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STUDIES ON THE BENTHIC FAUNA IN GAROLIM BAY, KOREA

Subtidal soft-bottom community

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加露林灣의 底棲動物群集에 관한 硏究

潮下帶 動物 群集

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Abstract: A semi-quantitative investigation on the subtidal macrobenthic community was carried out using dredge in Garolim Bay from February, 1980 to June, 1981. Of the 340 species of benthic fauna collected, the most dominant species with the numerical abundance of 12.3% was an ophiruroid, *Ophiactis modesta* which had a strong colony nature. Garolim Bay was also dominated by many suspension-feeders like *Ophiactis modesta* and *Musculista senhousia*.

Due to heterogeneous sediments, Garolim Bay appeared to be rich and diverse in the faunal composition. Based on the topography of the bay and sediment types, the study area is easily divided into two zones; inner bay and outward bay area.

要約: 가로림만의 조하대 저서 동물 군집에 관하여 1980년 2월부터 1981년 6월까지 dredge에 의해 격월로 채집된 결과를 분석하였다. 조사기간중 채집된 종수는 340종이었는데 이중 우점종은 거미불가사리류의 *Ophiactis modesta*로서 매우 심한 밀집 현상을 나타내면서 전체 개체수의 12.3%를 차지하였다. 또한 이들 분포종 중에서 *Ophiactis modesta*와 *Musculista senhousia*(종밋)과 같은 부유물 섭이자들이 매우 많이 서식되고 있었다. 대체로 가로림만은 양적으로 풍부한 생물상과 그리고 다양한 종 조성을 나타내었는데 이런 현상은 복잡하고 다양한 저질분포 특성에 기인된다고 보여진다.

정점간의 종유사도에 의한 분석결과 만의 지형과 저질의 입도 조성이 저서 동물의 분포에 크게 영향을 주는 것으로 나타났으며 내만과 만 바깥쪽의 두 구역으로 나누어지고 있다.

INTRODUCTION

Garolim Bay, which is located in the middle western coast of Korea, has received special attention because of the possibility of the tidal power generation. Informations on its physical, geological and oceanographical processes are available (KORDI, 1981; Han, 1982), but studies on its benthic faunal assemblages are scarce. On the other hand, many ecological benthic studies were carried out for the southern parts of the Korean Peninsula (Yi, 1975; Lee, 1976; Hong, Han, and Paik, 1982).

The present study on the subtidal benthic assemblages of the bay was conducted as a part of the feasibility studies of Garolim Tidal Power Plant from February, 1980 to June, 1981. Special attention was given to the distribution pattern and composition of the soft-bottom fauna with reference to environmental factors which may govern benthic processes.

MATERIALS AND METHODS

Six sampling stations were selected based on the morphological characteristics of the bay (Fig. 1). At each station, benthic organisms were collected bimonthly using a biological dredge (17×32cm, with canvas bag, devised by KORDI). Due to the lack of knowledge on the towing condition, the dredged samples are represented only as a semi-quantitative basis, although the dredge can be relied on in obtaining a large sample from a wide variety of sediments. Single successful haul was obtained at each station and sampling volume was limited to 15*l*. The samples were sieved on board using a 1-mm mesh sieve and the remainder on the sieve was fixed with 10% neutral formalin and was carried to the laboratory for analysis.

For the ecological interpretation of the benthic faunal assemblage, species diversity (Shannon and Weaver, 1963), dominance index (Simpson, 1949) and similarity index (Jaccard, 1908) were calculated, and the cluster analysis was made according to Lance & Williams (1967). To determine the grain size of the substrate, a 100ml of subsample was taken separately and the analysis was made according to the Wentworth's scale (Gelehouse, 1971; Ingram, 1971).

