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Periodicity and composition of summer phytoplankton in Ezcurra Inlet, Admiralty Bay, King George Island, South Shetland Islands *)

ABSTRACT: In the austral summer of 1977/78 phytoplankton populations in Ezcurra Inlet, Admiralty Bay, reached maximum abundance at the end of February; two smaller peaks of growth occurred in January. Flagellates and "monads" were dominant in the plankton, except two days in December, when diatoms were prevalent. *Thalassiosira antarctica* and a few species of the genera *Nitzschia* and *Chaetoceros* were the major diatoms during the summer. Several other diatoms, *Corethron criophilum*, *Eucampia balaustium*, and *Rhizosolenia* spp. together with the all-summer dominants, contributed to the diatom peak in December, following the breaking of ice. Algal peaks always followed periods of calm days and stable atmospheric pressure; the increased stability of the water column at such times appears to be the factor determining the onset of the periods of phytoplankton maxima. Decline of algal peaks could be largely attributed to grazing by *Euphausia superba* and *E. crystallorophias*.

Key words: Antarctic, phytoplankton, periodicity

1. Introduction

First observations on the seasonal variation of Antarctic phytoplankton were made by Hart (1934, 1942). On the basis of samples obtained over many years from vast areas of the Southern Ocean, Hart was able to demonstrate seasonal progression of maximum phytoplankton production with increasing latitude. He thought that hydrographic conditions such as ice duration, surface water stability and currents, could affect both the onset of the period of phytoplankton maximum and the magnitude of algal peaks. Hasle (1969) examined phytoplankton collections from the Pacific

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region of the Southern Ocean and found that her results were consistent with Hart's observations in terms of the southwards displacement of diatom and dinoflagellates peaks with the progression of summer, and also with regard to the role of local hydrographic conditions in influencing phytoplankton abundance and spatial distribution. Also Steyaert (1974) explained the differences in timing of phytoplankton maxima during two summer seasons in the Atlantic region, between Cape Town and Breid Bay, by changes in hydrographic conditions. The same workers and others (Kozlova 1966, Fryxell and Hasle 1972, Fryxell, Villareal and Hoban 1979) gave interesting comments on the seasonal distribution of some major diatoms in Antarctic waters.

There appears to be no record of any study on the periodicity of Antarctic phytoplankton observed in one locality, at short time intervals, during the entire summer growing season. The objective of the present study was to gain information about the summer succession of major phytoplankton groups and species in Ezcurra Inlet, Admiralty Bay, South Shetland Islands (62°09′S, 58°28′W). The purpose was been also to relate the summer variations of algae to the more significant environmental factors likely to affect phytoplankton growth.

2. Materials and methods

Phytoplankton samples were collected in the central part of Ezcurra Inlet, Admiralty Bay, during 30 days in the period between 20-th December 1977 and 10-th March 1978. Location of the sampling station is shown by Kopczyńska (1980) and good description of the study site is given by Rakusa-Suszczewski (1980). Samples were taken by Nansen bottles from eight depths between surface and bottom. During ten days, in the period 27 January to 18 February, 1978 additional eight samples were obtained on each date at 1 m interval between surface and 10 m depth. This material was used for an analysis of the small-scale vertical distribution of planktonic algae in Ezcurra Inlet (Kopczyńska 1980). Treatment of samples for the whole summer period is described in the same paper.

The oceanography observations made at the same time, published by Dera (1979) and unpublished (Bojanowski, Lauer and Woźniak) include data on currents, light, temperature, salinity, O_2 and phytoplankton nutrients. Meteorology and hydrography observations are summerized in an unpublished report of Palke, Kowalewski and Lauer. To facilitate comparison between these measurements and phytoplankton results some of the physical data are cited here in Table I.

3. Results

3.1. Phytoplankton abundances and periodicity

The results of the quantitative phytoplankton analysis are shown in Figures 1 to 4 and in Tables II and III. The maximum phytoplankton

Table I.

Basic meteorology and hydrographic observations for Ezcurra Inlet, Admiralty Bay, summer 1977/1978 *)

	Date	Wind speed (m·s⁻¹)	Atmospheric pressure (mb)	Surface water temperature (°C)	Wave height (m)	Surface salinity (‰)
December	20	08	1001.9	0.2	0.5	33.88
	21	09	994.2	0.2	0.5	33.86
	26	0.3	973.4	0.5	0.0	33.82
	28	00	1000.3	0.7	0.0	33.87
	30	14	998.9	0.5	1.0	33.92
January	2	07	992.1	0.6	0.5	33.88
	4	05	983.4	0.6	0.0	33.75
	6	12	987.4	0.8	0.5	33.91
	15	06	973.5	0.6	0.0	33.94
	16	02	971.8	0.7	0.0	—**)
	17	00	971.8	1.3	0.0	33.74
	18	04	980.6	1.1	0.0	33.80
	19	04	990.0	1.1	0.0	33.81
	20	08	999.5	1.0	0.0	—
	21	08	1001.8	1.2	0.5	33.78
	24	05	991.6	1.0	0.5	33.80
	25	08	992.6	1.0	0.5	—
	27	07	991.1	1.0	0.5	33.82
	28	01	992.1	1.1	0.0	—
	29	02	996.3	1.3	0.0	33.89
	30	04	994.9	1.3	0.0	33.80
February	2	09/15	1006.7	1.1	0.5	33.82
	4	09/15	992.2	1.0	0.5	—
	7	12	982.2	1.4	0.5	33.81
	8	22/30	975.2	1.0	1.5	33.98
	10	09/17	986.5	0.8	0.5	33.86
	12	15/22	984.6	0.8	1.0	—
	13	18/22	994.0	0.8	1.5	—
	14	00	984.6	0.9	0.0	33.85
	16	06	1012.9	0.8	0.0	33.79
	18	12/17	1001.1	0.8	1.0	33.83
	20	12/17	993.8	0.9	1.0	—
	21	0.5	995.1	1.0	0.0	33.82
	22	04	986.2	0.9	0.0	33.81
	23	02	986.2	1.2	0.0	—
	24	03	972.4	1.0	0.5	33.76
	25	06	985.2	0.8	0.0	33.71
	28	07	995.8	0.8	0.5	33.81
March	1	06/11	1007.0	1.2	0.5	—
	3	03	1017.4	0.5	0.0	—
	4	11	1013.2	0.9	0.5	33.64
	7	13 16	998.7	0.8	1.0	33.83
	10	15/21	982.0	0.8	1.0	33.73

