Studies on the Intertidal Macrofauna Community at Yong-ho Bay, Busan, Korea*

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龍湖灣 潮間帶의 動物群集에 關한 硏究*

異 舜 吉**

용호만의 조간대에서 서식하는 저서 동물군집에 대한 생태학적인 연구를 하였다.

총 29속 32종이 채집 되었고, 이중 *Armandia lanceolata*와 *Nephtys* sp. A가 수적으로 우점종이었으며, 무게로서는 *Neanthes japonica*와 *Laternula limicola*가 우점종이었다.

동물군의 분포는 3개의 지역으로 나누어 지며 이는 저질의 입도 조성 특히 니질의 함량에 영향을 받는듯 하며 이 결과는 steces diversity와 faunal affinity와도 잘 일치한다.

유기물 총량과 노출 시간이 동물군집 전체에 미치는 영향은 발견되지 않았다.

INTRODUCTION

Intertidal beaches are ecologically characterized by the various environmental conditions: the periodic exposure to desiccation, temperature and salinity fluctuations, predations by terrestrial as well as subtidal animals, high physical energy of pounding waves and food availability. This intertidal habitat supports a large number of benthic organisms which represent most of invertebrate phyla. They are usually burrowers and interstitial animals of which the distributions are closely related to grain size composition of the substrata.

Intertidal beaches have received considerable attention during the last two decades in terms of their ecology and taxonomic study. Petersen (1913) described the correlations between animal community and sea bottom; MacGinity (1939) reported the littoral marine community; Mare (1942) devided the marine benthic invertebrates into three size groups"macro-, meio- and microfauna". Bennet and Pope (1960), Thorson (1957, 1966) and Jansson (1967 a, b; 1968) have discussed general environmental factors influencing the zonation and establishment of benthic fauna. Sanders(1960, 1968) has described the diversity in various intertidal and subtidal zones. Stephenson (1961) and Pain (1966, 1969) have studied intertidal community structure and predatory-prey interactions in Heron Island and Washington coast respectively. Wigly and McIntyre (1964) have studied quantitative comparison of meiobenthos and macrobenthos in Massachusetts. Dommasnes (1968) has discussed effect of wave exposure, and Gurjanova (1968) has discussed role of water movements in intertidal zones. Straughan (1969) has described substrata type and larval settlement of intertidal

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polychaetes. Southward and Southward (1972) have studied the role of dissolved organic compounds in the nutrition of benthic invertebrates. Strömgren, Lande and Engen(1973) have reported the distribution pattern, composition and diversity of intertidal fauna in Borgenfjord, Norway.

In Korea intertidal environments have received little ecological attentions, and only limited taxonomical information was given by some authors(Kim, 1970; Paik, 1972, 1973; Rho and Song, 1975).

The main purpose of this study is to describe the quantitative composition and distribution of invertebrate macrofauna in the intertidal sand beach at Yong-ho Bay, Busan, Korea. Ecological factors influencing the distribution of fauna draws particular attention during one year period.

ACKNOWLEDGMENTS

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MATERIALS AND METHODS

Description of the study area

The study area, Yong-ho Bay, is one of small embayments of Su-yeong Bay which is located northeast about 6 *km* away from Busan Harbour (35°8′N, 129°6′E), and its intertidal zone is 1,500 *m* long and 170—350 *m* wide (Fig. 1.).

Three quarters of the upper boundary of the beach is enclosed by revetment. There are many sewage pipes pouring into the beach and two polluted fresh-water drainages flowing across the beach during tidal exposure. A large steel mill is located in the southern part of the bay

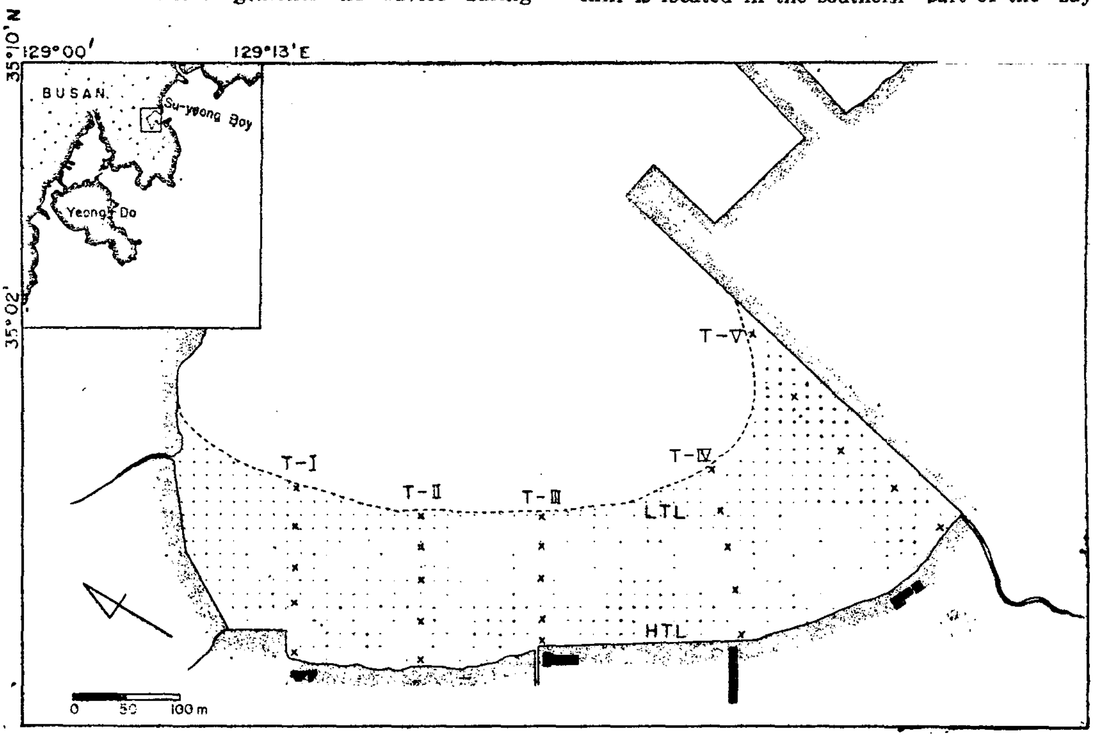

Fig. 1. Location of the study area. The symols(X) denote the sampling sites on the transects. (HTL: High Tide Level; LTL:Low Tide Level)

which discharges a great amount of industrial waste into the bay.

The bottom of the intertidal beach has an average inclination of 6/1,000(Fig. 2.).

