Surface Salinity Fluctuations Between 1956 and 1973 in the Western South Pacific Ocean

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17 October 1977 and 29 May 1978

ABSTRACT

For the western South Pacific Ocean, the 1956–73 surface salinity is compared with the rainfall and wind information along the 180° meridian. On the equator, short periods of low salinity are associated with strong rainfall and, south of 10°S, high salinity is associated with low rainfall, features recognized as abnormal; high salinity on the equator is associated with low rainfall and with east wind sustaining upwelling; low salinity, between 10 and 18°S, is associated with strong rainfall and with the presence of the intertropical convergence zone. Evidently, local rainfall and winds have a major influence on sea surface salinity in both normal and abnormal situations.

1. Introduction

For the southwest tropical Pacific Ocean, it has been possible to compile all available surface data including the salinity for the years 1956–74 and to draw up for each year two half-year charts of surface salinity (January–June and July–December) between Australia and 130°W (Donguy and Henin, 1976). The surface salinity taken along the 180° meridian from 10°N to 20°S on each chart is set out in a distance–time diagram (Fig. 1) showing long-term variations over the 18-year period.

Many meteorological stations are located approximately along the 180° meridian (Fig. 2) and their data are available between 1956 and 1969 (Taylor, 1973), although few data after 1969 are available. The amount of rainfall (mm) at each of these stations has been calculated for six-month periods, that is, from October to March (rainy season) and from April to September (dry season), since, according to Hires and Montgomery (1972), there is a three-month delay between the maximum rainfall and the spreading at the sea surface of a homogeneous salinity minimum. These data have been set out in a distance-time diagram (Fig. 3) similar to Fig. 1.

2. Comparison between meteorological and surface data

Figs. 1 and 3 show some similarities. The periods of high salinity on the equator (1959–63, 1966–72) are associated with the periods of low rainfall (<1000 mm for six months). In the same way, the periods of low salinity south of 10°S (1958–63, 1965–68, 1969–72) are associated with the periods of high rainfall (more than 1500 mm for six months).

On the equator, short periods of low salinity are associated with periods of high rainfall as in 1957–58, 1963–64, 1965–66 and 1972–73. The latter feature is characteristic of an anomalous year. Three such years occurred in the series studied (1958, 1965 and 1972) and have already been discussed (Donguy and Henin, 1976). During these anomalous years, the meteorological conditions were exceptional. On the equator west winds prevailed and heavy rainfall occurred instead of upwelling. South of 10°S, at the same time, high salinity was associated with low rainfall. Although 1958, 1965 and 1972 showed the appearance of a very characteristic event, in 1961–62 surface salinity less than 35.0‰ was not associated with rainfall; in 1963–64, a similar but less drastic feature occurred; and in 1969 strong rainfall was not connected with the absence of the equatorial upwelling.

The sequence of the equatorial high salinities associated with low rainfall is due to the occurrence of upwelling induced by easterly winds at the equator. East winds are generally dry and bring only low rainfall. Therefore, the high-salinity waters in the equatorial area do not seem to come from the central Pacific by advection, but to be brought to the sea surface locally by upwelling. The onset of equatorial upwelling was observed in 1973 (Fig. 4) along the track between New Caledonia and Japan. On the equator, from January to March 1973, the surface salinity was lower than 34.5‰ at 150°E with a wind blowing from the north or from the west. Starting in April, east winds blew strongly enough to sustain upwelling. As a result the low-salinity water ($S < 34.5‰$) was moved away from the equator and replaced by more saline water.