*) Pahlke, Kowalewski and Lauer, unpublished data

**) no data

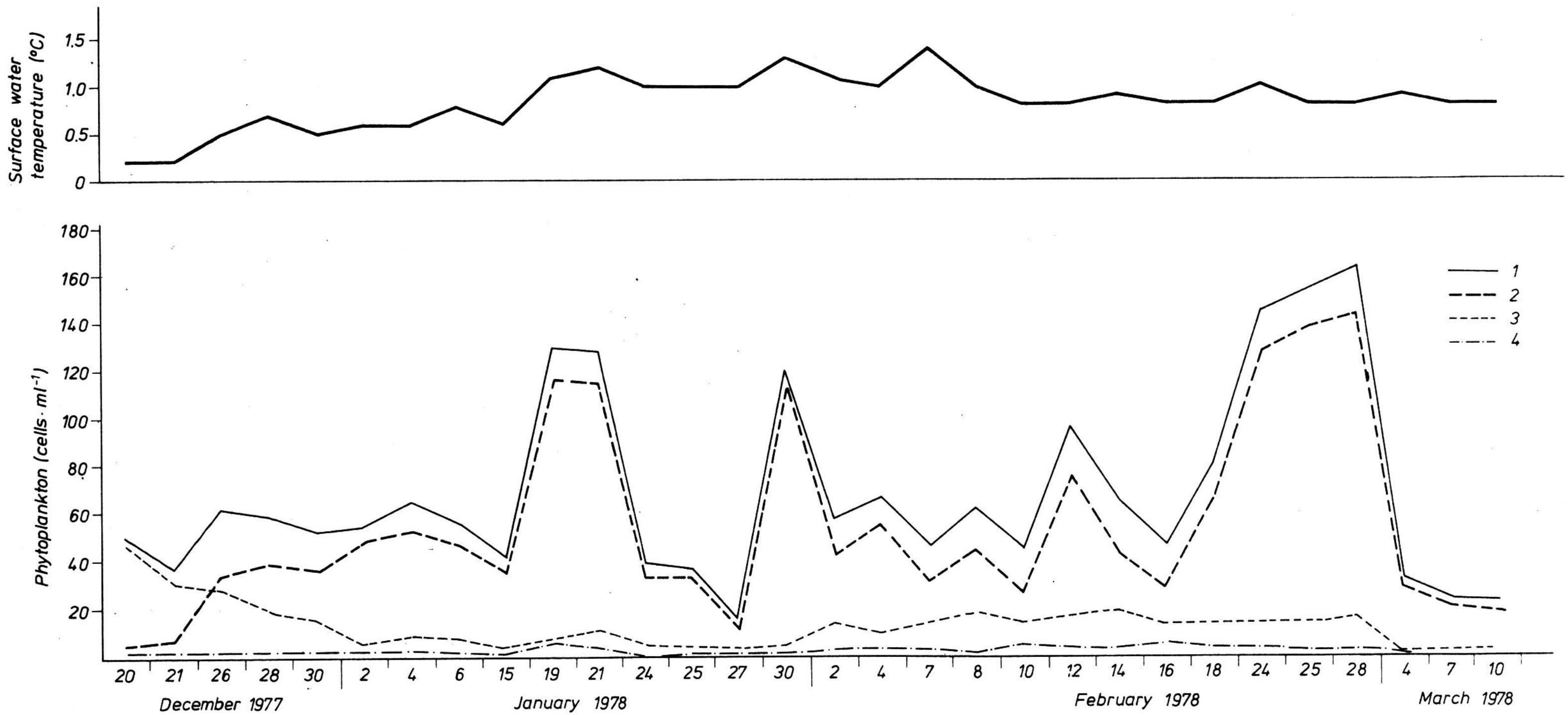

Fig. 1. Summer variations in the average cell numbers of total phytoplankton (1), flagellates and monads (2), diatoms (3) and dinoflagellates (4)
Averages are for the water column

standing stock (Fig. 1) was reached at the end of February with the highest cell concentration of 291.5·ml^{-1} at 5m (Table II). Two smaller peaks of average numbers occurred during the second half of January (max. 254.0 cells·ml^{-1} at 5 m), and on the last day of the same month (max. 1,600.0 cells·ml^{-1} at 30 m). On most sampling days average cell concentrations in the water column were less than 70·ml^{-1}. The summer standing stock was dominated by tiny flagellates and monads, 4—17 μm in diameter, which in majority of the samples made up more than 75% of the total phytoplankton and were the principal group contributing to the three algal peaks (90%). The only time when diatoms were prevalent

Table II.

Phytoplankton abundance in Ezcurra Inlet; maximum numbers of cells·ml^{-1} (n)

Date	Total algae		Diatoms		Dinoflagellates		Flagellates and monads	
	d_{max}	n	d_{max}	n	d_{max}	n	d_{max}	n
Dec. 20	50	143.0	50	139.0	10	2.2	50	4.0
Dec. 21	15	175.0	15	149.0	1	2.5	15	26.0
Dec. 26	20	84.0	15	35.5	15	0.7	20	54.0
Dec. 28	10	103.0	20	23.0	10	1.5	10	84.5
Dec. 30	10	93.5	10	29.5	10	1.0	10	63.0
Jan. 2	20	99.7	5	10.8	50	0.5	20	95.8
Jan. 4	20	146.5	20	27.2	20	4.7	20	114.5
Jan. 6	20	93.5	10	12.5	20	2.3	20	79.7
Jan. 15	50	60.8	50	8.0	50	7.3	5	54.7
Jan. 19	5	254.0	10	10.2	5	17.2	5	231.5
Jan. 21	10	198.0	10	16.5	20	5.3	10	180.5
Jan. 24	20	92.0	1	10.8	20	1.3	20	86.8
Jan. 25	1	55.5	1	3.5	15	3.7	1	51.5
Jan. 27	6	56.3	6	5.5	5	5.0	6	50.8
Jan. 30	30	1,600.0	4	7.4	10	2.4	30	1,587.0
Feb. 2	5	216.5	3	29.5	1	8.8	5	196.0
Feb. 4	5	215.0	1	17.0	3	2.7	5	191.0
Feb. 7	5	116.8	5	37.0	7	4.5	5	79.0
Feb. 8	10	110.0	10	32.5	5	0.4	10	77.0
Feb. 10	30	104.8	15	42.3	50	10.0	30	83.6
Feb. 12	10	146.8	10	36.0	10	4.0	20	126.0
Feb. 14	3	175.5	7	57.5	6	6.5	3	144.3
Feb. 16	5	104.6	15	29.3	4	12.3	5	81.8
Feb. 18	15	191.6	1	28.0	10	8.0	15	168.3
Feb. 24	10	225.0	15	23.2	10	8.1	10	209.7
Feb. 25	5	291.5	10	20.1	10	4.5	5	285.7
Feb. 28	10	210.5	30	24.4	30	6.9	10	187.0
Mar. 4	20	65.6	20	2.2	20	3.7	20	59.7
Mar. 7	50	56.1	50	5.1	20	1.5	50	50.7
Mar. 10	10	36.0	10	4.2	10	1.8	10	30.0

