STUDIES ON YOSA-NAIKAI

4. Classification of Phytoplankton Communities and Relation between Communities and Water Masses.※

Hiroshi MAÉDA

In the 2nd and 3rd reports of this series (MAÉDA, 1953), I refered to the influence of the river water upon the lagoon water, classification of water masses and the relation between benthonic communities and water masses. As the living benthos is confined to the narrow and shallow marginal part of the lagoon, the relative importance of the plankton investigation must be emphasized here much more than elsewhere from the productional point of view. Nevertheless, I have done only a little about the plankton, namely a short note about the settling volume. In this report, I want to examine the composition of phytoplankton collected at the observation of May 10~12 1950, and analyse phytoplankton communities by using MOTOMURA's correlation coefficient method to know whether phytoplankton communies found in the areas influenced strongly by water from other water systems, Miyazu Bay and the river Noda, differ from that of the lagoon proper or not and whether the composition of phytoplankton communities is changeable by stagnation or not.

Before entering the subject, I must express my sincere thanks to Prof. Dr. D. MIYADI for his kind guidance and criticism given to my work, also to Dr. T. TOKIOKA for his kind advices and to Mr. S. KAWAI (Zoological Institute, Kyōto University) who helped extensively during the observation.

Classification of Phytoplankton-communities

As reported in the 2nd report of this series, the lagoon water is stratified vertically in 3 layers, *e. i.* upper, chemocline and stagnant layers, besides the inflow of two layers, brackish one from the river Noda and the other from Miyazu Bay. For the reasons mentioned above, the composition of plankton-communities is considered naturally to be divisible vertically in several different types according to respective water layers. Thus, in order to catch plankton-communities in respective water layers separately, 1 l of sea water was collected by KITAHARA'S water sampler whenever the water for chemical analyses was sampled. The water was concentrated into 10 cc by filtration by silk plankton-net and after the settling volume was measured, individual or cell number of each species in 1 cc was counted in LAFTER's cell (25 mm long × 40 mm wide × 1 mm deep). The results are shown in table 1.

※ Contributions from the Shimonoseki College of Fisheries, No. 159.

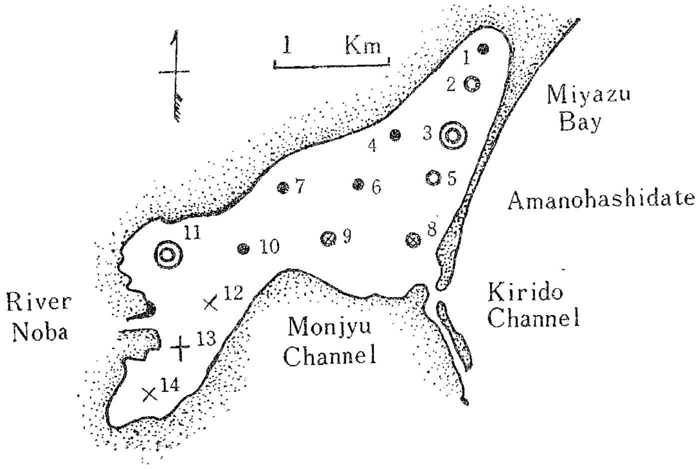

Fig. 1. Map of Yosa-naikai.

Remarks :

Numbers indicate the position of stations.

● : only the stagnant layer community was observed.
○ : besides the stagnant layer community, a layer of the upper layer community was observed.
◎ : besides the stagnant layer community, two layers of the upper layer community were observed.
× : besides the stagnant layer community, a layer of the intermediate community was observed.
+ : besides the stagnant layer community, two layers of the intermediate community were observed.
⊗ : besides the stagnant layer community, a layer of the intermediate community and that of the upper layer one were observed.

It is clearly desirable to pay some considerations also on zooplankton as well as phytoplankton when we refer to the classification of plankton-communities. However, I am obliged this time to treat phytoplankton only, because the used water sampler was not suitable for collecting zooplankton and consequently the amount of zooplankton in each sample was too small to be treated statistically.

