POLISH POLAR RESEARCH	14	4	383-392	1993

Elżbieta E. KOPCZYŃSKA

Department of Antarctic Biology,
Polish Academy of Sciences
Ustrzycka 10
02-141 Warszawa, POLAND

Net phytoplankton annual cycle (February 1990 – January 1991) in Admiralty Bay, King George Island, West Antarctic

ABSTRACT: Net phytoplankton cell numbers in 50 m water column of Admiralty Bay ranged between $0.2 \times 10^5 \times m^{-2}$ on 24 August 1990 and $2.3 \times 10^7 \times m^{-2}$ on 15 November 1990. Cluster analysis has confirmed the presence of two groups of samples: spring and summer ones (October to April), rich in cells and in species, and, on the other hand, winter samples (June to August) impoverished in algae. Spring and summer fluctuations of diatoms were mainly due to *Corethron criophilum*, *Rhizosolenia alata* and its varieties, *R. hebetata* f. *semispina*, *Thalassiosira* spp., *Chaetoceros* spp., and *Nitzschia* spp. (*Fragilariopsis* and *Pseudonitzschia* groups). The abundance and succession of species in Admiralty Bay reflect seasonal differences in diatom growth; they also reflect mixed populations of the Weddell and Bellingshausen seas entering Admiralty Bay via Bransfield Strait. Striking poverty of algae in some summer samples can most likely be attributed to zooplankton grazing.

Key words: Antarctic, South Shetland Islands, Admiralty Bay, net phytoplankton, annual cycle.

Introduction

Previous net phytoplankton analyses which included samples collected in Admiralty Bay are those of Kopczyńska and Ligowski (1982, 1985), Ligowski (1986), and Ligowski and Kopczyńska (1991, 1992). Except for the study of Ligowski (1986) these investigations were based on few summer samples and were part of large scale phytoplankton surveys conducted in the Antarctic Peninsula area. Many of these samples (Kopczyńska and Ligowski 1982, Ligowski and Kopczyńska 1991, 1992) revealed a comparative poverty of net phytoplankton in Admiralty Bay and in the Bransfield Strait in relation to the Drake Passage, or the Weddell-Scotia Confluence. The small numbers of diatom species and small cell abundances found in those collections have been attributed both to intensive krill grazing and deep mixing of these waters (Kopczyńska and Ligowski 1982, Ligowski and Kopczyńska 1992).

The most complete net phytoplankton study in Admiralty Bay (Ligowski 1986) showed algal variability during four months between March and November, exclusive up to now the winter months. A late summer decline in phytoplankton abundance was found in April; the winter months were followed by an increase of cell numbers in October to a maximum in November. In this study *Corethron criophilum* Castr. was the overall dominant diatom species in all samples.

Earlier net-phytoplankton studies from areas adjacent to Admiralty Bay, such as the Bransfield Strait and Drake Passage, include diatom floristic lists and information on the succession of species (Hart 1934, 1942; Fukase 1964, Frenguelli 1960). Floristic results from other small west Antarctic bays are given by Mangin (1922) and Frenguelli and Orlando (1958).

Quantitative summer studies in Admiralty Bay based on whole water samples were done by Kopczyńska (1980, 1981) and revealed the numerical dominance in abundance of microflagellates, and fluctuations of diatom species and flagellates.

The purpose of the present study conducted in Admiralty Bay was to obtain information on annual cycle of phytoplankton species and cell numbers retained by the 50 μm mesh size net.

Material and methods

Net phytoplankton samples were collected in the centre of Admiralty Bay, King George Island, once to three times a month between 21 February 1990 and 15 January 1991. The samples were obtained by means of a vertical net haul from 50 m depth to the surface. A Copenhagen type net with a mesh size of 50 μm and a 0.1963 m^2 opening mouth area was used for the sampling. Samples were fixed with 2% formaline and were examined under Zeiss microscope at 500 X magnification. At least 300 cells were counted in water drops of known volume. The counts were related to cell numbers in 50 m water column under 1 m^2 sea surface. Most of the 26 samples collected contained diatom cells which were very weakly silicified and fragile. To prevent damage of these cells by chemical cleaning, they were only rinsed of salt and mounted in Coumarone for diatom identification.

