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Size-fractionated Biomass and Productivity of Phytoplankton in Prydz Bay and the Adjacent Indian Sector of the Southern Ocean during the Austral Summer 1990/1991

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Size-fractionated biomass and productivity of phytoplankton, its cell abundance, the composition of the dominant species, concentration of particulate organic carbon (POC) and their relations with environmental factors in Prydz Bay and the adjacent Antarctic waters of the Indian Sector of the Southern Ocean were investigated during summer 1990/1991. The results showed that there were marked feature of spatial zonation in the studied area. In Prydz Bay and its adjacent continental shelf, the standing stock and productivity of phytoplankton were high, which resulted from higher stability of water masses being favorable to growth and reproduction of phytoplankton and ice algae. In the offshore beyond the continental shelf between West Ice shelf and Shackleton Ice Shelf, the biomass and productivity, and POC were also high, due to that the mixing depth being consistent with the euphotic depth. In these zone, nutrients were consumed and decreased, and dissolved oxygen released by phytoplankton. On the contrary, the opposite distribution trends of above parameters were displayed in both eastern and western zones of the studied area. The results of size-fractionation showed that the contributions of nanoplankton with picoplankton to total biomass was 53%, to total productivity, 69%, which proved their importance in phytoplankton community of the Southern Ocean.

Key words: phytoplankton, primary productivity, size-fractionation, Prydz Bay, Southern Ocean, Antarctica

INTRODUCTION

The standing stock and productivity of phytoplankton is the important content for the researches on biological oceanography and the basic link of food web structure and function in marine ecosystem. In the Southern Ocean, the phytoplankton is the main bait of krill, and the substantial base for supporting huge quantity of krill resource. In addition, the photosynthesis of marine phytoplankton fixes a huge quantity of carbon dioxide, and thus plays a significant role for regulating the global climate change.

The distribution of phytoplankton with different cell size takes the important role in the structure of natural community and the trophic relations in marine ecosystem (Sieburth *et al.*, 1978) and provides the important information for understanding the characteristics and abundance of predator populations, such as krill (Miller *et al.*, 1985). Owing the limitation of methodology, the previous researches, based on the concept of the classic food chain "diatom-krill-whale", laid emphasis on the net-plankton (with the cell size > 20 μm) collected by net. The research results in recent ten years proved that, as other sea area in the world, nanoplankton (with the cell < 20 μm) were mostly predominated in the phytoplankton community of the Southern Ocean, and because of its greater contribution to the biomass and productivity of phytoplankton, were double paid attention to (von Bröckel, 1981).

The existence of photosynthetic picoplankton (with cell < 2.0 μm) in marine was discovered fourteen years ago, but it is generally recognized by marine biologists and ecologists in recent years to be as an essential component of the plankton com-

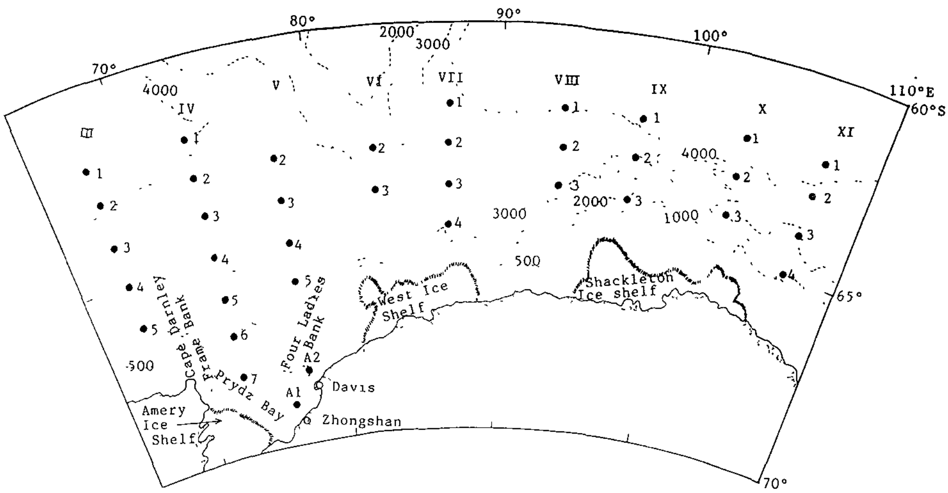


Fig. 1. Sampling locations and the topography of studied area.

munity in most sea areas of the world. Owing to its high metabolic activity and fast double rate, it played a important role in the growth of phytoplankton biomass (Vaulot and Ning, 1988; Ning and Vaulot, 1992; Joint, 1986). It was not until 1986 that the contributions of the picoplankton to total biomass and primary productivity of phytoplankton was studied for the first time and the results affirmed that it played a significant role in the material cycle and energy flowing in marine ecosystem of the Southern Ocean (Weber and El-Sayed, 1986).

However, in comparison with other sea areas, very few researches on the biomass and productivity of photosynthetic nanoplankton and picoplankton have been done in Antarctic sea area. Moreover, the most concentrated on the Atlantic Sector of the Southern Ocean, much fewer were in the Indian Sector of it, and no research on this aspect was reported in Prydz Bay and its adjacent sea area. This research is a part of the comprehensive studies on krill resources ecology done by CHINARE (Chinese National Antarctic Research Expedition), and provides comparable scientific data for this sea area.

MATERIALS AND METHODS

Sampling

Totally nine transections (68°00′, 73°00′, 78°00′, 83°00′, 88°00′, 93°00′, 98°00′, 103°00′, and 108°00′ E) including 37 stations were set up in Prydz Bay and its adjacent Southern Indian Sector near to Antarctic continent (South of 62°00′ S) and the most southern station of various transections were situated on the ice edge (Fig. 1). The investigation and sampling were conducted by "Ji Di" ship during January to March 1991.

