# INTRODUCTION INTO AYSEN CHILE OF PACIFIC SALMON

No. 2

## Transportation and Rearing Trials with Chum Salmon *(Oncorhynchus keta),* 1973-1975

by
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1976

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## SUMMARY

This paper is the second report of the program to introduce species of the Pacific salmon into the central province of Aysen, Chile. The program is being developed by the Division Proteccion Pesquera (formerly Pesca y Caza), Servicio Agricola y Ganadero, Chile, in association with experts from the National Salmon Hatchery Service, Hokkaido, Japan.

The first report described the preliminary trials with the cherry salmon (*Oncorhynchus masou*) in 1972 and 1973. This report deals with the transportation and rearing of the chum salmon (*Oncorhynchus keta*). Specific reference in the paper is made to:

1. The life history of the chum salmon in Japanese waters,
2. Egg collection and shipment to southern Chile from Japan,
3. Rearing and production in the Simpson River, Aysen,
4. Liberation data,
5. Enhancement data.

Successful transshipment of 5 million eggs of the chum salmon was made between 1973 and 1975. The first shipments of eyed eggs were reared in a temporary covered channel in the bed of the Claro River, and subsequent shipments in incubator channels in a salmon hatchery at Coyhaique in Aysen. About 4 million sac fry were released into the river in those years, or taken downriver to be released in the fjord area close to Aysen. The first returns of the fish released in 1974 are anticipated in 1977.



The program was supported through bilateral assistance of the Japan International Cooperation Agency (JICA) to the Government to Chile.

# INTRODUCTION

Nagasawa and Aguilera (1974) reported the first releases of *Oncorhynchus masou*, the Japanese cherry salmon, into the coastal waters of southern Chile near Aysen. The releases were part of a joint program by the Division de Proteccion Pesquera, Servicio Agricola y Ganadero, Chile, and the Japan International Cooperation Agency (JICA) to introduce Pacific salmon species into the country. The project was begun in 1972 with the transportation of 150,000 eyed eggs and the release of 85,000 fry. The goal of the program was to develop an economic fishery for salmon in the region, and to supplement the sport and recreational fishery.

The migratory passage of the juvenile salmon from Aysen to the open sea was uncertain. There were four possibilities. The juveniles could (1) remain in the fjord regions of that area, (2) move out but remain along the coastal area, (3) drift north in the Humboldt current into an inhospitable warm environment, or (4) drift south into the colder waters of the Southern Ocean. Only the northerly migration into tropical waters would prevent the establishment of salmon species in the region, as the feeding grounds were thought to be adequate to sustain a fishery for salmon.

Introductions of salmon species into the Southern Hemisphere had been made previously. Chile itself has resident populations of brown trout (*Salmo trutta*) and rainbow trout (*S. gairdneri*); New Zealand has established the brown trout (*S. trutta*) and the landlocked *Salmo salar* and *Oncorhynchus nerka*; Tasmania has *S. trutta* and *S. gairdneri*, and introduced *S. salar*; and other countries have freshwater species as reminders of the wide dispersion of salmonids early in the century.

The five-year bilateral program required Japan to provide the assignment of experts, equipment and supplies, and the provision of the eyed ova. Chile would provide counterpart staff, and construct a hatchery on suitable property. The hatchery was located at Coyhaique in the Province of Aysen, with access to the water of the Claro River, which joined the Simpson River nearby.

The first releases of the fry of *O. masou* were not successful (Nagasawa and Aguilera, 1974). The hatchery was not ready, and losses were sustained in both the temporary gravel incubators and during flooding which followed. The shipments of eyed ova were also small. In 1974 the major shipment of *Oncorhynchus keta*, the chum salmon, was made for the first time. One million eggs were transported to Coyhaique from National Salmon Hatchery Service in Japan, in March of that year, and after one more million eggs were transported in November of the same year, and incubated in the new hatchery before release into the Simpson River.

## SELECTION OF SPECIES

The chum salmon (*O. keta*) and pink salmon (*O. gorbuscha*) were considered to be appropriate species for introduction into Chile. The techniques for raising these two species, compared with those for the coho (*O. kisutch*), sockeye (*O. nerka*) or cherry (*O. masou*) are more established; the young fry can be released into saltwater quite early in their development, thus reducing the need for artificial feeding for long periods; and the behavior is thought to be more appropriate to the anticipated migratory movements offshore. Furthermore, and most significant, the large number of eggs required for shipping could be supplied from the chum and pink salmon hatcheries of the National Salmon Hatchery Service in Hokkaido. About 400–600 million eggs are taken from returning chum salmon each year in Hokkaido (Table 1 and Figure 1), and this would guarantee a large and continual supply of eyed ova for Chile each year of the program.

The new species were not anticipated to interfere with the resident populations of fish in the inland waterways. In fact, the Simpson River is one of the most famous for the largest brown trout and rainbow trout, which would be voracious predators of the young migrating fry. Any returning chum or pink salmon to the hatchery would not be competitors for food in the river as the Pacific species do not feed once they have returned to the fresh water to spawn.

Both chum and pink salmon have a simple life cycle. The cycle of the pink salmon is shorter than that of the chum. The time from egg to returning adult is about two years compared with the 3–5 years of the far-ranging chum salmon. Although returning pink salmon would demonstrate the success of the introduction of Pacific salmon into Chile in a shorter time, there were many arguments in favor of developing the project with the chum. For example, (1) the pink salmon fishery in Japan fluctuates between a large run on the odd year, and a small run every even year. Potential for maintaining large shipments of eyed ova each year was therefore restricted. (2) The season when the pink salmon return to fresh water, in Japan, and the lengthier time in fresh water before spawning, made it more difficult to synchronize the tolerable seasons in Chile, which are, of course, reversed. (3) The pink salmon produces fewer eggs than the chum salmon. And (4), the commercial value of chum salmon is greater than that of the pink salmon because the fish is larger and is more easily processed. A comparison of data for chum, pink and cherry salmon in Japan are given in Tables 2 and 3. The main emphasis of the enhancement program in Chile was therefore based on the use of the chum salmon, *O. keta*.

The chum salmon generally reach maturity at 3–5 years of age and return to their origin to spawn. Precocious two-year-old fish (mostly males) are not unknown. The average age of fish returning to Hokkaido and Washington, U.S.A. (1973–1975 data) is as follows:

| Age (years) | Hokkaido (%) | Washington (%) |
|---|---|---|
| 2 | 0.8 | — |
| 3 | 33.7 | 35.0 |
| 4 | 60.1 | 60.0 |
| 5 | 5.2 | 5.0 |

Table 1. Average egg collection by species, 1971–1975, Hokkaido, Japan.

| Month | | Chum | | Pink | | | | Cherry | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Odd year | | Even year | | | |
| | | Eggs (x1,000) | % | Eggs (x1,000) | % | Eggs (x1,000) | % | Eggs (x1,000) | % |
| Aug. | Early | – | – | 3 | – | – | – | – | – |
| | Middle | – | – | 3 | – | – | – | 167 | 1.6 |
| | Late | – | – | 63 | 0.1 | 1 | – | 674 | 6.8 |
| Sep. | Early | – | – | 1,909 | 2.0 | 2,179 | 5.1 | 2,109 | 21.2 |
| | Middle | – | – | 4,584 | 4.8 | 8,526 | 19.8 | 3,480 | 34.9 |
| | Late | 4,085 | 0.6 | 10,757 | 11.1 | 14,511 | 33.8 | 2,914 | 29.2 |
| Oct. | Early | 23,429 | 3.4 | 14,249 | 14.8 | 13,277 | 30.9 | 573 | 5.7 |
| | Middle | 71,108 | 10.5 | 21,326 | 22.1 | 3,984 | 9.3 | 47 | 0.5 |
| | Late | 118,321 | 17.4 | 32,969 | 34.2 | 476 | 1.1 | 9 | 0.1 |
| Nov. | Early | 74,558 | 11.0 | 9,393 | 9.7 | 9 | – | – | – |
| | Middle | 96,971 | 14.3 | 1,045 | 1.1 | – | – | – | – |
| | Late | 123,854 | 18.2 | 79 | 0.1 | – | – | – | – |
| Dec. | Early | 115,327 | 17.0 | 5 | – | – | – | – | – |
| | Middle | 51,519 | 7.6 | – | – | – | – | – | – |
| | Late | – | – | – | – | – | – | – | – |
| Total | | 679,163 | 100 | 96,385 | 100 | 42,963 | 100 | 9,973 | 100 |

