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Maciej LIPSKI and Krzysztof ZIELIŃSKI

Department of Polar Research,
Institute of Ecology,
Polish Academy of Sciences,
Dziekanów Leśny,
05-092 Łomianki, POLAND

Coarse-scale structure of chlorophyll *a* distribution in Scotia Front west of Elephant Island (BIOMASS III, October—November 1986)

ABSTRACT: Coarse-scale studies on chlorophyll *a* distribution in a region covering the Scotia Front zone showed an increased chlorophyll content and its deeper distribution at stations situated in the frontal zone. The sources of chlorophyll *a* were probably both the phytoplankton released from melting ice as well as spring bloom.

Key words: Antarctica, Scotia Front, chlorophyll *a*, BIOMASS III.

Introduction

During the first part of the cruise of r/v "Profesor Siedlecki" in the BIOMASS III Project (Rakusa-Suszczewski 1988a) chlorophyll *a* concentrations were determined in the region of Elephant Island. This area was studied by numerous authors (El-Sayed and Weber 1982; Lipski 1982; Uribe 1982; Hayes, Whitaker and Fogg 1984; Lipski 1985; Bodungen et al. 1986; Gieskes and Elbrächter 1986). However, these studies were carried out in much larger scale than the BIOMASS III space scale. So the results from these studies, remaining within the range of 0.15 mg m^{-3} (Gieskes and Elbrächter 1986) to 3.76 mg m^{-3}, are not a comparable material to the data presented in this paper. Coarse-scale studies at the present investigation area were carried out in order to trace the variability in the content and vertical distribution of chlorophyll *a* in three cross-sections of Scotia Sea Front (Fig. 1). Position of the frontal zone was outlined during an earlier hydrographic reconnaissance (Rakusa-Suszczewski 1988b) and oceanographic studies carried out in this sea area previously (Stein 1986). Variability in

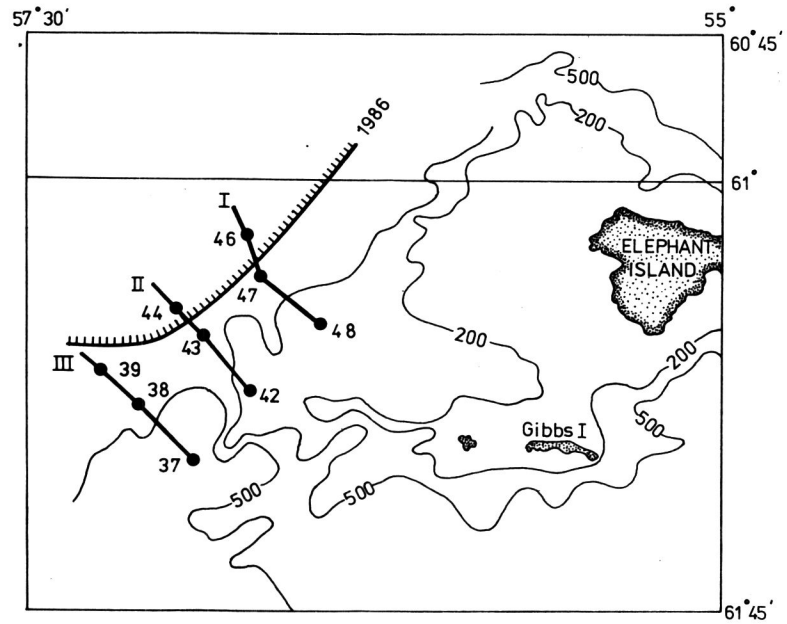

Fig. 1. Research area with stations situated along 3 transects; SF — Scotia Front

the contents of chlorophyll and other phytoplankton pigments can be used for positioning the frontal zone, what is particularily valuable for working with data from satellites (Brooks, Trees and Bidigare 1985).

During the cruise, the north-western part of the investigated sea area was covered with pack ice with underneath layers densely overgrown with algae as could be observed from their brownish-yellow colour (Bunt and Lee 1970).

2. Material and methods

At the turn of October and November 1986 r/v "Profesor Siedlecki" sailed in the region of Scotia Front west of Elephant Island (Rakusa-Suszczewski 1988a). Chlorophyll samples were collected in this area at 9 oceanographic stations. Water was sampled with a plastic Van Dorn type bathometer at standard levels 0, 20, 50, 75, 100, 150, 200, 500, 1000, 1500 m and over the bottom, at most to 1850 m depth. As a rule, 7–9 liters of water were filtered and at larger depths up to 13 liters. Chlorophyll was determined according to a procedure recommended by Evans, O'Reilly and Thomas (1987), but nannoplankton fraction was not separated. Pigment content was measured spectrophotometrically (Beckman Model 26). At the same time

the fluorescence of the acetone extract was measured with a Gilson fluorometer in order to check fluorometer calibration coefficient stability. Values of chlorophyll *a* contents were integrated for the layer of 150 m.

