Comparison of the Results of two West Pacific Oceanographic Expeditions FOC (1971) and WEPOCS (1985-86)

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1. Introduction

After study of the 1982-83 ENSO, oceanographic research has focused on phenomena occurring in western equatorial Pacific. Consequently, the Western Equatorial Pacific ocean Circulation Study (WEPOCS) was launched in order to study problems located in this area such as the circulation, heat storage and water properties.

Two expeditions were conducted (June-August 1985, WEPOCS1; January-February 1986, WEPOCS2) by Australian and US scientists, in the region north and east of Papua New Guinea (PNG) (Fig. 1) (Lindstrom et al. 1987).

Fifteen years before, a similar series of cruises occurred in the same area (Fig. 1) and at the same season (January-February 1971, FOC1; June-July 1971, FOC2) conducted by French scientists from centre ORSTOM de Nouméa (Anonyme, 1980).

The methods of investigation present large differences as a result of technological advancements. During FOC cruises, hydrographic casts with Niskin bottles provided discrete measurements of temperature, salinity, oxygen and nutrient. Current measurements were obtained with HYTECH currentmeters used as profilers from the surface to 600 meters depth. Similar data were provided by WEPOCS cruises but using CTD stations (including discrete sampling for oxygen and nutrients) and a ship board Acoustic Doppler current Profiler (ADCP).

Both of these cruise series point out interesting results concerning the New Guinea Coastal Undercurrent (NGCU) the source of the Equatorial Undercurrent, the Pacific Equatorial Monsoon jet and upper ocean heat storage.

2. New Guinea Coastal Undercurrent

Northwest of Vitiaz strait, along the coast of Papua New-Guinea, a subsurface northwestward flow was found during the four cruises. The velocity maximum is usually centred at 200 meter depth. As the measurements of the four cruises stopped at 142°E, it is not certain now much of the transport of the undercurrent was caught by the eastward Equatorial Undercurrent and how much continues to the west.

The reverse of the monsoon has no effect on the direction of the NGCU : figure 2 shows during FOC2 (June-July 1971) at 142°30E a westward core of 40 $cm.s^{-1}$ and during WEPOCS2 (January-February 1986) at 143°E a westward core of 50 $cm.s^{-1}$. This velocity core is associated with a spreading of the 15°C-25°C isotherms against the shore. This spreading may be easily explained during WEPOCS2 when the NGCU is covered by a surface eastward current due to the N-W monsoon.

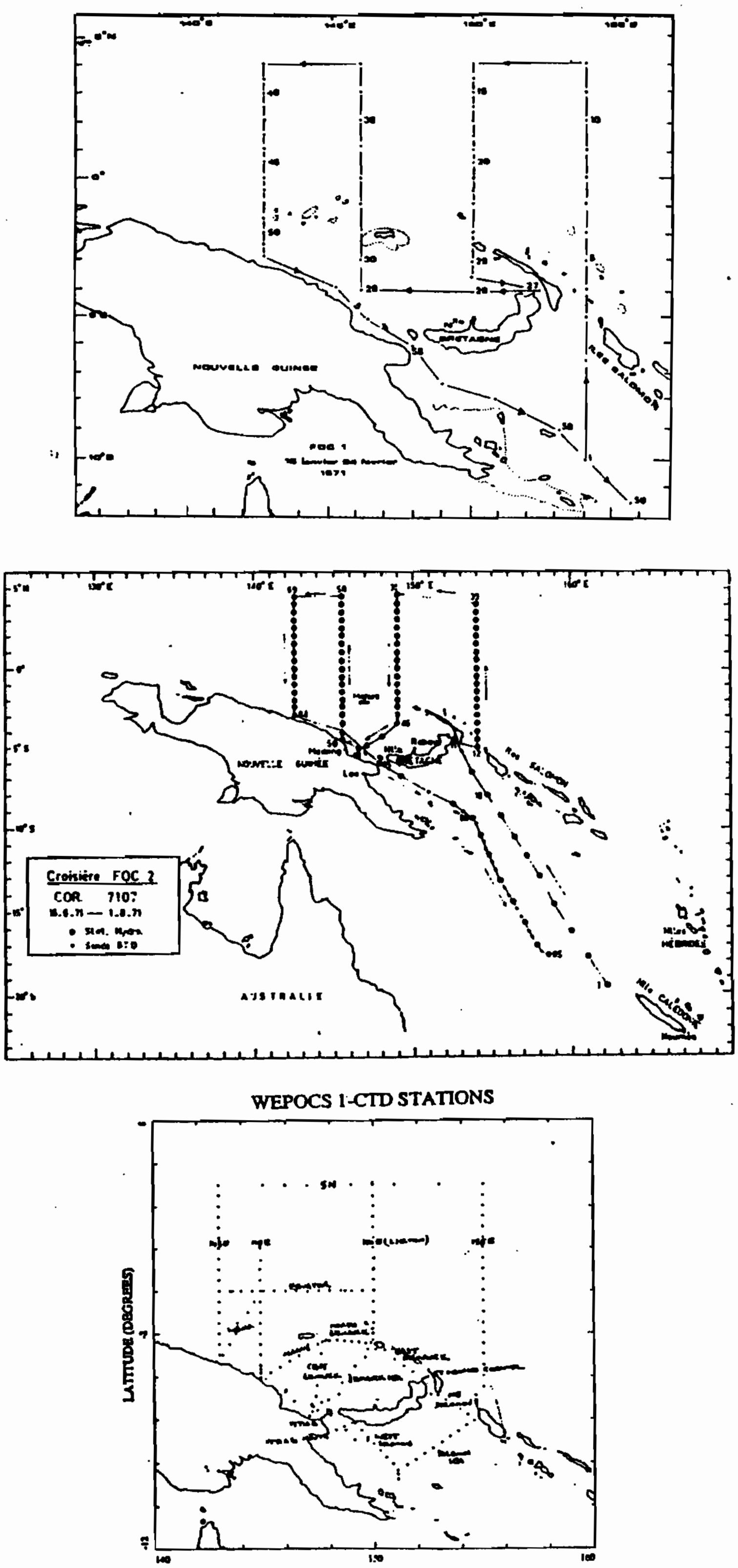

FIG.1. FOC1 (up), FOC2 (middle) and WEPOCS1 (down) cruises. Note that WEPOCS2 (not shown here) has the same design as WEPOCS1.

