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Primary productivity and chlorophyll *a* in Prydz Bay and its mouth in Antarctica during the austral summer of 1999/2000

Liu Zilin (刘子琳)[1,2], Cai Yuming (蔡昱明)[1,2], Ning Xiuren (宁修仁)[1,2], Liu Chenggang (刘诚刚)[2], Zhu Genhai (朱根海)[2] and Wang Xiaogu (王小谷)[2]

1 *Key Laboratory of Submarine Geosciences, SOA, Hangzhou 310012, China*

2 *The Second Institute of Oceanography, SOA, Hangzhou 310012, China*

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Abstract The investigation of phytoplankton standing stock, euphotic layer and photosynthesis rate were carried out in 19 - 27 of January, 2000 at three longitudinal sections (70°30′E, 73°00′E and 75°30′E). The results showed that the high value of chlorophyll *a* concentration was in inshore bay, polynya and the continental slope of the investigated sea area. At various investigated stations, average chlorophyll *a* concentration at sub-surface layer (25 m) was higher than that at surface layer; its concentration at the deeper layers of over 50 m decreased with increasing depth. At anchor station, the maximum chlorophyll *a* concentration appeared at surface layer in Antarctic summer's afternoon while the minimum value appeared in the morning; chlorophyll *a* concentration at water layer of 0 - 25 m was obviously higher than that at deep water layer, being related to the releasing of ice-algae. High productivity was in inshore bay and polynya of continental shelf. Chlorophyll *a* concentration at surface layer is closely correlated to the dissolved oxygen concentration in seawater. The sea area with chlorophyll *a* concentration of over 1.0 μg/dm^3 may be the convergence of CO_2 and that of below 1.0 μg/dm^3 may be the source of CO_2.

Key words primary productivity, chlorophyll *a*, carbon dioxide, Prydz Bay, Antarctica.

1 Introduction

The study of "the Action of Antarctic Area in global Change" is the frontal field of international science. Though mankind are gradually understanding the important action of the Southern Ocean in the global carbon cycle, especially the importance to phytoplankton in carbon cycle in the Southern Ocean (Wang 1992; Longhurst and Harrison 1989; Nelson *et al*. 1996; Bates *et al*. 1998; Legendre 1998), few researchers on the biomass and productivity have been done in Antarctic sea-area. Moreover, if done, the studies were mostly concentrated on the Atlantic Sector of the Southern Ocean, but less were in the Indian Sector of it (Arrigo *et al*. 1998, 2000; Rubin *et al*. 1998). The authors carried out several austral summer cruises of investigation in past ten years and over. The distribution features of phytoplankton standing stock and primary productivity in Antarctic Prydz Bay and its adjacent sea area in combination with the project of "researches on Ecology and Utilization of krill resource in Antarctica". The authors' these 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, b, c; Liu *et al*. 1998; Zhu *et al*. 1998). The execution of "studies on Response and Feedback Action of Antarctica to the Global Change", the State key project, is a contribution to the international frontal scientific researches. The study of particulate organic carbon (POC) source in the Southern Ocean is one of the important contents in "Studies on Dynamic Change of ecosystem and biogeochemisty". Studies on the phytoplankton standing stock and primary productivity were carried out at three longitudinal sections in Prydz Bay to inquire into the structure of phytoplankton communities and the distribution feature of standing stock and primary productivity in the investigated sea area, and provide scientific data for the studies on the ecological system structure and function, as well as basic data for the comprehensive studies on ecosystem of the Southern Ocean and the biogeochemical studies of carbon in the global range.

2 Materials and methods

2.1 Sampling

In 19 − 27 of January, 2000 we made sampling in three longitudinal sections with 18 stations in the continental rise of inshore shelf of Antarctic Prydz Bay to deep-sea area (62°S − 68°S, 70°30′E − 75°30′E), and the stations are perpendicular to the shore line. Among them, longitudinal section iv iv iv passes across continental shelf, continental slope and deep-sea area. The continuous observation was set up at an interval of 6 h in the iv iv iv-12 anchor station in polynya of continental shelf. Sampling and analysis were done at the stations set in the anchor ground in Davis Bay and Zhongshan Bay (Fig. 1). Water samples were collected with Rosette water sampler at selected depth to surface layer, 25, 50, 100, 150 m and 200 m water layers for analyzing the concentration of nutrient substances and chlorophyll *a* concentration. The water samples for determining photosynthesis of phytoplankton and potential primary productivity were collected according to the depths, of 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.

