Differentiation of Some Environmental Factors and Planktonic Communities of the Two Areas Divided by the Breakwater Between Youngdo and Jodo, Busan*

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釜山市 影島와 朝島사이의 防波堤 兩側 海域의 環境要素 및 浮游生物相의 差異에 關하여

閔 炳 書**

釜山直轄市 影島와 朝島 사이의 海域은 潮流疏通이 充分히 이루어지고 있었으나 1969年 4月 着工하여 1974年 11월 完工된 길이 約 800 m인 影島와 朝島間 防波堤와 이 防波堤와 이어진 길이 約 1,000 m인 朝島에 의하여 完全히 兩分되어 서로 直接的인 潮流疏通이 遮斷된 두 海域(北쪽灣, 南쪽灣)이 되었다. 이 두 海域의 環境要素와 浮游生物相을 比較하여 보고자 北쪽灣의 外側에 A, 內側에 B, 南쪽灣 內側에 C, 外側에 D를 選定하고, 1976年 3月부터 1977年 2月까지 1年間 月 1回 試料를 採取하여 調査하였다.

1. 環境要素로서는 水溫, 鹽分濃度, 溶存酸素, 透明度와 營養鹽類인 燐酸鹽, 硅酸鹽, 亞窒酸鹽을 調査하였으며, 部分的인 例外를 除外하면 北쪽灣의 A, B地点과 南쪽灣의 C, D地点間에는 各 環境要素에 있어서 差異를 가지고 있었다.

2. 植物性浮游生物은 A, B, C, D 全調査地点에서 調査期間 中 Diatom이 31屬 86種, Flagellata가 10屬 22種, Ciliata가 4屬 8種, Chlorophyta가 1屬2種이 出現하였다.

3. Diatom의 種構成에서는 A, B地点과 C, D地点間에 뚜렷한 差異가 없었으나, 出現量에 있어서는 A, B地点이 C, D地点에 比하여 2倍以上이었다. Diatom의 優占權은 *Skeletonema costatum*으로서 A, B地点과 C, D地点間 Diatom 現存量 差異의 主原因이 되고 있었다.

4. Flagellata와 Ciliata는 北쪽灣의 A, B地点이 南쪽灣의 C, D地点에 比하여 越等히 높은 出現量을 보였다.

5. 動物性 浮游生物은 全調査期間 中 主軸을 이루는 18屬 24種의 Copepoda를 비롯하여 *Evadne* sp., *Conchoecia* sp., *Balanus* 幼生, shrimp 幼生, Polychaeta 幼生, bipinnaria 幼生, ophiopleuteus 幼生, *Sagitta* sp., *Oikopleura* sp., *Doliolum* sp. 및 魚卵과 稚魚가 檢索되었다.

6. 動物性 浮游生物의 出現量은 南쪽灣의 C, D地点이 北쪽灣의 A, B地点에 比하여 많았으며, 이러한 差異를 主導한 것은 Copepoda로서 C, D地点에서 A, B地点의 2.5倍가 出現하였다.

7. Copepoda 中 優占種은 *Corycaeus affinis*와 *Paracalanus parvus*였으며, 이들의 出現傾向이 全体 動物性 浮游生物 出現傾向을 左右하였다.

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8. *Euglena* sp.는 總出現量의 大部分이 A, B地点에서 出現하였으며, *Synedra ulna*가 A地点에서만 出現하였다.

9. *Sagitta* sp.가 C, D地点에서 A, B地点에 比하여 約2倍 出現하였다.

10. 本 調査結果 防波堤와 朝島 自体에 의하여 兩分된 北쪽灣과 南쪽灣은 水溫, 鹽分, 透明度, 營養鹽 等의 環境要素와 plankton組成, 出現量, 消長傾向等의 浮游生物相에서 差異를 가지고 있었다.

INTRODUCTION

There are many coastal areas which were changed by engineering and constructions, and this kind of phenomena would be more frequent in the future. Such a change of an area may bring about other changes like the direction of tidal currents and the structure of drainage of precipitation and sewage from land and town in the vicinity, and as the result, the physical and chemical status would be changed and, subsequently, an alteration of the ecosystem of the area would be inevitable.

Youngdo, an island in front of the Busan harbour, Korea, has a daughter island, Jodo, 800 *m* away from the northeast coast of its southern half. Construction of a breakwater between them was begun in April 1969 and finished in November 1974. The breakwater divided the coastal water between Youngdo and Jodo into two small bays similar to each other in their equilateral triangle, and in their areas of 1.805 km^2 for the nothern part and 1.698 km^2 for the southern part.

The breakwater is 780 *m* in its length and Jodo is 1,000*m* long toward the same direction with the breakwater. They provide a dam of 1,780 *m* long enough to cut off the direct communication between the two small bays, Northern and Southern Bays. Before the construction of the breakwater, the water of this area was free to pass through the strait between Youngdo and Jodo.

By the construction of the breakwater, the direct tidal current in this area seems to have been shut off completely. And, eventually, the waters of Northern and Southern Bays would be somewhat stagnant. It should be not impossible to expect a certain transition of the environmental factors and the flora and fauna of the two areas.

We can refer to only one set of survey data on water qualities and planktonic communities of this area that was carried out by National Fisheries Research and Developement Agency (NIFRDA) in June 1971.

The author was very interested in the two new bays with the differentiation between them. And the understanding of the differences between the two, some environmental factors such as water temperature, salinity, dissolved oxygen, transparency, major nutrient salts and planktonic communities were studied monthly for one year from March 1976 to February 1977.

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MATERIALS AND METHODS

Samplings were conducted monthly, and mostly the hour of standing or near standing tide from March 1976 to February 1977 at the four stations; station A on the middle of the straight line connecting Sundummal and the northeasternmost of Jodo, station B in the inner middle of Nothern Bay, station C inside of Southern Bay, station D on the middle of the straight line between the most northeastern part of Jodo and Sang-i-mal (Fig. 1 & Table 1).

Table 1. Locality and depth of sampling stations

Station	Depth(*m*)	Latitude(N)	Longitude(E)
A	11.5	129°5′10″	35°4′50″
B	9.0	129 5 5	35 4 30
C	14.5	129 5 23	35 4 5
D	22.0	129 5 50	35 4 0

Phosphate (PO_4-P), silicate (SiO_2-Si) and nitrite (NO_2-N) were analysed by employing Strickland and Parson's method (1968) with 1 liter of samples from each station and kept in a refrigerator until processing for a time as short as possible.

Salinity was measured by salinometer (J. S. K.) and dissolved oxygen by Winkler's method. Transparency was read on the deck with a standard Secchi's disk. Water temperature was measured from the water in a sampler at the depth of 1 *m*. Sea water of 1 *l* from 1 *m* depth was collected and fixed with neutralized formalin, then, in the laboratory, was concentrated into 40 *ml*, of which 0.1 or 0.2 *ml* was observed for examining phytoplankton.

North Pacific Standard Net was prepared for vertical haul from the depth of each station. The samples were fixed with neutralized formalin for zooplankton examination.

