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The distribution feature of size-fractionated chlorophyll *a* and primary productivity in Prydz Bay and its north sea area during the austral summer

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Abstract The investigation of size-fractionated chlorophyll *a* and primary productivity were carried out in three longitudinal sections (63°–69°12′S, 70°30′E, 73°E and 75(30′E) at December 18 – 26, 1998 and January 12 – 18, 1999 in Prydz Bay and its north sea area, Antarctica. The results showed that surface chlorophyll *a* concentration were 0.16 – 3.99 $\mu g\ dm^{-3}$. The high values of chlorophyll *a* concentration (more than 3.5 $\mu g\ dm^{-3}$) were in Prydz Bay and in the west Ladies Bank. The average chlorophyll *a* concentration at sub-surface layer was higher than that at surface layer; its concentration at the deeper layers of 50 m decreased with increasing depth and that at 200 m depth was only 0.01 – 0.95 $\mu g\ dm^{-3}$. The results of size-fractionated chlorophyll *a* showed that the contribution of the netplanktion to total chlorophyll *a* was 56%, those of the nanoplankton and the picoplankton were 24% and 20% respectively in the surveyed area. The potential primary productivity at the euphotic zone in the surveyed area was 0.11 – 11.67 $mgC\ m^{-3}h^{-1}$ and average value was 2.00 ± 2.80 $mgC\ m^{-3}h^{-1}$. The in-situ productivity in the bay and the continental shelf was higher and that in the deep-sea area was lower. The assimilation number of photosynthesis was 1.53 ± 1.11 mgC/(mg Chl *a* · h). The results of size-fractionated primary productivity show that the contribution of the netplanktion to total productivity was 58%, those of the nanoplankton and the picoplankton were 26% and 16% respectively. The cell abundance of phytoplankton was $1.6 \times 10^3 - 164.8 \times 10^3$ cell dm^{-3} in the surface water.

Key words primary productivity, chlorophyll *a*, phytoplankton, size-fractionated, Prydz Bay, Antarctica.

1 Introduction

The phytoplankton is the most abundance particulate organic matte originated biocenosis in the Southern Ocean. It is the material base of providing nutrient allowance and maintaining the vast krill resource in the Southern Ocean. Chlorophyll *a* concentration and primary productivity are one of the most important contents of bio-oceanography researching. They provide important scientific data for the studies on the ecological system structure and function in the Southern Ocean. In the other hand, the vastly stationary quantity of CO_2

were assimilated among the photosynthesis of photoautotroph is decreasing the partial pressure of the CO_2 in the water of the Southern Ocean, letting atmosphere CO_2 move into surface sea water, regulating the change of earth atmosphere and "greenhouse effect" importantly. Though people are gradually understanding the important action of the Southern Ocean in the global carbon cycle, especially the recognition of the importance to phytoplankton in carbon cycle in the Southern Ocean (Wang 1992; Nelson *et al.* 1996; Bates *et al.* 1998; Legendre 1998). No more researches on the standing stock and productivity of phytoplankton have been done in Antarctica sea-area yet. Moreover, they mostly concentrated on the Atlantic Sector of the Southern Ocean, much fewer studies were in the Indian Sector of it (Arrigo *et al.* 1998, 2000; Rubin *et al.* 1998). The author carried out several austral summer cruises of investigation of distribution features of phytoplankton standing stock and primary productivity in Prydz Bay and its adjacent sea area in combination with the project of "researches on ecology and utilization of krill resource in Antarctica". These authors' work provided important scientific data for studying the structure and function of food link of Antarctic marine ecosystem and evaluating the abundance and distribution of Antarctic marine organisms resources (Ning *et al.* 1998a, 1998b; Liu *et al.* 1998; Zhu *et al.* 1998). During the 15*th* CHINARE, the researches on the standing stock and primary productivity were carried out at three longitudinal sections in Prydz Bay that inquire into the distribution feature of standing stock and primary productivity in the investigated sea area. And accumulate scientific data for the studies on the ecosystem structure and function, they provide basic data for the comprehensive studies on ecosystem of the Southern Ocean and the biogeochemical studies of carbon in the global range as well.

