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Phytoplankton composition and biomass distribution in the southern Drake Passage, the Bransfield Strait and the adjacent waters of the Weddell Sea in December 1983 — January 1984 (BIOMASS-SIBEX)*

ABSTRACT: Within the SIBEX study area greater concentrations of net-phytoplankton biomass and numbers were found in waters with clearly defined physical characteristics of either Bellingshausen Sea (an area north and west of Anvers Island and northern part of the Bransfield Strait) or Weddell Sea (south eastern entrance to the Bransfield Strait). Low biomass and cell numbers occurred in the southern Drake Passage and in the south central Bransfield Strait, which in the latter case, appears to be a characteristic feature of these waters during the entire phytoplankton growing season. Early summer blooms of *Chaetoceros neglectus* and *C. tortissimum* were mainly responsible for high values of phytoplankton biomass. Some diatoms, such as *C. socialis* were exclusively associated with Weddell Sea water; a replacement of one water type by another in the Bransfield Strait may considerably modify phytoplankton populations which are present there.

Key words: Antarctic, SIBEX, net phytoplankton, distribution

1. Introduction

Previous and recent net-haul phytoplankton studies (Fukase 1964, 1964, Fukase and El-Sayed 1965, Kopczyńska and Ligowski 1982, Witek, Pastuszak and Grelowski 1982) which included the areas of the southern Drake Passage and the Bransfield Strait, provided informations about the horizontal distributions of either phytoplankton biomass (in

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terms of wet or dry weight and cell volumes) or species. The feature in common of these distributions which were studied in all cases during late summer season (end of January, February, March) was the relative poverty of phytoplankton in the Bransfield Strait, especially in its central part, as compared to other localities. These results were corroborated by quantitative phytoplankton biomass estimates in terms of chlorophyll *a* (Fukase and El-Sayed 1965, Uribe 1982, Lipski 1982) which were usually obtained concurrently with net phytoplankton data. Another feature in common of these works was the comparative richness in phytoplankton of the southern Drake Passage (Fukase 1964, Kopczyńska and Ligowski 1982) and the area situated NW of the Anvers Island (Witek, Pastuszak and Grelowski 1982, Kopczyńska and Ligowski 1982).

The purpose of the present work was to evaluate a seasonal change in the phytoplankton biomass and species distribution during early summer (10 Dec. — 8 Jan.) as compared to late summer conditions studied in this area previously.

2. Materials and methods

Net-haul phytoplankton sampling in the southern Drake Passage and the Bransfield Strait was done in the period 10 December — 8 January 1983/1984, every few hours during day and night at previously fixed (Rakusa-Suszczwski and Lipski 1985) geographical positions of SIBEX stations which were the same for all countries participating in the experiment. Additional collections within a fisheries survey were made along transects between Joinville Island, South Orkney Islands and Elephant Island.

Phytoplankton collections were obtained by means of a vertical net-haul from 100 m depth to surface. A Copenhagen type net with a mesh size ca. 60 μm and a 0.1963 m^2 opening mouth area was used for the sampling. Theoretically the net filtered 19.625 m^3 of water. In order to obtain the wet settling volume and dry weight of particulate matter, and also for the estimates of total cell volumes, we have used identical methods of sample treatment and calculations, with those employed by us (Kopczyńska and Ligowski 1982) during the FIBEX phytoplankton study in the same area.

Live samples and fixed with 4% formaline were examined under Zeiss and Biolar PI (Polish made) microscopes at 500x magnification, and at least 300 cells were counted in a water drop of known volume for the purpose of relating the numbers to cells contained in 100 m water column under 1 m^2 sea surface. Duplicate samples were rinsed of salt and mounted in Canadian Balsam or Coumarone for diatom identification.

Annex 1 to the article by E. Kopczyńska, R. Ligowski

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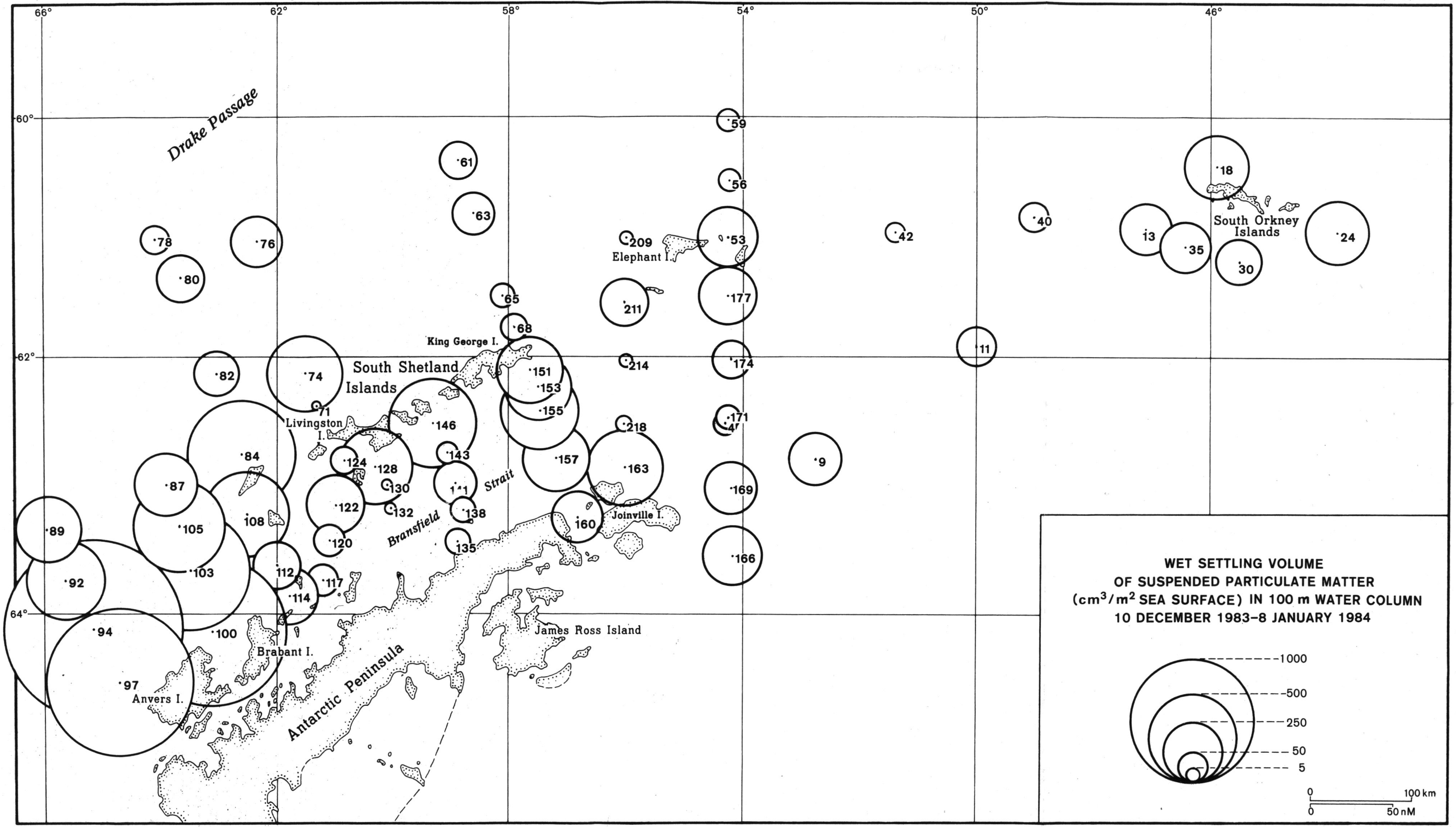

