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Distribution characteristics of planktonic nano- and microalgae in the Prydz Bay and its adjacent Southern Indian Ocean, during austral summer *

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Abstract Nano- and microalgae samples were collected from 34 stations in the Prydz Bay and its adjacent Southern Indian Ocean, Antarctica during a period from December 1990 to January 1991. 122 taxa belonging to 40 genera 5 phyla were identified. Among them diatom occupy 73%, dinoflagellates 20.5%, the other species 6.5%. The average cell abundance of nano- and microalgae was 2551×10^4 cells/m^3 in surface waters. The concentration of nano- and microalgae occurred in the Prydz Bay and its adjacent continental station Ⅳ7 and northern water area between West Ice Shelf and Shackleton Ice Shelf (Stations Ⅵ3, Ⅶ1, Ⅶ2, Ⅶ3, Ⅸ1, Ⅺ1); and minimal abundance occurred in northwestern area of the Prydz Bay (some stations of section Ⅱ and Station Ⅳ1-5). The average cell abundance of planktonic nano- and microalgae from net sample was 811.62×10^4 cells/m^3, and the concentration area occurred in the adjacent continent waters of the Prydz Bay (Stations Ⅳ2, Ⅳ4, Ⅳ5, Ⅳ7, Ⅴ4 and Ⅴ5) and northern area of the West Ice Shelf (Stations Ⅵ1 and Ⅵ3); low abundance occurred in eastern area of the Shackleton Ice Shelf (at each station of sections Ⅹ and Ⅺ). For the vertical distribution of planktonic nano- and microalgae, the maximum value was usually found at the surface and above 50 m depth, and gradually decreased with the water depth from 100 m to 200 m. The relationship between planktonic nano- and microalgal abundance and *Euphausia superba* density and nutrient (nitrate, phosphate and silicate) contents were negative significance.
Key words planktonic nano- and microalga, abundance, distribution, Antarctica, Prydz Bay, Southern Indian Ocean

1 Introduction

Planktonic nano- and microalgae are the main food of oceanic micro- or macrozooplankton, especially *Euphausia superba*. They are primitive oceanic organisms, but have an important effect on the oceanic ecosystem.

Some foreign scholars (Kozlova, 1964; El-Sayed and Jitts, 1973; Taylor, 1976; Kuroda and Fukuchi, 1982; Kawamura and Ichikawa, 1984; Sasaki, 1984;) have

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investigated the phytoplankton (the composition and distribution of diatom species in superficial water) and primary productivity (the amount and vertical distribution of superficial chlorophyll) in a part of the Indian Ocean of the Southern Ocean, but little study was made on the planktonic nano- and microalgae in the Prydz Bay and its adjacent sea area. During the 7th Chinese Antarctic Research Expedition we investigated the resource ecology of krill and carried out research on oceanology in the Prydz Bay and its adjacent Southern Indian Ocean. From the planktonic nanoalgae (2 ~ 20 μm) and microalgae (20~200 μm) here discussion is made on their composition ,distribution and their relationship to the environmental factors.

2 Materials and methods

From Dec. 28, 1990 to Jan. 11, 1991, the Chinese antarctic research vessel "Jidi" was used to investigate the Prydz Bay and its adjacent Southern Indian Ocean, Antarctica. The stations were set up from the south of 62°S to antarctic ice-edge (68°S). Nine sections were separately setted at 108°E, 103°E, 98°E, 93°E, 88°E, 83°E, 78°E, 73° E and 68° E (Fig. 1).

