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Short Term Variation in Particulate Organic Matter in the Shelf Waters of the Princess Astrid. Coast, Antarctica

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Abstract

Particulate matter collected at a single station in the shelf waters of Princess Astrid coast (70°S, 11°E) Antarctica, during the austral summer (Jan-Feb. 1986) was analysed for phytoplankton biomass (Chl a), living carbon (ATP-C), particulate organic carbon (POC) and its constituent fractions including particulate carbohydrates (PCHO), particulate proteins (PP) and particulate lipids (PL).

Chl a, ATP and POC varied from 0.051 to 3.1, 0.33 to 1.81 and 305 to 1850 μg l^{-1} respectively, whereas PCHO, PP and PL ranged from 8 to 176, 22 to 132 and 8 to 209 μg l^{-1} respectively. Data on these parameters showed large day to day variations and probably suggest patchy distribution.

Introduction

In the oceanic environments suspended particulate organic matter (POM) is generally derived from primary production by phytoplankton (Deuser et al., 1981). The POM in shallow coastal and shelf waters, on the other hand, is influenced by terrestrial particles and resuspension of bottom sediments (Degens and Ittekkot, 1985; Nelson et *al,* 1987).

Recently, much more attention has been focussed on large particles (>50μg), generally collected by sediment traps, in order to understand origin, fate, transport and composition of particulate organic material during its transport through water column (Hanjo, 1978; Ittekkot et *ah,* 1984; Bodungen et *al,* 1986, Nelson. *et al.,* 1987). Some advances have also been made in understanding the distribution and composition of suspended POM collected by conventional sampling bottles (Copin-Montegut and Copin-Montegut, 1983; Gordon and Cranford, 1985; Dortch, 1987; Saino and Hattori, 1987). These studies suggested that useful information on the dynamic water processes such as primary production in surface waters, transformation during vertical and lateral transport of suspended POM through water column can be obtained by studying the distribution and composition of suspended POM (Bishop, 1977; Gordon and Cranford, 1985; Harrison *et al,* 1987; Saino and Hattori, 1987).

In this paper, preliminary data on the short-term variation in living carbon, phytoplankton biomass, POM and its constituent fractions such as carbohydrates, proteins and lipids during austral summer (Jan to Feb 19.86) at a single station near the ice shelf have been presented.

Materials and Methods

Seawater samples were collected twice a week using 5 1 Niskin sampler when the ship was alongside of the ice shelf (70°S, 11°E) during January-February, 1986. Three discrete depths (just below sea ice, 10 and 30 m) were sampled within the euphotic zone which were predetermined using Secchhi disc. The water samples were filtered through pre-ignited Whatman glass fibre filter papers (47 mm dia, 1.2 μm pore size). Suspended matter left on filter paper was analysed in triplicate for particulate organic carbon (POC), particulate carbohydrates (PCHO), particulate proteins (PP) and particulate lipids (PL). The POC and PL were analysed following the method of Parsons *et al.* (1984). The PCHO and PP were determined as suggested by Hitchcock (1977) and Lowry (1951), respectively. The chlorophyll a was measured fluorometrically (Parsons et *al.,* 1984). In order to estimate adenosine triphosphate (ATP), water samples were filtered through sterilized Millipore filters (0.45 μm pore size) and analyzed as photon emitted by the luciferin-luciferase system on an SAI Photometer after extraction in hot tris-buffer (Parsons et *al,* 1984). ATP values were multiplied by 250 to obtain living carbon (Karl, 1980).

Results and Discussions

During the period of observations (Jan-Feb) nutrient concentrations were generally high (Naqvi, 1986). Nitrate, inorganic phosphate and silicate varied from 19.6 to 20.9, 1.6 to 2.3 and 56.7 to 58.1 μm dm^{-3} respectively. This implies that plankton growth was not limited due to nutrient starvation.

Chlorophyll a (Chl a) concentrations varied from 0.051 to 3.1 μg l^{-1} within euphotic depths (Table I). Chl a concentrations often but not always, were higher at 30 m as compared to surface suggesting accumulation of phytoplankton at this depth. This is probably due to the inhibitory effect of surface radiation (Liebezeit, 1984). Higher values of chl a were observed during first week of February and then again decreased during later period. This indicates considerable day-to-day variations in the chl a. Microscopic examination of water samples of vertical tows showed the presence of *Fragilana sp.,Nitzschia* sp., *Thallssiosira* sp., *Biddulphia* sp., *Eucampia* sp. and unidentified unicellular flagellates.

Variation in the concentrations of ATP during the period of study is shown in Table I. The ATP concentrations ranged from 0.33 to 1.81 μg l^{-1}. As observed for chl a, a subsurface ATP maximum at 10 or 30 m depth was evident. Although, generally ATP maximum was associated with chl *a* maximum, this was not always the case.

