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# Size distribution of phytoplankton community in oligotrophic tropical coastal waters

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**Abstract:** The size distribution of the phytoplankton community in oligotrophic tropical coastal waters at Okinawa, Japan was investigated. The chlorophyll *a* (Chl *a*) concentrations in surface seawater collected from 9 stations around Sesoko Island and determined using a Whatman GF/F filter varied from 0.131 to 0.60 1 $\mu$ g $l^{-1}$. The average contributions of the pico-, nano-, and micro-phytoplankton to the total chlorophyll biomass in this study were 55%, 28% and 17%, respectively. Due to the size distributions of Chl *a* in the surface waters, our study area was characterized as oligotrophic water because of its higher content of picoplankton (average 48%). Moreover our results revealed that picoplankton was mostly responsible for the change in the Chl *a* concentration and that microplankton also plays an important role in the variation of the Chl *a* concentration, although the relative abundance of microplankton was lower than that of picoplankton.

## 1. Introduction

It is well known that small cells of the nanoplankton and picoplankton are widely distributed and are thought to account for a large proportion of the total phytoplankton production. CHISHOLM (1992) reviewed phytoplankton size and pointed out that the fractional contribution of small cells to the standing crop increases as the total chlorophyll decreases. Until today, many studies have been conducted with respect to the size distribution of the phytoplankton community in the oligotrophic open ocean and eutrophic coastal waters (e. g. ODATE and MAITA, 1988; IRIARTE and PURDIE, 1994; LEE *et al.*, 1996). However, very few studies as to the phytoplankton biomass have been conducted in the oligotrophic tropical coastal area, although much attention has been given to coral reef area (e. g. DELESALLE *et al.*, 1993).

In this study, we investigated the distribution of fractionated chlorophyll *a* (Chl *a*) concentrations of micro-, nano- and picophytoplankton sizes in the tropical coastal waters where Chl *a* concentrations were low. We aimed to determine the relative importance of the pico-, nano- and microplankton in the oligotrophic tropical coastal waters.

## 2. Materials and methods

Oceanographic observations were made and samples were collected at 6 stations (Stn C1, C2, E1, E2, O1 and O2; Fig. 1) by the *R. V. Merulina II* on 28 May 1998. Surface seawater samples were collected with a clean plastic bucket at all sations. In addition, water samples below the surface were collected using Van Dorn bottles from several depths at Stn E1 and O2. Additionally, surface waters were collected using a plastic bucket at the pier of the Sesoko Marine Science Center, University of the Ryukyus (Stn S), Toguchi port (Stn T) and Motobu port (Stn M) on 27 May 1998. Water samples for Chl *a* measurements were imme-

