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Salt Water and Fresh Water Pond Rearing of the Chum Salmon, *Oncorhynchus Keta* (Walbaum)

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Summary

1. Chum Salmon fry, *Oncorhynchus Keta* (Walbaum), were put into salt water and fresh water ponds at a controlled water temperature below 19°C and fed on various fresh fishes and a dry mixed ration for three years.

2. The average length and weight of the salt water fish group was 255 mm and 220 g by the first fall, 397 mm and 962 g by the second fall and 530 mm and 1,950 g by the third fall. Some male fish of the salt water group matured by the second and third fall and the female fish of this group also matured by the third fall.

The average length and weight of the fresh water fish group was 182 mm and 83 g by the first fall and 237 mm and 242 g by the second fall. The growth of this fish group, however, was small in the third year. A few male fish of the fresh water fish group also matured by the second fall.

3. The average ratio of weight in gram to length in centimeter in the body of the salt water fish group was 23.7 and 34.7 in the second fall and the third fall. That of the fresh water fish group was 10.2 and 13.8 in the second fall and the third fall.

4. Cumulative percentage mortality of the salt water fish group was low in the second and third years though it reached 75 percent the first fall owing to a bacterial disease. That of the fresh water fish group was 9 and 45 per cent at the first and second falls, respectively. However, the third fall mortality rate was 98 per cent.

5. The average water content in the blood of the salt water fish group was 77.8 and 81.3 per cent in the second fall and the third fall. That of the fresh water fish group was 86.9 and 94.7 per cent in the second fall and the third fall.

6. The average freezing point depression of the blood of the salt water fish group was $\Delta -0.68^{\circ}\text{C}$ and $\Delta -0.73^{\circ}\text{C}$ in the second fall and the third fall. The fresh water fish group was $\Delta -0.71^{\circ}\text{C}$ and $\Delta -0.46^{\circ}\text{C}$ in the second and third falls respectively.

Chum salmon reared in fresh water and salt water ponds to the second fall from hatching had been reported on previously by Kashiwagi and Sato (1). The

rearing of these fish has been continued to the third fall in salt water and fresh water ponds. Therefore, comparative growth, survival rate and some blood properties of the two fish groups during three years of this experiment are shown here.

Materials and Methods

Chum salmon fry hatched in artificial hatcheries were used at the beginning of this rearing experiments. A group of the fry put into a salt water pond at a controlled water temperature below 19°C. The temperature was controlled by pouring cool spring water into running sea water in the summer season. The other group of fry was put into a fresh water pond with water temperature remained below 18°C by the use of running cool spring water. The rearing of the two fish groups was continued for three years and their growth and survival rates were observed.

Several fish, at one examination, were anesthetized with one percent Urethane solution (ethyle calbamate) and bled by cardiac puncture. The blood of about 100 mg in a capillary of known weight was weighed accurately, and dried for twenty hours at 100–110°C and reweighed to examine the water content of the blood. The other blood was centrifuged for fifteen minutes at 3,000 rpm for collecting plasma. The plasma was used for measuring the freezing point depression by the use of a melting point apparatus with Beckman's thermometer.

Results

Rearing of the chum salmon in the Salt water pond

The rearing of the chum salmon was performed by Mr. C. Konno at the sea side laboratory of Otsuchi Bay, Iwate Prefecture, Japan. In this experimental rearing, 2,250 chum salmon fry of 55 days old, 30 mm in average length and 0.3 g in average weight were put into a sea water pond having an area of 9.7 m² and a depth of 1.0 m on February 24, 1963. They were moved to the larger circulatory pond having 34.2 m² and a depth of 1.0 m on March 14, 1964. They were fed various fresh fishes and a dry mixed ration. The results of the rearing are shown in Fig. 1 together with records of the conditions of the rearing. In the rearing, the water temperature was 7 to 19.0°C and the chlorinity of the water was 10.96 to 15.95 permill. The average size of the fish reached 255 mm in length and 220 g in weight by the first fall and 397 mm in length and 962 g in weight by the second fall. The largest fish grew to 550 mm in length and 2,700 g in weight, and five male fish matured during the second fall. The fish continued to grow reaching 530 mm in average length and 1,950 g in average weight by the third fall, and five male fish matured as shown in Fig. 2. A female fish also seemed to mature with grown eggs. But the eggs could not be fertilized artificially. The average ratio of weight

