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Distribution, Migration, and Abundance Estimation of Asian Juvenile Salmon

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Distribution, migration, and abundance estimation of Asian Juvenile Salmon

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Abstract

To elucidate distribution and migration routes of Asia-origin juvenile salmon during their early ocean life, the Fisheries Agency of Japan (FAJ) surveyed the Sea of Okhotsk and the Pacific waters off Hokkaido and the Kuril Islands. Seventy operations of the drifting gillnets and 142 operations of the surface trawl were conducted in order to confirm distribution of juvenile salmon from the early summer to the late-autumn in 1993-1996. Juvenile sockeye (*Oncorhynchus nerka*), chum(*O. keta*), pink (*O. keta*), coho (*O. kisutch*), and masu (*O. masou*) mainly occurred in the southern and central waters of the Sea of Okhotsk from summer to mid-autumn. Their distribution except for masu spread out to the Pacific waters off the Kuril Islands in the mid-autumn. Only juvenile masu moved into the south-western part of the Sea of Okhotsk. Therefore, I considered that most of Asian juvenile salmon except for masu migrates into the Sea of Okhotsk and stay there from the summer to the mid-autumn. In late-autumn they are thought to migrate into the Pacific waters off Kuril Islands. Abundance of juvenile salmon can be estimated because the most of them concentrate in the limited areas in the Sea of Okhotsk. I showed the estimation of the stock abundance of juvenile salmon in the autumns of 1993 and 1996.

Introduction

To get the general information on the distribution of juvenile salmon around Japan, the National Research Institute of Far Seas Fisheries (NRIFSF), the Fisheries Agency of Japan (FAJ) conducted 4 research cruises in the Pacific and Okhotsk coasts off Hokkaido and the Kuril Islands using the purse seine from 1988 to 1996 (Ueno et al., 1992; Ueno and Ishida 1996). NRIFSF carried out 3 research cruises for juvenile salmon in 1993 and 1996 using the surface trawl. The central and southern Okhotsk and the Pacific coasts off the Kuril islands except for Russian territorial waters were surveyed in these research cruises.

As the results, I could get sufficient information on all salmon originating in Far East Asian rivers except for eastern Kamchatka stocks. In this report, I put together the data obtained from these 7 research cruises and described general distribution of juvenile salmon in these waters. I also made schematic migration routes of juvenile salmon by species based on these general distributions. Moreover, I suggest that the classic area swept method can be applied to estimate the numbers of survival juvenile salmon.

Materials and methods

NRIFSF conducted 7 research cruises for juvenile salmon in 1993-1996. Three research vessels and four kinds of sampling gears (drifting gillnet A, B, surface trawl A and B) were used in these research cruises (Table 1 and Table 2). I calculated the catch per unit effort (CPUE) according to the kind of sampling gear and made figures showing CPUE distribution according to species and season. In these cruises, I took sub-samples by sampling site and froze them onboard to make biological measurements. I made a figure showing seasonal fork length (FL) frequencies based on the data collected in the biological measurements. For estimating the survival number of juvenile salmon, I applied the classic area swept method in combination with the random stratified method. (Mackett 1973).

Results

NRIFSF carried out 212 sampling operations and got 51,039 juvenile salmon. I described general distributions of juvenile salmon according to the species as the following.

Sockeye salmon (Fig. 1): Juvenile sockeye was very few in the summer and early autumn in the survey areas. After the mid-autumn, juvenile sockeye were found in the Okhotsk coasts of the northern Kuril Islands. Juvenile sockeyes did not occur in the Pacific waters of the survey areas before the late autumn. Sockeye salmon are very abundant in rivers of western Kamchatka (for example, Burgner 1991). Shimazaki (1977) also found that juvenile sockeye were abundant in the coastal waters of western Kamchatka in the early autumn. Accordingly, juvenile sockeye collected in this study seem to migrate southwards along coastal waters of western Kamchatka. These juveniles are considered to move through the straits of northern Kuril Islands to the North Pacific Ocean in the late autumn and early winter. The average FLs of juvenile sockeye were about 263mm and 254mm in the mid and late autumn, respectively (Fig. 7 (a)).

Chum salmon (Fig. 2): Juvenile chum mainly occurred in the southern part of the Okhotsk Sea in the summer. They left the southern part of the Okhotsk Sea and occurred in the central part of the Okhotsk in the early autumn. In the mid-autumn they were distributed in all areas of central and southern Okhotsk Sea. In the late autumn their distribution in the Okhotsk Sea was limited within the most southern part and appeared in the Pacific coasts of the Kuril Islands. Juvenile chum did not occur in the Pacific waters until the mid-autumn except for near coastal waters. These seasonal changes of the distribution suggested juvenile chums migrate into the Okhotsk Sea and stay there from summer to mid-autumn. The appearances of juvenile chum in the Pacific waters in the late autumn indicate that they migrate from the Okhotsk Sea to the North Pacific Ocean. The averages of FLs increased from 154mm to 236mm from the summer to the late autumn (Fig. 7(b)).

Pink salmon (Fig. 3): The distribution pattern of juvenile pink salmon is very similar to that of juvenile chums. The average FLs increased from 124mm to 246mm from summer to autumn (Fig.7(c)).

Coho salmon (Fig. 4): Juvenile coho occurred in coastal waters off the western Kamchatka in the early autumn. They were abundant in the Okhotsk coasts of the northern Kuril Islands in the mid-autumn. They also occurred in the Pacific coasts of the northern Kuril Islands in this season. In the late autumn, few juvenile coho were found in the survey areas. Shimazaki (1977) reported that juvenile coho were abundant in coastal waters of western Kamchatka in the early autumn. Accordingly, I guess the main body of juvenile coho was distributed in the coastal waters off western Kamchatka in summer. After that, they must migrate southwards along coastline and move from the Okhotsk Sea through the straits of northern Kuril Islands to the North Pacific Ocean. The average FL of the late autumn was 314mm (Fig.7 (d)).

Chinook salmon (Fig. 5): In summer and early autumn, juvenile chinook were not found in the survey areas. They were mainly found in the Pacific coasts of the northern Kuril Islands in mid and late autumn. Shimazaki (1977) noted that a few juvenile chinook were distributed in the central part of the Okhotsk Sea in the early autumn. However, it is unclear whether the juvenile chinook collected in the Pacific waters off the northern Kuril Islands in this study came from the Okhotsk Sea.