d_{max} — depth in meters where the maximum count was found

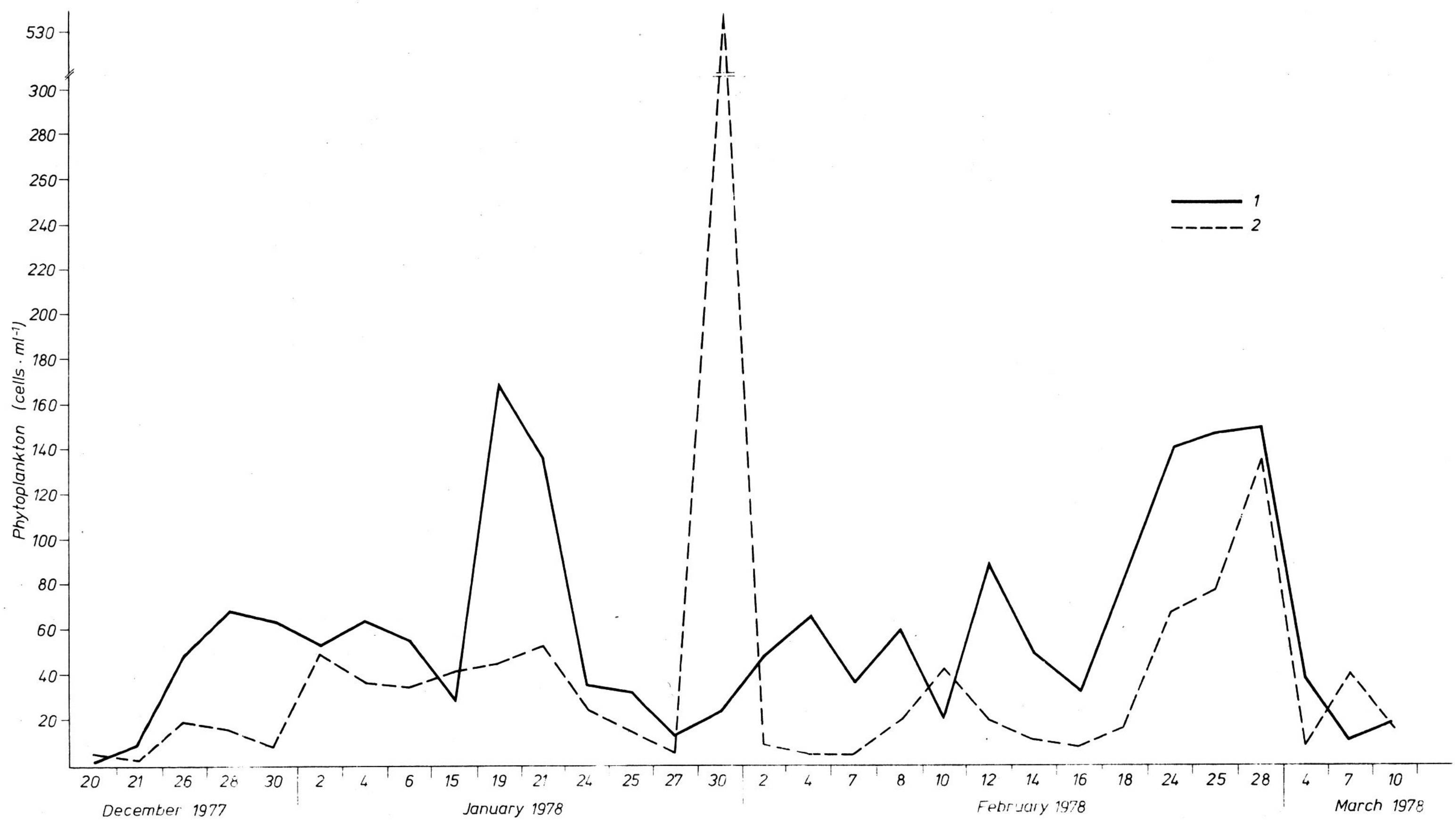

Fig. 2. Average numbers of total phytoplankton in 1—20 m layer (1) and 30—60 m layer (2)

