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Summer Distribution and Migration Routes of Juvenile Chum Salmon (*Oncorhynchus keta*) Originating from Rivers in Japan

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Abstract

To clarify the migration routes of juvenile chum salmon (*Oncorhynchus keta*) originating from Japanese rivers, Japan-Russia cooperative surveys were undertaken in waters off southeastern Hokkaido, Sakhalin, and the Kuril Islands (excluding the 12 nautical mile (about 22km) zone of Russia), using a purse seine, a surface trawl net, dip-nets, and drift net in the summers of 1988-1992. Chum juveniles were caught in nearshore waters of southeastern Hokkaido and coastal waters (> about 22km) of the Kunashiri and Iturup Islands. In contrast, no juvenile was found in offshore waters (> about 46km) of the Sea of Okhotsk and the Pacific Ocean. We proposed following two hypotheses for the migration routes of juvenile chum salmon after they enter these coastal waters based on these findings. The first hypothesis is that juvenile chum salmon migrate to offshore waters of the Sea of Okhotsk and the second hypothesis is that they move within coastal (territorial) waters off the Kuril Islands.

Introduction

Juvenile chum salmon (*Oncorhynchus keta*) originating from rivers in northern Japan are believed to migrate northwards in coastal waters off northern Honshu and Hokkaido as sea surface temperatures increase (Irie 1990). In early and mid July, juveniles, the fork length (FL) of which range from 80 to 150mm, are found off the southeastern coast of Hokkaido. In early August, the most of juvenile chum salmon are evacuated from coastal waters off Hokkaido (Agriculture Forestry and Fisheries Research Counsel 1985 ; Irie 1990).

In spring, immature chum salmon originating from Japan are known to appear in central waters of the northern North Pacific Ocean (Neave et al. 1976). Therefore, the juvenile chum salmon is thought to migrate northeastward from Hokkaido coast to central waters of the northern North Pacific after early August. However, the distribution of juvenile chum salmon was not reported in offshore waters of the Pacific coasts off Hokkaido and the Kuril Islands in August and September although some researches were conducted (for example, Irie ,1990).

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In North America, juvenile chum salmon originating from Washington to southeastern Alaska are known to migrate northwards and to remain within 37km from the coast until October (Neave et al. 1976 ; Harrt and Dell 1986). This suggests that Japan origin juvenile chum salmon may also migrate in coastal waters of the Kuril Islands by autumn. On the other hand, in the late summer (from mid August to mid September), many grown juvenile chum salmon were found in central waters of the Sea of Okhotsk (Birman 1969 ; Shimazaki 1977). Relation between these juveniles and Japan origin juveniles remains unknown.

To make juvenile salmon studies including the migration routes and general ecology of juvenile chum salmon after they leave the Hokkaido coast, the Japan-Russia cooperative surveys were undertaken in accordance with the agreement of Japanese and Russian governments in the summers of 1988 to 1992. Based on the data collected these surveys, we report the spatio-temporal distribution of juvenile chum salmon in these areas and discuss their migration routes to and from these areas.

Materials and Methods

The surveys were conducted in coastal waters off the Pacific coasts of southeastern Hokkaido and the Kuril Islands and in the southern part of the Sea of Okhotsk in the summers of 1988-1992. Survey areas were divided into three sub-Areas for analyzing distribution and size composition of juvenile chum salmon (Area A : Pacific coasts of Hokkaido, Area B : Pacific coasts of the Kunashiri and Iturup Islands, Area C : Okhotsk coasts of the Kunashiri and Iturup Islands). However, the surveys in the 12 mile zone (about 22km) of Sakhalin and the Kuril Islands were not allowed. Sampling were mainly performed using a purse seine, 273m long and 44m deep, made of 18mm mesh except for the bunt section made of 5mm mesh. A surface trawl, dip-nets (nighttime), and drift nets were also used for collecting juveniles (Table 1).

Juveniles collected were preserved in 10% formalin or 70% ethyl alcohol on the research vessel

Table 1. Number of operations by fishing gear and year. Numbers of juvenile chum salmon collected are given in parentheses.