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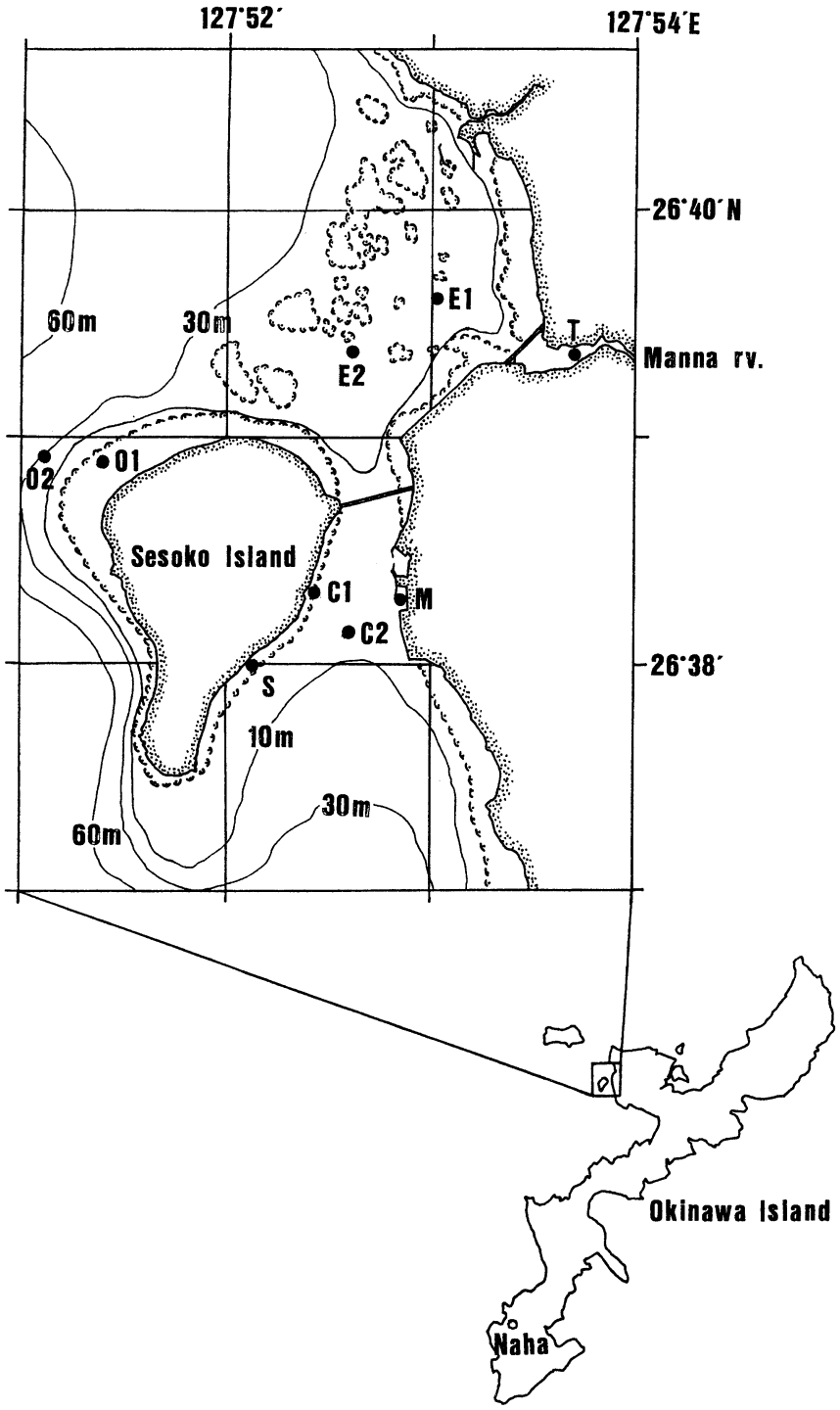


**Fig. 1.** Sampling stations around Sesoko Island, Okinawa. ..... shows a coral reef area.

diately filtered through a Whatman GF/F filter and preserved in N, N-dimethylformamide at −20℃ until analysis (Suzuki and Ishimaru, 1990). Additionally, the Chl *a* concentrations of three size-fractionated samples (0.2–2.0 μm, 2.0–20 μm and >20 μm) were measured using various filters which had different pore sizes using Nuclepore filters (pore size: 0.2 μm and 2.0 μm) and a 20 μm mesh screen (Tanaka Sanjiro Co). Chl *a* concentrations were determined using the fluorometric method of Holm-Hansen *et al.* (1965) as described in Parsons *et al.* (1984), with a fluorometer (Turner model 10-AU). Phytoplankton samples were collected by horizontal tows for about 10 minutes at Stn O2 and E1 using the plankton net with a mesh size of 20 μm (HD-20) and 100 μm (XX13). Phytoplankton samples were fixed by Adachi solution (Adachi and Irie, 1980) and dominant phytoplankton were determined under a microscope. Water temperature and salinity were measured using a YSI Multiparameter Monitoring System model 6000. Transparency was measured using a Secchi disk.

## 3. Results

Stns O1, C1 and S were located in a coral reef and the depths of their stations were very shallow (1.2 to 2.4m). Transparency was very high at all stations and the bottom could be seen from the boat at each station except for Stns O2 and E1. The transparency was 24m at Stn O2 (the water depth was 34m) and 13m at Stn E1 (the water depth was 17.7m). The water temperature and salinity ware similar at all stations, although Stn E1 is located on the Manna river estuaries (Table 1). Phytoplankton samples collected using the two types of nets at Stns O2 and E1 were dominated by *Trichodesmium* (Cyanophyceae), *Ceratium* (Dinophyceae), *Protoperidinium* (Dinophyceae) and *Chaetoceros* (Bacillariophyceae). The concentrations of Chl *a* in the surface seawater, which was determined using a Whatman GF/F filter, varied from 0.131 to 0.601 μg $l^{-1}$. In the horizontal distribution of Chl *a* concentrations in the surface seawater (0m), the Chl *a* concentrations in Toguchi port (Stn T: 0.589 μg $l^{-1}$) and Manna river estuary (Stn E1: 0.601 μg $l^{-1}$; Stn E2: 0.467 μg $l^{-1}$) were relatively higher.

