FISHERY OCEANOGRAPHY--V
OCEAN CIRCULATION AND DISTRIBUTION OF SOCKEYE SALMON

Felix Favorite

Early in this century, sealers frequently encountered a change in water color and an increase in sea birds and fur seals south of Attu Island, Alaska (near lat. 50° N., between long. 173° E. and 180°). The sealers believed these conditions were caused by a shallow bank. It was not until 1936 that forerunners of modern acoustic sounding devices showed that the ocean depths throughout this area not only exceed 3,500 meters but, in some places, 7,000. More than two decades later, the phenomenon was attributed to a westward intrusion of coastal water from the Gulf of Alaska.

This is not an unusual example of the time scale required to pursue maritime investigations. It is indicative of the challenging but frustrating aspects of fishery oceanography: lack of adequate funds, facilities, and equipment requires the gradual piecing together of fragmentary bits of data over long periods. Significant advances are delayed unduly when the investigators--discouraged by long intervals between major breakthroughs--abandon this field and carry away extensive background knowledge and untested theories. They leave behind them incomplete models.

Unusually Low Salinity Water

In 1935, and again in 1938, data from a few oceanographic stations indicated the presence of water of unusually low salinity south of Unimak Island (west end of the Alaska Peninsula). It was then believed that this water was carried into the area by a stream or eddy from the Gulf of Alaska. But extensive observations south of the Aleutian Islands since 1955 have enabled us to show that this low salinity water extends westward beyond the westernmost Aleutian Island--and has branches that shoot southward and eastward from this flow (thereby completing circulation in the Gulf of Alaska). Two specific examples of the flow, as indicated by the surface salinity in 1956 and 1958, and a schematic diagram for the years in which adequate data are available, are shown in figure 1. Although the westward flowing dilute water moves northward through eastern passes in the Aleutian Island chain, high salinity water (33 ‰) intrudes southward from the Bering Sea in the central part of the chain and forces the dilute water offshore. The flow assumes a jet-like character, with westward velocities in excess of 50 cm./sec. (about 1 knot) and sometimes as great as about 100 cm./sec.

In summer 1959, we were able to define this current system, which also advects warm water into the western North Pacific Ocean; we assigned it the name "Alaskan Stream." Evidence was obtained that the Stream terminated near long. 170° E., where the main flow was northward into the Bering Sea. Not until 1962 were we able to obtain winter observations and show that this flow was not limited to the spring and summer--but was a year-round feature. In 1966, we were able to show that the westward flow also ended near long. 170° E. in winter.

Sharp Surface Fronts Detected

During the spring of 1969, while using continuously recording surface temperature and salinity devices at long. 175° W., we encountered sharp surface fronts at the northern and southern boundaries of this flow. In some instances, the change in water color was very noticeable, although no unusual activities of sea birds or seals were reported. One would expect the changes in ocean conditions to be more striking farther westward, however, between long. 170° E. and 180° near lat. 50° N.; there, the Alaskan Stream meets with the northward branch of the Subarctic Current at the eastern boundary of the Western Subarctic Gyre (fig. 2).

An Asian source of dilute coastal water, shown to intrude seaward off the Kuril Islands

