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# Studies on the Osmoregulation of the Chum Salmon, *Oncorhynchus keta* (Walbaum)

## I. The Tolerance of Eyed Period Eggs, Alevins and Fry of the Chum Salmon to Sea Water

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### Summary

1. The degree of tolerance of different stages of the eyed period eggs, alevins and fry of the chum salmon, *Oncorhynchus keta* (Walbaum), to various concentration of sea water was examined in order to know the outline of the conversion of the mechanisms for osmoregulation in the seaward migration of the fish.

2. The rate of hatching of the eyed period eggs which were abruptly transfered to 100, 75, 50 and 25 per cent sea water from fresh water were 25, 50, 75 and 100 percent respectively. The days of incubation of the eyed period eggs tended to be more in the experimental salinities. The alevins hatched in these media were not able to live normally.

3. The alevins which were 1 day from hatching are not albe to live in the 100, 75 and 50 per cent sea water, though 95 per cent of the alevins survived in the 25 per cent sea water.

4. The survival rate of the alevins which were 10 days, 20 days and 40 days from hatching were reduced as the concentration of sea water to which the alevins are transfered from fresh water increased.

5. The fry which were more than 60 days from hatching and in which the yolk sac was completely absorbed were able to survive in the 100 per cent sea water when they were transfered abruptly to it from fresh water.

The chum salmon have no remarkable morphological changes in appearance but migrate to the sea shortly after hatching. It is well known that the fry of chum salmon in which the yolk sac was absorbed display not only the ability to survive in sea water as reported by many experiments but also to prefer this medium when they were given a choice between fresh and sea water as reported by Houston (1) and Baggerman (2). However, it has not been known whether the ability of the fry to tolerate environmental changes gradually developed through the alevins and fry period or whether it appeared as a sudden conversion prior to the seaward migration.

Therefore, the degree of tolerance of different stages of the alevins and fry of

chum salmon to various concentrations of sea water has been examined in the present experiments.

## Materials and Methods

The chum salmon used in this experiment were carried to the laboratory at the stage of eyed period egg from the Tsugaruishi River Salmon Hatchery, Miyako, Iwate Prefecture, and kept in a fresh water aquaria from January to May in 1966. The alevins which hacthed from the eggs began feeding at about forty days after hatching then they were fed on a dry mixed ration. The yolk sac of the fish were completely absorbed at about sixty days after hatching.

Some stages such as the eyed period egg, the alevin and the fry of chum salmon were examined. Each batch of twenty eggs, alvins or fry were kept in the tank with 10 leters aerated water for experimetns at 5.5 to 14.5°C. At the time of transfer from fresh water to sea water, the difference of water temperature between the two media was less than one centigrade. The control fish were kept in the fresh water.

The sea water used in the experiments was taken from Onagawa Bay, Miyagi Prefecture. To this natural sea water, artificial sea water was added to a chlorinity of 19 per mil. The sea water of 19 per mil chlorinity was treated as the 100 per cent sea water and diluted with spring water to obtain various concentrations such as 75, 50 and 25 per cent sea water.

The tolerance of each batch of the eggs and the fish which was exposed to various concentrations of sea water was measured by counting its lethal time and the water content of the body after being transfered to the experimental sea water.

## Results

### *Survival of the Eyed Period Eggs, Alevins and Fry of the Fish in Various Concentrations of Sea Water*

The rate of hatching of the eyed period eggs, which were about ten days before hatching, was 100 per cent in the 25 per cent sea water, but the rate of the eggs which were transfered to the 50, 75 and 100 per cent sea water decreased to 75, 50 and 25 per cent respectively. The days of incubation tend to increase in the eyed period eggs which were in the 75 and 100 per cent sea water as shown in Fig. 1. Most of alevins hatched in these experimental salinities died after a variable number of days. The median survival time of each batch after hatching which indicated its relative tolerance to the sea water was less than a day in the 100% sea water, about one day in the 75 per cent sea water, five days in the 50 per cent sea water and 17 days in the 25 per cent sea water as shown in Fig. 2.

