ECOLOGICAL NOTES ON THE DIATOM COMMUNITY OF THE SEA ICE IN ANTARCTICA

BULLETIN OF THE MARINE BIOLOGICAL STATION OF ASAMUSHI,
VOL. X, NO. 4, 1961

ECOLOGICAL NOTES ON THE DIATOM COMMUNITY OF THE SEA ICE IN ANTARCTICA[1)]

By

TAKAO HOSHIAI and MUTSUO KATÔ
星合孝男・加藤陸奥雄
Marine Biological Station of Tôhoku University, Asamushi, Japan
Biological Institute of Tôhoku University, Sendai, Japan

It is known that the restricted part of the sea ice above and below the surface of the sea water is coloured by the inhabiting of micro-organisms, such as flagellates and diatoms but the biological accounts on the assemblage of these micro-organisms are few (Fukushima 1960).

Fortunately Mr. Tatsurô Matsuda, a member of the fourth Japan Antarctic Research Expedition, brought back to Japan nine pieces of the coloured ice, ten fixed samples of micro-organisms inhabiting within the coloured part of the sea ice or its adjacent parts, snow, colourless part and sea water below it, and the samples of plankton obtained by towing of a plankton net from sea water.

From these materials the writers attempted to obtain some ecological informations on the micro-organism assemblage in the sea ice.

The materials used for this study were collected by Mr. T. Matsuda during Decebmer 1959 to February 1960 near Lützow Holm Bay.

The micro-organism assemblage of the coloured ice consists of diatoms, flagellates and ciliates, though only the diatoms will be dealt with in this report.

At first, the vertical distribution of the diatoms in the coloured sea ice was examined and the quantity of dimatoms in the sea water below it was ascertained. As is shown in Table 1, the density of diatoms is highest in the coloured part. Diatoms are also found in the colourless part and in the snow, but are thin in density. On the contrary they are scarce in the sea water.

Throughout the samples of the sea ice, 21 kinds of diatoms were distinguished, viz. *Coscinodiscus* sp. 1, *C.* sp. 3, *C.* sp. 4, *C.* sp. 5, *Actinocyclus* sp. *Thalassiosira* sp., *Rhizosolenia* sp. 1, *R.* sp. 2, *Chaetoceros* sp. 1, *Ch.* sp. 2, *Ch.* sp. 3, *Biddulphia* sp., *Streptotheca* sp., *Fragilaria* spp., *Climacophenia* sp., *Diatoma* sp., *Chuniella* sp., *Navicula* sp., *Amphiprora* sp., *Nitzschia* sp. 1 and *Ni.* sp. 2.

1) Contributions from the Marine Biological Station of Asamushi, Aomori-ken No. 285

Table 1
Vertical distribution of diatoms in a mass of the sea ice.

Cell number of diatoms (in 0.25 cc)

	St. 2	St. 6
Snow	6	40
Colourless ice	16	82
Coloured ice	275	221
Sea water below the ice	0	1