Table 1. Composition of Plankton in Yosa Naikai (May 10—12, 1950)

Station	2				3				5				
Depth of sampling (m)	0	3	6	9	0	5	10	12	0	3	6	9	12
Total Number													
Phytoplankton ($\times 10^3$ cells)	208.7	120.8	341.6	25.7	249.2	165.3	99.2	10.5	136.6	167.3	10.2	39.0	12.7
Dinoflagellata (cells)	0	600	0	110	30	900	9700	180	130	1400	100	60	20
Zooplankton (individuals)	340	390	420	80	300	900	2500	20	530	700	20	210	40
Settling Volume cc/l	1.0	1.1	0.8	0.15	0.3	1.1	0.1	0.1	0.2	0.6	0.1	0.1	0.1

Station	6							7			8					9				
Depth of sampling (m)	0	2	4	6	8	10	12	0	6	11	0	3	6	9	12	0	3	6	9	12
Phytoplankton ($\times 10^3$ cells)	26.8	17.8	106.3	182.1	23.7	17.3	7.0	27.0	51.8	3.7	291.3	58.1	91.1	37.4	12.8	25.3	125.7	70.6	43.2	10.4
Dinoflagellata (cells)	120	360	600	26900	5350	600	170	50	4800	60	0	200	850	3790	220	30	40	1650	340	70
Zooplankton (individuals)	620	510	440	2800	470	1040	120	200	90	60	1400	360	400	270	240	450	440	550	340	120
Settling Volume cc/l	0.4	1.9	1.1	1.2	0.2	0.2	0.1	0.2	0.3	0.1	0.8	0.3	0.5	0.2	0.1	0.4	1.0	0.3	0.2	0.1

Station	11			12				13			14		
Depth of sampling (m)	0	5	9	0	2	4	7	0	3	6	0	2	5
Phytoplankton ($\times 10^3$ cells)	19.0	113.6	24.6	48.9	54.1	78.2	105.7	65.3	110.5	169.9	25.9	315.3	27.8
Dinoflagellata (cells)	60	650	3560	130	5160	560	11650	160	280	4600	280	560	2000
Zooplankton (individuals)	560	600	560	980	100	1230	2800	680	610	1160	660	540	940
Settling Volume cc/l	0.1	0.4	0.3	0.3	1.0	2.7	0.7	0.2	0.8	0.8	0.2	0.7	0.4

A) Cell number per l l ($\times 10^3$)

Station	2				3				5				
Depth of sampling (m)	0	3	6	9	0	5	10	12	0	3	6	9	12
Skeletonema costatum	—	3.9	1.6	—	—	2.8	8.7	—	0.1	1.5	—	0.3	—
Leptocylindrus danicus	—	1.9	0.8	—	—	0.6	1.1	0.3	0.0	0.5	—	—	0.1
Coscinodiscus spp.	—	0.6	—	—	—	0.4	2.6	—	0.0	1.5	0.1	—	—
Chaetoceros danicus	0.4	80.6	20.4	0.9	6.8	128.5	56.0	1.0	6.8	94.0	0.6	1.8	1.1
Ch. didymus	97.2	12.0	49.6	7.5	109.4	7.6	10.4	1.6	27.7	22.1	2.8	12.0	3.0
Ch. affinis	94.0	16.4	157.2	16.7	110.4	23.2	17.2	6.9	92.8	35.3	4.8	20.2	6.4
Ch. spp.	16.4	—	105.6	—	20.2	—	1.6	0.6	9.2	5.3	0.8	4.0	0.3
Bacteriastrum hyalinum	—	—	5.6	—	—	—	—	—	—	—	—	—	—
Biddulphia sp.	—	—	—	—	—	—	0.1	—	—	—	—	—	—
Hemiaulus sp.	0.2	1.2	—	0.1	1.6	—	—	—	0.0	—	0.1	—	0.2
Rhizosolenia Stolterfothii	—	1.8	0.8	—	0.8	1.6	—	—	—	—	—	—	0.2
Rh. setigera	—	0.1	—	—	—	0.1	0.1	0.1	0.0	0.3	—	—	—
Thallassiothrix Frauenferdi	—	—	—	—	—	—	0.4	—	—	—	—	—	—
Naviculaceae	—	0.2	—	0.1	—	0.1	—	—	0.0	0.3	0.2	0.1	—
Nitzschia longissima	—	0.3	—	0.4	—	0.2	—	—	—	4.5	0.4	—	0.2
N. seriata	0.5	1.8	—	—	—	0.2	1.0	—	—	2.0	0.4	0.6	1.2

