DISTRIBUTION OF NUTRIENT SALT AND PHYTOPLANKTON IN THE ANTARCTIC OCEAN

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Abstract: The phytoplankton standing stock and the nutrient concentration around the Balleny Islands were compared with those in the vicinity of the pack ice. The concentrations of phosphate, nitrate and chlorophyll-*a* fluctuated noticeably around the Balleny Islands, on the other hand, silicate concentrations fluctuated in the vicinity of the pack ice. The concentrations of phosphate, nitrate, silicate and chlorophyll-*a* ranged 0.86–2.10 μg-at/*l*, 5.0–29.6 μg-at/*l*, 57.2–69.9 μg-at/*l* and 0.15–2.41 mg/m^3 around the Balleny Islands, respectively, and ranged 1.37–2.20 μg-at/*l*, 26.4–28.4 μg-at/*l*, 34.5–50.1 μg-at/*l* and 0.098–0.323 mg/m^3 in the vicinity of the pack ice, respectively. The concentrations of silicate around the Balleny Islands (mean=62.3 μg-at/*l*) were more abundant than those of observed in the vicinity of the pack ice (mean=41.5 μg-at/*l*). The inverse relationship between the concentrations of chlorophyll-*a* and those of nitrate were observed in the vicinity of the Young Island. This opposite relationship may suggest that nitrate and phosphate were uptaken by phytoplankton.

The maximum concentration of chlorophyll-*a* was observed at 66°20′ S, 162°05′ E, where the dominant species were *Thalassiosira gravida, Chaetoceros dichaeta* and *Fragilariopsis kerguelensis.*

1. Introduction

A survey of the ecosystem along the Southern Pacific Ocean was carried out as a part of the international project of the Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) by a group of scientists boarded on the Training Ship UMITAKA MARU III of Tokyo University of Fisheries.

There have been a number of reviews of the circulations and physical characteristics of Antarctic Ocean (DEACON, 1963, 1964; BRODIE, 1965; KNOX, 1970), while the ecological study have been discussed by EL-SAYED (1970), he has underscored the conspicuous regional differences in the productivity parameters of the Southern Ocean, and the striking differences between the productivity of the oceanic and neritic regions. Antarctic neritic waters seem to be a worthwhile subject to investigate, in particular an important problem of primary production in the vicinity of the pack ice and islands has been left unsolved, furthermore we could not confirm the relationship between nutrient salt and phytoplankton.

From the above point of view, the authors discuss distribution of standing stock of phytoplankton and nutrient salt in this paper, those of concentrations in the vicinity of pack ice and islands in the Antarctic Ocean were observed. Moreover, we would like to mention simply the content of the species composition of phytoplankton along the island.

2. Materials and Methods

The cruising of the UMITAKA MARU III in the vicinity of the pack ice and the Balleny Islands is shown in the Figs. 1 and 2. Sea water samples collected at surface and 7 meters depth. The samples were filtered through glass fiber filters (Whatman GF/C) in order to exclude particulate matter. Nutrient concentrations were determined using a autoanalyzer system (TECHNICON INDUSTRIAL SYSTEM, 1972, 1973). The phosphate in the sea water was determined using the formation of phosphomolybdenum blue complex which was read colorimetrically at 880 nm. The determination of nitrite and nitrate utilized the procedure whereby nitrate was reduced to nitrite in a copper-cadmium reductor column. The procedure for silicate was

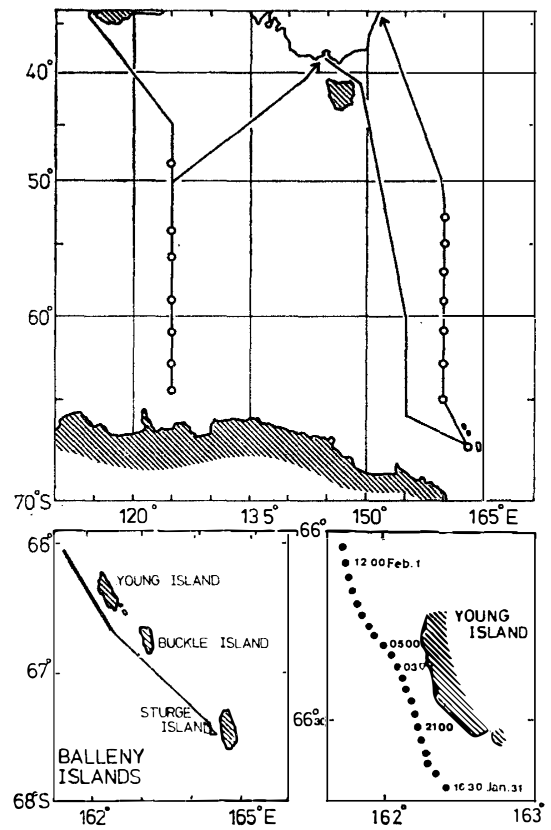

Fig. 1. Cruising course of the UMITAKA MARU in the Antarctic Ocean, and locations of sampling stations along the Young Island and location of the Balleny Islands.

