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Community Structures of Macrobenthos in Chonsu Bay, Korea

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Based on 53 quantitative samples collected in April (23 stations) and August (30 stations) of 1993, the species composition, distribution and abundance of macrobenthic invertebrates and bottom characteristics in Chonsu Bay were conducted. Bottom sediments consisted of mud at the close to the dyke, sandymud in the central bay, and coarse sand in the mouth of the bay. A total of 273 species (177 species in April and 200 species in August) were identified. Mean density per sampling station was 480 ind./m^2 in April and 1126 ind./m^2 in August, respectively. Number of species and densities decreased in the northern part of the bay. The macrobenthos showed a temporal difference in species composition, range of distribution, and community delimitation caused by larval settling. Although during the settling period in summer, large numbers of juveniles added in most of regions, unrelated to environmental conditions, but, successful recruitment may has been a rare event locally. *Theora fragilis* (bivalve), *Lumbrineris longifolia* (polychaete), *Neptys oligobranchia* (polychaete) were numerically dominant, but their densities varied seasonally. Community structures of macrobenthos in Chonsu Bay were affected by several bottom environmental conditions, related to tidal current speed, regionally.

INTRODUCTION

Coastal zones, which are economically important regions as a spawning and nursery ground, have been exploited for living marine resources for a long time. However, the coastal development by industrialization have given rise to serious environmental and marine ecological problems and have been deteriorated the coastal zones gradually. Topographic changes such as reclamation and artificial dyke construction affect to coastal currents pattern remobilizing the sediments, and reflect in the faunal distribution, may even result in the total disappearance of a given population. Especially, benthic ecosystems including dermersal fishes, diatoms as well as invertebrate animals living in the bottoms have influenced directly and indirectly by the grain size composition of sediment (Sanders *et al.*, 1962; Holland and Polgar, 1976; Flint and Holland, 1980). As recently reported, the distribution of the benthic macrofauna was closely related to environmental conditions and the bottom sediment. Accordingly, Some marine ecologists, using the number and quantity of macrobenthos, have used to determine the level of pollutants on the benthic environments, and shallow water benthic communities have been utilized as one of the major tools for the evaluation of environmental pollution. Precise analysis of the distribution of benthic organisms, and of the relationship between the distribution of macrobenthic fauna and bottom sediment are important in analysing the function and structure of the ecosystem of the sea bottom (McCall and Tevesz, 1982; Long and Lewis, 1987).

Chonsu Bay have semi-enclosed bay which constructed the dyke in 1984. So, about half of areas have changed the freshwater lake or reclaimed. After the dyke construction, some marine ecological studies, for example phytoplankton (Shim *et al.*, 1988; Shim and Yeo, 1988; Shim and Shin, 1989), zooplankton (Yoon, 1988; Shin, 1989), fish eggs and larvae(Lee and Seok, 1984; Shim *et al.*, 1988) and macrobenthic assemblages (KORDI, 1978; Je *et al.*, 1991; Shim *et al.*, 1988) have been carried in Chonsu Bay. But, most of studies about benthic assemblages were localized. Only, Shim *et al.* (1988) have carried in overall areas for 2 years, 1986—1987, but they had discussed on Class taxonomic level only.

We supposed that Chonsu Bay is appropriate area for investigating the effects of coastal development on the coastal marine ecosystems, beacuse it seems to be changed seriously since the dyke construction.

In this study, the spatial distribution pattern of benthic macrofauna by the change of benthic environments in Chonsu Bay has been examined in detail.

STUDY AREA

Chonsu Bay is a semi-enclosed bay connected to the Yellow Sea and tidal flat is developed along the shore (Fig. 1). The pattern of coastal currents are determined from tide. During ebb tide, sand dune, located on northwest of the bay, is exposed extensively.

The tide is predominantly semi-diurnal, and the mean tidal range is about 4.7 m. Maximum current velocity at the mouth of the bay was 3.4 knots at flood tide and 3.1 knots at ebb tide (OHA, 1991-1992). Current velocity is 1.51 m/s at Gojeongri, and 0.26 m/s at Kanwoldo (Shim *et al.*, 1988; Lee, 1988). Before the dyke construction, mean coastal current velocity (1.0—1.75 m/s) was faster than that of now (KORDI, 1974).

The monthly mean water temperature varied from about 5°C in February to about 26°C in August. The difference of temperature between surface and bottom layer was almost about 1.0°C.

There is no industry complex around the bay except Boryong Power Plant which located on the mouth of the bay. So, there are thermal discharges inflowing to the bay by tidal current, and some sewages from local villages discharges. In order to control the water-level in the lake, there are also freshwater discharges to the bay through the outlet intermittently. Before the dyke construction, lavel culture had been prevailed in the bay, but after that, it disappeared due to the reduction in the tidal current speed. And, the cockle, *Fulvia mutica*, had been sampled massively, but it is very rare now. Recently, aquacultures using the fish-cages have been prevailing around the dyke.

