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[Short communication]

Size-fractionated chlorophyll *a* concentration at the surface in the offshore subarctic North Pacific in summer 2000

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Abstract : Small-sized phytoplankton, <2 or 2-10 μm fraction, significantly contributed to the total chlorophyll *a* (chl *a*) concentration at all stations. Each fraction accounted for 35-71% of the total, and the sum of both fractions accounted for 67–93% of the total. Nevertheless, large-sized phytoplankton, >10 μm fraction, as well as the small-sized phytoplankton contributed to the relatively high total chl *a* concentration of ≧ 1 mg m^{-3}, accounting for about 30% of the total, in case of much influence of near-shore water.

Keywords : *size−fractionated chlorophyll a , large−sized phytoplankton, offshore subarctic North Pacific, summer*

1. Introduction

From studies of size-fractionated chlorophyll *a* (chl *a*) in the subarctic North Pacific (ODATE and MAITA, 1988/89; YAMAMOTO and TANIGUCHI, 1993; ODATE, 1996; SHIOMOTO *et al*., 1999; BOYD and HARRISON, 1999; HASHIMOTO and SHIOMOTO, 2002; IMAI *et al*., 2002), it gradually emerged that ordinarily small-sized phytoplankton (<5 μm fraction) contribute to total chl *a* concentration, whereas in case of total chl *a* concentrations exceeding 1 mg m^{-3}, large-sized phytoplankton (>10 μm fraction) contribute to total chl *a* concentration. However, information regarding the circumstances of the contribution of large-sized and small-sized phytoplankton in the subarctic North Pacific Ocean is currently far from sufficient. Hence, we investigated size-fractionated chl *a* concentrations in the offshore subarctic North Pacific in late summer 2000.

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2. Materials and methods

This study was conducted during a cruise of the R/V Kurosaki (450t) between 30 August and 9 September 2000. Stations were located between 165°E and 145°W along 48°N (Fig. 1). Seawater samples were collected from the surface by acid-cleaned plastic bucket. Separate surface seawater samples (1 liter) were filtered through Nuclepore filters with pore sizes of 10 μm (>10 μm fraction) and 2 μm (>2 μm fraction), and a Whatman GF/F (ca. 0.7 μm pore size: total), in order to determine chl *a* concentrations of the >10 μm, 2–10 μm and <2 μm fractions as well as total. The filters were stored frozen at −20℃ until analysis on land. Chl *a* concentrations were determined with a Hitachi F-2000 fluoro-photometer according to PARSONS *et al*. (1984) for samples extracted with 90% acetone. Calibration of the fluoro-photometer was performed with a commercially prepared chl *a* standard obtained from Wako Pure Chemical Industries, Ltd. (Tokyo).

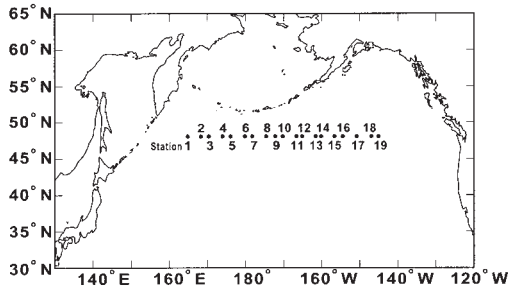

Fig. 1 Location of sampling stations in the subarctic North Pacific between 30 August and 9 September 2000.

