METEOROLOGICAL AND HYDROGRAPHICAL OBSERVATIONS MADE IN THE WESTERN PART OF THE NETHERLANDS EAST INDIAN ARCHIPELAGO

BY

K. M. VAN WEEL,

Hydrographic Assistant of the Laboratory for Marine Investigations at Batavia.

INTRODUCTION.

The Western part of the Indian Archipelago may be regarded as well known to the sailor, both hydrographically and meteorologically. We owe this knowledge chiefly to the excellent elaboration of the numerous observations by Dr. VAN DER STOK, then Director of the Meteorological Observatory, Batavia, whose labours are embodied in the standard work "Wind and Weather, Currents, Tides and Tidal Streams in the East-Indian Archipelago", — and further to the attention paid by the Commanders of the exploration craft to questions of hydrography and meteorology, during the surveying of the Java Sea and the Southern China Sea.

The hydrographic survey acquainted us with the bottom profile and gave us a general knowledge of the topography and the composition of the ocean bottom; we largely owe to it our acquaintance with the sea-currents and tides.

These seas were never explored for geophysical purposes; as far as I know general data are to be found only in the "Atlases of the Indian Ocean" published by the Meteorological Institute of de Bildt (Utrecht), the Deutsche Seewarte of Hamburg, and the Hydrographic Department of the Admiralty in London. [1]) The well-known Siboga expedition of 1900 and 1901 applied itself almost exclusively to the morphological investigation of the very interesting Eastern part of the Archipelago and the study of the fauna of this area of the sea; on the voyage out and the home voyage a few soundings only were taken and bottom samples collected in the Eastern part of the Java Sea. No records have been published either of temperatures or of salinities.

[1]) Neither these latter two atlases nor the tables of figures used in constructing them were at my disposal.

As early as 1893 SCHOTT in his important study relative to the hydrographic condition of the E. Asiatic seas (1) complained of the insufficient knowledge concerning the salinity and the temperature of the Java Sea and the S. China Sea. The same complaint was voiced by KRÜMMEL in his discussion of the areometrical observations of Prof. DAHL during the latters expedition from Naples to Matupi (2, p. 539). The few salinity determinations made in various seasons could not faithfully reflect the salinity, as this bears its special character in each season. Detailed observations are consequently required for this as well as for a knowledge of the course of the isotherms.

The scientific investigation of the sea, aiming at acquiring a more complete insight into questions relating to fisheries, has brought about a fortunate change in this state of things. In 1914 the then Fisheries Station [1]) of Batavia began to devote itself exclusively to collecting data concerning the life and the milieu in the foremost place of such marine animals as were economically important. From the nature of the case one point of the program was from the very beginning the acquisition of an accurate knowledge of the hydrographic conditions of the area to be investigated.

As a beginning the temperature and salinity of the Java Sea were reconnoitred; the latter by means of hydrometers, which work was continued, after my return to Holland in 1915, by my temporary successor Captain VAN KOESVELD, until May 1916.

During my furlough the Government commissioned me to acquaint myself with the practice of modern ocean-research and laboratory work at the Biological Station of Bergen in Norway. I remember with gratitude the extraordinary courtesy of my teachers there, Prof. HELLAND HANSEN and his assistant Dr. GAARDER, who spared no pains in training me as a practical hydrographer. I also seize this opportunity of gratefully recording my obligations to Prof. KNUDSEN of Copenhagen, for his assistance in procuring for me normal water and various instruments and utensils from the Laboratoire Hydrographique at his place.

Methods, Instruments etc.

The shallow sea area in the Western part of the East Indian Archipelago formed by the Java Sea, the S. China Sea and the Straits of Malacca is too extensive to be examined as to salinity and temperature, in one year with a single ship. In 1917 a start was made with the Java Sea, which observations were continued in 1918. In pursuance of these observations the S. China Sea and the Straits of Malacca were examined in the same way in 1919 and the early part of 1920.

[1]) Now called Laboratory for Marine Investigations (Laboratorium voor het Onderzoek der Zee).

The cruises were made in the months of February, May, August and November, i.e. in the months when, as a rule, the monsoons prevail regularly and strongly (February and August) and in the transition-months, at the changing of the monsoons (May and November).

As regards the Java Sea the following remarks may be made: the field of observation comprises the whole of the Java Sea, from the Sunda Strait to the Strait of Macassar, with the exception of the Strait of Madura, which, in view of the too long duration of these cruises, had unfortunately to remain unexplored. This latter circumstance is all the more to be regretted because some samples of water received later on afforded evidence showing that the salinity in this strait at certain seasons deviates considerably from that in the rest of the Java Sea: owing to its separation from the Java Sea by the island of Madura, and to the proximity of the Bali Strait with its strong tidal currents, it has a more oceanic character. This strait might also be of interest to the biologist because important fisheries exist not only to the north, but also south of Madura.

