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SOME ASPECTS OF THE EQUATORIAL AND INTERTROPICAL CIRCULATION IN THE WESTERN AND CENTRAL SOUTH PACIFIC

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Fairly extensive studies of the western South Pacific have been made by the Centre ORSTOM of Noumea, on board the *R. V. Coriolis*. They have given interesting information on the dynamics of the waters concerned, on the hydrological features which are bound to this circulation, on some aspects of the local time variations which occur within this region, and on the possible influence of the circulation on the distribution of certain marine organisms.

The main features of the circulation are now well known. An Equatorial Undercurrent (with its core at 200 m) lies below a slower undercurrent (with its core at 100 m) which in turn lies below a surface westward Equatorial Current. The latter is shallower at the equator than on both sides where it has two velocity cores. When the surface westward Equatorial Current disappears because of eastward winds at the equator in northern winter, the upper core of the Equatorial Undercurrent disappears and is replaced by a westward undercurrent lying below an eastward surface current. The flow of the lower cell deepens symmetrically to 1,000 m at least at 2°30 N and 2°30 S; thus, it surrounds an equatorial deep westward current. It is also connected to the North Equatorial Countercurrent by a continuous layer of eastward flow. Both the lower cell of the Equatorial Undercurrent and the deep westward equatorial current, which might be called the Equatorial Intermediate Current because it transports intermediate water, are in geostrophic balance; the upper cell of the Equatorial Undercurrent is not. The South Equatorial Countercurrent is geostrophic, extends at least to 140° W and is located close to 10° S. The so-called South Tropical Countercurrent also geostrophic is located at about 20° S and apparently extends to the Central Pacific.

Hydrological studies have shown that each of these currents transports specific water with characteristic hydrological properties. The northern part of the lower cell of the Equatorial Undercurrent is strongly influenced by waters from the North Equatorial Countercurrent; it is rather highly oxygenated, with a low salinity and a minimum of preformed phosphate. The upper part of the southern half is formed with waters originating in the Subtropical South Pacific; it has a high salinity and a rather low oxygen content. The lower part of the same southern half and the two deep eastward currents at 2°30 N and 2°30 S are of Coral Sea origin; the water is rich in oxygen and poor in phosphate. Besides, these two deep eastward currents are limited poleward by a ridge of the isanosteric surfaces and a strong meridional gradient of oxygen and phosphate. The Equatorial Intermediate Current is poor in oxygen, rich in phosphate, isohaline and associated to an equatorial ridge of the isanosteric surfaces. The South Equatorial Countercurrent has a surface minimum salinity and alkalinity and a maximum nitrate and phosphate content. On the contrary, the South Tropical Countercurrent has also a low salinity but a high oxygen and low nutrient content.

In spite of the link between the North Equatorial Countercurrent and the lower cell of the Equatorial Undercurrent, the exchanges of properties between these two water bodies occur only at the western end of the equatorial current system. The summer strengthening of the North Equatorial Countercurrent induces an increase of the amount of northern water in the Equatorial Undercurrent. The fluxes of the various currents fluctuate fairly rapidly, and there is a maximum of the Equatorial Undercurrent flux at the same period as the maximum of the North Equatorial Countercurrent flux. The greatest variations of the fluxes occur in the Equatorial Current and in the upper cell of the Equatorial Undercurrent. The fluxes of the Equatorial Intermediate Current and of the deep extensions of the Equatorial Undercurrent are, on the contrary, extremely stable.

Between 20° S and the equator, the average pigment concentration in the layer 0–200 m is fairly uniform, but the layer 50–100 m is richer. The greatest variations were observed in the layer 0–50 m where there are three maxima of the chlorophyll-a concentration, at 0°, 10° S and 18° S. The primary productivity measured by the ^{14}C method shows a similar meridional distribution with a maximum at 0° and at 10° S. This distribution seems due to the meridional alternation of westward currents and eastward countercurrents, inducing surface divergences at the southern limit of the countercurrents 10° S and 20° S and surface convergence at the northern limit of the same currents 5° S and 15° S. Then the thermocline depth is either minimum with an enrichment of the lower layers of the thermocline or maximum with an impoverishment of these layers. Finally, a relation has been shown between the water masses of the Central Pacific, in the region of the tropical convergence, and the distribution of phytoplankton.

