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2.2 AN EXPENDABLE BATHYTHERMOGRAPH AND SEA-SURFACE TEMPERATURE EXPERIMENT IN THE EASTERN AND WESTERN PACIFIC

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INTRODUCTION

Since 1969, the Centre ORSTOM de Nouméa has operated a surface observation system with the help of merchant ships. Several routes are used in the tropical Pacific; from west to east, there are the following main routes (Figure 1).

Nouméa	- Hong Kong	(1)
Nouméa	- Japan	(2)
Australia	- California	(3)
Tahiti	- California	(4)
Tahiti	- Panama	(5)

Other minor routes are also operated, such as Nouméa and Tahiti - New Zealand, Nouméa - Wallis Island and Tahiti - Honolulu.

The observations consist, mainly of SST measurements, and surface salinity sampling.

Starting from 1977, chlorophyll determinations and zooplankton sampling have been obtained along several routes. In 1979, as a result of a US-French agreement, XBTs have been gathered along routes (1) (2) (3) and (5), route (4) being operated by the US.

In this study only the routes (2) and (5) will be taken into consideration.

TAHITI-PANAMA

Available data of SST start in 1955. They have been provided by the French "Meteorologie Nationale" and gathered by merchant ships between Tahiti (17°33 S, 149°37 W) and Panama (8°57 N, 79°33 W). These data end in 1973 but the same observations start again along the same route in October 1974, operated by the Centre ORSTOM de Nouméa; they are still running.

The SSTs have been presented in a space-time diagram covering the 1955-1978 series (Figure 2). The main conclusions have been drawn by Donguy and Henin (1980). The seasonal variations are obvious: from January to June, the surface water is warm; from July to December, it is cold. On the equator, cold water is due to the equatorial upwelling. Warm water south of 1°S is due to the southern summer and, close to the equator, to the absence of equatorial upwelling.

The 1955-1978 SSTs show not only seasonal variations but also year-to-year variations of the equatorial upwelling intensity. In some years, the equatorial upwelling is strong, as in 1955, 1967, 1970, 1973, 1975. In others, the equatorial upwelling is weak, as in 1957, 1963, 1965, 1969, 1972, 1976. These years were marked by El Niño events.

Only two years of XBT observations are at present available. As XBTs sometimes fail, the observations are irregularly located and spaced. On the other hand, between Polynesia and Panama, two separated routes appear: one from Papeete to Panama, the other from Mururoa (22°S - 141°W) to Panama. The SST from XBTs also shows seasonal variations, with warm water from January to June, and from July to December cold water due to the equatorial upwelling and the southern winter (Figure 3).

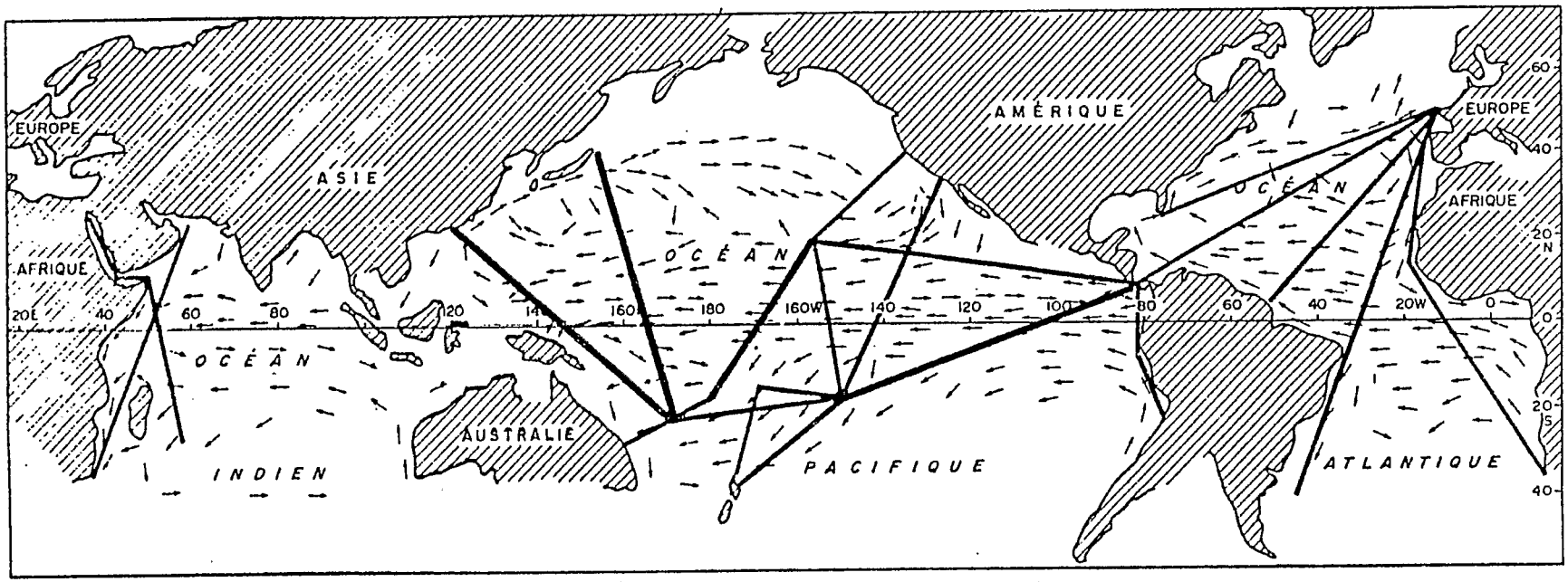
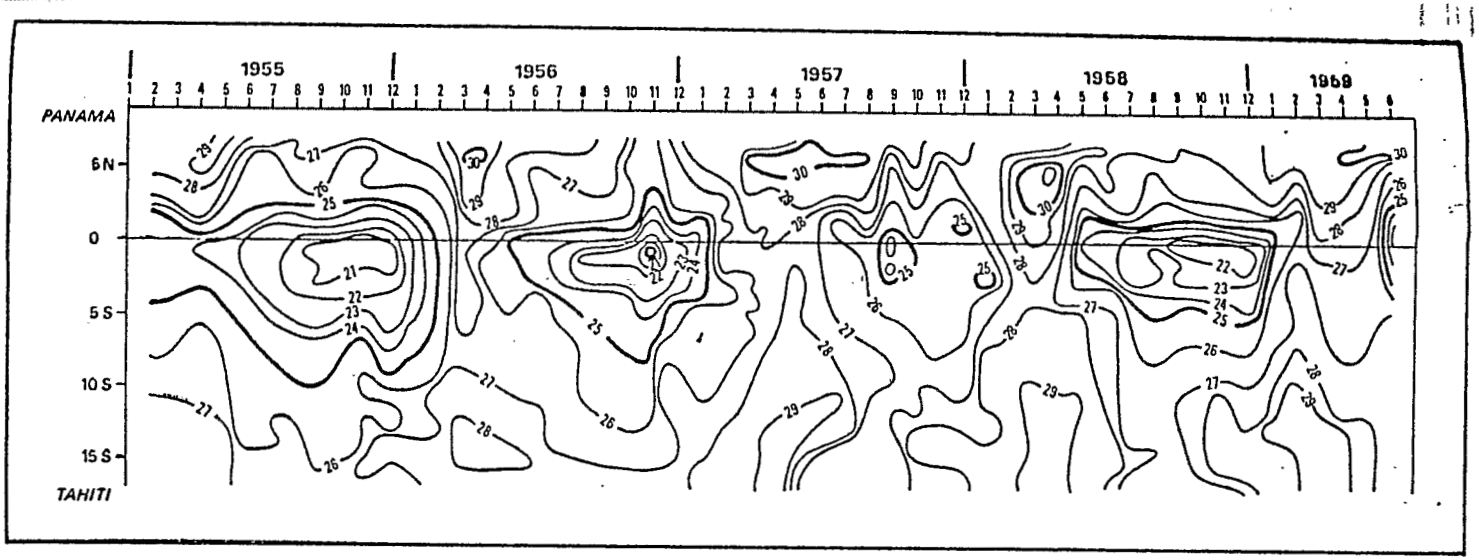