The alevins of the fish which were 1 day, 10 days, 20 dyas and 40 days from hatching were able to live in the 25 per cent sea water though the survival rate of the 1 day alevins was 95 per cent in this medium. However, they all died in higher

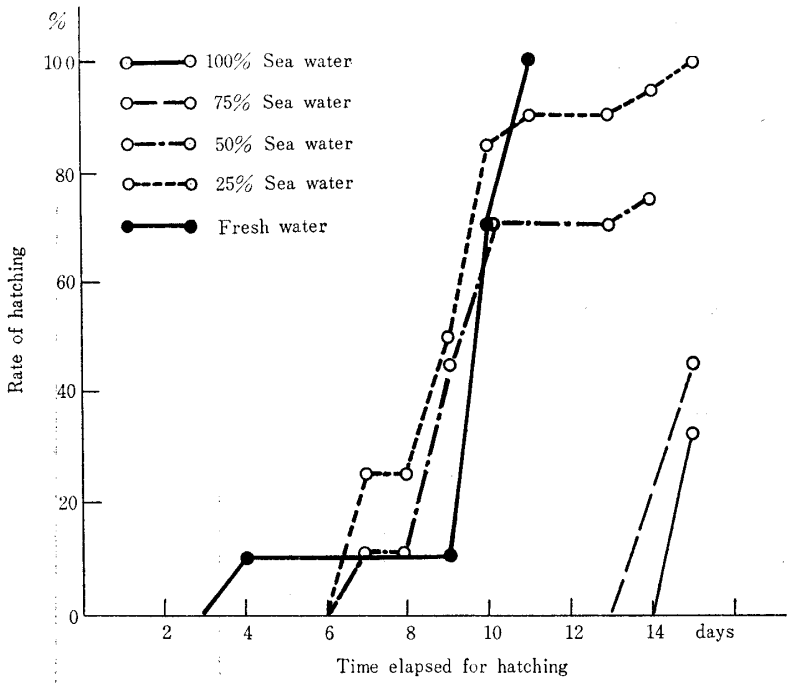


FIG. 1. Cumulative percentage of hatching of the eyed period eggs of chum salmon transfered to various concentrations of sea water from fresh water.

concentrations of the sea water: the 1 day alevins all died in more than the 50 per cent sea water, the 10 day ones all died in more than the 75 per cent sea water, both 20 and 40 day ones all died in the 100% sea water as shown in Table 1. The degree of development of tolerance to the sea water, which depends upon the age of the fish after hatching was also shown in the Fig. 2 as the relation between the median survival time and the concentrations of the sea water.

Most of the fry of the fish which were 60, 90 and 120 days from hatching and which had been absorbed their yolk sac were able to live in the sea water, though the survival rate of the 60 day fry was 85 per cent in the 100 per cent sea water as shown in Table 1.

*The Water Content of the Body of the Alevins and Fry of the Fish in Various Concentrations of Sea Water*

The water content of the body of the alevins which were 1 day and 20 days from hatching in fresh water were 59.6 and 66.0 per cent respectively, and it tended to increase with days after hatching, but to be stable at about 40 days, as shown in Fig. 3.

The water content of the body of the alevins which were transfered to sea water from fresh water, however, decreased. The 59.6 per cent water content of the body of the 1 day alevins in fresh water decreased to 47.0 per cent at the fifth day after transfering the fish to the 100 per cent sea water. That of the fish body which was transfered to the 50 per cent sea water also decreased to 53.0 per cent

