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Hydroclimatic anomalies in the South Pacific

Hydroclimatology
Monitoring
South Pacific
Surface Salinity
« El Niño »
Hydroclimatologie
Surveillance continue
Pacifique Sud
Salinité superficielle
« El Niño »

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ABSTRACT

Some 6 months after the appearance of the "El Niño" phenomenon in the Eastern Pacific, a hydroclimatic anomaly is observed in the Western Pacific. Data from a system of monitoring surface conditions using ships of opportunity show the occurrence of a weak "El Niño" in February-March 1976 and the corresponding Western Pacific anomaly in August-September 1976.

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Anomalies hydroclimatiques du Pacifique Sud

RÉSUMÉ

Environ 6 mois après l'apparition du phénomène « El Niño » dans le Pacifique oriental, une anomalie hydroclimatique est observée dans le Pacifique occidental. La mise en place d'un réseau de navires non spécialisés surveillant la surface du Pacifique a permis de saisir précisément en février-mars 1976 une anomalie hydroclimatique de même type mais plus faible dans le Pacifique Est ainsi que l'anomalie correspondante en août-septembre 1976 dans le Pacifique Ouest.

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INTRODUCTION

For several decades, meteorological offices have made provision for continuous monitoring of the lower atmosphere from many fixed or mobile stations (ships or aircrafts) deployed throughout the world. As a result our understanding of atmospheric phenomena has been improved, and the forecasting required especially for air traffic has become remarkably reliable. In its expansion, oceanography hesitates to follow a similar path. The sophistication of research vessels and laboratory-buoys is steadily increasing and, as a result, cruises are becoming more and more costly. Continuous monitoring of the ocean with such methods is consequently unthinkable. On the other hand, thousands of merchant and naval vessels are continually plying the seas : the use of these non-specialized ships for scientific research could provide a continuous monitoring of the oceans, initially at the surface, and subsequently at greater depths. A programme of surface sampling is currently being carried out by the Orstom Centre in Noumea. Since 1969 between New Caledonia and Japan, and since 1975 along several Transpacific sailing routes, the gathering of surface data has permitted a continuous survey of the surface temperature and salinity of the tropical Pacific. Thanks to this system, seasonal variations in the characteristics of the surface water masses have been observed and have been related to meteorological observations. Close connexions occur between wind, rainfall and surface salinity (Donguy, Hénin, 1974; Donguy, Hénin, 1975).

MAJOR HYDROCLIMATIC ANOMALIES

To obtain a view, albeit incomplete, of the surface conditions pertaining before 1975, it has been necessary to compile all available surface data, including those related to salinity, for the years 1956-1974. It has thus

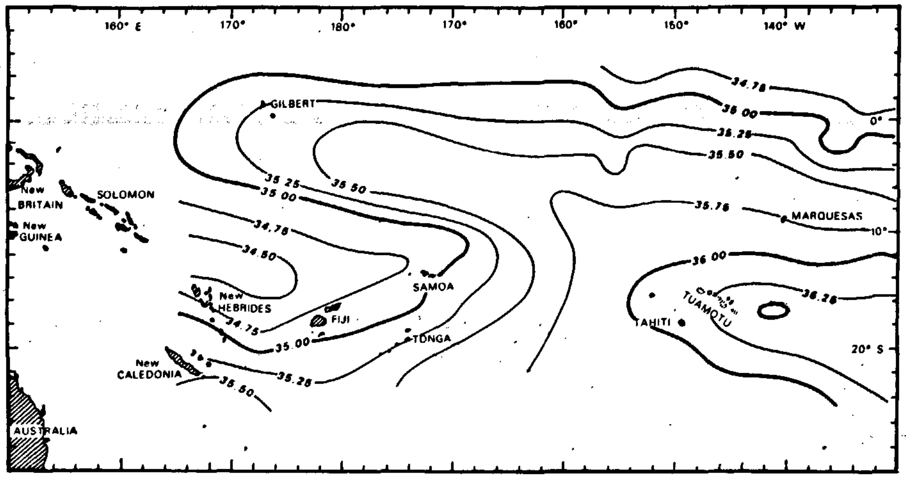


Figure 1
Mean surface salinity, per mil, 1956-1974.

