# Seabird Predation on Juvenile Chum Salmon

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Production of Pacific salmon (*Oncorhynchus* spp.) is affected by environmental and biological factors. High mortality of juvenile salmon has been considered to occur between the seaward migration and early coastal life (Parker 1968; Healey 1982; Bax 1982). However, little is known about the predation by fish and birds on juvenile chum salmon, *O. keta* (Nagasawa 1998). The river mouth is the habitat where juveniles adapt to a new frontier, and provides predators with a foraging ground. In this study, we examined the predation by fish and seabirds on juvenile chum salmon around a river mouth.

Our study area was the Syokanbetsu River mouth in the Mashike coast of the Sea of Japan off northern Hokkaido. Juvenile chum salmon have been released in the Syokanbetsu River since 1957, and about 13 million juveniles were released from the Mashike hatchery from early April to mid-April, 1995–1999.

Potential fish predators were captured with gillnet, set net, and Sayori townet (a small surface trawl net) in the coastal waters off Mashike from pre-release to post-released, 1995–1999, and stomach contents were analyzed. We took a census of seabirds, and observed their feeding behavior using binoculars.

We estimated the consumption of juvenile salmon by gulls within the river mouth area, 250-m long and 30-m wide, from late April to mid May in 1999. We used the following the equation for estimating consumption:

$$C=N \cdot T \cdot Af \cdot As$$

where, C is consumption (fish.bird$^{-1}$.day$^{-1}$), N is the number of seabirds feeding on juveniles in the census area, T is the amount of time spent feeding on juveniles in one day, Af is the frequency of occurrence of a bird's attacking behavior (per min), and As is the success of catching juveniles / occurrence of attacking behavior.

We examined the stomachs contents of 13 species of fish. Some juvenile chum salmon were found in the stomachs of adult arabesque greenling (*Pleurogrammus azonus*), masu salmon (*O. masou*), and white-spotted charr (*Salvelinus leucomaenis*) juveniles. However, arabesque greenling appeared to feed on juveniles only when they were in the set net, because the juvenile chum salmon were not digested compared with other stomach contents. We did not consider masu salmon and charr to be important predators because the sea entry of masu salmon was a month later than that of juvenile chum salmon and the abundance of charr was low.

We found seven birds (slaty-backed gull, *Larus schistisagus*; black-tailed gull, *L. crassiostris*; glaucous gull, *L. hyperboreus*; harlequin duck, *Historionicus histrionicus*; red-breasted merganser, *Mergus serrator*; Japanese cormorant, *Phalacrocorax capillatus*; heron, *Egretta garzetta*) around the river mouth and rhinoceros auklet (*Cerorhinca monocerata*) in offshore waters. Of the eight birds, gulls, mergansers and cormorants were observed feeding on juvenile chum salmon. Rhinoceros auklets were not observed feeding on juvenile salmon because of their diving behavior offshore waters. Because rhinoceros auklets establish a large colony (600 thousand birds) on Teuri Island near the Mashike coast, they are likely to be a potential predator. Abundance of gulls and mergansers reached a peak in April. The timing of the peaks coincided with the sea entry of juvenile chum salmon.

Gulls showed four different types of feeding behavior, which were ambushing, dipping, and surface seizing (stationary and mobile). Although dipping and mobile surface seizing showed a higher frequency of attacking behavior than other behavior types, surface seizing type showed a trend to decrease after releasing. Dipping behavior was observed during the seaward migration of salmon.

The relation between the occurrence of attacking behavior and days after salmon release was: $Y = 8.12–0.739X$ ($r2 = 0.895$), where Y is occurrence of attacking behavior (per min) and X is days after release. The average success rate was 0.63, which is similar to that of the ring-billed gull, *L. delawarensis* (Ruggerone 1986). The days examined ranged from the first day to the ninth day after release. The mean number of gulls feeding on juveniles in the census area was 80 birds. Feeding behavior was observed from 6 a.m. to 6 p.m. (720 min). The occurrence of attacking behavior per day was calculated with the equation. We estimated the loss of chum salmon juveniles by gulls at 1,443,500 fish. This was 11.1% of the total fish released (Table 1). Consumption may have been underestimated because of the restricted area and the limited number of predator species examined. Wood (1987) reported that maximum mortality rate by common mergansers (*M. merganser*) did not exceed 10% over the entire salmon seaward migration, thus our estimate may not be low.

**Table 1.** Total numbers of juvenile chum salmon consumed by gulls.

| Days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| N | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | |
| T | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | |
| Af | 7.38 | 6.64 | 5.9 | 5.16 | 4.42 | 3.68 | 2.94 | 2.2 | 1.46 | |
| As | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | |
| C | 267800 | 241000 | 214100 | 187200 | 160400 | 133500 | 106700 | 79800 | 53000 | 1443500 |

We concluded that predation by seabirds (gulls, cormorants, and mergansers, and possibly rhinoceros auklets) has more impact than predation by fish on survival of juvenile chum salmon during seaward migration and early coastal life. We need to examine more predators in the future and determine the mortality of juveniles quantitatively. We also want to examine the relationship between the magnitude of predation and salmon production.

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