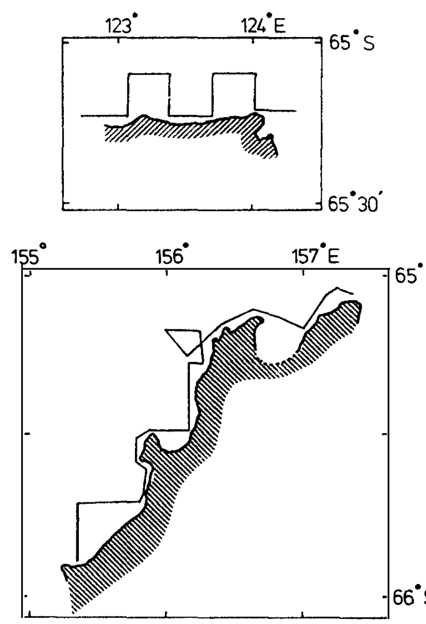

Fig. 2. Locations of sampling stations of the pack ice.

based on the reduction of a silicomolybdate in acid solution to molybdenum blue ascorbic acid.

Estimation of phytoplankton standing stock was also performed by the measurement of chlorophyll-*a* concentration in surface water using a fluorometer (Turner Model 111–003). To observe the species composition of phytoplankton in the sea water, one liter of each sample collected was added 20 m*l* of formalin neutralized, and left standing until microscopic observation after return to Japan. Some part of the plankton sample deposited in the bottle was observed and counted the number with a haemacytometer under microscope.

3. Results and Discussion

It is well known that the Antarctic Convergence (polar front) forms major boundary zone in the Southern Ocean, which divides into two characteristic zones, *i.e.*, the Antarctic zone and Subantarctic zone, and the silicate concentrations increased abruptly in the vicinity of the Antarctic Convergence (TORII *et al.*, 1959; EL-SAYED, 1970). There are many reports about oceanic survey in the Antarctic Ocean, but scarcity of reports on the variation of nutrient and chlorophyll-*a* concentrations in the vicinity of the pack ice and islands encouraged us to investigate it.

The phytoplankton standing stock and the nutrient concentration around the Balleny Islands were compared with those in 2 spots in the vicinity of the pack ice. Table 1 shows the result of those observations. Although the concentrations of phosphate and nitrate in the vicinity of pack ice were more abundant than those of around the Balleny Islands, the concentrations of silicate were relatively low in the vicinity of pack ice. The concentrations of phosphate and nitrate fluctuated from 0.86 μg-at/*l* to 2.10 μg-at/*l*, and from 5.0 μg-at/*l* to 29.6 μg-at/*l*, respectively, and the concentrations of silicate were approximately same level around the Balleny Islands. On the other hand, the concentrations of silicate in the vicinity of pack ice fluctuated from 34.5 μg-at/*l* to 50.1 μg-at/*l*. The concentrations of chlorophyll-*a* around the Balleny Islands were more than doubled compared with those in the vicinity of pack ice.

Authors discussed the correlations with nutrient and chlorophyll-*a* concentrations. As shown in Figs. 3, 4 and 5, the correlation of phosphate and nitrate concentrations was positive ($r=0.91$), the correlation of silicate and nitrate concentrations was negative, and the correlation of phosphate and silicate concentrations was

Table 1. Average of the nutrient salts and chlorophyll-a concentrations in the vicinity of pack ice (A area, n=35), in the province around the Balleny Islands (B area, n=36).

