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Distribution and Abundance of Planktonic Organisms in Bransfield Strait During Austral Summer 1989/1990

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Abstract : To delineate plankton distribution and abundance in Bransfield Strait, located between the Antarctic Peninsula and South Shetland Is., a total of 29 sampling stations was chosen in a systematic grid from December 29, 1989 to January 7, 1990. Phytoplankton were abundant in the northeastern entrance of Bransfield Strait and the coastal areas of the Antarctic Peninsula where water mass of the Weddell Sea might intrude. Diatoms were dominant (52 species out of 57 identified species) in most stations; especially, *Chaetoceros socialis* and *C. neglectus* were dominant near the Antarctic Peninsula coast. In mid strait, the biomasses of phytoplankton were low, and evenly distributed through the water column, while high biomasses were shown in the upper 50m of the water column at coastal stations. A total of 39 taxa of zooplankton were identified from samples. Several species of copepoda were the most abundant (57.7%) in terms of number, and followed by salpa (27.7%), chaetognatha (6.7%), and euphausia (1.3%). However, noticeably, macrozooplankton salpa (*Ihlea* sp. and *Salpa* sp.) predominated over the entire Bransfield Strait occupying 20 stations, and showed the highest biomass in zooplankton community. The highest number of salpa was shown in the northeastern entrance of Bransfield Strait, while low numbers were found along the stations near the Antarctic Peninsula coast. Fish larvae and euphausia were rarely found in the entire strait.

Key words : plankton, salpa, krill, Bransfield Strait

Introduction

Bransfield Strait is a long (about 300 km) and wide (about 100 km) strait between the Antarctic Peninsula and several islands of the South Shetland Islands – King George Is., Nelson Is., Livingston Is., and Smith Is. (Fig. 1). The northeastern tip of the strait faces the Scotia Sea and the Weddell Sea, and the southwestern entrance of the strait connects to Gerlache Strait and the eastern part of the Bellingshausen Sea. In the strait proper, one narrow and deep (max. over 2000 m) trough is present on the island side (i.e., in the northern part of the strait), and broad and shallow bottom topography is apparent in the southern part (see Fig. 1 in Hong et al. of this volume).

The composition of water masses in the surface of Bransfield Strait is complicated because the water masses are the mixture of the warm and dilute Bellingshausen Sea water and the cold and saline Weddell Sea water (Clowes, 1934; Heywood, 1985). Suk (1990) speculated that the most surface water entered from the southwestern entrance (i.e., Gerlache Strait, and passages between Low Is., Smith Is., and Snow Is.), and headed to the northeast in the northern part of the strait. A small amount of water mass seems to enter from the Weddell Sea via a pass between the Antarctic Peninsula

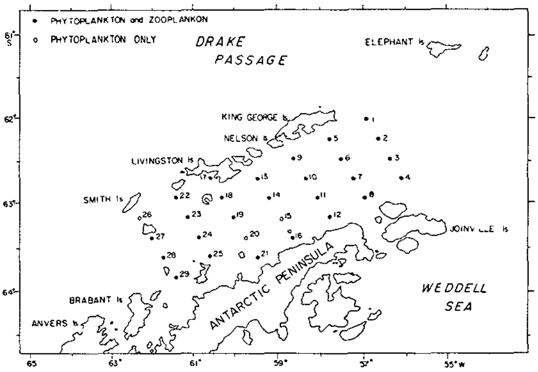

Fig. 1. Map showing the sampling station in Bransfield Strait. Open circles indicate phytoplakton sampling stations, and closed circles both phytoplankton and zooplankton

and Joinville Is., flows toward the southwest close to the Antarctic Peninsula, and turns to the north at the east of Trinity Is. (Suk, 1990).

The complexity of water sources in Bransfield Strait resulted in the variety of planktonic organisms, and the variabilities in oceanic environment could influence the species composition and abundance from year to year. Kopczynska and Ligowski (1985) argued that the joining of different water masses in Bransfield Strait might effect the growth of phytoplankton. Also, a group of scientists hypothesized the dispersion pattern of krill from Gerlache Strait to the Scotia Sea via Bransfield Strait. In this case, Bransfield Strait can be regarded as a bridge connecting these two areas, and the changes in coastal current along the Antarctic Peninsula is one of the important factors influencing krill survival and distribution (P.P. Niiler, personal communication, Scripps Institute of Oceanography, U S A).