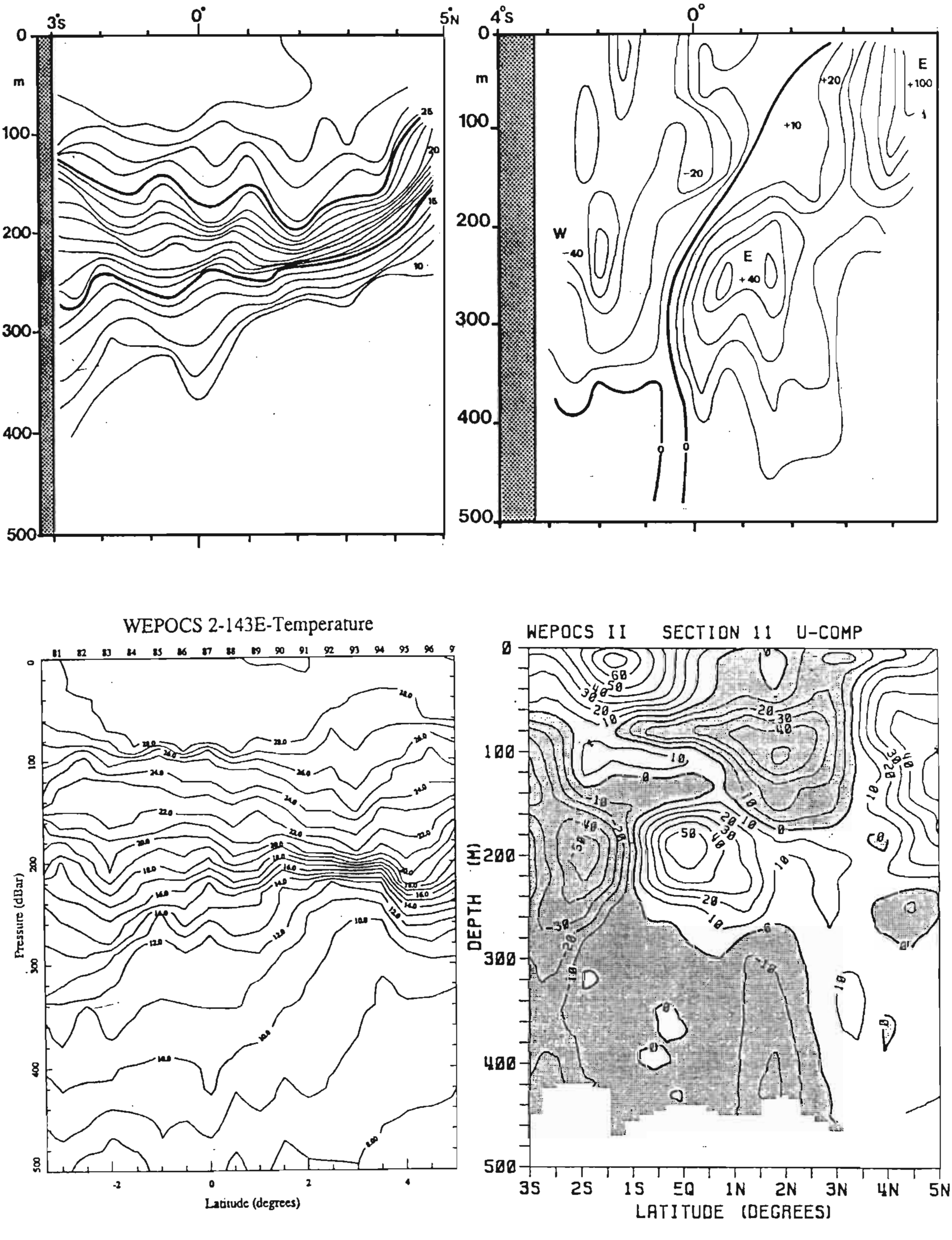

FIG.2. Sections of temperatrure and zonal velocity (cms^{-1}), in June-July 1971 at 142°.30E during FOC2 (upward panel) and in Jan.-Feb. 1986 at 143°E during WEPOCS2. Shaded areas and negative values indicate westward flows.

3. Source of the Equatorial Undercurrent

Isopycnal analysis for WEPOCS by Tsuchiya et al. (1989) provides interesting informations concerning the source of the Equatorial Undercurrent. A comparison with FOC cruises is added in this analysis.

At 300 cl/t (fig. 3), corresponding to 150-220 meter depth, salinities exceeding 35.6 extend to 146°E during the two series of cruises FOC and WEPOCS and have a westward extension. During the WEPOCS cruises, the high salinity tongue extends mainly through the Vitiaz Strait and along the coast of New Guinea, carried by the NGCU. A secondary source takes place north of New Ireland.

During the FOC cruises, the main source of the high salinity may occur north of New Ireland and the salinities exceeding 35.6 extends to 146°E during FOC1 and 143°E during FOC2, instead 150°E during WEPOCS. In the FOC data the secondary source is Vitiaz Strait (Colin et al., 1973), however the resolution of WEPOCS data in the Vitiaz Strait region is much greater.

At 200 cl/t, corresponding to 200-250 meters depth, there are two sources of water extending westward, one characterized by low oxygen content flowing north of New Ireland, other characterized by high oxygen content flowing through Vitiaz Strait along the coast of New Guinea (Fig. 4).

