Identification of Pink Salmon (*Oncorhynchus gorbuscha*) Runs in the Ocean off the Kuril Islands, Russia

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Abstract: We conducted studies in the Pacific waters off the Kuril islands to obtain data on catch-per-unit-effort and some biological characteristics of pink salmon (*Oncorhynchus gorbuscha*), migrating to spawning rivers in the Okhotsk Sea Basin. The pink salmon return migration in this basin within the Kuril waters lasts four months. Large intraspecific units—temporal groups—are formed in the ocean, hundreds of miles from the coast. The homing migration of pink salmon in marine waters has three distinct runs—two in summer (early- and late-summer runs), and one in the fall. The numbers and timing of the Okhotsk Sea pink salmon runs in the ocean correspond to the numbers and timing of runs near shores and in rivers. This allows differentiation of spawning runs far out at sea long before they reach shore.

INTRODUCTION

Pink salmon (*Oncorhynchus gorbuscha*) reproducing in rivers of the Okhotsk Sea Basin have a complex population structure. Populations near the shores and in rivers are distinguished by the timing of their runs, and have been called second rank populations (Gritsenko 1981). The Okhotsk Sea pink salmon have three such populations: two summer runs, early and late, and a fall run. The early pink salmon run near the shores occurs in July (northern coast of the Okhotsk Sea), the late run in August (western Kamchatka and eastern Sakhalin), and the fall run in September (southern Kuril Islands) (Ivankov 1967; Birman 1981; Gritsenko 1981; Takagi et al. 1981; Golovanov 1982).

Where are these groups formed–in the ocean or in the Okhotsk Sea? We suggest that different temporal groups of Okhotsk Sea pink salmon found near the coast gather in the ocean. If so, we have an opportunity to distinguish pink salmon stocks by run timing and biological characteristics while they are far from shore. However, there is also a possibility that all three temporal groups of pink salmon begin their return migration together from their wintering sites in the Pacific Ocean by following the 2°C isotherm. Then early summer pinks may continue through the Kuril waters to the Okhotsk Sea spawning grounds, while late summer and fall pinks may stop in waters off the Kuril Islands or in the Okhotsk Sea to feed. We decided to determine whether the Okhotsk Sea pink salmon run had a temporal structure in the ocean during their return to their spawning areas.

MATERIALS AND METHODS

Data were obtained from 1996–1999 during the Sakhalin Research Institute of Fishery & Oceanography studies with the objective of assessing abundance of pink salmon in spawning runs far from Sakhalin shores. The studies were conducted in the Pacific waters off the Kuril Islands within the Russian Exclusive Economic Zone between 45°N and 50°50'N, from mid or end of May to early or mid August, using 6 or 7 ships each year. Occasional observations were made in the second half of August to early September of 1994–96. In 1999 surveys began in late April. Driftnets were used for sampling. To investigate the spatial distribution of salmonids, ships were located at five survey sites within the Kuril waters (site # 1—from 50°50'N to 49°01'N; sites # 2, 3, 4, 5—at every 1 degree of latitude from 49° to 45°N). Sites extended great distances east and west, and therefore they were divided into eastern and western parts. At site # 1 the boundary was at 159°E, site # 2 at 158°E, site # 3 at 156°E, site # 4 at 154°E, site # 5 at 152°E (Fig. 1). In May–June sampling was mostly in the east survey area; in July–August and early September sampling was in the west, 60–80 miles east from the straits of Kuril Islands. Sites 5–3 (45°00'–48°00'N)

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Fig. 1. Survey area and location of the research sites.