Masu salmon (Fig. 6): In the early and mid-autumn, juvenile masu occurred in the southern Okhotsk Sea. A few juvenile masu were found in the western part of the Okhotsk Sea in the late autumn. The same tendency was reported by Russian research (Lapko and Startsev 1996). I considered that juvenile masu move from the southern Okhotsk to the Sea of Japan or the Pacific waters off Hokkaido after the late autumn. Few Juvenile masu were found in the Pacific waters.

Average FLs of juvenile masu were 294mm and 319mm in the early and mid-autumn, respectively (Fig. 7(f)). FLs of juvenile masu comparatively vary widely.

Estimation of survival number of juvenile salmon: Table 3 shows the estimation of the survival numbers of juvenile salmon in the research areas based on the data collected by the surface trawl operations using the area swept method in combination with the random stratified method. I assume that the fishing rates of the surface trawls were 0.5 for the estimation. The most abundant species are juvenile pink (300-500million fish) and the juvenile chum follows (60-300million fish). The estimate of juvenile masu in 1996 was about 3.7million fish.

Discussion

Distribution and migration of juvenile salmon: The survey conducted from the summer to late autumn showed that the juvenile salmon except for juvenile chinook occurred exclusively in the Okhotsk Sea, whereas the juvenile salmon were not found in the North Pacific waters off the Kuril Islands except in the late autumn. In the present study, territorial waters of the Kuril Islands could not be surveyed. Because juvenile salmon often migrate within narrow coastal waters (for example, Harrt and Dell 1986; Irie, 1992), there are some possibilities that they stayed within coastal waters of the Kuril Islands. However, Shuntov et al., (1993) conducted trawl surveys in territorial waters of the Kuril Islands in the summer and reported no juvenile salmon were caught in the Pacific waters of the Kuril Islands (Shuntov et al., 1995; Shuntov, personal communication). The results of the present survey and information on the Russian research suggests that the most juvenile salmon migrate into the Okhotsk Sea and stay there in these seasons and then start to migrate into the Pacific Ocean in the mid or late autumn.

The origin of the juvenile salmon has not been determined yet, Russian juvenile except for stocks of eastern Kamchatka and Arctic coast are considered to migrate into the Okhotsk Sea, because their natal rivers are located in the Okhotsk coasts or the northern Japan Sea (for example, Neave et al. 1976). Japanese juvenile salmon originating in the Japan Sea and Okhotsk Sea coasts are also thought to migrate into the Okhotsk Sea. For Japanese juvenile salmon originating in the Pacific coasts, it is necessary to confirm the migration routes by the minute stock identification and the tagging experiments although I suppose that the juvenile salmon migrate into the Okhotsk Sea. Considering the seasonal changes of CPUE distributions of juvenile chum and pink, I made the schematic diagram on the migration routes of juvenile chum salmon (Fig. 8).

Abundance estimation of juvenile Asian salmon: The present study has indicated that many Asian juvenile salmon stocks spent their first summer and autumn ocean life in the Okhotsk Sea. I suppose the area swept method can be used for abundance estimation of juvenile salmon in these seasons, because they live within the limited areas in the Okhotsk Sea. Moreover, average FLs of juvenile salmon attained more than 200mm after summer. I empirically considered that the natural mortality of juvenile would decrease after the summer. Accordingly, abundance estimation of juvenile salmon would directly contribute to estimate abundance of the returning salmon stocks. Moreover, when estimation of juvenile salmon abundance is carried out in combination with the adequate stock identification techniques, we can get the strong scientific base for fishing management.

Acknowledgments

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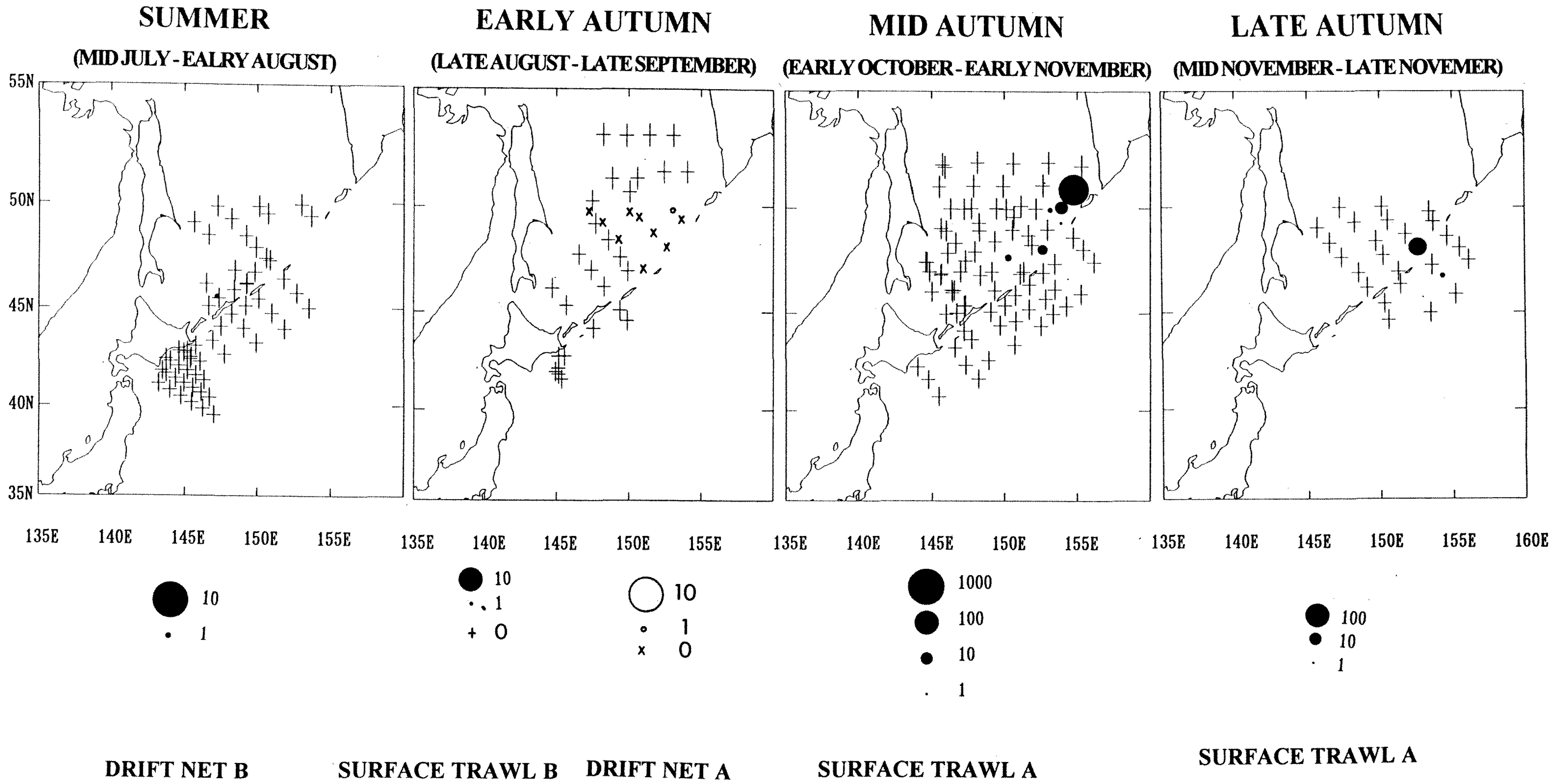


Fig. 1. Seasonal changes of CPUE distribution of juvenile sockeye salmon.