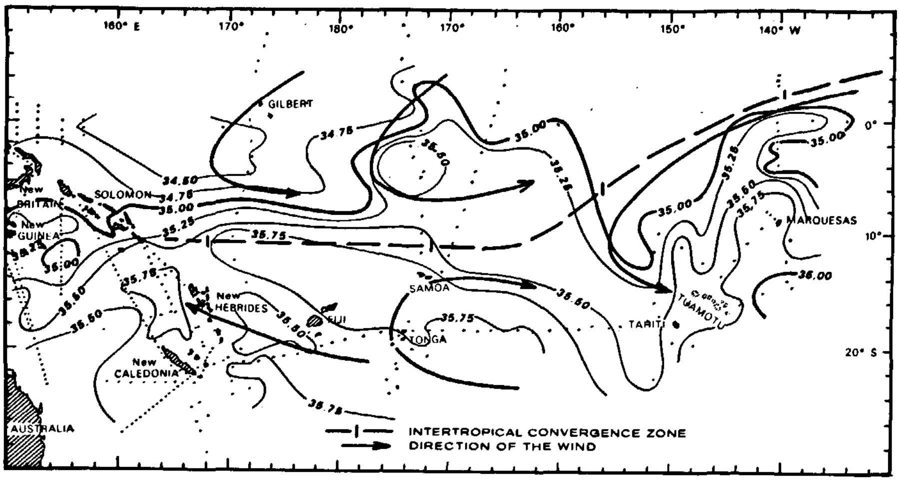


Figure 2
Surface salinity, per mil, January-June 1958. Wind direction is indicated by arrows, and the intertropical convergence zone of winds by a broken line.

been possible to draw up, for each year between 1956 and 1973, two half-yearly charts of surface salinity, as well as four quarterly charts covering the period since 1973. The same main features appear on each chart (Fig. 1): south of 10°S and east of 160°W, the tropical salinity maximum generally reaches 36.0°/$_{oo}$ and extends westward as far as 170°E; while from 5 to 20°S, west of 170°W, a minimum of salinity is observed. However, completely anomalous surface conditions may occur within the same period, as at the end of the years 1957, 1965 and 1972. The latter part of each of these years was characterized by major hydroclimatic anomalies which continued into the beginning of the following year. Their occurrence has been noted in the South-West Pacific (Fig. 2) by Donguy and Hénin (1976). In the place of an equatorial salinity maximum due to upwelling induced by the trade-winds, a salinity minimum occurred, due to westerly winds and to the creation of a convergence zone of winds connected with rainfall. South of 10°S, instead of the salinity minimum, in the reverse, a salinity maximum occurred, under the influence of drought-inducing trade-winds.

At the beginning of these years (1957, 1965, 1972), the hydroclimatic anomaly called "El Niño" was observed in the Eastern Pacific. According to Wyrtki (1975), "El Niño" is the result of the response of the equatorial Pacific Ocean to atmosphere-forcing by the trade-winds; as a result of the weakening of the south-east trade wind in the Central Pacific after a long period of strong ones, warm and desalted surface water from the north spreads south of the equator, and salinity is further lowered by precipitations due to the presence of the convergence zone of the wind. These phenomena were particularly closely examined in 1972 (Wooster, Guillen, 1974; Ramage, 1975).

It therefore appears that the hydroclimatic anomalies occurring in the Western Pacific in August-September follow the major hydroclimatic anomalies (El Niño) which occur in February-March in the Eastern Pacific.

