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# Sedimentation processes in the Antarctic coastal area

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**Abstract:** A party of 27th Japanese Antarctic Resarch Expedition during 1985 and 1987, designed a moored system for monitoring temporal variation in phytoplankton standing stocks and downward flux at Breid Bay in the Antarctic Ocean. A total of 1127 hourly data sets of water temperature, chlorophyll conentration and current at 52 m depth as well as every 3.5 day period of 12 trap samples at 120 m depth were obtained. Integrated chlorophyll *a* standing stock in the upper 200 m water column were higher in December reaching 400 mg $m^{-2}$ than in February of 330 mg $m^{-2}$. Lager than 20 $\mu$m fraction of chlorophyll *a* was dominant in the water column in December and February.Vertical flux of particulate pigments, total cell volume and POC increased to the mid-January and each peak of pigment, cell volume and POC fluxes were observed 4.7 $mgm^{-2}$ $day^{-1}$, 450$\mu$l $m^{-2}$ $day^{-1}$ and 105mg C $m^{-2}$ $day^{-1}$, respectively. A marked increase of pigment flux and cell volume flux in mid-January was observed 3.5 to 10.5 days after an increase in the upper layer chlorophyll. Thus sinking rate was calculated as about 6.5 to 19.4 m $day^{-1}$. Sediment samples were dominated by intact cells of *Thalassiosira antarctica* throughout the period of observation. Large diatom, *T.antarctica* blooming may represent typical Antarctic blooms and this species may be an important source of food for benthic and planktonic animals.

## Introduction

There are vast areas covered with seasonal sea ice in both polar oceans. Their maximum areas are generally 15 and 20 million $km^2$ in the Arctic and Antarctic, respectively (GLOERSEN and CAMBELL, 1988). Marginal ice zones in the Antarctic and Arctic are known to be major area of high production through several tropic levels of organisms (MCROY and GOERING, 1974, SMITH *et al.*, 1988). Biological investigations in these polar areas are very limited partly because of the logistic difficulties. Mooring systems are considered to be useful devices for overcoming the logistic difficulties.

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In the Southern Ocean, particularly in the Antarctic Ocean during austral summer, average values of downward organic carbon flux are reaching around 100 mg $m^{-2}$ $day^{-1}$ (FUKUCHI and SASAKI, 1981; WEFER *et al.*, 1982). These values of organic carbon flux are much higher than those obtained in other temperate and tropical waters (HONJO *et al.*, 1982). However, higher values of the flux in the Antarctic Ocean have been observed in the bloom season in austral summer, particularly higher flux was observed around vanish of the seasonal ice (MATSUDA *et al.*, 1987; WEFER *et al.*, 1988).

Time-series investigation, such as temporal changes in phytoplankton stading stocks in the euphotic layer and the downward flux from the surface is necessary to clarify and evaluate biological processes about energy flow from the surface to the deeper layer. This investigation has been carried out in Breid Bay, Antarctic polynya, during December 1985 and Fedruary 1986 (FUKUCHI *et al.*, 1988).

In this paper, we would like to introduce the results obtained in Breid Bay by FUKUCHI *et al.* (1988) and some other results to consider the sedimentation processes in the Antarctic coastal water.

**Materials and methods**

A party of 27th Japanese Antarctic Research Expedition (JARE-27) during 1985 and 1987, designed a moored system for monitoring both long-and short-term temporal variation in phytoplankton standing stocks and downward flux at Breid Bay Antarctic Ocean. The objectives of this study are 1) to develop long-term mooring system for polar marine biology, particularly chlorophyll in the upper productive layer and its sedimentation into deeper layer, 2) to analyze blooming process in the Antarctic water, 3) to evaluate the process of downward flux in the blooming period.

Mooring array of the system consisted of a continuous chlorophyll measuring buoy, a current meter and a time-series sediment trap were set at depths of 52, 57, and 120 m, respectively. The system was deployed in the Antarctic polynya in Breid Bay from 28 December 1985 to 13 February 1986. Further details of the moored system were shown in FUKUCHI *et al.* (1988).

**Results and discussion**

A total of 1127 hourly data sets of water temperature, chlorophyll concentration and current as well as every 3.5 day period of 12 trap samples were obtained.

The bloom had already started before the start of the mooring experiment in late December and had not yet terminated when the experiment ended in mid-February.

Vertical profile of size fractionated chlorophyll *a* observed just before deployment of the system and after recovering it were shown in Fig.1. Subsurface chlorophyll maximum was reaching about 6 mg $m^{-3}$ at the beginning and end of the study. Larger than 20 $\mu$m fraction was abundant throughout the period. The bloom in the coastal polynya continues for more than 2 to 3 months when favorable conditions persist in summer. Integrated chlorophyll *a* standing stock in the upper 200 m water column were higher in December reaching 400 mg $m^{-2}$ than in February of 330 mg $m^{-2}$. However, the stocks above the pycnocline were higher in February than in December.

