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**Preliminary results on the long-term changes of return season and some biological characteristics of chum salmon (*Onchorhynchus keta*) in relation to the environmental factors in Namdae-cheon, eastern area of Korea**

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# **Preliminary results on the long-term changes of return season and some biological characteristics of chum salmon (*Onchorhynchus keta*) in relation to the environmental factors in Namdae-cheon, eastern area of Korea**

## **ABSTRACT**

The season to return home stream of chum salmon for spawning have become earlier as years go. Main returning season of chum salmon were in mid-November in 1980s, in early November in 1990s and in late October in 2000s. Return season did not show significantly related to water temperature in the coastal area and river. However extremely cold year as 2002 delayed the return season and advanced warm year as 1990.

The return rate was less than 0.4% for the broods released in 1984 to 1986. And fluctuated from 1.0 to 1.5% for those released in 1987-1995, and dropped to 0.7% for that released in 1996 and further dropped to 0.1% that for 1997. For those released in 1998-2000 was 0.2~0.3%. The Number of released fingerings was very high during 1997-1999, the return rate for those broods were very low. Water temperature for April to June during 1997 to 1999 was higher to 1-3 °C compared to mean temperature. The biomass of zooplankton during April and June shows increasing trends The proportion of female for the returned adults in Namdae-cheon ranged 34-43% for the late 1980s and increased to 45-55% in 1990s and 2000s except 2001. For the group by returning season, the proportion of female was lower in earlier returning groups and it has become increased in late returning group.

Age compositions of returned chum salmon for spawning to Namdae-cheon are from 2 to 5 years old with the main age groups are 3 and 4. However, for female in late 1980s the proportions of age 3 and 4 groups were about the same, however, in 1990s and 2000s the age 4 group became dominant. Mean fork length of female for age 3 has tendency to be smaller from 1985 to 1998. However, for male showed increasing trend since 1990. In 1980s the length of female was larger than male, though, in late 1990s there are not different between sexes for both age groups.

## **Material and Method**

To understand the long term changes of returning season and biological characteristics of chum salmon into rivers, daily catch data of chum salmon by sex for propagation, aging from scale and growth of chum salmon from Namdae-cheon were analyzed for 1985 to 2003. Water temperature in Namdae-cheon for 1997-2003 and coastal areas near the mouth of Namdae-cheon from 1984-2003 in October to November and April to June were analyzed.

Zooplankton biomass for April and June in the coastal area near Namdae-cheon for 1985-2000 was used.

## **RESULTS**

### **Return season of mature chum salmon to Namdae-cheon**

Cumulative curves of occurrence rate for returning chum salmon into Namdae-cheon are shown in Fig. 1. In late 1980s most chum salmon were returned during November 1st to November 13th, however, it had become earlier as years go, and the main returning season was early November in 1990s and late October in 2000s. For 1989, 1990 and 1996 returning season were earlier than the other 1980s or 1990s and rather similar trends to 2003. In 2002 the main returning season was during November 1st to November 13th, which was similar trend to those of late 1980s.

### **Environmental characteristics in returning season**

The mean water temperature for October to November by ten-days, returning season of chum salmon into Korean waters for 19 years (1985~2003) was 18.7 °C for mid October, 17.4 °C for late October, 15.9 °C for early November, 14.6 °C for mid-November and 13.1 °C for late November. It showed increasing trend since late 1980s except those warmer years of 1988, 1990 and 1998 and cold years of 2002 (Fig. 2).

The mean water temperature in Namdae-cheon for October to November by ten days from 1997 to 2003 was 14.3 °C in mid October, 12.5 °C in late October, 10.6 °C in early November and 8.4 °C in late November. It also showed increasing trend till 2001. However, in 2002 water temperature was abnormally lower especially during late October to early November, which is the main returning season of chum salmon in Korea (Fig.3).

The relationship between return season and water temperature of coastal area and river were not significantly related ( $p>0.1$ ). However, in 1990, abnormally warmer year the return season was earlier and showed similar trends as that of 2003 and in 2002, abnormally cold year, the return season was delayed and showed similar trends as that of 1980s.

