Adults returning and ages at return of chum salmon around northern Japan

By

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Abstract

Total number of Japanese chum salmon returning reached the historically highest level in 1996 and declined to the level under the average of the last two decades in 1999. The number of adults returning around Hokkaido accounted for most of the total returning. Total number of adults returning by year class was the largest in the year classes born after the middle of 1980s around Hokkaido. Proportions of older adults (5- or 6-year-old) to the total adults returning by year class increased throughout the year classes of the last two or three decades. Maximum age at return correspondingly rose. The results show the possibility that change in the adults returning to Hokkaido might be brought by the change in the growth rate during the period in ocean residence.

Introduction

Chum salmon returning around northern Japan has reached the historically highest level for the last couple of decades. This is the fruit of salmon hatchery programs in Japan (Kaeriyama 1996; Hiroi 1998). But, some reports noted the possibility that the growth of chum salmon slowed down (Kaeriyama 1989; Ishida *et al*. 1993). If the change in growth is the real event, we should evaluate its effect on adults returning of Japanese chum salmon.

This paper describes the change in number of chum salmon returning around northern Japan and examines the ages at return to detect the change in growth of chum salmon around Hokkaido to where the most of Japanese chum salmon returns.

Materials and methods

In this paper, the term "year" represents the period from August to March of the next year because Japanese chum salmon returns during this period.

Almost all the chum salmon return to and are released from two regions of northern Japan, that is Hokkaido and northern Honshu (Fig. 1). The numbers of yearly return of chum salmon around these regions were compiled from the numbers of adults caught by coastal fisheries and those trapped at trapping sites of hatcheries. Catch and trapping data were collected yearly by National Salmon Resources Center for Hokkaido and prefectural governments for northern Honshu from 1975 to 1999. Besides, data were collected monthly after 1988.

The number of adults returning by age and that of juveniles released were calculated for year classes from 1950 to 1994. Data were collected by National Salmon Resources Center around Hokkaido.

Results

Total number of adult chum salmon returning continued to increase till 1996 (Fig. 2). After that, it took a downward turn and decreased to the level under the average of the last two decades in 1999.

The number of adults returning around Hokkaido accounted for 60 to 80% of the total return and changed similar to that in the total. The level of the return in 1999 was still higher than that of the last two decades' average of Hokkaido but the second lowest in the last 10 years. Around northeastern Honshu, recent decrease in the number of adults returning was marked. The level of

the return in 1999 was about 40% lower than that of the last two decades' average of northeastern Honshu and the lowest in the last 15 years.

About 60 to 75% of the adults returned on and before September in each year (Fig. 3). Most of them were the fish returned to Hokkaido. The remainder that returned on and after October, largely consisted of the fish returned to northeastern Honshu.

Around Hokkaido, total number of adults returning by year class was the largest in the year classes born after the middle of 1980s with exceptions of moderately abundant 1988 year class and remarkably abundant 1991 year class (Fig. 4). The number of juveniles released increased in the period between the late 1960s and the early 1980s and reached the stable level of 100 to 120 million (Fig. 4).

Proportions of the adults for each age to the total adults returning by year class fluctuated. Among them, changes in the proportions of 3-year-old adults and 5-year-old adults showed a counter tendency (Fig. 5). The proportion of 3-year-old adults declined from about 40 % in the year classes born before the early 1970s to less than 6 % in 1989 year class and the later. That of 5-year-old adults increased from about 10 % in the year classes born before the early 1970s to more than 34 % in 1988 year class and the later. The proportion of 6-year-old adults of recent year classes increased too.

Maximum age at return rose from four or five in the year classes before the late 1970s to seven in those after the late 1980s (Fig. 5).

Discussion

Continual increase and following decrease in adults returning of Japanese chum salmon might be the combined results of changes in the mortality during the period of early life and the growth in ocean. The survival in early life of chum salmon must be the main cause in determining the abundance of a given year class (Fukuwaka and Suzuki 1998; Watanabe 1999a, b). Along with this, the growth during the period of ocean residence may affect the survivorship of the year class.