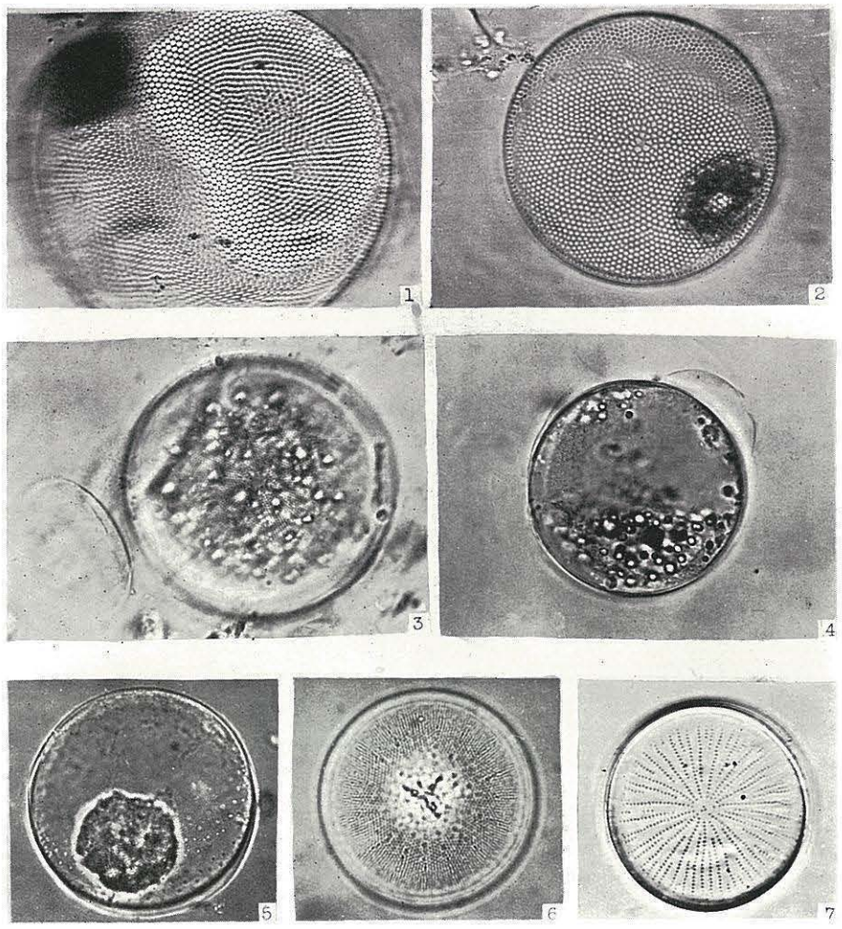


Fig. 1. 1, 2 : *Coscinodiscus* sp. 1, 3, 4 : *C.* sp. 3, 5 : *C.* sp. 4, 6 : *C.* sp. 5, 7 : Actinocyclus sp. (× ca 150).

To know whether the composition of the diatom community in every samples are equal to each other, the relative numerical composition of the constituent

species in each diatom community in every sea ice sample was compared with one another. For the comparison of the community, the occurrence probability method (Katô, Matsuda and Yamashita 1952) was used, namely the percentage of the cell number of each constituent to the total cell numbers in each sample was estimated and represented by the confidence interval in 90 percent reliability. Here, judging from the similarity of the tendency of appearance in every smaple, four kinds which belong to the Genus *Coscinodiscus* and *Actinocyclus* sp. were treated as one group (Fig. 1) and from the synecological view-point *Coscinodiscus* spp., *Chaetoceros* sp. 1, *Fragilaria* spp., *Nitzschia* sp. 1 and *Chuniella* sp. each of which is the dominant species in the diatom community, are dealt with in the present paper.

By this treatment eight types of the diatom community were distinguished as follows ; 1. *Fragilaria* community, 2. *Fragilaria-Nitzschia* sp. 1 community, 3. *Fragilaria-Nitzschia* sp. 1–*Chuniella* sp. community, 4. *Fragilaria-Chaetoceros* sp. 1-*Nitzschia* sp. 1 community, 5. *Chaetoceros* sp. 1–*Fragilaria-Nitzschia* sp. 1 community, 6. *Niztschia* sp. 1–*Fragilaria-Chaetoceros* sp. 1 community, 7. *Chaetoceros* sp. 1–*Nitzschia* sp. 1–*Fragilaria* community and 8. *Coscinodiscus-Chaetoceros* sp. 1-*Fragilaria* community. The composition of the constituent species of the diatom community in every sea ice sample is shown in Fig. 3.

Judging from Fig. 3, the community constitution of these eight types of the diatom community can be classified into three large groups as is shown in the following schema.