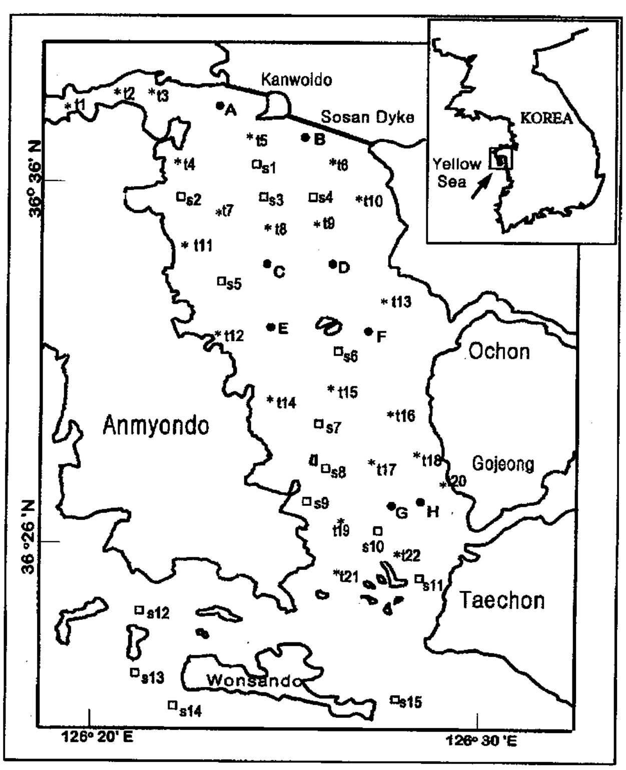

Fig. 1. A map of the study area showing sampling stations. Station s1—s15: sampled in April, 1993; Station t1—t22: in August, 1993; Station A—H: both in April and August.

MATERIALS AND METHODS

Sampling of macrobenthos and sediment were carried out at 53 stations in Chonsu Bay, 23 stations in April and 30 stations in August 1993, respectively (Fig. 1). Three repeat samplings were made at each station using a weighted 0.1 m^2 van Veen grab sampler. From each sample a small aliquot of sediment was retained for grain size analysis and organic contents, and the remainder was sieved through 1 mm mesh. The residue containing the macrobenthos was fixed with 10% neutral formalin. After sorting, the animals were rinsed in distilled water and preserved in 70% alcohol. They were identified at family level whenever possible and the number of individuals counted.

Grain size composition was determined by wet sieving and pipette analysis (Folk and Ward, 1957). Organic contents of sediment were measured by determining the loss in the weight of dried sediment at 550°C for 2 hours and carbon, nitrogen, and sulfur contents in sediment were measured using a CHN Analyser.

Salinity and temperature were measured with CTD (SBE-19) during all sampling period. Dissolved oxygen of the bottom layer was measured only in August, 1993.

Shannon-Wiener diversity (Shannon and Wiener, 1963) and Dominance index were calculated to compare community structure and to check spatial variability. Dominance ranking of the leading species in each faunal assemblage was calculated using the Le Bris Index (Le Bris, 1988). Pearson's Correlation were performed to compare the relationship between faunal assemblages and environmental variables. The similarity of macrobenthos among the sampling points was compared by PCA (principal component analysis).

RESULTS

Sedimentary facies

About three sedimentary facies were identified based on analyses of bottom sediment at 53 sampling stations in Chonsu Bay (Fig. 2). The middle area of the bay and around the dyke, located on the northern area, showed mud bottom (mean grain size greater than 7φ). Sand dune area and around the outlet of the lake were muddy sand (from 4φ to 7φ), and the mouth of the bay consisted of sand (less than 4φ) and rock bed partly.

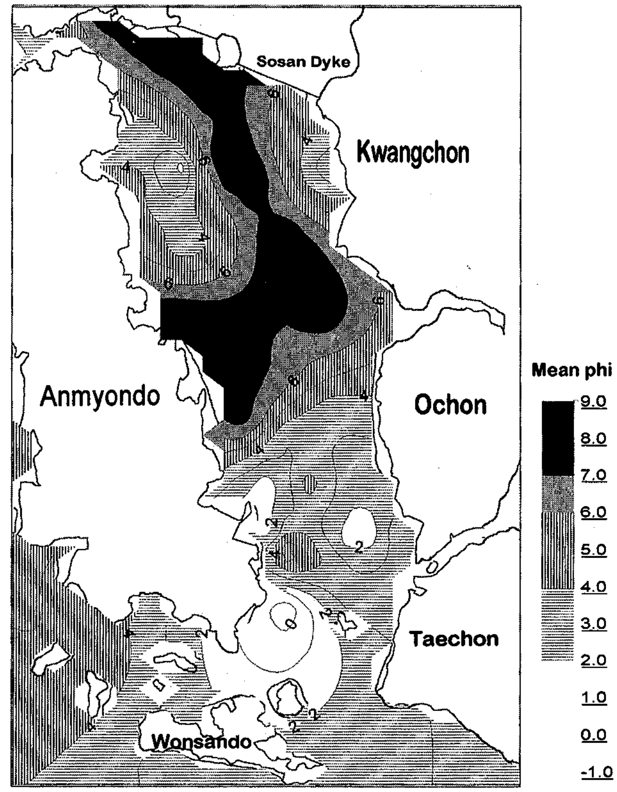

Fig. 2. Geographical distribution of mean grain size (φ) of the surface sediment.