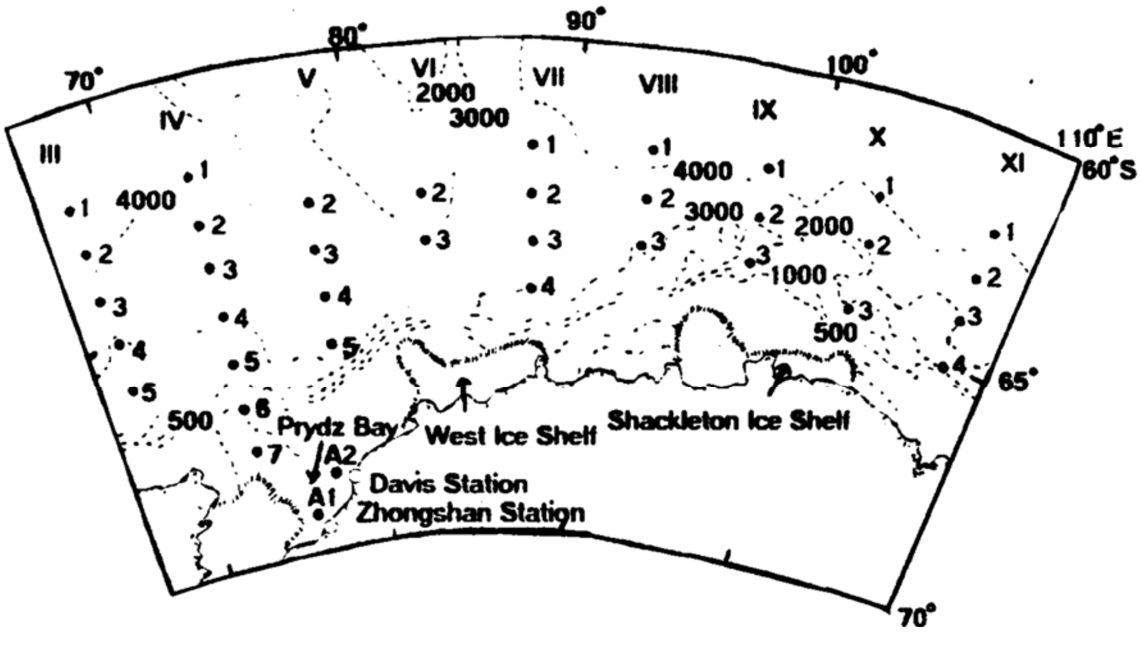

Fig. 1. Position of sampling stations and the topography of studied area.

Water samples were taken with QII-3 Water Sampler (5 dm^3); planktonic nano- and microalgae from net samples were got by Juday microphytoplankton net (diameter: 37 cm; length: 270 cm; pore size: 64 μm; material: silk sieve). The net was drawn vertically from the water depth of 200 m to the surface. Samples were fixed by neutrol formalin (Sournia, 1978). Samples were observed with optical microscope and electron microscope after being condensed. Each sample was counted with 2~3 whole slides, the averages were used for analysis.

3 Results

3.1 *The species composition and cell abundance of planktonic nano- and microalgae*

3.1.1 *Species composition*

After identification, the samples which were got from the investigated sea area contain 122 taxa belonging to 40 genera 5 phyla, of which 105 taxa belonging to 35 genera were from net samples, 59 taxa belonging to 26 genera were from water samples, 37 taxa belonging to 18 genera were from the both (Table 1).

Table 1. Species composition of nano- and microalgae in summer

Species catelogue	Net samples (0~200 m)	Water samples (surface)
Bacillariophyta		
1. *Actinocyclus bifrons* Kar.	+	+
2. *A. curvatulus* Jan.	−	+
3. *A. oceanicus* Rattr.	+	−
4. *A. senarius* (Ehr.)Ehr.	+	−
5. *Actinocyclus* sp.	+	−
6. *Amphiprora alata* (Ehr.)Kutz.	+	−
7. *A. kufferathii* Manguin	−	+
8. *Amphiprora* sp.	+	−
9. *Anaulus ellipticus* Hendey	+	+
10. *Asteromphalus brookeri* Bail.	+	−
11. *A. hookeri* (Ehr.)Cleve	+	−
12. *A. parvulus* Kar.	+	−
13. *A. parvulus* f. *trimera* Freng. et Or.	+	−
14. *Biddulphia striata* Kar.	+	+
15. *B. translucida* V.H.	+	−
16. *Biddulphia* sp.	+	−
17. *Chaetoceros atlanticus* Cleve	+	−
18. *C. bulbosus* (Ehr.)Heidet-Kolbe	+	+
19. *C. castracanei* Kar.	+	−
20. *C. criophilum* Castr. (=*C. convolutus*)	+	+
21. *C. debilis* Cleve	+	−
22. *C. dichaeta* Ehr.	+	+
23. *C. dichaeta* f. *longa* Mangin	+	+
24. *C. neglectus* Kar.	+	−
25. *C. tortissimus* Gran	+	−
26. *Charcotia bifrons* (Castr.)M. Per.	+	+
27. *C. irregularis* M. Per.	+	−
28. *Corethron criophilum* Castr.	+	+
29. *Coscinodiscus antarcticus* (Grun.)Ratt.	+	−
30. *C. asteromphalus* Ehr.	+	−
31. *C. argus* Ehr.	+	−
32. *C. bouvet* Kar.	+	−
33. *C. denarius* Schmidt	+	−
34. *C. excentricus* Ehr.	+	−
35. *C. lineatus* Ehr.	+	−
36. *C. oculus−iridis* Ehr.	+	−
37. *C. radiatus* Ehr.	+	−
38. *C. stellaris* Roper	+	−
39. *C. stellaris* v. *antarctica* Freng. et Or.	+	−
40. *C. subtilis* Grun.	+	−
41. *C. tabularis* Grun.	+	−
42. *Cyclotella* sp.	−	+
43. *Dactyliosolen antarcticus* Castr.	+	−

