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Phytoplankton Community off the Coast of Kunsan, Korea

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韓國 群山近海域에서의 植物플랑크톤 群集

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Abstract: Multivariate analysis has been performed on both qualitative and quantitative data of phytoplankton samples collected off the coast of Kunsan in October, 1980, and in March, 1981. The result shows that structure of the phytoplankton community largely depended on hydrological conditions. Thus the study area can be divided into three phyto-hydrographic zones; the waters under influence of the proper water of the Yellow Sea, the waters where mixing with fresh water occurred, the waters from the south. Biomass was estimated of plasma volume and cell carbon content. The mean value of cell carbon was 30.0 $\mu g/l$ in October and 26.6 $\mu g/l$ in March. Relatively low value of biomass seems to be related to great turbidity of the area. Microflagellates of about 5μm were abundant with a density of million cells per liter. Their abundance showed on considerable seasonal variation.

要約: 1980년 10월과 1981년 3월에 군산 근해에서 채집된 식물플랑크톤의 정성 및 정량 자료를 토대로 환경자료와 함께 다변량 분석을 한 결과, 식물플랑크톤 군집의 구조는 해수조건에 따라 크게 좌우됨을 알 수 있다. 이에 따라서 연구해역은 3개의 식물해양학적 구역, 즉 황해 고유수의 영향권에 있는 수역, 담수와의 혼합이 일어나는 수역, 그리고 남쪽에서 올라오는 해수역 등으로 나누어 진다. Plasma volume과 cell carbon으로 추정된 생체량은 그 평균이 10월에 30.0 $\mu g/l$, 3월에 26.6 $\mu g/l$여서 다소 낮은 값을 보이는데, 이는 연구 해역의 높은 탁도에 기인하는 것으로 생각된다. 5μm 내외의 미세 편모조류는 l당 100만 개체 정도로 풍부하며 그 양은 현저한 계절변화를 보인다.

INTRODUCTION

Community structure changes as environmental conditions change, either in space or time. In phytoplankton ecology, communities are generally regarded as 'recurrent organized systems of organisms' (Fager, 1963), or association of organisms that are responding in a related way to environmental changes (Legendre and Legendre, 1978). Individual species has representing distribution according to its ecological requirements or regional circulation patterns which influence the dispersal, accumulation and isolation of phytoplankton community. Thus individual organism or an assemblage of species conveys information of watermasses which carry them (Smayda, 1978). In this context, there were several studies attempting to relate phytoplankton communities to specific watermasses (Margalef, 1967; Thorrington-Smith, 1971).

The area of the present study (Fig. 1) is of relatively small scale, but it has peculiar environmental conditions of shallow depths, strong tides, very high turbidity and mixing of different watermasses. There are four potential influences in the vicinity; water of Gyeong-gi

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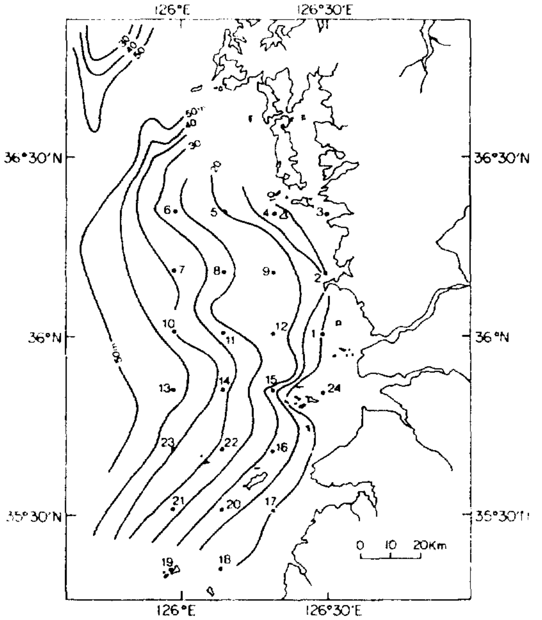

Fig. 1. Map showing sampling stations and bathymetry of the area

Bay and Cheonsu Bay from north, the proper water of the Yellow Sea, fresh water influx from three rivers nearby, and warm water from south. In a previous study, Aikawa (1936) observed that in the Yellow Sea, neritic species and cold water species were mixed with the Kuroshio species. In a study covering the present study area, Lee, Shim and Kim (1967) discussed the possibility that a tributary current of the Kuroshio joined into the neritic current and flowed toward the north along the coast of Korea in summer. They also attributed the diverse flora of cold-water species, warm-water species and temperate species to the current patterns of the Yellow Sea. Recently, Shim and Park (1984) reported the significance of nanofraction in a study of adjacent area.

Thus the phytoplankton community of the area is subject to various environmental stresses. Interpreting the change of structure of the phytoplankton community in relation to the environment is the aim of this study.

MATERIALS AND METHODS

Field and Laboratory Works

The study area covers approximate 5012 km^2 between from 35°20'N to 36°20'N and from 126°E to 126°30'E and 24 sampling stations were set systematically therein (Fig. 1). Cruises were made in October, 1980 and in March 1981.