Aside from the importance of natural phenomena in Bransfield Strait, easy access to this area during austral summer caused the intensive researches. Due to the relatively mild weather condition of this region, South Shetland area is becoming a capital of the Antarctica. For example, 6 overwintering scientific stations (Argentina, Chile, China, Korea, Uruguay, USSR) have been established in Maxwell Bay of the King George Is., and a total of 9 stations located in the South Shetland Is. area. Consequently, the areas adjacent to the South Shetland Is. including Bransfield Strait have been the first place for the Antarctic research by several research groups (KORDI, 1988 and 1989; INACHI, 1985; RDEPA, 1989).

To understand the structure of foodweb in Bransfield Strait the species composition, distribution, and abundance of phytoplankton and zooplankton were investigated in relation to some environmental factors such as sea water temperature and salinity. Furthermore, this study could be one of the basis to delineate the ecosystem of Antarctic and the mechanism controlling the fluctuation of the population abundance of plankton.

Materials and Methods

The survey was conducted aboard the M/V *Eastella* in Bransfield Strait from Dec. 29, 1989 to Jan. 9, 1990. Phytoplankton were collected using 12 10-ℓ Niskin water samplers mounted on a rosette at 29 sampling stations (Fig. 1). At each sampling station, CTD cast and water collection at the standard depth (0, 10, 20, 30, 50, 75, 100, 150, 200, 250, and 300 m) were done at the same time. For the phytoplankton study, 1-ℓ of water was taken from the water bottle and filtered with 20 μm mesh. The concentrated samples were fixed with 5 % formalin.

Zooplankton was collected at 26 stations (Fig. 1). At the first 12 stations, a 60 cm diameter bongo sampler with 0.250 mm and 0.505 mm size mesh was lowered, and a 1-m ring net (mesh: 0.335 mm) was used at another 14 stations due to the loss of the bongo net during the survey. Oblique tows were initiated at a ship speed of about 2 knots from 200−300 m in depth and hoisted to the surface. Flowmeters in the nets recorded the amount of water filtered. When the nets reached the surface, they are brought aboard and hosed down to wash the sample into the codend. Samples were transferred to 1-ℓ or 3.5-ℓ sample bottles, and preserved in about 10 % formalin.

In the laboratory, numbers of phytoplankton were counted on a Sedgwick-Rafter counter, and transformed to cell numbers per liter. Samples were identified under a microscope (400 x, or 1000 x) and a scanning electron microscope (JEOL 35CF). For the large amount of zooplankton samples, subsampling was done using Folsom plankton splitter, and specimens were identified and quantified to the species level, if possible. Flowmeter calibration and zooplankton density at the sampling station were calculated according to Smith and Richardson (1977), and zooplankton numbers in the entire Bransfield Strait were estimated by polygon method.

Results and Discussion

1. Phytoplankton

A total of 57 taxa of phytoplankton was found from the survey (Table 1 ; Fig. 2), and diatoms were especially dominant (23 genus, 40 species, and 2 unidentified). Genus *Chaetoceros, Nitzschia* and *Thalassiosira* showed the variety in species composition (5, 8 and 11 species, respectively), and most species that appeared were representative of Antarctic species. Also, as reported by Kopczynska and Ligowski (1985), *Chaetoceros neglectus, C. socialis,* and *C. tortissimus* were frequently found.

A relatively high abundance of phytoplankton was found in the areas (stations 1, 2, 3, 4, 7, and 8) close to the Weddell Sea and coastal area along the Antarctic Peninsula (stations 12, 16, 20, and 21) (Fig. 3). At stations 1 and 2,

Table 1. List of phytoplankton collected from Bransfield Strait during austral summer 1989/1990.(Some species marked with * are shown in Figure 2.)