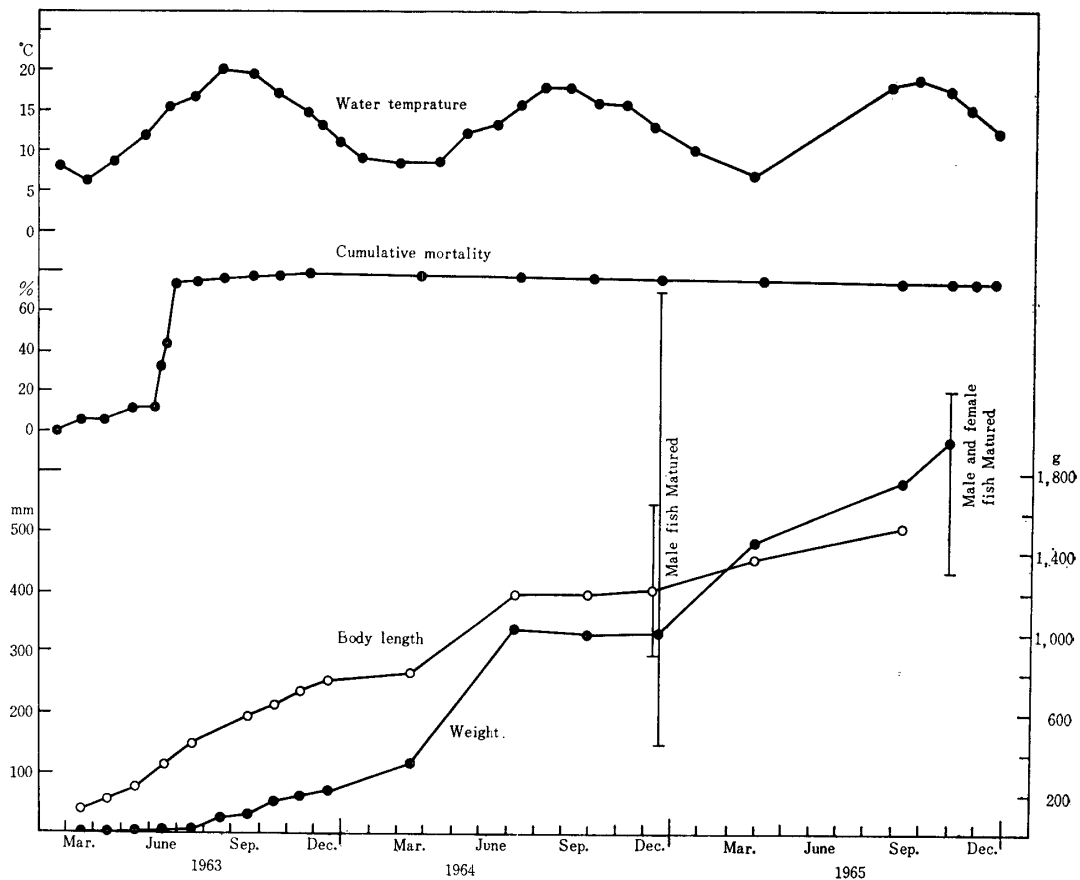


FIG. 1. Growth of chum salmon in the salt water pond.

in gram to length in centimeter in the fish body was 23.7 and 34.7 in the second fall and the third falls as shown Fig. 3. As a bacterial disease infected the fry in the salt water pond, the cumulative percentage mortality was 75 per cent by the first fall. A few dead fish, however, were found in the second and third year periods, also.