Water temperature was higher in December. Thermocline deepened in February (Fig. 1). Salinity profile in December was uniform

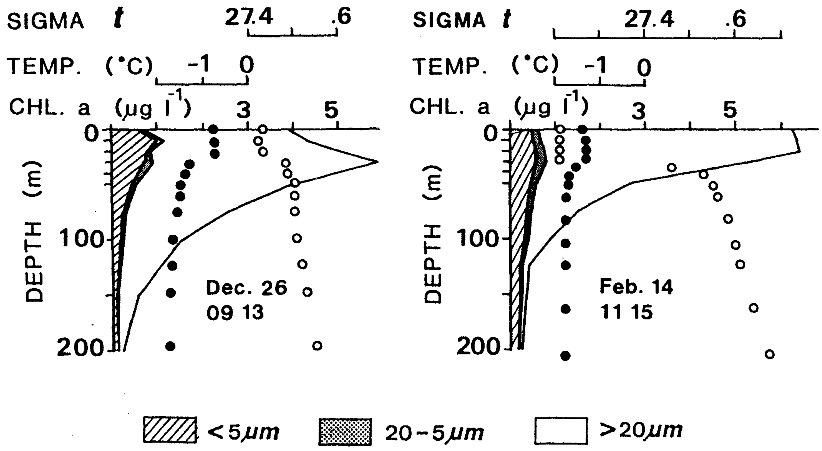


Fig. 1. Vertical profiles of size fractionated chlorophyll *a* in Breid Bay in December (left) and February (right). Temperature and Sigma-t profiles also shown by filled and open circles, respectively.

and higher than 34.00. In February, however, salinity in the surface layer decreased to less than 33.80 and a strong halocline was formed between 30 to 50 m. Sigma-t profiles were similar to salinity profiles in December and February. A strong pycnocline between 30 and 50 m was formed in February (Fig.1).

The chlorophyll-measuring buoy was set just below the pycnocline and below the subsurface chlorophyll *a* maximum. The sediment trap was set in vertically uniform water having temperatures below −1.7℃ and salinities above 34.10. Euphotic depths are around 20 m depth in December and February.

Figure 2 shows the schematic representation of results obtained from the continuous chlorophyll measuring buoy and the time series sediment trap. Chlorophyll *a* concentration in the upper layer fluctuated mainly in the range of 0.7 to 5.6 mg $m^{-3}$, and the values tended to decrease toward mid-February. Highest value was observed in the period of No. 3 at 52 m depth.

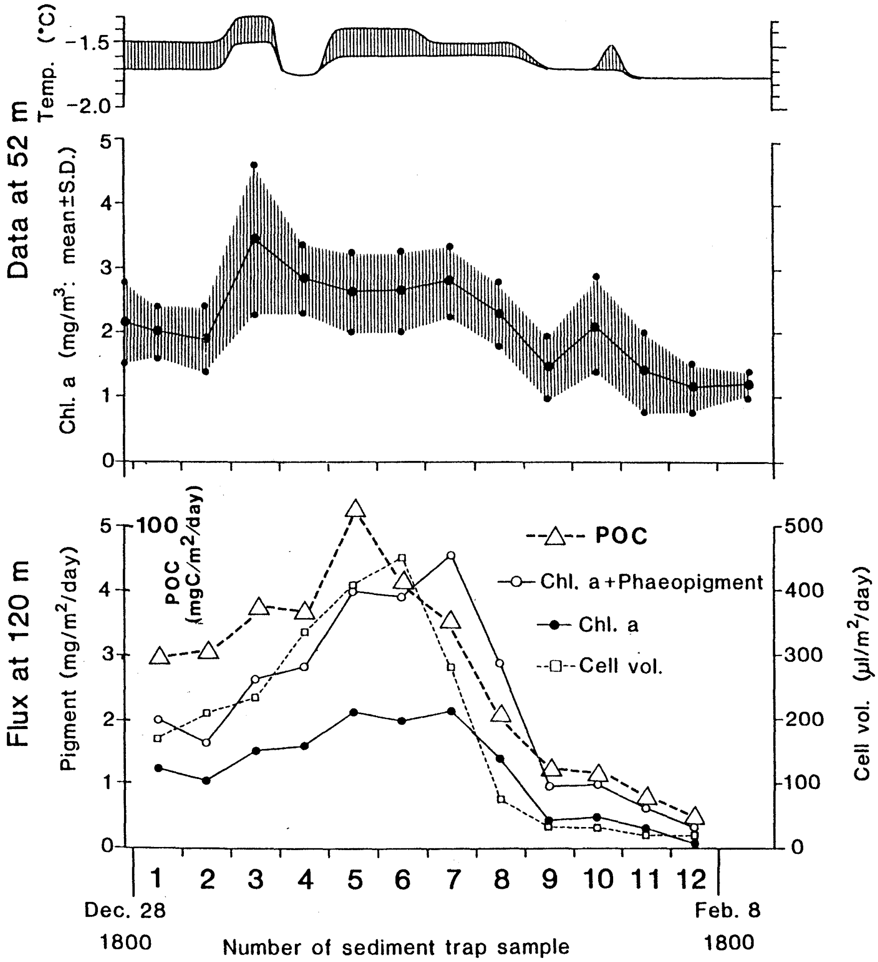


Fig. 2. Schematic representation of results obtained from the continuous chlorophyll measuring buoy at 52 m depth and the time series sediment trap at 120 m depth from Decemder 1985 to February 1986. Temperature and chlorophyll *a* data from 47 days of 1 hour interval are averaged to correspond to every 3.5 day period of the intervals of trap samples. Shaded area in the chlorophyll *a* is standard deviation of the 3.5 day period and a line means mean chlorophyll *a* concentration.