Bacillariophyceae
- *Actinoeyelus actinochilus* (Ehr.) Simonsen
- *Amphiprora kjelmanii* Cleve
- *Chaetoceros bulbosus* (Ehr.) Heiden
- *C. convolutus* Castracane
- * *C. neglectus* Karsten
- *C. socialis* Lauder
- C. tortissimus Gran
- *Cocconeis costata* Gregory
- * *Coscinodiscus bouvet* Karsten
- * C. centralis Ehrenberg
- *C. oculus-iridis* Ehrenberg
- * *Corethron criophilum* Castracane
- *Cylindrotheca closterium* (Ehr.) Reimann & Lewin
- *Dactyliosolen antarctica* Cartracane
- D. tenuijuntus (Manguin) Hasle
- * *Eucampia antarctica* (Castr.) Mangin
- *Fragilaria* sp.
- *Gomphonema* sp.1
- *Gomphonema* sp.2
- *Gyrosigma* sp.
- * *Licmophora gracilis* (Ehr.) Grunow
- *Licomphora* sp.
- *Navicular* sp.
- *Nitzschia curta* (Van Heurck) Hasle
- * *N. cylindrus* (Grun.) Hasle
- *N. heimii* (Manguin) Hasle
- *N. kerguelensis* (O'Meara) Hasle
- *N. lineata* Hasle
- *N. lengissima (Breb.) Ralfs*
- *N. sublineata* Hasle
- *Nitzschia* sp.
- *Odontella weissiflogii (Janisch) Grunow*
- *O. litigiosa* (Van Heurck) Hoban
- *Odontella* sp.
- *Pinnularia* sp.
- *Porosira glacialis* (Grun.) Jorgensen
- *Rhizosolenia alata* Brightwell
- * *R. alata* f. *inermis* (Castr.) Hustedt
- *R. hebetata* f. *semispina* (Hensen) Gran
- *Stellarima microtrias* (Ehr.) Hasle & Sims
- * *Thalassiosira antarctica* Comber
- *T. gracilis* (Karst.) Hustedt
- *T. gravida* Gleve
- *T. lentiginosa* (Janisch) Hasle
- *T. ritscheri* (Hust.) Hasle
- *T. trifulta* Fryxell
- *T. tumida* (Janisch) Hasle
- *Thalassiosira* sp.1
- *Thalassiosira* sp.2
- *Thalassiosira* sp.3
- *Thalassiothrix antarctica* (Schimper) Karsten
- *Tropidoneis antarctica* (Grun.) Cleve

Dinophyccae
- *Protop[eridinium antarctica* (Schimper) Balech
- *Protoperidinium* sp.
- *Prorocentrum* sp.
- Gymnodinium sp.
- *Gyrodinium* sp.

