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ENVIRONMENTAL STUDIES OF THE JINHAE BAY
1. ANNUAL CYCLE OF PHYTOPLANKTON POPULATION, 1976-1978

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요 지

1976년 7월부터 1978년 5월까지 2년동안 매 기수월에 진해만의 6개 정점에서 식물성플랑크톤군집의 년변화를 조사하였다.

조사기간 중 수온은 2.28° C~25.48° C, 염분도는 27.42 ‰~33.90 ‰, pH는 8.0~8.5, 투명도는 0.5 m~8.0 m, 용존산소량은 2.23 ml/l~12.32 ml/l의 분포를 보였다.

식물성플랑크톤의 출현종수는 30속, 79종, 2품종, 3변종으로 나타났다. 이들의 우점종은 *Skeletonema costatum*, *Thalassiosira hyalina*, *Leptocylindrus danicus*, *Chaetoceros curvisetus*, *Chaetoceros costatus*, *Nitzschia pungens*, *Nitzschia seriata*였으며, *Chaetoceros affinis*, *Chaetoceros curvisetus*, *Coscinodiscus centralis* var. *pacifica*, *Ditylum brightwellii*, *Navicula distans*, *Nitzschia pungens*, *Pleurosigma elongatum*, *Thalassiosira hyalina*, *Thalassiothrix frauenfeldii*등은 출현빈도에 있어서 이 지역의 대표종이었다. 출현종의 생태적 구분은 연안종이 67.86%로서 내만의 특성을 나타내고 있다.

현존량의 계절적인 변화는 808~12,461,000 cell/l까지 심한 변화폭을 보이고 있으며, 1976년 7월, 11월, 1977년 5월, 9월, 1978년 5월에 10^6 cells/l대의 대발생이 있었다. 대발생때의 다양성지수는 1976년 7월에 0.5625~1.0345로 낮은 값을 보여 *Skeletonema costatum*에 의한 대발생이었으며, 11월의 3.0702~4.1019의 높은 값을 보인때는 18~33종의 다양한 출현종에 의한 것이었다.

INTRODUCTION

Among the phytoplankton population the diatom species frequently plays an important roles for the primary production in marine ecosystem. Therefore, the spatial-temporal distribution of the diatom population is not only grasping their productivity, but also understanding the unusual bloom caused by the eutrophication in the coastal zone.

Nothing has been published on the annual phytoplankton cycles of the Jinhae Bay, and little is known of the taxonomy and seasonal cycles of the phytoplankton (Park, 1956; Park and Kim, 1967; Choe, 1967, 1969; Yoo and Lee, 1976).

This study will provide data on physico-chemical parameters, seasonal fluctuation of species composition, standing crops, and species diversity. Thus, the purpose of this investigation is to observe the annual cycles of the Jinhae Bay that has not been studied previously, to compare the data with that of other coastal zone in southern coast of Korea.

MATERIALS AND METHODS

1. Samples

Samples were obtained bimonthly from 6 stations in the Jinhae Bay during the period from July 1976 to May 1978 (Fig. 1).

For the sampling one liter of sea water was collected from surface and near bottom (0.5

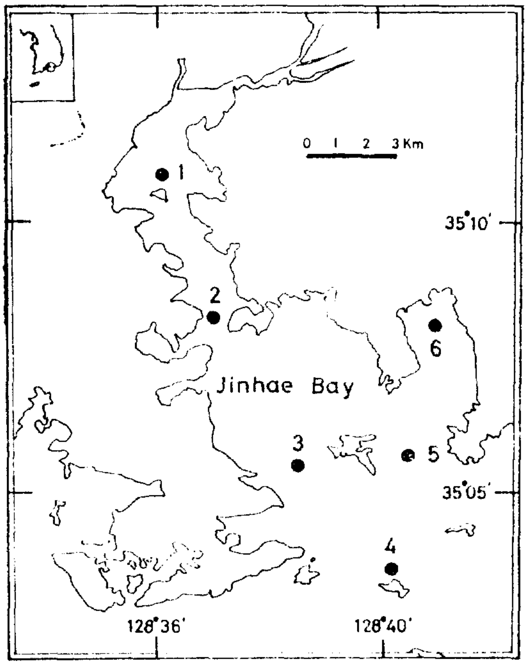

Fig. 1. Map showing stations in the Jinhae Bay

meter below surface and above bottom) using Van Dorn water sampler. The samples were fixed with 5% neutralized formalin on board.

