# THE RELATIONSHIP BETWEEN THE DISTRIBUTION OF PLANKTON BIOMASS AND PLANKTON COMMUNITIES IN THE DRAKE PASSAGE AND THE BRANSFIELD STRAIT (BIOMASS-FIBEX, FEBRUARY–MARCH 1981)

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***Abstract:*** In the investigated area of *ca.* 79 thousand miles², krill biomass, as designated by Data Workshop 1981 in Hamburg, makes up about 17% of zooplankton wet weight in the surface 100 m water layer. Based on our own hydroacoustic measurements over an area of 48 thousand miles², krill biomass there makes up about 44% of the total zooplankton biomass. Three plankton communities with distinct trophic relations and the dominance of certain taxa have been distinguished in the area investigated. The "continental" community comprises phytoplankton with large quantities of flagellata, small phytoplankton consumers, predatory Cyclopoida, krill, carnivorous *Parathemisto,* and also larvae and young Channichthyidae. The "antarctic" community contains planktonic diatoms, Radiolaria, phytophagous Calanoida, Pteropoda and carnivorous Chaetognatha. The "intermediate" community is completed by Appendicularia, naupli, krill larvae, predacious Polychaeta and immature Nototheniidae. The distribution of plankton communities and plankton biomass in the research area may provide biological indicators for the intensity of water inflow from the Weddell Sea.

## 1. Introduction

An area of the southern part of the Drake Passage and the Bransfield Strait designated by the symbol "A" in the FIBEX programme, had been chosen for the investigations of Poland and Chile. The purpose of the research had been to gain information about the size and distribution of krill biomass. The interdisciplinary works performed in this area out board of the R.V. PROFESSOR SIEDLECKI give a picture of biomass distribution and composition of plankton communities in relation to hydrology conditions.

## 2. Materials

The works were done as part of the FIBEX programme in the "A" area, comprising the Drake Passage and the Bransfield Strait, south from 60°S, between 56°W and 66°W, in the period February 14–March 19, 1981. For the purpose of krill biomass computations in the surface water stratum between 6 and 130 m, the area of our research had been divided by the international working group in Hamburg into three survey blocks (1, 2 and 3) with surface areas of 17.6, 26.1 and 35 thousand miles², respec-

