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The preliminary study of the phytoplankton ecology in the Great Wall Bay, Antarctica

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Abstract This paper presents the identification and quantitative analysis of the phytoplankton samples collected in the Great Wall Bay, Antarctica from March 1988 to February 1989. The results indicate that the specific composition of phytoplankton clearly shows their ecological characteristics. That is the community mainly composed of cold-water species and neritic-eurythermal species. The dominant species altered with seasonal variation, their number showed the high-peak in the austral summer and the abundance of phytoplankton in each month mainly depended upon the dominant species. The distribution of phytoplankton is influenced by many environmental factors. Among them the hours of sunshine are the main factor.
Key words Great Wall Bay, phytoplankton, dominant species, cell number

1 Introduction

The marine phytoplankton is the main primary producer in the Antarctic Ocean, and its species composition, population distribution and the variation of cell number influence directly or indirectly the marine productivity. There have been many reports on the phytoplankton of Antarctica (Balech and El-Sayed, 1965; Bunt, 1960, 1964, 1968; Ealey and Chittleborough, 1965; Frenguelli and Orlando, 1958; Holm-Hansen *et al.*, 1977; Serickland, 1956). The marine biological survey in the Great Wall Bay, King George Island, Antarctica, began in Dec. 1984, and a lot of data and results have been obtained in recent years. The previous works were done mostly on the determination of chlorophyll-a and primary productivity, whereas there were only a few reports on the species composition and abundance of the phytoplankton. Lu *et al.* (1991) described the species composition of ice algae in fast ice along the shoreline of the Great Wall Bay . Li *et al.* (1992) reported the abundance and distribution of net phytoplankton in February 1985. This paper presents the year-round species composition of the net phytoplankton, the succession of dominant species and their cell number in the Great Wall Bay, which provides some basic information for the systematic study of antarctic marine ecosystem.

2 Material and method

Three observation stations were set up in the Great Wall Bay and one station at the bay mouth from March, 1988 to February, 1989 (see Fig. 1 on page 10 of this issue).

The phytoplankton samples were collected monthly by vertical hauling from the bottom to the surface with a micro-plankton net (diameter of net mouth: 37 cm, length: 150 cm, mesh size: 77 μm). In freezing months a hole was first drilled and then sampling conducted. The sample was preserved with 5% formalin solution. In the laboratory, the concentrated samples were diluted to 50 ml, 0.5 ml was taken and put in the counter frame to identify the species and to make cell number counting under the microscope.

3 Results

3.1 The species composition of phytoplankton

After identification of the net phytoplankton sampled year-round from the Great Wall Bay, 65 species, 4 varieties and 3 formas (not including unidentified species) may be recognized. Among them, there are 70 species of diatoms belonging to 30 genera, one species of dinoflagellate and one species of silicoflagellate. It is clear that the phytoplankton community was dominated by diatoms and their species accounted for 97.22% of the total number. The species composition of different ecological type in each month was showed in Table 1.

Table 1. Species composition of phytoplankton of different ecological types from Mar. 1988 to Feb. 1989

Ecological type	Species number												
	1988										1989		
	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	total
Cold-water species	9	23	11	8	6	7	7	6	7	7	11	13	33
Neritic-eurythermal species	11	21	11	7	5	6	6	5	7	8	16	17	31
Neritic-temperate species	2	1	1	1	1		1	1	1	2	1	1	2
Adherent species				1		1						1	1
Fresh-water species			1		1		1		1		1		2
Species with undefinite ecological characteristics		1	1	1				1					3
Total	22	46	25	18	13	14	15	13	16	17	29	32	72

It can be seen from Table 1 that 33 species belong to cold-water type, accounting for 45.83% of the total; 31 neritic-eurythermal species, accounting for 43.06 %; 2 neritic temperate species (2.78%); 2 fresh-water species (2.78%); 1 adherent species; 3 species with their ecological habits unclear. Obviously there exist differences in the species composition of phytoplankton in each month. In frigid weather (Mar. ~Oct.) the cold-water species occupied a leading position and accounted for 40.91~50% of the total. In warm weather (Nov. ~Feb.), when temperature was rising, ice and snow on the land melting and seawater temperature going up, the proportion of the cold-water species decreased and the neritic-eurythermal species took a leading position. It is evident that under such an ecological environment as low and relatively stable temperature in the