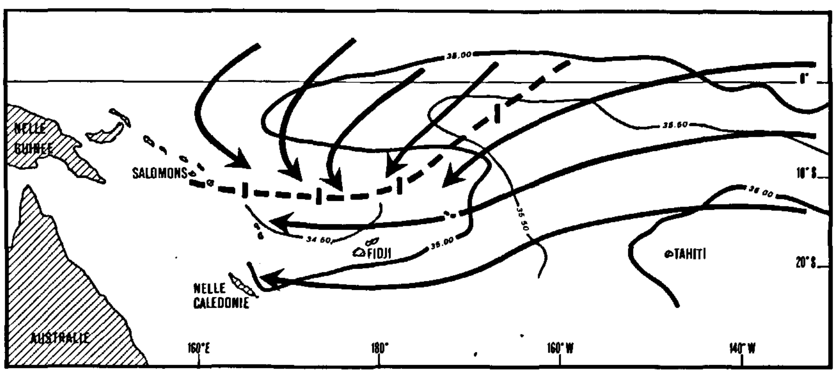


Figure 3
Mean surface salinity, per mil, January-March 1956-1974. Wind direction is indicated by arrows and the intertropical convergence zone of winds by a broken line.

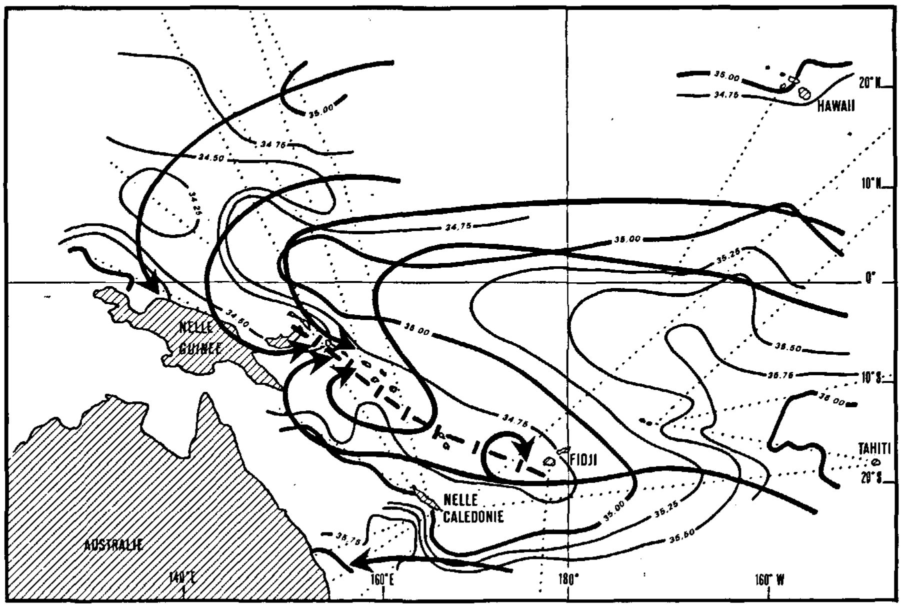
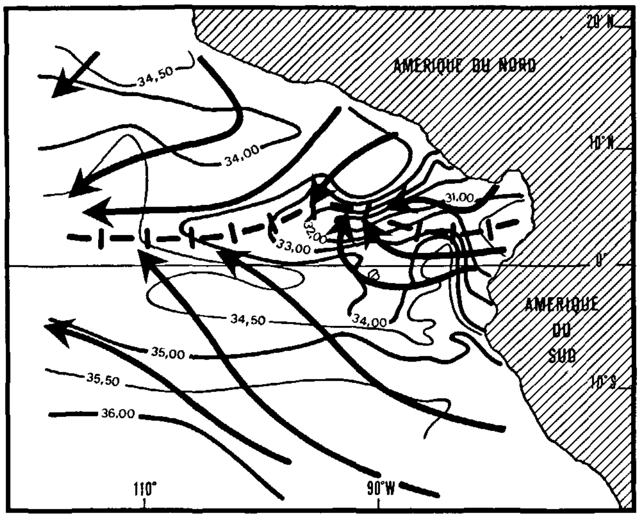


Figure 4
Surface salinity, per mil, March 1976 in the Western Pacific. Wind direction is indicated by arrows and the intertropical convergence zone of winds by a broken line.