The seawater samples were collected with the Q2-3 type of water sampler (similar to Niskin bottle, made by Qingdao Institute of Marine Instrumentation) at six depths of surface, 25, 50, 100, 150 and 200 m respectively for determining chlorophyll, phytoplankton and POC. The water samples for determining photosynthesis and primary productivity were collected according to the depths at which the incident light attenuated to 100, 50, 32.5, 10, 3 and 1% of the incident light strength on the sea surface respectively.

Using a Judy plankton net, the netplankton was collected by vertically hauling from 200 m to the surface, after that, the samples were immediately fixed with neutral formalin solution to preserve (State Technology Supervisual Bureau, 1991).

Methods

The temperature and salinity were measured *in situ* by using CTD, Model Mark III. Dissolved oxygen, nitrate and nitrite, phosphate and silicate were analyzed by standard chemical methods

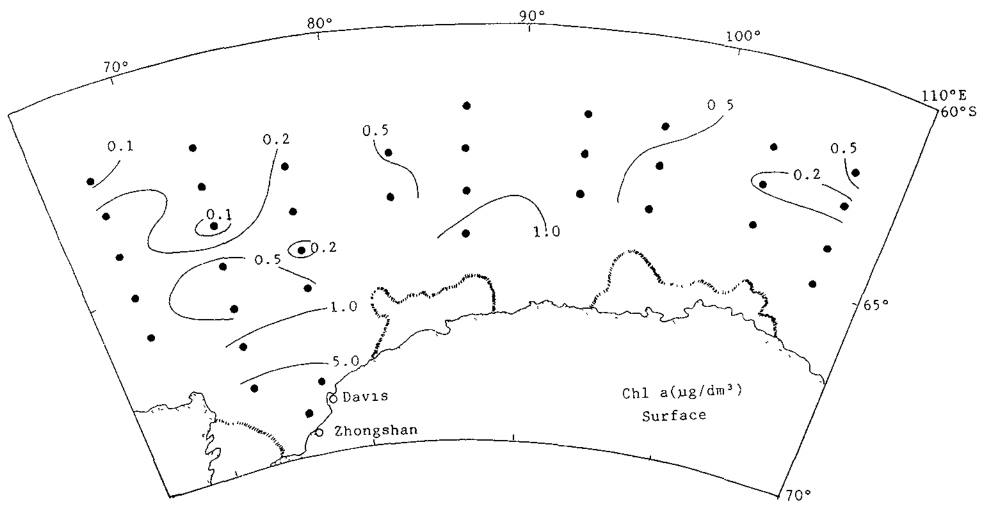


Fig. 2. Chlorophyll a concentration (μg/dm³) in surface water.

(Strickland and nitrite, phosphate and silicate were analyzed by standard chemical methods (Strickland and Parsons, 1972).

Chlorophyll a (Chl a) and phaeopigments (Phaeop.) were determined by adopting fluorescence method, according to Holm-Hansen *et al.* (1965). 250 cm^3 of water sample were filtered, the pigments were extracted with 90% acetone for 24 h and determined with the Turner Designs Fluorometer, Model 10. The phytoplankton carbon, C_{ph} was calculated by Chl a x 60 (Steele and Baird, 1962).

Photosynthetic rate and primary productivity were determined by using the isotopic (^{14}C) trace method established by Steemann Nielson (1952) and improved by Evans *et al.* (1987) and Ning *et al.* (1988). The water samples from each light levels were filled into two parallel light bottles and one dark bottle of 250 cm^3, each bottle was added in 10 $\mu Ci \cdot NaH^{14}CO_3$, laid in an incubator on the ship's deck, and incubating for 3-6 h. The incubator possessed the sieve with different neutral light densities to control the light intensity and made them complied with the light intensities at original sampling depths. The incubator equipped with sea water cycle system to keep the temperature as at the sea. After incubation, the water sample was filtered, then the filter was fumed over concentrated hydrochloric acid, dried and preserved in the dark. ß-counts were made by using Beckman 5801 model liquid scintillation counter after adding scintillation cocktail. Finally quenching calibration was conducted by ESCR method.

Take 2-3 dm^3 of water sample, filter it through the Whatman GF/F filter which has been pre-scorched (450°C for 24 h), the filter which retained particles was preserved at low temperature (–30°C), then carry it back to laboratory for quantitatively determine POC. The method is based on Parsons *et al.* (1984).

Before all water samples were collected, they were pre-filtered through a mesh with a pore size of 280 μm to remove most zooplankton. The water samples for determining size fractionated Chl a, and photosynthetic rate were filtered through 20 μm mesh (mainly separating netplankton from nanoplankton) and Whatman GF/F filter (retaining the sum of nano-and pico-plankton).

The identification of phytoplankton species and the cell counts were conducted with Olympus optic microscope and electronic microscope in the laboratory.