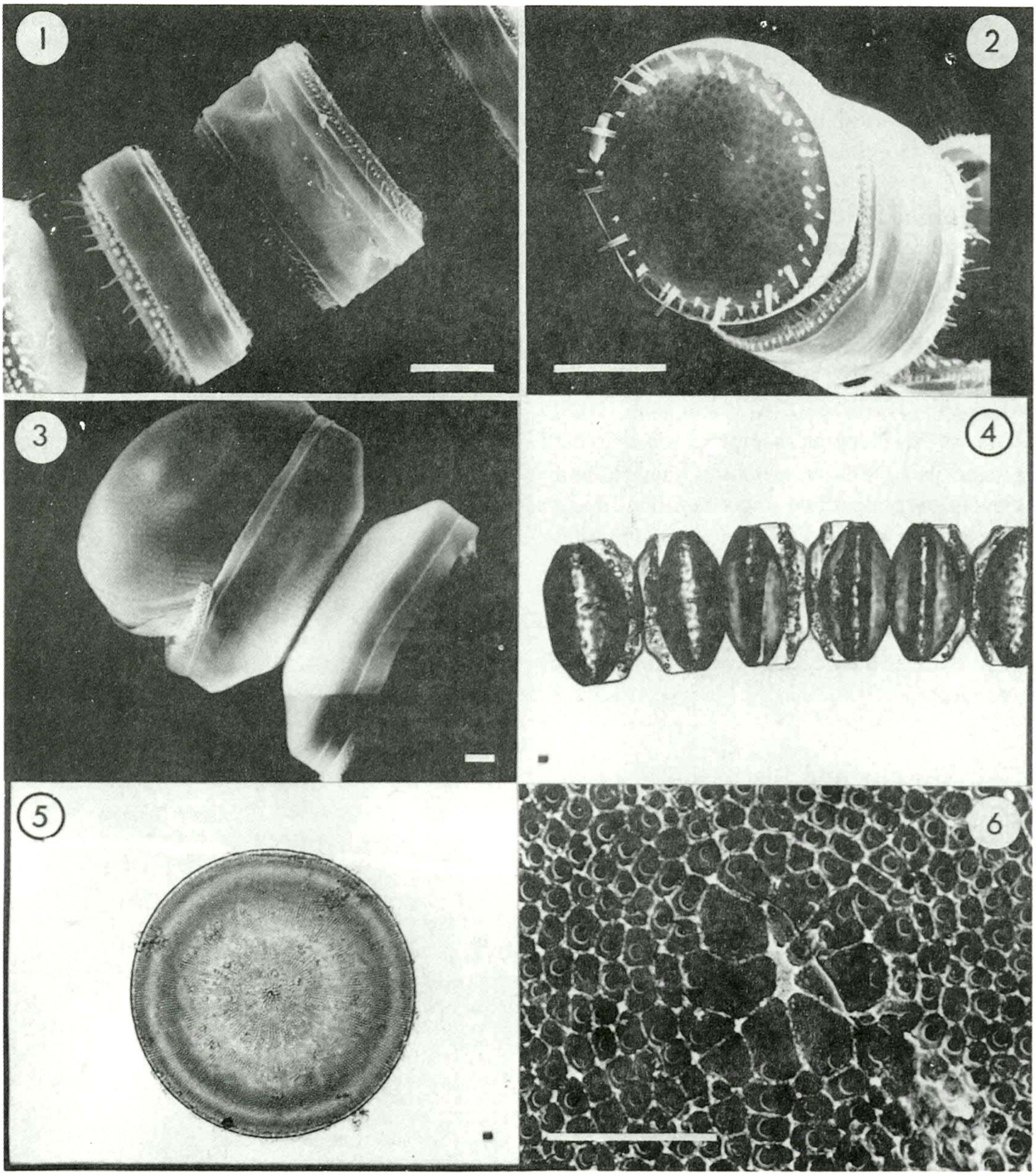

Fig. 2. Some photographs of phytoplankton found in Bransfield Strait in 1989/90.

1. *Thalassiosira antartica* (girdle view)
2. *Thalassiosira antartica* (valve view)
3. *Coscinodiscus bouvet* (girdle view)
4. *Coscinodiscus bouvet* (chain form)
5. *Coscinodiscus centralis* (valve view)
6. *Coscinodiscus centralis* (central rosette)