Cluster analysis (Batko and Moraczewski 1991) was used on a PC computer in order to group those samples which had similar species associations, the ultimate purpose being to ascertain differences between such algal groups and the periods of their occurrence.

Results

Total phytoplankton concentrations. Phytoplankton cell numbers (Fig. 1 A and B) in 50 m water column ranged between $0.2 \times 10^5 \times m^{-2}$ on 24 August and $2.3 \times 10^7 \times m^{-2}$ on 15 November. Nearly clear water with little detritus and without intact cells was collected on two sampling occasions in June. Generally, in an annual cycle, small cell concentrations were found in the period between February and May 1990; the maximum was $18 \times 10^5 \times m^{-2}$. The numbers decreased to zero in June, and minimal quantities ($0.2-0.8 \times 10^5 x m^{-2}$) were found in July and August. They increased in October (13.4×10^5) and reached a summer maximum in November (2.3×10^7) to decrease again in December and January ($0.5-45 \times 10^5 \times m^{-2}$). Two nearly empty samples with very few cells were found on two summer dates, the 19 December and 13 January. One of the samples (13 January) came from the Bransfield Strait at the entrance to Admiralty Bay.

Species succession. Fluctuations of dominant diatoms are shown in Figures 2 A and B, and 3 A and B. Late summer samples from February 1990 contained moderate quantities of *Rhizosolenia* spp., *Chaetoceros* spp. and *Corethron criophilum* Castr. (Fig. 2 A, B). Peak of *Rhizosolenia hebetata* f. *semispina* (Hensen) Gran. was reached in the middle of April (max. 1260×10^3; 70% of all cells), and the species was conspicuously absent from samples taken between the end of April and December. In comparison, *R. alata* Brightw. and its varietes were more frequently encountered, and reached peak numbers in January 1991 (max. 1150×10^3; 26–100%). *Corethron criophilum* dominated most of the spring and summer samples (October, November, December). It showed a maximum on 15 November; $22525 \times 10^3 \times (m^{-2})$ (59–99%). The species was surprisingly absent from few last summer collections (19 December and 13, 15 January).

The genus *Chaetoceros* was mainly represented by the following species: *C. neglectus* Karst. (max. in February–March: 133×10^3), *C. atlanticus* Cl. (max. 87×10^3 in April), *C. criophilus* Castr. (max. 191×10^3 in November) and *C. socialis* Lauder (max. $2454 \times 10^3 \times m^{-2}$ on 15 January; 55% of all cells). Sporadically occurred: *C. bulbosus* (Ehr.) Heiden, *C. flexuosus* Mangin, *C. pendulus* Karst. and *C. schimperianus* Karst.

Species of the genus *Nitzschia* (*Pseudonitzschia* group) were found in appreciable concentrations in February till May 1990 and in January 1991 (Fig. 3 A and B). The species included mainly *N. lineola* Cl., *N. turgiduloides* Hasle, *N. heimii* Mangin and *N. turgidula* Hust. They were not detected during the winter, spring and early summer months.

Fluctuations of the *Nitzschia* species (*Fragilariopsis* group) were mainly due to *N. kerguelensis* (O'Meara) Hasle (peak 413×10^3 on 6 December) and *N. cylindrus* (Grun.) Hasle (peak 507×10^3 on 22 October).

The combined group of *Thalassiosira* spp. and *Coscinodiscus* spp. were represented mainly by the following species: *Thalassiosira antarctica* Comber