RESULTS

The Standing Biomass and Predominant Species of Phytoplankton

Size-fractionated chl a: The high value of Chl a appeared in Prydz Bay and on several transections in the middle part of the investigated sea area near to continent. The surface concentration in

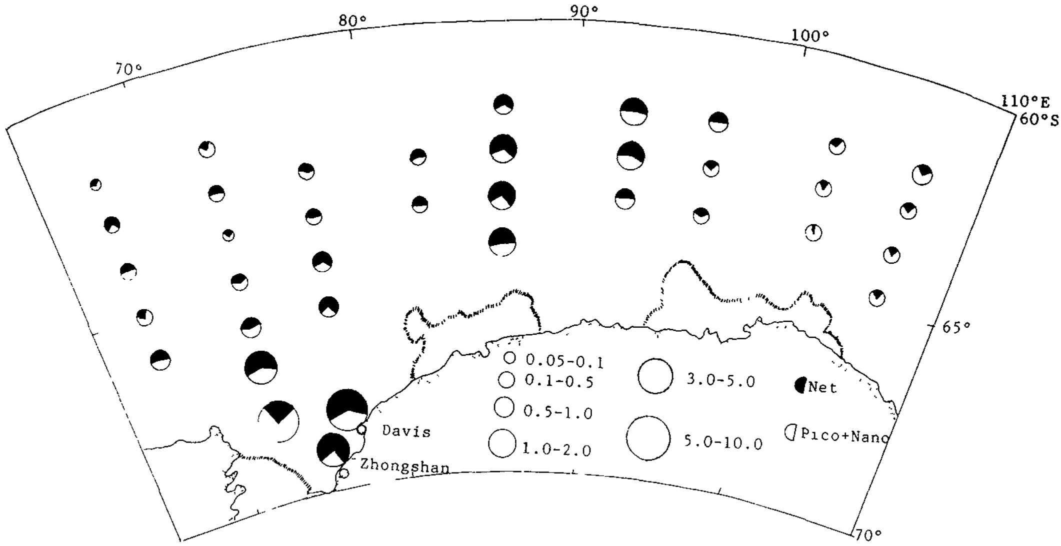


Fig. 3. Average concentrations of chlorophyll a and the contributions of net- and nano- with pico-plankton to total chlorophyll a in euphotic zone.

Table 1. Average values (X ± SD) of chlorophyll a, POC and the related parameters in euphotic zone of Prydz Bay and the adjacent sea area during 1990/1991(ED, Euphotic depth; DO, Dissolve oxygen; Chl-a, Chlorophyll a; Cn+p/Cs, ratio of nano-and pico-plankton chlorophyll a to sum chlorophyll a; POC, particulate organic carbon and C_{ph}, phytoplankton carbon)

Sea area Parameter	Zone 1. Prydz Bay (n=4)	Zone 2. West region (n=16)	Zone 3. Central region (n=7)	Zone 4. East region (n=10)	Mean (n=37)
ED (m)	23.2±11.1	53.8±10.1	35.3±7.9	61.8±6.8	49.2±15.5
T (°C)	–0.39±0.67	–0.26±0.27	–0.17±0.78	–0.61±0.69	–0.35±0.56
S (‰)	32.71±2.03	33.91±0.13	34.15±0.15	33.92±0.13	33.83±0.72
DO (cm^3/dm^3)	9.24±0.98 (n=3)	7.86±0.23	7.95±0.55	7.82±0.13	7.98±0.53 (n=36)
PO_4 ($\mu M/dm^3$)	0.93±0.64 (n=3)	1.95±0.28	1.40±0.18	1.84±0.17	1.73±0.41 (n=36)
SiO_3 ($\mu M/dm^3$)	54.47±28.59 (n=3)	43.78±7.23	52.56±8.68	57.82±7.72	50.27±11.64 (n=36)
NO_3+NO_2 ($\mu M/dm^3$)	12.74±9.19 (n=3)	31.24±1.88	27.41±1.03	28.70±1.69	28.26±5.67 (n=36)
Chl-a ($\mu g/dm^3$)					
Net	2.75±1.27	0.19±0.12	0.63±0.11	0.12±0.11	0.53±0.89
Nano+Pico	2.62±1.84	0.17±0.06	0.42±0.08	0.30±0.14	0.52±0.92
Sum	5.37±2.12	0.36±0.17	1.05±0.11	0.42±0.23	0.86±1.25
Cn+p/Cs	0.47±0.21	0.45±0.12	0.40±0.07	0.71±0.10	0.60±0.16
POC ($\mu g/dm^3$)	303.7±105.9 (n=3)	104.0±24.3	162.1±35.0	117.9±40.2	134.6±68.1 (n=36)
C_{ph}/POC	0.920±0.080 (n=3)	0.219±0.128	0.410±0.119	0.213±0.072	0.327±0.275 (n=36)

Prydz Bay was above 5 $\mu g/dm^3$ (Fig. 2) and the average concentration in euphotic zone reached over 3 $\mu g/dm^3$ (Fig. 3) . The surface concentration in the middle of the investigated sea area mostly was 1 $\mu g/dm^3$ or so (Fig. 3), the maximum value (12.63 $\mu g/dm^3$) appeared in the depth of 10 m at Station A2 of Prydz Bay. In the sea areas north of 66° S, west of 78° E and east of 98° E of the investigated sea area, Chl a concentrations were low, its surface value generally was less than 0.5 $\mu g/dm^3$, and the average value in the euphotic zone generally was below 0.5 $\mu g/dm^3$. The lowest value (0. 02