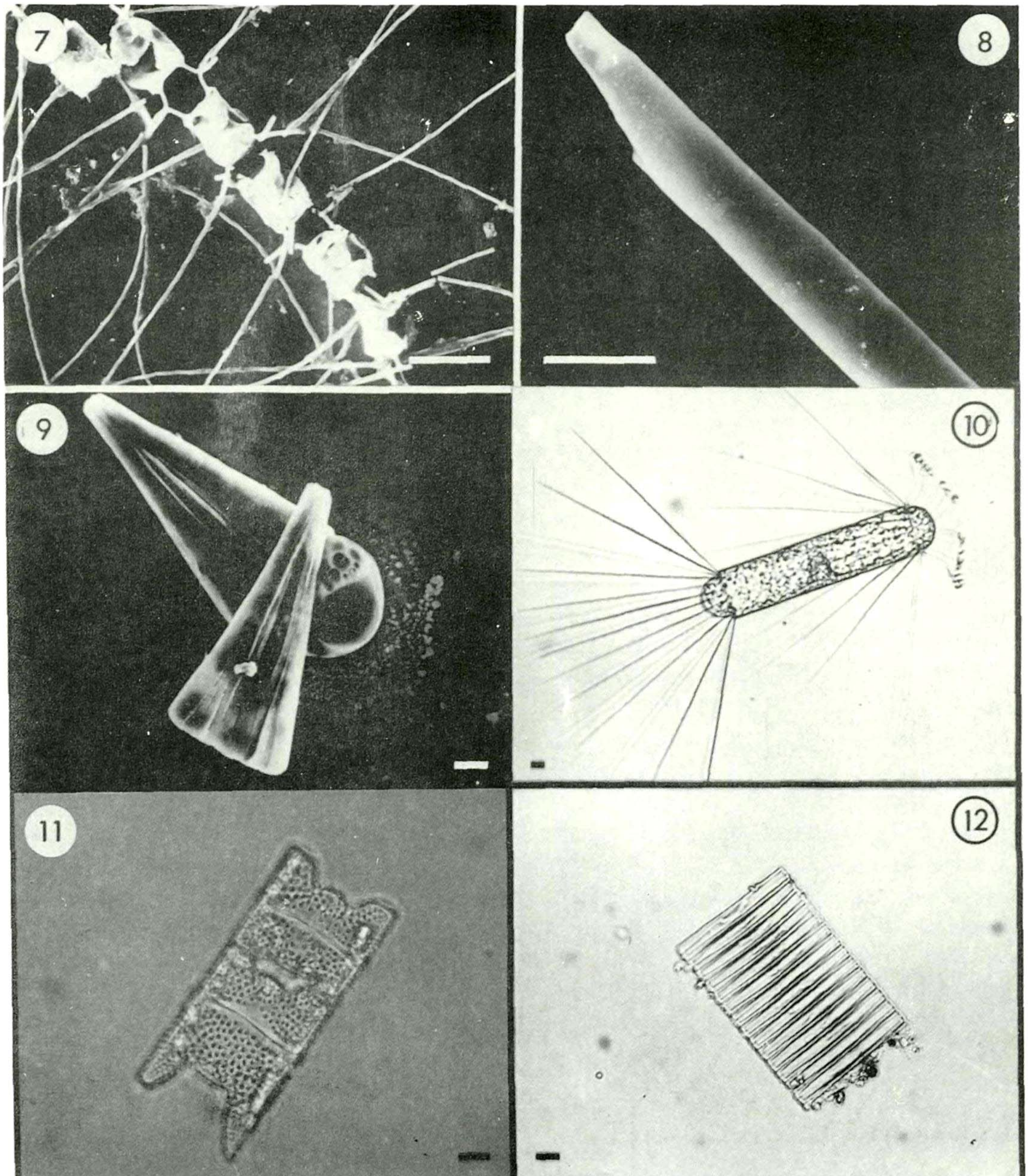

Fig. 2. (Continued)

7. *Chaetoceros neglectus*
8. *Rhizosolenia alata* f. *inermis*
9. *Licmophora gracilis*
10. *Corethron criophilum*
11. *Eucampia antarctica*
12. *Nitzschia cylindrus*

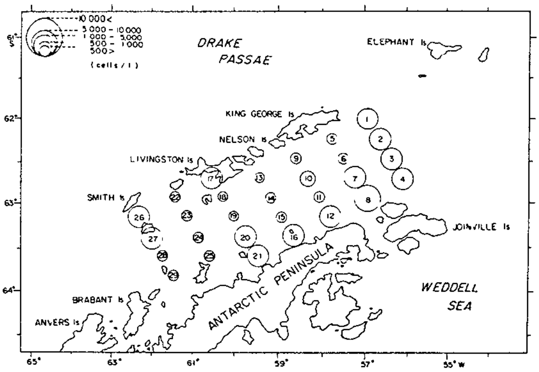

Fig. 3 . Densities of phytoplankton(cell/ ℓ) in study area.

Rhizosolenia hebetata f. *semispina* was dominantly distributed, while *Corethron criophilum* occupied a large proportion in biomass at stations 3, 4 and 7, and *C. socialis* and *C. neglectus* at stations 8, 12 and 20. Such a distinction in distribution of dominant species might be caused by the influence of oceanic environment. Especially, the more than 70 % total of phytoplankton biomass, *C. socialis* at station 8 which faces the entrance of Weddell Sea, serves as good evidence showing the environmental effect on organism distribution because *C. socialis* is a representative species of the Weddell Sea. It is apparent that low biomass was popular in the central and northern parts of the strait except in a few areas near islands. The mixture of several water masses originating from different regions may have produced the low stability of ocean surface layer which, in turn, prohibited the growth of phytoplankton (Kopczynska and Ligowski, 1985).

There was no typical pattern of vertical distribution of phytoplankton in Bransfield Strait. However, phytoplankton distributed evenly at the central part of the strait (stations 5, 6, 9, 11, 13, 14, 18, 19, 22, 23, 24, 25, 28, and 29) where the biomasses were low, while the high proportions appeared in 10−50 m at some fertile regions (stations 1, 2, 8, 16, and 17) (Fig. 4). Also, it is worthy to note that some stations (stations 12, 20, and 21) near the Antarctic Peninsula had high densities of phytoplankton below 100m.

2. Zooplankton

A total of 39 taxa of zooplankton were identified in the survey area (Table 2). Amongst these, 20 groups were examined to species level, 10 groups to genus, and others to family or group. In general, the number of taxon groups found at sampling stations was small (less than 8 groups in average). The area near the Antarctic Peninsula, however, showed a relatively high numbers in species composition (i.e., 11−16 groups in stations 4, 8, 12, and 19).

Salpa, copepoda, and chaetognatha were found in, at least, 50 % of total stations, while other groups of zooplankton had occupied only a small portion of Bransfield Strait (Fig. 5). *Ihlea racovitzai*, a salpa species, appeared at 17 stations out of 26 stations (i.e., 65 % of occurrence), *Calanoides acutus* (copepoda) at 16 stations, *Eukrohita hamata* (chaetognata) at 14 stations, *Salpa thompsoni* at 13 stations, and 27 taxon groups (73 %) were found at less than 7 stations (less than 30 % of occurrence). Unexpectedly, *Euphausia superba* (a krill species) was rarely found during the survey period, though some investigations described high abundance of krill in Bransfield Strait (Uribe, 1983; Arcos and Bonilla, 1989).

