Phytoplankton communities and primary production in the Western Equatorial Pacific and Bismarck Sea

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Phytoplankton community structure and productivity were studied in the Western Equatorial Pacific (WEP) and in the Bismarck Sea (BS) as part of the JGOFS and TROPICS (Tropical River Ocean Processes In Coastal Settings) programs. Cruise details are given in Table 1 and the study area is shown in Figure 1. The phytoplankton community structure was estimated from HPLC pigment data using the program CHEMTAX.

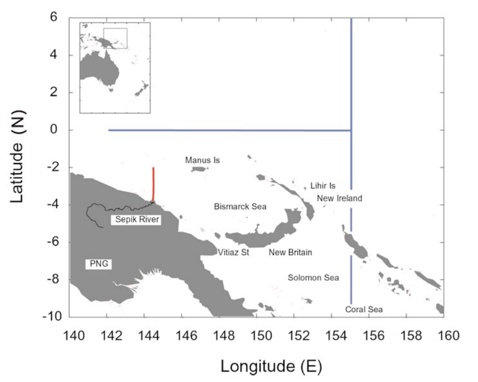


Figure 1 Australian Western Equatorial Pacific (JGOFS) and Bismarck Sea (TROPICS) study region. Transects along the equator (all cruises) and along 155 °E (JGOFS) are shown in blue. Stations were also occupied at various locations in the Bismarck Sea (TROPICS) with the 1997 N-S transect from the Sepik River mouth shown in red.

Table 1 Australian cruises in the Western Equatorial Pacific and Bismarck Sea during the Equatorial Pacific JGOFS and TROPICS programs.

Program	Cruise	Dates	Latitude	Longitude	Conditions at equator
JGOFS	FR08/90	02/10/90 – 17/10/90	10 °S – 5 °N	155 °E	normal
JGOFS	FR05/92	15/06/92 – 13/07/92	10 °S – 10 °N	155 °E	mid 1991 – 1993 El Niño
JGOFS	FR08/93	05/11/93 – 01/12/93	10 °S – 10 °N	155 °E	end 1991 – 1993 El Niño
TROPICS	FR07/97	05/08/97 – 17/08/97	4 °S – 0 °	143 °E – 152 °E	early 1997 – 1998 El Niño
TROPICS	FR01/00	18/01/00 – 01/02/00	4 °S – 2 °N	143 °E – 150 °E	normal

In the WEP there is usually a shallow halocline(s) overlying a deep thermocline and nutricline which limits upwelling of nutrient-rich water into the euphotic zone. A Deep Chlorophyll Maximum (DCM, 60 -100 m) develops at the base of the oligotrophic warm pool where light is limited but macronutrients increase sharply. Under El Niño conditions, the thermocline and nutricline can shallow by up to 50 m. Despite this uplift and major changes in currents in 1992 compared to 1990, the shape of the DCM, the maximum chlorophyll *a* (Chl *a*, sum of mv-Chl *a* and dv-Chl *a*) concentration (0.45 and 0.4 μg l^{-1}) and the depth integrated Chl *a* (Table 2) were similar while the depth of the DCM (S of 2 °N) was only slightly shallower (Figure 2).