According to Tsuchiya (1968), low oxygen water is carried westward by the South Equatorial Current from the eastern Pacific. The values are increasing from the east to the west. High oxygen water comes from the Coral Sea and the values are decreasing westward away from the PNG coast. It seems that the convergence and the mixing of these two kinds of water lead to a water containing 3.4 ml/l of oxygen. This water is feeding the EUC in the vicinity of 140°E (Rougerie, 1969).

This feature is corroborated by oxygen content at 160 cl/t (220-300 meter depth) (Fig. 5). During the four cruises, high values are found from Coral Sea to the coast of New Guinea, whereas low values (less than 3.2) occur north of New Ireland reaching 145°E during WEPOCS cruises and only 153°E during FOC cruises.

4. Equatorial Monsoon Jet

During the N-W monsoon (January-February), westerlies are prevailing in the equatorial zone. At this time, the westward South Equatorial Current is replaced by an eastward current distinct from the Equatorial Undercurrent. Subsurface remanents of Westward flow are embedded between the surface eastward current and the eastward undercurrent. The surface eastward current is named Pacific Equatorial Monsoon Jet (Lindstrom et al., 1987).

This feature occurred in January-February during the cruises FOC1 and WEPOCS2. At 154°E and 155°E (Fig. 6), the Pacific Equatorial Monsoon Jet is exactly located on the equator, whereas at 142°30E and 143°E (fig. 7) it has shifted to the south.

Some occurrences of eastward flow at the surface are observed in the June-July cruises and may be the results of unseasonable transient wind forcing. The current system observed at 143°E and 155°E (Fig.9) in June-July 1985, is not noticeable at 165°E at the same period (Delcroix et al., 1987; Fig.4d). This observation is in favor of an explanation involving the transient influence of a wind change as already suggested by Hisard et al. (1970).

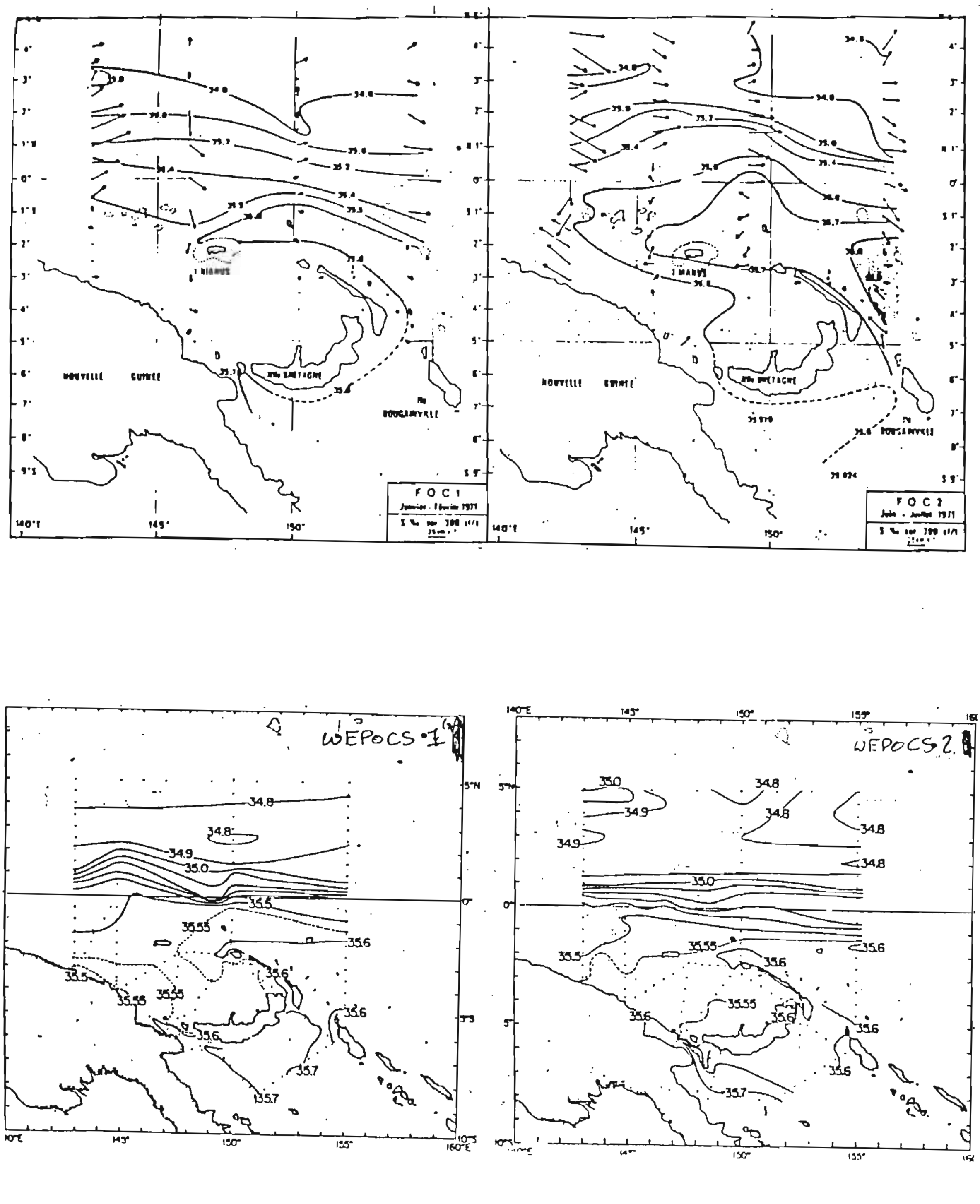

FIG.3. Salinity on surface 300 cl.t⁻¹, during FOC1 (upper left), FOC2 (upper right), WEPOCS1 (lower left) and WEPOCS2 (lower right).