Faunal composition

A total of 273 species (177 spp. in April and 200 spp. in August) representing 10 taxonomic groups (Bryozoans were not included) were identified for both seasons (Table 1). Polychaetes comprised 91 species (33.3%) and was the most abundant and widespread. Crustaceans (78 species), molluscs (74 species), echinoderms (12 species) were also ranked as abundant taxonimic groups. The mean density of macrofauna per each station was 846 individuals/m^2 (480 ind./m^2 in April and 1,126 ind./m^2 in August, respectively). Total individuals of the four most abundant taxonomic groups accounted for 97.6% in April and 98.9% in August, respectively.

The number of species per each station varied

Table 1. Number of species, total density, percentage composition and frequency occurrence of all taxonomic groups of macrobenthos during each sampling period in Chonsu Bay (Sp.=number of species, (%)=percentage composition, Den.=total density (ind./m^2), Freq.= frequency occurrence (%))

Taxon	Total no. Sp.		April, 1993					August, 1993				
	Sp.	(%)	Sp.	(%)	Den.	(%)	Freq.	Sp.	(%)	Den.	(%)	Freq.
Cnidaria	5	(1.8)	3	(1.7)	17	(0.1)	21.7	5	(2.5)	40	(0.1)	26.7
Platyhelminthes	1	(0.4)						1	(0.5)	73	(0.2)	36.7
Nemertina	4	(1.5)	4	(2.3)	79	(0.7)	56.5	2	(1.0)	205	(0.6)	70.0
Brachiopoda	1	(0.4)	1	(0.6)	102	(0.9)	13.0					
Sipunculida	3	(1.1)	2	(1.1)	46	(0.4)	21.7	4	(2.0)	20	(0.1)	16.7
Mollusca												
Polyplacophora	1	(0.4)	1	(0.6)	23	(0.2)	8.7	1	(0.5)	17	(0.0)	10.0
Gastropoda	29	(10.6)	10	(5.6)	99	(0.9)	60.9	18	(9.0)	788	(2.3)	90.0
Bivalvia	43	(15.8)	30	(16.9)	2181	(19.7)	87.0	22	(11.0)	12570	(37.2)	96.7
Cephalopoda	1	(0.4)	1	(0.6)	3	(0.0)	4.3					
Annelida												
Polychaeta	91	(33.3)	63	(35.6)	6079	(55.0)	91.3	84	(42.0)	14566	(43.1)	100.0
Arthropoda												
Crustacea	78	(28.6)	48	(27.1)	2251	(20.4)	87.0	54	(27.0)	4457	(13.2)	96.7
Echinodermata												
Crinoidea	1	(0.4)	1	(0.6)	3	(0.0)	4.3					
Asteroidea	2	(0.7)	2	(1.1)	17	(0.1)	17.4	2	(1.0)	89	(0.3)	13.3
Ophiuroidea	7	(2.6)	5	(2.8)	79	(0.7)	34.8	4	(2.0)	436	(1.3)	53.3
Echinoidea	3	(0.7)	2	(1.1)	10	(0.1)	13.0	2	(1.0)	69	(0.2)	30.0
Holothuroidea	1	(1.1)	3	(1.7)	54	(0.5)	30.4	1	(0.5)	449	(1.3)	53.3
Chordata	1	(0.4)	1	(0.6)	7	(0.1)	8.7					
Total	273	(100.0)	177	(100.0)	11048	(100.0)		200	(100.0)	33779	(100.0)	

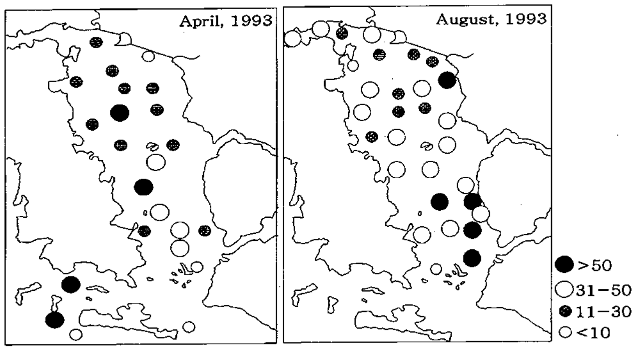

Fig. 3. Spatial distribution of the number of species in April and August, 1993.

from 1 (Stn B, s15) to 64 species (Stn s12) in April and 7 (Stn t21) to 88 species (Stn t22) in August, respectively. It was high in the middle area of the bay, and declined slightly toward both directions of the mouth and the head in April. But in August, the number of species were increased markedly in all area, showing the highest value in the mouth area (Fig. 3).

The density per each station ranged from 3 ind./m^2 (Stn s15) to 1521 ind./m^2 (Stn s7) in April, and from 43 ind./m^2 (Stn t10) to 2782 ind./m^2 (Stn t22) in August. Most of sampling station showed higher densities in the summer than the spring. Around the dyke and the mouth of the bay also increased in the summer (Fig. 4).