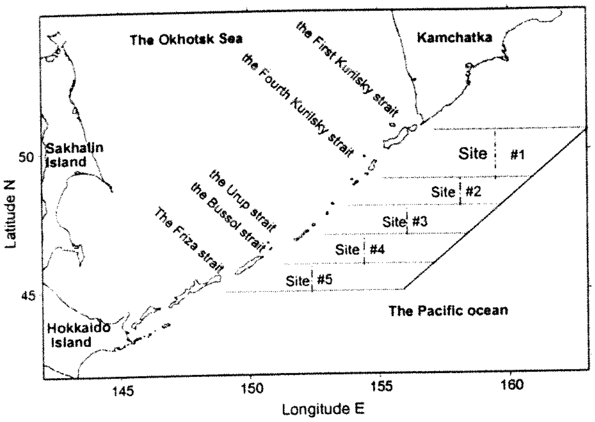
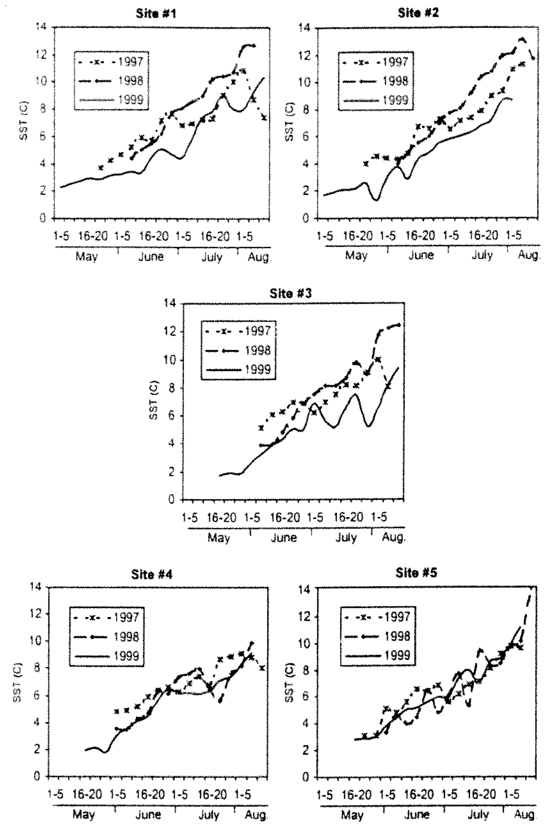


Fig. 2. Sea surface temperature at driftnet stations in sites 1–5, 1997–1999.



were considered as the south, and sites 2–1 (48°01'–50°50'N) as the north of the study region. Sampling was conducted without intermission and simultaneously at all five survey sites to allow us to trace the changes in abundance and biological characteristics of the salmon. Sea surface temperature (SST) was measured daily where driftnets were set, using the ship's remote thermometers (Fig. 2).

Catch-per-unit-effort (CPUE) was used as a measure of pink salmon abundance at sampling sites. On the charts (Figs. 3–5) CPUE was calculated as mean catch per month based on the total number of stations within the area 1° latitude to 3° longitude at sites 5–2, and 1°50' latitude to 3° longitude at site 1, which were east and west of the mid boundary. On the graphs (Figs. 9–10) CPUE has been calculated as mean catch per driftnet during 5 days within the sampling site. Data from stations located only within an area of 1° latitude and 1° longitude were used.

In 1996–1999 driftnets used for sampling were of a standard length (50 meters), and mesh size (55 mm Russian size). In addition, we used data collected in 1994–1995, when drift net mesh size was primarily 65 mm. Usually there were 80 drift nets in a line in May–June, and 25–40 in July–August. Lines of nets were set at night for 10–12 hours. In total there were from 342 to 579 sets.

We recorded sex ratios in catches, the gonad somatic index determined as the ratio of gonad weight to the weight of eviscerated fish (GSI, %), fork length (FL) and body weight. One sample consisted of 100 individuals. During 1996–1997, biological data were collected once every ten days; each season 5,500–6,000 fish were examined. During 1998–1999 biological data were collected once every five days; each season 11,000–12,000 fish were examined. Fish and gonad weights were estimated by weighing in groups. Biological data on pink salmon were obtained only from fish caught in nets with mesh size of 55 mm.

Fig. 3. CPUE of pink salmon in the Pacific waters off the Kuril islands, 1994–1995 (mesh size 65 mm).

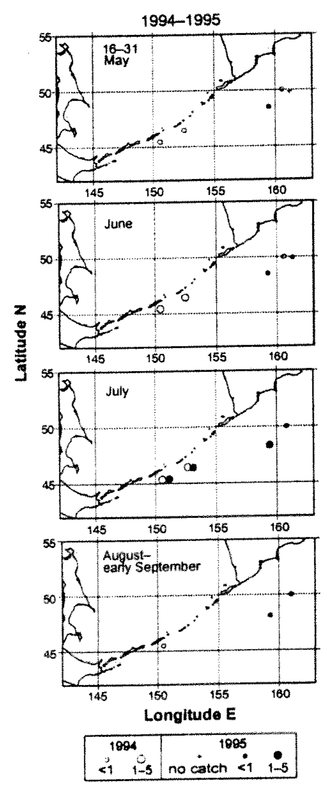


Fig. 4. CPUE of pink salmon in the Pacific waters off the Kuril islands, 1996 and 1997 (mesh size 55 mm).