Vertical flux of particulate pigments, total cell volume and POC increased to the mid-January and each peak of pigment, cell volume and POC fluxes were observed in the period of No.7 (4.7 mg $m^{-2}$ $day^{-1}$), No.6 (450 $\mu$l $m^{-2}$ $day^{-1}$) and No. 5 (105 mgC $m^{-2}$ $day^{-1}$), respectively. A marked increase of pigment flux and cell volume flux in mid-January was observed 3.5 to 10.5 days after an increase in the 52 m layer chlorophyll. If the increase from sample No.1 to sample No.7 in flux at 120 m depth was due to the rapid increase in chlorophyll *a* from sample No.2 to No.3 at 52 m depth, then an estimate of the sinking rate of particles can be made. The increase in pigment flux followed the increase in chlorophyll *a* by 3.5 to 10.5 days. Thus sinking rate was calculated as about 6.5 to 19.4 m $day^{-1}$.

Particles sinking down from the upper layer to the 120 m depth were intact diatom, *Thalassiosira antarctica*. Trap samples were dominated by intact cells of this species throughout the period of observation. In the Antarctic Peninsula region, main constituent of the trap sample was also intact and apparently viable cells of *T.antarctica* (BODUNGEN *et al.*, 1986). Size of this species is about 20 $\mu$m in diameter. In Fig.1, size fraction larger than 20 $\mu$m was abundant in the whole water column during December and February. Abundance of this size in the trap samples was also observed by an Elzone Particle Counter. About 18 $\mu$m (equivalent spherical diameter) particles were dominant throughout the study. These results reveal that the sinking rate of 6.5-19.4 m $day^{-1}$ is that of *T. antarctica*. This rate is higher than those of single phytoplankton cells (e. g. SMAYDA, 1970). Probably, sinking cells of *T. antarctica* are chain-forming and the sinking rates become large.

It is not known why the peaks of the pigment, cell volume and POC fluxes differed by one sampling period of the trap samples. But, once these fluxes reached their peak in the mid-Junuary, those values were rapidly decreasing. These were apparent in the cell volume and pigment fluxes. In the vertical profiles of Sigma-t in Fig.1, pycnocline became larger in February. In general, when water stability in the surface become higher, phytoplankton remains longer in the upper layer of pycnocline. Hence it appears that the decreasing of fluxes in the mid-January represents beginning of higher water stability in the surface.

Smaller size, of fecal pellets less than 200 $\mu$m long were found in the trap samples. And their estimated volume were similar to that of sinking cells. SEM observations of the pellets revealed that *T. antarctica* was main food source for organisms inhabiting in the upper layer. Based on the results, large diatom, *T.antarctica* blooming may represent typical Antarctic blooms and this species may be an important source of food for benthic and planktonic animals.

To observe that the temporal variability of downward particulate flux using time-series sediment traps with reference to the sersonal variation of ice coverage in the Antarctic Ocean, we will deploy similar mooring systems in Prydz Bay and Antarctic polynya near Syowa Station in coming austral summer. After successfull recovering of these system, the sedimentation process in the Antarctic Ocean will become clearer.

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# 南極沿海域における粒子の沈降過程

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表層での植物プランクトン現存量と下層での沈降粒子量の系列変化を観察するための繫留ブイシステムを用い，南極のブライド湾において1985年12月から1986年２月の期間測定を行なった。52m水深における3.5日毎の12本の沈降粒子試料を得ることが出来た。200m 以浅の水柱内におけるクロロフィル現存量は12月，２月共に高く，それぞれ400，330mg $m^{-2}$ に達し，20$\mu$m 以上のサイズの植物プランクトンが優占していた。沈降粒子量は１月中旬に多く，１日当たり，単位面積($m^{-2}$)当たりの色素，植物プランクトン細胞量とPOC量はそれぞれ，4.7mg，450$\mu$l と105mgC に達した。１月中旬における色素と細胞量のピークは，上層でのクロロフィル量のピークが：現れた後3.5から10.5日後に得られた。このことから粒子の沈降速度は，１日当たり6.5から19.4mと推定された。珪藻の *Thalassiosira antarctica* は沈降粒子の中で観測期間を通し優占していた上，トラップで採集された糞粒内にも非常に多かった。これらのことから，*T. antarctica* の増殖は南極海沿岸の夏期における大増殖を形成し，なおかつ底棲生物や浮遊生物にとっても重要な餌生物であると考えられた。