However, juvenile Dolly Varden were comparatively abundant in waters off the southwestern the Kamchatka Peninsula.

Fork lengths of juvenile salmon (Fig. 3): Fork length frequencies of juvenile salmon and Dolly Varden were shown in Fig. 3. Fork lengths of juvenile chum ranged from 90 mm to 230 mm with a mean of 142 mm. Fork lengths of juvenile chum of the western part were larger than those of the juveniles of the eastern part (Fig.4). This difference of the fork lengths is considered to reflect the difference at the time of emergence of juvenile chum in the two parts. The main body of juvenile chum in the eastern part was less than 120 mm in fork length.

Fork lengths of juvenile pink were smaller than those of juvenile chum and they ranged from 80 mm to 140 mm with a mean of 108mm. The range of fork lengths of juvenile masu was comparatively large and they ranged from 180 mm to 290 mm with a mean of 204 mm. The range of juvenile Dolly Varden was from 180 mm to 290 mm and the mean was 226 mm.

Relationship between CPUE of juvenile salmon and sea water temperature: I showed the relationship between CPUE of juvenile salmon and the surface sea temperature (SST, Fig. 5).

These suggest that the SST range of juvenile salmon distribution was between 13.1 ℃ and 7.4℃. The SST range for juvenile chum was between 11.8 ℃ and 7.4 ℃, the range for juvenile pink between 13.1 ℃ and 9.0 ℃, and the range for juvenile masu between 13.1 ℃ and 7.4 ℃. The serious differences of SST ranges among species of juvenile salmon were not found.

I showed CPUE distribution of juvenile chum on the chart of surface sea temperature distribution (the left hand of Fig.6). The surface sea temperatures (SST) distribution chart was cited from the oceanographic and fisheries chart of waters off the Kamchatka Peninsula No.23, 1997 and oceanographic and fisheries chart of waters off eastern Hokkaido and Kuril Islands No.23, 1977 (Japan Fisheries Information Service Center. 1997A and B.). Fig. 5 showed that juvenile chum were distributed in waters of both sides of 10℃ isotherm line in the southern Okhotsk Sea. I also showed relationship between CPUE distribution of juvenile chum and vertical distribution of the sea water temperatures (the right hand of Fig. 6). The sites that juvenile salmon were found often coincided with the sites that the surface mixing reached from the surface to 20 m or deeper layers.

By-catch species: I listed names, total numbers, and total weights of organisms collected in the 1997 Shunyo-maru juvenile salmon research (Table 2). CPUE distributions of mature and immature salmon were given in Appendix Fig. 1. CPUE of mature pink was very abundant in waters from 47° N to 50° N of the Okhotsk Sea. CPUE distributions of main by-catch species were shown in Appendix Fig. 2. Greenlings (*Pleurogrammus azonus*) were very abundant in the southern part of the Okhotsk Sea. They are mainly found in waters south of distribution of juvenile salmon.

Discussion

Distribution and migration of juvenile salmon: This survey showed that juvenile salmon were distributed in southern part of the Okhotsk Sea in the early summer. Especially, there was abundant distribution of juvenile salmon in waters near the coast [1]. These waters are directly connected with coastal waters of Hokkaido, Sakhalin, and the Kuril Islands (See Fig. 2). It is well-known that juvenile salmon are staying within coastal waters in their early ocean life (for example, Harrt and Dell, 1976; Irie, 1991). Accordingly, I considered that the juvenile salmon collected in this survey were on the way from coastal waters of these areas to offshore waters of get the Okhotsk Sea.

Ueno and Sakai (1997) reported that juvenile salmon were mainly found in the central part of the Okhotsk Sea and hardly found in the southern part in the early autumn. The results of them and the present survey suggest that juvenile salmon migrate northwards from the southern part of the Okhotsk Sea to the central part in the summer. I showed the schematic diagram of juvenile salmon migration based on these results (Fig. 7).

Biological characteristics of juvenile salmon: Juvenile salmon collected in this survey were considered to be on the way from coastal waters to offshore waters. Accordingly, the fork length of juvenile salmon collected in this survey must be corresponding with the fork length when juvenile salmon migrate from coastal waters to offshore waters. These fork lengths were estimated to be 142 mm in average for juvenile chum, 108 mm for juvenile pink, and 204 for juvenile masu.

Relationship between juvenile distribution and sea water temperatures: It is not clear what oceanographic conditions affect or facilitate migration from coastal waters to offshore waters of juvenile salmon. The sites that juvenile salmon were collected in this survey often coincided with

[1] We could not get the permission to enter the Russian territorial waters (12 mile zone) for this survey. Accordingly, this "waters near the coast" means the coastal waters outside the territorial waters.

the sites that the surface mixing layers reached a thickness from the surface to 20 m or more layer. Accordingly, this suggests that the development of surface mixing layer may facilitate juvenile salmon to move from coastal waters to offshore waters. SST range where juvenile salmon were abundant in this survey is not so much different from SST range suitable for salmon reported in the previous papers (Irie, 1991; Neave et al., 1976; Takagi et al., 1982; Kato, 1991) .

Estimation of stock abundance: The goal of this survey is to establish the method for estimating stock abundance of juvenile salmon. When estimating the abundance of juvenile salmon, it is necessary that juvenile gather in a small specific area suitable for estimating the abundance of them.

The results of this survey showed that distribution of juvenile chum was abundant in waters near the coasts. Moreover, numbers of juvenile collected in this survey were not so many compared with the results of the previous research conducted in the autumn (for example, Ueno et al., 1994). It is reported that some juvenile salmon were still found northern Hokkaido in the early summer (Irie, 1990; Ueno and Ishida, 1996). Thus, I guess that considerable numbers of juvenile salmon are still staying in near coast water. Because the 12 mile zone of the near coast waters belongs to Russian territorial waters, Japanese research vessel can not conduct scientific survey there. Accordingly, I considered that this season (the early summer) is too early to estimate stock abundance of juvenile salmon.

Distribution patterns of pelagic organisms: The results of trawl operations showed that some specific organisms exclusively occupied the survey areas in the Okhotsk Sea. In most northern part of the survey areas (north of 50° N), Dolly Varden and Pacific herring (*Clupea pallasii*) were dominant species. Mature pink salmon dominated the waters south of the above area. In the more southern waters, juvenile salmon were abundant. Juvenile greenlings (*Pureurogrammus azounus*) were dominant in the most southern part. These sharing are considered to be related to the environmental factors (for example SST) and ecological factors. It is reported that mature pink salmon fed a juvenile chum in the Okhotsk Sea (Ueno et al., 1992). There are some possibilities that juvenile salmon might be staying the southern area in this season in order to avoid encountering mature pink.

Acknowledgments

I wish to thank the Captain Hajime Shimojima and the crew of the R/V Shunyo-maru. I would also like to express thanks to the staff of the Fisheries Agency of Japan for their kind assistance. We also thank the Russian researchers, Velyaev Vladimir Alexeevich (TINRO), and Kovalenko Sergei Alexandrovich (SakhNIRO) for their kind cooperation onboard research vessels.

Reference

Birman, I. B. 1969: Distribution and growth of young Pacific salmon of the genus *Oncorhynchus* in the sea. J. Ichtyol. 9(5), 651-666.

Harrt, A. G. and M. B. Dell. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. Int. North Pacific. Fish. Comm. Bull. 46:1-105.

Irie T., 1990. Ecological studies on the migration of juvenile chum salmon, *Oncorhynchus keta*, during early ocean life. Bull. Seikai. Natl. Fish. Res. Inst., No.68. 1-142.

Japan Fisheries Information Service Center. 1997. Oceanographic and fisheries chart of waters off eastern Hokkaido and Kuril Islands No.23. Japan Fisheries Information Service Center. Ikenohata-nisshoku Building, 9-7, Ikenohata 2-chome, Daitoh-ku. Tokyo.