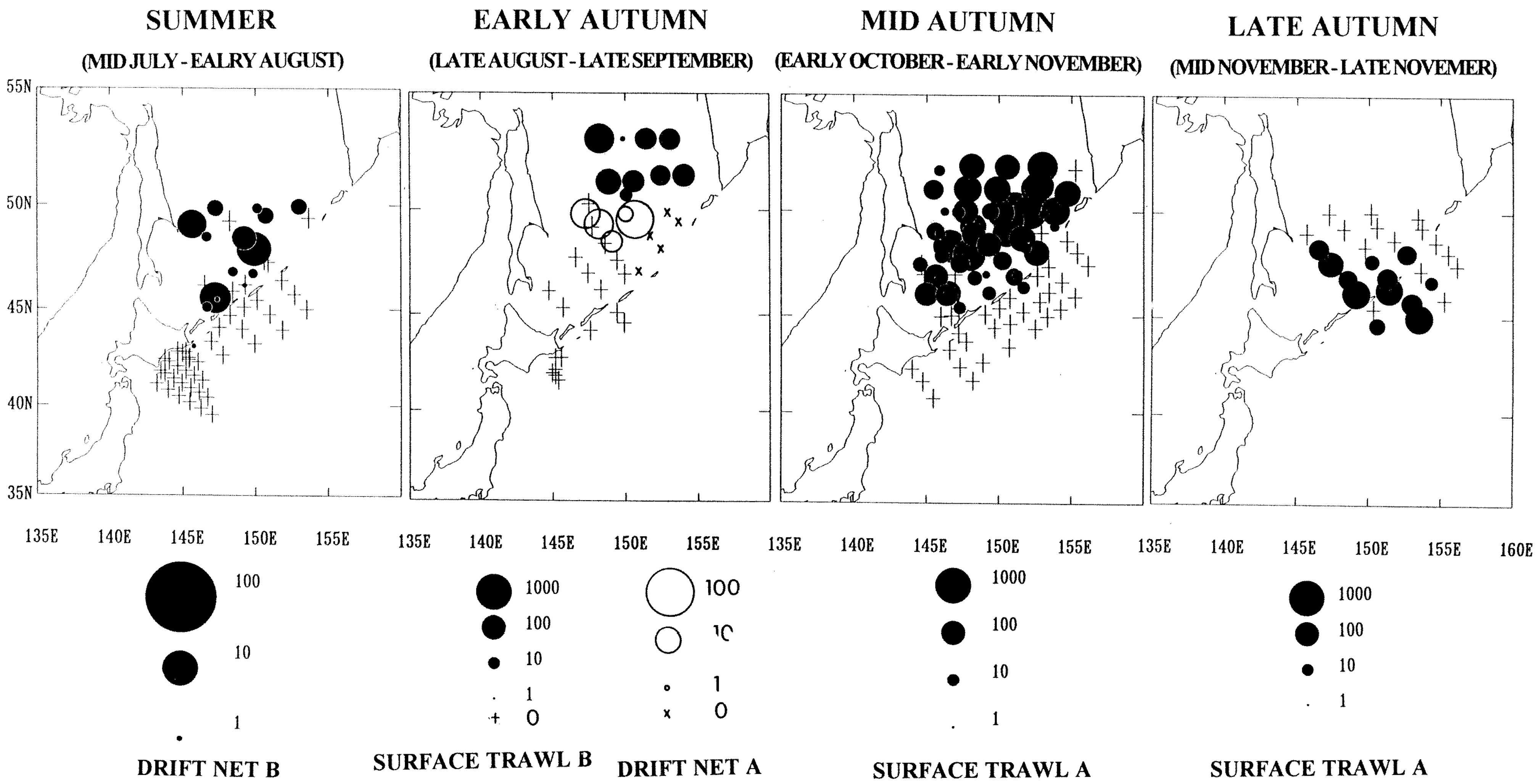


Fig. 2. Seasonal changes of CPUE distribution of juvenile chum salmon.