Figure 5
Surface salinity, per mil, February-March 1967, in the Eastern Pacific (Eastropac Expedition). Wind direction is indicated by arrows and the intertropical convergence zone of winds by a broken line.



MINOR HYDROCLIMATIC ANOMALIES: 1976

Hydroclimatic anomalies in the South Pacific are not, however, all of the same intensity and less important phenomena than those observed in 1957, 1965 and 1972 may also appear. Thanks to the merchant ship system of Pacific Ocean sampling, it was possible to observe one of these in 1976.

February-March 1976

The chart of the mean surface salinity in February-March in the south-west tropical Pacific Ocean (Fig. 3), drawn up the basis of all the surface data available for the period between 1956 and 1974, shows features connected with the wind field: east of 165°E, the equatorial salinity maximum is due to the upwelling induced by the trade-winds; west of 165°E, the winds are deflected to the north-west and, the upwelling vanishing, salinity falls to less than $35.0^{\circ}/_{oo}$. South of 5°S, the salinity minimum ($S < 35.0^{\circ}/_{oo}$) is connected with the presence of west winds and the convergence zone of the rain-bearing wind. In March 1976 (Fig. 4), the surface salinity chart and the wind field showed the same features as in Figure 3. The situation could thus be considered as normal.

For the Eastern Pacific, in the absence of a mean salinity chart, we may refer to the Eastropac data for February-March 1967 (Love, 1972). The surface salinity chart (Fig. 5) shows that the usually low salinity between the equator and 10°N is connected with the presence of the convergence zone of the winds. Between the Galapagos Islands and the American continent, an increase of surface salinity occurs, together with a decrease of surface temperature; this is indicative of equatorial upwelling induced by east winds along the Equator. In February-March 1976 (Fig. 6), the convergence zone of the winds

