Factors Affecting Survival of Hatchery-Reared Chum Salmon in Japan

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Keywords: Hatchery, growth, return rate, coastal ocean conditions

Most of the chum salmon in Japan are sustained by hatchery programs. Annual fry releases have increased since the mid 1970s to a plateau of 1.8–2.1 billion during the last two decades. The number of chum salmon returning to Japan has also increased dramatically since the mid 1970s and reached a historic peak (about 88 million returns) in 1996. This steady increase was realized by aggregate effects of successful hatchery programs and changes in oceanographic conditions (e.g. Kaeriyama 1998). However, annual returns began a gradual decline from 1997 to 2000. To evaluate potential effects of large-scale hatchery releases on the growth and survival of Japanese chum salmon annual scale growth and return rates of 1976–96 brood year stocks are analyzed.
Scales from age 0.3 females caught in five rivers of Hokkaido (Ishikari, Shari, Nishibetu, Tokachi, and Yurappu rivers) were measured, about 30–50 scales per brood year for each river population. The width between scale annuli is regarded as an indication of annual fish growth. Comparisons in mean annual growth of brood year stocks revealed differences among the river populations in the first year of ocean life. Comparisons in the second, third andfourth years found annual growth to be largely similar. This suggests that growth differences between populations during the first year likely stems from localized coastal water influences. In the 1980s, annual fluctuations in average fork length of age 0.3 females were stable despite an obvious decline in 1984. In the 1990s the variation increased suggesting that ocean conditions for growth of chum salmon might have changed in the 1990s as compared to those in the 1980s. While some researchers have reported a negative correlation between population abundance and somatic growth (e.g. Ishida et al. 1993; Kaeriyama 1996, 1998), adult returns in the Hokkaido river revealed no relationship between the average fork length and adundance of age 0.3 females, based on data for the last 20 years. However, as the brood population has been abundant in Hokkaido river, average age at maturity of brood year stocks has increased in the same period. These results indicate that increased population size may slow growth and delay maturation increasing average age of the population.

Return rates of 1976–93 brood year stocks were calculated for seven regions of Japan (Okhotsk, Nemuro, East and West Hokkaido Pacific coast, Japan Sea, Honshu Japan Sea, and Honshu Pacific coast regions). There was no significant relationship between the number of released fry and return rates in the seven regions. Correlation analysis for the return rates revealed significant positive relationships in three pairs of regions; Okhotsk-Nemuro, Nemuro-East Hokkaido Pacific coast, and Honshu-West Hokkaido Pacific coast regions. Cluster analysis determined the Okhotsk-Nemuro and Honshu-West Hokkaido Pacific coast regions to be similar groups. Since these regions, i.e., Okhotsk-Nemuro and Honshu-West Hokkaido Pacific coast regions, are geographically close each other, I examined the following coastal ocean conditions as possible factors affecting the return rates: (1) November-July sea surface temperature (SST) and (2) surface area of SST ranging 5–13°C, in which juveniles are distributed during the early ocean life. Original SST data were provided by Japan Meteorological Agency as 10-day mean sea surface temperatures analyzed for 1 temperature degree by 1 degree grid points (NEAR-GOOS Regional real time database). The above-noted two factors were calculated using a software package for marine geographic information systems, "GIS Marine explorer version 3.1" (Environment simulation laboratory Co. Inc., Kawagoe, Japan) across an area for each pair of regions (area for Okhotsk-Nemuro regions, 43°N–46°N latitude and 142°E–147°E longitude; area for Honshu-West Hokkaido Pacific coast regions, 35°N–43°N latitude and 140°E–146°E longitude excluding an area 35°N–41°N latitude and 143°E–146°E longitude). Sea surface temperatures for years 1976 through2000 were positively correlated with stock returns in Okhotsk-Nemuro regions, but not in Honshu-West Hokkaido Pacific coast regions. Alternately, increase in the surface area was associated with higher stock returns in the Honshu-West Hokkaido Pacific coast regions, but not in the Okhotsk-Nemuro regions. Although the underlying mechanisms to link these coastal ocean conditions to survival are not well known, results of this study suggest that in the northern regions (e.g. Okhotsk-Nemuro regions) ocean productivity is enhanced by warmer ocean temperatures and this increases the survival of juveniles and in the southern regions (e.g. Honshu-West Hokkaido Pacific coast regions) the formation of suitable area is a determinant for success of migration in the early ocean life.

Annual fluctuations of adult returns in Japan were pronounced in the 1990s.This occurance may be partly explained by fluctuations in survival rates of stocks in Okhotsk and Nemuro regions. From the late 1980s to the early 1990s, survival of stocks in these regions probably improved due to warmer SSTs in the early ocean life. These stocks obviously contributed to the increase in adult returns during the early-mid 1990s then SSTs shifted to normal levels after the mid 1990s. This change in SST might be the cause of recent declines of adult returns in the

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late 1990s. Since chum salmon are the most abundant of the salmon species in Japan their survival rates are a primary factor influencing total salmon returns.

This study suggests that survival of Japanese chum salmon may be strongly influenced by coastal ocean conditions and that the oceanographic factors affecting their survival probably differ among regions. Future studies should examine effects of hatchery techniques (e.g. size at release and timing of release), to assess the effect of hatchery practices on survival under variable oceanographic conditions.

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