Station	6							7			8					9				
Depth of sampling (m)	0	2	4	6	8	10	12	0	6	11	0	3	6	9	12	0	3	6	9	12
Skeletonema costatum	—	—	12.6	13.3	1.5	1.4	—	—	9.7	—	1.3	1.6	3.1	1.4	—	0.0	0.8	9.5	0.6	0.3
Leptocylindrus danicus	0.1	0.2	1.6	3.2	0.4	0.1	—	0.2	0.7	—	1.5	0.5	3.3	0.9	0.0	0.1	—	1.5	0.2	0.4
Coscinodiscus spp.	0.0	0.2	2.5	14.4	0.7	—	0.1	—	1.3	—	—	—	—	0.1	0.0	—	—	0.5	0.2	0.0
Chaetoceros danicus	0.7	2.0	1.6	3.9	0.9	1.6	0.4	6.9	3.8	0.2	8.4	13.8	28.2	15.9	1.5	0.5	62.4	18.5	4.2	0.6
Ch. didymus	2.4	1.6	14.2	22.6	2.3	8.8	1.1	1.5	4.7	0.2	75.6	10.0	20.8	9.4	5.3	11.8	24.8	11.0	14.8	5.6
Ch. affinis	16.9	11.0	34.5	91.1	14.1	3.4	4.3	17.2	23.8	2.7	195.2	31.5	34.0	7.7	4.9	12.4	37.2	17.8	17.2	2.8
Ch. spp.	—	—	—	—	—	—	—	0.2	—	0.5	3.5	—	—	1.3	0.7	—	—	2.4	1.8	—
Bacteriastrum hyalinum	0.1	0.1	0.4	—	—	—	—	—	—	0.1	—	—	—	—	0.0	—	—	—	0.1	—
Biddulphia sp.	—	—	0.1	0.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hemiaulus sp.	0.6	0.1	0.3	0.3	—	0.5	—	0.2	0.1	—	4.0	0.2	0.1	0.1	—	—	0.1	1.2	0.2	0.1
Rhizosolenia Stolterfothii	0.1	—	—	—	—	—	—	0.3	0.2	—	—	0.3	0.1	0.2	0.1	0.5	0.4	0.3	0.5	0.1
Rh. setigera	0.3	0.9	2.5	1.6	0.1	0.1	—	—	0.1	0.0	1.8	—	0.3	0.1	—	—	0.0	0.4	0.1	0.1
Thallassiothrix Frauenferdi	—	0.1	0.2	1.5	0.1	—	—	—	—	—	—	—	—	—	—	—	—	0.2	—	—
Naviculaceae	0.1	0.2	0.3	0.6	0.4	—	0.1	0.1	0.1	—	—	—	—	0.1	0.0	—	0.0	0.2	0.0	0.0
Nitzschia longissima	5.5	1.4	1.0	21.7	2.5	0.3	0.5	—	5.3	—	—	—	1.0	0.1	0.1	—	—	7.1	3.2	0.3
N. seriata	—	—	34.5	7.5	0.7	1.1	0.5	0.4	2.0	—	—	0.2	0.2	0.1	0.2	—	0.0	—	0.1	0.1

Station	11			12				13			14		
Depth of sampling (m)	0	5	9	0	2	4	7	0	3	6	0	2	5
Skeletonema costatum	0.1	8.5	3.0	—	8.5	1.4	19.3	0.1	2.1	18.2	0.2	0.2	5.2
Leptocylindrus danicus	—	1.2	0.3	0.1	1.4	—	2.3	—	0.4	0.5	0.1	0.2	0.4
Coscinodiscus spp.	0.1	0.9	0.7	0.2	1.5	—	7.2	0.1	0.2	1.8	0.1	0.3	4.2
Chaetoceros danicus	0.4	46.2	8.7	1.3	8.5	6.8	8.5	1.1	36.8	53.6	4.4	36.8	3.4
Ch. didymus	1.6	15.7	4.0	16.7	10.1	49.7	24.6	33.1	24.8	42.8	6.7	116.4	5.3
Ch. affinis	15.3	35.5	5.8	26.9	10.2	19.7	16.4	29.5	40.4	36.0	8.7	156.4	6.2
Ch. spp.	1.1	—	—	—	—	—	—	—	—	—	—	—	—
Bacteriastrum hyalinum	—	—	—	—	—	—	—	—	—	—	—	—	—
Biddulphia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—
Hemiaulus sp.	—	0.4	0.0	—	—	0.6	0.7	—	0.2	0.2	—	0.0	—
Rhizosolenia Stolterfothii	0.2	—	—	—	—	—	—	0.4	0.2	0.0	0.0	0.6	0.1
Rh. setigera	—	0.1	—	—	1.1	—	0.8	0.0	—	0.1	—	—	0.1
Thallassiothrix Frauenferdi	—	—	—	0.1	0.3	—	0.8	—	—	0.2	0.0	0.1	0.1
Naviculaceae	0.1	0.1	—	1.5	—	—	6.8	0.1	0.1	0.8	1.2	0.3	0.5
Nitzschia longissima	0.1	5.0	0.9	1.7	12.5	—	18.2	0.9	5.2	14.8	4.3	2.8	2.2
N. seriata	—	—	1.2	0.4	—	—	0.1	—	0.1	0.9	0.2	1.2	0.1

B) Individual number per l l (×10)