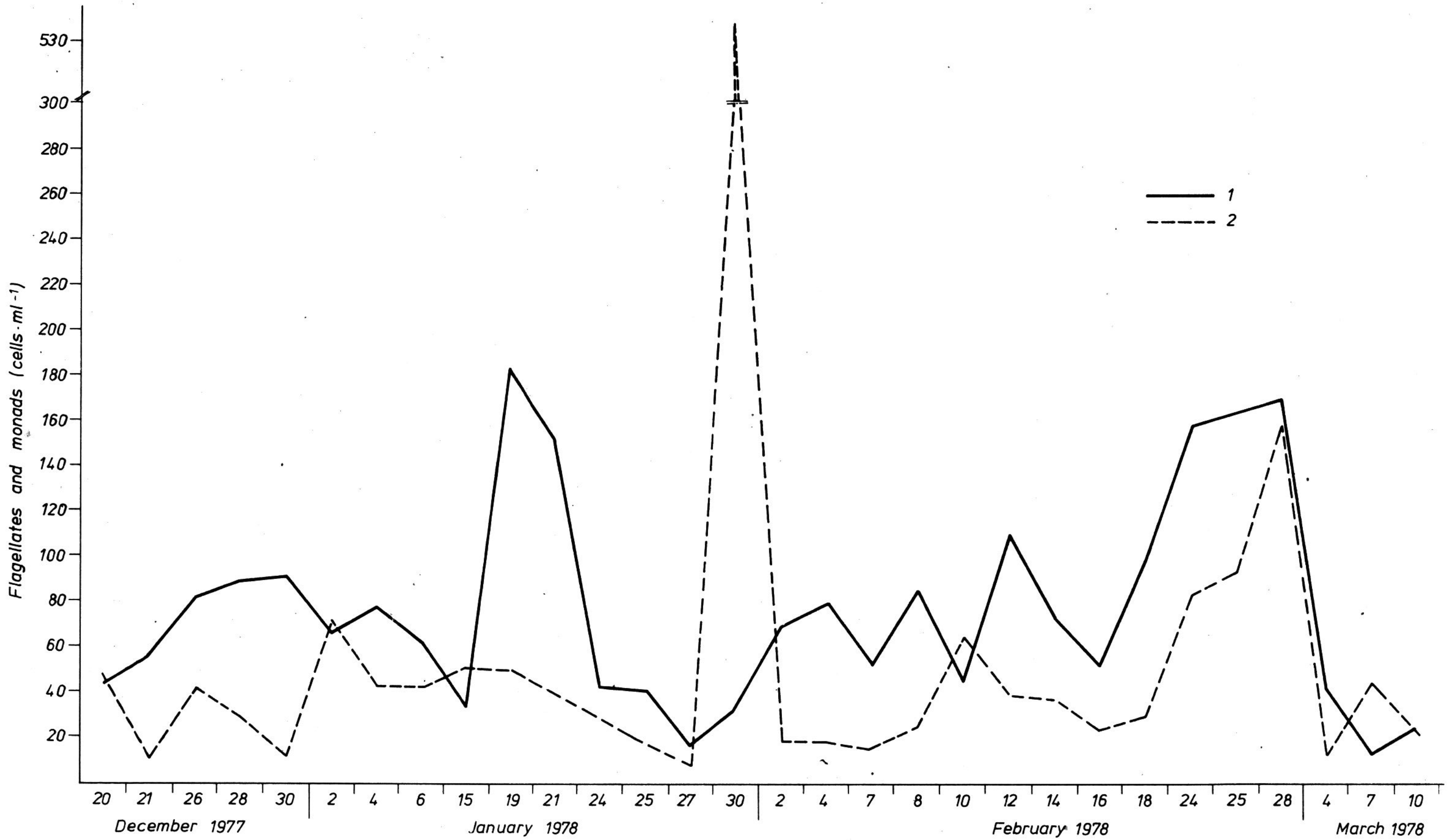

Fig. 3. Average concentrations of flagellates and monads in 1—20 m layer (1) and in 30—60 m layer (2)

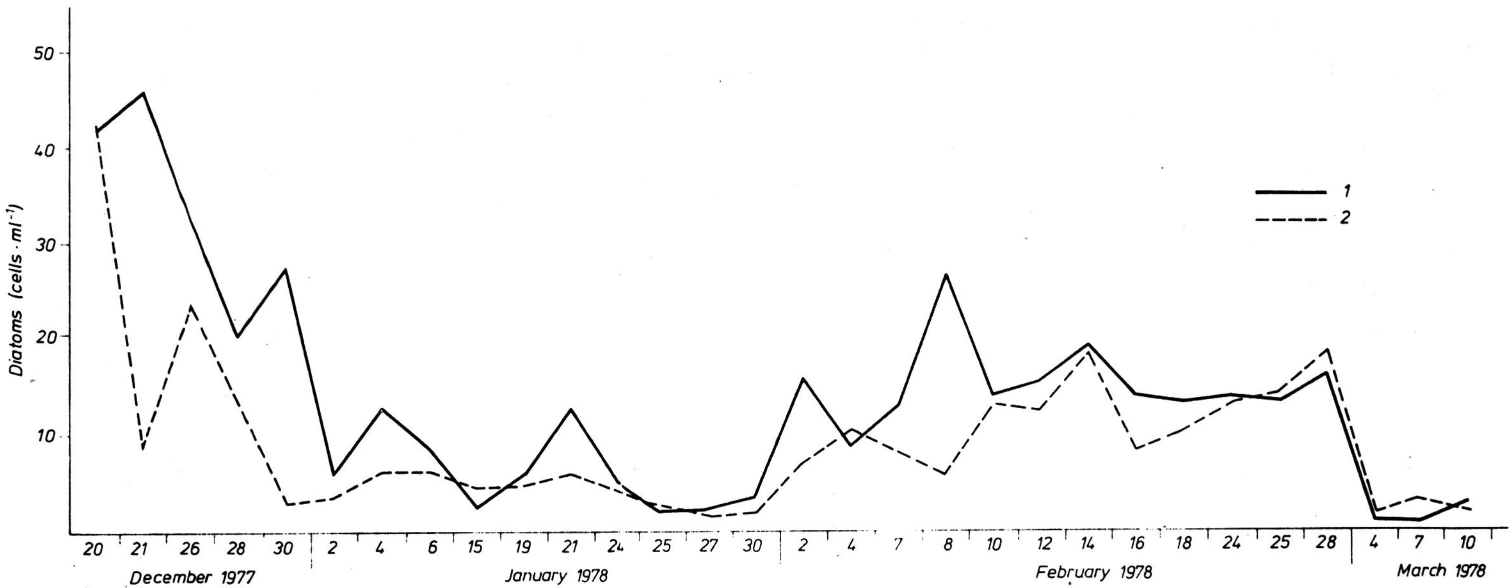

Fig. 4. Average concentrations of diatoms in 1—20 m layer (1) and in 30—60 m layer (2)

(60—100%) were the two first sampling days in December. Maximal concentrations of diatoms found on these dates were 149.0 and 139.0 cells·ml^{-1} at 15 and 50 m, respectively. The average quantities of diatoms during the rest of the summer were less than 10 cells·ml^{-1} in January, less than 20 cells·ml^{-1} in February, and no more than 3 cells·ml^{-1} in March. The representatives of the other algal groups, such as *Dinophyceae, Silicoflagellatae* and *Haptophyta*, were always present in very small numbers with the highest concentration of 17.2 cells·ml^{-1} reached by dinoflagellates at 5 m on 19 January.