Figure 1 - Surface sampling routes operated by ORSTOM.

(a)



(b)

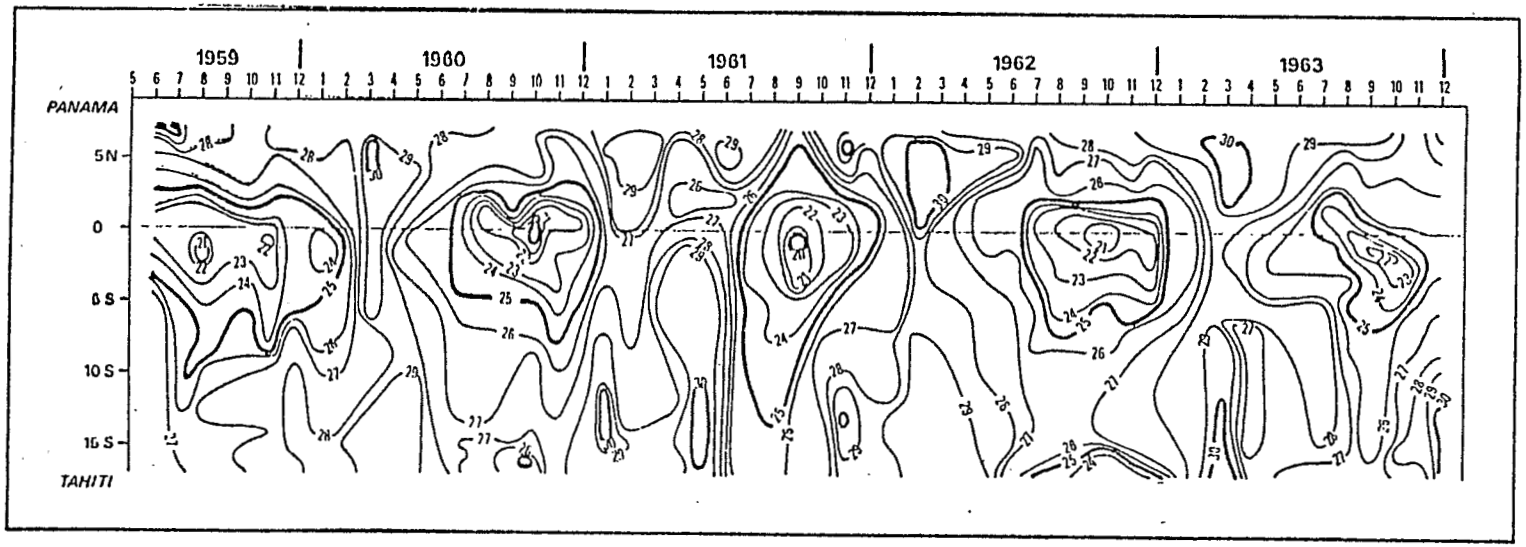
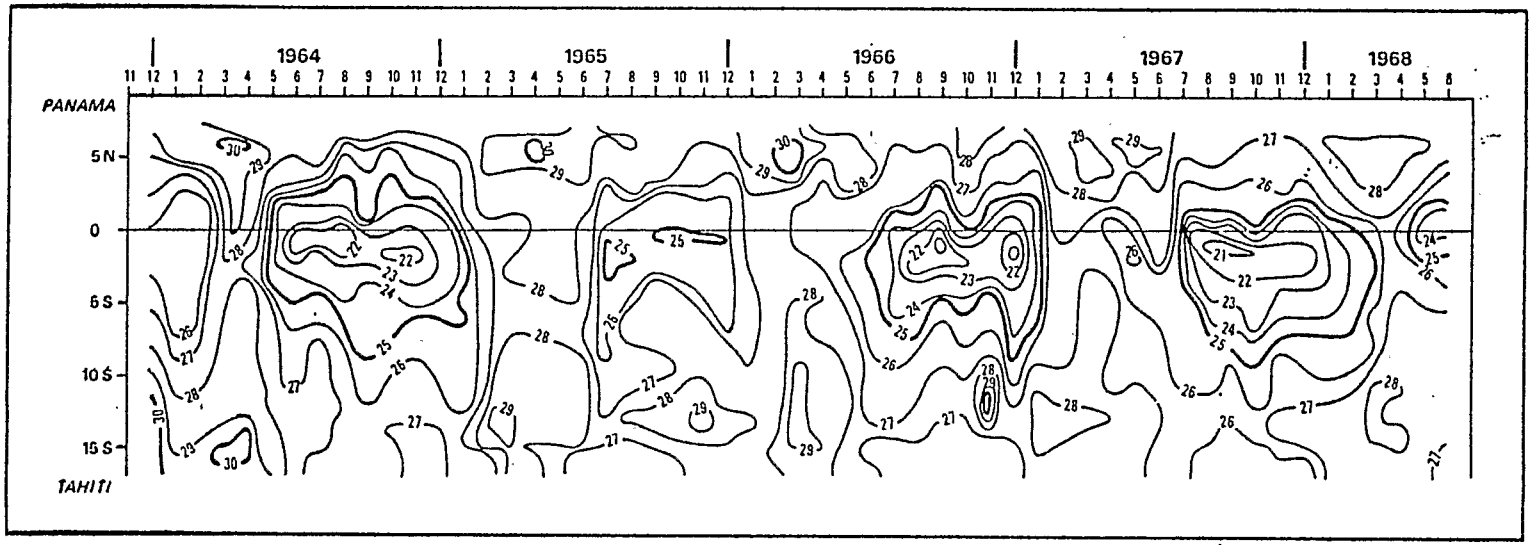


Figure 2(a) & (b) - Space-time isopleths of sea-surface temperature, Tahiti-Panama, 1955-63.

