Phytoplankton biomass and productivity in The Great Astrolabe Lagoon

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Abstract

Phytoplankton biomass and productivity of the Great Astrolabe Reef lagoon were studied using measurements of chlorophyll concentration and carbon uptake. Average chlorophyll concentration was 0.8 mg m^{-3} with 45% of phytoplankton passing through 3µm. Primary production was 1.3 gC m^{-2} day^{-1} (30m depth) with 47 % due to phytoplankton <3µm.

1. Introduction

Coral reef lagoons can play an important role in Pacific Islands economy when used for aquaculture. However, lagoon productivity studies are necessary to estimate their potential for mariculture.

Here, we present results from primary production experiments carried out in the Great Astrolabe Reef (GAR) lagoon in April and May 1993. The experiments were undertaken with two goals : (1) to estimate the average productivity of the lagoon and (2) using size-fractionation methods, to estimate relative contributions of phytoplankton sub-populations to community productivity.

2. Materials and Methods

2.1 Water sampling

The ASTRO expedition has studied the lagoon of the Great Astrolabe Reef and the surrounding ocean between April 17th and May 1st. Twenty five station were sampled in the GAR lagoon and one in ocean outside the reef (Figure 1). Water samples were collected with acid-cleaned Niskin bottles at 5m depth intervals between 0 m and 40m (the deepest station). In ocean outside the reef, water samples were collected at 20m intervals to 120m and then at 150m and 200m.

2.2 Primary production measurements

Two to five subsamples of unscreened sea-water (Furnas, 1987) were incubated *in situ* with 2 µCi of ^{14}C-bicarbonate in polycarbonate bottles. Surface irradiance was recorded during incubations with a LI-COR solarimeter. Following incubation, bottles were filtered through 3 µm Nuclepore filters ; pressure heads during fractionation never exceeded 0.004 atm. The filtrates were immediately refiltered onto 1 µm Nuclepore filters and then onto 25 mm Whatman GF/F glass fiber filters. Filters were acidified with 250 µl of 0.5N HCl to remove inorganic carbon. Radioactivity was measured with a liquid scintillation counter. Areal production was calculated by trapezoidal integration and daily production estimated by dividing the production measured during the incubation period by the fraction of total daily irradiance during that period.

2.3 Chlorophyll determination

Chlorophyll concentrations were determined by fluorometry (Yentsch & Menzel, 1963). Water samples for chlorophyll determinations were size fractionated by the same methods as productivity samples : They were successively filtered through a 3 µm filter (Nuclepore), then through a 1 µm filter (Nuclepore) and finally through a GF/F (Whatman) filter.

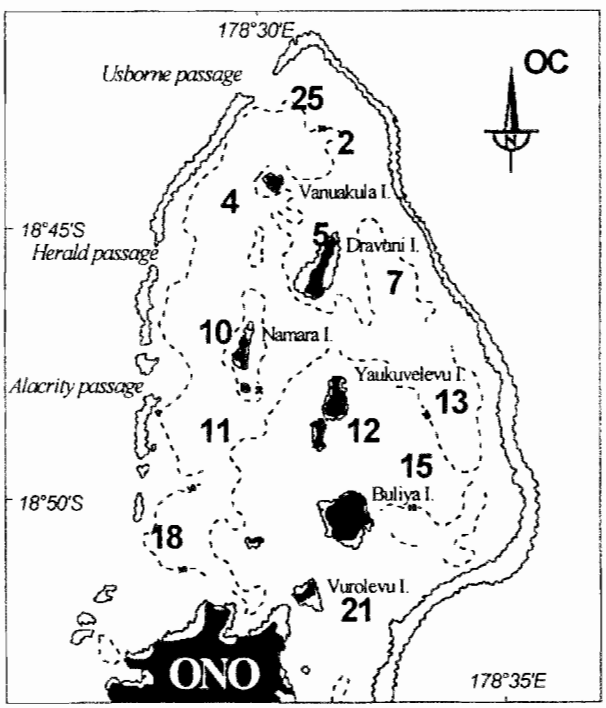

Figure 1: Station locations in GAR lagoon (OC = oceanic station)

