Verification of the Immature Ratio at Age of Chum Salmon in the Bering Sea and Central North Pacific Ocean, 1971–2010

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The mean age at return of Japanese chum salmon populations, as with other Pacific salmon, increased from the 1970s–2000s, which could be associated with variability of the immature ratio (IMR) at age. Nominal IMRs calculated from Japanese offshore surveys and returns at age given by fishery data will be subject to uncertainty due to biases. To estimate reliable annual IMRs of Japanese chum salmon, we evaluated the IMRs at ages 3-4 by using fishery independent and fishery dependent data separately: (*i*) Japanese experimental chum salmon survey data (sex, age, gonad weight, and fork length) collected in the Bering Sea and central North Pacific Ocean, July-August, 1971–2010, and (*ii*) Japanese chum salmon return at age. For data (*i*) examined using generalized linear mixed models (GLMM), annual means of male and female IMR at age 4 ranged from 0.2–0.8 and 0.1–0.9, respectively, fluctuated in parallel, and increased on a long-term basis. For data (*ii*) investigated by virtual population analysis (VPA), the sex–combined IMR at age 4 ranged from 0.1–0.5, i.e., was relatively low compared to the GLMM–IMR. All correlations among the VPA– and GLMM–IMRs were positive and significant, thereby supporting the reliability of both the types of relative IMR. As a result of testing factors on IMR variability, the growth rate of immature ages 2–3 chum salmon and the mean sea surface temperature in the Bering Sea were significant indices common to VPA– and GLMM– IMRs. We provide a probable cause whereby the immature ratio of age 4 chum is affected mainly by the growth rate of ages 2–3 chum salmon and environmental conditions.