Great Wall Bay, the cold-water species and the neritic-eurythermal species took the dominant part in the composition of phytoplankton. This result seems to conform with that in other previous reports (Yu *et al.*, 1986; Li *et al.* 1986; Balech and El-Sayed, 1965; Frenquelli *et al.*, 1958)

3.2 The variation of cell number and the succession of dominant species

The variation of cell number of phytoplankton in each month depended evidently upon the variation of dominant species. The cell number of phytoplankton in this bay annually averaged 18.92×10^4 cells/m^3. The peak appeared from Nov. 1988 to Feb. 1989 and low value from Mar. to Oct. 1988 (Table 2, Fig. 1). The cell number in each month varies greatly ranging from 0.09×10^4 to 56.8×10^4 cells/m^3.

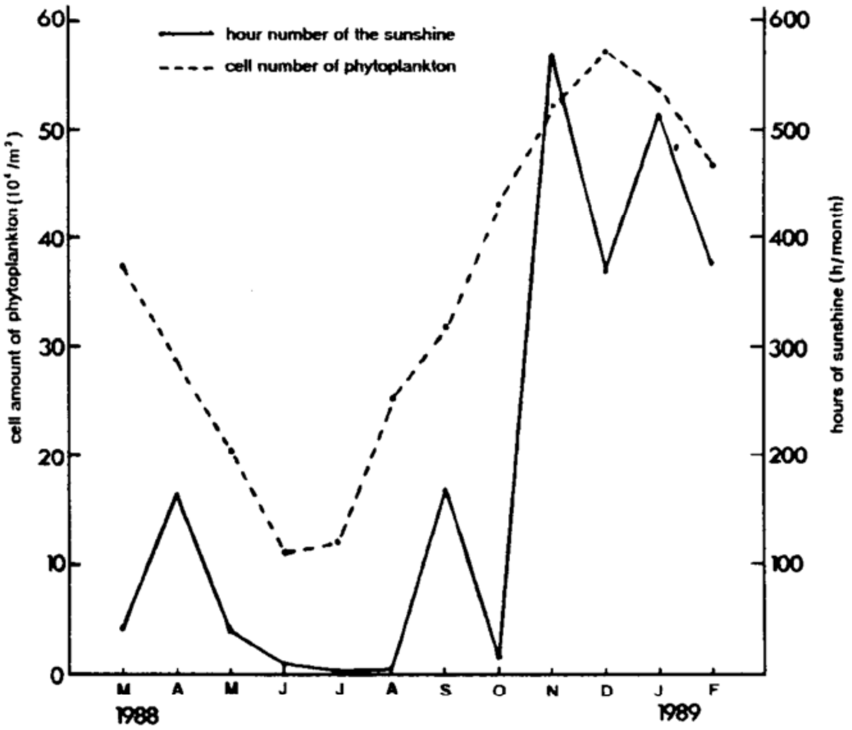

Fig. 1. Relation between seasonal variation of phytoplankton and hours of sunshine within the Great Wall Bay.