(c)



(d)

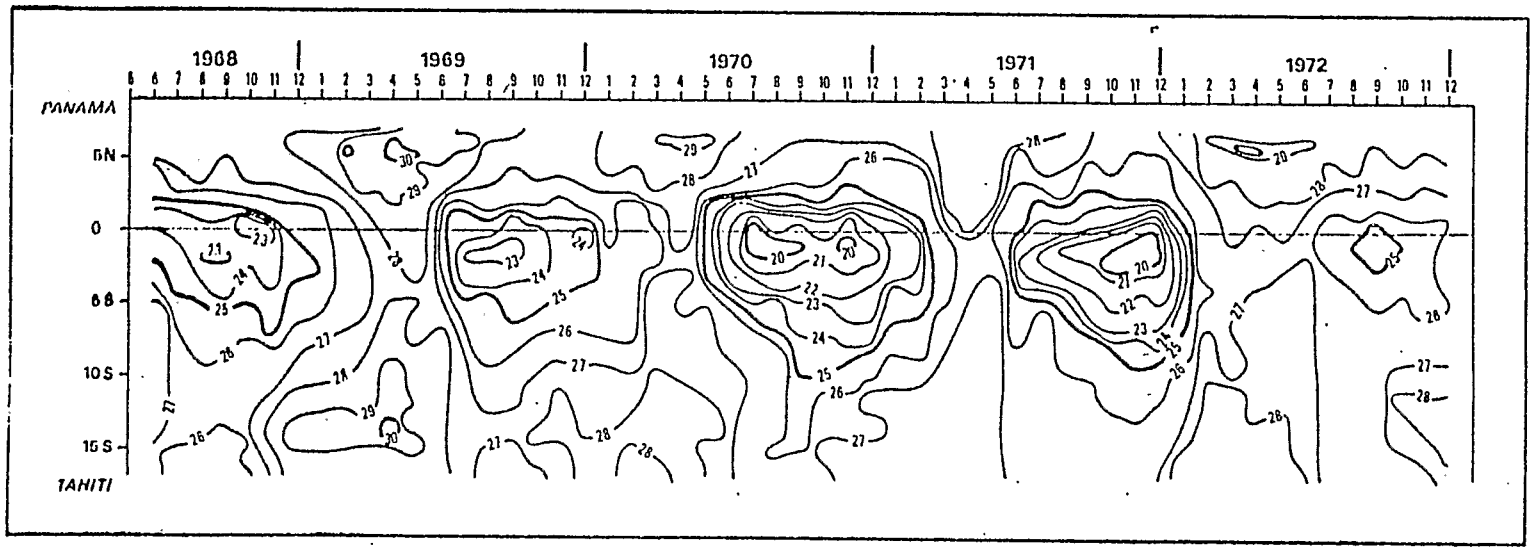
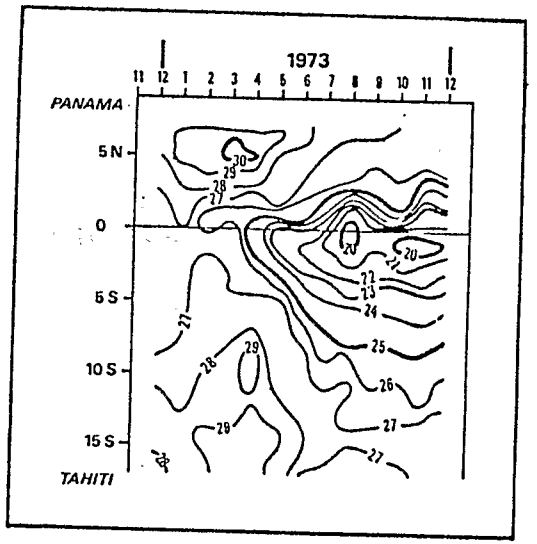


Figure 2(c) & (d) - Space-time isopleths of sea-surface temperature, Tahiti-Panama, 1964-72.

(e)



(f)