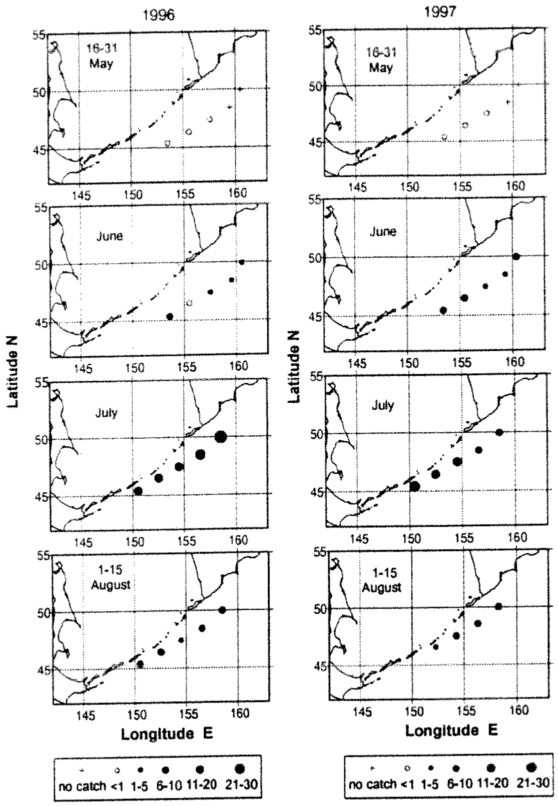


Fig. 5. CPUE of pink salmon in the Pacific waters off the Kuril islands, 1998 and 1999 (mesh size 55 mm).

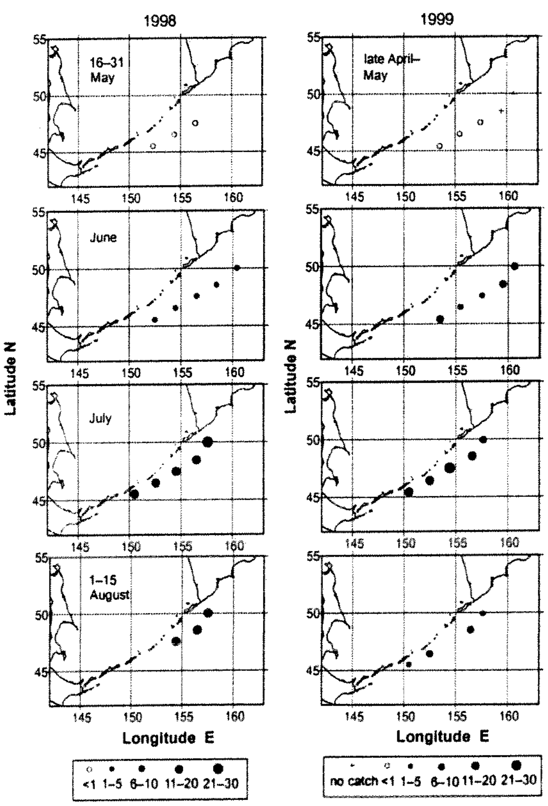


Fig. 6. Pink salmon fork length and percent of males during May–August 1998 and 1999 (arrows indicate boundary of runs).