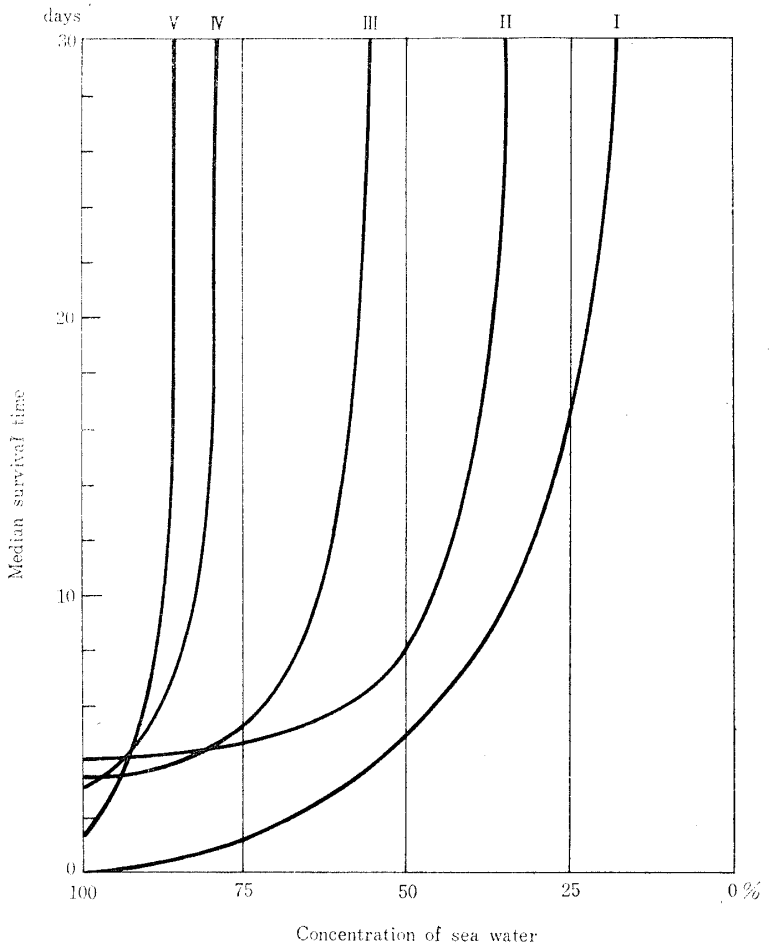


FIG. 2. Median survival time of different stages of chum salmon transfered to various concentrations of sea water from fresh water.
I; alevins hatched in the experimental salinity II; alevins 1 day from hatching
III; alevins 10 days from hatching IV; alevens 20 days from hatching
V; 40 days from hatching

TABLE 1. *Survival Rate of Different Stages of Chum Salmon at 30 Days afetr Transfering to Various Concentration of Sea Water from Fresh Water.*

| Age | Body Length | Body weight | Fresh water | 25% Sea water | 50% Sea water | 75% Sea water | Sea water |
|---|---|---|---|---|---|---|---|
| | cm | g | % | % | % | % | % |
| Eyed period eggs | — | 0.3 | 100 | 10 | 0 | 0 | 0 |
| 1 day alevins | 2.2 | 0.3 | 100 | 95 | 0 | 0 | 0 |
| 10 days alevins | 2.6 | 0.3 | 100 | 100 | 85 | 0 | 0 |
| 20 days alevins | 2.8 | 0.3 | 100 | 100 | 90 | 80 | 0 |
| 40 days alevins | 2.9 | 0.3 | 100 | 100 | 100 | 80 | 0 |
| 60 days fry | 3.3 | 0.4 | 100 | 100 | 100 | 100 | 85 |
| 90 days fry | 3.8 | 0.8 | 100 | 100 | 100 | 100 | 100 |
| 120 days fry | 6.2 | 2.7 | 100 | — | 100 | — | 100 |

after five days. That of the fish body which was transfered to the 25 per cent sea water, however, recovered to 60.0 per cent, though it somewhat decreased for about three days at the beginning as shown in Fig. 4.

The 66.2 per cent water content of the body of the alevins which were 20 days

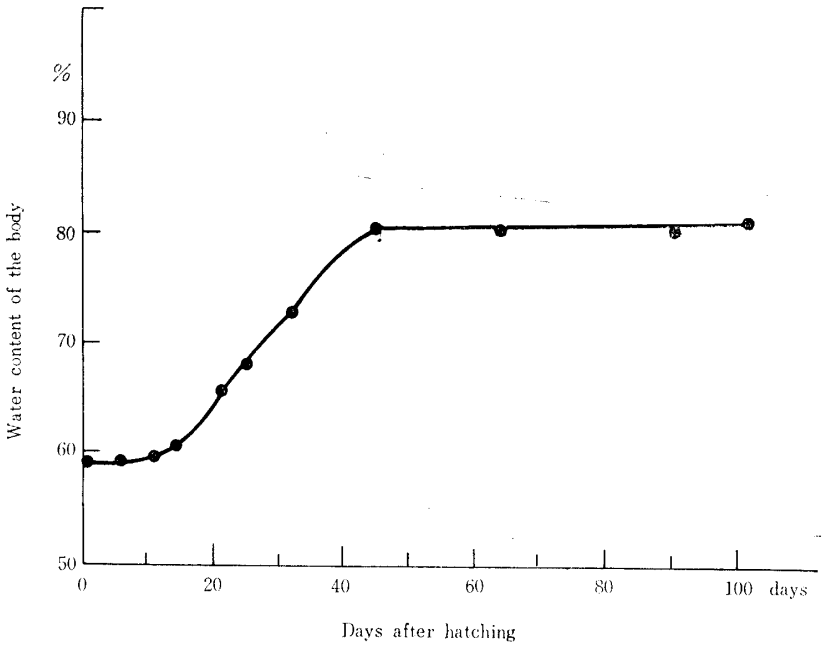


FIG. 3. Water contents of the body of the alevins and fry of chum salmon reared in fresh water.

