

## What Happened to Pacific Salmon in the North Pacific Ocean During the Years of an El Niño Event?

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In the spring of 1997, a strong El Niño event occurred and extremely high sea surface temperatures (SSTs) were observed in the Gulf of Alaska and Bering Sea during the salmon surveys in summer in the North Pacific Ocean. In this study, (1) SST and relative abundance of Pacific salmon in 1997 were compared between the El Niño and normal years on the basis of data collected by salmon research vessels in offshore waters from 1991 to 1997, and (2) an index of survival rate of pink salmon calculated from coastal catch data in Japan, Russia, Alaska, and Canada was examined for the period 1980-1997, which had four El Niño events and one La Niña event.

Four Japanese salmon research vessels conducted gillnet and longline fishing operations in the western and central North Pacific (WNP and CNP), Bering Sea (BS), and Gulf of Alaska (GA) during the period June to August from 1991 to 1997. Four major survey areas were defined as follows: the western North Pacific (38-50°N, 154-177°E), the central North Pacific (35-48°N, 179°E-179°W), the Bering Sea (55-59°E, 175°E-175°W), and the Gulf of Alaska (50-57°N, 144-146°W).

SSTs in the western and central North Pacific in 1997 were 1.17°C and 1.22°C significantly colder, and Bering Sea and Gulf of Alaska SSTs were 1.01°C and 1.81°C significantly warmer than the previous six-year means. Higher SSTs in the Bering Sea and Gulf of Alaska in 1997 may be due to the strong El Niño event occurring in the spring of 1997. However, different SSTs were observed in the 1991 and 1992 El Niño years. SSTs were high in the western and central North Pacific in 1991, and SSTs were low in the Bering Sea in 1992 (Fig. 1). The magnitude of the El Niño event was different between 1991-92 and 1997-98. El Niño events are a phenomena in equatorial waters. These factors may cause the differences in SSTs between 1991-92 and 1997-98.

The relative abundance (catch per unit effort, CPUE) of salmon was compared between normal years from 1993 to 1996 and the 1997 El Niño year. Sockeye salmon CPUE increased in the Bering Sea and Gulf of Alaska, but decreased in the western and central North Pacific in 1997 (Fig. 2). Chum salmon CPUE decreased in the Gulf of Alaska, but increased in the western and central North Pacific in 1997. In the Bering Sea, chum salmon CPUE in odd years is usually lower than that in even years. In 1997, chum salmon CPUE was higher than the previous odd-year means from 1993 to 1995 (Fig. 3). In 1997, pink salmon CPUE increased in the western and central North Pacific and substantially increased in the Bering Sea, but decreased in the Gulf of Alaska compared to the previous odd-year mean (Fig. 4).

For year-*t* class of pink salmon, four life stages, spawning (fall and winter in year *t*), juvenile (spring and summer in year *t*+1), wintering (fall and winter in year *t*+1), and adult period (spring and summer in year *t*+2), were classified as El Niño, La Niña, or normal year. However, there was no clear relation between changes in survival rates and El Niño events. However, a weak but positive correlation was observed in the index of survival rates between Russian and Alaskan pink salmon (Table 1). This suggests that Russian and Alaskan pink salmon may be affected by the same factors such as SSTs. It is necessary to examine the relations between the survival index of pink salmon and SSTs by time and space in the North Pacific Ocean. A detailed analysis will be presented elsewhere.

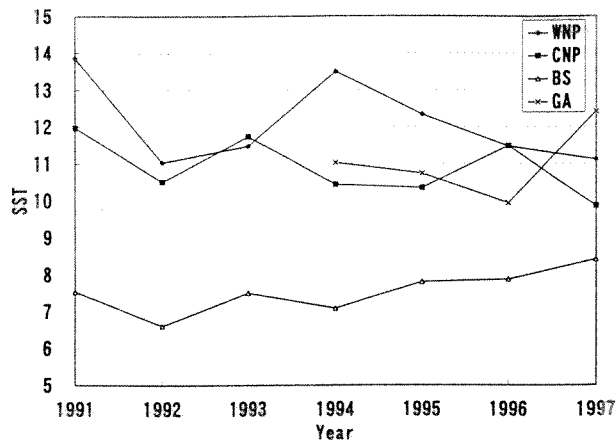


Fig. 1. Mean sea surface temperatures (SST) in four major survey areas from 1991 to 1997.

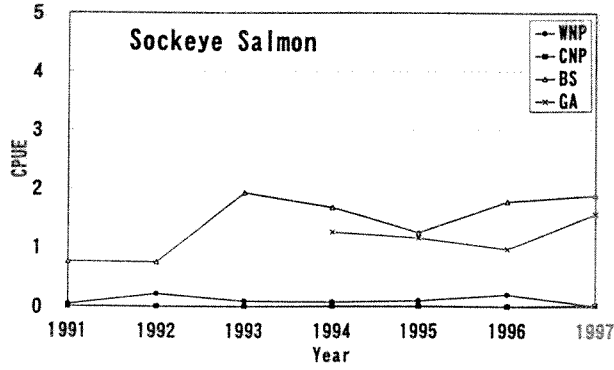


Fig. 2. Sockeye salmon catch per unit effort (CPUE) in four major survey areas from 1991 to 1997.

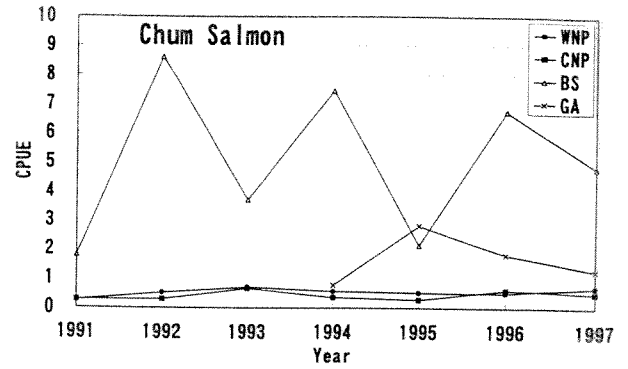


Fig. 3. Chum salmon catch per unit effort (CPUE) in four major survey areas from 1991 to 1997.

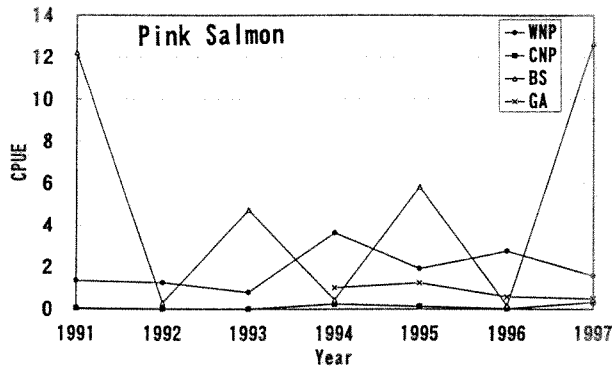


Fig. 4. Pink salmon catch per unit effort (CPUE) in four major survey areas from 1991 to 1997.

Table 1. Correlation in the survival index between stocks of pink salmon.

	Japan	Russia	Alaska	Canada
Japan		-0.147	0.229	0.060
Russia			0.302	-0.087
Alaska				0.035
Canada				