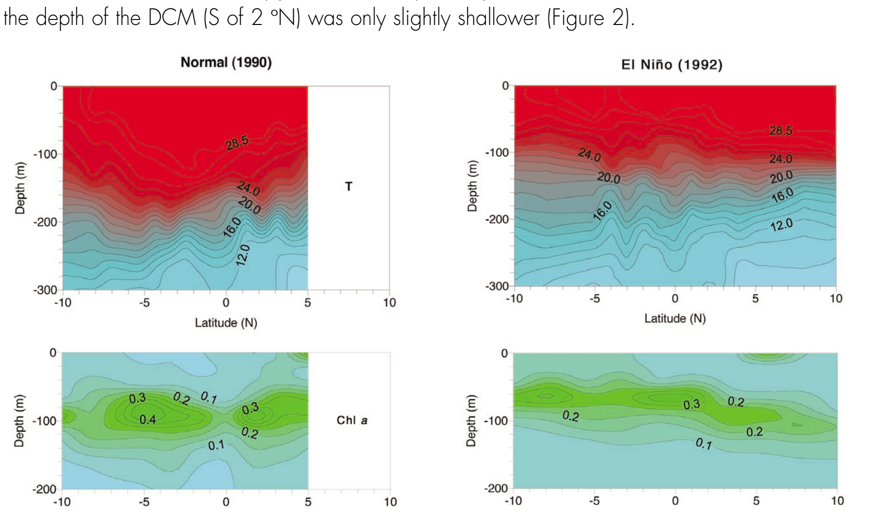


Figure 2 Contour plots of temperature (T) and Chl *a* from *in situ* fluorescence along 155 °E in the warm pool during normal and El Niño conditions.

Picoplankton dominate the phytoplankton community of the WEP. Picoeukayotes, particularly haptophytes, and the prokaryotes, *Prochlorococcus* and *Synechococcus* are the major contributors to Chl *a* (Table 2). The depth integrated Chl *a* was similar between cruises and also generally between stations. Apart from diel affects, a quasi-steady state exists where growth is balanced by losses through predation, cell lysis, advection and export.

However, there is considerable interannual, interstation and temporal variability in the phytoplankton community composition (particularly with *Prochlorococcus*, *Synechococcus*, chlorophytes and haptophytes), and also in the Chl *a* normalized maximum light-saturated rate of photosynthesis (Table 3).

This suggests phytoplankton composition is a complicated function of ENSO, seasonal and short term events such as transient nutrient enrichment of the euphotic zone.

Table 2 Percentage contribution of algal taxa to the depth integrated Chl *a* (mg m^{-2}) measured by HPLC or flow cytometry fluorescence (FC; Jean Blanchot, unpublished data)) at the equator during Australian Western Equatorial Pacific JGOFS or TROPICS cruises.

Cruise Longitude at equator	1990 155 °E	1992 155 °E	1997 149 °E	2000 150 °E	2000 150 °E
	HPLC	HPLC	HPLC	HPLC	FC
Chl *a*	23.4	21.8	27.5	26.2	
prokaryotes					
Prochlorococcus	19.3	16.2	35.0	46.3	41.4
Synechococcus	12.6	14.8	1.8	11.4	13.5
	31.9	*31.1*	*36.8*	*57.7*	*54.9*
picoeukaryotes					
chlorophytes [1]	10.3	14.3	nd [2]	1.2	
chrysophytes T2	11.6	10.7	15.9	4.0	
cryptophytes	0.1	4.2	3.2	5.1	
diatoms	1.8	5.5	0.3	0.1	
dinoflagellates	4.2	2.8	nd	nd	
haptophytes T3	39.0	27.8	43.9	31.9	
prasinophytes	1.0	3.7	nd	nd	
	68.1	*68.9*	*63.2*	*42.3*	*45.1*

1 includes prasinophytes not containing prasinoxanthin. **2** not detected, although may be assigned to an endosymbiont.

Table 3 Mean values of Chl *a* normalized maximum light-saturated rate of photosynthesis (P^B_m ; mg C (mg Chl *a*)$^{-1}$ h^{-1}) along 155 °E by depth band and local time of day during Australian Western Equatorial Pacific JGOFS cruises.

	0 – 50 m [1]			50 – 100 m			100 – 150 m		
Time of day [2]	**1990**	**1992**	**1993**	**1990**	**1992**	**1993**	**1990**	**1992**	**1993**
04:30 – 09:30	2.2	5.2	5.0	1.6	1.5	3.2	0.9	1.3	1.8
09:30 – 14:30	1.5	5.2	4.1	1.6	1.5	3.9	0.9	1.3	1.9
14:30 – 19:00	1.5	2.1	4.0	1.6	1.5	2.8	0.9	1.3	1.6
19:00 – 04:30	0.8	2.1	1.1	1.6	1.5	2.9	0.9	1.3	1.6

1 Despite similar Chl *a* m^{-2} and DCM depths, values of P^B_m were higher in 1992 and 1993 due to increased euphotic zone nutrients.
2 Diel effects were apparent in 1992 and 1993.