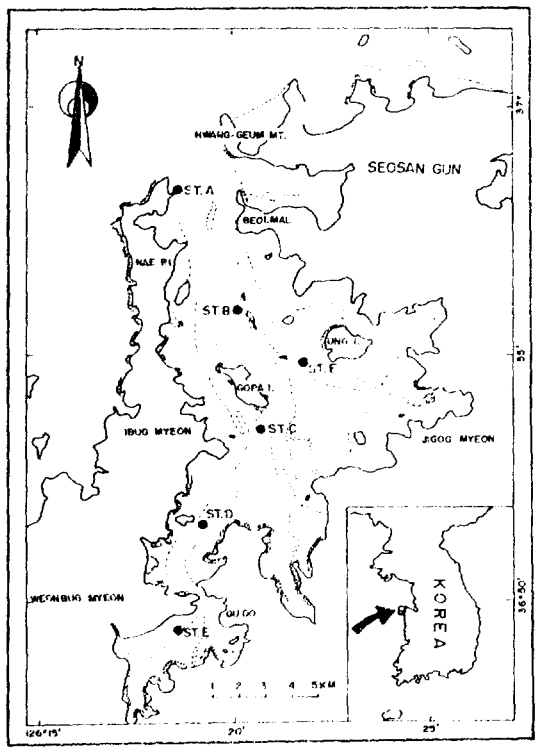

Fig. 1. Sampling stations in Garolim Bay.

SITE CHARACTERISTICS

Garolim Bay is a semiclosed bay, opening to the eastern Yellow Sea with NW direction (Fig. 1). The topography of the bay is largely divided into two channels by a sand bank near the mouth of the bay and some scattered small islands.

The difference of the total water volume of spring high and low tide is estimated to 500MT in Garolim Bay. The tides are predominantly semi-diurnal, which affect all of the physical processes in the region. The mean spring tidal range is known to be 6.4m and the mean neap is 2.9m. The instantaneous difference of the water level between the mouth and the tail of the bay ranges up to ±80cm at spring tide and ±20cm at neap. The western channel is ebb-dominant, while the eastern channel is flood-dominant.

The monthly mean water temperature varied from a minimum of 0.8°C in Junuary to a maximum of 22°C in August (KORDI 1981). The daily temperature fluctuation was known to be 2~3°C at the inner bay and 0.5°C at the outer bay (Fig. 2). The vertical temperature difference between the surface and bottom layer was 1.0~4.0°C in September and October, 0.6~2.6°C in February and 0.6~4.0°C in July. The monthly mean salinity varied from a minimum of 30.6~31.0‰ in July and August to a maximum of 32.0% in February and March. The vertical gradient

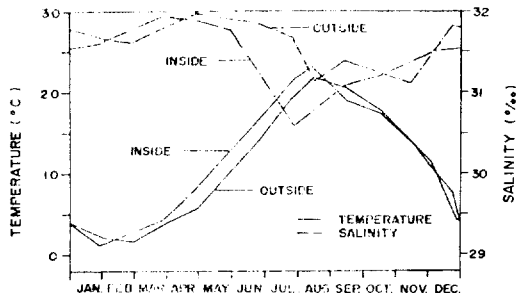

Fig. 2. Monthly variation of water temperature and salinity in Garolim Bay in 1981 (By KORDI 1981).

was a little steep during rainy season and showed 4% in July. In general, the vertical gradient of temperature and salinity were small.

RESULTS AND DISCUSSIONS

Grain size compostiion

In general, the sediment distribution represents muddy sand associated with some gravels or pebbles (Table 1). Through the all sampling stations many bioclastic elements, such as shell debris, were mixed in the sediments. Two inner bay stations, St. E and F, were characterized by high mud fraction of over 40%, whereas, on the bottom of station B near Gopado, much coarse grains were included. Sediments of stations A,C and D were very simillar to each other, that is, they were all composed of gravelly muddy sand and included mud fractions of 20~30%.

Table 1. Sediment type and depth at each subtidal sampling station.

Station	Textural class	Mud fraction (%)	Depth (m)
A	Gravelly muddy sand	20.2	14
B	Slightly gravelly sand	4.7	10
C	Gravelly muddy sand	25.8	8
D	Gravelly muddy sand	26.8	7
E	Slightly gravelly muddy sand	40.1	3
F	Muddy sand	41.5	7

Composition of the fauna

The fauna samples during the study period were composed of 4 major groups of benthic invertebrates; polychaetes, mollusks, crustaceans and echinoderms. Among 340 species found, polychaetes were dominant with 147 species and with 35.5% of the total population. And it was followed by mollusks and crustaceans with 24.1% and 22.6%, respectively. Polychaetes were the most dominant group in the area, although the dominance was much less striking than in the other coastal muddy bottoms, such as Busan (over 90%) or Ulsan (88%) (Lee, 1976; Yi, Hong, and Lee, 1982). Near Inchon, Oh (1976) found high occurrence of polychaete group with 45~65% on the soft bottom of mud fraction. Compared to the other region, this feature seems to be caused by the heterogenous substrate type of Garolim Bay which consists of the mixture of gravels, pebbles and shell fragments.

