The Journal of the Oceanological Society of Korea
Vol. 18, No. 2, p. 91～103, December 1983.

PLANKTON STUDY IN THE SOUTHEASTERN SEA OF KOREA (I)

—Phytoplankton Distribution in September, 1981—

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韓國 東南 海域의 플랑크톤 硏究(I)

—1981年 9月의 植物플랑크톤 分布—

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Abstract: Qualitative and quantitative phytoplankton samples collected during a cruise in the southeastern sea of Korea in September 1981, were analysed.

A total of 185 species of phytoplankters were identified in the present study. Of the numbers 124 species of diatoms and 56 dinoflagellate forms were found. The rest were 3 silicoflagellate forms, a cryptomonad and a euglenoid each.

On the basis of the analyses of the phytoplankton communities, two vegetation areas were recognized. It is demonstrated that the extent of each vegetation area largely depends on hydrographical features. In southeastern coastal waters, the vegetation was fairly rich, and consisted of small celled diatoms and minute flagellates. In the northern part of the area, abundant phytoplanktons were present consisting of various diatoms and dinoflagellates.

The size of standing stock of phytoplankton was compared with hydrography and the specific composition of phytoplankon. The importance of mixing between the Tsushima warm current water and North Korean cold water in distributing phytoplankton stocks was stressed.

要約: 1981년 9월에 한국 동남해역의 연안역, 대륙붕역 및 대륙사면역에 이르는 각 수역에서 수심별로 채집된 식물 플랑크톤의 정성 및 정량시료를 분석하였다.

본 연구에서는 185종류의 식물 플랑크톤을 동정하였으며, 이는 규조류 124종류, 쌍편모조류 56종류, 규질편모류 3종류 및 각 1종류씩의 갈색편모조류와 유글레나류로 구성되어 있다.

식물 플랑크톤 군집을 분석한 결과 연구해역은 2개의 식생역으로 구분됨을 알게 되었고, 해수의 물리적 특성에 의하여 이들 식생역의 범위가 크게 좌우됨이 밝혀졌다. 동남 연안역의 경우 식생은 매우 풍부하였으며 소형 규조류와 미세 편모류가 주종이었고 연구 해역의 북부 수역에서는 여러 종류의 규류조 및 쌍편모조류가 다량 출현하였다.

식물 플랑크톤 현존량을 해수의 물리적 특성, 식물 플랑크톤의 종조성과 비교 하였다. 연구 해역의 북부 수역에서는 식물 플랑크톤 현존량분포에 있어서 대마난류수와 북한한류 계수의 혼합현상이 특히 중요함을 알게 되었다.

INTRODUCTION

This paper is based on both qualitative and quantitative survey of the phytoplankton of the southeastern sea of Korea in September 1981, which was undertaken with a view to supplementing and extending the present knowledge of the flora, ecology and biogeography of the region.

The phytoplankton studies around the southeastern sea of Korea are not many in numbers. Skvortzow (1931) firstly described the pelagic diatoms of the Korea Strait, identifying 68 species. Park (1956) studied the seasonal change of plankton, Uhm and Yoo (1967) discussed the distribution of diatoms and their relation to currents. Choe (1966, 1969a) examined the specifiic distribution and abundance of phytoplankton. These studies are confined to the area of Korea Strait. Choe (1969b) dealt with the quantitative and qualitative phytoplankton samples from three major waters of Korea.

The present state of knowledge does not permit detailed, quantitative comparison between production and specific composition of the phytoplankton communities, but the material seemed to justify an attempt to establish a quantitative relationship between the standing stock of phytoplankton and its specific composition. In addition to the attempt just outlined, regional studies involving phytoplankton distribution are likely to yield information of interest.

MATERIALS AND METHODS

During the cruise of the training ship "Hanbada" in September 1981, large phytoplankton material was collected at each station of the study area (Fig. 1). A great number of data on hydrography were obtained as well. Information on the hydrography should be referred to Lim(Lim, 1983).

The quantitative samples of phytoplankton were collected at those stations where physical properties were determined, using Van Dorn Water Samplers. The samples were stored in 500 ml bottles, fixed with modified Lugol's solution as a preservative. For qualitative purpose a Norpac Type plankton net was towed at each