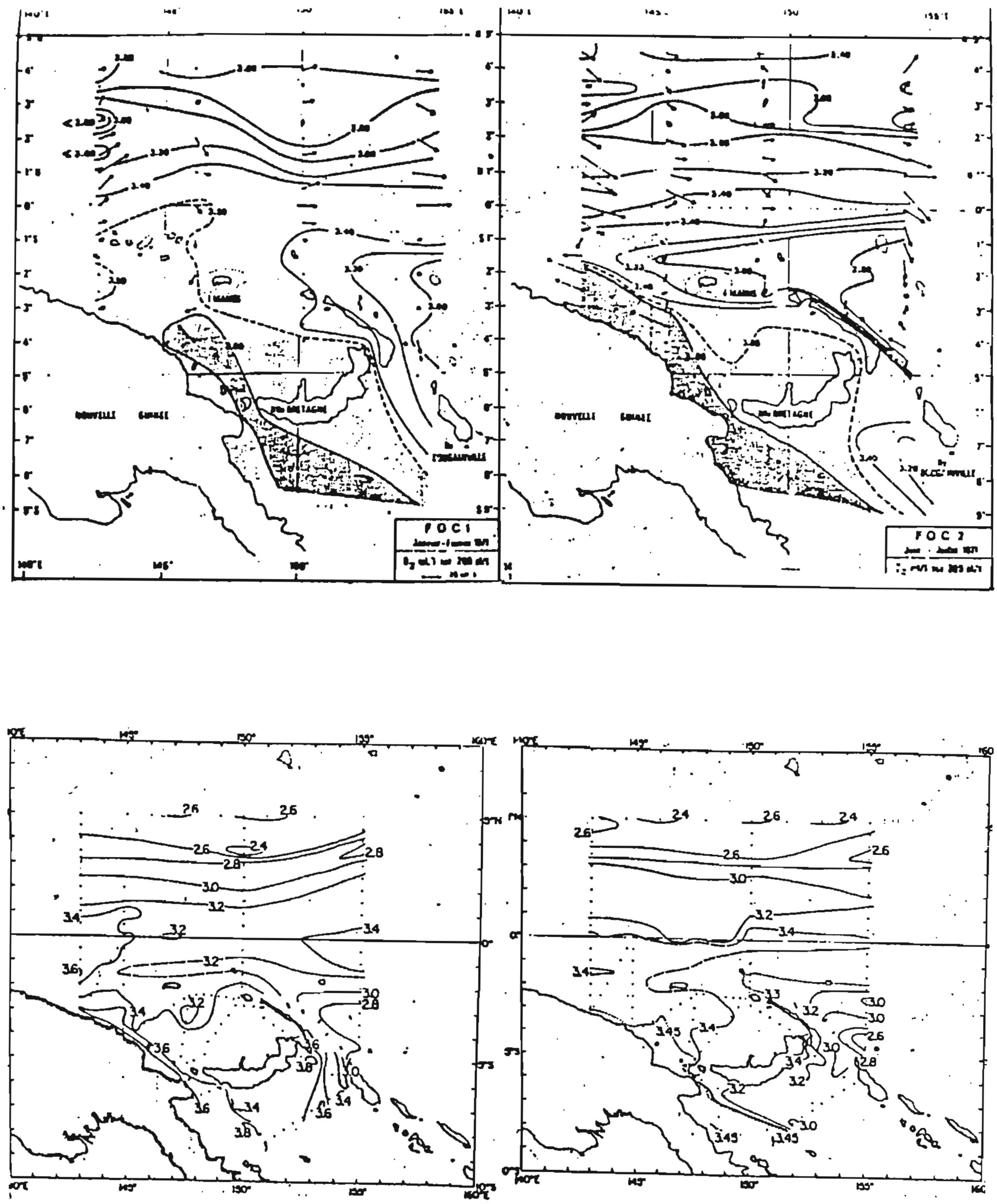

FIG.4. Oxygen (ml.l-[1]) on surface 200 cl.t[-1], during FOC1 (upper left), FOC2 (upper right), WEPOCS1 (lower left) and WEPOCS2 (lower right).