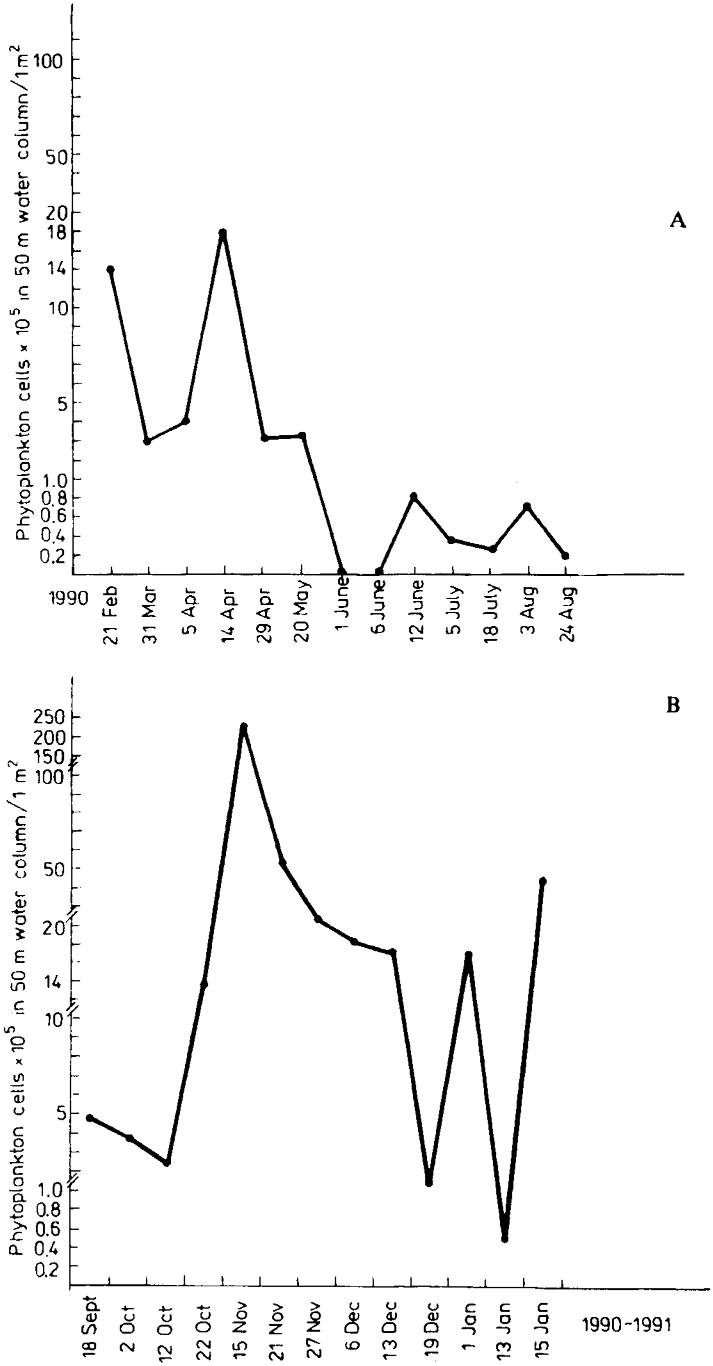

Fig. 1 (A and B). Total cell fluctuations, 21 February 1990—15 January 1991, Admiralty Bay