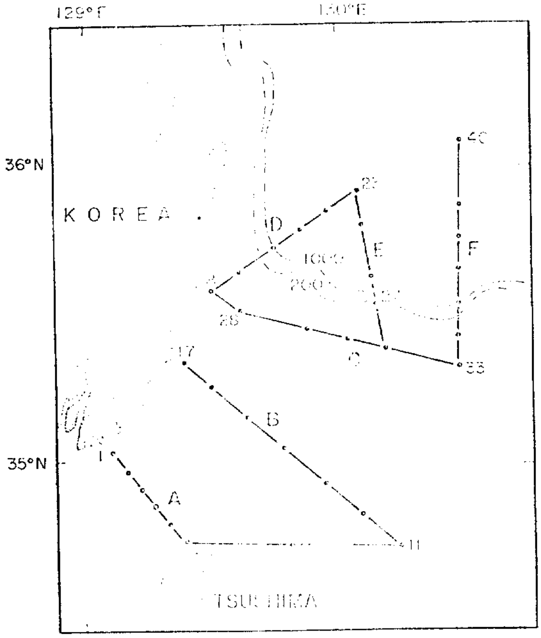

Fig. 1. A map showing sampling lines and stations.

station and the mesh size of the net was 53 μm. The samples were preserved with neutralized formalin at a concentration of 4%.
Of the samples, 38 qualitative samples of 38 stations and 166 quantitative samples of 29 stations were analyzed with a light microscope at up to 2000 times of magnification. Sedgwick-Rafter slide and Palmer-Maloney slide were used for quantitative analyses. The identification of very small forms, however, frequently offered some difficulty. In many cases naked cryptophyceans lose their flagella and many of these small organisms may have eluded counting altogether. Even smaller forms have been inevitably excluded from counting in this study.

It should be stressed that the numbers presented in the counting can be taken only as approximations to the true concentrations of organisms present at the localities where the samples were collected. This is due in part to the statistical uncertainties related to the sampling procedure(Lund et al., 1958).

THE STUDY AREA

The study area is the southern part of Korean eastern sea and covers approximately 10,000 km^2. Most of the study area overlies continental shelf and its northern part includes continental slope exceeding 1,500 m in depth.

The waters of the area are characterized by four components: the Tsushima warm current which is passing through the Korea Strait, the North Korean cold water coming down along the eastern coast, Japan Sea proper water which overlies deep water on the basin of the Sea of Japan, and the coastal waters of low salinities (Lim, 1983; Kim, C.H. and K. Kim, 1983).

RESULTS AND DISCUSSION

(a) Composition of Phytoplankton

A total of 185 species of phytoplankters were identified and a complete list is added in the (e) section of this chapter.

Diatoms

124 species of diatoms were found. Some slight differences of opinion on the taxonomy of certain species are found in the literatures (Skvortzow, 1931; Choe, 1969a) which follow old system. A diatomaceous flora predominated in the waters of the study area, ranging from 181,485 cells/*l* at station 16 (30m depth) to 876 cells/*l* at station 5 (75m). The most common species of the area were *Bacteriastrum delicatulm*, *Chaetoceros affinis*, *Ch. decipiens*, *Ch. lorenzianus*, *Coscinodiscus asteromphalus*, *C. oculus-iridis*, *Ditylum brightwellii*, *Guinardia flaccida*, *Navicula* sp., *Nitzschia closterium*, *N. seriata*, *Rhizosolenia calcar-avis*, *Rh. setigera*, *Stephanopyxis turris*, *Thalassionema nitzschioides and Thalassiothrix frauenfeldii*. And the most abundant species of which concentrations were frequently more than 10% of total cell numbers of a sample were *Navicula* sp., and *Nitzschia closterium*. In addition to these species, those species such as *Nitzschia delicatissima* and *Ch. compressus* predominated at more than five stations. Large concentrations of diatom cells were common at stations 16, 18, 19 and 22 during the cruise, up to the value of 181,485 cells/*l*.

The general pattern of transects showed a decrease in total numbers of diatoms and species of diatoms in offshore stations with the lowest counts at stations 32, 33, 35 and 37.

Dinoflagellates

There were 56 dinoflagellate species identified in the samples. Dinoflagellates were generally less abundant than diatoms, but were more numerous than diatoms at stations 11, 13, 23, 33 and 35. The most common species of dinoflagellates were *Ceratium breve*, *C. furca*, *C. fusus*, and *Prorocentrum micans*.

Of the dinoflagellates observed 21 species (38%) are oceanic and warm water forms which include 13 species of 18 indicator species of Kuroshio water (Motoda and Marumo, 1963), reflecting the influence of Kuroshio water. Thirteen neritic species occurred mainly in inshore waters together with 1 cold water species.

Silicoflagellates

Silicoflagellates were noted frequently, but were never abundant. *Dictyocha fibula* is a warm water form and was the most common of the 3 silicoflagellates observed.

Crytomonad and Euglenoid

Cryptomonas sp. smaller than 20 μm appeared only in quantitative samples and in almost all stations. *Cryptomonas* sp. was one of the dominants in the study area with highest concentration of 279,450 cells/*l* at station 20 (10 m). *Eutreptiella marina* was the only euglenoid and observed only at station 2.

