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VARIATIONS IN THE LIGHT ABSORPTION PROPERTIES OF PHYTOPLANKTON IN THE EQUATORIAL PACIFIC : OLIGO- TO MESOTROPHY

(8)

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ABSTRACT

The *in vivo* specific absorption coefficient of phytoplankton a*ph (λ) was measured along an equatorial transect in the Pacific Ocean during the JGOFS-cruise in October 1994 in order to validate bio-optical models of primary production. The fiber filter technique was used on board, as well as spectrofluorometry for pigment determination and flow cytometry for cells counting. The a*ph (435-441nm) values strongly decreased from oligotrophic to mesotrophic waters (between 170°E and 153°W). This zonal variation reflected a change in phytoplankton composition, dominated by *Prochlorococcus* in the oligotrophic zone and by picoeucaryotes in the mesotrophic one. Such variations in a*ph have to be taken into account for estimating primary production of the equatorial Pacific Ocean from ocean colour imagery.

KEY WORDS: Bio-optics, Phytoplankton, *in vivo* absorption, Equatorial Pacific

OBJECTIVES

In order to validate bio-optical models of primary production estimation in the Equatorial Pacific, *in vivo* spectral absorption properties of phytoplankton were measured during the JGOFS-FLUPAC cruise in October-November 1994. In order to more specifically assess spatial variations in the specific absorption coefficient a*ph (λ) in relation to pigment and cell composition, a regular sampling was made along an equatorial transect from the western to the central part of the Pacific (170°E to 153°W).

MATERIAL AND METHODS

Spectra of total particulate absorption were obtained on fresh samples with a Beckman DU 26 spectrophotometer with the quantitative filter technique method (Mitchell, 1990). The detrital part was obtained by the Kishino et al. (1985) method, within three months following the cruise. On board spectrofluorometry with a Perkin-Elmer provided photosynthetic pigments (Neveux and Lantoine, 1993), and the sum of chla + div chl a was used for normalization of the specific absorption coefficient, a*ph (λ). On board flow cytometry with a Facs-Scan provided cell numbers of *Prochlorococcus*, *Synechococcus* and red-fluoresceing picoeucaryotes (Blanchot and Rodier, submitted).

RESULTS

From west to east of the equatorial transect, the vertical hydrological structure changed so that, at 171°W, the euphotic depth tilted from 100m to 68m and the nitracline tilted from 80m to the surface (> 0.1 μM NO3) (Le Borgne *et al.*, 1995). The chlorophyll distribution was representative of the change between oligotrophic to mesotrophic conditions, with surface values increasing from 0,08 to 0,3 mg/m3 (Figure 1).