The Great Wall Bay lies in the sub-antarctic region, generally the air temperature begins to go up a month early ahead of other regions of Antarctica. The ice begins to melt in the middle of Nov. 1988~Feb. 1989 is the season with the longest daytime in a year (464.4 h/month to 574.1 h/month), when the air temperature was -1.81 °C to 2.43 °C and surface water temperature was -0.8 °C to 2.9 °C. Because sea ice melted, the algae were set free from the ice to the waters, and a part of them continued to grow in the waters and their number evidently increased in the sea water. Thus the cell number of the phytoplankton reaches the peak in this time ($36.9 \times 10^4 - 56.8 \times 10^4$ cells/m^3). Diatoms dominated absolutely in the phytoplankton community. During this season, cell number became highest in November, being 56.8×10^4 cells/m^3. The cell number was especially dense in Station 5, amounting to 101.56 $\times 10^4$ cells/m^3. The dominant species of this month were *Chaetoceros socialis* and *Corethron criophilum* which are neritic-eurythermal species. The number of them were 41.97 $\times 10^4$ cells/m^3 and 10.38 $\times 10^4$ cells /m^3, and accounted for 73.89% and 18.27%, respectively. *Chaetoceros socialis* concentrated in Station 5 in November. Its amount reached as high as 83.9 $\times 10^4$ cells /m^3, accounted for 82.65% of the total in this station. The second peak of phytoplankton was in January 1989. The cell number was 51.55 $\times 10^4$ cells/m^3. The cell number of the phytoplankton was distributed unevenly in this month and was most dense in Station 2, the amount reached as high as 121.23 $\times 10^4$ cells/m^3, being 4 times as high as that in Station 9 and 60 times that in Station 5. The dominant species in this month were mainly neritic-eurythermal species, of which *Thalassiosira* spp. amounts to 15.91 $\times 10^4$ cells/m^3, accounted for 30.86% of the all, and *Chaetoceros convolutus* averaged 1.66 $\times 10^4$ cells /m^3, and accounted for 22%. In Dec. 1988 and Feb. 1989 the cell number were almost equal, with a mean value of 37.81 $\times 10^4$ cells/m^3 and 36.91 $\times 10^4$ cells/m^3, respectively. But the dominant species in the two months were completely different, the dominant species in Feberuary were *Rhizosolenia alata f. inermis* and *Corethron criophilum* which are the cold-water species, and that in December were *Chaetoceros socialis* and *Thalassiosira* spp. which belong to neritic-eurythermal species.

Table 2. Comparison of phytoplanktonic cell number in the Great Wall Bay with that in the coast waters of Davis Station (10^4 cells/m^3) (Mar., 1988~Feb., 1989)

Region	1988 Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1989 Jan.	Feb.	mean
Within the bay*	4.15	16.37	4.12	1.1	0.09	0.33	16.53	1.23	56.8	36.91	51.55	37.81	18.92
In the bay mouth*		16.44	16.4	0.41	0.55	0.26	9.7	1.96					
Davis Station**	1.9	0.5	0.9	1.2	0.3	5.6	2.2	4.3	12.8	22.8	16.8	22.4	7.81

Source of data: * this survey; ** in 1986.

The long frigid season in the Great Wall Bay is from March to October 1988. The surface water in the whole Bay was frozen. The thickness of ice was about one meter. Because the air temperature decreased rapidly, sea water temperature also dropped with it, and the hours of sunshine shortened rapidly. During this period, the cell number of phytoplankton dropped sharply to the lowest. The monthly minimum value was in July (only 0.09 $\times 10^4$ cells/m^3). Although the cell number was not high, the dominant species was relatively evident.

The monthly precentage of cell number of the phytoplanktonic dominant species in different stations of the Great Wall Bay is showed in Fig 2. There were one to three dominant species. They accounted for more than 60% of the total, or even as high as 96.55%. The dominant species showed clearly their seasonal succession (Fig. 2). The composition of the dominant species at Station 5 within the bay and at Station 12 in the bay mouth were generally similar in each month, although they showed slight difference in some months. To sum up, the succession of dominant species at each station in each month was in close relationship with the environmental changes in this bay. The neritic-eurythermal species occupied a leading position in warm season and the cold-water species in frigid season. So, the cell number of the dominant species determined the horizontal distribution and seasonal variation of the phytoplankton.

From the results mentioned above the phytoplanktonic species composition and cell number in the Great Wall Bay, Antarctica evidently showed their seasonal variation. The variation of biomass depended upon the amount of dominant species. The changing tendency and feature was similar to that in the coast of Davis, but the cell number of phytoplankton was higher than that in the coast of Davis and the peak occurred earlier than that in the latter (Table 2).

