# SIZE RELATIONSHIP BETWEEN SALMON JUVENILES IN SHORE WATERS AND THEIR PREY ANIMALS

Shun OKADA* and Akira TANIGUCHI*

It is reported that the growth of juveniles of the Pacific salmon (*Oncorhynchus*) in shore waters was remarkably large, showing 2.5–3.0 cm in length and 3 g in weight a month (Ivankov & Shershnev, 1968). Accordingly, further studies on their food habits as well as other ecological subjects in shore waters should be carried out. At the present time, however, very little is known about the food habits of juveniles of the Pacific salmon in shore waters, though a relatively large amount of knowledge has been accumulated on the same subject about fry stage in fresh water.

As far as we know, the following informations are almost all already published on this field: namely, brief notes on food of chum, pink, silver and king salmon juveniles near the coast of Nanaimo, British Columbia, by Foskett (1951) and on food of chum and pink salmon juveniles in shore waters of the southern Kurile Islands by Ivankov & Shershnev (1968), and experimental works on the food habits of chum and pink salmon juveniles by LeBrasseur (1969).

Foskett (1951) and Ivankov & Shershnev (1968) reported that the juvenile salmon in shore waters ate mainly small crustaceans, fish larvae and aerial insects. Foskett mentioned also that the juveniles changed gradually their food animals from small to larger kinds with their growth. On the other hand, LeBrasseur (1969) examined the selective ability of the juvenile chum and pink salmon ranging from 37 to 44 mm in fork length for 3 different size groups of food animals and found that most of the juveniles selected the copepods of 1.6–4.5 mm long and that larger preys (euphausiids) of 6–20 mm long were selected only by the juveniles which had previously eaten euphausiids.

The present paper offers the data on stomach contents of the juveniles of the c um salmon, *Oncorhynchus keta* (WALBAUM) and the pink salmon, *O. gorbuscha* (WALBAUM) in shore waters of southern Hokkaido and reports that the juveniles displayed a rapid change in the size of their food animals from a small-size group to a large-size group at a certain stage of growth, instead of a gradual change.

We are indebted to Mr. M. Fukuchi of the Faculty of Fisheries, Hokkaido University for his collaborations in identification of amphipods. We also thank Mr. H. Yanagawa of our laboratory for his help in samplings.

* *Laboratory of Marine Zoology, Faculty of Fisheries, Hokkaido University*
(北海道大学水産学部水産動物学講座)

## Materials and methods

Four hundred and seventy-three juveniles of the chum and pink salmon were sampled near the shores of Mori and Usujiri in southern Hokkaido during the period from May 28 to June 24, 1970. The former place is located southeastward about 30 km along the coast line from the mouth of the Yurappu River, and the latter farther southeastward about 40 km from Mori (Fig. 1). Samplings were made by the trap set-nets which had been settled at about 200 m (20 m in depth) away from the shores of Mori and 2000 m (60 m in depth) from Usujiri. The mesh size of both nets was about 10 mm at the end in stretched measure.

It seems to be reliable that the juveniles sampled near Mori and Usujiri were mostly derived from the fries released into the Yurappu River by the operation

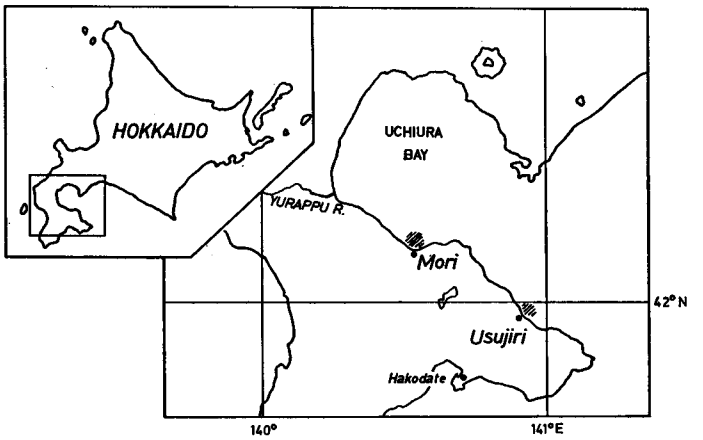


Fig. 1. Locations of sampling of juveniles of the chum and pink salmon (shaded areas)