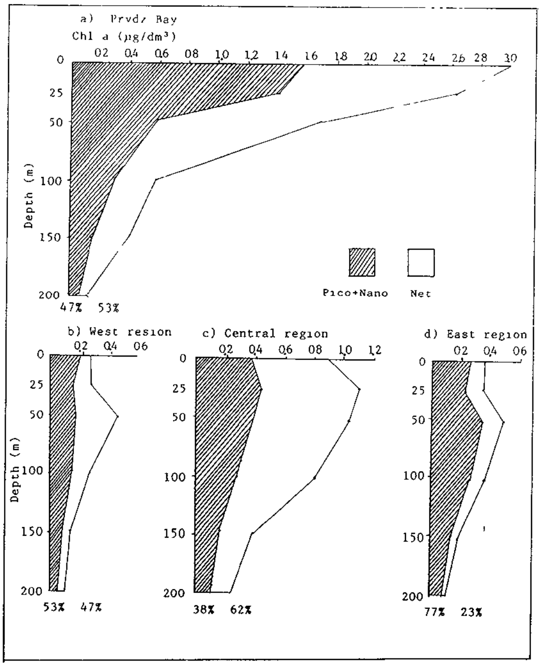


Fig. 4. Vertical distributions of zonal average size-fractionated chlorophyll a(μg/dm^3) in (a) Prydz Bay, (b) west region, (c) central region and (d) east region of the studied sea area.

μg/dm^3) appeared at the depth of 200 m at station IV-3.

Results of size-fractionated Chl a showed that in the continental shelf area south of 60° S, Prydz Bay and above middle sea area investigated, the proportion of the net-fraction at euphotic zone in total Chl a was higher, averagely accounting for 53% and 59% respectively; while the proportion of nano with pico-fraction lower, 47% and 41% respectively. The proportion of the most stations investigated north of 65° S in the western region and all stations of eastern region turned out contrary to those values, i.e., the proportion of nano with pico-fraction in total Chl a was higher, averagely for 52% and 75%; while those of net-fraction was lower, for 47% and 25% (Fig. 3, Table 1).

From 200 m depth to the surface, the value of Chl a averaged according to the regions were: 1.649, 0.275, 0.721 and 0.301 μg/dm^3 separately in Prydz Bay, the western region, the middle region and the eastern region. The proportion of net-fraction in the four zones were 53, 47, 62 and 23% separately (Fig. 4).

The maximum value of average Chl a appeared at the depth less than 25 m in Prydz Bay and the middle zone, while that appeared at the depth of 50 m in the western zone and eastern zone. (Fig. 4).

Cell abundance and predominant species of phytoplankton: The results of the water sample analysis showed that the average cell abundance of phytoplankton at the surface in the studied sea area was 25.51 x 10^3 cell/dm^3, that in Prydz Bay and the middle zone was higher, and the maximum of 582 x 10^3 cell/dm^3 appeared at the Station IV-7 in Prydz Bay; that in the western zone and eastern zone was lower, and the lowest value at the surface was 0.2 x 10^3 cell/dm^3 appearing at Station IV-2 (Fig. 5).

In the respect of species composition, through identification, there were totally six categories (Bacillariophyta, Pyrrophyta, Chrysophyta, Prymnesiophyta, Choanoflagellata and Cyanophyta) were found. Among them the Bacillariophyta predominated, accounting for 58% of total species; Pryrrophyta, followed, accounting for 34%, others accounted for 8%. The most important predominant species was *Nitzschia cylindrus* of Bacillariophyta, accounting for 70% of total cell abundance, the next was *N. barkley*, *N. curta*, *N. castracanei* and *Gyrodinium lachryma*, accounting for 9.7%, 7.2%, 3.6% and 1.2% of total abundance separately, the other, only for 8.2% (Table 2).

Particulate Organic Carbon (POC)

The POC concentration at the surface was the highest in Prydz Bay and generally exceeded 200 μg/dm^3. The maximum value appeared at Station IV-7, reaching 320 μg/dm^3. The sub-highest value appeared in the middle zone, their concentrations generally were over 100 μg/dm^3. POC concentrations at the surface in the western zone and eastern zone were lower, the lowest value was 77.5 μg/dm^3 at Station XI-3 (Fig. 6).

As the vertical distribution of POC concentration in water column, generally, the POC concentration above thermocline was higher and that below thermocline was markedly lower, its fluctuating trend was roughly consistent with that of Chl a.

The distribution trend of the proportion of phytoplankton carbon in total POC (C_{ph}/POC) was consistent with that of Chl a, i.e., its average value in Prydz Bay was the highest (0.92); that in the middle zone followed (0.41), that in the western (0.21) and eastern (0.22) was the lowest (Table 1).

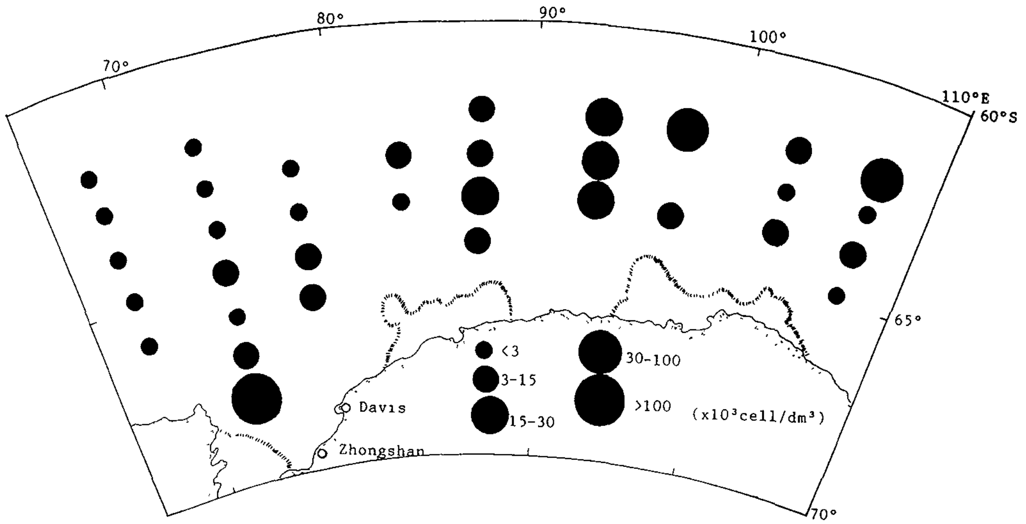


Fig. 5. Abundances (x 10^3 cell/dm^3) of net- with nano-phytoplankton in surface water.