	A(M.±S.D)	B(M.±S.D)
Phosphate (μg-at/*l*)	1.94 ±0.03	1.55 ±0.06
Nitrate (μg-at/*l*)	27.4 ±0.3	20.8 ±1.2
Silicate (μg-at/*l*)	41.5 ±5.9	62.3 ±0.5
Chlorophyll-*a* (mg/m^3)	0.179±0.012	0.496±0.069

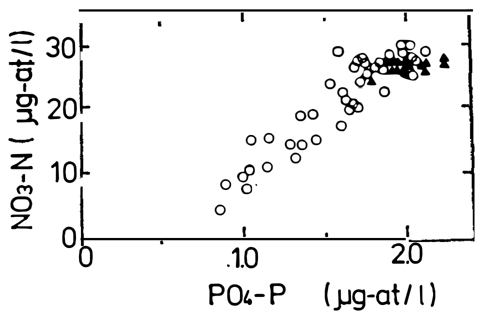

Fig. 3. Relationship between the concentrations of phosphate and nitrate. Open circle: The province of the Balleny Islands. Solid triangle: The province of pack ice.

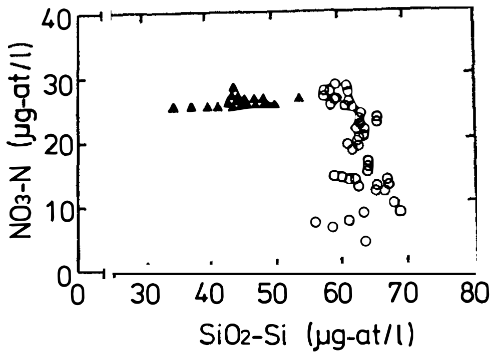

Fig. 4. Relationship between the concentrations of silicate and nitrate. Symbols are the same as Fig. 3.

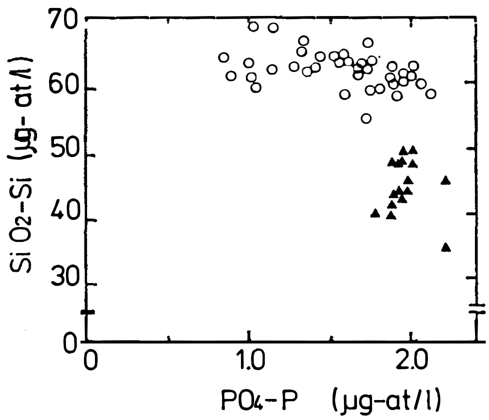

Fig. 5. Relationship between the concentrations of phosphate and silicate. Symbols are the same as Fig. 3.

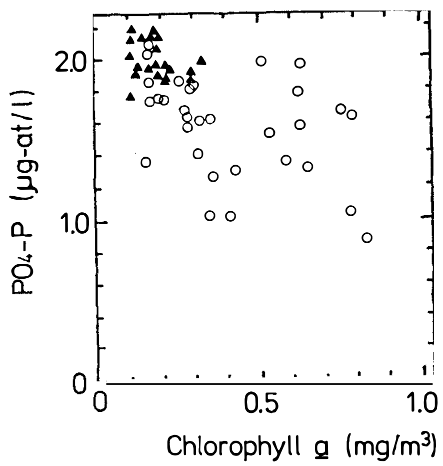

Fig. 6. Relationship between the concentrations of chlorophyll-a and phosphate. Symbols are the same as Fig. 3.

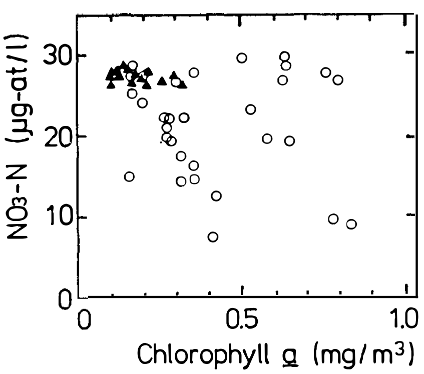

Fig. 7. Relationship between the concentrations of chlorophyll-a and nitrate. Symbols are the same as Fig. 3.

negative around the Balleny Islands. On the other hand, in the vicinity of pack ice the correlation of phosphate and nitrate concentrations was positive, the correlation of silicate and nitrate concentrations was positive, too. As the thing to be emphasized among nutrient salt, it is more significant the correlations of phosphate

