

Early Summer Movements of Tagged Pink Salmon off Southwestern Sakhalin Island, 1995–1998

I.M. Ivanova

Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO)
196 Komsomolskaya St., Yuzhno-Sakhalinsk, 693023 Russia



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Abstract: A tagging experiment on mature pink salmon (*Oncorhynchus gorbuscha*) was conducted from small fishing vessels in southwestern Sakhalin coastal waters during June–July from 1995 to 1998 during the period of their feeding migration. In total 17,696 fish were tagged and released, and 1,225 or 6.9% were recaptured. Recaptures were distributed mainly along Sakhalin Island: 1,195 fish along the southwestern coast (95.7%), 21 fish in Aniva Bay (1.7%), 5 fish in the Terpeniya Gulf (0.4%). A few tagged fish were recaptured outside Sakhalin Island in the River of Tumnin, Khabarovsk Territory (1 fish), and near the Soya Cape, Hokkaido, Japan (2 fish). The majority of tagged fish were recaptured in Sakhalin waters. Movements of tagged pink salmon were observed along southwestern Sakhalin coast both northward, and southward to bays Aniva and Terpeniya, and northwestern Hokkaido.

INTRODUCTION

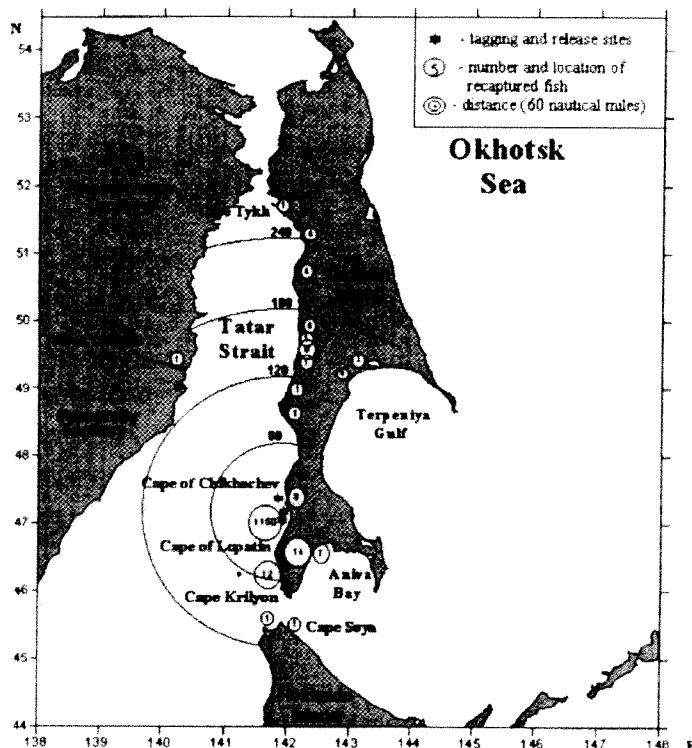
Pink salmon (*Oncorhynchus gorbuscha*) that have over-wintered in the Sea of Japan complete their final summer feeding, as indicated by their distended stomachs, in the coastal waters of southwestern Sakhalin at temperatures of 6–9°C. Pink salmon first arrive in this area in late May. For 1.5–2 months (June to early July) they form commercial aggregations near the southwestern Sakhalin coast (Dvinin 1949, 1950; Landyshevskaya 1962; Landyshevskaya and Volovik 1967). The main aggregations are usually observed in coastal waters north of Cape Lopatin and south of Cape Chikhachev (Fig. 1). Fishing is conducted with traditional gear—gigantic trap nets. For the last 40 years salmon catches here varied from 110 to 16,130 tons (Ivanova 1997).

There are no rivers on this part of the coast with high quality spawning grounds for pink salmon. The main spawning areas are located in rivers of the middle and northern parts of Sakhalin Island. Pink salmon caught off southwestern Sakhalin Island have poorly developed gonads: in May gonads make up 1.2% of body weight of males, and 3.2% of females; in June, mean gonad weight increases to 3.1% for males, and 5.7% for females; in early July it is 4.8% for males and 6.9% for females.

A tagging experiment was conducted to determine the movements of pink salmon and their distribution while feeding in the coastal zone of

southwestern Sakhalin Island. The results are the subject of this work.

Fig. 1. Release and recapture sites and numbers of pink salmon tagged in southwestern Sakhalin waters in 1995–1998. Portions of circles show straight-line distances (nautical miles) from the central release site.