(b) The Phytoplankton in Relation to the Hydrographical Features

Hydrography

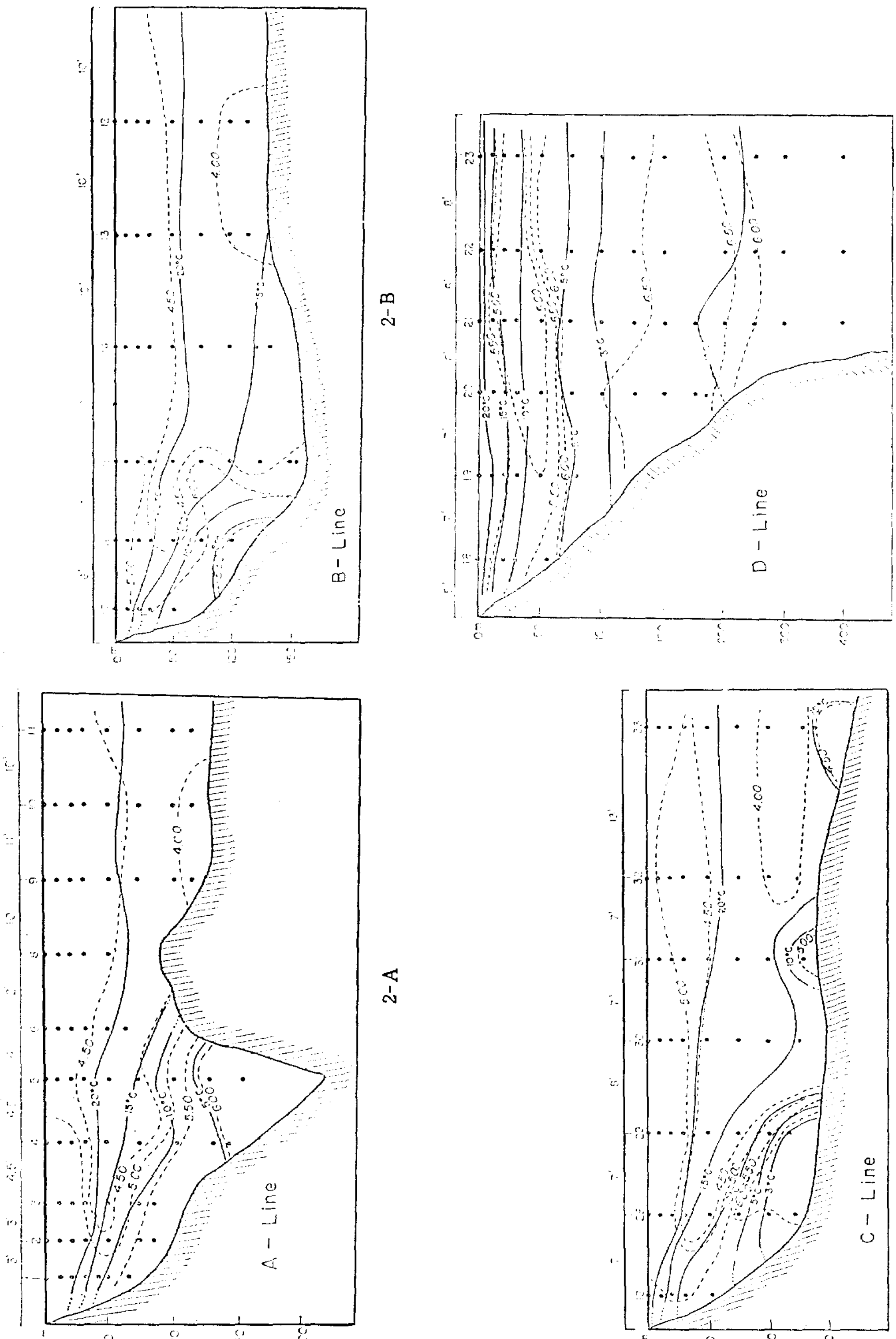

Fig. 2. Temperature and dissolved oxygen sections (From Lim, 1983).

The Tsushima warm current water and the cold water mass in the study area have shown various types of spatial distributions seasonally and annually (Lim and Chang, 1969; Lim, 1974; An, 1974; Hong and Cho, 1983a; Kim and Kim, 1983), which exerts major influences on the hydrography of the study area. During the days in July 1981, the cold water mass showed a extraordinarily great influence since 1966. The 10°C isothermal contour line of the cold water moved southwards by 20-150 miles compared with the average (Hong and Cho, 1983b). At the time of investigation, the cold water mass had its 5°C isothermal contour line at the depths of 75m, 85m, 100m, 125m in line D,C,B,A, respectively (Fig. 2-A, 2-B, 2-C, and 2-D), and from the dissolvd oxygen and salinity distribution the cold water mass was characterized as North Korean cold water (Lim, 1983).