3.2. Vertical distribution

During 24 of 30 sampling days, maximal algal cell numbers occurred within the upper 1—20 m layer (Table II). This refers to all three phytoplankton groups, however, the highest count of flagellates (1,587.0 cells·m^{-1}) and next to the highest count of diatoms (139.0 cells·ml^{-1}) were found at 30 and 50 m, respectively.

During about half of the sampling period, the average quantities of total phytoplankton (Fig. 2) were twice as large in the surface 20 m layer than in the 30—60 m layer below. On the remaining days, except one in January, the vertical distribution of cells was strikingly uniform (e.g. 20 December, first days of January, end of February and March). Only on 30-th January were the concentrations in the lower water stratum exceedingly greater than above.

The distribution of flagellates and monads (Fig. 3), which composed the predominent group of phytoplankton, did not essentially differ from the total algae vertical distribution.

Only during five days of the summer, diatoms (Fig. 4) occurred in visibly greater concentrations in the upper (1—20 m) layer. At other times, they were uniformly distributed from surface to 60—70 m depth at the bottom. A detailed examination of samples collected at 1-m intervals during the period 27 January — 18 February (Kopczyńska 1980), showed much variation in the vertical distribution patterns of dominant diatoms with an apparent preference for the upper 1—20 m layer. The same study revealed that total phytoplankton vertical distribution was characterized by small peaks of numbers (ca. 100 cells·ml^{-1}) within the upper 1—10 m layer and occasional peaks at the lower level of the euphotic zone, at 15—30 m.

3.3. Phytoplankton composition and species fluctuations

A total of 96 taxa were recorded in this study. They are listed in Table III along with their seasonal distribution and degree of abundance. In terms of the numbers of species, diatoms were the dominant group. Among 86 diatom species identified, only several, representatives of various genera, accounted for the highest cell concentrations in December and

February. The peak in December was equally due to a few large-size diatoms, such as *Corethron criophilum* Castr., *Rhizosolenia truncata* Karst., *Eucampia balaustium* Castr., as well as to a few small species, such as *Thalassiosira antarctica* Comber, *Chaetoceros neglectus* Karst., a small form of *C. criophilum* Castr. and *C. dichaeta* Ehr. A few diatoms of the genus *Nitzschia*, group *Fragilariopsis*, such as *N. kerguelensis* (O'Meara) Hasle, *N. cyclindrus* (Grun.) Hasle, and *N. curta* (Van Heurck) Hasle and the representatives of the *Pseudonitzschia* group, such as *N. lineola* Cl. and *N. prolongatoides* Hasle, also contributed to the December bloom. The same *Nitzschia* species together with *T. antarctica*, *C. neglectus* and *C. sociale* Lauder, contributed alone to the diatom increase in February. In contrast to most diatoms, the February dominants except for *C. sociale* were present in the samples throughout the summer period, with the numbers fluctuating from a peak in December to a low in January, and another small increase of growth in February. Among diatoms, *Thalassiosira antarctica* was the most important numerically species which, except in December, contributed at least 50% to the diatom cell numbers throughout the entire sampling period.

The dominant in the plankton unarmed flagellates became unrecognisable in the preserved samples, and no identifications of these organisms could have been made, even to the generic level. Two prevalent flagellates have been tentatively called *Chlamydomonas* spp. *Dinoflagellates* also became disintegrated and were difficult to identify. In the counts, the nannoplankton flagellates and monads were divided into three size categories (Table III). While the flagellates increased rapidly in numbers in December to dominate through the rest of the summer, the tiny 4—6 μm monads appeared suddenly in the scene in January to disappear as suddenly in March.

4. Discussion

The peak abundance of diatoms in December occurred a few days following the brak-up of ice in Ezcurra Inlet, and apparently was mainly due to the liberation of ice associated algae. Although no ice samples were examined in this study, prolific growth of algae on, in and under sea ice has been well documented (Bunt 1963, 1964, 1966, Bunt and Wood 1963, Rakusa-Suszczewski 1972). The blooming of phytoplankton in the Antarctic following the melting of ice, has been observed in the past by Hart (1934, 1942), Walsh (1969), Hasle (1969), Steyaert (1973) and others. *Corethron criophilum*, one of the major species forming the peak here, although considered essentially planktonic and cosmopolitan (Fryxell and Hasle 1972), has been reported growing in pack ice by Hart (1942), and was found to be the dominant species of those released from ice in the Indian Ocean region of the Antarctic (Fukushima and Meguro 1966). Some of the other diatom species which have contributed to the bloom in December, such as *Eucampia balaustium*, *Thalassiosira antarctica* and several species of *Nitzschia* (= *Fragilariopsis*), have been reported growing in an ice foot community at Signy Island in the South Orkney Islands

Table III.