3. RESULTS

3.1 Lagoon

Results are summarized in Table 1

Table 1 : Average ± SE of chlorophyll concentrations (Chl) and percentage of biomass and Primary Production (PP) of size classes

	>3µm	3-1µm	<1µm	Total
mg Chl m^{-3}	0.423 ± 0.018 N=47	0.123 ± 0.013 N=47	0.237 ± 0.018 N=47	0.830 ± 0.040 N=53
% Chl	55.2 ± 2.0 N=47	15.2 ± 1.2 N=47	29.6±1.5 N=47	
% PP	47.1 ± 2.1 N=43	22.6 ± 1.4 N=43	30.3±1.4 N=43	

3.1.1

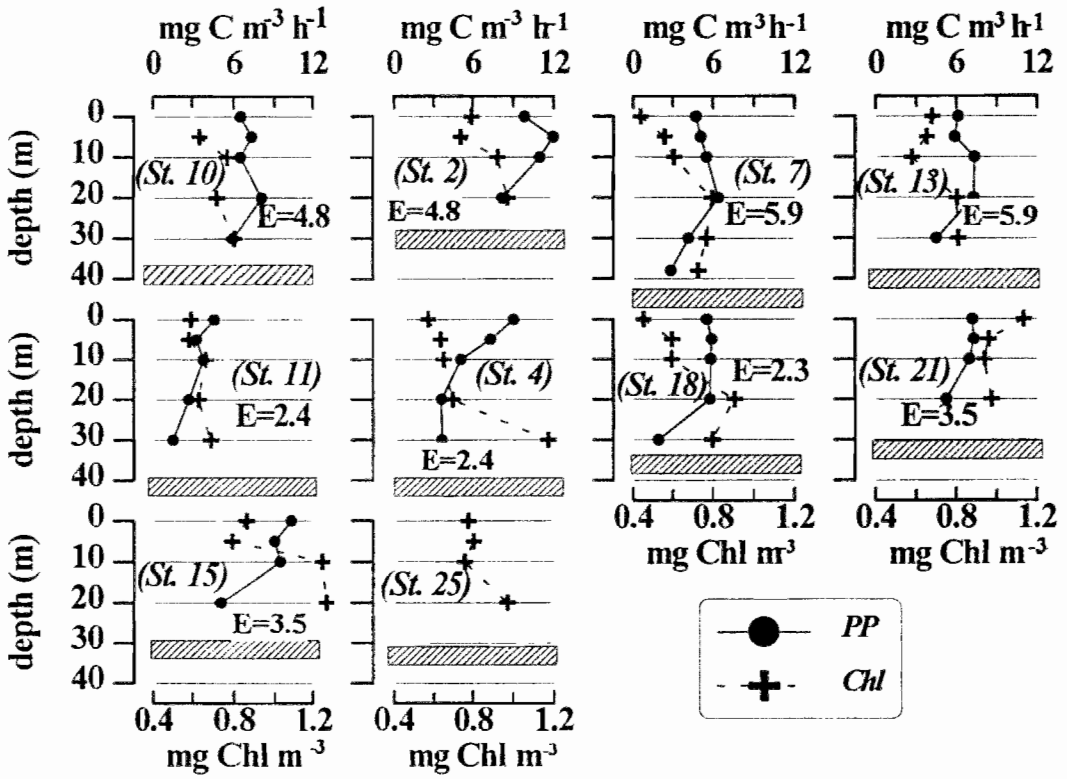

Figure 2: Chlorophyll (*Chl*), primary production (*PP*) and light energy (E : E m^{-2} h^{-1}) in GAR lagoon

3.1.1 Vertical variations

Phytoplankton biomass estimated by chlorophyll concentration ranged from 0.4 to 1.2 mg m^{-3} and generally increased with depth except at station 21 (Figure 2).