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Fig. 1. Wet settling volume of suspended particulate matter (cm^3/m^2 sea surface) in 100 m water column, 10 December 1983 — 8 January 1984

Annex 2 to the article by E. Kopczyńska, R. Ligowski

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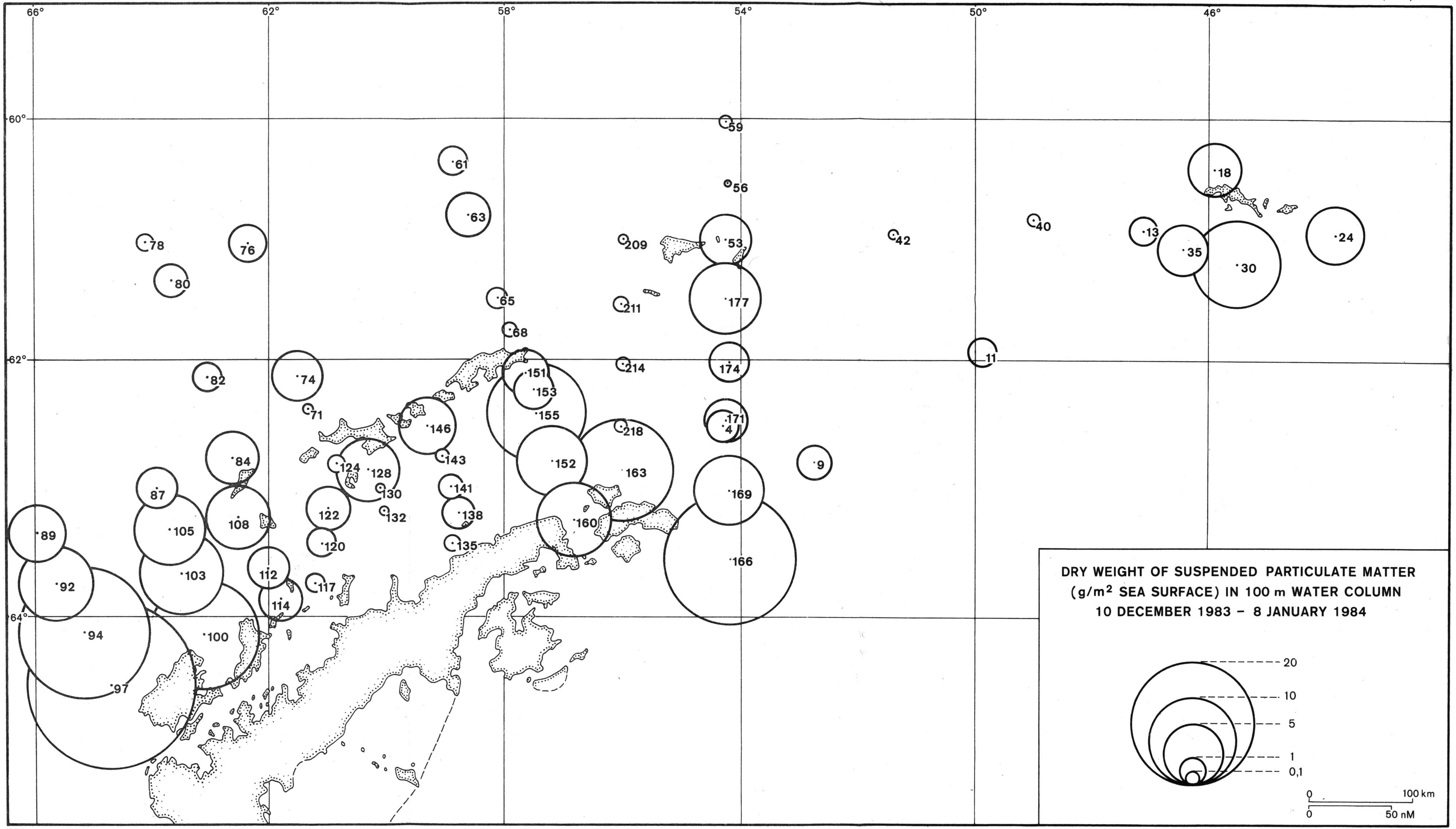

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Fig. 2. Dry weight of suspended particulate matter (g/m^2 sea surface) in 100 m water column, 10 December 1983 — 8 January 1984

Annex 3 to the article by E. Kopczyńska, R. Ligowski
Polish Polar Research 6(1–2) 1985