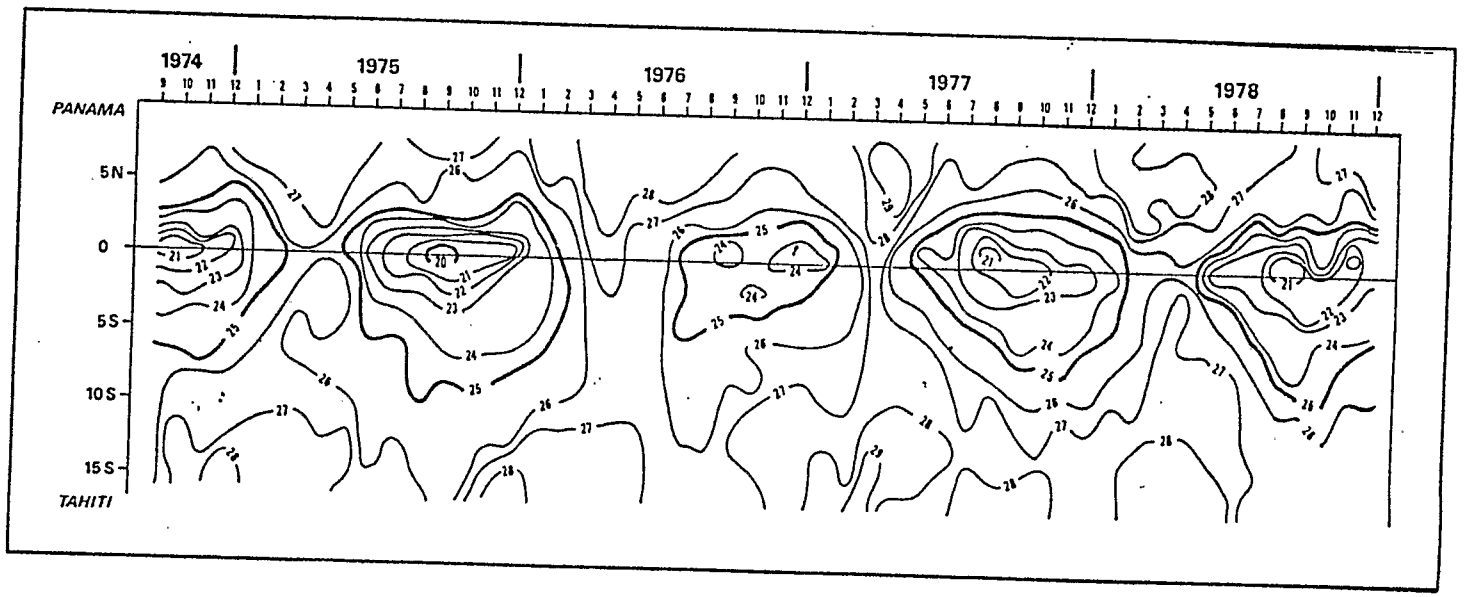
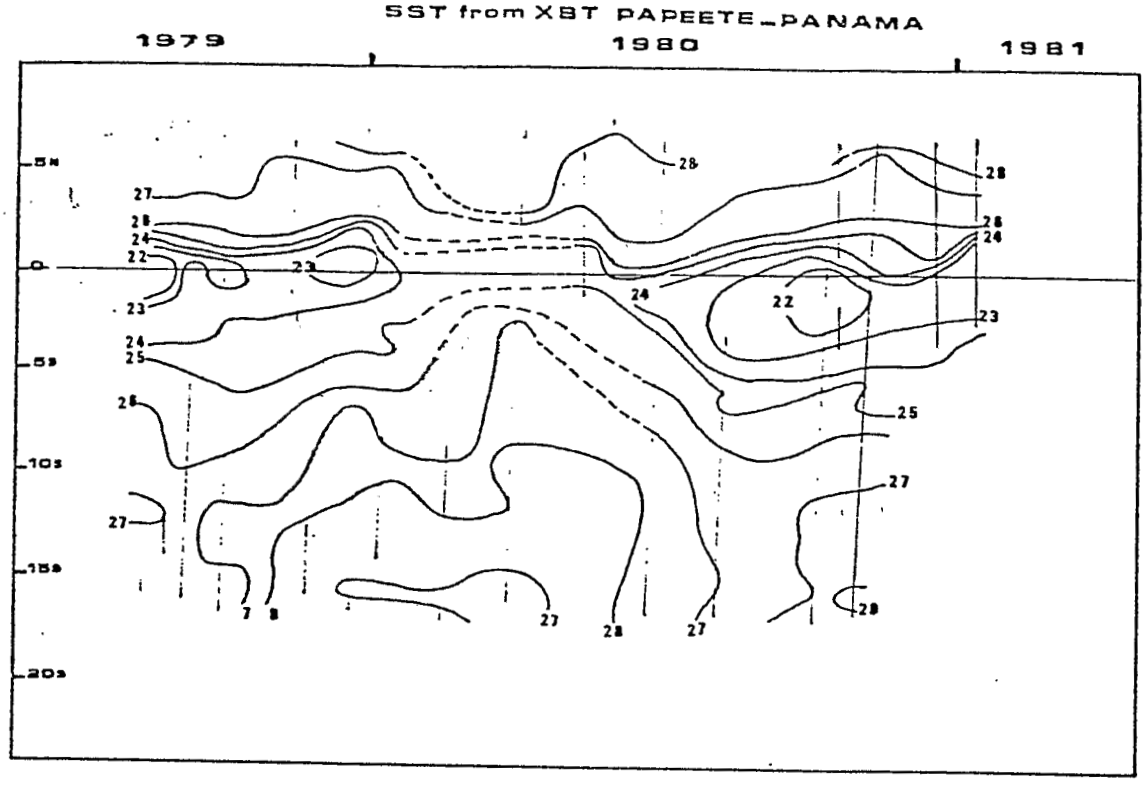


Figure 2(e) & (f) - Space-time isopleths of sea-surface temperature, Tahiti-Panama, 1973-78.



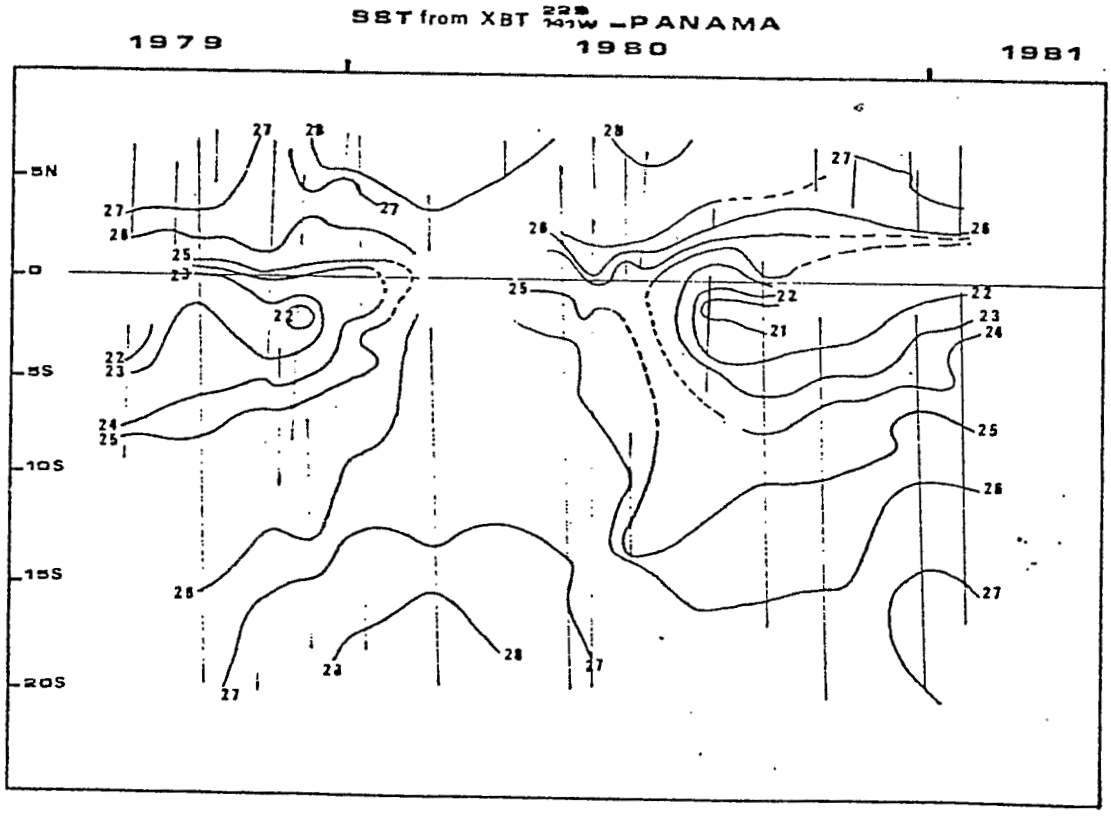
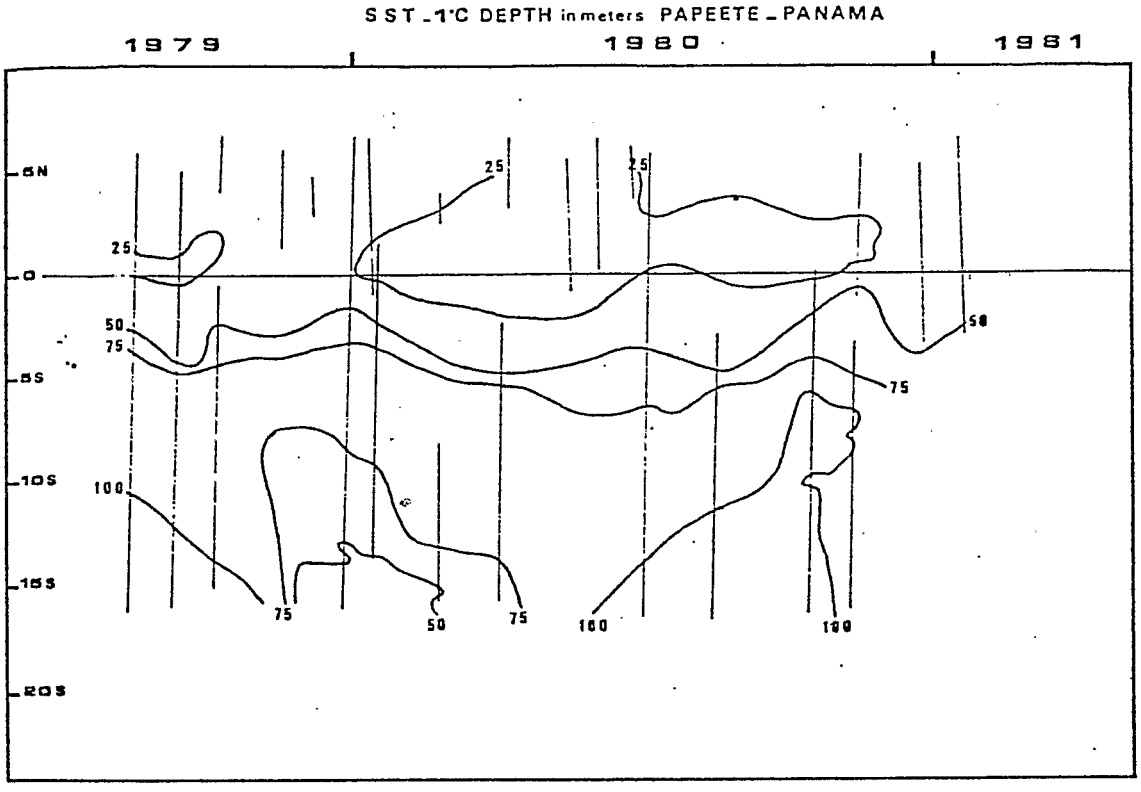