If the growth rate during this period slow down, the abundance of the year class becomes poorer. Because the drop in the growth rate causes the delay in age of maturation and prolonged stay in the ocean, cumulated death toll of chum salmon consequently increase for the year class. Accelerated growth rate brings the adverse result on chum salmon survival of course.

Increase in the proportions of older adults returning of the recent year classes which returned to Hokkaido shows that the delay in the growth must have occurred in the ocean. Rise of the maximum age at return supports this view. Helle and Hoffman (1998) report the increase in age at return and the decline of size at return by age for two stocks of North American chum salmon.

Causes of the delay in the growth of chum salmon of Hokkaido are still unclear, but one of them may be the density effect in the ocean (Kaeriyama 1989; Ishida et al. 1993). Corresponding changes in the adults returning by year class and the proportion of older adults returning shown in Fig. 4 and 5 were the possible evidence of density effect on growth.

Japanese chum salmon consists of two groups, one mainly returns to Hokkaido in the earlier period of spawning season and the other mainly returns to northeastern Honshu in the later period of spawning season. Ecological characteristics are different between them, but changes in the adults returning by year class are likely similar. Because changes in yearly adults returning of them are similar and they resident in the same area of the North Pacific Ocean including Bering Sea.

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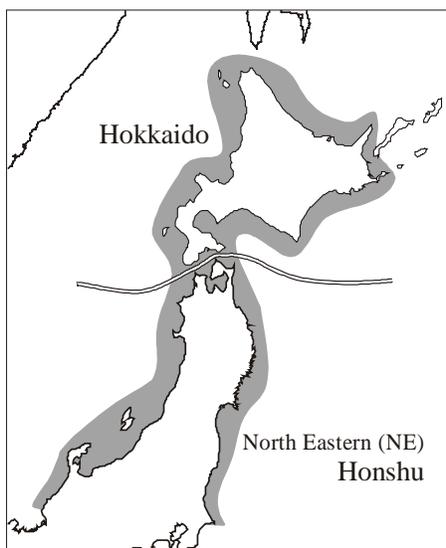
Figure 1. Map of northern Japan. Coastal chum salmon fishery and hatchery programs are operated in two regions of Japan (shaded).
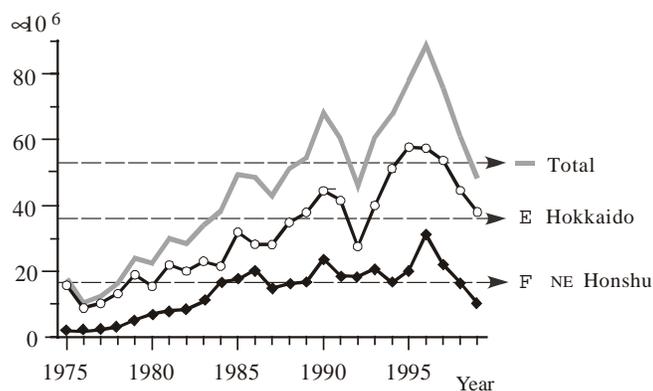
Figure 2. Number of chum salmon returning around northern Japan. Year is the period from August to March of the next calendar year. Dashed arrows show the averages of number of chum salmon returning in the last two decades.
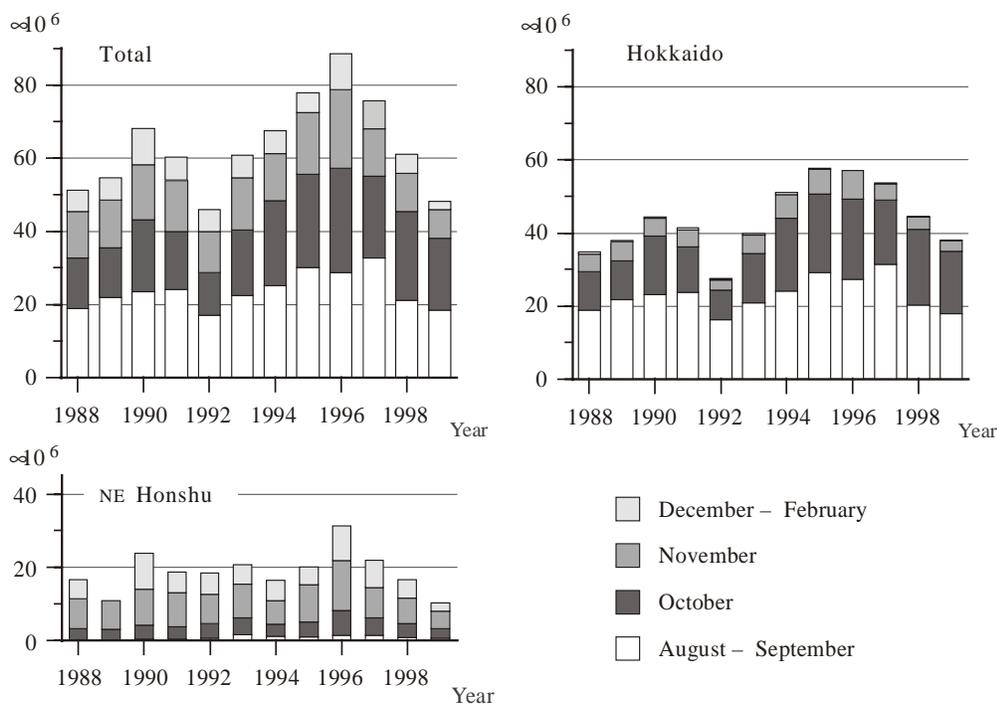