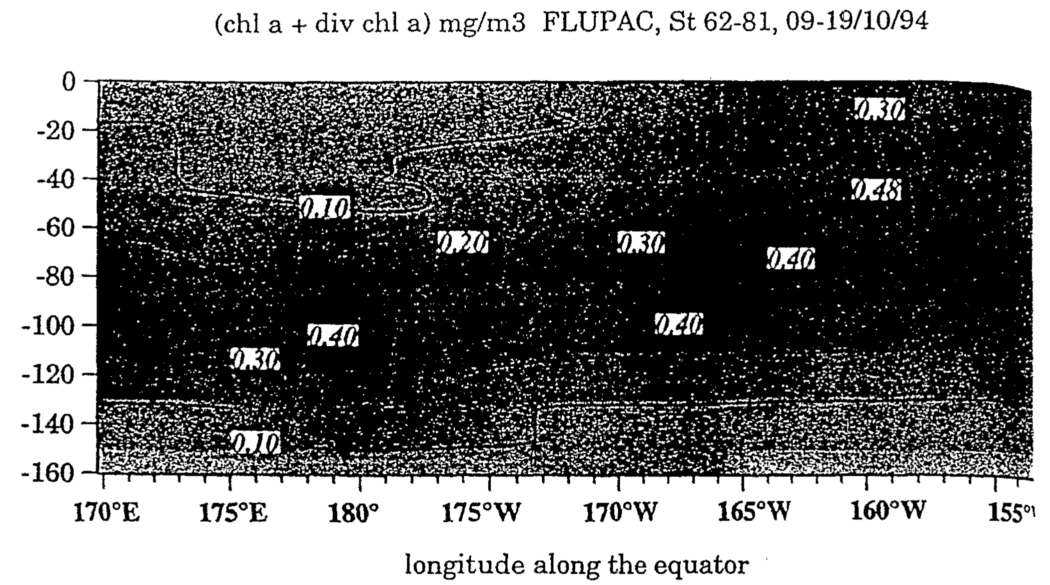

Fig. 1. Distribution of the sum of chl a+ div chl a (mg/m3) along the equator during October 1994 from 170°E to 153°W. In the oligotrophic zone, the DCM was situated under the nitracline (> 0.1 µM NO3). It rised from 100 to 60 meters at about 170°W. In the mesotrophic zone where nitrate was present, high values of (chl a +div chl a) occured from the surface down to 100 -120 m.

These environmental changes showed in the relative abundance of *Prochlorococcus* vs picoeucaryotes which decreased from west to east of the transect (Figure 2a, Figure 2b).

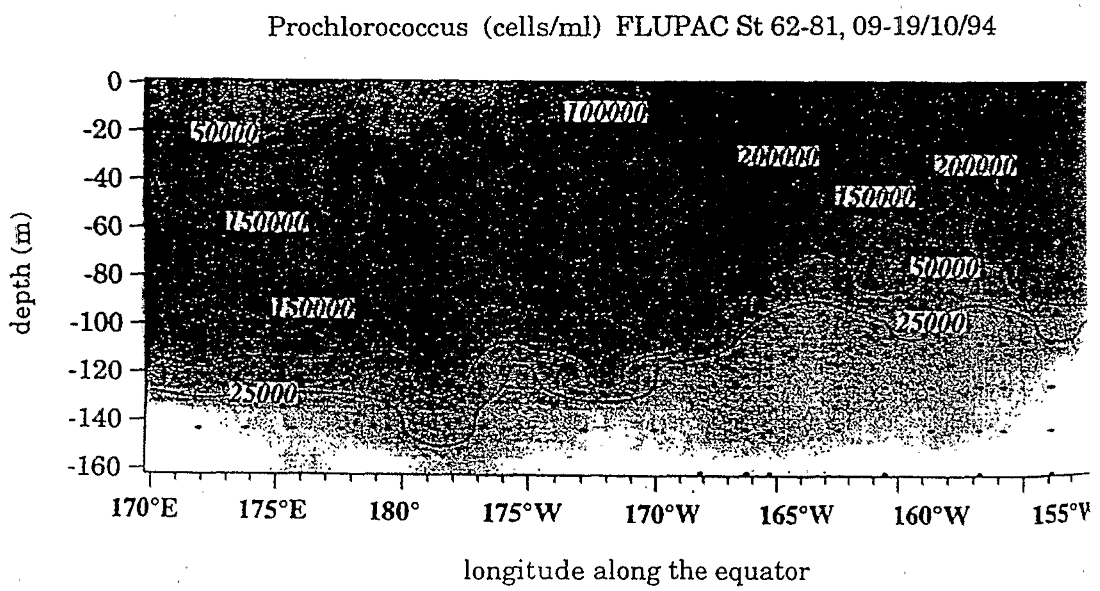

Fig. 2a. Distribution of *Prochlorococcus* cell numbers (c/ml) along the equator during October 1994 from 170°E to 153°W. An ubiquitous and high abundance was found along the equator. The maximum abundance was found at the DCM in the oligotrophic zone (west of 172°W) and in the euphotic layer in the mesotrophic zone (east of 172°W). Dominance of *Prochlorococcus* in the oligotrophic zone west of 172°W (ratio of div chl a/chl a + div chl a was > 60% and ratio of cell numbers > 99 %).