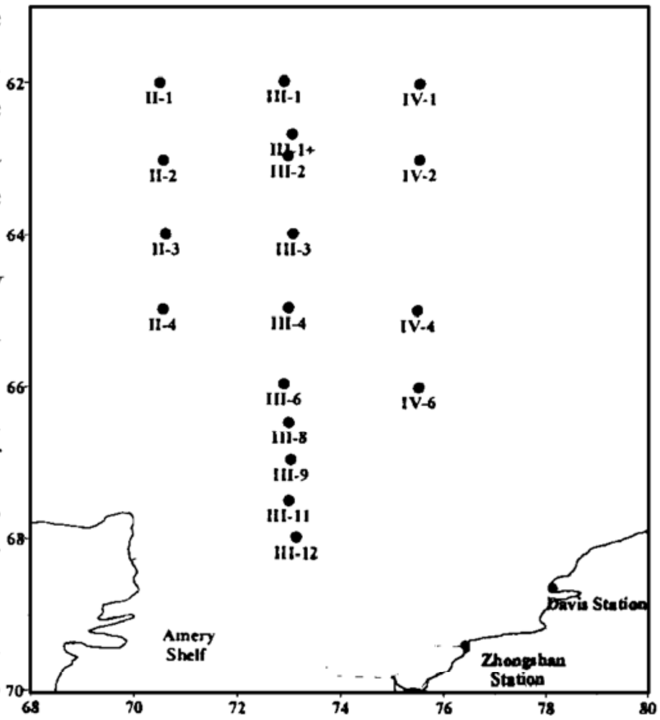

Fig. 1. Sampling stations.

500 cm^3 water sample was collected from surface layer, it was preserved with neutral formalin solution and it was used for counting phytoplankton after condensation.

2.2 Methods

The chlorophyll *a* concentration was analyzed and determined with the fluorescence method in the "Standards of Marine Survey" (The State Technical Supervision Administration 1991). Take 250 cm^3 water sample, filter it through the Whatman GF/F filter; extract the phytoplankton cells on filter membranes with 90% acetone for 24 h, then the extracting liquid was determined with Turner Designs Fluorometer, Model 10. For the determination of photosynthesis rate and potential primary productivity, the water samples were collected according to the depths in which the incident light attenuated to 100%, 50%, 32.5%, 10%, 3% and 1% of the original light strength on the sea surface respectively. The water samples were pre-treated through the sieve, 280 μm in pore diameter to remove most zooplanktons. The water samples from each light strength level 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, then they were placed in an incubator on the ship's deck for incubation of 3 - 6 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. The incubator was equipped with seawater cycle system to simulate the temperature of site seawater. After incubation, the water sample was filtered through GF/F filter; the filter membrane was fumed over concentrated hydrochloric acid, dried and preserved in the dark, and then taken to Laboratory to carry out β-counting with PAKARD 2450CA Liquid Scintillation Analysis meter after adding scintillation cocktail. Finally we calculate its primary productivity according to the "Standards of Marine Survey" (The State Technical Supervision Administration 1991) and the formula recommended by Parsons *et al*. (1984). And we also determine the Chlorophyll *a* concentration of water samples at six water layers. The identification of phytoplankton species and the cell counting were conducted with Olympus biological microscope.

The water temperature and salinity were determined with CTD and chemical nutrient salts (PO_4^{3-}, NO_3^-, NO_2^-, NH_4^+ and SiO_3^{2-}) were determined according to the methods for common seawater analysis and stipulated by the "Standards of Marine Survey" (The State Technical Supervision Administration 1991).

3 Results

3.1 Distribution of phytoplankton standing stock (chlorophyll a)

The high chlorophyll *a* concentration with over 3.0 μg/dm^3 at surface layer in the determined area appeared at the stations ⅳⅳⅳ6 - ⅳⅳⅳ8 in the middle of continental slope. Low chlorophyll *a* concentration appeared in deep-sea area and the low value of less than 0.2 μg/dm^3 appeared at 62°S nearby in the northwest of this area (Fig. 2a). Chlorophyll *a* concentration at surface layer in inshore continental shelf was 1.18 - 2.93 μg/dm^3; its average value ((2.29 ± 0.96) μg/dm^3) was the greatest among those in continental shelf, continental slope and deep-sea area. Chlorophyll *a* at surface layer in continental slope ranged from 0.82 - 3.75 μg/dm^3; average value was (2.07 ± 1.35) μg/dm^3. Chlorophyll *a* concentration in the deep-sea area of determined sea area was mostly below 0.5 μg/dm^3 and average value was (0.34 ± 0.13) μg/dm^3.