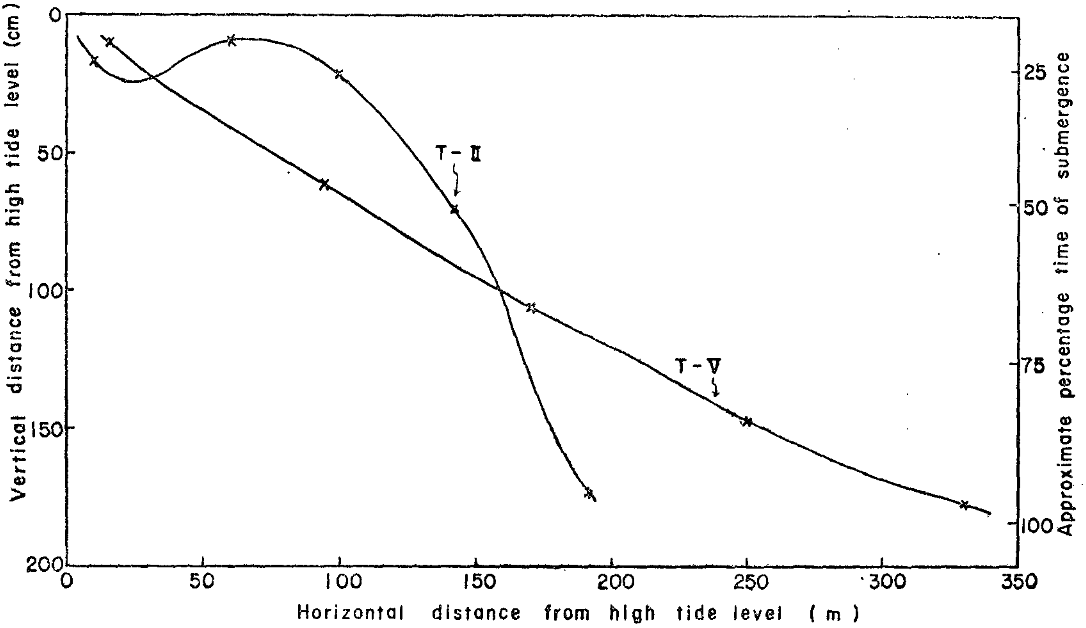

Fig. 2. Vertical profile of transect-II and transect-V in terms of tide level and submergence time.

Fine-sand fraction dominates in the most part of the beach. On the upper part boulders and cobbles are scattered, and they offer a substratum for some benthic algaes, *Enteromorpha linza* and *E. compressa*. Unknown microscopic benthic algaes temporally bloom during tidal exposure and they seemed to constitute main primary producers. Below 10—15*cm* from the surface of the bottom, the sediment is black in color with organic matter contamination of hydrogen sulfide.

The beach is quite exposed to waves and frequent local storms(twenty five stromy days during the study).

Sampling Sites and sampling Methods

Five transects were chosen, and five sampling sites were set on each transect in respect to the gradient of the beach. At the time of spring tide of every lunar month, core samples were taken from all the sampling sites from February, 1974 to February, 1975.

Core samples were taken by a tubular polyethylene core sampler which was 15.6 *cm* in inner diameter and 35 *cm* in length. After removal from the core, the upper 25 *cm* of the sample were seived directed through a fine-mesh screen with 0.5 *mm* aperture, and the remainders on the seive were preserved with 5% buffered formalin. In the laboratory the animals were carefully picked out and examined under a dissecting microscope.

Core samples for grain size analysis of upper 25 *cm* sediment were collected by using a polyethylene corer of 3 *cm* in inner diameter near all the biological sampling sites. The sand fractions were divided into various size categories using graded series of seives, while the silt and clay fractions were determined by the pippeting method(Soil Survay Staff, 1951; Emery, 1938). The coarse fractions larger than 1 *cm* were not considered.

Hydrographical data at Yon-ho Bay were measured monthly during the study period. Temperature and salinity data were collected at transect-II and bay water. Substratum temperature was measured by inserting a thermometer into substratum 4 *cm* below the surface.

To measure the organic matter content of the sediment, the same corer for grain size analysis was used again. And the organic matter content of upper 25 *cm* sediment was measured by ignition method at 700°C for one hour after removing the large organic debries.

The samples collected in February, 1975 were used only as a reference data to the samples in February, 1974.

RESULTS AND DISCUSSIONS

Sampling efficiency

In order to know the sampling efficiency the probability of occurrence of the species was checked based on fifty core samples(Approximate total covered area was 1 m^2.) which were collected from the all sampling sites in February, 1974. The species were ranked by abundance, and their percentage composition and cumulative percentage were tabulated(Table 1.). A modified sampling efficiency curve(Sanders, 1960; Strömgren, Lande and Engen, 1973), the expected number of species as a function of specimens and number of samples was extrapolated from these data(Fig. 3.). If one takes 1,000 individual size sample, the percentage composition of each individual is 0.1%. In Table 1 fourteen species each comprise 0.1% or more, and totally they compose 99.4% of the original sample by number. Therefore, each fourteen species will be present in the 1,000 individual size sample. The other thirteen species will consist of remaining 0.6%. Because none of these remaining species group that will appear in the sample cannot be represented by more than one individual. Since one individual spec-

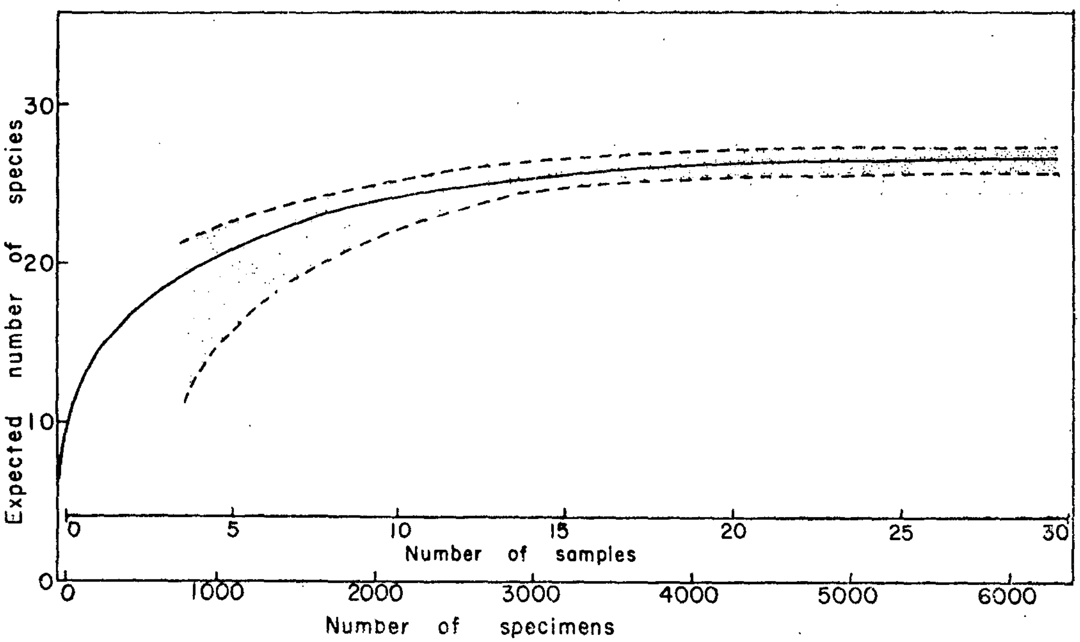

Fig. 3. Expected number of species as a function of number of specimens and number of samples. Standard deviation is indicated by the shaded area.