Rearing of the chum salmon in the fresh water pond.

The rearing of the chum salmon was performed by Mr. K. Kubota at the salmon hatchery of Tsugaruishi River, Iwate Prefecture, Japan. 2,994 chum salmon fry of 15 days old, 30 mm in average length and 0.3 g in average weight were put into a fresh water pond having an area of 32.5 m² and a depth of 0.4 m on March 1, 1964. They were fed various fresh fishes and a dry mixed ration. The results of the rearing are shown in Fig. 4 together with records of the conditions of the rearing. The water temperature was 7.0 to 16.0°C. The average size of the fish reached 182 mm in length and 83 g in weight by the first fall and 237 mm in length and 242 g in weight by the second fall. The largest fish reached to 300 mm in length and 400 g in weight, and two male fish matured by the second fall as shown in Fig. 3.

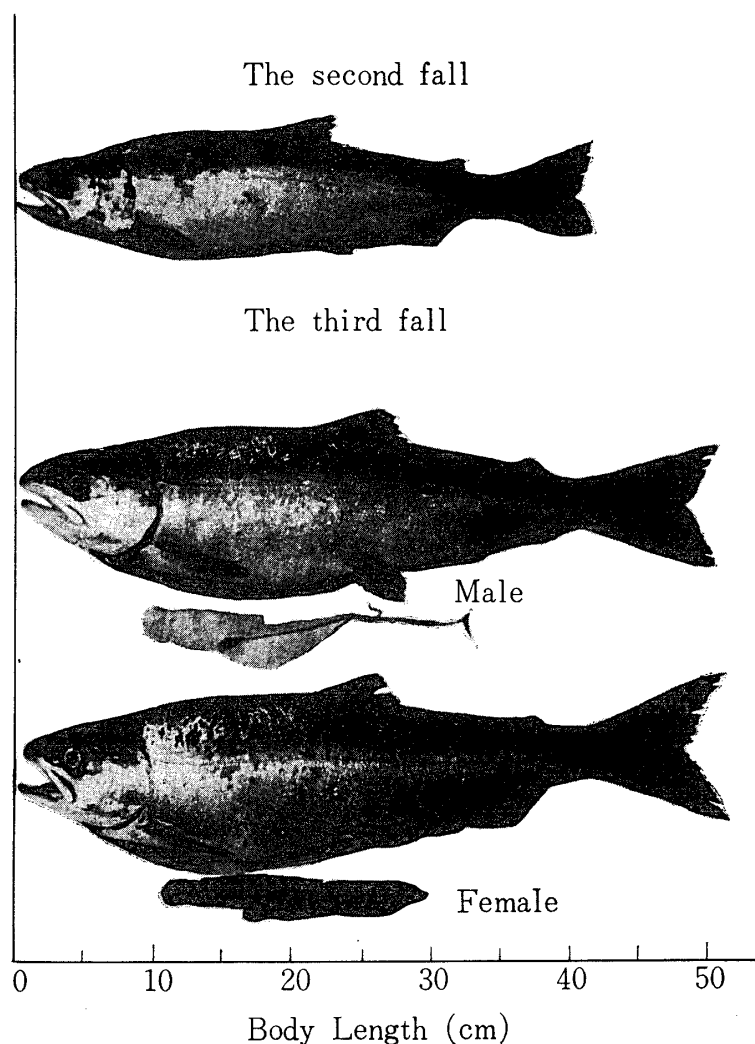


FIG.2. Chum salmon reared in the salt water pond.

The fish grew to 398 mm in average length and 410 g in average weight by the third fall. The growth of each fish in the third year, however, was variant and most of them died of a "dropsy like disease" which seemed to be caused by an osmoregulation problem in the fresh water as shown in Fig. 5. The average ratio of weight in gram to length in centimeter in the fish body was 10.2 and 13.8 in the second fall and the third fall as shown in Fig. 3. The cumulative percentage mortality of the fish reached 98 per cent by the third fall, though it was 9 per cent in the first fall and 45 per cent in the second fall.

