THE KUROSHIO OR JAPAN CURRENT

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(Reproduced from *United States Naval Institute Proceedings*, Annapolis, October, 1937, page 1426).

On a chart that depicts the main systems of the surface currents of the sea, the Kuroshio in the North Pacific appears to be the counterpart of the Gulf Stream in the North Atlantic. And in many respects they are, in fact, similar. Both currents have their origin in the westerly-setting drifts brought about by the northeasterly trade winds, the Kuroshio being the current deflected to the north by the shores of the western rim of the Pacific while the Gulf Stream is the current deflected north by the shores of the western rim of the Atlantic. Both currents, furthermore, after flowing north along the western coasts of their respective oceanic basins, turn gradually eastward, and in about latitude 35° N. they come under the influence of the westerly winds and are thus impelled across the wide expanse of waters toward the eastern shores of their basins.

In view of these similarities, it has become customary to take for granted that the features that characterize the Gulf Stream are also characteristic of the Kuroshio. Along the southeastern coast of the United States the Gulf Stream is found to be a swift, highly saline current of warm water; hence these characteristics have been ascribed to the Kuroshio along the coast of Japan. Furthermore, the climatic effects of the Gulf Stream extend to high latitudes along the eastern shores of the North Atlantic — up to 70° N. in fact — and it has therefore been assumed that the Kuroshio likewise influences the coasts of the eastern rim of the Pacific Ocean in high northern latitudes.

Recent researches, however, have shown that while in many respects the Kuroshio may be considered the counterpart of the Gulf Stream, there are also important differences between these two great current systems. These differences, together with the differences in the hydrographic features of the two ocean basins, bring about decided differences in the climatic effects of the two ocean currents.

In this connection it is to be remembered that until recently the Kuroshio has received relatively little investigation, so that it is not nearly so well known as the Gulf Stream. The latter current, because of its importance in navigation between the Old World and the New, had been studied much earlier and much more systematically, the classic work having been done by Lieutenant (later Rear Admiral) John Elliott Pillsbury, U.S. Navy, while attached to the Coast and Geodetic Survey between the years 1885 and 1889. But it is only in recent years that the Kuroshio has been studied systematically, the Japanese being the principal investigators.

The term "Kuroshio" has frequently been stated to mean "blue salt" or "blue water", but according to the more recent translations it means "black current". The Chinese and Japanese mariners, unquestionably, were familiar with the Kuroshio for ages, but the Western world came to know it only toward the end of the eighteenth century; and it was not until the third decade of the past century that it was depicted on a chart. Systematic investigation of the Kuroshio may be said to date from 1918 when the Japanese fishery authorities began extensive oceanographic observations which have been continued to date. Since 1929 these have been re-enforced by detailed current observations by the Japanese Hydrographic Department.

From these recent researches, the principal features of the Kuroshio may be briefly summarized as follows. Considering the Kuroshio to begin abreast of the island of Taiwan (Formosa) in latitude 22° N., the current there has a width at the surface of more than 100 nautical miles. Further northward the width becomes less, since part of the waters of the Kuroshio branch off to enter the Yellow Sea and Japan Sea. In latitude 32° N., off the island of Kyushu, the Kuroshio has a width of about 75 miles and this width it maintains more or less constantly until the current turns eastward in latitude 35° N., where it merges with the westerly moving waters of the North Pacific West Wind Drift.

On the average, the surface waters of the Kuroshio move with a velocity of about 1.5 knots in its lower reach, about 2 knots in its central portion, and about 1.5 knots in its northeastern stretch. But it is to be emphasized that the moving waters of the Kuroshio do not constitute a "river in the sea" as it is sometimes picturesquely phrased. Across its width of 75 miles or more there are encountered bands of water moving with

different velocities and sometimes even in opposite directions. The figures given above represent average velocities. Wind and weather influence both the width of the different bands and the velocity of the water. Velocities of as much as 5 knots have been observed in the Kuroshio, but these are exceptional.

In winter the surface waters of the Kuroshio have a temperature of about 75° F. in its lower reach, abreast of Taiwan. This decreases in going northward more or less gradually so that in its upper reach in latitude 35° the temperature becomes about 55°. In summer these temperatures are respectively about 80° and 65°. Here again it is to be noted that these are average figures.

One further feature of the surface waters of the Kuroshio is of interest to the navigator and that is the salinity of its waters. On the customary salinity scale, in which each unit represents one part of salt in a thousand parts of water, the surface waters of the Kuroshio have a salinity of 34.5 along its whole course.

For comparison with the Gulf Stream, we may now summarize briefly the features that characterize the surface waters of the latter stream. Considering the Gulf Stream to begin in the Straits of Florida, its width there is less than 50 miles, or less than half the width of the Kuroshio at its head. Further northward, however, the Gulf Stream widens, for north of Cape Canaveral the Antilles Current merges with the Gulf Stream so that the current now has a width of about 100 miles and this increases to about 150 miles off Cape Hatteras, which width it maintains until it turns easterly, southward of Nova Scotia.

