

DISTRIBUTION AND RACIAL COMPOSITION OF SALMON ON THE HIGH SEAS

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The Protocol to the International Convention for the High Seas Fisheries of the North Pacific Ocean directs the Commission "to investigate the waters of the Convention area to determine if there are areas in which salmon originating in the rivers of Canada and of the United States of America intermingle with salmon originating in the rivers of Asia", and to "conduct suitable studies to determine a line or lines which best divide salmon of Asiatic origin, and salmon of Canadian and United States of American origin". Since its organization the United States Section of the Commission has conducted extensive investigations on the problems of the Protocol to determine whether or not the present provisional line at 175° W. (fig. 1) adequately protects North American runs of salmon from exploitation by the Japanese fisheries. The results of research to date show that the provisional line protects most North American runs of salmon with the exception of Bristol Bay red salmon which range far to the westward and into the area of high seas fishing.

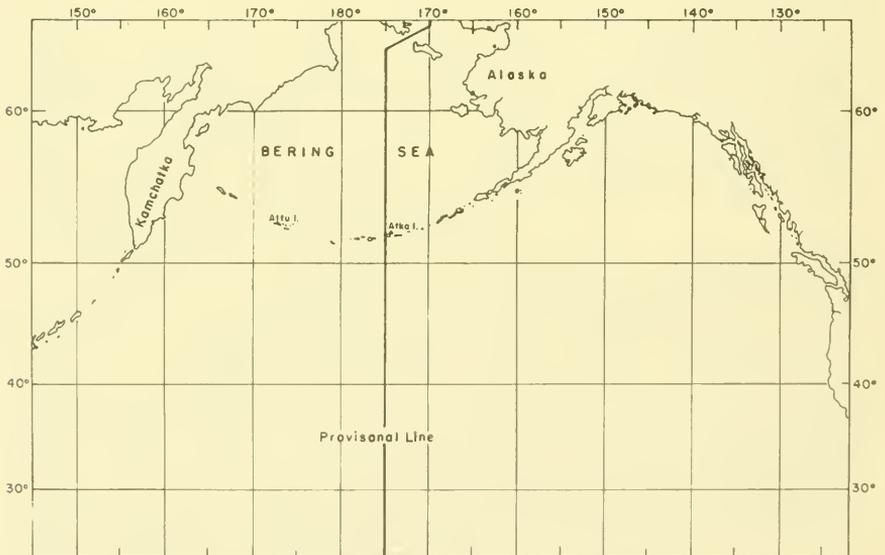


Figure 1.--North Pacific Ocean and Bering Sea, showing position of Provisional Abstention Line.

At the time the treaty was signed, almost no information was available on distribution of Asian or North American salmon on the high seas. It is true that the Japanese in the 1930's had undertaken a detailed survey of the Bering Sea west of 180°, but the main purpose of their survey was to determine where salmon were most abundant for purposes of establishing a commercial fishery, and no attention was given to whether the fish taken were of Asian or North American origin. The limited research of the United States in 1937 and 1938 in eastern Bering Sea indicated that salmon were probably confined to the continental shelf.

After entry into force of the Treaty on June 12, 1953, the Commission was organized in February of 1954 and its program of research was approved in the fall of that same year. The first explorations to determine distribution of salmon were made in the spring of 1955 when the U. S. Fish and Wildlife Service vessel John N. Cobb was sent out along the west coast of North America, across the Gulf of Alaska, and along the Alaskan Peninsula. Wherever the Cobb set its nets, salmon were taken.

Based upon this information, two halibut schooners were chartered in July 1955 to investigate the critical waters between 175° E. and 165° W. lying on both sides of the provisional line. Again, they took salmon all along the Aleutian Islands north of about 48° N. But when the boats passed into more southern waters, salmon disappeared from their catches and instead, quantities of albacore were taken. It was now obvious that two separate environments had been found. This was most important to us because it meant that we had found the southern range of salmon distribution (fig. 2).