MATERIAL AND METHODS

The tagging experiment on maturing pink salmon was conducted in June–July 1995–1998. Due to differences in time, duration of movement and catches for pink salmon occurring in coastal waters from Cape Lopatin to Cape Chikhachev, we divided this coastal zone into three tagging sites: 47°03'N and 141°58'E (1st southern site), 47°08'N and 141°59'E (2nd central site), 47°23'N and 141°57'E (3rd northern site). In 1995 tagging was carried out at all three sites from 10 June to 15 July, the majority of tagging in June (Table 1). In 1996 because of variable and small salmon runs to coastal waters, tagging was carried out only at two sites (1st and 2nd) from 14 June to 17 July, the majority again in June. In 1997 tagging was carried out at all three sites, but only from 11 to 27 June. In 1998 tagging was carried out only at the 2nd site from 9 June to 6 July.

Pink salmon were caught by trap nets, and transported in live-holds aboard boats to offshore waters a distance of 5–5.5 km, tagged and released. Water in live-holds was aerated for maximum survival. Fresh seawater was pumped under high pressure and sprayed into the holds. Survival during transportation was 98–100% (Ivanova 1997).

Fish were tagged with bright red plastic tags 25 mm long and 5 mm wide. A tag was attached to the flesh in front of the dorsal fin with a 10–12 mm fish-hook. Tags had a number and address, and an appeal to send or report the tag to SakhNIRO or Fishing Inspection. To encourage returns, announcements were made on the radio, TV, and in newspapers.

Posters were distributed in the main regions of pink salmon fishing and processing on Sakhalin Island.

Annual catches, distribution, migrations, biological characteristics (length, body weight, absolute fecundity), of mature pink salmon collected in coastal waters and on spawning grounds of the southwestern Sakhalin rivers (within Cape Tykh in the north, and Cape Krilyon in the south of the western Sakhalin coast) were recorded.

The following biological characteristics were used for analyses: fork length (cm), fish weight (g), gonad weight (g), coefficient of maturity (proportion of gonad weight to total weight of fish, %), absolute fecundity (number of eggs) (Pravdin 1966).

RESULTS

The proportion of pink salmon recaptured in rivers and coastal zone varied significantly among years (χ^2 test, $p < 0.01$). Most of this variation arose in 1997 when more tagged fish were recovered in rivers than expected (Table 2).

Recaptures were tabulated by approximate distance north or south of their release site, using the middle site as the starting point (Fig. 1), and by number of days between release and recapture, to look for differences in rate and distance of travel among months (June or July) or years (Table 3–6). This analysis showed no obvious patterns in direction or speed of migration among months or years. Most recaptures occurred within 25 days of release, and rates of travel usually were between 8 and 15 miles per day, with a few individuals travelling much faster (20–60 miles per day over several days). A pink

Table 1. Numbers of maturing pink salmon tagged at three sites near the southwestern Sakhalin coast in 1995–1998.

| Year | Site ¹ of tagging | Number of operations | Number of fish tagged | | Total tagged fish |
|-------|---------------------------------|-------------------------|-----------------------|------|----------------------|
| | | | June | July | |
| 1995 | 1 | 3 | 1657 | 0 | 1657 |
| | 2 | 4 | 2202 | 0 | 2202 |
| | 3 | 2 | 743 | 432 | 1175 |
| | Sub-total | 9 | 4602 | 432 | 5034 |
| 1996 | 1 | 4 | 1280 | 780 | 2060 |
| | 2 | 5 | 3428 | 400 | 3828 |
| | 3 | 0 | 0 | 0 | 0 |
| | Sub-total | 9 | 4708 | 1180 | 5888 |
| 1997 | 1 | 1 | 1099 | 0 | 1099 |
| | 2 | 3 | 1949 | 0 | 1949 |
| | 3 | 1 | 960 | 0 | 960 |
| | Sub-total | 5 | 4008 | 0 | 4008 |
| 1998 | 1 | 0 | 0 | 0 | 0 |
| | 2 | 5 | 1966 | 800 | 2766 |
| | 3 | 0 | 0 | 0 | 0 |
| | Sub-total | 5 | 1966 | 800 | 2766 |
| Total | | 28 | 15284 | 2412 | 17696 |

¹Site locations: 1, 47°03'N, 141°58'E
2, 47°08'N, 141°59'E
3, 47°23'N, 141°57'E

Table 2. Recaptures of tagged pink salmon by regions (coast and rivers).