Total number of species in the study area was generally very high (Fig. 3). Stations C and D comprised more than 200 species and

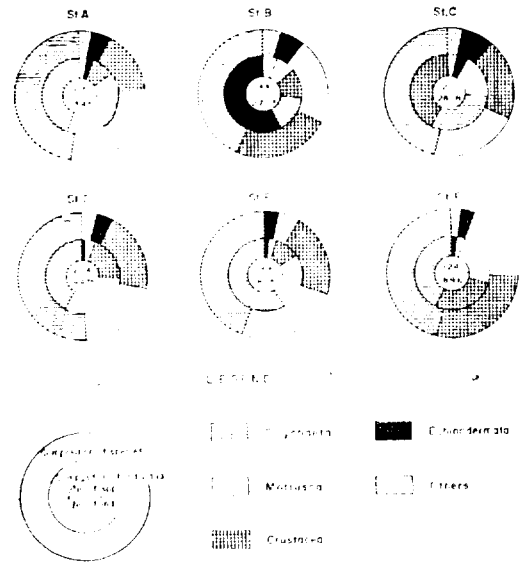

Fig. 3. Composition of benthic faunal groups at each sampling stations of Garolim Bay.

stations A,B and F showed 115~133 species. The minimum of 99 species was found at Station E. The stational variation in the total number of individuals was simillar to the number of species. However, station B and D represented high numerical abundance in comparison with the number of species.

In the distribution of the fauna, a patched brittle star, *Ophiactis modesta* topped the numerical abundance with 11.7% of the total individuals sampled. Of the other dominant species, a bivalve *Musculista senhousia* occurred with 6.5%, a polychaete *Lumbrineris longifolia* with 3.4% and a cumacean species also with above 3% composition. The majority of the dominant species showed a strong patchiness except in the case of *L. longifolia*. Distribution pattern of benthic fauna at each station showed significant differences in the dominant species. Dominant species at Stations A and E was *L. longifolia*. This species belonging to polychaeta is presented only near the coastal zone with the abundant muddy sediments. Dominant species at station B was extremely patched *O. modesta*, *Photis logicaudata* at station C, *M. senhousia* at station D, and *Armandia lanceolata* at station F.

Besides these dominant species, many sessile animals such as *Coptothyris grayi* and *Megabalanus rosa* occurred possibly on account of some proportion of the gravel type of bottom sediments. These sessile animals and patchy species affected the faunal composition and reflected the gravel elements of the whole bottom. A majority of sedentary animals including these sessile fauna and some echinoderms feed by capturing suspended particles that drift into their mucous traps or filtration system. Garolim Bay was dominated by the suspension-feeders such as *O. modesta*, *M. senhousia* and cumacean species.

Community structure

The calculated values of Simpson's Index of Dominance (C) were shown to be low or very low. The maximum value for this index is 1.0 which would indicate a fauna consisting of a single species. In this survey, the range of values was C=0.03 to 0.3, which suggested little change in the relative dominance of the benthic fauna between sampling stations. This was born out by the fact that 15 taxa made up the first 50% of the total number of individuals (Table

Table 2. Dominant species based on the total samples collected in Garolim Bay.