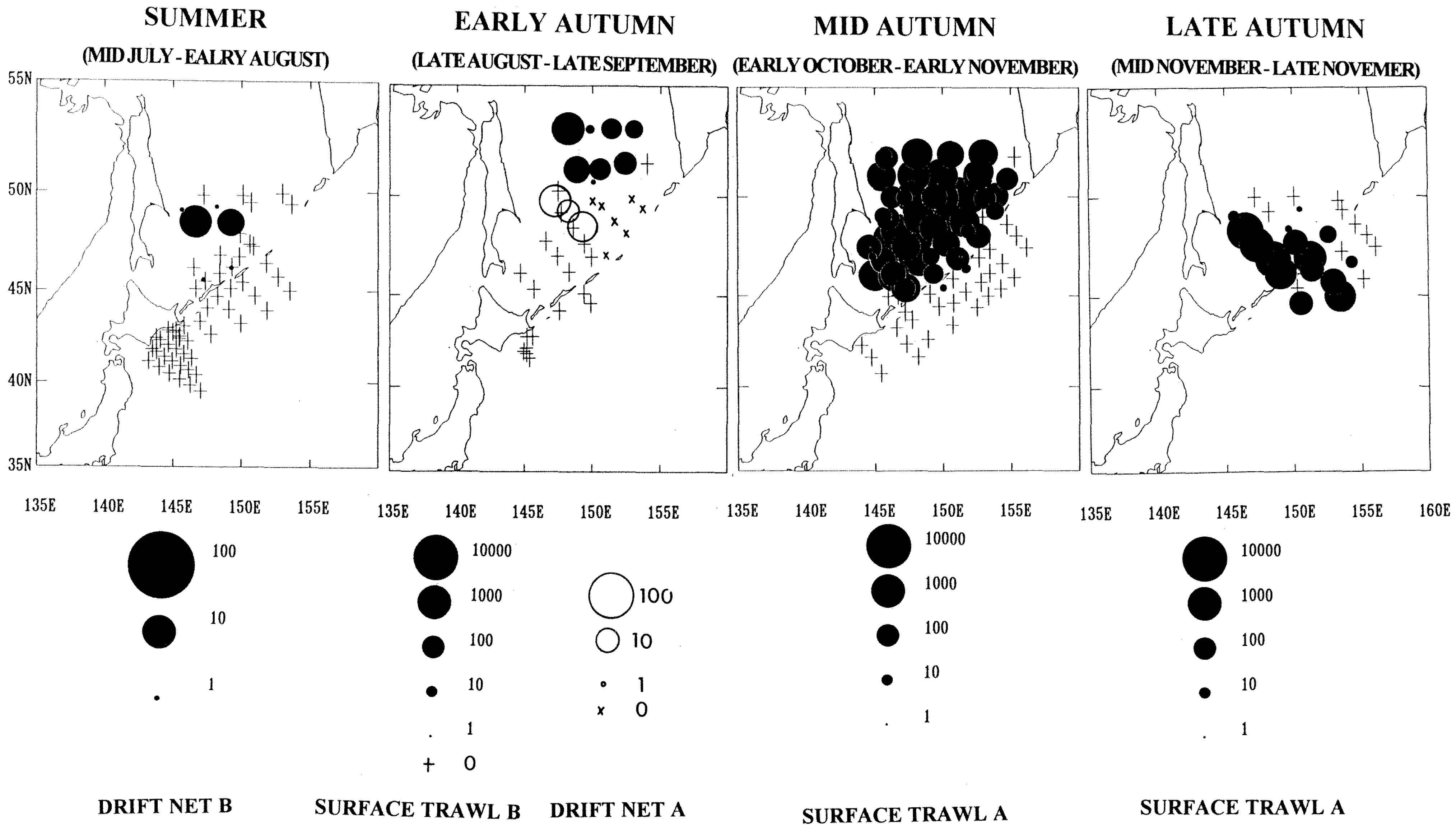


Fig. 3. Seasonal changes of CPUE distribution of juvenile pink salmon.

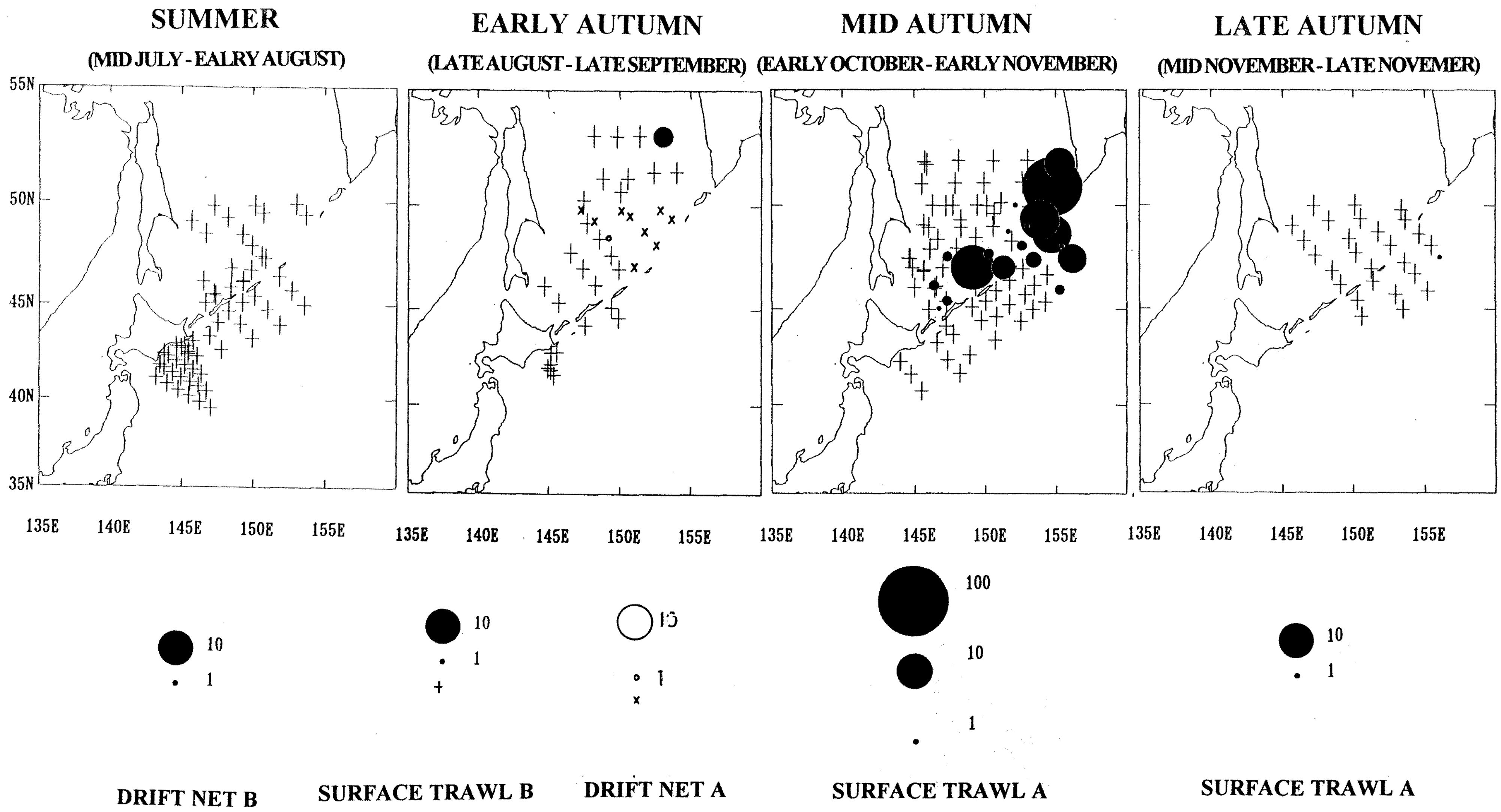


Fig. 4. Seasonal changes of CPUE distribution of juvenile coho salmon.