The distribution of chlorophyll *a* concentration at the water layer of 25 m depth: the maximum value 5.08 μg/dm^3 appeared at station iv iv iv6; the average concentration in continental slope was higher than that at surface layer by 66%, reaching (3.43 ±1.62) μg/dm^3. Chlorophyll *a* concentration in continental shelf was slightly lower than that at surface layer while its concentration in deep-sea area is basically in conformity with that at surface layer. The distribution trend of average chlorophyll *a* concentration in euphotic zone was basically in conformity with that at surface layer; its high value with 2.0 μg/dm^3 and over appeared in continental shelf and continental slope; its distribution range was greater than that at surface layer (Fig. 2b).

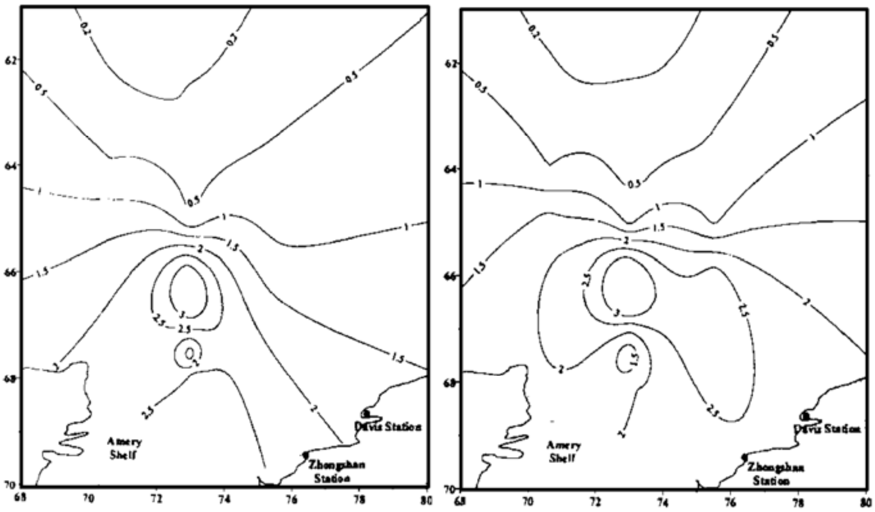

Fig. 2. The plane distribution of chlorophyll *a* concentration (μg/dm^3). a) 0 m; b) the average values in the euphotic zone.

The vertical distribution of chlorophyll *a* concentration was: the maximum value appeared in the sub-surface layer; chlorophyll *a* concentration at 25 m layer in overwhelming majority of determined stations (accounting for 83% of total stations) was higher than that at other water layers. The longitudinal section iv iv iv stretches from continental shelf and continental slope and towards deep-sea area. Chlorophyll *a* concentration more than 4.0 μg/dm^3 appeared at 25 m layer of stations iv iv iv6 and iv iv iv8 in continental slope. The chlorophyll *a* at 50 m layer still maintained a high value area of 3.0 μg/dm^3 and over, where its concentration gradually lowered towards two sides and deep layer. Chlorophyll *a* concentration at 100 m layer in continental shelf and continental slope was lower than that in deep sea area, this maybe because the shallow euphotic zone in these area, weak light of deep layer water or free light zone are disadvantageous to the growth of phytoplankton. Viewing from the profile section iv iv iv, the area with chlorophyll *a* concentration below 0.50 μg/dm^3 occupied most space of the determined area (Fig. 3a). Due to the consumption of phytoplankton, the nutrient concentration in high phytoplankton area was lowering, phosphate concentration being below 1.6 μmol/dm^3 and nitrate being below 30.0 μmol/dm^3 (Fig. 3b, 3c). There was difference in the water layer thickness of high phytoplankton at different geographic areas. The high concentration of Chlorophyll *a* in continental shelf was confined at the shallow water layer of 25 m. The thickness of high chlorophyll *a* concentration in continental slope stretches to the water layer of 50 m. The Chlorophyll *a* concentration of the upper layer water at 0 − 100 m in deep-sea area was lower, but its relative high value in this area stretches to the water layer of 100 m, where lies the bottom of the euphotic layer (Table 1). Chlorophyll *a* concentration at 150 m layer and over was lower than 0.1 μg/dm^3. Chlorophyll *a* concentrations at 200 m layer at stations of iv iv iv2, iv iv iv4, iv iv2 and iv⑼2 were all lower than 0.01 μg/dm^3.