The number of species at 8 stations (Stn A—H) which were sampled continuously during both seasons increased mostly, except Stn C and G, in August (Fig. 5). Stn B, located on around the dyke, remained low. Abundance also increased in August, and in the middle area was deeply higher than any other areas.

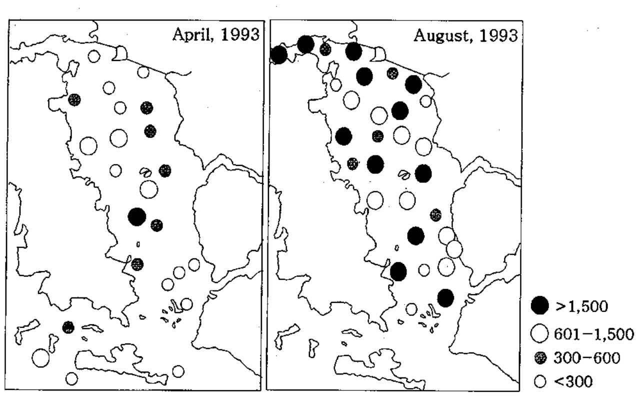

Fig. 4. Spatial distribution of macrobenthos density (ind./m^2) in April and August, 1993.

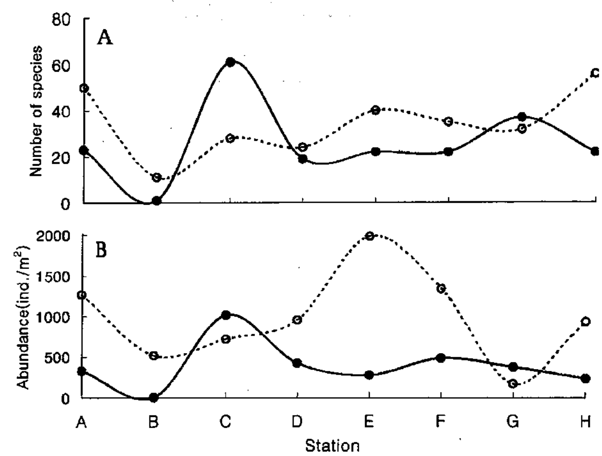

Fig. 5. Spatial changes in the number of species (**A**) and mean density (ind./m^2) (**B**) of macrobenthos (● = April, 1993, ○ = August, 1993).

Species dominance

Dominance ranking of the species based on Le Bris Index showed that polychaetes, *Lumbrineris longifolia* (69 ind./m^2, mean density), *Nephtys oligobranchia* (66 ind./m^2), a molluscan, *Theora fragilis* (937 ind./m^2) and crustaceans (Aoridae unid., *Eriopisella sechelensis*) dominated for both seasons, although their densities are different greatly between sampling period. In August, most of these dominant species showed high density strikingly throughout the bay, and a gastropod, *Philine argentata* (27 ind./m^2), a ploychaeres *Sternaspis scutata* (74 ind./m^2) and a bivalve *Moerella jedoensis* (39 ind./m^2) were also dominant (Table 2).

Fig. 6 showed four numerically dominant species at 8 stations for both seasons. *Theora fragilis* increased sharply from the head and the mouth to the middle of the bay in August. At this time, *Lumbrineris longifolia* also appeared highly in the head and increased gradually along the middle of the bay. But *Neptys oligobranchia* and *Sternaspis scutata* showed decrease in Stn C and Stn D, E, respectively in August.

Community structure

From the Pearson s correlation values, some significant correlation ($P=<0.05$) between biological and environmental variables were conducted. Most of the environmental factors showed the low correlation value with the biological data based on macrobenthos. Among them, the grain size of sedi-

Table 2. Dominance ranking (Le Bris index) in density (ind./m^2) of macrobenthos during each sampling period (po=polychaete, bi=bivalve, ga=gastropod, cr=crustacean, ho=holothuroidean)