Table 1. Number and fork length of juveniles of the chum and pink salmon sampled in the shore waters near Mori and Usujiri during the period from May 28 to June 24, 1970

| Location | Date | Chum salmon | | | | Pink salmon | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number | Fork length (mm) | | | Number | Fork length (mm) | | |
| | | | Max. | Min. | Mean | | Max. | Min. | Mean |
| Mori | May 28 | 16 | 85 | 48 | 67.1 | 46 | 70 | 43 | 55.0 |
| | June 3 | 94 | 89 | 48 | 66.0 | 52 | 78 | 42 | 58.8 |
| | June 11 | 17 | 88 | 53 | 71.7 | 4 | 60 | 70 | 66.3 |
| | June 12 | 72 | 76 | 39 | 53.0 | 2 | 52 | 65 | 58.5 |
| | June 13 | 38 | 83 | 50 | 67.5 | 3 | 65 | 70 | 67.7 |
| | June 24 | 0 | — | — | — | 0 | — | — | — |
| Usujiri | June 7 | 62 | 101 | 70 | 78.9 | 1 | 58 | 58 | 58.0 |
| | June 8 | 64 | 94 | 61 | 78.8 | 2 | 65 | 61 | 63.0 |
| | June 9 | 0 | — | — | — | 0 | — | — | — |

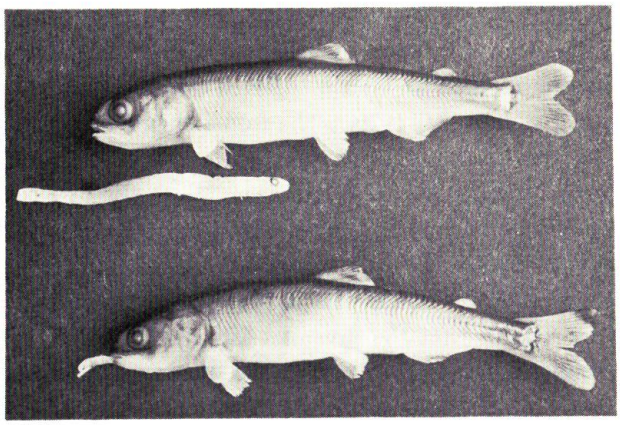

Fig. 2. Juveniles of the pink salmon swallowing fish larvae heads first.
Above: a fish larva (35 mm long) fed from its head by a juvenile pink is pulled out from the stomach of the predator (56 mm in fork length).
Below: a juvenile pink (57 mm) swallowing a fish larva the tail of which is still out of the predator's mouth.
These larvae are perhaps a species of pricklebacks.

branch of the Hokkaido Salmon Hatchery located 20 km up the river, because the individuals marked at the Hatchery were frequently recaptured in these locations.

The number and fork length of the juveniles of the chum and pink salmon sampled are given in Table 1. After June 24 at Mori, and after June 9 at Usujiri, none of the juveniles of the chum and pink salmon was captured. The juveniles of both kinds collected were identified by the specific characteristics in external appearance reported by Okada & Nishiyama (1970).

Ninety-four chum and forty-three pink juveniles among them were offered for the examination of the preys in their stomachs. At the same time, the size of the prey animals was measured in their body width to examine the size relationship between the juveniles and their prey animals. The upper limit of the size of edible preys may be mostly determined by their body width, not by their body length, because long and slender preys are swallowed by the predators from head along the long axis of body as shown in Fig. 2.