| Return location | Region | Year of tagging (Number of recaptured fish) | | | | Total recaptures in region | |
|----------------------|-----------------|--|----------------|----------------|----------------|----------------------------|------------|
| | | 1995 (5034) | 1996 (5888) | 1997 (4008) | 1998 (2766) | Number | Percentage |
| | | River | S-W Sakhalin | 8 | 4 | 12 | 9 |
| | Aniva Bay | 5 | 5 | 4 | 0 | 14 | 26.4 |
| | Terpeniya Gulf | 1 | 4 | 0 | 0 | 5 | 9.4 |
| | Tumnin River | 0 | 0 | 0 | 1 | 1 | 1.9 |
| | Okhotsk Sea * | 0 | 0 | 0 | 0 | 0 | 0 |
| | Hokkaido Island | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 14 | 13 | 16 | 10 | 53 | 100 |
| Coast | S-W Sakhalin | 434 | 414 | 246 | 68 | 1162 | 99.1 |
| | Aniva Bay | 7 | 0 | 0 | 0 | 7 | 0.6 |
| | Terpeniya Gulf | 0 | 0 | 0 | 0 | 0 | 0 |
| | Tumnin River | 0 | 0 | 0 | 0 | 0 | 0 |
| | Okhotsk Sea * | 0 | 1 | 0 | 0 | 1 | 0.1 |
| | Hokkaido Island | 2 | 0 | 0 | 0 | 2 | 0.2 |
| | Total | 443 | 415 | 246 | 68 | 1172 | 100 |
| Total | S-W Sakhalin | 442 | 418 | 258 | 77 | 1195 | 97.5 |
| | Aniva Bay | 12 | 5 | 4 | 0 | 21 | 1.7 |
| | Terpeniya Gulf | 1 | 4 | 0 | 0 | 5 | 0.4 |
| | Tumnin River | 0 | 0 | 0 | 1 | 1 | 0.1 |
| | Okhotsk Sea * | 0 | 1 | 0 | 0 | 1 | 0.1 |
| | Hokkaido Island | 2 | 0 | 0 | 0 | 2 | 0.2 |
| | Total | 457 | 428 | 262 | 78 | 1225 | 100 |
| Percentage of return | | 9.1 | 7.3 | 6.5 | 2.8 | 6.9 | - |

*tag was returned without information on date and location of recaptured fish

Table 3. Distance and time between release and recapture of pink salmon tagged in 1995, and direction north or south of release site.

| Distance (nautical miles) from release location * | Days after release | | | | | | Average Time | Av. Nautical miles/day | |
|--|--------------------|------|-------|-------|-------|-------|-----------------|---------------------------|------|
| | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-30 | | | |
| June | | | | | | | | | |
| North | 241-300 | | | 4 | 1 | | | 14.0 | 19.3 |
| | 181-240 | | | | | | | | |
| | 121-180 | | | 1 | | | | 12.0 | 12.5 |
| | 61-120 | | 1 | | | | | 11.0 | 8.2 |
| within 60 miles | | 248 | 65 | 87 | 4 | 6 | 5 | 6.3 | 4.8 |
| | 61-120 | 1 | 1 | | | | | 5.2 | 17.4 |
| South | 121-180 | | 2 | | 7 | 3 | | 17.6 | 8.6 |
| | 181-240 | | | | | | | | |
| | 241-300 | | | | 1 | | | 18.0 | 15.0 |
| July | | | | | | | | | |
| North | 241-300 | | | | | | | | |
| | 181-240 | | 1 | | | | | 7 | 30.1 |
| | 121-180 | | | | | | | | |
| | 61-120 | | | | | | | | |
| within 60 miles | | 12 | 3 | 4 | | | | 5.6 | 5.4 |
| | 61-120 | | | | | | | | |
| South | 121-180 | | | | | | | | |
| | 181-240 | | | | | | | | |
| | 241-300 | | | | | | | | |
| Total recaptured | | 261 | 73 | 96 | 13 | 9 | 5 | | |

*central tagging and release site (2nd) is assumed starting point for calculating distance.