Rank	Species	Taxa	Mean density ±STD	Total density	% of total density	Frequency occurence
April, 1993						
1	*Lumbrineris longifolia*	po	69±100	897	8.1	56.5
2	*Sigambra tentaculata*	po	18±21	238	2.1	56.5
3	*Nephtys oligobranchia*	po	66±85	855	7.7	56.5
4	*Theora fragilis*	bi	93±114	1112	10.0	52.1
5	*Aoridae unid.*	cr	57±14	452	4.0	34.7
6	*Eriopisella sechelensis*	cr	16±16	142	1.2	39.1
7	*Ampharete arctica*	po	16±24	231	2.0	56.5
8	*Prionospio krusadensis*	po	43±71	746	6.7	60.8
9	*Ampelisca* sp.	cr	14±8	96	0.8	30.4
10	*Glycinde* sp.	po	29±21	429	3.8	65.2
11	*Dorisca cf. nana*	bi	13±11	79	0.7	26.0
12	*Glycera chirori*	po	15±11	218	1.9	65.2
13	*Heteromastus* sp.	po	29±41	234	2.1	34.7
14	*Eteone longa*	po	9±6	46	0.4	21.7
15	*Sternaspis scutata*	po	22±16	201	1.8	39.1
August, 1993						
1	*Theora fragilis*	bi	433±452	9517	28.1	73.3
2	*Lumbrineris longifolia*	po	206±274	4333	12.8	70.0
3	*Philine argentata*	ga	28±18	581	1.7	70.0
4	*Nephtys oligobranchia*	po	10±8	251	0.7	80.0
5	*Raphidopus ciliatus*	cr	23±22	508	1.5	73.3
6	*Sternaspis scutata*	po	73±18	881	2.6	40.0
7	*Glycinde* sp.	po	29±19	515	1.5	63.3
8	*Heteromastus* sp.	po	16±17	241	0.7	50.0
9	*Moerella jedoensis*	bi	39±37	660	1.9	56.6
10	*Glycera chirori*	po	12±10	281	0.8	76.6
11	*Ampharete arctica*	po	62±127	865	2.5	46.6
12	*Arcidea* sp.	po	21±36	360	1.0	56.6
13	*Sigambra tentaculata*	po	19±17	363	1.0	63.3
14	*Tharyx* sp.	po	22±24	347	1.0	53.3
15	*Protankyra bidentata*	ho	28±42	449	1.3	53.3

ment and bottom salinity were slightly related to biological data (Table 3). Preference for specific ranges of these factors presumably induces the localization of respective species.

The degree of similarity of each sampling station was analyzed for the macrobenthos community using the PCA method, with variables being the individual number of all species sampled. In April, the eigenvalue of the first component (PCA-1) was 8.88 with a contribution rate of 33.8%. The cumulative contribution rate up to the second component (PCA-2) was 43.7%. Thus, the degree of similarity between each pair of sampling station was almost entirely represented by PCA-1 (Table 4). The cumulative contribution rate up to PCA-3 was 49.6%. The score distribution for PCA-1 and PCA-2 at each sampling station was showed in Fig. 7. The sampling stations were divided by 4 groups approximately. Among them, group G-1 were composed of 10 stations located from the middle of bay to the head regions, and were consisted of fine sediment (6.6φ) and highly organic content (Table 5). Group G-2 (6 stations) were located on the mouth of the bay mainly, and included many of species numbers and recorded highly diversity (H'). Group G-3 (4 stations) covered the sampling stations which some of the mouth of the bay, and consisted on coarse sediment (2.5φ) and recorded low organic carbon on surface sediment. Group G-4 (only 3 stations) comprised the defaunated area mainly such as the mouth of the bay and adjacent to the dyke. Most of the species were ranked positive correlation for PCA-1, but in case of PCA-2, species with fairly high positive correlation were ranked *Neptys oligobranchia, Lumbrineris japonica*, and those with negative correlation were *Gricinde* sp. *Prionospio krusadensis*. Therefore, the group can be characterized by large and small individual numbers of the numerically dominant species.

In the case of August, there were some different conditions, comparing with April. The eigenvalue of the first component (PCA-1) was 13.82 with a

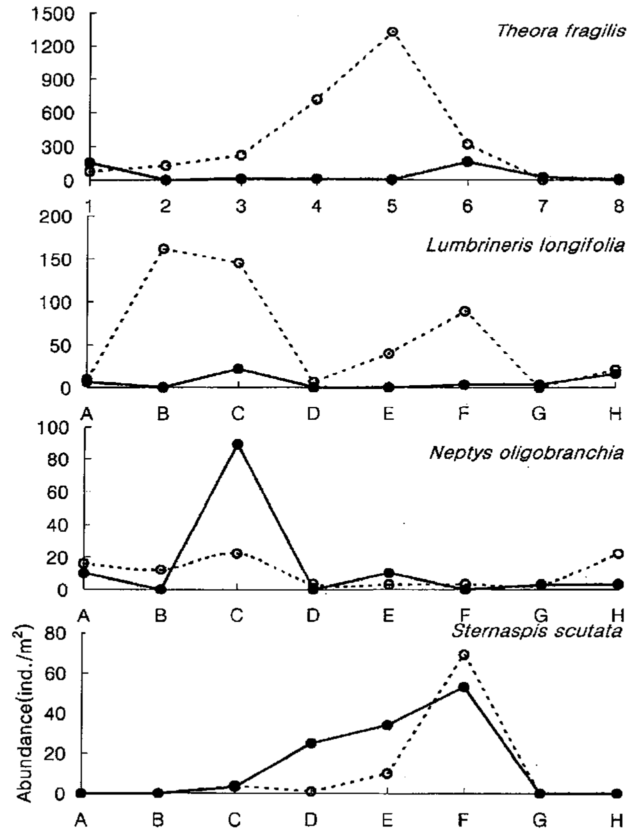

Fig. 6. Spatial changes in the abundance of 4 dominance species (● = April, 1993, ○ = August, 1993).

contribution rate of 42.0%. The cumulative contribution rate up to the second component (PCA-2) was 51.4% (Table 4). Consequently, the degree of similarity between each pair of sampling stations was represented almost same conditions as April. The area which contains group C-1 included sampling stations (16 stations) in the area from the central to some of the head regions of the bay (Fig. 8), and were composed of fine sediment (6.9φ) with high organic content (Table 6).

