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The Three-Month Continuous Observation of Oceanographic Parameters in King George Island

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It is not unusual that most oceanographic studies in Antarctica were carried out through only one or two measurements of a certain oceanographic parameter during the short austral summer period. It was excused due to the remote location and the harsh weather condition of Antarctica, especially extensive ice coverage of the coastal zone during austral winter. However such oceanographic results might mislead other researchers to wrong directions because of small number of the original data and lack of understandings on other seasons except austral summer. Herein continuous observations of almost three months were carried out on seven major parameters which might influence the coastal zone of Antarctica during the transition period from austral winter to summer. They covered oceanographic parameters (salinity, suspended solids, chlorophyll content and benthic zooplankton biomass) as well as meteorological factors (sun hours, wind direction and wind velocity). The study was executed at the pier of the King Sejong Station, the King George Island. The wind direction was found a key factor to control the temporal fluctuation of coastal environment in Antarctica and its relationships with other factors were discussed.

Key words: continuous observation, wind direction, King George Island

INTRODUCTION

A paradox of Antarctic marine ecosystem is that these waters are relatively less productive despite its high nutrient concentrations. To explain this phenomenon, several hypotheses are suggested; (1) instability of water column, (2) severe grazing pressure and (3) limitation of micronutrients.

Holm-Hansen (1989) suggested that low annual carbon fixation of the Southern Ocean is apparently attributed to deep mixing of water column. Yet, his efforts failed due to the lack of synoptic data. Martin and Fitzwater (1988) proposed the inhibition of primary production due to the depletion of micronutrients such as dissolved iron in seawater on the basis of several culture experiments. However their explanation had limitation that the primary production was still lower than the expected even with abundant iron content in the Antarctic Continental Shelves.

Assuming that grazing pressure is dependent on the biomass of zooplankton, Kim *et al.* (1991) found that primary production was still low despite zooplankton biomass was also very low in the studied area. So severe grazing pressure is not the answer for the paradox, either. Still the paradox is waiting for scientists as a puzzle unsolved. Nonetheless, among the above hypothesis, the first one on the instability of water column is getting more and more attention. Early fifty, Sverdrup (1953) pointed the correlation between the mixing depth and the phytoplankton bloom. Recently Yang (1990) suggested that the low phytoplankton biomass might be due to lack of incident light concurring to the instability of water column caused by strong wind in this area.

The stability of seawater is known to be determined by density profiles through water column and by wind activity at water surface. First of all, temperature and salinity are two major factors to

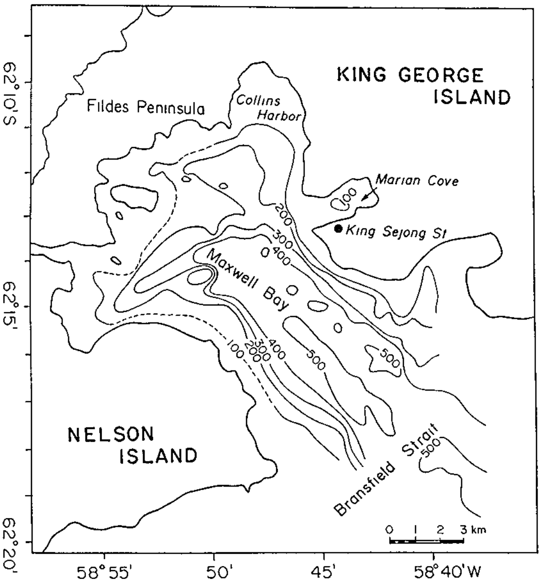

Fig. 1. Location map.

determine the density of seawater. However, the nonlinear response of density to temperature and salinity and narrow vertical variation of temperature (the maximum difference between surface and bottom water is about 2°C), especially in the cold Antarctic water, salinity is the main factor to determine the density of seawater.

Another factor to influence the stability of water column is strong wind, which causes turbulent movement of surface water. The turbulent movement of surface water triggers the resuspension of bottom sediment in shallow depths. Consequently, incident light is blocked by suspended solids. Strong wind, very common in this area was recorded annual mean of 7.6 m/s and frequently over 30 m/s for several days.