The distribution of the biomass of the micronectonic fishes shows a great stability of the fauna, but a high variability, both in time and space, of some species wtih a minimum at 5° S where there is a surface convergence, and a maximum at the equator where an upwelling has been noticed at all cruises but two. The equatorial vertical distribution of some species indicates a stratification according to the size of the organisms. Thus, the latter can drift either eastward or westward depending upon their preferred depth. Consequently, it has been shown that the equatorial currents system could be responsible for the peculiar geographical distribution of certain species. Similarly, the composition of the equatorial fauna varies from east to west with the hydrological composition of the upper watermass.

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CURRENT SYSTEM OF THE EASTERN TROPICAL PACIFIC

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The current system of the eastern tropical Pacific has been studied during the 14-month EASTROPAC survey (1967–1968) and the two-month *Piquero* expedition (1969). On EASTROPAC, *in situ* salinity-temperature-depth profiles were made across the current system on seven surveys within the 14-month period. These sections provide a basis for description of the longitudinal distribution of water properties from the central Pacific eastward to the eastern boundary and the geostrophic flux of water into and out of the region. Features in the distribution of properties discussed are the high and low-salinity cores in the Equatorial Undercurrent and the properties of the relatively homogeneous "13°C water" beneath the thermocline near the equator. During *Piquero* expedition, direct measurements of the current velocity profile were made in th Equatorial Undercurrent during the summer of 1969. The maximum speed and volume transport of the Undercurrent were roughly the same as on the *Swansong* expedition (fall of 1961) but were significantly less than on *Dolphin* expedition (spring of 1958). The results of the EASTROPAC survey and the *Dolphin, Swansong* and *Piquero* velocity measurements suggest the following relationship between the two currents: when the trades are strongly developed, the fluxes of the South Equatorial Current and the North Equatorial Countercurrent are large and the flux of the Undercurrent is small; when the trades are relatively weak, the flux of the Undercurrent is large and the fluxes of the South Equatorial Current and the North Equatorial Countercurrent are small.

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SPECIFIC FEATURES OF WATER CIRCULATION IN THE TROPICAL PACIFIC, BASED ON THE DATA OF THE SOVIET STUDIES

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Studies in more or less detail of the structure and dynamics of the Tropical Pacific currents were made by the Soviet expeditions on 22 meridional sections between 127° E and 85° W longitudes and in 1957 to 1958, 1961 and 1965 to 1966. The analysis of the direct current measurements and deep-sea hydrological observations makes possible the following conclusions:

1. The Trade-wind and Equatorial currents have a complicated structure characterized by the expansion with the depth of the equatorial (inter-trade wind) countercurrent, its intrusion beneath the trade-wind currents and the formation of countercurrents at 150 to 350 m depths.

2. The meridional circulation in the system of equatorial currents favours the stabilization of the major zonal currents, whereas the short-time variability is caused by an intensive formation of gyres at the current boundaries.

3. The boundaries of the equatorial currents agree well with the boundaries of the equatorial and tropical waters structures, and the tropical fronts diverge with depth following the expansion of the equatorial countercurrent.

4. The Cromwell Current is not fully isolated but represents a stream which at least at times, joins the surface equatorial (inter-trade-wind) countercurrent and sometimes also the deep countercurrent beneath the South Trade-wind Current.

5. In the equatorial region between 132° and 135° E longitudes, the Cromwell Current "goes out" of the deep layers (700 to 800 m) ; therefore this region can be considered as the region of generation of this current, which can be traced almost up to the northwestern coast of South America (to 85° W longitude). The Cromwell Current meanders along essentially its entire length.

6. The data obtained confirm the existence of the deep-ocean countertrade-wind current under both the north and the south trade winds. The existence of such a countercurrent indicates that in the trade-wind zone of the Pacific Ocean, a huge vertical gyre of water masses evidently exists