Table 1. Occurrence of the species found at Yeng-ho Bay based on 50 core samples collected in February 1974

Rank of species by abundance	Species	Number of individuals	Percentage of occurrence	Cumulative percentage of occurrence
1	*Armandia lanceolata*	5301	43.087	43.087
2	*Nephty* sp. A	2821	22.927	66.016
3	*Neanthes japonica*	1202	9.770	75.786
4	Capitellidae	913	7.421	83.207
5	*Pseudopolydora antennata*	746	0.066	89.273
6	*Microphotis* sp.	556	4.519	93.792
7	*Cyathura* sp.	187	1.520	95.312
8	*Edwarsia* sp.	175	1.422	96.734
9	*Nephtys polybranchia*	115	0.935	97.667
10	Cumaceae	82	0.667	98.336
11	*Haploscoloplos elongatus*	55	0.447	98.783
12	Veneridae	35	0.248	99.067
13	*Laternula limicola*	29	0.236	99.303
14	*Soletellina olivacea*	14	0.114	99.417
15	*Prionospio japonicus*	11	0.089	99.506
16	*Tapes japonica*	10	0.081	99.587
17	*Nephtys* sp. B	9	0.073	99.660
18	*Urothoe* sp.	7	0.057	99.717
19	*Glycera chirori*	6	0.049	99.766
19	*Macoma incongrua*	6	0.049	99.815
19	*Brachiodentes senhousia*	6	0.049	99.864
22	*Nephtys caeca*	5	0.041	99.905
22	*Magelona japonica*	5	0.041	99.946
24	*Cirriformia tentaculata*	3	0.024	99.970
25	*Monoculodes* sp.	2	0.016	99.986
26	*Lumbrinereis* sp.	1	0.008	99.994
26	*Hemigrapsus sinensis*	1	0.008	100.002

imen comprises 0.1% of the original sample, a total of twenty {20=14+(0.6-0.1)} species will appear per 1,000 individual size sample. If 2,000 individual size sample is taken, it will contain twenty four species in the same manner. Based on this calculation, this doubled effort would add only four species more.

In the present study every twenty five core samples including actually about 5,000 individuals were taken. Theoretically, they represented twenty six species, and it was 96% of the original sample species. Also those twenty five samples comprised 81% of total species which occured during the study.

Hydrographycal data

The seasonal temperture fluctuation of air, tide pool, beach substrata and bay water were plotted in Fig. 4. The annual range in temperature was —4 —30°C in atmosphere, 7-32°C in substrata, 7-31°C in tide pool and 11-21°C in the bay water. The maximum daily range of temperature fluctuation of the tide pool was within 16°C and that of substrata was within 10°C.

Tide pool salinity changes were so drastic that the minimum value was 7‰. and the maximum was 34‰. While the minimum salinity values were found during low tide due to the the large influx of fresh-water, the maximum values appeared during high tide, and were pratically the same salinity of the bay water. The annual salinity range of the bay water was within 26—35‰.

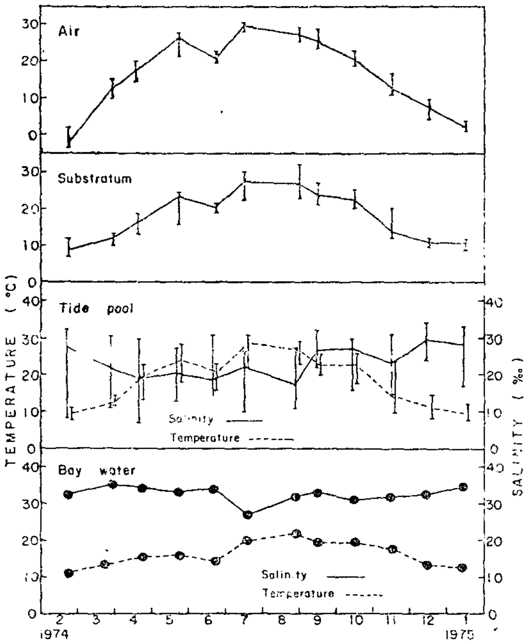

Fig. 4. Seasonal fluctuation of salinity and temperature of air, substratum, tide pool and bay water. Bars represent daily fluctuation range.

Grain size analysis

The grain size composition of the substrata was shown in Table 2. Fine-sand fraction were dominated (approximately 90% of total sediment in weight) that the beach can be classified as a fine-sand beach. The maximum mud fraction content was 11.4% at T-V-2 and the minimum was 0.1% at T-Ⅲ-3. Generally southern part of the beach contains more mud fraction than northern part. By their mud content the beach can be divided into three areas (Fig. 5.), which represent resultantly different faunal distributions (area A: 〈1%; area B: 1-5%; area C:〉 5%). It is noted that compositional gradient of mud fraction distribution along the transects was not observed.

Organic matter content

Organic matter content was within the range of 4.7—12.2%; mean content was 8% in weight (Table 3.). This value is somewhat higher than those of other similar habitats. Sanders (1960) reported 6—7.4% of organic matter content in Buzzards Bay, and Yoo (1974, personal communication) found 4% of organic matter content in a tidal flat of Buan area. A great amount of organic matter content (exceed 15% in weight) was reported by Johonson and Matheson (1968) from the sediment of Hamilton Bay.

No distributional pattern of the organic matter content was found during the study.

Composition of the fauna

In number, major taxonomical group is polychaetes which comprise 14 species representing 11 genera. Of a total of 61,572 sampled individuals 56,018 (approximate 90%) were polychaetes (Table 4.). In weight, however, bivalves ranked more dominant group than polychaetes. The former comprises 44% of total specimens in weight: the latter comprises 49%.