Vegetation Areas

The cluster analysis based on the quantitative distribution of 98 species in the 166 samples (surface, 10m, 20m, 30m, 50m, 75m depths), provided a possible division of the region into 2 vegetation areas (Fig. 3). The distribution pattern of the four most dominant species (Fig. 4) showed nearly the same division of the study area.

Area I is located in coastal and offshore areas in part with low surface salinities (Fig. 2-D). The phytoplankton vegetation in this area was dominated exclusively by *Cryptomonas* sp. (Fig. 5) and *Nitzschia closterium* (Fig. 6). Many neritic species were observed in area I. At stations 18, 19, 20 and 22 *Cryptomonas* sp. predominated with its average fraction ranging from 25% to 60% of the total cell numbers. *Nitzschia closterium* is a neritic species and noted at 3 stations (17, 18, 19) with fairly high concenrations.

Stations 18 and 19 are in the most rich region in terms of phytoplankton standing stocks and

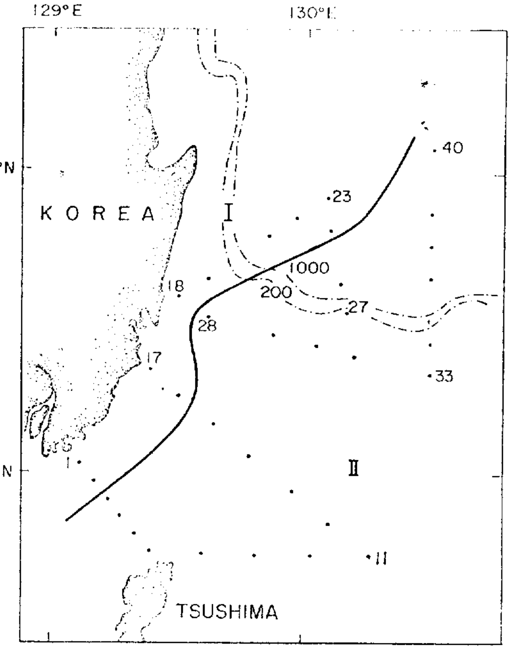

Fig. 3. Vegetation areans in the southeastern sea of Korea, September 1981.

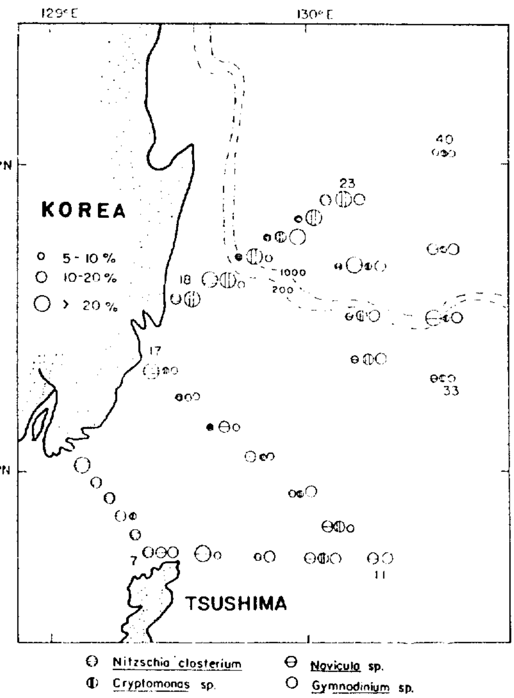

Fig. 4. Distribution of four dominant species based on average fractions to total cell numbers.

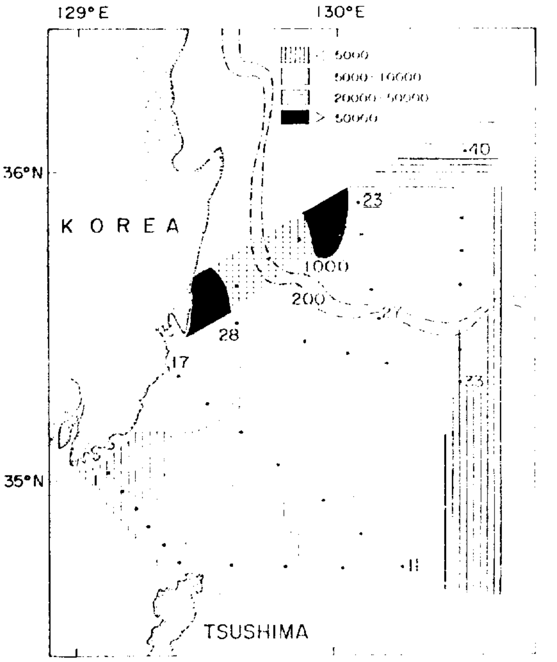

Fig. 5. Distribution of *Cryptomonas* sp. based on average values of cells/*l*.