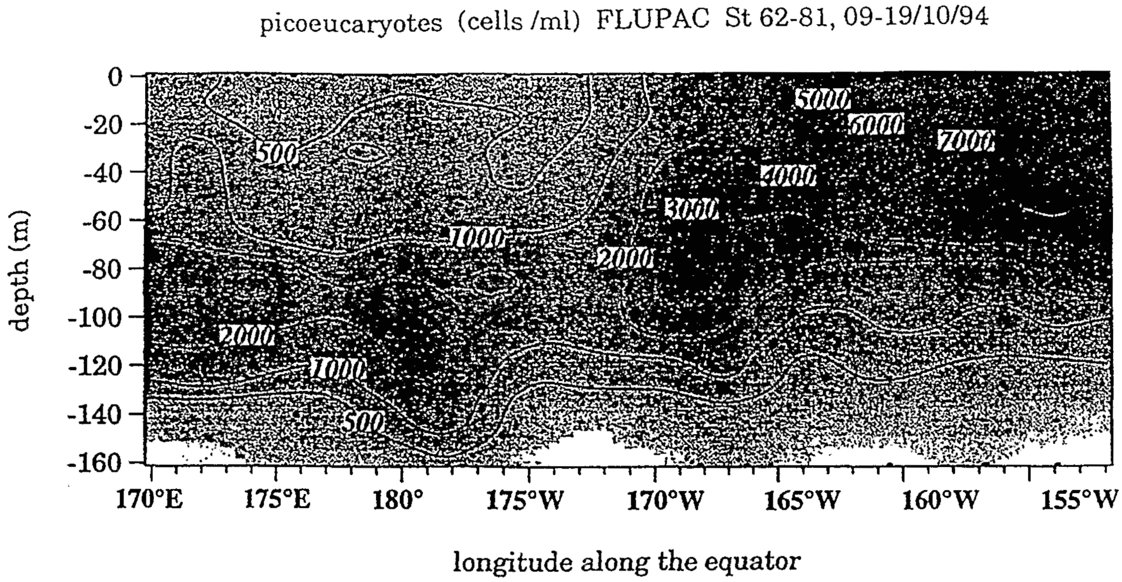

Fig. 2b. Distribution of red-fluoresceing picoeucaryotes cell numbers (c/ml)) along the equator during October 1994 from 170°E to 153°W. The maximum abundance was found at the DCM in the oligotrophic zone (west of 172°W) and above the euphotic layer in the mesotrophic zone (east of 172°W). Dominance of picoeucaryotes in the mesotrophic zone east of 172°W (ratio of div chl a/chla + div chl a < 50% and ratio of cell numbers < 97%).

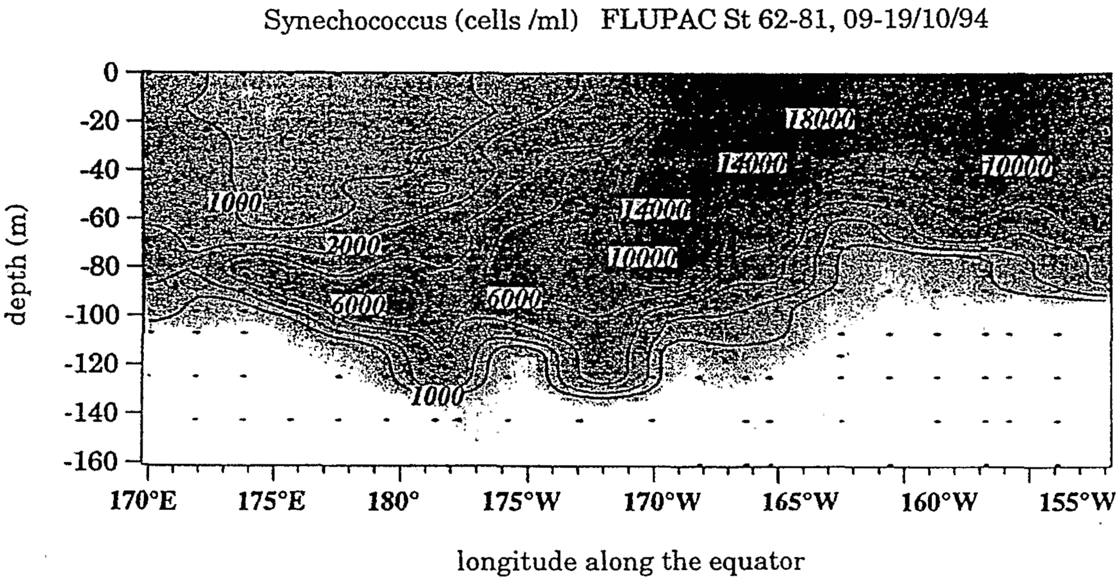

Fig. 2c. Distribution of *Synechococcus* cell numbers (c/ml) along the equator during October 1994 from 170°E to 153°W. Weak abundance in the oligotrophic zone west of 172°W, medium abundance in the mesotrophic zone east of 172°W. Weak influence on the total biomass.