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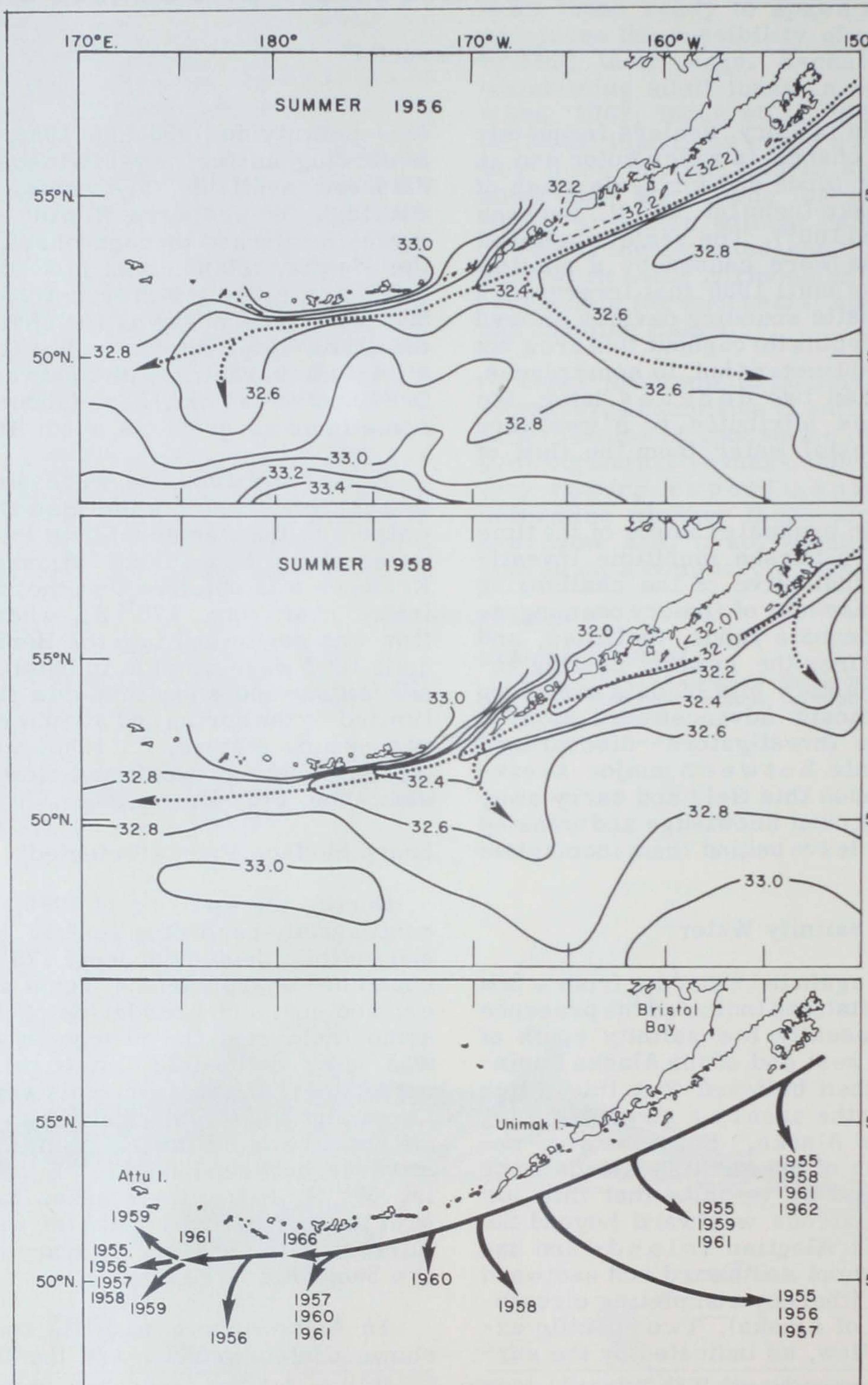


Fig. 1 - Surface flow along the south side of the Aleutian Islands (as indicated by surface salinity, in parts per thousand) showing continuity of the westward flow in summer 1956 and 1958; lower panel, variability in location at which southern branches diverge from main flow.