Group C-2 (9 stations) was composed of the mouth of the bay mainly, and included many of species numbers, recorded to highly diversity (H') (Table 6). Group C-3 (5 stations) comprised both side of the bay, and was composed of coarse sediment (1.7φ) and low organic carbon. All of the species were ranked positive correlation for Prin 1. Species with a positive correlation for PCA-2 were ranked *T. fragilis, P. argentata,* and negative correlation for PCA-2 were *Lumbrineris longifolia, Ampelisca* sp. *Ampharete arctica* and so on.

DISCUSSION

Sediment grain size is an important environmental factor in the distribution and structure of benthic community. In addition, co-varing factors like organic content, microbial content, food supply and trophic interactions in sediment are also important. No single factor has been able to explain solely benthic environmental processes (Snelgrove and Butman, 1994). Results of sediment analysis in the study area showed a distinct regional difference in grain size, but this results were similar to previous findings in this area by Shim *et al.* (1988). Accordingly, we suppose that regional difference of sedimentary facies is due to the change on tidal current speed and topographical conditions for some time since the dyke construction, but now, overall sedimentary facies almost seem to be changed.

Table 3. Pearson's correlation coefficients matrix (5% of significant level) between abiotic and biotic variables in Chonsu Bay (Sal.=bottom salinity, D.O.=bottom dissolved oxygen, Sand=sand proportion in surface sediment, Phi=mean grain size, O.C.=organic content in surface sediment, Sp.=number of species, Ind.=individuals, H'=diversity index, R=richness index, N=nitrogen content in surface sediment, S=sulfur content in surface sediment)

	Sal.	D.O.	Sand	Phi (φ)	O.C.	Sp.	Ind.	H'	R	N	S
						April, 1993					
Sal.			0.42	−0.62	−0.46	0.62	0.67	−0.59	−0.51	−0.26	0.03
D.O.	−0.26										
Sand	0.13	−0.04		-0.31	−0.18	0.35	0.36	−0.18	−0.33	−0.13	−0.02
Phi (φ)	0.08	−0.17	0.19		0.27	−0.42	−0.43	0.18	0.24	0.21	0.03
O.C.	−0.43	0.79	−0.09	−0.14		−0.32	−0.34	−0.04	0.12	0.94	0.68
Sp.	0.33	−0.42	0.17	−0.29	−0.41		0.89	−0.39	−0.20	−0.27	−0.15
Ind.	0.69	−0.17	0.11	−0.29	−0.29	0.46		−0.39	−0.28	−0.27	−0.21
H'	−0.54	0.39	0.12	0.09	0.18	−0.42	−0.37		0.16	−0.16	−0.30
R	−0.43	0.45	−0.08	−0.13	−0.02	−0.15	−0.29	0.54		−0.10	−0.19
N	0.01	−0.22	0.04	0.86	−0.21	−0.12	−0.40	−0.12	0.01		0.86
S	0.41	−0.21	0.22	−0.01	−0.29	0.33	0.25	0.13	−0.26	−0.10	
						August, 1993					

Table 4. Factor loading and eigenvalue for characteristic species of macrobenthos in all sampling stations by PCA

Species	April, 1993		Species	August, 1993	
	PCA-1	PCA-2		PCA-1	PCA-2
Theora fragilis	0.95	−0.18	*Theora fragilis*	1.87	0.92
Lumbrineris longifolia	0.80	0.00	*Lumbrineris longifolia*	1.33	−0.30
Neptys oligobranchia	0.84	0.39	*Sternaspis scutata*	0.64	0.15
Glycinde sp.	0.94	−0.46	*Moerella jedoensis*	0.77	0.22
Prionospio krusadensis	0.94	−0.42	*Philine argentata*	0.93	0.30
Aoridae unid.	0.54	0.25	*Ampelisca* sp.	0.33	−0.33
Arcidea sp.	0.45	−0.18	*Owenia fusiformis*	0.04	−0.10
Lumbrineris japonica	0.28	0.48	*Byblis japonica*	0.07	−0.15
Sigambra tentaculata	0.61	−0.44	*Maera* sp.	0.07	−0.15
Pisidia serratifrons	0.04	0.16	*Ampharete arctica*	0.41	−0.43
Eigenvalue	8.88	2.61	Eigenvalue	13.82	4.20

