SUNSPOT ACTIVITY AND OCEANIC CONDITIONS IN THE NORTHERN NORTH PACIFIC OCEAN[1]

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During periods of sunspot maxima (approximately every 11 years) the mean winter position of the center of the Aleutian low pressure system shifts from the Gulf of Alaska to the western Aleutian Islands, and the mean, cyclonic, wind-stress transport of warm Pacific surface waters into the Gulf of Alaska is reduced by roughly 20%. Coastal sea level data in the Gulf do not reflect an 11-yr cycle, but spectral energy densities indicate an approximate 6-yr periodicity also present in trans-Pacific annual mean sea surface temperatures that, in the last one or two decades, parallels large year classes of Pacific herring in southeastern Alaska, large escapements of sockeye salmon fry in the Bristol Bay area, and maxima in the January catch of Dungeness crab in Alaska.

Because of the wide geographical distribution of individual fish stocks and the limited facilities available for assessment purposes, it has been necessary to rely on various statistical methods to ascertain estimates of distribution and abundance. However, there are still large year-to-year differences in patterns that in many instances may be related to short- or long-term changes in environmental conditions and processes. Knowledge of such phenomena could result in improved estimates of stock condition and sustainable yields, and forecasts of these conditions could result in better sampling techniques and resource management measures. One periodic phenomenon that might influence oceanic conditions is sunspot activity. The literature on this subject is extensive, identifying also a double sunspot cycle of 22-23 years, and an a cycle of alternating 80- and 100-year periods. Apparent relations to biological (Gilhousen 1960) and weather (Newman 1965; Mitchell 1965) phenomena are becoming more frequent. However, few investigations have

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[1]Summarized from: J. Oceanogr. Soc. Japan 32:107-115.

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considered possible effects of sunspot activity on ocean conditions.

Mean pressure data from the winter half-years (October-March) of 3-yr periods centered around the sunspot maxima, and 3-yr periods centered around the minima, indicate a pronounced westward shift in the mean position of the Aleutian low pressure system from the Gulf of Alaska to the western Aleutian Islands during years of sunspot maxima (Fig. 10.1). Wind-stress transport calculations indicate a 20% reduction in northward transport into the Gulf during periods of sunspot maxima compared to that during sunspot minima, but there are no direct current measurements available to permit showing any actual changes in flow patterns. Nor is there any indication in coastal sea level data to suggest a dominant 11-yr periodicity, but this is not considered proof that changes in circulation and upwelling do not occur. There is an approximate 5- to 6-yr fluctuation in trans-Pacific sea surface temperature maxima that is largely in phase not only with mean sea level maxima in the Gulf of Alaska (most clearly evident at Prince Rupert during 1950-74), but also with solar phenomena. Although deviations of about 5 cm in sea level can be accounted for as a result of changes in specific volume of the surface layer due to seasonal heating and cooling from winter to summer (temperature range of 5-10C), the observed deviations in excess of 10 cm cannot be attributed solely to the 1-2C changes in temperature associated with the 5- to 6-yr temperature cycle.

The 5- to 6-yr cycle does have subtle, if not direct, relations to living marine resources. Reid (in press) has shown that dominant year classes of Pacific herring in southeastern Alaska from 1950 to 1958 occurred in 1953 and 1958, years of temperature maxima in that area (Favorite and McLain 1973). Hoopes (1973) has shown that the Alaskan Dungeness crab landings in January reached maxima in 1963 and 1964, and again in 1968 that were nearly 3 times the minima in 1961, 1966, and 1971--roughly 12-13 vs. 4-5 million pounds (Favorite, in press). Finally, the 5- to 6-yr temperature cycle appears to have a parallel in sockeye salmon abundance in river and lake systems in Bristol Bay. The annual pack of canned sockeye salmon in western Alaska for 1950-74 (Fig. 10.2) shows maxima in 1952, 1956, 1961, 1965, and 1970 that are obviously out of phase with the temperature cycle, but if one considers the critical early life stages in lake and river systems 2 to 4 years earlier, a parallel is evident. Considering only the three recent maxima, 83% of the sockeye salmon returning to Bristol Bay in 1960 grew in fresh water from spring 1957 to spring 1958; 88% of those returning in 1965, from spring 1961 to spring 1963; and 82% of those returning in 1970, from spring 1966 to spring 1968.[3] Although in terms of numbers, spawning success is certainly dependent on the number of spawning adults and other factors, this pattern of fish returns suggests that the sea surface temperature maxima phase of the recent and prolonged trans-Pacific cycle could have a salutary effect on spawning survival.