Both net samples and water samples were collected. In collecting qualitative samples the net used was made of synthetic nylon clothes with mesh size of 53 μm and the diameter of the net mouth was 50cm. The samples were preserved with neutralized formalin so that the final concentration of formalin in the sample be 4%. For collecting quantitative samples, 3-6 water samples were taken from each of the stations at depths of 0m, 5m, 10m, 20m, 30m and 40m. From the 3 liter Van Dorn water samplers, approximate 230ml of sea water was subsampled in glass bottles and these bottles were wrapped with aluminium foil to protect photo-oxidation after preserving samples with Lugol solution. With these samples cell countings have been done using Sedgiwick-Rafter cell following the McAlice's method (1971). For counting cells of under 20μm, Palmer counting cell was used.

Secchi transparent depths were observed at each station. Also, temperature, salinity and dissolved oxygen were measured at the same time.

Multivariate Analysis

For analyzing data the cluster analysis was performed. To normalize the raw data logarithmic transformation was used. Cluster analysis was performed on both binary and quantitative data using Jaccard's index and correlation coefficient, respectively, as similarity indices.

Estimation of Biomass

Cell size varies greatly in phytoplankton organisms both interspecifically and intraspecifically, for instance, from 3 μm of microflagellate to 600 μm of *Odontella sinensis* in the specimens of the study. Therefore, the routine estimation of standing stock with cell numbers is imprecise and inadequate in understanding energy relationships (Smayda, 1978).

In the study, using Smayda's formula (1965), plasma volume of each species has been calculated;

$$PV = (\text{surface area}, \mu m^2)\ (\text{cyt. lay.}, 1\text{-}2\mu m) + (0.10)\ (\text{total cell volume}, \mu m^3)$$

While plasma volume provides a measure of assimilative activity, cell carbon may provide a better estimate of standing crop. According to Eppley et al. (1970),

$\log_{10}C = 0.76(\log_{10}V) - 0.352$ for diatoms,

$\log_{10}C = 0.94(\log_{10}V) - 0.60$ for other phytoplankton.

The dimension used in calculation was derived from one third of the specimens of the study. Total volume and surface area were calculated using 11 shapes. The list of estimate of plasma volume and carbon content of each species is shown in Appendix I.

RESULTS

Hydrography

In October, 1980, temperature of the area ranged from 16.3°C to 19.7°C and in March, 1981, from 3.9°C to 7.3°C. Salinity ranged from 30.57‰ to 32.63‰ in October, from 31.41‰ to 32.43‰ in March. Wider range of salinity in October may have resulted from the higher discharge from the adjacent rivers (Kim, 1982). T-S diagrams of the stations are represented in Fig. 2 and Fig. 3. In each of the diagrams, three typical water bodies can be recognized; the water where fresh water is mixed (st. 24) the water from the south (st. 18) and cold saline bottom water of the Yellow Sea (st. 7, st. 10 and st. 13). In October, well-stratified, distinct water mass can be recognized in the lower right-hand corner of Fig. 2. In March, the diagram shows rather well-mixed situation due to greater turbulences. Secchi depths measured in March were about half of those measured in October (Table 1). In both seasons, st. 4 and st. 5 were different from st. 7 and st. 10.

Species Composition

In total, 131 species of phytoplankton were identified from collections made in Oct., 1980; 88 diatom species, 40 dinoflagellate species, 2 silicoflagellate species and 1 cryptomonad species. 8 diatoms, 9 dinoflagellates and 1 euglenoid were not identified. In collections made in March, 1981, there were 66 diatom species, 12 dinoflagellate species, 1 silicoflagellate and 1 cryptomonad species, in total 78 species. Of these,

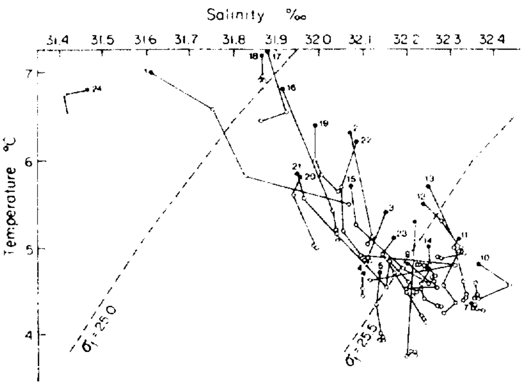

Fig. 2. T-S diagram of 24 stations in March, 1981

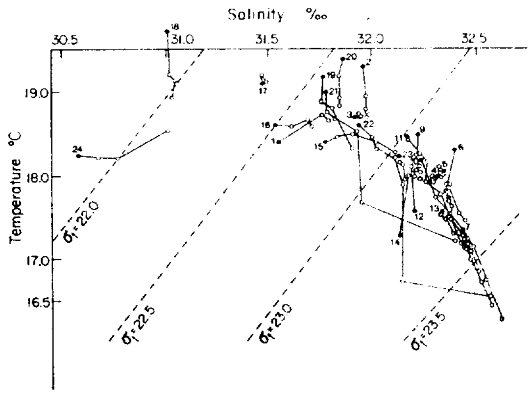

Fig. 3. T-S diagram of 24 stations in October, 1980

Table I. Comparison of Secchi Depth in Oct., 1980 and in Mar., 1981 (units: m)