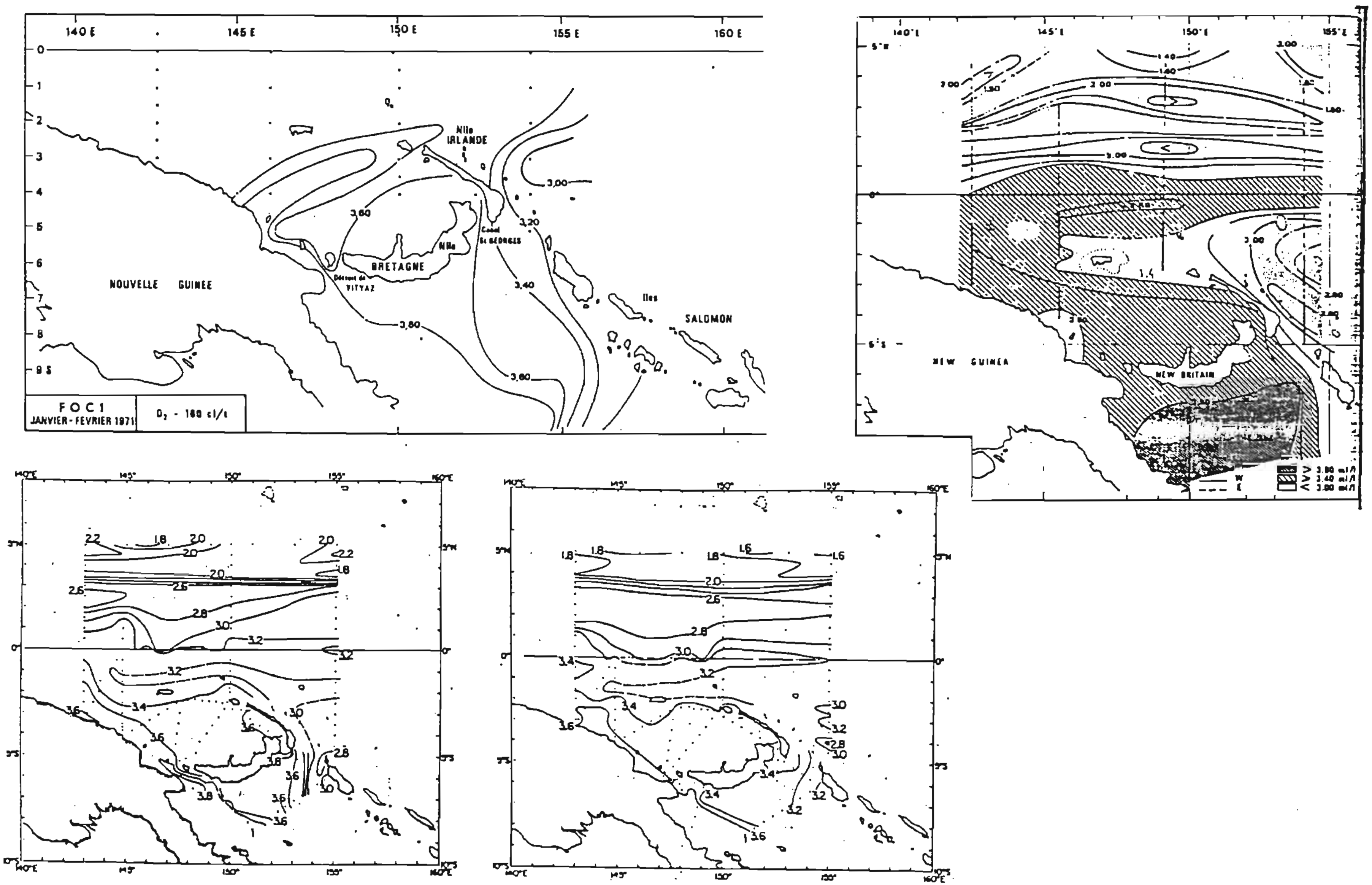

FIG.5. Oxygen ($ml.l^{-1}$) on surface 160 $cl.t^{-1}$, during FOC1 (upper left), FOC2 (upper right), WEPOCS1 (lower left) and WEPOCS2 (lower right).

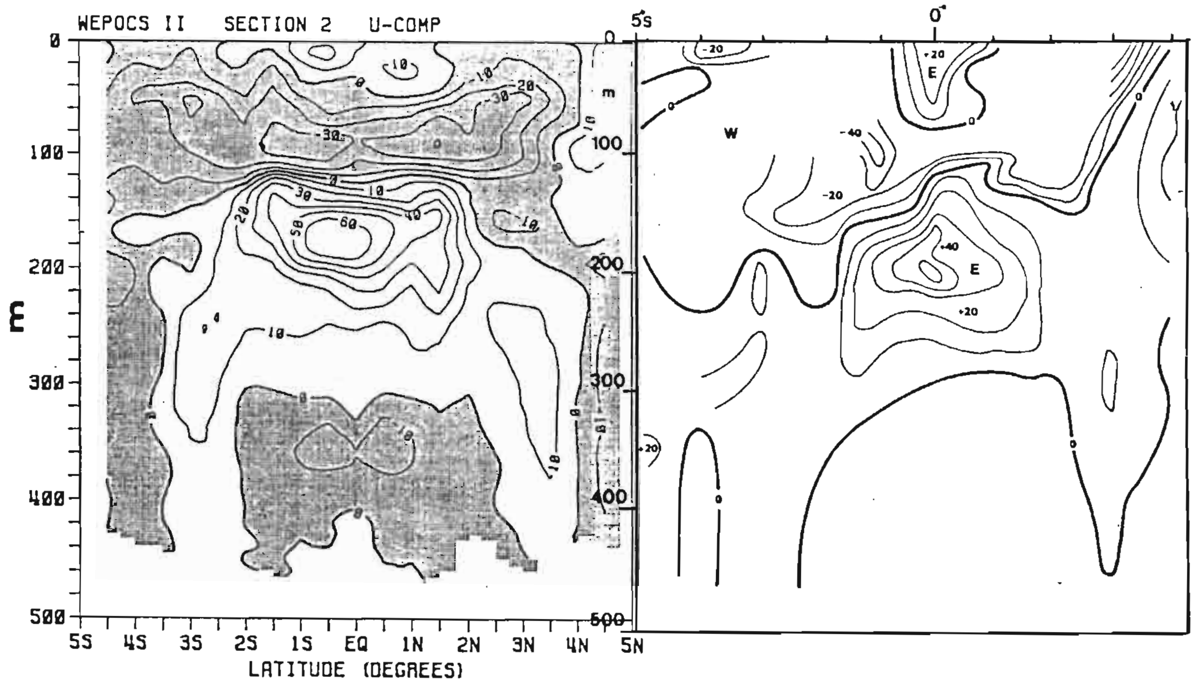

FIG.6. Section of zonal velocity (cm.s^{-1}) during FOC1 (right) at 154°E and WEPOCS2 (left) at 155°E. Shaded areas and negative values indicate westward flows.