Species catelogue	Net samples(0～200 m)	Water samples(surface)
44. *Eucampis balaustium* Castr.	+	+
45. *Fragilaria striatula* Lyng.	+	−
46. *Leptocyclindrus danicus* Cleve	+	−
47. *Licmophora gracilis* (Ehr.)Grun.	+	−
48. *Melosira charcotii* M. Per.	−	+
49. *M. sulcata* (Ehr.)Kutz.	+	−
50. *Navicula frequens* V. H.	+	−
51. *N. glaciei* V. H.	+	−
52. *Navicula* sp.	+	+
53. *Nitzschia angulata* Hasle	+	+
54. *N. barkleyi* Hust.	+	+
55. *N. barkleyi* v. *obtusa* Manguin	+	+
56. *N. castracanei* Hasle	+	+
57. *N. closterium* f. *tenuissima* Manguin	+	+
58. *N. curta* (V. H.)Hasle	+	+
59. *N. cylindrus* (Grun.)Hasle	+	+
60. *N. cocconeiformis* Grun.	+	−
61. *N. grunowii* Hasle	+	−
62. *N. heimii* (Manguin)Hasle	+	+
63. *N. kerguelensis* (O'Meara)Hasle	+	+
64. *N. panduriformis* v. *minor* Grun.	+	−
65. *N. sublinearis* (Hust.)Hasle	+	−
66. *Rhizosolenia alata* Brightw.	+	+
67. *R. alata* f. *inermis* (Castr.)Hust.	+	−
68. *R. bergonii* Per.	+	−
69. *R. bidens* Kar.	+	−
70. *R. chunii* Kar.	−	+
71. *R. fragilissima* Bergon	+	−
72. *R. hebetata* f. *semispina* (Hen.)Gran	+	−
73. *R. imbricata* Brightw.	+	−
74. *R. robusta* Norm. -Ralfs	+	−
75. *R. stolterfothii* Per.	+	−
76. *R. styliformis* Brightw.	+	+
77. *R. styliformis* v. *latissima* Brightw.	+	−
78. *R. styliformis* v. *longispina* Hust.	+	−
79. *Synedra reinboldii* V. H.	+	+
80. *Sticholonche* sp.	+	−
81. *Thalassiosira antarctica* Comber	+	+
82. *T. decipiens* (Grun.)Jorg.	+	+
83. *T. gracilis* (Kar.)Hust.	−	+
84. *T. ritscherii* (Hust.)Hasle	+	+
85. *Thalassiosira* sp.	+	+
86. *Trachyneis aspera* (Ehr.)Ehr.	+	−
87. *Trublionella punctata* (W. Sm.)Grun.	+	+
88. *Tropidoneis antarctica* (Grun.)Cleve	+	−
89. *T. antarctica* v. *adeliana* Manguin	+	−
Pyrrophyta		
1. *Amphidinium sphaenoides* Wulff.	−	+
2. *Ceratium horridum* (Cl.)Gran	+	−
3. *Dinophysis rotundata* Clap. -Lachm.	+	−
4. *Gonyaulax minima* Matz.	−	+
5. *Gymnodinium agiliforme* Schill.	+	+
6. *G. baccatum* Balech.	+	+
7. *G. blax* Harris	−	+
8. *G. frigidum* Balech	+	+
9. *G. fusiformis* Kof. et Sw.	−	+
10. *G. gracile* Bergh.	+	+
11. *G. grave* (Meu.)Kof. et Sw.	−	+
12. *Gymnodinium* sp.	+	+
13. *Gyrodinium flagellare* Schill.	+	+
14. *G. glaciale* Hada-Balech	+	−
15. *G. lachryma* (Meu.)Kof. -Sw.	+	+
16. *Gyrodinium* sp.	+	+
17. *Protoperidinium antarcticum* (Sch.)Balech	+	−
18. *P. archiovatum* (Balech)Balech	+	+

Species catelogue	Net samples(0～200 m)	Water samples(surface)
19. *P. cepa* Balech	−	+
20. *P. conicoides* (Pau.)Balech	−	+
21. *P. metananum* (Balech)Balech	+	+
22. *P. nanum* Balech	−	+
23. *P. pyriforme* (Pau.)Balech	+	+
24. *P. unipes* (Balech)Balech	+	−
25. *Protoperidinium* sp.	−	+
Chrysophyta		
1. *Distephanus speculum* (Ehr.)Haeck.	+	+
Haptophyceae		
1. *Chrysochromulins* sp.	+	−
2. *Phaeocystis pouchetii* (Hariot)Lagerh.	+	+
3. *Prymnesium* sp.	+	−
Craspedophyceae		
1. *Acanthocorbis apoda* (Lead.)Hara	−	+
2. *Parvicorbicula socialis* (Meu.)Def.	−	+
Cyanophyta		
1. *Chroococcus* sp.	+	−
2. *Oscillatoria* sp.	+	+

3. 1. 2 The percentage and cell abundance

Diatom occupied the prominant position in the planktonic nano- and microalgae, of the study area amounting to 73. 0% of the total ; dinoflagellate being 20. 5% and the others only 6. 5%. The cell abundance of planktonic nano- and microalgae : the average cell abundance of planktonic nano- and microalgae from net sample was 811. 62 $\times 10^4$ cells/m^3, in which, diatom was 99. 75%, the others 0. 25%; the average cell abundance of water samples was 2551 $\times 10^4$ cells/m^3, in which, diatom was 95. 72%, dinoflagellate and chrysophyta were only 4. 11% and 0. 17%, respectively (Table 2).