Table 4. Distance and time between release and recapture of pink salmon tagged in 1996, and direction north or south of release site.

| Distance (nautical miles) from release location * | Days after release | | | | | Average Time | Av. Nautical miles/day |
|--|--------------------|------|-------|-------|-------|-----------------|---------------------------|
| | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | | |
| June | | | | | | | |
| North 241-300 | | | | | | | |
| North 181-240 | | | | 2 | 1 | 19.7 | 10.7 |
| North 121-180 | | | | | | | |
| North 61-120 | | 1 | | | | 7.5 | 12.1 |
| within 60 miles | 358 | | | | | 2.5 | 12.0 |
| South 61-120 | | | | | | | |
| South 121-180 | | 1 | | | | 8.0 | 18.8 |
| South 181-240 | | | | | | | |
| South 241-300 | 1 | 1 | | | | 5.2 | 52.0 |
| July | | | | | | | |
| North 241-300 | | | | | | | |
| North 181-240 | | | | | | | |
| North 121-180 | 1 | | | | | 2.5 | 60.2 |
| North 61-120 | | | | | | | |
| within 60 miles | 56 | | | | | 2.5 | 12.0 |
| South 61-120 | | | | | | | |
| South 121-180 | | | 2 | 2 | | 20.5 | 7.3 |
| South 181-240 | | | | | | | |
| South 241-300 | | 1 | | | 1 | 15.1 | 17.9 |
| Total recaptured | 416 | 4 | 2 | 4 | 2 | | |

*central tagging and release site (2nd) is assumed starting point for calculating distance.

Table 5. Distance and time between release and recapture of pink salmon tagged in 1997, and direction north or south of release site.

| Distance (nautical miles) from release location * | Days after release | | | | | Average Time | Av. nautical miles/day |
|--|--------------------|------|-------|-------|-------|-----------------|---------------------------|
| | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | | |
| June | | | | | | | |
| North 241-300 | | | | | | | |
| North 181-240 | | | | | | | |
| North 121-180 | | 7 | 2 | | 1 | 10.5 | 14.3 |
| North 61-120 | | | | | | | |
| within 60 miles | 155 | 82 | 3 | 8 | | 4.9 | 6.1 |
| South 61-120 | | | | | | | |
| South 121-180 | | 1 | 1 | 1 | 1 | 15.5 | 9.7 |
| South 181-240 | | | | | | | |
| South 241-300 | | | | | | | |
| Total recaptured | 155 | 90 | 6 | 9 | 2 | | |

*central tagging and release site (2nd) is assumed starting point for calculating distance.

Table 6. Distance and time between release and recapture of pink salmon tagged in 1998, and direction north or south of release site.

| Distance (nautical miles) from release location * | Days after release | | | | | Average Time | Av. nautical miles/day |
|--|--------------------|------|-------|-------|-------|-----------------|---------------------------|
| | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | | |
| June | | | | | | | |
| North 241-300 | | | | | | | |
| North 181-240 | | | | | | | |
| North 121-180 | | | | 1 | | 19.0 | 7.9 |
| North 61-120 | | | | | | | |
| within 60 miles | 31 | 6 | 4 | | | 4.3 | 7.0 |
| South 61-120 | | | | | | | |
| South 121-180 | | | | | | | |
| South 181-240 | | | | | | | |
| South 241-300 | | | | | | | |

continue...

Table 6. continued.

| Distance (nautical miles) from release location * | Days after release | | | | Average Time | AV nautical miles/day |
|--|--------------------|------|-------|-------|-----------------|--------------------------|
| | 0-5 | 6-10 | 11-15 | 16-20 | | |
| | July | | | | | |
| North | | | | | | |
| 241-300 | | | | | | |
| 181-240 | | | | | | |
| 121-180 | | | | | | |
| 61-120 | | 1 | | | 10.0 | 9.1 |
| within 60 miles | 8 | 27 | | | 6.7 | 0.5 |
| 61-120 | | | | | | |
| South | | | | | | |
| 121-180 | | | | | | |
| 181-240 | | | | | | |
| 241-300 | | | | | | |
| Total recaptured | 39 | 34 | 4 | 1 | | |

*central tagging and release site (2nd) is assumed starting point for calculating distance.

salmon tagged in July 1998 and recaptured in the River Tumnin 10 days later travelled a distance of more than 160 nautical miles. Another recaptured in the Krasnogorka River (southwest Sakhalin Is.) nine days after release had travelled about 90 nautical miles (Table 6).

Although there was no discernible relation between month or year of release of tagged fish and direction in which they later were recaptured, there was a definite relation among the three release sites and direction of recapture. Of all fish released from the most southerly site (site 1), 45.2% (97 fish) migrated southwards, and 54.7% (117 fish) migrated northwards (direction not significant, $p > 0.05$, binomial distribution). At site 2 (middle), 73.1% (629 fish) migrated mainly southwards, and 26.7% (229 fish) migrated northwards (difference in direction significant, $p < 0.01$, binomial distribution). One fish migrated in a northwest direction and was recaptured in the River Tumnin. At site 3 (most northerly), 94% (142 fish) migrated southwards, and only 6.0% (9 fish) migrated northwards ($p < 0.01$, binomial distribution). The differences in direction from release sites were statistically significant ($\chi^2 = 100$, $p < 0.001$).