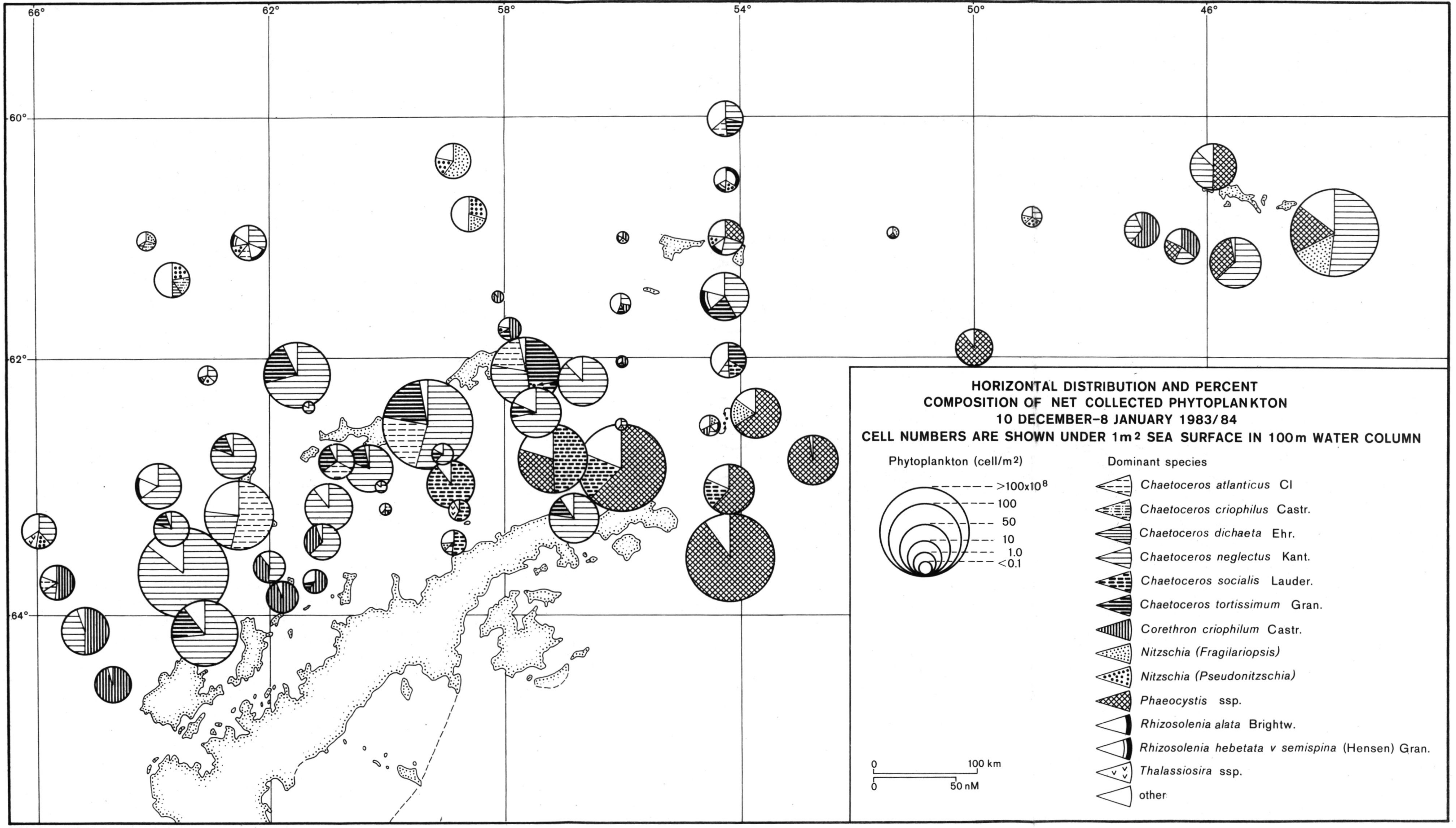

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Fig. 3. Horizontal distribution and percent composition of net-collected phytoplankton, 10 December — 8 January 1983/84. Cell numbers are shown under 1 m^2 sea surface in 100 m water column

Annex 4 to the article by E. Kopczyńska, R. Ligowski

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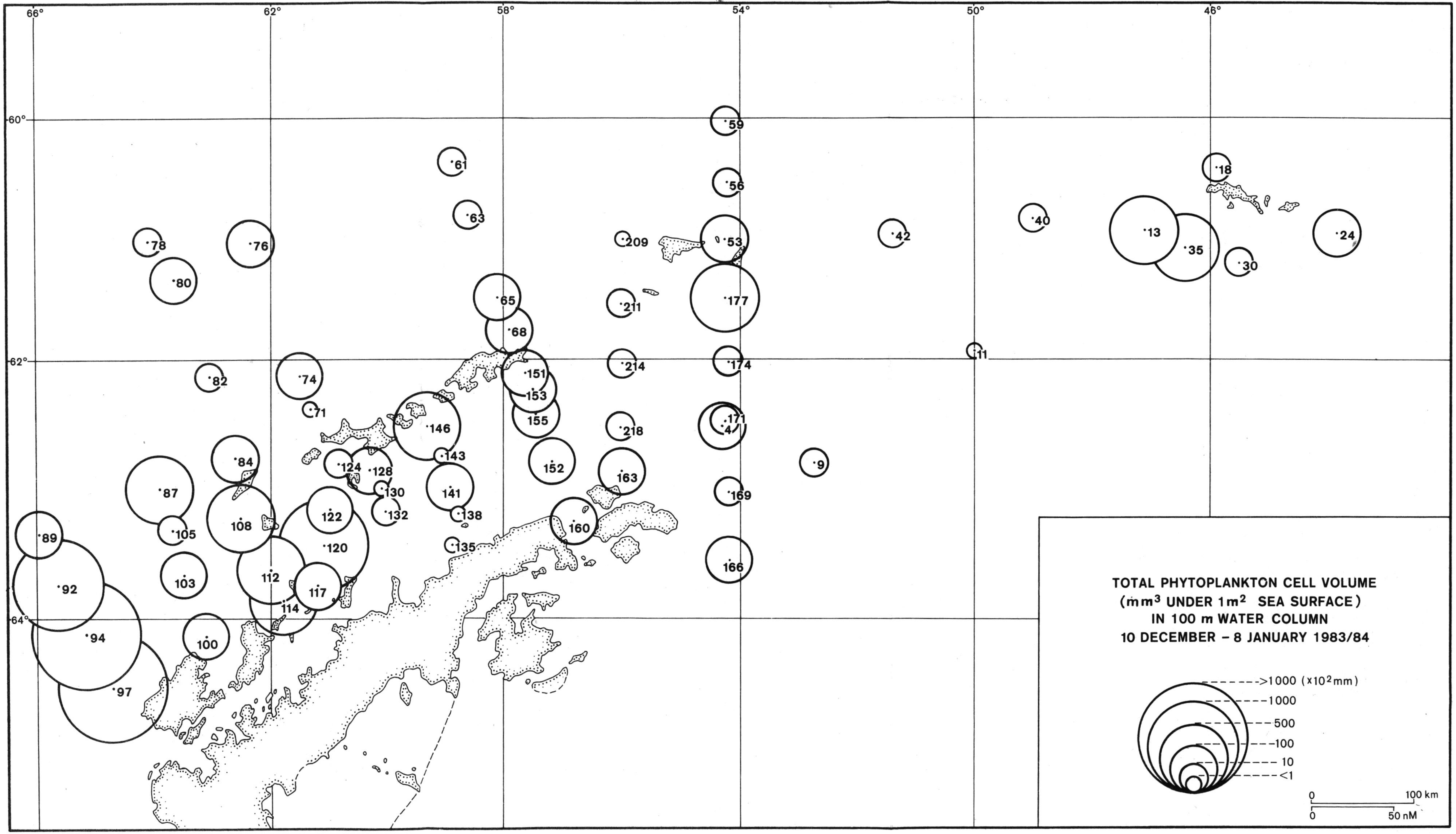

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Fig. 4. Total phytoplankton cell volume (mm³ under 1 m² sea surface) in 100 m water column, 10 December — 8 January 1983/84

3. Results

3.1. Distribution of suspended particulate matter

High values of wet settling volumes (400 to 2100 cm^3/m^2, Fig. 1 and Table I) were found at most of the shallow water stations (190—560 m depth) located west and north of Anwers Island and in the vicinity of islands Smith and Low. Maximum values (1500—2150 cm^3/m^2) occurred within this area at stations 94, 97 and 100. Moderately high values (280—550 cm^3/m^2) were noted in the northern and eastern stations of the Bransfield Strait (e.g. sta 128, 146, 151 to 163), and also at a few isolated stations such as those at South Orkney Islands (sta 18 and 24; $\sim$250 cm^3/m^2), in the Weddell Sea (sta 166, 230 m^3/m^2) and east of Elephant Island (sta 53 and 177; 230—250). Low values of settling volumes, usually 30—150 m^3, were characteristic of the southern Drake Passage and along the triangle Elephant Island — Joinville Island — South Orkneys. Minimum values (10—50 cm^3/m^2) were typical of the south-central Bransfield Strait and of the oceanic part of the Weddell Sea (stations between Joinville and Elephant Islands).