In laboratory the settling method was adopted for both qualitative and quantitative analysis. From each of sample a well-mixed aliquot (1/5 ml) was then transferred to a slide and all species identified. Cell counting was performed with Sedgwick-Rafter Cell and all counts was expressed in cells per liter of sea water.

2. Physico-chemical analysis

Temperature was determined with reversing thermometer on board and transparency with Secchi disc. Salinity was measured with a multiparameter *in situ* water quality analyzer (The Hydrolab Model 6D Surveyor). The value of pH was measured by using a portable pH meter (Analytical Measurements Model 707).

Dissolved oxygen was determined at the laboratory by modified Winkler Method (Strickland and Parsons, 1972).

3. Diversity index

Diversity was calculated by Shannon-Wiever formula (Odum, 1969).

$$H=-\sum_{i=1}^{s} n_i/N\cdot\log_2 n_i/N$$

where N is the total number of cells/liter, s is the number of species, and n_i is the number of cells in each species. H is the community diversity and is an approximation combining variety and equiltabitiy components of diversity into one number. Diversity computations were accomplished on the Minimicro-computer (Sharp Compet Model 365-P).

RESULTS AND DISCUSSION

1. Environmental parameters

Temperature and salinity data are presented in Fig. 2 and 3. Average surface water temp-

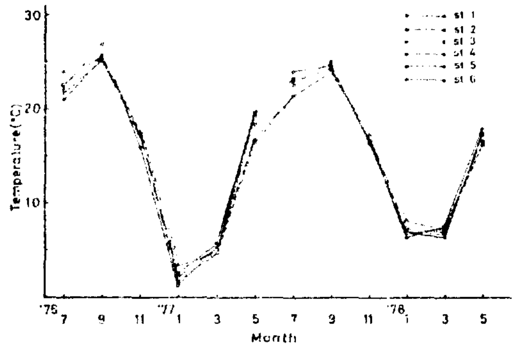

Fig. 2. Seasonal variations of water temperature in the Jinhae Bay (surface)

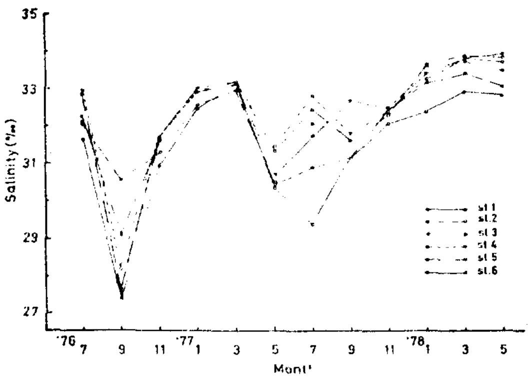

Fig. 3. Seasonal variations of salinity in the Jinhae Bay (surface)

erature for the stations was highest in September 1976, 25.48°C, and lowest in January 1977, 2.28°C, during the course of study. On any particular data the surface water temperature did not vary more than ±1.5°C from one station to another.

The lowest salinity recorded was 27.42‰ at St. 1 in September 1976 and highest was 33.90 ‰ at St. 6 in May 1978. In general the salinity showed a little higher at offshore stations.

pH value recorded for the stations showed ranging from 8.0 to 8.5.

Transparency measured variable extensively by months and stations: ranging from 0.5 to 8.0 meters.

The highest oxygen concentration of 12.32

Table 1. Systematic list of diatom species in the Jinhae Bay.

