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On the temperature and salinity changes in the Dakar and Takoradi areas

by

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The purpose of this paper is to summarize the results of observations on temperature and salinity in the different areas off Dakar and Takoradi over the past 6-7 years. The work is based mainly on the material collected by the research expeditions organized by the Baltic Institute of Marine Fisheries and Oceanography during 1957-62.

Besides was used the material of all Soviet and of a number of foreign expeditions that were working during this period in the areas of Cape Verde and Gulf of Guinea, as well as the data collected at the hydrometeorological stations in Dakar and Kotonu.

The area covered by the investigations extends from the borders of the territorial waters to the depths of the order of 2000 m. By the Dakar area is understood the oceanic region which is situated between Cape Verde and the mouth of River Gambia, and by the Takoradi area the region from 3°W to the Greenwich meridian. To describe these two areas were used the observations for the period of 1957-1962, comprising 370 stations for the area of Dakar and 362 stations for that of Takoradi. A sporadic character of these observations, however, reduces their value.

To characterize the variability of water temperature and salinity the mean charts of the T-S values were constructed for different layers. Because of the scattered pattern of hydrological stations within the boundaries of these areas, in order to obtain the mean values for the whole area an average value had to be taken for the area with due account of the space distribution between the isotherms and isohalines.

There are several water masses in both areas: the equatorial waters (to the depth of 30-35 m), the tropical water mass (30-200 m), and the Atlantic water mass proper (over 200 m). Besides, a coastal water mass is traced in the vicinity of the river Gambia. Consequently, for characterizing the variability of the oceanological features of the water masses in both areas the following sub-areas were defined:

A - with depth up to 30 m
B - from 30 m to 200 m
C - over 200 m

Solid lines on Figs. 1 and 2 show the long-term temperature values of the surface waters for each sub-area, and the dotted lines denote the long-term averages for the near-bottom layers. For sub-area B a 500 m layer is used instead of the near-bottom layer. This was found possible (see below) for the Dakar area only.

In view of the lack of data on salinity we shall limit ourselves to the pattern of its distribution by the hydrological seasons.

The analysis of the long-term averages of temperature and salinity has enabled us to define the hydrological seasons from their changes during a period of 6-7 years, i.e., during a longer period than that used by Berrit (1) and Louis Vincent-Cuaz (3).

The area of Dakar

Hydrological conditions of the area are determined by the interaction of the Canary current, the northern branch of the Equatorial counter-current and the local circular current in the Goret Bight. The hydrological regime of the area is greatly affected by the continental outflow and by the regime of prevailing winds.

The longterm average values of the surface water temperature within the area do not differ by more than 4°, and those of salinity not by more than 1.5-2.0 ‰. In view of the seasonal changes of the climatological factors the maximum values of salinity during the year are clearly observed in May-June and those of temperature in July-October; the minimum temperatures are observed in February-March, and minimum salinity values in August-September. In separate years the temperature values of the near-bottom waters within the area differ by as much as 17°, whereas the salinity values differ by not more than 2 ‰. Minimum and maximum temperatures of the near-bottom waters are displaced in time by one month, and those of the 500 m depth by 2-3 months.

In the area of Dakar two hydrological periods can be distinguished:

1. A cool period (second half of December till mid-May) when the long-term average temperature of the surface waters is 18°-24°C, and that of the near-bottom layers (starting from 500 m) from 9° to 19°C. This period can be considered as a period of higher salinity. The long-term salinity averages in the upper 500 m water layer vary within the range of 35.2 to 36 ‰.

2. A warm period lasting from mid-May till the first half of December. The long-term averages of the surface water temperature rise to 28-29°C. The temperature of the near-bottom waters at a depth of 200 m rises by 4°, at a depth of about 30 m by 9°, and in the 500 m layer by 3°. With respect to the distribution of the long-term averages of salinity this period can be divided into 2 parts: 1) higher salinity (mid-May till mid-July) when salinity varies within 35.0-36.0 ‰, and 2) lower salinity (mid-July till first half of December) during which the long-term averages of salinity are within the limits of 35.5-33.2 ‰; at this time the thickness of the upper freshened layer does not exceed 20-30 m.

The area of Takoradi

This area is in the zone encompassed by the Guinea current. The subsurface waters, especially in the eastern part of the area are in our opinion affected by the water wedges of the cold Benguela current.

In contrast to the area of Dakar, the hydrological regime of the Takoradi area is less influenced by the seasonal air temperature fluctuations, precipitation and continental outflow. Fluctuations of the average long-term values of water temperature and salinity during the year show two maximum and two minimum values. The first decrease of salinity is observed from the second half of April, and that of temperature from May; salinity minimum is observed in May-June and temperature minimum in August. The second, less important decrease of both factors begins in September for salinity, reaching its minimum in December, and in November for temperature, reaching the minimum in January.