Fig. 2 and Table I show that the horizontal distribution of dry weight was very similar to that of wet settling volumes. High values (7—36 g/m^2) were observed in the vicinity of Anvers Island, in the northern-eastern parts of the Bransfield Strait (4.5—13 g) and also at some stations at South Orkney Islands (3—9.6 g) and in the Weddell Sea (sta 166; 23 g/m^2). Similarly, the minimum values of dry weight (0.1—1.5 g) occurred at stations with the lowest settling volumes in the central part of the Bransfield Strait, in Drake Passage and along the traverses between Joinville, Elephant Island and South Orkney Islands.

Generally, a comparison of phytoplankton data with distribution of water masses (Grelowski and Tokarczyk 1985) showed that highest biomass concentrations in the entire study area were encountered in waters with well defined physical characteristics (of salinity, T, density) typical for either the Bellingshausen Sea (e.g. north west of Anvers Island, southern shores of South Shetland Islands) or the Weddell Sea (south eastern entrance to the Bransfield Strait).

3.2. Phytoplankton cell numbers

Distribution of cell numbers (Fig. 3, Table I) not always, but generally did follow the distribution pattern of particulate matter. Highest numbers of phytoplankton ($1.3 \cdot 10^{10}/m^2$) were observed either at stations dominated by *Phaeocystis* sp. (sta 163 north of Joinville J.), sta 166 in the Weddell Sea, and sta 24 at South Orkney Islands), or by small cells of *Chaetoceros*

Table I.

Net-phytoplankton biomass and cell numbers at SIBEX stations, 10 December 1983 — 8 January 1984

Station No	Depth (m)	Surface water T (°C)	Surface salinity	Wet settling volume (cm^3/m^2)	Dry weight (g/m^2)	Total cell volumes (mm$^3 \cdot 10^2$/ /m^2)	N $\cdot 10^8$ (cells/m^2)
4	376	−0.92	34.49	38	1.4	14.7	0.29
9	2250	−0.80	34.35	180	1.6	2.9	28.69
11	3430	−0.44	34.25	110	1.0	0.5	4.73
13	678	−0.07	34.17	187	1.1	270.0	1.87
18	333	−0.51	33.98	254	3.7	5.9	22.04
24	260	−0.30	34.04	266	4.5	93.0	123.07
30	276	−0.40	34.10	141	9.6	4.9	13.45
35	248	−0.17	34.05	168	3.2	470.0	5.24
40	1150	−0.20	34.43	68	0.1	2.4	0.21
42	1300	−0.35	34.49	27	0.1	1.3	0.03
53	600	0.00	34.38	248	3.5	31.5	7.04
56	3080	0.50	34.16	28	0.03	7.8	0.23
59	3080	0.54	34.07	40	0.2	1.6	1.17
61	3500	0.98	33.89	100	1.0	3.7	2.02
63	3500	0.84	33.86	115	2.8	1.8	1.12
65	718	0.58	34.17	44	0.5	15.4	0.07
68	307	0.63	34.13	36	0.3	72.6	0.52
71	343	0.75	34.18	7	0.1	0.03	0.05
74	2350	0.65	33.97	380	3.3	42.8	52.32
76	3500	0.85	33.93	174	1.7	51.7	3.11
78	3500	1.07	33.90	55	0.4	1.3	0.33
80	3500	0.70	33.88	154	1.6	16.6	3.70
82	3700	0.55	33.91	141	1.3	10.0	0.42
84	418	0.25	33.94	748	4.0	14.7	20.97
87	2570	0.36	33.93	268	2.2	116.2	14.40
89	3160	0.47	33.99	294	4.5	30.8	3.20
92	423	0.57	33.93	406	7.7	597.6	4.20
94	530	0.13	33.95	2153	23.3	1872.0	16.45
97	386	0.31	33.91	1471	37.6	1267.0	9.60
100	560	0.24	33.96	1493	16.5	63.2	85.33
103	389	0.40	34.02	924	9.5	59.2	43.4
105	307	0.65	33.94	540	7.0	6.0	8.60
108	190	0.76	33.95	475	5.7	125.8	67.22
112	283	0.63	33.96	155	2.5	301.0	3.14
114	177	0.73	33.95	218	2.6	400.4	1.82
117	108	1.50	33.87	54	0.5	50.8	0.27
120	581	0.83	33.99	69	1.1	911.0	4.4
122	900	0.78	33.99	240	2.8	21.7	43.40
124	109	1.00	34.15	50	0.4	2.2	1.97
128	837	0.62	34.09	423	4.9	35.5	48.94
130	933	1.00	34.24	8	0.1	0.03	0.06
132	803	0.45	34.30	10	0.1	1.2	0.02

Net-phytoplankton species composition at BIOMASS-SIBEX stations, 10 December 1983 — 8 January 1984