Figure 3. Cumulative number of monthly returning of chum salmon around northern Japan. Year means the same as figure 2.

$\times 10^6$

Return

Age at return

6
5
4
3

1950   1960   1970   1980   1990   Year class

$\times 10^6$

Release

1000

500

0

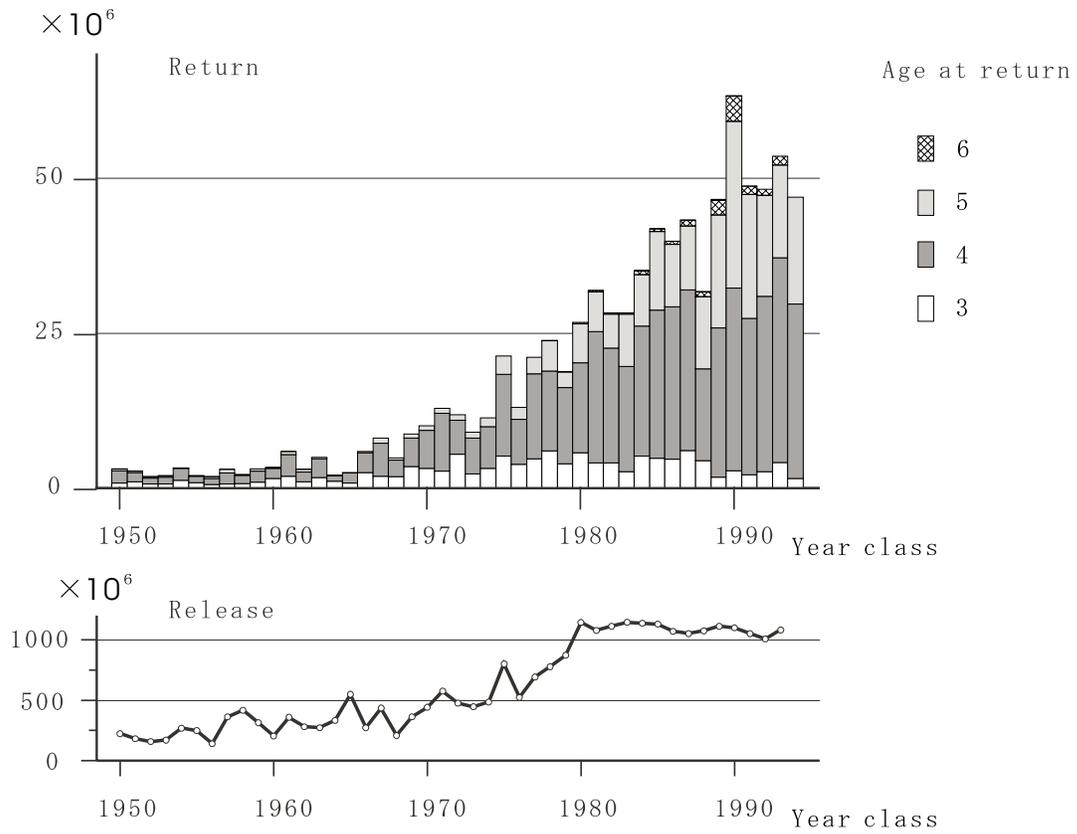1950   1960   1970   1980   1990   Year class