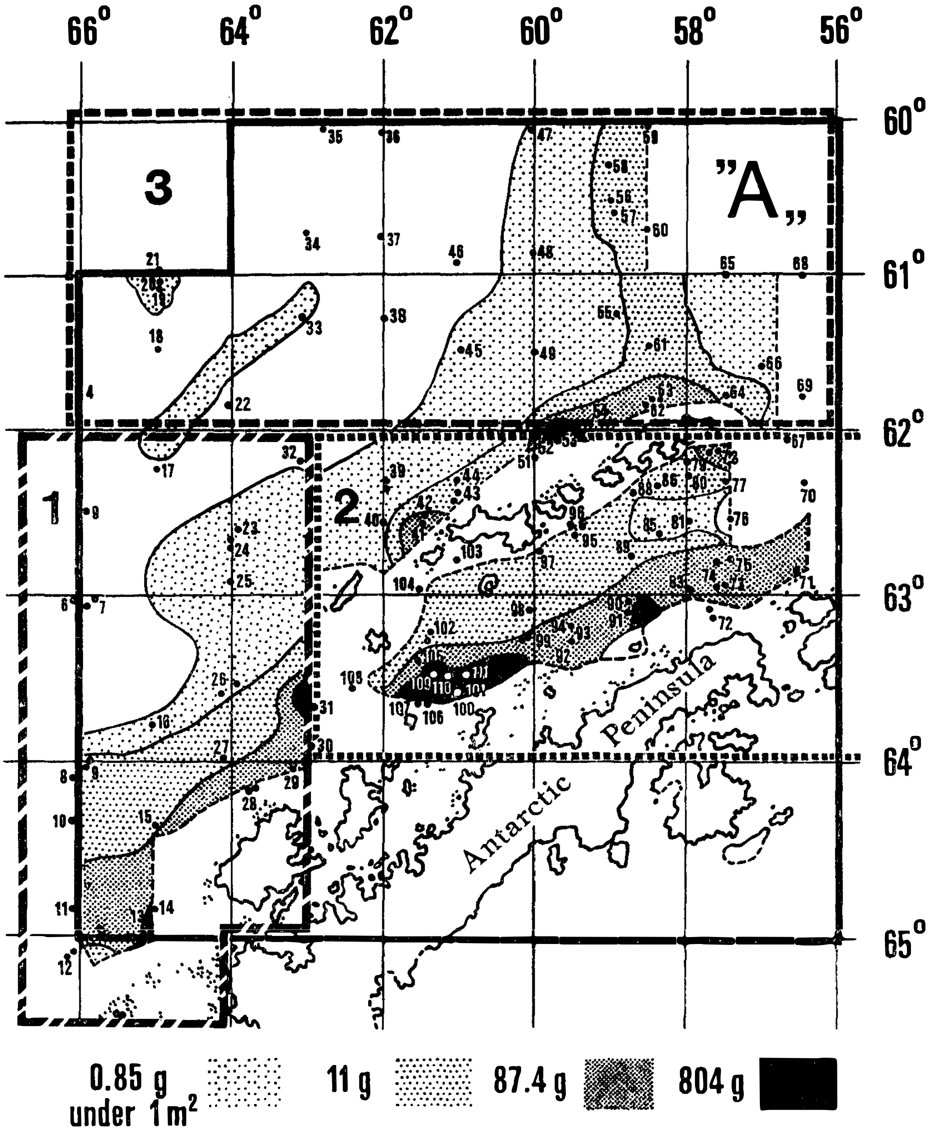


*Fig. 1.* *Polish research area "A", during BIOMASS-FIBEX. The area has been divided by a working group in Hamburg into three survey blocks (1, 2 and 3) for a calculation of krill biomass.* KALINOWSKI *distinguished five subareas which differed by krill biomass; 1: 0, 2: 0.85 g/m², 3: 11.0 g/m², 4: 87.4 g/m² and 5: 804 g/m².*

tively (Fig. 1 and Table 1). In this paper, this division into three survey blocks has been retained; although it does not correspond exactly with geographic regions, it gives a possibility of comparing the quantitative relations between krill biomass and the biomass of phytoplankton and total zooplankton. The biomass of phytoplankton and of zooplankton has been determined on the basis of net collections in the water stratum from 100 m depth to surface. In the three survey blocks 10, 25 and 17 oceanography-biology stations were investigated. The average values obtained within each survey block have been chosen as characteristic for the particular areas.

In the "A" area, KALINOWSKI (in prep.) distinguished five subareas of 19.9, 16, 6.3, 5 and 0.6 thousand miles² which differed by krill biomass (Fig. 1 and Table 2). In these

*Table 1. The mean values of biomass in the area "A".*

| Survey blocks | Net phytoplankton settling volume cm³ under 1 m² in 100 m water column | Dry weight of net phytoplankton g under 1 m² | Chlorophyll *a* integrated value mg under 1 m² | Wet weight of net zooplankton g under 1 m² | Dry weight of net zooplankton as 20% of wet weight g under 1 m² | Wet weight of krill, calculated by Data Workshop Hamburg 1981 g under 1 m² | Wet weight of total zooplankton g under 1 m² | Dry weight of total zooplankton as 20% of wet weight g under 1 m² |
|---|---|---|---|---|---|---|---|---|
| 1 | 444 | 7 | 80 | 38 | 8 | 3.15 | 41 | 8.2 |
| 2 | 52 | 0.7 | 52 | 2 | 0.4 | 14.75 | 16 | 3.2 |
| 3 | 267 | 5 | 62 | 41 | 8 | 0.50 | 41 | 8.2 |