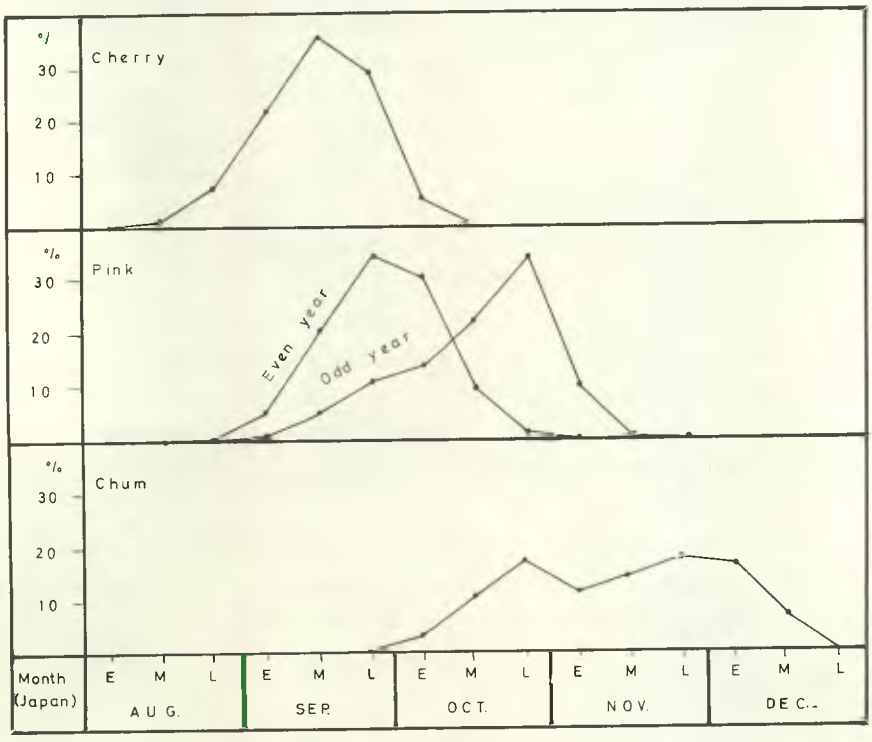


Figure 1. Average monthly distribution of egg collection by species, 1971–1975, Hokkaido, Japan.

Table 2. Percentage of collecting and artificial spawning centers involved in the hatchery propagation program in Hokkaido, 1971–1973.

| Year | O. keta (Chum) | O. gorbuscha (Pink) | O. masou (Cherry) |
|---|---|---|---|
| 1971 | 90.1 | 88.0 | 80.1 |
| 1972 | 90.8 | 81.7 | 81.7 |
| 1973 | 88.5 | 85.5 | 80.4 |
| Average | 90.0 | 85.5 | 80.4 |

Table 3. Data and life history of Pacific salmon in Hokkaido.

| | O. keta (Chum) | O. gorbuscha (Pink) | O. masou (Cherry) |
|---|---|---|---|
| Total length (cm) | 50–90 | 40–55 | 40–60 |
| Body weight (kg) | 2.5–6.0 | 1.5–2.0 | 1.0–3.5 |
| Life span | 3–5 years | 2 years | 3 years |
| Young stay in fresh water | Few days | Few days | 1 year |
| Period of ocean life | 2–4 years | 1.5 year | 1–2 years |
| Anticipated return by month | Sept.–Jan. | July–Oct. | Mar.–July |
| Spawning season | Sept.–Jan. | Sept.–Nov. | Sept.–Oct. |
| Eggs per fish | 3,300 | 1,800 | 2,400 |

In Hokkaido, the returning chum salmon arrive along the coasts between September and January. The peak period is usually late October and November (Figure 1). Natural spawning on the pebble and gravel beds of streams therefore can occur any time until late January, although the majority of eggs are reared in hatcheries as the returning fish are caught in coastal nets and traps constructed on the many small rivers. The eggs of the chum are incubated and the fry emerge in March. The fry of the chum salmon are able to move into saltwater earlier than other Pacific salmon species, and the downstream migration continues throughout April, May and June. The life cycle of the chum salmon is illustrated in Figure 2.

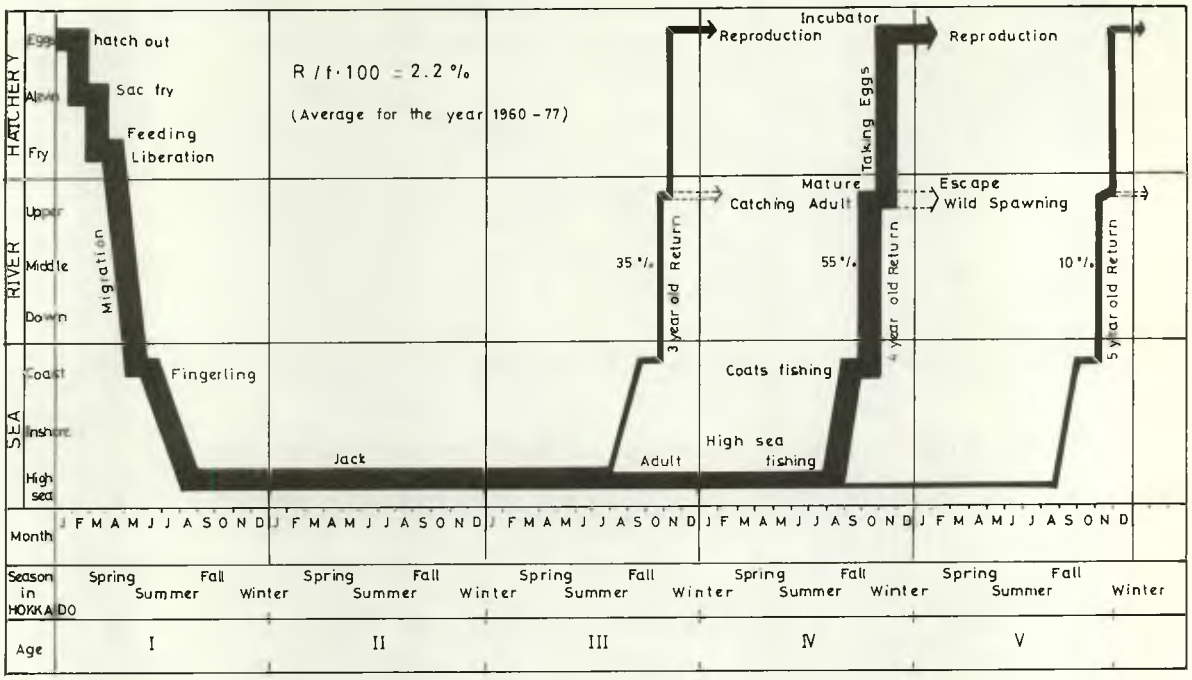


**Figure 2. Enhancement cycle of *Oncorhynchus keta* (Hokkaido, Japan).**

The chum salmon, which may spend from two to four years at sea, may travel 15,000 km and complete several circuits of an ocean current system before returning to its river of origin. Salmon from Hokkaido, for example, journey along the Kuril Islands to the northeast of Japan, follow the East Kamchatka along the coast, and then travel east into the Bering Sea and the North Pacific (Figure 3).

The young fry in the rivers feed on benthos, aquatic insects and other invertebrates. In the coastal seas the juveniles develop strong jaws and sharp teeth and feed on the larger aquatic organisms in the zooplankton. As maturing fish and adults in the ocean of the Pacific Northwest they feed on small fish, euphausids, shrimps, amphipods, copepods, pteropods, squids and jellyfish. In turn, all the stages of salmon are consumed by predators, particularly the marine mammals.

The adult chum salmon are healthy and strong when they return to the coastal estuaries, often collecting in large numbers offshore and feeding for the last time. Then, over a short period of two months, they move in to begin the struggle against the freshwater currents and the lack of food. Exhaustion leaves them bruised and gaunt. The flesh becomes white and flaccid, and the teeth protrude from the jaws. Following the final debilitating act of spawning, the adults die.