The dominance indices value {$C=(ni/N)^2$} of number is different from those of weight. When dominance group considered in weight, more

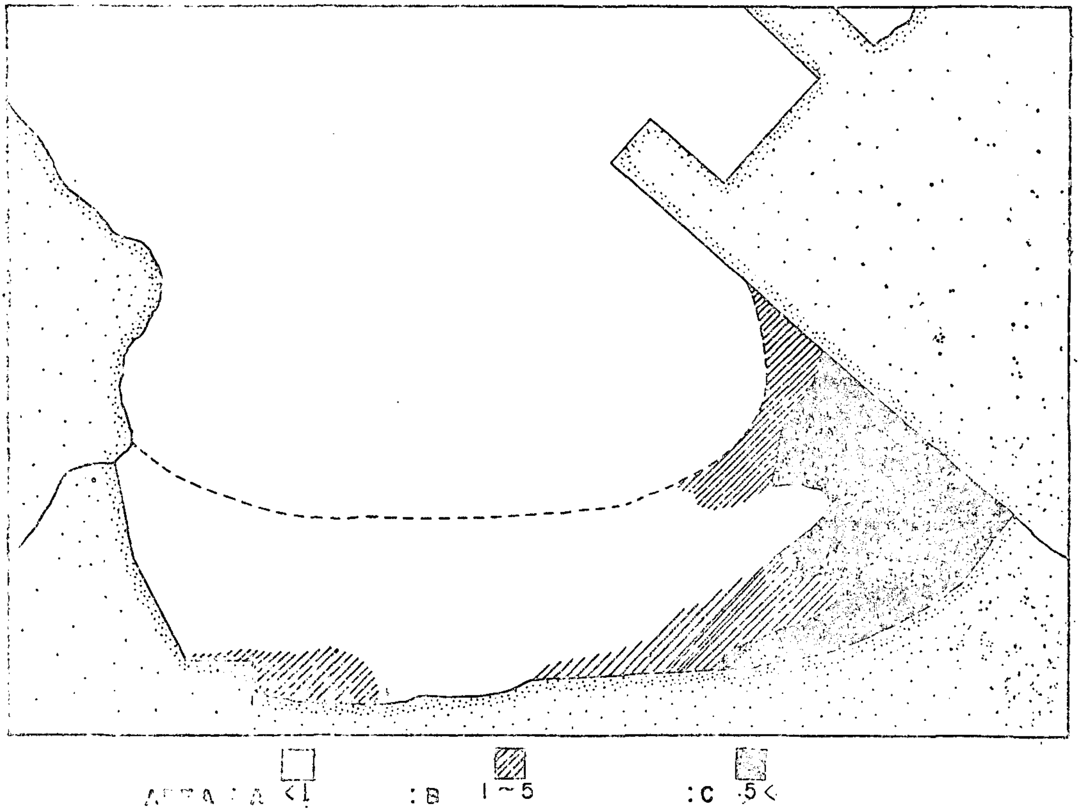

Fig. 5. Percentage distribution of mud fraction in the substratum.

Table 2. The grain size analysis by percentage weight based on the 25 core samples from Yong-ho Bay

Grain size Tran.	Sites	Granule ≧2mm	Coars sand <2～≧1mm	Medium sand <1～≧ 0.25mm	Fine sand <0.25～≧ 0.05mm	Silt <0.05～≧ 0.002mm	Clay <0.002mm	Mud (Silt+Clay)
	1	—	0.10	3.57	95.01	1.17	0.15	1.32
T	2	0.07	0.05	3.47	96.03	0.26	0.12	0.38
～	3	0.05	0.01	5.77	93.94	0.18	0.13	0.31
I	4	—	0.03	4.58	95.21	0.16	0.03	0.19
	5	—	0.03	2.68	97.14	0.14	0.01	0.15
	1	—	0.19	4.93	94.67	0.06	0.14	0.20
T	2	0.10	0.18	5.18	93.78	0.47	0.30	0.77
～	3	—	0.16	13.20	86.27	0.16	0.04	0.20
II	4	0.08	0.03	9.93	89.78	0.14	0.03	0.17
	5	0.06	0.02	7.31	92.46	0.09	0.05	0.14
	1	16.48	1.13	8.33	72.99	0.75	0.32	1.07
T	2	0.56	0.02	6.87	92.01	0.21	0.08	0.29
～	3	0.21	0.07	8.81	90.08	0.12	0.02	0.14
III	4	0.52	0.20	6.28	92.76	0.20	0.05	0.25
	5	0.40	0.33	10.14	88.88	0.17	0.05	0.22

T~IV	1	0.50	0.19	3.77	88.39	5.66	1.49	7.15
	2	2.10	0.73	13.99	78.38	4.06	0.74	4.80
	3	0.97	0.65	28.67	69.34	0.30	0.06	0.36
	4	0.20	0.30	8.24	90.45	0.57	0.20	0.77
	5	0.26	1.01	22.43	73.04	2.96	0.29	3.25
T~V	1	1.35	0.96	10.80	77.30	7.20	2.21	9.41
	2	2.15	0.56	8.33	77.55	6.92	4.48	11.41
	3	1.77	0.91	21.36	70.48	4.30	1.17	5.47
	4	1.75	0.96	31.88	55.07	8.84	1.50	10.34
	5	1.43	0.41	32.61	62.44	2.70	0.41	3.11

Table 3. Percentage of total organic matter content of the sediment (loss on ignition) found at Yeng-ho Bay from February, 1974 to January, 1975