The water content and freezing point depression of blood of the reared chum salmon.

The average water contents of the blood of the chum salmon reared in the salt water pond were 77.8 to 81.3 per cent from the second fall to the third fall as shown in Table 1 and Fig. 6. Those of the salt water fish group tended to decrease after

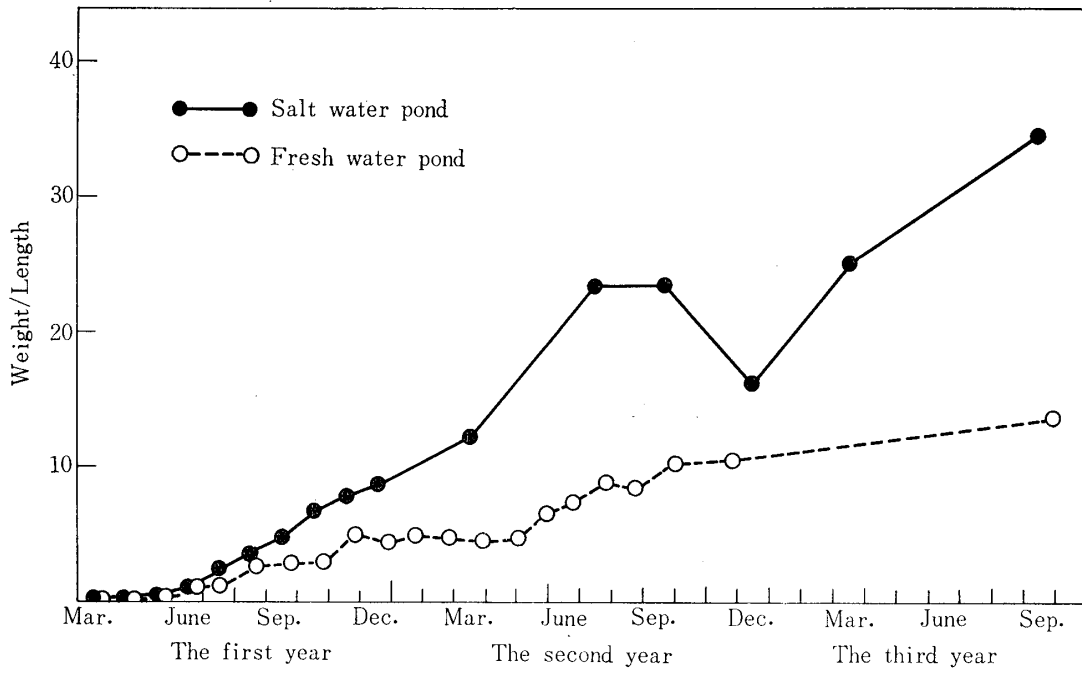


FIG. 3. The ratio of weight in gram to length in centimeter in chum salmon reared in the salt water and fresh water ponds.