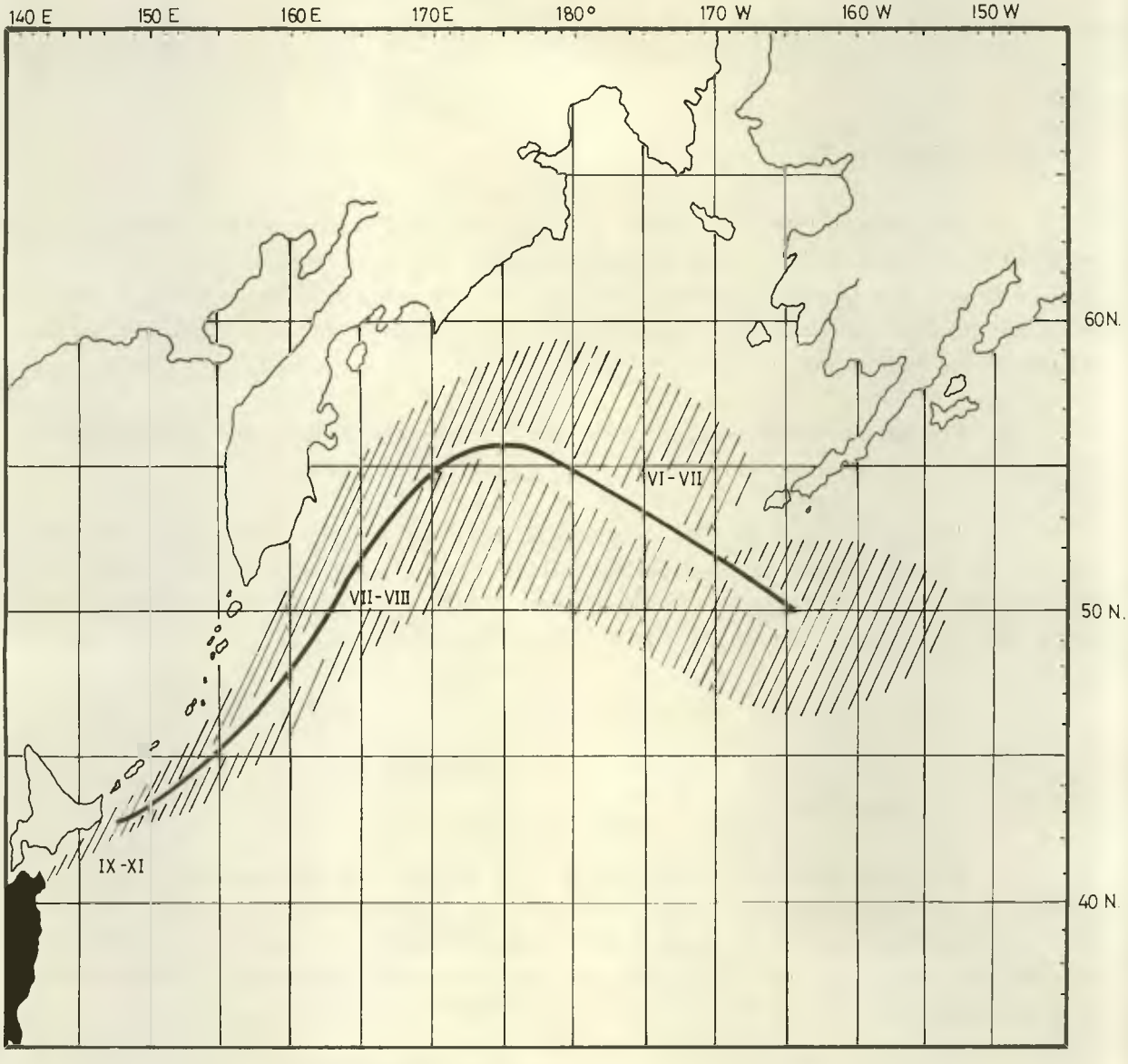


Figure 3. Estimated area of distribution and migration route of chum salmon originating from Japan (Kondo et al., 1965). Month is given in Roman numerals.

## MORPHOLOGY OF THE CHUM SALMON

### 1. *Adults*

The body of the chum salmon is elongate and more compressed laterally than other species of Pacific salmon. The caudal peduncle is slender. The head length is about 4.4 into the standard length. The mouth is terminal and large, and the snout is rather pointed. Teeth are strong and fanglike, especially in the males which take on a canine appearance and give the fish its name of dog slamon (Figure 4).

The gill rakers are comparatively short, slender and widely spaced. The scales are deciduous.

The fish is a metallic blue on the dorsal surfaces and silver below. A few dark specklings may be present behind the head, but there are no black spots or other marks. The spawning adult is black on the dorsal surface and sides, with irregular colored streaks or bars in yellow, purple, red or black, with white on the tips of the pelvic and anal fins.

### 2. *Fingerlings and fry*

The body form of the very young chum salmon is slender and deeper than other species. The parr marks are slender dark bars, extending to the lateral line but hardly below it. There are fine black spots on the back, interspersed with larger spots, darker toward the distal end. The fins are pale in color. The background color of the young fish has green irridescence on the dorsal surface. (See Figure 5.)

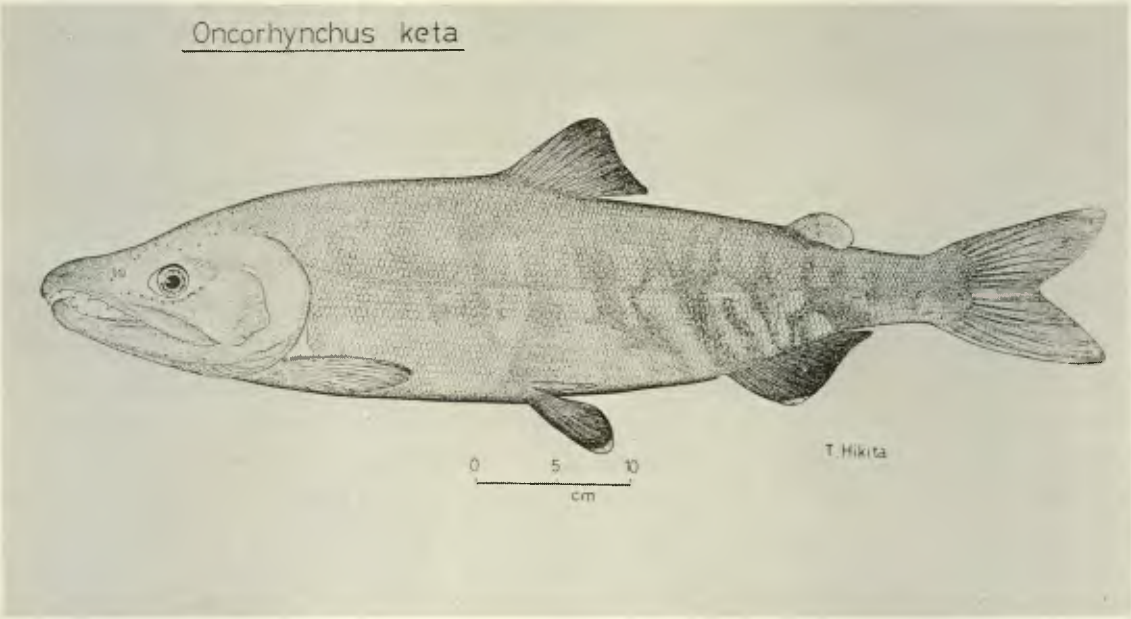


Figure 4. Mature male chum salmon.

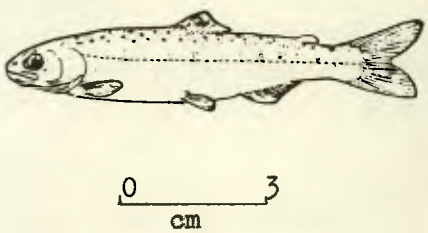


Figure 5. Fingerling of chum salmon.

## EGG TRANSPORTATION

The logistics of egg transportation was considered in great detail. How many eggs of the chum salmon would be necessary to establish a returning population in Chile? Obviously the larger the quantity the better, but what would be a realistic number in terms of operating a hatchery and obtaining returning numbers which would resupply it each year? Probably 100 million young fry released each year would guarantee success, but this would be unrealistic in terms of providing that number of eggs from Hokkaido. With anticipated returns of 1–2%, a total of 10 million eggs was chosen as being realistic in terms of the job to be done, and to be within the capabilities of the egg suppliers in Japan.

Transportation was phased over a period of five years, 1974–1978. Two million eggs were shipped each year to Chile from Japan. The purpose of the experimental shipment was to test the incubation and rearing procedures being established at the rearing site in Aysen.

In Hokkaido, the season for the stripping and collection of chum salmon eggs is September through December (Figure 1), late autumn and early winter. In the Japanese hatcheries, the eggs incubate through the cold winter and emerge from the gravel into the incubator channels in early spring. The free-swimming fry are fed in the channels, or allowed to move out into larger raceways. In late spring or early summer, the juveniles are liberated from the hatcheries and move downstream toward the sea.