Primary production (Figure 2) ranged from 1.6 mg C m^{-3} h^{-1} at 30 m depth (station 11) to 12 mg C m^{-3} h^{-1} at 5 m depth (station 2). Maxima were observed close to the surface.

3.1.2 Horizontal variations

South east stations (15 and 21) presented maxima of chlorophyll and stations 7 and 11 the minima (Figure 3).

Stations 15 and 21 presented highest percentage of cells < 1µm (45%) and stations 10, 2, 7, 4, 18, 25, highest percentage of cells > 3 µm (> 60%) (Figure 4).

To compare station productivity, we calculated the integrated (upper 20m and 30m) plankton production (Table 2). Values vary from 604 (station 11) to 1337 mg C m^{-2} d^{-1} (station 2).

Table 2: Incident light energy (E m^{-2} d^{-1}) during the day (Ed) and during the incubation (Ei) and integrated primary production (IPP: mg C m^{-2} day^{-1}) in GAR lagoon

date	stat	Z st.	Ed	Ei	dt	IPP_{20m}	IPP_{30m}
18/04/1994	10	37	30.85	15.24	3.18	912	1363
18/04/1994	2	28	30.85	15.24	3.18	1337	
19/04/1994	7	43	36.71	18.25	3.09	694	1025
19/04/1994	13	38	36.71	18.25	3.09	852	1221
20/04/1994	11	39	20.8	7.33	3.00	604	788
20/04/1994	4	39	20.8	7.33	3.00	987	1295
21/04/1994	18	34	20.43	9.83	4.27	1036	1378
22/04/1994	21	30	21.18	10.92	3.09	803	
22/04/1994	15	29	21.18	10.92	3.09	1002	
					Average	**914.0**	**1178.3**
					n	**9**	**6**
					SE	**71.5**	**94.0**

