

Cyclic Climate Changes and Pacific Salmon Stock Fluctuations: A Possibility for Long-Term Forecasting

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Key Words: Pacific salmon, production, climate indices, earth rotation velocity, long-term forecast

Maximums of Pacific salmon production took place in the 1870s, 1930s, and 1990s with roughly 60-year periodicity. Total harvest of Pacific salmon amounted to 1 million tons (mln. t) in the 1930s, declined to 0.4 mln t. in the 1950-60s and increased again to about 1 mln. t. in the 1990s (Fig.1). The carrying capacity of the North Pacific for salmon is not constant and exhibits long-term climate-governed fluctuations (from 1.4-1.7 to 0.4-0.6 mln. t). The populations of Pacific salmon of Asian and American origin undergo long-term simultaneous

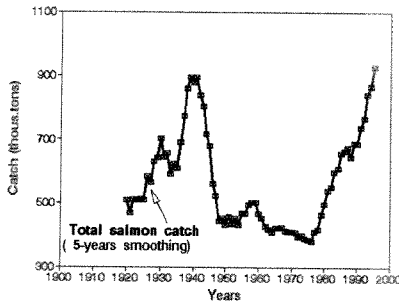


Fig. 1. Total Pacific salmon catch 1920-1995.

oscillations. This is believed to be caused by large-scale climate changes (Fig. 2). The dynamics of the Surface Air Temperature Anomalies (dT) and Aleutan Low Pressure Index (ALPI) over the Northern Hemisphere are weakly correlated with the dynamics of the main commercial stocks because of high interannual variation. In contrast, the Atmospheric Circulation Index (ACI), characterizing regular periods (the so-called "epochs") of dominant meridional or latitudinal direction of atmospheric transport, is substantially less variable. The ACI dynamics have been observed over the N. Hemisphere for more than 100 years (since 1891). The ACI dynamics are in phase with the general trend of dT and are highly correlated ($r = 0.75-0.90$) with Pacific salmon stock dynamics and long-term fluctuations of Japanese sardine, Californian sardine, Alaskan pollock, and some other species (Fig. 3). Recent data on the cyclic alternation of meridional and latitudinal ACI epochs suggest that ACI can be used as a predictive index, and allows one to forecast the long-term dynamics of Pacific Salmon stocks for 5-15 years. This is also confirmed by the close correlation between ACI and an important global geophysical characteristic: the Earth Rotation Velocity Index (ERVI). ERVI has been measured continuously by astronomic methods for more than 200 years and can be used as an additional predictive index. The changes that have occurred to the Pacific salmon population during the last century can be pictured as two sequential climate-governed "waves" with the maximums in the late 1930s and in the late 1990s (Fig. 4).

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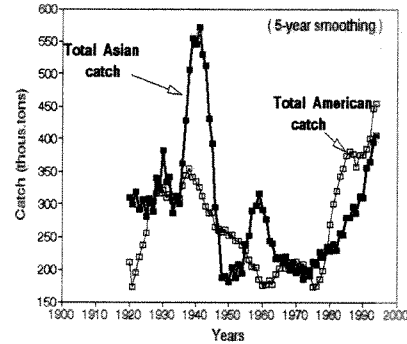


Fig. 2. Asian and American salmon catch 1920-1995.

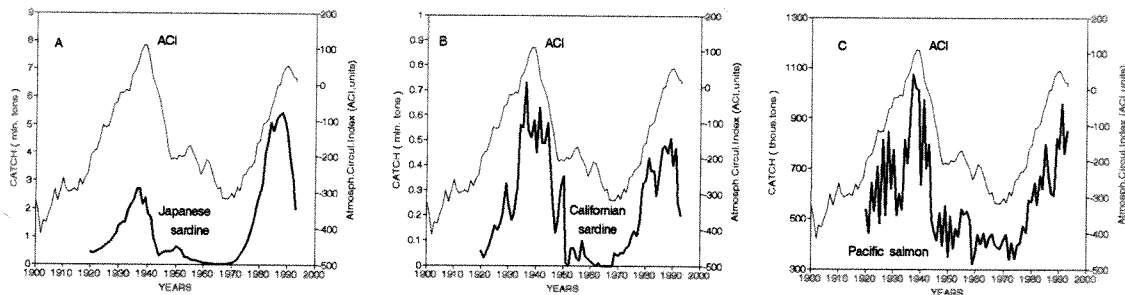


Fig. 3. Salmon and sardine catch and Atmospheric Circulation Index (ACI) dynamics for 1900-1994.