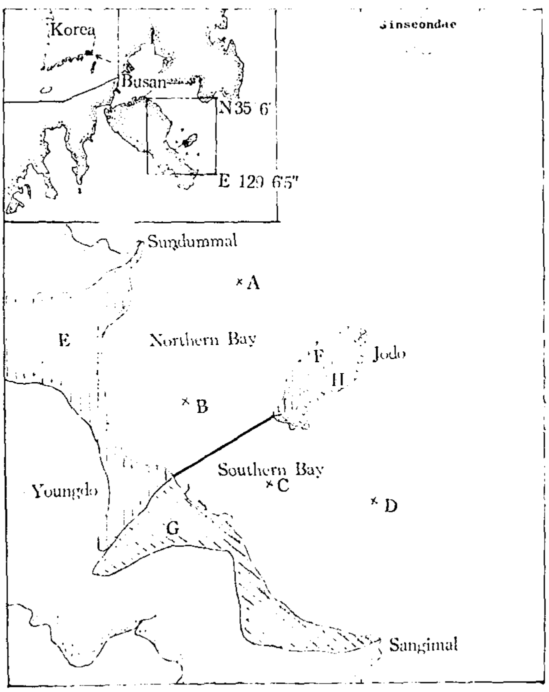

Fig. 1. Locality of the sampling stations, A, B, C, and D, E, F, G and H are drainage area to each bay.

RESULTS

I. ENVIRONMENTAL FACTORS

1. Water temperature

The water temperature at station A showing the lowest annual average of 14.5℃ among the four stations, ranged from the lowest 5.7℃ in January 1977 to the highest 24.0℃ in June 1976. At station B the highest was 23.0℃ in July 1976, the lowest 7.3℃ in January 1977 with the annual average of 16.3℃. At station C the highest was 24.0℃ in August 1976, the lowest 9.0℃ in January 1977, annual average of 16.9℃, and at station D the highest 24.0℃ in August 1976, the lowest 9.0℃ in January 1977. The inner station of each bay showed somewhat higher water temperature than their outer counterpart, in Northern Bay 1.8℃, in Southern Bay 1.6℃ respectively. In annual mean of the two bays, Northern Bay is 0.7℃ higher than Southern Bay. For their seasonal variation of the water temperature, Northern Bay ascended in spring and in contrast descends in fall earlier than Southern Bay, and showed somewhat less stable fluctuation mode than Southern Bay (Fig. 2).

2. Salinity

The salinity of station A showing the lowest annual average of 29.695 ‰ ranged from the lowest 19.330‰ in April 1976, to the highest 34.435 ‰ in November 1976, at station B the lowest of 22.737‰ in April 1976 the highest 34.487‰ in January 1977 with the average of 30.021‰, and at station C the lowest 23.910 ‰ in April 1976, the highest 37.012‰ in September 1976 with the average of 30.679 ‰, and at station D the lowest of 20.408 ‰ in april 1976, the highest of 34.870‰ in February 1977 with the average of 31.653‰ which was the highest mean value of the four stations.

The Northern Bay was lower than the Southern Bay in its salinity with an annual average difference of 1.308‰. All the stations were easily affected and fluctuated by precipitations (Fig. 3).

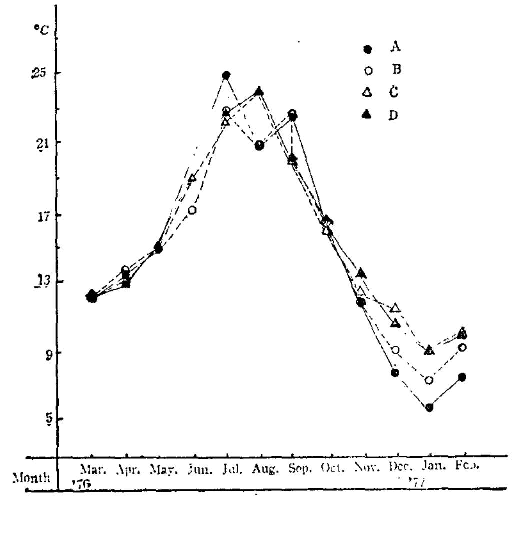

Fig. 2. Monthly fluctuation of water temperature of 1 *m* depth at sampling stations A, B, C and D.

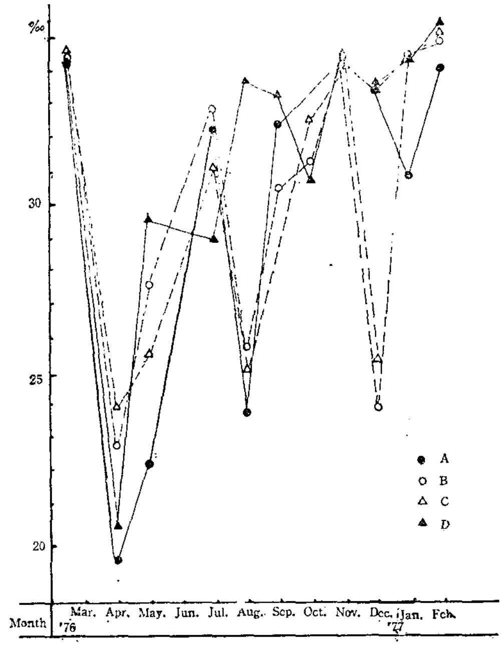

Fig. 3. Monthly fluctuation of salinity of 1 *m* depth at sampling stations A, B, C and D.

3. Dissolved oxygen

The dissolved oxygen at station A ranged from the lowest 4.51 *ml/l* in October 1976 to the highest 6.04 *ml/l* in January 1977 with the annual average of 5.48 *ml/l*, at station B the lowest 4.48 *ml/l* in October 1976, the highest 6.80 *ml/l* in July 1976 with the annual average of 5.66 *ml/l*. The annual average of station A was a little lower than that of station B by 0.22 *ml/l*. At station C the lowest 4.24 *ml/l* in September 1976, the highest 6.34 *ml/l* in August 1976 with the annual average of 5.56 *ml/l* which was 0.15 *ml/l* higher than the annual average of 5.41 *ml/l* of station D with the lowest of 4.00 *ml/l* in September 1976, the highest of 6.32 *ml/l* in August 1976. Station D is the lowest in dissolved oxygen of the four stataons. The Northern Bay showed a little higher value than the Southern Bay and the inner stations of the two bays were also a little higher in dissolved oxygen than the outer counterparts (Fig. 4).

4. Transparency

At station A, the transparency was 1.5 *m* in April, May, December 1976 and January 1977, and 4 *m* in October 1976 with the average of 2.1 *m* which was the lowest of the four stations. At station B, 1.5 *m* in April and May 1976 was the lowest and 3.0 *m* in October 1976 was the highest with the annual average of 2.2 *m*. At station C, the lowest was 2.5 *m* in May 1976, the highest was 6.5 *m* in April 1976 and the annual average was 4.2 *m*. At station D, 2.0 *m* in May 1976 was the lowest and 9.0 *m* in February 1977 was the highest and the annual average was 4.2 *m*, which was the same value with that of station B but a wider range of fluctuations was found. In April 1976 the lowest value was marked in Nothern Bay at station B, and a lower one appeared at staion D. The Southern Bay was two times clear as the Northern Bay (Fig. 5).