Unfortunately, any teleconnections or servomechanisms between sunspot activity and physical or biological phenomena on earth are not clear at this time. It should be obvious that the search for cause and effect relations between environmental conditions and fluctuations in fishery data is exceedingly complex, requiring not only extensive data, but multidisciplinary approaches as well, before accurate forecasts will be possible. Forecasts of conditions based on trends indicated in this paper would be imprudent because the end of the 100-year sunspot cycle will occur in the mid-1970's. This should result in two consecutive negative maxima, and deviations from established conditions may occur.

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[3]Percentage data obtained from: Donald E. Rogers. Forecast of the sockeye salmon run to Bristol Bay in 1973 and 1975. University of Washington College of Fisheries, Fisheries Res. Inst. Circ. No. 73-1, 33 p., and Circ. No. 73-3, 45 p.

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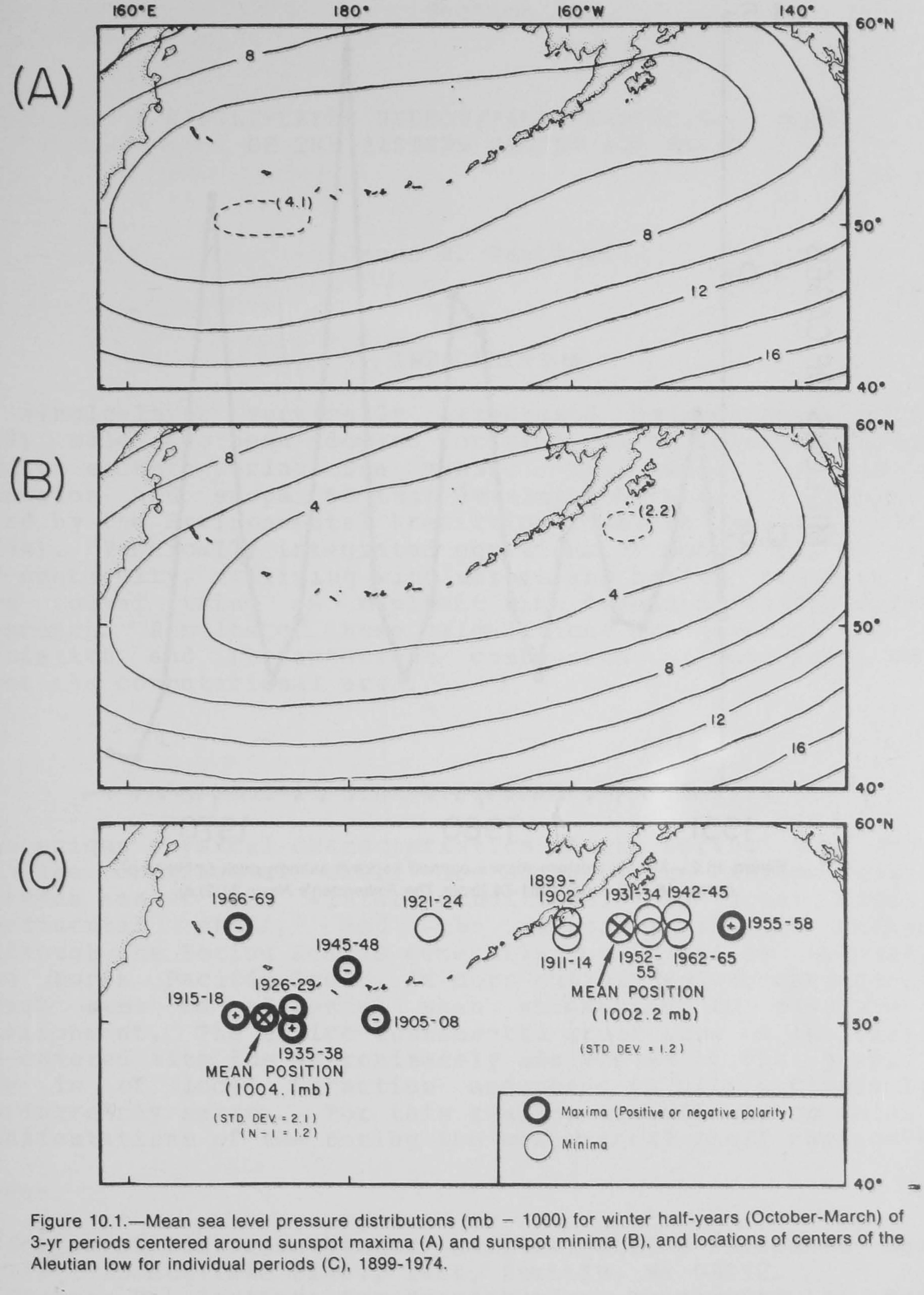