Japan Fisheries Information Service Center. 1997A. Oceanographic and fisheries chart of waters off the Kamchatka Peninsula No.23. Japan Fisheries Information Service Center. Ikenohata- nisshoku Building, 9-7, Ikenohata 2-chome, Daitoh-ku. Tokyo.

Japan Fisheries Information Service Center. 1997B. Oceanographic and fisheries chart of waters off eastern Hokkaido and Kuril Islands No.23. Japan Fisheries Information Service Center. Ikenohata-nisshoku Building, 9-7, Ikenohata 2-chome, Daitoh-ku. Tokyo.

Kato, F. 1991. Life history of masu and amago salmon (*Oncorhynchus masou* and *Oncorhynchus rhodurus*), p. 447-520. In C. Groot and L. Margolis [ed.] Pacific salmon life histories. UBC Press, Vancouver.

Lapko, V. V. and A. V. Startsev. 1996. New data on the marine life of the young masu salmon *Oncorhynchus masou* in the Sea of Okhotsk. Russian Journal of Marine Biology. 22(3). 151-154.

Machidori, S. and Kato, F. 1984. Spawning populations and marine life of masu salmon (*Oncorhynchus masou*). International North Pacific Fisheries Commission Bulletin, 43, 1-138.

Neave F., T. Yonemori, and R. G. Bakkala, 1976. Distribution and origin of chum salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 35:1-79.

Shimazaki, K. 1977. Ohotsuku-kai ni okeru sakezoku yougyo (Genus *Oncorhynchus*) no bunpu tokusei ni kansuru kenkyu. (Studies on ecology of juvenuiles salmonids in offshore waters of the Sea of Okhotsk). Ph. D. thesis, Univ. Hokkaido, Hakodate, Hokkaido. 224p. (In Japanese).

Shuntov, V. P., 1989. Distribution of juvenile Pacific salmon, *Oncorhynchus*, in the Okhotsk Sea and adjoininig Pacific waters. J. Icthyol. 29(2):155-164.

Shuntov, V. P., V.V. Lapko, A. A. Balanov, and A. V. Startsev. 1995. Interannual changes in anadromous migrations of salmon in the Sakhalin-Kuril region. Russian Journal of Marine Biology. 21(2) 97-105.

Ueno, Y., I., Shmizu., and O.Shubin. 1992. 1992-nen no Wakashio-maru ni yoru Nichi-ro kyodo sakemasu chosa. (Cruise report on the 1992 R/V Wakashio-maru Japanese-Russian cooperative salmon research). Salmon Report Series, 36: 45-52. National Research Institute of Far Seas Fisheries. 424, 7-1, Orido 5-chome, Shimizu, SHIZUOKA, JAPAN.

Ueno, Y. and T., Azuma, M. Ogura, J. Seki, I. Shimizu, Y., Kawasaki, and T. Kono. 1994. Summary of Japan-Russia-Canada cooperative juvenile salmon research aboard the Research vessel *Kaiyo-maru* in 1993. 19p. (NPAFC Doc.75). National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, Shimizu, Shizuoka 424, Japan. 16p.

Ueno, Y. and Y. Ishida 1996. Summer distribution and migration routes of juvenile chum salmon (*Oncorhynchus keta*) originating from rivers in Japan. Bull. Nat. Res. Far. Seas. Fish., 33. 139-147.

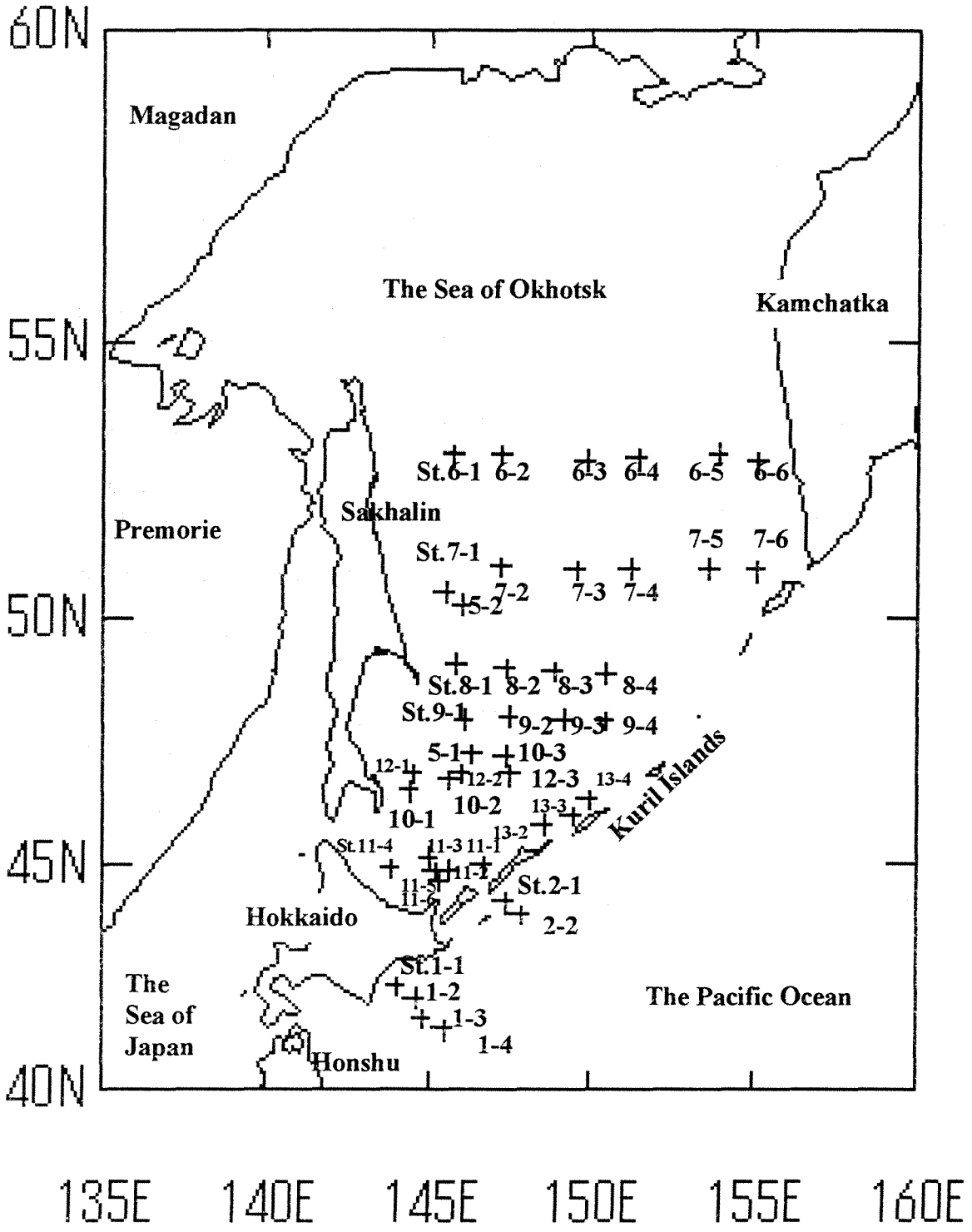


Fig. 1. Distribution of the sampling stations in the 1997 shunyo-maru juvenile salmon research.