## Stomach contents of the juveniles

Among 94 chum and 43 pink juveniles, only 4 individuals had an entirely empty stomach. The prey animals identified from the stomach contents of the remainders (which ranged from 36 mm to 104 mm in fork length) are shown in Table 2.

Micro-copepods (*Pseudocalanus minutus*, *Paracalanus parvus*), amphipods

Table 2. Occurrence of prey animals in stomachs of juveniles of the chum and pink salmon sampled in the shore waters near Mori and Usujiri during the period from May 28 to June 24, 1970. +: the prey was found in the stomachs, −: the prey was not found in any stomach.

| | Usujiri | | Mori | | | | | |
|---|---|---|---|---|---|---|---|---|
| | June 7 & 8 | | May 28 | | June 3 | | June 11–13 | |
| | chum (27) | pink (3) | chum (14) | pink (12) | chum (27) | pink (22) | chum (26) | pink (6) |
| Copepoda | | | | | | | | |
| *Calanus finmarchicus* | + | − | + | + | + | + | + | − |
| *C. plumchrus* | − | − | − | − | + | + | − | − |
| *Eucalanus bungii bungii* | + | − | − | − | − | − | − | − |
| *Labidocera japonica* | + | − | + | − | + | + | + | − |
| *Pseudocalanus minutus* | + | + | + | + | + | + | + | + |
| *Paracalanus parvus* | + | + | + | + | + | + | + | + |
| *Metridia* spp. | + | + | − | − | − | − | − | − |
| *Tigriopus japonicus* | − | − | + | + | − | − | + | + |
| Amphipoda | | | | | | | | |
| *Parathemisto japonica* | + | + | + | + | + | + | + | + |
| young *P. japonica* and *P. pacifica* (?) | + | + | + | + | + | + | + | + |
| Mysidacea | | | | | | | | |
| *Neomysis czerniawskii* | − | − | − | − | − | − | + | − |
| Euphausiacea | | | | | | | | |
| *Euphausia pacifica* | + | + | + | + | + | + | − | − |
| *Thysanoessa longipes* | − | − | − | − | + | − | − | − |
| *T. inspinata* | − | − | − | − | + | − | − | − |
| *T. raschii* | − | − | − | − | + | + | − | − |
| Ostracoda | + | − | − | − | + | − | + | + |
| Cumacea | − | − | − | − | − | − | + | − |
| Isopoda | + | − | − | − | − | − | − | − |
| young Stomatopoda | − | + | − | − | − | − | − | − |
| Decapoda | | | | | | | | |
| Zoea larva | + | + | − | + | + | + | + | − |
| Mysis larva | + | − | − | − | − | − | + | − |
| planktonic shrimp | + | − | − | − | − | − | − | − |
| Spider | + | − | − | − | − | − | − | − |
| Insects | | | | | | | | |
| Diptera & Hymenoptera | + | + | + | + | + | − | + | + |
| planktonic Gastoropoda | + | − | − | − | − | − | + | − |
| Fish | | | | | | | | |
| eggs | − | − | + | + | + | + | − | − |
| larvae | + | + | + | + | + | − | + | + |

( ): Numeral letters in parentheses indicate the number of individuals examined

(adult and young *Parathemisto japonica* and *P. pacifica*), insects (Diptera, Hymenoptera) and fish larvae (pre- or post-larvae of one species of pricklebacks) were commonly found in the stomachs with no great difference between chum and pink juveniles throughout the period of investigation. This may indicate that these preys are the most important food for the juveniles of the chum and pink salmon in shore waters. Euphausiids (mainly adult and young *Euphausia pacifica*) and decapods larvae (mainly crab zoea) also occurred in the stomachs of comparatively numerous predators. Each important diet mentioned above and its maximum number of occurrence in the stomachs of the predators are listed in Table 3.

