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Vertical Distribution of Suspended Particulate Matter in Bransfield Strait and Adjacent Embayments, February 1993: Modified Niskin Bottles for Near-bottom Water Samples

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In Antarctic seas, most of suspended particulate matter (SPM) are produced during austral summer in the surface waters of coastal areas. SPM sinks gradually to the bottom, and might be transported far to open coastal areas. Organic particles are an important food source for benthic organisms, and organic contents in both near-bottom SPM and bottom sediment influence the abundance and species composition of benthic fauna according to their feeding strategies. To compare the composition and vertical profile of SPM in open coastal waters with those in sheltered bay waters, water samples were taken in Bransfield Strait and adjacent embayments in Feb. 1993. Specially modified Niskin Bottle was casted to sample the near-bottom waters (ca. 40-60 cm above the bottom), while CTD (MK5)-Rosette system was used for collection of the regular samples at several standard depths. Two patterns of SPM distribution were observed: 1) In sheltered (shelf) areas, SPM is high in surface waters, and the concentration gradually decreases with depth. 2) In open (slope) areas, SPM increases abruptly in near-bottom waters regardless of those of overlying waters. Highly concentrated SPM in the surface of sheltered areas is a result of high primary production or massive input of melt-water streams. However, the sudden increase of SPM on the bottom of coastal slope areas is a result of resuspension of fine particles at the bottom.

Key words: suspended particulate matter (SPM), particulate organic matter (POM), Bransfield Strait, modified Niskin bottle, near-bottom waters, lateral transport of SPM

INTRODUCTION

In Antarctic seas, most of suspended particulate matter (SPM) are produced during austral summer in the surface waters of coastal areas (El-sayed and Weber, 1982; Matsuda *et al.*, 1990), and sinks gradually to the bottom. Antarctic SPM is composed of biogenic (organic) particles produced from phytoplankton blooms and terrigenous (inorganic) particles coming with melt-water streams (Clarke, 1985). Phytoplankton is the major source of biogenic organic particles, the important food material for deep-sea benthic organisms, and Antarctic benthic fauna is wholly dependant on the organic particles from the seasonal rain of phytoplankton blooms during austral summer. In the shallow coastal areas, however, benthic algae are the important primary producer and the major source of organic materials (El-sayed, 1971; El-sayed and Weber, 1982; Whitaker, 1982; Clarke, 1985). Terrigenous inorganic particles are also produced during austral summer in the coastal areas (Clarke, 1985), and most of terrigenous sediment are transported mainly by melt-water streams, although glacial sediments are also considerable (because there is no river or stream in the Antarctic) (Szafranski and Lipski, 1982).

Benthic boundary layer (BBL), the interface between the water and bottom sediment, is the important feeding ground of benthic organisms, and the major sink of SPM (Wilde, 1976). However, the environmental nature of BBL is not fully

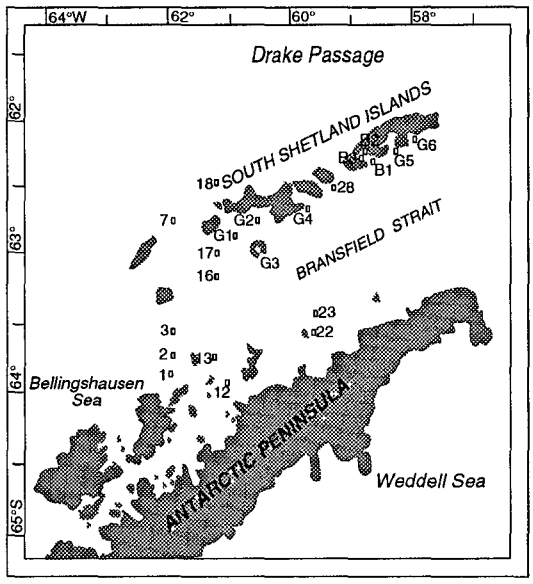

Fig. 1. Sampling stations in Bransfield Strait and adjacent embayments; G1, G2, G3, G4, G5, G6, B1, B2, B3 are located in relatively sheltered areas, while the rest labeled with numerals are located in open coastal areas.

understood in Antarctic seas, because it is difficult to sample the near-bottom waters. In an attempt to estimate the quantity of food particles in BBL of the Bransfield Strait area, specially modified Niskin Bottles (Fig. 2) were introduced for the collection of the near-bottom water samples. Further, the percentage organic ratio of SPM is compared in Bransfield Strait and adjacent embayments, because the contents of particulate organic matter (POM) in both near-bottom SPM and bottom sediment influence the abundance and species composition of benthic fauna according to the feeding strategies of benthic organisms.