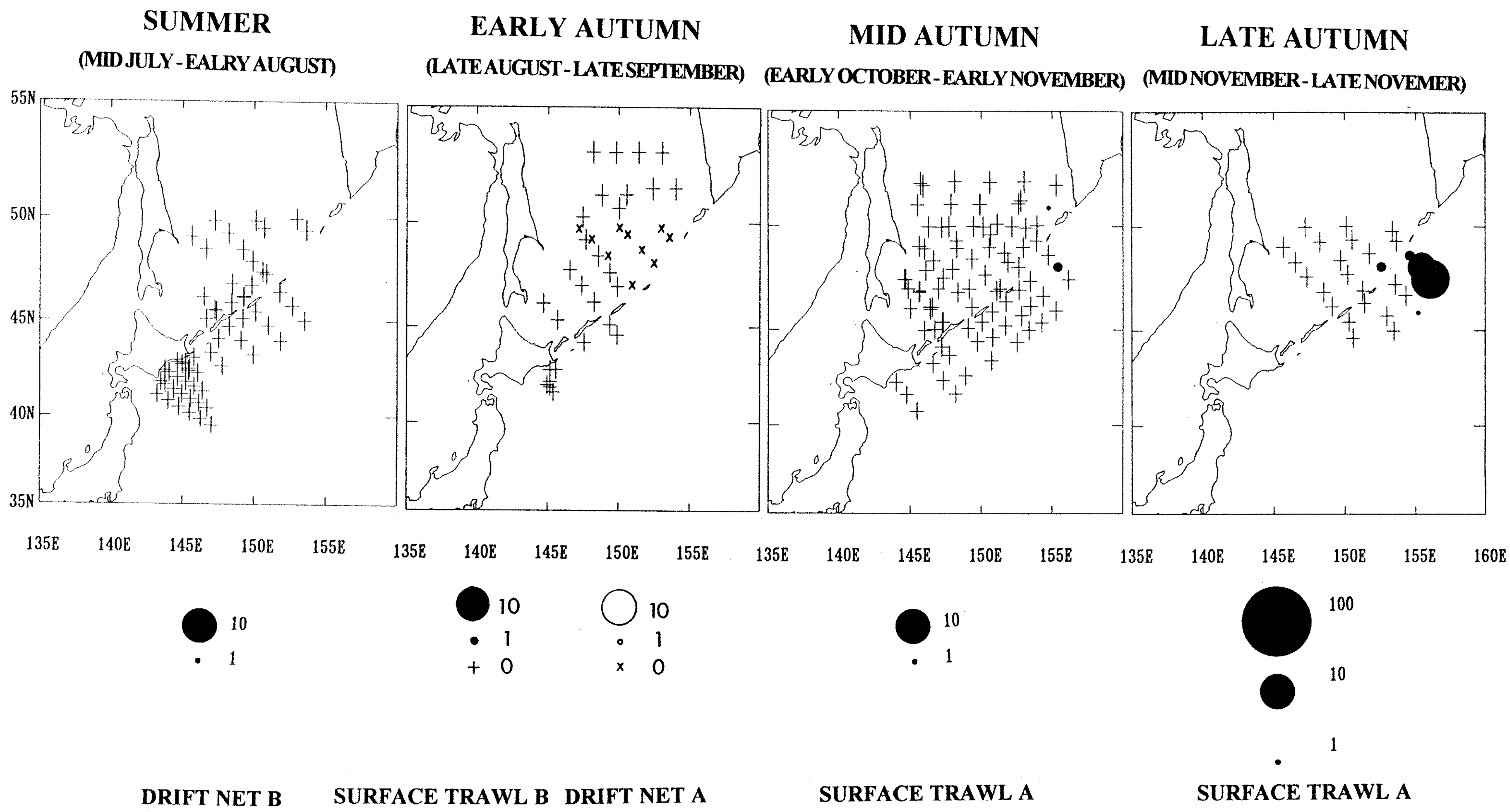


Fig. 5. Seasonal changes of CPUE distribution of juvenile chinook salmon.