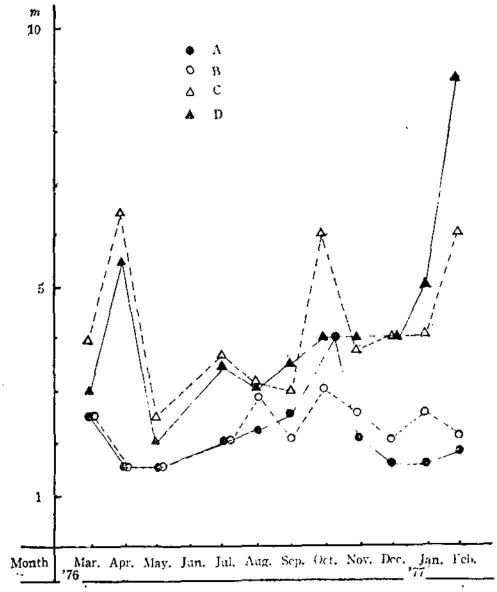

Fig. 5. Monthly fluctuation of transparency at sampling stations A, B, C and D.

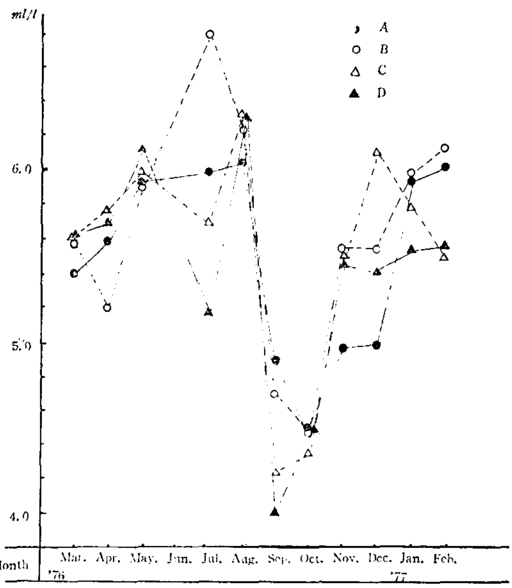

Fig. 4. Monthly fluctuation of dissolved oxygen of 1 *m* depth at sampling stations A, B, C and D.

5. Phosphates

The lowest was 0.156 *μg-at./l* in July 1976 and 0.896 *μg-at./l* was the highest in March 1976 for station A with the annual average of 0.5 36 *μg-at./l*. The lowest of 0.170 *μg-at./l* in July 1976 and the highest of 0.994 *μg-at./l* in March 1976 at station B with the annual average of 0.536 *μg-at./l* were measured. At station C and D, 0.170 and 0.185 *μg-at./l* in July 1976 were the lowest respectively, and the highest was found in March 1976 at station C with the value of 0.582 *μg-at./l*, and at station D of 0.682 *μg-at./l* in a different month from the other station. The annual average was 0.353 *μg-at./l* for station C, 0.396 *μg-at./l* for station D. The phosphates were 1.43 times plentier in Nothern Bay than Southern Bay (Fig. 6).

6. Silicates

Silicates were most abundant at station A with the annual average of 18.858 *μg-at./l*, the lowest 6.679 *μg-at./l* in July 1976 and the highest

28.601 μg-*at.*/*l* in September 1976. At station B, the lowest was 8.004 μg-*at.*/*l* in July 1976, the highest was 30.015 μg-*at.*/*l* in September 1976 and the annual average was 18.191 μg-*at.*/*l*. In March and July 1976 the lowest of 6.003 μg-*at.*/*l* was observed at station C with the highest 29.348 μg-*at.*/*l* in October 1976 and the annual average of 15.765 μg-*at.*/*l*. At station D, the lowest 7.337 μg-*at.*/*l*. in July 1976 and the highest 24.012 μg-*at.*/*l* in September 1976 with the annual average of 15.645 μg-*at.*/*l* were observed (Fig. 7).

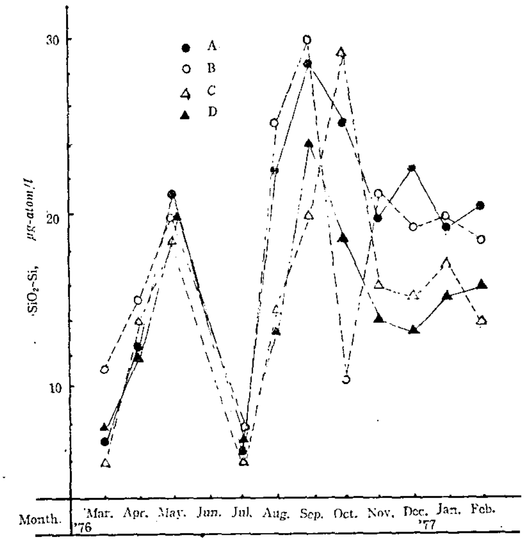

Fig. 7. Monthly fluctuation of silicates of 1 *m* depth at sampling stations A, B, C and D.

7. Nitrites

At station A, the lowest 0.176 μg-*at.*/*l* appeared in July 1976, the highest 1.056 μg-*at.*/*l* in May 1976 and the annual average of 0.545 μg-*at.*/*l*. The lowest 0.142 μg-*at.*/*l* in July 1976, the highest 1.045 μg-*at.*/*l* in May 1976 and the annual average of 0.578 μg-*at.*/*l* were read for station B. At station C, 0.132 μg-*at.*/*l* in July 1976 as the lowest, 0.740 μg-*at.*/*l* in May 1976 as the highest were observed with the annual average of 0.350 μg-*at.*/*l* which was the lowest value of the four stations. At station D, the lowest was 0.165 μg-*at.*/*l* in July 1976, the highest was 1.078 μg-*at.*/*l* in May 1976 with the annual avarage of 0.407 μg-*at.*/*l*. Northern Bay was 1.48 times plentier in nitrites than Southern Bay (Fig. 8).

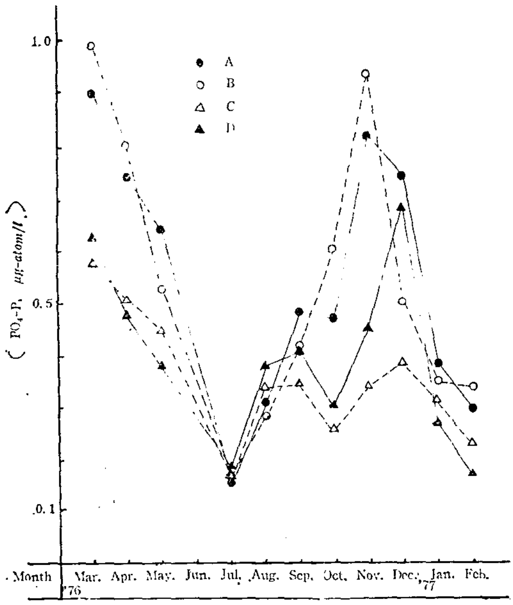

fig. 6. Monthly fluctuation of phosphates of 1 *m* depth at samping stations A, B, C and D.