Table 2. The percentage and cell abundance of planktonic nano- and microalgae of each phylum

Phylum	Net Samples					Water Samples					Total		
	G. N.	S. N.	S. P. (%)	C. A. ($\times 10^4/m^3$)	A. P. (%)	G. N.	S. N.	S. P. (%)	C. A. ($\times 10^4/m^3$)	A. P. (%)	G. N.	S. N.	S. P. (%)
Bacillariophyta	24	83	79. 0	809. 62	99. 75	16	34	57. 6	2442	95. 72	25	89	73. 0
Pyrrophyta	5	16	15. 2	1. 37	0. 17	5	20	33. 9	105	4. 11	7	25	20. 5
Chrysophyta	1	1	1. 0	0. 58	0. 07	1	1	1. 7	4	0. 17	1	1	0. 8
Haptophyceae	3	3	2. 9	-	-	1	1	1. 7	-	-	3	3	2. 5
Craspedophyceae	-	-	-	-	-	2	2	3. 4	-	-	2	2	1. 6
Cyanophyta	2	2	1. 9	0. 05	0. 01	1	1	1. 7	-	-	2	2	1. 6
Total	35	105	100	811. 62	100	26	59	100	2551	100	40	122	100

* G. N. =generic number; S. N. =species number; S. P=percentage of species; C. A. =cell abundance; A. P. =abundance percentage.

3. 1. 3 Main species composition and cell abundance

The dominant species of the investigated planktonic nano- and micro algae were *Nitzschia cylindrus*, *N. barkleyi*, which reached to 70. 19% and 9. 70% of whole cell abundance respectively. The major species were *N. curta*, *N. castracanei* and *Gyrodinium lachryma*, which amounted to 7. 19%, 3. 57% and 1. 18% of the whole cell abundance respectively. These five species occupied 91. 83% of the whole cell abundance in water samples , the others only 8. 17% (Table 3).

Table 3. The cell abundance of main species of planktonic nano- and microalgae from surface waters

Main species	Average cell abundance ($\times 10^4$ cells/m^3)	Percentage of total abundance (%)	Frequency of appearance (%)
Nitzschia cylindrus	1790.6	70.19	41.12
Nitzschia barkleyi	247.4	9.70	64.71
Nitzschia curta	183.5	7.19	29.41
Nitzschia castracanei	91.2	3.57	32.35
Gyrodinium lachryma	30.0	1.18	20.59
Total	2343	91.83	

The dominant species of planktonic nano- and microalgae from net samples were *N. barkleyi*, *Corethron criophilum* and *Rhizosolenia styliformis*, which occupied 27.48%, 19.24% and 15.24% of the total cell abundance respectively; appearance frequency was 87.9 ~ 100%. The major species were *R. alata*, *Chaetoceros criophilum*, *Synedra reinboldii*, *C. dichaeta*, *N. curta* and *Eucampia balaustium*, which amounted to 2.11% ~ 7.14% of the total cell abundance. The major nine species (planktonic nano-and microalgae from net samples) occupied 91.67% of the whole cell abundance, the others were only 8.33% (Table 4).

Table 4. The cell abundance of main species of planktonic nano- and microalgae from net samples

Main species	Average cell abundance ($\times 10^4$ cells/m^3)	Percentage of total abundance (%)	Frequency of appearance (%)
Nitzschia barkleyi	223.0	27.48	87.9
Corethron criophilum	156.2	19.24	90.9
Rhizosolenia styliformis	123.65	15.24	100
Rhizosolenia alata	57.95	7.14	84.8
Chaetoceros convolutus	47.6	5.85	84.8
Synedra reinboldii	44.15	5.44	93.9
Chaetoceros dichaeta	25.98	3.20	36.4
Nitzschia curta	19.31	2.38	75.8
Eucampia balaustium	17.11	2.11	30.3
Total	743.99	91.67	

3.2 The distribution of planktonic nano- and microalgal abundance

3.2.1 Planktonic nano- and microalgal abundance from net samples

The investigated 33 stations of where the planktonic nano- and microalgae from net samples are concentrated are located in adjacent continent water of the Prydz Bay (Stations Ⅳ2, Ⅳ4, Ⅳ5, Ⅳ7, Ⅴ4, Ⅴ5) and northern water area of the West Ice Shelf (Stations Ⅶ1, Ⅶ3). The cell abundance was more than 10×10^6 cells/m^3, and the maximal cell abundance lies in station Ⅴ4, which was 34.6×10^6 cells/m^3; secondly , the cell abundance were comparatively high in Stations Ⅲ2, Ⅲ4, Ⅲ5, Ⅵ3, Ⅶ1-3, Ⅸ1-3, the average cell abundance was in the range of $5\times10^6 \sim 10\times10^6$ cells/m^3, and the cell abundance was evenly distributed in sectors Ⅶ1-3 and Ⅸ1-3. The minimal cell abundance lies in eastern water area of the Shackleton Ice Shelf (at each station in sectors Ⅹ, Ⅺ, especially in station Ⅹ3, the cell abundance was only 1800 cells/m^3(Fig. 2).