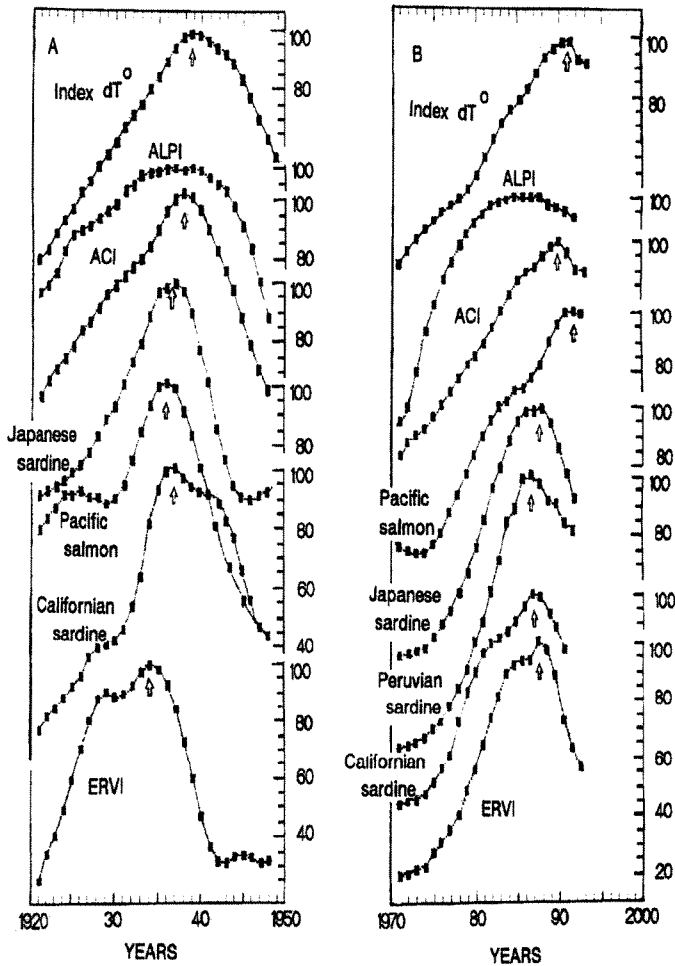


Fig. 4. The scheme of general trends of climatic indices and commercial catches in the Pacific for the periods of 1920-1950 (A) and 1970-1994 (B). All curves are presented in per-unit form relative to a specific maximum taken as 100 percent (marked by the arrows). All catches are smoothed by 5-year averaging.

dT - Annual air surface temperature anomaly (13-year smoothing); ALPI - Aleutan Low Pressure Index (13-year smoothing); ACI - Atmospheric Circulation Index (5-year smoothing); ERVI - Earth Rotation Velocity Index (5-year smoothing).

The recent "wave" is not completed and is now reaching its final phase, similar to the one in the 1940-50s. Nowadays, total Pacific salmon harvest is at its peak, but all of the above-discussed indices suggest that the Pacific salmon population will decline gradually in the near future (according to the trends in predictive indices and main pelagic stock dynamics in the N. Pacific). There is good reason to believe that future changes in climate and salmon stocks will follow the same dynamics that took place in the past climatic phase in the 1940-50s (Fig. 5 and 6).

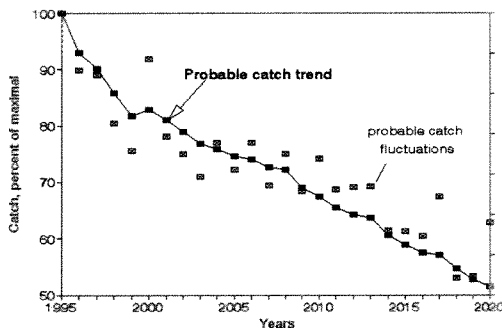


Fig. 5. Probable dynamics of American salmon catch 1995-2020 (in percent of maximum).

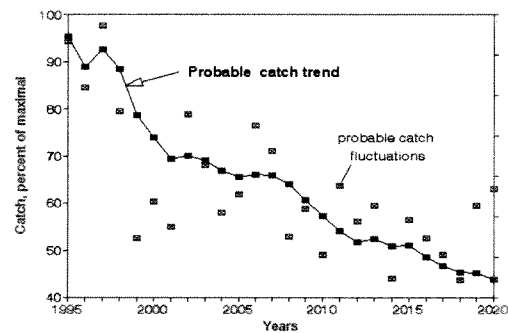


Fig. 6. Probable dynamics of sockeye salmon catch 1995-2020 (in percent of maximum).