Figure 3 - Sea-surface temperature from XBTs, Polynesia-Panama, 1979-1981.

The variations of the depth of the sea-surface temperature minus 1°C, (figure 4) as a space-time diagram, show interesting features. Along both the routes, between Polynesia and Panama, this depth is at a maximum in the cold season and during equatorial upwelling, and at a minimum in the warm season and during the absence of the equatorial upwelling. As this depth is representative of the mixed layer thickness, we conclude at a first approach that along these routes cold water exists with a great thickness, and warm water exists with a small thickness.



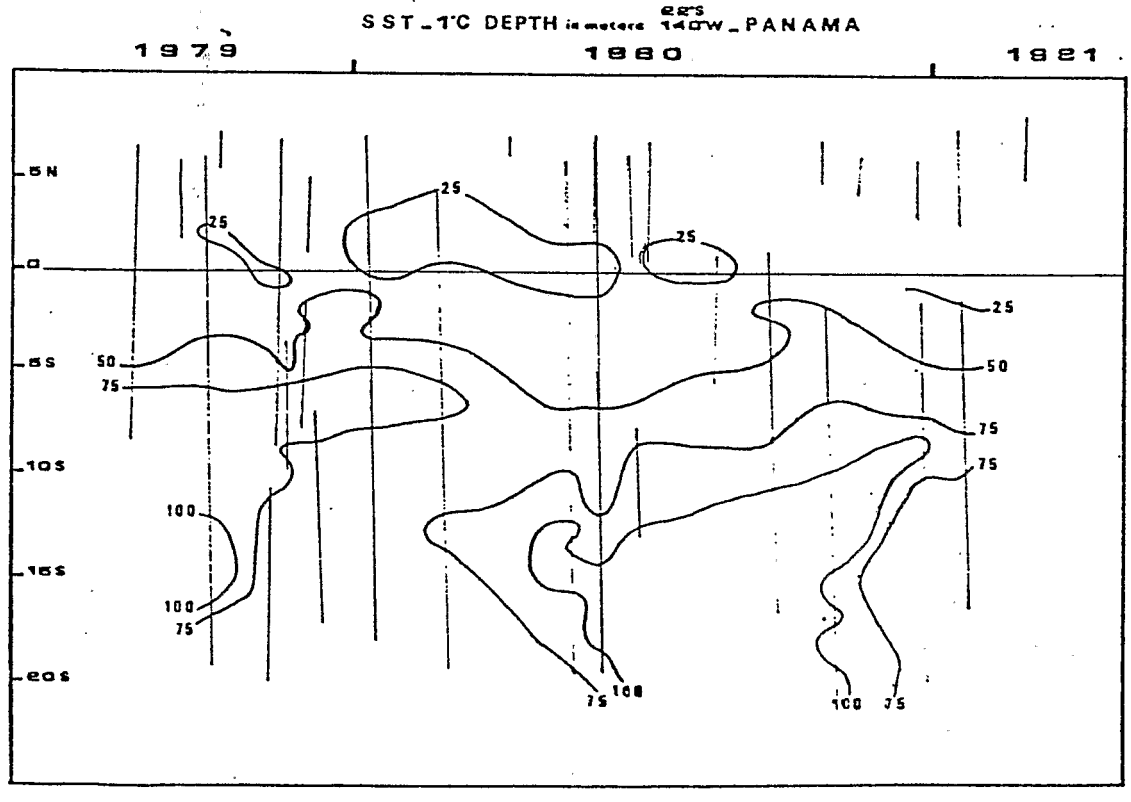
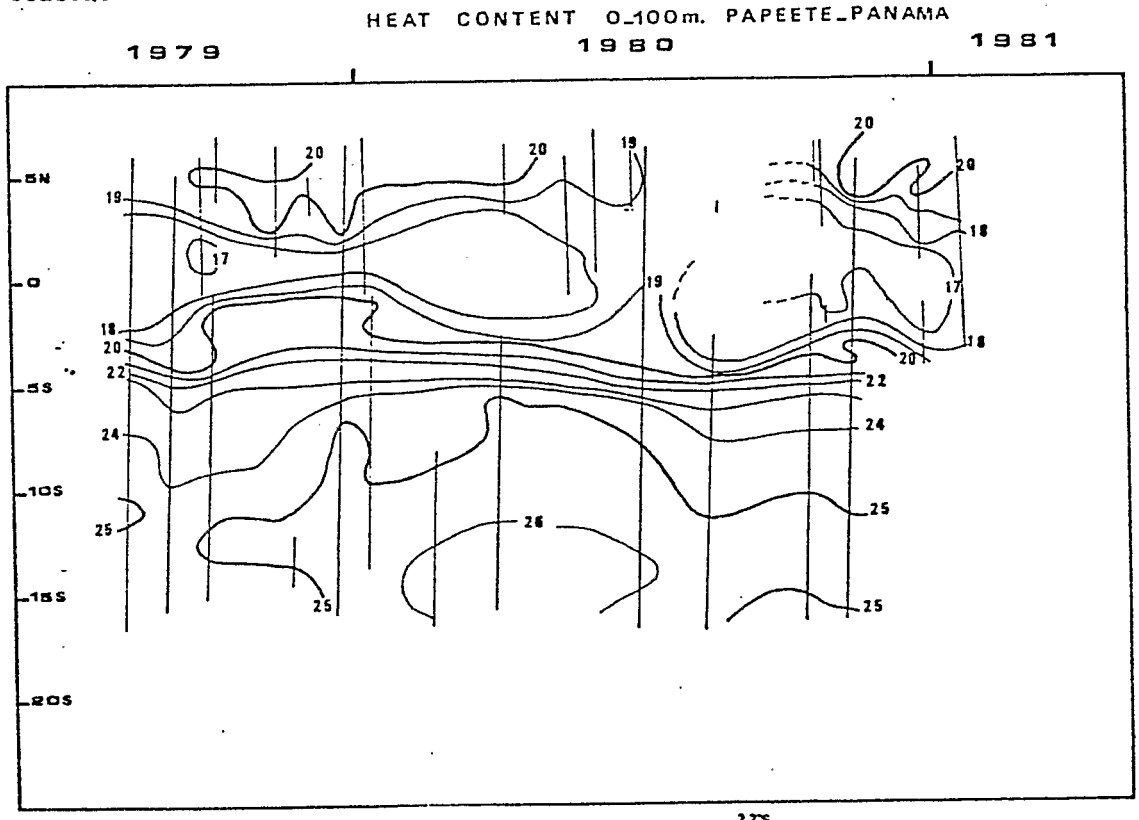