Station No	4	9	11	13	18	24	30	35	40	42	53	56	59	61	63	65	68	71	74	76	78	80		84	87	89	92	94	97	100	103	105	108	112	114	117	120	122	124	128	130	132	135	138	141	143	146	151	153	155	157	160	163	166	169	171	174	177	209	211	214	218
T. gracilis v. *expecta* G. Fryxell et Hasle				M										F	M																																F				C			M			F					
T. lentiginosa (Jan.) G. Fryxell	F				F		F				F		F	M		F						F			F						F	F								F			F	C					F						F			F			F	F
T. oliverana (O' Meara) Makar. et Nikolaev														F							F	F							F											F																						
T. tumida (Jan.) Hasle											F				F		F						F																		F																	F				
Thalassiosira spp.	C	F	F			M			M		M	M	F	F	M		M				F	F	F	F		F			F	F						C			F	F		C	M	C	M	F	F	F		C	M	C	F	F	M	F	C	M				F
Pennales																																																														
Achnanthes sp.		F																																																												F
Amphiprora kjelmanii Cl.											F																																																			
Cocconeis costata Greg.						F																																														F										
Licmophora sp.																						F														M	F															F									F	F
Navicula criophila (Castr.) De Toni			F								F							F																						F																						F
N. glaciei Van Heurck		F									F		M								F																																									
Nitzschia curta (V. Heurck) Hasle		F	M				F			F					M						F	F															F		F																							F
N. cylindrus (Grun.) Hasle	C		M				F	F							F																															M	F							F	F		F					F
N. kergulensis (O' Meara) Hasle		F	F	F			F	F						A	C	F	C			C	C	F	C		F	F							M					F		F									F							C		F			F	C
N. lineata Hasle		F	M	F				F		C	F											F																																				F			F	
N. obliquecostata (V. Heurck) Hasle					F		F			F																																																				
N. pseudonana Hasle													M	F			M								F																																					
N. ritscheri (Hust.) Hasle					F																																			F																						F
N. rhombica (Hust.) Hasle	M		F	F			F	F					F	C								F	F								F									F																			F			
N. separanda (Hust.) Hasle																																								F																					F	
N. sublineata Hasle					F		F	F		F																																										F										F
Nitzschia spp. (Fragilariopsis gr.)	C					C			C								M																										C																			
N. closterium (Ehr.) W. Sm.			F																																																											
N. heimii Manguin			F	F	F	C		F	C	F	M	M	M	C	F			F	F	F	M	C	M	F	M	C		F		M		M				M	F	F		F					F		F	F		F	F	F					M	F	C	M	F	C
N. medioconstricta Hust.																																								F																						
N. prolongatoides Hasle									M										F					F				F				F															F	F														
N. subcurvata Hasle				F																F														F																F												
N. “*turgiduloides* (*lineola*)”	M		F	F	F	F	F		C	F	M	C	C	C	C		C		F	C	C	C	C	F		C		F	F	F		F	F	M		M	F	F	F	F	F	C			F	C	F		F	M			F	F			C	F		C		F
Pleurosigma directum Grun.																						F																														F									F	
Synedra reinboldii V. Heurck														M	C		F																																													
Thalassiothrix antarctica Schimper et Karsten				F		F	F	M		F	F				F	C		F				C			F		F		M		F	F					F	F		F	F					F	F		F			F				F		F	F		F	F
T. longissima Cl. et Grun.					M				M			M		M			M		F	F	F			F		F		F		F			F	F	F	M			M					M						F				F								
Tropidoneis spp.			F	F							F			F								F																														F										F
Gyrodinium spp.																																F		F																												
Prorocentrum spp.									F										F		F																																									
Protoperidinium spp.	F	F				F				F	F														F				F		F	F					F										F					F										F
Distephanus speculum Lemm.		F	F	F			F							F					F	F				F	F		F			F	F	F	F					F		F							F		F									F				
Phaeocystis pouchetii (Hariot) Lagerth.		A	A		A	C	C	C			C													C					F	F	C	C	M					F		F							F				C		A	A	A	A		F				
Flagellates												C	M	F																													F		F	M				F							C			C		

A — abundant > 50%
C — common 5—50%
M — moderate 1—5%
F — few < 1%

Table II.

Net-phytoplankton species composition at BIOMASS-SIBEX stations, 10 December 1983 — 8 January 1984

Station No	4	9	11	13	18	24	30	35	40	42	53	56	59	61	63	65	68	71	74	76	78	80	82	84	87	89	92	94	97	100	103	105	108	112	114	117	120	122	124	128	130	132	135	138	141	143	146	151	153	155	157	160	163	166	169	171	174	177	209	211	214	218
Bacillariophyceae																																																															
Centrales																																							F																						
Asteromphalus hookeri Ehr.			F				F	F															F																	F																			F				
A. hyalinus Karst.																						F									F																														
A. parvulus Karst.																									F		F	F													F																								
Biddulphis aurita (Lyngb.) Brebisson																																											F								F										
B. striata Karst.	M	F	F		F	F	F				F																																							F	F	F	F	F	F			F				F
Chaetoceros atlanticus Cl.	C	F				M	F	F	C			C	F	M				F	C		M	C		M	M	C			F	F	F	A					F	C	F	C						C	C	F			F				F						F
C. atlanticus v. skeleton (Schütt) Hust.																									F																	C																				
C. bulbosus (Ehr.) Heiden																																																													
C. concavicorne Mangin																						F																																			F				F
C. convolutus Castr.															C					M			M																				M	M						F			F	F		M				
C. criophilus Castr.	M	F		M	F		F	M	M	F				F			M	F			C	C	F		F	M											F	F		F	C		F							F		F				F					F	F
C. dichaeta Ehr.	M	F		F	F	F		F		F			M	C	C					M	C	C	M	F		F											F	F									F					F	F	F	F						M		F
C. flexuosus Mangin	M	F	F		M	F					F							F			F			F	F													F															F	F	M	F	F		F				
C. neglectus Karst.	C	F	M	C	C	A	A	C	C	F	C	C	C					A	A	C	C		C	A	A	C	C	A	F	A	A	A	C	A	M	C	A	A	C	A	A	C	C		M	A	A	C	A	A	C	A	M	M	M	M	C	C		C	F	C
C. peruvianus Brightw.				F		F																					F																				F															
C. schimperianus Karst.						F									C				F	M						F	F																																			
C. socialis Lauder																															F												A	A	A		M			C	A		C	F	C	M	C	F				
C. tortissimus Gran.	M					M	F				F		C				C		C						C		M				C	M	C	C	M		C		C	C	C		C	C			C	C	C	C	C	M	C	M	M	M	M	C	C		C		
Chaetoceros spp.												M	C	M	C					M			F										C	F																								M				C		
Charcotia actinochilus (Ehr.) Hust.	F	F	F				F			F																			F	F	F	F						F		F													F						F			F	F
Corethron criophilum Castr.	C	F	F	A	M	M	F	C	M	F		M	M	M	M	A	C	F	M	M	M	C	M	F	C	M	A	A	A	C	F	F	F	C	A	A	C	F	M	F	F	C	C	F	F	M	F	F	F	F	F	F	F	F	F	F	F	F	C	C	C	C
Coscinodiscus bullatus Jan.																																																									F				
C. furcatus Karst.	F	F			F						F																											F		F										F			F	F					F				F
C. inflatus Karst.																																							F		F																		F				F
C. oculoides Karst.	F	F	F	F	F		F	F		F	F					F																																	F			F						F				F	
C. symbolophorus Grun.		F	F							F	F																																												F											F
C. tabularis Grun.		F	F							F	F																																F								F			F						F			F	F
Coscinodiscus spp.						F				F	F																										M																			F			F							
Dactyliosolen antarcticus Castr.		F	F	F	F	F	F								F								F		F	F						F	F					F	F		F	F									F			F										
Eucampia antarctica (Ehr.) Mann	C	F		F	M	F	F	F	M	F	F											F			F	F					F					M		F					F							F	M	M	F	F	M		M	F				F
Leptocylindrus mediteraneus (H. Perg.) Hasle						F			F										F																																F	F														
Melosira sol (Ehr.) Kütz.																																																					F										
Odontella weissflogii (Jan.) Grun.							F																								F																															
Porosira pseudodenticulata (Hust.) Zhuse	F	F	F				F			F	F					F							F										F									F														F						F				F
Rhizosolenia alata Brightw.	C		F	F						F	C					F		C				C			C				F		F	M					M	F		F	F			F					F			F			F			M	C		C	F
R. alata f. gracillima (Cl.) Grun.												C	M		F		M		M	C	M		C	F	F	C	C	F	F	F		F		M	F								C			F	M	F	F										F			C		
R. alata f. indica (Perag.) Osten.		F	F	F	M	F	F				F																											F																F	F	F		F		F		F			F	
R. alata f. inermis (Castr.) Hust.	F					F						M	M		F		F		F	C	F	F	M	F		C	M	F		F		F	M	F		F			M				F		F		F	F		F	F	F			F	F	C			M		
R. hebetata f. *semispina* (Hensen) Gran			F	F	F	F	F	M	M	C	M	C	M	F	F	F	M	F	F	C	M	C	C	F	C	C	M	F		F	F	F	F	F	F		M	F	F	F	F					F	F		F	F							M	C		C	C	F
R. imbricata v. *shrubsolei* (Cl.) Schröder																										M																																			
R. simplex Karst.				F							F	F							M																																				F												
R. styliformis Brightw.										F																																																			
Thalassiosira antarctica Comber	C										F																															C										M									
T. gracilis (Karst.) Hust.		F					F				F																																														F				