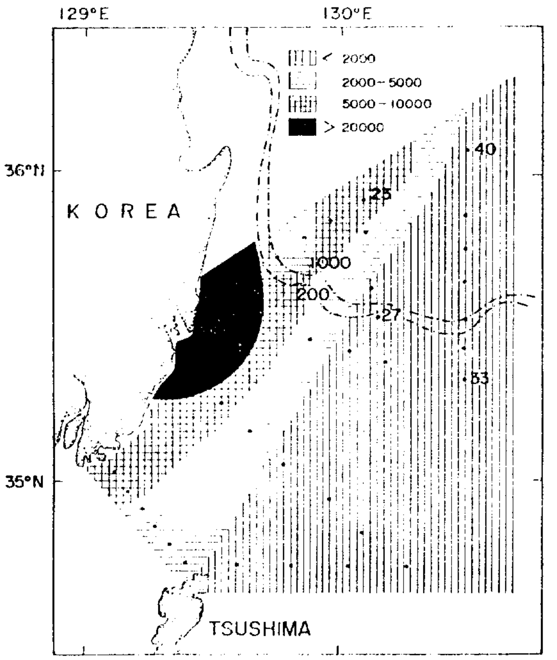

Fig. 6. Distribution of *Nitzschia closterium* based on average values of cells/*l*.

are supposed to the location where the cold water mass and Tsushima Current warm water met together in the upper layer at the time of investigation.

Area II located farther offshore. The most abundant species in area II was *Navicula* sp. reaching 22,968 cells/*l* (station 14, 30m) and *Gymnodinium* sp. and *Cryptomonas* sp. were dominant, too. Among the 6 stations where dinoflagellates outnumbered diatoms 5 stations are in area II and *Chaetoceros coarctatus* which was suggested as useful indicator of pure Kuroshio water(Motoda and Marumo, 1963) appeared in only area II. The pattern of phytoplankton distribution demonstrates that area II was under much stronger influence of Kuroshio water than area I.

(c) The Distribution of the Total Standing Stocks and the Relative Importance of Some Dominant Species

The size of standing stocks of phytoplankton was tentatively calculated in cell counts. The chart shown in Fig. 7 is based on the average cell numbers per liter at each station. Large biomass were restricted to the region around stations 16, 17, 18, 20, 21, 22 where the warm and cold water were supposed to be met in the upper layer. It seems justified to conclude that there was a very good indication of production intensity in this region. On the basis of the distribution of component species, species with similar pattern of distribution could be grouped together as follows:

A. Species distributed almost entire area with high concentrations:

Cryptomonas sp. *Gymnodinium* sp.

B. Species having their center of distribution and attaining the largest concentration in the high production region(Fig. 7), but frequently occurring in less productive region:

Nitzschia closterium

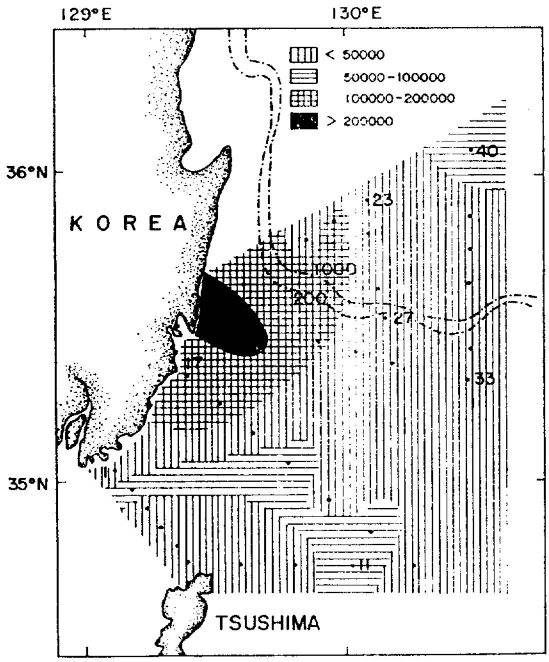

Fig. 7. Standing stock distribution in September 1981, based on average values of cell/*l*.