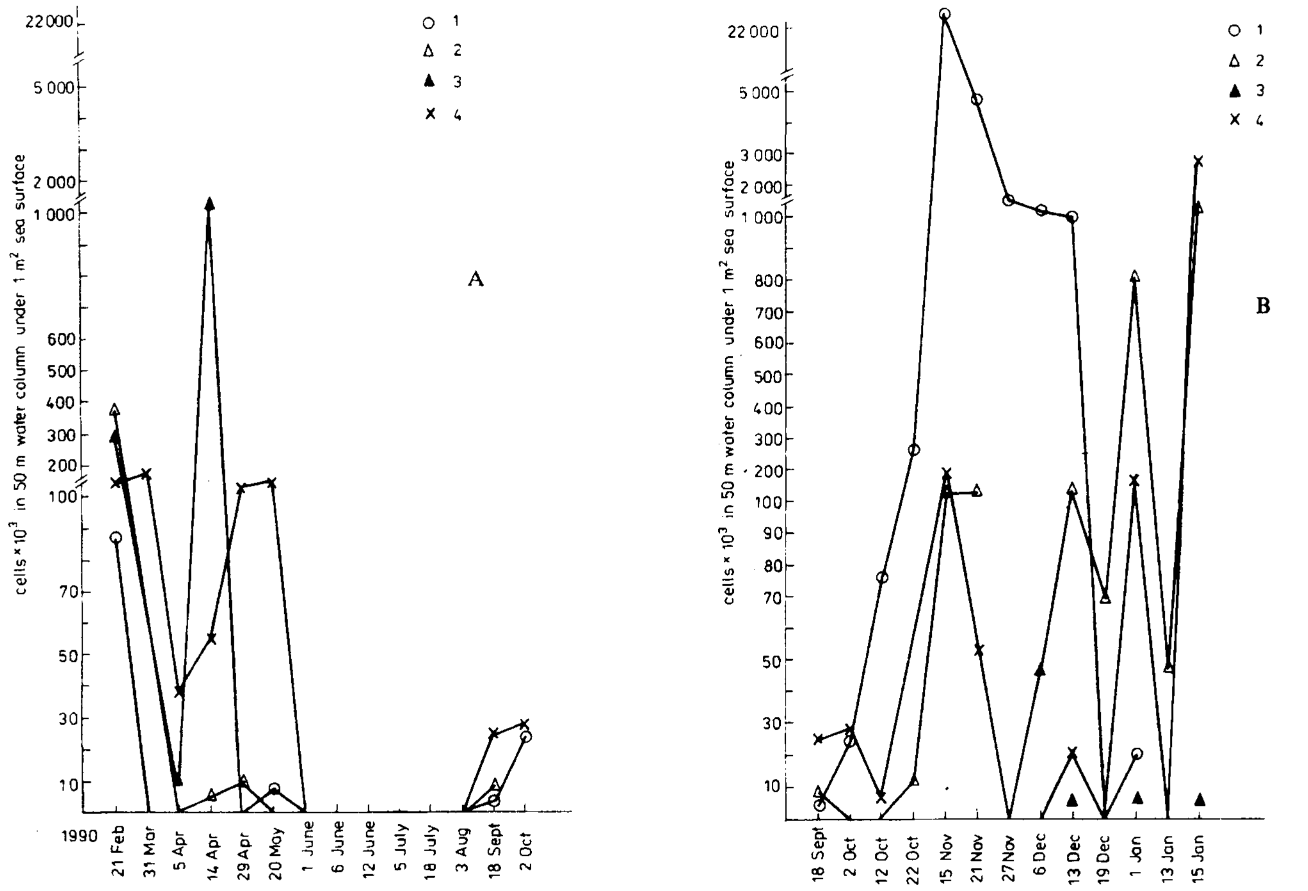

Fig. 2 (A and B). Annual cycle of dominant diatoms: *1 Corethron criophilum; 2 Rhizosolenia alata* and its varieties; 3 *R. hebetata* f. *semispina; 4 Chaetoceros* spp.; 21 February 1990 – 15 January 1991