*Table 2. The mean values of plankton biomass in five areas characterized by different wet weight of krill biomass.*

| Net phytoplankton settling volume cm³ under 1 m² in 100 m water column | Dry weight of net phytoplankton settling volume g under 1 m² | Chlorophyll integrated value mg under 1 m² in water column | | Wet weight of net zooplankton g under 1 m² in 100 m water column | Wet weight of krill biomass g under 1 m² as a mean value for Bransfield and Drake Passage calculated by hydroacoustic methods by Kalinowski | Wet weight of total zooplankton g under 1 m² | Phytoplankton / Zooplankton | Chlorophyll / Zooplankton × 10⁻³ | |
|---|---|---|---|---|---|---|---|---|---|
| | | J & H 0–100 m | Lorenzen 0–150 m | | | | | 0–100 m | 0–150 m |
| 357 | 5.7 | 61 | 38.1 | 44.9 | 0 | 44.9 | 7.9 | 1.3 | 0.8 |
| 132 | 2.1 | 89 | 70.2 | 13.3 | 0.85 | 14.15 | 9.3 | 6.2 | 4.9 |
| 167 | 3.4 | 51 | 37.4 | 15.5 | 11.0 | 26.5 | 6.3 | 1.9 | 1.4 |
| 160 | 2.08 | 71 | 29.6 | 6.5 | 87.4 | 93.9 | 1.7 | 0.7 | 0.3 |
| 112 | 2.2 | 42 | 26.3 | 25.5 | 804 | 829.5 | 0.13 | 0.05 | 0.03 |

five subareas of different krill concentrations 13, 10, 13, 11 and 4 oceanography-biology stations were investigated and they included the collections of phytoplankton and zooplankton in the surface water layer down to 100 m depth. This allowed to make a preliminary comparison between the plankton communities and biomass, and krill biomass in the 6–130 m stratum as calculated by KALINOWSKI on the basis of the hydroacoustic method.

Phytoplankton samples were analysed by KOPCZYŃSKA and LIGOWSKI (in press). A Copenhagen-type net with an opening diameter of 50 cm and a mesh size 60 $\mu$m was used collection of samples. Phytoplankton settling volumes obtained from net samples overestimate the values of algal biomass; on the other hand, they underestimate it, since many of the small forms, especially flagellates common in the Bransfield Strait, escape through the nets. Chlorophyll *a* content was determined by LIPSKI (in prep.) according to the combined method of Jeffrey and Humphrey, and Lorenzen. LIPSKI (in prep.) analysed also the T, S diagrams. Zooplankton samples were collected with a closed Nansen net, 70 cm diameter and 260 $\mu$m mesh size. They were analysed quantitatively by JAŻDŻEWSKI *et al.* (in prep.). Sex, development stage and size analyses of *Euphausia superba* were done by WOLNOMIEJSKI *et al.* (in prep.). In the three survey blocks 8, 38 and 6 krill catchments obtained both by STERN—trawls and Bongo nets were analysed. Distribution of krill larvae was studied by KITTEL and JAŻDŻEWSKI (in prep.). Problems connected with krill feeding were analysed by RAKUSA-SUSZCZEWSKI (in prep.). Composition and distribution of ichthyofauna found in krill-catches are presented by SŁÓSARCZYK and REMBISZEWSKI (in prep.).

## 3. Results and Discussion

In the area investigated, the net-phytoplankton biomass is highest in the survey block 1, and lowest in the survey block 2 (Table 1). Comparisons between the mean integrated values of chlorophyll *a* are similar to the algal biomass distribution, however, the differences between survey blocks are much less pronounced. Net-phytoplankton quantities are small above the shelf of the Antarctic Peninsula and in the Bransfield Strait, while the amounts of chlorophyll *a* there are relatively high. The situation is reverse at the northern edge of the investigated area. The highest chlorophyll *a* values were found at the northern edge of the shelf of the South Shetlands Islands. Our data corroborate earlier results obtained in this area (FUKASE, 1964). Previous investigations (HART, 1934; KANAYEVA, 1969) showed, that also in the northern part of the Weddell Sea phytoplankton was poor in the surface 0–100 m water stratum and its biomass ranged between 25–100 $cm^3$ under 1 $m^2$ sea surface.