135	155	0.32	34.31	36	0.3	0.3	0.55
138	106	0.15	34.52	42	1.4	0.7	0.15
141	630	0.58	34.37	141	0.9	11.0	21.94
143	1500	1.31	34.12	37	0.2	0.5	0.57
146	533	1.30	34.04	550	4.6	160.0	128.13
151	190	1.05	34.15	285	2.8	81.2	54.28
153	2000	1.32	34.04	280	2.1	15.1	30.30
155	1500	1.57	34.28	391	13.0	17.0	34.22
157	221	0.12	34.56	284	6.8	27.9	80.83
160	120	−0.63	34.55	176	7.6	19.4	27.09
163	316	−0.15	34.63	394	13.4	21.4	112.38
166	258	0.16	34.44	228	23.0	11.2	112.09
169	244	−0.56	34.55	187	6.3	7.6	39.38
171	430	−0.42	34.48	41	2.3	5.4	10.26
174	578	−0.06	34.44	95	2.3	6.2	5.19
177	448	0.34	34.30	228	7.1	301.0	17.50
209	590	0.82	34.01	10	0.1	0.7	0.01
211	388	0.81	34.15	34	0.4	6.0	0.13
214	2200	1.25	34.23	14	0.2	9.0	0.06
218	310	0.04	34.52	20	0.2	2.9	0.9

neglectus and *C. tortissimum* (e.g. sta 146, 151 in the northern Branfield Strait; sta 103 north of Anvers Island). Moderately high numbers, often one order of magnitude lower (3 to $8 \cdot 10^9$) than the maxima, were also found at some stations (128, 155, 153) in the northern and eastern Bransfield Strait following the distribution of the moderately high values of particulate matter. These quantities were also mainly due to the small species of *Chaetoceros* including *C. socialis*. Other moderately high counts were observed north of the Anvers Island and included mostly either *Chaetoceros* species (sta 100, 108) or the large *Corethron criophilum* (sta 94). Generally low numbers (0.05 to $3 \times 10^8 m^2$) were typical of the southern Drake Passage (below 60°S), of several stations in the vicinity of Elephant Island, mainly along two transects parallel to 54 W meridian and of the south central Bransfield Strait. In the Drake Passage they were due to a low abundance of *Nitzschia* and *Rhizosolenia* species. Some of the minimum counts (0.01 to 0.9 $10^8/m^2$) occurred between Joinville and Elephant Islands (sta 214), north of King George (sta 65) and in the central part of the Bransfield Straitc (sta 130, 132).

3.3. Phytoplankton cell volumes

As expected the highest values of algal biomass expressed as total cell volumes (1000 mm^3/m^2) were found (Fig. 4) at stations with greatest concentrations of the large size *Corethron criophilum*. These waters in the western part of the Bransfield Strait and west of Anvers Island had about twice as high values of total cell volumes as the waters with maximum numbers of *Chaetoceros* spp. The same values were also about one order of magnitude greater than those at stations dominated by *Phaeocystis.*

3.4. Species composition

Table II shows the relative abundance and horizontal distribution of phytoplankton species identified during this study. Percent compositions of dominant species are presented in Fig. 3.

Except for about seven stations in the southeast part of the Bransfield Strait and in the Weddell Sea, which contained mainly *Phaeocystis* (51—98%), all remaining stations were dominated by diatoms (68—100%).. The characteristic feature of the diatom assemblages in almost entire SIBEX area was a preponderance of small (< 10 μm) *Chaetoceros* spp. Thus *Chaetoceros neglectus* (diam. 5—9.5 μm] was present at most stations and was abundant at about 20 of them (50—90%) in the vicinity of Anvers Island and in the western and northern Bransfield Strait. It was usually, except in the South Orkney Islands area, accompanied by *C. tortissimum* (forming 10—45% of cells at sixteen stations). Sometimes, as in the northern Bransfield Strait (sta 146) the species was associated with *C. atlanticus* (5—53%). Another small species, *C. socialis* (diam. 8—9 μm) was abundant (49—90%) at several stations in the south-eastern Bransfield Strait, often those which contained also higher than usually numbers of *Thalassiosira* spp. (sta 138, 174) and *Phaeocystis* sp. Many thick — wall endospores of *C. socialis* were observed at stations 160 and 163 indicating that it is a meroplanktonic species.

Corethron criophilum was present in all except one sample (sta 53) but occurred in a great abundance only west of Anvers Island (sta 92, 94, 97; 50—98%). High concentrations were also found in the western part of the Bransfield Strait. Much lower quantities were present north-east of King George and west of South Orkney Islands. Its bloom in the neighbourhood of the Anvers Island may have been related to the inflow of Bellingshausen Sea water bringing ice-melt waters along with algae liberated from ice. On previous sampling ocassions this species had been found to be typical of the Bransfield Strait (Hart 1934, 1942, Hendey 1937, Kopczyńska 1980, Kopczyńska and Ligowski 1982).

A few species of *Rhizosolenia*, chiefly *R. alata* and its variations, as well as *Nitzschia* spp. (*Pseudonitzschia* and *Fragilariopsis*) were characteristic of the Drake Passage and the vicinity of Elephant Island. Their quantities were generally low. The same diatoms were present in only conspicuously small numbers (forming < 1%) in the Bransfield Strait.

Thalassiosira spp. were only found in higher numbers in the south-east part of the Bransfield Strait (sta 155 to 163) and on a traverse parallel to 54°W meridian. They contributed 4 to 10% to the algae in these waters.

4. Discussion

Considering all the drawbacks involved in net-phytoplankton sampling the present data should mainly be treated, like in the case of our previous FIBEX results (Kopczyńska and Ligowski 1982) as a picture of the relative horizontal distribution of the larger size algae retained by the net (Fig. 3, Table II). The estimates of algal biomass in terms of wet and dry weight can be compared not only with our own FIBEX results but also with data of other researchers, who have employed the same as ours (Witek, Pastuszak and Grelowski 1982) or similar methods of measurement (Fukase 1964, Fukase and El-Sayed 1965).