The growing period of phytoplankton in Antarctic water is believed to be from November to April, and a recent sediment trap study in the Bransfield Strait indicated growing intervals of just 30-60 days (Wefer *et al.*, 1988). As a consequence, the necessities of studies on the temporal variations through one or two months is increasing. Especially, a transition period, from austral winter to summer, is a very critical period to complete a puzzle of understanding on the Antarctic ecosystem.

It is not unusual that most oceanographic studies in Antarctic were carried out through only one or two measurements of a certain oceanographic parameter during the short austral summer period. It was excused due to its remote location and harsh weather condition, especially with extensive ice coverage of the coastal zone during austral winter. However such oceanographic results might mislead other researchers to wrong direction because of small number of the original data and lack of understandings on other seasons except austral summer.

Herein in order to complete a part of the puzzle, continuous observations of almost three months were carried out on seven major parameters which might influence the coastal zone of Antarctica during the transition period from austral winter to summer. They covered oceanographic parameters (salinity, suspended solids, chlorophyll content and benthic zooplankton biomass) as well as meteorological factors (sun hours, wind direction and wind velocity).

MATERIALS AND METHODS

Sampling

A Van Dorn sampler was used to collect water samples from surface every day at 17:00 hour from October 9 to December 10, 1990. The water samples were collected from surface at the pier of the King Sejong Station, Korea Antarctic Station in the King George Island. The location is shown in Fig. 1.

Meteorological Data

Wind direction, wind speed and sun hours were observed by an Automatic Meteorological Observation System (AMOS) in the King Sejong Station. The data were collected every 30 seconds and recorded every 30 minutes.

Oceanographic Parameters

Salinity, suspended solids, chlorophyll content and benthic zooplankton biomass were determined immediately after sampling. Salinity was determined by a Smart CTD (EG & G Ocean Products). For suspended solids, 1 liter of water samples were filtered through 0.45 μm Millipore filters and kept in a dessicator after filtration. Later the weight difference was measured before and after filtration. Chlorophyll content was determined with a spectrophotometer (Shimazu) after extraction and the

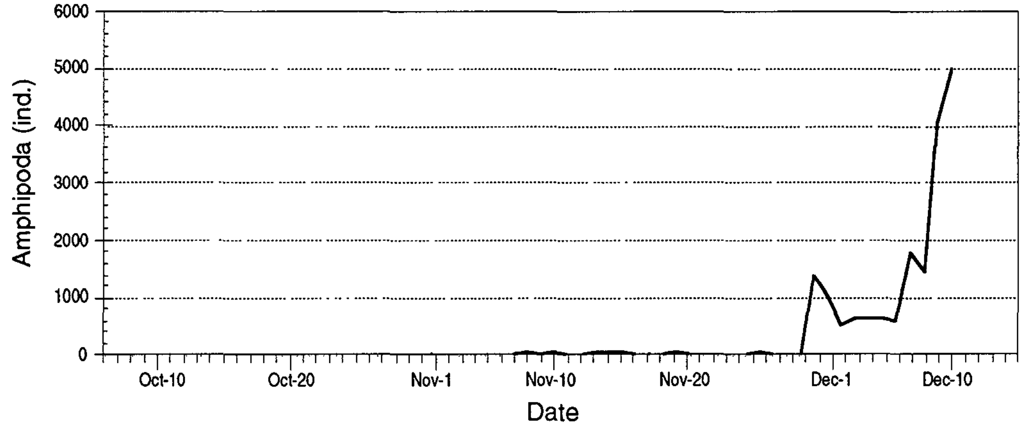

Fig. 2. Appearance of amphipods through the studied period.

Table 1. Comparison of wind velocity, salinity, chlorophyll and suspended solids between the easterly days and the ordinary days

	Wind velocity (m/s)	Salinity (‰)	Chlorophyll (mg/l)	Suspended solids (mg/l)
Easterly days*	6.34	33.34	3.4	280
Ordinary days**	10.28	33.53	3.5	360
T-test	significant (95%)	significant (90%)	not-significant (90%)	significant (95%)

* It denotes easterly-wind-blown-days. It was 7 days.
** It denotes northerly and westerly-wind-blown-days. It was 56 days.
Note: Data of a blizzard case (October 12th and 13th) are not included in the table.

total chlorophyll contents were calculated through the method of Parsons *et al.* (1984). Benthic zooplankton was counted after filtration of 1 liter of seawater with bare eyes.