Actinoptychus seranius (*A. undulatus*)*	*D. sol*
Amphiprora gigantea var. *sulcata*	*Eucampia zodiacus*
Asterionella gracialis (*A. japonica*)	*Guinaridia flaccida*
Asteromphalus heptactis	*Hemiaulus sinensis*
Bacteriastrum delicatulum	*Lauderia borealis*
B. hyalinum	*Leptocylindrus danicus*
Bacillaria paxillifer (*B. paradoxa*)	*Licmophora abbreviata*
Biddulphia sinensis	*Navicula distans*
Chaetoceros affinis	*N. membranacea*
C. anastomosans	*Nitzschia longissima*
C. atlanticus	*N. pacifica*
C. brevis	*N. pungens*
C. compressus	*N. seriata*
C. constrictus	*Paralia sulcata* (*Melosira sulcata*)
C. costatus	*Pleurosigma elongatum*
C. curvisetus	*P. normanii*
C. danicus	*Rhizosolenia alata*
C. debilis	*R. alata* f. *indica*
C. decipiens	*R. calcar-avis*
C. didymus	*R. delicatula*
C. difficilis	*R. fragilissima*
C. diversus	*R. hebetata* f. *semispina*
C. gracilis	*R. imbricata*
C. laciniosus	*R. robusta*
C. lorenzianus	*R. setigera*
C. pelagicus	*R. stolterfothii*
C. perpusillus	*R. styliformis*
C. peruvianus	*Schroederella delicatula* (*Delicatula pumila*)
C. socialis	*Skeletonema costatum*
C. teres	*Stephanopyxis palmeriana*
C. tortissimus	*S. turris*
Corethron criophilum (*C. hystrix*)	*Streptotheca thamensis*
Coscinodiscus centralis var. *pacifica*	*Thalassionema nitzschioides*
C. concinnus	*Thalassiosira angstii* (*Goscinodiscus angstii*)
C. granii	*T. decipiens*
C. lineatus	*T. exentrica* (*Coscinodiscus exentricus*)
C. nitidus	*T. gravida*
C. perforatus	*T. hyalina*
C. radiatus	*T. polychorda* (*Coscinodiscus polychorda*)
C. wailesii	*T. rotula*
Cylindrotheca closterium (*Nitzschia closterium*)	*Thlassiothrix frauenfeldii*
Ditylum brightwellii	

* The synonyms are indicated in brackets.

ml/l was found at St. 6 in July 1977, whereas the lowest of 2.33 ml/l was recorded at St. 1 in September 1977.

2. Species composition of phytoplankton population

A total of 84 taxa, representing 30 genera, 79 species, 2 forma and 3 varieties, of phytoplankton diatom were identified in the present study (Table 1).

There are clear fluctuation in species numbers by months (Fig. 4 and 5). Total number of species for all stations was highest at St. 5 and 6 in September 1977, being 26 and lowest, only 1, was observed at St. 1 in September 1977 and St. 6 in July 1977 in surface layer and the differences may not be significantly different in bottom.

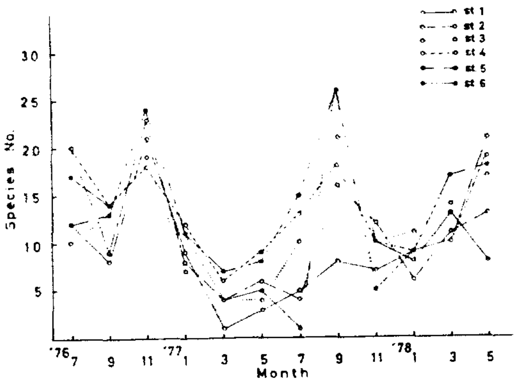

Fig. 4. Species number/months in the Jinhae Bay (surface)

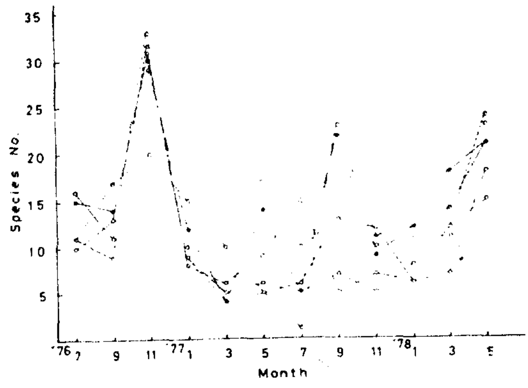

Fig. 5. Species number/months in the Jinhae Bay (bottom)

It is higher than the 43 species of total phytoplankton species that Park (1956) found in summer season, as well as the 33 species in autumn season (Choe, 1967) in the Jinhae Bay, but similar to the 63 species of total diatom from the Masan Bay (Yoo and Lee, 1976).