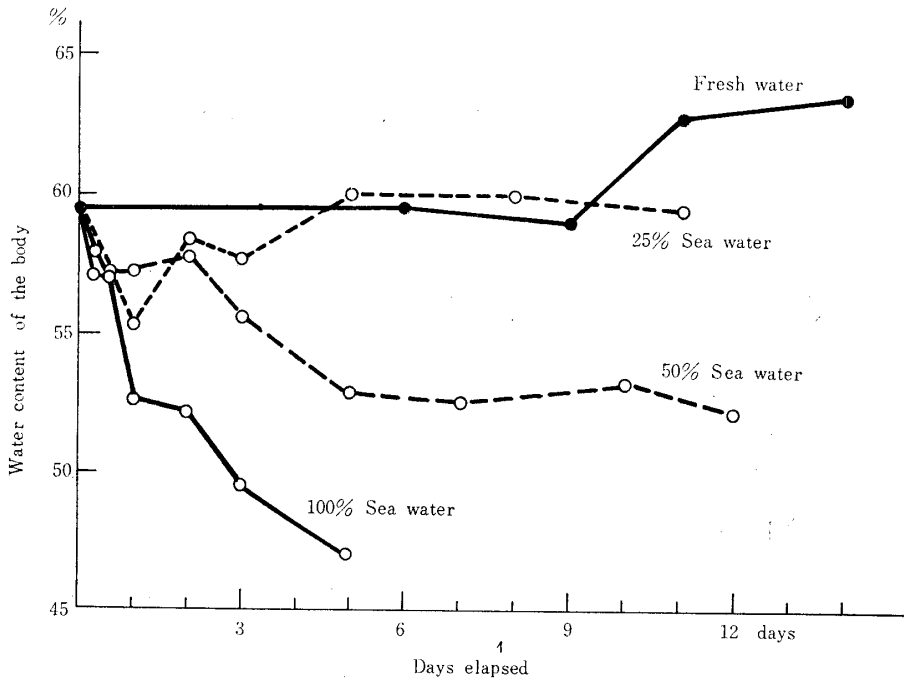


FIG. 4. Change of water contents of the body of the 1 day chum salmon alevins after transfering to various concentrations of sea water from fresh water.

from hatching in fresh water decreased to 57.5 per cent at the second day after transfering the fish to the 100 per cent sea water. That of the fish body which was transfered to the 50 per cent sea water recovered to 72.5 per cent after decreasing somewhat for about six days as shown in Fig. 5.

The 80.1 per cent water content of the body of the fry which were 90 days

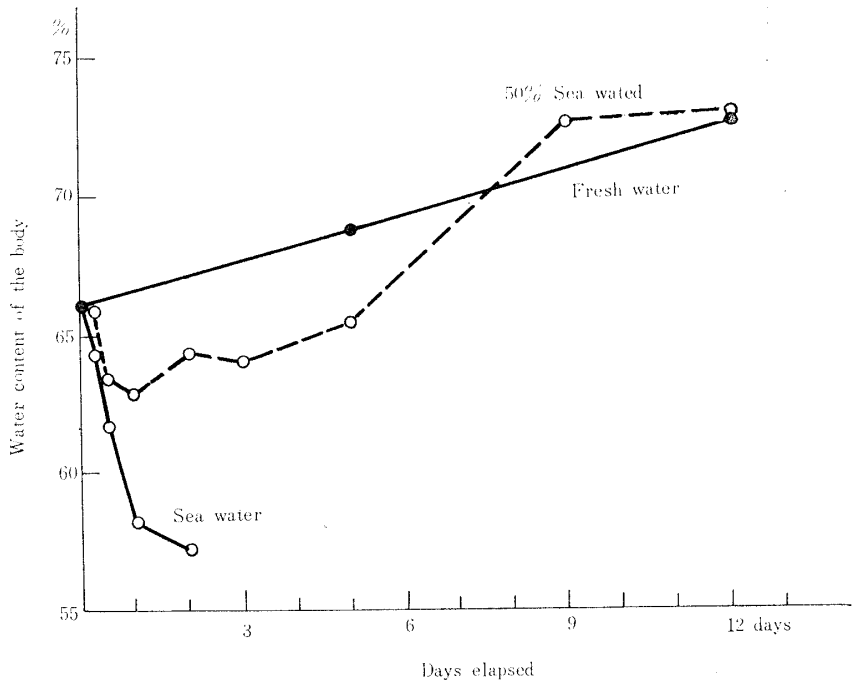


FIG. 5. Changes of water content of the body of the 20 day chum salmon alevins after transfering to various concentrations of sea water from fresh water.