3. Results

In the studied profiles, the vertical distribution of chlorophyll *a* showed the following characteristic features (Tab. 1, Figs. 2, 3 and 4):

- the largest chlorophyll *a* contents, expressed in integrated values (max. 143.5 mg m $^{-2}$) were observed at stations of profile I (st. 46, 47, 48);
- in each profile the highest quantities of chlorophyll *a*, expressed in integrated values (average 120 mg m $^{-2}$) occured at middle station (st. 38, 43 and 47);

Table 1

Chlorophyll *a* concentrations (mg m $^{-3}$) at stations investigated during BIOMASS III (Area 1, October — November 1986)

Station No / Depth (m)	37	38	39	42	43	44	46	47	48
0	0,68	1,00	0,85	0,94	0,82	0,80	1,03	1,13	0,78
20	0,65	1,03	0,91	0,81	0,80	0,75	0,96	1,14	0,72
50	0,64	1,04	0,68	0,82	0,79	0,72	0,93	1,20	0,81
75	0,34	0,74	0,46	0,57	0,87	0,56	0,89	1,07	0,64
100	0,18	0,61	0,44	0,16	0,83	0,53	0,66	0,96	0,29
150	0,14	0,23	0,15	0,10	0,10	0,21	0,09	0,32	0,09
200	0,12	0,09	0,13	0,08	0,10	0,03	0,04	0,23	0,07
400				0,08					
420									0,04
465	0,05								
500		0,04	0,02		0,03	0,02	0,04	0,07	
670		0,06							
1000			0,04			0,04	0,03	0,04	
1200					0,03				
1500						0,02	0,05		
1850							0,04		

- significant contents of chlorophyll *a* (0.2 mg m $^{-3}$) were noted to 150 m depth, with the exception of station 47, where 0.23 mg m $^{-3}$ of chlorophyll *a* were measured at 200 m depth;
- the lowest contents of chlorophyll *a* (integrated values 60—77 mg m $^{-2}$) were found at shallowest stations situated on a shelf (st. 37, 42 and 48);
- there were only traces of chlorophyll (< 0.07 mg m $^{-3}$) at depths below 500 m.

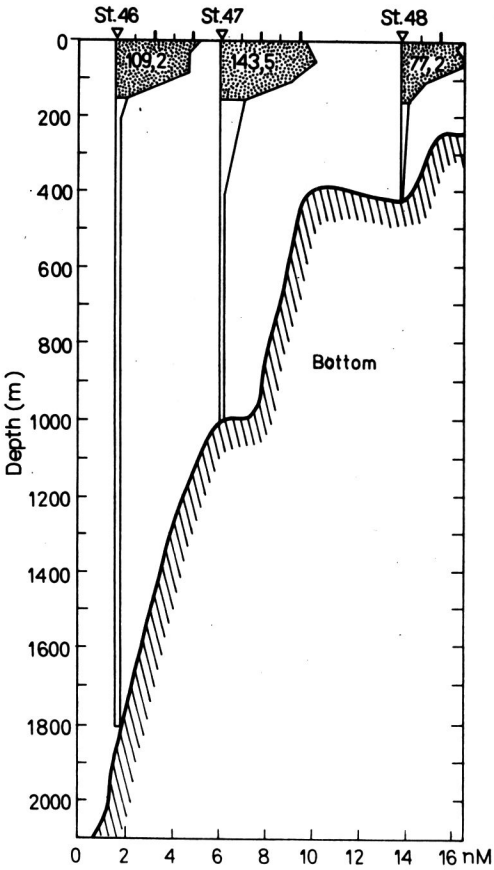

Fig. 2. Vertical distribution of chlorophyll *a* in the transect I. Dotted area denotes the integrated values of the chlorophyll *a* contents in the layer of 150 m. Upper horizontal scale indicates the chlorophyll *a* amount; 1 cm ≙ 0.5 mg m^{-3}

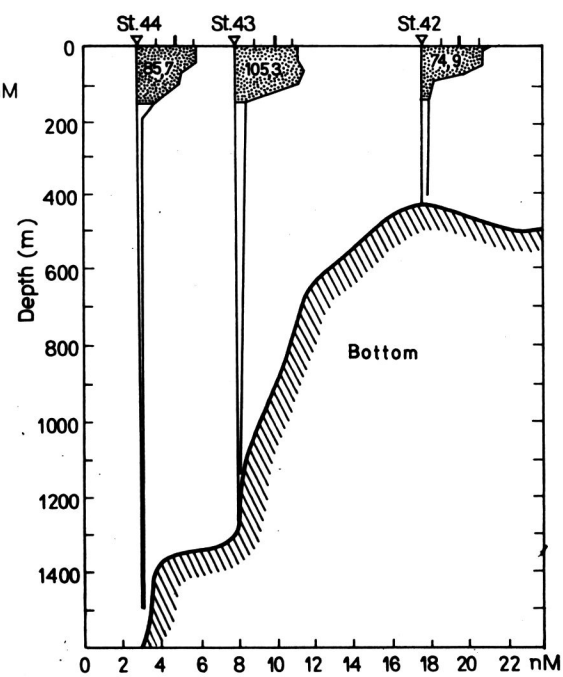

Fig. 3. Vertical distribution of chlorophyll *a* in the transect II. Explanations as in Fig. 2