Station	2				3				5				
Depth of sampling (m)	0	3	6	9	0	5	10	12	0	3	6	9	12
Radioralians	—	—	—	—	—	—	—	—	5	—	—	—	—
Tintinnopsis subacuta	25	5	39	5	10	15	30	1	13	—	—	3	2
Tin. tenuis	1	1	—	—	—	—	—	—	—	5	1	1	—
Amphorella brandti	3	2	—	—	—	—	—	1	—	—	—	—	—
Sagitta spp.	—	—	—	—	—	—	—	—	—	—	—	—	—
Polychaeta larvae	2	1	—	1	1	—	—	—	—	—	—	—	—
Lamellibranchia larvae	—	—	—	—	—	—	—	—	—	—	—	—	—
Gastropoda larvae	—	—	—	1	—	—	—	—	—	—	—	—	—
Oithona nana	—	5	1	1	6	10	30	—	7	20	—	2	—
Paracalanus parvus	—	5	—	—	—	—	—	—	1	—	—	—	—
Penillia schmackeri	1	1	—	—	—	35	—	—	—	25	—	—	2
Nauplii	2	24	2	—	13	30	190	—	27	20	1	15	—

6							7			8					9				
0	2	4	6	8	10	12	0	6	11	0	3	6	9	12	0	3	6	9	12
—	—	—	35	—	—	—	—	—	—	—	4	—	—	—	—	14	—	—	—
22	5	2	5	—	—	6	—	—	—	60	16	—	7	14	34	4	10	15	5
—	—	7	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	2	2	5	6	—	—	—	—	—	—	—	15	1	8	—	2	—	15	5
—	1	—	25	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	3	6	65	20	84	—	10	3	2	10	8	5	10	2	4	4	5	—	—
—	1	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—
1	8	4	15	10	10	—	—	4	2	20	—	10	1	—	—	14	10	2	—
21	30	23	130	19	10	2	5	2	2	50	8	10	7	—	7	6	30	2	2

11			12				13			14		
0	5	9	0	2	4	7	0	3	6	0	2	5
—	—	2	—	—	44	50	—	12	—	—	—	—
4	—	—	2	—	3	5	—	2	—	6	—	2
—	—	—	—	—	—	—	—	2	—	—	—	—
—	—	—	—	5	—	—	—	—	—	2	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	2	2	—	5	—	—	1	—	—	—	—
—	—	—	—	—	—	5	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
15	20	44	32	5	18	70	12	14	18	28	14	30
—	—	—	1	—	—	—	2	2	—	—	—	—
—	20	4	—	—	9	—	—	8	12	2	6	10
35	20	4	61	—	44	150	54	20	86	28	34	62

C) Cell number of dinoflagellata per l l (X10)

Station	2				3				5				
Depth of sampling (m)	0	3	6	9	0	5	10	12	0	3	6	9	12
Noctiluca scintillans	—	—	—	—	—	15	—	—	—	—	—	—	—
Dinophysis ovum	—	—	—	—	—	—	70	2	1	10	—	1	—
Peridinium spp.	—	—	—	—	—	35	260	2	6	40	5	3	—
Pyrophacus horolongicum	—	40	—	1	1	40	50	2	3	70	3	—	—
Ceratium furca	—	—	—	—	2	—	20	2	—	10	1	—	—
C. fusus	—	20	—	10	—	—	530	10	2	5	1	2	2
C. spp.	—	—	—	—	—	—	—	—	—	—	—	—	—
Dictyocha sp.	—	—	—	—	—	—	40	—	1	5	—	—	—

6							7			8					9				
0	2	4	6	8	10	12	0	6	11	0	3	6	9	12	0	3	6	9	12
1	1	1	5	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—
—	—	12	245	32	—	—	—	—	—	—	4	10	19	4	—	—	20	5	5
3	5	13	990	237	20	2	—	60	—	—	—	30	26	4	3	2	20	7	—
1	28	18	65	2	5	1	—	30	2	—	12	5	—	—	—	2	5	—	—
4	—	4	145	11	—	—	5	20	—	—	—	5	10	2	—	—	—	—	—
3	1	7	915	245	30	14	—	360	4	—	4	30	320	10	—	—	60	15	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	2	—
—	1	5	325	8	5	—	—	10	—	—	—	—	4	2	—	—	40	5	—

11			12				13			14		
0	5	9	0	2	4	7	0	3	6	0	2	5
—	—	—	—	—	—	—	—	—	—	—	—	—
—	10	18	—	55	7	70	2	22	54	2	12	26
4	40	54	3	155	21	300	2	2	36	18	14	44
—	5	2	4	—	14	30	—	4	24	2	14	6
—	—	—	—	30	7	35	—	—	—	—	—	—
—	10	246	6	266	4	700	12	—	320	6	16	98
—	—	4	—	—	—	—	—	—	14	—	—	14
2	—	32	—	10	3	30	—	—	12	—	—	12