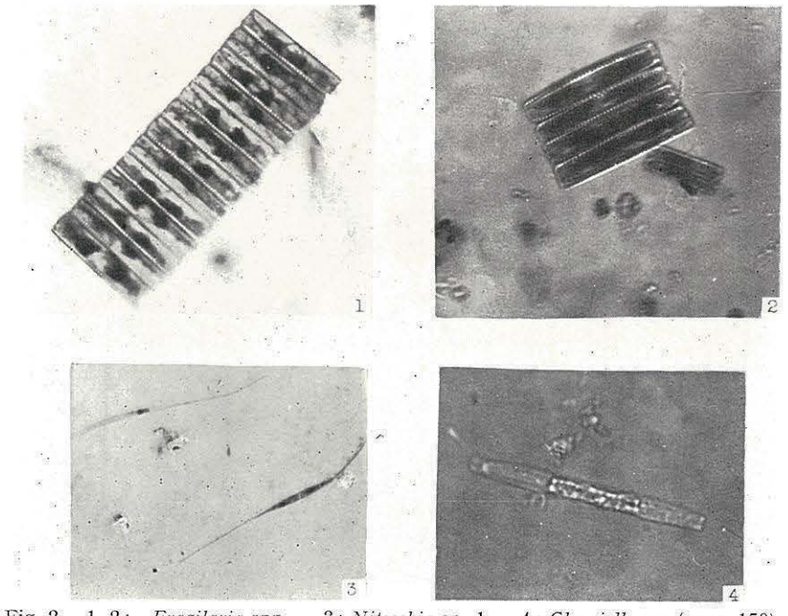


Fig. 2. 1, 2 : *Fragilaria* spp., 3 : *Nitzschia* sp. 1, 4 : *Chuniella* sp. (× ca 150).

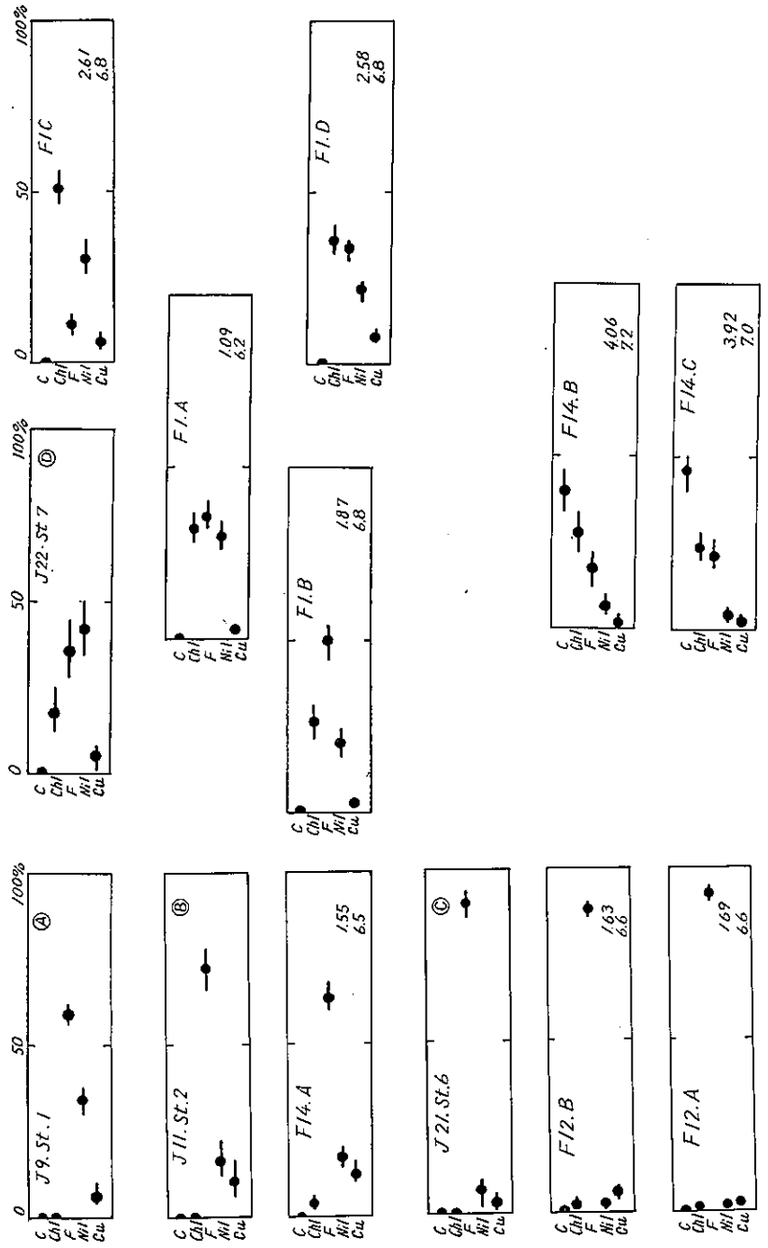
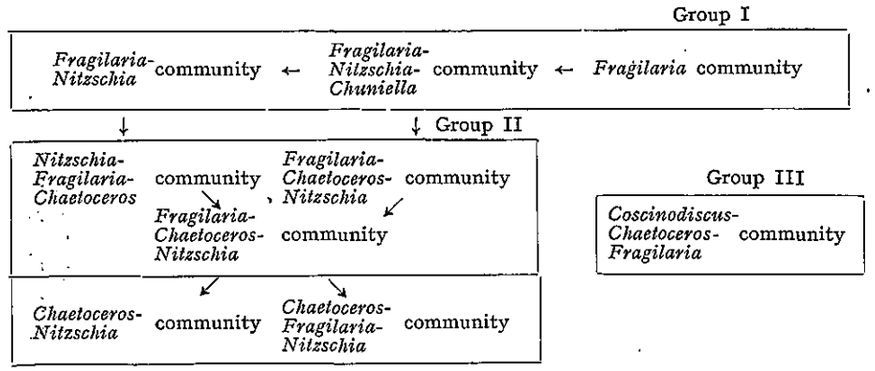