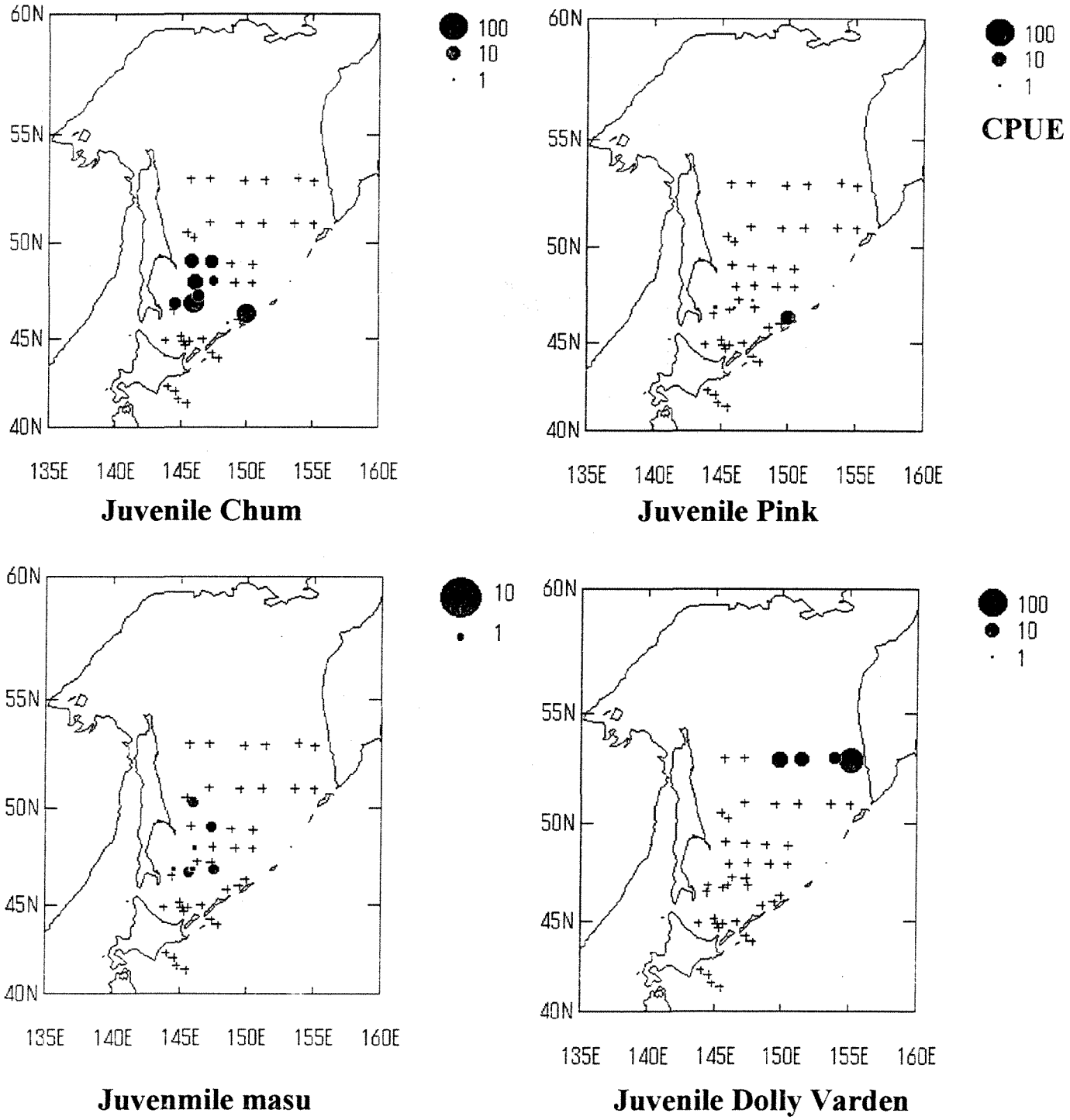


Fig. 2. CPUE distribution of juvenile salmon. CPUE is the number of juveniles caught per 60 min towing

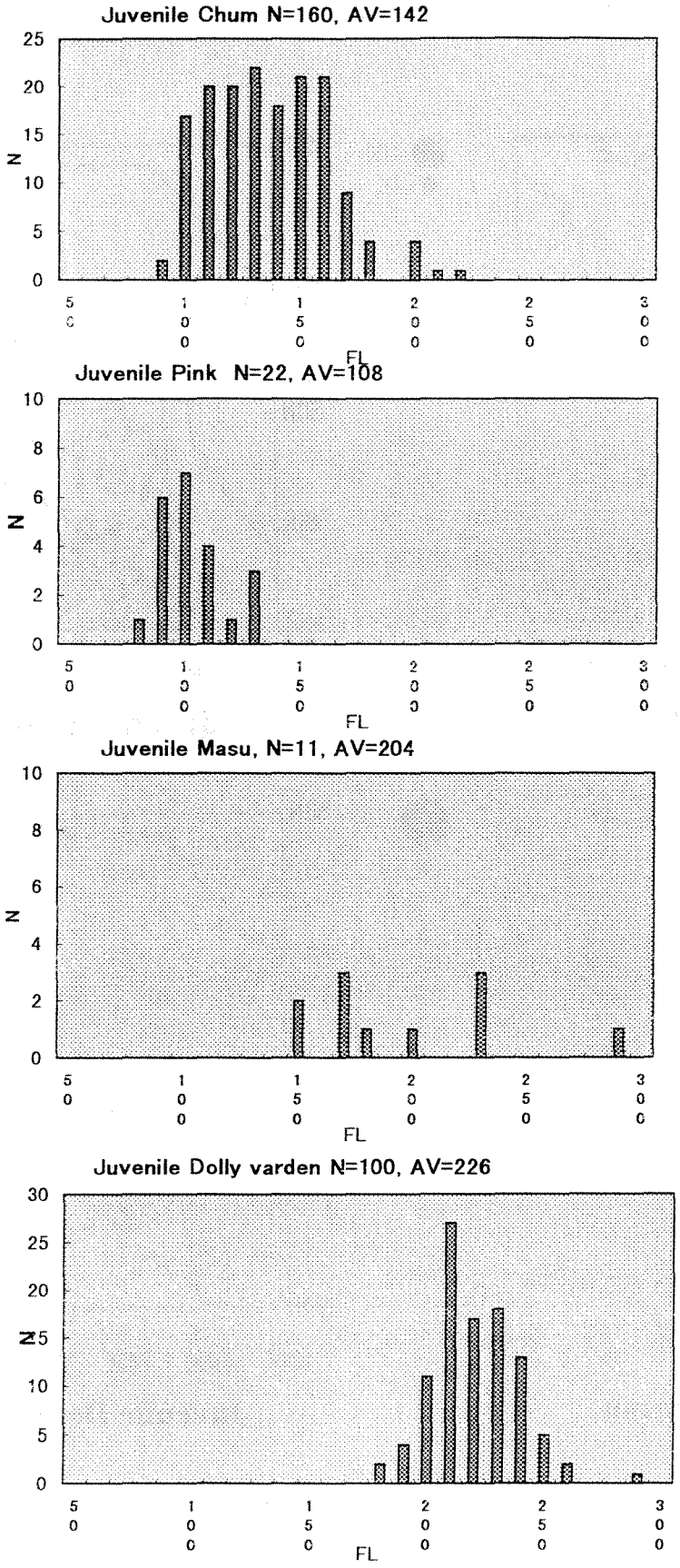


Fig. 3. Fork length frequency of juvenile salmon.