The table 1 and Figs. 2 ~ 4 showing the results of the analyses by using MOTOMURA's correlation coefficient method indicate that there is no special species occurring solely in the water flowed into the lagoon from Miyazu Bay or the river Noda and that influences of the stagnation of lagoon water and the inflow

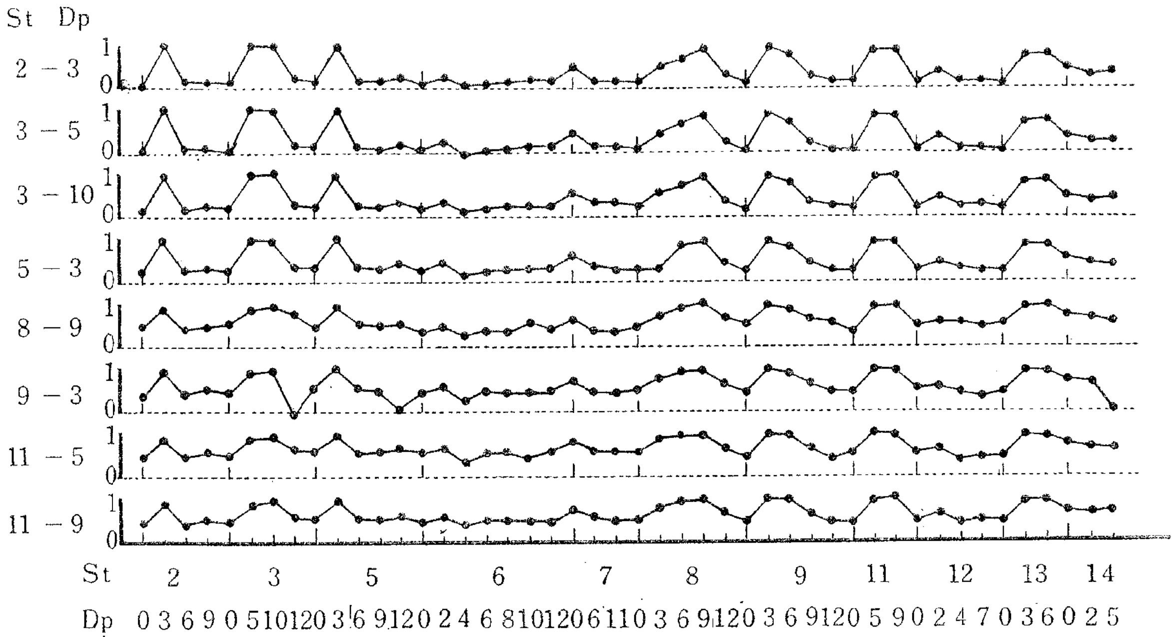

Fig. 2. Correlation coefficient diagrams of the upper layer community with thephytoplankton compositions at every sampling point. Remarks : St : number of station. Dp : depth in meter.

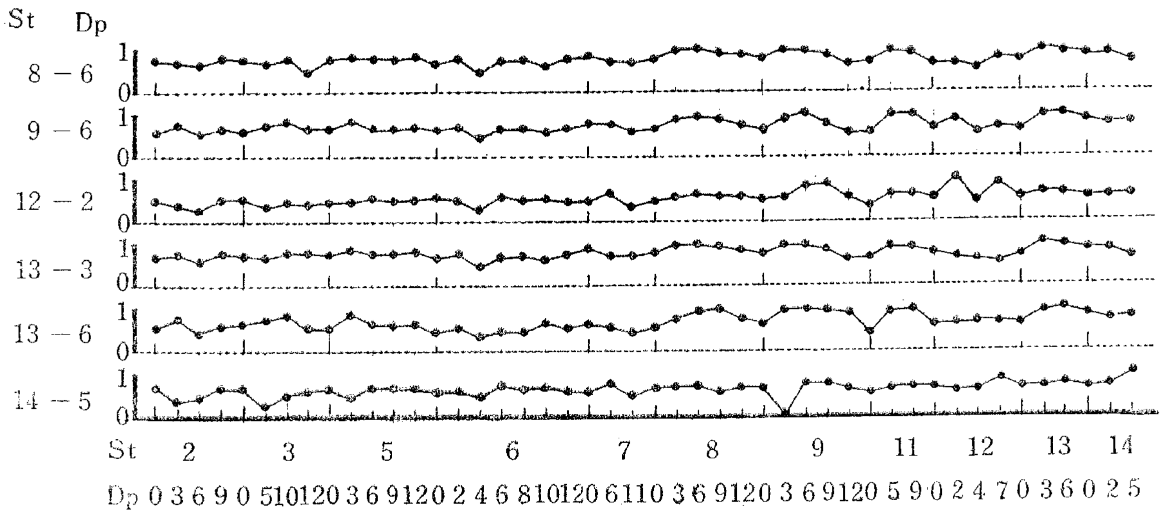

Fig. 3. Correlation coefficient diagrams of the intermediate community with the phytoplankton compositions at every sampling point. Remarks : St : number of station. Dp : depth in meter.

