Hydrographic and Water Masses Variability in the Tanzanian Coastal waters

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The vertical profile for Temperature, Salinity and Oxygen obtained from second international Indian ocean expedition research cruise under S.A Agulhas research vessel conducted from 15th October- 15th November 2017 (V028), following by second survey under the same research vessel began from Dar es Salaam to Comoro in June 2018 (V032), bridged the gap of water masses existed since the last study of the hydrographic structure of Tanzanian coastal water in 1983. For a purpose analyzing the status of water masses of the coastal water of Tanzania, the transects made during the 1st and 2nd survey on Tanzania Coastal water from Tanga (Northern part of Tanzania) to Mtwara (Southern of Tanzania) have been considered in the present manuscript. In the 1st cruise (V028), a total of 31 stations were surveyed of which 3 stations were established at Chwaka bay, Zanzibar, 7 stations at Dar es Salaam, 8 stations at Pwani, 4 stations at Mafia Island, 5 stations at Lindi and 4 stations along the Ruvuma River plume in Mtwara. In the 2nd cruise (V032), a total of 18 stations were surveyed along the coastal zone of Tanzania. During this survey the setting of stations differed from the 1st survey. Only three stations were surveyed in Mtwara, Mafia Island and Dar es Salaam (make a total of 9 stations) and the remaining 9 stations were distributed equally from Dar es Salaam towards the Northern part of Tanzania. The physical properties (Conductivity, Salinity, Temperature and Dissolved Oxygen) in both surveys were measured to a maximum depth (depending to the bathymetry of each station) using Seabird Conductivity-Temperature-Depth sensor (CTD). The performance of the CTD was checked against water bottle salinity samples using salinometer. The CTD was also equipped with Oxygen and Fluorescence sensors. The data from the CTD was scanned by SeaSave software before processed by Seabird tool. The final outputs were visualized by Ocean Data View (ODV).

The results showed that, the surface temperature throughout the coastal waters from Northern to Southern of Tanzania varied between 26.7 and 28.5°C. The maximum sea surface temperature occurs between Zanzibar and Dar es Salaam, while the minimum tends to occur at Mtwara, Pwani and Tanga. The surface salinity was ranged from 35.2 to 35.6psu. Although in some stations, particularly Mtwara, Mafia island and Tanga stations, water of lower salinity predominates which was demonstrating the influence of the freshwater outflow, especially off the mouths of major rivers such as Rufiji, Ruvuma, Ruvu and Pangani. The surface layer throughout the coastal zone, was well mixed up to a depth of 200 m and the dissolved oxygen in this layer was saturated. These characteristics observed in the surface layer of Tanzanian coastal water are in-line with characteristics of Tropical Surface Water originated from near the Equator where there is an excess of precipitation over evaporation leading to a freshening of surface water warmer than 24 °C. In comparison with a study by FAO (1983), the surface water mass

lying above 100 m was seemed to be originated in the Bay of Bengal and the eastern Indian Ocean area and brought to the west by the South Equatorial Current. Unlike surface water, the bottom water observed at Mtwara and Lindi are more likely similar. These bottom waters which were found at a depth between 733 to 1364 m, associated with low dissolved oxygen, low temperature (5-7^{o}C) and the salinity ranges from 34.8 to 35. According to characterization of water masses by Lutjeharms (2006), the bottom water observed in Lindi and Mtwara comprise the water masses from the Red Sea. This Red Sea Water derives its high salinities and thus densities in the Red Sea and, partially, the Persian Gulf, due to an excess of evaporation over precipitation and moves directly poleward along the east coast of Africa. It was not possible to identify Red sea water and other water masses during the study of Tanzanian Coastal waters by FAO (1983) because the hydrographic sections studied were limited to a depth of 500 m only. The subsurface layer at Mtwara and Lindi (depth 210-610 m), the water has a salinity ranges from 34.8 to 35.4 psu and moderate dissolved oxygen. Based on this characteristic, this subsurface layer can be a subtropical surface water, originated in the austral subtropical anticyclonic gyre, under the influence of an excess of evaporation over precipitation.

The water masses observed in Zanzibar at a depth between 852- 1188m have the same characteristics of with water masses observed at Mafia, Pwani and Dar es Salaam. At the bottom, the water was characterized with salinity ranging from 34.85 to 35.3 psu, low dissolved oxygen and the temperature ranging 5 to 10^{o}C, in contrast to bottom water, the dissolved oxygen in the subsurface water (185 – 455m) was saturated at a temperature ranging between 10 – 15^{o}C and a salinity between 34 – 35 psu. The surface water was well mixed with high level of dissolved oxygen and temperature ranging from 20 to 27^{o}C. Due to this observation, the coastal waters within the mentioned area, consists of Tropical surface water at the surface layer, Subtropical surface layer at subsurface layer and South Indian Central Water at the bottom.

The present study through analysis of the field data from 028 and 032 voyages in Tanzanian Coastal waters has therefore revealed the presence of 5 major water masses: (i) Tropical Surface Water (ii) Arabic Sea Water (iii) Subtropical surface water (iv)South Indian Central and (v)Water and Red Sea Water