Phytoplankton species found in Ezcurra Inlet during the austral summer 1977/1978

	December 1977					January 1978										February 1978												March 1978		
	20	21	26	28	30	2	4	6	15	19	21	24	25	27	30	2	4	7	8	10	12	14	16	18	24	25	28	4	7	10
Bacillariophyceae																														
Centrales																														
Actinocyclus subtilis (Greg.) Ralfs	1*)	1						1						1	1	1	1	1	1	1	1	1	1							
Asteromphalus hookeri Ehr.																				1										
Biddulphia aurita (Lyngb.) Brébisson																				1										
B. anthropomorpha V. Heurck						1	1									1	1				2*)			1						
B. striata Karst.	1	1					1		1		2		1				1					1	1							
Chaetoceros atlanticus Cl.	1	1																1	1		1	1								
C. chunii Karst.																		1		1	1	1		1						
C. criophilum Castr.	5*)	5	2	2	1	1								1			1			1		1	1							
C. dichaeta Ehr.	5	5	2	2	1										2	1		1		1	1			1						
C. neglectus Karst.	4*)	4	2	1		1		1				1		2	2	2	2	3*)	3	5	4	4	4	4	4	3	3	1		
C. sociale Lauder	2	1	1											1	2	1	1	3	3	4	4	4	4	4	4	3	3			
C. tortissimum Gran.	2	2															1	1		1	1		1		1					
Chaetoceros spp.	2	2	1	1	1		1			1		1		1			1			1	1	1								1
Charcotia actinochilus (Ehr.) Hust.	1																													
C. australis (Karst.) M. Peragallo																				1										
C. bifrons (Castr.) M. Peragallo	1																			1										
Corethron criophilum Castr.	5	5	5	5	4	2	2	2		1	1	1			1	1		1	1	1	1	1	2	2	1	1	2	1		
Coscinodiscus bouvet Karst.	1	1	1	1		1	1	1									2						1	1	1	1				
C. inflatus Karst.																					1		1	1						
C. lineatus Ehr.													1									1					1			
C. oculoides Karst.			1																	1							1			
C. oculusiridis Ehr.	1																					1								
C. radiatus Ehr.			1				1						1								1									
C. tumidus Janish																		2	1	1	1	2	1							
Coscinodiscus ssp.	3	3	2	1	1	1	2		1				1	1		1			1			1		2	2		1			1
Coscinosira antarctica Kozlova																					1	1								
Dactyliosolen antarcticus Castr.																					1									
Eucampia balaustium Castr.	4	4	3	3		1	1	1							1		1	1			1					2	1			
Melosira sol (Ehr.) Kütz.						1														1		1								
Melosira sp.																					1	1								
Podosira hormoides (Mont.) Kütz.	1																													
Rhizosolenia alata Brightw. *f. gracillima* (Cl.) Grun.	1	1				2	1	1					1			1				1	1	1								
R. alata Brightw. *f. innermis* (Castr.) Hust.	1	1		1		2	1							1	1	1				1	1									
R. hebetata Bailey *f. semispina* (Hensen) Gran	4	3				1	1	1	1		1	1			1	1				1	1	1	1	2	1	1	1			
R. styliformis Brightw.							1																							
R. truncata Karst.	5	3	1	1		1	1	1	1						1					1	1	1			1	1				
Rhizosolenia spp.	2	2	1			1	1	1	1	1	1	1	1	1	1	1							1		1				1	
Thallassiosira antarctica Comber	5	5	5	5	5	4	4	4	3	4	4	4	2	2	3	4	4	5	4	4	4	5	4	4	4	4	4	2	2	2
T. delicatula Hust.	1	1		1												1		1	1	1			1	1						
T. gracilis (Karst.) Hust.																	1	1				1								
T. perpusilla Kozlova																		1						1						
T. polychorda (Gran.) Pr. Lavr.	1	1	1															1					1							
T. ritscheri (Hust.) Hasle	1	1		1		1	1	1								1			1	1	1		1							
Thalassiosira spp.	2	2	2		2	2	2	2	1	2	2	2	2	2	1	1	2	2	2	2	2	3	3	3	3	3	3	1	1	1
Pennales																														
Achnanthes kerguelensis Castr.															1	1	1	1		1	1	1		1						
Achnanthes sp.																1							1							
Amphiprora kjelmanii Cl.										1				1	1	1	1	1		1	1	1	1		1		1			
Amphora sp.															1	1						1		1						
Cocconeis curiosa Hust.																					1									
C. imperatrix A. Schm.	1	1	1	1		1	1	1	1	1					1	1	1		1	1	1	1	2			1	1			
Cocconeis sp.																		1		1	1	1	1	1						
Gomphonema charcotti Peragallo				1																			1							
Gyrosigma spp.																					1		1	1			1			
Licmophora gracilis (Ehr.) Grun.	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	2	1	1	1	1	1	2	1			1		1	
Navicula criophila (Castr.) De Toni	1																													
N. directa var. incus (A. S.) Cl.	1							1			1														1					
N. glaciei Van Heurck							1	1			1			1		2	2			1		2	2	2						
N. imperfecta Cl. *var. antarctica* Heiden et Kolbe																									1					
Navicula spp.	1		1					1	1	1			1		1	1	1	1			1						1		1	
Nitzschia angulata Hasle	2	2	1	2	1	2	1		1	1	1			1					1	2	1	1	1							
N. curta (Van Heurck) Hasle	4	3	3	3	3	1	2	2	1	1	2	1	1	2	2	2	2	2	2	2	3	3	2	2	2	2	1			
N. cylindrus (Grun.) Hasle	4	3	3	3	2	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	2	2	1	1	1	1	1	1		
N. kerguelensis (O'Meara) Hasle	6*	5	5	4	4	4	3	3	2	1	4	1	1	2	2	2	3	2	2	3	3	3	4	2	2	1	2	1	1	
N. lineata Hasle	1	1	1	1	2											1	1						1							
N. obliquencostata (Van Heurck) Hasle	1	1	1	2	1	1					1			1					1	1	1	2	1	1						
N. ritscheri (Hust.) Hasle																		1		1			1							
N. sublineata Hasle	2	2	1	1	1		1							1	1	1				1	1									
N. vanheurckii (M. Per.) Hasle	1														1	1														
N. closterium (Ehr.) W. Sm.	1	1	1	1									1			1	1	1				1		1						
N. heimii Manguin	3	3	1		2	1	2	2	1	3	1		1	1	1	2	2	3	3	3	3	4	3	4	2	2	1		1	
N. lineola Cl.	4	1	1	1			1				1		1	1	1	1	2	2	2	2	2	2	2	2	2	2	1			
N. longissima (Bréb.) Ralfs	1	1		1													1	1												
N. medioconstricta Hust.	1																						1							
N. neglecta Hust.																					1									
N. prolongatoides Hasle	3	3	3	1	2	1	2	2	2	2	2	2	2	2	1	2	3	3	3	3	3	4	3	3	2	2	3	1	1	1
N. turgidula Hust.	4	1	3	1	2		2	2		2	2	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1			
N. turgiduloides Hasle	1	1	1										1		1	1		1		1	1	1	1		1		1			
Nitzschia spp.	2	2	3			1	2		1	1	1	1	1			1	1	1	1	1	2	1	1	2	2		1			
Pleurosigma sp.									1	1						1		1		1	1	1			1	1				
Synedra reinboldii Van Heurck	2	1	1	1		1	1	1	1				1			1	1	1	1	1	1	1	1				1			
Synedra sp.	1	1																			1									
Thalassionema elegans Hust.																				1	1									
Thalassiothrix antarctica Schimper et Karsten																				1	1	1	1							
T. longissima Cl. et Grun.									1				1							1		1								
Tropidoneis antarctica (Grun.) Cleve	1	1												1	1	1	1	1	1	1			1		1		1			
Dinophyceae																														
Gonyaulax spp.			1	1	1	1	2	1	2	3	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	1	2	1	1	1
Dinophysis spp.	2	2					1	1		1	1		1	1		1		1		1	1	1	1	1	1		1			
Oxytoxum criophilum? Balech			1		1		1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	
Peridinium spp.	1		1	1	1		1	2	1	1	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	2	1	2	1
Silicoflagellatae																														
Dictyocha speculum Lemm.						1											1			1			1	1	1	1				
Haptophyta																														
Paeocystis antarctica Karsten	1	1					2								1										1					
Flagellates and monads																														
flagellates (6—17 μm)	3	3	6	6	6	6	6	6	6	6	6	6	6	6	3	5	5	5	5	5	5	5	5	5	6	6	6	6	6	4
monads (4—6 μm)										3		3	1	3	6	6	6	6	6	6	6	6	6	6	6	5	5			1
monads (10—17 μm)	3		1	1			1		1	3		2	2	2	2	2	3	3	1	2	2	3	1	1						