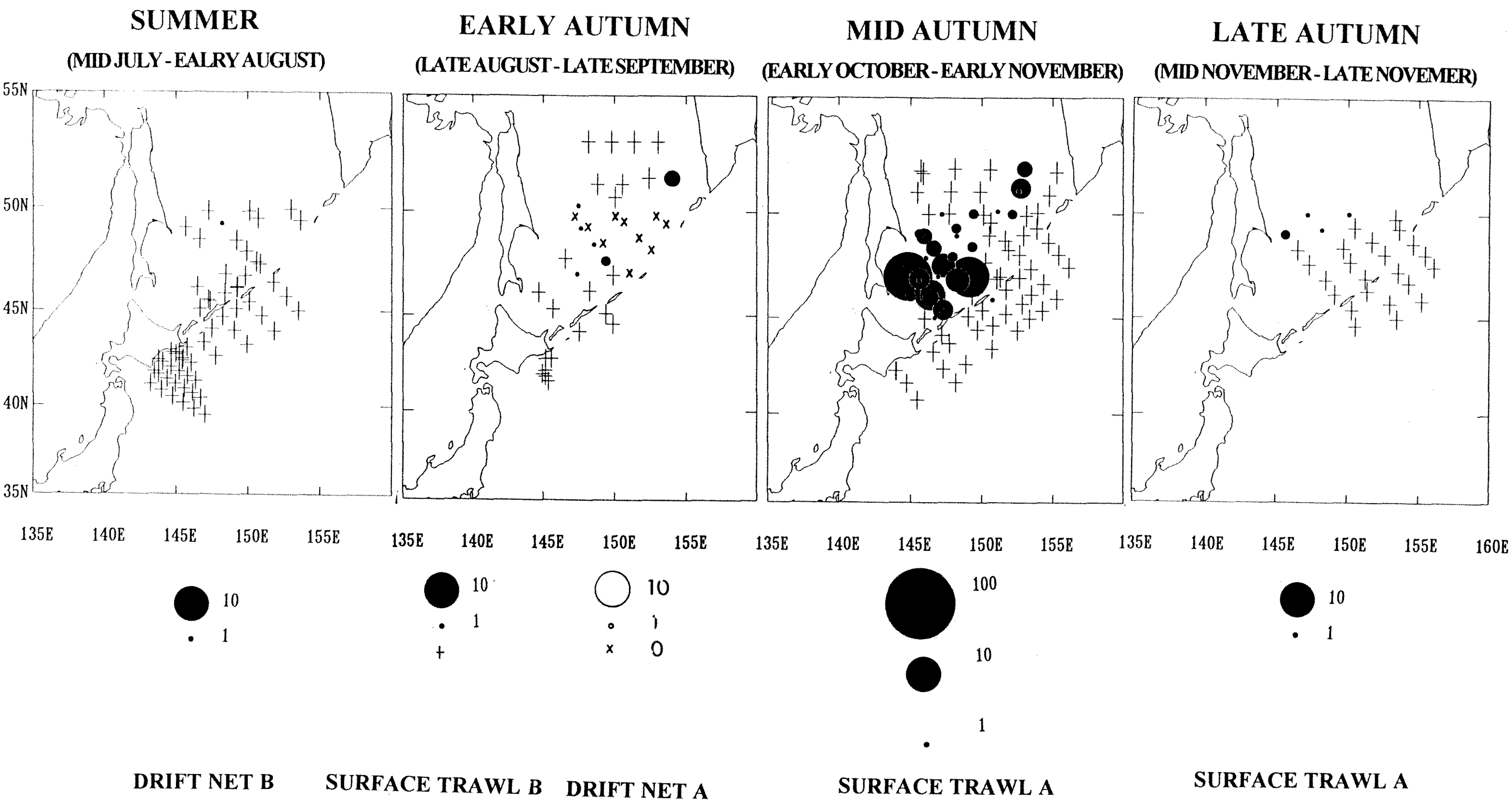


Fig. 6. Seasonal changes of CPUE distribution of juvenile masu salmon.

SUMMER (MID JULY TO EARLY AUGUST)

EARLY AUTUMN (LATE AUGUST TO LATE SEPTEMBER)

MID AUTUMN (EARLY OCTOBER TO EARLY NOVEMBER)

LATE AUTUMN (MID NOVEMBER TO LATE NOVEMBER)

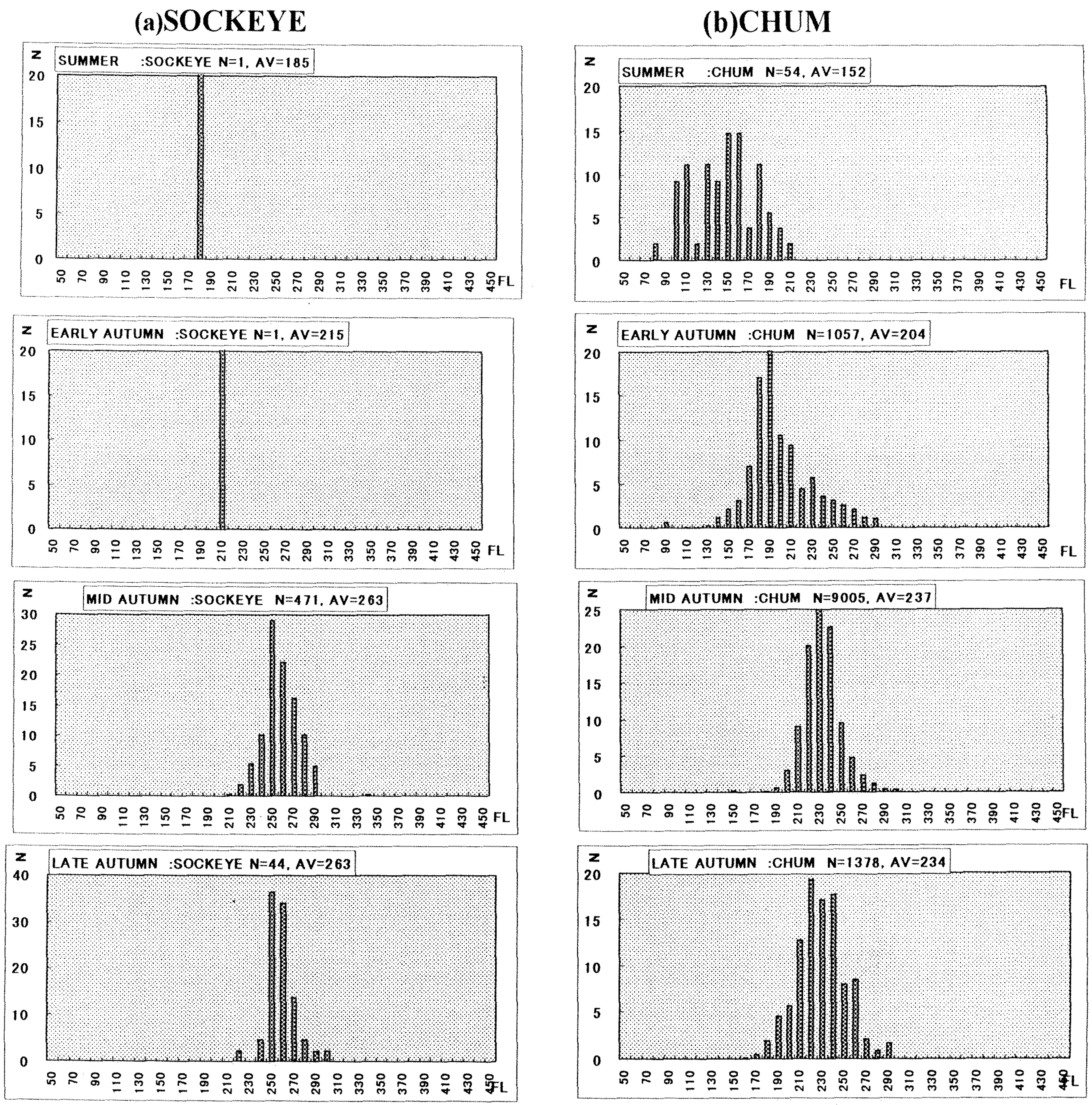


Fig. 7-1. Seasonal changes of fork length frequencies by species (sockeye and chum).