T.	S.	1974 2	3	4	5	6	7	8	9	10	11	12	1975 1
T~I	1	6.8	6.5	6.8	7.6	7.9	6.7	8.0	7.7	9.0	7.4	8.8	7.8
	2	7.9	7.7	7.3	6.7	7.1	8.9	7.3	7.2	6.9	7.2	7.3	7.5
	3	8.1	8.0	7.4	7.4	8.0	7.5	7.8	7.6	6.9	6.5	7.4	6.3
	4	7.5	8.9	7.7	11.3	9.1	5.7	7.2	6.9	8.1	8.5	8.1	7.8
	5	5.3	7.0	6.6	9.3	8.7	8.7	6.9	6.3	6.1	7.6	7.0	6.7
T~II	1	8.5	8.8	8.2	6.4	9.1	7.3	7.5	9.8	8.9	7.4	7.3	7.4
	2	6.8	9.9	6.4	6.7	6.9	9.8	7.8	8.0	7.5	7.5	8.1	8.1
	3	7.6	8.4	8.5	9.7	7.6	6.5	9.0	12.2	8.7	4.7	8.0	7.3
	4	9.1	9.0	9.0	9.6	8.4	8.5	9.2	7.8	7.7	8.6	11.3	9.1
	5	7.8	8.1	8.7	9.8	8.5	7.5	11.1	7.0	6.2	8.7	6.3	7.2
T~III	1	7.9	8.0	8.3	9.1	8.7	5.6	7.8	6.4	9.0	8.3	8.1	8.1
	2	7.3	8.0	7.5	8.4	7.0	7.5	7.8	8.2	8.1	7.2	7.3	7.6
	3	7.1	8.6	9.7	7.8	6.7	5.8	8.6	7.6	3.0	7.7	8.6	8.0
	4	9.1	10.9	9.4	8.1	10.2	6.2	8.6	7.6	9.8	7.8	6.7	8.3
	5	8.7	10.3	8.0	9.8	9.0	6.5	7.6	7.0	7.6	7.6	10.0	9.3
T~IV	1	7.9	9.3	10.1	8.4	8.3	6.7	7.9	7.6	7.9	7.6	7.2	7.3
	2	7.3	10.3	7.8	10.4	11.1	6.8	4.7	7.4	7.1	8.5	8.7	8.6
	3	21.1	7.3	7.8	7.8	7.7	6.2	8.5	9.5	10.6	8.2	8.3	6.9
	4	8.0	8.7	7.7	9.1	8.0	5.5	7.6	7.5	6.5	7.4	10.8	8.1
	5	6.7	7.7	8.6	9.5	8.8	5.8	6.7	7.6	7.7	8.2	9.2	7.3
T~V	1	9.9	7.5	6.7	6.7	7.7	6.9	7.6	6.6	9.1	7.8	7.3	7.7
	2	8.6	8.1	6.7	6.4	7.3	6.7	7.4	8.5	9.6	7.3	8.3	8.6
	3	7.4	7.7	9.3	7.3	5.6	6.7	9.9	7.2	7.3	8.1	7.7	8.0
	4	7.8	7.8	7.0	8.8	9.1	7.1	7.9	7.4	6.5	6.7	11.0	10.1
	5	9.8	8.0	7.9	6.6	6.9	—	8.0	6.8	7.6	6.6	7.6	7.6

animals were ranked as dominant species (7 species comprise 80% of total weight) than in number(4 species comprise 80% of total individuals). And the dominance index value in number (0.25) is higher than in weight (0.14). In other words the dominance species was more concentrated in number than in weight (Table 5).

Diversity of the fauna

When the diversity is concerned with percentage time of submergence, there is no signific-

Table 4. Total number of occurrence of the species in taxonomical groups at Yong-ho Bay during the study

Species / Sites (Transects)	T—Ⅰ 1	2	3	4	5	T—Ⅱ 1	2	3	4	5	T—Ⅲ 1	2	3	4	5	T—Ⅳ 1	2	3	4	5	T—Ⅴ 1	2	3	4	5	Total
(Polychaeta)																										
Armandia lanceolata	72	3532	761	339	62	1115	1776	1974	1963	216	91	2737	4432	3234	795	66	271	691	5186	587	1	5	31	121	74	26, 505
Nephtys sp. (A)	13	70	661	1601	1695	429	49	15	121	456	6	426	727	436	1343	63	171	32	1925	1398	655		1	254	1558	14, 105
Nephtys caeca		1			2	1							6	2	2	1	1	1	3	1			3		2	26
Nephtys polybranchia	7		7	43	56	20	1	37	64	85	17	10	21	32	82	8	4	6	17	36	1		4	8	8	574
Nephtys sp. (B)			5						30	10		1										1				47
Neanthes japonica	1108	2			3	121	3			1	236	10	22	2	1	727	1191	659	191	235	510	415	283	149	142	6, 011
Capitellidae	56	5	1	2		20	5	8	3		85	6	19	4	4	158	488	93	196	66	602	403	1514	526	417	4, 621
Pseudopolydora antennata	392	395	176	14	26	114	154	74	40	5	283	348	764	212	29	28	82	99	286	160		5	19	14	8	3, 727
Prionospio japonicus					6	1	4		2		2	6	5		6	4	11		6							53
Haploscoloplos elangatus	19	4	6	2	1	31	22	25	2	2	11	28	36	16	5		1	8	29	5		1	4	3	13	274
Glycera chirori		1	6	2	4	1		1	2	2		2	2		6					2	1					32
Magelona japonica	2		1		2	1		1	1	3	1		1	4	2					5						24
Cirriformia tentaculata	1					1	1				1		3				1				3		1	1		13
Lumbrinereis sp.						2	1		1	1															1	6
(Bivalvia)																										
Veneridae	4	3				2	2	15	18	1	16	90	14	3		3	4									175
Laternula limicola						2					21					63	50	9			1			1		147
Soletellina olivacea	4									1	11		1			20	21	2	8			1	1			70

Table 4. Con't

Species / Transects / Sites	T—I					T—II					T—III					T—IV					T—V					Total
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Tapes japonica	1			1		3	1		1	13	3	1			3	16	2	2			1		1			49
Macoma incongrua	1										5					9	5	6	3					1		30
Brachiodentes senhousia	2					1										3	15	1	7							29
Solen strictus			1																	1						2
Mactra sulcataria															1											1
Dosinia japonica									1																	1
(Crustacea)																										
Microphotis sp.	2	1116	1319	186	39	18	52	24	10		2	109	23	2	1	1	2									2,780
Urothoe sp.	6				1	1	1	7	4			2	2	8						1						33
Monoculodes sp.						1	1			3	1				1		1				1					9
Cyathura sp.	166	73	124	11	8	125	42	7	1		106	60	40	4	2	63	12	47		13				27	3	934
Cumacea	23	17	6		27	17	5	9	1	5	85	18	6	1	12	41	14	16	6	39	6		9	31	17	411
Hemigrapsus sinensis						2								1							1			1		5
Scopimera globasa							1				1															2
(Sipunculida)																										
Golfingia sp.												1		1												2
(Anthozoa)																										
Edwarsia sp.	68	83	84	46	19	116	89	58	33	7	52	72	49	11	2	32	18	5	5	6	3	2	2	2	10	87

ant correlation of diversity values in both Sannon-Wiener function $\{H=-\Sigma(p_i)(\log_2 p_i)\}$ and Simpson's index $\{D=1-\Sigma(p_i)^2\}$ (Fig. 6.). It should be also considered that on the upper part of the beach a tide pool is located lying north to south which supplies water to the exposed beach substrata. Also the two fresh-water influx degrade the gradient of submergence. Thus there was no definite gradient of submergence on the beach along the transects. It is noted that a little decreasing of diversity value in Simpson's index with increasing of submergence time, however, it is not sufficient to support the indication of influence of submergence to diversity.

