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ENSO EVENTS AND CONSEQUENCES ON NUTRIENT, PLANKTONIC BIOMASS, AND PRODUCTION IN THE WESTERN TROPICAL PACIFIC OCEAN

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ABSTRACT

ENSO events change the hydrographical structures and the planktonic biomass and production particularly in the low latitude region of the Pacific Ocean. We compare here the consequences of these variations at 165°E, in two opposite situations, i.e. during an ENSO event in September 1987 and during an non ENSO event in September 1988.

Preliminary conclusions show: (i) for the **nutrients** in September 1987, a thick nutrient-depleted mixed layer (under detectable limits) along the transect, except at 10°S and 9°S and in September 1988, a wide upwelling between 5°S and 2°N with surface nitrate concentrations ranging between 0.3 and 2 µM; (ii) for **phytoplankton**, the abundance of cyanobacteria (procaryotes) and microalgae (eucaryotes) shows large changes both in cells abundance and depth distribution between the two periods. Overall, there is a close relationship between upwelling and increase of phytoplankton abundance and chlorophyll biomass. The integrated values over 0-120m are higher in September 1988 than in September 1987: 5 times for cyanobacteria cells, 3 times for microalgae and 1.4 times for chlorophyll between 6-5°S and 2°N; *(iii)* **primary** production maximum is deeper during ENSO event whereas it is shallow in the upwelling situation. The level of production increased during the upwelling: the integrated value in the 0-120 m averaged (n=7), about 150 versus 59 $mgCm^{-2}h^{-1}$; (iv) for zooplankton (200-2000 µm), there is a significant increase due to the equatorial upwelling in non-ENSO period and none in ENSO event, although a biomass peak appears around 10°S together with the nutrient enrichment.

1. Introduction

14 transects were undertaken on the 165°E meridian between 20°S and 6°-10°N, from 1984 to 1989, within time frames of 3 to 6 months, under 2 ORSTOM programs PROPPAC and SURTROPAC. These cruises occured during the El Nino/Southern Oscillation (ENSO) event and non-El Nino periods. Data collected in the 200m upper layer provide an important basis for the study of effects of long-term hydroclimatic variations on the chemical and biological stuctures in the open western tropical Pacific Ocean. We restrict our study here, to the comparison of two opposite situations, the first in September 1987 (PROPPAC 1 cruise) during an ENSO event, the second in September 1988 (PROPPAC 3 cruise) during a non-ENSO event.

2. Results

a. Physical and chemical environment

The main physical and chemical features during the two periods are presented Figure 1. In September 1987, low salinity waters water (<35.0) originating from the north of New Guinea and the Solomon islands were at the surface north of 14°S, associated with an eastward current. Deeper water originating from the south central Pacific between Tahiti and Easter island formed a tongue of high salinity (>35.5) between 20°S and 2°S. The core (>35.5) was located at 120 m at 8°S. The nutrients were absent at the surface along the whole transect except at 10°-9°S where a slight enrichment, a consequence of the divergence between the South Equatorial Current (SEC) and the South Equatorial Counter-Current (SECC), could be observed.

In opposition with the above situation, high salinity surface waters (>35) were present between 5°S and 2°N in September 1988. This drastic change in sea surface salinity was the direct consequence of the equatorial upwelling. However below 100 m, high salinity waters from the central Pacific (S>35.8), were observed as in the opposite situation. The 35.5 isohaline crossed 2°S as previously. Linked with high surface salinity, the nutrients concentration were important from 5°S to 2°N, with values up to 2.29 µM at 1°S.

b. Biological consequences

* Chlorophyll concentrations

In September 87, surface values >0.2 gl^{-1} were observed in the divergence zone around 12°S-10°S. A deep chlorophyll maximum >0.3 gl^{-1} near 90m, occurred from 6°S to 6°N. In September 88, maximum chlorophyll concentrations were found in the equatorial upwelling, with concentrations higher than 0.2 $g.l^{-1}$ in the whole photic zone (Fig.2).

* Distribution and abundances of procaryotic chrococcoïd cyanobacteria and eucaryotic microalgae.

The maximum abundance of phytoplankton cells always occurred at the same location as the maximum biomass of chlorophyll *a*. In September 87, the maximum cell abundances of cyanobacteria (>7 10^6 cells l^{-1}) occurred from the surface to 80-90m, between 11°S and 6°S (Fig.2). The eucaryotes abundances were weak and located at several stations only at the bottom of the euphotic zone (Fig.3). In September 88, the maximum occurence of cyanobacteria was observed in the equatorial area from 5°S to 2°N (Fig.2) coincident with increase of cyanobacteria abundances, one important zone of great abundance of microalgae occurred from the surface to the bottom of the euphotic zone in the equatorial upwelling (Fig.3).