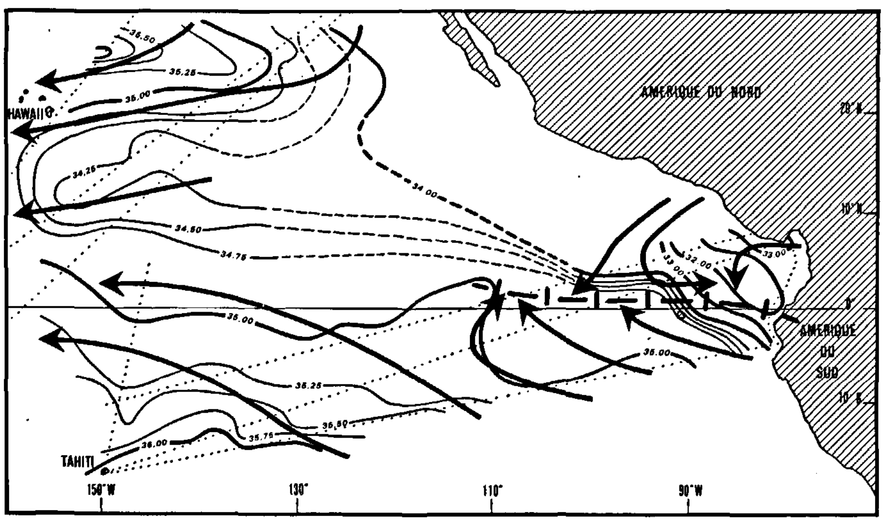
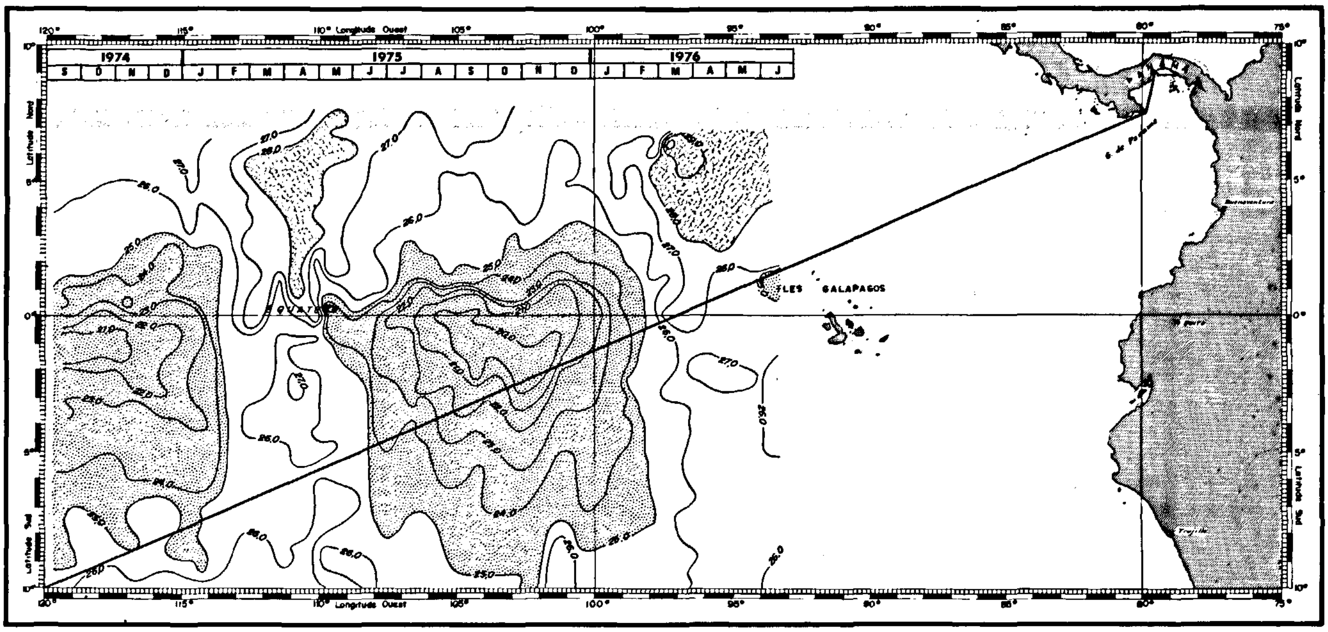


Figure 6
Surface salinity, per mil, February-March 1976, in the Eastern Pacific. Wind direction is indicated by arrows and the intertropical convergence zone of winds by a broken line.



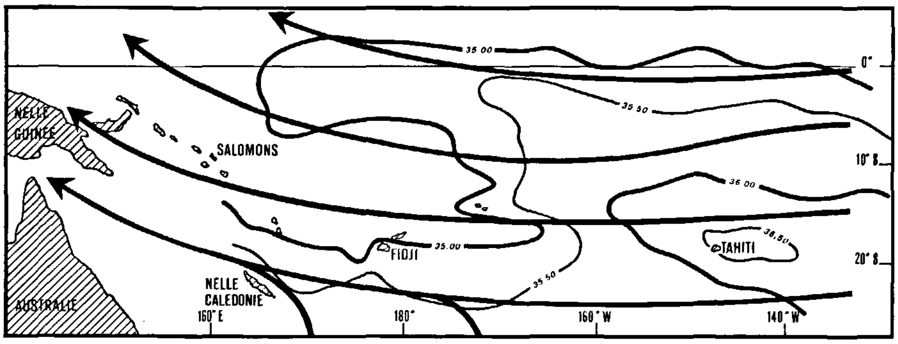


Figure 7

Thermic diagram of the course taken by ships between Tahiti and Panama. Abscissa: months of the year. Ordinate: latitude on the same scale as the marine chart.