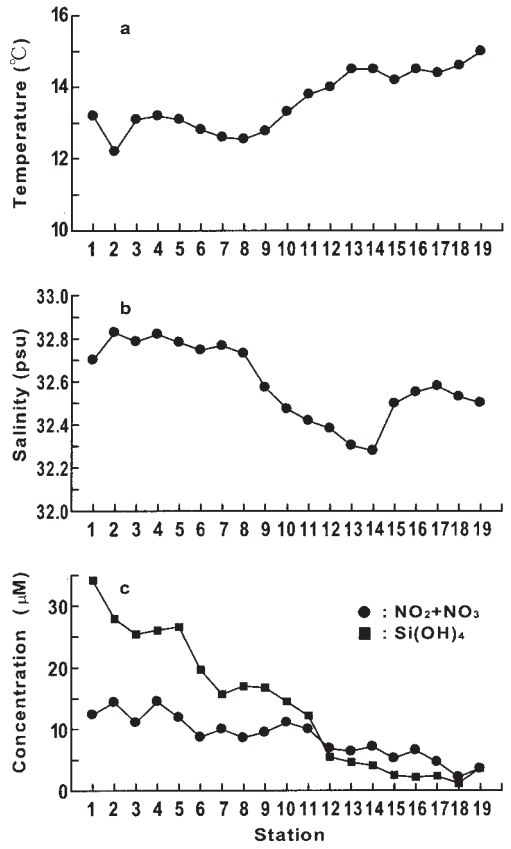

Fig. 2 Variations of (a) temperature (℃), (b) salinity (psu), (c) nitrite + nitrate ($NO_2 + NO_3$) and silicate ($Si(OH)_4$) concentrations (μM) at the surface.

Temperature and salinity were measured with a thermometer and a Guildline AUTOSAL, respectively. Nitrite + nitrate and silicate concentrations were measured with a Bran and Luebbe Auto Analyser Traacs 800 after storage at −20℃.

3. Results and discussion

Surface temperatures were nearly uniform between Stations 1 and 9, and tended to increase after Station 10 (Fig. 2a). Surface salinity was nearly uniform between Stations 1 and 8, and decreased markedly after Station 9 (Fig. 2b). Salinity increased again at Station 15 and was nearly uniform after that station. Less saline water with salinity of <32.5 psu was observed between Stations 10 and 14, and a minimum value of 32.28 psu was observed at Station 14.

Both nitrite + nitrate and silicate concentrations tended to decrease from Stations 1 to 19 (Fig. 2c). However, the decrease in the concentration was steeper in silicate than in nitrite + nitrate between Stations 1 and 12. The silicate concentrations were lower than the nitrite + nitrate concentrations between Stations 12 and 18.

Total chl *a* concentrations ranged from 0.32 to 1.32 mg m^{-3} (Fig. 3a). Concentrations of $\geqq$ 1 mg m^{-3} were observed at Stations 1, 9, 11, 12 and 14. Although the percentage contribution of the <2 or 2–10 μm fraction (small-sized phytoplankton) to the biomass of the phytoplankton community was highest at all five stations, the contribution of the $>10\,\mu$m fraction (large-sized phytoplankton) to the biomass differed between the five stations (Fig. 3b). The contribution of large-sized phytoplankton was relatively high at Stations 11, 12 and 14, and low at Station 1. The chl *a* concentrations of the total, the $<2\,\mu$m fraction and the 2–10 μm fraction showed 1.3-fold, 1.6-fold and 1.4-fold changes, respectively, between the five stations, whereas the concentration of the $>10\,\mu$m fraction showed 5.5-fold change. The different contributions of large-sized phytoplankton between the five stations can be thus attributed to different chl *a* concentrations of large-sized phytoplankton. Consequently, for phytoplankton communities with the relatively high chl *a* concentration, even if the total phytoplankton biomass is equal, the

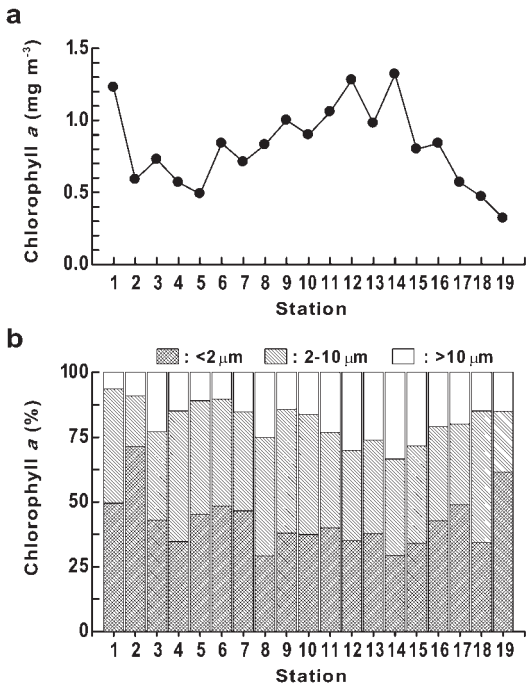

Fig. 3 Variations of (a) total chlorophyll *a* concentration (mg m^{-3}) and (b) percentage contribution of the $>10\,\mu$m, 2–10 μm and $<2\,\mu$m fractions to total chlorophyll *a* concentration at the surface.