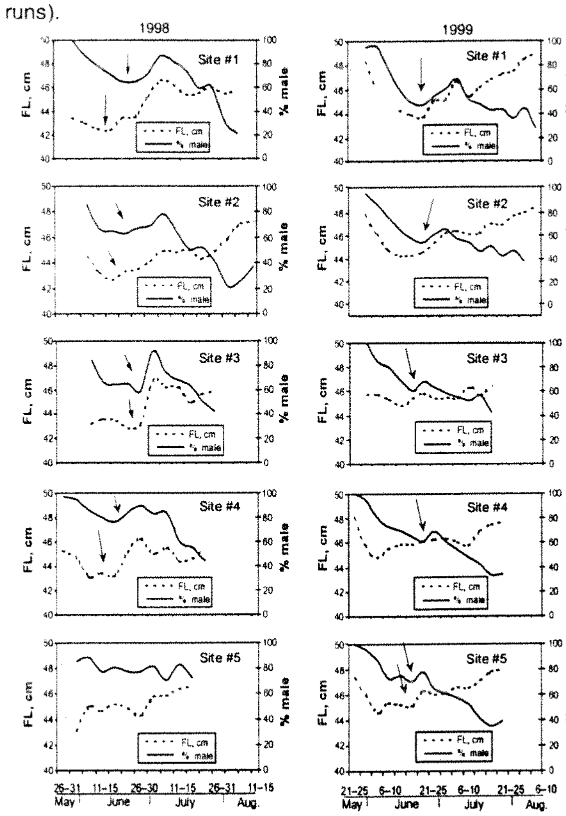


Fig. 7. Pink salmon GSI for males (left) and females (right) in May–August 1998 (arrows indicate boundary of runs).

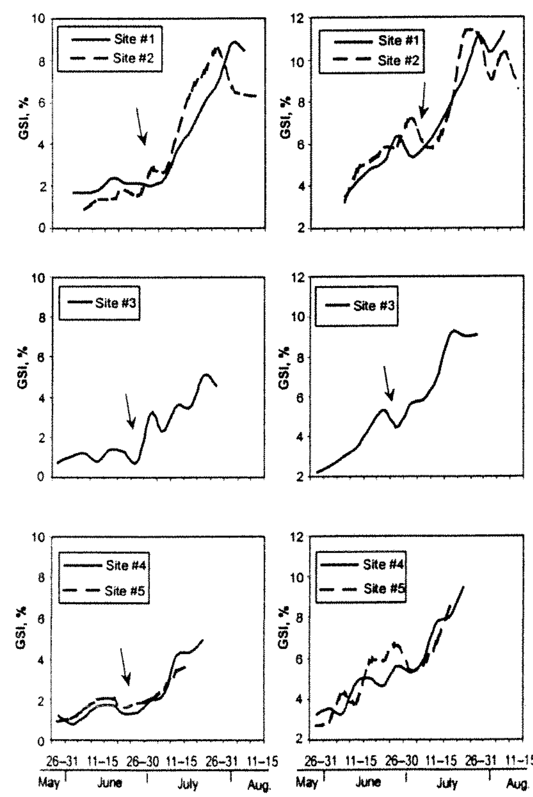


Fig. 8. Pink salmon GSI for males (left) and females (right) in May–August 1999 (arrows indicate boundary of runs).

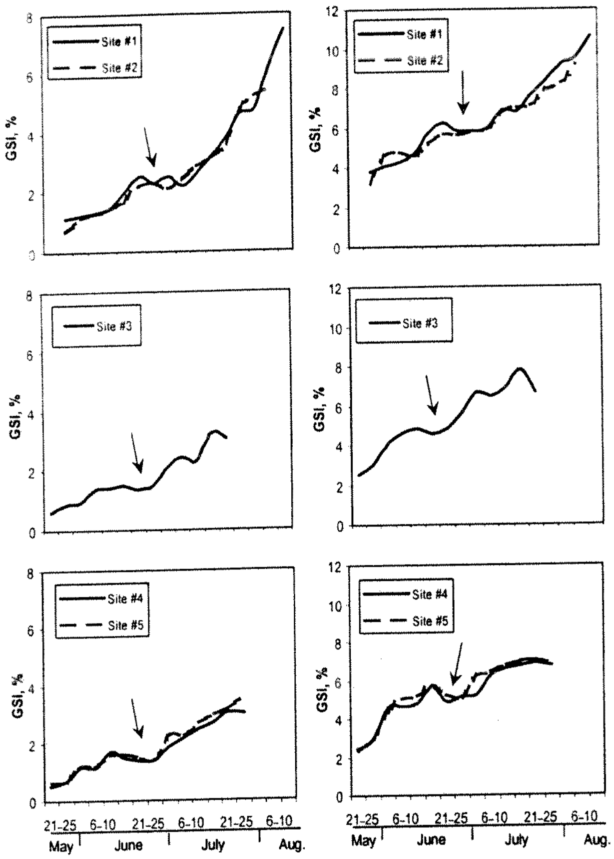


Fig. 9. Pink salmon CPUE during May–August 1996 and 1997 (arrows indicate boundary of runs).