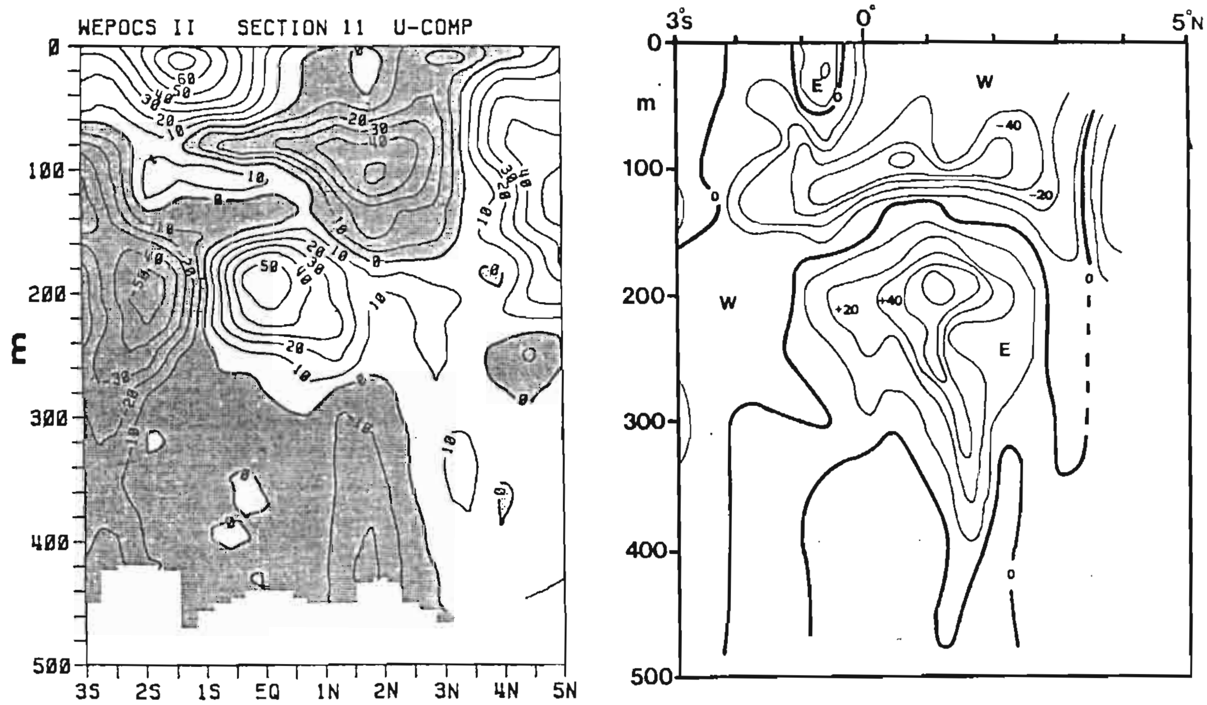

FIG.7. Section of zonal velocity (cm s^{-1}) during FOC1 (right) at 142°30E and WEPOCS2 (left) at 143°. Shaded areas and negative values indicate westward flows.

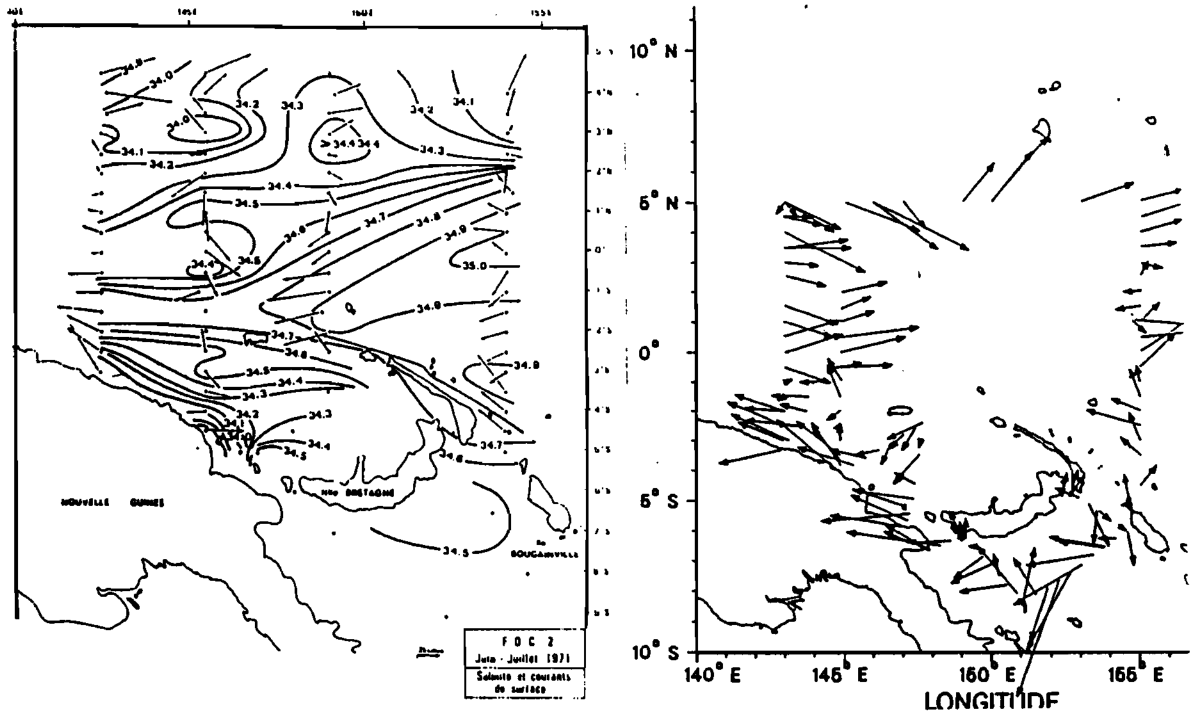

FIG.8. Surface circulation during FOC2 (left) and WEPOCS1 (right).