2 Materials and methods

2.1 Sampling

Three longitudinal sections with 24 stations were laid from the continental rise of the inshore shelf of Prydz Bay towards the deep-sea area (63°–69°12'S, 70°30'E, 73°E and 75°30'E) and perpendicular the shore line during December 18–26, 1998 and January 12–18, 1999. Among them, II longitudinal section is crossing the continental shelf, the continental slope and the deep-sea area, III, IV longitudinal section is crossing the Bay, the continental shelf, the continental slope and the deep-sea area (Fig. 1). Water samples were collected with Niskin water sampler at selected depth-surface layer, 25 m, 50 m, 100 m, 150 m and 200 m water layers for analyzing the nutrients concentration and chlorophyll *a* concentration. The water samples for determining photosynthesis of phytoplankton and potential primary productivity were collected according to the depths at which the incident light strength attenuated to 100%, 50%, 32.5%, 10%, 3% and 1% of the original light strength on the sea surface respectively. Collect 500 cm^3 water sample from surface water, and fix it with neutral formalin solution to preserve and concentrate it for counting phytoplankton.

2.2 Methods

The chlorophyll *a* concentration was analyzed and determined with the fluorescence method in the "Standards of Marine Survey" (STSA 1991). Take 250 cm^3 water samples and filters it through 20.0 μm mesh (retaining netplankton), Nuclepore 2.0 μm filter (retaining nanoplankton) and the Whatman GF/F filter (retaining picoplankton). The phytoplankton cells cutoff on filters were extracted with 90% acetone for 24 h, then the extracting liquid was determined with Turner Designs Fluorometer, Model 10.

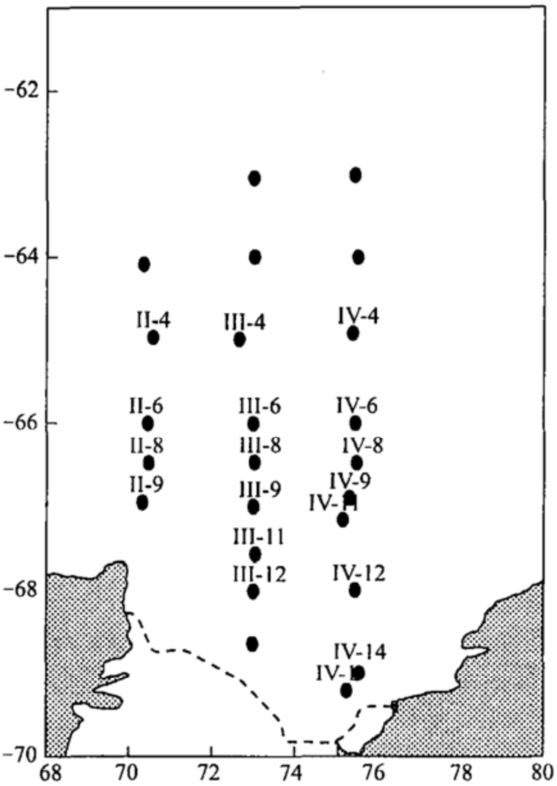

Fig. 1. Sampling stations.

For the determination of photosynthesis rate and potential primary productivity, the water samples were collected at 6 depths at which the different incident light attenuated. The water samples were pre-treated through the bolting-silk with 280 μm pore width to remove most zooplankton. The water samples from each light strength levels were filled into two parallel light bottles and one dark bottle of 250 cm^3, each bottle was added 3.7×10^5 Bq $NaH^{14}CO_3$ solution, placed in an incubator on the ship's deck to be incubated for 4 h. The incubator possessed the sieve with different neutral light densities to control the light intensity and make them complied with the light intensities at original sampling depths. After incubation, the water sample was filtered through 20.0 μm mesh, 2.0 μm and GF/F filter. Then the filters was fumed over concentrated hydrochloric acid, dried and preserved in the dark, and ready in Lab. for β-counting measurement with PAKARD 2450CA Liquid Scintillation Analysis meter after been added by scintillation cocktail. Finally calculate primary productivity according to the "Standards of Marine Survey" (STSA 1991) and the formula recommended by Parsons *et al.* (1984). And determine chlorophyll *a* concentration of water samples at six water layers for calculate the assimilation number of photosynthesis.