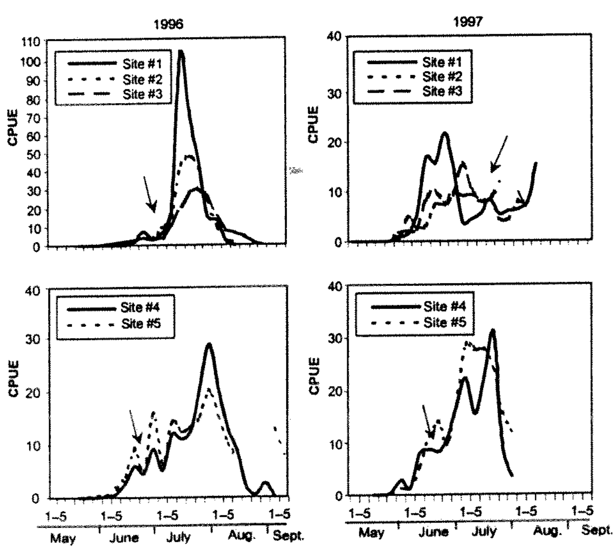
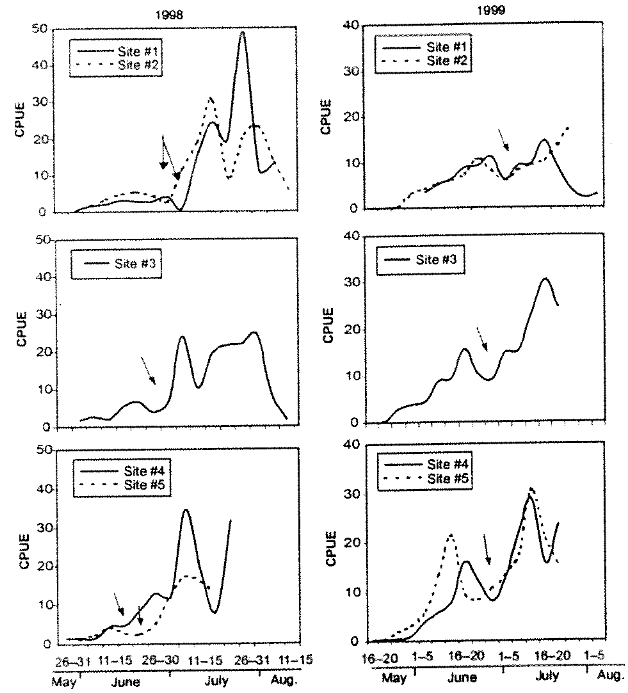


Fig. 10. Pink salmon CPUE during May–August 1998 and 1999 (arrows indicate boundary of runs).



RESULTS

The first pink salmon migrating to spawning streams around the Okhotsk Sea shores were caught in driftnets 200 miles to the north of the Kuril Islands in late April. In the southern part of the study region, pink salmon began appearing regularly in catches around 16–20 May, and in the northern part of the region 10–15 days later. Within this period SSTs were 2.2–2.8°C (Fig 2). In late May to early June pink salmon were distributed throughout the Pacific waters off the Kuril Islands, but in low abundance (CPUE 0.01–0.03fish/net, Figs. 3–5). The proportion of males in May catches was 95–100% (Fig. 6). Gonad maturity index was low: GSI of males was 0.6–1.0% and of females 2.5–3.2% (Figs. 7, 8).

After early June abundance of pink salmon increased, the peak occurring between 16–20 of June in the southern area, and between 25–30 of June in the northern area, when CPUE was 15–20 fish/net (Figs. 9, 10) in some years. The proportion of males gradually decreased to 30–40%, but GSI slowly increased: for males, to 1.8–2.5%; for females, to 5.6–6.2%. By the end of June CPUE always decreased, appearing to end the pink salmon run.