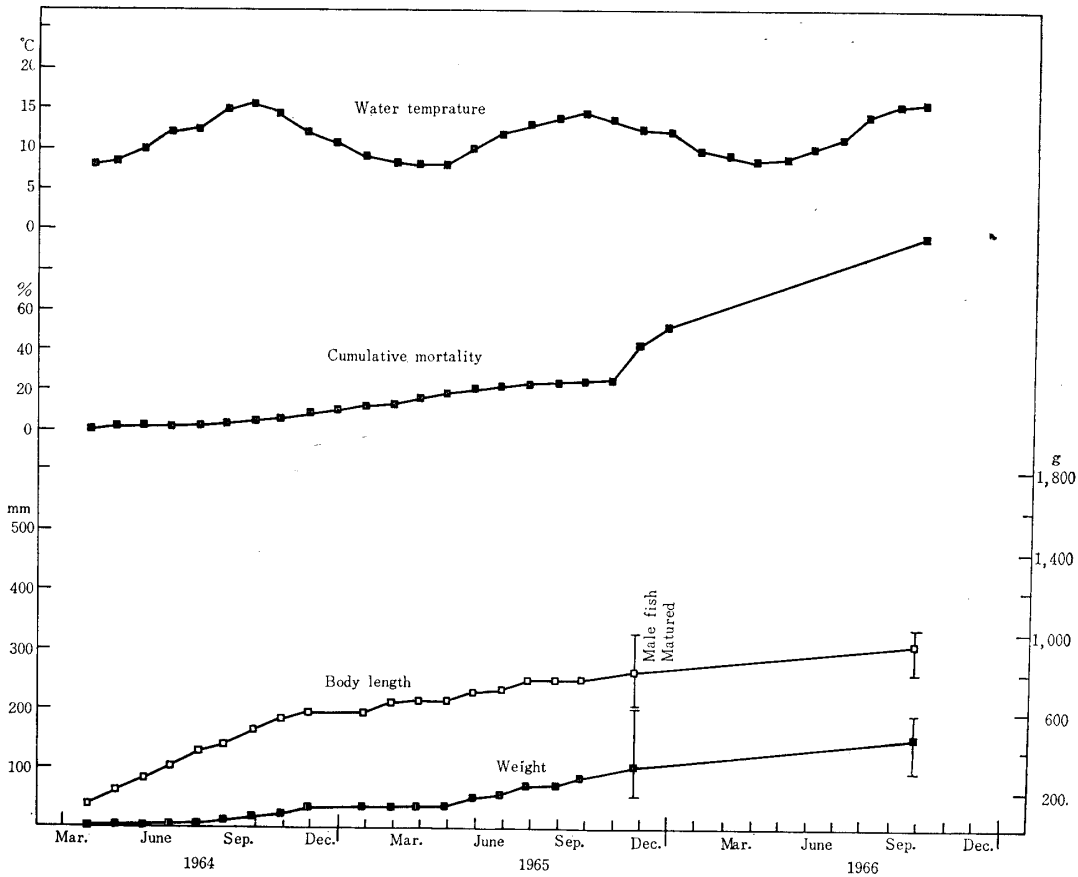


FIG. 4. Growth of chum salmon in the fresh water pond.