Table 1. The average value of Chlorophyll *a* concentration (μg/dm^3) in the surveyed area during the austral summer of 1999/2000

Depth/m	Continental shelf (n= 3)	Continental slope (n= 5)	Deep-sea area (n= 10)	Average value (n= 18)
0	2.29 ±0.96	2.07 ±1.35	0.34 ±0.13	1.14 ±1.19
25	2.01 ±0.79	3.43 ±1.62	0.37 ±0.15	1.49 ±1.61
50	0.55 ±0.39	2.14 ±1.26	0.43 ±0.35	0.86 ±0.96
100	0.08 ±0.02	0.23 ±0.12	0.29 ±0.17	0.24 ±0.16
150	0.05 ±0.01	0.08 ±0.03	0.07 ±0.05	0.07 ±0.02
200	0.03 ±0.01	0.03 ±0.01	0.02 ±0.02	0.03 ±0.02
Average	0.54 ±0.18	1.07 ±0.40	0.24 ±0.10	0.52 ±0.43

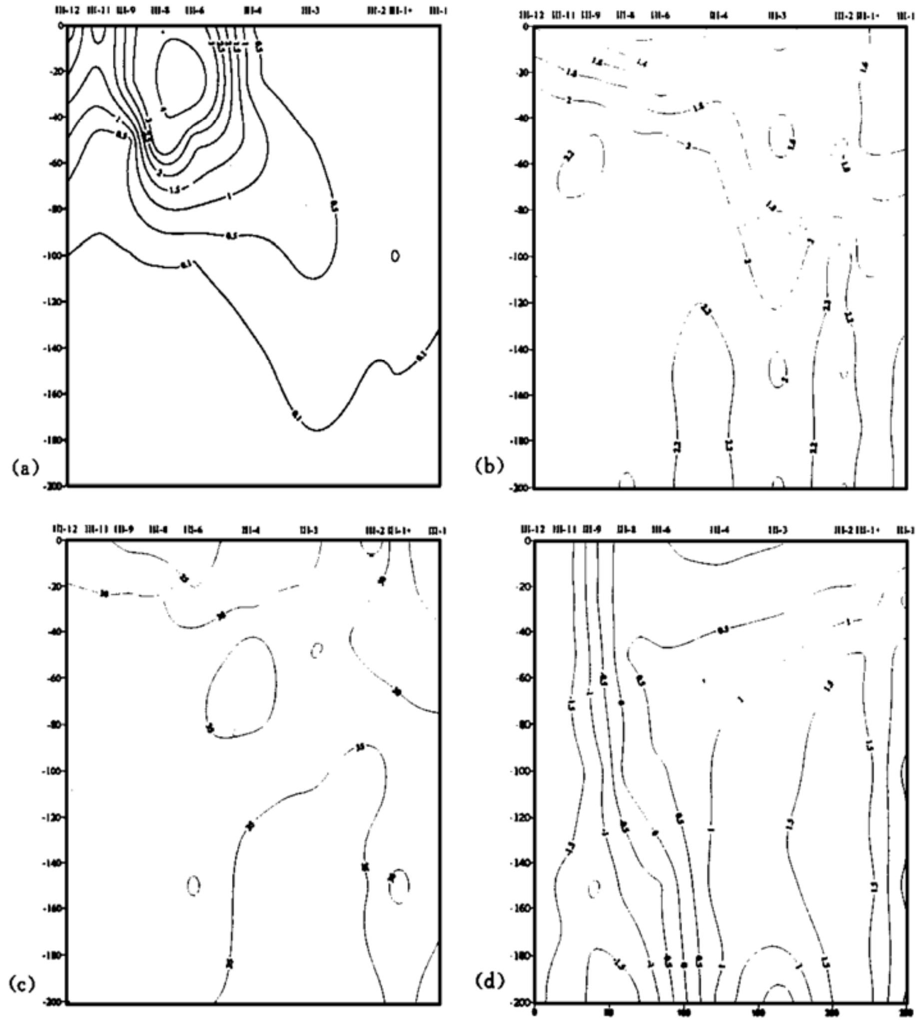

Fig. 3. The section distribution of the chlorophyll *a*, phosphate, nitrate and temperature. a) chlorophyll *a*; b) phosphate; c) nitrate; d) temperature.