In order to know the condition of the surrounding waters of the Java Sea part of each cruise was spent in also examining the water of the Sunda Strait and of the southernmost part of the S. China Sea. The more northerly part of the S. China Sea was explored in 1919 and early 1920 as far as Lat. N. 2°; the Straits of Malacca as far as Lat. N. 4°; there a cross section of the straits was made.

The routes followed give a well distributed network of observation points (see the charts); the intervals between the stations are about 20 English miles. The positions of the stations were ascertained wherever possible by taking the bearings of known points on the land; in the great majority of cases, however, the compass and log yielded a position by dead reckoning, which was regularly checked and corrected by solar and stellar observations.

In consequence of the long duration of the cruises (3 weeks) it was possible on the home voyage in the months of February and May in the Java Sea to ascertain some modification of the salinities at the intersections of the routes. In February the isohalines did not undergo changes from this cause, but in the transition month of May this influence was greater, especially in the Western part: between the stations 129 — 135 the fresher water of the middle of the Java Sea had shifted to the West, as a consequence of the steady blowing of the S. E monsoon. This caused a curve of the N — S isohaline for 32 $^0/_{00}$, which was thereby bent towards the West. In accordance however with the observations of 1918, in which year the Java Sea was investigated only in the W — E direction along zigzag courses N.N.E — S.S.E, the direction from N. to S. of this isohaline was maintained.

For the purpose of collecting the water samples we had at our disposal one water-bottle EKMAN system, one of the model of the Laboratoire Hydrographique besides one NANSEN-PETERSSON water-bottle, which latter however

was never used, the apparatus being too heavy (All the instruments were pulled up by hand).

The first of these instruments was by far the most satisfactory. In 1917 two reversible thermometers were used on each water-bottle; several of these instruments, however, got out of order through continuous use, so that in 1918 the work had to be done with only one thermometer for each water-bottle. The reversible thermometers manufactured by SCHMIDT and VOSSBERG were very satisfactory.

For the purpose of preserving the water-samples we used bottles which would hold some 400 c.c. and whose stoppers were furnished with an india-rubber ring.

All the thermometers used had been tested by the Physikalische Reichsanstalt at Charlottenburg. The correctness of the thermometers was checked by means of a precision thermometer.

The water-samples were taken and the temperatures determined at depths of 0, 5, 10, 20, 30, 40 M. etc. The salinity was determined after MOHR's method of chlorine titration. From the Laboratoire Hydrographique of Copenhagen a supply of normal water had been obtained, which had to be handled with the utmost economy, as it was quite impossible to renew the supply during the war. In the course of my voyage out from Holland to the East-Indies viâ the Cape of Good Hope water-samples were also collected in the Canary current, the N. Equatorial, the Benguela and the Agulhas currents, and further in the middle of the Indian Ocean, from which on arrival at Batavia, upon being mixed with water from the Java Sea, a large bottle of auxiliary normal water was made; this bottle was tightly closed with a rubber stopper and kept in a dark place. After each periodic cruise this auxiliary normal water was compared with the normal water from Copenhagen, the result being that hardly any alteration became noticeable in the chlorine percentage (max. 0,01 $^0/_{00}$). In 1917, 1919 and 1920 all the samples were titrated by myself, in 1918 this was done partly by a native assistant, under my supervision.

In 1917 the meteorological observations and those referring to the surface temperature were made every hour; this was done partly by myself, partly by the officers on duty, who acquitted themselves of this task with great devotion. Eventually the double duty of bearing the command over the exploration vessel and of carrying out and controlling the observations every hour, proved to be too much of a strain; this is why it was resolved in 1918 to have the observations every two hours.

The surface-water was, as is usual, collected from the fore-part of the ship in a canvas bucket; two thermometers being always used to mutually check each other.

The temperature of the air and the relative humidity were determined by means of ASSMANN's aspiration psychrometer (Fuess No. 1060). SCHOTT's experiments have shown (1. p. 100) that even if this psychrometer be kept overboard in the hand on the lea-side, radiating influences are not to be avoided

on board of ships, owing to which the average readings are too high. Another drawback of this method is that it often proves impracticable on board of small vessels owing to sea-water coming overside. Therefore the forepart of the ship was chosen to put up the apparatus, where the wind comes mostly in and consequently a good ventilation is secured. When the wind came in from behind the observations were not taken. On several occasions they had to be passed over during heavy showers. Depending on the direction of the wind the psychrometer was hung up either on starboard or on backboard under the double awning; the elevation of the instrument above the deck was 1.7 M, above sea-level 4 M, the distance to the awning 1 M.

In the tables the force of the wind is expressed in the scale of BEAUFORT, the cloudiness in a scale from 1 to 10 as prescribed for the ship's journals of the R. Neth. Meteorological Institute at de Bildt.