CPUE began to increase in late June to early July when SST was higher than 4.8–6.0°C (Fig. 2). Maximum CPUE of pink salmon occurred in mid to late July: in the southern area CPUE increased to 30–35 fish/net, in the northern area to 80–100 fish/net. In late July to early August CPUE for pink salmon in the Kuril waters sharply decreased (Figs. 9, 10). Sex ratios in July changed gradually in favour of females, reaching 60–70% by the end of the month (Fig. 6). Fish maturity substantially increased, with the male GSI rising to 5–6%, and female GSI to 8–10% (Figs. 7, 8).

In 1998 the more frequent sampling showed that all observed changes were interrelated. Over the wide area from 46° to 51°50'N, changes in CPUE and biological properties occurred at each site in turn, from south to north, over a very short period of 10–15 days (Figs. 6, 7, 10). The same picture was observed in 1999, when in late June to early July the CPUE decrease and increase of pink salmon were accompanied by a sharp increase in length and percentage of males (Fig. 6). Maturity decreased in this period (Fig. 8.). As in 1998, this change occurred at all sites during a short period and from south to north. (Figs. 6, 8, 10).

The majority of ships left the survey areas in August and September, but occasional observations showed that the pink salmon run in Kuril waters continued during this period. Through August and early September at some sampling sites off the Kuril Islands the CPUE of pink salmon reached 5–10 fish/net, while the percentage of males was higher comparatively than those at the end of July. Pink salmon were 50–60% males at the fifth site in early September of 1994, and at the first site in the third week of August, 1995. During the third week of July and the first week of August, 1996, the percentage of males increased from 22–36% to 50–58% at sites # 1 and # 2, and GSI simultaneously decreased (male GSI was almost 2%; female GSI 1%). In the third week of July, 1997, the percentage of adult male pink salmon in catches increased from 41% to 49–52%. This was accompanied by some decrease in maturity and an apparent rise in their size-weight indices. Fish weight, for instance, increased from 1.26–1.28 kg. in the first half of July to 1.40–1.48 kg. by the end of July. The percentage of males at site # 2 in the early half of August, 1998, increased from 21% to 38%, again accompanied by a decrease in maturity and a rise in their size-weight indices. During this period at site # 5 the proportion of males was stable at 48% until mid-August, but the size of fish was significantly larger, comparable to sizes at the end of July. At the end of July beginning of August of 1999, the proportion of males in some catches of pink salmon rose from 26–35% to 49–51% at sites 1 and 2. Because these observations in August–September were unsystematic, are not presented in tables and figures.

DISCUSSION

The maps of salmon seasonal distribution (Fig. 3–5), show pink salmon moving into the waters off the Kuril Islands in May. Pink salmon become most abundant in July, but their run in Kuril waters continues in August and even in early September. Superficially there appears to be one pink salmon run, but lasting in Kuril waters for four months, exceeding by three times the duration of the run near shore. However, the CPUE of pink salmon off the Kuril Islands and the changes in their biological characteristics show that homing migrations occur in three distinct runs, characterized by their temporal patterns. Early summer pinks constitute the first run during late May–June. They are followed by the late summer pinks (the end of June–July). The final fall run of pink salmon occurs through August–September.

The end of early summer and the beginning of late summer pink salmon runs are marked by the decrease-increase in CPUE at the turn of June and July, accompanied by the increase in percentage of males in catches, and also the increase in fish length and decrease in their maturity. This change occurred rapidly, in 10–15 days. In 1996–1997 the changes in CPUE and biological indices were not often visible due to the low frequency of sampling. In 1998–1999 with the higher frequency of sampling, the concurrent change in CPUE and biological indices was apparent. The CPUE decrease-increase occurred not only at the turn of June and July, but also during July. These changes in CPUE and biological indices have not been linked to the beginning and end of separate runs because the June–July changes occur sequentially from south to north, and the later changes, in July and August, were never associated with definite dates, and never accompanied by significant changes in biological indices.

The temporal separation between early summer and late summer runs in the ocean is apparent, but we still have insufficient data from July and August to clearly distinguish the fall run. However, pink salmon certainly occur in Kuril waters till early September with larger proportion of male adults in some runs compared with July. It is not clear yet whether pink salmon enter the Kuril straits from southwest or, on the contrary, from the northwest, nor how wide their migration band is.