Considering influence of grain size on diversity, the distribution of mud fraction was closely related to diversity values. The area which contains 1-5% of mud fraction (area B) showed somewhat higher diversity value than other two areas (area A and C) which contain <1% and >5% of mud fraction respectively. According to mud fraction content, the substrata and their

Table 5. Comparative dominance index values of the species deduced by total number of individuals and total wet weight based on the total samples collected during the study

Species	Important values			
	Total no. of indiv.	Ranking	Total wet wt. (g)	Ranking
Armandia lanceolata	26,505	1	41.10	6
Nephtys sp. (A)	14,105	2	65.00	4
Neanthes jvponica	6,011	3	195.50	1
Capitellidae	4,621	4	14.21	10
Pseudopolydora antennata	3,727	5	12.27	11
Microphotis sp.	2,780	6	1.51	23
Cyathura sp.	934	7	8.03	13
Edwarsia sp.	874	8	39.80	7
Nephtys polybranchia	574	9	5.53	17
Cumaceae	411	10	0.41	22
Haploscoloplos elongatus	274	11	4.02	19
Veneridae	175	12	10.42	12
Laternula limicola	147	13	173.20	2
Soletellina olivacea	70	14	73.10	3
Prionospio japonicus	53	15	0.09	28
Tapes japonica	49	16	49.70	5
Nephtys sp. (B)	47	17	0.03	31
Urothoe sp.	33	18	0.08	29
Glycera chirori	32	19	4.21	18
Macoma incongrua	30	20	36.70	8
Brachiodentes senhousia	29	21	6.12	16
Nephtys caeca	26	22	0.13	27
Magelona japonica	24	23	0.07	30
Cirriformia tentaculata	13	24	6.86	14
Monoculodes sp.	9	25	0.01	32
Lumbrinereis sp.	6	26	0.16	26
Hemigropsus sinensis	5	27	1.88	21
Solen strictus	2	28	6.41	15
Scopimera globosa	2	28	2.39	20
Golfingia sp.	2	28	0.36	25
Mactra sulcataria	1	31	20.50	9
Dosinia japonica	1	31	1.79	22
Indices of dominance $C=\Sigma(n_i/N)^2$	0.25		0.14	

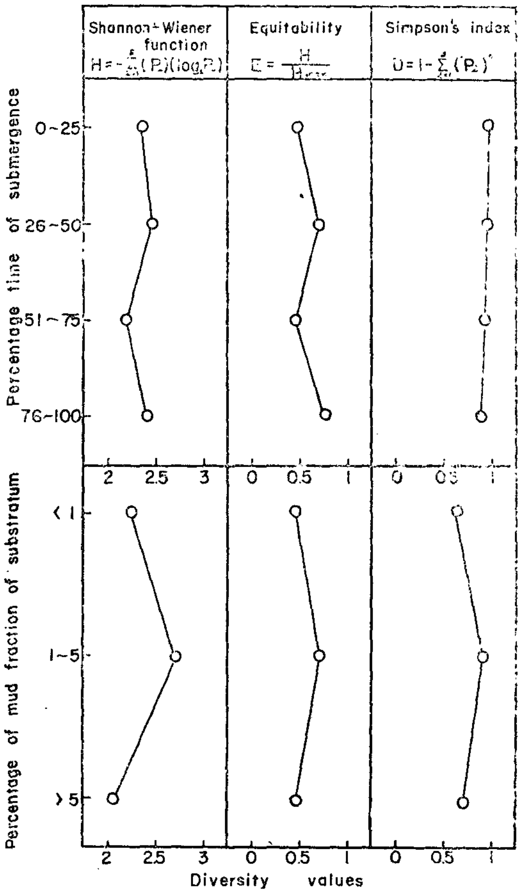

Fig. 6. Comparative values of diversity indices between percentage time of submergence category and percentage of mud fraction category.

faunal composition of the beach was divided into three areas which represent three different faunal distributions. It was well agreed with the following faunal affinity. In area B species represented by a few individuals were abundant than the other two areas A and B.

Faunal distribution of intertidal beach is subjected to various ecological factors. Among them sediment composition plays a significant role. But it is not a sole factor. Dommasnes (1968) remarked the compactness reduces the interstitial space where animals can move and thus affects the composition of the fauna. Sanders, Goudsmit, Mills and Hampson (1962) assumed that sediment indicated the availability of food, while they were not a first order factor in determining the distribution of the animals. Strömgren, Lande and Engen (1973) reported the sediment composition showed no significant correlation either to number of species or total number of individuals.

On the present beach grain size distribuiton

		T - I					T - II					T - III					T - IV					T - V				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
T-I	1																									
	2	15.6																								
	3	17.9	56.7																							
	4	8.9	27.7	48.8																						
	5	8.7	9.7	30.4	80.5																					
T-II	1	28.2	63.1	58.8	40.2	28.9																				
	2	17.8	80.5	40.6	22.1	10.8	67.2																			
	3	13.4	71.8	33.8	21.7	9.9	62.7	89.1																		
	4	8.7	60.4	34.4	25.1	14.5	62.3	36.7	92.6																	
	5	7.7	30.4	49.3	75.9	65.8	50.8	31.4	31.7	33.3																
T-III	1	65.4	20.6	22.9	14.5	10.3	35.4	23.5	19.9	15.4	13.9															
	2	19.1	81.9	48.6	32.3	20.2	74.5	85.6	79.3	80.3	40.8	25.5														
	3	20.3	77.7	45.1	29.9	18.9	72.9	83.6	78.9	81.0	41.2	25.6	93.1													
	4	11.6	74.1	42.4	28.2	17.3	70.5	88.9	87.6	90.2	40.3	16.7	80.5	89.9												
	5	7.4	38.1	49.3	76.7	67.5	58.3	39.3	39.4	44.8	89.7	13.7	48.5	49.1	48.6											
T-IV	1	75.4	12.3	19.3	14.0	13.5	20.8	14.9	12.5	14.3	13.1	57.7	17.5	15.2	13.7	13.3										
	2	63.8	18.1	23.9	21.0	14.4	31.2	19.4	17.8	20.0	21.3	49.9	25.1	24.9	23.1	21.5	80.8									
	3	58.4	50.7	36.5	19.1	8.9	60.0	52.2	47.5	45.8	31.4	49.4	52.7	51.6	49.9	39.5	59.8	69.5								
	4	20.3	46.0	53.3	52.4	51.5	69.6	47.2	43.1	45.2	74.6	25.5	58.3	58.0	54.9	83.1	21.4	30.8	54.4							
	5	25.0	31.9	52.1	73.1	63.5	57.5	32.9	30.0	32.1	81.4	31.3	42.4	43.0	41.0	82.5	26.8	35.4	44.9	83.1						
T-V	1	33.9	2.1	22.5	37.3	37.7	27.5	3.2	1.8	5.9	37.7	32.3	12.1	13.1	11.6	37.7	45.9	57.2	36.8	44.8	49.3					
	2	53.7	1.7	1.7	1.7	1.8	8.2	1.9	2.0	1.7	2.0	32.5	2.2	2.3	1.7	1.7	62.9	71.2	46.6	9.3	19.0	62.7				
	3	22.0	2.6	3.5	2.9	4.0	14.7	3.6	4.1	3.3	6.0	27.2	4.3	4.3	3.6	4.1	31.1	39.4	24.6	11.3	15.6	49.6	65.0			
	4	26.3	15.2	36.9	35.2	29.7	43.0	16.8	14.8	18.3	35.6	38.4	26.0	25.9	24.3	35.9	48.2	54.5	36.9	42.8	49.0	70.1	60.9	63.1		
	5	16.4	6.1	26.6	76.0	74.8	62.3	7.1	6.7	10.1	62.6	21.5	16.9	17.7	16.2	63.8	29.3	37.6	20.0	58.5	69.8	62.7	26.7	28.5	53.1	