The anchored survey station is located in polynya of inshore continental shelf; the change of chlorophyll *a* concentration at surface layer ranges from 1.90 − 3.08 μg/dm^3. The high value appeared in afternoon and low value appeared in morning and evening.

The change range at 25 m layer increased, being 1.01 – 4.14 μg/dm^3; the chlorophyll *a* concentrations at 50 – 200 m were all lower than 0.50 μg/dm^3. In Antarcticia, as summer's solar radiation enhanced, ice and snow molted and Ice-algae released, the abundance of micro phytoplankton in water increased and the chlorophyll *a* concentration rose. On the other hand, the water temperature and salinity lowered at surface layer, with the consumption of phytoplankton, the lowering of nutrient concentration and the increase of dissolved oxygen when as ice and snow melted (Table 2). The dominant species of phytoplankton were more single, mainly being *Nitzschia barkley* and *Nitz. curta*; both the species accounted for 66% – 90% of the cells abundance in the surveyed stations.

Table 2. The distributions of the surface chlorophyll *a*, cell abundance of phytoplankton and the physical and chemical parameters in the anchored survey station

	03:00	08:00	13:00	19:00	01:00	Average
Temperature/ ℃	– 1.90	– 1.88	– 1.88	– 1.85	– 1.88	– 1.88
Salinity	34.56	34.57	34.56	34.52	34.56	34.55
Dissolved Oxygen/ μmol·dm^{-3}	730	/	729	/	719	726
Silicate / μmol·dm^{-3}	55.7	/	57.2	/	57.8	56.9
Phosphate/ μmol·dm^{-3}	1.59	/	1.57	/	1.67	1.61
Nitrate/ μmol·dm^{-3}	26.0	/	27.2	/	28.2	27.1
Chlorophyll *a* / μg·dm^{-3}	2.93	1.96	3.08	1.90	2.04	2.38
Cell abundance/ × 10^3·dm^{-3}	162.00	155.70	207.90	155.70	122.40	160.74

3.2 The cell abundance and dominant species of phytoplankton

The abundance of phytoplankton at surface water in surveyed area was (6.3 – 162.0) × 10^3 cell/dm^3 and average value was (29.35 ±40.25) × 10^3 cell/dm^3. The high value of cell abundance appeared at the stations in polynya and low cell abundance appeared in deep-sea area (Fig. 4). The average cell abundance in continental shelf ((106.20 ± 48.40) × 10^3 cell/dm^3) was four times higher than that in continental slope ((21.42 ±16.10) × 10^3 cell/dm^3) and nine times higher than that in deep-sea area ((10.26 ±3.94) × 10^3 cell/dm^3). Bacillariophyta in the micro phytoplankton accounted for 70.5%, Cyanophyta accounted for 22.0%; Pyrrophyta accounted for 7.0%, Chrysophyta accounted 0.5%. The dominant species were *Nitzschia barkley*, *Nitz. curta*, *Nitz. Heimii*, *Rhizosolenia alata*, *Corethron criophilum*, *Cylindrotheca closterium*, *Coscinodiscus granii*, *Nitz. Linearis*, *Nitz Cylindrus*, *Gymnodinium* sp. and *Oscillatoria* sp.