Fig. 3. Relative abundance of constitutent species of the diatom community in the coloured ice is represented by the confidence interval in 90 percent reliability. Species by which the community is characterized are selectively illustrated, i.e. *Coscinodiscus* spp. (C), *Chaetoceros* sp.1 (Ch1), *Fragilaria* spp. (F), *Nitzschia* sp.1 (Ni 1) and *Chuniella* sp. (Cu).

Nine samples of the ice piece are shown as F 1 A, B, C and D, so on, according to the day of collection, February, 1, 12 and 14, 1960. In each of them the chlorinity (‰) and pH are noted.

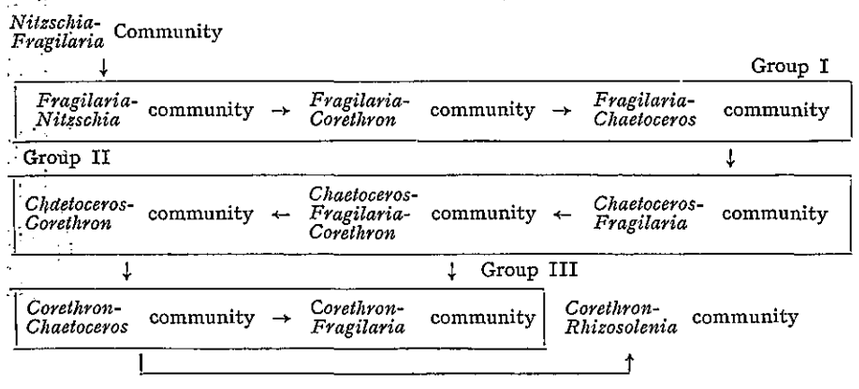


The relation between the diatom community of the coloured ice to that of the sea water was the next question. Before solving this, it is necessary to aquire some accounts on the characters of the diatom community in the sea water.

Coscinodiscus sp.1, *C.* sp.3, *C.* sp.4, *Actinocyclus* sp., *Corethron* sp., *Rhizosolenia* sp.1, *R.* sp.2, *Chaetoceros* sp.2, *Ch.* sp.3, *Ch.* sp.4, *Biddulphia* sp., *Streptocheca* sp., *Fragilaria* spp., *Climacophenia* sp., *Chuniella* sp., *Navicula* sp., *Amphiprora* sp., *Nitzschia* sp. 1, *Ni.* sp. 2 and two species of *Pennales* were recognized in the samples collected by a plankton net.

The same method as in the above case was applied to analyse the diatom community of the sea water. Ten types of community were distinguished as follows; 1. *Corethron-Chaetoceros* sp.2 community, 2. *Chaetoceros* sp.2–*Corethron* community, 3. *Corethron-Rhizosolenia* sp.2 community, 4. *Corethron-Fragilaria* community, 5. *Chaetoceros* sp.2–*Fragilaria-Corethron* community, 6. *Chaetoceros* sp.2-*Fragilaria* community, 7. *Fragilaria-Chaetoceros* sp.2 community, 8. *Fragilaria-Corethron* community, 9. *Fragilaria-Nitzschia* sp.1 community, 10 *Nitzschia* sp.1-*Fragilaria* community.