St.	Oct.	Mar.	St.	Oct.	Mar.
1	1.2	1.2	16	2.9	1.6
2	2.6	1.3	18	1.7	0.5
3	1.2	0.8	19	1.6	1.0
9	4.4	1.4	24	2.6	0.9
12	3.4	2.0			

52 species had occurred in October collections. The list of phytoplankton species occurred is represented in Appendix 3. Also significant were 7 unidentified microflagellates. Their shapes vary from coccoid to irregular and their size, from 15 to 3-5 μm. Because of their minute size, it was almost impossible to identify them with light microscope. Only their total number was counted.

In October, the most abundant species was *Chroomonas amphioxeia*, a cryptomonad, whose abundance ranged from 16,480 cell/l (st. 6) to 294,827 cells/l (st. 21). Other abundant species were *Paralia sulcata*, *Skeletonema costatum*, *Chaetoceros debilis*, *Diatoma elongatum*, *Nitzschia longissima*, *Rhizosolenia delicatula*, *Guinardia flaccida*, *Dictyocha fibula*, *Distephanus speculum*, *Gymnodinium biconicum* and *Prorocentrum perforata*, whose abundance was in the order of thousand per liter.

In March, total cell number of phytoplankton other than microflagellates ranged from 48,400 cells/l to 197,800 cells/l. *Paralia sulcata* formed from 32.0% (st. 18) to 92.8% (st. 5) of the total cell number and was the most abundant species at all the stations except st. 18 where the most abundant was *Campylosira cymbelliformis* (42.8%). *C. cymbelliformis*, known as warmwater species occurring at the east coast of the Pacific, appeared only in March collections at st. 17, st. 18 and st. 19 with the center at st. 18. Other common species were; *Asterionella kariana*, *Ditylum brightwellii*, *Nitzschia longissima*, *Skeletonema costatum*, *Thalassiosira baltica*, *T. condensata*, *T. eccentrica*, *T. nordenskiöldii*, *T. anguste-lineata* *Thalssionema nitzschioides*.

Striking feature in seasonal change was a decrease in species number, particularly of dinoflagellates. *Amphidinium* spp. and *Gymnodinium* spp. were not detected in March. On the other hand, *Thalassiosira nordenskiöldii* and *T. gravida*, cold-water species, became dominant in March. Gessner (1970) reported, in South Atlantic Ocean, 68 species out of 90 dinoflagellates, especially, *Amphidinium* spp., occurred north of the 16°C isotherm.

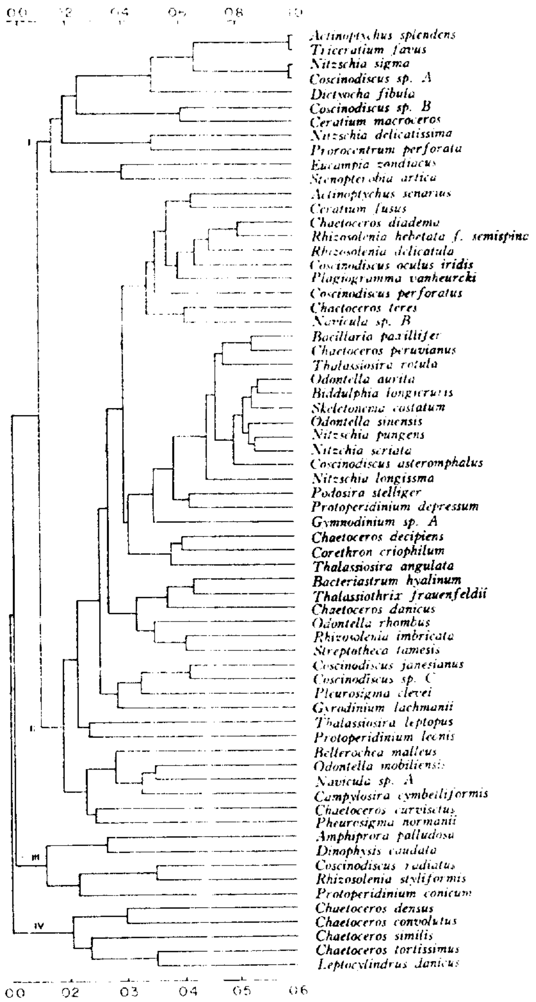

Fig. 4. Cluster anaysis of co-occuring groups in March, 1981

Cluster Analysis

Cluster analysis using Jaccard's index based on the presence-absence data divided 122 species of October collections into 11 major groups and 66 species of March collections into 4 major groups (Fig. 4). Each group had different cores of distribution.