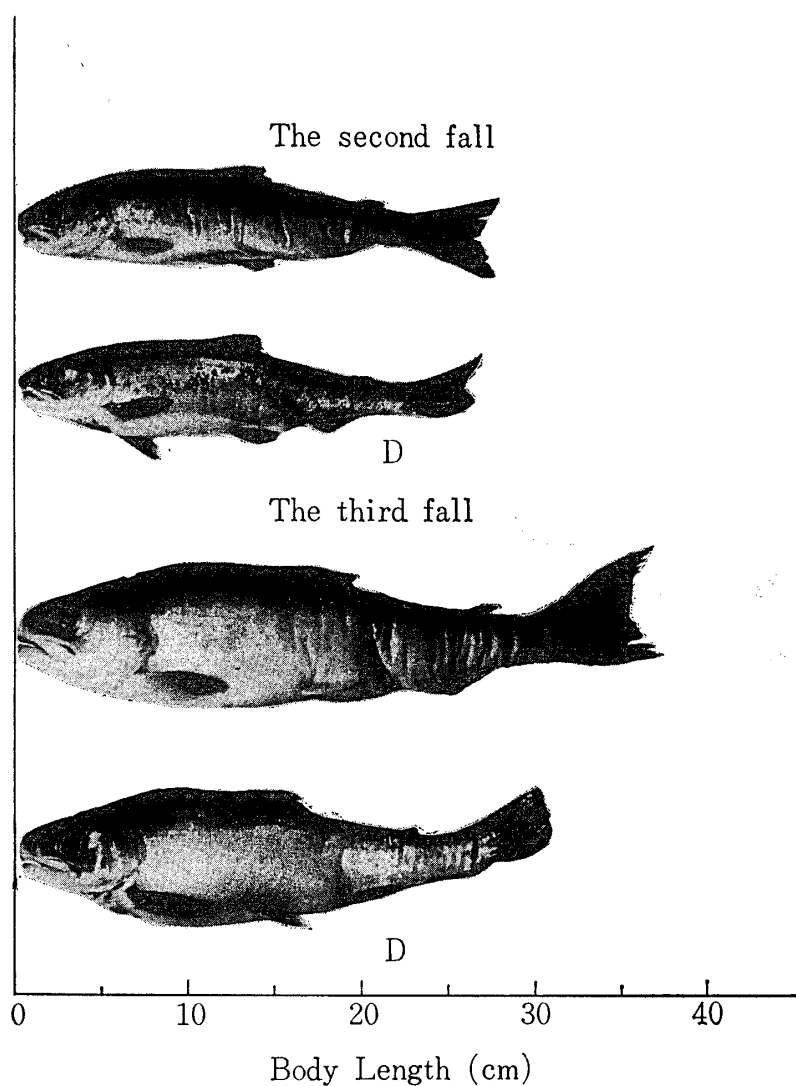


FIG. 5. Chum salmon reared in the fresh water pond. D indicates "dropsy like disease"

TABLE 1. *The Water Content and the Freezing Point Depression of the Blood of the Chum Salmon Reared in Salt Water and Fresh Water Ponds*

Age	Salt Water				Fresh Water			
	Fish	Water (%) content	Fish	Δ ($^{\circ}\text{C}$)	Fish	Water (%) content	Fish	Δ ($^{\circ}\text{C}$)
The first year Sept. (6 months)	3	87.9 \pm 2.4	3	0.83 \pm 0.10	3	84.9 \pm 0.9		
The second year Mar. (12 months)					4	83.4 \pm 0.9	4	0.47 \pm 0.06
Sept. (18 months)	12	77.8 \pm 4.3	15	0.68 \pm 0.14	11	86.9 \pm 4.3	15	0.71 \pm 0.19
Nov. (21 months)					10	83.3 \pm 3.9	7	0.47 \pm 0.01
The third year Mar. (25 months)	14	76.5 \pm 3.9	8	0.58 \pm 0.13				
Sept. (31 months)	5	81.3 \pm 5.2	4	0.73 \pm 0.26	3	94.7 \pm 0.9	2	0.46 \pm 0.16

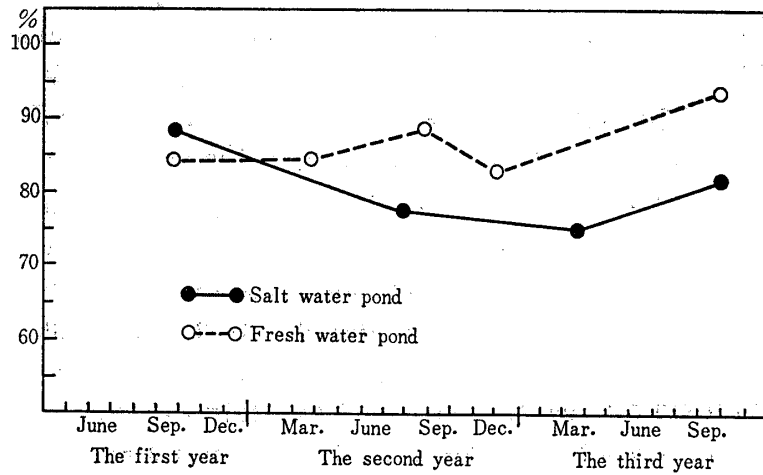


FIG. 6. The water content of the blood of the chum salmon reared in the salt water and fresh water ponds.