Figure 4 - Depth (m) of sea-surface temperature minus 1°C, Polynesia-Panama, 1979-81.

These features are confirmed by consideration of the heat content from the surface to 100 meters (Figure 5). On the equator, during the absence of the equatorial upwelling (January-June 1980), the heat content is not much greater than during the upwelling (18 units instead of 17) when the SST is very different (more than 25°C instead of less than 23°C). In the same way, in the tropical area a heat content maximum appears during the warm season but another appears also during the cold season.



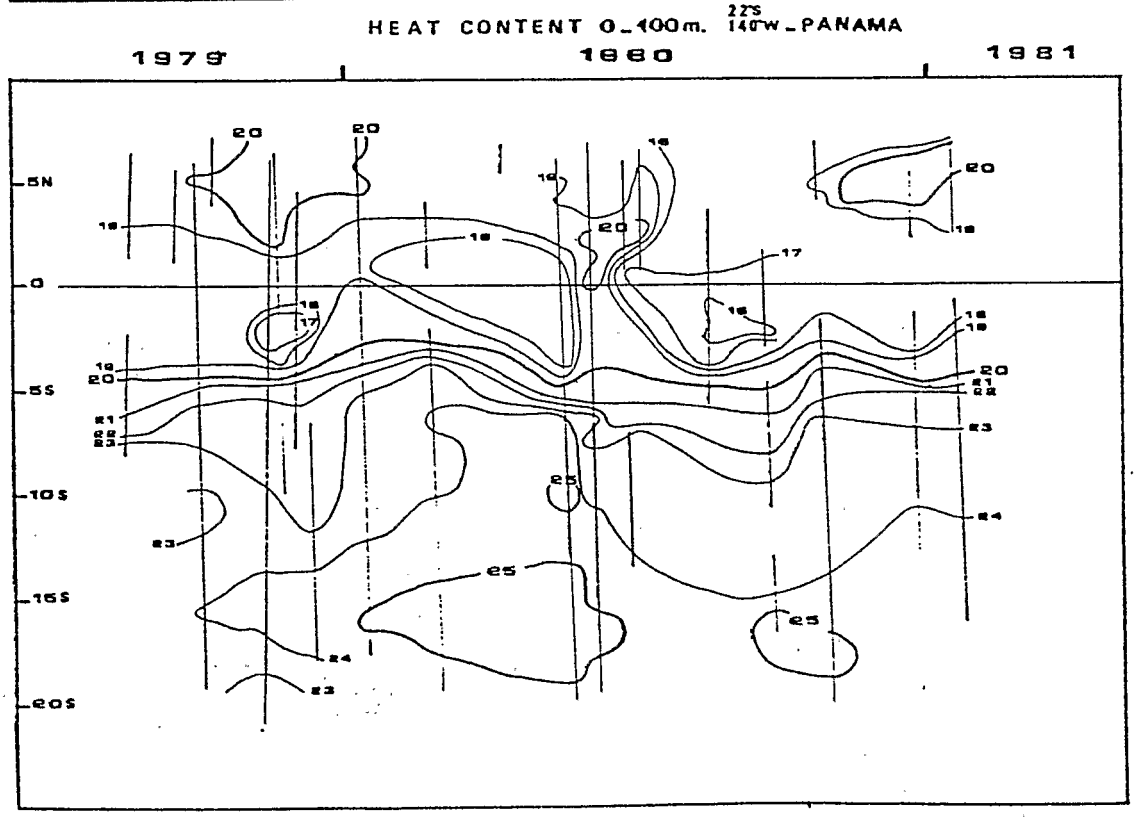


Figure 5 - Heat content, 0-100m, Polynesia-Panama, 1979-81.

NOUMEA-JAPAN

The surface observations started in 1969 but were restricted at 10°N until 1972. From 1972 to the present, sea-surface temperature and salinity are gathered regularly from Nouméa to Japan. The merchant ships, according to their destination, have two different sailing routes, one crossing the equator at 150°E, the other at 160°E. Only this last one is considered here. It starts at Nouméa (22°16 S, 166°27 E) and ends at Hachimohe (40°32 N, 141°32 E).

The sea-surface temperature shows seasonal variations north of 10°N and south of 10°S. Between these latitudes, there are not seasonal variations: the temperature varies from 28°C to 30°C, with long periods of cold (28°C) and warm (30°C) waters. Except for short periods with temperature less than 28°C on the equator, the equatorial upwelling is not marked by water colder than elsewhere. Surface conditions in the North-West Pacific Ocean have been discussed by Donguy and Henin (1977).