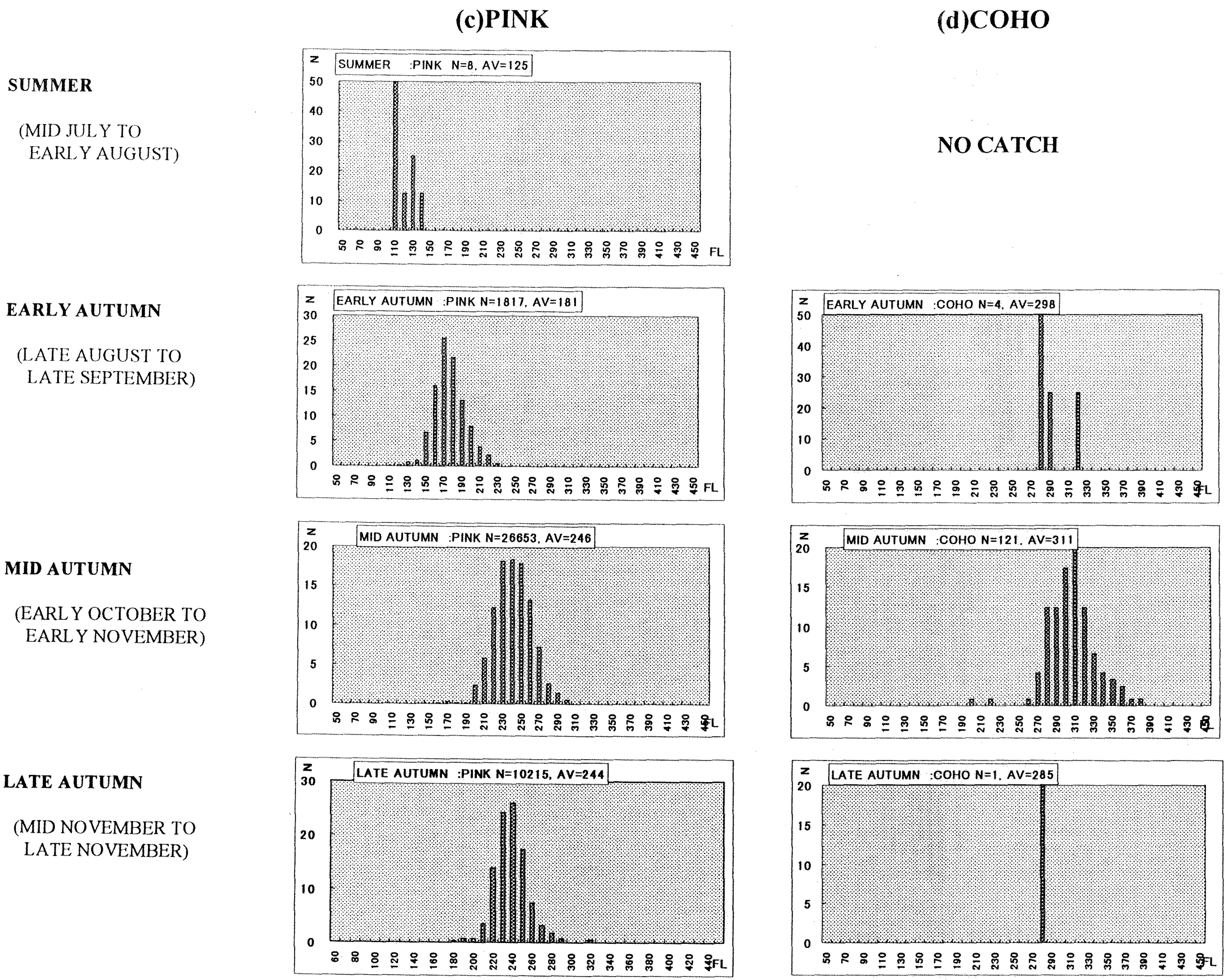


Fig. 7-2. Continued (pink and coho)

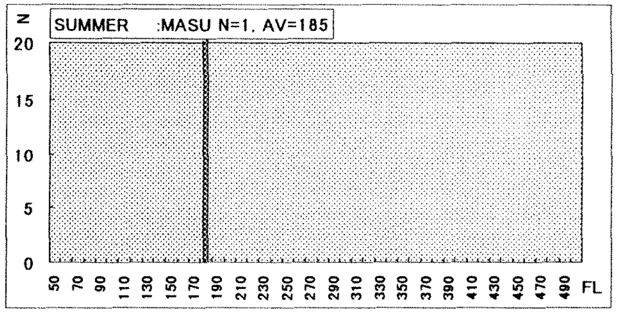
(e)CHINOOK

(f)MASU

SUMMER

(MID JULY TO
EARLY AUGUST)

NO CATCH



EARLY AUTUMN

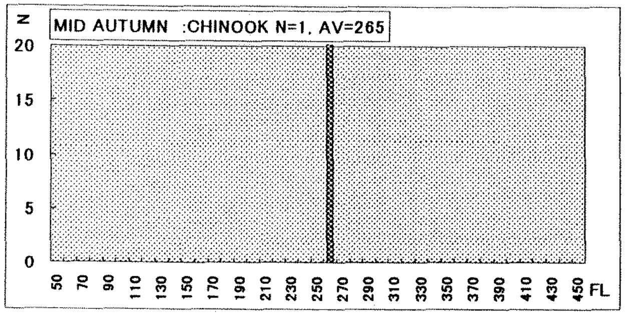
(LATE AUGUST TO
LATE SEPTEMBER)

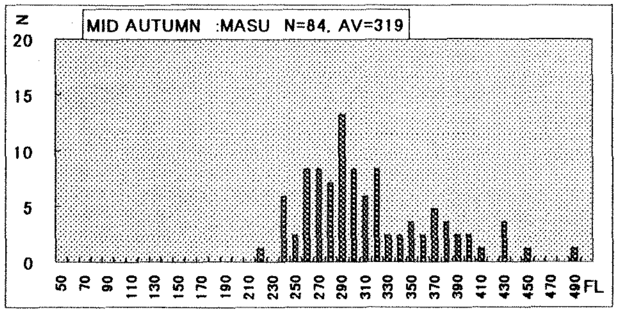
NO CATCH

NO CATCH

MID AUTUMN

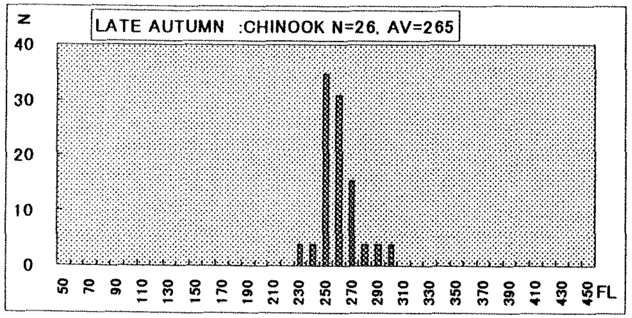
(EARLY OCTOBER TO
EARLY NOVEMBER)





LATE AUTUMN

(MID NOVEMBER TO
LATE NOVEMBER)



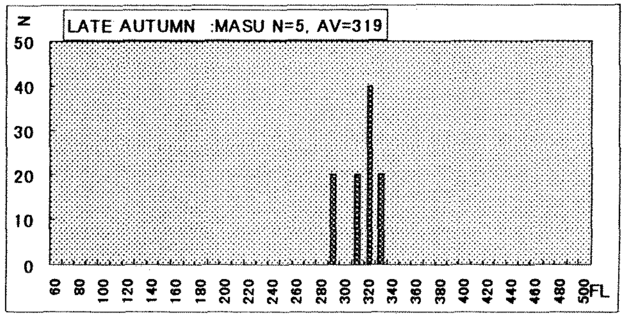


Fig. 7-3. Continued (chinook and masu).