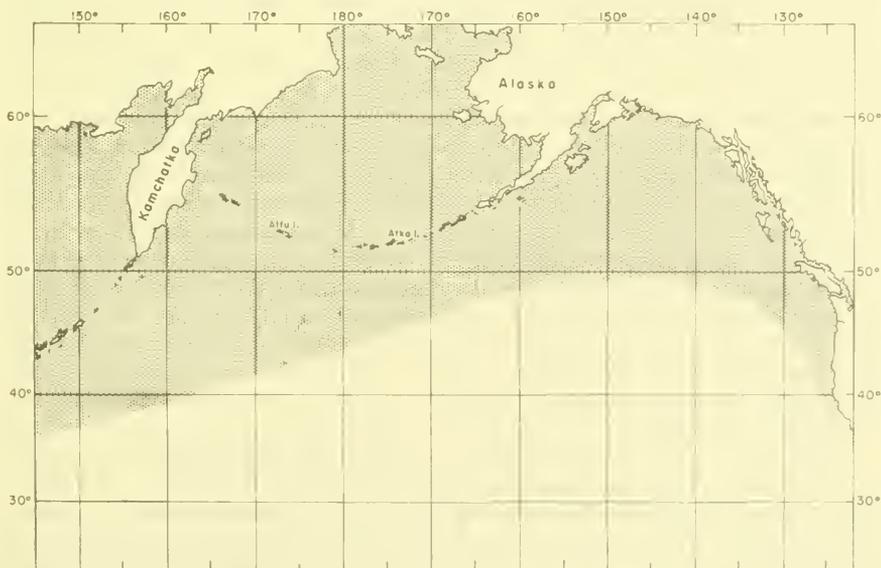


Figure 2.--North Pacific Ocean and Bering Sea showing area inhabited by salmon in May - June.

However, further evidence was required on distribution of salmon in spring (winter in the sea) when the colder water of the North Pacific extends as far south as about 40° N. Arrangements, therefore, were made for vessels from the laboratory of the Bureau of Commercial Fisheries at Honolulu to extend their spring cruise for tuna into waters north of 40° N. and, as predicted, salmon were found in these waters. It was evident that the distribution of salmon was intimately associated with conditions in the ocean, varying from season to season and, of course, from year to year.

Coupled with this knowledge of the southern limit of salmon distribution, subsequent studies have shown that the northern limit lies at a temperature of about 3° C., and here again the temperature pattern varies markedly between seasons and years.

Yearly changes in abundance of salmon have been followed closely since 1955 by fishing the same stations on the high seas. In this work we discovered that the numbers, kinds, and sizes of salmon on the high seas vary from time to time and place to place. For example, we have found the ocean near the central Aleutian area to be heavily populated with pink salmon (*Oncorhynchus gorbuscha*) during odd-numbered years, and we have found that these are Asian fish. In marked contrast, very few pink salmon are present in the even-numbered years, and these fish are predominantly of North American origin. Pink salmon invariably return to spawn at the end of their second year of life, hence these patterns are not surprising.

The distribution of salmon within this area varies as the season progresses. In 1959 pink salmon were first observed in large numbers about 200 miles south of the Aleutian chain. As the summer progressed, pink salmon became more and more abundant near and north of the Aleutian chain in the Bering Sea, but by mid-July they could be found only in the westernmost part of the ocean, near the Asian continent.

Similar changes have been found for red salmon (*O. nerka*). In May and June of 1959, the central area just north of the Aleutians was heavily populated with adult red salmon almost certainly of Bristol Bay origin, and red salmon remained abundant here until about the end of June. In July, the larger, more mature red salmon became scarce but we began to catch large numbers of immature red salmon. In 1959 these immature red salmon were about 10 times more abundant than in previous years and were certainly part of the very large outmigration of small fish from Bristol Bay in 1958.