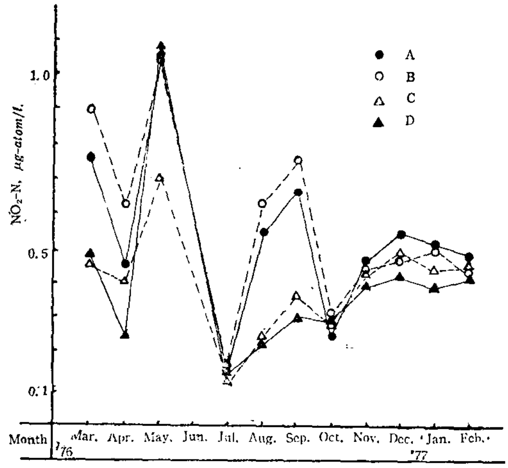

Fig. 8. Monthly fluctuation of nitrites of 1 *m* depth at sampling stations A, B, C and D.

Ⅱ. PHYTOPLANKTON

During the period of study, 86 species belonging to 31 genera of diatoms, 22 species 10 genera of flagellates, 8 species 4 genera of ciliates and 2 species of 1 genus of chlorophytes were found from the four stations, A, B, C and D.

1. Diatoms

Thirteen species of diatoms were found at station A, 16 species at station B, 13 species at station C, and 15 species at station D. The compositions and varieties of species from Northern and Southern Bay were not the same(Fig. 9). The standing crop of station A was 1,215,400 cells/l in annual average, and station B, 1,295,100 cells/l, station C, 561,100 cells/l and station D, 620,900 cells/l. Northern Bay had a standing crop of 2.06 times Southern Bay, but the seasonal tendencies of occurence of each bay were very similar (Fig. 10). The dominant species of diatom community was *Skeletonema costatum* which showed the composition ratio of 80 % of the total at station A, 82 % at station B, 72 % at station C, and 70 % at station D so that Northern Bay was 10 % higher than Southern Bay. The standing crop of this species was, in average, 967,000 cells/l at station A, 1,057,000 cells/l at station B, 403,000 cells/l at station C, and 438,000 cells/l at station D, and was the main cause to establish the difference of standing crop of all the phytoplankton between Northern and Southern Bay (Fig. 11). One diatom species *Synedra ulna* appeared only once at station A in April 1967 with the amount of 200 cells/l.

2. Phytoplankton other than diatoms

Flagellates appeared through spring to fall except winter season at all the stations. The proportion of the standing crop of this group to each station was 31 % for station A, 48% for station B, and 9 % for station C, and D, and it made that Northern Bay had 4.6 times higher

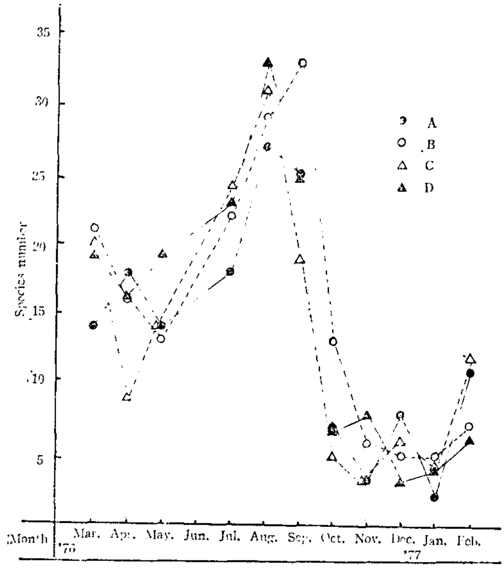

Fig. 9. Monthly fluctuation of species number of diatoms at station A,B,C and D.

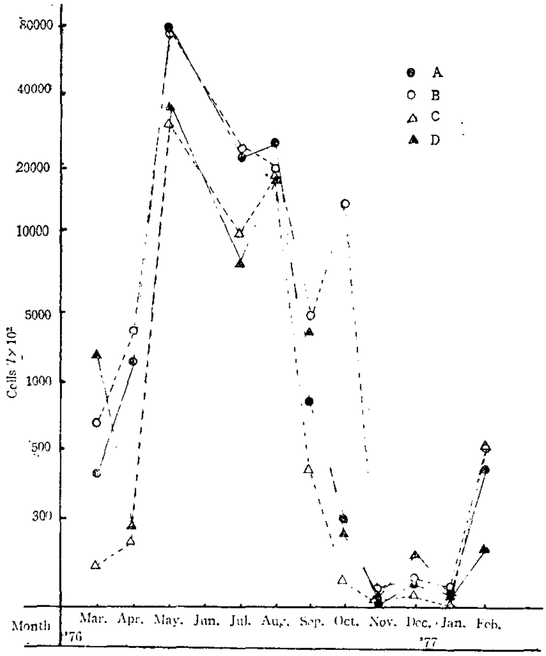

Fig. 10. Monthly occurence of diatoms at station A,B,C and D.

population density of this species than Southern Bay. The dominant species of the group were the *Euglena* sp. and *Prorocentrum micans*. The composition of flagellate group is shown in table 3.

Table 3. Composition of flagellate group at each station (cells/*l*)

Station	A	B	C	D
Total flagellates	8,964	12,618	2,273	2,328
Euglena sp.	2,491	2,309	127	182
Prorocentrum micans	3,745	6,709	0	418
Others	2,727	3,600	2,145	1,727

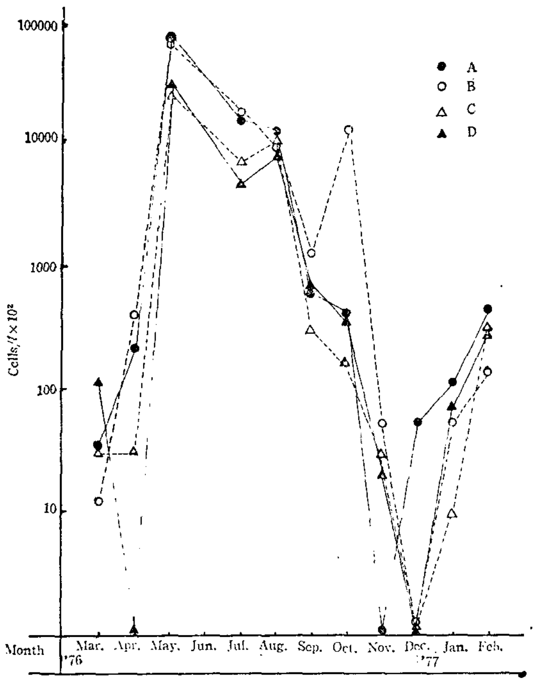

Fig. 11. Monthly occurence of *Skeletonema costatum* at stations A, B, C and D.