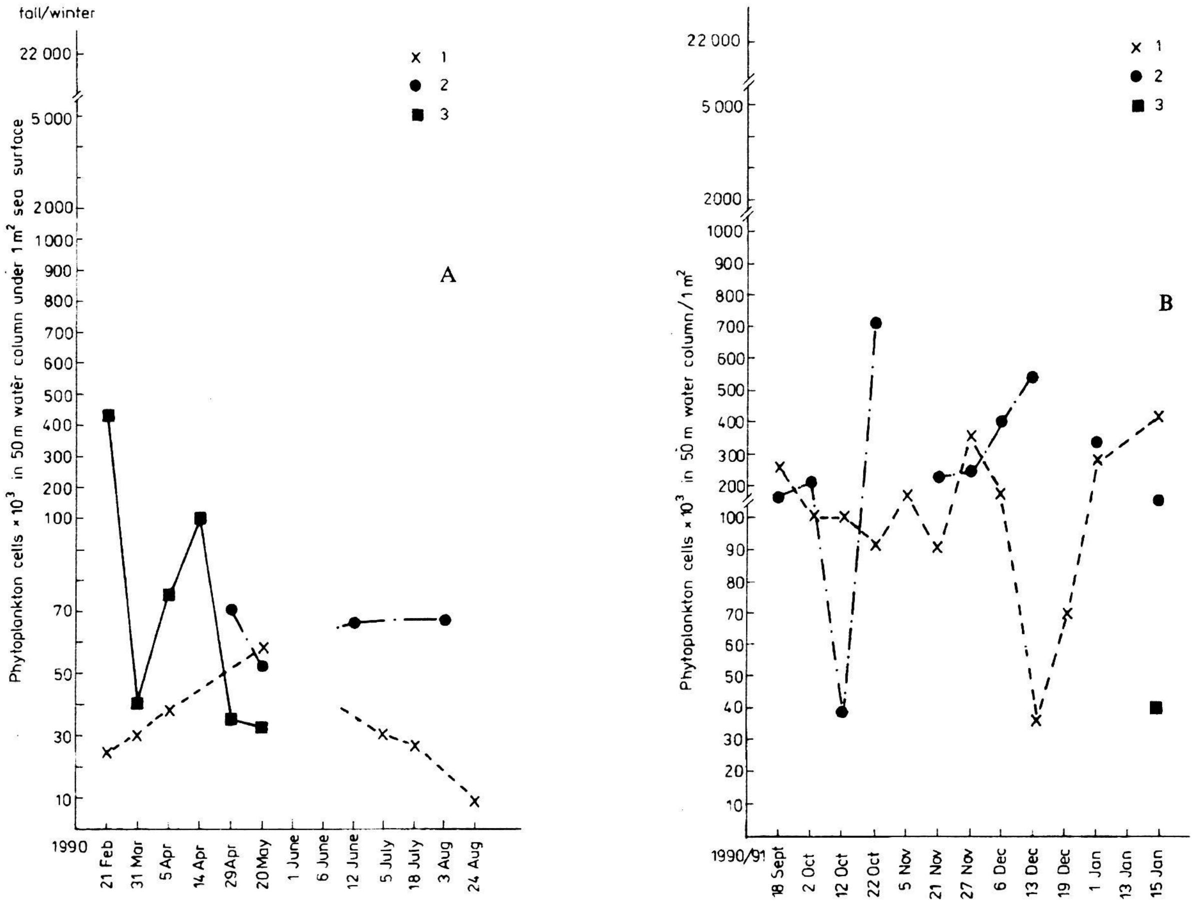

Fig. 3 (A and B). Annual cycle of dominant diatoms: — *Thalassiosira* spp.; — *Coscinodiscus* spp., *Porosira* spp.; — *Nitzschia* spp. (*Fragilariopsis*); — *Nitzschia* spp. (*Pseudonitzschia*)

(max. 253 × 10^3 on 15 January), *T. gracilis* (Karst.) Hust., *T. frenguelli* Kozlova, *T. tumida* (Jan.) Hasle, *Coscinodiscus furcatus* Karst. (max. 250 × 10^3 on 18 September), *C. oculus-iridis* Ehr. and *C. curvatulus* Grun.

Thalassiothrix antarctica Schimper et Karsten was mainly found in March, April and May contributing 5.5–11% to the total phytoplankton quantities.

Only single cells were found in some of the summer samples representing species of the benthic or periphyton communities: *Cocconeis* spp., *Gomphonema* spp., *Licmophora* spp. Among other algal groups very few cells of dinoflagellates (*Prorocentrum* spp.) and silicoflagellates were retained by the net in February and April.

Cluster analysis. Cluster analysis (Batko and Moraczewski 1991) gave results (Fig. 4) which are in line with those shown in Figs. 2 A through 3 B. The larger of the two major sample clusters includes spring and summer samples (October