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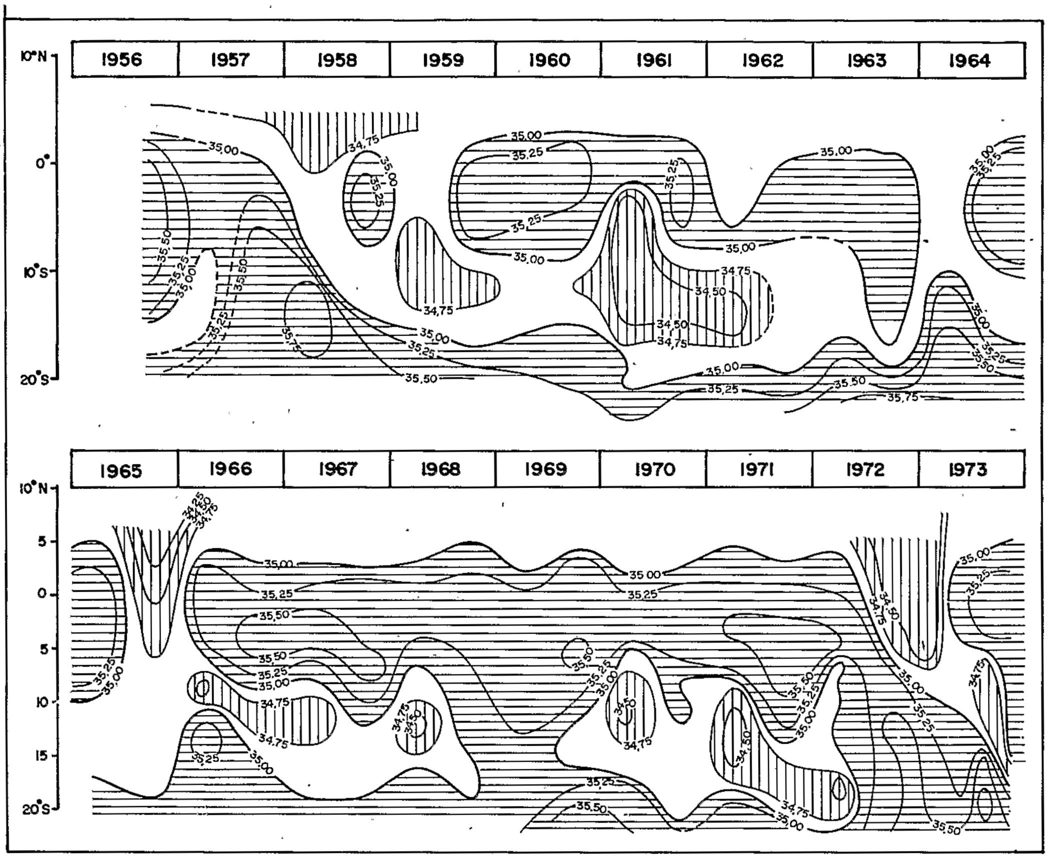

FIG. 1. Salinity (‰) along the 180° meridian.

South of 10°S, surface low salinity associated with strong rainfall occurred during three sequences between 1956 and 1973: 1958–63, 1965–68 and 1969–72. These sequences are separated by the 1965 anomalous year, by the 1969 year characterized by unexpectedly strong rainfall on the equator, and by the 1972 anomalous year. So, it seems that, as already noted by Donguy and Henin (1976), the low salinity observed south of 10°S is a normal feature. The causes of this low salinity are the west winds and the intertropical convergence zone, both bringing rainfall and occurring south of 10°S at least from January to March (Donguy and Henin, 1975). During this time, the rainy season leads to lower sea surface salinity; the lower salinity water can persist, although with somewhat higher values of salinity, during the dry season. The location of the intertropical convergence zone at 180° as estimated from Wyrtki and Meyers (1975) is indicated in Fig. 3 and is generally consistent with the occurrence of high rainfall (more than 1500 mm for six months).

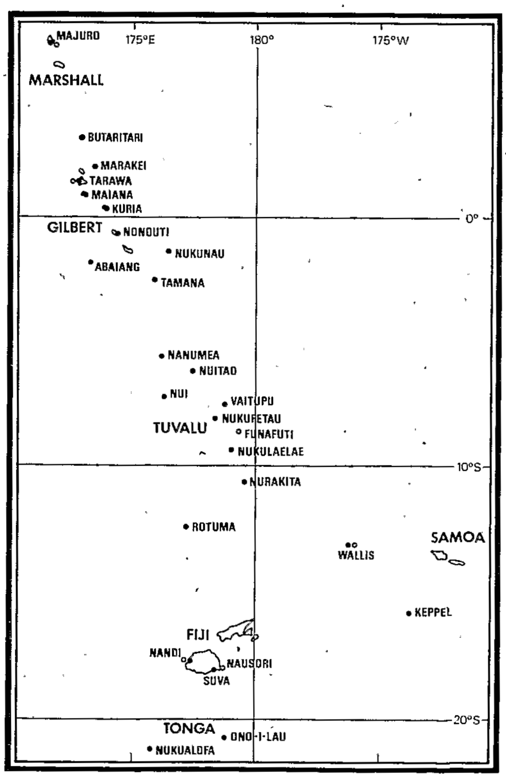

FIG. 2. Position of the meteorological stations located approximately along the 180° meridian. The stations with the 1956–69 available data are marked by a dark point and the ones with the 1969–73 data by a white point.