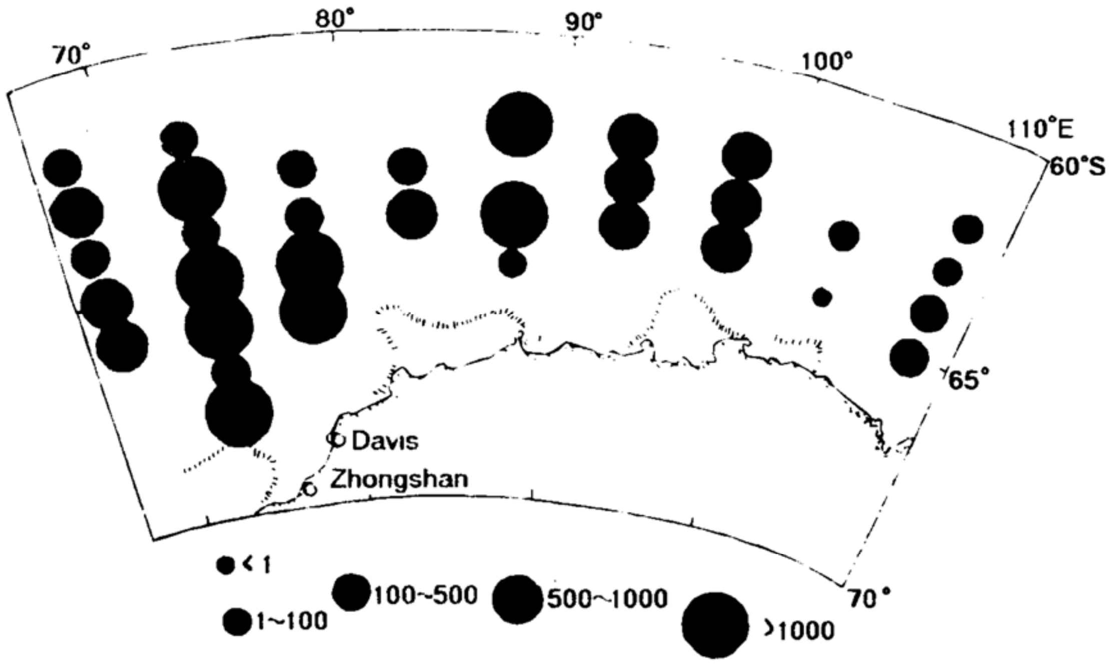

Fig. 2. Horizontal distribution of net planktonic nano- and microalgae in summer($\times 10^{4}$ cells/m^3).

3. 2. 2 Planktonic nano- and microalgal abundance in superficial water

Distributionally in the 34 investigated stations planktonic nano- and microalgae in superficial water was similar to those of the net samples. The maximal abundance is located in the central area, the minimal abundance is located in the west. The concentrated area lies in adjacent continent water of the Prydz Bay (Station Ⅳ 7) and northern water area of the West Ice Shelf and the Shackleton Ice Shelf (Stations Ⅶ 3, Ⅷ 1-3, Ⅸ 1 and Ⅺ 1), the cell abundance was more than 15×10^{6} cells/m^3, with the highest abundance in Station Ⅳ 7, amounting to 582×10^{6} cells/m^3. The cell abundance was high in sectors Ⅶ, Ⅷ, Ⅸ in investigated central area, and the distribution was even. The cell abundance was fairly low in westnorthern the Prydz Bay, mainly in continental slope and outer sea area (sections Ⅲ, Ⅳ, Ⅴ, Ⅵ, not including Ⅳ 7), in which it was less than 9×10^{6} cells/m^3(Fig 3).

3. 2. 3 Planktonic nano- and microalgal abundance

In the investigated sections (64°S), the vertical distribution of planktonic nano- and microalgal abundance was very clearly shown, the superficial water was higher in abundance than the bottom, the maximal lying in the center, the minimal is located in the west . The concentration area is located in the center (Stations Ⅶ 3 and Ⅷ 3) and the east (Station Ⅹ 3), water layer was between surface and 50 m in depth. The average cell abundance were 10.1×10^{3} cells/m^3 ~ 53.5×10^{3} cells/m^3. The cell abundance gradually decreased with the water depth from 100 m to 200 m. The minimal cell abundance is located in Stations Ⅲ 3 and Ⅳ 3. There were no phytoplanktonic cells in 100 m water depth or even deeper. In 200 m water depth, phytoplanktonic cells were only found in station Ⅴ 3 and Ⅵ 3 (2.25×10^{3} cells/dm^3 and 10^{3} cells/dm^3 respectively), few cells were found in the other stations (Fig 4).

