NEW DATA ON EQUATORIAL CURRENTS IN THE WESTERN PACIFIC OCEAN

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NEW DATA ON EQUATORIAL CURRENTS IN THE WESTERN PACIFIC OCEAN

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Until recently we had notions only of the surface equatorial currents. At the equator and in the narrow equatorial belt of both hemispheres this is the well-known South Trade-Wind Current, flowing westward. True, eastward currents at the surface were also known, indications of which could be found as early as Puls ([4]), and also on pilot charts. The difficulties of applying indirect methods for calculating currents at the equator and the almost complete absence there of instrumental measurements of them at deep horizons for a long time hindered the study of the vertical structure of equatorial currents. Very little was known about currents at deep horizons.

On 12 VIII 1952, at the equator at 150° W, Cromwell, Montgomery, and Stroup ([2]) discovered the Equatorial Undercurrent—a strong deep current flowing eastward, i.e., in the direction opposite to the South Trade-Wind Current lying above it (after Cromwell' s death, it was proposed to name the deep current after him). The remarkable discovery of a major element of the circulation of the Pacific Ocean, about which essentially nothing had been known and which had not been predicted by any theory of currents, aroused enormous interest among oceanographers. From the moment of its discovery, increasingly numerous measurements of the Equatorial Undercurrent began to be carried out at different longitudes and depths and in different seasons. Thanks to the work of oceanographers of many countries ([1], [3], [5]), by 1960 it had become possible to obtain a first, of course very approximate, picture of the Equatorial Undercurrent in the Pacific Ocean over an enormous extent—from 140° E to the Galápagos Islands.

A more fundamental investigation of the undercurrent was carried out for that part of it which lies east of 140° W as far as the shores of America. These investigations were conducted by American oceanographers. Instrumental measurements of the undercurrent were also made west of 140° W, including in the equatorial region north of New Guinea. However, these measurements were made by imperfect methods, and uncertainty remained as to the existence of the undercurrent in the western part of the Pacific Ocean in the form of a stable high-velocity flow such as it is in the eastern part.

Figure 1. Distribution of the mean daily zonal components of current velocity in the plane of the equator (A) and in the plane of the meridian 140° E (B). The hatched areas (positive velocity values) correspond to eastward motion. Velocity isolines are drawn at intervals of 20 cm/sec.

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On the 38th cruise of the *Vityaz*, the task was set of investigating the equatorial currents west of 150° E, with the main emphasis on studying the undercurrent. It was necessary to determine whether it exists in the western part of the ocean in the form of a flow analogous to that in the eastern part, and also to try to locate its sources in the west of the ocean.

To solve the problem, numerous measurements of currents were made in the narrow equatorial belt at anchored buoy stations. The buoys were set out for not less than a day, in groups of three buoys. The central buoy was placed on the equator, and the other two 30 miles from it along the meridian to the north and to the south. The groups were arranged at a distance of 150 miles

Fig. 1. Distribution of the mean daily zonal components of current velocity in the plane of the equator (**A**) and in the plane of the meridian 140° E (**B**). The hatched areas (positive velocity values) correspond to eastward motion. Velocity isolines are drawn at intervals of 20 cm/sec.

one from another. At each buoy station the currents were measured at the horizons 25, 100, 200, 300, 500, and 1000 m by Alekseev autonomous self-recording current meters, with direction and velocity recorded at 5-minute intervals.

The daily duration of the measurements made it possible to calculate mean daily currents, i.e., vectors from which, at least, the periodic components of the principal tidal waves had been excluded. From the mean daily currents one can judge the vertical and horizontal structure of the equatorial currents.

Figure 1 shows the distribution of the zonal component of current velocity in the plane of the equator from 132 to 152° E, in the layer from 0 to 1000 m. Even in this upper layer, which constitutes one quarter of the depth along the section, the equatorial currents have a complex multilayer structure. Before the measurements carried out by the *Vityaz* on its 38th cruise, it was believed that in this layer there existed only three currents: in the upper layer, the South Equatorial Current, westward; in the intermediate layer, the Equatorial Deep Countercurrent, eastward; and, finally, in the lower layer, a current again of westerly direction.

According to the new measurements, in the eastern part of the section there exist 4–5 oppositely directed flows arranged one beneath another.

To the previously known scheme two eastward currents have been added: one in the thin surface layer and the other in the layer from 750 to 1000 m, the lowest of these having, at the 1000 m horizon, a very high velocity—more than 20 cm/sec. In the western part of the section the number of streams is only three; however, their structure has hitherto been entirely unknown. Attention is drawn to the fact that the Equatorial deep countercurrent is substantially more powerful than has usually been assumed, and occupies the layer from 250 to 1000 m. It seems to "emerge" from the deep layers, giving rise to a narrow, long band of eastward current with a core located at a depth of 200-250 m and with a velocity exceeding 40 cm/sec. Thus, it may be considered established that in the western part of the Pacific Ocean, almost right up to its western shores, there exists at the equator in the subsurface layers a rapid, steady current directed eastward—the Equatorial deep countercurrent—which, consequently, is a phenomenon characteristic not only of the eastern part of the ocean, as was previously thought, but of the entire Pacific Ocean as a whole.

It had been noted earlier that the axis of some equatorial currents, including the deep countercurrent, may not coincide with the geographic equator. This fact to a certain extent predetermined the method used for measuring currents during the 38th cruise of the *Vityaz*. As noted above, the anchored buoys were set not only on the equator, but also to the north and south of it.

The measurements showed that the axis of the Equatorial deep countercurrent is displaced somewhat to the north; however, the displacement does not exceed 1° of meridian. This feature, and in general the structure of the equatorial currents in the meridional plane along 140° E, crossing the equator, is illustrated by Fig. 1, which also shows the distribution of the zonal component of current velocity in the layer from the surface to 1000 m.

An important feature of the horizontal structure of the currents is also their interlacing over a comparatively small oceanic distance: from 2° S to 2° N. For example, at a depth of 500 m the direction of the currents changes four times: near the shores of New Guinea the water moves westward, near 1° S—eastward, under the equator again westward, and north of 1°30′ N eastward.

The section along 140° E illustrates one more important feature, namely that the Equatorial deep countercurrent at this meridian is not an isolated stream and is connected with eastward currents outside the equator. In the north it apparently merges with the Mid-Trade-Wind Countercurrent, which expands with depth. The axis of the entire eastward flow, however, lies on the equator or near it.

As a result of the measurements carried out during the 38th cruise of the *Vityaz*, our knowledge of equatorial currents has been substantially enriched. In order to form a clear picture of the equatorial currents of the entire Pacific Ocean, it remains to make measurements in its central part, between 150° E and 150° W.

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Note: Figure translations are in progress. See original paper for figures.