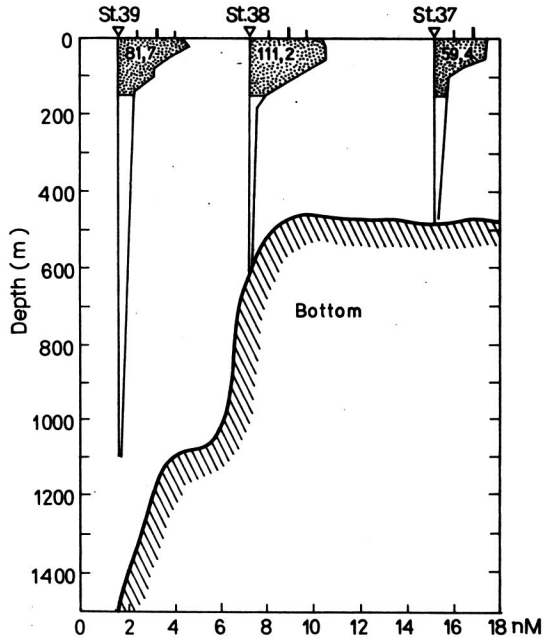

Fig. 4. Vertical distribution of chlorophyll *a* in the transect III. Explanations as in Fig. 2

4. Discussion

On the basis of a detailed analysis of T and S data it was possible to determine the position of Scotia Front (Fig. 1) (Grelowski and Wojewódzki 1988; Rakusa-Suszczewski 1988b). Results of chlorophyll *a* determination showed highest values for stations 43 and 47, i.e. situated close to the frontal zone. Increased concentrations at 150 and 200 m depths occurring at station 47 and partially at station 43 coincide with the region of surface water sinking in the zone of Scotia Front (Rakusa-Suszczewski 1988b).

The phenomenon of the occurrence of increased chlorophyll *a* concentrations in frontal zones with various hydrodynamic characteristics was observed in the Antarctic by Lutjeharms, Walters and Allanson (1985). This regularity was observed also in other climatic zones, e.g. in the Celtic Sea (Pingree et al. 1976). Analysis of variance confirmed the decisive role of water dynamics for local phytoplankton concentration (Platt 1972, Denman 1976).

As it is known, biogenic salts contents are very high in Antarctic waters ond do not limit phytoplankton growth (El-Sayed 1968), although the inflow of waters richer in biogenic elements to the euphotic zone is strongest in frontal zones (Holm-Hansen 1985). Thus, higher chlorophyll *a* content in these regions may be explained, at least in part, with more favourable hydrochemical conditions.

Sea-ice algae were very abundant in the investigated area at that time. Thus it seems that total determined chlorophyll *a* was originated from phytoplankton released from ice, melting in this period (Ligowski, Zieliński and Lipski 1988) and from spring population of Antarctic surface water phytoplankton (Ligowski 1988).

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6. Streszczenie

Na przełomie października i listopada 1986 r., w czasie rejsu r/v "Profesor Siedlecki" w rejonie Frontu Scotia, na zachód od Wyspy Elephant, na 9 stacjach oceanograficznych prześledzono zmienność zawartości chlorofilu *a* i jego pionowego rozmieszczenia na trzech przekrojach Frontu Scotia. Próbki wody były pobierane na standardowych poziomach w zakresie głębokości 0—200 m i głębiej aż do 1850 m, a zawartość chlorofilu *a* oznaczano bez oddzielania frakcji nannoplanktonu.

Najwyższe ilości chlorofilu *a*, wyrażone w wartościach integrowanych występowały na stacjach profilu I (do 140 mg 100 m ^{2}), jak też na środkowych stacjach każdego z badanych profilów (tab. 1; rys. 1, 2, 3, 4). Znaczące ilości chlorofilu *a* stwierdzano do głębokości 150 m (0.2 mg 1000 m ^{3}). Wyjątek stanowiła stacja 47, gdzie do głębokości 200 m stężenie chlorofilu *a* wynosiło 0,23 mg 1000 m ^{3} (rys. 1). Poniżej głębokości 500 m stężenia chlorofilu *a* były już śladowe (poniżej 0,07 mg 1000 m ^{3}). Zatem największe ilości chlorofilu *a* występowały na stacjach leżących blisko strefy Frontu Scotia, a podwyższone wartości stężeń (na głębokościach 150 i 200 m) występowały na obszarze zagłębiania się wody powierzchniowej (downwelling) w strefie Frontu Scotia, potwierdzając hydrodynamiczny obraz tego rejonu.

Wyższa zawartość chlorofilu w rejonie Frontu Scotia mogła być związana z charakterystycznym dla stref frontalnych, zwiększonym dopływem wód bogatych w biogeny do strefy eufotycznej. O zawartości chlorofilu w badanym rejonie decydowało zarówno występowanie pierwszych wiosennych zakwitów fitoplanktonu antarktycznej wody powierzchniowej, jak i obecność fitoplanktonu pochodzącego z topniejącego w tym czasie lodu.