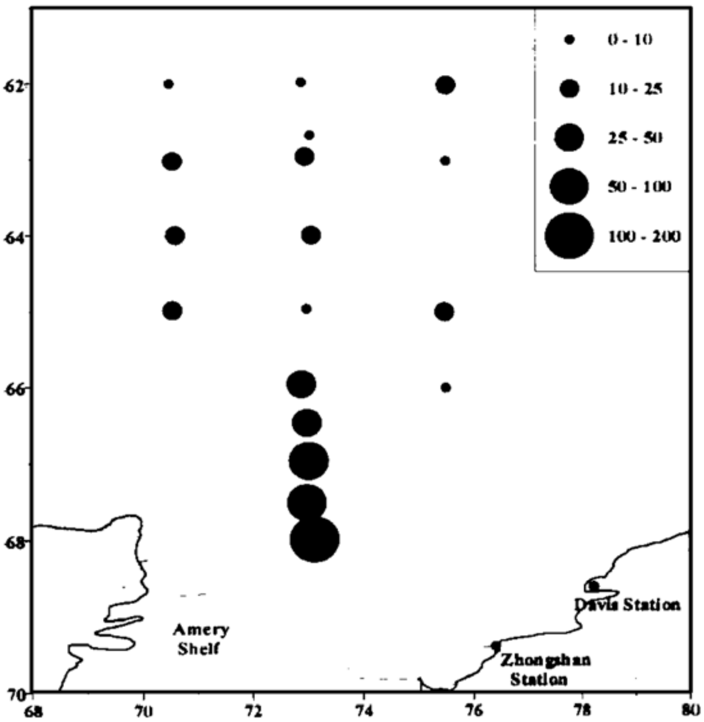

Fig. 4. The cell abundance and distribution of micro-phytoplankton in the surface water.

3.3 Primary productivity

The high primary productivity in surveyed area appeared in Antarctic nearshore bay and inshore continental shelf; the potential primary productivity ranged from 5. 68 mgC/ (m^3•h) to 12. 59 mgC/ (m^3•h) and in situ primary productivity was over 1. 5 gC/ (m^2•d) . The seawater were stable, summer solar radiation enhanced, water temperature rose, ice-algae was released and phytoplankton was high in the bay and inshore continental shelf. Primary productivity in continental slope was lower than that in bay and continental shelf and its high value was at the Station iv iv iv6 (4. 72 mgC/ (m^3•h)) . The productivity on the east and west sides of the continental slope was lower and was basically approximate to that in deep-sea area. The potential productivity in deep-sea area ranged 0. 09 - 1. 40 mgC/ (m^3•h) . Viewing from the vertical distribution of primary productivity, the productivity at surface layer was higher, as depth increase, the productivity markedly lowered. Productivity at the water layers where the light strength of surface layer attenuated to 10% and less were all lower, even if being at the Stations iv iv iv12 and iv iv iv6 in the continental shelf and continental slope where there were high chlorophyll *a* and high productivity at the surface layer. In the seawater where the light strength of surface layer attenuated to 1% , the productivity lowered to 0. 1 mgC/ (m^3•h) or less. It can be seen from Table 3 that the potential productivities in bay and shelf were over 5 mgC/ (m^3•h) both, in situ productivity was over 1. 5 gC/ (m^2•d) ; the phytoplankton standing stock and potential productivity in deep-sea area were less than those in continental slope, but there was thicker euphotic zone in the deep-sea area (53 m) , thus, in situ productivity ((0. 59 ±0. 20) gC/ (m^2•d)) was higher than that in continental slope ((0. 46 ±0. 23) gC/ (m^2•d) . The average value of assimilation number of phytoplankton photosynthesis at the surveyed stations is within 0. 88 - 3. 10 mgC/ (mg Chl *a*•h) and the total average value is within (2. 12 ±0. 86) mgC/ (mg Chl *a*•h) , the change range being unobvious (Table 3) .

Table 3. The potential primary productivity (mgC/ (m^3•h) and the assimilation number (mgC/ (mg Chl *a*•h)) in the different surveyed area.

	Euphotic zone /m	Primary productivity /mgC•(m^3•h)$^{-1}$	Primary productivity /gC•(m^2•d)$^{-1}$	Chlorophyll *a* /μg•dm^{-3}	Assimilation number /mgC•(mg Chl *a*•h)$^{-1}$
Prydz Bay	18. 5 ±0. 7	10. 11 ±3. 51	1. 79 ±0. 68	4. 85 ±3. 22	2. 27 ±0. 71
Continental shelf	29. 0	5. 68	1. 56	1. 93	2. 94
Continental slope	30. 3 ±16. 9	2. 25 ±2. 16	0. 46 ±0. 23	1. 72 ±1. 10	1. 15 ±0. 42
Deep-sea area	53. 0 ±11. 5	1. 16 ±0. 25	0. 59 ±0. 20	0. 44 ±0. 13	2. 66 ±0. 39
Average value	35. 1 ±17. 5	4. 01 ±4. 07	0. 92 ±0. 66	2. 01 ±2. 14	2. 12 ±0. 86

4 Discussion

Prydz Bay is a nearly triangle one around Antarctic continent. Its top links to the Amery Ice Shelf and the east and west sides are Princess Elizabeth Land and Mac. Robertson respectively and its northeast end links to Cape Darnley, occupying 6. 0 × 10^4 km^2 area. Four Ladies Bank and Frame Bank are located in the northeast and northwest respectively, blocking great ice mount to transfer towards Prydz Bay, and forming a sea basin in the hollow between both banks (Dong *et al*. 1984) . The longitudinal section iv iv iv crossing the continental shelf is situated in the sea basin and its northern sea area.