The variations of size fractionated Chl *a* biomass in surface waters was characterized by the high contribution of picoplankton (Fig. 2). In our size fractionated data, picoplankton accounted for 48% of the total biomass in average value.

In the surface water at E1 where the total Chl *a* was the highest (0.601 μg $l^{-1}$), the Chl *a* concentration of the microplankton was also highest (0.181 μg $l^{-1}$ in Stn E1). In the vertical

**Table 1.** Water temperature, salinity and Chl *a* concentrations of surface seawater at sampling stations. Chl *a* concentrations were determined using Whatman GF/F fillter.

| Sampling station | depth (m) | W.T. (℃) | Sal. (psu) | Chl *a* (μg $l^{-1}$) |
|---|---|---|---|---|
| C1 | 0 | 25.74 | 35.09 | 0.267 |
| C2 | 0 | 25.53 | 35.04 | 0.191 |
| O1 | 0 | 25.46 | 34.96 | 0.131 |
| O2 | 0 | 25.68 | 35.07 | 0.330 |
| | 5 | 25.51 | 35.09 | 0.285 |
| | 20 | 25.36 | 35.10 | 0.323 |
| E1 | 0 | 25.51 | 35.12 | 0.601 |
| | 5 | 25.36 | 35.10 | 0.467 |
| | 15 | 25.25 | 35.12 | 0.668 |
| E2 | 0 | 25.70 | 35.11 | 0.467 |
| S | 0 | n.d. | n.d. | 0.234 |
| Toguchi port | 0 | n.d. | n.d. | 0.589 |
| Motobu port | 0 | n.d. | n.d. | 0.304 |

W. T; water temperature, Sal.; salinity n.d.; no data

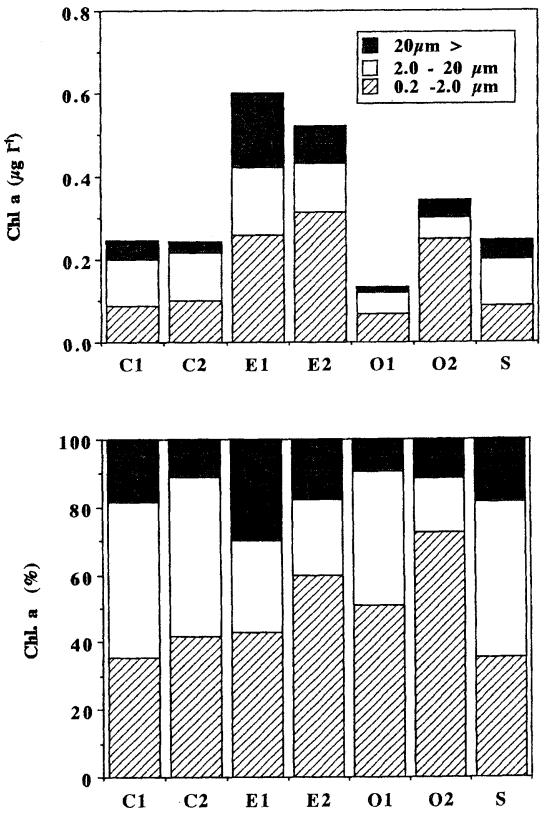


**Fig. 2.** Three size-fractionated concentrations of chlorophyll *a* at surface seawater (Top) and their relative abundance(bottom).