Figure 4. Cumulative number of adults returning and the number of juveniles released by year class for chum salmon around Hokkaido. Up to 1994 year class.
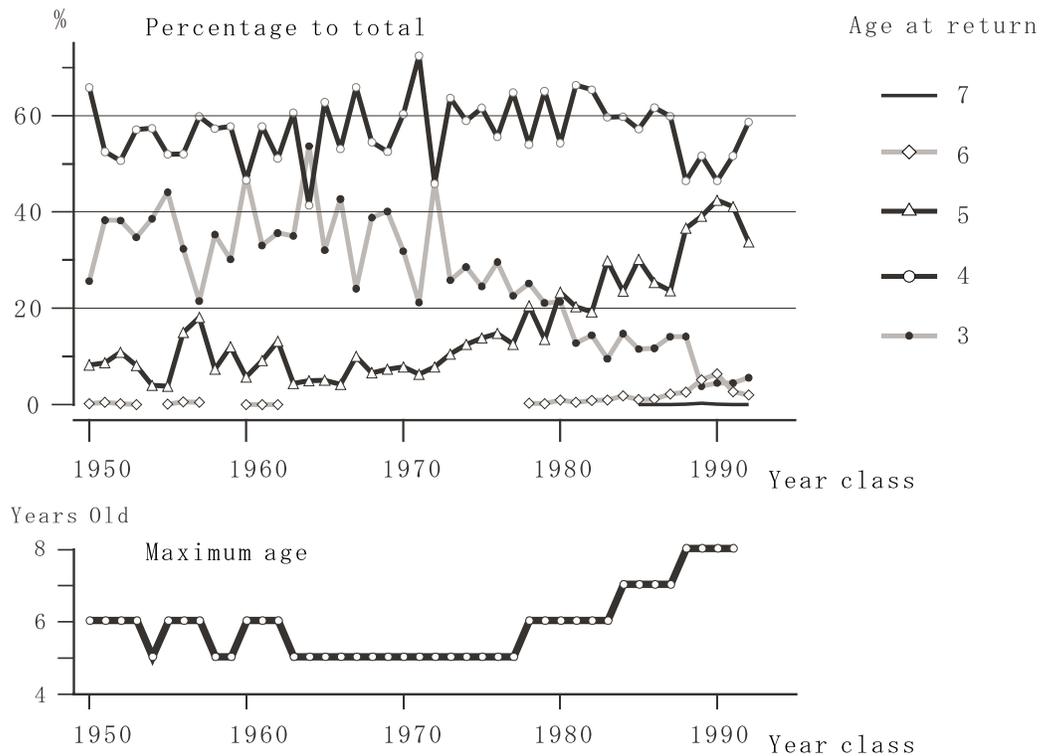
%

Percentage to total

Age at return

7
6
5
4
3

60

40

20

0

1950   1960   1970   1980   1990   Year class

Years Old

Maximum age

8

6

4

1950   1960   1970   1980   1990   Year class

Figure 5.Proportion of the number of adults returning at each age to the total return of a year class and the maximum age at return in each year class for chum salmon around Hokkaido. Up to 1992 year class