* Primary production in the equatorial zone

Vertical profiles of dawn-to-dusk rates of in situ primary production showed that in the equatorial area, during EL NINO events, the maximum rate was observed at 60 m. Observations made in the equatorial upwelling in April 1988 (PROPPAC 2 cruise) showed that the maximum rate of primary production was just below the surface at 20 m (Fig.4)

* Zooplankton biomasses

In September 87, the zooplankton biomasses were weak and rather uniform (less than 1000 $mg.m^{-2}$) except at 12°S where a slight enrichment was measured (Fig.3). A year later, a strong increase was measured between 5°S to 2°N. The maximum zooplankton biomass was 2500 $mg.m^{-2}$ at 1°N (Fig.3).

3. Discussion

Looking at all transects, a slight enrichment is often observed around 10°S in the SEC-SECC divergence zone. However, temporary surface nutrients are unusual and are observed only once in September 1987. This enrichment seems to be higher during ENSO events, and has a direct consequence on the increase of phytoplankton abundance.

During PROPPAC 3 (September 1988), when nitrates were present from the surface to the bottom of the photic zone, maximum chlorophyll concentrations were in this case at the same level than the maximum cell counts. Inputs of nutrients in the photic layer allow higher vegetal production and biomass-increases in upper levels of the food-web (here, zooplankton). Such inputs are very important during the NON-ENSO period, when the equatorial upwelling is present. No such a phenomenon, which may be seen on surface salinity nitrate or chlorophyll occurs during ENSO at the equator.

The upwelling consequences are between 5°S and 2°N to 5°N:

- an increase of integrated chlorophyll (1.4 times), numbers of phytoplankton cells (5 times increase for cyanobacteria and 3 times for microalgae) and zooplankton biomass (2.5 times);
- a change of vertical profile of in situ primary production (most of phytoplankton production is achieved in upper layers);
- an increase of integrated primary production (2.5 times).

Nevertheless, equatorial upwelling in the western Pacific is not a general feature of NON-ENSO periods. Since SURTROPAC and PROPPAC transects started in January 1984, it has only been observed for the different parameters in April, July, September 1988 (Blanchot et al. 1988a,b) and January 1989. However in January and August 1984 a change of the salinity structure was reported (Delcroix et al., 1987; Eldin, 1989) and in February 1986 a chlorophyll signature was described by Barber and Kogelschatz, 1989. Intermediate situations during NON-ENSO periods are characterized by different increases of planktonic biomasses. The increases are directly dependent on the depth of the nutricline.

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FIG.1. Meridional profiles of salinity and nitrate along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom).

FIG.2. Meridional profiles of chlorophyll and cyanobacteria along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom).

FIG.3. Meridional profiles of microalgae and zooplankton along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom).

FIG.4. Depth distribution of in situ rates of carbon fixation at the equator in September 1988 and 1989.