Table 3. Important prey animals and their maximum number of occurrence through all stomachs of juveniles of the chum and pink salmon sampled in the shore waters near Mori and Usujiri during the period from May 28 to June 24, 1970

| Predator (fork length) | Prey animal and its maximum number through all stomachs | Other preys found in the same stomach (individual number) |
|---|---|---|
| Chum(42 mm) | Micro-copepods 256 | Young *Parathemisto* spp. (13), insects (2), others (10) |
| Chum(72 mm) | Young *Parathemisto* spp. 222 | Micro-copepods (42), adult *P. japinica* (4), young euphausiids (4), *Calanus finmarchicus* (4), insects (2) |
| Chum(81 mm) | Adult *P. japonica* 10 | Young *P.* spp. (3), fish larvae (3), adult euphausiid (1) |
| Chum(68 mm) | Young euphausiids 26 | Young *P.* spp. (153), adult *P. japonica* (9), micro-copepods (3), *C. finmarchicus* (2) |
| Chum(72 mm) | Adult euphausiids 3 | Micro-copepods (10), fish larva (1), decapod zoea larva (1) |
| Chum(42 mm) | Decapods zoea larvae 151 | Young *P.* spp (13), insects (2), others (10) |
| Chum(79 mm) | Insects 15 | Decapods zoea larvae (22), adult *Neomysis czerniawsky* (1), fish larva (1) |
| Pink(58 mm) | Fish larvae 33 | Adult *P. japonica* (8), adult euphausiid (1), fish egg (1) |

It may be of interest to note that the insects commonly found in the stomachs were referable to the aerial Diptera and Hymenoptera, and that *Tigriopus japonicus* known as tide pool species and benthic cumaceans were also often found in stomachs. These facts may suggest that the juveniles feed on the preys frequently at the surface layer of waters, sometimes near intertidal shore waters or at the bottom layer of waters. Fish larvae probably belong to one species of pricklebacks, the size of the larvae measuring mostly from 4 to 6 mm with the exception of several individuals which were from 30 to 40 mm in length.

### Size relationship between the juveniles and their preys

The size of the largest prey found in each stomach of the examined 137

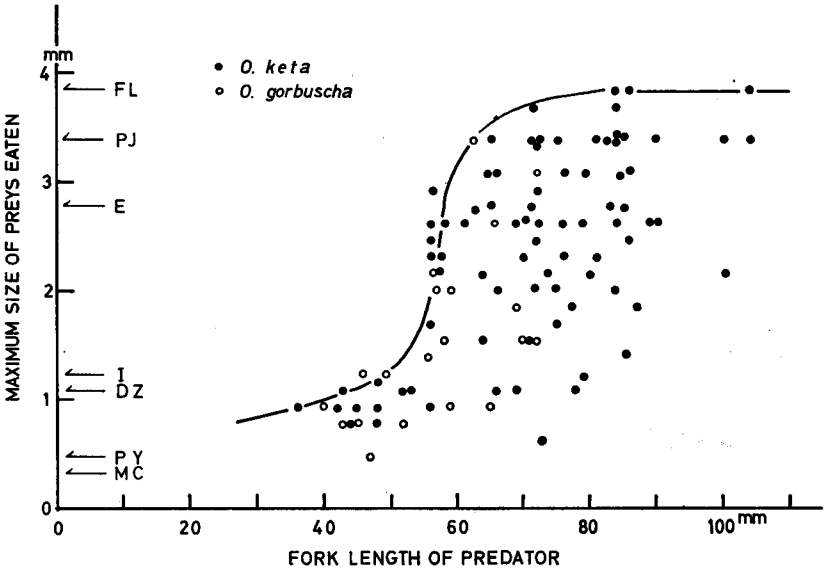


Fig. 3. Size relationship between juveniles of the chum and pink salmon and the largest prey animals eaten by them. Horizontal arrows indicate the largest size of preys in body width (MC: micro-copepods, PY: young *Parathemisto* spp., DZ: decapods zoea, I: insects, E: adult euphausiids, PJ: adult *Parathemisto japonica*, FL: fish larvae)

juveniles varied from 0.4 mm (micro-copepods) to 3.8 mm (fish larvae) in body width, not in body length. All prey animals were separated into two main groups according to the size in body width. Namely, the large-size group ranged from 1.3 mm to 3.8 mm such as the adult euphausiids and the adult *Parathemisto japonica*, and the small-size group was less than 1.3 mm such as the micro-copepods, decapods zoea, insects and young *Parathemisto* spp. The fish larvae were excluded from these two groups, since their size varied widely in body width.