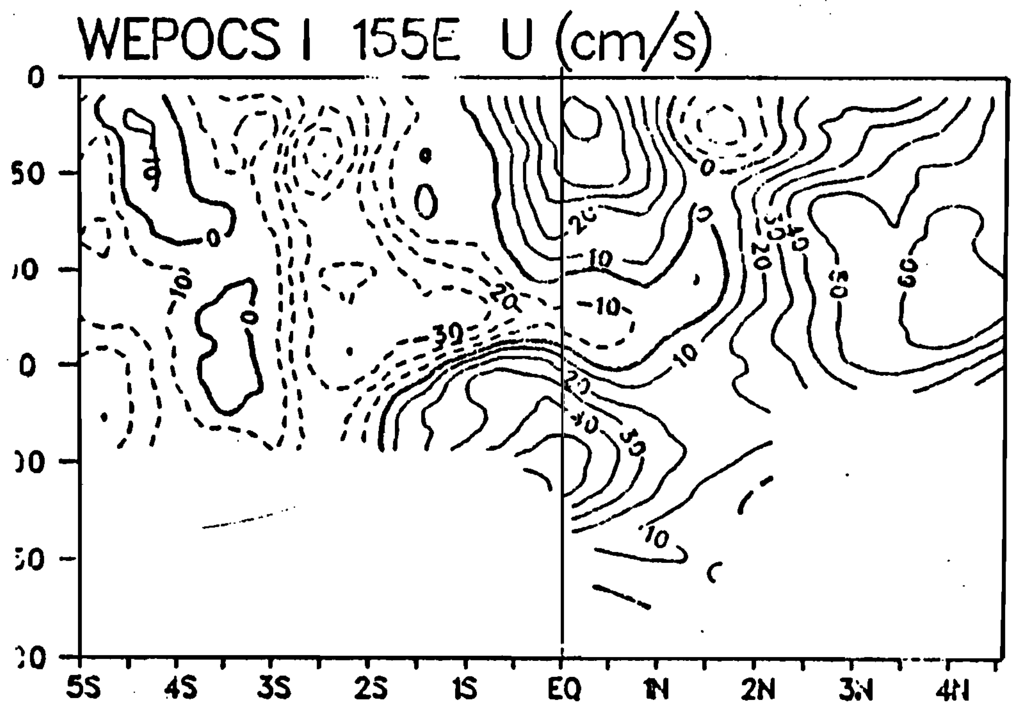

FIG.9. Section of zonal velocity (cm.s[-1]) during WEPOCS1 (June-July 1985) at 155°E. Positive values indicate eastward flow.

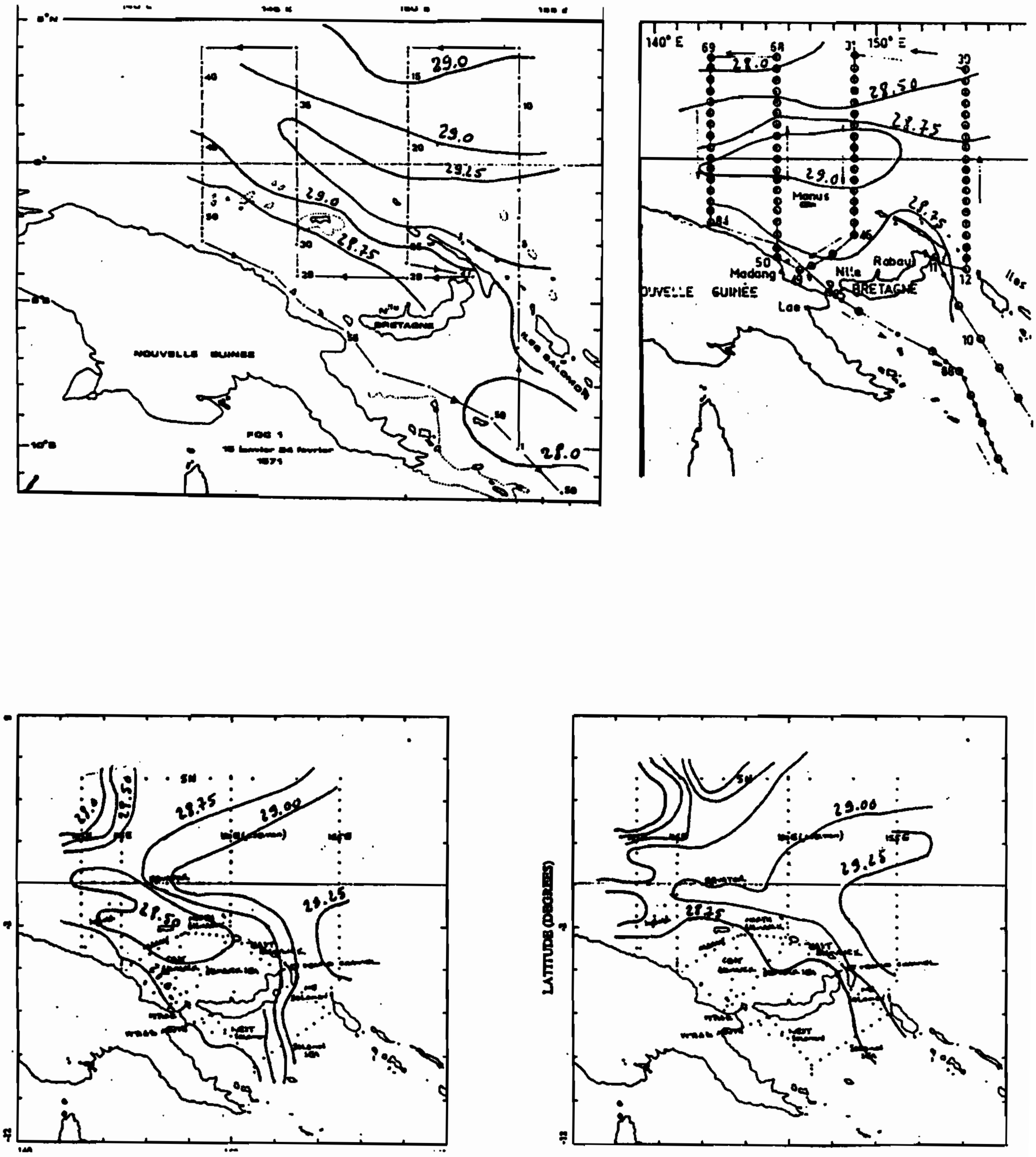

FIG.10. Mean temperature of the 0-100 meter-depth layer (°C). Up : FOC1 and FOC2 cruises. Down : WEPOCS2 and WEPOCS1 cruises.