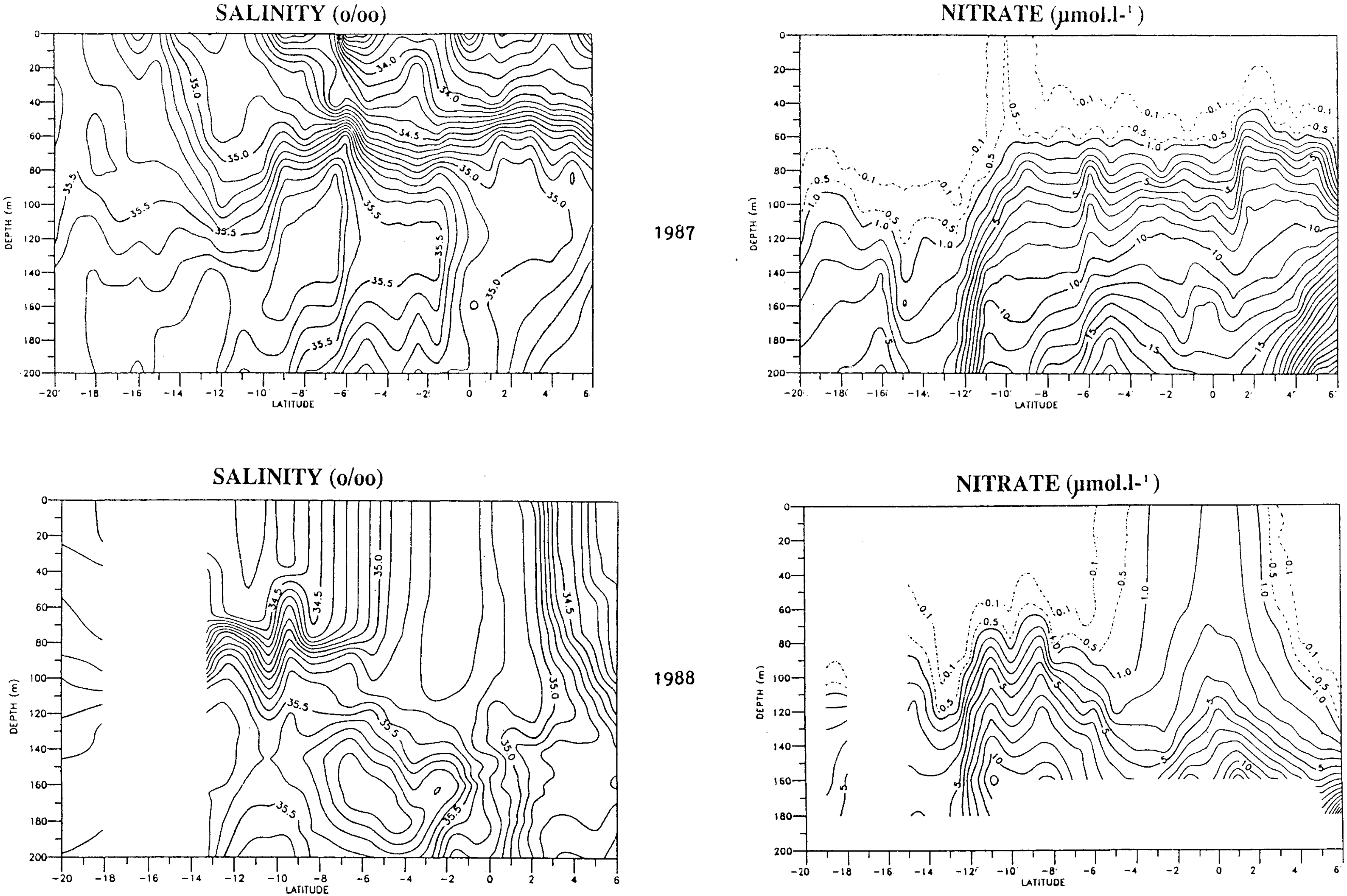

Figure 1 - Meridional profiles of salinity and nitrate along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom)