The distribution of aph (435-441 nm) followed the distribution of the biomass all along the equator with maximal values of 0.025 m-1 at the DCM west of 172°W, and of 0.03 m-1 in the surface layer in the mesotrophic area east of 172°W. Lower values (< 0.10 m-1) characterized the surface layer in the oligotrophic zone and values less than 0.005 m-1 were found in the deeper layer all along the transect.

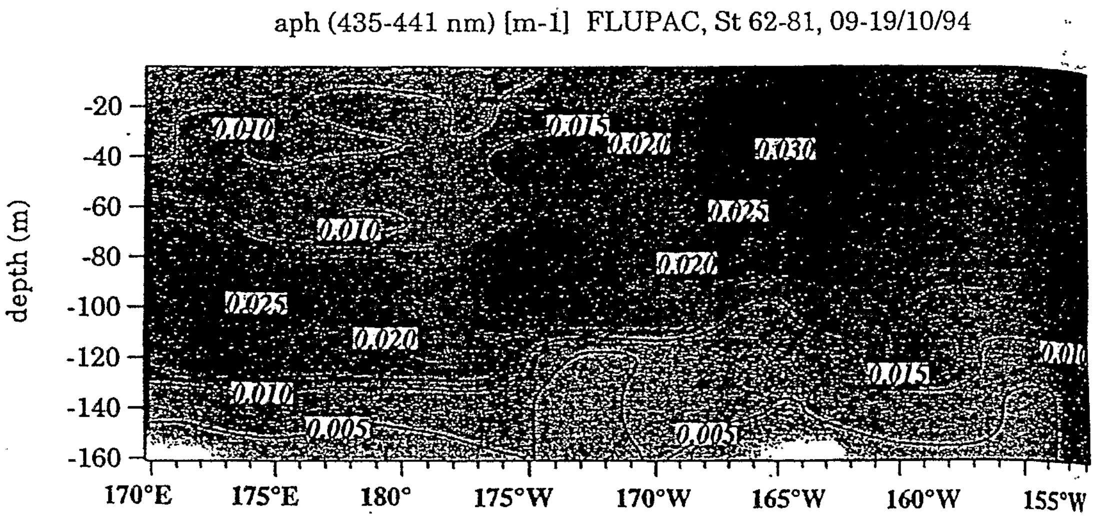

Fig. 3. Distribution of the phytoplankton absorption coefficient, aph (ap-ad), in the blue (435-441 nm) along the equator during October 1994 from 170°E to 153°W.

Maximal values of 0.15 [m2 (mg chl a+ div a)-1] were found in the first 40 meters in the oligotrophic zone, from 170°E to about 165°W, while lower values of 0.08 [m2 (mg chl a+ div a)-1] characterized the surface layer in the central mesotrophic waters from 165°W to 153°W (Figure 4). The a*ph values at the 445 nm wavelength, more related to the div chl a of *Prochlorococcus*, decreased from 0.18 to 0.08 m2 (mg chl a+div chl a)-1 (not shown). The blue to red ratio in a*ph changed from 7 to 4 in the 40 first meters. In the oligotrophic area, a*ph showed a strong vertical gradient, while it was more homogeneous in the mesotrophic zone.