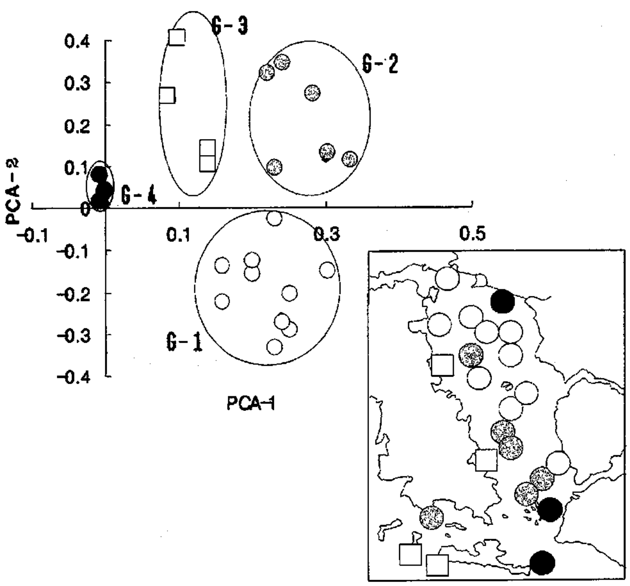

Fig. 7. Distribution and grouping of sampling stations in a two dimensional PCA for the all species sampled in April, 1993.

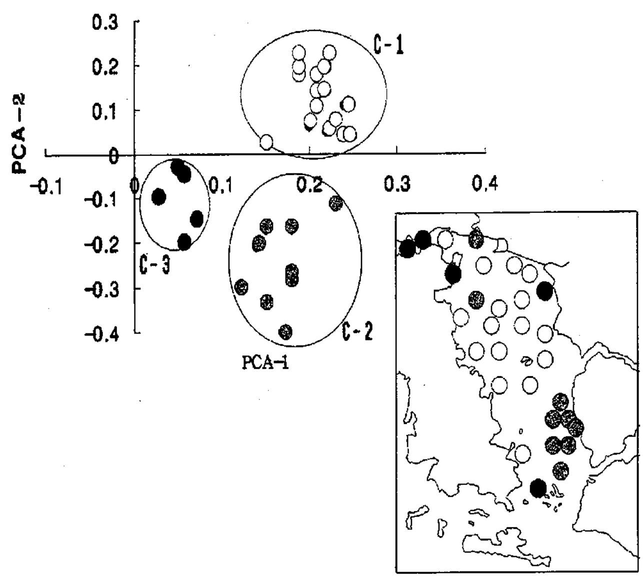

Fig. 8. Distribution and grouping of sampling stations in a two dimensional PCA for the all species sampled in August, 1993.

Table 5. Number of stations, environmental and biological conditions for each station group in April, 1993 (b=bivalve, p=polychaete, c=crustacean)

	G-1	G-2	G-3	G-4
Number of stations	10	6	4	3
Environmental conditions				
Bottom temperature (°C)	7.9±0.3	7.3±0.5	7.0±0.6	7.2±0.9
Bottom salinity (‰)	321±0.4	322±0.1	322±0.1	322±0.1
Mean grain size (φ)	6.6±2.4	3.7±1.8	25±0.9	5.0±3.3
Organic content (%)	3.6±1.7	22±1.0	1.4±0.8	27±1.5
Biological conditions				
Number of species	102	116	97	5
Mean density (ind./m^2)	441±264	749±463	531±455	2±1
Diversity (H')	20±0.3	29±0.2	1.9±0.5	
Characteristic species	*Theora fragilis* (b) *Lumbrineris longifolia* (p) *Prionospio krusadensis* (p) *Neptys oligobranchia* (p) *Arcidea* sp. (p)	*Neptys oligobranchia* (p) *Theora fragilis* (b) *Lumbrineris longifolia* (p) *Aoridae unid.* (c) *Photis longicaudata* (c)	*Lumbrineris japonica* (p) *Neptys oligobranchia* (p) *Pisidia serratifrons* (c)	

Table 6. Number of stations, environmental and biological conditions for each station group in August, 1993 (n=nemertean, g=gastropod, b=bivalve, p=polychaete, c=crustacean)

	C-1	C-2	C-3
Number of stations	16	9	5
Environmental conditions			
Bottom temperature (°C)	229±0.3	227±0.2	229±0.5
Bottom salinity (‰)	29.2±0.2	29.4±0.3	29.2±0.4
Mean grain size (φ)	6.9±1.3	3.4±2.2	1.7±1.9
Organic content (%)	4.8±1.7	3.3±1.8	1.4±0.5
Biological conditions			
Number of species	112	153	78
Mean density (ind./m²)	1,237±548	1,118±723	787±999
Diversity (H')	24±0.5	3.0±0.3	25±0.3
Characteristic species			
	Theora fragilis (b)	*Lineus* sp. (n)	*Mytilus edulis*
	Lumbrineris longifolia (p)	*Maera* sp. (c)	*galloprovincialis* (b)
	Stenaspis scutata (p)	*Byblis japonicus* (c)	*Owenia fusiformis* (p)
	Moerella jedoensis (b)		
	Philine argentata (g)		

Chonsu Bay affect the cyclic tidal current. At the mouth of the bay, the tidal current speed increase relatively, but, going along the northern areas, it decline gradually because it is almost blocked up. However, sediment of adjacent to the outlets were consisted of coarser than around the dyke, because when freshwater discharges from the lake, bottom sediment was eroded along the channel. Tidal current is known to determine the nature of bottom substrate to a large degree and it influences on the stability of the sediment and food supply for benthic organisms (Widish and Kristmanson, 1979). Actually, tidal current also plays an important role in dispersal of macrobenthos (Dobb and Vozarik, 1983; Miller *et al.*, 1992; Snelgrove and Butman, 1994; Taghon and Greene 1992). Thus, in Chonsu Bay, larval dispersion is more active by tidal current.