Rhizosolenia setigera

Rhizosolenia pungens

C. Species attaining large concentrations at southeastern region while being much less important in the region of high production:

Chaetoceros compressus

Chaetoceros debilis

Chaetoceros laciniosus

Gymnodinium gelbum

Nitzschia longissima

Prorocentrum micans

Thalassiothrix frauenfeldii

D. Species having large distributional region including northern part of the sea:

Chaetoceros affinis

Leptocylindrus danicus

Paralia sulcata

Rhizosolenia delicatula

Rhizosolenia fragilissima

Rhizosolenia stolterfothii

Skeletonema costatum

Obviously, only those species which formed a significant component of the phytoplankton, i.g. species which belong to groups A and B could be held responsible for the high production in this area. Assuming that the cell surface area of planktonic algae serves as reasonably close estimate of their ability to carrry out photosynthesis (Paasche, 1960), it would seem that *Cryptomonas* sp. was, on the whole, the most active individual producer. In high production area, *Cryptomonas* sp. reached 60.4% of the total cell counts. In reality, the relative shares of different algae in production probably varies greatly from one locality to another.

(d) Nanoplankton, Taxonomic Identification, Numerical Abundance

***Cryptomonas* sp.**

The taxonomy of the cryptophceans has always been problematical.For classification at the light-microscope level 5 principal characteristics have been used: chloroplast numbers and starch patterns: presence and arrangement of large ejectosomes(Gantt, E., 1980). In this study identification to the genus level was possible according to "the key to the chief genera of the Cryptophyceae" (Butcher, R.W., 1967). Most *Cryptomonas* species range from 8μm up to 40μm in length, but all the cells observed in this study were under 20μm in length. This genus is recorded for the first time in Korean waters.

***Gymnodinium* sp. and *Gyrodinium* sp.**

Unarmored dinoflagellates less than 30 μm in total length were classified as *Gymnodinium* sp. and *Gyrodinium* sp. according to the key to genera of the unarmored dinoflagellates (Hulburt, E.M., 1957; Dodge, J.D., 1983).

Cryptomonad species can be very abundant at times (Knight-Jones, 1951; Raymont, 1980) and Shim (1980) found that cryptomonad cells were one of the most abundant algal forms in the southern sea of Korea. *Gymnodinium* sp. and *Chroomonas* sp. (a cryptomnad) were the 2 most dominant nanoplankton species in the south western sea of Korea in June (Park, Y.C., 1981).

(e) The List of the Phytoplankton Species Observed in the Study

PHYLUM CHRYSOPHYTA
CLASS BACILLARIOPHYCEAE
Order Centrales
Suborder Conscinodiscineae
Family Melosiraceae Kützing

Corethron criophilum CASTRACANE(=*C. histrix*)
Leptocylindrus danicus CLEVE
Leptocylindrus mediterraneus (H. PERAG.) HASLE
Melosira moniliformis (D.F. MÜLLER) AGARDH
Paralia sulcata (EHR.) CLEVE
Stephanopyxis palmeriana (GREV.) GRUNOW
Stephanopyxis turris(GREV. & ARN.) RALFS
Schröderella delicatula (RERAG.) PAVILLARD

Family Thalassiosiraceae Lebour Emend. Hasle 1973

Lauderia annulata CLEVE (=*Lauderia borealis*)
Planktoniella sol (WALLICH) SCHÜTT
Skeletonema costatum (GREV.) CLEVE
Thalassiosira angulata(=*Thalassiosira decipiens*)
Thalassiosira condensata CLEVE
Thalassosira eccentrica (EHRENB.) CLEVE
Thalassiosira gravida CLEVE
Thalassiosira lineata JOUSÉ

Family Conscinodiscaceae Kützing

Coscinodiscus asteromphalus EHRENBERG
Coscinodiscus commutatus GRUNOW
Coscinodiscus concinniformis SIMONSEN(=*C. concinnus*)
Coscinodiscus gigas EHRENBERG(=*C. gigas var. praetexta*)
Coscinodiscus granii GOUGH
Coscinodiscus jonesianus(GREV.) OSTENFELD
Coscinodiscus normanii GREGORY
Coscinodiscus oculus-iridis EHRENBERG
Coscinodiscus perforatus EHRENBERG
Coscinodiscus radiatus EHRENBERG
Coscinodiscus stellaris ROPER
Gossleriella tropica SCHÜTT

Family Hemidiscaceae Hendy Emend. Simonsen

Actinocyclus octonarius (=*A. ebrenbergii*) EHRENBERG

Family Asterolampraceae H.L. Smith

Asteromphalus cleveanus GRUNOW
Asteromphalus heptactis (BREB.) RALFS
Asteromphalus robustus CASTRACANE