0 < 30 %   30 - < 50 %   50 - < 70 %   ≥ 70 %

Fig. 7. A comparison of the average faunal index of affinity at Yong-ho Bay.

was a significant factor which determined diversity and distribution of the fauna. Particularly mud fraction content was closely related to the diversity and distribution. It seems that other factors such as temperature, salinity, submergence time and organic matter content can be considered as ecological limiting factors only when they are extreme. The effects of those factors were discussed by Jansson (1967 a, b 1968).

Faunal affinity

The index of affinity is a measure of the percentage of the fauna common to a pair of samples, and it is obtained by summing the smaller percentage of those species present in both samples (Sanders, 1960). It was immediatly evident from Fig. 7 that samples collected from area A had low affinity index with those from either area B or area C though there exsisted high index of affinity values within each area. These three area represented different faunal compositions.

Distributions of the fauna in time and space

The distribution of the fauna was closely related to sediment types divided into three areas of different mud contents. And these three areas were different in terms of not only diversity index but also faunal affinity. The occurrence of the fauna varied seasonally.

In area *A* two polychaetes species dominated, *i. e. Armandia lanceolata* and *Nephtys* sp. (A). Within their distributional range the former species was concentrated in the central part of the beach, and the latter in the lower part of the beach. In area C a polychaetes species *Neanthes japonica* dominated and its distribution seems to be little affected by submergence time. In the remaining area B which is represented by high diversity value many bivalves species with a few individuals were abundant. Submergence time affected the distribution of some species, but the influence to the whole community was little(Fig. 8.).

A. lanceolata and *Edwarsia* sp. were found in all sampling sites. But their densities varied from site to site, and only one or two individuals were collected in some sites.

Monthly occurrence of some dominant species were plotted (Fig. 9.). The seasonal occurrence mode of *A. lanceolata* was binodial. In October this species reached the maximum occurrence (about 12,000 ind./m^2) and a smaller second peak was found in April. The minimum occurrence was found in July, and only 180 ind./m^2 were collected. During July this species reached maximum body size in length. From August the number of young individuals sharply increased and they composed major portion of the samples in October. With regard to these facts, it is assumed that the breeding occurres in summer. The minium occurrence of this species in July suggested some influences of abrasive wave action on the beach substrata by frequent local storms.

Nephtys sp. (A) represented a trinodial curve, but these peaks were not related to size composition of the samples. It seems that the fluctuation of the curve is not subjected to breeding time, but presumably some other factors, such as patchness, wave actions and predation.

In April *N. japonica* increased gradually in number and in May they reached maximum density about 1,000 ind./m^2. In October this species increased again as in April. At these two peaks more young individuals were collected than usual. The breeding time of this species was assumed to occur twice a year in spring and autumn. It is noted that these polychaetes were not severely affected by wave actions because they were deep burrowing animals.

Decreasing tendency in number was found to some extent in total bivalves. It was considered that its density was remarkable affected by the shell collectors.

From May to July, 1974 the total number of crustaceans increased remarkably owing to breeding of *Microphotis* sp. At this time most of the females are ovigerous. Except this ampipod on characteristic seasonal fluctuation was found. Curiously, this *Microphotis* sp. disappeared from the beach since October, 1974 and was not observed as in March, 1975. Whether this species migrated to other habitat or perished from the beach was not known.