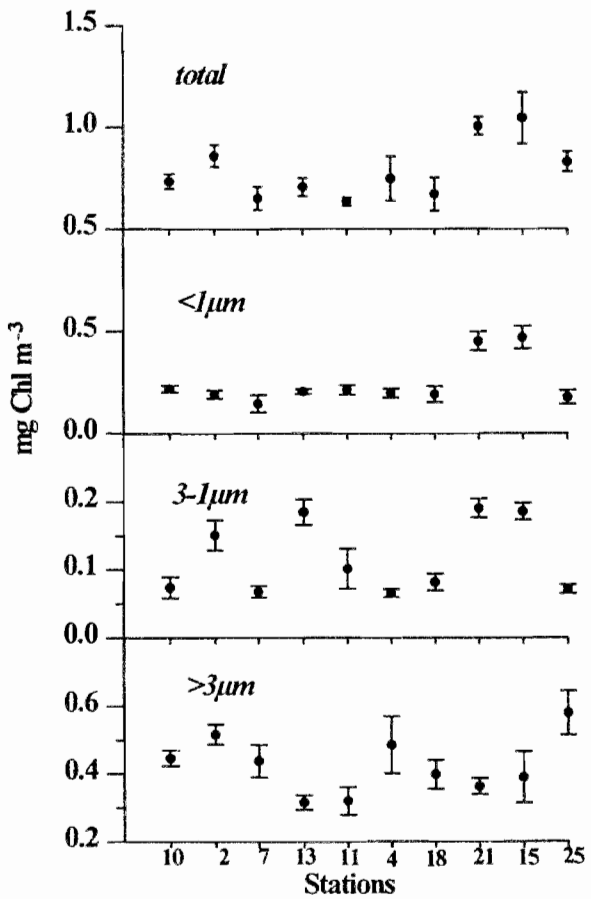

Figure 3: Average ± SE of Chl in different size fractions in GAR lagoon

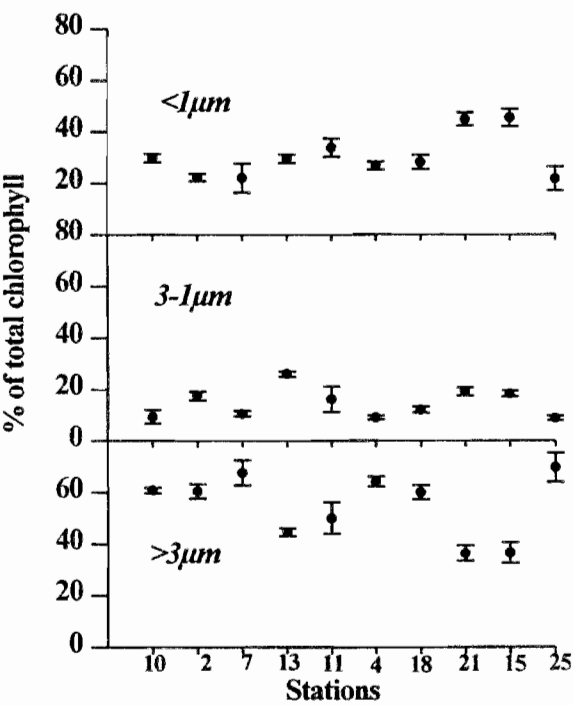

Figure 4: Percentages of Chl in different size fractions in GAR lagoon

3.2 Ocean

The maximum of chlorophyll in ocean was at 30 m depth (0.44 mg m^{-3}) and represented 40 % of the lagoonal Chl. The >3µm size class dominate phytoplankton in the upper 40 m and the <1µm size class below (Figure 5).

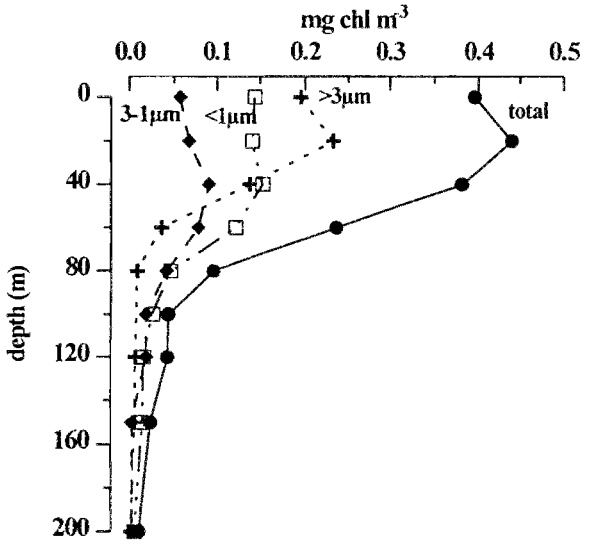

Figure 5: Vertical profiles of chlorophyll at oceanic station

4. Summary conclusions

The GAR lagoon phytoplankton biomass estimated with chlorophyll was 0.8 mg m^{-3}. Four times higher than Tuamotu atoll lagoon (Charpy-Roubaud et al. 1989, Charpy et al. 1992). Differences can be observed according to the station location. The stations located in the south east of the lagoon presented highest biomass. At these stations, we observed a dominance of picoplankton < 1µm. However, in average 55% of phytoplankton cells had a size >3µm. In Tuamotu atoll lagoons, this percentage was only 30% (Charpy & Blanchot 1996).

Primary production in the upper 30m was in average 1.3 g C m^{-2} day^{-1}. This value is 2 to 3 times the values recorded for atoll lagoons (Charpy-Roubaud et al. 1989, Charpy et al. 1992, Charpy & Blanchot 1996) and 100 times higher than the value published by Sorokin (1979) for an other Fijian island : Ngellelevu atoll. The oceanic station sampled, showed a maxim of Chl in the upper 40m. In this layer, phytoplankton size was very similar to lagoon, however, below, the picoplankton <1µm dominated the biomass.

5. References

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