High abundances of zooplankton were found at the northeastern and southwestern tips of the strait (Fig. 6). Copepoda, *Amallothrix* sp. and *Oithona similis*, were dominant (revealing 84 % and 64 % of the total numbers of zooplankton, respectively) at the area near the tail part of the Antarctic Peninsula where it might be strongly influenced by the Weddell Sea water mass. Especially, *Amallothrix* sp. seems to originate from the Weddell Sea because that area only contained *Amallothrix* sp. in Bransfield Strait. The fact that the high abundance appeared at the boundary area with Gerlache

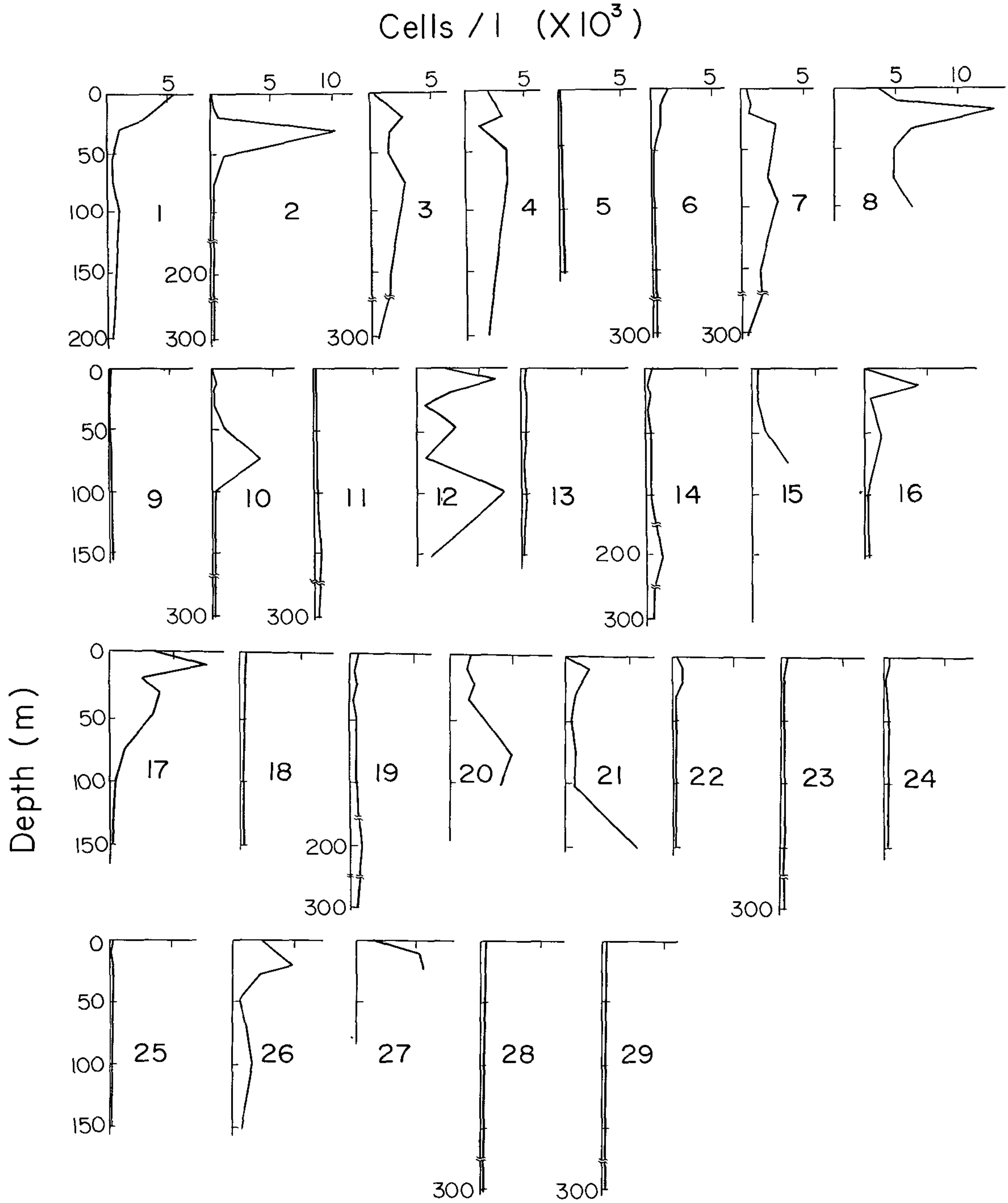

Fig. 4. Vertical distribution of phytoplankton from Bransfield Strait. Numbers indicate samping stations