In seasonal fluctuation of standing crop of flagellates, the maximum occured in July and August 1976 in Northern Bay, and in Southern Bay the maximum occured in August and September one month later than Northern Bay (Fig. 12). Ciliates showed irregular occurences at all the stations through the year. The total occurences at each station of this group were composed of the ratio of 11 % at station A, 65 % at station B, 3 % at station C, and 20 % at station D. And it showed that Northern Bay was 3.3 times denser in its ciliate population than Southern Bay. The dominant species of this group was *Tintinnopsis* sp. and at station A the occurence was dispersed all the seasons, but at station B concentrated in the cold season, at station C in spring and fall, and at station D in summer months (Fig. 13). Chlorophytes appeared at station A in September 1976 and at station C in April 1976 with the density of 800 cells/*l*.

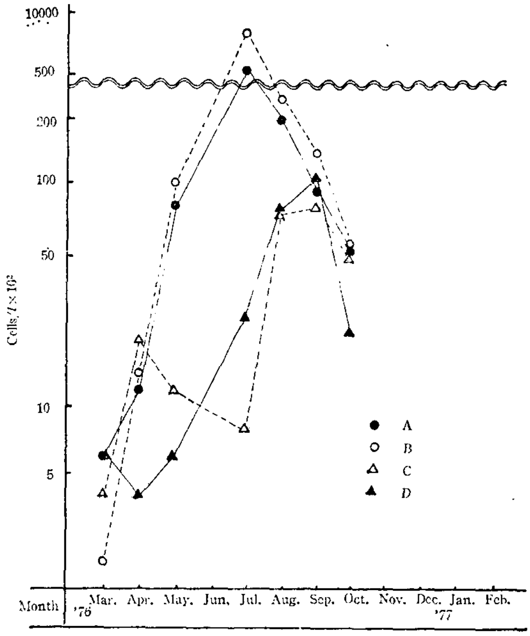

Fig. 12. Monthly fluctuation of flagellates at stations A, B, C and D.

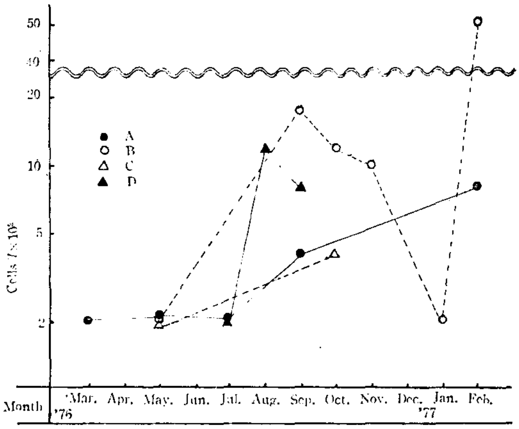

Fig. 13. Monthly occurence of ciliates at sampling stations A, B, C and D.

Ⅲ. ZOOPLANKTON

Zooplanktonic communities were composed of copepods of 24 species belonging to 18 genera, the dominant component being *Evadne* sp., *Conchoecia* sp., *Balanus* larvae, shrimp larvae, polychaete larvae, *bipinnaria* larvae, ophiopleuteus larvae, *Sagitta* sp., *Oikopleura* sp., *Doliolum* sp., fish eggs and larvae. The density of zooplanktonic population was higher at the outer stations of each bay, A and D stations, than the inner B and C stations. And the same phenomena was also found that Southern Bay was populated more densely than Northern Bay in more distingushable way. The average number of indiv-

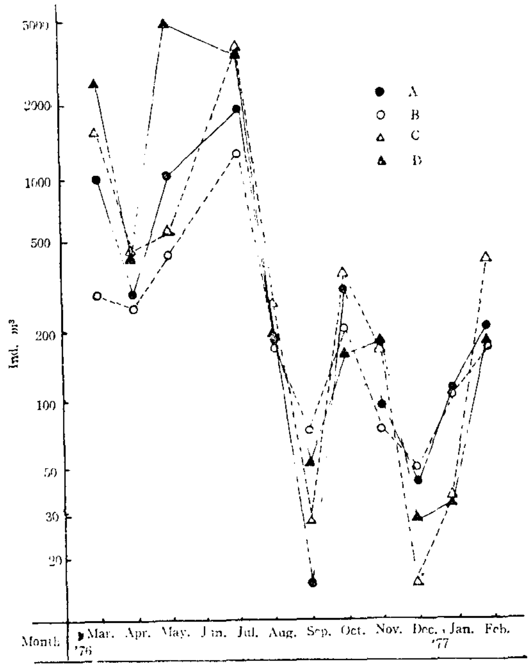

Fig. 15. Monthly occurence of copepods at sampling stations A, B, C and D.

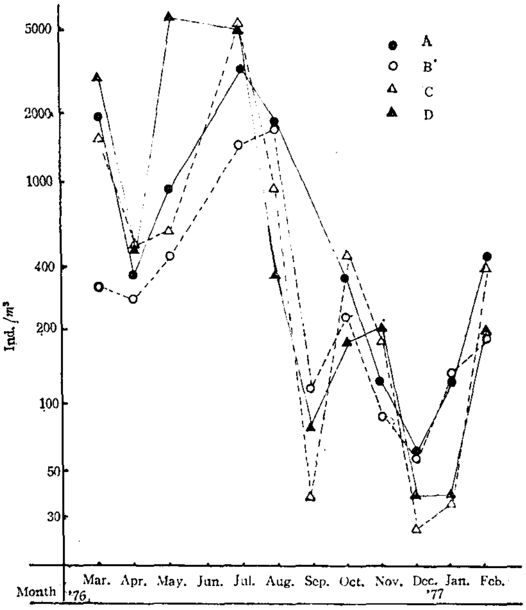

Fig. 14. Monthly occurence of zooplankton at stations A, B, C and D.

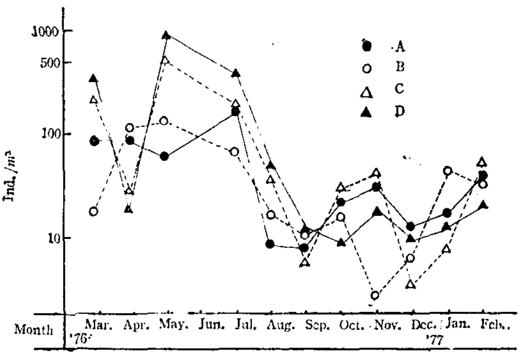

Fig. 16. Monthly occurence of *Corycaeus affinis* at each sampling station.

iduals at each station, A, B, C and D were 820 ind./m^3, 442 ind./m^3 907 ind./m^3 and 1,307 ind./m^3 respectively. The seasonal occurence was highest in July 1976 at all the stations and the mode of seasonal fluctuation was similar to each other (Fig. 14). The dominant group of zooplankton was copepods, which affected the comparative occurence of each station in total zooplankton. The copepods were found at station A with the density of 461 ind./m^3, at station B 275 ind./m^3, at station C 698 ind./m^3 and at station D 1,130 ind./m^3 showing the differences of the comparative occurence among stations more distinctly; and the density of copepods in Northern Bay was 40 % of Southerns Bay. The copepods took an initiative of the occurence tendency of the total zooplanktonic community (Fig. 15). The dominant species of the copepod's group were *Corycaeus affinis* and *Par-*