The eggs for transportation to Chile were collected in October. This was early in the season, but these eggs could be advanced in the hatchery to the eyed egg stage ready for transportation. The eggs could then be shipped to Chile in January, which is the beginning of the summer season in the Southern Hemisphere. Thus, the seasonal changes were minimized. If the eggs were collected in November or December in Japan, they could not be accelerated in development as fast, because of the lower temperatures in winter, which would mean that the eyed eggs could not be moved until March or April. The seasonal cycle for the young fish would then be very much out of phase.

However, the Pacific salmon species do have both spring and autumn runs resulting in respective winter and summer releases. The first trials in Chile therefore tested the possibilities of seasonal variations and planned the release of fry from one million eggs in both winter and summer in the first year.

Every batch of eggs from Japan was given a special code to establish the records for shipment and also for the future returns and selection of breeding populations at the hatchery. The codes established between 1973 and 1977 are given in Table 4.

The eggs of the chum salmon were supplied to Chile from the hatcheries of the National Salmon Hatchery Service, particularly that at Chitose which is close to the airport of Sapporo. The transportation boxes were identical to those described by Nagasawa and Aguilera

(1974).

A summary of the egg shipment dates and conditions is given in Table 5. The eggs were shipped to the hatchery at Coyhaique in the Province of Aysen, Chile. A description of the Coyhaique Hatchery is being made available by Nagasawa and Aguilera (in preparation).

Table 4. Codes for the transplanted stocks and shipment program.

| Code* | Parent Year | Egg Collection | Eyed Egg Shipment | Liberation | Anticipated Return | Remarks |
|---|---|---|---|---|---|---|
| KJ-73-B | 1973 | December | Mar. 1974 | May 1974 | 1977–1979 | Experimental |
| KJ-74-A | 1974 | October | Nov. 1974 | Jan. 1975 | 1978–1980 | Pilot culture |
| KJ-74-B | 1974 | December | Mar. 1975 | May 1975 | 1978–1980 | Pilot culture |
| KJ-75-A | 1975 | October | Nov. 1975 | Jan. 1976 | 1979–1981 | Pilot culture |
| KJ-75-B | 1975 | December | Mar. 1976 | May 1976 | 1979–1981 | Pilot culture |
| KJ-76-A | 1976 | October | Nov. 1976 | Jan. 1977 | 1980–1982 | Pilot culture |
| KJ-76-B | 1976 | December | Mar. 1977 | May 1977 | 1980–1982 | Pilot culture |
| KJ-77-A | 1977 | October | Nov. 1977 | Jan. 1978 | 1981–1983 | Pilot culture |
| KJ-77-B | 1977 | December | Mar. 1978 | May 1978 | 1981–1983 | Pilot culture |

*Code:

K = Oncorhynchus *keta*
J = Japan as original source
Number
(as 73) = parent year
A = early season
B = late season

## Table 5. Summary of egg shipment dates and conditions.

| Code | Origin | | | | | | | | | Shipment from Chitose Hatchery | | | Arrival at Coyhaique, Aysen | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date of Collection | River Source | Hatchery | Date Eggs Eyed | Temp. | pH | Egg Mortality (%) | Treatment | Condition at Transfer | Date | Treatment | Development | Date | Number of Eggs Received | Temp. in Incubator | No. of Dead Eggs | Egg Condition |
| 1. KJ-73-B | Jan. 7, 8, 10, 17, 1974 | Tokachi | Obihiro | Feb. 20–27, 1974 | 5.0–5.5°C | 6.8 | 10.7 | Malachite green 1/300,000 30 min. 3/week | Soft, more or less good | Mar. 15, 1974 | 1/200 Iodine before packing | 340–370°C U.T., eyed egg stage | Mar. 16, 1974 | 1 million | 9.8°C | —— | Soft, without tension, but normal |
| 2. KJ-74-A | Oct. 11, 12, 1974 | Tokachi | Obihiro | Nov. 2–3, 1974 | 9.0°C | 6.8 | 2.0 | Malachite green 1/300,000 30 min. 2/week | Excellent | Nov. 15, 1974 | At destination, 1.0% Iodine 50 cc/10 liters | 330°C U.T., eyed egg stage | Nov. 16, 1974 | 1 million | 13.0°C | 4,170 (0.42%) | Excellent, normal |
| 3. KJ-74-B | Dec. 11, 1974 | Tokachi | Obihiro | Feb. 11, 1975 | 3.0–4.0°C | 6.8 | 6.2 | Malachite green 1/300,000 30 min. 2/week | Fair | Mar. 14, 1975 | 1.0% Iodine 50 cc/10 liters at destination | 330°C U.T., eyed egg stage | Mar. 16, 1975 | 950,000 (1 box lost) | 11.0°C | 1,780 (0.19%) | Slightly soft but normal |
| 4. KJ-75-A | Oct. 5, 1975 | Tokachi | Obihiro | Oct. 27, 1975 | 11.0°C | 6.8 | 2.5 | Malachite green 1/300,000 30 min. 2/week | Excellent | Nov. 14, 1975 | 1.0% Iodine 50 cc/10 liters at destination | 380°C U.T., eyed egg stage | Nov. 16, 1975 | 1 million | 8.4°C | 300 (0.03%) | Excellent |
| 5. KJ-75-B | Dec. 5, 1975 | Chewlui | Ichani | Feb. 4, 1976 | 4.0°C | 7.0 | 6.0 | Malachite green 1/200,000 30 min. 2/week | Good | Mar. 5, 1976 | 1.0% Iodine 50 cc/10 liters at destination | 360°C U.T. eyed egg stage | Mar. 6, 1976 | 1 million | 6.0°C | 9,400 (0.94%) | Good |
| 6. KJ-76-A | | | | | | | | | | | | | | | | | |
| 7. KJ-76-B | | | | | | | | | | | | | | | | | |
| 8. KJ-77-A | | | | | | | | | | | | | | | | | |
| 9. KJ-77-B | | | | | | | | | | | | | | | | | |

## FRY PROPAGATION AND LIBERATION

1. *Group KJ-73-B*

This group of 1 million eggs of the chum salmon was the first to be shipped laterally across the Pacific Ocean from 45°N to 45°S. The eggs arrived safely in March 1974 in Santiago and were then shipped by a plane of Fuerza Aerea de Chile to Balmaceda. They were then taken the last 70 km to Coyhaique by road.

The eggs were accommodated in a provisional and emergency incubator channel (24 x 3 m) with a gravel base. Direct sunlight was obstructed from the eggs and yolk-sac fry by covering the channel with wooden boards (see Figure 6). The main hatchery was still being completed at the time.