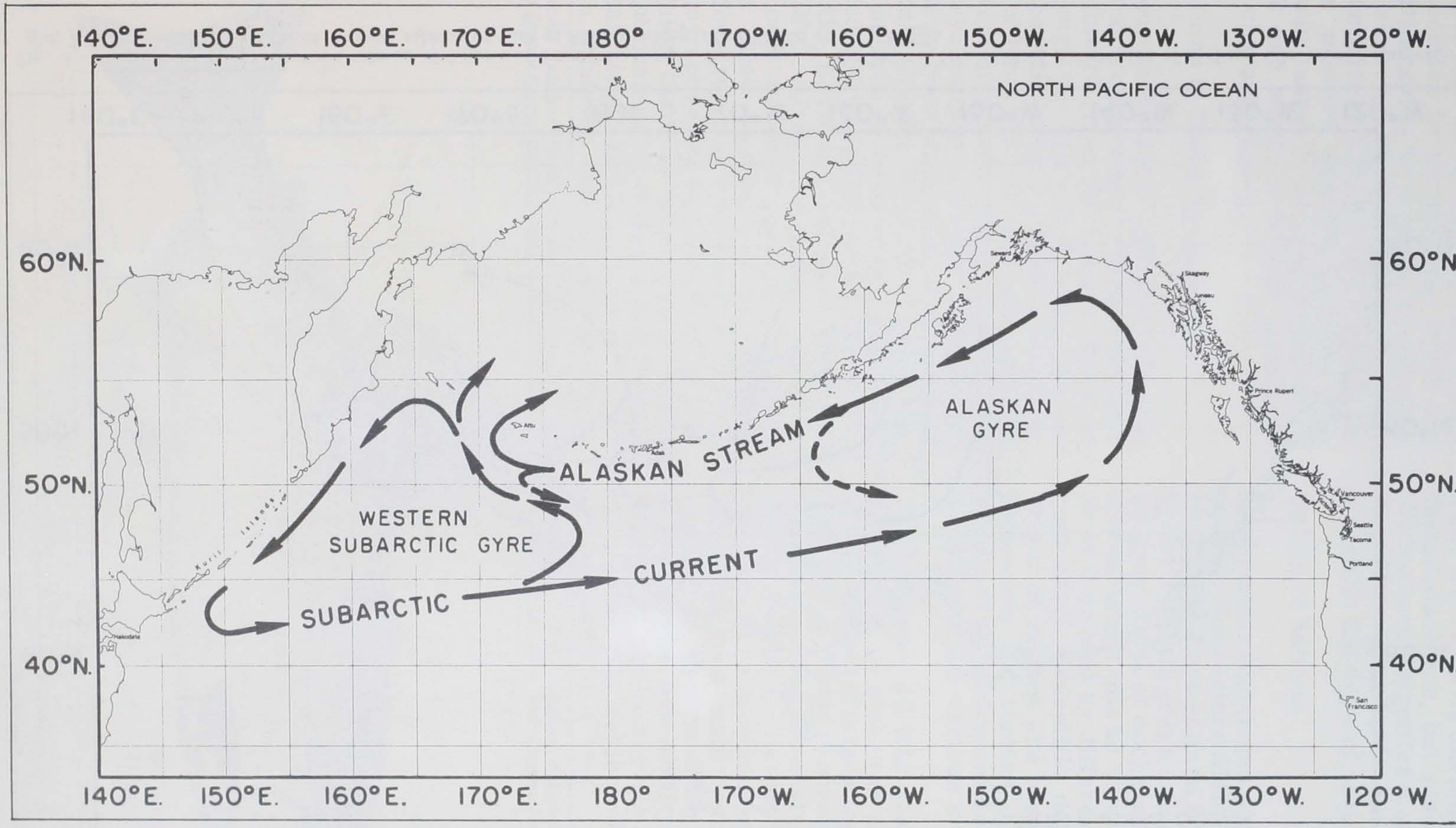


Fig. 2 - Schematic diagram of circulation in Subarctic Pacific Region south of the Aleutian Islands, showing Alaskan and Western Subarctic Gyres--and location (long. 170° E.) where westward-flowing Alaskan Stream meets northern branch of Subarctic Current.