Table III summarizes our present and FIBEX data (Kopczyńska and Ligowski 1982) revealing an almost entirely reversed distribution of phytoplankton biomass during early summer (10 December 1983—8 January 1984) to that in late summer (14 February-14 March 1981). Particularly significant seasonal change has been noted in the Bransfield Strait, where the values of phytoplankton biomass during SIBEX were one to two orders of magnitude greater than during FIBEX. It must be remembered, however, that the present high values were only found in the northern, eastern and western „boarder" stations, while the central and southern part of the Bransfield Strait showed a poverty of algae much the same as the entire strait when investigated during FIBEX. Low net phytoplankton biomass values in the central Bransfield Strait have been observed also on other occassions in late summers of 1978/1979 (Witek, Pastuszak and Grelowski 1982) and in 1963 (Fukase 1964). Similarly, low phytoplankton biomass values in terms of chlorophyll *a* (ca. 0.5 mg/m^3) have been found in the Bransfield Strait by Fukase and El-Sayed (1965), Uribe (1982) during the Chilean FIBEX investigations in January-February 1981, by Lipski (1982) in February-March 1981, and by the latter author during the present Polish SIBEX stage (personal cummunication). Both studies of Lipski were concurrent to ours during FIBEX and SIBEX. A German unpublished report (Gieskes, Beese and Elbrächter) on SIBEX results from the period October-November 1983 also gave low chlorophyll *a* values (0.3 to 0.5 mg/m^3) from the Bransfield Strait, but at this time of the year they were quite comparable to those in Drake Passage NW of Elephant Island. It also turns out that the poverty of algae in the central Bransfield Strait occurs not only regardless of the advance in the phytoplankton growing season, but also irrispective of the concurrent presence of large krill concentrations (as during the Chilean and Polish stages of FIBEX) or absence of krill or other zooplankters (as during Polish SIBEX). This is easily seen when the data are compared with appropriate krill biomass reports (for FIBEX:

Lillo and Guzman 1982, Kalinowski 1982; for SIBEX: Kalinowski, Godlewska and Klusek 1985, Witek et al. 1985).

The question how to explain the characteristic phytoplankton poverty in the central Bransfield Strait may probably be best answered by considering the complex circulation of waters which has been documented for this area (Clowes 1934; BIOMASS Rep. Ser. 30, 1982; Stein and Rakusa-Suszczewski 1984). Excessive turbulance and low stabilities in this region of interaction of different water types of the Bellingshausen and Weddell Seas origin (BIOMASS Rep. Ser. 30, 1982, Grelowski and Tokarczyk 1985) are the likely major factors preventing greater development of phytoplankton. The possible influence of low water stability on hindering phytoplankton growth had been discussed in the past by various investigators (Sverdrup 1953, Hasle 1956, El-Sayed 1978, Kopczyńska 1980, 1981).

Table III.

Comparison of average values of suspended particulate matter, cell volumes and cell counts during SIBEX (10 Dec. 1983 — 8 Jan. 1984) and FIBEX (14 Feb. — 14 March 1981)

Area	Period	No of samples	Wet volume (cm^3/m^2)	Dry weight (g/m^2)	Total cell volumes (mm^3/m^2)	$N \cdot 10^8$ cells ($cells/m^2$)
Drake Passage	SIBEX	12	185	1.60	2890	8.25
	FIBEX	29	288	5.31	7617	22.42
North-West of Anvers I.	SIBEX	7	1040	15.16	55654	23.94*)
	FIBEX	5	351	7.14	6623	118.42**)
Bransfield Strait	SIBEX	21	206	3.50	10495	29.44
	FIBEX	26	45	0.40	240	0.34
Weddell Sea	SIBEX sta 4—59	13	135	2.31	6973	16.00
	SIBEX sta 166—218	109	102	4.70	3888	20.60**)

*) — dominant *Corethron criophilum*
**) — dominant *Phaeocystis* spp.

A different explanation should be given for the relatively low phytoplankton abundance in the Drake Passage (Table III). Only 12 stations were sampled during the present study as compared to 29 during FIBEX, nevertheless, the algal biomass and numbers were at least one half to one order of magnitude lower than during FIBEX. Apparently the surface temperatures (0.36 to 1.07°C) noted presently during early summer (10 December-8 January) were too low for the species of *Nitzschia* (*Pseudo-*

nitzschia and *Fragilariopsis*), *Chaetoceros atlanticus* and *C. dichaeta* to reach a greater abundance of the kind observed by us during FIBEX when the temperatures were higher (+1.0 to +4.0°C). On the other hand, *Rhizosolenia* spp. were among dominant diatoms now, while they were scarce in Feb-March during FIBEX. In other oceanic areas, such as the one along transect between Africa and Antarctica, *Rhizosolenia* spp. and *Nitzschia* spp. *(Pseudonitzschia* and *Fragilariopsis*) were found prevalent in late summer (March) net collections both from the sub-Antarctic and Antarctic zones (Kopczyńska, Weber and El-Sayed in print), thus they flourished in waters with a considerable range of surface temperatures — 1.4 to +17.6°C). In the same study it was concluded that the *Pseudonitzschia* species were the most characteristic diatoms of the warmer sub-Antarctic regions.

The phytoplankton standing crop in the Drake Passage may have been partly decimated by salpa which was present there, as in several other localities (Witek et al. 1985), in particularly large quantities. However, very low concentrations of pheopigments found during the investigation (Lipski — personal communic.) suggest, that there was not a significant exertion of zooplankton grazing pressure.

Excluding the low phytoplankton biomass areas, an early summer algal bloom was evident in all waters, particularly in the northern and eastern parts of the Bransfield Strait, in the region of Anvers Island and to a lesser degree south of the South Orkney Islands. This prolific phytoplankton growth was mainly due to *Chaetoceros neglectus* and *C. tortissimum*, which were, especially the former species, virtually present in the entire study area, but reached the highest concentrations in shallow near-shore waters, although some of the stations close to islands were situated in deep waters (sta 155: 1500 m, sta 153: 2000 m; 87: 2570 m; 74: 2350 m). Early summer (Dec.-Jan.) blooms of *C. neglectus* have been reported from extensive open oceanic areas in the sub-Antarctic zone of the Eastern Pacific (Hasle 1969) and from the Indian Ocean sector of the Antarctic zone (Steyeart 1973). However, records of this species, and of *C. tortissimum* which accompanied it, from the present study area, have been mainly made in neritic waters (Hendey 1937, Macchiavello 1972, Kopczyńska and Ligowski 1982). Based on the available data on these species from the Bransfield Strait and the southern Drake Passage, we think that in the season 1983/1984 they must have developed sometime between 20 November and 10 December since they were not recorded as conspicuous in the plankton in the preceeding study period beginning with 15 October (unpublished German SIBEX report of Elbrächlter and Neuhaus). If the development cycle of these species is similar from year to year, it follows, that after a peak in mid December to mid January when they flourish in neritic and oceanic waters (present data), they decline in numbers and become gradually confined to shallow waters by the end of January (FIBEX study, Uribe, 1982) where they can still be found in rather smaller quantities at the end of February and in March (Kopczyńska and Ligowski 1982). During the next winter months, both species are probably present in the plankton in more or less unditectable numbers and form resting spores capable of wintering over. This latter supposition is partly based on the fact that they were not observed among more conspicuous species by Priddle (in Heywood 1984), who sampled the areas off Elephant Island, South Georgia and the Weddell-Scotia sea confluence in the period 27 July -29 September 1983.