The three seasonally spaced runs of Okhotsk Sea pink salmon differ both in abundance and ecology. The Okhotsk Sea pinks overwinter in a zone of the North Pacific Current in two stock groups (Yerokhin 1990). The northern less abundant group of pink salmon is distributed from 42° to 44°N, and spends the winter at SST 2–6°C, mean SST 4.5°C. The southern group is larger in number and distributed from 38° to 42°N. This group spends the winter at SST 4.3–9.6°C, on average 5.6–6.5°C. In spring, pinks migrate northwestward to the spawning areas by following the 2°C isotherm line (Yerokhin 1990). We observed pink salmon runs in the Kuril waters at

SST 2.2–2.8°C, while the temperature of the Okhotsk Sea off the mainland coast was 0°C. However, it is not the main body of the Okhotsk Sea pink salmon population but only early summer groups that pass through the Kuril straits in May and June at low SST. The early summer run and the groups of pink salmon described by Yerokhin (1990) may be identical. Some 1-year old pink salmon stay in the southeast Okhotsk Sea until January (Radchenko et al. 1991). However, it is uncertain yet whether this group is the same as a stock overwintering in the north. Late summer pink salmon follow the early summer run when SST rises to 5–6°C. SSTs are even higher, 10–12°C, when the fall run replaces the early summer run.

Currently there is only one stock of pink salmon in the Okhotsk Sea Basin which is abundant enough to support a commercial fishery. This stock originates from the northern Okhotsk Sea coast and migrates in July (Golovanov 1982). Therefore we believe that pink salmon from this region constitute the bulk of the early summer run migrating into the waters off the Kuril Islands in May and June. The minority of the same run originates from another traditional spawning area–the Kuril Islands (Ivankov 1967, 1997) and eastern Sakhalin. The abundant late summer stock from western Kamchatka, eastern Sakhalin and, partially, from the south of Kuril Islands makes up the July run. In August–September a relatively small fall pink salmon run arrives in this area, the majority of which migrates to spawn in rivers of southern Kuril and Hokkaido islands.

According to Takagi et al. (1981), pink salmon of northern Okhotsk Sea migrate to spawn mainly through the northern straits of Kuril Islands. According to Shuntov (1994), pink salmon of western Kamchatka and the majority of pink salmon of eastern Sakhalin migrate towards those northern straits. Our observations show that both early and late summer runs migrate towards the Kuril straits in a broad line 500 kilometers in width, and they are found outside the Kuril straits between the Freeze Strait and the First Kuril Strait. In June and July dense aggregations of pink salmon, first early, then late runs, occur not only in the vicinity of the Kuril straits north of 47°N, but also in the Freeze, Urup and Bussol straits (Fig. 3–5). The existence of pink salmon runs near these straits should be taken into account when considering pink salmon spawning migrations proposed by Takagi et al. (1981) and Shuntov (1994).

Fluctuations in timing and abundance of runs, and sampling limitations hinder conclusions about run structure. Nevertheless, the run structure we have proposed is in accordance with conclusions drawn earlier from the distribution of spawning areas, and it appears to be a reasonable picture of what is occurring in the ocean.

CONCLUSION

Studies of pink salmon homing migration in waters off the Kuril Islands suggest that it lasts 4 months. The run timing is complex. During May–June a stock of Okhotsk Sea pink salmon, corresponding to an early summer run, migrates through Kuril waters. Pink salmon form large aggregations in July during the migration of the late summer run, which constitutes the bulk of the Okhotsk Sea pink salmon population. Abrupt changes in pink salmon CPUE and in length, sex ratios and maturity at the turn of June–July indicate the end of the early and beginning of the late summer runs. Early and late summer runs migrate to a spawning area at different SSTs. The fall run of Okhotsk Sea pink salmon appears in the Kuril basin around July–August. Low abundance of this run makes it difficult to differentiate from the previous run. On the whole, pink salmon occurring in Kuril waters may be divided into three runs: early and late summer, and fall runs. Each run continues for about one month, and is identifiable by characteristics similar to those of runs near the spawning areas: increase in CPUE during the run, decrease in proportion of males, and increase in maturity. The pink salmon runs that we have distinguished in the ocean correspond to those arriving at the spawning grounds.

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