Some species belonging to these two groups always occurred together in each stomach throughout the investigation, while the species composition of prey animals in each stomach usually varied. Accordingly, it may be supposed that the availability of both small and large-size preys were essentially the same regardless of time or location of samplings (Table 2).

The relationship between the size of the juveniles (fork length) and the largest size of preys (body width) in each stomach is illustrated in Fig. 3.

Preys larger than 1.3 mm in width were not found in the stomachs of juveniles smaller than 55 mm in fork length. The size of the largest preys eaten by juveniles of the same size increased slightly with the growth of the juveniles and jumped suddenly when the juveniles grew up to about 55 mm in fork

length; it increased slightly again until about 85 mm in fork length. Thereafter, any increase in the size of preys was not observed in the sampled juveniles.

It seems to be a remarkable feature that the largest preys eaten by predators rapidly changed from a small-size group (micro-copepods, young *Parathemisto* spp., decapods larvae, insects) to a large-size group (adults of euphausiids and *Parathemisto japonica*) when predators grew up to about 55 mm in fork length. Anraku & Azeta (1965) also reported similar facts in the juvenile yellowtails, namely that their diets changed rapidly from small size to large size fish larvae when the predators attained to 75 mm in length. It is regrettable that we can not given at the present time any satisfactory interpretation of these facts reported by Anraku & Azeta and mentioned by us in this paper.

## Summary

1. The stomach contents of 94 chum and 43 pink juvenile salmon, *Oncorhynchus keta* and *O. gorbuscha* sampled by the trap set-nets in the shore waters near Mori and Usujiri, southern Hokkaido, during the period from May 28 to June 13, 1970 were examined.

2. Small-size prey animals such as micro-copepods, young *Parathemisto* spp., decapods zoea and insects were the food for juveniles smaller than 55 mm in fork length and large-size prey animals such as adults of *Parathemisto japonica* and euphausiids for juveniles larger than 55 mm.

3. The body width of the largest prey animals eaten by various size juveniles (36–104 mm in fork length) ranged from 0.5 mm to 3.8 mm. The size of the largest diet eaten by juveniles changed rapidly from a small-size group to a large-size group when the predators attained to about 55 mm in fork length.

4. Pre- or post-larvae of one species of pricklebacks also seemed to be important preys for both small and large juveniles in shore waters.

## References

Anraku, M. & Azeta, M. (1965). The feeding habits of larvae and juveniles of the yellowtail, *Seriola quinqueradiata* Temminck et Schlegel, associated with floating seaweeds. *Bull. Seikai Reg. Fish. Res. Lab.*, No. 33, 13–45.

Foskett, D.R. (1951). Young salmon in the Nanaimo area. *Fish. Res. Bd. Canada, Prog. Rept. Pacific Coast Sta.*, No. 86, 18–19.

Иванков, В. Н. и Шершнев, А. П; (1968) Биология Молоди Горбуши и Кеты в Море. Рыбное Хозяйство 1968, No. 4,16-17(translated from Russian into Japanese in 1968).

LeBrasseur, R.J. (1969). Growth of juvenile chum salmon (*Oncorhynchus keta*) under different feeding regimes. *J. Fish. Res. Bd. Canada*, **26**, 1631–1645.

Okada, S. & Nishiyama, T. (1970). Notes on morphological differences between the juveniles of chum and pink salmon in shore waters. *Bull. Fac. Fish., Hokkaido Univ.*, **20**, 277–286.