Mean values of net-zooplankton biomass are similar in survey blocks 1 and 3, and many times greater than in survey block 2 (Table 1). Krill biomass, as calculated by the working group in Hamburg is lowest in survey block 3, and highest in block 2 (Table 1). Comparison of these values shows that in survey blocks 1, 2 and 3 krill makes up 19, 87 and 1% respectively of the total zooplankton biomass. For the whole research area it gives an average of 17%. In the whole Antarctic ecosystem, krill biomass in relation to the total zooplankton biomass, has been estimated as 10 to 50% (EVERSON, 1977; HOLDGATE, 1967).

An analysis of the quantitative relations between phytoplankton and zooplankton in areas of different krill biomass, as calculated by us, gives a more detailed picture (Table 2). Net zooplankton may make up 4 to 92% of the total zooplankton wet weight. In the whole area of our research (47.9 thousand miles$^2$) krill makes up on the average 44% of the total zooplankton biomass. In the Bransfield Strait, below 100 m depth, the amounts of net-zooplankton increase. The actual krill contribution to the total zooplankton biomass of the research area (including depths below 100 m) might be then much smaller. Small net zooplankton which contributes more than a half to the total zooplankton biomass, probably plays a role in the processes of circulation of matter and energy flow which, south of the Antarctic Convergence has not been appreciated enough so far. This problem needs further investigations, which perhaps will question the key role of krill in the energetics of the functioning of the Antarctic ecosystem. Differences in the net zooplankton biomass between areas where krill does not occur and an area of its concentration in quantities of 87.4 g under 1 m$^2$, are near one order of magnitude. Local differences between area as in the zooplankton concentrations, expressed as biomass, might be multiple and as great as 58 times. This is reflected in the values of the phytoplankton/zooplankton ratios (Table 2). The formation of areas of large zooplankton biomass concentration, is characteristic of the Antarctic ecosystem, and plays a decisive role in the circulation of matter and energy flow, to the zooplankton consumers living in the near shore areas of the continent and the islands (RAKUSA-SUSZCZEWSKI, 1980).

The occurrance of a number of species and taxa which make three main groups of distinct trophic relations has been ascertained in the investigated area of the Drake Passage and the Bransfield Strait, in the surface 100 m water layer. Substantial changes occur in the numbers and proportions of various planktonic taxa (Fig. 2) and they correspond to an increase of krill biomass at approaching the shelf of the Antarctic Peninsula (Fig. 1). In the Bransfield Strait, where the maximum krill biomass was found, both the biomass and numbers of net-zooplankton were lowest. Krill populations there were accompanied by taxa forming a plankton group which we will call "continental". This group contained phytoplankton with species characteristic of

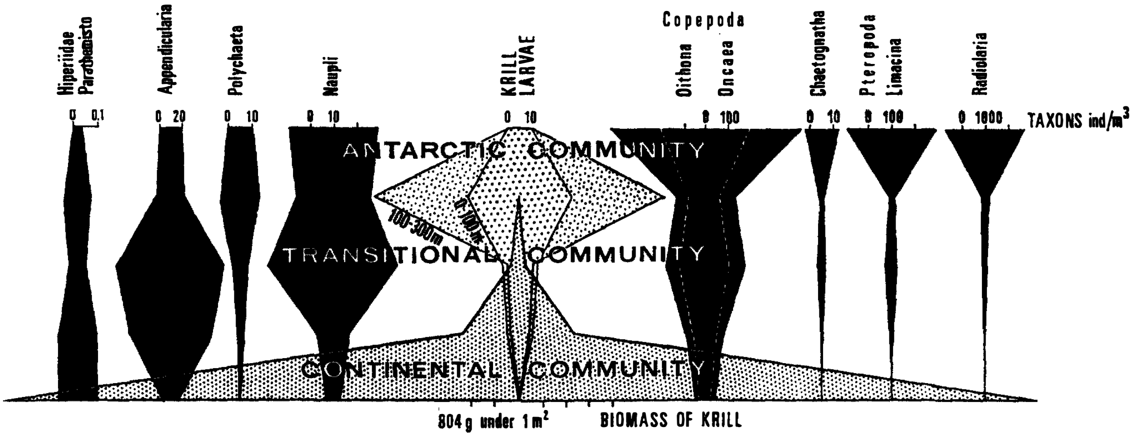


*Fig. 2. Zooplankton composition in the Polish research area "A". Three plankton communities have been distinguished in the areas of different krill biomass.*