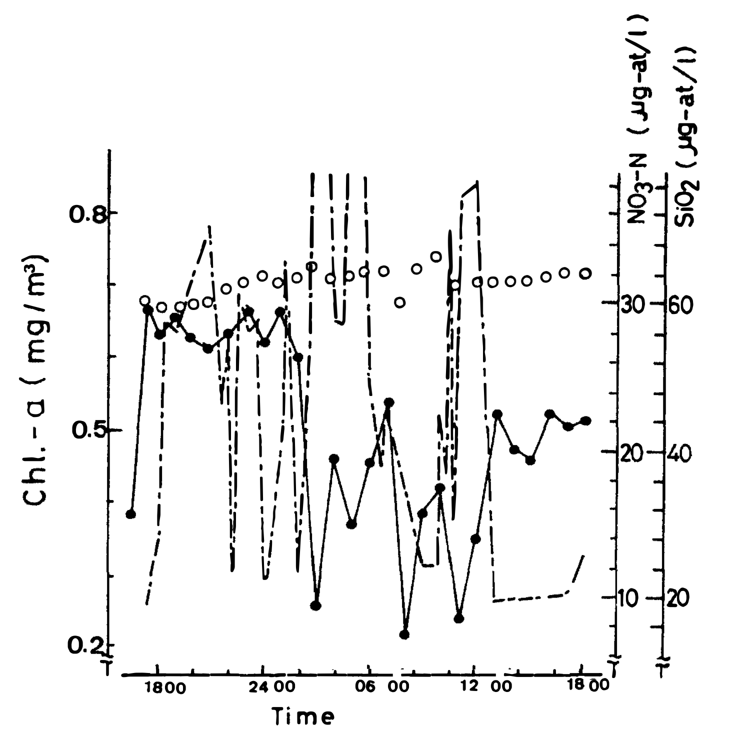

Fig. 8. Variations of the concentrations of nitrate, silicate and chlorophyll-a in surface water along the Young Island from January 31 to February 1, 1981. Solid circle: The concentration of nitrate. Open circle: The concentration of silicate. Dashed line: The concentration of chlorophyll-a.

Table 2. The species composition along the Young Island.

Date	Species	Number of cell (cell/*l*)
January 31, 1981 2100LT	*Nitzschia longissima*	1.31×10^4
	*Fragilariopsis kerguelensis**	1.09×10^4
	Thalassiothrix longissima	5.8×10^3
	Chaetoceros sp.*	5.1×10^3
	Thalassiosira gravida	4.4×10^3
	Prorocentrum sp.	4.4×10^3
February 1, 1981 0300LT	*Thalassiosira gravida*	2.70×10^4
	Chaetoceros sp.*	1.17×10^4
	Fragilariopsis sp.*	6.6×10^3
	Thalassiosira sp.	5.8×10^3
	Nitzschia seriata	2.9×10^3
February 1, 1981 0500LT	*Thalassiosira gravida*	2.01×10^4
	Thalassiothrix longissima	6.7×10^3
	Thalassiosira sp.	5.2×10^3
	Nitzschia longissima	3.0×10^3
	Chaetoceros sp.*	3.0×10^3
February 1, 1981 1200LT	*Fragilariopsis* sp.*	3.0×10^3
	Thalassiosira gravida	2.0×10^3
	Nitzschia sp.	1.3×10^3

* Number of colony.

and nitrate concentrations. The correlation of chlorophyll-*a* and phosphate concentrations was negative in the both province (Figs. 6 and 7).

The more detailed measurement of nutrient salt and chlorophyll-*a* in the surface water was performed at interval of one hour (about 3.7 km in distance) along the Young Island, one of the Balleny Islands. As can be seen from Fig. 8, the inverse relationship between the concentrations of chlorophyll-*a* and those of nitrate and phosphate were observed, but the concentrations of silicate were approximately same level. From the inverse relationship described above, it may conclude that nitrate and phosphate were uptaken by phytoplankton. The present results were in agreement with the report of EL-SAYED and TAGUCHI (1981) in the Weddell Sea, they suggested that nitrate in the nutrient salts is more important than silicate for phytoplankton.

On the other hand, the species composition of phytoplankton along the Young Island is shown in Table 2. The maximum concentration of chlorophyll-*a* was observed at 66°20′ S, 162°05′ E (0300 LT, February 1, 1981), where the dominant species *Thalassiosira gravida* (2.7×10^4 cell/*l*), *Chaetoceros dichaeta* (1.17×10^4 cell/*l*), and *Fragilariopsis kerguelensis* (6.6×10^3 cell/*l*). *Nitzschia closterium*, *N. seriata*, *N. longissima*, *Chaetoceros* spp., *Rhizosolenia simplex* and *Thalassiothrix longissima* were observed at another stations as dominant species. The above diatoms are the most important species of standing stock. Dinoflagellatas are to be next importance in standing stock, but scarcely reported in the Antarctic Ocean. As a problem to be solved in future, it is necessary to perform the survey for dinoflagellata and monad.

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