NPAFC
Doc. 258
Rev. ___

Has Climate Change Affected the Survival of the Hokkaido Chum Salmon Population since the 1970s?

by

Masahide Kaeriyama

National Salmon Conservation Center
2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan

submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
by
Japan
October 1997

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Masahide Kaeriyama. 1997. Has Climate Change Affected the Survival of the Hokkaido Chum Salmon Population since the 1970s? (NPAFC Doc. 258). National Salmon Conservation Center. 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan. 6p.

Has Climate Change Affected the Survival of the Hokkaido Chum Salmon Population since the 1970s?

ABSTRACT

Result of multiple regression analysis of return rate of Hokkaido chum salmon in 1977-1991 brood years on mean body size and number of juvenile released, and the ACI showed that the return rate depends entirely on the mean body weight of released juveniles, and is independent of the fluctuation of the ACI and the number of juvenile released. Therefore, return rate of the Hokkaido chum salmon released from hatchery may be closely associated with size-selective mortality in the early marine life period. The survival of hatchery juveniles, which was larger than that of wild fish, may depend on their body size and optimum period at the release.

INTRODUCTION

Since the 1980s, the biomass of Pacific salmon has increased dramatically in the North Pacific Ocean. According to statistics reported at the 1996 NAPAC meeting, the annual worldwide catches of the six major species of Pacific salmon reached more than 0.95 million tons in 1995. The catch of pink (*Oncorhynchus gorbuscha*) in North America and Japan, chum (*O. keta*) in Japan, and sockeye (*O. nerka*) in North America is increasing. In the last two decades, the population size of chum salmon released from hatcheries in Japan has increased significantly. The catch of Japanese chum salmon reached about 88 million individuals in 1996. This is equal to more than 70% of the worldwide chum salmon catch. I think that these increases have coincided with successful artificial enhancement program and favorable oceanic conditions (Kaeriyama 1989, 1996). However, all the correlation between long-term fluctuations of Pacific salmon abundance and climate changes was demonstrated recently by a number of papers (e.g. Beamish and Bouillion 1993; Brodeur and Ware 1992; Noakes 1996; Klyashtorin 1997).

The purpose of this paper is to examine effect of climate changes and artificial enhancement program on return rate, which indicate survival from juvenile released to adult returning, of Hokkaido chum salmon population.

METHODS

I used salmonid data in the National Salmon Hatchery concerning numbers of adult return and juvenile released, average juvenile body size, and other information on hatchery operation.

The atmospheric circulation index (ACI) trend corresponds to the long-term global climate changes, although the ACI is calculated from the data obtained only in the Atlantic-European region. The ACI fluctuation is synchronous with the dynamics of Aleutian Low Pressure Index (Klyashtorin 1997). The ACI data was referred from Figure 4 of Klyashtorin (1997). Mean ACI was calculated as

a 5-year average over the ocean life period of a brood-year group. For instance, the mean ACI of the 1960 brood year was averaged ACIs from 1962 to 1965. Multiple regression analysis was used to investigate the effects of the mean ACI, body weight and number of juvenile released on the return rate of Hokkaido chum salmon population.

RESULTS AND DISCUSSION

The number of adult chum salmon returning to Japan from 1900 through 1970 averaged about 3 million individuals per year, ranging from 1 to 5 million individuals. Since the late 1970s, adult returns have exponentially increased to more than 50 million individuals through the late 1980s, and reached 88 million individuals (57 million individuals in Hokkaido and 31 million individuals in Hoshu) in 1996. The number of juveniles released increased from 800 million individuals in the early 1970s to 2 billion individuals in 1982, and has been limited to about 2 billion individuals since the early 1980s. Therefore, recent increase in population size of Japanese chum salmon will be based on increase in return rate.

The return rate of chum salmon, which had fluctuated around 1% until the 1965 brood year, increased to above 2% since the 1966 brood year, when feeding with dry diets before release began in earnest, after the previous 4 years of testing. The return rate has always exceeded 3% since 1984 brood year, and attained more than 5% in 1990 brood year (Fig. 1). A significant positive relationship between the body weight of juvenile released and return rate was observed in the Hokkaido chum salmon ($r = 0.8260$, $P < 0.001$; Fig. 1). The correlation coefficient between juvenile size and return rate was obviously higher than that between atmospheric circulation index (ACI) and return rate ($r = 0.5778$, $P < 0.01$; Figs. 2).

Table 1 shows the result of multiple regression analysis of return rate of Hokkaido chum salmon in 1977-1991 brood years on mean body size and number of juvenile released, and the ACI. From partial correlation and their t-values and probabilities, it is obvious that the return rate depends entirely on the mean body weight of released juveniles, and is independent of the fluctuation of the ACI and the number of juvenile released.

This result suggests as follows;

1) Return rate of the Hokkaido chum salmon released from hatchery may be closely associated with size-selective mortality in the early marine life period. Therefore, the survival of hatchery juveniles, which was larger than that of wild fish, may depend on their body size and optimum period at the release (Kaeriyama 1989).
2) On the other hand, the survival of wild juvenile chum salmon may be influenced by climate change immediately after seaward migration in the North Pacific Ocean. For instance, favorable ocean conditions, such as increases in water temperature and abundance of zooplankton (Brodeur and Ware 1992), may causes high growth rates (Jaenicke et al. 1994) and reduction in predatory

pressure for juvenile salmonids in the early marine life period.

ACKNOWLEDGEMENTS

I thank Katherine W. Myers, Fisheries Research Institute, University of Washington edited the manuscript.

REFERENCES

Beamish, R. J., and D. R. Bouillion. 1993. Pacific salmon production trends in relation to climate. *Can. J. Fish. Aquat. Sci.*, 50: 1002-1016.