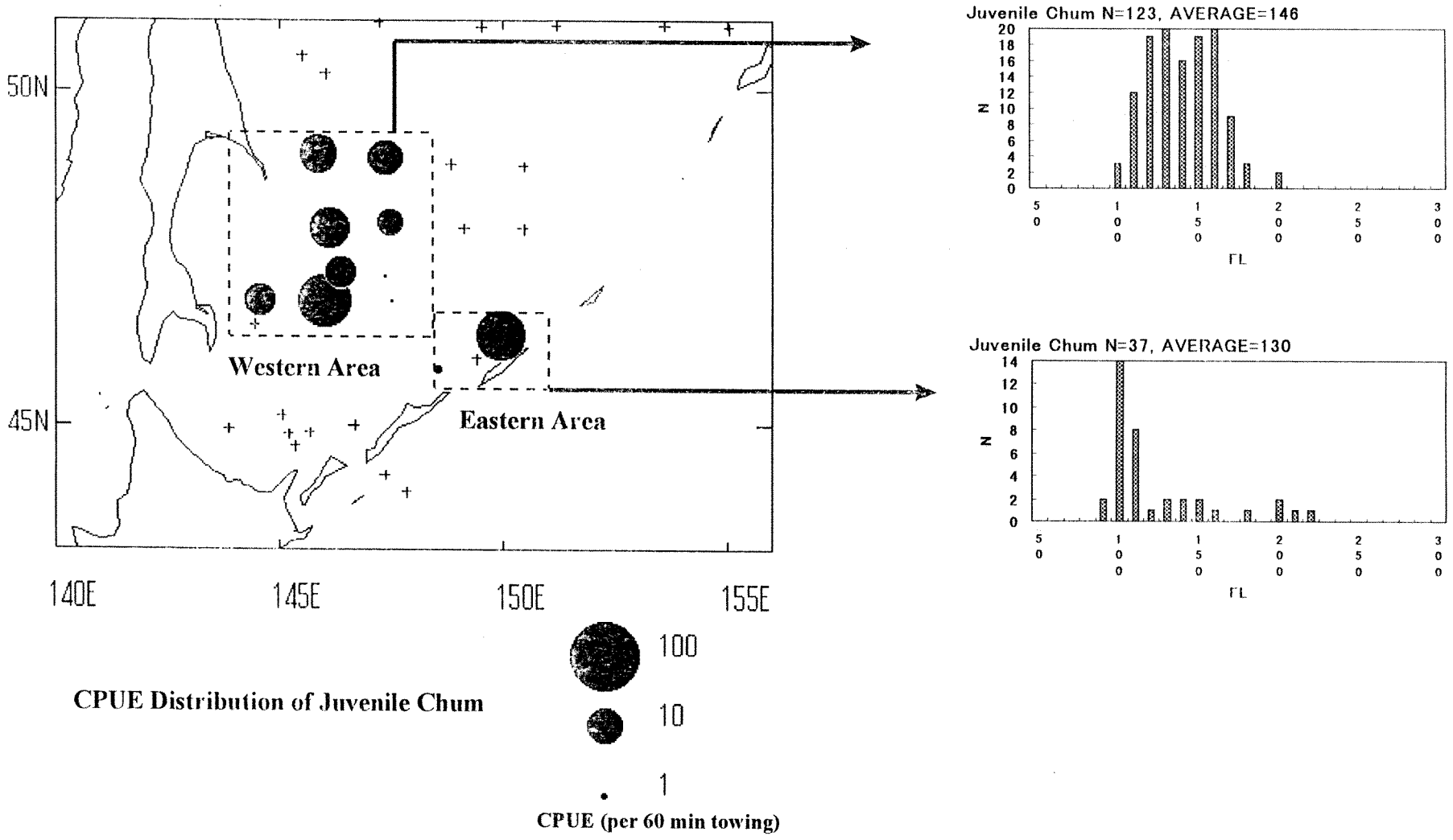


Fig. 4. Defference of fork length frequencies of juvenile chum between the western area and the eastern area.

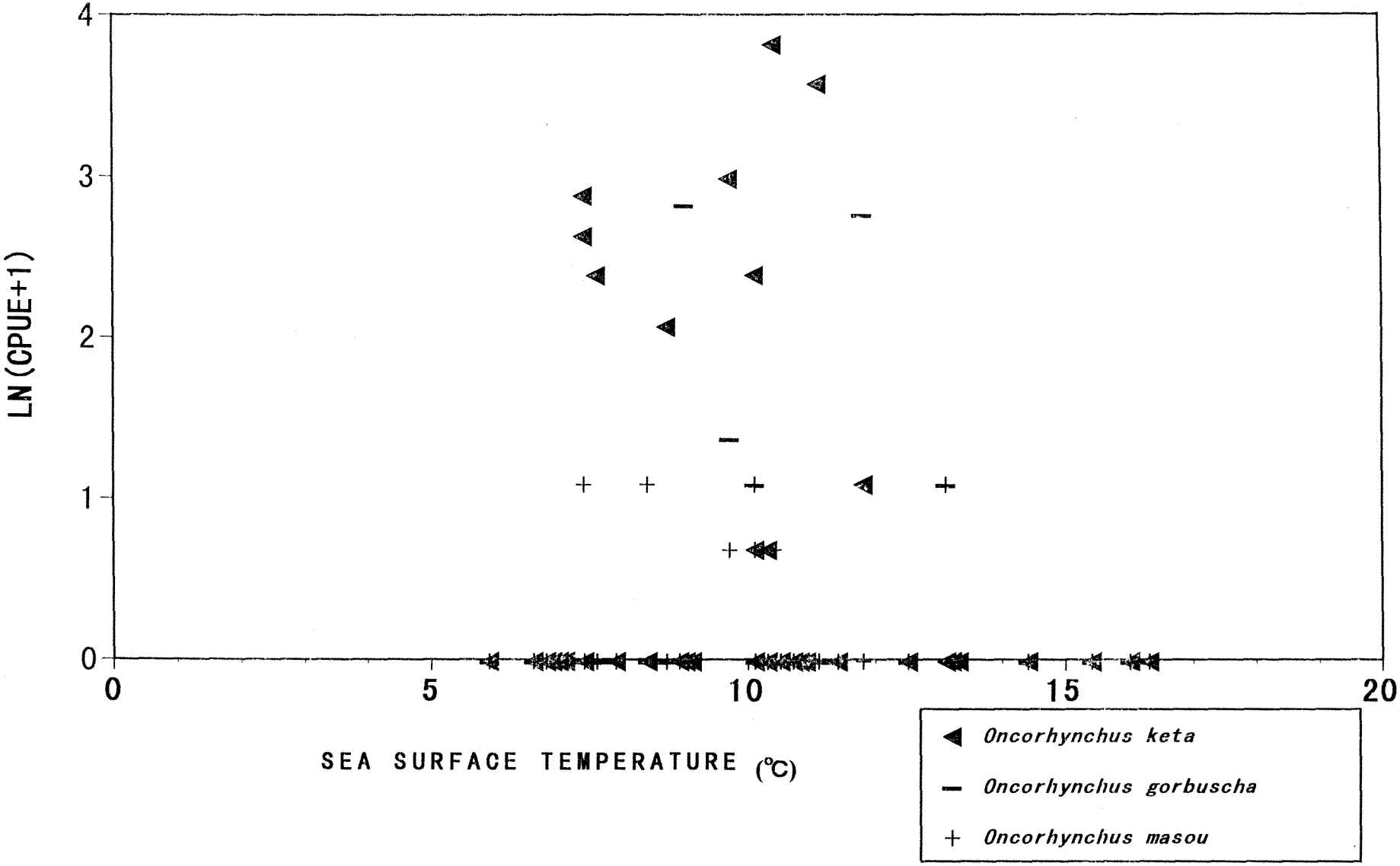


Fig. 5. Relationship between CPUE of juvenile salmon and the surface sea temperature.