Family Heliopeltaceae H.L. Smith

Actinoptychus senarius EHRENBERG

Subdorder Rhizosoleniineae
Family Rhizosoleniaceae Petit

Guinardia flaccida (CASTR.) H. PERAGALLO
Rhizosolenia acuminata (H. PERAG.) GRAN
Rhizosolenia alata BRIGHTWELL
Rhizosolenia alata form. *curvirostris* GRAN
Rhizosolenia alata form. *gracillima* (CLEVE) GRAN
Rhizosolenia alata form. *indica* (H. PERAG.) ORTENFELD
Rhizosolenia bergonii H. PERAGALLO
Rhizosolenia calcar-avis M. SCHULTZE
Rhizosolenia castracanei H. PERAGALLO
Rhizosolenia cylindrus CLEVE
Rhizosolenia delicatula CLEVE
Rhizosolenia fragilissima BERGON
Rhizosolenia habetata form. *hiemalis* GRAN
Rhizosolenia hebetata from. *semispina*(HANSEN) GRAN
Rhizosolenia imbricata var. *shrubsolei* SCHRÖDER
Rhizosolenia pungens CLEVE
Rhizosolenia robusta NORMAN
Rhizosolenia setigera BRIGHTWELL

Rhizosolenia stolterfothii H. PERAGALLO
Rhizosolenia styliformis BRIGHTWELL
Rhizosolenia styliformis form. *longispina* HUSTEDT

Family Biddulphiaceae Kützing

Subfamily Hemiauloideae Jousé, Kiselev & Poretskii

Cerataulina bergonii H. PERAGALLO
Climacodium frauenfeldianum GRUNOW
Eucampia cornuta (CLEVE) GRUNOW
Eucampia zodiacus EHRENBERG
Hemiaulus hauckii GRUNOW
Hemiaulus membranaca CLEVE
Hemiaulus sinensis GREVILLE

Subfamily Biddulphioideae Schütt

Biddulphia longicruris GREVILLE
Biddulphia tuomeyi (BAIL.) ROPER

Family Chaetoceraceae H.L. Smith

Bacteriastrum comosum PAVILLARD
Bacteriastrum delicatulum CLEVE
Bacteriastrum elongatum CLEVE
Bacteriastrum hyalinum LAUDER
Bacteriastrum hyalinum var. *princeps* IKARI
Bacteriastrum varians LAUDER
Chaetoceros affinis LUDER
Chaetoceros affins var. *willei* (GRAN) HUSTEDT
Chaetoceros anastromosans GRUNOW
Chaetoceros atlanticus CLEVE
Chaetoceros borealis BAILEY
Chaetoceros brevis SCHÜTT
Chaetoceros coarctatus LAUDER
Chaetoceros compressus LAUDER
Chaetoceros concavicornis MANGIN
Chaetoceros costatus PAVILLARD
Chaetoceros curvisetus CLEVE
Chaetoceros danicus CLEVE
Chaetoceros debilis CLEVE
Chaetoceros decipiens CLEVE
Chaetoceros denticulatus LAUDER
Chaetoceros diadema (EHR.) GRAN (=*C. subsecundus*)
Chaetoceros didymus EHRENBERG
Chaetoceros didymus var, *protuberans* LAUDER
Chaetoceros difficilis CLEVE
Chaetoceros diversus CLEVE
Chaetoceros eibenii GRUNOW
Chaetoceros laciniosus SCHÜTT
Chaetoceros lorenzianus GRUNOW
Chaetoceros messanensis CASTRACANE
Chaetoceros pendulus KARSTEN
Chaetoceros peruvianus BRIGHTWELL
Chaetoceros pseudocrinitus OSTENFELD
Chaetoceros pseudocurvisetus MANGIN
Chaetoceros radicans SCHÜTT
Chaetoceros seriacanthus GRAN
Chaetoceros seychellarum KARSTEN
Chaetoaeros socialis LAUDER
Chaetoceros tetrastichon CLEVE
Chaetoceros wighami BRIGHTWELL

Family Lithodesmiaceae H. & M. Peragallo

Ditylum brightwellii (WEST.) GRUNOW
Ditylum sol GRUNOW
Streptotheca indica KARSTEN
Streptotheca thamesis SCHRUBSOLE

Eamily Eupodiscaceae

Subfamily Eupodiscoideae

Erataulvs turgidus EHRENBERG
Odontella mobiliensis (BAIL.) GRUNOW
Odontella sinensis (GREV.) GRUNOW

Order Pennales

Suborder Araphidineae

Family Diatomaceae Dumortier

Asterionella kariana GRUNOW
Licmophora paradoxa (LYNGB.) AGARDH
Podocystis spathulata (SHADB.) VAN HEURCK
Rhaphoneis sp.
Thalassionema nitzschioides (GRUN.) HUSTEDT
Thalassiothrix frauenfeldii GRUNOW

Suborder Raphidineae

Family Naviculaceae Kützing

Navicula sp.