The identification of phytoplankton species and the cell counting were conducted with Olympus-VANOX biological microscope.

3 Results

3.1 *Distribution of chlorophyll* a *concentration* (*Chl* a)

The change range of Chl *a* at surface layer lay within 0.16 – 3.99 μg dm^{-3}. Chl *a* concentration with over 3.5 μg dm^{-3} appeared in the nearshore zone of the southern continental shelf and Prydz Bay. Low concentration of Chl *a* appeared in the deep-sea area. The average Chl *a* in deep-sea area is one order lower than that in the continental shelf and the bay. The distribution tendency of Chl *a* concentration at 25 m layer is similar to that at the surface layer, the higher value (5.02 μg dm^{-3}) appeared at 25 m layer of the station IV14. The average Chl *a* at 50 m layer descend slightly, and high value appeared in the continental shelf and the bay still. The highest value (5.45 μg dm^{-3}) appeared at 50 m layer of the station IV11. The lower Chl *a* concentration appeared at depth of 100 m and more, lower 0.5 μg dm^{-3} of Chl *a* concentration appeared at 100 m layer in most stations by 80%, and lower 0.05 μg dm^{-3} of Chl *a* concentration appeared at 200 m layer in most stations by 94%. III, IV longitudinal section crossing Prydz Bay, the continental shelf, the continental slope and the deep-sea area. The regional distribution feature of Chl *a* concentration is very obvious: the high Chl *a* concentration appeared in Prydz Bay, the average value of the depth 0 – 50 m is more than 3.0 μg dm^{-3}, those of 100 m layer is 1.10 ± 1.25 μg dm^{-3}. The average value of Chl *a* concentration appeared lower in the continental shelf and the continental slope, and that is lowest in the deep-sea area (Table 1). It can be seen from Table 1 that the average Chl *a* concentration at sub-surface layer was greater than that at surface in the continental slope and the deep-sea area where influence was low by Antarctica nearshore ice. The result statistics indicate that the stations where Chl *a* concentration at the sub-surface was greater than that at the surface is more than those at which Chl *a* concentration at the surface was greater than that at the sub-surface.

Table 1. The average of chlorophyll *a* concentration in the austral summer 1998/1999

	Prydz Bay (n=5)	Cont. Shelf (n=5)	Cont. Slope (n=6)	Deep-sea (n=8)	Average (n=24)
0 m	3.12 ±0.93	1.96 ±1.64	0.87 ±0.71	0.28 ±0.08	1.44 ±1.42
25 m	3.31 ±2.10	1.70 ±1.85	0.89 ±0.69	0.30 ±0.12	1.47 ±1.72
50 m	2.94 ±2.08	1.86 ±2.13	0.75 ±0.47	0.31 ±0.10	1.36 ±1.69
100 m	1.10 ±1.25	0.38 ±0.45	0.20 ±0.08	0.22 ±0.10	0.46 ±0.71
150 m	0.57 ±0.60	0.14 ±0.15	0.12 ±0.12	0.10 ±0.12	0.22 ±0.35
200 m	0.31 ±0.24	0.08 ±0.04	0.04 ±0.03	0.04 ±0.03	0.11 ±0.19
Average	1.61 ±1.05	0.83 ±0.83	0.41 ±0.24	0.20 ±0.06	0.71 ±0.82

The result of size-fractionated Chl *a* concentration in the surveyed area showed that the contribution of the netplankton (>20 μm) to the total chlorophyll predominate generally an account for 61% and 57% in the bay and in the shelf, respectively. The contribution of the nanoplankton (2.0 – 20.0 μm) and picoplankton (<20 μm) to the total chlorophyll were lower. And in the continental slope and deep-sea area, the contribution of the netplankton to the total chlorophyll low obviously. The contribution rate is nearly same for the netplankton and for the nanoplankton, the contribution of the picoplankton predominate generally in deep-sea area (Table 2).