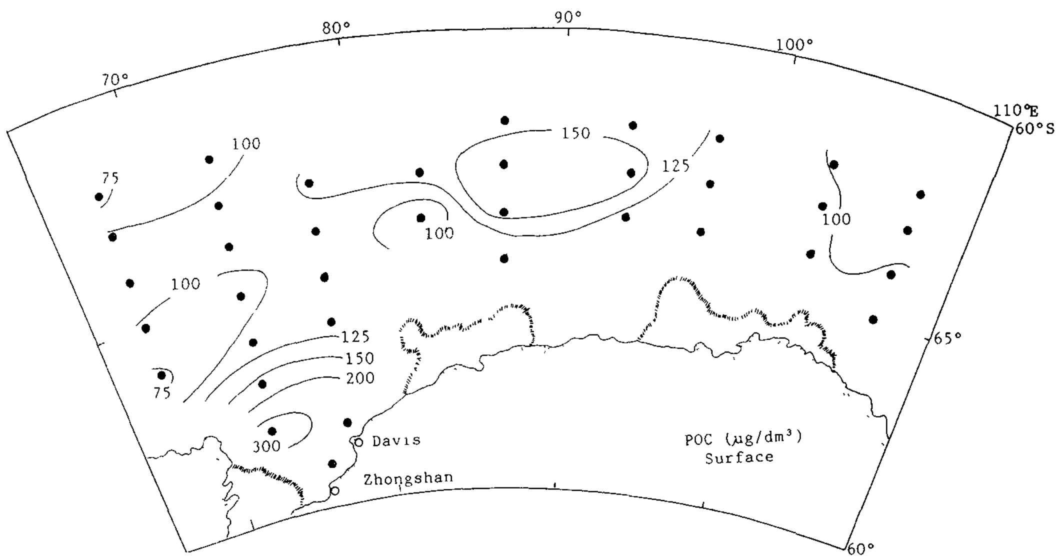


Fig. 6. Concentrations (µg/dm^3) of POC in surface water.

Size-fractionated Primary Productivity

Accounting for per cent of primary productivity and the contributions of netplankton and nano- with picoplankton are listed in Table 2. It can be seen from the Table 2 that in Davis Bay of Prydz Bay and Station IV-6 situated in the continental shelf north of Prydz Bay, the primary productivity was the highest, about being over 1000 mg·C·m^{-2}·d^{-1}; at the station investigated in the east (XI-4 and IX-1), they were the second highest; ranging from 400 to 700 mg·C·m^{-2}·d^{-1}; at the station investigated in the west (V-3, IV-5, and III-1), the values were less than 250 mg·C·m^{-2}·d^{-1}; while only at one station in the middle (VIII-1), its value was 285.6 mg·C·m^{-2}·d^{-1}.

Viewing some results from size structure of primary productivity, except in Davis Bay, the contri-

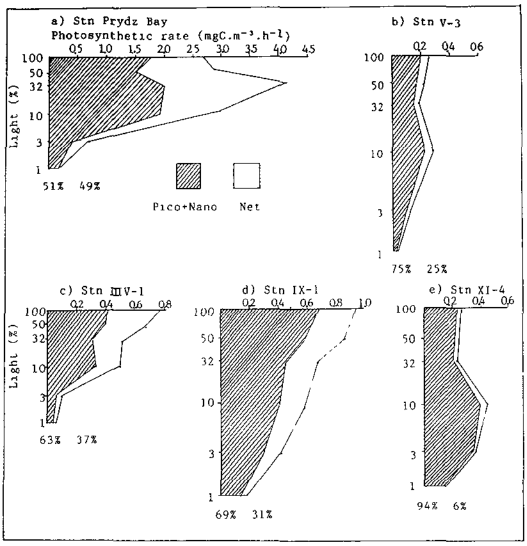


Fig. 7. Vertical distributions of size-fractionated primary productivity ($mgC \cdot m^{-3} \cdot h^{-1}$) at some typical stations of the studied area.

bution of nano- plus pico-plankton (cell < 20 μm) to total primary productivity was higher than that of netplankton (cell > 20 μm). Total photosynthesis assimilation numbers were generally lower than 1 $mg \cdot C \cdot m^{-2} d^{-1}$, that of nano- + pico-fractions were higher than that of net-fraction (Table 3).

Regarding to the vertical distribution of size-fractionated primary productivity (Fig. 7), the maximum value of potential primary productivity of the fractions was mostly in the surface, the potential primary productivity in the water column at which the sea surface light intensity attenuated to below 10% was very low.

DISCUSSION

Spatial Zonation

This sea area investigated includes: Prydz Bay and its bordering sea area of the Southern Indiain Ocean near Antarctic continent. In the sea area, the standing stock and productivity of phytoplankton and its size structure and the distributions of related physico-chemically environmental factors possessed distinctly spatial zonation features.

Although Prydz Bay and its bordering continental shelf situated in the east-wind-drifting zone, in the eastern side of the Bay mouth, due to obstructing by Four Ladies Bank and piling of iceberg,

Table 2. The dominant species composition and the cell abundance of phytoplankton in surface water of Prydz Bay and the adjacent sea area.