These initial explorations were sufficient to give us an answer to the first question posed by the Protocol, that is, did Asian and North American salmon intermingle on the high seas? There is no question but that large numbers of salmon from Asia and North America intermingle in the mid-Pacific and the Bering Sea. We also found that the amount of mixing and the actual distribution of the salmon was related to the abundance of fish from certain mainland

rearing areas and to the configuration of the hydrography of the sea.

Our next problem was to define this area of mixing for the three important species of salmon: red, pink and chum (*O. keta*) salmon. Tagging experiments provided the best way to define these areas, and such investigations were arranged by contract with the Fisheries Research Institute of the University of Washington.

Finally, to answer the problem set forth in the Protocol, we must know not only where salmon are, but also the relative abundance of North American salmon at any point on the high seas. The answer to this question required the development of new methods for identifying Asian and North American fish. In effect, we must examine a salmon, and by certain differences, such as variations in size, shape, or numbers of parts in various sections of the body, be able to say that this fish is from Asia or from North America. Three successful methods for identifying stocks of salmon are now being used.

These areas of the North Pacific Ocean mentioned above were all fished by our research vessels for the purpose of securing samples to determine where fish in the high seas originated. In studying these fish samples, examination of the structure of scales of individual fish was the first approach followed. It has been found that salmon tend to deposit rings (or circuli) on their scales in patterns characteristic for each area. A careful study of these characters of red salmon scales demonstrated by 1957 that Bristol Bay red salmon were found far to the west in the central Pacific. Subsequently, we have devised means of making quantitative separations into continent of origin of scale samples taken on the high seas.

Similarly, we have experienced considerable success in the study of the counts of body structures of salmon. This different approach makes use of variations in the number of scales on the fish, bones in the backbone, bones in the gill arches, and fin rays, as well as a number of other readily-examined portions of the fish which tend to show differences. This method has been particularly useful to us in developing quantitative separation of red salmon on the high seas. We have been able to determine with reasonable precision what portion of the salmon in a sample taken in the middle of the ocean came from North America and what portion came from Asia.

One of the newer and more fascinating approaches, or techniques, applied is that of serological or blood chemistry differences between Asian and North American fish. It has been necessary to develop this research from a rather scanty basis of knowledge of blood types in fish. However, it has been found that salmon and other fishes do indeed have blood types. It has been possible to produce antisera which will react with the blood of North American red salmon but will not react with the blood of Asian red salmon. By this means it is possible to collect samples of blood on the high

seas and, subsequently to determine whether the blood was from Asian or North American fish, although the fish may have been taken thousands of miles from its point of origin.

To summarize briefly the results and progress at this point, we have worked out, for the years during which research has been possible, a picture of the distribution of North American red, pink, and chum salmon on the high seas.

For red salmon it has been found that Bristol Bay fish are dominant in the Aleutian area as far west as 175° E. longitude; that is, a matter of about three-fourths of the distance from Bristol Bay to Kamchatka (fig. 3). Asian fish in smaller numbers are found as far east as the eastern Aleutian Islands.

