

THE PERUVIAN CURRENT AND THE SUMMER OF 1939.

Extracts from a lecture by Dr. SCHWEIGER delivered on 28th August 1939
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..... Two publications have appeared on the Peruvian Current which are well worth the attention of those interested in maritime phenomena. They give, among others, several indications on the subject of the contingencies which may influence the migration of fish.

The first of these publications, written by the German scientist SCHOTT on the Peruvian Current, is based on the thermographic observations effected by all the German ships which are engaged in the coastwise trade along the Peruvian coasts or which navigate off this coast in the adjacent seas while making passage direct from Panama to the Chilean ports. The "Deutsche Seewarte" of Hamburg has at its disposition observations of this kind extending over more than 50 years, and SCHOTT has combined these observations with his own experience in the course of his voyages along the coast of South America. We find in this publication a general description of the phenomena of the Humbolt Current in its relations to the vast expanse of the Pacific Ocean and the explanation of the accidents which occurred in 1891 and 1925, correlatively with the penetration of the Niño Current further to the southward than its normal limits.

The second publication is presented as the fruitful result of a profound study brought to completion by the English scientist GUNTHER on board a specially equipped vessel during the months of July and August 1931. The investigation in question was effected on a voyage from the Straits of Magellan to Cape Blanco, with numerous traverses perpendicular to the coast.

That which is most important in these works is the effort made by the authors to delimit for the first time the zones of "upwelling", i.e. the localities where the cold waters from the depths surge upwards to freshen the superficial layers of warmer waters. It has been known for a long time that the cause of this phenomenon must be attributed to the lower temperature of the Humbolt Current. While the publication of SCHOTT is restricted to the mention of the zones in accordance with the author's conception, the work of GUNTHER is concerned more with a study of the details of the phenomenon and explains several facts observed in the course of the research undertaken with a view to locating the origin of this upwelling. That which is most striking in the investigations of GUNTHER is the presence of two tongues of lukewarm water, at a temperature slightly higher than that generally considered normal and somewhat higher than that of the adjacent waters. The first tongue extends from the north from a point located off Cape Blanco towards the south to about the latitude of Callao, with its greatest width about opposite Salaverry, while the second tongue of water is found to the south of San Gallán, from about the latitude of San Juan to the port of Arica.

The tongues of lukewarm water are supposed to mix with the colder waters, thus producing zones where great shoals of fish remain by preference; for this reason a special study of these zones, revealed by the research of GUNTHER permits us to obtain certain information regarding the relations existing between the sea and the fish.

But, since the publication of SCHOTT makes no allusion to the existence of the tongues of lukewarm water, the question arises as to whether these are normal and occur every year and at all seasons, or whether they occurred simply as a result of special conditions obtaining in the year 1931, when the investigations of GUNTHER were carried out.

From the start the programme of oceanographic research in Peru was limited to two distinct theses: first to verify whether these tongues of warm water existed, and second, to determine the origin of the cold waters in the Humbolt Current; these two studies being intimately related, as we have stated, to the abundance of fish.

These two studies were therefore the reason for our voyages in the waters adjacent to the coast where we obtained results so unexpected that the conditions encountered will have to be considered as abnormal, and thus an added reason for their publication. The occasion was first offered, as a result of an unexpected event, to undertake a study of the tongue of warm water between Cape Blanco and the latitude of Callao. The meteorological service of Peru had received advice of an abnormal rise of temperature in the sea near Cape Blanco at the end of October 1938.

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According to the advices received at Lima, this condition returned to normal shortly after, near Cape Blanco, but on the 6th of November there was found another considerable rise in the temperature. For this reason, the Administration of the Guano Co. put their steamer *CHINCHA* at our disposal for undertaking this research work. The steamer left Callao on 19th November, having on board the Chief of the National Meteorological Service of Peru, M. WAGNER, since deceased, to whose memory we wish to offer the most sincere respect and admiration.

Since the vessel was not equipped in advance with any special apparatus, the investigation was limited to the surface of the ocean, which permitted taking notes on the general climate in the zones visited also. After the first voyage, five others were undertaken.