MATERIALS AND METHODS

To compare the composition and vertical profile of SPM in open coastal waters with those in sheltered bay waters, water samples were taken from 21 stations in the Bransfield Strait and adjacent embayments at several standard depths in Feb. 1993 (Fig. 1). CTD(MK5)-Rosette system was used for collection of the regular samples at several standard depths. However, specially modified Niskin Bottle (Fig. 2) was casted to sample the

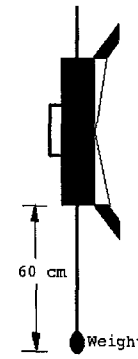

Fig. 2. Modified Niskin Bottle designed for near-bottom waters; Free falling speed of 1 m/sec. Open during going down, and closes instantaneously after the weight touches the bottom.

near-bottom waters (about 40-60 cm above the bottom). Sampling depths were selected in situ on the basis of CTD data (T/S profiles) just before sampling (one of the depths was the surface, two or three depths were selected in mixed layer over thermocline, and two or three were taken from the waters under thermocline). Water samples were filtered through pre-combusted GF/C filters, and the filters kept frozen at –20°C (2 sets of water samples were filtered at every selected depth). SPM is the dry weight of the GF/C filter minus the weight of the filter itself, and the weight lost from SPM after combustion is regarded as POM (Grasshoff *et al.*, 1983).

RESULTS

SPM Concentration

SPM concentration ranges < 1 mg/l to 5.59 mg/l in the surface, and < 1 mg/l to 35.08 mg/l in near-bottom waters (Table 1). SPM is highly concentrated in the surface waters of the stations near or sheltered by islands (Fig. 3a). SPM concentration increases abruptly in near-bottom waters regardless of those in overlying waters in the stations located in coastal slope areas (Fig. 3b).

POM Concentration

POM concentration ranges 0.5 mg/l to 2.32 mg/l in the surface waters, and 0.24 mg/l to 2.44 mg/l in near-bottom waters (Table 1). The pattern of POM distribution is not consistent with SPM distribution (Fig. 4).

Table 1. Spatial distribution of SPM (mg/l), POM (mg/l), and organic content (%) with depths; a) sheltered group and b) open coastal group