In October collection, group 1 of 12 species, had its cores at st. 4, 1, 5, 7, 9, 12, 16, 19, 24; group 2 of 10 species, at st. 1, 4, 5, 6, 15, 16; group 3 of 10 species, at st. 8, 5, 6, 7, 11, 13, 14, 16; group 4 of 14 species, at st. 5, 6, 19, 20; group 6 of 5 species, at st. 15, 18, 22, 23; group 7 of 5 species, at st. 5, 6, 17, 18; group 8 of 5, at st. 4, 5, 16, 24; group 9 of 7 species, at st. 8, 14, 21; group 10 of 8 species, at st. 6 and 9. The members of group 5 of 38 species, the lar gest one, were mainly common species and appeared nearly all the stations. Group 11 of 8 species had no core. Members of each group were mixture of cold-water species and showed no specific trend.

In March collections, group 1 had its cores at st. 3 and st. 4; group 3, at st. 7, 11, 13 and 5; group 4, at st. 7, 8, and 10. Members of group 4 were mainly cold-water species; *Chaetoceros densus*, *C. similis*, *C. tortissimus*. Members of group 2 were common species and can be divided into five subgroups. The first two subgroups covered nearly all the stations. The next two subgroups appeared along the coast (st. 1, 2, 3, 4, 9, 16, 17, 18, 24). The last subgroup had its cores at st. 4, 17 and st. 18. Members of this group were warm-water species; *Bellerochea malleus*, *Campylosira cymbelliformis*, *Chaetoceros curvisetus*. From the 54 species occurring in both seasons, only one group was reccurrent; *Bacillaria paxillifer*, *Biddulphia longicruris*, *Nitzschia seriata* and *Thalassiosira rotula*. Other groupings appeared to be random, which suggest the distribution of species of the area largely depended on circulation patterns.

Clusters of stations derived from both tran sposed presence-absence data matrices and quantitative data are represented in Figs. 5-6.

In October, 1980, while the result based on presence-absence data fails to reveal a heterogenicty at st. 18, the result based on quantitative data fails to distinguish st. 10, 11, 13 and 14 from the rest (Fig. 5). In March, 1981, while the result from presence-absence data again fails to reveal the discontinuity at st. 18, the result from quantitative data only separates st. 18 and 19 from the rest. Ordination of

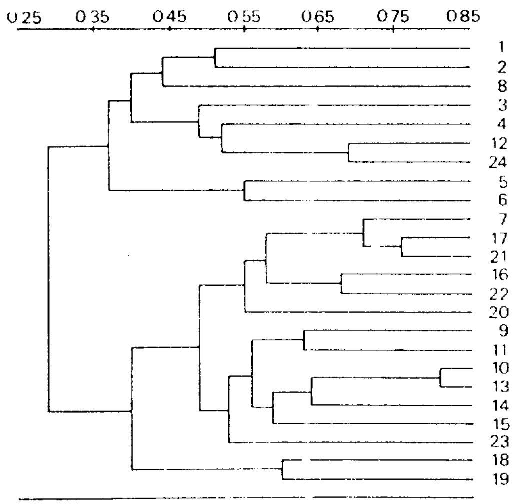

Fig. 5. Clusters of stations based on quantitative data of October.

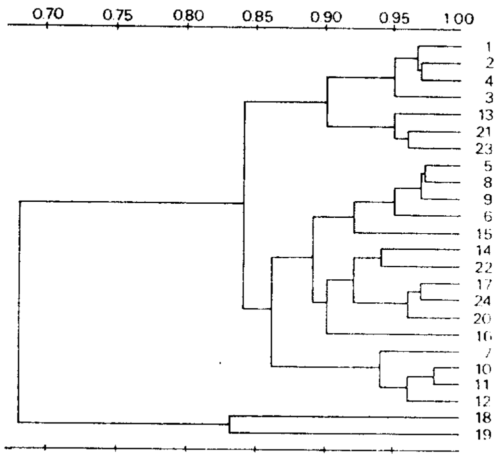

Fig. 6. clusters of stations based on quantitative data of March.

station points from October collections (Fig. 5) shows some resemblance with T-S diagram, forming triangle whose vertices are st. 10, st. 18 and st. 24, where three different water bodies are recognized (Fig. 2). The rest stations are scattered inbetween the vertices. The difference from T-S diagram shows that temperature and salinity are not direct factors controlling distribution but they indicate particular water body. A major difference from T-S diagram is that st. 4, 5, 6 are related more to st. 1 and st. 24 than to st. 7, 10 and st. 11. This is confirmed by cluster analysis and imply the influences of Kyeong-gi Bay water in the north of the area.

Ordination of station points from March collections is more closely packed than in October collections, which means that March collections are less variable (Fig. 6). St. 7, 11 and st. 18 are separated from the rest. In this case, st. 4, 5, 6 and st. 8 again are related more to st. 1 and st. 24 than to st. 7 and st. 11. Also, st. 17 is related more to st. 24 than to st. 18, which means there was a discontinuity between st. 17 and st. 18.