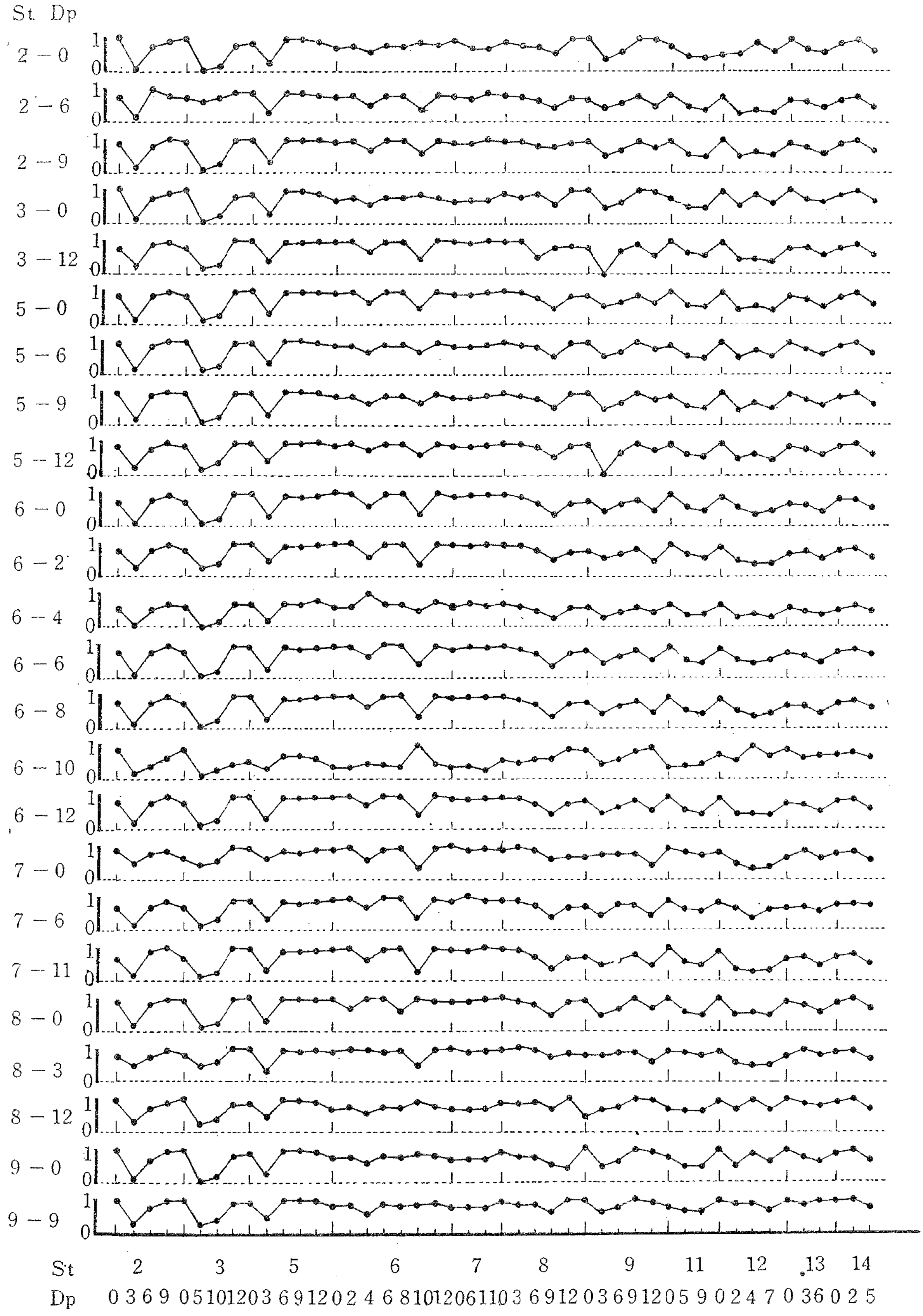

Fig. 4. Correlation coefficient diagrams of the stagnant layer community with the phytoplankton compositions at every sampling point. Remarks : St : number of station. Dp : depth in meter.