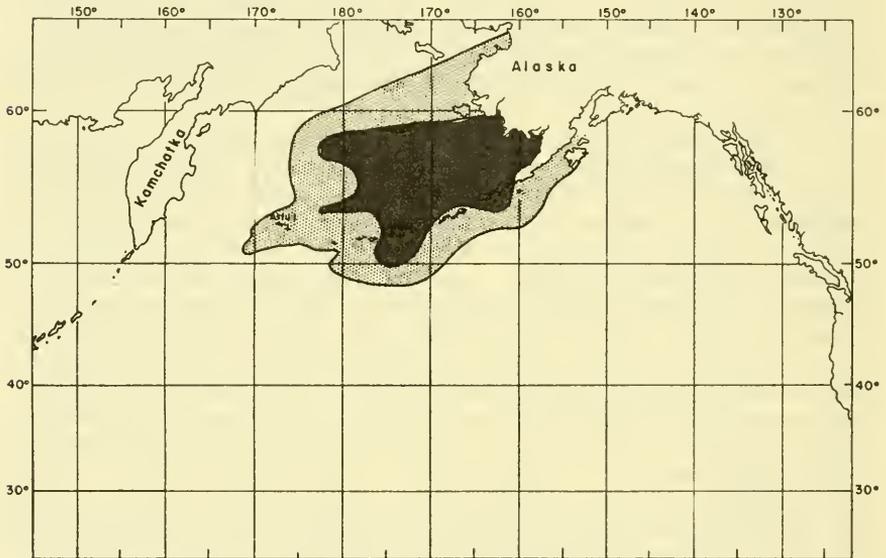


Figure 3.--Distribution of western Alaska red salmon in 1957. In the shaded areas, western Alaska-type red salmon were dominant, and their relative abundance was proportional to the depth of the shading.

Pink salmon from the Bering Sea coast of North America were found very nearly as far west as Bristol Bay red salmon; however, not nearly so abundantly. Conversely, Asian pink salmon in 1957, and apparently also in 1959, were found as far east as the tip of the Alaska Peninsula in very considerable numbers. It seems that in these odd-numbered years Kamchatka fish overwhelmingly dominated the entire mid-Aleutian pink salmon population.

Chum salmon were distributed in approximately the same manner as pink salmon. Asian chums have been caught near the Shumagin Islands, and North American chums, while they go far to the west, do not appear actually to reach the Asian mainland. Again, the numbers of Asian chum salmon in mid-ocean appear to far outnumber those from North America.

The results of racial studies provide two important answers related to problems of the Protocol. First, information on the extent of mixing of the salmon on the high seas is further strengthened. The east-west extent of the mixing area is shown in figure 4. North American red salmon, the species of greatest concern, have been recognized by the Commission to predominate in catches as far west as 175° E; these red salmon originated in the Bristol Bay region.

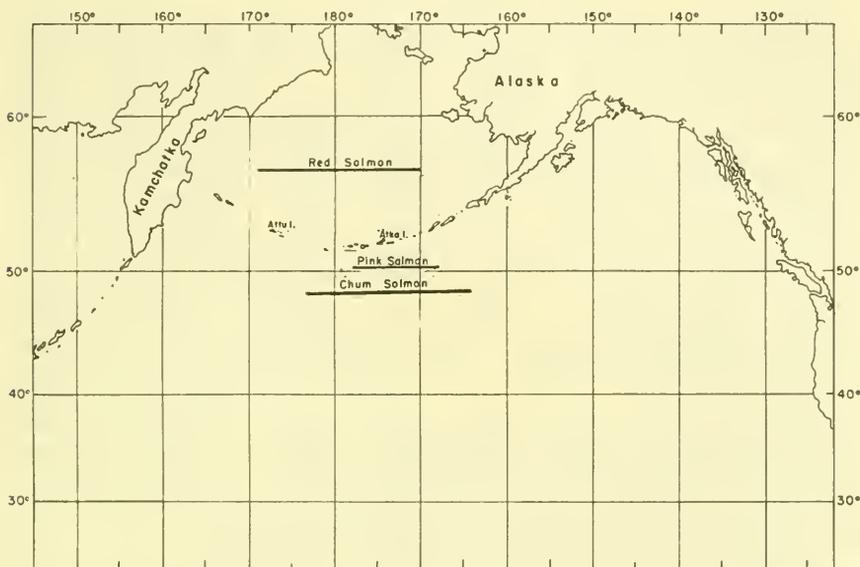


Figure 4.--East-west extent of high seas mixing between American and Asian salmon. The area observed was near the Aleutians. The bars indicate for each species the range of latitude over which American and Asian fish are commonly found in the same waters.

But the most important problem at this time is raised by the information on proportions of Bristol Bay red salmon found in various areas of the high seas (fig. 1). Even though the data presented here are only of the most general nature, the chart does show the extent of the Bristol Bay red salmon runs which migrate beyond the provisional line and are subject to capture by the Japanese fishery. This is the problem of the Protocol now before the Commission.