The POC concentrations ranged from 305 to 1850µ g 1^{-1} (Table. I). Highest values of POC were generally accompanied by high chl a concentrations. These POC concentrations are similar to those reported for surface waters of coastal and shelf water (Karl, 1980; Pocklington and Mackinnon, 1982; Bhosle *et al.* (in press); Harrison *et al.,* 1987). As observed for chl a and ATP, on many occasions POC values were higher at 30 m than those observed at the surface.

Table I. Short-term variation in particulate organic carbon (POC), Chlorophyll a (chl a)and adenosine triphosphate (ATP) in euphotic zone. (All values in µg1^{-1}).

Sampling Dates	Depths	POC	Chl a	ATP
January, 1986	Om	409 (±12.12)	1.33	0.95
4	10m	631 (±10.0)	1.30	1.20
	30 m	569 (±12.66)	1.86	1.60
8	Om	41.1.07 (±18.02)	1.24	1.25
	10m	488.4 (±12-83)	0.99	0.75
	30 m	529.1 (±24.08)	1.20	0.96
16	Om	305.25 (±12.27)	0.16	0.35
	10m	407 (±18.87)	0.23	0.45
	30 m	447 (± 6.47)	0.36	0.38
21	Om	569 (±18.62)	0.061	0.48
	10m	447 (±22.65)	0.079	1.11
	30 m	610 (±12.22)	0.051	0.46
24	Om	447.7 (±16.67)	0.093	0.33
	10 m	610.5 (±16.43)	1.06	0.76
	30 m	407.5 (± 6.101)	1.15	0.61

Table I. (Contd.)

Sampling Dates	Depths	POC	Chla	ATP
28	Om	936 (±72.02)	1.45	ND
	10m	610 (±36.04)	1.07	ND
	30 m	710 ±46.69)	2.52	ND
February, 1986				
1	Om	956 (±42.66)	3.1	0.75
	10m	702 (±46.02)	1.36	0.87
	30 m	575 (±28.21)	2.30	1.07
4	Om	509 (±14.83)	2.53	1.17
	10 m	509 (±20.41)	1.54	1.03
	30 m	407 (±16.61)	1.72	1.11
8	Om	509 (±10.65)	1.3	1.68
	10 m	1850 (±160.61)	1.20	1.81
	30 m	733 (±60.22)	1.63	1.60
12	Om	620.6 (±26.83)	0.72	1.59
	10 m	651.2 (±16.84)	ND	1.61
	30 m	631.0 (±40.21)	1.2	0.91

The organic matter in the shelf waters is derived from allochthonous (terrestrial material) and autochthonous (in *situ* aquatic production) sources (Degens and Ittekkot, 1985). In order to understand the contribution of living carbon, ATP values were converted to living carbon (Living carbon = ATP X 250, Karl, 1980) and compared with POC values. Based on this conversion, living carbon showed a large variation and ranged from about 18-80% (Table II). This data either suggests variable concentration of living organisms and/or detrital particles

during the period of study. The probable sources of detrital material in these waters are dead phytoplankton, heterotrophic organisms and terrestrial sediments. Modern Antarctic shelf suspended matter have unusual sources and transport pathways unique to the present glacial setting. There are no fluvial supply systems

Table II. Short-term variation in the living and detrital carbon in the euphotic zone.

Sampling Date	Depth	Total living Carbon ATP x 250	Percent Detrital Carbon
January, 1986	0m	237.5	41.93
4	10m	300.0	52.45
	30 m	400.0	29.70
8	0m	312.5	23.97
	10m	187.5	61.60
	30 m	240.0	54.63
16	0m	87.5	71.33
	10m	112.5	72.35
	30 m	95.0	78.74
21	0m	120.0	78.91
	10m	277.5	35.53
	30 m	115.0	81.14
24	0m	82.5	81.68
	10. m	190.0	68.87
	30 m	152.5	62.45
28	0m	—	—
	10 m	—	—
	30 m	—	—
February,1986			
1	0m	187.5	80.38
	10m	217.5	69.01
	30 m	267.5	53.47
4	0m	292.5	42.41
	10m	257.5	49.41
	30 m	277.5	31.81
8	0m	420.0	17.48
	10m	452.0	75.54
	30 m	400.0	45.43
12	0m	397.5	35.98
	10m	402.5	38,17
	30m	227.5	63.94

and sediment input by melt water is considered to be minimum along most of the Antarctic coastline (Dunbar *et al.,* 1985). Terrestrial material is supplied directly by subglacial sedimentation or by ice-rafting or material entrained in iceberg or floating ice-bergs or floating ice tongues. Large variations observed in suspended living carbon indicate that suspended matter collected during January to February was probably influenced by above processes. Furthermore, because of the dependence of both, the terrigenous and biogenic sediment sources on temperature, sunlight, sea-ice conditions and wind regime, major variations were expected in the quantity of living carbon as a result of the sea-ice formation, maintenance and decay processes. Alternatively, the nearby penguin hatchery at Old Lazarev station might have played important role in controlling the concentration of living carbon.