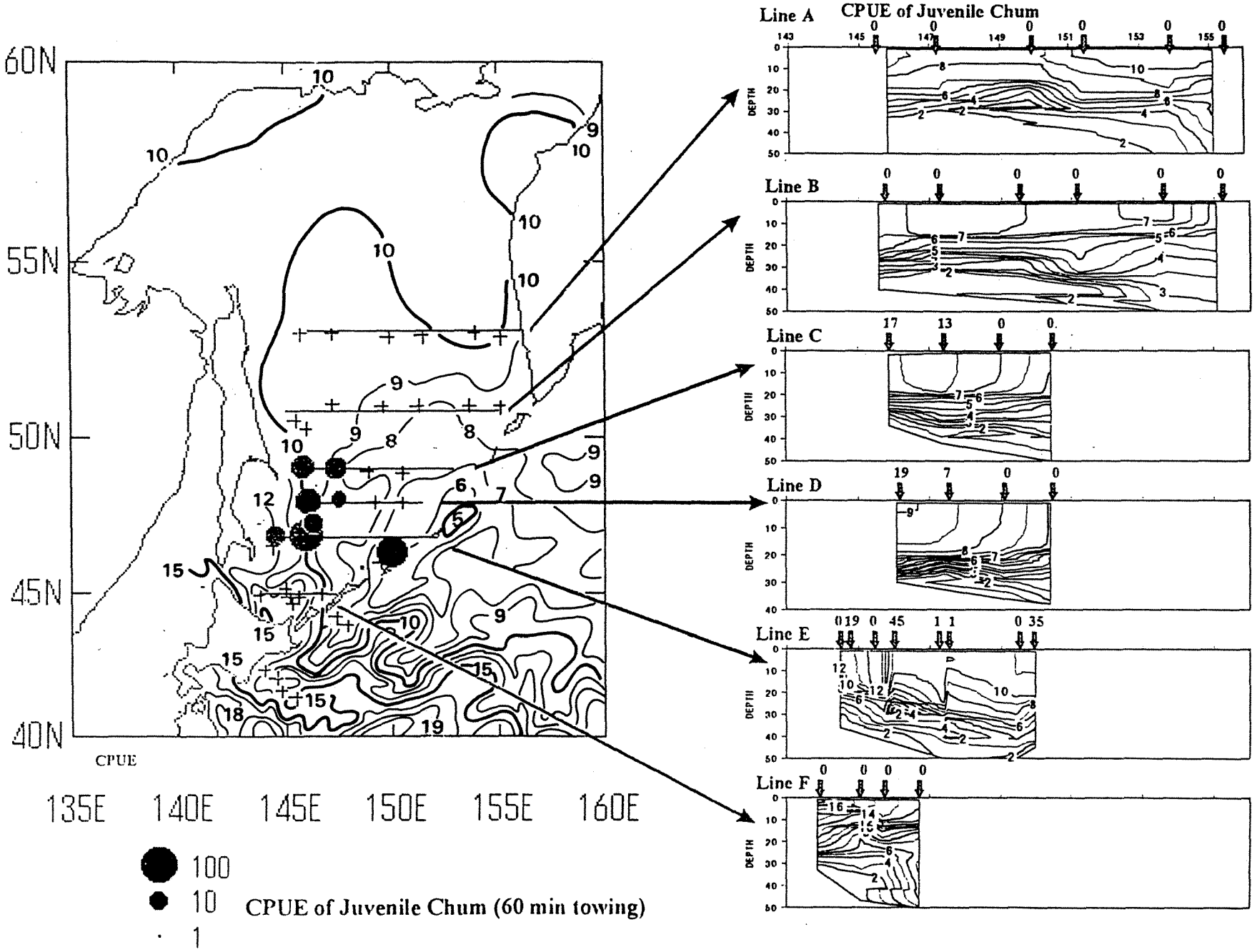


Fig. 6. Relationships between CPUE distribution of juvenile chum and horizontal/vertical distibutions of sea water temperatures.

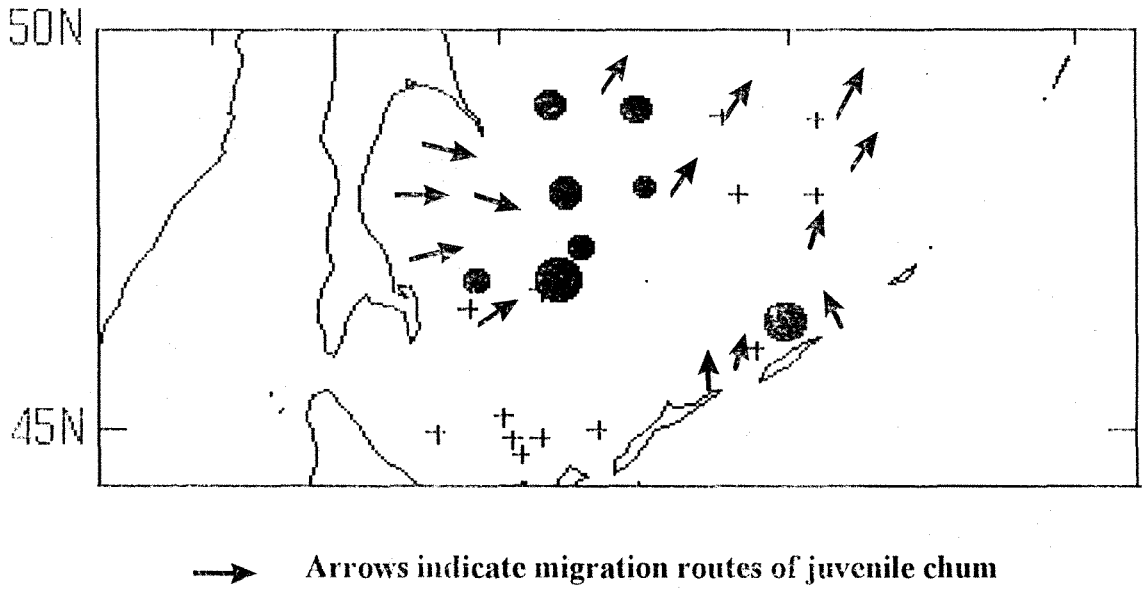


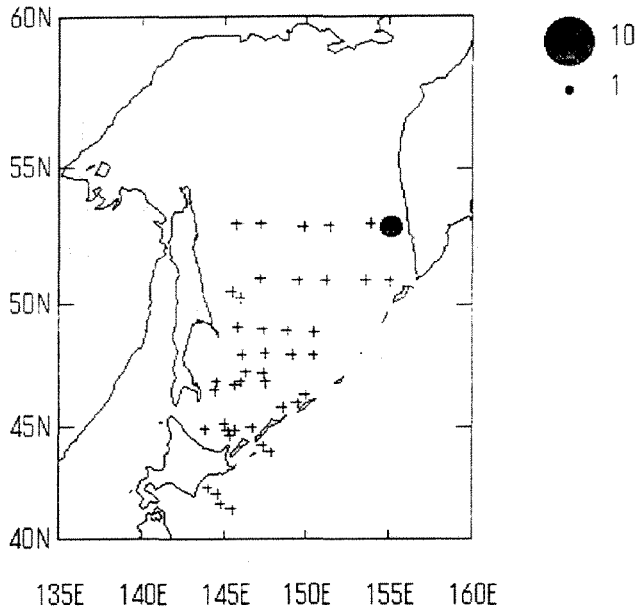
Fig. 7 Schimatic migration routes of juvenile chum in the southern Okhotsk Sea.

Table 1. Location and date of the trawl operations and numbers of salmon caught in the 1997 Shunyo-maru juvenile salmon research.

