Early Sea Mortality of Chum Salmon Juveniles in the Open Coastal Waters of the Japan Sea

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The early sea life is regarded as a critical period determining year-class strength in Pacific salmon. However, there are few estimates of early sea mortality available. For hatchery-reared chum salmon, Bax (1983) estimated early sea mortality ranged from 31 to 46% in the 2–4 day period after release from a hatchery. This high mortality may apply to that portion of the population remaining close to the release site in the first 4 days after release. In the Japan Sea, chum salmon juveniles ranging from 50 to 75 mm in fork length are distributed in river plumes (Fukuwaka and Suzuki 1998). There is concern about the mortality associated with this practice. Thus, the objectives of the study are to estimate juvenile mortality in early coastal life after release, and to compare the coastal mortality with successive offshore mortality of immature or maturing fish.

To estimate daily mortality in early coastal life, we analyzed the data record of 9 mark-recapture experiments. In these experiments, 2,572,323 juveniles had the adipose fin or both of the ventral fins clipped. These marked fish were released from hatcheries in 1992–1997 into the Miomote River, Sho River, and Hime River, which flow into the Japan Sea coast of Honshu, Japan. In the 14–43 day period after release, 1,538 marked juveniles were recaptured in coastal waters by the prefectural fisheries experimental stations or commercial fishermen using pelagic trawls, setnet, and beach seines. To calculate mortality, we used a mark-recapture model and the maximum likelihood method for parameter estimation (Kitada et al. 1992). To compare coastal mortality and offshore mortality, we used the mean age-specific return rate in Japan Sea coasts of Honshu over the past 20 years as a survival rate during the whole ocean life. We estimated mortality during the coastal life by assuming the duration of coastal life to be 32 days. We determined the offshore mortality by subtracting the coastal mortality from the age-specific mortality rate.

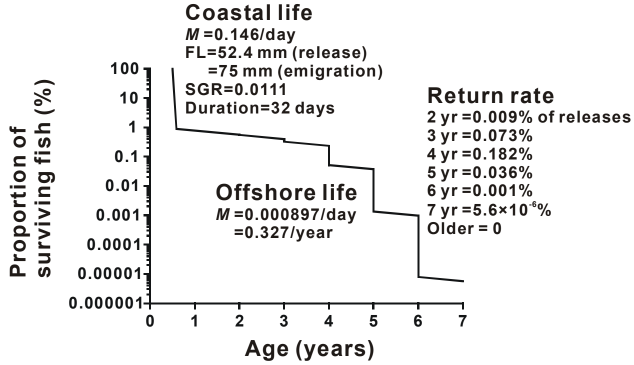
Estimated instantaneous mortality rate ranged from 0.033 to 0.268 day^{-1} in the 14–43 day period after release (Table 1). It is equivalent to a daily survival rate from 76.5 to 96.7%. This is higher than 54–69% in the 2–4 day period estimated by Bax (1983). This may be due to the difference in length of study period and size of study area. Bax's estimates may apply to that portion of the population remaining close to the release site in the first 4 days after release. Survival rate of chum juveniles may be the lowest in the near shore area and may increase with growth in coastal waters.

The instantaneous mortality rate during offshore life (0.000897 day^{-1}) was much lower than that during coastal life (Fig. 1). Mortality rate summed during coastal life was 99.1% of released juveniles, while during the offshore

Table 1. Estimated mortality rate (mean ± standard deviation) of mark-released chum salmon juveniles during early sea life in Japan Sea coastal waters.

Year	Release site	Duration of surveys (days after release)	Instantaneous mortality rate (day^{-1})	Daily survival rate (%)
1992	Miomote R.	6–15	0.192 ± 0.055	82.5
1993	Sho R.	4–30	0.245 ± 0.064	78.3
1994	Miomote R.	0–43	0.105 ± 0.011	90.0
1994	Sho R.	2–14	0.268 ± 0.051	76.5
1995	Sho R.	1–26	0.193 ± 0.025	82.5
1996	Miomote R.	2–33	0.033 ± 0.020	96.7
1996	Sho R.	1–30	0.180 ± 0.024	83.5
1997	Hime R.	10–41	0.059 ± 0.015	94.3
1997	Sho R.	1–35	0.039 ± 0.034	96.2

Fig. 1. A hypothetical survivorship curve of hatchery-released chum salmon.



life it was 0.6%. This indicated that early coastal mortality was 99.3% of overall ocean mortality.

While we cannot show direct evidence for mortality agents during early sea life in this study, some possible mortality agents are suggested from our studies on chum salmon populations in the Japan Sea. Spring coastal sea surface temperatures in the release year were negatively correlated with year-class strength of returning adults (Fukuwaka and Suzuki 2000). Juveniles may be easily transported out of the narrow nursery area in open coastal waters of the Japan Sea. Starvation might be a mortality agent, because chum juveniles competed with each other for food in coastal waters (Fukuwaka and Suzuki 2000). Predation on chum salmon juveniles by masu salmon smolts was observed in the study area (unpublished data).

In summary, we could estimate early sea mortality during coastal life using large-scale marking experiments and intensive coastal surveys. Estimated early mortality during coastal life was much higher than the successive mortality during offshore life. Results indicated that large-scale mark-recapture experiments are useful for monitoring the coastal environment, where salmon juveniles may experience a critical survival period. Censuses of juvenile salmon abundance after their early sea life may be needed for assessment of the abundance of salmon entering the Pacific basin area.

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