The constituent fractions of POC such as carbohydrates, proteins and lipids also showed variations with time (Table III). These compounds, together constituted a large portion of particulate organic carbon. Relative contribution of these lible compounds to total organic carbon also varied. The concentration of carbohydrates, proteins and lipids ranged from 8 to 176, 22 to 132 and 8 to 209 μg l^{-1} respectively. These values are similar to those reported from polar regions (Jeffrey and Bottino, 1967; Bolter and Dawson, 1982; Harrison *et al.,* 1987).

The concentrations of these compounds were high at the surface and low at 30 m from 28th January to 12th of February (Table III). Overall, on many occasions, there was a decrease in these constituents with depth, at least, between surface and 30 m which could be due to loss during descent by remineralization, ingestion and assimilation of these compounds by aquatic organisms or through dilution by input of resuspended and/or terrestrial particles that are poorer in these compounds.

The relative contribution of these compounds as percentage of organic carbon varied during the period of sampling (Table III). It is known that relative content of carbohydrates, proteins and lipids are affected by nutrient status of the community (Morris, 1981). Thus, nutrient deficient culture of natural population of phytoplankton will show variations in the concentrations of these compounds. This is unlikely because nutrients were abundant and therefore may not be responsible for the variations of these compounds. On the other hand, Hecky et *al.* (1973) found pronounced differences in these compounds for various fresh and brackish water diatoms species. The species composition of phytoplankton varied during the period of observations. Thus, it might be reasonable to attribute the variations to the species composition of phytoplankton during the period of sampling.

Table III. Short-term variation of some biochemical compounds such as particulate carbohydrate (PCHO), protein (PP) and lipid (PL) in the euphotic zone. (All values in μg l^{-1})

Sampling Date	Depth	PCHO		PP		PL	
		a	b	a	b	a	b
January, 1986							
4	Om	122 (±3.04)	29.82	58 (±4.3)	14.0		
	10 m	113 (±8.67)	18.43	77 (±2.64)	12.0	—	
	30 m	156 (±6.06)	27.41	81 (±2.0)	14.23		
8	Om	59 (±4.82)	14.33	78 (±3.5)	18.97		
	10m	49 (±5.13)	10.07	132 (±17.19)	27.02	"	
	30 m	87 (±3.77)	16.44	89 (±4.5)	16.82		'
16	Om	30 (±4.35)	9.82	22 (±1.73)	7.20		"'
	10 m	16 (±2.64)	3.93	38 (±2.78)	9.33	—	
	30 m	8 (±1.8)	1.78	29 (±2.17)	6.48	"	'
21	0m	48 (±1.80)	8.45	76 (±7.56)	13.35	'	~
	10m	24 (±3.04)	5.37	70 (±6.76)	38.03	68 (±4.76)	15.21
	30 m	59	9.67	—	—	54	8.85
24	0m	28 (±6.72)	6.25	29 (±3.0)	6.47	25 (±2.17)	5.58
	10m	10 (±1.0)	1.64	37 (±2.17)	6.07	53 (±3.52)	8.69
	30 m	34 (±2.29)	8.34	29 (±0.76)	7.12	57 (±4.09)	13.98
28	0m	176 (±3.01)	18.80	63 (±2.5)	6.73	112 (±4.03)	11.96
	10 m	30 (±3.40)	4.92	66 (±6.5)	10.82	209 (±3.27)	34.26
	30 m	36 (±6.5)	5.07	43 (±1.80)	6.06	119 (±8.32)	16.76

Table III. (Contd.)

Sampling Date	Depth	PCHO		PP		PL	
		a	b	a	b	a	b
February, 1986							
1	0m	100 (±6.06)	10.46	62 (±3.28)	6.49	32 (±2.29)	3.35
	10 m	90 (±3.90)	12.82	82 (±1.80)	11.68		
	30 m	59 (±5.67)	19.34	42 (±3.2)	13.77		
4	0m	122 (±4.33)	23.97	79 (±4.09)	15.52	33 (±1.80)	6.48
	10 m	74 (±1.80)	14.53			22 (±2.5)	4.32
	30 m	67 (±4.33)	16.46	90 (±3.90)	22.11	30 (±3.12)	7.37
8	0m	148 (±5.79)	29.08	88 (±8.86)	17.29	16 (±2.0)	3.14
	10 m	98 (±6.06)	5.30	55 (±3.46)	2.92	30 (±3.12)	1.62
	30 m	68 (±2.59)	9.28	98 (±5.76)	13.37	56 (±2.54)	7.64
12	Om	155 (±4.27)	24.97	28 (±3.6)	4.51	8 (±2.2)	1.54
	10 m	130 (±8.41)	19.96	58 (±6.56)	8.91	60 (±9.2)	9.21
	30 m	116 (±5.89)	18.38	85 (±10.10)	13.64	28 (±2.78)	4.43

a = μ l^{-1}
b = % of POC

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