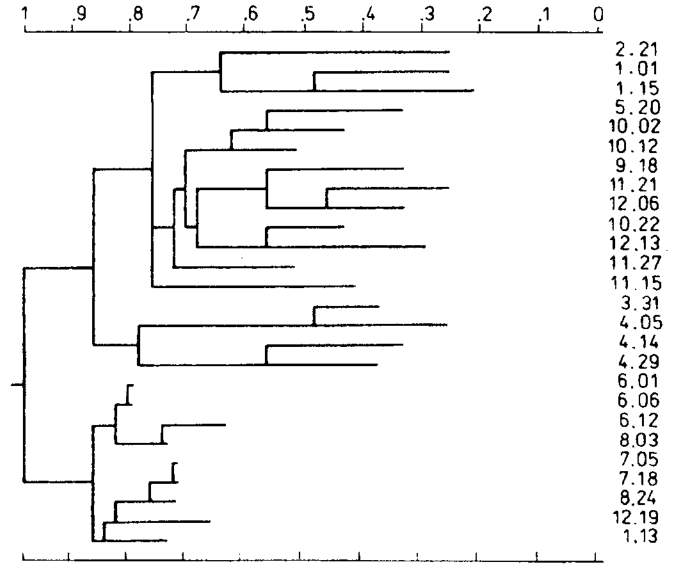

Fig. 4. Cluster analysis dendrogram of 26 phytoplankton samples produced by ultrametric triangulation of inframetric distance matrix

to April and even May) containing characteristic summer algal species and greater cell abundances as compared to winter samples. Within this cluster samples from September through December are more related to one another than these from January and February, and those from March and April. They reflect respectively the changes from the overall dominance of *Corethron criophilum* and *Fragilariopsis* (September to December) to that of *R. alata* and *Pseudonitzschia* (January, February) and *Chaetoceros* spp. (March, April, May). The smaller cluster comprises samples collected during winter (June, July, August) that are very poor in species and cells. Among these the nearly empty June samples are set apart from those obtained in July and August. Two almost empty samples collected during summer (19 December and 13 January) are also attached to the same winter cluster.

Discussion

All diatom species found in the year-round net phytoplankton collections from Admiralty Bay have been previously reported from this bay (Kopczyńska 1980, 1981, Ligowski 1986). They are typical of the entire Antarctic Peninsula area (Hendey 1937, Hart 1942, Kopczyńska and Ligowski 1982, 1985). They are also found in collections from other areas of the Antarctic such as the Indian (Steyaert 1973, 1974, Kopczyńska, Weber and El-Sayed 1985, 1986) or the Pacific (Hasle 1969) sectors of the Southern Ocean. Moreover, many of the species present in Admiralty Bay are cosmopolitan, occurring in both hemispheres. To these belong *Corethron criophilum, Rhizosolenia alata, R. hebetata* f. *semispina, Chaetoceros socialis, C. neglectus, C. atlanticus*. In the Antarctic some of them (*C. socialis*) are typically observed in coastal neritic waters (Hendey 1937, Semina 1974, Kopczyńska and Ligowski 1985). Others, such as *Corethron criophilum* or *Chaetoceros neglectus* are found both near the shores and in open waters (Hasle 1969). Some of the presently found diatoms, such as *C. flexuosus* of *Thalassiothrix antarctica* are endemic to the Antarctic zone.

Corethron criophilum was the predominant diatom species in summer samples (October – December) at the time of the highest cell concentrations. Dominance of this species is typical of the summer season in Admiralty Bay (Ligowski 1986), as well as of the entire Antarctic Peninsula area, regardless of whether or not the net collections are rich or poor in algae (Kopczyńska and Ligowski 1982, 1985). It is interesting to note, that *Corethron* has been observed to be the only numerous diatom species found in quantitative water samples from areas of deep mixing and/or krill concentrations (Kopczyńska 1992).

Cell quantities (0.2×10^5 to 2.3×10^7 m^{-2}) recorded in Admiralty Bay during the present study are similar to the ranges of cell numbers found is this bay by Ligowski (1986) during the summer of 1983. Particularly, the peak numbers of the summer dominant *Corethron criophilum* are similar, and in both studies had occurred in November. Cell concentrations in Admiralty Bay reported earlier in March 1981 (Kopczyńska and Ligowski 1982), were of the same order of magnitude. However, those observed in the northern part of the Bransfield Strait in December – January 1983/84 close to the entrance to Admiralty Bay (Kopczyńska and Ligowski 1985) exceeded several times the present results.