The depth at station ⅳⅳⅳ12 is about 600 m; the depth in the northern continental slope ranges from 1000 m to 3000 m (Stations ⅳⅳ4, ⅳⅳⅳ6, ⅳⅳⅳ8, ⅳ㈨4 and ⅳ㈨6). The terrain slopes are relatively gently in the deep-sea area (Stations ⅳⅳ1-3, ⅳⅳ1-4, ⅳⅳⅳ1+, ⅳ㈨1, ⅳ㈨2) of more than 3000 m. Productivity and chlorophyll *a* concentration of phytoplankton and various environmental physio-chemical factors in different geographic regions showed obvious regional features (Table 4). The low water temperature and high salinity in euphotic zone in continental shelf are the features of Antarctic winter's water; convecting and mixing of the winter's water with high salinity carried the surface cold water to quite great depth (Dong *et al*. 1984). Chlorophyll *a* concentration, phytoplankton cell abundance, productivity and nutrient concentration in this area were all higher. The nutrient in water had not been utilized and its concentration obviously decreased, indicating that high standing stock mainly originated from the releasing of ice-algae and only extended to the upper of euphotic zone. Because high standing stock only was distributed in the water layer of 25 m and less and was corresponding to the thickness of the euphotic zone observed in continental shelf, it was basically controlled by the Antarctic surface water of below 0 ℃ that the water is lower temperature in the east of continental slope. The water temperature was higher relatively in the west of the slope. At stations ⅳⅳⅳ6 and ⅳⅳⅳ8, lower temperature water (< 0 ℃) was in the water depth at 100-200 m, maybe it is so-called: there was a closed circulating current in Prydz Bay, the cold water in western ice shelf flowed southwards and entered into Prydz Bay, convering with in the circulating current, then flowed out of the Bay nearby (Dong *et al*. 1984). The thermocline layer lay between 50 m and 100 m depth, above which biomass and productivity were high and chlorophyll *a* concentration was over 3.0 μg/dm^3. The highest value of 5.08 μg/dm^3 appeared at the 50 m depth at ⅳⅳⅳ6 station; below the thermocline layer, biomass markedly lowered and was less than 0.12 μg/dm^3, being basically in conformity with the conditions in deep water layer in deep sea area. Chlorophyll *a* concentration in upper layer water in deep-sea area ranged from 0.2-0.5 μg/dm^3 and the relatively high value stretched from surface water layer to 100 m layer (Table 1). The thickening of euphotic zone in deep-sea area and quick exchange of water bodies are the main factors of their formation.

The transparency at the stations ⅳⅳⅳ6 and ⅳⅳⅳ8 in continental slope was 5.2 m.

Table. 4 The average values(X ±SD) of the chlorophyll *a*, primary productivity and concerning parameters in the euphotic layer of the Plydz Bay shelf, slope and deep sea

	Continental shelf (n=3)	Continental slope (n=5)	Deep-sea area (n=10)	Average value (n=18)
Temperature/℃	-1.41 ±0.80	-0.21 ±0.74	0.68 ±0.38	0.06 ±0.98
Salinity	34.54 ±0.01	34.42 ±0.49	34.66 ±0.06	34.58 ±0.25
Euphotic zone/m	27.0 ±3.5	29.2 ±14.6	51.7 ±12.6	41.3 ±16.7
DO/μmol·dm^{-3}	695.4 ±17.2	705.5 ±25.6	685.7 ±8.2	693.1 ±17.8
Silicate/μmol·dm^{-3}	53.69 ±10.82	37.87 ±8.07	37.39 ±9.13	39.58 ±10.00
Phosphate/μmol·dm^{-3}	1.69 ±0.20	1.61 ±0.25	1.59 ±0.27	1.61 ±0.24
Nitrate/μmol·dm^{-3}	28.13 ±1.46	26.73 ±2.26	31.87 ±10.77	29.79 ±8.33
Nitrite/μmol·dm^{-3}	0.16 ±0.04	0.20 ±0.06	0.24 ±0.06	0.22 ±0.06
Ammonium salts/μmol·dm^{-3}	0.13 ±0.00	0.25 ±0.15	0.53 ±0.40	0.39 ±0.34
Chlorophyll *a*/μg·dm^{-3}	2.12 ±0.88	2.77 ±1.50	0.37 ±0.16	1.33 ±1.38
Productivity/mgC·(m^3·h)$^{-1}$	5.68	2.25 ±2.16	1.16 ±0.25	2.27 ±2.03
Cell abundance/×10^3·dm^{-3}	106.2 ±48.4	21.4 ±16.1	10.3 ±3.9	29.4 ±40.3