Table 2. List of zooplankton sampled in Bransfield Strait during austral summer 1989–1990

Chaetognatha
Eukrohnia hamata
Eukrohnia sp.
Sagitta sp.
Copepoda
Amallothrix sp.
Calanus propinqnus
Clausocalanus laticeps
Ctenocalanus vanus
Cyclopoida spp.
Haloptilus ocellatus
Metridia gerlachei
Oithona frigida
Oithona similis
Oncaea antarctica
Oncaea sp.
Paralabidocera antarctica
Pareuchaeta antarctica
Racovitzanus antarcticus
Rhincalanus gigas
Rhincalanus nasutus
Scaphocalanus subbrevicornis
Scolecithricella glacialis
Harpacticoida spp.
Amphipoda
Brachyscelus sp.
Cyllopus magellanicus
Themisto gaudichaudii
Vibilia sp.
Ostracoda
Euphausia
Euphausia superba
Thysanoessa macrura
Thysanoessa sp.
Appendicularia
Salpa
Ihlea megalhanica
Ihlea racovitzai
Ihlea sp.
Salpa thompsoni
Salpa sp.
Polycheta larva
Decapoda larve
Fish larvae

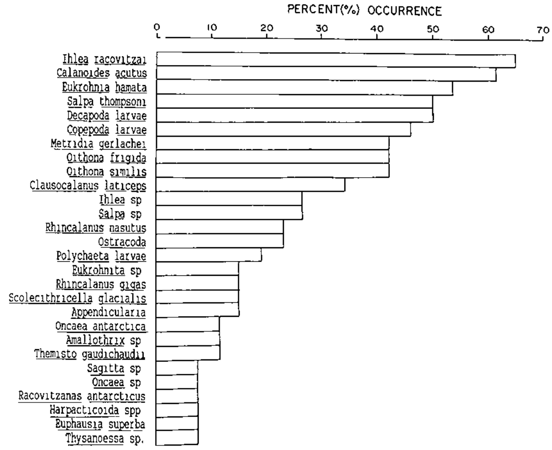

Fig. 5. Percentage occurence of zooplankton caught from 26 samping stations in Bransfield Strait during austral summer 1989/90.

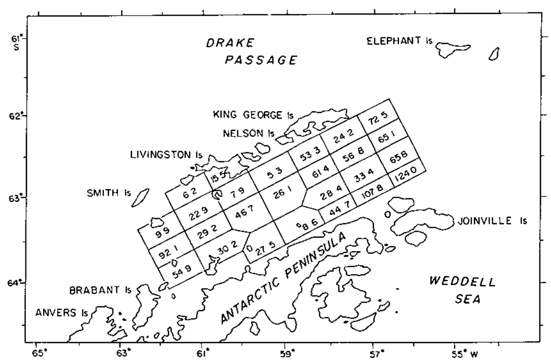

Fig. 6. Zooplankton abundance (in number $\times 10^{10}$) in the upper part (shallower than 300 m) of the water column in Bransfield Strait during austral summer 1989/90. Polygon method was used for the boundary of each grid.

Strait inferred some productive biological processes in Gerlache Strait.

The estimated number of total zooplankton was 1120.7×10^{10} which was composed of copepoda (57.7 %), salpa (27.7 %), chaetognatha (6.7 %), and euphausia (1.3 %) (Table 3).

Table 3. Composition of zooplankton caught from Bransfield Strait during austral summer 1989–1990.

Zooplankton	Abundance ($\times 10^{10}$)	Relative abundance (%)
Copepoda	647	57.7
Salpa	310	27.7
Chaetognatha	75	6.7
Ostracoda	16	1.4
Euphausia	15	1.3
Amphipoda	7	0.6
Appendicularia	5	0.5
Polychaeta larvae	11	1.0
Decapoda larvae	34	3.0
Fish larvae	1	0.1
Total	1,121	100.0

This species composition is significantly different from Mujica and Asencio's (1985) study. They showed 74.8 % of copepoda, 13.1 % of salpa, 2.9 % of chaetognatha, and 4.2 % of euphausia during the austral summer 1983/1984, which revealed a large fluctuation in zooplankton biomass of each species between years.