Figure 8

Mean surface salinity, per mil, July-September 1956-1974. *Wind direction is marked by arrows.*

was situated almost on the Equator; between the Galapagos Islands and the American continent, the equatorial front had disappeared. Data gathered by merchant ships between Tahiti and Panama (Fig. 7) show that, in this area, in February, the trade-winds weaken or completely disappear with the result that the equatorial upwelling vanishes. Water from the Northern Hemisphere then crosses the Equator in a southerly direction. In 1975, this phenomenon lasted for almost three months, and the low-salinity water did not reach the American coast (Wyrtki *et al.*, 1976). In 1976 (Fig. 6), on the other hand, water with salinity less than 34.0‰ flowed into the Southern Hemisphere and induced surface conditions resembling the "El Niño" phenomenon. The surface temperature was also between 1 and 3°C higher than the average, and this anomaly persisted until June, disturbing the industrial fisheries to a certain extent (Fishing Information, La Jolla, Calif.). Thus, a hydroclimatic anomaly occurred in February-March 1976 in the equatorial zone of the Eastern Pacific, while conditions were normal in the Western Pacific Ocean.

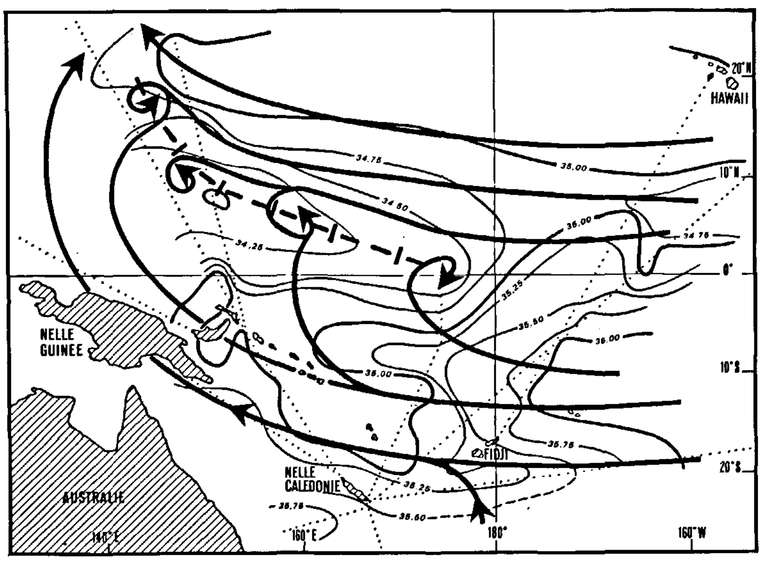


Figure 9

Surface salinity, per mil, August 1976, *in the Western Pacific. Wind direction is marked by arrows and the intertropical convergence zone of winds by a broken line.*