Stauroneis membranacea (CLEVE) HUSTEDT

Family Nitzschiaceae Grunow

Nitzschia closterium (EHRENB.) W. SMITH

Nitzschia delicatissima CLEVE

Nitzschia longissima (BREB.) RALES

Nitzschia pacifica CUPP

Nitzschia pungens GRUNOW (=*N. pungens* var. *atlantica*)

Nitzschia seriata CLEVE

CLASS CHRYSOPHYCEAE

Order Ebriales

Family Ebriaceae

Ebria tripartita var. *simplex* SCHULZ

Order Dictyochales

Family Dictochaceae

Dictyocha fibula EHRENBERG

Distephanus speculum (EHRENB.) HAECKEL

PHYLUM DINOPHYTA

CLASS DINOPHYCEAE

Order Prorocentrales

Family Procentracae

Prorocentrum micans EHRENBERG

Prorcentrum sp.

Order Dinophysiales

Family Amphisoleniaceae

Amphisolenia bidentata SCHRÖDER

Amphisolenia rectangulata KOFOID

Amphisolenia thrinax SCHÜTT

Triposolenia intermedia KOFOID

Family Dinophysiaceae

Dinophysis caudata SAVILLE-KENT

Dinophysis forthii PAVILLARD

Dinophysis ovum SCHÜTT

Family Ceratocorys

Ceratocorys horrida STEIN

Ceratocorys horrida var. *extensa* PAVILLARD

Family Ornitoceraceae

Ornithoceros steinii SCHÜTT

Ornithoceros thumii (SCHMIDT) KOFOID & SKOGSBERG

Order Gymnodiniales

Family Gymnodiniaceae

Gymnodinium gelbum KOFOID

Gymnodinium splendens LEBOUR

Gymnodinium sp.

Gyrodinium sp.

Order Pyrocystales

Family Pyrocystaceae

Pyrocystis noctiluca MURRAY ex HAECKEL

Order Periodiniales

Eamily Peridiniaceae

Protoperidinium conicum (GRAN) BALECH

Protoperidinium depressum (BAIL.) BALECH

Protoperidinium divergens (EHRENB.) BALECH

Protoperidinium elegans CLEVE

Protoperidinium hirobis ABE

Protoperidinium leonis (PAVIL.) BALECH

Protoperidinium bipes (PAUIS.) BALECH

Protoperidinium oceanicum (VANH.) BALECH

Protoperidinium ovatum POUCHET

Protoperidinium pallidum (OSTEN.) BALECH

Protoperidinium pentagonum (GRAN) BALECH

Family Gonyaulaceae

Gonyaulax fratercula BALECH

Gonyaulax polygramma STEIN

Family Ceratiaceae

Ceratium breve (OSTENF. & SCHM.) SCHRÖDER

Ceratium candelabrum (EHRENB.) STEIN

Ceratium carriense GOURRET

Ceratium contortum CLEVE

Ceratium contortum var. *karstenii* (PAVILL.) SOURNIA

Ceratium deflexum JÖRGENSEN

Ceratium extensum (GOURRRET) CLEVE

Ceratium furca (EHRENB.) CLAPAREDE & LACHMANN

Ceratium fusus (EHRENB.) DUJARDIN

Ceratium gibberum GOURRET

Ceratium gravidum GOURRET

Ceratium trichoceros var. *contarium* (GOURR.) SCHIPPER

Ceratium kofoidii JÖRGENSEN

Ceratium longipes (BALL.) GRAN
Ceratium lunula SCHIMPER
Ceratium macroceros (EHRENB.) VANHeFFEN
Ceratium massiliens JÖRGENSEN
Ceratium platycorne DADAY
Ceratium pulchellum SCHPÖDER
Ceratium ranipes CLEVE
Ceratium trichoceros (EHRENB.) KOFOID
Ceratium tripos (O.F. MULLER) NITZSCH
Ceratium vultur var. *summatranum* STEEMAN NIELSEN

Family Oxytoxaceae
Oxytoxum sp.

Family Podolampaceae
Podolampas spinifera OKAMURA

PHYLUM CRYPTOPHYTA
CLASS CRYPTOPHYCEAE
Order Cryptomonadales
Family Cryptomonadaceae
Cryptomonas sp.

PHYLUM EUGLENOPHYTA
CLASS EUGLENOPHYCEAE
Order Eutreptiales
Family Eutreptiaceae
Eutreptiella marina DA CUNHA

CONCLUSION

i) The study area could be divided into 2 vegetation areas, area I and area II. In area I highest production was found at those stations where Tsushima current water and North Korean cold water met in the upper layer of the water column. Much more influence of Kuroshio water was noticed in area II.

ii) In addition to diatoms which have been major materials in phytoplankton study in this area, dinoflagellates and microflagellates are very important in the primary production and phytoplakton distribution of the study area.

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