In general, the abundance and succession of species noted during spring and summer (September – March, April) and poverty of algae during winter (June – August) seem to reflect, first of all, the seasonal differences in diatom growth. However, poverty of algae at two summer stations (19 December and

13 January) can be most likely attributed to herbivorous grazing; zooplankton studies conducted at the same time (Menshenina and Rakusa-Suszczewski 1992) revealed a swarm of salps *Ilea racovitzai* at one of these stations. Nearly all the present phytoplankton collections contained copepods and Tintinnidae, the likely consumers of algae.

Since Admiralty Bay contains mixed waters of the Bellingshausen and the Weddell seas inflowing from the Bransfield Strait (Grelowski and Tokarczyk 1985, Lipski 1987), the phytoplankton populations in Admiralty Bay must also reflect those present in these waters (Kopczyńska and Ligowski 1985). Their success will depend on local environmental conditions, such as deep mixing and krill grazing (Kopczyńska 1992), or, for example, light attenuation by large amounts of suspended inorganic particles (Pruszak 1980, Kopczyńska 1980, 1981).

Acknowledgments

Thanks are due to Prof. Dr. S. Rakusa-Suszczewski for making the study possible. I also thank Stuart Donachie and Mariusz Sapota for collecting phytoplankton samples.

References

BATKO A. and MORACZEWSKI I., 1991. Tytan 87 (Computer Analysis Programme Package). Typescript Warsaw University (distributed by authors).

FRENGUELLI J., 1960. Diatomeas y Silicoflagelados recogidas en Tierra Adelia durante las Expediciones Polares Francesas de Paul Emile Victor (1950–1952). — Rev. Algol., 5: 3–47.

FRENGUELLI J. and ORLANDO H.A., 1958. Diatomeas y Silicoflagelados del sector antartico sudamericano. — Publ. Inst. Antart. Argent., 5: 1–191.

FUKASE S., 1964. Distribution and abundance of diatoms along the coast of Argentina, in the Drake Passage and Bransfield Strait during the period February–March 1963. *In:* S.Z. El-Sayed (ed.), Annual Report. Texas A. and M. University, Department of Oceanography and Meteorology.

GRELOWSKI A. and TOKARCZYK R., 1985. Hydrological conditions in the region of Bransfield Strait and the southern part of Drake Passage in the period from December 10, 1983 and January 8, 1984 (BIOMASS-SIBEX) — Pol. Polar Res., 1–2: 31–41.

HART T.J., 1934. On the phytoplankton of the South-West Atlantic and Bellingshausen Sea. — Discovery Rep., 8: 3–268.

HART T.J., 1942. Phytoplankton periodicity in Antarctic surface waters. — Discovery Rep., 21: 261–365.

HASLE G.R., 1969. An analysis of the phytoplankton of the Pacific Southern Ocean: abundance, composition and distribution during the Bratteg Exp. 1947–48. — Hvalradets Skr., 52: 1–168.

HENDEY N.I., 1937. The plankton diatoms of the Southern Seas — Discovery Rep., 16: 151–364.

KOPCZYŃSKA E.E., 1980. Small-scale vertical distribution of phytoplankton in Ezcurra Inlet, Admiralty Bay, South Shetland Islands. — Pol. Polar Res., 1: 77–96.

KOPCZYŃSKA E.E., 1981. Periodicity and composition of summer phytoplankton in Ezcurra Inlet, Admiralty Bay, South Shetland Islands. — Pol. Polar Res., 2: 55–70.

KOPCZYŃSKA E.E., 1992. Dominance of microflagellates over diatoms in the Antarctic areas of deep vertical mixing and krill concentrations. — J. Plankt. Res., 14: 1031–1054.

KOPCZYŃSKA E.E. and LIGOWSKI R., 1982. Phytoplankton abundance and distribution in the northern Drake Passage and the Bransfield Strait in February–March 1981 (BIOMASS-FIBEX). — Pol. Polar Res., 3: 193–202.