Biomass in Terms of Plasma Volume and Cell Carbon

As already mentioned, plasma volume is more effective for indirect estimation of primary production. Smayda(1965) found that ^{14}C uptake

Table II. Biomass and Nano-fraction in October, 1980

st.	Cell Number		Plasma Volume		Cell Carbon	
	total $10^3/l$	nanofraction %	total $10^9\mu m^3/l$	nanofraction %	total $\mu g/l$	nanofraction %
1	1379.9	94.0	787.9	10.1	70.7	27.2
2	657.1	94.8	340.9	10.9	33.2	32.4
3	667.2	97.7	111.0	35.5	18.2	59.2
4	751.0	96.5	299.7	15.0	28.5	36.8
5	362.9	95.6	110.5	19.2	11.9	43.4
6	486.0	95.9	144.9	19.9	15.8	43.0
7	243.9	95.9	112.7	12.5	16.9	23.6
8	200.8	95.6	165.7	6.7	17.3	21.3
9	474.3	96.1	414.6	6.5	36.3	24.1
10	670.2	99.0	80.6	45.8	21.7	71.4
11	405.7	98.5	151.3	15.9	22.6	29.7
12	496.8	93.1	259.7	10.6	23.6	29.5
13	533.4	97.8	122.4	24.1	20.6	57.3
14	626.5	98.1	90.8	37.4	21.5	70.4
15	419.8	96.7	148.2	15.3	19.7	48.0
16	335.6	94.3	242.1	7.6	25.2	25.5
17	853.9	97.9	318.5	15.1	38.6	46.4
18	1392.5	98.6	662.9	12.3	67.8	37.7
19	1327.2	98.5	374.6	21.3	43.2	48.6
20	1051.1	98.8	206.0	29.5	31.2	66.0
21	1095.9	99.0	197.9	30.9	41.1	61.4
22	549.1	98.2	157.3	17.6	19.4	52.8
23	1097.7	99.5	133.3	48.3	26.7	74.8
24	951.5	94.7	331.9	16.3	47.9	36.8
mean	682.2	93.8	240.9	20.2	30.0	44.5

in 24-hour experiments varied directly with standing crop size, especially with surface area and plasma volume, and to a considerable degree, irrespective of floristic or environmental change. Thus, to evaluate the contribution of nanoplankton more correctly, total and nano-fraction biomass in terms of plasma volume and cell carbon content are estimated on the basis of Appendix I (Tables II and III). Higher level of cell number in March was due to greater contribution of microflagellates and *Paralia sulcata*. Amount of plasma volume was rather similar in both seasons, but more variable in October than in March (standard deviation= 176.6, 82.8, respectively). Cell carbon content was a little bit higher in October due to contribution of large-celled species. In general, it was observed that cell size was greater in October in intraspecific variation (Appendices I and II). There were many nanoplankters in October (*Amphidinium* spp. *Gymnodinium* spp. *Prorocentrum perforata*, *Diatoma elongatum*, etc.), but in March, only microflagellatea showed significance.

DISCUSSION

While the results of cluster analysis of qualitative and quantitative data in October shows general agreement, those of March collections are quite dissimilar. Because classification me-

Table III. Biomass and Nano-fraction in March, 1981

st.	Cell Number		Plasmic Volume		Organic Carbon Content	
	total $10^3/l$	nanofraction %	total $10^9 \mu m^3/l$	nanofraction %	total $\mu g/l$	nanofraction %
1	1083.2	83.1	268.1	26.5	32.8	35.7
2	920.1	87.4	191.5	33.2	24.0	43.6
3	1211.8	89.3	211.0	40.5	28.1	50.1
4	1271.7	88.4	256.8	34.6	32.2	45.4
5	746.9	81.7	180.3	26.7	22.8	34.8
6	554.9	91.3	95.3	42.0	12.4	52.9
7	374.3	79.6	129.6	18.1	14.2	27.4
8	809.0	85.4	198.0	27.6	24.0	37.3
9	769.4	75.4	263.6	17.4	30.7	24.6
10	684.6	81.8	206.5	21.4	23.4	31.1
11	387.5	72.4	184.3	12.0	19.5	18.8
12	475.5	79.0	191.9	15.5	20.6	23.6
13	612.1	85.0	163.9	17.1	17.8	25.8
14	423.5	79.8	236.8	11.3	23.2	18.8
15	717.8	86.6	242.3	20.3	26.4	30.7
16	486.9	74.8	259.4	11.1	24.7	19.3
17	982.8	79.9	417.6	14.8	43.5	23.5
18	2331.5	94.5	331.0	52.6	43.5	65.9
19	1317.6	93.4	190.9	50.9	26.4	60.6
20	1267.3	86.8	445.1	19.5	48.7	29.3
21	855.8	82.0	274.4	20.2	31.4	29.0
22	672.9	93.0	154.3	32.0	18.3	44.5
23	578.1	73.4	178.5	18.9	16.0	34.9
24	1095.1	84.7	319.6	22.9	34.6	35.0
mean	824.8	83.7	232.9	25.4	26.6	35.1