Year	Survey period	Purse seine	Surface trawl	Dip-net	Drift net	Total
1988	Mid June-early July	75(676)	0(−)	0(−)	0(−)	75(676)
1989	Mid July-early Aug.	59(14)	30(23)	22(220)	0(−)	111(257)
1990	Mid July-early Aug.	12(28)	39(145)	11(54)	0(−)	62(227)
1991	Mid July-early Aug.	43(2)	13(5)	10(4)	0(−)	66(11)
1992	Mid July-early Aug.	66(88)	0(−)	16(69)	1(0)	83(157)
Total		255(808)	82(173)	59(347)	1(0)	397(1328)

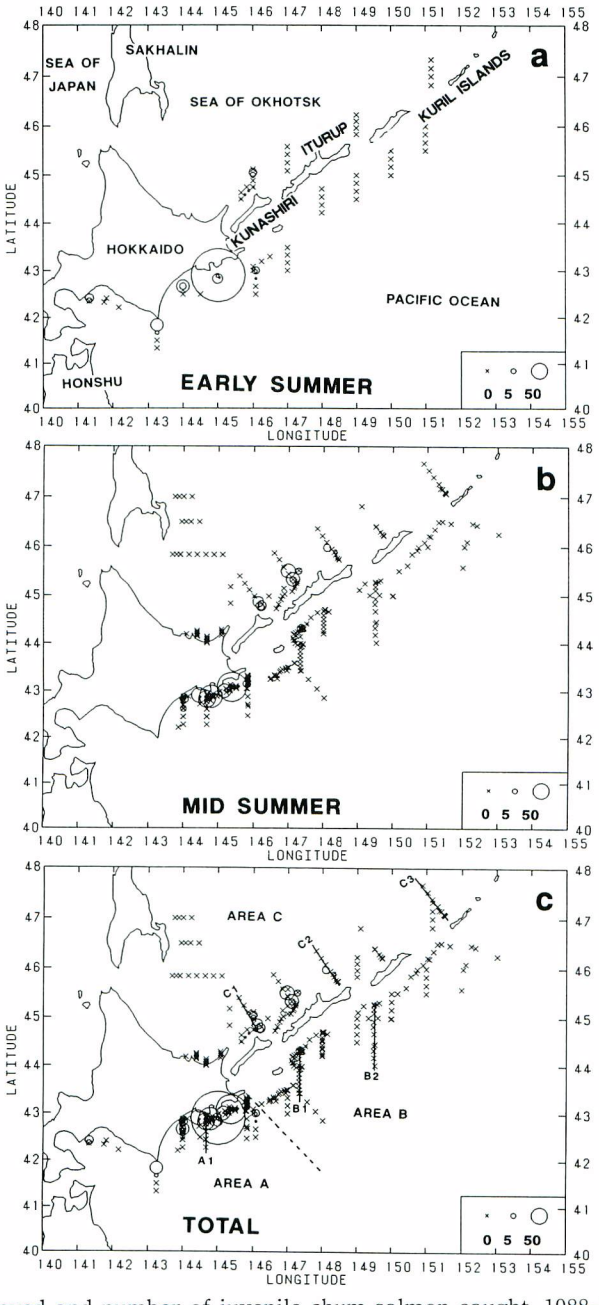

FIG. 1. Sites surveyed and number of juvenile chum salmon caught, 1988–1992. Size of circle is proportional to number of juvenile caught: (a) in mid June to early July, 75 sites were surveyed and 676 juveniles were collected; (b) in mid July to early August, 180 sites were surveyed and 652 juveniles were collected; (c) sites and numbers of juveniles in total. Surveys were grouped into Areas A, B, and C for analysis of fork lengths. Six transections were chosen for vertical profiles of water temperature.

and transferred to the laboratory, where the fork length and body weight were measured and number of gill rakers (1st arch on the left side) was counted.

Oceanographic observations were also carried out at a certain site of sampling locations from surface to 500m or 200m using the CTD system.

Results

Catch distribution : A total of 1,328 juvenile chum salmon was collected and numbers of individuals collected by each gear were 808 (purse seine), 173 (surface trawl), 347 (dip-net), 0 (drift net), respectively (Table 1). The distributions of juvenile chum salmon catches were shown in Fig. 1. From mid June to early July (the early summer), 654 out of 676 juvenile chum salmon collected occurred off the Pacific coasts of Hokkaido (Area A), while 22 were caught off the Okhotsk coasts of the Iturup and Kunashiri Islands (Area C, Fig. 1-a).

From mid July to early August (the mid summer), numerous juvenile chum salmon were caught off the Pacific coast of Hokkaido (Area A, N = 472) and off the Okhotsk coast of Iturup and Kunashiri Islands (Area C, N = 157), while a few juvenile chum were found off the Pacific coasts of the Kunashiri and Itutup Islands (Area B, N = 23 ; Fig. 1-b). The total distribution of juvenile chum salmon catches in this survey is shown in Fig.1-c.