Brodeur, R. D., and D. M. Ware. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. *Fish. Oceanogr.*, 1: 32-38.

Jaenicke, H. W., M. J. Jaenicke, and G. T. Oliver. 1994. Predicting northern southeast Alaska pink salmon returns by early marine scale growth. Proceedings of the 16th northeast Pacific pink and chum salmon workshop, p. 97-109.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. *Physiol. Ecol. Jpn.* Vol. 1: 625-638.

Kaeriyama, M. 1996. Population dynamics and stock management of hatchery-reared salmons in Japan. *Bull. Natl. Res. Inst. Aquacult.*, Suppl. 2: 11-15.

Klyashtorin, L. 1997. Pacific salmon: climate-linked long-term stock fluctuations. *PICES Press*, 5: 2-7, 30-34.

Noakes, D. J. 1996. On the coherence of salmon abundance trends and environmental fators. Abstracts of International Symposium on Assessment and Status of Pacific Rim Salmonid Stocks, p. 44.

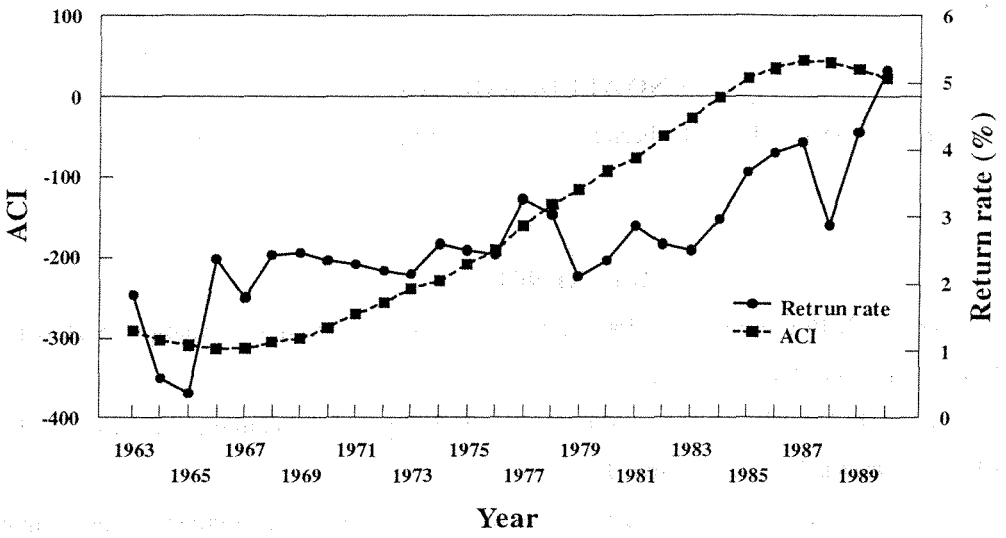

Fig. 1. Changes in the mean atmospheric circulation index (ACI) and the return rate of Hokkaido chum salmon population during 1963-1990 brood years. The ACI data was referred from Klyashtorin (1997).

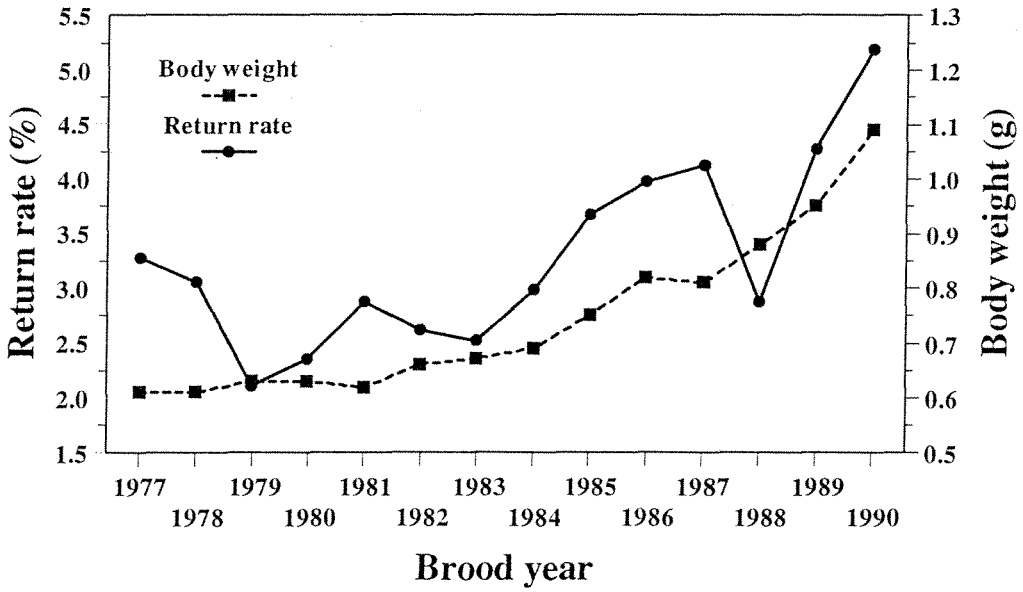

Fig. 2. Changes in average body weight of juvenile released and return rate of Hokkaido chum salmon population during 1977-1990 brood years.

Table 1. Result of multiple regression analysis in return rate of Hokkaido chum salmon population on body size and number of juvenile released, and atmospheric circulation index (ACI).

Variable	Slope	Partial correlation	T	P
Juvenile size	4.649	0.796	2.904	0.016
Release number	-0.002	-0.323	-1.223	0.249
ACI	0.003	0.211	0.564	0.585
Constant	1.898		0.763	0.463

r^2=0.729, D.F.: n_1=3, n_2=11, F=8.977, P=0.003

The ACI data was referred from Klyashtorin (1997).