### **Return rate**

The number of returning adults of chum salmon into Korean waters, both in coastal areas and rivers, had increased steadily since 1984 to 1989, from 5,000 fish to 20,000 fish. In 1990 it jumped up to over 100,000 fish and steadily increased till 1995 and then jumped again to over 200,000 in 1996. However, it had sharply declined since 1998 and dropped to 17,000 fish in 2000. Since 2001 it has recovered to 40,000 to 60,000, though, it showed still very low level compared to those of 1990s (Fig. 4).

The number of fingerings released had increased with increasing the number of returning adults from 1984 to 2000 (Fig. 4). In 1984 about 3 millions of fingerings were released and it increased to over 10 millions in 1990 and over 20 millions for 1998-2000. However, it declined sharply to 5 millions in 2001 as the results of low return adults in 2000. For 2001-2004, 10-14 millions of fingerings were released.

Number of fingerings released and their return rate after 3 years (age 4) are shown in Fig 5.

The return rate was less than 0.4% for the broods released in 1984 to 1986. And then it increased sharply to 1.5% for that released in 1987 and fluctuated from 1.0 to 1.5% for those released in 1988-1995. However, it had dropped to 0.7% for that released in 1996 and further dropped to 0.1% that for 1997. For those released in 1998-2000 was ranged to 0.2~0.3%.

The number of released fingerings was very high during 1997-1999, however, the return rate for those broods were very low.

### **Environmental characteristics in releasing fingerings**

Chum salmon fingerings are released into Namdae-cheon in March and they seem to stay in the river about 20 to 30 days and then move to the coastal area according to the follow-up survey after releasing. They seem to stay in the coastal areas for a while before moving to far seas. Therefore the period of chum salmon fingerings staying in the coastal areas are about April to June in Korea.

Mean water temperature for 19 years (1985~2003) in the coastal waters near the mouth of Namdae-cheon was 10.3°C in April, 13.5 °C in May and 17.0 °C in June (Fig. 6).

The return rate and water temperature In 1986 April and May were abnormally cold as 4.6 °C and 10.1 °C. In 1997 to 1999 water temperature was higher to 1-3 °C compared to mean temperature. The biomass of zooplankton during April and June shows increasing trends (Fig. 7).

### **Biological characteristics for return chum salmon**

#### **Sex ratio**

The proportion of female for the returned adults in Namdae-cheon ranged 34-43% for the late 1980s and increased to 45-55% in 1990s and 2000s except 2001.

For the group by returning season, the proportion of female was lower in earlier returning groups and it has become increased in late returning group (Fig. 8).

#### **Age composition**

Age compositions of returned chum salmon for spawning to Namdae-cheon are from 2 to 5 years old with the main age groups are 3 and 4. However, the proportion of each age groups are different by sex and year (Fig. 9)

For female in late 1980s the proportions of age 3 and 4 groups were about the same, however, in 1990s and 2000s the age 4 group became dominant with composed to 70 to 90%, and the proportion of age 3 group was reduced.

For males, also age 4 group has become increasing trend and become dominant group in 1990s and 2000s, not as clear as female case, though.

Annual changes of mean fork length by sex for age 3 and 4 are shown in Fig. 10 and 11.

For age 3, mean fork length of female had become smaller from 64cm in 1985 to 58cm in 1998. However, in 2002 and 2003 it increased to 63cm and 65cm. For male it had become smaller from 62cm in 1985 to 58cm in 1989, however, it showed increasing trend since then. For age 4 the mean fork length and in 1980s the length of female was larger than male, though, in late 1990s there are not different between sexes for both age groups.