Table 2. The distributions of size-fractionated chlorophyll *a* concentrations (μg dm^{-3}) in the surveyed area

Chlorophyll *a*	Prydz Bay	Cont. Shelf	Cont. Slope	Deep-sea	Average
Netplankton (%)	1.00 ±0.69 (61%)	0.47 ±0.46 (57%)	0.18 ±0.16 (44%)	0.07 ±0.04 (34%)	0.40 ±0.53 (56%)
Nanoplankton (%)	0.34 ±0.23 (23%)	0.19 ±0.19 (23%)	0.12 ±0.07 (30%)	0.07 ±0.02 (35%)	0.17 ±0.17 (24%)
Picoplankton (%)	0.27 ±0.18 (16%)	0.17 ±0.18 (20%)	0.11 ±0.05 (26%)	0.06 ±0.02 (31%)	0.14 ±0.14 (20%)
Sum phytoplankton	1.61 ±1.05 (100%)	0.83 ±0.83 (100%)	0.41 ±0.24 (100%)	0.20 ±0.06 (100%)	0.71 ±0.82 (100%)

Note: Netplankton: <20.0 μm, Nanoplankton: 2.0 – 20.0 μm, Picoplankton: < 2.0 μm

3.2 Primary productivity

The potential primary productivity lay within 0.11 – 11.67 mgC $m^{-3}h^{-1}$ in the surveyed area. The high primary productivity appeared in Antarctic nearshore polynya and Four Ladies Bank and it lay within the depth at surface water till the incident light strength attenuated to 10% of the original light strength on the sea surface. The low primary productivity appeared in the north deep-sea area and where the depths of the incident light strength attenuated to 3% and 1% of the original light strength on the sea surface in the all surveyed stations. The potential primary productivity was trend to 0 mgC $m^{-3}h^{-1}$ at the depths of the incident light strength attenuated to 1% of the original light strength on the sea surface in some surveyed stations. The surface potential primary productivity was highest by 28.57 mgC $m^{-3}h^{-1}$ at the anchor ground of vessel "*XueLong*" in Zhongshan Bay, where the ice-algae was releasing to the surface water of the abundant nutrients and quickly blooming.

The seawater were stable, summer's solar radiation enhanced, water temperature rose, nearshore ice burst and melted, the ice-algae was released and the standing stock of phytoplankton was high, the average Chl *a* concentration was more than 3.0 μg dm^{-3} at the euphotic zone in Prydz Bay. Phytoplankton possessed higher photosynthetic activity, primary productivity was higher in the bay, and that was lowering gradually to the continental shelf, the continental slope and north deep-sea area step by step. The in situ primary productivity was 0.86 gC $m^{-2}d^{-1}$) and 0.59 gC $m^{-2}d^{-1}$ in the bay and in the shelf respectively. Because standing stock of phytoplankton is low in the slope and deep-sea area, although where have deeper euphotic zone, the average productivity have only half of that in the shelf (Table 3).

Table 3. The potential primary productivity and assimilation number in the different surveyed area