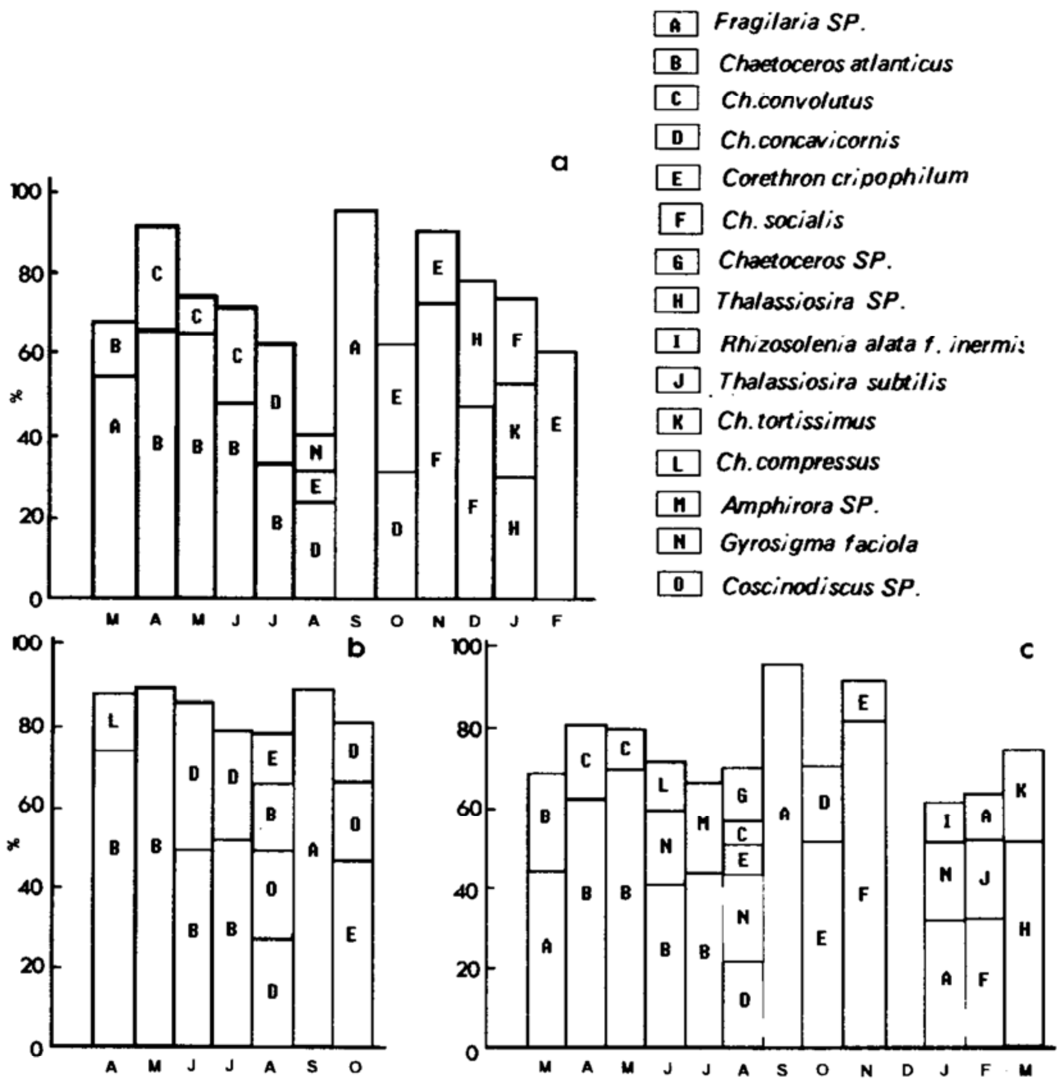

Fig. 2. Percentage of dominant species in the Great Wall Bay monthly from Mar. 1988 to Feb. 1989.
a: Within the bay; b: Station 5; c: Station 12 in the bay mouth.