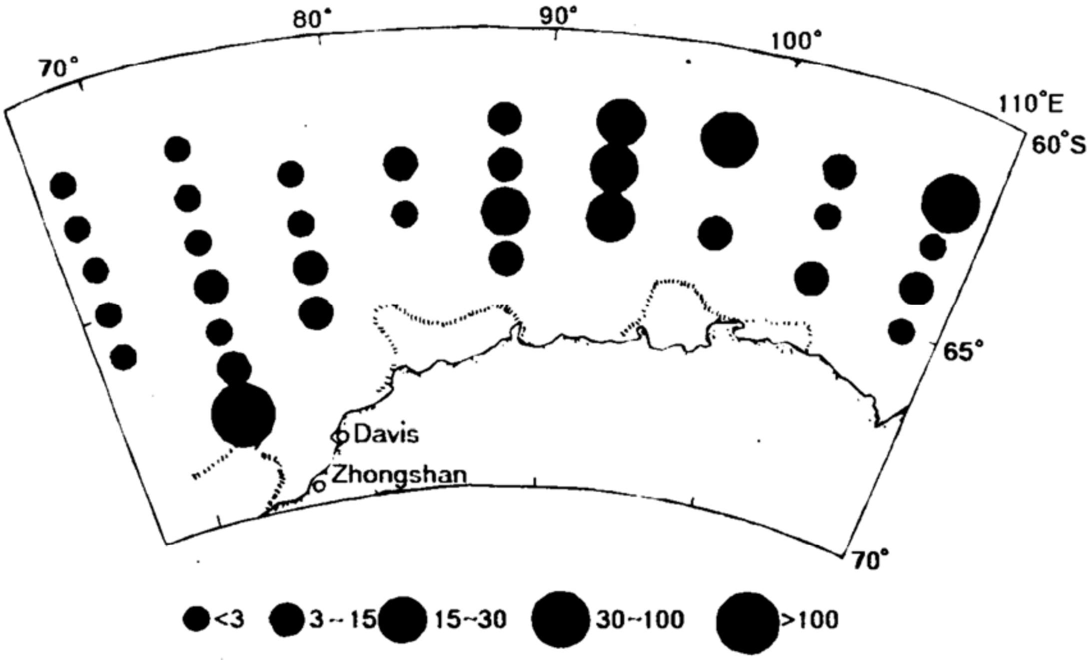

Fig. 3. Distribuction of planktonic nano- and microallgae in the surface waters in summer ($\times 10^3$ cells/m^3).

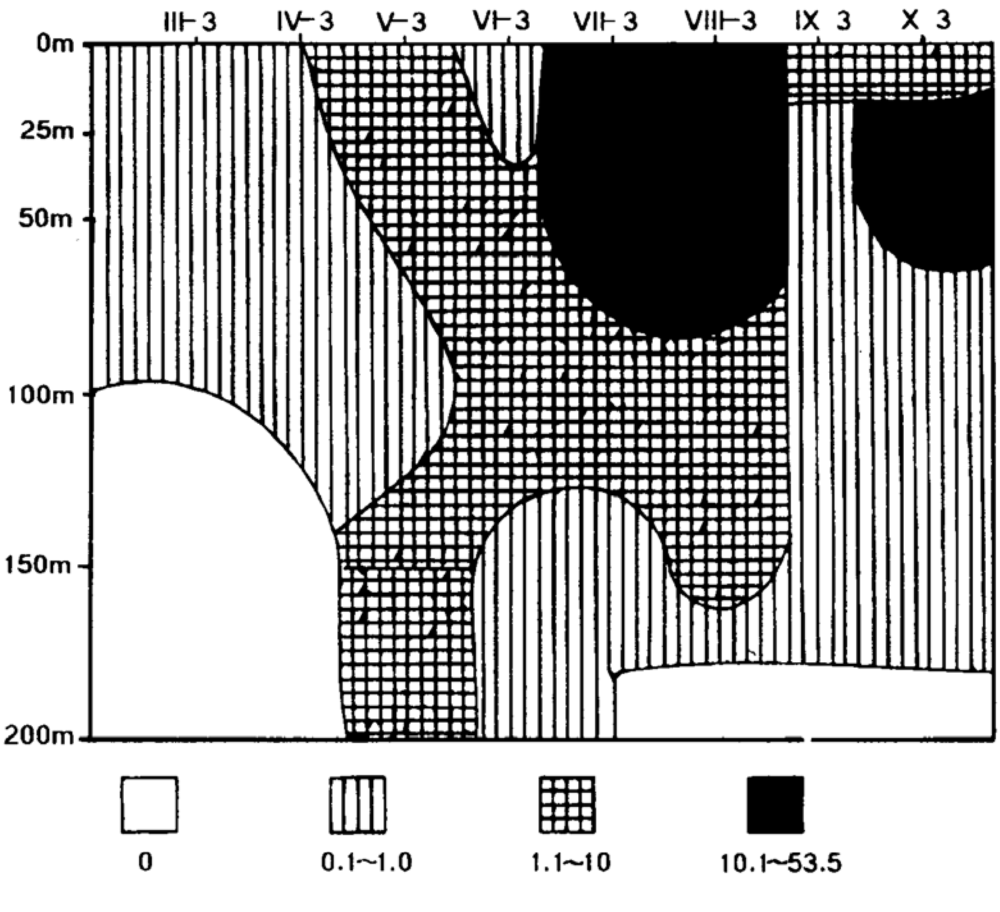

Fig. 4. Vertical distribuction of planktonic nano- and microalgae in summer($\times 10^3$ cells/m^3).

4 Conclusion and Discussion

4.1 *The distribution of planktonic nano- and microalgae*

Planktonic nano- and microalgae are mainly distributed in western adjacent continental shelf area and the central area in the investigated sea area. The cell abundance was low in western continental shelf area and outer sea area , where in the vertical distribution, the planktonic nano- and microalgae was concentracted at the layer between surface and 50 m depth. Few phytoplanktonic cells were found at 100 m water depth or even deeper.