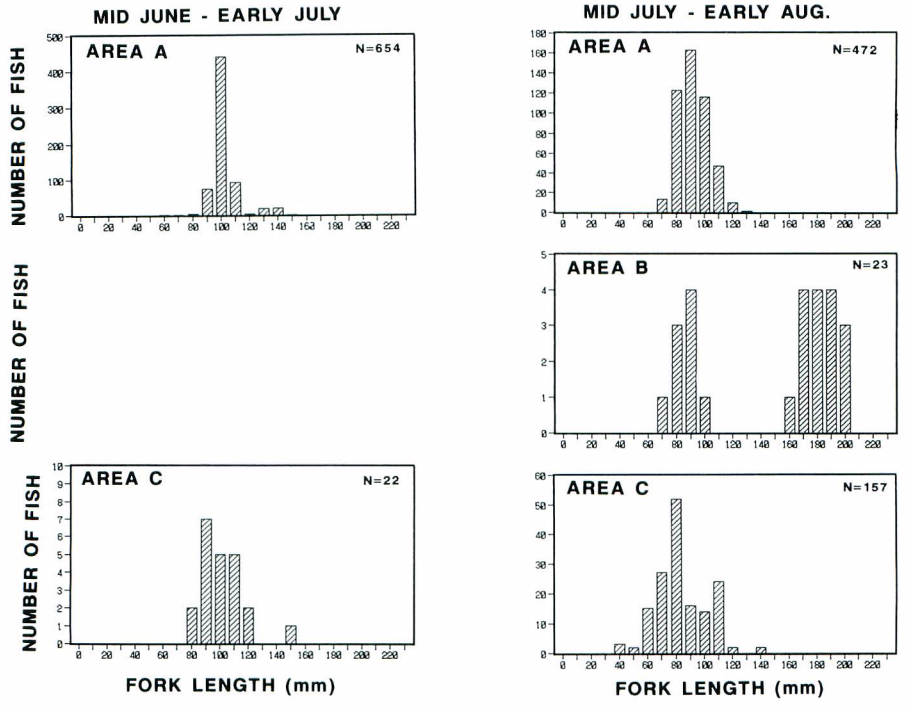

FIG. 2. Fork length distribution of juvenile chum salmon by sampling area and period.

Size composition of juvenile chum salmon: Distributions of the fork lengths are examined by sampling area and period (Fig. 2). During the early summer, the distributions of fork length were relatively narrow with most of the fish ranging from 80 to 130mm. During the mid summer, the fork length of most juvenile chum salmon caught off the Pacific coast of Hokkaido (Area A) and off the Okhotsk coast of Iturup and Kunashiri Islands (Area C) were ranging from 70 to 140mm. While, off the Pacific coasts of the Kunashiri and Itutup Islands (Area B), small sized juveniles (70 -110mm FL) and large sized juvenile (160-210mm FL) were observed.

Oceanographic features: The schematic diagram of sea surface temperature distribution based on 322 observations is shown in Fig. 3. Sea surface temperatures of the Sea of Okhotsk were higher than those of the Pacific coasts waters at the similar latitudinal range. Waters of 10-15°C prevailed over the areas near the Okhotsk coasts of the Kunashiri and Iturup Islands. Coldest waters (<5°C) were widely distributed off the Pacific coasts on the north of Urup Island.

Vertical distribution of water temperature along six transections (A1, B1, B2, C1, C2, and C3 in Fig. 1-c) are shown in Fig. 4. All sections show the warm waters (> 5°C) lying upper 30m. Coldest waters (<1°C) extend below 50m (Section C1) or 200mm (Section C2) in the Sea of Okhotsk.

Sea surface temperature in relation to catches: Number of juvenile chum salmon caught was plotted against sea surface temperature at catch site (Fig. 5). Minimum and maximum water temperatures when juvenile chum salmon were obtained were 8.2°C and 15.8°C, respectively, and the most of juvenile chum salmon occurred at water temperature ranging from 10°C to 15°C.