3. Seasonal occurrence of phytoplankton population

Of these population *Skeletonema costatum*, *Thalassiosira hyalina*, *Leptocylindrus danicus*, *Chaetoceros curvisetus*, *C. costatus*, and *Nitzschia seriata* were the dominant species in the surveyed area. In addition to these the principal species in abundance of phytoplankton population are: *Chaetoceros affinis*, *Coscinodiscus centralis* var. *pacifica*, *Ditylum brightwellii*, *Navicula distans*, *Nitzschia pungens*, *Pleurosigma elonga-*

Table 2. Seasonal occurrence of dominant species in the Jinhae Bay (S: surface, B: bottom).

Month	Layer	Species	Occurrence (%)
1976 July	S	*Skeletonema costatum*	91.54
	B	*Skeletonema costatum*	89.67
Sept.	S	*Skeletonema costatum*	64.79
	B	*Skeletonema costatum*	86.51
Nov.	S	*Skeletonema costatum*	45.15
	B	*Skeletonema costatum*	35.75
1977 Jan.	S	*Thalassiosira hyalina*	50.67
	B	*Thalassiosira hyalina*	36.19
Mar.	S	*Chaetoceros curvisetus*	22.50
	B	*Chaetoceros costatus*	52.04
May	S	*Leptocylindrus danicus*	88.68
	B	*Leptocylindrus danicus*	58.10
July	S	*Skeletonema costatum*	29.20
	B	*Skeletonema costatum*	32.22
Sept.	S	*Skeletonema costatum*	53.82
	B	*Skeletonema costatum*	50.19
Nov.	S	*Skeletonema costatum*	53.73
	B	*Skeletonema costatum*	57.94
1978 Jan.	S	*Skeletonema costatum*	25.04
	B	*Skeletonema costatum*	53.19
Mar.	S	*Thalassiosira hyalina*	31.90
	B	*Thalassiosira hyalina*	41.92
May	S	*Nitzschia pungens*	34.42
	B	*Nitzschia seriata*	22.64

tum, and *Thalassiothrix frauenfeldii*.

The seasonal occurrence of dominant species shows in Table 2. *Skeletonema costatum* appeared predominantly in July to November and it replaced by *Thalassiosira hyalina* in January or March. And then *Chaetoceros curvisetus*, *C. costatus*, *Leptocylindrus danicus*, *Nitzschia pungens*, and *N. seriata* appeared and comprised predominant part of total occurrence in spring season, but their ratio is not higher.

Skeletonema costatum has reported as a predominant species in southern coast of Korea (Choe, 1967; Choe, 1970; Yoo and Lee, 1976) and also *Chaetoceros decipiens* (Yoo et al., 1974) and *Leptocylindrus danicus* (Yoo and Lee, 1976) recorded as dominant species in this area.

Of the species in Table 1, 57 species (67.86%) are described as neritic species, 17.86% of oceanic, 2.38% of neritic-oceanic, and 8.33% of brackish species.

In the Kwangyang Bay it comprised 64.41% of neritic species (Yoo et al., 1974) and also 80.95% in the Masan Bay (Yoo and Lee, 1976). It is suggested that the surveyed area showed the characteristics of embayment with special references to species composition.

4. Seasonal fluctuation of standing crops

The fluctuation of phytoplankton standing crops varied extensively by months and stations: ranging from 808 to 12,461,000 cells/l and showed five major quantitative peaks in July, November 1976, May, September 1977 and May 1978. After bloom the diatom standing crops were decreased gradually and showed minimum in January, March 1977 and January 1978 (Fig. 6 and 7).

In general it observed two-peak populations with largest counts occurring in November and another minor bloom in May throughout the year in southern coast of Korea. The seasonal abundance of standing crops in the present study