With regard to width, therefore, the Kuroshio begins as a current of much wider extent, but over the greater stretch becomes only half as wide as the Gulf Stream. In regard to velocity, too, the Gulf Stream takes the lead; for against a velocity of 1.5 knots in the lower reach of the Kuroshio, the Gulf Stream within the Straits of Florida has an average surface velocity of about 3 knots; in the central part the Kuroshio velocity of 2 knots is matched by a like velocity in the central part of the Gulf Stream; in their upper parts, before the currents turn east, the velocity of the Kuroshio is about 1.5 knots while the velocity of the Gulf Stream is more nearly 2 knots.

But what is of even greater consequence than the velocity is the stability of the current. In the Kuroshio there is less stability, evidenced by a greater tendency toward the formation of different bands of water. In the Gulf Stream this is not nearly so frequent, the current maintaining a more uniformly northward flow.

With regard to temperature, the surface waters of the Gulf Stream in summer are about 80° F. in the lower reach, decreasing to about 65° in the upper reach. These compare with similar Kuroshio summer temperatures of 80° and 65°. In winter the surface waters of the Gulf Stream have a temperature of about 75° in the lower stretch and about 55° in the upper stretch, which correspond to like temperatures of the Kuroshio of 75° and 55°. For the surface waters, therefore, the two currents have like temperatures in winter and in summer.

As regards salinity, the surface waters of the Gulf Stream are definitely more saline throughout its course than the Kuroshio, the salinity of the former being about 36 against a salinity of 34.5 in the Kuroshio.

Coming now to a consideration of the characteristics of the water within the depths of the two currents, it is obvious that the observational data are more limited than for the surface waters, observations on the velocities of the current being especially limited. In general, the velocity of the current in both the Kuroshio and the Gulf Stream decreases from the surface downward. In round numbers it may be said that the current in the Kuroshio extends to a depth of about 300 fathoms, while in the Gulf Stream it extends to a depth of about 500 fathoms. That is, at these depths the velocity of the respective currents becomes zero.

Within the depths of the sea the seasonal changes in temperature are less than at the surface. Furthermore, sufficient data are lacking for an accurate determination of such seasonal changes. In general, however, it appears that at a depth of 300 fathoms within the Kuroshio the temperature is about 50° while in the Gulf Stream at that depth the temperature is about 60°.

Finally, as regards salinity, in the Kuroshio at a depth of 300 fathoms the water has a salinity of a little less than 34.5, while in the Gulf Stream at that depth the salinity is a little over 35.

Between latitudes 35° and 40° N. where the Kuroshio and the Gulf Stream turn east, they may be said to lose their individual identities, for here they merge with the slower west wind drifts of the open sea. Comparing the two currents in these regions, we find the Kuroshio to have a width of about 75 miles and a depth of about 300

fathoms, while the Gulf Stream has a width of almost 150 miles and a depth of 500 fathoms. At the surface the Kuroshio here has an average temperature of about 60°, and at the depth of 300 fathoms a temperature of about 50°. The corresponding temperatures for the Gulf Stream where it merges into the west wind drift are about 60° at the surface and about 55° at the 300 fathom depth. As a whole, therefore, the Gulf Stream contributes to its west wind drift a great deal more warm water than does the Kuroshio. And in this we have one factor that explains the greater effect of the Gulf Stream on the climate of the northern lands on the east shores of its basin.

But another reason is found in the lesser distance which the warm waters of the Gulf Stream must traverse to reach the eastern shores of the Atlantic. Taking the area south of the Grand Banks of Newfoundland as the region in which the Gulf Stream merges into the west wind drift, the distance to the eastern shores of the Atlantic is 45° of longitude or approximately 2,000 miles. From where the Kuroshio merges into the west wind drift to the eastern shore of the Pacific is a distance of about 75° of longitude or 3,500 miles in round numbers.

The tempering influence of the Gulf Stream on the climate of northwestern Europe is effected through the agency of winds. In winter the winds in that region are prevailingly from the southwest. Blowing over the relatively warm waters which the west wind drift has brought to the northeastern rim of the Atlantic, they are laden with warm air which is brought to the coast. How great this influence is becomes evident from the fact that the average temperature for the month of January in northern Norway is some 40° F. higher than the temperature normal for that latitude.

From the Gulf of Alaska southward to the 35th parallel of latitude, the prevailing winds are likewise southwesterly. Hence, the winter climate of the Pacific coast of Alaska is moderated by the winds bringing in relatively warm air from the region of the west wind drift. But this latter drift does not penetrate as far north as in the case of the Atlantic Ocean. A glance at a map of northwestern Europe shows a wide expanse of water between Iceland and Norway through which the relatively warm waters of the Atlantic west wind drift may move as far as 70° N. On the northwestern coast of America, however, the southern coast of Alaska acts as a barrier in 60° latitude against the northward drift of the water.

It is sometimes asserted that the waters of the Kuroshio, or rather a branch of the Kuroshio, enter Bering Sea. But this is not at all well established. In winter the winds blow southward over Bering Sea, and hence a northward drift of the waters from the Pacific into that Sea is out of question during the winter. In summer there are light southerly winds into Bering Sea but it is problematic whether any Pacific Ocean water enters the Sea on its west side, though unquestionably some does enter through the Aleutian Island Passes.