High phytoplankton biomass and numbers in the south-eastern stations at the entrence to the Bransfield Strait and in the waters north-east off Joinville. I were caused, first of all, by concentrations of *Phaeocystis* sp. and *Chaetoceros socialis*. The species were confined to waters of low temperatures and high salinities (Table I) characteristic of the Weddell Sea. It is of interest that *C. socialis* and *Thalassiosira tumida* (the latter species present now in smaller numbers) had been noted exclusively in the same locality and same water type in January-February 1981 by Uribe (1982). Evidently the presence of some diatom species in the Bransfield Strait can be closely linked to waters of the Weddell Sea origin, which follows that an inflow of different water types (having different characteristics of salinity, T, density etc.) into the Bransfield Strait, may considerably modify the algal populations which might be present there. In other words, a seasonal succession of species in such an area as the Bransfield Strait will be dependent on the water types which flow into it and the kind of phytoplankton species they happen to bring along.

The values of particulate matter and total cell volumes north and west of Anvers Island (Table III) were one order of magnitude greater than during FIBEX, although at that time this area was also found rich in phytoplankton due to an abundance of *Phaeocystis* sp. At the present survey it was mainly (besides *C. neglectus*) *Corethron criophilum* which was responsible for the high algal biomass. This diatom in the vicinity of the Anvers Island was observed in waters characterized by lowered salinity and by temperatures typical of the Bellingshausen Sea (Grelowski and Tokarczyk 1985). The lowered salinity values suggest that its growth may have been enhanced by the seeding with cells liberated from melting ice. A similar phenomenon had been previously noted by one of us (Kopczyńska 1980) when *Corethron criophilum* was one of the major plankton diatoms following the breaking of winter ice in Ezcurra Inlet, at King George Island.

5. Conclusions

1. A seasonal change was evident in the kinds of dominant species and the size of phytoplankton biomass in the Bransfield Strait and the southern Drake Passage during early summer studies (10 December-8 January

1983/1984) as compared to late summer conditions (14 February-14 March 1981).

2. Greater algal biomass concentrations were encountered in waters with clearly defined physical characteristics (T, salinity, density) typical for either Bellingshausen Sea (e.g. north-west of Anvers Island) or Weddell Sea (south-eastern entrance to the Bransfield Strait). Thus a greater "stability" (in terms of the acting of all abiotic and biotic factors) attained by such water masses, compared to regions of meeting of different water types (e.g. Bransfield Strait) has evidently provided the necessary conditions for more prolific algal growth.

3. The relative poverty of phytoplankton in the central Bransfield Strait appears to be a characteristic feature of these waters during the entire phytoplankton growing season, and most likely it is related to physical factors, such as the complex water circulation, excessive turbulence and low stability, and not to krill or salpa grazing.

4. *Chaetoceros neglectus* and *C. tortissimum* were chiefly responsible for an early summer phytoplankton bloom in all waters, especially south of 62°S latitude. If their growth cycle is similar from year to year, than we assume that they multiply at the end of November or in early December, reach a peak in mid December-January, gradually decline in numbers and become confined to near shore waters in February and March; they overwinter as resting spores and are present in plankton in undetectable numbers.

5. The occurence of some diatoms in the Bransfield Strait such as *C. socialis* has been found to be exclusively associated with a water type of the Weddell Sea origin; thus a replacement of one water type in the Strait by another will considerably modify the phytoplankton populations which might be observed there.

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6. Резюме

Пробы сетного фитопланктона отбирались с палубы нис „Профессор Седлецки" в исследовательском районе программы БИОМАСС-СИБЭКС (в каждой части пролива Дрейка и в проливе Брансфилда) в период с 10 декабря 1983 до 8 января 1984 года. Самые большие концентрации биомассы фитопланктона и самые большие численности клеток (таблица I, рис. 1—4) были установлены в водах, физические параметры которых (Т, соленость, плотность) сходны с параметрами вод моря Беллингсгаузена (район на запад от острова Анверс и северная часть пролива Брансфилда) или же моря Уедделля (юго-восточный вх од в пролив Брансфилда). Небольшие значения биомассы и численности фитопланктона были установлены в южной части пролива Дрейка и в юго-центральной части пролива Брансфилда. В случае пролива Дрейка это явление кажется типичным для всего вегетационного периода. Высокие значения биомассы фитопланктона (для мокрого объема 400—2150 см³/м² и для сухой массы 3—36 г/м²) были вызваны главным образом цветением двух видов диатомовых водорослей *Chaetoceros neglectus* и *C. tortissimum*) (таблица II, рис. 3). Присутствие некоторых диатомовых водорослей таких как напр. *C. socialis* связано только с водами моря Уедделля: обмен разных типов вод в проливе Брансфилда может вызывать значительные изменения видового состава фитопланктона в этом районе.

7. Streszczenie

Próby fitoplanktonu sieciowego pobrane zostały ze statku "Profesor Siedlecki" w rejonie badawczym BIOMASS-SIBEX w południowej części Cieśniny Drake"a i w Cieśninie Bransfielda Uzyskano je w okresie od 10 grudnia do 8 stycznia 1983/1984. Największe koncentracje biomasy fitoplanktonu i największe liczebności komórek znalezione zostały (tabela I, rys. 1—4) w wodach charakteryzujących się fizycznymi parametrami (T, zasolenie, gęstość) typowymi albo dla Morza Bellingshausena (rejon na zachód od wyspy Anvers i północna część Cieśniny Bransfielda) albo dla Morza Weddella (południowo-wschodnie wejście do Cieśniny Bransfielda). Małe wartości biomasy i liczebności fitoplanktonu znalezione zostały w południowej części Cieśniny Drake'a i w południowo-centralnej części Cieśniny Bransfielda. W przypadku Cieśniny Bransfielda zjawisko to wydaje się być typowe dla całego okresu wegetatywnego. Duże wartości biomasy fitoplanktonu (dla mokrej objętości 400 do 2150 cm³/m² i dla suchej masy 3 do 36 g/m²) spowodowane były głównie wiosennym zakwitem dwóch gatunków okrzemek *Chaetoceros neglectus* i *C. tortissimum* (tabela II, rys 3). Występowanie niektórych okrzemek, takich jak np. *C. socialis* związane było wyłącznie z wodami Morza Weddella: wymiana różnych typów wód w Cieśninie Bransfielda może powodować znaczne zmiany w składzie gatunkowym fitoplanktonu tego rejonu.

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