Changes in Abundance of Far East Pink Salmon (*Oncorhynchus gorbusha*) Stocks in the Context of Climatic Variability in the North Pacific Region

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Spatial and temporal features of climatic variations in the North Pacific region over the last 40 years were analyzed. Data on mean winter (January-April) sea surface temperatures (SST) in the North Pacific (20-55°N), mean winter (December-February) sea level pressure in the North Pacific area (20-70°N, 100°E-90°W), and geopotential heights on the 700-hPa surface in the Northern hemisphere were used. Data on SST and sea level pressure are available from the Russian Hydrometeorological Center (Moscow), and those on geopotential heights are available from the U.S. National Center for Atmospheric Research. To characterize the changes in the Far East pink salmon production data on catches for West and East Kamchatka, and the South Kuril Islands areas were used. Five large-scale subdomains with coherent SST anomaly fluctuations were defined, using a Ward's hierarchical clustering method. They are the eastern part (Region 1), the central part (Region 2), the northwestern part including the most of the Sea of Okhotsk and waters east off Kamchatka (Region 3), the southwestern part (Region 4), and the southern part (Region 5) of the North Pacific Ocean. Results of correlation analysis show that the spatial structure of SST anomaly variations in the North Pacific is characterized by two almost independent patterns: changes in the SST anomalies in the eastern and central North Pacific, as well as in its northwestern and southwestern parts, are out-of-phase. These two patterns are significantly correlated with well-known atmospheric teleconnection patterns: the Pacific/North American and Western Pacific patterns, respectively). In each subdomain defined, there are clear decadal variations in SST anomalies. The most prominent shifts from one climatic regime to another occurred in early 1960s, 1976-1977, and around 1987, when the clear tendency toward warming appeared in all regions. It is very possible that another shift occurred in the mid-1990s, but available data do not allow us to confirm this with certainty. The changes in SST anomaly patterns strongly correspond to changes in the character of atmospheric circulation that occurred during shifts from one climatic regime to another. For example, weakening of Aleutian Low since 1988-1989 was accompanied by the apparent surface warming in the central North Pacific and cooling in the Gulf of Alaska and the area of Aleutian Islands.

Beginning in 1996, the signs of cooling during the winter period appeared in the southern part of Region 2, where the drop in SST anomalies exceeded 0.6°C compared with the period of 1989-1995. Possibly this indicates the start of the next decadal change in the North Pacific climate system. Partly, this is confirmed by the 1997 El Niño event, because all previous shifts occurred during the period of or just after the warm events in the tropical Pacific. All four Far East pink salmon stocks also exhibit clear decadal variations both in odd and even years. Catches of eastern and western Kamchatka pink salmon declined until about 1977. After this time, their constant increase is observed. For South Kurils and Southeast Sakhalin the situation is somewhat different. There, the constant increase in catches started in the early 1970s. The comparison of variations in SST anomalies in Regions 1, 2, and 3, and in East and West Kamchatka pink salmon catches shows their strong relationship. The best relationship was found for Region 1, which includes the area of Aleutian Islands, where these stocks spend the winter (Fig.1a,b). A weaker relationship was obtained for Region 3, where fish stay during their early marine period of life. This indicates that favorable winter conditions are more important for survival and subsequent formation of the level of East and West Kamchatka pink salmon stocks than environmental conditions during their early marine period of life. For Southeast Sakhalin and South Kuril Islands pink salmon stocks, the strongest relationship was obtained for Region 3 (Fig.1c), and a weaker relationship was obtained for Region 1. This may confirm the hypothesis that for these two stocks favorable environmental conditions during their early marine period of life, when fish start to feed, are more important than those in the area where they spend their first winter, as compared to East and West Kamchatka pink salmon. Fish migrating to the wintering area located near the Aleutian Islands are stronger and larger in size. Thus, they may survive more unfavorable winter conditions. Further research on this problem with oceanic circulation, primary production, food base, and other data is needed.

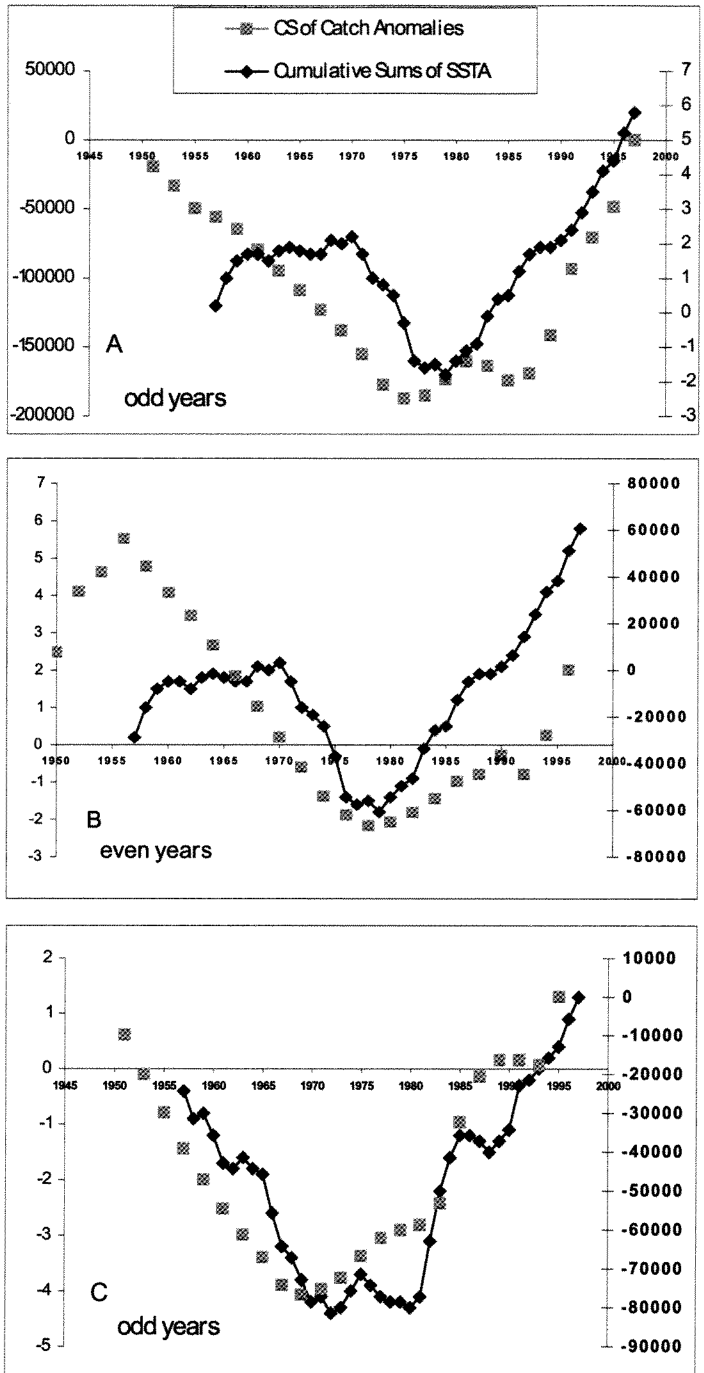

Fig. 1 Cumulative sums of sea surface temperature anomalies (SSTA) and pink salmon catches in eastern Kamchatka (A), western Kamchatka (B), and south Kurile Islands (C) areas. SSTA are in Region 1 (eastern North Pacific) for A and B and Region 3 (northwestern North Pacific) for C.