Station (Depth)	Surface			0 - 20 m			20 - 50 m			50 - 100 m			100 - 200 m			200 - 500 m			> 500 m			Near-Bottom		
	SPM	POM	%	SPM	POM	%	SPM	POM	%	SPM	POM	%	SPM	POM	%	SPM	POM	%	SPM	POM	%	SPM	POM	%
a) Sheltered group																								
G1 (213 m)	0.78	0.78	100.0	0.8	0.8	100.0	0.86	0.74	86.0	0.9	0.52	57.8	0.68	0.39	57.4							1.13	0.46	40.7
G2 (425 m)	0.9	0.9	100.0	0.88	0.79	89.8	0 83	0.71	85.5	1.03	0.73	70.9	1.31	0.56	42.7	0.92	0.53	57.6				0.88	0.5	56.8
G3 (100 m)	3.05	2.32	76.1	1.78	1.16	65.2	0.31	0.31	100.0	0.84	0.51	60.7										0.58	0.53	91.4
G4 (653 m)	0.6	0.6	100.0	0.83	0.7	84.3	1.06	0.59	55.7	1.28	0.63	49.2	0.86	0.45	52.3	0.75	0.5	66.7				1.6	0.52	32.5
G5 (439 m)	1.24	1.03	83.1	1.02	0.66	64.7	1.37	0.71	51.8	1.49	0.7	47.0	0.75	0.56	74.7	1.29	0.6	46.5				1.08	0.6	55.6
G6 (460 m)	1.51	0.85	56 3	1.17	0.67	57.3	0.85	0.58	68.2	0.95	0.46	48.4	1.31	0.52	39.7	1.47	0.49	33.3				1.23	0.46	37.4
B1 (490 m)	1.68	0.68	40.5	0.76	0.51	67.1	0.88	0.27	30.7	0.89	0.34	38.2	0.88	0.35	39.8	0.39	0.2	51.3				0.71	0.24	33.8
B2 (80 m)	5.59	0.66	11.8	2.39	0.61	25.5	0.47	0.44	93.6													0.85	0.53	62.4
B3 (490 m)	2.17	0.59	27.2	1.25	0.64	51.2	0.62	0.47	75.8	1.01	0.46	45.5	1.39	0.39	28.1	1.09	0.3	27.5				1.0	0.34	34.0
22 (500 m)	1.56	0.72	46.2	8.76	0.42	4.79	0.81	0.37	45.7	0.83	0.53	63.9	0.9	0.34	37.8	0.91	0.35	38.5				1.2	0.53	44.2
b) Open coastal group																								
01 (300 m)	1.95	0.75	38.5	0.85	0.56	65.9	1.46	0.55	37.7	1.46	0.51	34.9	1.17	0.5	42.7	1.62	0.54	33.3				-	-	-
02 (380 m)	0.9	0.62	68.9	-	-	-	0.61	0.41	67.2	2.32	0.83	35.8	1.42	0.5	35.2	1.67	0.56	33.5				-	-	-
03 (650 m)	1.69	0.85	50.3	0.65	0.5	76.9	1.14	0.7	61.4	1.35	0.64	47.4	0.91	0.48	52.7	0.83	0.54	65.1				1.42	0.74	52.1
07 (230 m)	0.97	0.69	71.1	0.79	0.71	89.9	0.78	0.61	78.2	0.88	0.68	77.3	1.99	0.68	34.2							-	-	-
12 (360 m)	1.62	0.89	54.9	0.73	0.73	100.0	0.77	0.71	92.2	0.86	0.49	57.0	1.09	0.72	66.1	0.9	0.73	81.1				1.75	0.72	41.1
13 (923 m)	1.19	0.9	75.6	1.03	0.9	87.4	0.59	0.45	76.3	1.0	0.59	59.0	0.61	0.43	70.5	0.63	0.53	84.1	0.68	0.61	89.7	13.0	1.32	10.2
16 (600 m)	1.57	1.22	77.7	1.02	0.88	86.3	0.54	0.54	100.0	1.04	0.57	54.8	1.11	0.62	55.9	3.04	0.67	22.0				1.26	0.55	43.7
17 (300 m)	1.74	1 38	79.3	0.93	0.93	100.0	1.43	0.75	52.4	1.22	0.72	59.0	0.68	0.58	85.3	0.81	0.54	66.7				2.32	0.85	36.6
18 (354 m)	1.01	0.87	86.1	0.86	0.76	88.4	0.73	0.82	100.0	0.44	0.44	100.0	1.49	0.79	53.0	1.02	0.6	58.8				1.79	0.56	31.3
23 (800 m)	0.9	0.5	55.6	0.87	0.72	82.8	0.54	0.41	75.9	0.4	0.26	65.0	0.98	0.39	39.8	0.84	0.23	27.4	0.95	0.31	32.6	2.1	0.39	18.6
28 (440 m)	1.83	1.06	57.9	1.06	0.79	74.5	1.06	0.67	63.2	0.35	0.35	100.0	1.09	0.54	49.5	0.92	0.56	60.9				35.1	2.44	6.96