It seems that these types change in their constitutional character as shown in Fig. 4 and the following schema and can be classified into three groups.



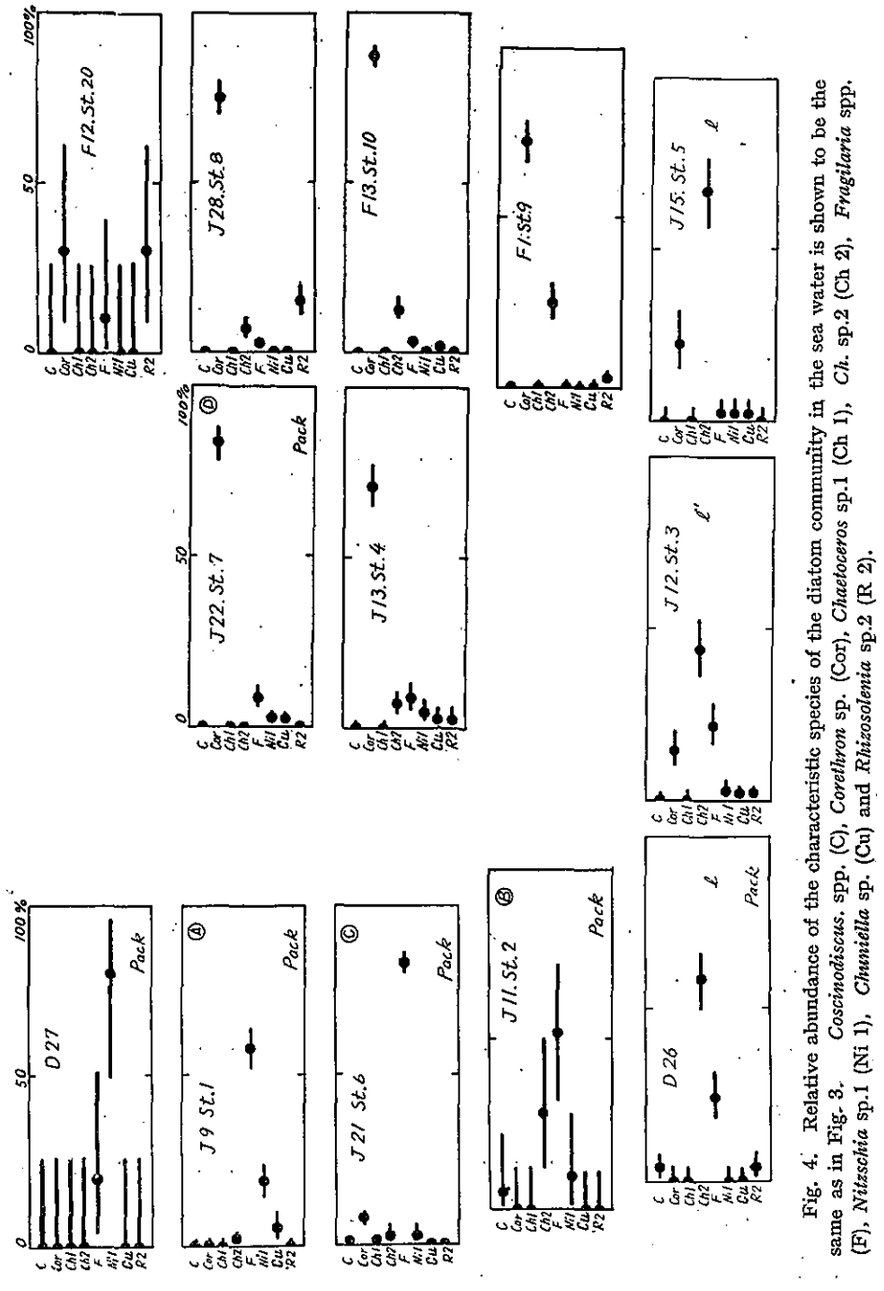


Fig. 4. Relative abundance of the characteristic species of the diatom community in the sea water is shown to be the same as in Fig. 3. *Coscinodiscus.* spp. (C), *Corethron* sp. (Cor), *Ch.* sp.2 (Ch 2), *Fragilaria* spp. (F), *Nitzschia* sp.1 (Ni 1), *Chunitella* sp. (Cu) and *Rhizosolenia* sp.2 (R 2).