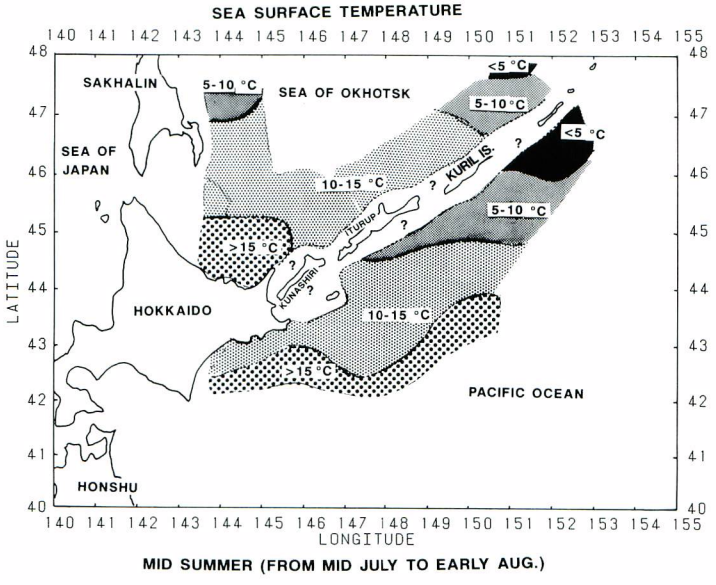

FIG. 3. Schematic diagram of sea surface temperatures around Hokkaido and the Kuril Islands in summer (mid July to early August) based on the juvenile salmon research, 1989-1992.

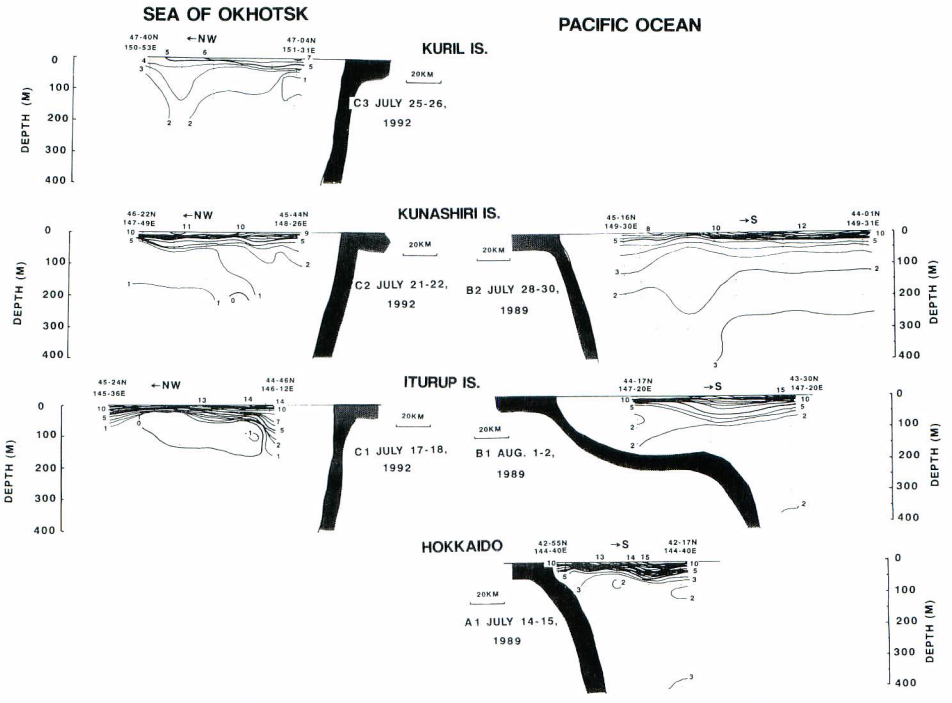

FIG. 4. Vertical sections of water temperatures along the oceanographic observation transections (See Figure 1-c).