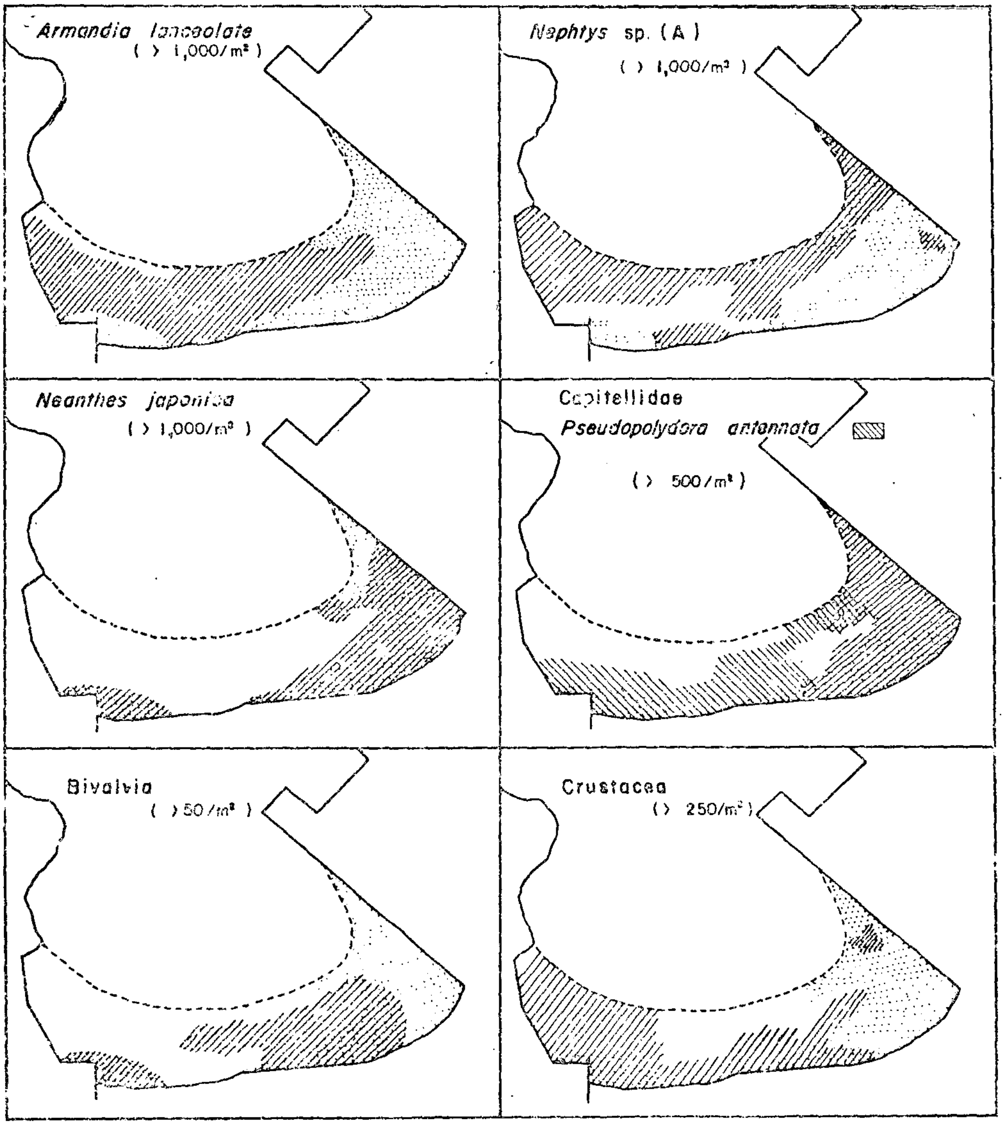

Fig. 8. Horizontal distribution of some dominant species at Yong-ho Bay. Dotted areas represent the sediment which contain more than one percent of mud fraction(<50μ).

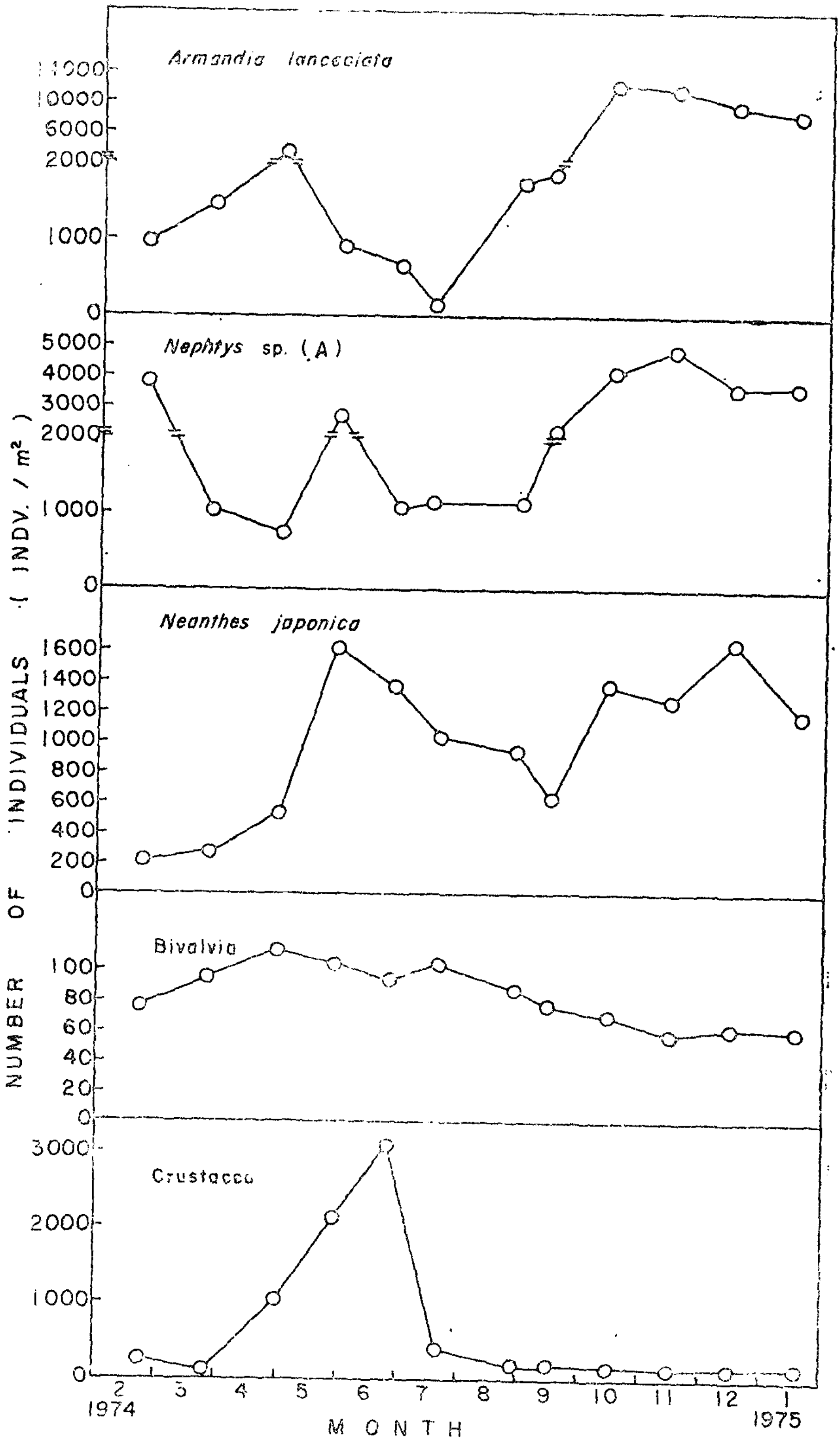

Fig. 9. Monthly fluctuation of some dominant polychaetes species, bivalves and crustaceans.

SUMMARY

1. A quantitative ecological investigation of the intertidal sand beach at Yong-ho Bay, located about 6*km* NE of Busan Harbour was carried out from February, 1974 to February, 1975. Composition of the fauna, diversity, faunal affinity and distributions in time and space were studied. Some ecological factors influencing to the commuity also discussed.
2. The beach can be classified as a fine-sand beach which is dominated by *Armandia lanceolata* and *Nephtys* sp. (A). Thirty two species of animals representing 29 genera were found. In number, two polychaetes, *A. lanceolata* and *Nephtys* sp. (A) were dominant, while one polychaete, *Neanthes japonica* and one bivalvia, *Laternula limicola* were dominant in weight.
3. Distribution of the fauna was devided into three areas of different faunal compositions with sediment types particularly by mud fraction content, and it well agreed with faunal affinity and diversity index value.
4. Seasonal fluctuation of the three dominant species, *A. lanceolata, Nephtys* sp. (A) and *N. japonica* was studied. Except *Nephtys* sp. (A), the fluctuation were closely related to the breeding time.
5. There was no relationship between faunal distribution and organic matter content. Submergence time affected the distribution of some species but the influence to the whole-community was little.

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