There is a high discharge of sediment, freshwater and solutes into the BS by the Sepik River. The plume from the Sepik River tends to flow to the SE during the NW monsoon (November – March) and to the NW during the SE tradewinds (May – September). The turbid waters of the plume can extend for 150 km (Figure 3) and can affect the spatial distribution and physiology of phytoplankton due to mixing processes and the decrease in ambient light.

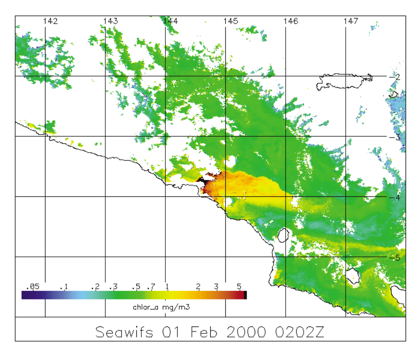
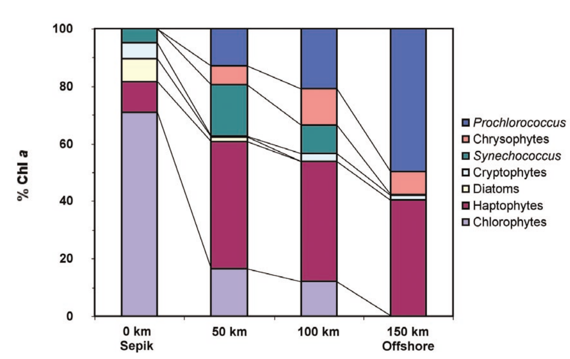


Figure 3 Seawifs image during the NW monsoon showing the Sepik River plume extending about 150 km to the SE.

On a transect north from the mouth of the Sepik River (Figure 1) the depth integrated contribution of chlorophytes, diatoms and cryptophytes, which were high in the Sepik River (low flow), decreased considerably away from the mouth as river and marine waters mixed and suspended sediments and light attenuation decreased. Haptophytes were significant throughout marine waters whereas *Prochlorococcus* increased markedly only in oligotrophic waters (Figure 4).

Figure 4 The % contribution of algal taxa to the depth integrated Chl *a* at 50 km intervals along a N-S transect in 1997 from the Sepik River, Papua New Guinea to oligotrophic waters.



In general, phytoplankton pigment : Chl *a* ratios of photoprotective pigments decreased with increasing depth and decreasing light whereas the ratios of photosynthetic pigments usually increased with depth if the increase in the cellular concentration of the photosynthetic pigment was greater than that of Chl *a* (Figure 5).

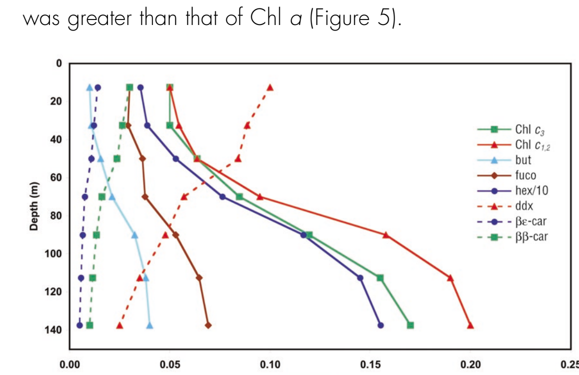


Figure 5 Typical profile of pigment : Chl *a* ratios; haptophytes in the 2000 TROPICS cruise.

Although there were exceptions, most likely due to differences in species, variations in the pigment : Chl *a* ratios in a given phytoplankton taxa were similar in the suspended sediment laden waters of the coastal BS and clear equatorial waters despite significant differences in light attenuation and were within the range reported in the literature.

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