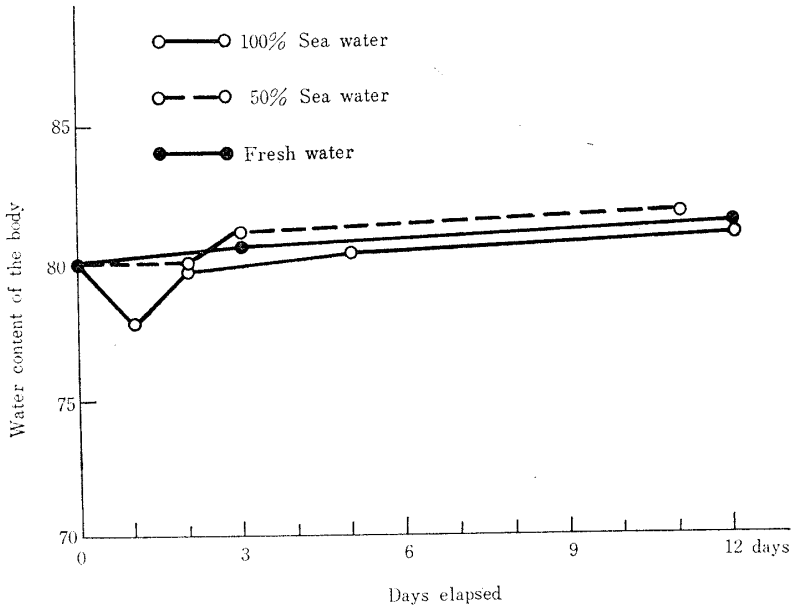


FIG. 6. Changes of water content of the body of the 90 day chum salmon fry after transfering to various concentrations of sea water from fresh water.

from hatching in fresh water recovered to 80.5 per cent at the fifth day after transfering the fish to 100 per cent sea water though it somewhat decreased immediate after the transfer. That of the fish body which was transfered to the 50 per cent sea water also slightly increased to 81.0 per cent at the third day as shown in Fig. 6.

## Discussion

The rate of hatching of the eyed period eggs of the chum salmon decreased as the concentration of sea water to which the eggs were transfered from fresh water increased. Most of the alevins hatched in the experimental salinities died after a variable number of days after hatching. These results are similar to those of the Atlantic salmon, *Salmo salar* (Linneaus), reported by Busnel et al. (3).

The tolerance of the alevins and fry of chum salmon to sea water, however, gradually increased as the fish become older in the days from hatching, and more than 85 per cent of the fry which are older than 60 days from hatching are able to live in all experimental salinities. Such tolerance of the fish to sea water is similar to the results reported by Inukai (4) that chum salmon fry which hed absorbed their yolk sac can live in sea water. Such tolerance of the fry to sea water has also been examined by Black (5), Houston (6) and Sato and Kashiwagi (7).

The water content of the body of the alevins whch are 1 day and 20 days after hatching decreased when they were transfered to the sea water from fresh water in the present experiments. That of the fry which are 90 days from hatching, however, showed little decreasing after transfered to the sea wafer. Such development of the salinity tolerance which depends upon the age of the fish after hatching comes from an increase of the ability of the osmoregulation.

The development of the ability of the osmoregulation of the fish in the sea water seems to come from physiological changes such as the development of the so called 'chloride secretory cell' in the gills at the stage of the smolt, as indicated by Hoar (8) and Nishida (9). A physiological study of the fry of chum salmon which come down into the sea shortly after hatching, therefore, will be necessary to understand the conversion of osmoregulation from a fresh water fish type to a marine fish type.

## References

1) Houtson, A.H., *Canadian J. Zool.*, **33**, 371 (1957)
2) Baggerman, B., *J. Fish. Res. Bd. Canada*, **17**, 295 (1960)
3) Busnel, R.G., *Drillhon, A., and Raffy, A., Bull. Inst. Oceanogr., Monaco*, **893**, 1 (1946)
4) Inukai, T., *Zool. Mag.*, **48**, 907 (1936) (in Japanese, with English summary)
5) Black, V.S., *J. Fish. Res. Bd. Canada*, **8**, 164 (1951)
6) Houston, A.H., *J. Fish. Res. Bd. Canada*, **18**, 401 (1961)
7) Sato, R., and Kashiwagi, M., *Tohoku J. Agr. Res.*, **19** (2), 127 (1968)
8) Hoar, W.S., *J. Fish. Res. Bd. Canada*, **15**, 391 (1958)
9) Nishida, H., *Sci. Repts. Hokkaido fish Hatchries*, **8**, 33 (1953) (in Japanese, with English summary)