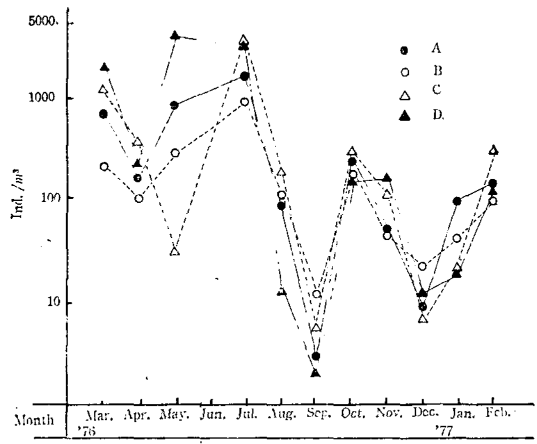

Fig. 17. Monthly occurence of *Paracalanus parvus* at each sampling station.

acalanus parvus which occupied 75 % of the copepod population enough to affect the tendency of occurence and comparative densities among stations (Figs. 16, 17). At stations A, B, C and D, the zooplankton except copepods occured 356 ind./m^3, 167 ind./m^3, 211 ind./m^3 and 180 ind./m^3 respectively in annual average. This group showed a similar tendency to the total zooplankton in seasonal fluctuation; but station A showed a mode of occurence different from that of the total in appearence with the highest density. It comprised the fish eggs and larvae, and when this components were excluded it showed the same tendency as the whole (Fig. 18). *Sagitta*

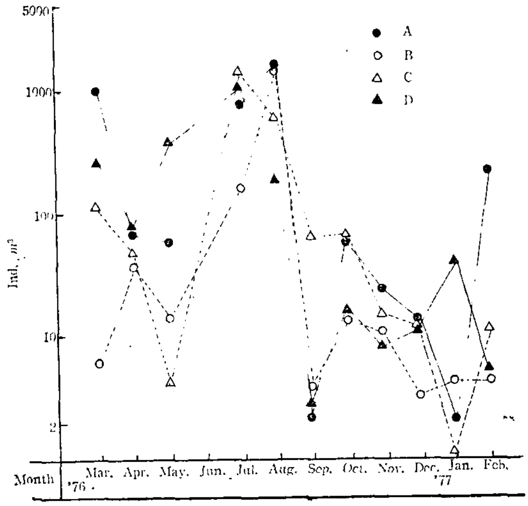

Fig. 18. Monthly occurence of zooplankton except copepods at each station.

sp. was common at each station but the density of Northern Bay was half that of Southern Bay (Fig. 19).

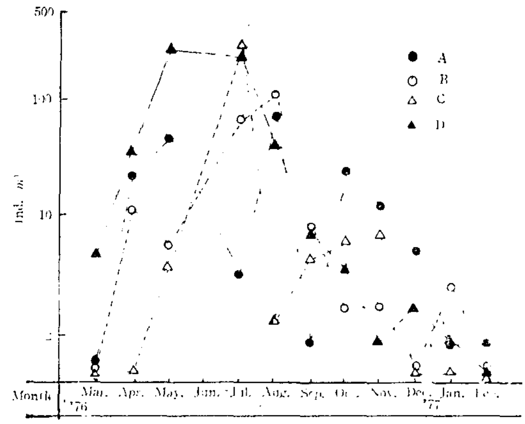

Fig. 19. Monthly occurence of *Sagitta* sp. at each station.

DISCUSSION

The coastal area between Youngdo and Jodo for present study was about 3 km^2, and 5 *m* deep in the middle of the shortest straight line between Youngdo and Jodo, 20 *m* deep in the middle of the line from Jodo to Sang-i-mal and 13 *m* deep in the middle of the line from Jodo to Sundummal(Fig. 21). Before the construction of the breakwater, tidal currents flew passing through the strait between Youngdo and Jodo by 0.43—0.6 Kts (21.5—30 *cm/sec*) in maximum (Fig. 20). The construction of the breakwater was begun in April 1969, and during the construction period, in June 1971, National Fisheries Research and Developement Agency surveyed the flora, fauna and some environmental factors in this area. According to the data from the survey, this area was an almost homogeneous unity having no indication of partial differentiation, so that the planktonic flora were similar to common coastal waters and the environmental factors were not particular (NFRDA, 1972). The construction of the breakwater was completed in November 1974, and the tidal currents in this area were cut off and then there were the birth of two new isolated areas (Northern Bay and Southern Bay). One is faced to the Busan Harbour, covers 1.805 km^2 and receives fresh water from the Dongsam-sang-ri and the northern half of Jodo (E and F in Fig. 21). Dongsam-sang-ri covering 1.706 km^2 has 14,000 inhabitants and drains its precipitations and sewages to Northern Bay. The other facing the open sea, covers 1.698 km^2 and receives fresh water from Dongsam-ha-ri and southern half of Jodo (G and H in Fig. 21). Dongsam-ha-ri covers 1.706 km^2 with 4,800 inhabitants and drains its precipitations and sewages to Southern Bay (Table 5).

The two bays, especially Northern Bay, may not have a chance to exchange their own waters with the waters from the open sea enough to maintain the same condition as they enjoyed the tidal currents between them before the breakwater isolated the area into the two. Futhermore, the drainage of precipitation and sewage from the land in the vicinity exert some changes on them. Especially, Northern Bay receives

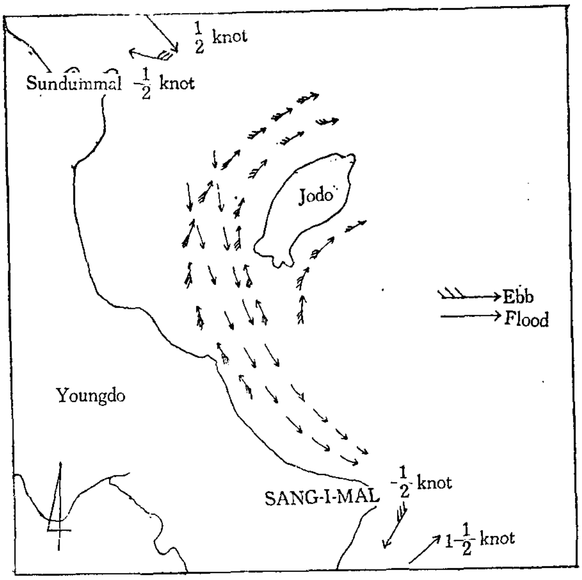

Fig. 20. Tidal motion in Youngdo-Jodo area measured in 1971. By the courtesy of S. S. Lee, NFRDA from unpublished data.