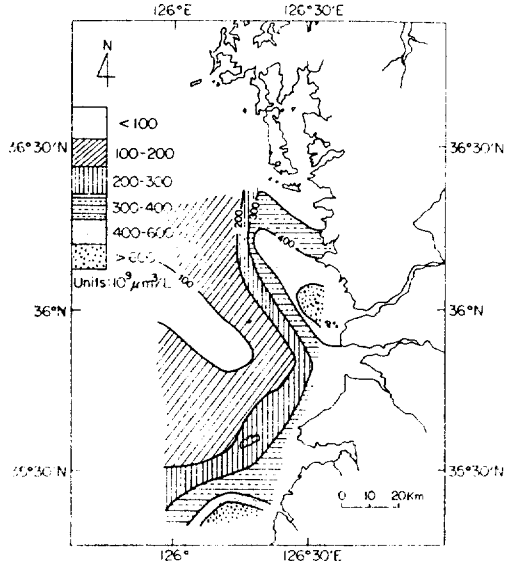

Fig. 7. Map showing the distribution of biomass in terms of plasma volume in October, 1980

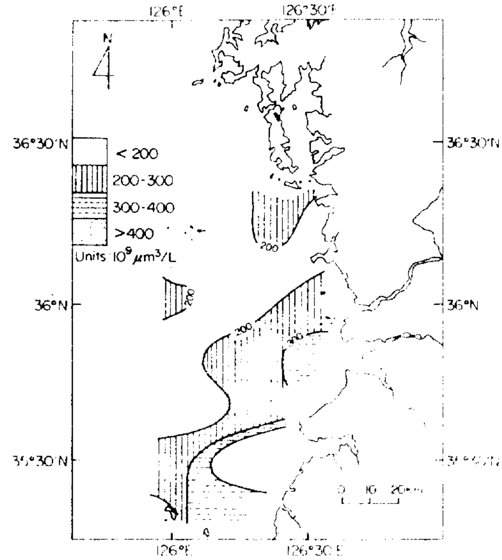

Fig. 8. Map showing the distribution of biomass in terms of plasma volume in March, 1981

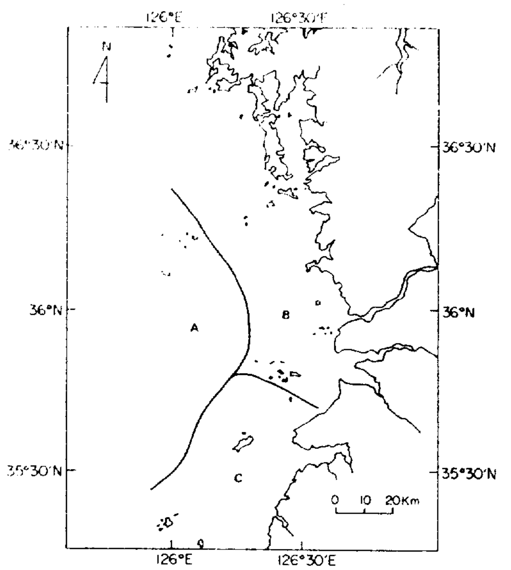

Fig. 9. Phytohydrographic regions in October, 1980

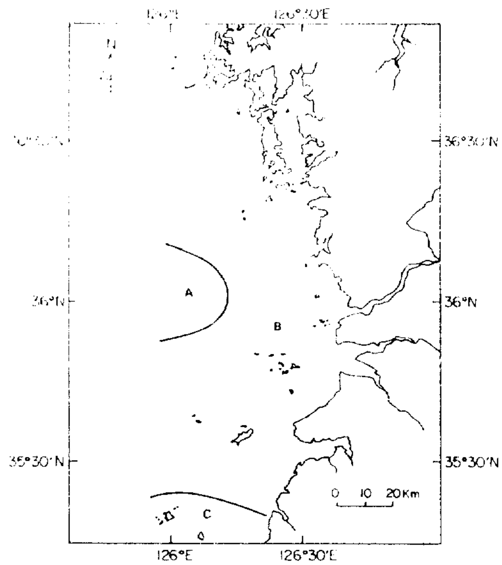

Fig. 10. Phytohydrographic regions in March, 1981

thod assumes that objects can be classified into well-defined separate parts, in a more or less homogeneous situation the result may be an arbitrary classification (Pielou, 1969). In other words, community structure in March appeared to be rather homogeneous and the result of T-S disgram and distribution of biomass support this view.