cold waters, such as *Nitzschia curta*, *Corethron criophilum*, *Thalassiothrix antarctica* (SANINA, 1973) and small flagellates and "monads" (HASLE, 1969; KOPCZYŃSKA, 1980). In the net-zooplankton, very few small phytophagus naupli and krill larvae occurred Copepoda were dominated by predatory Cyclopoida—*Oithona* and *Oncaea*. An increase in the numbers of predatory Copepoda in the south has been also reported by RAMIREZ and DINOFRIO (1976), and FUKUCHI and TANIMURA (1981). These authors found the dominance of Cyclopoida and Appendicularia in the near shore waters of the continent. Compared to the krill population found in the trawls in the north, outside of the shelf, krill populations found in the Bransfield Strait and in a shelf area of the Antarctic Peninsula were characterized by smaller size of specimens. This has been found also in earlier investigations (JAŻDŻEWSKI *et al.*, 1978). The "continental" plankton group contained also *Parathemisto* and substantial numbers of larvae and young stages of fish, mainly Channichthyidae, Bathydraconidae and Harpagiferidae which occur in the Bransfield Strait.

A plankton community, which could be called "antarctic" was found in the southern part of the Drake Passage. It contained diatoms, mainly *Chaetoceros atlanticus* and *Chaetoceros dichaeta*, numerous Radiolaria, large phytophagous species of Calanoida and Pteropoda, mainly *Limacina*, and also predatory Chaetognatha. Large quantities of phytophagous A ppendicularia, krill larvae and naupli, and also predatory Polychaeta occur at the SW to NE border of the "continental" and "antarctic" communities (Fig. 2). This area corresponds approximately to the "Continental Water Boundary" (WHITWORTH, III, 1980) at the junction of continental and antarctic water masses. Highest values of chlorophyll *a* were found there. This is also an area of the most intensive krill feeding. Considerable quantities of postlarval Nototheniidae were found in the krill catchments obtained above the shelf, on the northern side of the South Shetland Islands.

Our results support observations of MACKINTOSH (1934) and to his conclusions, they add informations about the distribution of many taxa. These organisms form communities with distinct trophic interrelations. In our opinion, the main decisive force which determines the distribution of these plankton assemblages and individual species is not, as MACKINTOSH (1934) stated, the upwelling of the "new" water in the area of South Shetland Islands, but an inflow of waters from the Weddell Sea, the intensity of the inflow and its extent. The meeting boundary of waters inflowing from the Weddell Sea with waters of the Bransfield Strait runs at the surface in the centre of the Strait and it is parallel to the Antarctic Peninsula. A clear boundary of the shelf waters of the Antarctic Peninsula and the Bellingshausen Sea with waters inflowing from the Weddell Sea and the local Bransfield waters are visible in the western part of the Bransfield Strait. Another boundary exists north of South Shetland Islands between "continental" it means Antarctic Peninsula waters from the Bellingshausen Sea and Drake Passage waters. The mixing water boundaries are main areas of krill concentrations. As suggested previously (RAKUSA-SUSZCZEWSKI, 1978; RAKUSA-SUSZCZEWSKI and STĘPNIK, 1980), our present results indicate, that hydrodynamic conditions are the decisive forces in the formation of krill swarms. Net plankton collections are characterized by the presence of certain distinct taxa and groups of organisms. An analysis of distribution of these distinct communities and particular species, may provide good indicators of the hydrological situation in the research area. It may also provide indicators of the dynamics of seasonal changes which should be one of the basic research goals during SIBEX.

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