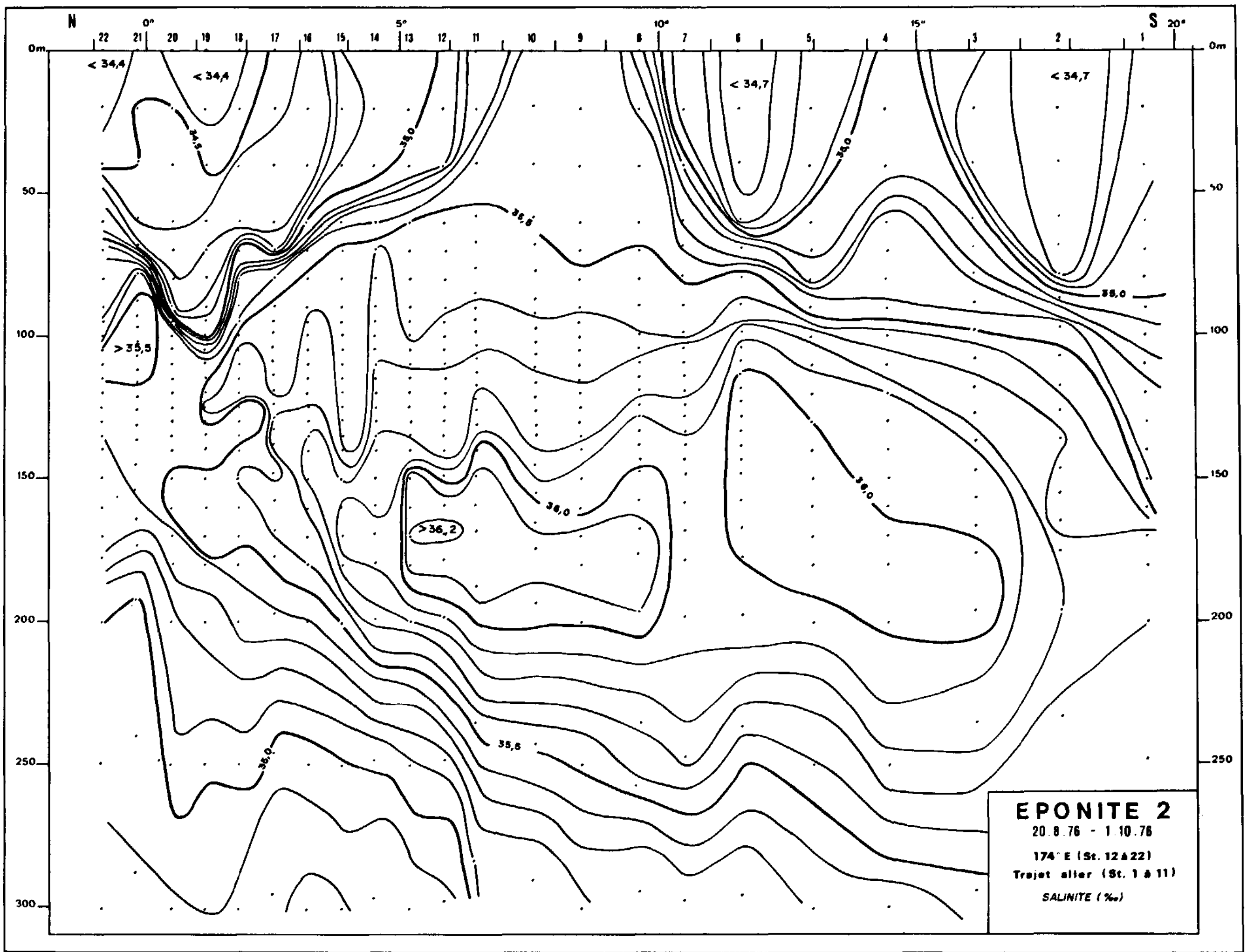


Figure 10
Vertical distribution of salinity at 174°E *in August* 1976.

August-September 1976

The chart of mean surface salinity for the south-west tropical Pacific in August-September (Fig. 8), established from all the data available between 1956 and 1974, is very similar to that for February-March (Fig. 3): the equatorial maximum of salinity, which indicates equatorial upwelling extends further than in February-March, due to the setting of the east trade-winds, the isohaline 35.0‰ reaching westward 165°E. South of 5°S, the persistence of a low-salinity zone is observed but salinity is higher than in February-March, the convergence zone of the winds being located about 10°N, east of 150°E.

In August 1976 (Fig. 9), on the contrary, west of 180°, the equatorial salinity maximum did not appear, and was replaced by a salinity minimum due to the location of the convergence zone of the winds from 10°N to the Equator. A salinity maximum was centred about 10°S. The vertical distribution of salinity at 174°E during the cruise Eponite 2 (Fig. 10) in August 1976 indicates that the equatorial divergence was replaced by a convergence. The Coral Sea, generally characterized by low-salinity water, was on this occasion occupied by water of salinity greater than 35.0‰, a phenomenon confirmed by the drought observed in the South Pacific islands. Finally, the tropical salinity maximum (S >36.0‰) reached the 177°W instead of the 150°W longitude. These anomalies closely resemble those observed in 1958 (Fig. 2).