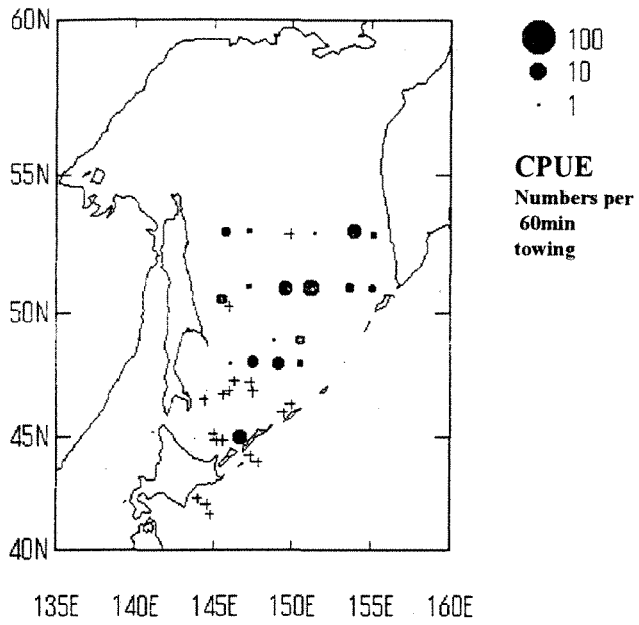
ST	DATE	LOCATION				Time	SST	Juvenile				Mature or immature			
		LAT (N)		LONG (E)			(℃)	chum	pink	masu	dolly Varden	sock	chum	pink	chinook
ST1-4	970705	41	23.9	145	30.7	6:55	10.8							1	
ST1-3	970705	41	39.5	144	51.5	14:28	10.9								
ST1-2	970706	42	6.2	144	37.6	6:43	8.9								
ST1-1	970706	42	23.3	144	4.2	14:52	11.4								
ST5-1	970708	47	19.6	146	21.3	7:19	7.6	10						19	
ST5-2	970709	50	14.9	146	1.5	6:39	8.4			2			5	24	
ST6-1	970710	53	0.2	145	45.5	6:43	9.1						3	6	
ST6-2	970710	53	1.4	147	14.7	14:41	9.0							10	
ST6-3	970711	52	55.4	149	49.5	6:42	8.9				18		2	14	
ST6-4	970711	52	56.7	151	23.3	15:07	10.1				16		10	8	
ST6-5	970712	53	2.9	153	52.3	6:40	10.7				10		3	4	
ST6-6	970712	52	53.5	155	5.8	13:15	10.3				90	3	4	5	
ST7-6	970713	50	53.7	155	3.2	6:36	5.9						5	44	
ST7-5	970713	50	55.7	153	36.6	14:37	7.1						12	9	
ST7-4	970714	50	56.2	151	12.1	6:35	6.8						9	45	
ST7-3	970714	50	54.5	149	32.5	15:08	7.0						3	3	2
ST7-2	970715	50	58.1	147	14.4	6:42	7.4						6	5	
ST7-1	970715	50	30.4	145	30.5	15:33	6.6						1	4	
ST8-1	970716	49	5.6	145	51.4	6:37	7.4	17					1	33	
ST8-2	970716	49	1.6	147	22.0	15:24	7.4	13		2			2	178	
ST8-3	970717	48	56.6	148	50.6	6:37	7.1						5	50	
ST8-4	970717	48	54.8	150	28.2	14:53	5.9						3	107	
ST9-4	970718	47	59.1	150	27.3	6:37	6.9						8	196	1
ST9-3	970718	47	59.6	149	8.6	14:34	7.9						7	68	
ST9-2	970719	48	4.4	147	29.0	6:35	8.7	7					2	154	
ST9-1	970719	47	59.9	146	6.9	14:06	9.7	19		1			1	94	
ST12-1	970720	46	54.8	144	33.6	6:37	10.1	10	3	1				32	
ST12-2	970720	46	54.4	146	0.2	14:48	10.4	45	2	1				59	
ST12-3	970721	46	53.9	147	31.3	6:45	10.1	1		2			1	96	
ST11-4	970725	44	56.3	143	52.4	6:34	16.3							1	
ST11-3	970725	45	9.6	145	3.3	14:11	16.0								
ST11-5	970726	44	52.0	145	12.4	6:37	13.2						1		
ST11-6	970726	44	40.5	145	20.6	10:22	13.3							2	
ST11-1	970728	44	53.7	145	40.8	6:38	15.4						10	1	
ST11-2	970728	45	0.3	146	40.7	12:55	14.4							3	
ST10-1	970729	46	33.1	144	26.7	6:37	12.5							26	
ST10-2	970729	46	46.7	145	41.1	14:40	13.1			2				25	
ST10-3	970730	47	16.2	147	22.1	6:37	10.3	1	2				1	36	3
ST13-2	970802	45	51.1	148	33.4	13:28	11.8	2						4	
ST13-4	970803	46	22.4	149	56.0	6:18	11.1	35	15					9	
ST13-3	970803	46	1.9	149	24.9	12:08	10.8							26	
ST2-1	970804	44	12.8	147	22.0	6:29	10.5								
ST2-2	970804	43	57.1	147	51.1	11:43	9.0							16	
Total								160	22	11	134	3	105	1417	6

Table 2. List of organisms collected in the 1997 Shunyo-maru juvenile salmon research.

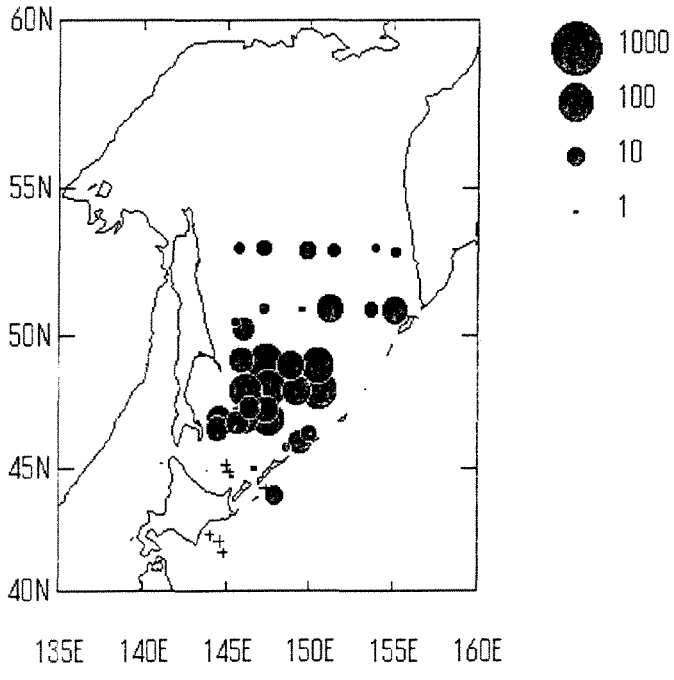
Species	Numbers of individuals collected	Total weight
SCYPHOZOA (Medusa)	-	392.9
EUPHAUSIACEA (Krill)	-	27.4
Todarodes pacificus	8	0.7
Gonatus spp.	908	3.8
Lampetra japonica	12	0.1
Salvelinus malma	134	23.5
Oncorhynchus nerka (Juvenile)	0	-
Oncorhynchus keta (Juveniele)	160	4.7
Oncorhynchus gorbuscha (Juvenile)	22	0.1
Oncorhynchus masou (Juvenile)	11	0.9
Oncorhynchus nerka (Mature/immature)	3	6.9
Oncorhynchus keta (Mature/immature)	105	243.3
Oncorhynchus masou (Mature)	1417	1874.1
Oncorhynchus tshawytscha	6	22.7
Anotopterus pharao	1	2.1
Myctophidae	1	-
Clupea pallasii	3284	752.2
Engraulis. japonicus	801	25.2
Zaprora silenus	2	0.7
Eumicrotremus taranetzi	143	1.1
Eumirotremus barbatus	1	-
Anarhichas orientalis	63	0.8
Ammodytes personatus	41	0.1
Aptocyclus ventricosus	10	5.4
Theragra chalcogramma	11	2.7
Eleginus gracilis	1	-
Pleurogrammus azonus	17661	254.9
Hemilepidotus gilberti	47	-
Hemitripterus villosus	6	-
Blepsias bilobus	3	-
Limanda aspera	14	7.5
Sebastes taczanowskii	8	0.7
Sebastes steindachneri	1	1.4
Phocoenoides dalli	1	-