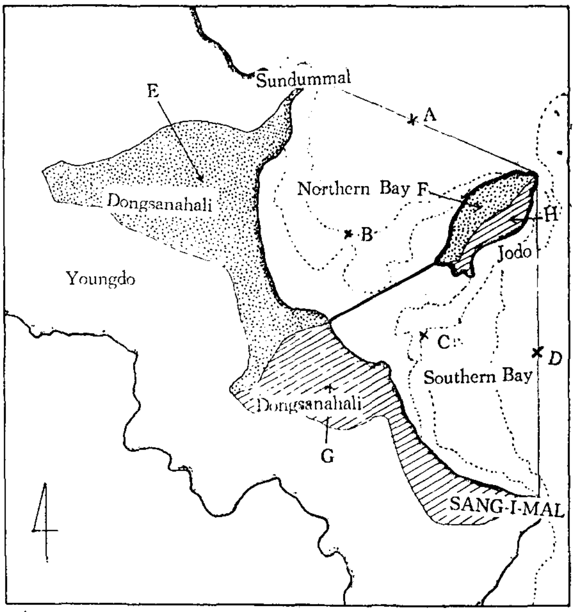

Fig. 21. Drainage areas to Northern Bay (dotted, E, F) and to Soutbhern Bay (lined, G, H).

more drainage from the land and may have few opportunity to exchange its water with the water from the open sea. Now, it is not impossible to expect that some alterations have occured in their environments as habitats and some differentitaions have developed between the two neighbouring bays. In March 1976 when this study was initiated, the waters of the two bays were not same for the naked eyes in their colours.

Table 5. Northern Bay and Southern Bay with their drainage areas and numbers of inhabitants in the areas

	Northern bay	Southern bay
Area of bay (km^2)	1.805	1.698
Drainage area (km^2)	1.706	0.843
Inhabitants	14,000	4,800

The annual mean of water temperature was 15.4℃ in Northern Bay and 16.1℃ in Southern Bay which is higher than the other by 0.7℃. The annual average of salinity was 29.898‰ in Northern Bay and 31.166‰ in Southern Bay. The latter was higher than the former by 1.268‰. The annual average of salinity in Northern Bay is much lower than that (32.23‰) in the inner side of the outer port of Busan Harbour and that (32.32‰) of outer side of Busan Harbour (Data Report 1976). We can find out more drastic comparisions between the two bays in transparency. The annual mean trasparency of Northern Bay is 2.15 *m* which is about a half of 4.2 *m* in Southern Bay and about 1.7-1.0 *m* less than 3.9 and 3.2 *m* of the inner side and outer side of Busan Harbour respectively. Dissolved oxygen also showed some differences between the two bays. The annual mean of dissolved oxygen was 5.57 *ml/l* in Northern Bay and 5.49 *ml/l* in Southern Bay, and the former has a little higher value than the latter by 0.08 *ml/l* (Table 6). Although there are some differences beween Northern Bay and Southern Bay in water temperature, salinity, dissolved oxygen and transparency, the more distinct differences between them are in their nutrient salts (Table 6, 7).

As shown in Table 7, the data of Youngdo-Jodo area in June 1971 (Lee, *et al.*, 1972) read that phosphates were 0.345 *μg-at./l*, silicates 7.158 *μg-at./l* and nitrites 0.047 *μg-at./l* of which, in comparison with the results of present study, phosphates are more or less similar, silicates less than half, and nitrites one tenth showing some increase in nutrient salts after the construction

Table 6. A brief comparison of environmental factors in annual averages between Northern and Southern bay

	Northern bay (A)	Southern bay (B)	A−B	B/A
Water temperature (℃)	15.4	16.1	0.7	1.045
Salinity (‰)	29.898	31.166	1.268	1.042
Dissolved oxygen (*ml/l*)	5.57	5.49	0.08	0.985
Transparency (*m*)	2.15	4.20	2.05	1.953
Phosphates (*μg-at./l*)	0.536	0.375	0.161	0.700
Silicates (*μg-at./l*)	18.525	15.250	3.275	0.823
Nitrites (*μg-at./l*)	0.562	0.379	0.183	0.673

of the breakwater.

Table 7 shows that except the results from the Estuary of the Nackdong River and out-port of Busan Harbour, these two small bays have a value higher than the others in their nutrients contents. The difference in nutrient salts between Northern Bay and Southern Bay is clear that Nothern Bay is 38% higher than Southern Bay. This higher contents of nutrient salts result in the higher standing crop of phytoplankton in the Nothern Bay.

It is difficult to compare a certain area with another by the planktonic community by its tendency of occurence, standing crop or species in occurence. But in the present study, the comparative differences between the two bays in standing crop, species in occurence and the tendency of seasonal fluctuation would be discussed because the comparative difference might give us a notion to identify the two bays, Northern Bay and Southern Bay.

There had been no differentiated part in the Youngdo-jodo area in the planktonic community before the construction of the breakwater was completed (F R D A 1972) showing that the dominant species in phytoplanktonic community were *Chaetoceros curvisetus*, *Ch. affinis* and *Nitzschia seriata*, of which *Ch. curvisetus* occupied 45% of the total community. And two species of genus *Tintinnopsis* were found. In the present study, the same species were found, but the dominant species was *Skeletonema costatum*, and many other genera belonging to flagellates, ciliates and chlorophytes were observed(Table 8). A coastal water adjacent to the Youngdo-Jodo area was studied by Park (1972) on diatom com-

Table 7. Compsriaon of the average values of nutrient salts from various coastal waters (μg-*at.* /*l*)

Place	Constituents			Remarks
	PO_4-P	SiO_2-Si	NO_2-N	
Northern bay	0.536	18.252	0.562	Present study
Southern bay	0.375	15.250	0.379	〃
Average of Northern and Southern bay	0.456	16.751	0,471	〃
Youngdo-Jodo area, June 1971	0.345	7.158	0.047	Lee, *et al.*, 1972
Inner side of out-port of Busan Harbor, Mar. 1974-May 1976	0.504	—	0.820	Data report Pub. I.M.S. 1976
Outer side of out-port of Busan Harbor, Mar. 1974-May-1976	0.355	—	0.657	〃
Haeundae, Mar. 1971-Feb. 1972	0.390	10.41	0.20	Park, 1972
Gujora, Nov. 1969-Apr. 1970	0.260	12.166	0.075	Gi 1970
Gugryongpo, Nov. 1969-Apr. 1970	0.367	7.517	0.157	〃
Ockdong, Nov. 1969-Apr. 1970	0.438	9.517	0.095	〃
Chungmu, May-Oct. 1970	0.357	26.367	0.085	〃
Estuary of Nakdong River, Feb.-Dec. 1970	0.958	71.574	0.636	Choi, 1972
Pyoungildo, Oct. 1968-Feb. 1969	0.180	8.230	0.010	Won, 1970
Wando, Oct. 1968-Feb. 1969	0.214	8.488	0.007	〃
Taeindo, Feb. 1-2. 1962	0.530	19.72	0.140	Won, 1963

Table 8. A brief comparison of annual average of planktonic status between Northern Bay and Southern Bay (Cells/*l* for phytoplankton, Ind./m^3 for zooplankton)

	Northern Bay (A)	Southern Bay (B)	A−B	B/A
Total plankton	1,255,300	591,000	664,300	0.471
Skeletonema costatum	1,011,400	419,500	591,900	0.415
Composition ratio of *S. costatum* to total phytoplankton	81%	71%	10%	—
Synedra ulna	present	non	—	—
Total flagellata	10,791	2,300	8,491	0.213
Euglena sp.	2,400	309	2,091	0.129
Prorocentrum micans	5,227	418	4,809	0.080
Total ciliata	559	173	386	0.309
*Total zooplankton	631	1,107	476	1.754
Total copepoda	368	914	546	2.484
Corycaeus affinis	50	142	92	2.840
Paracalanus parvus	265	691	426	2.608
Sagitta sp.	19	40	21	2.105

* Fish eggs and larva comprised.