Comparing biological information with hydrological data, the area can be divided into three phytohydrographic regions (Figs. 7, 8, 9 and 10) in both seasons. The region A being under influence of the proper water of Yellow Sea had relatively poor biomass. The region B seemed to be affected by fresh water influx. It is not clear what kind of water movement is there in the northern part of this region. In the region C, there was a discontinuity, particularly, in March. There might be a current from south in which a tributary current of the Kuroshio joined (Lee, Shim and Kim, 1967). ***Guinardia flaccida***, one of the indicator species of the Kuroshio, occurred in st. 18 with a density of one order higher than other stations in October. In March, ***Campylosira cymbelliformis***, a warm water species, occurred only at st. 17, st. 18, st. 19 and dominated st. 18, indicating a strong intrusion of heterogenous water body.

However, the above subdivision of the area does not indicate the exact water movement. The result of sedimentological and physical survey(Kim, 1982) shows that the main directions of dispersal of suspended particles from the Keum Estuary into the adjacent sea are both south-westward and westward.

The biomass was largest at st. 1 and decreased as the depths increased in October, indicating nutrients and/or light was major limiting factor in primary production at the time(Fig. 12). In March, the highest biomass did not occur at near estuary and southern extreme. This might result from great silt load, beside the decreased river discharge.

Comparing the biomass after conserting it into chlorophyll content (conversion factor; 1 μg chlorophyll=15 μgC) with that of other temperate region shows the biomass of the area in both seasons were rather low (Paymont, 1980).

The nanoplankton crop fraction in terms of plasma volume were 20.2% in October and 25.4% in March. Nanoplankters are usually much faster growing species than the large cells and hence may contribute more to the daily production than is suggested by their relatively small biomass (Guillard and Kilham, 1977). Thus their contribution in primary production should not be underestimated. Among them, microflagellates were abundant in both seasons and showed no considerable seasonal variation.

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Appendix 1. Surface Area, Plasma Volume and Cell Carbon Content of Specimens of March. 1981

	S (μm^3)	V (μm^3)	S/V	C.L. (μm)	P.V. (μm^3)	C (PgC)
DIATOMS						
Actinoptychus senarius	8,718	54,978	0.159	2	22,934	1,781
Asterionella glacialis	780	1,320	0.591	1	912	105
A. kariana	401	332	1.206	—	332	37
Bacillaria paxillifer	1,727	1,396	1.237	—	1,396	106
Bellerochea malleus	4,657	17,672	0.264	2	11,080	752
Biddulphia longicruris	3,085	12,070	0.256	2	7,377	562
Campylosira cymbelliformis	342	165	2.068	—	165	22
Coscinodiscus asteromphalus	74,613	850,586	0.088	2	234,284	14,275
C. radiatus	11,310	84,823	0.133	2	31,102	2,476
C. sp. A	9,582	66,955	0.143	2	25,859	2,068
C. sp. B	21,206	190,852	0.124	2	61,496	4,285
Ditylum brightwellii	21,214	171,617	0.124	2	59,589	4,229
Navicula sp. A	7,764	39,008	0.199	2	19,428	1,372
N. sp. B	3,000	6,185	0.486	1.5	5,119	338
Nitzschia longissima	407	350	1.163	—	350	38
N. Pungens	1,289	1,131	1.139	—	1,131	93
Odontella aurita	6,883	35,343	0.195	2	17,299	1,273
Paralia sulcata	566	1,027	0.551	1	669	86
Plagiogramma vanheurckii	564	655	0.861	1	629	61
Pleurosigma normanii	5,946	15,740	0.378	2	13,465	688
P. clevei	3,075	4,300	0.175	1	3,505	257
Podosira stelliger	4,656	24,871	0.187	2	11,799	974
Skeletonema costatum	239	252	0.947	—	252	30
Thalassionema nitzschioides	413	278	1.487	—	278	32
Thalassiosira angulata	2,026	1,000	0.289	2	4,751	372
T. anguste-lineata	4,073	19,047	0.214	2	10,051	796
T. baltica	26,125	267,657	0.098	2	79,015	5,929
T. condensata	6,428	39,668	0.162	2	16,823	1,389
T. eccentrica	9,082	64,806	0.140	2	24,644	2,018
T. gravida	1,261	3,463	0.364	1.5	2,237	218
T. leptopus	6,008	31,808	0.190	2	12,016	1,175
T. nordenskiöldii	1,264	3,491	0.362	1.5	2,245	219
T. rotula	5,687	25,536	0.223	2	13,928	994
DINOFLAGELLATES						
Ceratium kofoidii	4,200	15,959	0.263	—	11,969	—

Gymnodinium sp.	1, 163	3, 767	0. 309	—	2, 826	577
G. lohmanni	5, 296	31, 542	0. 168	—	23, 657	4, 256
Protoperdinium conicum	11, 748	97, 128	0. 121	—	72, 846	12, 249
P. deprossum	4, 023	20, 944	0. 192	—	15, 708	2, 896
P. leonis	7, 997	56, 549	0. 141	—	42, 412	7, 367
Prorocentrum perforatus	823	1, 832	0. 449	—	1, 375	2, 240
MICROFLAGELLATES	79	63	1. 2	—	63	13

Appendix II. List of Phytoplankton Species Occurring in the Collections of Oct. 1980 and Mar. 1981