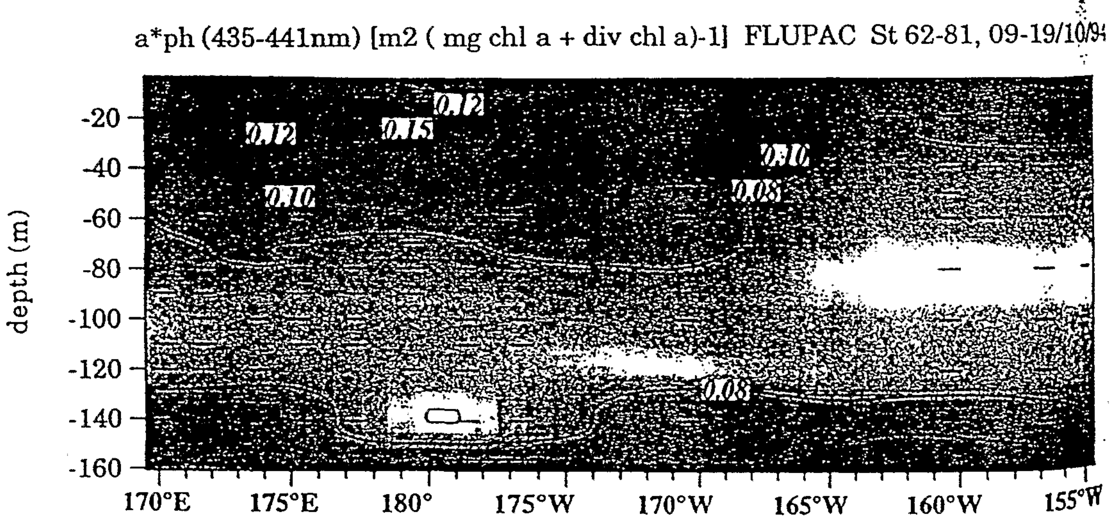

Fig. 4. Distribution of the specific absorption coefficient, a*ph in the blue (435-441 nm) normalized to the sum of (chl a + div chl a) along the equator during October 1994 from 170°E to 153°W.

DISCUSSION

Vertical variations of the blue a*ph were related to the variation of the package effect due to the increase of chl a/cell with depth as a photoadaptation to low light levels, and to the vertical decrease in the relative contribution of photoprotectant pigments per cell (Bricaud and Stramski, 1990). Zonal variations of a*ph along the equator were most probably related to package effect and photoprotectant pigment relative concentration in cells. From oligotrophic to mesotrophic waters, the decrease in the relative abundance of *Prochlorococcus* vs. picoeucaryotes leaded to a decrease in photoprotectant accessory pigments content vs. chl a (div chl a) per cell (Claustre, preliminary data), and to an increase in chl a biomass and in the mean size of cells (Le Bouteiller *et al.*, 1992). Both effects (added to a possible overestimation of a*ph by the use of a unique beta-effect correction, not well adapted to *Prochlorococcus*, Moore et al.. 1995) leaded to higher values of a*ph in the oligotrophic waters.

APPLICATIONS TO REMOTE SENSING

In the equatorial Pacific, surface chlorophyll is a good index of the upwelling enrichment (Dupouy-Douchement *et al.*, 1993). Large zonal variations in a*ph (λ) were associated to a change in phytoplanktonic community related to a change in the trophic situation. These changes in a*ph (λ) must be taken into account, after correction by the non photosynthetic pigment effect, to estimate production at large scales with bio-optical models and ocean colour images.

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EARSeL European Association of Remote Sensing Laboratories

ISPRS International Society for Photogrammetry and Remote Sensing (Commission VII, Working Group 1)

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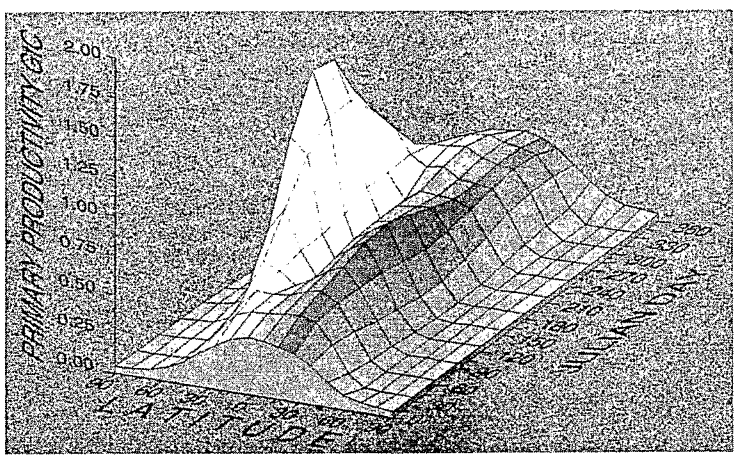
Assessment of Remote sensing Tools
for the
Estimation of Photosynthesis and Primary Production
Present and Future Potential



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