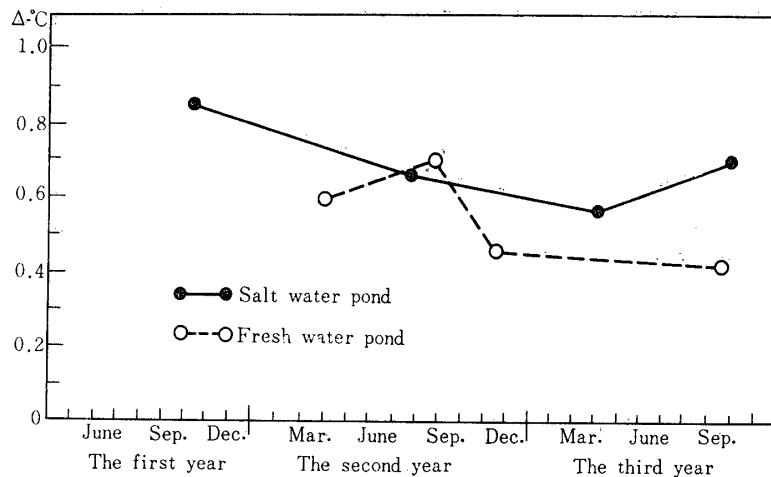


FIG. 7. The freezing point depression of the blood of the chum salmon reared in the salt water and fresh water ponds.

the second fall. The water contents of the blood of the chum salmon reared in the fresh water pond were 86.9 to 94.7 per cent from the second fall to the third fall. Those of the fresh water fish group increased after the second fall and the maximum value was 94.7 per cent by the third fall. The average freezing point depression of the chum salmon reared in the salt water pond were $\Delta-0.68^{\circ}\text{C}$ to $\Delta-0.73^{\circ}\text{C}$ from the first fall to the third fall as shown in Table 1 and Fig. 7. Those of the chum salmon reared in the fresh water pond were $\Delta-0.71^{\circ}\text{C}$ to $\Delta-0.46^{\circ}\text{C}$ and the minimum value was $\Delta-0.46^{\circ}\text{C}$ by the third fall.

Discussion

Chum salmon enter into the sea shortly after hatching in streams and rivers.

The fry, therefore, can be reared in sea water as already reported by Awakura and Tamura (2). However, the continuing this culture using natural sea water for more than several months was not possible, because it has been difficult for the fish to live through the high water temperature of the summer season in Japan. In the present experimental rearings of the chum salmon, the water temperature of the salt water pond can be kept below 19°C by mixing it with cool spring fresh water as already reported by Sato et al. (3). The fish show good growth in such a cool salt water pond, and the maturation of the male fish is seen by the second and third fall. The maturation of the female fish is also seen at the third fall. The ages of these matured fish are similar to those of the spawning male and female fish which naturally ascend the rivers. The size of the matured chum salmon reared in the salt water pond seems to be larger than that of natural spawned fish. Chum salmon can also be reared in a fresh water pond with water temperature remaining below 16°C. However size of the matured male fish after two years in the fresh water pond is less than that of the matured male fish of the same age reared in the salt water pond. The ratio of weight in gram to length in centimeter which means the fatness of the fish body is inferior in the fish reared in the fresh water pond than in that reared in the salt water pond. This is similar to the experimental results reported by Canagaratnam (4) that underyearings of coho, sockeye and chum salmon grow more rapidly in saline than in fresh water. These results may also be analogous to the case referred by Canagaratnam (4) that the growth of *Oncorhynchus nerka* (Walbaum) is inferior in its land locked form, kokanee, than in the sea run form, sockeye salmon. The water content of the blood of the chum salmon of the fresh water group is higher than in the salt water group after the second fall of the rearing. The freezing point depression of the blood of the fresh water fish group is smaller than that of the salt water fish group, too. Therefore, the inferiority of the growth of chum salmon reared in the fresh water pond seems to come from the overloading of the osmoregulation of the fish. This idea of the overloading of the osmoregulation in the fish of the fresh water group can be supported by the suggestion of Kashiwagi and Sato (1) that the blood of the fresh water chum salmon group tended to be diluted.

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