KOPCZYŃSKA E.E. and LIGOWSKI R., 1985. Phytoplomakton 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 (BIOMAS-SIBEX). — Pol. Polar Res., 6: 65 – 77.
KOPCZYŃSKA E.E., WEBER L.H. and EL-SAYED S.Z., 1985. Phytoplankton data from the February – March 1980 cruise of r/v "Agulhas"; quantitative species counts and net tow data from the Indian Sector of the Antarctic Ocean. — Technical Rep., Texas A. and M. University; 29 pp.
KOPCZYŃSKA E.E., WEBER L.H. and EL-SAYED S.Z., 1986. Phytoplankton species composition and abundance in the Indian sector of the Antarctic Ocean. — Polar Biol., 6: 161 – 169.
LIGOWSKI R., 1986. Net phytoplankton of the Admiralty Bay (King George Island, South Shetland Islands) in 1983. — Pol. Polar Res., 7: 127 – 154.
LIGOWSKI R. and KOPCZYŃSKA E.E., 1991. Distribution of net phytoplankton in the sea-ice zone between Elephant Island and the South Orkney Islands (December 1988 – January 1989). — Pol. Polar Res., 12: 529 – 546.
LIGOWSKI R. and KOPCZYŃSKA E.E., 1992. Fitoplankton. *In:* S. Rakusa-Suszczewski (ed.), Zatoka Admiralicji, Antarktyka. Wyd. Inst. Ekol. PAN, Dziekanów Leśny, 77 – 82.
LIPSKI M., 1987. Variations of physical conditions, nutrients and chlorophyll a contents in Admiralty Bay (King George Island, South Shetland Islands, 1979). — Pol. Polar Res., 8: 307 – 332.
MANGIN L., 1922. Phytoplankton antarctique. Expedition Antarctique de la „Scotia" 1902 – 1904. — Mem. Acad. Sci., 57: 1-134.
MENSHENINA L. and RAKUSA-SUSZCZEWSKI S., 1992. Zooplankton changes during the year in Admiralty Bay (February 1990 – January 1991). — Pol. Arch. Hydrobiol., 39: 65 – 76.
PRUSZAK Z., 1980. Currents circulation in the waters of Admiralty Bay (Arctowski Station region, King George Island). — Pol. Polar Res., 1: 55 – 74.
SEMINA G.L., 1974. Fitoplankton Tichogo Okeana. — Izd. Nauka, Moskva; 239 pp.
STEYAERT J., 1973. Difference in diatom abundance between the two summer periods of 1965 and 1967 in Antarctic inshore waters (Breid Bay). — Investig. Pesq., 37: 517 – 532.
STEYAERT J., 1974. Distribution of some selected diatom species during the Belgo-Dutch Antarctic expedition of 1964 – 65 and 1966 – 67. — Investig. Pesq., 38: 259 – 288.

Revised and accepted September 1, 1994

Streszczenie

Próby sieciowe fitoplanktonu zbierano trzy razy na miesiąc w centrum Zatoki Admiralicji (Wyspa Króla Jerzego, Szetlandy Południowe) w okresie od 21 lutego 1990 do 15 stycznia 1991 r. Ilości komórek w 50 m kolumnie wody wahały się w granicach od $0.2 \times 10^5/m^2$ w sierpniu do $2.3 \times 10^7/m^2$ w listopadzie. Analiza klasterowa potwierdziła występowanie dwóch grup prób fitoplanktonu. Wiosenne i letnie próby (październik – kwiecień) bogate były w gatunki i ilości komórek, natomiast próby zimowe (czerwiec – lipiec) odznaczały się ubóstwem glonów. Ilościowe i jakościowe fluktuacje okrzemek, stwierdzone wiosną i latem, spowodowane były głównie przez takie gatunki, jak *Corethron criophilum*, *Rhizosolenia alata* i jej formy, *R. hebetata* f. *semispina*, *Thalassiosira* spp., *Chaetoceros* spp. i *Nitzschia* spp. (grupy *Fragilariopsis* i *Pseudonitzschia*). Ilość i sukcesja gatunków w Zatoce Admiralicji odzwierciedlają sezonowe różnice wzrostu okrzemek; odzwierciedlają również mieszanie się populacji fitoplanktonu z mórz Weddella i Bellingshausena które napływają do Zatoki Admiralicji poprzez Cieśninę Bransfielda. Ubóstwo glonów w niektórych letnich próbach było prawdopodobnie spowodowane spasaniem przez zooplankton.