The most abundant zooplankton was copepoda, especially *Oithona similis*, which occupied 15 % of total zooplankton population density of 402 ind./10 m^2 (Fig. 7). The total number of salpa species (*I. racovitzai*, *S. thompsoni*, *Ihlea* sp., and *Salpa* sp.) occupied 28 % of total zooplankton population and such a explosion of salpa species happened not rarely in the Antarctic Ocean (V. Marin, personal communication, Universidad de Antofagasta, Chile). Because of its large size compared to other zooplankton species sampling nets were full of salpa at almost every station, which may have caused improper samplings and biased results due to the clogging of the nets. Also, near the Elephant Is., east of Bransfield Strait, the major species of zooplankton was salpa in 1989/1990 summer (C. Park, personal communication, Chung Nam National University, Korea), and a

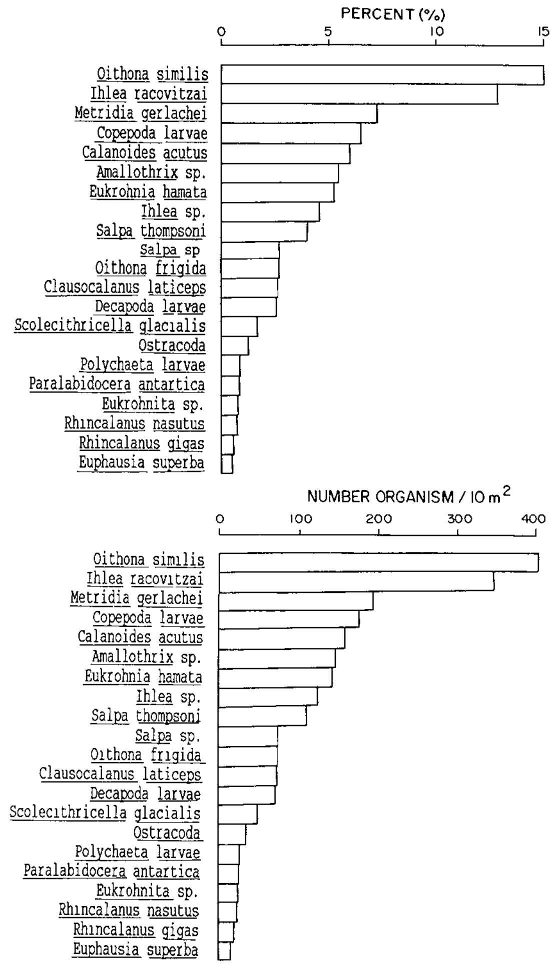

Fig. 7. Rank abundance of zooplankton abundance caught in Bransfield Strait during austral summer 1989/90; (a) percent, (b) population density.

German expedition reported similar results in that they found a massive salpa population in Bransfield Strait (V. Siegel, Unpublished manuscript, Inst. fur Seefischerei, F. R. Germany). The only difference is that *S. thompsoni* was more abundant in the German survey and *I. racovitzai* in the Korean survey.

Salpa appeared at 20 stations, and in high abundance at the northeastern tip of Bransfield Strait, while there were no salpa in areas (i.e.,

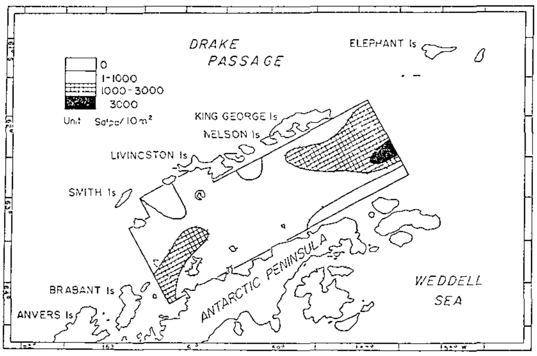

Fig. 8. The spatial distribution of salpa (*Ihlea* sp. and *Salpa* sp.) within Bransfield Strait during austral summer 1989/90.

near the Joinville Is. and Smith Is.) where it is influenced by the Weddell Sea water mass and the Bellingshausen Sea water mass (Fig. 8). Also, salpa abundance tended to increase toward Gerlache Strait at the southwestern entrance. Uribe (1985) revealed extremly high primary production, and Musica and Asencio (1985) showed a high density of zooplankton including krill in Gerlache Strait. The fact that krill become a minor group when salpa flourish is very suggestive. There could be an ecological explanation (e.g., competition for food, or prey—predator relationship) between the fluctuation of krill and salpa populations, as seen in ϕresland (1990) about the relationship between chaetognatha and their food organism (i.e., small size zooplankton).

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