	Euphotic zone (m)	potential primary productivity (mgC $m^{-3}h^{-1}$)				In situ PP. (gC $m^{-2}\cdot d^{-1}$)	A. N. (mgC mgChl$a^{-1}\cdot h^{-1}$)
		Netplankton	Nanoplankton	Picoplankton	Sum		
Prydz Bay	17.5 ±1.5	3.46 ±3.76 (69%)	1.05 ±0.68 (21%)	0.50 ±0.52 (10%)	5.02 ±4.09 (100%)	0.86 ±0.78	1.81 ±1.24
Cont. Shelf	31.7 ±10.8	1.23 ±1.56 (51%)	0.64 ±0.67 (27%)	0.54 ±0.63 (22%)	2.40 ±2.82 (100%)	0.59 ±0.63	1.39 ±1.01
Cont. Slope	33.4 ±3.5	0.35 ±0.53 (36%)	0.36 ±0.25 (37%)	0.27 ±0.21 (27)	0.98 ±0.88 (100%)	0.30 ±0.25	1.56 ±1.10
Deep-sea	44.5 ±8.4	0.14 ±0.14 (33%)	0.16 ±0.15 (39%)	0.12 ±0.10 (28%)	0.43 ±0.39 (100%)	0.17 ±0.14	1.52 ±1.30
Average	33.4 ±12.0	1.15 ±2.19 (58%)	0.51 ±0.55 (26%)	0.33 ±0.41 (16%)	2.00 ±2.80 (100%)	0.45 ±0.55	1.53 ±1.11

The average percentage of the contribution of netplankon, nanoplankton and picoplankton to primary productivity and assimilation number are listed in Table 3. It can be found in Table 3 that the results of size-fractionated primary productivity shows that the netplankton (>20 μm) predominate generally in the bay and the shelf, the contribution rates of netplankon, nanoplankton and picoplankton to primary productivity respectively was approached in the slope and deep-sea area. The contribution of netplankton, nanoplankton and picoplankton to total primary productivity account for 58%, 26% and 16% respectively in the surveyed area.

The average assimilation number of photosynthesis of phytoplankton in the surveyed area is 1.53.4 ± 1.11 mgC mgChl a^{-1} h^{-1}. The highest assimilation number is at Station III4 (9.92 mgC mgChl a^{-1} h^{-1}) and the next are at Stations IV6 and IV14 (4.14 and 3.61 mgC mgChl a^{-1} h^{-1}), respectively); the lowest assimilation number is at Stations IV11 and II6 (0.11 and 0.16 mgC mgChl a^{-1} h^{-1}), respectively).

3.3 The cell abundance and dominant species of phytoplankton

The abundance of phytoplankton at surface water in surveyed area was 1.6×10^3 – 164.8×10^3 cell dm^{-3} and average value was $21.27 \times 10^3 \pm 38.47 \times 10^3$ cell dm^{-3} (n = 23). Bacillariophyta in the micro phytoplankton accounted for 84.51%, Pyrrophyta accounted for 5.12%, Cyanophyta accounted for 10.11%, the other species accounted for 0.26%. The high value of cell abundance appeared in Prydz Bay and low cell abundance appeared in the continental slope and in the deep-sea area. Owing to the differences of the geographic environment and the hydrological conditions, the distribution of phytoplankton show distinctively spatial zonation features. The average cell abundance in the bay and the shelf ($49.60 \times 10^3 \pm 51.38 \times 10^3$ cell dm^{-3}) was ten times higher than that in the continental slope ($4.67 \times 10^3 \pm 2.55 \times 10^3$ cell dm^{-3}) and was fourteen times higher than that in the deep-sea area ($3.50 \times 10^3 \pm 1.94 \times 10^3$ cell dm^{-3}). The dominant species was Nitzschia curta. The average cell abundance was 8.54×10^3 cell dm^{-3} for account of the total cell abundance of 38.02% in the surveyed area, appearance frequency is 81.8%. The principal species were *Nitz. barkley*, *Cylindrotheca closterium* and *Nitz. kerguelensis.*