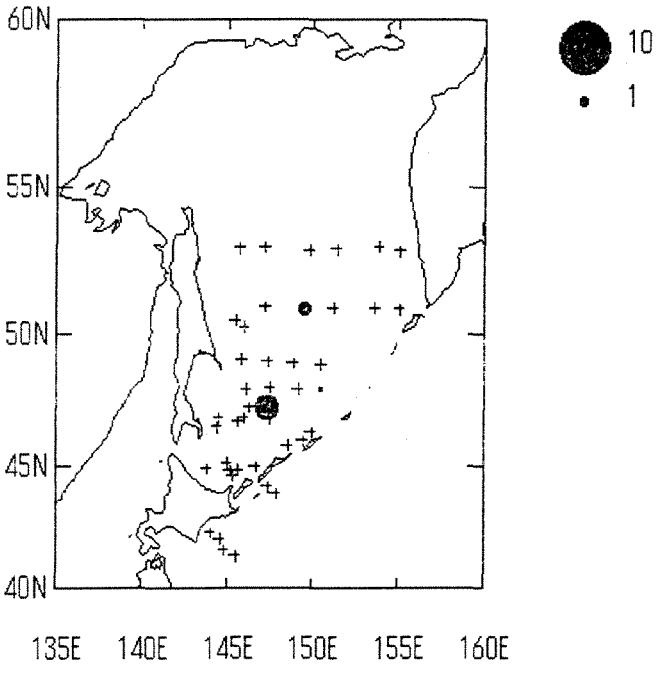
Mature/immature sockeye



Mature/immature Chum

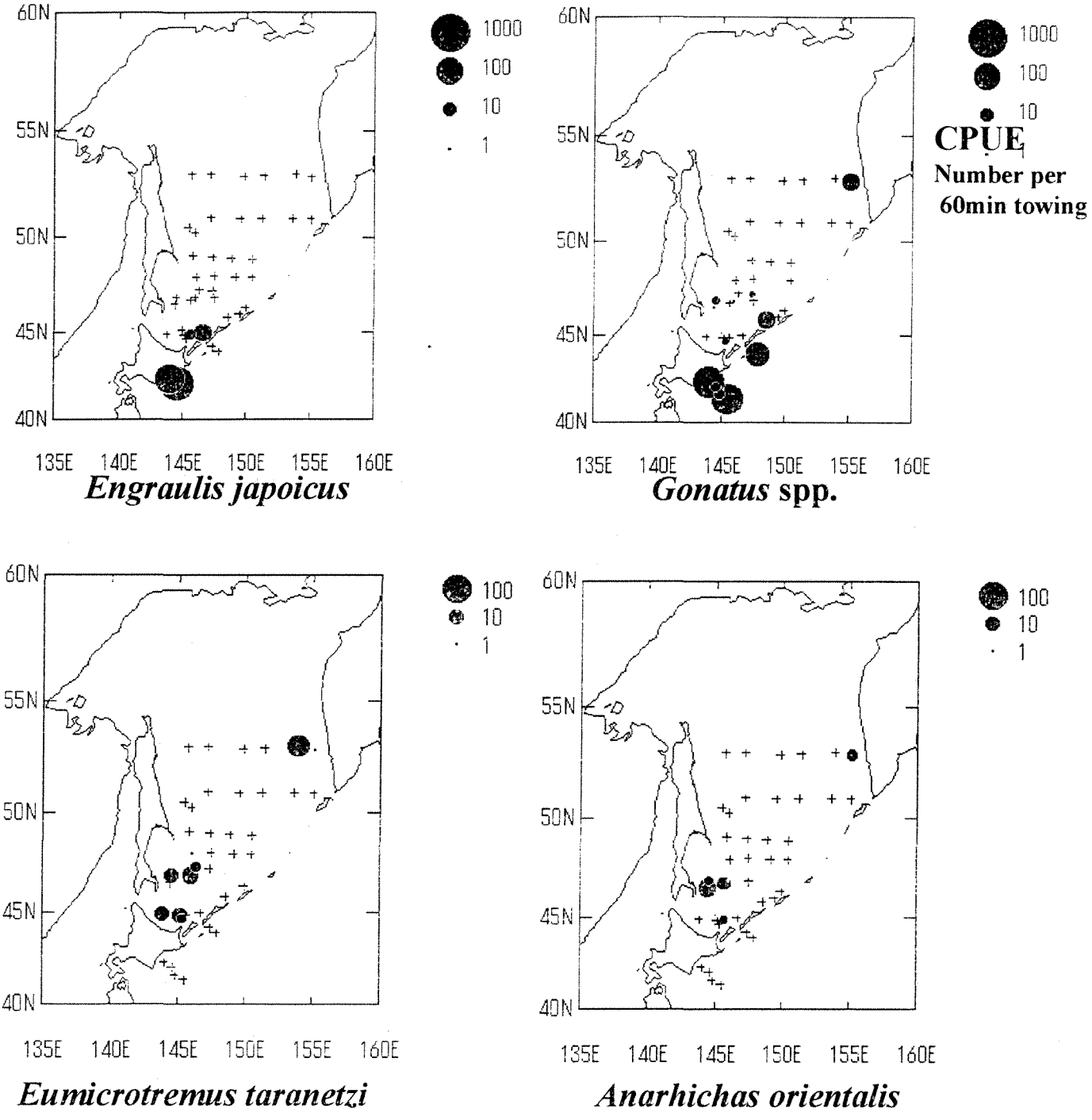


Mature/immature Pink

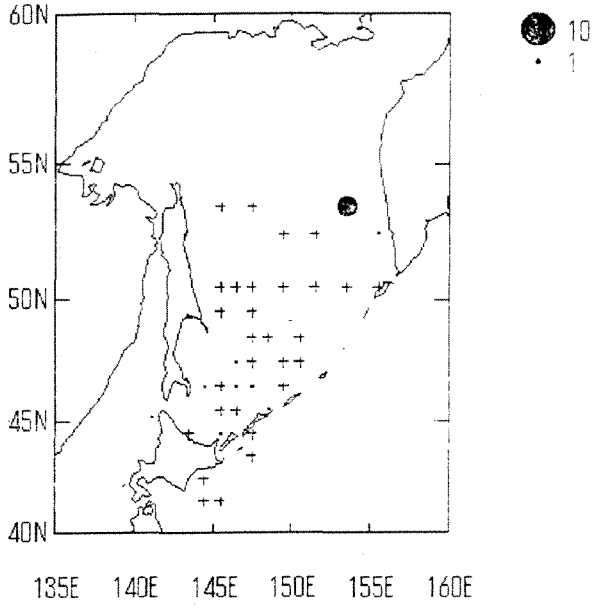


Mature/immature Chinook

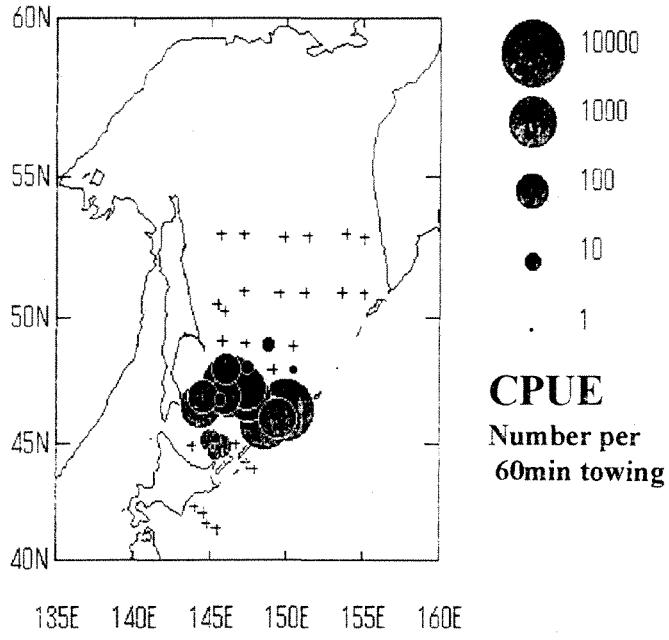
Appendix Fig. 1 CPUE Distribution of mature and immature salmon in the 1997 Shunyo-maru juvenule salmon research.