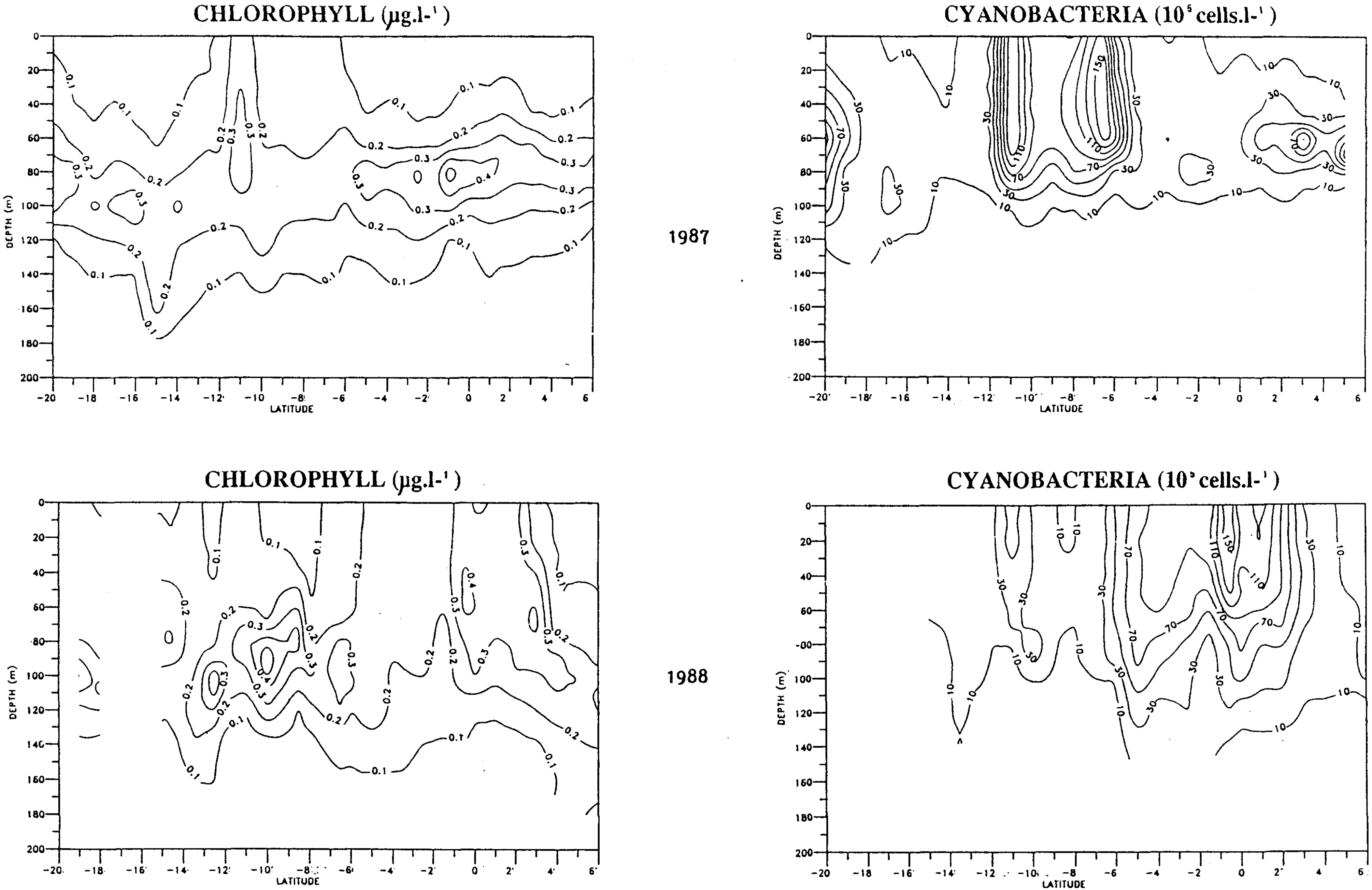

Figure 2 - Meridional profiles of chlorophyll and cyanobacteria along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom)