Only two years of XBT observations are at present available. On a space-time diagram (Figure 6) seasonal variations of SST appear south of 10°S and north of 10°N and, as deduced from the SST sampling, there are not seasonal variations in the equatorial zone.

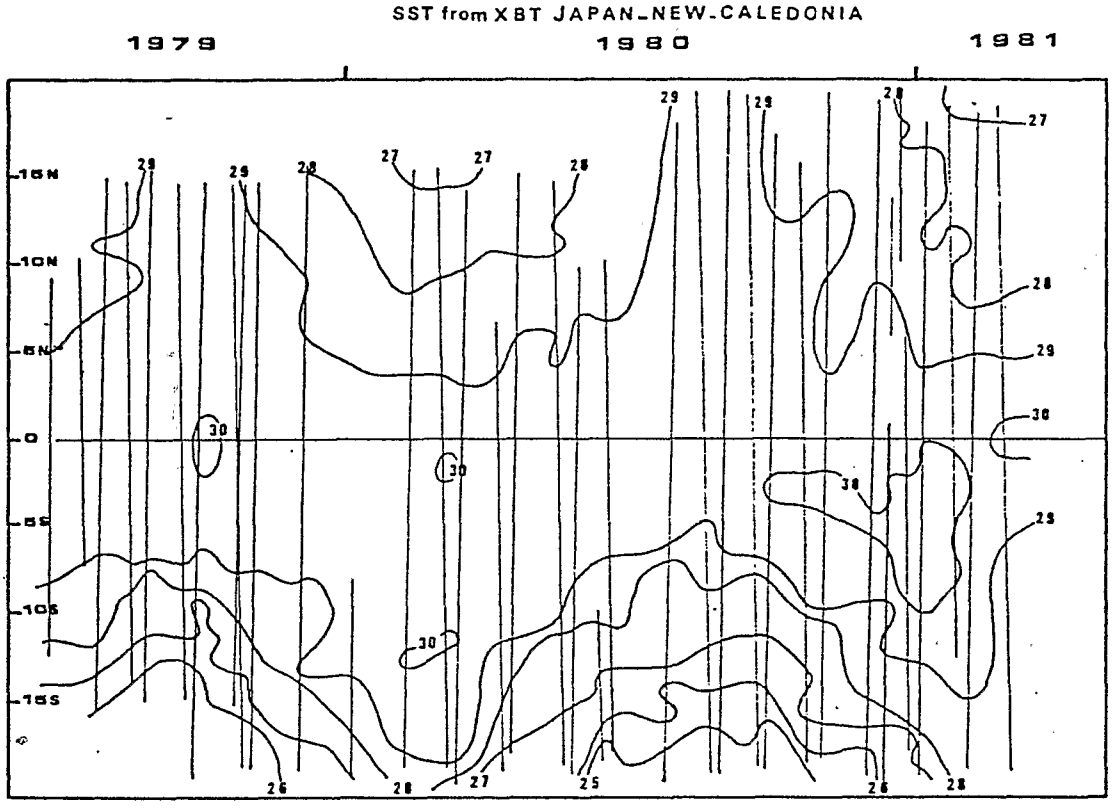


Figure 6 - Sea-surface temperature from XBTs, Japan-Nouméa, 1979-81.

The mixed layer depth may be represented by the depth of SST minus 1°C in a space-time diagram (Figure 7). In tropical areas warm water is usually present in small thickness, whereas cold water occurs in great thickness, as in the Eastern Pacific. The equatorial area, on the contrary, is characterized by a trough close to the equator with a mixed layer depth more than 100 meters. This feature is consistent with the dynamic heights computed from the XBT observations (Figure 8), assuming durect relations of Δst with the temperature. The trough is consistent with a line of dynamic height maximum. From June 1979 to April 1981, the equatorial area is characterized by the importance of the Eastward Counter-Currents.

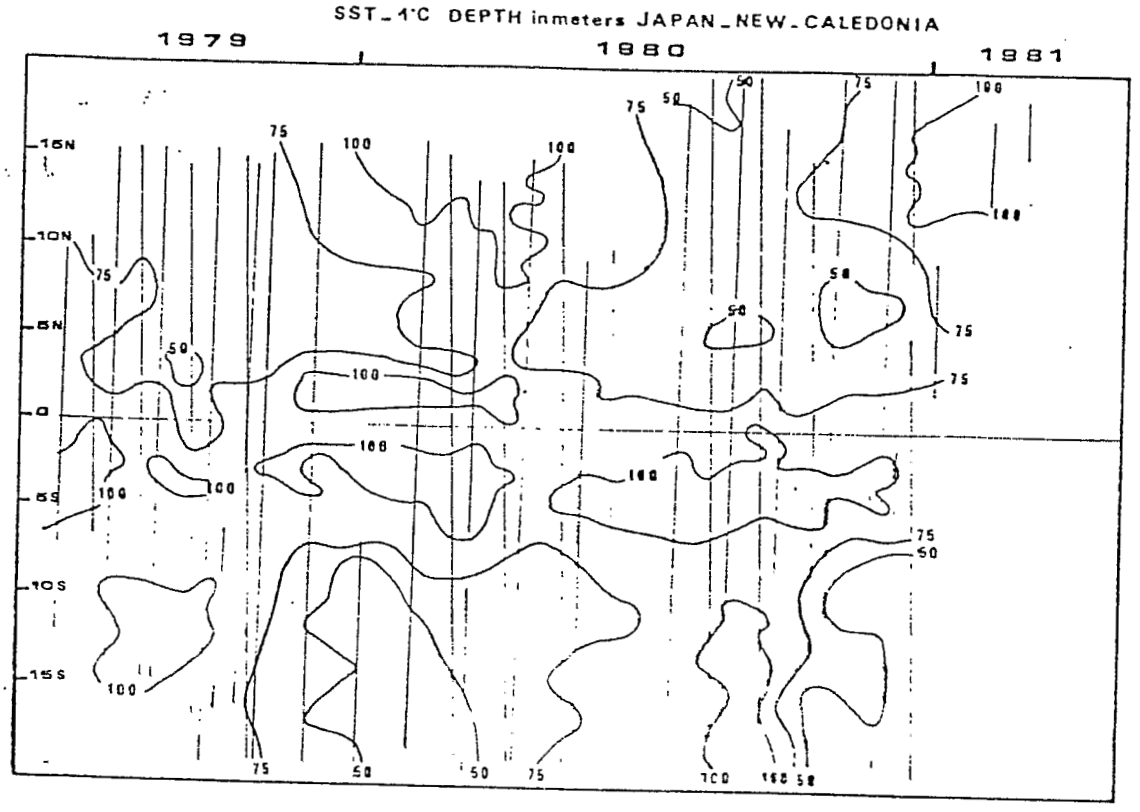


Figure 7 - Depth (m) of sea-surface temperature minus 1°C, Japan-Nouméa, 1979-81.