RESULTS AND DISCUSSION

Wind Direction, Salinity and Suspended Solids

The northerly and northwesterly wind prevailed during the studied period (Table 1, refer Appendix for detail), which is typical in this area (Lee *et al.*, 1990). The northerly and northwesterly winds were recorded for 56 days and easterly wind for 7 days. Herein northerly and northwesterly-wind-blown-days are thought as "the ordinary days" and easterly-wind-blown days as "easterly days". An interesting finding from this work is that, whenever easterly wind blow, less saline water appeared simultaneously (Table 1). During the period, daily mean salinity for 33.53‰ of "ordinary days" dropped to 33.34‰ for "easterly days". In addition, the contents of suspended solids decreased drastically from 360 mg/l for "ordinary days" to 280 mg/l for "easterly days" (Table 1). The difference of the means between two groups were proved by T-test with 95% confidence levels.

The King Sejong Station locates in Marian Cove and its mouth is opened offshore to the west and it is faced a well developed glacier area to the east (Fig. 1). When easterly wind prevailed, ice melted water, which originated from the glacier that locates inner part of the cove, spread out to the

Table 2. Three-month observation data at the King Sejong Station

Month	Date	Wind direction	Wind vel. (m/s)	Salinity (‰)	Chlorophyll (mg/l)	Suspended solids (mg/l)	Amphipods (ind.)	Sun hours (h)
October	9	WNW	11.1	33.77	6.5	316	0	0
	10	WNW	10.6	33.48	5.2	468	0	4
	11	NNW	10.9	33.54	3.2	322	0	1.5
	12	N	5.9	32.27	14.1	478	0	2
	13	ESE	18.3	33.17	6.2	2719	0	7.5
	14	E	8.1	33.76	2.2	196	0	0
	15	NW	9.5	33.47	3.1	220	0	0
	16	WSW	10.9	33.82	3.2	267	0	0
	17	NW	8.8	33.77	3.3	224	0	0
	18	NNW	10.4	33.87	2.5	266	0	2
	19	NW	8.5	33.76	2.5	283	0	1
	20	NNW	6.8	33.85	4.1	303	0	10.5
	21	N	7.1	33.72	2.2	225	0	0
	22	SSW	2.9	33.91	1.5	460	0	1
	23	WSW	7.5	33.31	1.8	256	0	5
	24	N	5.1	33.31	1.8	256	0	5
	25	NNW	6.4	32.99	2.2	306	0	5
	26	N	13.7	33.56	2.2	318	0	0
	27	WNW	8.6	33.58	3.2	348	0	0
	28	SSE	2.3	33.43	3.1	233	0	0
	29	N	7.2	32.82	6.5	381	0	3.5
	30	NNW	9.9	33.14	3.4	554	0	12.5
	31	NNW	9.6	32.88	2.3	346	0	6
November	1	N	11.5	31.83	2.2	451	0	9.5
	2	NNE	6.9	32.85	3.3	296	5	3
	3	SE	4.1	33.15	4.1	149	0	0
	4	NW	8.7	33.76	4.5	385	0	0
	5	N	17.9	33.78	4.3	405	0	5
	6	NW	11.7	33.42	2.5	389	0	1.5
	7	NW	7.1	33.73	3.6	355	0	2
	8	WNW	8.1	33.64	3.6	311	0	5.5
	9	NW	10.5	33.48	3.5	867	55	0
	10	N	12.0	33.01	3.8	264	4	0
	11	NNW	10.6	33.39	4.3	292	61	0
	12	WNW	9.9	33.21	4.5	387	0	0
	13	N	16.5	33.41	4.2	342	1	0
	14	N	12.7	33.41	3.2	702	63	0.5
	15	NW	9.1	33.46	4.5	486	62	1
	16	W	4.8	33.53	4.2	387	65	8
	17	NNW	4.6	33.55	2.8	285	0	0
	18	NNW	10.9	33.51	3.5	451	5	5
	19	NNW	10.9	33.45	4.1	407	0	0
	20	N	12.1	33.42	4.6	384	52	4
	21	W	4.1	33.64	4.2	341	3	0
	22	NNE	9.1	33.41	3.2	290	0	0
	23	SSE	10.1	33.61	5.1	493	0	7
	24	W	8.6	33.53	4.0	355	0	10
	25	SW	5.0	34.02	3.2	422	0	13
	26	W	6.2	33.89	4.2	306	42	14
	27	W	6.6	33.61	2.8	413	0	4
	28	N	9.1	33.72	2.9	380	0	4
	29	N	8.7	33.56	3.6	355	0	2
	30	W	7.6	33.91	4.1	262	1392	0
December	1	WNW	2.5	33.42	2.2	331	996	6
	2	WNW	3.1	33.75	4.2	339	535	3
	3	N	7.2	33.64	2.9	295	638	6
	4	NW	2.4	33.41	2.6	159	619	14
	5	ESE	3.8	33.14	2.8	301	637	0
	6	SW	6.1	33.91	3.1	499	612	7
	7	W	4.1	33.53	2.6	252	1802	0
	8	NW	7.9	33.76	4.2	341	1446	0
	9	NW	9.7	33.77	4.6	352	4061	0
	10	NW	10.1	33.87	5.8	383	5002	16