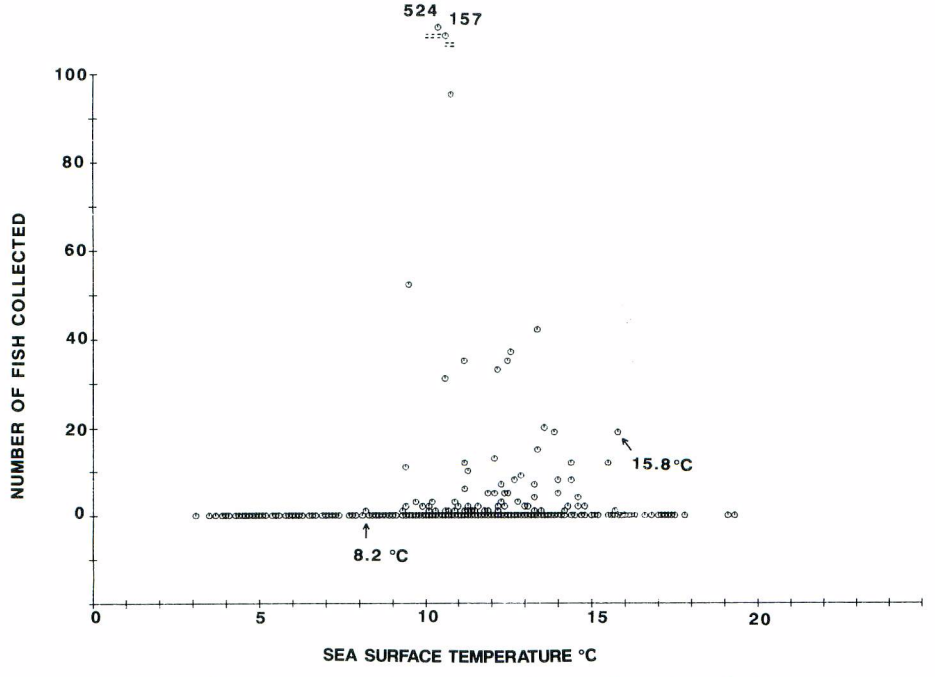

FIG. 5. Relationship between sea surface temperature and number of chum salmon caught.

Discussion

Because of certain variables in catchability of three kinds of sampling gears, the catches and sizes of juvenile chum salmon are not strictly comparable between all areas and periods. Nevertheless, the catch data are deemed suitable to show general distribution of juvenile chum salmon. In the present survey, the distributions of juvenile chum salmon were limited in coastal waters off southeastern Hokkaido and the Kunashiri and Iturup Islands. It is known that juvenile chum salmon evacuate waters off the Hokkaido coast in August (Agriculture Forestry and Fisheries Research Counsel 1985; Irie 1990). Juvenile chum salmon entering the ocean from Washington, British Colombia, and southeastern Alaska migrate northward relatively near the shore and the great majority remained within a coastal belt less than 37km wide (Harrt and Dell 1986). This suggests that juvenile chum salmon migrate from nearshore waters of Hokkaido to coastal waters of the Kunashiri and Iturup Islands including the 12 nautical mile zone, which was not investigated.

It is possible to build up the following two hypotheses on the migration after they leave coastal waters off Hokkaido and the Kunashiri and Iturup Islands.

Hypothesis I: Birman (1969) and Shimazaki (1977) found many large sized juvenile chum salmon were found in central waters of the Sea of Okhotsk in the late summer (from mid-August to mid September). The origins of them, however, have not been exactly determined, and relationship between them and Japan origin juvenile chum salmon is not yet clarified. Based on the data of the present study and table 2 of Shimazaki (1977), the distribution of juvenile chum salmon in the summer (from mid June to mid September) was extrapolated and shown in Fig. 6. The juveniles being distributed off the Okhotsk coast of the southern Kuril Islands seem to be closely related with those of central waters of the Sea of Okhotsk. Therefore, it would be suggested that as the juvenile chum salmon grow, they migrate to the central waters of the Okhotsk after leaving coastal waters of Hokkaido and the Kunashiri and Iturup Islands. The fact that waters ranging 10-15°C supposedly preferred by the juveniles prevail over these areas may support this hypothesis. The large sized juveniles in the present study could be a fraction of the grown juvenile population just leaving this coastal area for central waters of the Sea of Okhotsk.

Hypothesis II: All juvenile chum salmon collected off the Kunashiri and Iturup Islands were small (<150mm FL) except for sixteen large sized juveniles (> 150mm FL) caught in coastal waters off the Pacific coast of Iturup Island. The origin of juvenile chum salmon collected in this study could not be yet clarified, however, we found that the large sized juveniles were thought to come from rivers of northern Japan based on the mean circuli number counts of the scales (The detail of this origin estimation were reported in the other report; Ueno et al., 1992). Therefore, it is suggested that the main body of the grown juvenile chum salmon may remain within the 12 nautical mile zone of the Kuril Islands, which was not investigated. The large sized juveniles collected in the present survey could be a fraction on the outskirts of the main body of the grown juveniles remaining this