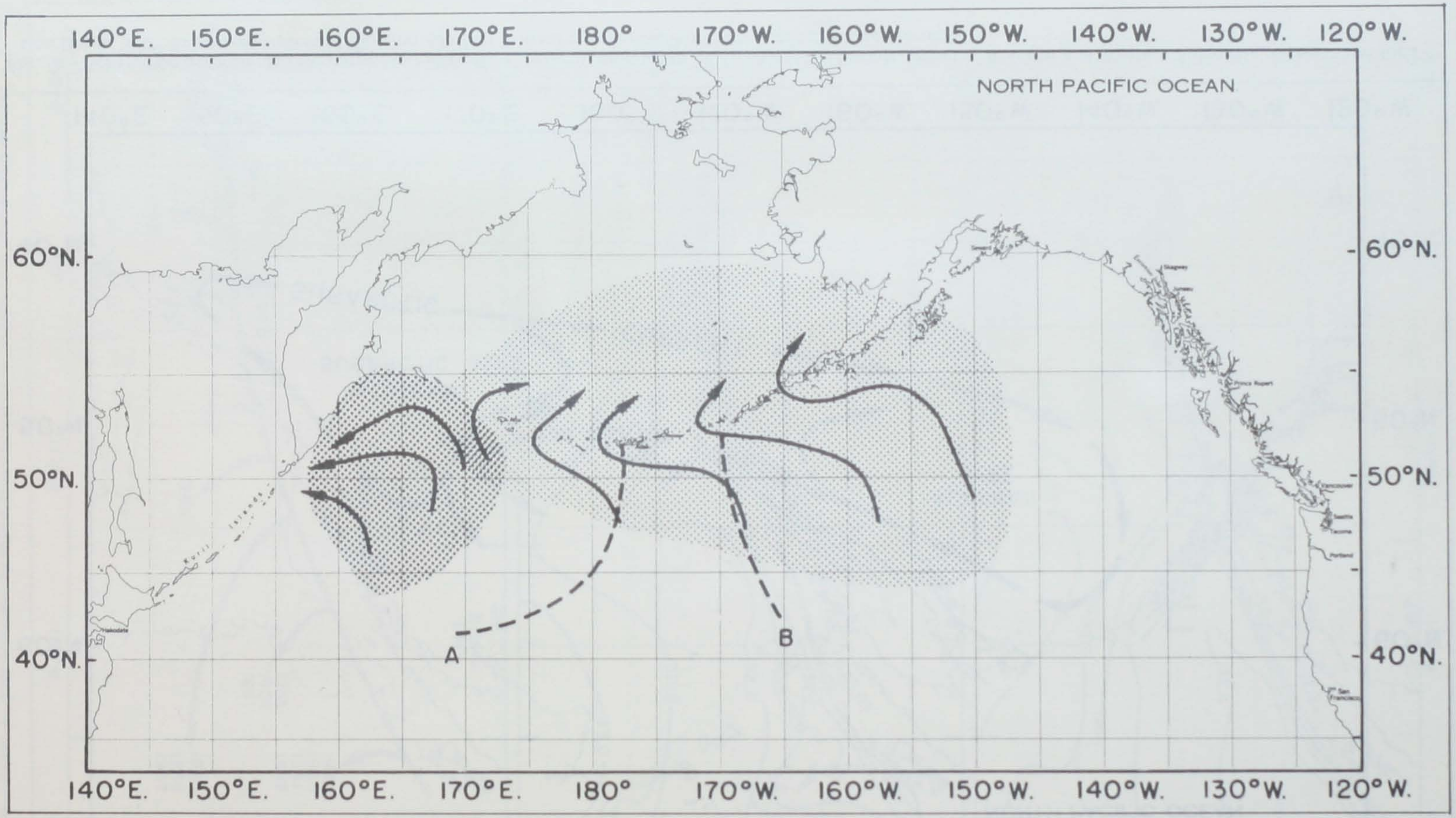


Fig. 3 - Migration routes of sockeye salmon of Asian and Bristol Bay origin during spring, the eastern limit (A) of distribution of sockeye salmon of Asian origin, and the western limit (B) of sockeye salmon of Gulf of Alaska origin (after Kondo et al., 1965).

('Fishery Oceanography IV', CFR, Nov. 1969), enters the ocean in southwestern part of Western Subarctic Gyre. Part of this water, whose properties in the surface layer are strikingly different from those in the Alaskan Stream, is advected cyclonically around the gyre and encounters water from the Stream south of the western Aleutian Islands. The rest continues eastward and mixes with water to the north and south, gradually losing its identifying characteristics.