The period between release and recapture along the southwestern coast of Sakhalin Island varied among months and years from 2.5 to 20 days on average (Tables 3-6), and for individual fish from a few hours to 30 days. The period between release of the 21 fish recaptured in Aniva Bay was 8 to 20.5 days, and of the seven fish recaptured in Tereniya Gulf 5.2 to 18 days. One tagged pink salmon was recaptured in coastal waters off Hokkaido Island six days after release, and another individual was recovered at Hamasaruhtsu Fish market, Hokkaido Island, four days after release.

DISCUSSION

The comparison of data collected in June-July 1995-1998 with the results of earlier tagging studies has revealed the general pattern of Japanese Sea pink

salmon migrations at the final stage of feeding along the southwestern Sakhalin coast.

Earlier Russian and Japanese studies have shown that two pink salmon stocks spend the winter in the southwestern part of the Sea of Japan, one in Korean Bay and the other near the southwestern Hokkaido coast (Okushiri Island) (Kaganovsky 1949; Hirano 1951; Dvinin 1952; Enutina 1954; Miyaguchi 1957). Further, pink salmon migrate from the southwestern part of the Sea of Japan northwards, and in May they mix with those wintering near Hokkaido Island and continue migrating to waters of Tatar Strait. In the region of 46°N they distribute by the individual areas: Primorye coast, West Sakhalin and partially through La Perouse Strait to the Okhotsk Sea. North of 47°N pink salmon annually migrate to the Primorye coast (Hirano 1951; Darda 1968). The distribution of tagged fish within the rather wide area near Okushiri Island in 1958, 1960, 1961 and near southwestern Sakhalin Island in 1958, 1962 (Dvinin 1958; Landyshevskaya 1962), 1969, 1973, and 1979 (Efanov and Ivanova 1979—SakhNIRO archives "unpublished data") has been documented through tagging. Tag returns were recovered from the western and eastern Sakhalin coasts, Aniva Bay, Primorsky Territory, Khabarovsk Territory, Sakhalin Bay and the northern coast of the Okhotsk Sea. The main results of our experiment illustrate the distribution of tagged pink salmon towards the regions of their reproduction on Sakhalin Island and Khabarovsk Territory after completion of their feeding migration along southwestern Sakhalin. Unusually, tagged pink salmon were recaptured near Hokkaido Island; this is the first such record.

In addition, the analysis of scale patterns from pink salmon caught at feeding sites and in spawning rivers, allowed us to conclude that mixed pink salmon stocks mainly reproducing on Sakhalin Island, fed along the southwestern Sakhalin coast (Ivanova 1990, 1994, 1997, 1999).

As we have already noted, the pink salmon tagged at different sites migrated mainly in two directions—north and south. Almost 70% of the total

tagged fish migrated to the south, in accordance with the results of tagging in 1947, but in contrast with the distribution of 1962 (Dvinin 1947; Landyshevskaya 1962). In the opinion of A.E. Landyshevskaya, the predominant direction of pink salmon migrations after feeding in the southeastern part of Tatar Strait is determined mainly by their abundance on the feeding grounds.

The results of our long-term attempts to increase the abundance of southwestern Sakhalin pink salmon populations through management provide indirect evidence of mixed stocks growing in southwestern Sakhalin waters. Management by restricting the catch, or the number of trap nets and fishing intervals, and even a full fishery closure in the coastal zone for almost 11 years in the mid 1970s, were not a success. Spawners on spawning grounds of the southwestern Sakhalin rivers did not increase in number.

The recapture of the majority of tagged pink salmon along southwestern Sakhalin Island, and the different directions of their migration from different tagging sites are explained, to a great extent, by the behavior of these pink salmon during feeding and maturation. Favorable temperature and food conditions in the coastal zone allows them to remain in this area until sexually mature, when they migrate to spawning areas.

The method of tagging used in this experiment can also be used for tagging salmon at their final stages of growth or migrations in the sea. Its application does not demand any special equipment or great financial expenditure. A well organized tag collection program in regions of expected catches of tagged fish is the condition required for a successful experiment.

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