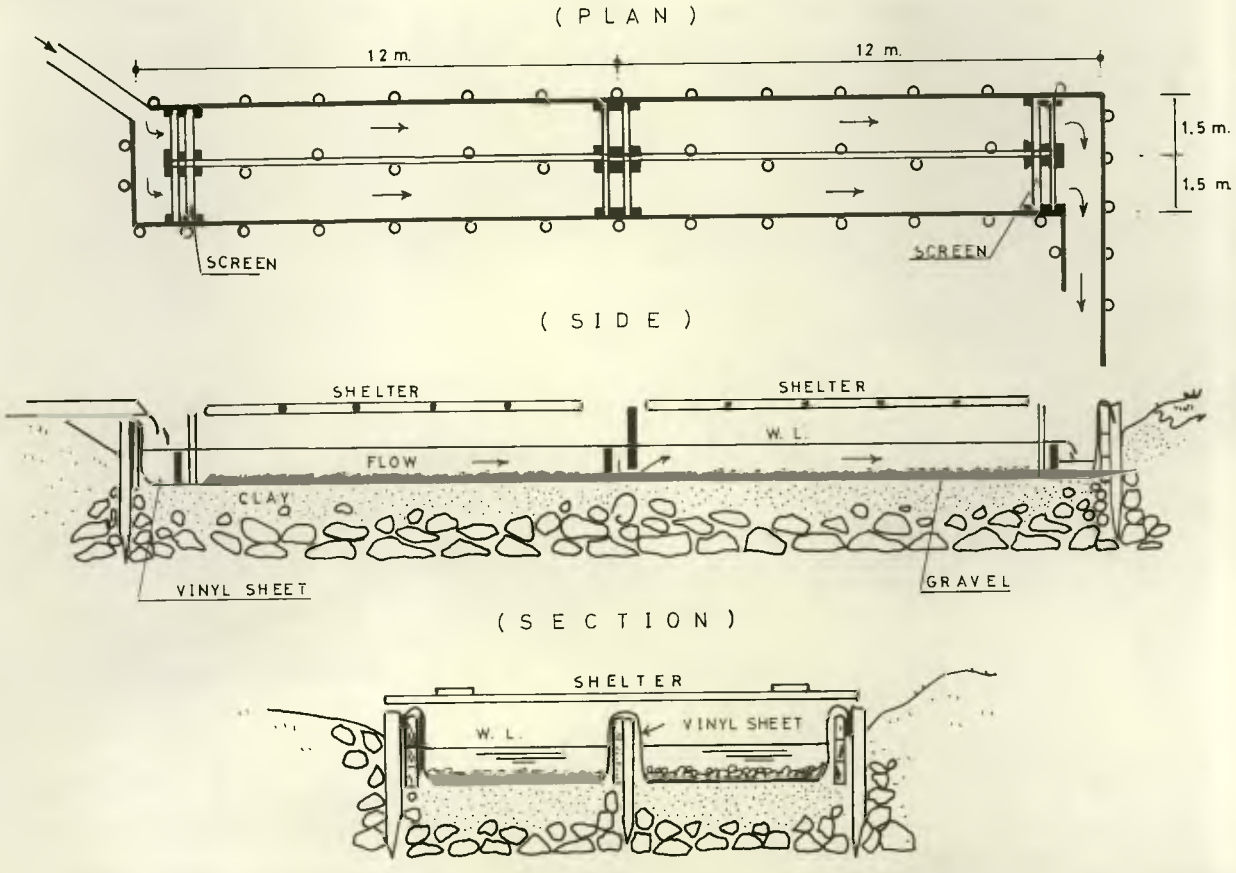


Figure 6. Temporary incubation channel, Coyhaique, 1974.

The eggs were exposed to the autumn environmental conditions of the Southern Hemisphere. The following observations were planned:

1. Incubation time, and yolk-sac stage development time,
2. Climatic conditions at the hatchery,
3. Behavior and survival on release.

The temporary hatchery was again located on the Claro River. Without a reservoir or dam, a gravity-fed delivery system of water through the incubators was hard to regulate. Water led through a trough to the incubator channel soon destroyed the channel. Delivery was therefore regulated by pumping the water through at a rate of about 5,000 liters per hour. Temperature conditions in the incubator channel are illustrated in Figure 7. The oxygen level fluctuated between 8.4 and 12.8 ppm at the inlet.

The eggs were distributed in the gravel at a maximum density of 10,000 per square meter. This was equivalent to a single layer of eggs, although it was difficult to establish. About 200,000 eggs were lost during incubation, probably through asphyxia, followed by fungus. Many could not totally escape from the egg, and soon died. The fry were treated with Malachite Green to control the fungus, at a level of 1 part per 200,000 for 30 minutes three times each week.

The eyed eggs hatched over a period of one week following arrival in Coyhaique. Many of the emergent yolk-sac fry, estimated to be about 100,000, hatched prematurely and were abnormal.

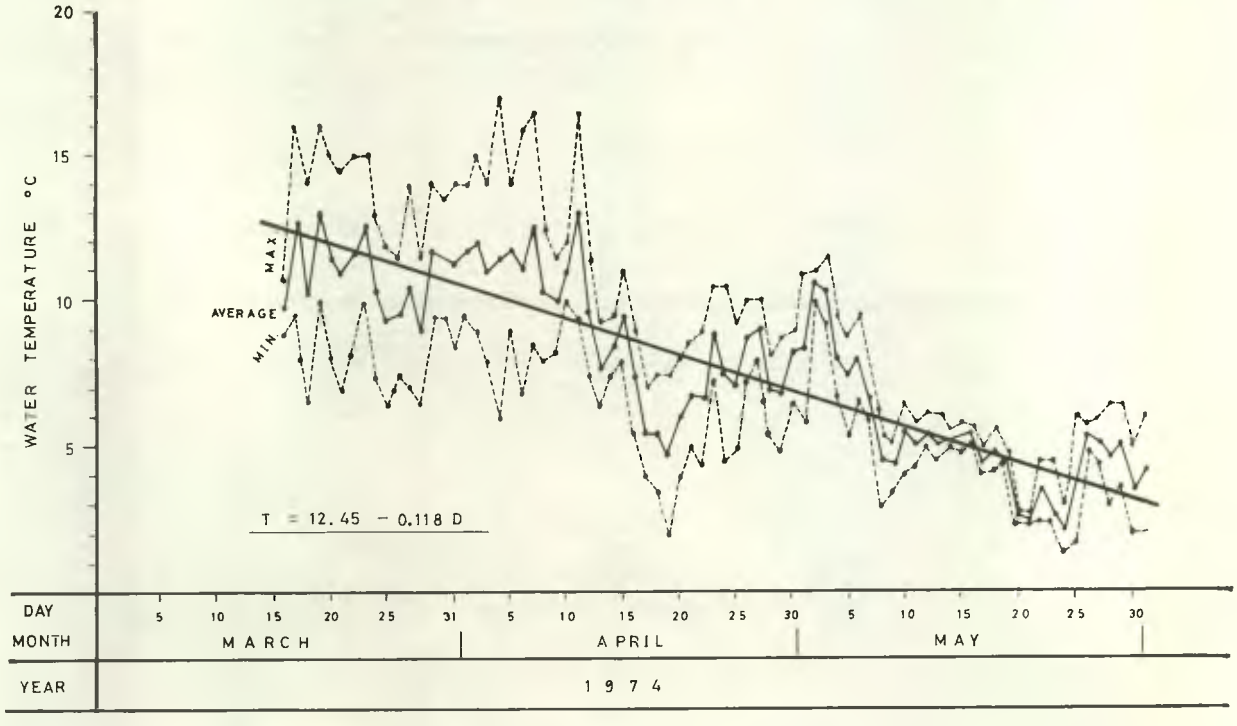


Figure 7. Daily water temperature during the breeding period for KJ-73-B.

An estimated 645,000 fry were released into the Simpson River of Aysen in May 1974. The size of the fry at liberation was 3.2 cm in length and 0.33 g in weight. Unfortunately, heavy rains followed the time of release causing the river to rise. As it fell later, many young fry were trapped in the small pools where they were lost through predation or oxygen depletion as the pools dried. About 100,000 fry were estimated to be lost from observations close to the hatchery site.

2. *Group KJ-74-A*

Collection, transportation and delivery of this shipment was excellent. The hatchery at Coyhaique was partially completed and the eggs could be incubated and reared through the sac-fry stages in the new facilities.

The eggs were located in the six raceways. Seven stacks of trays were placed in each channel (Figure 8). About 25,000 eggs were contained in each stack, thus making a total of about 1 million eggs.

After hatching, the sac-fry were distributed among the same channels. About 25,000 fry occupied 1 square meter of channel bottom, which was a high density. The total number of about 168,000 fry in each channel was divided horizontally by a netted screen tray. About 100,000 were maintained below the screen, and the remaining 68,000 above the screen.

Water flow through the hatchery was regulated. Delivery rates were 20 liters per minute across the eyed eggs, and increased to 45 liters per minute throughout the sac-fry stage, and more as the fry developed. Temperature conditions are illustrated in Figure 9. The pH of the water from the Claro River which supplied the hatchery was 6.9.

Approximate losses incurred throughout rearing were as follows:

| | |
|---|---|
| Transportation loss | 4,000 eggs |
| Abnormalities | 6,000 emergent larvae |
| Undeveloped | 10,000 eggs |
| Dead sac-fry | 60,000 (probably asphyxiated in lower level) |
| Dead fry | 20,000 (caught on outlet screens) |
| Total | 100,000 |

An estimated 900,000 fry were liberated in January 1975. The Claro River in the summer season was low and had a temperature of 16°C (range 12–22°C). The average size of the fish liberated was 3.47 cm fork length, and 0.44 g body weight.