	October	March
DIATOMS		
Actinoptychus splendens		*
A. senarius	*	*
Amphiprora paludosa	*	*
Amphora hyalina	*	*
Asterionella glacialis	*	*
A. kariana		*
Bacillaria paxillifer	*	*
Bacteriastrum hyalinum	*	*
Bellerochea malleus	*	*
Biddulphia longicruris	*	*
Campylosira cymbelliformis		*
Cerataulina pelagica	*	
Chaetoceros affinis	*	
C. brevis	*	
C. compressus	*	
C. constrictus	*	
C. convolutus	*	*
C. costatus	*	
C. curvisetus	*	*
C. danicus	*	*
C. debilis	*	*
C. decipiens	*	*
C. densus	*	*
C. diadema	*	*
C. didymus	*	
C. didymus v. aggregata	*	
C. laciniosus	*	
C. lorenzianus	*	
C. messanensis	*	
C. mitra	*	
C. peruvianus	*	*
C. pseudocurvisetus	*	
C. similis	*	*
C. teres	*	*
C. tortissimus	*	*
C. sp. A	*	
Corethron criophilum (=*C. pelagicum*)	*	*
Coscinodisus asteromphalus	*	*
C. granii	*	*
C. jonesianus	*	*
C. oculus-iridis	*	*
C. perforatus	*	*
C. radiatus	*	*
C. sp. A	*	*
C. sp. B	*	*
C. wailesii	*	
Cyclotella striata	*	
Diatoma elongatum	*	*
Ditylum brightwellii	*	*
Eucamphia zodiacus	*	
Guinardia flaccida	*	
Hemiaulus membranaceus	*	
H. sinensis	*	
Leptocylindrus danicus	*	*
Melosira dubia		*
Navicula salinarum	*	
N. sp. A	*	*
N. sp. B	*	
Nitzschia delicatissima	*	*
N. longissima	*	*
N. pungens	*	*
N. seriata	*	*
N. sigma	*	*
Odontella aurita	*	*
Odontella mobiliensis	*	*
Odontella rhombus	*	
Odontella sinensis	*	*
Paralia sulcata	*	*
Pinnularia sp.	*	
Plagiogramma vanheurckii	*	*
Pleurosigma aestuarii	*	
P. angulatum	*	*

	October	March
P. elongatum	*	
P. normanii	*	
(=*P. affine*)		
P. rigidum	*	
P. sp. A	*	*
P. sp. B	*	
Podosira stelliger	*	*
Rhizosolenia alata f. indica	*	*
R. calcar-avis	*	
R. delicatula	*	
R. hebetata f. semispina	*	*
R. imbricata	*	*
R. robusta	*	
R. setigera		*
R. stolterfothii	*	
R. styliformis		*
Skeletonema costatum	*	*
Stauroneis membranacea	*	
Stenopterobia arctica	*	*
Streptotheca tamesis	*	
Stephanophyxis palmeriana	*	
S. turris	*	
Surirella ovata	*	
Thalassionema nitzschioides	*	*
Thalassiosira angulata		*
T. anguste-lineata		*
T. baltica	*	*
T. condensata	*	*
T. eccentrica	*	*
T. gravida		*
T. leptopus	*	*
T. nordenskiöldii		*
T. rotula	*	*
Thalassiothrix frauenfeldii	*	*
Triceratium favus	*	*
Tropidoneis antarctica	*	
SILICOFLAGELLATES		
Dictyocha fibula	*	*
Distephanus speculum	*	
DINOFLAGELLATES		
Amphidinium acutissimum	*	
A. crassum	*	
A. extensum	*	
A. globosum	*	
A. kesslitzi	*	

	October	March
A. longum	*	
A. lacustre	*	
A. stigmatum	*	
A. sp. A	*	
A. sp. B	*	
A. sp. C	*	
A. sp. D	*	
Ceratium furca	*	
C. fusus	*	*
C. kofoidii	*	*
C. macroceros	*	*
C. tripos	*	
Crypthecodinium cohnii	*	*
Dinophysis caudata	*	*
D. recurva	*	
Diplopsalis asymmetrica	*	
Gonyaulax sp.	*	
Gymnodinium albulum	*	
G. flagellare	*	
G. gelbum	*	
G. pulchrum	*	
G. semidivism	*	
G. splendens	*	
G. wulfii	*	
G. biconicum	*	
G. lohmanni	*	*
Gyrodinium sp. A	*	
Gyrodinium sp. B	*	
Oxytoxum oblicum	*	
O. sp.	*	
Protoperidinium bipes	*	*
P. conicum	*	*
P. depressum	*	*
P. leonis	*	*
P. oceanicum	*	
P. pallidum	*	
P. pentagonum	*	
P. pentagonum v. latissimum	*	
Polykrikos kofoidii	*	
Prorocentrum maximum	*	
P. micans	*	
P. perforata	*	*
P. triestinum	*	
Pyrocystis hamulus	*	*