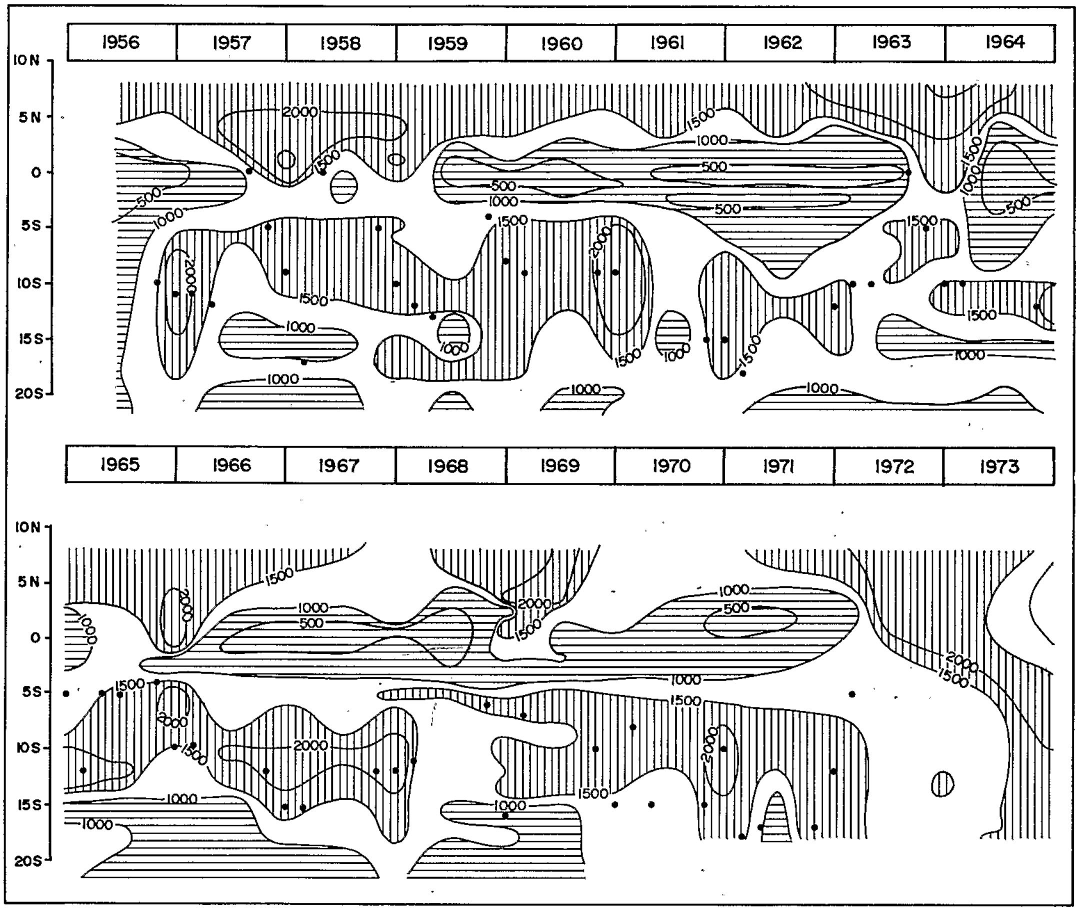

FIG. 3. Rainfall (mm) along the 180° meridian calculated from October to March and from April to September. The bimonthly position of the intertropical convergence zone of the winds is marked by a point.

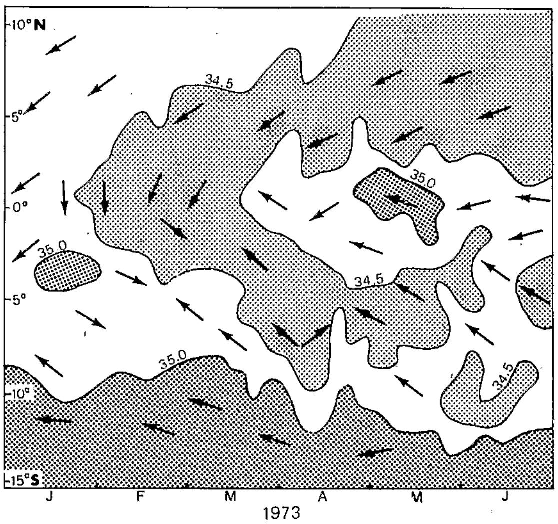

FIG. 4. Salinity (‰) along the track between Noumea and Japan, January–June 1973. The direction of the wind is marked by arrows.

Thus, in addition to seasonal variations in spreading and intensity, the low-salinity zone undergoes long-term variations of meteorological origin and, in the western part of the South Pacific, the local formation of low-salinity water by rainfall seems well established.

REFERENCES

Donguy, J. R., and C. Henin, 1975: Surface waters in the north of the Coral Sea. *Aust. J. Mar. Freshwater Res.*, **26**, 293–296.

——, and ——, 1976: Anomalous navifacial salinities in the tropical Pacific Ocean. *J. Mar. Res.*, **34**, 355–364.

Hires, R. I., and R. B. Montgomery, 1972: Navifacial temperature and salinity along the track from Samoa to Hawaii, 1957–1965. *J. Mar. Res.*, **30**, 177–200.

Taylor, R. C., 1973: *An Atlas of Pacific Islands Rainfall.* Data Report No. 25, HIG 73-9, University of Hawaii, 165 pp., 13 Figs.

Wyrtki, K., and G. Meyers, 1975: The trade wind field over the Pacific Ocean, Part II. Bimonthly fields of wind stress: 1950 to 1972. HIG 75-2, University of Hawaii, 16 pp., 138 Figs.

Reprinted from JOURNAL OF PHYSICAL OCEANOGRAPHY, Vol. 8, No. 6, November 1978
American Meteorological Society
Printed in U. S. A.

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