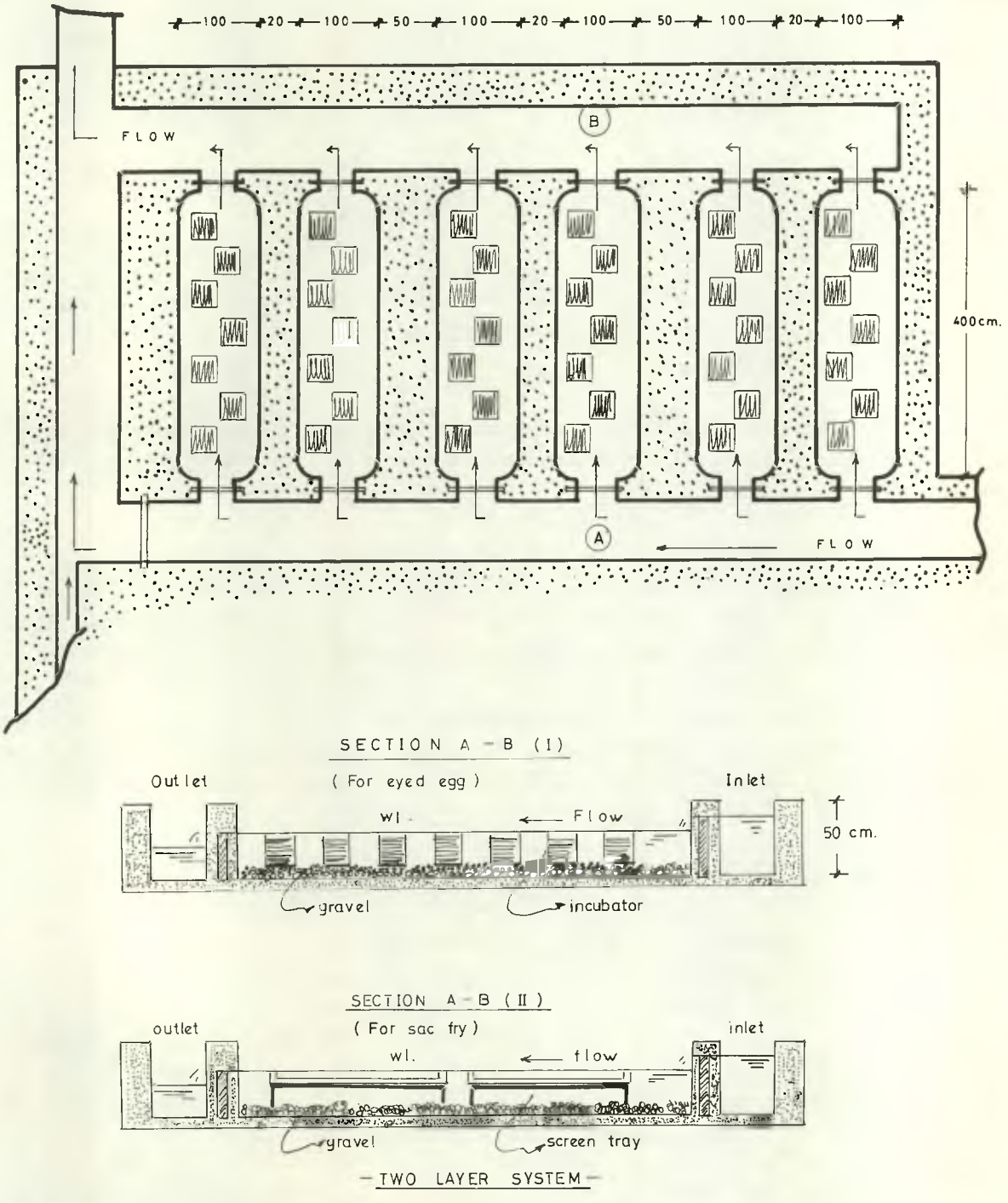


Figure 8. Indoor incubator channel, Coyhaique hatchery, 1974.

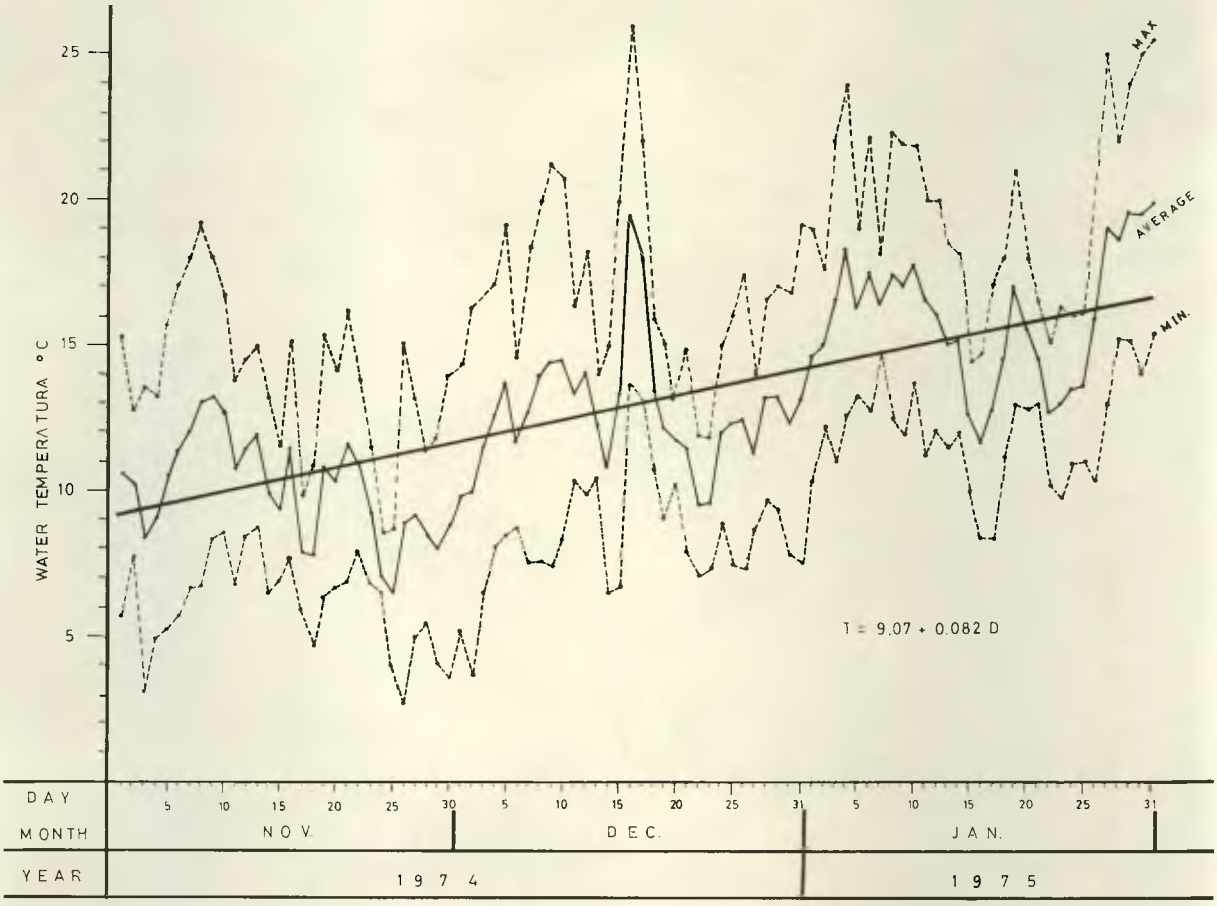


**Figure 9.** Daily water temperature of the breeding period for KJ-74-A.

3. *Group KJ-74-B*

The group of eggs planned for the winter release of 1975 were also shipped and delivered with excellent results, although one container of 50,000 eggs was lost in route.

About 800,000 fry were liberated into the Simpson River in May 1975, at the onset of winter in the Southern Hemisphere. Rearing conditions and facilities were similar to those described for KJ-74-A (above), and the environmental conditions are illustrated in Figure 10.