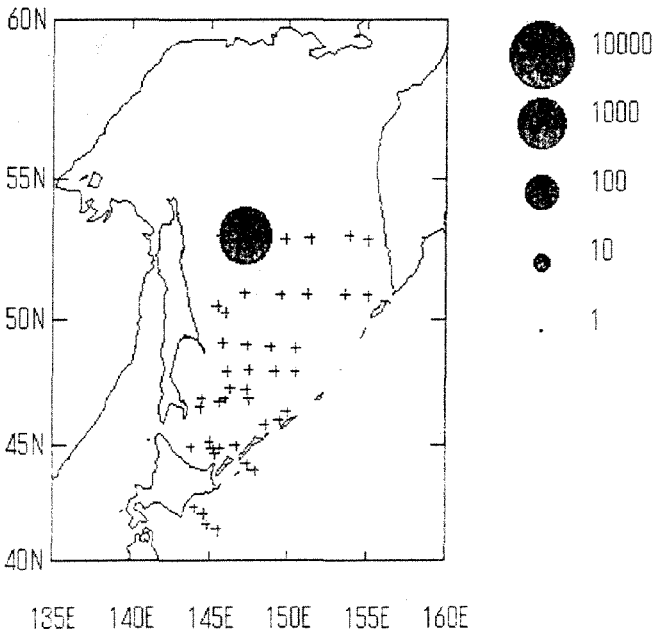
Appendix Fig.2-1. CPUE distribution of major by-catch species.



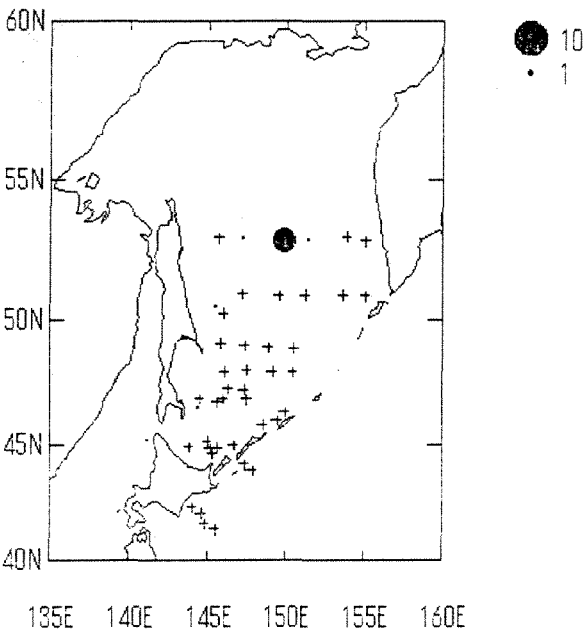
Lampetra japonica



Pleurogrammus azonus

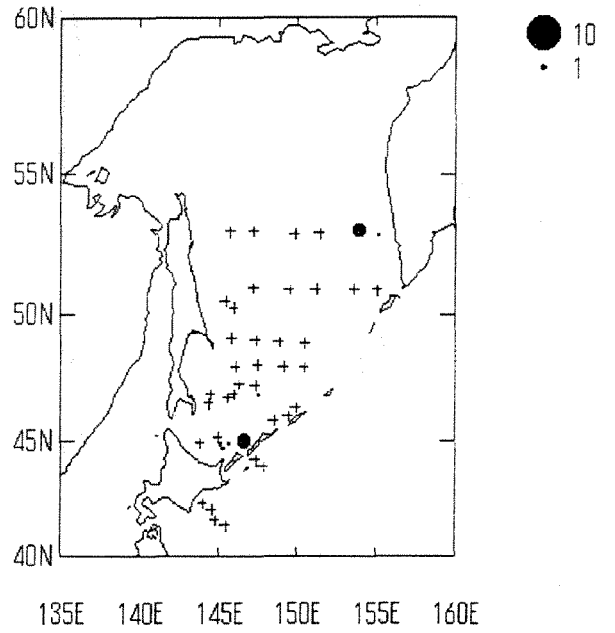


Clupea pallasii

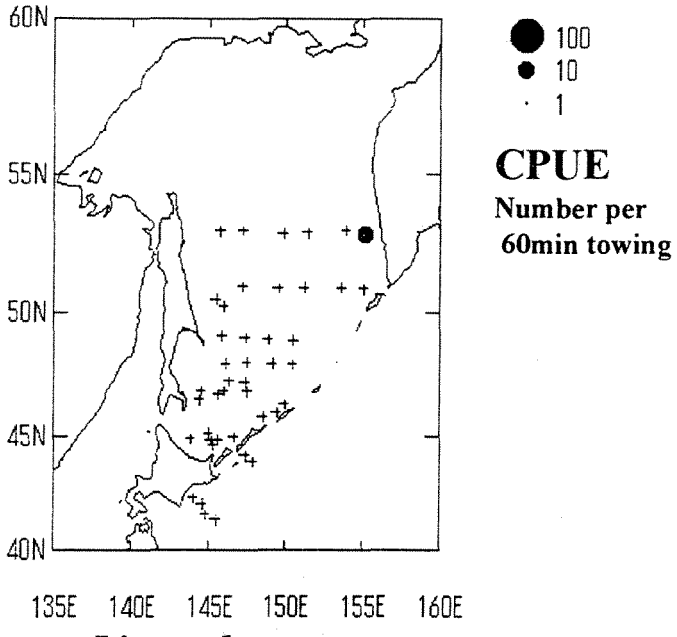


Aptocyclus ventricosus

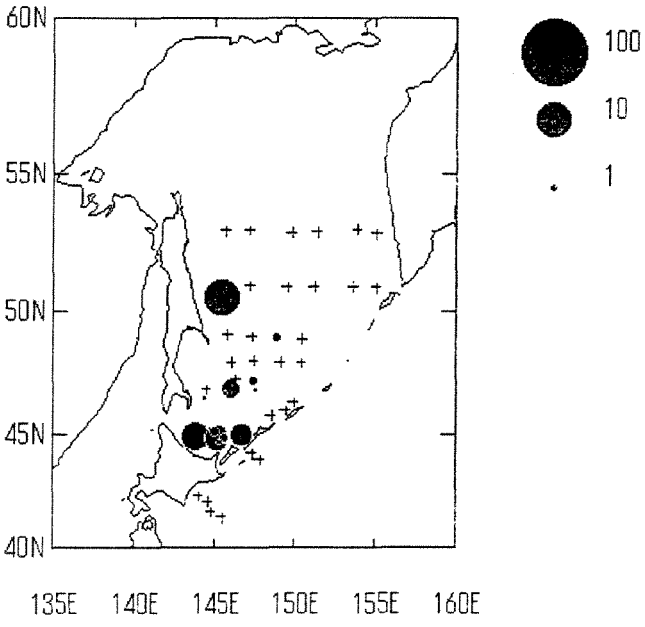
Appendix Fig.2-2. CPUE distribution of major by-catch species.



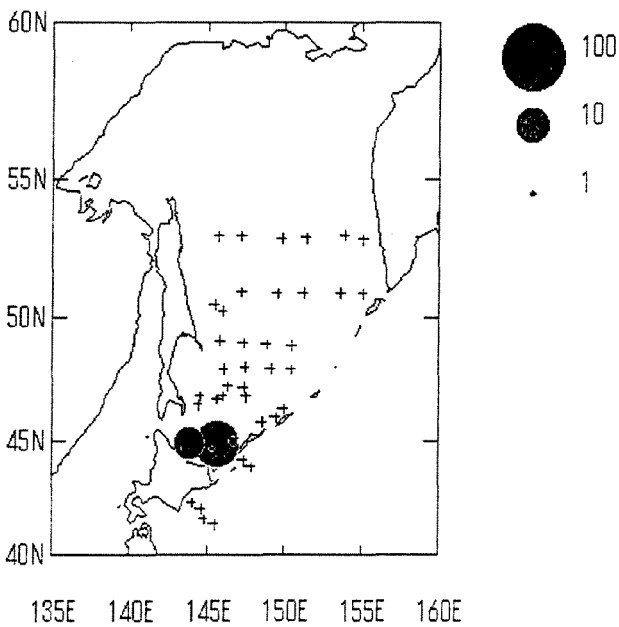
Theragra chalcogramma



Limanda aspera



Hemilepidotus gilberti



Ammodytes personatus

Appendix Fig.2-3. CPUE distribution of major by-catch species.