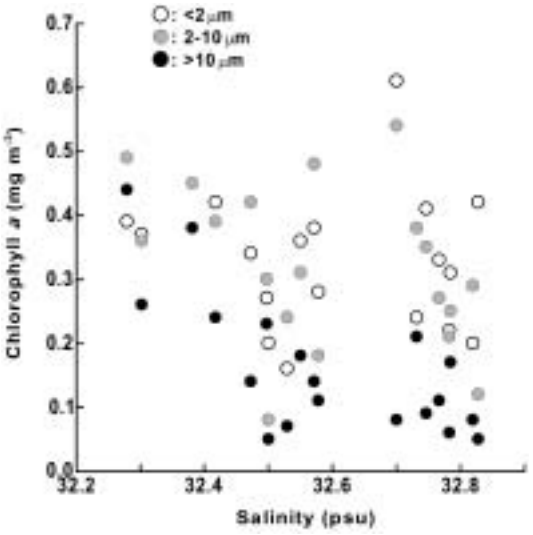

Fig. 4 Relationships between salinity (psu) and chlorophyll *a* concentrations (mg m^{-3}) of the $>10\,\mu$m, 2–10 μm and $<2\,\mu$m fractions at the surface. The Spearman rank correlation coefficient (rs) is -0.66 ($p<0.01$) for the $>10\,\mu$m fraction, -0.49 ($p<0.05$) for the 2–10 μm fraction and -0.23 ($p>0.3$) for the $<2\,\mu$m fraction.

contribution of various-sized phytoplankton, especially the large-sized, may differ between the communities, implying a different species composition of phytoplankton between the communities.

Stations 11, 12 and 14 with relatively high chl *a* concentrations of the $>10\,\mu$m cell size coincided with the less saline water (Figs 2b and 3). A significant negative relationship was observed between chl *a* concentrations of the $>10\,\mu$m and 2–10 μm fractions and salinity, but not for the $<2\,\mu$m fraction (Fig. 4). This means that the near-shore water has an effect in particular on large-sized phytoplankton in the offshore area, but little effect on small-sized phytoplankton.

In the North Pacific, the Subarctic Current flows eastward between 40°N and 50°N east of 165°E, and the Alaskan Stream flows westward north of the Subarctic Current along the Aleutian Islands (e.g., FAVORITE *et al*., 1976). Southward branches from the Alaskan Stream have been observed to flow into the Subarctic Current west of 155°W (THOMSON, 1972; REED, 1984; REED and STABENO, 1994; BOGRAD *et al*., 1999). Salinity in the upper waters decreases from the offshore area to the near-shore area in the subarctic North Pacific (DODIMEAD *et al*., 1963; FAVORITE *et al*., 1976). The low saline water between Stations 10–14 can be thus attributed to the southward branches of the Alaskan Stream. Consequently, large-sized phytoplankton in the less saline water can be generated in the near-shore area and carried into the offshore area by the southward branches of the Alaskan Stream.

Concentrations of nitrite + nitrate and silicate in the less saline water (Stations 10–14) were mostly less than 10 μM and 5 μM, respectively (Fig. 2c). The concentration ratios of nitrite + nitrate to silicate of less than 1 were observed in the less saline water (Stations 12-14). In contrast, concentrations of nitrite + nitrate and silicate were 10–15 μM and 20–30 μM at the surface in the Alaskan Stream in

summer 2000 (data between 50–51°N along 180° and 165°W in June 2000; ANONYMOUS, 2001). Concentration ratios at the surface were within the range of 1 and 2 (ANONYMOUS, 2001). The concentrations and ratios are judged to be lower in the less saline water than in the source water (the Alaskan Stream). The low concentration ratios as well as the low concentrations in the less saline water are considered to be a result of the active uptake of nutrients, especially silicate, implying abundant diatoms. Relatively high chl *a* concentrations of large-sized phytoplankton at Stations 11, 12 and 14 can thus be attributed to diatoms in the near-shore area.

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