According to the attenuation coefficient $K = 1.7 \times s^{-1}$ and Beer's law $E_z = E_0 \cdot e^{-kz}$ for calculating vertical light attenuation in sea water by Poole and Atkins (1929), the thickness of Euphotic zone is calculated to be 16 m from the Secchi disc. The chlorophyll *a* was high in this area and had a maximum value at 25 m layer (chlorophyll *a* concentration was 5.08 μg/dm^3 and 4.21 μg/dm^3, respectively), and extended to 50 m water depth. Thus, an abnormal phenomenon appeared, i.e., the biomass below "euphotic zone" is corresponding to or higher than that in the euphotic zone. For example, the average chlorophyll *a* concentrations in the calculated "Euphotic zone" at the stations iv iv iv6 and iv iv iv8 were 3.91 μg/dm^3 and 4.02 μg/dm^3, respectively. The average concentrations below "Euphotic zone" (16 - 50 m) were 3.77 μg/dm^3 and 4.04 μg/dm^3; those in the water layer of 0 — 50 m depth were 4.52 μg/dm^3 and 3.94 μg/dm^3. As biomass increased, phytoplankton hindered light strength from penetrating, and the reflecting and refracting ability of light in water bodies increased. Thus, the formula for the conversion of the euphotic zone depth which has been extensively applied and was introduced by Poole and Atkins (1929) may be suitable to many sea areas in oceans (such as the deep sea area of this surveyed sea area), but, whether it is suitable to the special sea area of the Southern Ocean where a large number of ice-algae released, should be pending further studies.

The course of phytoplankton photosynthesis adsorbs CO_2 and exhausts oxygen to make chlorophyll *a* concentration and dissolved oxygen concentration at surface layer in surveyed stations to be closely correlated to each other ($Y = 0.059x - 41.02$, $r = 0.931$, $p < 0.001$, $n = 18$). Chlorophyll *a* concentration is correlated to the ΔpCO_2. The partial pressure of the CO_2 in sea water is lower than that of the CO_2 in air over it; the CO_2 in air possesses the trend of transferring towards the sea and these sea areas may turn into the converging area of CO_2 in air (Huang *et al.*, 1998); such as the continental shelf and slope areas of the surveyed area; on the contrary, if carbon dioxide in sea water transferred from the sea towards air, the sea area may turn into the source area of CO_2 in air, such as the deep sea area of this surveyed area. Comprehensively viewing of "Xuelong Routing", the distribution of ΔpCO_2 is basically conformity with that of chlorophyll *a* concentration in surface layer at the surveyed stations. And the distribution trend of the isoline of chlorophyll *a* concentration 1.0 μg/dm^3 is basically in conformity with that of the isoline of ΔpCO_2 being 0. From these results, it can be deemed that the sea area of chlorophyll *a* concentration of over 1.0 μg/dm^3 may be the converging area of CO_2 and the sea area of below 1.0 μg/dm^3 may be the source area of CO_2. Concerning the correlation between chlorophyll *a* and ΔpCO_2 in surface layer should be pending further inquiry and study in future investigation of the Southern Ocean.

5 Conclusions

The cell abundance, standing stock and primary productivity of phytoplankton displayed the spatial zonation features obviously in Prydz Bay and its mouth. The cell abundance, chlorophyll *a* and productivity in the Bay and Shelf are more than that in the Slope and Deep-sea area. The influence of environment factors on the phytoplankton biomass and productivity are distinct, and chlorophyll *a* and dissolved oxygen concentration in the euphotic layer are higher than that in deep-sea.

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