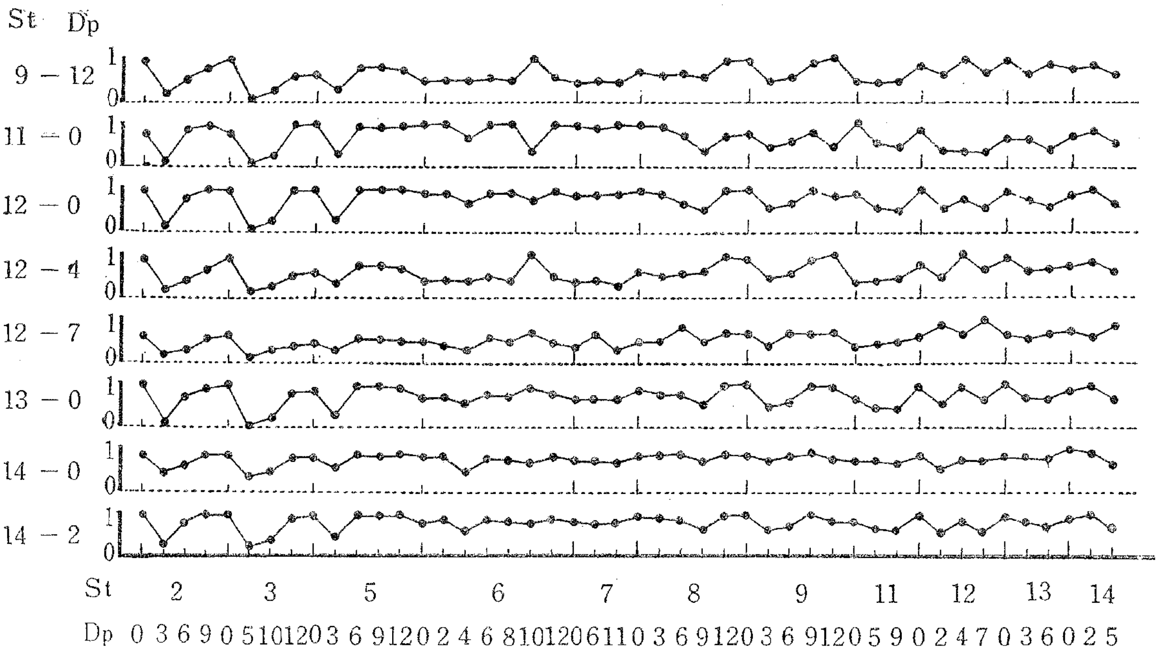

Fig. 4. continued.

from other water systems upon the phytoplankton communities specific to lagoon water are superficially similar to each other.

As shown in Figs. 2 ～ 4, the phytoplankton-communities are classified into three types : the community of the upper layer, that of the stagnant layer and the intermediate one.

The community of the upper layer consists of

Chaetoceros danicus	35 — 50 — 80 %
Ch. didymus	5 — 10 — 20 %
Ch. affinis	15 — 20 — 30 %
Skeletonema	1 — 5 — 10 %
Leptocylidrus	0 — 2 — 5 %

the community of the intermediate type consists of

Chaetoceros danicus	12 — 20 — 33 %
Ch. didymus	15 — 20 — 25 %
Ch. affinis	20 — 25 — 40 %
Skeletonema	3 — 10 — 20 %
Leptocylindrus	0 — 2 — 3 %

and the community of the stagnant layer consists of

Chaetoceros danicus	0 — 8 — 25 %
Ch. didymus	5 — 20 — 65 %
Ch. affinis	20 — 45 — 75 %
Skeletonema	1 — 20 %
Leptocylindrus	0 — 4 %

But all correlation coefficients are not negative. This fact indicates the compositions of these three communities are not so different but rather similar and the characteristics mentioned above are also not showing comspicuous difference. The distribution of these three communities may be understood easily at Figs. 1 and 5. These figures show obviously that (1) the upper layer