westward direction. The ice-melted water is characterized with low salinity and low suspended solids contents. This phenomenon probably caused the appearance of less saline clear water at the surface of Marian Cove, the sampling site.

Wind Velocity and Suspended Solids

During the studied period, the wind velocities were ranged the daily means of from 2.3 m/s to 18.3 m/s. The maximum wind velocity was found 35.1 m/s and a minimum 0.00 m/s. An episodic case of the maximum wind velocity was recorded as easterly wind, the so-called Antarctic blizzard, which generally continues one or two days of strong wind. This work is not purposed for the blizzard case, the data of the blizzard (October 12th and 13th) are exempted from the calculation of means etc. Regarding to the blizzard, other work has already been reported (Lee *et al.*, 1990). In this work, except the case of a blizzard, "easterly days" was reported lower mean value (6.34 m/s) of wind velocity than that (10.28 m/s) of the "ordinary days" (Table 1). This is checked by T-test with a 95% confidence level. As prescribed previously, suspended solids showed a similar trend. Generally if wind blows strongly, surface water is disturbed and then sedimented material from the bottom was resuspended, which probably resulted high suspended solids contents in the samples.

Chlorophyll and Benthic Zooplankton

No distinct trend was found between chlorophyll and other parameters. Before the initiation of the study, phytoplankton biomass, symbolized as chlorophyll content in this study, was expected to increase with growing day length from October to December, yet such trend was not found. Again, no distinct correlation between benthic zooplankton and phytoplankton was found either. In the work all the benthic zooplankton identified with bare eyes is amphipoda (Table 1). This probably explains that amphipoda do not prey phytoplankton or maybe other biological parameters were involved. Instead a striking feature is found that the appearance of amphipoda was an explosive event. Amphipoda began to appear on November 2, but in a couple of days later, the number of individuals increased to 55 and then their numbers continues to increase to reach 5000 in a month (Fig. 2). This phenomenon could be explained with response of the bugs to the elongated day lengths from October to December.

REFERENCES

Holm-Hansen, O., B.G. Mitchell, C.D. Hewes and D.M. Karl. 1989. Phytoplankton blooms in the vicinity of Palmer Station, Antarctica. *Polar Biol.* **10:** 49-57.

Kim, D.Y., S. Kim, K.I. Yoo, M.S. Han and Y.O. Kim. 1991. Distribution and abundance of planktonic organisms in Bransfield Strait during austral summer 1989/1990. *Korean J. Polar Res.* **1:** 79-86.

Lee, B.Y., D.H. Kim and Y. Kim. 1990. A study of the climate characteristics over King Sejong Station, Antarctica. *Korean J. Polar Res.* **1:** 47-57.

Martin, J.H. and J. Priddle. 1987. Iron deficiency limited phytoplankton growth in the north-east Pacific Subarctic. *Nature* **331:** 341-343.

Sverdrup, H. 1953. On condition for the vernal blooming of phytoplankton. *J. Cons. Int. Explor. Mer* **18:** 287-295.

Wefer, G., G. Fisher, D. Fuetterer and R. Gersonde. 1989. Seasonal particle flux in the Bransfield Strait, Antarctica. *Deep-Sea Res.* **35:** 891-898.

Yang, J.S. 1990. Nutrients, chlorophyll-a and primary productivity in Maxwell Bay, King George Island, Antarctica. *Korean J. Polar Res.* **1:** 11-18.