Hydrologic structure of waters in the north-western Tropical Atlantic

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Abstract—Analytical data based on hydrological observations (34th cruise of the RV Akademik Vernadsky) are used to show that the basic element contributing to oceanic circulation is the well-developed North Equatorial countercurrent. The latter is considered as a frontal zone separating two structures of water mass. It has been demonstrated that in the salinity field—besides the meridional exchange of subtropical and Antarctic waters—the zonal advection of low-salinity waters also plays an essential role. The water masses have been specified, their parameters determined, and volumes calculated. We have found that the thermohaline indices in the cores of tropical and west equatorial water masses have different salinity values.

The research was conducted in the north-western Tropical Atlantic between 34° and 52° W in September–October 1986. The basic role in producing water circulation in this region belongs to the well-developed North Equatorial countercurrent (Fig. 1), which originates from the North Brazil current which turns eastwards near 8° N and 51° W. However, the flow rate increasing from 14 Sv at 50° W up to 34 Sv at 46° W indicates that during the period considered, the major contribution to the formation of the North Equatorial countercurrent is made by one of the branches of the North Brazil current which forks off the main flow around 4° N and 47° W. This inference seems to be novel, since it has been believed [1] that the major turn of the North Brazil current with a maximum flow rate, and consequently the origin of the North Equatorial countercurrent, occurs at 52° W. From the north, it is additionally fed by the waters of the North Equatorial current, but their general contribution (roughly 8 Sv) to the North Equatorial countercurrent is insignificant. For the first time, the North Equatorial countercurrent was observed to turn abruptly northwards and flow in that direction in the form of a narrow stream as far as 450 miles between 37 and 38° W. The qualitative difference of the examined circulation from previous patterns [1] consists of baroclinic instability and meandering of the North Equatorial countercurrent and vigorous vorticity at its north and south borders.

The temperature field structure is controlled by the dynamics of the region, and the variable depth of the subsurface salinity maximum permits areas of tropical divergence and convergence to be readily identified which correspond to the north and south borders of the North Equatorial countercurrent. In the north tropical divergence region, located approximately at 8° N, the salinity maximum depth is 50–70 m. The lower boundary of the quasi-homogeneous layer is limited by 10–20 m, i.e. the thermocline lies closer to the sea surface.

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The north tropical convergence zone on the right-hand side of the North Equatorial countercurrent (3°–4° N) has a larger depth (up to 100 m) of the quasi-homogeneous layer lower boundary and of the maximum salinity core (up to 150 m). Thus, the variation of depths of those parameters in divergence and convergence areas equals, on average, 80–100 m.

On the map of the temperature distribution at a depth of 100 m (Fig. 2), the North Equatorial countercurrent is visualized as a strongly pronounced frontal zone with a 1°C horizontal temperature gradient per 10 miles. The gradient values may be comparable with thermohaline parameter gradients in such emphatically marked fronts as the sub-Arctic or subtropical one. However, the highest temperature and salinity gradients are observed not on the surface where they are 'diffused' owing to an almost continual supply of heat and salt annually, but are traceable at depths