Dominant species	Average cell abundance (× 10^3cell/dm^3)	% of total abundance	Occurrence rate (%)
Nitzschia cylindrus	17.91	70.2	41.1
Nitzschia barkleyi	2.47	9.7	64.7
Nitzschia curta	1.84	7.2	29.4
Nitzschia castracanei	0.91	3.6	32.4
Gyrodinium lachryma	0.30	1.2	20.6
Sum	23.43	91.9	

wind and wave failed to propagate toward the interior of the bay, the exchange of waters out of and into the bay at deep layer was quite less. The current westward in the bay was obstructed by Frame Bank on west side of the bay mouth, the exchange of waters at deep layer was also much weaker, thus Prydz Bay was just as a isolate system (Shi, 1993). In such a closed system, the waters were very stable, it is advantageous to the growth and reproduction of phytoplankton. In the continental shelf bank of the north of Prydz Bay, owing to the piling of iceberg and floating ice, wind and wave were difficult to propagate, it also increased the stability of waters. Moreover, since sun's radiation in summer increased, ice and snow melt, the release and great reproduction of ice algae to form the bloom. As a result, in the bay and its bordering continental shelf and bank, the cell abundance of phytoplankton, concentrations of Chl a and POC and the ratio of phytoplankton carbon to POC (C_{ph}/POC) were higher. Moreover, the organic carbon photosynthetic production rate was also higher (Table 1). The great bloom of phytoplankton led to the following changes of the ecologic environment in the areas:

1) Dissolved inorganic nutrients, especially, the concentration of NO_3+NO_2 and PO_4, greatly lowered (Fig. 8a);

2) The increase of releasing oxygen by photosynthesis raised the dissolved oxygen content and saturation in the waters (Fig. 8b);

3) The increase of cell abundance and particulate matters decreased the transparency of light, the euphotic depth got shallow (Table 1).

The sea area north of the continental shelf bor-

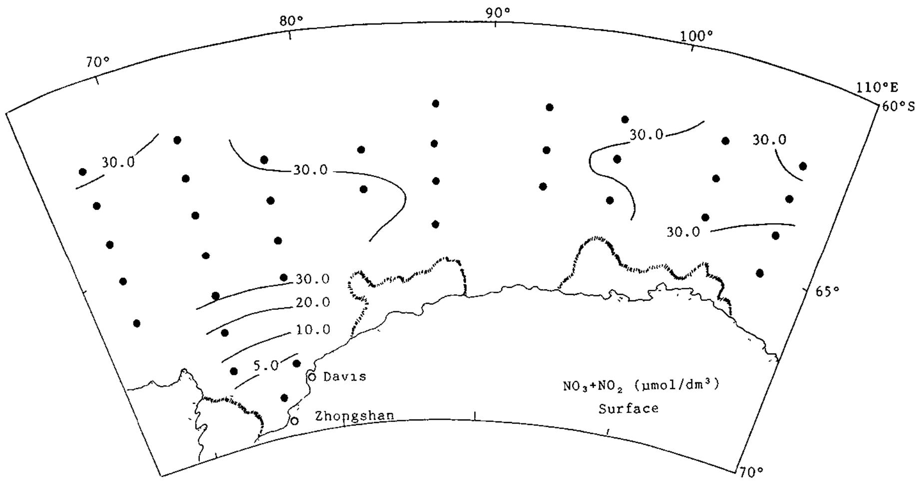
Table 3. Contributions of netplankton and nano- with pico-plankton to primary productivity at some tipical stations of Prydz Bay and the adjacent sea area during 1990/1991

Stn	Euphotic depth (m)	Primary productivity (mg·C/(m²·d))			Primary productivity (%)			Assimilation number (mgC/(mgChl·h))		
		Net	Nano+Pico	Sum	Net	Nano+Pico	Sum	Net	Nano+pico	Sum
XI-4	65	18.1	383.1	401.2	4.5	95.5	100	0.36	1.21	1.04
IX-1	65	223.4	485.3	708.7	31.5	68.5	100	0.50	1.34	0.84
VIII-1	39	112.0	173.6	285.6	39.2	60.8	100	0.39	0.85	0.56
V-3	71.5	62.0	192.0	254.0	24.4	75.6	100	0.48	1.08	0.80
IV-5	42.2	80.0	157.9	237.9	33.6	66.4	100	0.37	0.99	0.6
IV-6	39	784.8	919.9	1704.7	46.0	54.0	100	0.68	0.73	0.70
III-1	65	11.1	61.8	72.9	15.2	84.8	100	0.41	1.08	0.84
Davis	17.5	516.7	433.3	950.0	54.4	45.6	100	0.31	0.37	0.34