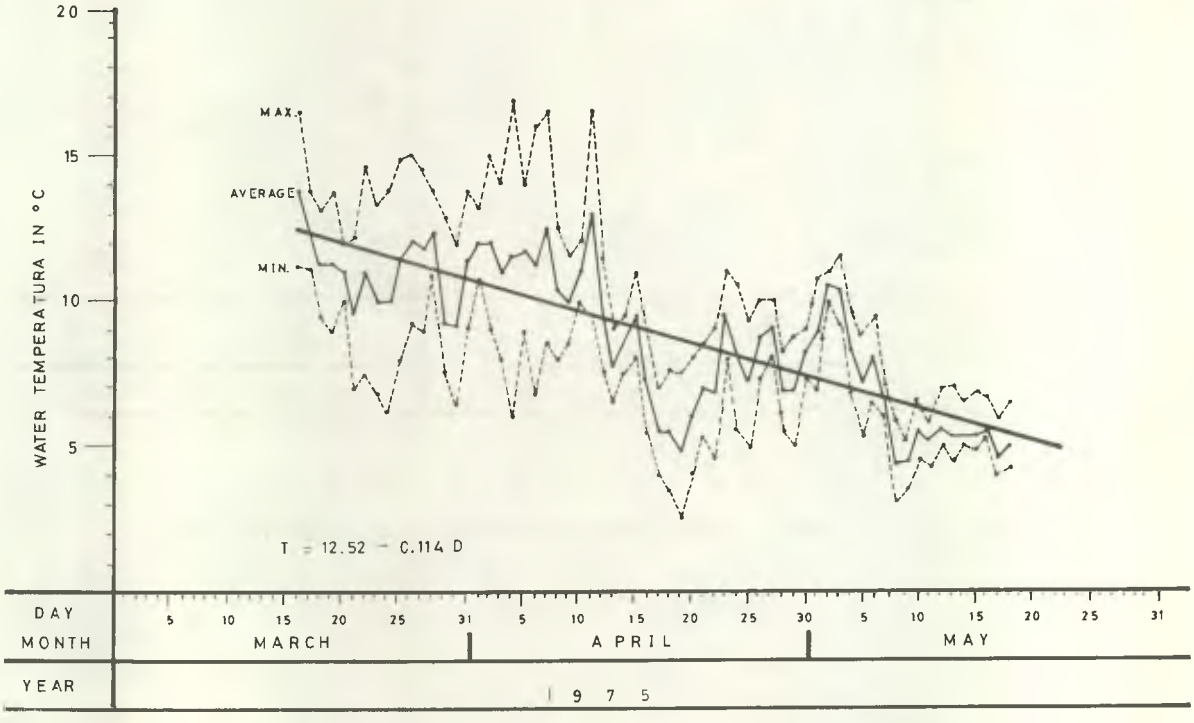


Figure 10. Daily water temperature of the breeding period for KJ-74-B.

4. *Group KJ-75-A*

Management of the group at Coyhaique was greatly improved because of the completion of the hatchery facilities. The eggs were incubated in the troughs, and the sac-fry distributed among the rearing channels at the correct density of about 10,000 per square meter.

About 970,000 fry were reared successfully and released into the Simpson River in January 1976. At the time, the low running river had concentrated many predators, particularly brown and rainbow trout (*Salmo trutta* and *S. gairdneri*). To avoid these predators, about 120,000 fry were taken by road downstream to Aysen, where the Simpson River opens into the freshwater fjord area. The remainder were liberated at usual close to the hatchery. See Figure 11.

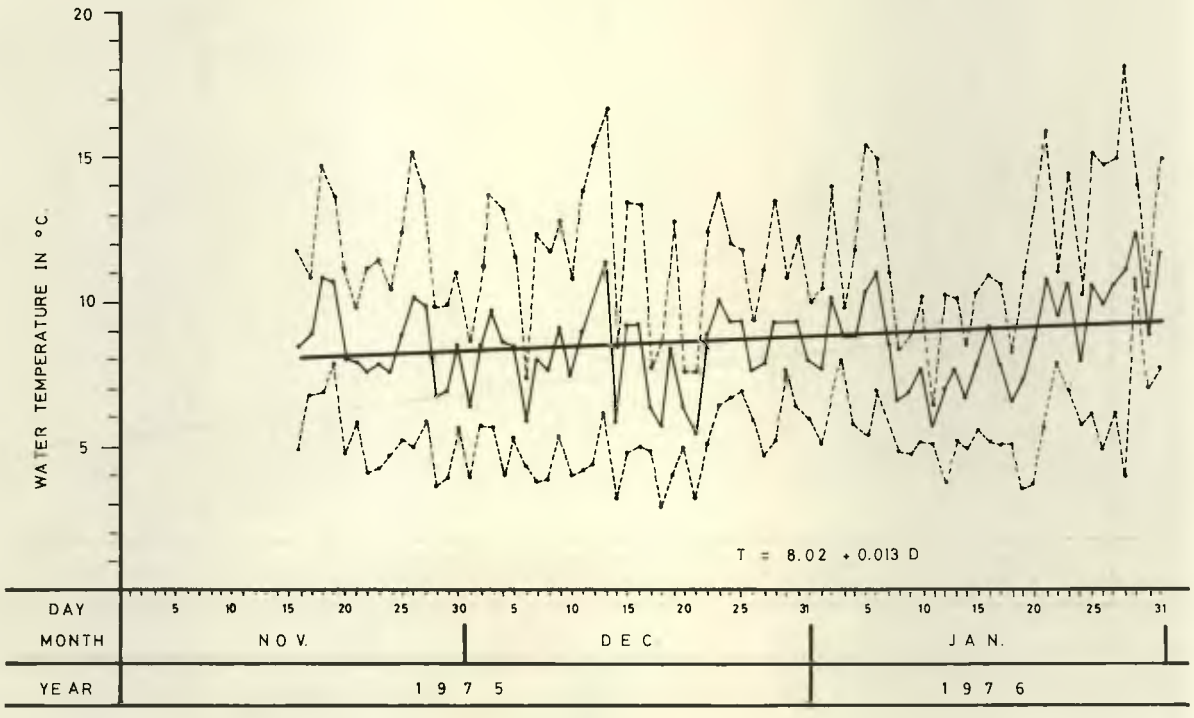


**Figure 11. Daily water temperature of the breeding period for KJ-75-A.**

5. *Group KJ-75-B*

The million eyed ova transported in this group were again reared satisfactorily in the new hatchery at Coyhaique. Temperature conditions through the winter months in Chile are illustrated in Figure 12.

An outbreak of fungus reduced the sac-fry by an estimated 155,000. The fungus was treated with Malachite Green as before.

An estimated total of 836,000 fry were released in late May and early June 1976. About 120,000 were taken by road downstream of the Simpson River to Aysen; another 80,000 were taken to the Salto River near Puerto Chacabuco; and the remainder released from the hatchery directly.

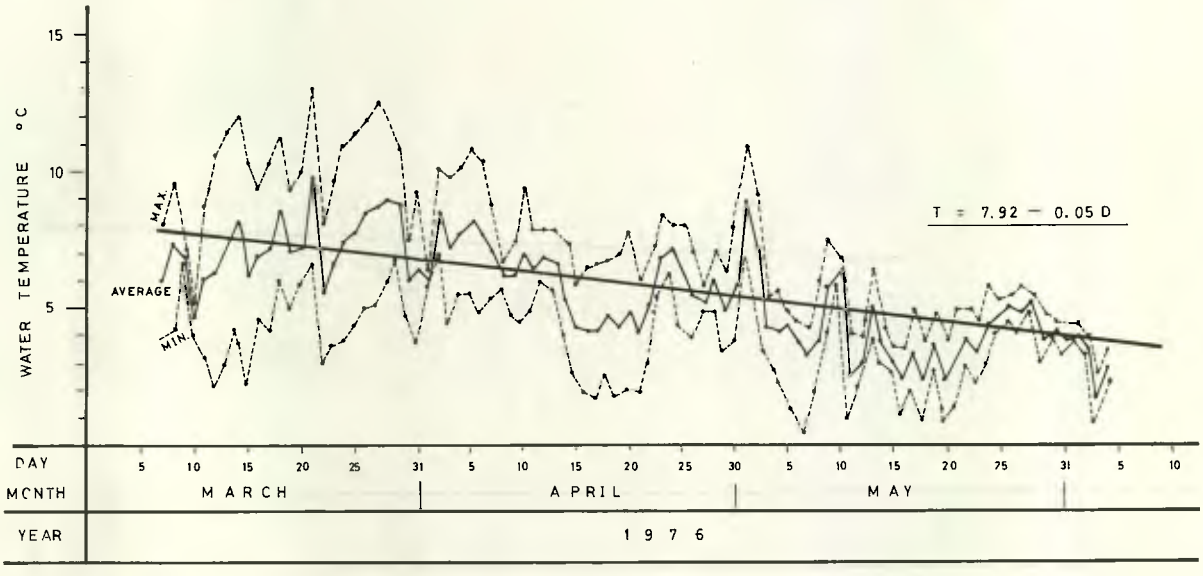


Figure 12. Daily water temperature of the breeding period for KJ-75-B.

## SUMMARY OF RELEASES AND DISCUSSION

The first objective of the introduction program is to establish a migratory population of fish in Chilean waters. The return of one fish to its point of origin in Chile will provide the encouragement and incentive for the program to expand.

Although everything possible was done to make the first transportations and releases successful, the efforts in the first two years were not without problems. Preliminary releases were made without the benefit of adequate onshore facilities, and it was not until the hatchery was completed in 1975 that subsequent trials were more productive.