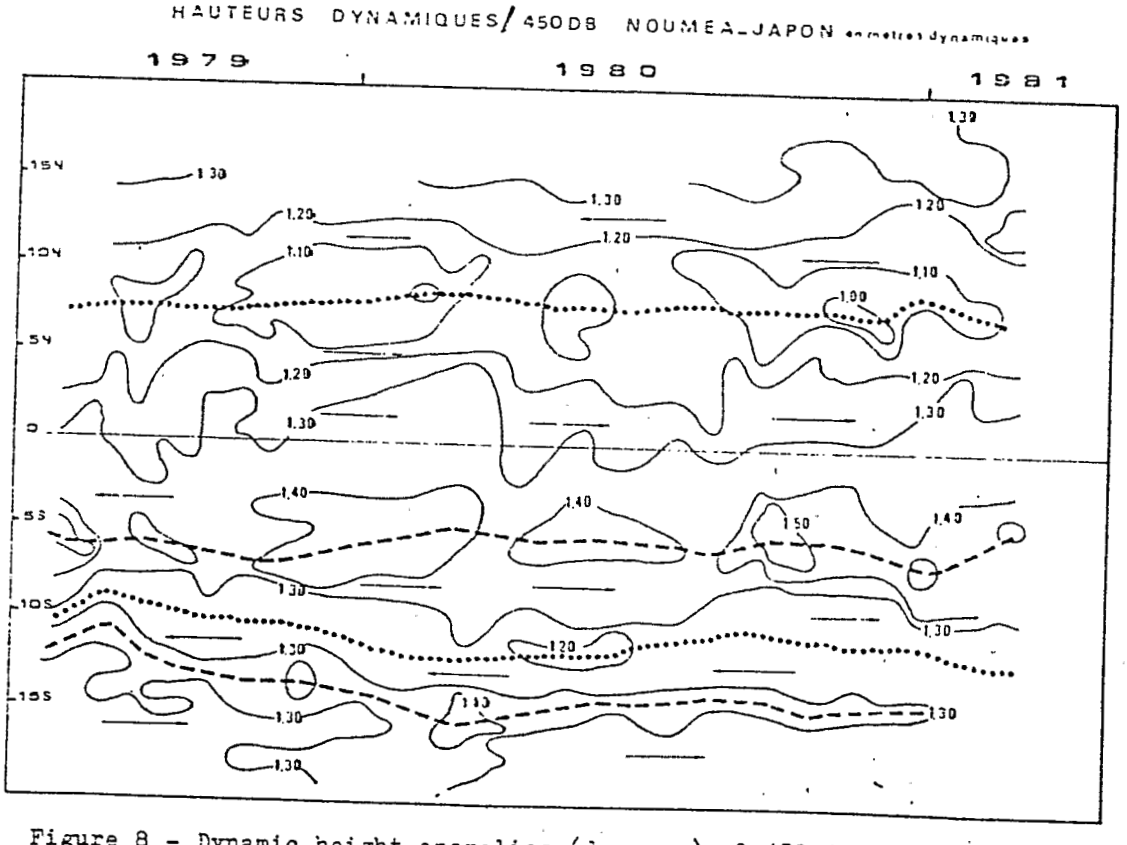


Figure 8 - Dynamic height anomalies (dyn. m.), 0-450 db, Japan-Nouméa, 1979-81.

The 0-100m heat content (Figure 9) shows weak seasonal variations in the tropical area. On the equator, there is no change during the series: a maximum of heat content occurs from 5°S to the equator and does not seem to have seasonal variations. This maximum is low and characteristic of a post El Niño period. Before El Niño, we expect a stronger heat content in the equatorial area.

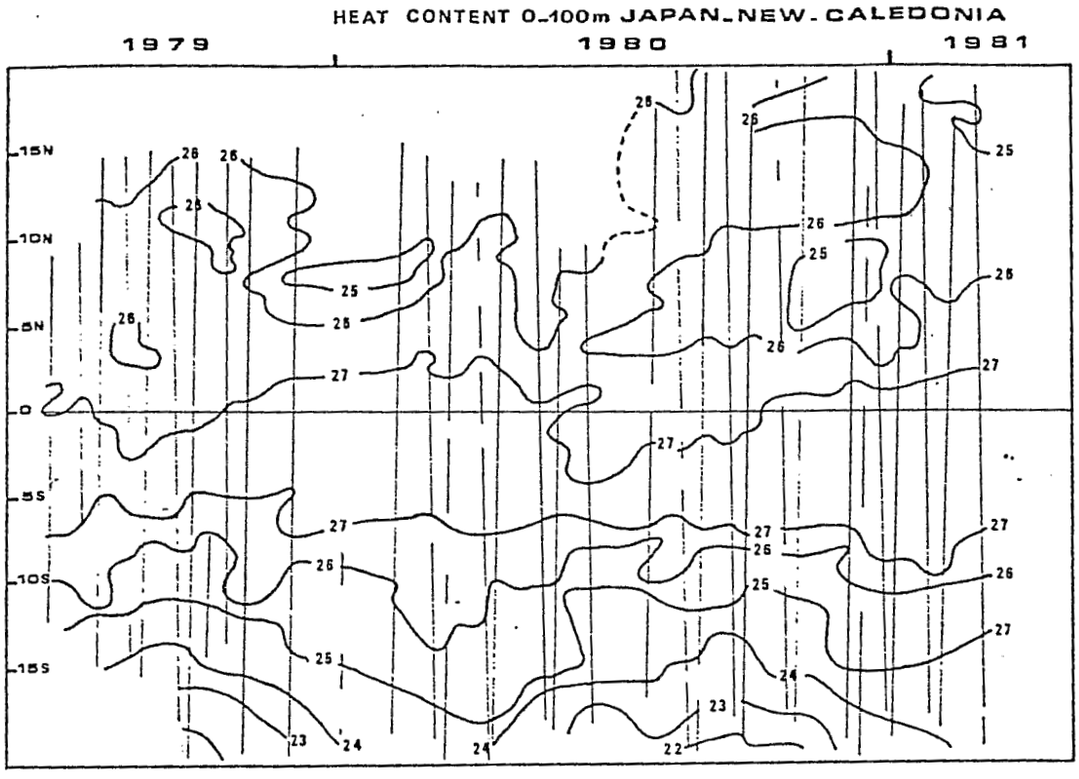


Figure 9 - Heat content, 0-100m, Japan-Nouméa, 1979-81.

CONCLUSION

The XBT experiment has been running for only two years in the Pacific Ocean. However, interesting results have appeared already but are only characteristic of the present post El Niño period.

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