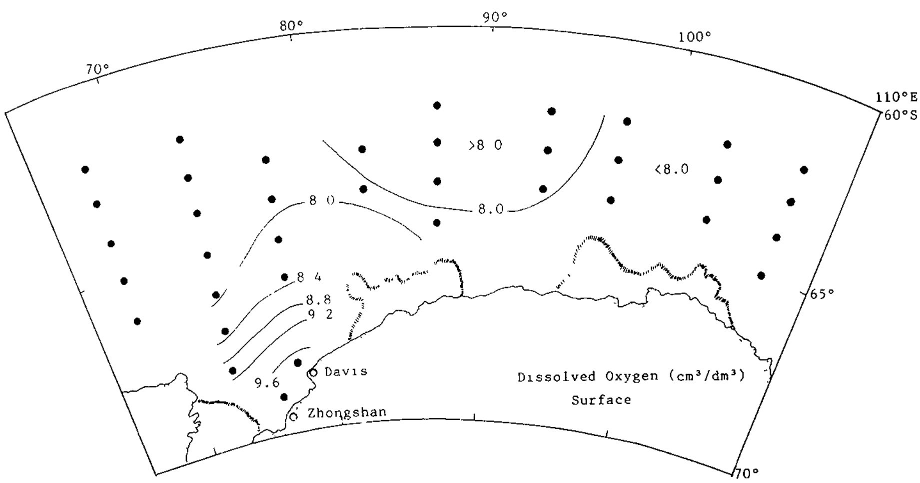
dering Prydz Bay belongs to Antarctic divergent zone and open ocean of the west-wind-drifting zone, where the stability of waters were poor. In the west of 83° E, the water columns less than 50 m were occupied by the Summer Surface Water stretching toward the southeast from lower latitude with the features of high temperature and low salinity (T > 0.5°C, S < 33.9‰) (Fig. 9); the water below the Summer Surface Water (< 100 m) was featured by the Winter Surface Residual Water with low temperature and middle salinity (T < –1.0°C, S > 33.9‰). Moreover, in local area (around 65° S, 68° E), the Continental Shelf Water with low temperature (< –1.5°C) and high salinity (> 34.2‰) intruded from the south. That below 100 m was the Antarctic Deep Water with high temperature (> 1.0°C) and high salinity (> 34.5‰) rising there (Shi, 1993). The latter strongly mixed with the Summer Surface Water sinking in the sea area of 63-64° S, made the depth of mixed layer being much greater than that of the euphotic depth (40-65 m), affected the retentive time needed for the photosynthesis production of phytoplankton at euphotic zone, and was disadvantageous to the growth of phytoplankton. Thus, the phytoplankton abundance, concentration of Chl a and POC in the sea area west of 83° E became low, and the photosynthetic rate became low as well. As a result, the euphotic depth increased, the dissolved oxygen concentration and the saturability decreased and the nutrients concentration raised (Table 1, Fig. 8).

In the east of 83° E, the water columns less than 50 m was mainly dominated by the Antarctic Summer Surface Water with high temperature (> 0°C) and low salinity (33.9-34.0‰); but in it, the water area north of 64° S, 85°-98° E, i.e., in the middle of the sea area beyond the continental shelf between West Ice Shelf and Shackleton Ice Shelf and the water column less than 50 m possessed the characteristics of high temperature (> 0.5°C) and high salinity (> 34.0‰) (Fig. 9). This is due to the result of mixing of Antarctic Deep Water upwelling with the Summer Surface Water, where, the mixing depth was roughly consistent with the euphotic depth. Furthermore, the Antarctic Deep Water carried abundant nutrients to the euphotic zone, it is advantageous to the growth of phytoplankton. Therefore the cell abundance (Fig. 5), Chl a (Fig. 2), POC concentration (Fig. 6) and Cph/POC (Table 1) were all higher in this sea area. Moreover the primary productivity (Table 3) was also higher, leading to the nutrients greatly consumed and the dissolved oxygen concentration and saturability raised (Fig. 8).

Thus, average values of various parameters (Table 1) at the euphotic zone in Prydz Bay and its bordering continental shelf (zone 1), west region (zone 2), middle region (zone 3) and east region (zone 4) were summed up according to above phytoplankton standing stock, photosynthesis production rate, the physico-chemical factors of ecologic environment and the difference of spatially regionalized distribution of water masses; and the correlation matrix of the phytoplankton and its related environmental parameters was listed in Table 4. It can be seen from Table 3 that the phytoplankton



(a)



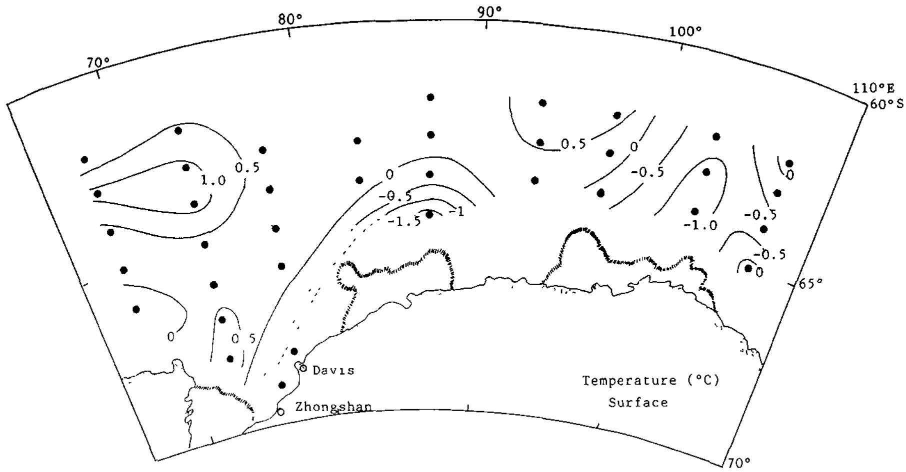
(b)

Fig. 8. Concentrations of nitrate with nitrite (μM/dm^3) (a) and (b) concentration of dissolved oxygen (mM/dm3) in surface water.