In the Eastern Pacific, the surface features observed in August-September 1967 during the Eastropac expedition may be regarded as normal. The chart showing surface salinity and wind field (Fig. 11) reveals that the convergence zone of the winds is located at 10°N and that on the

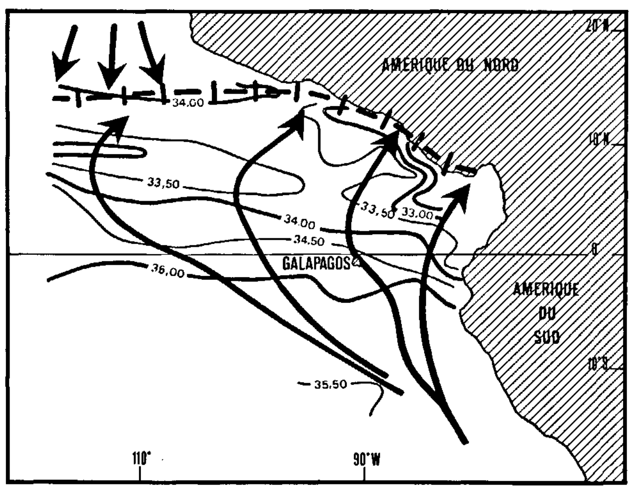


Figure 11
Surface salinity, per mil, August-September 1967, in the Eastern Pacific (Eastropac Expedition). Wind direction is marked by arrows and the convergence zone of winds by a broken line.

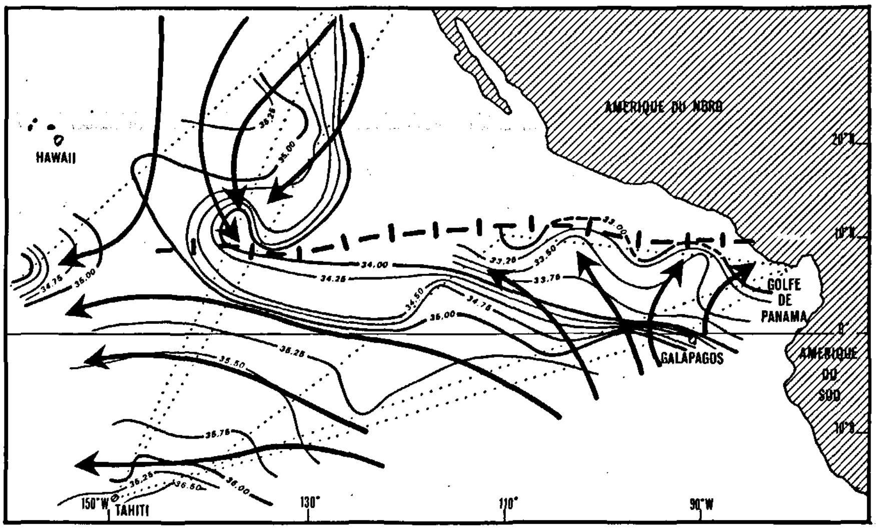


Figure 12
Surface salinity, per mil, August-September 1976, in the Eastern Pacific. Wind direction is marked by arrows and the convergence zone of winds by a broken line.

equator, west of 100°W, east wind induced upwelling prevails. South of the Equator, salinity exceeds 35.0°/$_{oo}$. In August-September 1976, surface conditions had returned to normal; the chart of surface salinity and wind field (Fig. 12) shows that the convergence zone of the winds is located at 10°N, as in August-September 1967 and that east winds are inducing the equatorial upwelling characterized by an intense salinity front separating the northern from the southern low-salinities (S > 35.0°/$_{oo}$).

CONCLUSION

A hydroclimatic anomaly which occurs in September in the Western Equatorial Pacific Ocean is connected with another anomaly observed six months earlier in the Eastern Equatorial Pacific. The economic implications of such anomalies are far-reaching; the study of their mechanisms, which are probably closely related to meteorological factors, might well constitute a preferential field of atmosphere-ocean research.

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