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The first voyage, in the month of November 1938, was productive of the following results: first, on the same coast, low temperatures were found which were lower than those indicated on the chart in the SCHOTT publication relating to the months of August and September; but one might expect, however, that they would rise in the second half of November to the level of those given by SCHOTT for mid-winter. We see from this to what point the temperature dropped in this very cold winter which brought about such serious disturbances in the life of the fish and the guano birds. Secondly, the distribution of the waters and their isotherms opposite Cape Blanco showed the same tendencies as those determined by GUNTHER, but with the difference that the colder waters extended more to the north and the west, in such a manner that on parallel 7° S the zone of 18° was displaced about 30 miles to the westward. Third, in latitude 11° S, there was noted a heating of the waters to almost 19° in the zone in which GUNTHER, on his charts, showed the cooling on the western border of this tongue of warm water of 20° temperature. If these waters of a temperature of slightly less than 19° represent the eastern limit of the body of lukewarm water, the latter would show a displacement of at least 60 miles to the west, in comparison with the locality in which they were found by GUNTHER.

The contrary was found on the voyages undertaken during the summer of the year 1939, where a movement of warm water was manifested further to the eastward than is usually considered normal. In order to make a comparison we shall take the two charts, one by SCHOTT which shows the isotherms for the months of February and March and the other by the SCRIPPS Oceanographic Institute, based on the observations effected during a voyage in the first half of January 1935 relating to the part of the ocean to the westward of the Peruvian coast.

The difference between the two charts is quite marked. But, admitting that the maximum seasonal temperature at the surface of the ocean will only become manifest after the first days of February to the end of March, we may consider the isotherms given for January 1935 as precursors of the distribution shown on the Schott chart.

The temperatures for January 1939 show discrepancies not only with the Schott chart but also with those indicated on the chart of the Scripps Institution. In other words, near the coast the waters were colder, while in the open sea, temperatures were recorded higher than those shown on either of the charts.

At this time the eastern front of the 23° waters was found at about longitude 78° 20', while on the chart of Schott this limit is shown for the height of summer at the same latitude in about 80° W. longitude.

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In the course of the voyage, there was observed at the end of January a narrow band of water of 24° having its centre at about 12° S, 79° W; the temperatures to the northward averaging about 23.7° which appears to indicate the entrance of warmer waters into this southwesterly region.

It was only 23 days later that the steamer *CHINCHA* traversed the zone in question for the second time and entirely different temperatures were recorded, showing an increase which was surprising by the rapidity of its development. The eastern limit of the 23° waters was displaced about 15 miles to the eastward, but even at a distance of 5 to 6 miles further west, the ocean showed a temperature of 24° and near longitude 80° W it was 25° ; that is, in the region where SCHOTT indicated a normal temperature of 23° . There was observed a small isolated island of water of temperature 25.2° in $78^{\circ} 45'$ W and $11^{\circ} 5'$ S.

The observations made in the course of this voyage can only lead us to believe that in the middle of February the isotherms of 23 and 24° , beginning at 11° latitude, run towards the north, parallel to the coast at a mean distance of 30 to 40 miles from the coast, while from 12° S latitude they lie offshore at a distance of 60 miles. But north of latitude 8° S, they begin to draw away from the coast so that the islands of Lobos de Afuera and Lobos de Tierra remain about in the middle of these isotherms. The isotherm of 25° follows another course. In latitude 11° S, it is found at a distance of 160 miles off the coast. To the north we encounter it distant seven miles only to the west of the island of Lobos de Afuera.

Starting from this island, en route to the southwest, the steamer *Chincha* penetrated a distance of 15 miles into temperatures of 26° , and for 30 miles traversed a band of water of 27° , leaving this zone about ten miles further on to enter again into a zone of 26° .

On the whole there was covered an expanse of 82 miles in this zone, including the band of 27° . Finally, the temperature dropped to 25° , which was observed along a course for 85 miles, while further to the westward and to the south there was an influx of 26° water, having its centre at $10^{\circ} 10'$ S and $81^{\circ} 55'$ W.

In accordance with the chart of SCHOTT, the ocean at these distances shows temperatures clearly inferior to 22 and 23° and does not approach, in the region traversed during the voyage, the temperature of 24° , and still less that of 25° .

While the distribution of the temperature to the north of Lima conforms very readily to a complete, although exceptional, phenomenon in the region to the south of Lima, (that is, the region explored during the first two weeks in March), it does not give us a very clear representation of the prevailing conditions. The isotherms deduced from observations made during the month of March are readily understood. One should note, however, the extension of the colder waters towards the coast in the region located further north. At the latitude of Lomas, the influence of the Rio Grande manifests itself very strongly in the discharge of its waters into the ocean, which, influencing the temperatures to a distance of 70 miles off the coast, must be considered as cold. This could be checked by the titrations for salinity, which dropped at the point the steamer passed into a temperature of 19° , after having passed through waters of 20° .