Table 9. A brief comparison of the two areas, Youngdo-Jodo, and Haewundae in their maximum standing crop of phytoplankton

	Y ungdo-Jodo area, May 24, 1976		Coastal water of Haewundae July 16, 1971
	Nothern Bay	Southern Bay	
PO_4-P (μg-at./*l*)	0.590	0.419	0.25
SiO_2-Si (〃)	20.68	19.34	10.23
NO_2-N (〃)	1.051	0.076	0.04
Total phytoplankton (cells/*l*)	7,894,900	3,295,200	788,900
Dominant species	*Skeletonema costatum*	*S. costatum*	*Chaetoceros curvisetus*
Density of dominant species(cells/*l*)	7,420,000	2,937,000	572,400
Compositional portion of dominant species	94%	89%	73%

munity in relation with the major nutrient salts. A brief comparison between the results of the two separate studies is shown in Table 9. Table 9 shows very clearly the relationship between the nutrient salts and the standing crop of the planktonic flora. The higher the nutrient value the higher the standing crop can be expected to a certain level of nutrient. And the compositional portion of dominant species may indicate some relationship between the environmental factors and planktonic flora. The areas of Northern Bay and Southern Bay have plentier nutrient salts than the areas receiving direct effects of open sea and have a higher standing crop. In comparison between Northern Bay and Southern Bay (Table 8), there are many differences in planktonic flora. The standing crop in Northern Bay is 2 times as much as that of Southern Bay in average.

One of the indicator Species of water pollution (津田, 1964), *Synedra ulna*, was examined only in Northern Bay where flagellates were 4.7 times as much as the other, and the dominant were *Euglena* sp. and *Prorocentrum micans*. *Euglena* sp. occured 7.8 times and *P. micans* 12.5 times plentier in Northern Bay than in Southern Bay. Ciliates in Northern Bay occured 3.2 times more than the other. It seems that Northern Bay is in its way to a certain phase of eutrophication.

The zooplanktonic communities in the present study show a very interesting fact that standing crop in Northern Bay is about a half of that in Southern Bay in contrast with phytoplankton (Table 8). *Sagitta* sp. which is the most valuable indicator species for water quality (Park, 1973), occurs all through the stations throughout the period during the present study. The standing crop of this species in Southern Bay is about 2 times higher than in Northern Bay showing a difference between the two environments.

For a brief summary, both the Northern Bay and Southern Bay altogether seem to be in a way to eutrophication, and Northern Bay is probably faster in its way. And there are some distinct differences in water temperature, salinity, dissolved oxygen, transparency and nutrient salts between the two bays. The differences in planktonic communities of these areas are also observed. These differentiations between the two bays are apparently the results of the existence of the breakwater which shuts off the tidal currents over the area to inhibit the exchange of water of the two bays and to change the way of drainage of precipitations and sewages from the land in the vicinity.

SUMMARY

1. The coastal area between Youngdo and Jodo was a common coastal water not much different from other coastal waters before the construction of the breakwater between them.

2. The breakwater between the two islands shuts off the tidal currents and divides the area into the two small isolated bays to create quite different environments.

3. To understand the differences between them present study examined some environmental factors such as water temperature, salinity, dissolved oxygen, transparency, and major nutrients, phosphates, sillicates and nitrites and the phyto- and zooplankton. The samplings were carried out monthly from March 1976 to February 1977 at 4 stations: 2 stations in each bay.

4. Some differences were observed in the environmental factors such as water temperature, salinity, dissolved oxygen and transparency between the two bays.

5. The distribution and occurence of nutrient salts of the two bays were distinctly different each other. Northern Bay had 138% of nutrients in comparison with Southern Bay.

6. Phytoplankton in Northern Bay was about 200% plentier than in Southern Bay.

7. Zooplankton in Southern Bay was about 180% richer than in Northern Bay.

8. One of the pollution indicator species, *Synedra ulna*, was observed in Northern Bay and the occurence of *Euglena* sp. and ciliates were much higher in Northern Bay than in Southern Bay, but, in contrast, *Sagitta* sp. was more abundant in Southern Bay than in the other.

9. The areas of the two bays seem to be in its way to eutrophication especially in Northern Bay.

10. The two bays have been differentiated enough to identify each other.

REFERENCES

Chee, C. K. (1970): A study on the environmental factors for the development of the pearl-culturing grounds over the winter. Pub. No. STF.-69-14, MOST.

Choe, S. (1966). Phytoplankton studies in Korean waters. 1. Phytoplankton survey of the surface in the Korea strait in summer of 1965. Jour. Oceanol. Soc. Korea 1 (2), 14-21.

_______(1967): Phytoplankton studies in Korean waters. 2. Phytoplankton in the coastal waters of Korea. ibid. 1 (2), 1-12.

_______(1969): Phytoplankton studies in Korean waters. 3. Surface phytoplankton survey of the north-eastern Korea strait in May of 1967. ibid. 4 (1), 1-18.

_______(1969): Phytoplankton studies in Korean waters. 4. Phytoplankton in the adjacent seas of Korea. ibid. 4 (2), 49-67.

_______and T. W. Chung (1972). Nutrient and suspended organic particulates in the estuary of Nak-dong River. ibid. 7 (1), 1-14.

Data report(1976): Some oceanographical data in Busan area from March 1974 to May 1976. Pub of Institute of Marine Science Nat. Fish. Univ. Busan.

Fisheries Research and Development Agency (1972): Report of water pollution surveys in Korea (1967-1971). 15, 105-112.

Lee, S. S. (1972): Distribution of copepods in Chinhae bay and its adjacent region. Bul. Fish. Res. Dev. Agency 9, 7-27.

Park, E. H. (1972): Seasonal changes in the abundance and composition of planktonic diatoms of the coast of Haewundae. Rep. for M. S., Nat. Fish. Univ. Busan. p. 38.

Park, J. S. (1973): The distribution of chaetognaths in the Korea strait and their relation to the character of water masses. Jour. Oceanol. Soc. Korea 8 (1), 22-32.

Park, J. S. (1973): Zooplankton abundance in Korean waters. ibid. 8 (1), 33-45.

Strickland, J. D. H. and Parsons(1968): A practical handbook of analysis. Fish. Res. Bd. Canada, Bull. 167, 311.

Won, J. H. and K. S. Park (1970): Tidal variation of the chemical constituent in the laver bed sea waters in Wando Gun from October 1968 to February 1969. Jour. Oceanol. Soc. Korea 5 (1), 14-29.

_______(1970): Investigtion of water quality in the laver bed at Yongwon Ri, Changwon Gun during the spring and neap tide in March 1970. ibid. 5 (1), 30-36.

津田松苗 (1964): 汚水生物學. p. 134-140.