Taking into consideration the obtained long-term averages of temperature and salinity and the available data from the neighbouring areas (2,3), one may distinguish between the following four hydrological periods with more or less stable hydrological conditions:

1. A long warm period of lower salinity (from the beginning of February till the end of June). The average long-term temperature of the surface waters is 25.0 to 29.1°C; the temperature of the near-bottom waters at a depth of 30 m is from 19.5° to 26°C; and at a depth of 200 m from 18.0° to 22.0°C. Salinity of the surface waters is 34.0-34.8 ‰, and at the bottom 35.0-35.6 ‰.

2. A long cool period of higher salinity (from July to mid-October). The long-term average temperature of the surface waters in the coastal part of the area equals 21°C and in the seaward part amounts to 24°C. The respective temperatures of the near-bottom waters are 17.0° and 16.5°C. Salinity of the surface waters amounts to 35.5 ‰ and at the bottom to about 35.4-35.8 ‰.

3. A short warm period of lower salinity (from the second half of October till mid-December). The long-term average temperature of the surface waters is 25°C in the coastal part of the area and 28.6°C over the oceanic depths. Salinity is 34.2 ‰ and 35.2 ‰, respectively. This period begins in the near-bottom water layers at the second half of September (Fig. 2).

4. A short cool period of higher salinity (from the second half of December to the beginning of February). The average long-term temperature of the surface waters is 26.8°C in the coastal part and 28.0°C in the seaward part of the area. The respective temperatures of the near-bottom waters are 18.1° and 22.0°C. Salinity of the surface layers increases to 34.8 ‰-34.9 ‰, and at the bottom remains within a range of 35.7-35.9 ‰.

The analysis of sloping curves (Fig. 2) shows that by its hydrological conditions the area of Takoradi should be related to the equatorial area. Nevertheless, it is mainly influenced by the climate of the southern hemisphere responsible for lengthy hydrological periods - this is called the displacement of the thermal equator against the geographical one.

It is worth mentioning that a common feature of the Dakar and Takoradi areas is a decreased heat content of the surface waters in the coastal regions permanently throughout all periods. This can probably be explained by the permanent upwelling of the sub-surface waters. Our supposition is confirmed by the pattern of the distribution of nutrient salts and dissolved oxygen. A temporary decline of the curve (Fig. 1) for sub-area B during the period from April till July evidently shows the predominance at this time of a seasonal warming of the surface waters of the coastal sub-area A for the area of Dakar, as a more northward area with a greater amplitude of climatic seasons.

The foregoing decline of the long-term average temperatures of the near-bottom water layers in relation to the surface waters in the Dakar area in July-September, and in the Takoradi area in April-June and October-January, suggests the upwelling of cooler subsurface waters as the main cause of the hydrological changes in these areas.

This inference is further supported by the data on the distribution of the long-term average salinities. Similar conclusions on this point were drawn by other researchers (3,4).

It must be noted that the periods of upwelling are in good agreement with the periods of formation of dense near-bottom concentrations of sardinella (on the figures shown in the form of shaded areas under an index "a").

The decisive influence of the upwelling factor on the formation of the hydrological regime of the Dakar and Takoradi areas (especially the latter) suggests that it is necessary to carefully study the subsurface transformation of water masses, the more so as until now the current observations in the area were of only sporadic and occasional character.

Summary

On the basis of the material collected by the Soviet and foreign research expeditions and observations of the hydrometeorological shore stations in the ports of Dakar and Kotonu, the long-term average values of temperature and salinity of the sea water were obtained for the Dakar and Takoradi areas for the period of 1957-1962.

In view of the existence in both areas of several different water masses the description of the variability of the long-term average values of the oceanological components is given for the sub-areas of different depths.

The analysis of the long-term average values of temperature and salinity permitted to define the hydrological seasons (or periods) from the changes of these factors.

Two hydrological periods were established for the Dakar area:

1. A cool period of higher salinity (second half of November till mid-May).
2. A warm period which can be further divided into periods of higher salinity (mid-Maytill mid-July) and of lower salinity (mid-July till second half of December).

In the area of Takoradi 4 hydrological periods were registered:

1. A long warm period of lower salinity (beginning of February till end of June).
2. A long cool period of higher salinity (July till mid-October).

3. A short warm period of lower salinity (second half of October till mid-December).

4. A short cool period of higher salinity (second half of December till beginning of February).

Both areas are characterized by an almost stable decline of the heat content in the surface waters of the coastal regions because of upwelling of the subsurface waters.

The upwelling of the subsurface waters serves as the main cause of hydrological changes, especially in the Takoradi area.

The periods of upwelling agree in time with the periods of formation of dense commercially important concentrations of sardinella which makes it possible to organize trawl fishing by means of bottom trawls.

In view of the decisive influence of the upwelling on the formation of the hydrological regime of these areas there is a necessity for a thorough study of the subsurface transformation of water masses.

Literature

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4. I.C.D. Watts: Thermocline off the coast of tropical West Africa.- Nature, Vol. 181. No. 4612, (1958).

N.B. The figures 1 and 2 mentioned in this paper were not received with the manuscript.

List of Figures

Figure 1. The area of Dakar. The long-term average temperature and the periods of formation of commercially important near-bottom concentrations of sardinella.

Figure 2. The area of Takoradi. The long-term average temperature and the periods of formation of commercially important near-bottom concentrations of sardinella.