Although the differences which sampling method and number of stations make it difficult to exact comparisons between surveys, the number of species of macrobenthos sampled was higher in this study than any previous studies. For example, KORDI (1978) identified 20 species in 10 stations, Je *et al.* (1990) identified 20 species in only 1 station using the dredge sampler. Shim *et al.* (1988) identified only class taxonomic level except three dominant species: *Pisidia* sp. (crustacean), *Theora fragilis* (molluscan), *Polydora* sp. (polychaete).

Most of species showed that patterns of abundance changed according to time and area both seasons. Especially, dominant species in Chonsu Bay got a little proportion in total density of the community. Namely, overall benthic communities in Chonsu bay may have high diverse conditions potentially. More diverse communities contained species with a high reproductive potential. Thus it may be possible to predict the species diversity of highly diverse communities after catastrophe (Poore and Kudenov, 1978). But in Chonsu Bay, nevertheless the high diverse communities, some of dominant species were composed of 'opportunistic species' and other species fluctuated deeply according to time and area. So, we suppose that most of juveniles recruited rather originated from outer sea by tidal current than produce themselves in the bay. The mouth of the bay was influenced directly than any other area because many of juvenile inflow firstly from outer sea. But, the bottom sediments were disturbed and resuspended periodically due to tidal current. So, inhabited sessile filter feeder, for example hydrozoans, brachiopods, bryozoans, and a small amount of polychaetes, and in summer, many of juveniles recruited only the edge of the bay, composed of sandymud. As compared with other areas, the macrobenthic assemblages of the middle area may had stable species composition relatively, nevertheless temporal difference found in abundance for both seasons. The bottom sediment around the dyke consisted of mud because of declining tidal current speed, and in order to control the freshwater level in the lake, freshwater discharges prevailed into the bay. Abrupt changes of salinity and increase of turbidity due to discharges were seriously affected the macrobenthos assemblages (Tenore, 1972; Boesch *et al.*, 1976), and an excessive outfalls of particulate organic debris and dissolved organic matter from freshwater resulting in hypoxia. The recovery of macrobenthic assemblages from hypoxia should be largely dependent on the relationship between timing of the return to normal conditions and species life histories. Faunal colonization in newly open space will depend on a combination of water exchange, proximity of reproducing organisms with opportunistic life-history characteristics, and larval availability (Llanso, 1991). Opportunistic species often colonize benthic habitats rapidly after defaunation as a result of physical disturbance or pollution abatement (Arbugov, 1982; Ferraro *et al.*, 1991; McCall, 1977; Pearson and Rosenberg, 1978; Santos and Simon, 1980). Actually, most of macrobenthos recruited around the dyke in August were opportunistic species, *Theora fragilis, Lumbrineris longifolia*, but when interpolated April data, we know that opportunistic species recruited in these area disappear gradually, so we suppose that these areas maintain unstable environmental conditions. In the distribution of dominant species, *Theora fragilis* was some different from that of *Lumbrineris longifolia. Lumbrineris longifolia* was localized in the mouth of bay. while *Theora fragiis* was concentrated in the middle of bay.

Correlation analysis between biological factors and environmental factors provides an important preliminary information to an understanding of the physical control community structure and function (Warwick and Uncles, 1980). Correlations between sediment type and faunal community have been considered for the static pattern of sediment granulometry, not for the dynamic physical environment in which the animals live (Widish and Kristmanson, 1979). Many studies on infaunal invertebrate distributions have correlated sediment with grain size, leading to the generalization of distinct associations between animals and specific sediment types. But there is, little evidence that sedimentary grain size alone is the primary determinant of infaunal species distributions (Miller and Sternberg, 1988; Snelgrove and Butman, 1994). As results, one particular environmental factor might have not influenced overall benthic communities, Also in this study, only sedimentary facies found the slightly correlations with biological data, but we suppose that the bottom environmental conditions including several factors must be an important delineating benthic macrofaunal assemblages in Chonsu Bay.

Results of the numerical classification of the macrobenthos by PCA in Chonsu Bay, showed that sampling stations located on the middle of the bay had high similarity for both seasons, but the head and mouth of the bay indicated temporal difference. In August, number of individuals deeply higher than April in most of regions, because many of macrobenthos recruited newly in the summer. But the results of the numerical classification between each station may have little diffrernce both seasons.

Field studies on environmental impacts are necessary at appropriate time and space intervals and for sufficient duration (Gray, 1981), Although these results are infered based on the data only in two seasons, we suppose that the benthic communities in Chonsu Bay has been supported under unstable conditions regionally, and community structures of macrobenthos also varied. Especially, the construction of the dyke influenced community structures generally, because it was changed the current system affecting the sedimentary facies and induced irregular freshwater discharges in the north area of the bay.

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