The total number of fry released by the program up to May 1976 was approximately 4,037,000. The majority were released directly into the Simpson River adjacent to the hatchery at Coyhaique, and others were released nearby (Table 6). The releases are planned to continue until 1978. The anticipated return of these fish between 1974 and 1983 is anticipated by the illustration in Figure 13.

The developing chum salmon spend between 3 and 5 years in the ocean. The migratory patterns of the fish released in the autumn and spring of 1974 are anticipated to follow the illustration described in Figure 14. The first returns might be anticipated in the middle of 1977. About 15% of chum salmon return in the third year. With an anticipated survival at sea of an established population of chum salmon at 2%, the expected survival for a new population in a new environment might be no more than 1%. Therefore, if the two groups of fish released in 1974 (KJ-73-B and KJ-74-A) merge at sea and return together (see Figure 14), then the anticipated and optimistic return of adult fish in 1977 will be no more than 2,700 fish. This will continue to increase as the different year classes return and merge (see Figure 13).

Table 6. **Numbers of chum salmon fry liberated into Simpson River, Coyhaique, 1974–1976.**

| Stock Code name | Number of eyed eggs | Fry liberation | | | | Remarks |
|---|---|---|---|---|---|---|
| | | Number of fry | Period | Year | River | |
| KJ-73-B | 1,000,000 | 645,000 | 15–26 May | 1974 | Simpson | Experiment |
| KJ-74-A | 1,000,000 | 900,000 | 07–10 Jan. | 1975 | Simpson | Pilot Culture |
| KJ-74-B | 950,000 | 800,000 | 20–25 May | 1975 | " | " |
| KJ-75-A | 1,000,000 | 976,000 | 08–27 Jan. | 1976 | Simpson | " |
| KJ-75-B | 1,000,000 | 756,000 | 26 May–04 June | 1976 | " | " |
| | | 80,000 | 28 May | 1976 | Salto | Experiment |
| Total | 4,950,000 | 4,037,000 | | | | |

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| Year of return | Brood year class | | | | | Remarks |
|---|---|---|---|---|---|---|
| | 1974 | 1975 | 1976 | 1977 | 1978 | |
| 1974 | | | | | | seeding |
| 1975 | | | | | | |
| 1976 | | | | | | |
| 1977 | 3 | | | | | harvest |
| 1978 | 4 | 3 | | | | |
| 1979 | 5 | 4 | 3 | | | |
| 1980 | | 5 | 4 | 3 | | |
| 1981 | | | 5 | 4 | 3 | |
| 1982 | | | | 5 | 4 | |
| 1983 | | | | | 5 | |

Numbers (3, 4, 5) indicate fish age.

Figure 13. Anticipated return of adult chum salmon by brood year class.

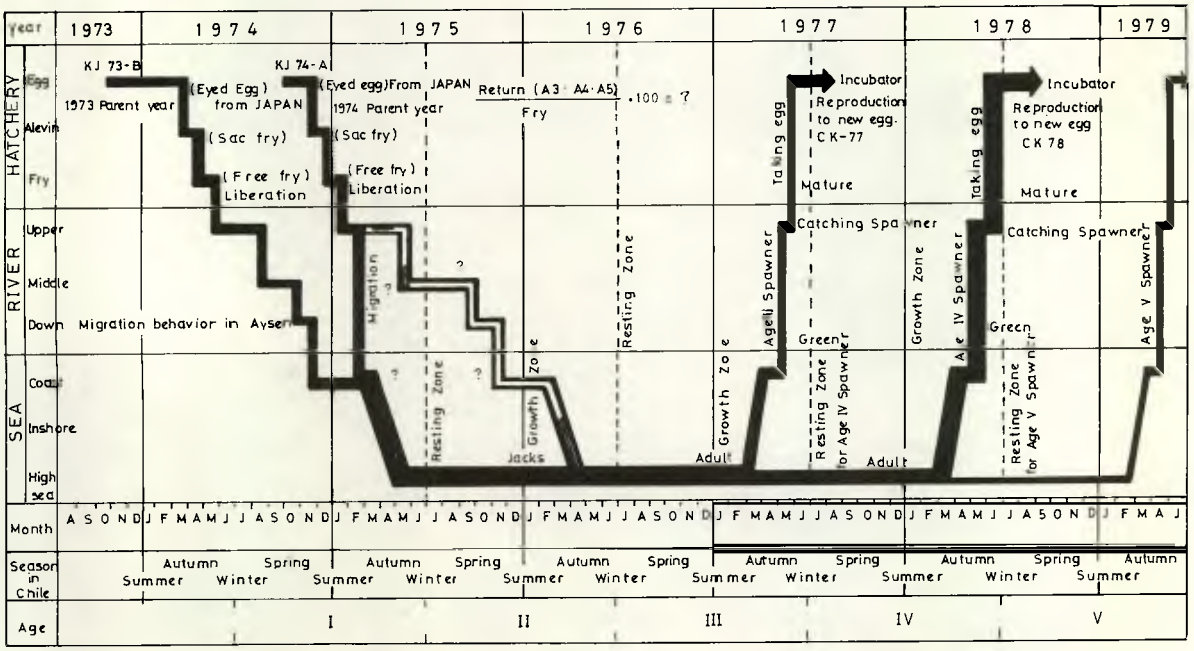


Figure 14. Anticipated enhancement cycle of transplanted chum salmon at Coyhaique, Chile.

Transportation of eyed ova to Southern Hemisphere and the different environmental conditions to which they were exposed did not appear to upset the physiology during development. Abnormalities in Group KJ-73-B were probably due to the poor condition of the eggs at the time of transportation. Many were still soft (Table 5). Water temperature conditions at each release are summarized in Table 7. The colder temperatures simply prolonged incubation and development.

Table 7. Water temperature during period of chum salmon breeding, Coyhaique, 1974–1976.

| No. | Stock | Period | Season | Formula | Coefficient |
|---|---|---|---|---|---|
| 1 | KJ-73-B | 16 Mar.–30 May 1974 | Autumn | T=12.45-0.018D | -0.86 |
| 2 | KJ-74-A | 01 Nov. '74–31 Jan. '75 | Spring | T=9.70+0.082D | 0.70 |
| 3 | KJ-74-B | 16 Mar.–18 May 1975 | Autumn | T=12.52-0.114D | -0.81 |
| 4 | KJ-75-A | 16 Nov. '75–31 Jan. '76 | Spring | T=8.02+0.013D | 0.19 |
| 5 | KJ-75-B | 07 Mar.–4 June 1976 | Autumn | T=7.92-0.050D | -0.72 |
| 6 | KJ-76-A | | | | |
| 7 | KJ-76-B | | | | |
| 8 | KJ-77-A | | | | |
| 9 | KJ-77-B | | | | |

where

T = temperature (°C)

D = days

## ACKNOWLEDGMENTS

The authors express their gratitude to the ex-Director of Division de Pesca y Caza, Augusto Bruma V., and his successor in the new Division Proteccion Pesquera, Ivan Petrowitsch F., for their continued support and direction; also staff of the Divisions, namely Irma Vila, Juan Delard, and Victorino Garrido, for coordinating the activities of the project.

In addition, the authors would like to thank the technical field staff from SAG, Coyhaique, namely Hector Nova and Gustavo Araya; together with the many students of the Universidad Tecnica del Estado, Instituto Tecnologico, Aysen, who worked hard to develop salmon farming in Aysen. Also, the construction of the hatchery at Coyhaique was helped considerably by the SAG Director, Alberto Saini, and his staff.

Considerable appreciation is given to the Fuerza Aerea de Chile, without which prompt transportation of the eggs to Coyhaique would not have been possible; and also to the Japanese International Cooperation Agency for financial support, and the National Salmon Hatchery Service of Hokkaido, Japan, for supplies of eggs each year.

Finally, the authors thank Dr. Colin E. Nash, Director, and Dorothea Rosinsky, Publications, of the Oceanic Institute, Hawaii, for the translation and preparation of this report in English.

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Plate 1. Returning female adult chum salmon (*O. keta*) captured in coastal waters.

Temporary incubator channel, 1974, Coyhaique.

Plate 2. (Left) under construction

Plate 3. (Right) Complete

Plate 4. View of temporary incubator channel.

Plate 5. View of temporary incubator channel and hatchery construction.

Plate 6. Egg receivers with incubator screen trays.

Plate 7. Egg trays stacked in indoor incubation channels.

Plate 8. Hand picking dead eggs before hatch-out.