The entire region to the northward of San Gallán and as far as the islands to the westward of Callao, offer difficulties of explanation; according to the isotherms deduced from later experiments, we shall see that something is occurring here which merits close attention, particularly from the point of view of Lima and its relations to our climate.

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We should call attention to the rise in temperature in the vicinity of the Chincha islands. All the ship captains who pass at the latitude of Asia Island on the passage to the southward, or later at the altitude of Cerro Azul, invariably encounter a current setting to the southward. At the Chincha islands, situated 14 miles off the coast, there blows a north wind during the winter nights and also in the summer, which in the majority of cases is not strong, but is always perceptible as a light movement of the air.

It is particularly interesting to observe the distribution of temperatures in the Bay of Pisco, which is closed off to the west by the three Chincha Islands, to the southwest by the Ballestas Islands and the San Gallán island and to the south by the Paracas Peninsula. The cold current arriving from the south is bifurcated at the island of San Gallán into

two arms, one passing outside the Chincha islands, while a small part only passes between the island and the peninsula of Paracas.

According to numerous observations effected in this bay, we may picture the phenomenon somewhat as follows: One current enters from the north into the Bay of Pisco. It manifests itself by its high temperature. For instance, in the course of a voyage effected in March, there were measured over the whole run, from the Fronton Island to the north of the Chincha Island, temperatures of about 21° . At half a mile north of North Chincha the temperature rose to 22° and in the morning there entered an intense current from the north which attracted attention solely by the noise which it made. The current carried branches, trees and brush, and had a temperature of 23° . On passing through the Bay of Pisco a little later on the same day, there was observed another current entering from the north, very strong, between the islands of North Chincha and central Chincha, which was marked by the noise it made and by the agitation of the waters in the torrential flow. This current showed a temperature of 24° . On reaching the Ballestas Islands, some 7 miles distant from this locality, we determined the presence of colder waters from the south, which lowered the temperature to 22.7° and to the south of San Gallán it was maintained at 18° to 19° .

With regard to these observations it should be remarked that near the islands of Pachacamac and Asia, the temperatures are always found to be much higher than at the islands further north, as far as the Macabi Island.

One cannot deny that this entire region is subjected to certain processes which resemble the eddy currents which GUNTHER locates at two points opposite the Peruvian Coasts, considering them as the cause of the tongues of warm water which we discussed above. In any case one cannot state definitely in what manner these eddy currents act in this part of the coast, but it appears that the cold water surges up from the depths at some place near the coast, with the intention of passing out to the westward, but that it soon encounters a current from the south which changes the direction on the surface, thus forming this eddy current. It is probable that this eddy current entrains the warmer waters of the surrounding ocean adjacent to the southern coasts, that is, opposite the Bay of Pisco, and passing by the Chincha Islands, leaves with a northern orientation along the same coasts, until these waters are lost near the Islands of Asia and Pachacamac at a distance of about 30 kms. from the capital.

The observations made in the middle of May indicate a regression of the warmer waters towards the west. We find the temperatures of 22° in the region in which the SCHOTT chart reports them also; while the temperatures of 23° and 24° are located somewhat nearer the coasts than those given by SCHOTT for mid-summer, normal for the months of February and March.

There remains for us only to give the results of the observations made at sea after having traversed the Peruvian Coastal Current and entered into the Peruvian Oceanic Current (according to the nomenclature employed by GUNTHER). The separation between the two zones is clearly defined, as GUNTHER has remarked, by the colour of the water. We might almost designate the temperature of 23.5° as that of the water which shows a deep aqua-marine coloration, while the waters ranging in temperature from 23.4° to 22° are characterised first by a discoloration, followed by a lighter milky blue colour and finally a mixture with green; at the last the waters of 22° show the deep green which is so well known along the Peruvian coasts. The differences between the zones is also marked clearly by the meteorological observations as well as the biological.

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It appears that the entrance of the waters of higher temperature than 24° coming from the north and the northwest as far as the regions to the north of the coasts of Peru, corresponds with the evolution of the famous Niño Current, as was found in the years 1891 to 1925, with the sole difference that during the year 1939 this current did not have sufficient strength to carry to the southward the belt of cold waters existing along the coast, and to produce the disastrous results which occurred during the years in question.