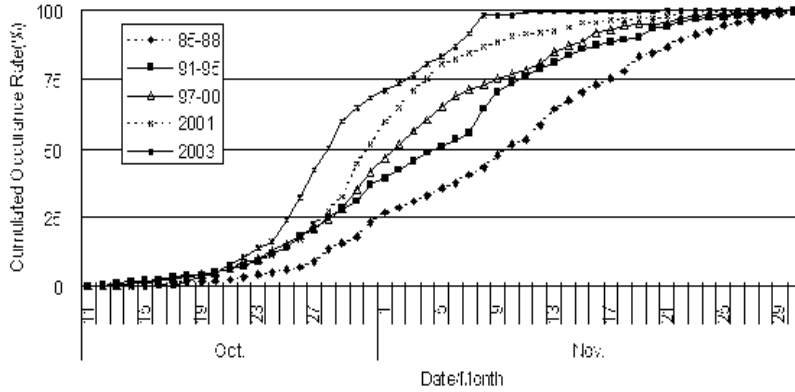


Fig. 1. Cumulative curves of occurrence rate (%) for return chum salmon in Namdae-cheon for October to November, 1985~2003..

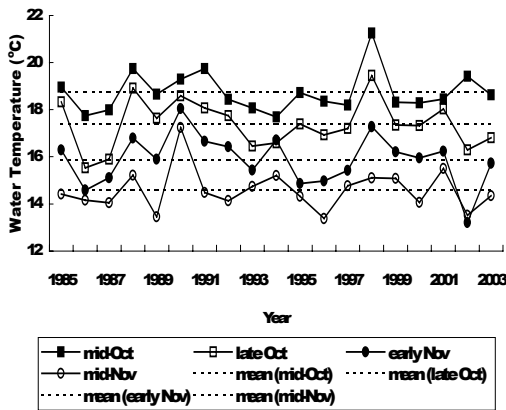


Fig. 2. Mean temperature by ten days in October and November in the coast of Jumunjin, 1985~2003.

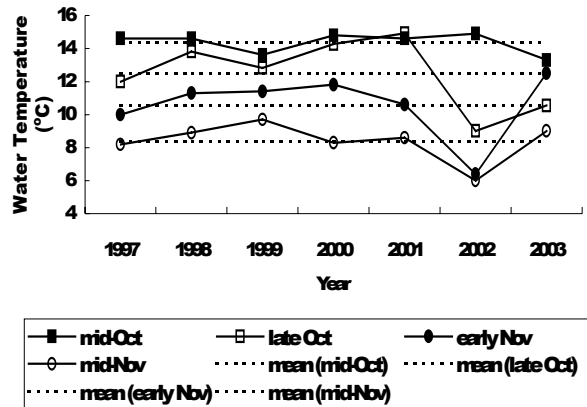


Fig. 3. Mean temperature in Namdae-cheon by ten days in October and November, 1997~2003

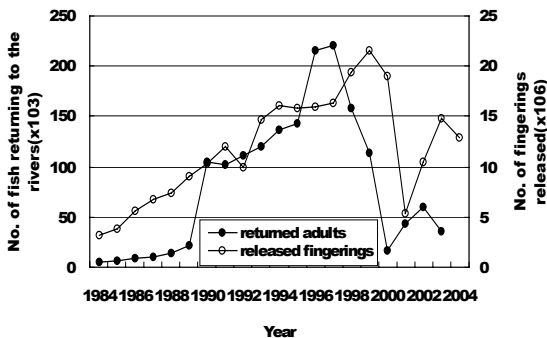


Fig. 4. Number of chum salmon return and Released, 1984-2003.

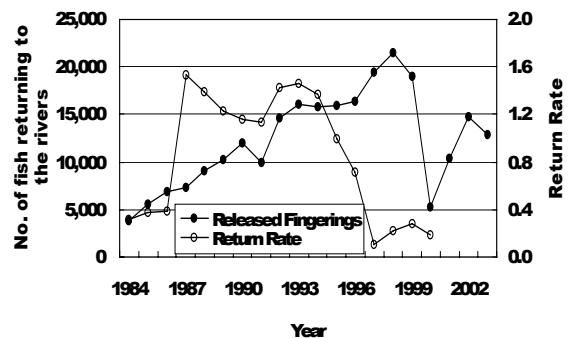


Fig. 5. Number of fingerings released and their return and return rate, 1984~2003.