*) 1 present; ≤1 cell · ml⁻¹

*) 2 common; >1 cell · ml⁻¹

*) 3 very common; >5 cells · ml⁻¹

*) 4 abundant; >10 cells · ml⁻¹

*) 5 very abundant; >20 cells · ml⁻¹

*) 6 dominant; >50 cells · ml⁻¹

Marks 3 to 6 refer to the highest abundance in at least two samples during one day.

(Richardson and Whitaker 1979). *Nitzschia curta* (Van Heurck) Hasle and *N. sublineata* Hasle, have been found to colonise a variety of sea ice habitats (Whitaker 1977). Stayeart (1974) considered *N. curta* as a species released from ice and able to grow in open waters, and Hasle (1965) found it together with *N. cylindrus* under the surface of pack ice.

The diatom populations here were composed of cosmopolitan species (i.e. *Corethron criophilum, Chaetoceros dichaeta, Rhizosolenia alata* Brigtw.) and species endemic to the Southern Ocean (*Synedra reinboldii* Van Heurck, *Nitzschia turgiduloides* Hasle, most of the *Fragilariopsis* forms). There appears to be a growing evidence now, that most, if not all the species in the Antarctic, are capable of growth on ice, and in the plankton.

There might be at least three reasons for the rapid decline of diatoms, and particularly the large-size species at the end of December. Firstly, the decrease may have been hastened by grazing of *Euphausia superba* Dana found to be present at that time in Ezcurra Inlet (Węgleńska and Chojnacki, unpublished data). Other zooplankters, mostly very small *Calanoida*, although found then in a peak abundance, would not have been able to feed on the large diatoms (Węgleńska, personal communication). Secondly, the large species, liberated from melting ice may have been mechanically damaged on release, which in turn could influence their settling rates. Finally, the rapid diatom decline coincided with a rapid increase of flagellates (Fig. 1). This suggests that diatoms may not have been able to compete with flagellates for some, possibly rate of growth limiting, essential micronutrients. Macronutrients-silicates, phosphates and nitrates were always present in high concentrations (Bojanowski, unpublished data) and were not likely to limit algal growth.

Like diatoms, the flagellates could have been also released from melting ice (see But 1960). An increase in day length in December and thus increase in illumination combined with warming of surface waters were the most likely factors to initiate an outburst of their growth.

Comparison of Figure 1 with Table I shows that all three peaks of flagellates and monads, and of phytoplankton as a whole, followed periods of calm days and of stable atmospheric pressure. The increased stability of the surface waters during calm days, seems to be the major factor determining the onset of the periods of maximal algal growth in Ezcurra Inlet. Small cell numbers, on the other hand, were generally associated with periods of stormy weather, as between the 2-nd and 20-th February (Table I, Fig. 1). In the past, greater phytoplankton abundance has been related to the increased stability of the water column which aids in retaining algal cells in the optimal light zone (Hasle 1956, El-Sayed and Mandelli 1965, El-Sayed 1978).

It is of interest also, that the increase in cell numbers to a maximum standing crop in February, coincided with an increase of phosphate concentrations from a summer average of about 1.90 $\mu gat \cdot l^{-1}$ (Bojanowski, unpublished data) to more than 2.00 on 16 February and values are ranging between 2.61 and 4.13 $\mu gat \cdot l^{-1}$ on 24 February. It is possible, that high phosphate concentrations stimulate the rates of growth of flagellates at low Antarctic temperatures, and are increasing their ability to utilise other nutrients at a faster rate. This could be tasted in laboratory experiments on the kinetics of nutrients uptake similar to those performed for different oceanic species (Thomas and Dodson 1968, Eppley and Thomas 1969).

The decline of flagellates and monads numbers, following their peak of abundance in February, may have been largely due to grazing by *Euphausia crystallorophias* Holt et Tattersall which was found by Kittel (1980) to comprise 70% of a 700 individuals krill sample obtained on 7 March. This small species of krill and juvenile forms of *E. superba* were also abundant at the end of January following the first peak of algae.

The present observations on the vertical phytoplankton distributions are in agreement with the findings of Hart (1942) and Hasle (1969) who reported frequent occurrence of phytoplankton maxima in the 1—10 m surface layer. Analysis of the small-scale vertical distribution of algae in Ezcurra Inlet (Kopczyńska 1980) led to the conclusion that light, water movements, and density micro-gradients were controlling the vertical distribution of algae.