4.2 *The effect of environment on planktonic nano- and microalgae*

(1) Temperature and salinity are major factors, which have an effect on the phytoplanktonic growth and reproduction. But the temperature and salinity varied little in this investigated area. Temperature varied in the range of −1.72 ~ 1.10 C, salinity, 33.29 ~ 34.84 (Table 5, 6). The phytoplanktons in Antarctic Ocean had the capbility to adapt to low temperature. Multivariate regressive analysis indicated that there were no apparent correlation between phytoplanktonic abundance and temperature and salinity ,

Table 5. The abundance of planktonic nano- and microalgae from net sample and environmental factors in the maximal and minimal abundance regions in the surface waters

Item		Algae abundance ($\times 10^4$ cells/m^3)	Tempera-ture (C)	Salinity (S)	Dissolved oxygen (μmol/dm^3)	Nitrate NO_3+NO_2 (μmol/dm^3)	Phosphate (μmol/dm^3)	Silicate (μmol/dm^3)
Maximal abundance regions Ⅳ-2 Ⅳ-4 Ⅳ-5 Ⅳ-7 Ⅴ-4 Ⅴ-5 Ⅶ-1 Ⅶ-3 Ⅸ-1	CA	992~3458.4	−1.17~0.89	34.26~34.34	0.55~0.75	24.78~37.75	1.79~2.37	57.77~64.09
	AV (X)	1916.6	−0.27	34.29	0.67	31.99	2.04	60.27
	(SD)	±817.7	±0.57	±0.02	±0.05	±3.88	±0.20	±2.01
Minimal abundance regions Ⅶ-4 Ⅹ-2 Ⅹ-3 Ⅺ-4	CA	0.18~126.5	−1.72~0.15	34.01~34.44	0.65~0.72	28.44~33.24	1.55~2.18	52.49~71.45
	AV (X)	60.2	−0.71	34.12	0.68	30.55	2.01	65.51
	(SD)	±39.9	±0.76	±0.14	±0.02	±1.77	±0.20	±6.14
Change amplitude (CA)		0.18~3458.4	−1.72~0.89	34.01~34.54	0.55~0.75	24.78~37.75	1.55~2.65	42.93~72.20
Average value (X)		822.62	−0.21	34.25	0.67	31.77	2.08	61.87
Standard deviation (SD)		±847.76	±0.70	±0.12	±0.04	±2.81	±0.23	±7.12

* CA=change amplitude; AV=average value; SD=standard deviation.

but from Tables 5, 6, we could see that the temperature and salinity were apparently higher in the maximal cell abundance area than in the minimal cell abundance area. In summer, with the rising temperature, melting ice, ice algae entered water body, which helped phytoplankton reproduction rapidly in a short time. The maximal phytoplankton abundance lies in Station Ⅳ 7 in water samples, where the temperature is 0.54 ℃, in continental shelf and outer sea area (Stations Ⅲ, Ⅳ, Ⅴ, Ⅵ) where phytoplankton abundance was low, water temperature was comparative low.

Table 6. The abundance of planktonic nano- and microalgae and environmental factors in the maximal and minimal abundance regions in surface waters

Item		Algae abundance ($\times 10^3$ cells/dm^3)	Temperature (℃)	Salinity (S)	Dissolved oxygen (μmol/dm^3)	Nitrate NO_3+NO_2 (μmol/dm^3)	Phosphate (μmol/dm^3)	Silicate (μmol/dm^3)
Maximal abundance region Ⅳ-7 Ⅴ-3 Ⅶ-1 Ⅶ-2 Ⅶ-3 Ⅸ-1 Ⅺ-1	CA	17~582	0.35~0.71	33.73~34.12	0.40~0.80	9.49~29.62	0.36~1.79	28.75~56.78
	AV (X)	110.2	0.40	33.98	0.69	25.02	1.38	45.46
	(SD)	±193.1	±0.32	±0.12	±0.12	±6.41	±0.44	±8.73
Minimal abundance region Ⅱ 1~5 Ⅳ 2~5 Ⅸ-1 Ⅹ 2	CA	0.2~1.0	−1.18~1.07	33.29~33.92	0.65~0.71	28.53~35.19	1.60~2.23	32.9~55.82
	AV (X)	0.73	0.29	33.67	0.70	32.24	1.97	45.11
	(SD)	±0.3	±0.67	±0.23	±0.02	±1.85	±0.17	±6.90
Change amplitude (CA)		0.2~582	−1.66~1.10	33.29~34.84	0.40~0.80	9.49~35.19	0.36~2.23	28.75~68.78
Average value (X)		25.51	0.15	33.86	0.70	29.51	1.70	48.40
Standard deviation (SD)		±97.7	±0.63	±0.28	±0.06	±4.56	±0.35	±10.33

* CA=change amplitude; AV=average value; SD=standard deviation

(2) Phytoplanktonic photosynthesis gives a large amount of oxygen. During rich reproduction period, dissolved oxygen was supersaturated. In investigated area dissolved oxygen content ranged from 0.40 μmol/dm^3 to 0.80 μmol/dm^3. The range was not great, and had no clear correlation with phytoplankton.