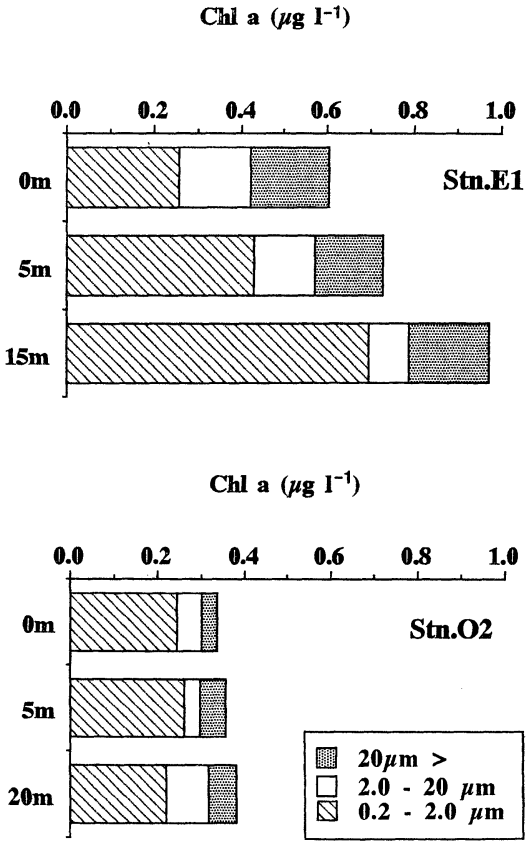


**Fig. 3.** Vertical distributions of three size-fractionated concentrations of chlorophyll *a* at Stns E1 and O2.

distributions of the three size-fractionated concentrations of Chl *a* at Stn E1, the total Chl *a* concentrations increased with depth and the Chl *a* concentrations of the picoplankton also increased with depth. At Stn O2, the total Chl *a* concentrations and the relative abundance of each of the three fractions of Chl *a* was almost vertically constant (Fig. 3).

## 4. Discussion

*Comparison of the Chl a concentrations determined by different filters*

In this study, four types of filters for the Chl *a* determination were used, such as Whatman GF/F filter, Nuclepore filters (pore size; 0.2 μm and 2.0 μm) and a 20 μm mesh screen. When comparing the Chl *a* concentrations using the GF/F filter and 2.0 μm Nuclepore membrane, all Chl *a* concentrations using the 0.2 μm Nuclepore membrane, except for one sample at Stn C1, were higher than those using the GF/F filter (Fig. 4). Whatman GF/F filter is made from the glass fibers and the average opening of the filter is 0.7 μm. Our result indicated that the small phytoplankton pass through the Whatman GF/F and that the Chl *a* concentration, which passed through the Whatman GF/F, but were retained on the 0.2 μm Nuclepore membranes, varied from 0 to 0.302 μg $l^{-1}$. Its fraction contributed up to 36% of the total Chl *a*. Taguchi and Laws (1988) reported on the content of microparticles which passed through the Whatman GF/F but were retained on the 0.2 μm Nuclepore membranes in Kaneohe Bay, Hawaii. Furthermore, Dickson and Wheeler (1993) reported that the surface Chl *a* concentrations measured with the 0.2 μm Nuclepore filters were up to four-fold higher

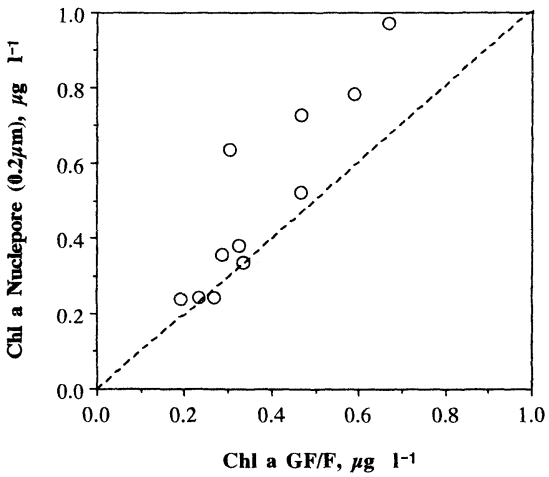


**Fig. 4.** Comparison of chlorophyll *a* measurements made with Whatman GF/F fillters and Nuclepore fillter(pore size: 0.2 μm).

than those measured with the Whatman GF/F filters. In contrast CHAVEZ *et al.* (1995) reported that these two types of filters produce results that differ only by a few percent. Our results from tropical coastal waters indicated that the small phytoplankton pass through the Whatman GF/F and they can not be ignored. Our results also suggested that filtration through the widely used GF/F filters underestimated Chl *a* concentration in tropical coastal seawater.

*Three size-fractionated concentrations of Chl a*

The average contributions of the pico-, nano-, and micro-phytoplankton to the total chlorophyll biomass in this study were 55%, 28% and 17%, respectively. Moreover the mean contribution of the picoplankton size to the total chlorophyll biomass in surface waters was 48%. On the other hand, vertical profiles of three size-fractionated concentrations of Chlorophyll *a* from the two stations (Stns E1 and O2) showed that their relative abundances did not widely change vertically (Fig. 3). It is known that the fractional contribution of small cells to the standing crop of phytoplankton increases as the total chlorophyll decreases (CHISHOLM, 1992). ODATE and MAITA (1988)