Rank	Species	Total number of Individuals	% of occurrence	Cumulative % of occurrence
1	*Ophiactis modesta*	1521	11.7	11.7
2	*Musculista senhousia*	848	6.5	18.2
3	*Lumbrineris longifolia*	557	4.3	22.5
4	Cumacea indet.	395	3.0	25.5
5	*Coptothyris grayi*	380	2.9	28.4
6	*Photis longicaudata*	373	2.9	31.3
7	*Pista* sp.	373	2.9	34.2
8	*Ctenoides lishikei*	372	2.9	37.1
9	*Ruditapes philippinarum*	337	2.6	39.7
10	Amphipoda indet.	329	2.5	42.2
11	*Nephtys polybranchia*	293	2.2	44.4
12	*Tharyx* sp.	245	1.9	46.3
13	Anturidae indet.	234	1.8	48.1
14	*Sternaspis scutata*	210	1.6	49.7
15	*Glycera decipiens*	167	1.3	51.0

2). Of the stational value of dominance index, the highest was 0.3 at station B mainly due to the high concentration of *Ophiactis modesta*. The dominance indices of other stations were only below 0.05.

As for faunal diversity, the difference of interstational composition was not notable, but the whole part of the bay appeared to be considerably diverse in biological assemblages. Stations C and D had the highest diversity values of the overall diversity level. Oh (1976) reported low diversity values (2.04~2.47) for the nearby area of Garolim Bay. Hartly (1983) described that the coarse sediments like Forties Field (North Sea) would show a particular distribution pattern of benthos with low dominance values and very diverse distribution. In general, coarse bottoms show more diverse distribution and lower dominance value than do muddy bottoms. The diverse faunal distribution of Garolim Bay seems to be due to the bottom type mixed with gravel, sand, mud fraction and, in addition, many bioclastic elements such as shell fragments.

Seasonal variation in the faunal distribution appeared to be minimal, except for several species. *Lumbrineris longifolia* and *Nephtys polybranchia* showed high occurrence from April to August, but on the other side a cumacean species appeared from August onwards and peaked in February showing 219 individuals.

The distribution pattein of benthic fauna shows a certain similarity in species composition between stations, which groups the samples most ecologically related. The dendrogram produced by this method suggests the presence of 2 groups of stations (Fig. 4).

Group I consists of stations A,B,C and D which are located rather in the outward of Garolim Bay. These 4 stations are found to have coarse sediments and the bottom containing low mud fraction of below 25%. The correlation

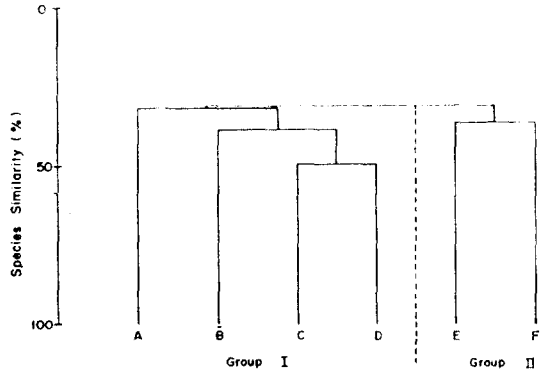

Fig. 4. Dendrogram of species similarity for benthic fauna.

between stations C and D showed highest affinity. Bottom textures of stations C and D were also very similar.

Group II contains stations E and F which are located in the innermost area of two channels in this bay. The sediments of these 2 stations which cluster to the same group contained mud fraction of over 40%. It seems that these two groupings are mainly due to the topographical characteristics of the bay and sediment texture of the bottom.

CONCLUSION

Of benthic animals collected, polychaete which comprised 147 species of a total 340 benthic species was the major group of the study area but was rather less dominant than those of other coastal areas. The most dominant species was a brittle star, *Ophiactis modesta* with the numerical abundance of 12.3% of the total specimens sampled and with strong colony nature. Garolim Bay was dominated by many suspension feeders like *O. modesta*, *Musculista senhousia*, cumacean species and others. Many sessile animals like *Coptothyris grayi* and *Megabalanus rosa* occurred, which would be due to the bottom type mixed with gravel. Based on the heterogeneous bottom sediments, the whole part of Garolim subtidal bottom appeared to be con-

siderably richer and more diverse in the faunal composition than the nearby Inchon area.

Seasonal trends in the faunal distribution appeared not to be variable except only a few species like *Lumbrineris longifolia*, *Nephtys polybranchia* and cumacean species.

The structure and bottom type of the bay affected the distribution of the benthic fauna and induced this bay to be divided into two zones; inner bay (stations E and F) and outward bay area (stations A,B,C and D).

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