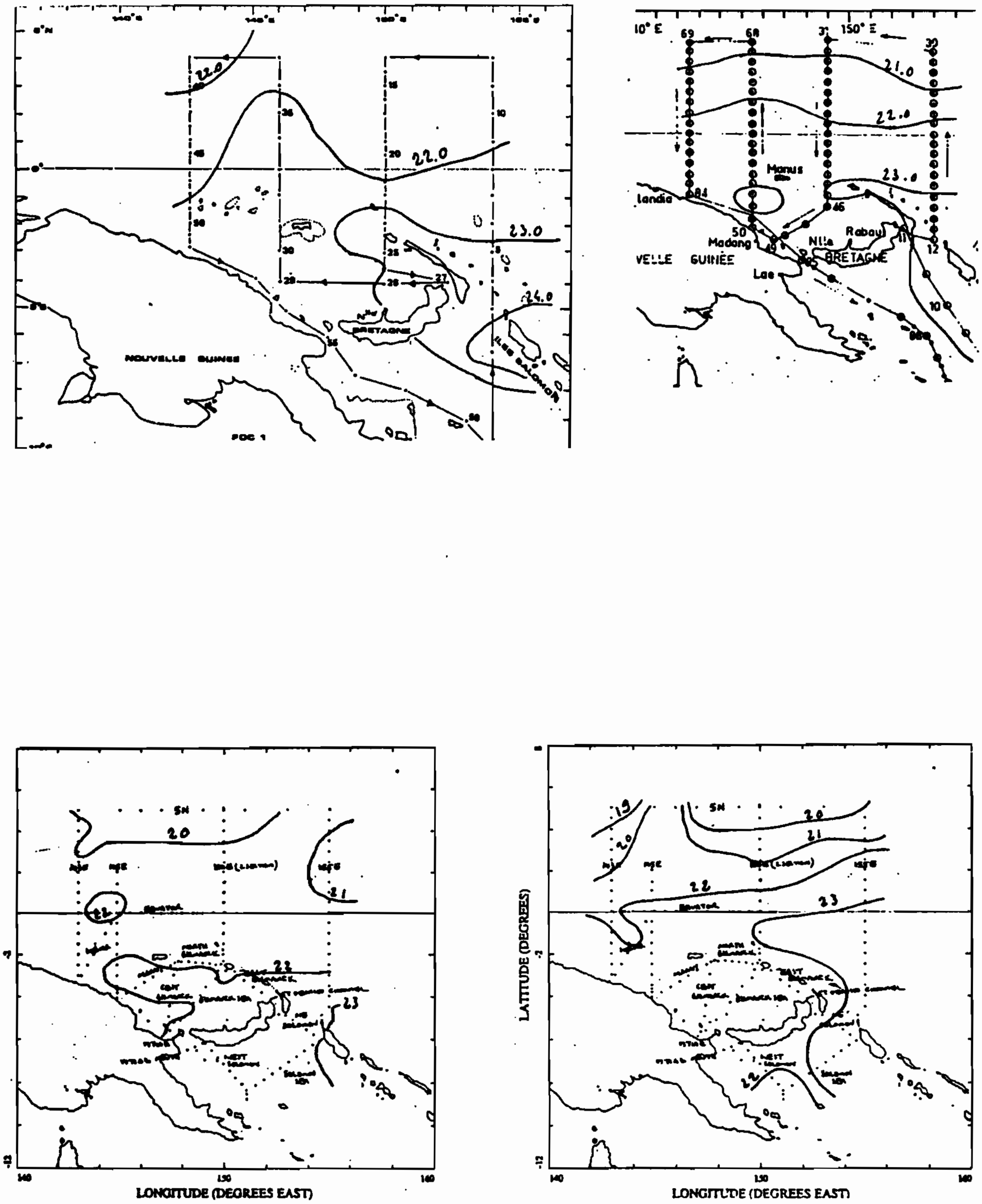

FIG.11. Mean temperature of the 0-300 meter-depth layer (°C). Up : FOC1 and FOC2 cruises : Down : WEPOCS2 and WEPOCS1 cruises.

5. Heat storage

Heat storage is considered during the FOC and WEPOCS cruises under the form of the mean temperature from the surface to 100 meters depth, and the mean temperature from the surface to 300 meters.

0-100 m mean temperature (Fig. 10) is very similar during the four cruises whatever the season : a maximum more than 29°C is located in the vicinity of the equator. West and north of this maximum, heat storage is decreasing.

O-300 m mean temperature (Fig. 11) is homogeneous for three cruises (FOC1, FOC2 and WEPOCS1) : a maximum more than 23°C is found south of the equator and heat storage is decreasing northward. The pattern is different during WEPOCS2 (January-February, 1986) : the mean temperature is 1° less than during the three other cruises. This low heat storage is connected to the appearance of the 1986-87 El Nino : it is likely that a part of the heat content stored in the equatorial western Pacific was already transported to the eastern Pacific through the North Equatorial Countercurrent (Meyers and Donguy, 1984).

6. Conclusion

These four cruises carried out at the same seasons but 15 years apart display very similar features. It seems that the patterns of the equatorial current system (eastward-westward-eastward and westward-eastward from the surface to 300 m depth), which has been observed are worthy of further investigation as to their relationship with the wind forcing. It would be interesting to ascertain how heat storage decrease in the western Pacific could be considered as a precursor of El Nino.

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