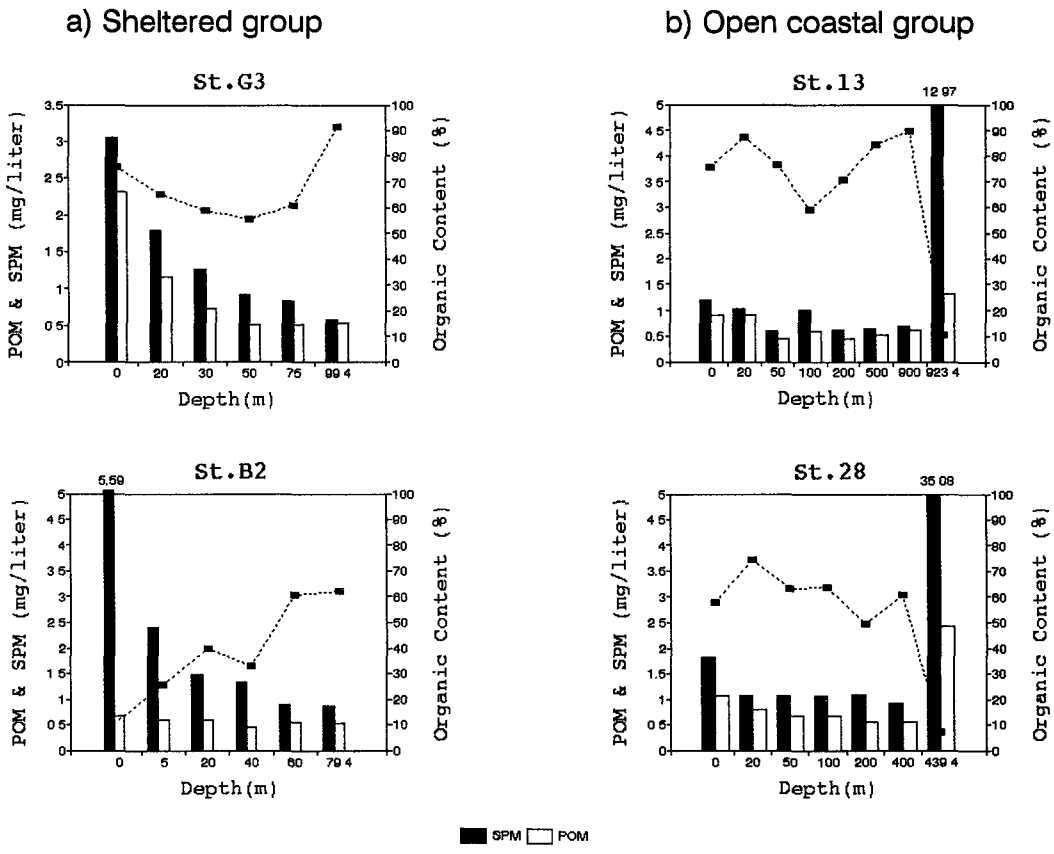

Fig. 3. Representative vertical profiles of SPM (black bar), POM (white bar), and organic content (dashed line); a) typical pattern of sheltered group, and b) open coastal group.

Vertical Profiles

Both SPM and POM decrease with depth, but increase suddenly in near-bottom waters in more than half of the stations. The high SPM of near-bottom waters in this area is mainly due to the elevated level of inorganic particles.

The Percentage Ratio of POM in SPM (= Organic Content)

Organic content is high in the surface, reaches maximum at the depth between 20 m and 50 m, and continuously decreases with depth. The ratio in the surface waters ranges > 30% to 90%, but in the center of Maxwell Bay and Marian Cove, the ratio is between 10% and 20% (Table 1).

DISCUSSION

Vertical profile of SPM concentration shows two patterns in Bransfield Strait and adjacent embayments (Figs 3, 4): 1) In sheltered (shelf) areas, SPM is high in surface waters, and the concentration gradually decreases with depth. 2) In open (slope) areas, SPM increases abruptly in near-bottom waters regardless of those of overlying waters. Highly concentrated SPM in the surface of sheltered areas is a result of high primary production or massive input of melt-water streams in this areas. However, the sudden increase of SPM on the bottom of coastal slope areas is a result of resuspension of fine particles at the bottom. Near-bottom increase of SPM indicates water movements on the bottom, and suggests SPM transportation along the slope (lateral transport of SPM). Contour current might be one of the possible modes of persistent SPM transportation to the deep-sea floor along the continental slope in this areas (Pickering *et al.*, 1989).