Sockeye Salmon & Their Environment

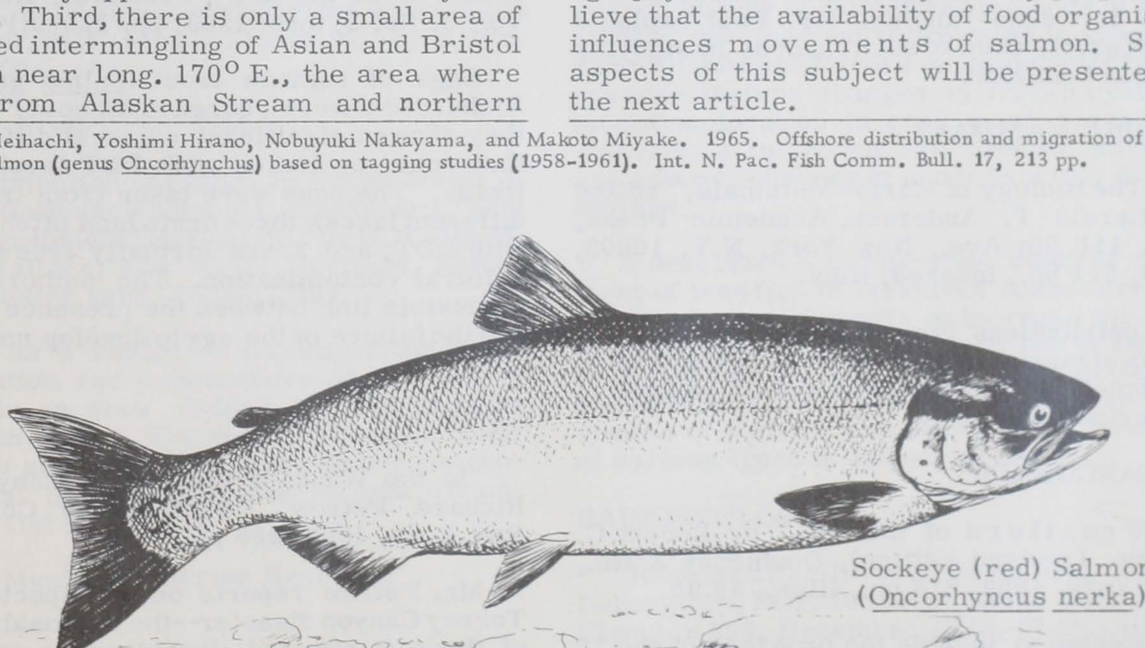
During our early investigations, changes in salmon catch occurred as the vessels proceeded southward from the western Aleutian Islands through the Alaskan Stream and into Western Subarctic water. But our investigations west of long. 175° E. have been limited. Three particularly interesting relations between sockeye salmon and their ocean environment have been indicated from tagging experiments[1/] (fig. 3): First, the distribution of sockeye salmon of Asian origin appears to be associated with the general extent of Western Subarctic Gyre and the distribution of those of Gulf of Alaska origin with Alaskan Gyre. Second, sockeye salmon of Bristol Bay origin move westward in the Alaskan Stream before turning eastward to Bristol Bay; thus they appear to be influenced by this current. Third, there is only a small area of presumed intermingling of Asian and Bristol Bay fish near long. 170° E., the area where water from Alaskan Stream and northern branch of Subarctic Current meet. The foregoing suggests not only that these stocks inhabit different environments during their ocean residence, but also that oceanic conditions have a significant effect upon salmon--as well as upon birds and mammals, as reported in the days of sailing ships.

Origin of Salmon

Japanese fishermen say that while fishing south of the western Aleutian Islands they can identify sockeye salmon of Bristol Bay origin by their subtle green coloring, in contrast to the gray-black of sockeye salmon from Asia. If true, might this be a racial characteristic, or is it caused by differences in ocean environments? Scientific determinations of the origin of salmon are based upon tagging experiments and studies of the scales, parasites, and physiological-biochemical characteristics of the various stocks.

Of course, all this evidence is offered as conjecture, or pieces of a puzzle, and not as proof. Models of migration paths are emerging--some related to oceanographic features, some not; some contested, some not completely tested. Nevertheless, even though numbers of salmon caught may show what is happening, one must turn to fishery oceanography to ascertain why. Many people believe that the availability of food organisms influences movements of salmon. Some aspects of this subject will be presented in the next article.

1/Kondo, Heihachi, Yoshimi Hirano, Nobuyuki Nakayama, and Makoto Miyake. 1965. Offshore distribution and migration of Pacific salmon (genus Oncorhynchus) based on tagging studies (1958-1961). Int. N. Pac. Fish Comm. Bull. 17, 213 pp.



Sockeye (red) Salmon
(Oncorhyncus nerka)