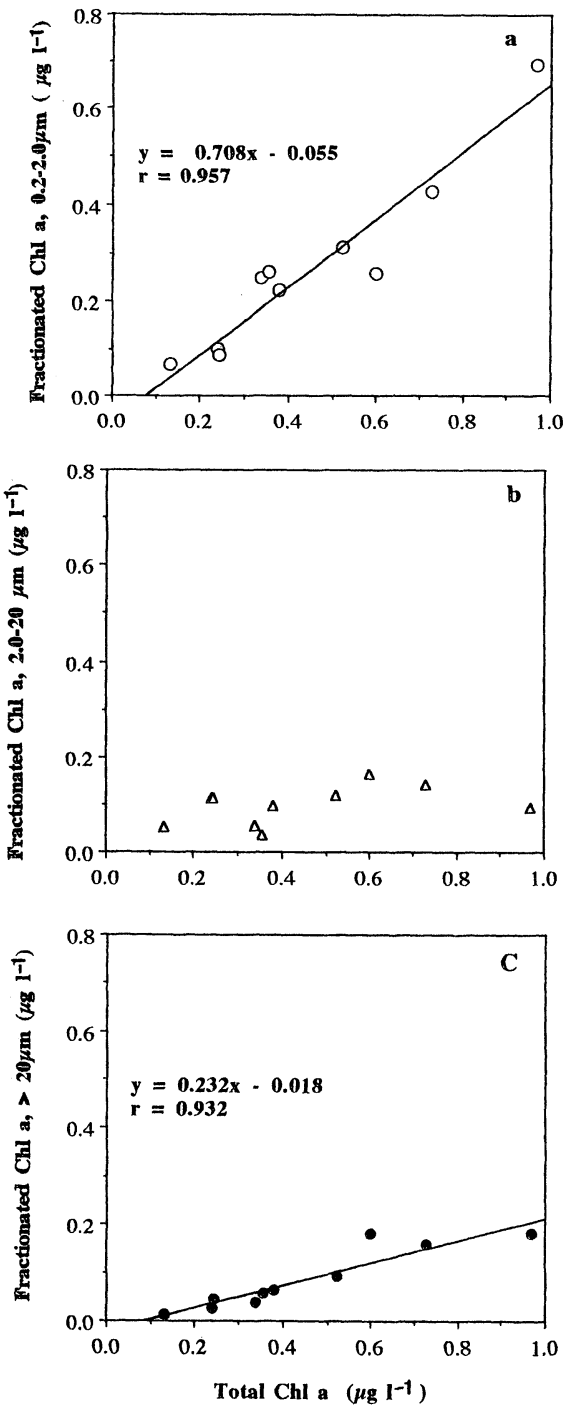


**Fig. 5.** Relationship between Chl *a* concentrations, total Chl *a* concentration and Chl *a* concentratins in 0.2–2.0 μm (a) 2.0 –20 μm (b) and >20 μm (c) fractions.

showed that picoplankton was estimated to constitute from 80% to 90% of the subtropical waters in which the Chl *a* concentrations are low. On the other hand, it has been reported that the picoplankton was estimated to constitute up to 10% or 20% of the eutrophicated area (IRIARTE and PURDIE, 1994; LARSSON and HAGSTROM, 1982). We conclude that our study area is characterized by oligotrophic waters because of its higher contribution of picoplankton size (48%) than that of eutrophic coastal waters (up to 10 or 20%).

Generally, nano- and picoplankton usually dominates in oceanic systems, while the microplankton show marked seasonal trends and dominate when conditions became favourable for diatom (e. g. MAITA and ODATE, 1988). In the marine environment picoplankton contribute significantly to the total biomass of phytoplankton communities (STOCKNER, 1988) and can be responsible for more than 50% in waters where total Chl *a* concentration is less than 0.5 $\mu$g $l^{-1}$ (IRIATE and PURDIE, 1994). On the other hand, RODRIGUEZ and GUERRERO (1994) reported that the largeincreases in biomass consisted mostly of nanoplankton (2.0 to 20 $\mu$m) and this generally represents some 50% of the Chl *a* in Malaga Bay, South Spain. TADA *et al.* (1994) also reported that the contributions of nanoplankton (2.0 to 25 $\mu$m) was 50% (average) in Hiroshima Bay, Japan and that the change in nanoplankton fraction was reflected in the total Chl *a* concentrations. In our size fractionation data the phytoplankton community was dominated by picoplankton and the changes in the picoplankton fraction was reflected in the total Chl *a* concentration (Fig. 5a). The variation in the Chl *a* concentration of microplankton also correlated with that of the total Chl *a* concentration (Fig. 5c), although the variation in microplankton was small compared to that of the picoplankton. Our results indicated that microplankton also play an important role in the increase in the Chl *a* concentration, although picoplankton was mostly responsible for the high Chl *a*.

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