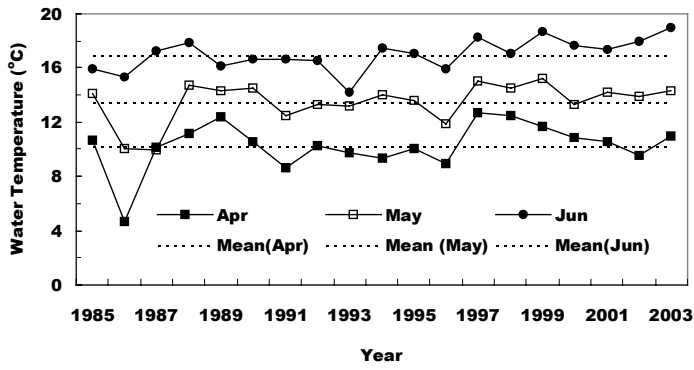


Fig. 6. Mean water temperature variations from May to June in the coast of Jumunjin, 1985~2003.

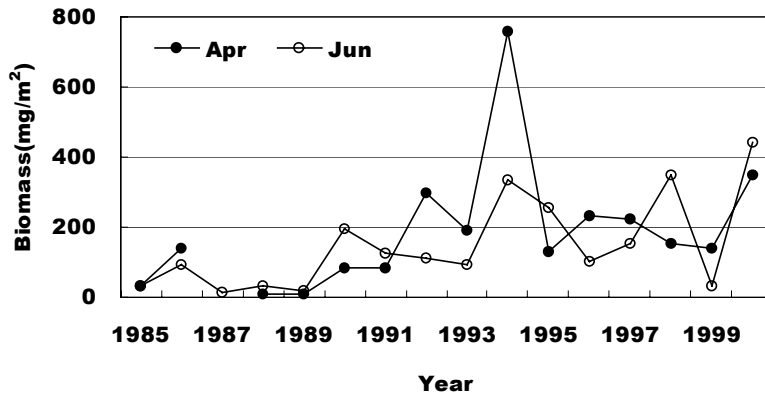


Fig.7. Zooplankton biomass in April and June in the coast of Jumunjin, 1985~2003.

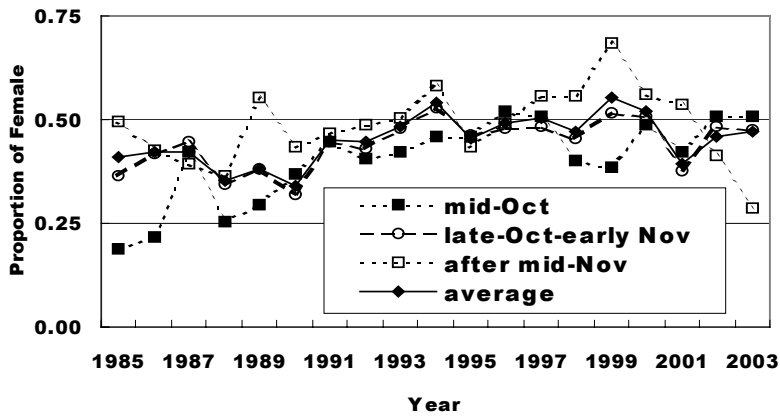


Fig.8. Annual variations of sex ratio (female proportion) by return season of chum salmon in Namdae-cheon, 1985~2003.