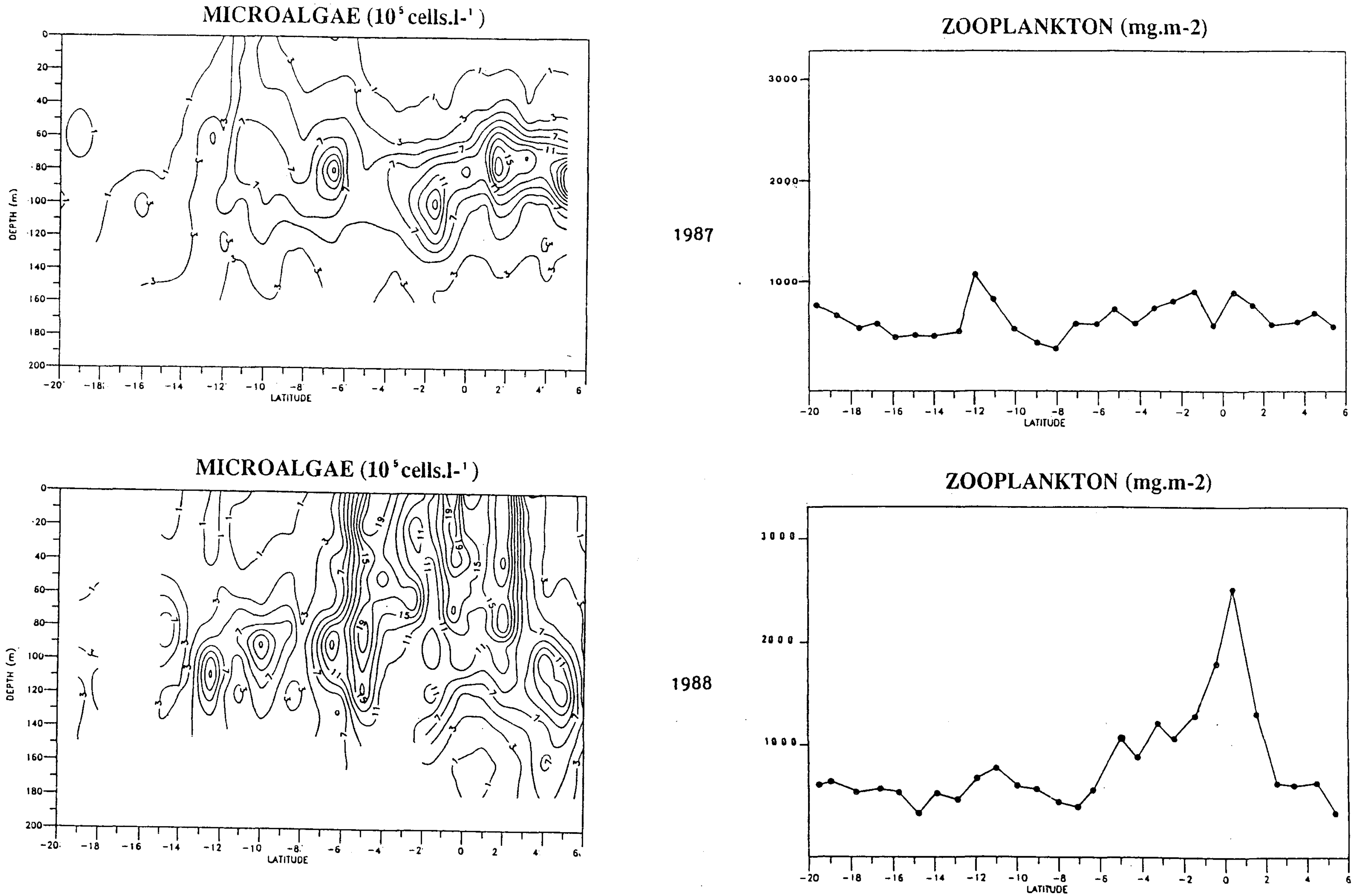

Figure 3 - Meridional profiles of microalgae and zooplankton along 165°E from 20°S to 6°N in September 1987 (top) and September 1988 (bottom)

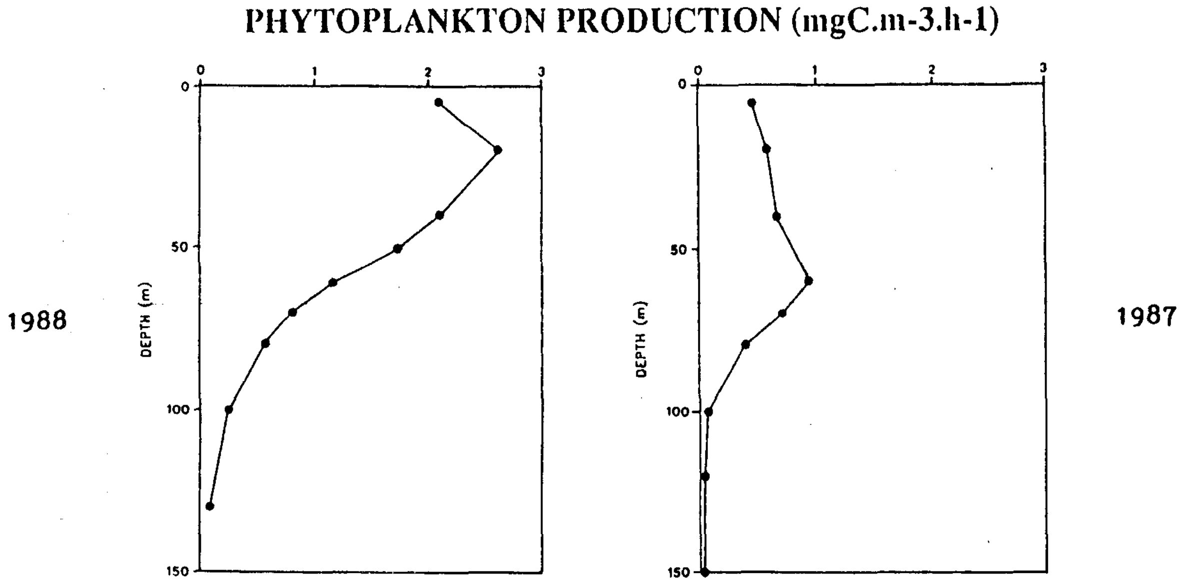

Figure 4 - Depth distribution of in situ rates of carbon fixation at the equator in September 1988 and in September 1987.