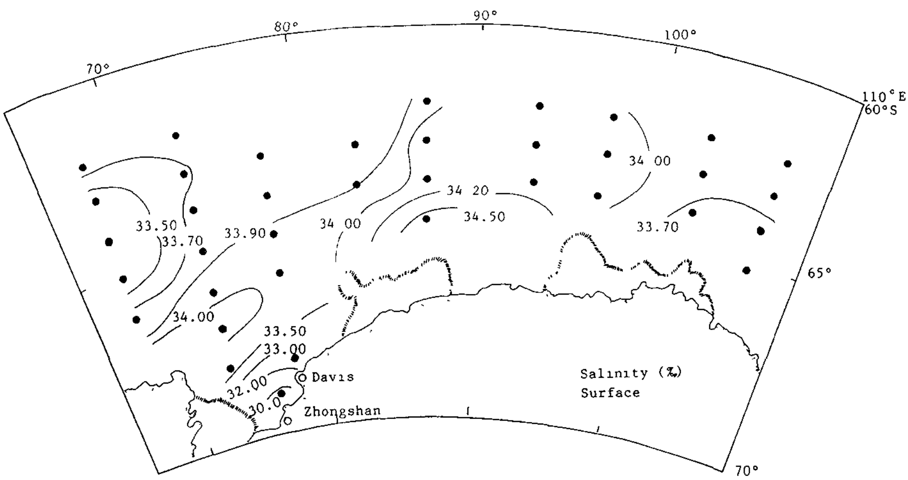
standing stock, POC, the proportion of phytoplankton carbon in POC (C_{ph}/POC) are negatively correlative to nutrients (NO_3+NO_2 and PO_4) and the euphotic depth, and positively correlative to the dissolved oxygen concentration.

The Importance of Nano-and Pico-plankton in Phytoplankton Community

The investigated results of cell size-fractionated Chl a and primary productivity in the sea area showed that the contribution of nano+pico-plankton to total Chl a were 47% and 41% in Prydz Bay and the middle region respectively, while in the west region and the east region, 52% and 75% respectively (Table 1). But the contribution of them to primary productivity, except 50% in Prydz Bay, that in other three region were higher than 60%, and the assimilation numbers of nano-and pico-



(a)



(b)

Fig. 9. Distributions of a) temperature (°C) and b) salinity (‰) in surface water.

phytoplankton were larger than those of net-phytoplankton (Table 1, 3), thus the importance of nano- and pico-plankton in the natural community of phytoplankton is very clear. It proves the deficiency of the traditional food chain "diatom - copepods and krill - fish and whale".

Moreover, the result that the contributions of small sized plankton (nano- and pico-plankton) to biomass and productivity of phytoplankton community were higher than those of larger sized plankton (netplankton) in the west and east regions with less stability of the water column and deeper mixed layer depth fits well with the results obtained by Parsons and Takahashi (1973), who reported that it is possible for the large phytoplankter to grow faster than the small one only in a region of high light intensity and high nutrient concentration which are closely related to a decreased sinking rate, higher rate of upwelling and shallower mixed layer depth, as appeared in the central

Table 4. The correlation coefficients between phytoplanktonic and the related environmental parameters observed in Prydz Bay and the adjacent sea area during January to February 1991 (ED, euphotic depth; C_S, total chlorophyll a concentration; C_M, chlorophyll a concentration of net-plankton; C_{Np}, chlorophyll a concentration of nano-and pico-plankton; POC, particulate organic carbon and C_{ph}, phytoplankton carbon)*

	ED	T	S	DO	PO_4	SiO_3	NO_3	C_S	C_M	C_{Np}	POC	C_{ph}/POC
ED	1											
T		1										
S			1									
DO	-0.51^{b}		0.48^{b}	1								
PO_4	0.47^{b}			-0.5^{b}	1							
SiO_3		-0.39^{c}				1						
NO_3	0.44^{c}		0.45^{b}	-0.80^{a}	0.78^{a}		1					
C_S	-0.65^{a}		-0.43^{c}	0.82^{a}	-0.76^{a}		-0.94^{a}	1				
C_M			-0.46^{b}	0.82^{a}	-0.70^{a}		-0.90^{a}	0.94^{a}	1			
C_{Np}			-0.37^{c}	0.75^{a}	-0.74^{a}		-0.88^{a}	0.96^{a}	0.80^{a}	1		
POC	-0.46^{b}	0.30^{d}		0.66^{a}	-0.80^{a}		-0.82^{a}	0.85^{a}	0.73^{a}	0.88^{a}	1	
C_{ph}/POC	-0.76^{a}			0.78^{a}	-0.73^{a}		-0.84^{a}	0.92^{a}	0.93^{a}	0.83^{a}	0.74^{a}	1

* Correlation significance, a: < 0.001, b: < 0.01, c: < 0.05, and d: < 0.1
(Coefficients with correlation significance greater than 0.1 were not tabulated)

region of the present studied sea area.

The results of size-fractionated Chl a and primary productivity in Prydz Bay and its bordering sea area during the survey during January-March 1990 showed that the contribution of pico-plankton to total Chl a were averaging 8% and the contribution of it to total primary productivity were averaging 31% (Ning *et al.*, 1993). It proves that pico-plankton possesses high metabolic physiologic activity and great energy conversion rate.

CONCLUSIONS

The fist researches on standing stock and productivity of phytoplankton and its restricting mechanism of environment displayed the spatial zonation features in investigated sea area. The influence of environmental factors on the phytoplankton biomass and productivity and the importance of nano- and pico-plankton in the phytoplankton natural community to provide the foundation for studying the structure and function of the ecosystem and abundance and production ability of krill's food source in the studied sea area. The future work, beside the investigation of the interannual variation, should enhance the researches on the relationship between phytoplankton and the distribution of krill, it will make us further understanding of the trophic dynamics of low trophic levels of the pelagic ecosystem in Antarctic water.

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