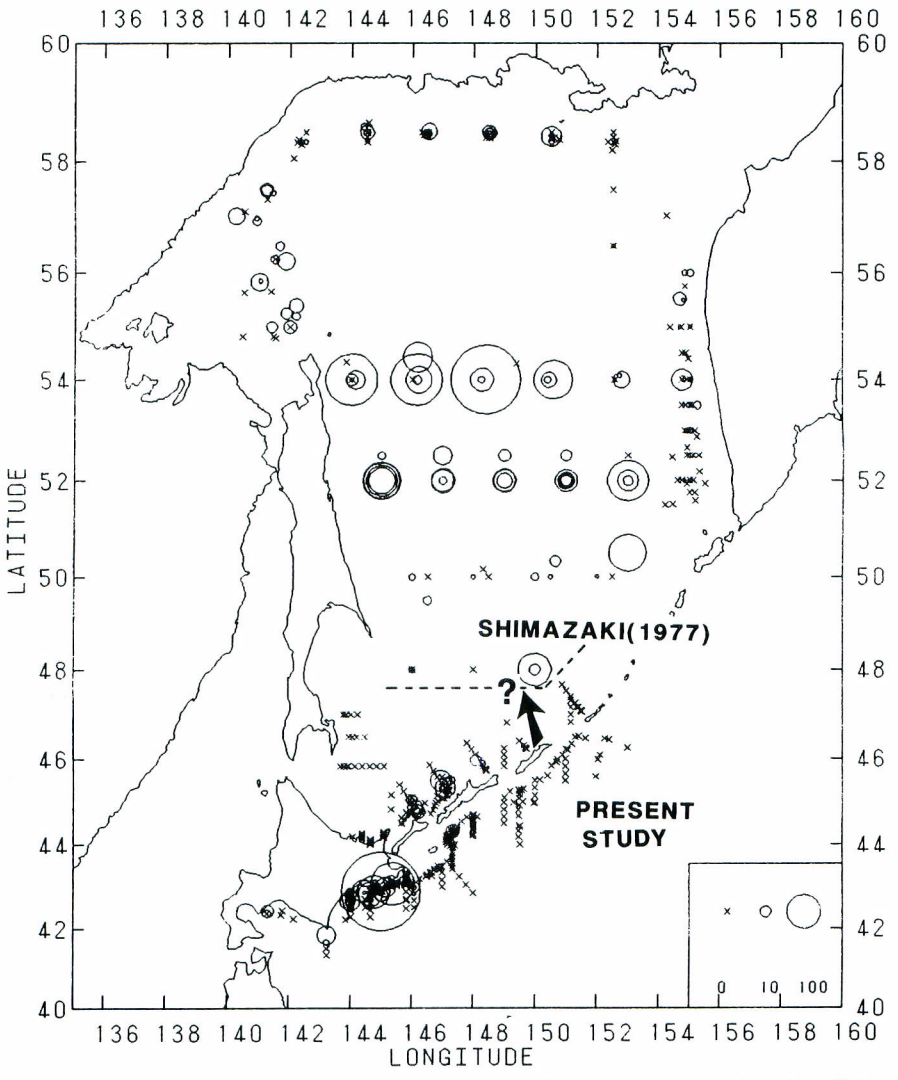

FIG. 6. Location of chum salmon catches in the Sea of Okhotsk in summer based on Shimazaki (1977) and the present study. Size of circle is proportional to number of juvenile chum salmon caught.

zone. It should be noted juvenile salmonids originated from western North America remain in coastal waters of the Pacific coast until autumn.

Future Research : It would not be possible to perform further investigations in coastal (territorial) waters of the Kunashiri and Iturup Islands and the Kuril Islands at present because of political complications between Japan and the Russian Republic. Therefore we can not verify the above hypothesis II. Alternatively, we should focus on clarifying the origin of juvenile chum salmon being

distributed in central waters of the Sea of Okhotsk to examine the above hypotheses I. In the future research, we intend to conduct sampling operations in central waters of the Sea of Okhotsk and determine the origin of the fish using scale pattern, genetic method, and other stock identification analyses.

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日本系シロザケ幼魚の夏季の分布と回遊経路

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1988-1992年の日露共同さけます幼魚分布調査の結果を基に夏季の日本起源シロザケ幼魚の回遊経路について解析を行った。調査は千島のロシア沿岸域（領海）を除く北海道，サハリン，千島列島の沿岸・近海においてまき網，表層トロール，たも網，および流し網により行なわれた。シロザケ幼魚は北海道および南部千島列島沿岸に分布していたが，千島列島および北海道の沖合いでは見られなかった。これらの知見から，シロザケ幼魚は，①北海道の沿岸を離れた後，オホーツク海へ回遊するかまたは　②千島列島のごく沿岸域を回遊するものと推測された。