4 Discussion

Prydz Bay is the third large gulf implanted to Antarctic continent. It's the first large bay in the eastern Antarctica. Its top links to the Amery Ice Shelf and the both sides of the Four Ladies Bank and Frame Bank are located in the northeast and northwest respectively, occupying 6.0×10^4 km^2 area. The bay freeze-over, and the thickness of ice are nearby 2 m in the austral winter. In the austral summer, sea-ice burst and some melt, but the floe coverage rates are higher and the coverage area is shift (Dong *et. al.* 1984). In the surveyed area, the longitudinal section crossing Prydz Bay (depth 400 – 700 m), the continental shelf (depth < 1000 m), the continental slope (depth 1000 – 3000 m) and the deep-sea area (depth > 3000 m, the topography is rather placid). Productivity and chlorophyll *a* concentration of phytoplankton, water temperature, salinity, nutrients and so on various environmental physio-chemical factors in different geographic regions showed obvious regional features (Table 4). With the water temperature rising in austral summer, Antarctica, the nearshore ice relaxation, broken and drifting in the bay and the shelf. Some surveyed stations were located polynya, and the ice-algae were released to the water. It led to the standing stock of phytoplankton increasing, the photo-plankton blooming in the upper water. The maximum value of primary productivity appeared in the station IV14. In the south 68°S, shallow db50, the austral summer surface water temperature was about 1.9°C, salinity was about 34 in the Prydz Bay. There is the highest temperature of the water mass in the surveyed area (Pu *et al.* 2000). Chl *a* concentration, the cell abundance of phytoplankton and productivity in this area were higher. Even though the nutrient concentration in water had been depleted by photo-plankton blooming and its concentration obviously decreased, but the nutrient concentration was higher still. The dissolved oxygen concentration increment, the average dissolved oxygen concentration is 785.07 ± 9.64 μmol/dm^3 in the bay and shelf. The continental slope situated nearby Antarctic Convergence, the water of lower temperature (−1.8°C) and higher salinity (34.4 − 34.5) was under db100 where the surface water cooled and separated out salt and forming boundary with eastern drift and western drift in the austral autumn and winter. The shearing current was formed in ocean, where had common boundary with easterly wind drift and westerly wind drift. The stability of the water descended, this is not beneficial for the roosting and growing of photo-plankton, influencing photo-production, Chl *a* concentration, productivity, phytoplankton cell abundance descended. At db50 in the deep-sea area, there was a winter water of low temperature (−1.8 − −1.5°C) and low salinity (nearby 34) in Prydz Bay (Pu *et al.* 2000). This area situated the south of the westerlies, wind vast and wave high, the water exchanged strongly, it's not beneficial for the growth and propagation of the photosynthesis phytoplankton. The environment makes Chl *a* concentration, productivity, phytoplankton cell abundance the lowest, euphotic zone of water thickening, nutrients concentration increasing and dissolved oxygen content decreased (Table 4).

Table 4. The average values of chlorophyll *a*, cell abundance of phytoplankton, primary productivity and parameters of the physical and chemical in the euphotic layer

	Prydz Bay (n = 5)	Cont. Shelf (n = 5)	Cont. Slope (n = 6)	Deep-sea (n = 8)	Average (n = 24)
Temperature (°C)	−0.29 ± 1.27	−1.64 ± 0.18	−1.42 ± 0.26	−1.29 ± 0.21	−1.19 ± 0.74
Salinity	34.15 ± 0.07	33.92 ± 0.13	33.43 ± 0.25	33.73 ± 0.18	33.78 ± 0.31
Euphotic Zone (m)	17.5 ± 1.5	31.7 ± 10.8	33.4 ± 3.5	44.5 ± 8.4	33.4 ± 12.0
DO (μmol dm^{-3})	778.9 ± 44.6	728.9 ± 27.2	713.3 ± 15.7	700.4 ± 26.6	725.9 ± 40.3
Silicate (μmol dm^{-3})	50.89 ± 17.35	55.70 ± 3.80	52.73 ± 7.03	52.03 ± 4.70	52.73 ± 8.67
Phosphate (μmol dm −3)	1.15 ± 0.40	1.51 ± 0.37	2.02 ± 0.35	1.95 ± 0.32	1.72 ± 0.48
Nitrate (μmol dm^{-3})	18.86 ± 8.15	28.10 ± 3.09	28.70 ± 2.42	26.80 ± 2.30	25.89 ± 5.50
Nitrite (μmol dm^{-3})	0.12 ± 0.03	0.13 ± 0.01	0.18 ± 0.06	0.25 ± 0.03	0.18 ± 0.06
Ammonium salt (μmol dm^{-3})	0.30 ± 0.26	0.54 ± 0.60	0.50 ± 0.62	0.29 ± 0.22	0.40 ± 0.43
Chlorophyll *a* (μg dm^{-3})	3.07 ± 1.58	1.89 ± 1.51	0.87 ± 0.70	0.30 ± 0.10	1.35 ± 1.45
Productivity (mgC m^{-3}h^{-1})	5.02 ± 4.09	2.40 ± 2.82	0.98 ± 0.88	0.43 ± 0.39	2.00 ± 2.80
Phytoplankton (× 10^3 cell dm^{-3})	49.12 ± 29.34	50.20 ± 76.75	4.67 ± 2.55	3.54 ± 1.72	22.69 ± 39.16