4 Discussion

The sea current, water mass, sea water temperature, the salinity, pH, nutrients, the thickness of ice, transparency and hours of sunshine, etc. are considered as the main factors influencing the species composition and quantitative distribution of the phytoplankton. From this survey, when the warm season was coming, the ice along the coast of the bay began to melt, the fresh water with the eacretion of sea birds and seals drained into the bay. The nutrient could be supplemented sufficiently. The concentration of the phosphate analyzed in the investigation ranged over 0.738～4.873 μg/L. The abundant nutrient could meet the need of algae growth. The current in the Great Wall Bay was mainly tidal current. According to the results, the differences are not great in the specific composition and the quantitative variation of phytoplankton between stations. It seems that current, water mass and nutrients were not the leading factors influencing the distribution of phytoplankton. From the relationship of the specific composition of phytoplankton and the succession of dominant species with the change of sea water temperature, it may be seen that the temperature was one of the main factors influencing phytoplankton distribution in antarctic region. Certainly, whether the air temperature or water temperature they were all directly restricted by the hours of sunshine. In the studied sea area the greatest amount of phytoplankton appeared once in warm season. Its appearance evidently has a positive correlation with the hours of sunshine in that area (Fig. 1). So we think that the multiplication of the phytoplankton in this region was mainly controlled by the hours of sunshine. In addition, the thickness of ice and snow was also one of the environmental factors affecting quantitative variation of phytoplankton. Because of the melting of sea ice, ice algae were set free to the sea waters and subsequently increased in number. Meanwhile, the ice algae released into the sea water also played a leeding role, a feature seen only in the antarctic region.

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Appendix: List of Phytoplankton Species

Bacillariophyta
Achnanthes sp.
Amphiprora kjellmanii Mangin
A. sp.
Amphora pulchella M. Per.
A. sp
Arachnoidiscus ehrenbergii Bacil
Biddulphia aurita Lyngb.
B. litigiosa H. V. H. , Vista Valvor
B. obtusa Kiitzing
B. pulchella Gray
B. striata Karst.
B. translucida H. V. H.
B. sp.
Chaetoceros atlanticus Cleve
C. compressus Laud.
C. concavicornis Mangin
C. convolutus Castr.
C. dichaeta Ehr.
C. socialis Laud.
C. tortissmis Gran
C. sp
Charotia bifrons(castr) M. Per.
Cocconeis antarctica H. V. H.
C. costata Greg
C. costata var. pacifica (Grun.)Cleve
C. Gaurieri H. V. H.
C. pinnata Greg.
Cocconeis sp.
Corethron criophilum Castracane
C. valdirvix Karsten
Coscinodiscus asteromphalus Ehr.
C. excentricus Ehr.
C. kiitzingi A. Schmidt
C. oculus—iridis Ehr.
C. radiatus Ehr.
C. subtilis Ehr.
Coscinodiscus sp.
Dactyliosolen antarctica Castracane
Eucampia antarctica (Castr.) Mangin.
E. balaustium Castracane
Fragilaria bongranii M. per.
F. islandica Grunow
F. oceanica Cleve
F. sp.
Gomphonema margaritx Frengulli Y. A. Orlando
G. sp.
Grammatophora charcotii M. Per.
Gyrosigma fasciola (Ehr) Griffith et Henfrey
G. fasciola var sulcata (Grun) Cleve
Hemiaulus sp.
Licmophora antarctica M. Per.
L. charcotii M. Per.
L. gracilis (Ehr.) Kutz.
L. sp.
Melosira distans (Ehr.) Kutz.
M. islandica O. Miitz.
M. sol (Ehr) Kutz.
M. sp.
Navicula cancellala Donkin
N. longa (Greg) Ralfs
N. muticopsis H. V. H.
N. sp..
Nitzschia closterium (Ehr.) W. Smith
N. delicatissima Cleve
N. longissima (Breb.) Raalfs
Pleurosigma antarcticum angusta Heiden- Kolbe
P. sp.
Rhizosolenia alata Brightw.
R. alata f. curvirotris Gran.
R. alata f. gracilima (Cl.) Grun.
R. alata f. inermis (Castr.) Mangin
R. styliformis Brightw.
R. styliformis f. bidens (Karst.)
R. sp.
Rhiocosphenia curvata (Kutz.) Grun.
Synedra Lavigata Grun.
S. sp.
Thalassionema nitzschioides Grun.
Thalassiosira decipiens (Grun.) Jorg.
T. hyalina (Grun.) Gran
T. nordenskioldi Cleve
T. subtilis (Oslf) Gran
T. sp.
Thalassiothrix longssima Cleve et Grun
Triceratium arcticum Brightw.
T. favus Ehr.
Tropidoneis peragalloi f. lala (M. Per.)
T. sp.
Pyrrophyta
Peridinium parallelum Broch
P. sp.
Chrysophyta
Distephanus speculum (Ehr.) Haechel