Figure 10.1.—Mean sea level pressure distributions (mb − 1000) for winter half-years (October-March) of 3-yr periods centered around sunspot maxima (A) and sunspot minima (B), and locations of centers of the Aleutian low for individual periods (C), 1899-1974.

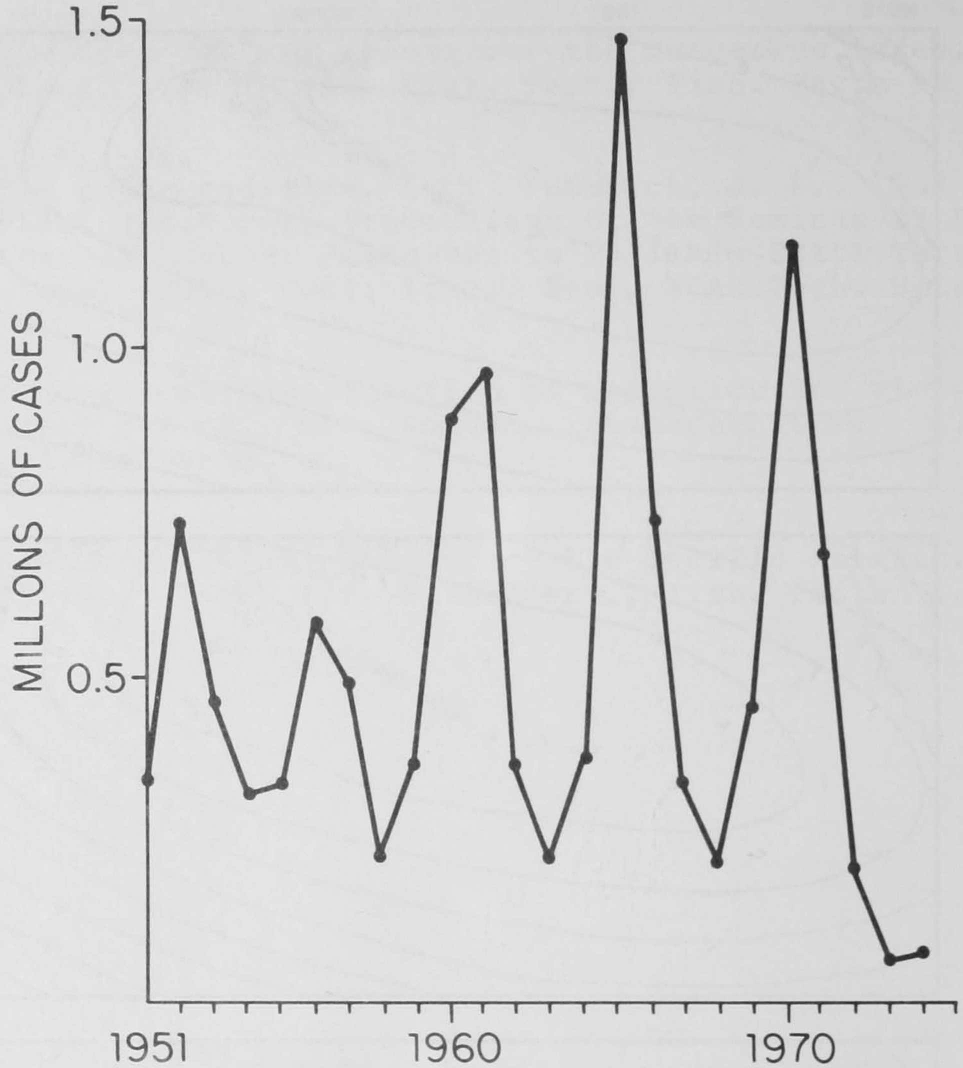

Figure 10.2.—Annual western Alaska canned sockeye salmon pack (millions of cases; 48 1-lb cans) 1951-74 [from *The Fisherman's News* 31(2):4].