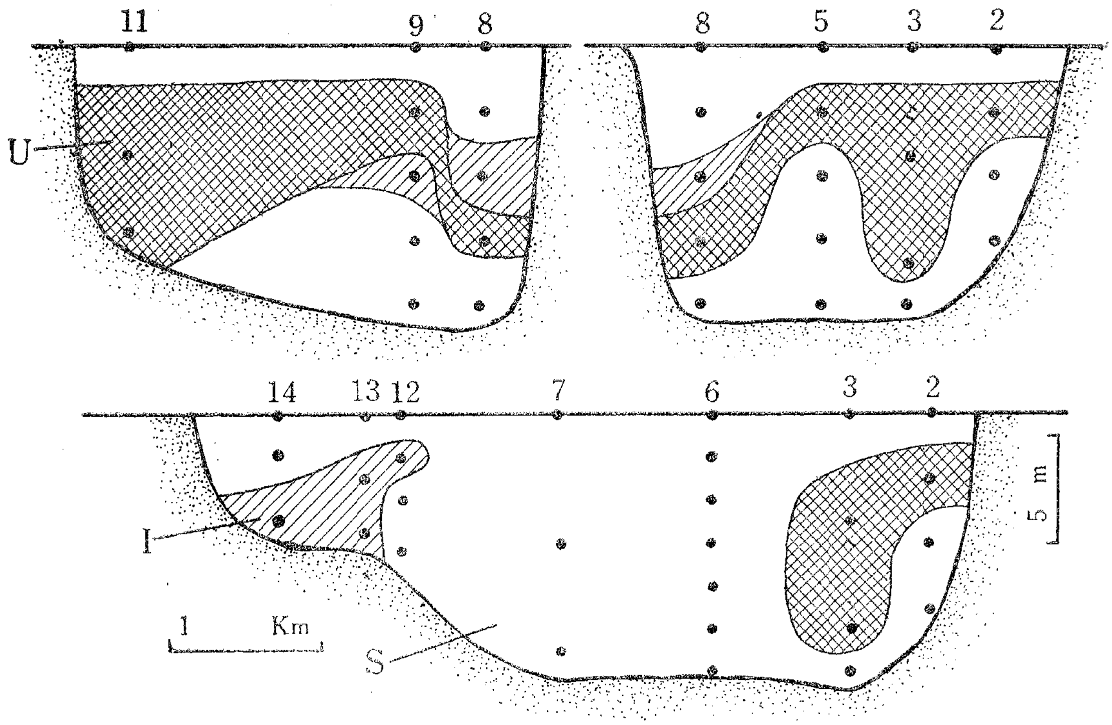

Fig. 5. Vertical section of Yosa-naikai.
Remarks : U : the upper layer community.
I : the intermediate community.
S : the stagnant layer community.

community was distributed in the middle layer, which was named "upper layer" from the chemical characteristics of the water, in the eastern part of the lagoon and the zone combining openings of channels with the northern bank of the river Noda near the mouth, (2) the intermediate community was found in the lagoon in the area south from the line connecting openings of channels to the mouth of the river Noda a little deeper or shallower than those occupied by the upper layer community and (3) other parts of the lagoon were occupied by the stagnant layer community.

Relation between the Phytoplankton Communities and the Characteristics of the Water.

At Fig. 2 in the 2 nd report of this series and Fig. 5 in this report, it may be perceived that the distribution of phytoplankton communities is not always corresponding strictly to the arrangement of water layers. A considerable number of plankton samples do not belong to communities expected generally in water layers where the chemical characteristics of water are similar to those observed at points where the samples were collected, but to different types of the community. Such samples were distributed in the lagoon as follows:

1) Samples belonging to the stagnant layer community, although the chemical characteristics of the water at sampling points suggest the prevalence of the upper layer community.

1. deeper part of the upper layer : St. 2 (6 m), St. 5 (6 m) and St. 7 (6 m).
2. Station 6 (2,4 and 6 m).
3. south-western part of the lagoon : St. 12 (4 m and 6 m) and St. 14 (3 m).
4. near openings of channels : St. 8 (3 m).

2) Samples belonging to the intermediate community, although the chemical characteristics of water at sampling points suggest the prevalence of the upper layer community.

1. near openings of channels : St. 8 (6 m) and St. 9 (6 m).
2. south-western part of the lagoon : St. 12 (2 m), St. 13 (3 m and bottom) and St. 14 (bottom).

3) Samples belonging to the stagnant layer community, although the chemical characteristics of water at sampling points suggest the prevalence of the intermediate community. St. 6 (8 m).

4) Samples belonging to the upper layer community, although the chemical characteristics of the water at sampling points suggest the prevalence of the stagnant layer community. St. 3 (10m), St. 8 (9 m) and St. 11 (bottom).

The above mentioned data seem to indicate that the phytoplankton composition of samples obtained from the south-western part of the lagoon, St. 6, the area near openings of channels and the deeper part of the upper layer was probably in a faded state of the community which is naturally suggested by the chemical characteristics of the water.

Summary

1. The individual or cell numbers of plankton in water samples of 1 L. obtained at the observation of May 10~12 1950 are shown in table 1.

2. By using MOTOMURA's correlation coefficient method, the phytoplankton communities are classified into the following three types: upper layer type, stagnant layer type and intermediate one.

3. The distribution of each community is shown in Figs. 1 and 5.

4. Samples obtained from the south-western part of the lagoon, St. 6, the area near openings of channels and the deeper part of the upper layer show the plankton composition in a faded state of the community naturally suggested by the chemical

characteristics of the water.

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