Here it is noteworthy that Group I is mainly found in the pack-ice region and Group II and Group III outside the same.

As the results of the comparison between the species in the diatom community of the coloured ice and those in the sea water, it is clarified that the majority of the species are common between the coloured ice and the sea water.

In the sea water, especially in the sea water of the pack-ice region, *Fragilaria* and *Nitzschia* sp. 1 are as common and abundant as in the coloured ice (Group 1). However, one of the remarkable differences between the communities in these two is that *Corethron* sp. *Chaetoceros* sp. 2 and *Rhizosolenia* sp. 2 are characteristic in the sea water outside the pack-ice region, where *Chaetoceros* sp. 1, *Fragilaria* and *Nitzschia* sp. 1 are rather few (Groups II and III in the sea water). Accordingly, the types of the community of the coloured ice are different from those of the sea water outside the pack-ice region.

However, it is imposible to consider that the diatom community of the coloured ice directly relates with that of the sea water, on which the said coloured ice is floating, because the sea ice drifts due to winds and currents (Sverdrup et al, 1942) and because when the ice was formed is obscure. In fact, in the sea ice of St. 7 the *Fragilaria* community is found but in the sea water of the same station the *Corethron-Fragilaria* community (Figs. 3 and 4). On the other hand, the community type of one of three ice pieces which were collected on Feb. 14th belongs to Group I but the others the Group III (Fig. 4). It may be supposed that the ice-masses in which the materials were collected on Feb. 14th had been brought from different locations and mixed by winds and currents where the diatom communities are different from one another or that they are formed at a different time, when the community appeared in the sea.

On the other hand, it is easily supposed that the character of the ice-masses themselves which are formed under the different conditions may differ from each other. Accordingly, if the diatom community develops in the sea ice, it is considered that under different conditions one community diverges to different communities and that in a definite place the community changes with the lapse of time.

To analyse these problems, the chlorinity and pH of each of the pieces of the sea ice were estimated as the indicator of the habitat of the diatoms. As is illustrated in Fig. 3, chlorinity and pH agree with each other. In Group I, chlorinity and pH are lower and in Group III they are higher. The values of these two factors are characteristic in each of the groups of the diatom community, except Feb. 14 A of Group II.

Consequently, it becomes necessary to analyse how the community changes with the lapse of time in each of the definite stations, whose environmental conditions differ from each other as well as to know the composition of the diatom community in the sea water at the time when it freezes and the kinds of diatom

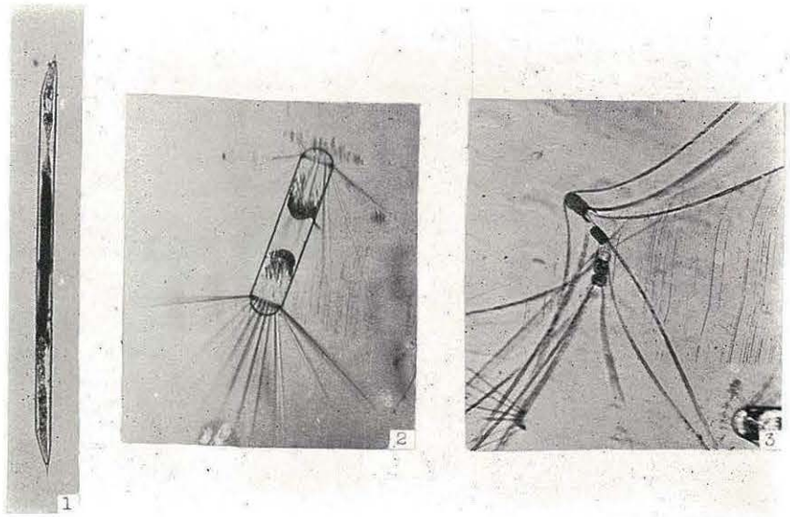


Fig. 5. 1: *Rhizosolenia* sp.2, 2: *Corethron* sp., 3: *Chaetoceros* sp. 2 (× ca 150).