Prydz Bay is a semien-closed one with obstruction of Four Ladies Bank and Frame Bank is located in the northeast and northwest of the bay respectively. The water exchange is weak, stability of the water is strong. In the other hand, there is an upwelling activity in the west of the bay, the nutrients in the upper water were supplemented continuously. There is beneficial for the growth and propagation of the photosynthesis phytoplankton. Therefore, the cell abundance of phytoplankton, Chl *a* concentration and photosynthetic production rate of the organic crbon were higher in the bay. The dissolved oxygen concentration raised and nutrents are consumed with the blooming of the photo-plankton in the austral summer. Making chlorophyll *a* concentration and dissolved oxygen concentration in surveyed stations to be closely correlated to each other ($r = 0.743$), Chl *a* concentration and nitrate, nitrite and phosphate in surveyed stations to be remarkable negative correlated to each other (r = −0.707, r = −0.677, r = −0.554, respectively).

The ocean-ecological scientists have common recognition of the importance to nanoplankton and picoplankton in phytoplankton community in the Southern Ocean. The authors carried out several austral summer cruises of investigation in combination with the State tackling key problem project of "researches on ecology and utilization of krill resource in Antarctica". And provided the contribution of nanoplankton and picoplankton to total standing stock and primary productivity of phytoplankton are more than that netplankton in Antarctic surveyed area. In this paper, the average contribution of netplankton, nanoplankton and picoplankton to total Chl *a* concentration is 56%, 24% and 20% respectively, to total primary productivity is 58%, 26% and 16% respectively. Because of various environmental physio-chemical factors in different geographic regions, the contribution of size-fractionated phytoplankton to Chl *a* concentration and productivity are different. In Prydz Bay and the continental shelf, Chl *a* concentration and productivity are higher, the contribution of netplankton gain upper hand, the contribution rate of netplankton account for 61% and 57% in Chl *a* concentration and for 69% and 51% in productivity, respectively. In the continental slope and the deep-sea area, the contributions of netplankton descended apparently and the contributions of nanoplankton and picoplankton raised (Table 3). The result is fundamental identical with before conclusion (Liu *et al.* 1998; Ning *et al.* 1998a,b).

5 Conclusions

The surveyed area longitudinal section cross Prydz Bay, the continental shelf, the continental slope and the deep-sea area. The cell abundance, standing stock of phytoplankton and primary productivity in Prydz Bay and the continental shelf are higher than that in the continental slope and the deep-sea area. The contributions of netplankton to Chl *a* concentration and primary productivity gain upper hand, the contributions of nanoplankton to Chl *a* concentration and primary productivity is slightly higher than that of picoplankton in Prydz Bay and the continental shelf. Chlorophyll *a* concentration and dissolved oxygen concentration in surveyed stations is closely correlated to each other (r = 0.743), Chl *a* concentration and nitrate, nitrite and phosphate in surveyed stations to be remarkablly negative correlated to each other (r = −0.707, r = −0.677, r = −0.554, respectively).

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