(3) Nutrient salts (N. P. Si) in water have a close relationship with phytoplanktonic reproduction. Nutrient salt content was one of the important factor which influence the distribution of phytoplanktonic abundance. The higher abundance is, the more it demands nutrient salt. Nutrient salt changed much in the investigated area. The relationship of phytoplankton abundance and N. P. Si was negative correlation, nutrient salt content was low in maximal phytoplankton abundance area, nutrient salt

content was comparative high in minimal area, especially at the superficial water. After many linear regressive analyses, phytoplankton abundance in water samples and nitrate (N) and phosphate (P) were very apparently negative correlation, the correlation coefficients were −0.78 and −0.68 respectively ($P<0.001$, $n=34$). To silicate (Si) the relationship was also negative correlation ($P<0.05$, $n=34$) (Table 7). The relationship between cell abundance of planktonic nano- and microalgae from net samples and the average phosphate (P) content in the layer from 0 ~ 200 m water depth were negative significance. The negative significance for the cell abundance of planktonic nano- and microalgae from net samples and the average nitrate (N) content and the average phosphate (P) content in the layer from 0 ~ 200 m water depth was not clear. This was also influenced by other factors.

4.3 The cell abundance distribution of planktonic related to upwelling current

At station Ⅳ 7 (73°E, 68°S) there was a clock wise vertical circular upwelling current (radioactive) center, the strong upwelling current brought abundant nutrients, which made phytoplankton to the acme of abundance. The cell abundance of water and net samples were highest, being 58200 × 10^4 cells/m^3 and 2462.4 × 10^4 cells/m^3, respectively, and being mainly composed of neritic diatom, for instance, cell abundance of *Fragilaria striatula*, *N. barkleyi*, *E. balaustium*, *N. curta* in net samples was 1972.4 × 10^4 cells/m^3, amounting to 80.1% of the stations, and 7.36% of the total net samples. The cell abundance of *N. cylindrus*, the dominant species in water samples, was 549 × 10^4 cells/m^3. It occupied 94.33% of the cell abundance of the station, 21.52% of the total cell abundance of the water sample.

Table 7. Relationship between the cell abundance of planktonic nano- and micrealgae and nutrient in summer

Nutrient	Correlation equation	Correlation coefficient	Station number	Degree of confidence
NO_3^-	y=509.41−16.42*X*	−0.78	34	$P<0.001$
PO_4^-	y=338.61−184.24*X*	−0.68	34	$P<0.001$
SiO_3^-	y=556.45−138.93*X*	−0.34	34	$P<0.05$

The high phytoplankton abundance lies in the central investigated area (88° E ~ 98° E). Phytoplanktonic abundance was more than 1000 × 10^4 cells/m^3 in Stations Ⅶ 1 and Ⅶ 3. The cell abundance in sectors Ⅷ 1-3 and Ⅸ 1-3 all ranged from 500 × 10^4 to 1000 × 10^4 cells/m^3, this is related to current movement. According to hydrological data, ocean current moved to the south in the west area (68° ~ 73° E); in 83° ~ 88° E, to the north; in 98° ~ 108° E, ocean current turned to the south, but the concentrated area of planktonic nano- and microalgae just lies at the mixed point of the south and north current, which brought not only a large amount of planktonic nano- and microalgae, but also abundant nutrient.

4. 4 The relationship between the distribution of plankton and Euphausia superba

During investigated period, three *E. superba* groups were found at 64°S, 107°E, 84° E, 68°E, where the cell abundance was low. According to hydrological data, antarctic winter superficial water cold center occurred near 68° E, the lowest temperature was −1. 64℃, but the concentrate area of *E. superba* occurred in the strong temperature gradient area which is located between the cold center and antarctic deep water. From the distribution of krill juvenile, the amount in west area was more than that in the east. But the cell abundance in west area was low, the distribution of planktonic nano- and microalgae from net samples in west area was uneven. Perhaps it is somewhat related with the dense distribution of *E. superba*.

References

El-Sayed, S. Z. and Jitts, H. R. (1973): Phytoplankton production in the southeastern Indian Ocean. In: The biology of the Indian Ocean. Ed. by Zeitschel, B., Chapman and Hall, London, 131−142.

Kawamura, A. and Ichikawa, T. (1984): Distribution of diatoms in a small area in the Indian sector of the Antarctic. *Proc. Sixth Symp. Pol. Biol.*, National Institute of Polar Research, Tokyo, Japan, 9−10, 25−37.

Kozlova, O. G. (1964): Diatoms of the Indian and Pacific sectors of the Antarctic.

Kuroda, K. and Fukuchi, M. (1982): Vertical distribution of chlorophyll a in the Indian sector of the Antarctic Ocean in 1972−1973. *Nankyoku Shiryo*, 35, 52−67.

Sasaki, H. (1984): Distribution of nano- and microplankton in the Indian sector of the Southern Ocean. *Proc. Sixth Symp. Pol. Biol.*, National Institute of Polar Research, Tokyo, Japan, 9−10, 38−50.

Sournia, A. (1978): Phytoplankton manual. UNESCO.

Taylor, F. J. R. (1976): Dinoflagellates from the international Indian Ocean Expedition. *Bibliotheca Botanica*, Stuttgart, 132, 1−234, Pl. 1−45.