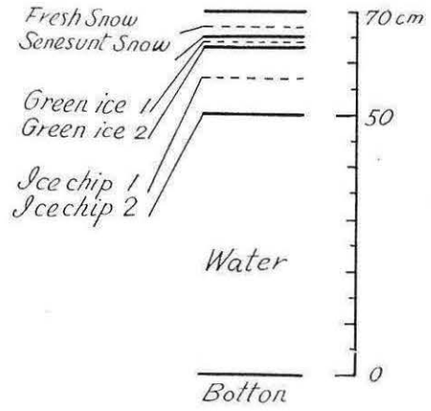


Fig. 6. Schema of the vertical situation of the green ice in the ice-mass of the pond.

that are enclosed in the sea ice.

But, as it is difficult to trace the developmental process of the diatom community in the sea ice of Antarctica, the materials to be used for comparative study were searched for and the green ice coloured by *Chlamydomonas* sp. is found in a pond near the Asamushi Marine Biological Station.

Snow and ice are divided into six parts (Fig. 6). The population density of *Chlamydomonas* sp. is higher at the green granulated ice layer near the surface of the ice-mass (Table 2). In the layers where chips of ice are floating, its density is not so high and no *Chlamydomonas* sp. is found in the water below the ice-mass but *Colpidium* sp., *Volticera* sp., *Halteria* sp., *Melosira* sp., *Pleurosigma* sp. and *Navicula* sp. are observed.

The horizontal distribution of *Chlamydomonas* sp. in the ice, especially in the green layer, is not uniform.

To observe how *Chlamydomonas* sp. is enclosed within ice, a preliminary experiment was carried out.

Table 2

Vertical distribution of *Chlamydomonas* sp. in the ice-mass of the pond.

	Individual number of *Chlamydomonas* sp. (in 0.05 cc)
Fresh snow	0
Senescent snow	121
Green ice 1	159
Green ice 2	390
Ice chip 1	6
Water of ice chip 1	48
Ice chip 2	16
Water	0

Chlamydomonas suspension, the melted green ice, is divided into two parts, A and B. After a mass of snow is added to A and the melted snow to B, they are left under the open sky from 7 p.m. of Feb. 23, 1961 to 7 a.m. of Feb. 24, at dark night.

In A, water froze completely but the ice was not uniform. In B, only the upper half of the water frozed and the condensed *Chlamydomonas* suspension remained. The population density of *Chlamydomonas* sp. in each of the different parts of the ice in A and that in B is illustrated in Table 3. In both A and B, it is rather high on the upper surface, but it is lower in the colourless ice of B. The density of *Chlamydomonas* sp. varies among the different parts of the green ice and it is highest at the granulated ice part.

Table 3

Individual number of *Chlamydomonas* sp. enclosed in the various parts of ice. (in 0.05cc)

A	
Uppersurface of ice	141
Hard part	208
Granulated part	251
Green ice Snow-mass remained	189
Thin coloured part	85
Colourless ice	53
B	
Upper surface of ice	173
Colourless hard ice	5
Remained suspension	294

In the remaining *Chlamydomonas* suspension the population density is rather high. From this observation it is possible to say that *Chlamydomonas* sp. is able to be enclosed in the ice-mass and that under such a condition as snow floating on the water surface the density of embedded *Chlamydomonas* sp. is higher.

LITERATURE CITED

FUKUSHIMA, H., 1960. Biocommunities in Ongul island district. Bull. Yokohama City Univ. Soc. **12** (Nat. Sci.) : 29–37.

KATÔ, M., T. MATSUDA and Z. YAMASHITA, 1952. Associative ecology of insects found in the paddy field cultivated by various planting forms. Sci. Rep. Tôhoku Univ. (Biol.) **19** : 291–301.

SVERDRUP, H.U., et al, 1942. The oceans. Their phisics, chemistry and general biology. pp. 623, New York, Printice-hall, Inc.