Survivorship of Juvenile Chum Salmon Released from Hokkaido, Japan: Independence of the Density Effect

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For the last couple of decades, chum salmon returns to northern Japan have reached the historically highest level. This is due to the success of the salmon hatchery programs in Japan (Kaeriyama 1996; Hiroi 1998). However, some reports noted the possibility that the growth of chum salmon has decreased (Kaeriyama 1989; Ishida et al. 1993). This paper describes the extent of the effect of density of juvenile chum salmon on their population dynamics.

Records of return and release of chum salmon in five regions around Hokkaido were collected for year classes from 1950 to 1994 by the National Salmon Resources Center. The number of survivors at each age was derived from iterative backward calculation by using the equation, $N_t = (N_{t+1} + R_t)e^M$ (N_t, the number of survivors at the beginning of age t; R_t, the number of fish returned at age t; M, coefficient of natural mortality in the period of ocean residence, postulated to be stable). M was calculated as $2.5/T_{max}$ (T_{max}, maximum age of return), proposed by Tanaka (1960) and cited in Watanabe (1999). The maximum age of return was 6 in regions A and C, and 7 in other regions. The survival rate of one-year-old juveniles was the percentage of N_1 to the number of juveniles released. The rates of change in juveniles released and one-year-old survivors were calculated as the percent ratio between the number juveniles released (or survivors) in each year class and the average number released (or survivors) from 1950 to 1961 year classes. As the salmon resource enhancement program in Hokkaido was started in 1962, the average shows the level of release and survival before the start of the program. From the values of N_t and R_t, the rate of spawners in total survivors at each age was calculated as $100R_t / (N_{t+1}+R_t)$.

The numbers of one-year-old survivors and spawners reached the maximum level in the year classes after the mid 1980s in all the regions. The survival rate of one-year-old salmon and the return rate also reached the highest levels in the corresponding year classes (Fig. 1). The rates of change in the number of one-year-old survivors in the year classes after 1970 far exceeded those of juveniles released. The percentage of age two- and three-year old spawners decreased in the year classes after the end of 1960s (Fig. 2). The maximum age of return increased in recent year classes.

The rise in juvenile survival and increase in the return of spawners to Hokkaido is due to the success of the salmon resource enhancement program. Maturation of chum salmon may have lagged with increase in the juvenile survival.

Survival of juvenile chum salmon released from Hokkaido is possibly independent of the density of juvenile salmon, or the number of juveniles released may not be high enough to cause an increase in the density effect. However, the decrease in the rate of the spawners at age and the increase in the maximum age of return suggest that the slowdown of growth of chum salmon in the period of ocean residence is an effect of increased density.

Fig. 1. Numbers of juveniles released, spawners returning, and 1-yr.-old survivors. A, coast along Okhotsk Sea; B, Nemuro Strait; C, east coast of Pacific Ocean; D, west coast of Pacific Ocean; E, Coast along Sea of Japan. ◁; calculated from provisional figure.

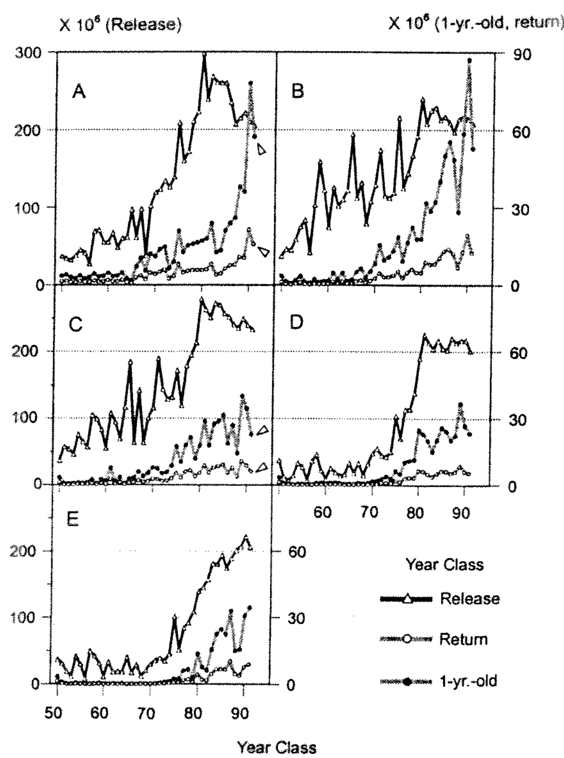
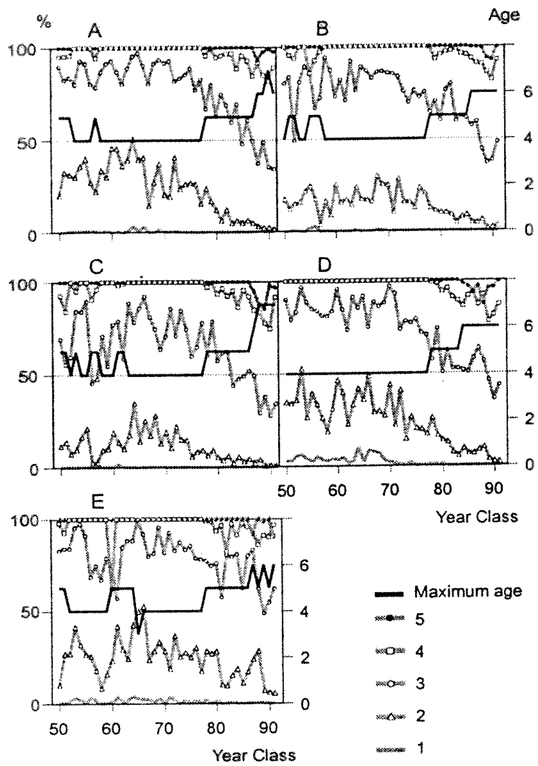


Fig. 2. Percentages of spawners in total survivors at age and maximum ages at return.



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