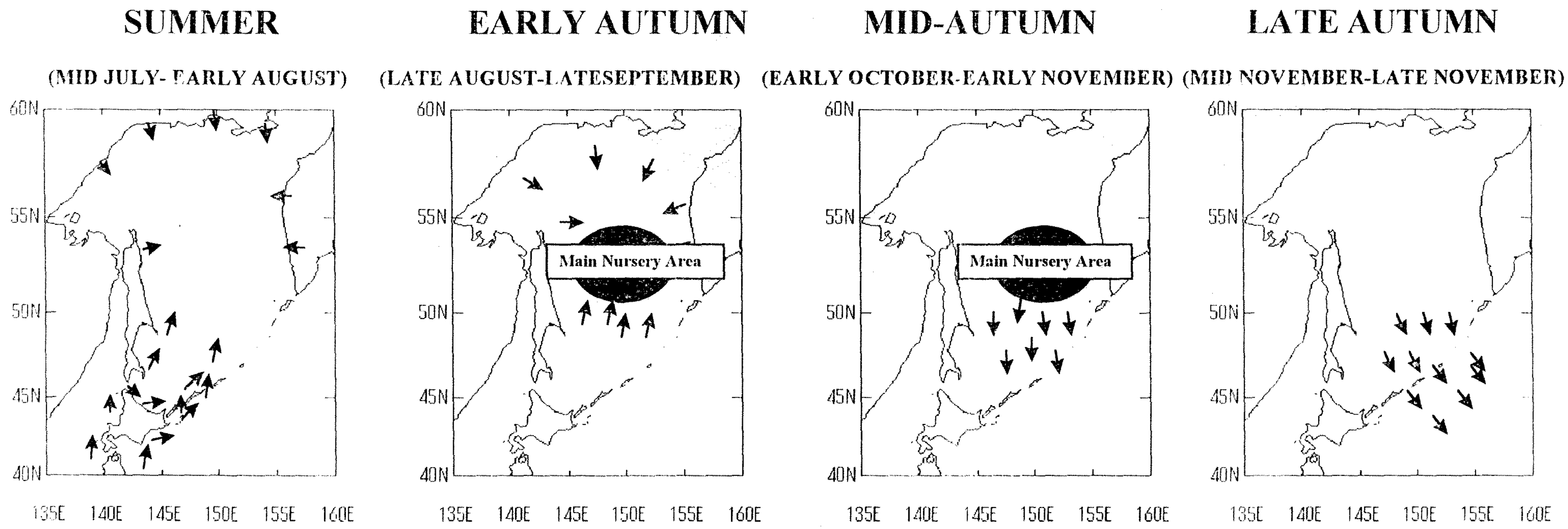


Fig. 8. A schematic diagram on the migration routes of juvenile chum and pink salmon

Table 1. Fishing gears used for collecting juvenile salmon.

Gear	Composition	Standard operation time	Towing velocity (m/se)	Widt h (m)	Depth (m)	Length (m)	Vessel
Drift net A	Mesh size 30,35,42,48,55,63mm, each 2 tans, total 12 tans	Night, 5-6 hours	Drifting	-	8	50	Wakashio-maru (August-September, 1993)
Drift net B	Mesh size 22,26,30,35,42,48,55,63mm, each 2 tans, total 16 tans	Night 5-6 hours	Drifting	-	8	50	Wakashio-maru (July-August, 1994 and 1995)
Surface trawl A	Warp 400m, Cod-end 12mm	Daytime 60 minutes	2.6 (5 knots)	60	60	202	Kaiyo-maru
Surface trawl B	Warp 350m, Cod-end 17mm	Daytime 60 minutes	2.6 (5knots)	30	30	86	Shunyo-maru

Table 2. List of recent juvenile salmon research surveys conducted by the National Research Institute of Far Seas Fisheries (NRIFSF), Fisheries Agency of Japan (NRIFSF).

Vessel	Gross tonnage	Period	Fishing gear	Number of operations	Research Area	Number of juvenile salmon collected
Wakashio-maru	199.51	August 22-September 9, 1993	Drift net A	10	Okhotsk Sea	156
Kaiyo-maru	2,630	October 15-November 26, 1993	Surface Trawl A	62	Okhotsk Sea and Pacific coasts of the Kurils	24,489
Wakashio-maru	199.51	July 16-August 7, 1994	Drift net B	21	Okhotsk Sea and Pacific coasts of the Kurils	14
Wakashio-maru	199.51	July 14-August 5, 1995	Drift net B	15	Okhotsk Sea	60
Wakashio-maru	199.51	July 14-August 8, 1996	Drift net B	24	Pacific coasts of Hokkaido	1
Shunyo-maru	397	August 29-September 26, 1996	Surface Trawl B	29	Okhotsk Sea and Pacific coasts of the Kurils and Hokkaido	2,740
Kaiyo-maru	2,630	October 6-November 9, 1996	Surface Trawl A	51	Okhotsk Sea and Pacific coasts of the Kurils and Hokkaido	2,3579
Total	-	-	-	212	-	51,039

Table 3. Estimates of numbers of juvenile salmon in the Sea of Okhotsk and the Pacific Coasts of the Kuril Islands by the area swept method. Catching coefficient is 0.5.

Year	1993		1996	
Month	October	November	August to September*	October to November
Vessel	Kaiyo-maru	Kaiyo-maru	Shunyo-maru	Kaiyo-maru
Area	The southern Okhotsk and the Pacific coasts off the Kurils		The central Okhotsk	The central and southern Okhotsk
	Estimates of numbers in thousand fish (Coefficient of variation)			
Sockeye	710 (48.7%)	1,701 (92.3%)	-	29,781 (23.8%)
Chum	102,145 (27.7%)	61,103 (29.3%)	333,863 (35.4%)	202,475 (99.8%)
Pink	310,908 (20.9%)	528,971 (27.9%)	600,269 (59.0%)	663,007 (31.2%)
Coho	3,196 (38.3%)	117 (77.5%)	-	6,037 (63.9%)
Chinook	32 (100.0%)	851 (52.2%)	-	68 (100.0%)
Masu	1,391 (27.3%)	1,119 (37.8%)	-	3,756 (47.6%)