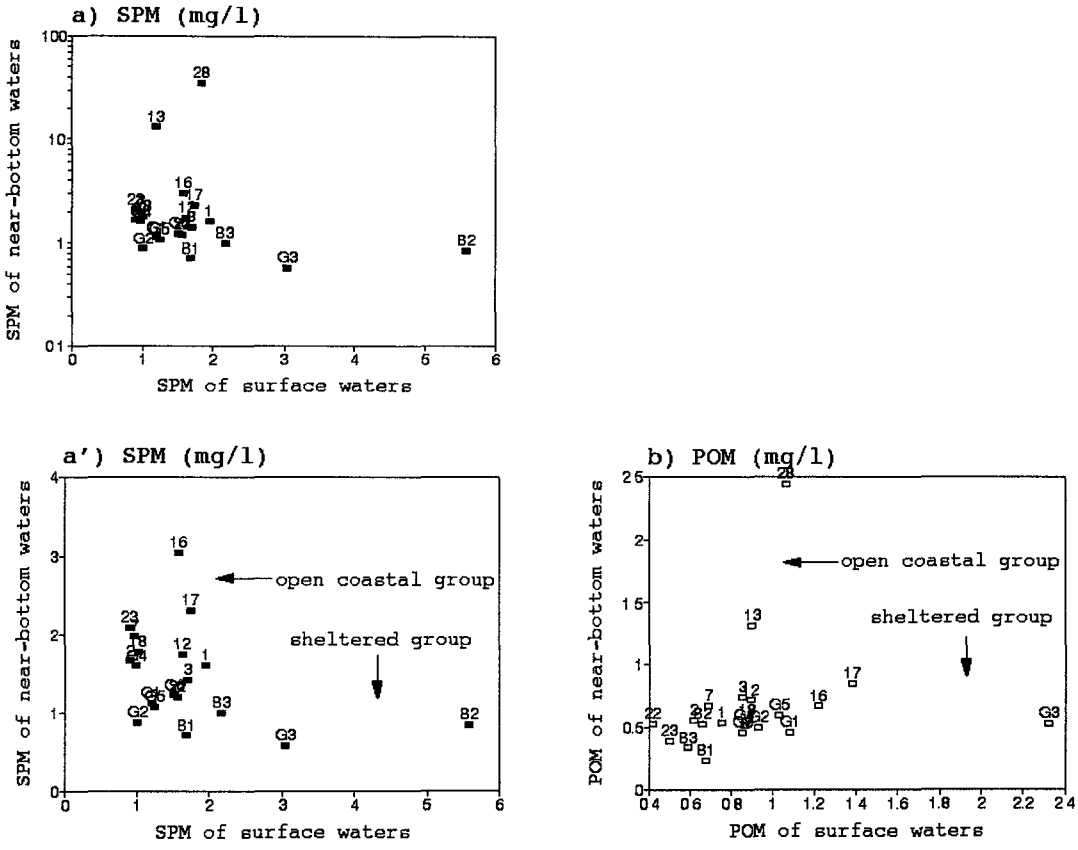

Fig. 4. Distribution of SPM & POM in surface and near-bottom waters. Sheltered group (lower right) and open coastal group (upper left); a) SPM, and b) POM.

The high SPM at mid-water depth and low SPM on the surface waters of open coastal areas might reflect the post-blooming of phytoplankton, and result from particle retention on the pycnocline due to density differences between surface mixed waters and underlying waters (Middleton, 1992). The low organic contents in Maxwell Bay and Marian Cove is due to relatively elevated level of terrigenous inorganic particles (Table 1).

It is suggested that near-bottom POM, which serves as the food for benthic organisms, may not be supplied directly from overlying waters, and the abundance of benthic fauna seems to be decoupled with SPM & POM concentrations of overlying waters, because the SPM & POM concentrations of near-bottom waters are very different from those of overlying waters.

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