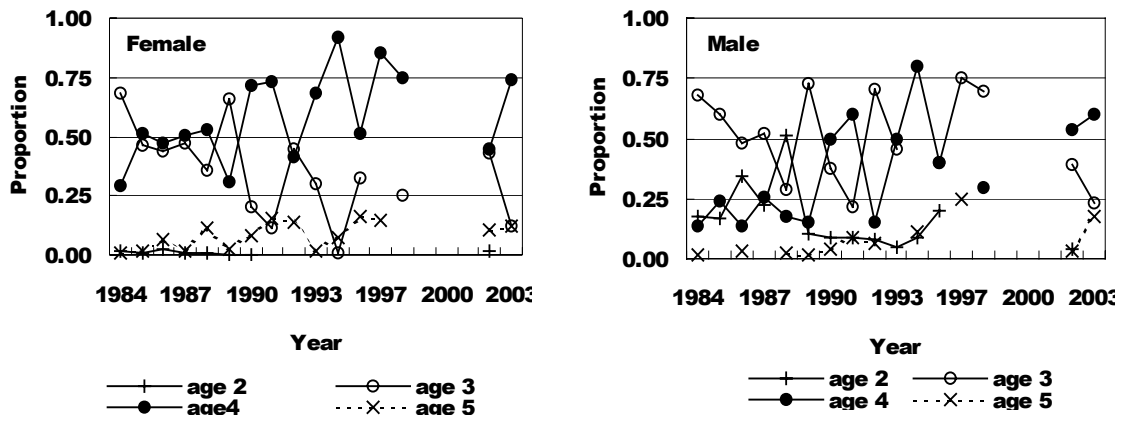


Fig. 9. Age compositions of chum salmon returned to Namdae-cheon by sex, 1984~2003.

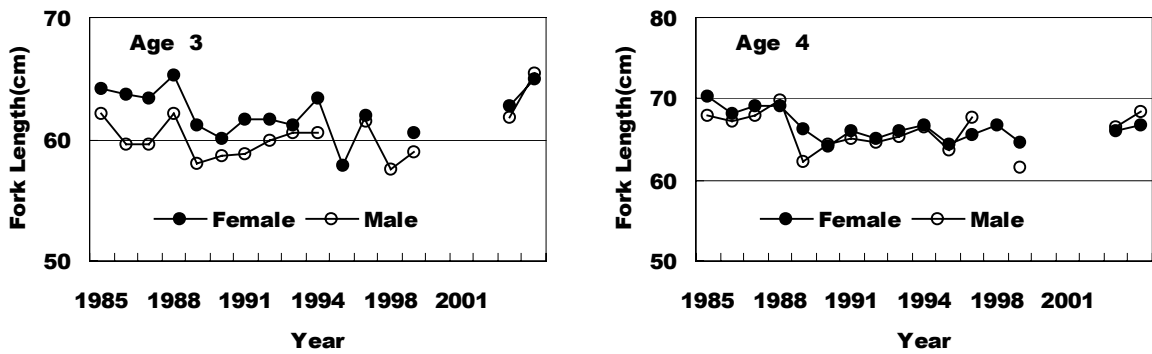


Fig. 10. Annual variations of mean fork length of returned chum salmon to Namdae-cheon for age 3 (left) and age 4 (right), 1985~2003.

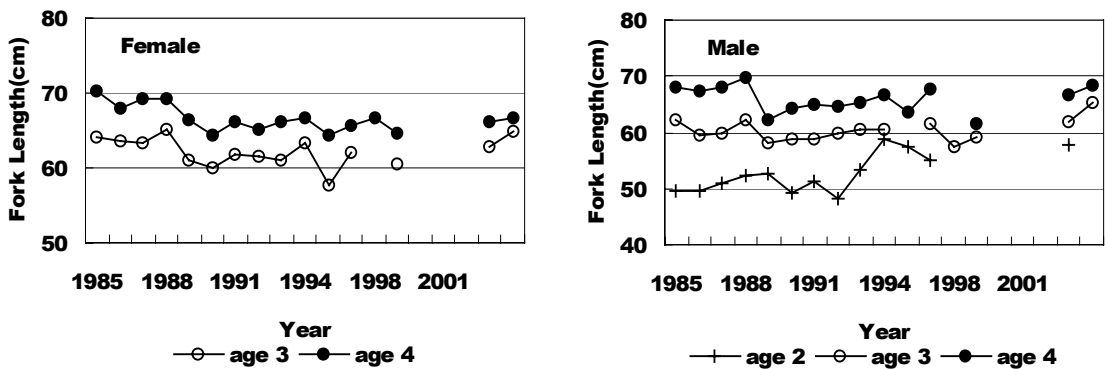


Fig. 11. Annual variations of mean fork length by sex and by age for returned chum salmon to Namdae-cheon, 1985~2003.