Phytoplankton cell concentrations found in this study are comparable to small cell numbers reported by Hasle (1969) from stations located along the Graham Land during the Norwegian Brategg Expedition. This author also found that the same stations, and particularly one in the Bransfield Strait, were dominated by flagellates and monads which showed peak abundance in the second half of February. Similarly small cell numbers were found by Kozlova (1970) in the open oceanic waters of the Indian and Pacific sectors of the Southern Ocean. Kopczyńska (1980) discussed physical characteristics of Ezcurra Inlet and stated that high turbidity, shallowness of the euphotic zone, and general instability of the surface waters were most likely factors influencing phytoplankton numerical abundances in the study area.

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5. Summary

Summer phytoplankton populations in Ezcurra Inlet, Admiralty Bay, South Shetland Islands were dominated by nannoplankton flagellates and monads (75—90%), and reached a maximum standing crop at the end of February (Fig. 1). Two smaller peaks of growth occurred in the second half of January. Maximal cell concentrations of the total algae ranged between 36 and 1600 cells·ml^{-1} (Table II). Diatoms were always present in small quantities, but showed peak numbers (max. 149 cells·ml^{-1}) in December following the breaking of ice; this was the only time, when diatoms, many of them probably released from ice, were prevalent in the plankton. Among 86 diatom taxa recorded (Table III), only a few species, *Thalassiosira antarctica* and representatives of the genera *Chaetoceros* and *Nitzschia*, sections *Fragilariopsis* and *Pseudonitzschia*, were dominant within the group in the summer. Their numbers fluctuated showing seasonal variations. A few other diatoms (e.g. *Corethron criophilum*, *Eucampia balaustium*, *Rhizosolenia truncata*) contributed to the diatom peak in December, but became unimportant numerically within the group later in the season. Peaks of total phytoplankton were always found to follow periods of calm days and stable atmospheric

pressure (Fig. 1, Table I); the increased stability of the surface waters during calm days appears to be the major factor determining the timing of the periods of maximal phytoplankton growth. Decline of total phytoplankton numbers following their peaks in January and February, and also the decline of diatoms at the end of December, could be largely attributed to grazing by *Euphausia superba* and *E. crystallorophias*. Other possible causes of diatom decline and flagellates dominance in the plankton and a later decline, are discussed.

6. Резюме

В фитопланктоне фиорда Эзкурра (Залив Адмиралты, Южные Шетланды) в летнем сезоне преобладали наннопланктоонные жгутиковые и „монады" (75—90%). Максимум фитопланктона констатировано под конец фенраля: два меньшие расцветы выступили во второй половине января (рис. 1). Максимальные концентрации водорослей выступали в пределах от 36 до 1600 клеток·мл$^{-1}$ (таблица II). Диатомеи всегда выступали в небольших количествах, достигая самого, большого количества (149 клеток·мл$^{-1}$) в декабре после перелома льдов. Это был единственный период, когда диатомеи в большинстве освобождены от льда становили преобладающую группу фитопланктона. Среди 86 видов диатомей (таблица III) летом преобладающими формами были *Thalassiosira antarctica* и виды родов *Chaetoceros* и *Nitzschia* из групп *Fragilariopsis* и *Pseudonitzschia*. Концепции преобладающих видов диатомей были переменчивы указывая сезонные перемены. Несколько других видов (i.e. *Corethron criophilum*, *Eucampia balaustium*, *Rhizosolenia truncata*) стало причиной расцвета этой группы в декабре,· чтобы скоро дать место главным доминантам в следующих неделях. Максима фитопланктона выступали всегда после безветренных дней и постоянного атмосферического давления (рис. 1, таблица I). Увеличена стабильность поверхностных вод во время тишины является вероятно главным фактором детерминирующим выступление фитопланктона во время максимальных расцветов. Понижение количества водорослей, после максимальных расцветов в январе и феврале, а также понижение количества диатомей в конце декабря мог быть в большой мере вызван консумпцией крыля (*Euphausia superba* и *E. crystallorophias*). Обсуждаются также другие возможные причины понижения количества диатомей и жгутиковых после периодов максимального расцвета, а также возможные причины преобладания жгутиковых в фитопланктоне.

7. Streszczenie

Fitoplankton we Fiordzie Ezcurra (Zatoka Admiralicji, Południowe Szetlandy) w sezonie letnim zdominowany był przez nannoplanktonowe wiciowce i „monady" (75—90%). Maximum fitoplanktonu stwierdzono pod koniec lutego; dwa mniejsze zakwity wystąpiły w drugiej połowie stycznia (rys. 1). Maksymalne koncentracje glonów zawarte były w granicach od 36 do 1600 komórek·ml^{-1} (tabela II). Okrzemki zawsze występowały w małych ilościach, osiągając największą liczebność (149 komórek·ml^{-1}) w grudniu, po przełamaniu lodów. Był to jedyny okres, kiedy okrzemki, w większości prawdopodobnie uwolnione z lodu, stanowiły dominującą grupę fitoplanktonu. Wśród 86 gatunków okrzemek (tabela III) dominującymi formami w ciągu lata były *Thalassiosira antarctica* i gatunki rodzajów *Chaetoceros* i *Nitzschia* z grup *Flagilariopsis* i *Pseudonitzschia*. Koncentracje dominujących gatunków okrzemek były zmienne ukazując różnice sezonowe. Kilka innych gatunków okrzemek (i.e. *Corethron criophilum*, *Eucampia balaustium*, *Rhizosolenia truncata*) przyczyniło się do grudniowego zakwitu tej grupy, aby szybko ustąpić miejsca głównym dominantom w nastęnych tygodniach.

Maksima fitoplanktonu następowały zawsze po okresach bezwietrznych dni i niezmiennego ciśnienia atmosferycznego (rys. 1, tabela 1). Zwiększona stabilność wód powierzchniowych w okresach ciszy jest prawdopodobnie głównym czynnikiem determinującym występowanie w czasie maksymalnych zakwitów fitoplanktonu. Spadek liczebności glonów, po maksymalnych zakwitach w styczniu i w lutym, a także spadek ilości okrzemek pod koniec grudnia, mógł być w dużej mierze spowodowany konsumpcją przez kryla *Euphausia superba* i *E. crystallorophias*. Dyskutowane są również inne możliwe powody spadku liczebności okrzemek i wiciowców po okresach maksymalnego zakwitu, a także możliwe powody dominacji wiciowców w fitoplanktonie.

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