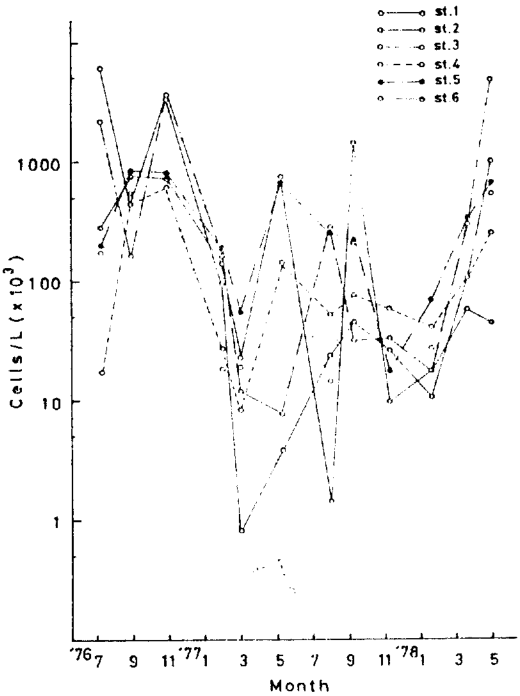

Fig. 6. Seasonal variation of phytoplankton standing crops (cells/l) in the Jinhae Bay (surface)

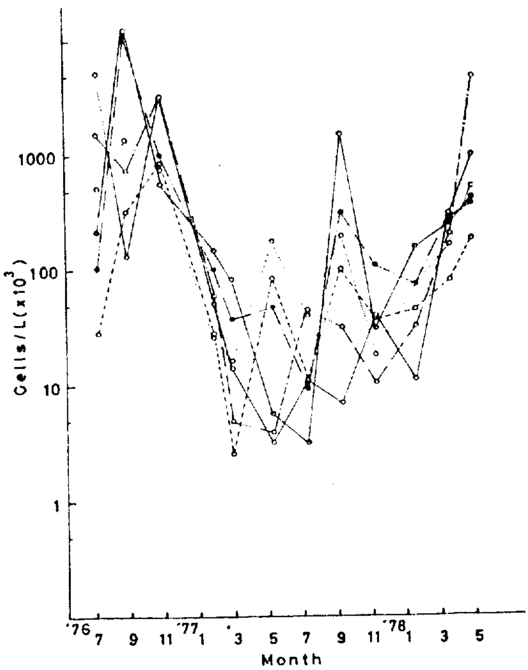

Fig. 7. Seasonal variation of phytoplankton standing crops (cells/l) in the Jinhae Bay (bottom)

is similar to that reported by Yoo et al. (1974), except July 1976. This pulse was unexpected, but may be explained by means of the eutrophication in this area.

5. Species diversity

In July 1976 at St. 1 and 2 their diversity index comprised 0.5625 and 0.7353, respectively, and species diversity for all stations in November 1976, between 3.0700 and 4.1019, were observed in spite of their similarity of species numbers and abundance (Fig. 8 and 9).

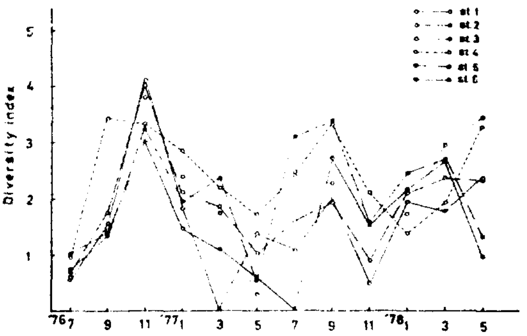

Fig. 8. Species diversity/months in the Jinhae Bay (surface)

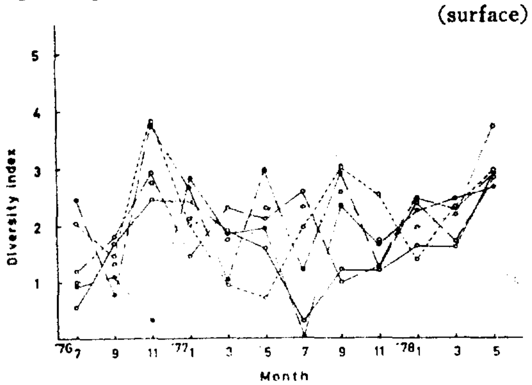

Fig. 9. Species diversity/months in the Jinhae Bay (bottom)

It is interesting to note that while diversity levels was the lowest in July 1976, the largest quantitative populations occurred at that time. *Skeletonema costatum* provided 91.54% of the total population in July 1976.

It is suggested that the diversity index indicates the eutrophication in coastal zone and useful indice for analyzing population dynamics concering eutrophication.

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