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Distribution Pattern of Polychaete Worms on the Continental Shelf and Slope of the East Sea (Southwestern Sea of Japan), Korea

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한국 동해 대륙붕 및 대륙사면에서의 다모류 분포

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This study was carried out to obtain some informations on the species composition and distribution pattern of polychate community on the continental shelf and slope area in the East Sea. Fauna samples were collected from three sampling cruises in April of 1985, and April and October of 1987. Total 112 polychaete taxa included in 36 families were collected. Dominant species in the study area were *Chaetozone setosa, Aglaophamus malmgreni, Ampharete arctica, Terebellides horikoshii, Tharyx* sp., and *Magelona pacifica*. Northern and cold water species were major contributors of polychaete communities in this study area. Dominant species showed their specific depth ranges from shelf area to upper slope and middle slope depth. The overall density was 300 indiv./m^2 and species richness was around 15 species/0.2 m^2. Significant changes in mean polychaete density and species richness along depth gradient were found approximately at 600 m or deeper depth. Among physical factors, water depth, temperature and clay content, mean grain size were significantly correlated with the mean density of dominant species.

본 연구는 동해의 대륙붕 및 대륙사면에서의 다모류 군집의 종 조성과 분포를 알기 위해 수행되었다. 다모류의 채집은 1985년 4월과 1987년 4월, 10월의 3회의 항해동안 이루어졌다. 채집된 다모류는 총 36과 112종이었으며, 우점다모류는 *Chaetozone setosa, Aglaophamus malmgreni, Ampharete arctica, Terebellides horikoshii, Tharyx* sp.와 *Magelona pacifica* 등이었다. 본 조사지역의 다모류 군집에 대한 주요 기여종들은 북반부의 냉수종들이었다. 특히 우점종들은 대륙붕에서부터 대륙사면 상부 혹은 중부에서 주로 분포하며, 특정 서식 깊이를 보였다. 전반적인 평균서식밀도는 300개체/m^{2}이며, 종풍부도는 15종/0.2 m^2 정도이다. 평균서식밀도와 종풍부도지수는 600 m 나 그 이상의 수심에서 뚜렷한 변화를 보였다. 우점종의 평균서식밀도와 밀접한 상관관계를 보인 물리적 환경요인은 수심, 수온, 니질함량, 평균입도 등이었다.

INTRODUCTION

This paper presents some results of research on the polychaete worms inhabiting the continental shelf and slope region of the southern East Sea, Korea. Previous studies on the benthic communities in Korean waters have been concentrated at shallow coastal regions including estuarian bays and tidal flats. In the case of these small scale researches, the important environmental factors related to the structure and the organization of benthic communities have been the sedimentary properties, mainly mean grain size and sedimentary facies, organic content and other sediment-related parameters. Thus some physical factors such as water depth, temperature and salinity which have been treated in large scale researches have been excluded in most coastal studies as important factors. In recent, Lee (1987a) studied benthic polychaete communities on the southeastern part of the Yellow Sea, and considered water depth and temperature, tidal range and turbidity, as well as the conventional sedimentary properties as important environmental factors related to the polychaete composition.

The East Sea (southwestern part of the Japan Sea) is far exceeding in both water depth and volume, compared with neighboring seas such as the Yellow Sea and the southern sea of the Korean peninsula. The existence of warm and cold water current systems and massive cold water down to 3,000 m depth, and the mixing would make diverse the faunal composition. In this study we paid our main interest to the depth-related processes enforcing the organization of polychaete communities in the East Sea.

Shin and Koh (1990) found faunal zonations of ophiuroids (brittlestars) in this study area, and related the distribution of ophiuroids with the water depth rather than sedimentary facies. In most studies on the deeper benthic fauna, depth itself or depth-related processes have been considered as important factors concerning to the organization of bathyal and deep-sea benthic communities (Sanders *et al.*, 1965; Rowe, 1981; 1983; Lampitt, *et al.*, 1986; Kojima and Ohta, 1989). Carney *et al.* (1983) proposed three categories of factors affecting the distribution of macrobenthic invertebrates on sloping parts of the ocean floor. Among them, the bottom temperature has most often been implied as a determinant.

The purpose of the present study are to provide preliminary and basic data of benthic polychaetous annelids, mainly focused on the species composition and abundance distribution in the study area, and to detect some relationship, if any, between the fauna and depth or depth-related environmental factors. There are a few reports on the distribution and feeding characteristics of polychaetes in the East Sea, but they were restricted on the continental shelf area (Choi and Koh, 1986; 1988; 1989).

MATERIALS AND METHODS

Study area

The study area located in the southwestern part of the East Sea comprises the long but narrow continental shelf and slope area, covering approximately 15,000 km^2, from 35°30′N to 37°50′N in the eastern coast of Korean peninsula (Fig. 1). About an half of the study area is deeper than 200 m. The topographical feature of the study area is the existence of the Hupo Bank in the central region. Hupo Bank has a dimension of 120 km in length and 7-11 km in width; the mean water depth is 140-150 m and its slope ranges 2-12° (Lee *et al.*, 1989).

The northern part of the study area is mainly under the influence of the North Korean Cold Current (NKCC) or Liman Current, whereas the southern part is under the Tsushima Warm Current or the East Korean Warm Current (EKWC). These two currents formed a strong thermal front near 37°N off Juckbyon, though its positon seemed to be changed from north to south depending on the seasonal strength of these two currents (Kim and Kim, 1983). The physical condition of bottom water layer consists of three different water masses; the North Korean Cold Water, the East Korean Warm Water and the proper water of the East Sea. Thus the temperature and salinity of bottom layer are determined by the mixing of three water masses; mean temperature showed regional variations from greater than 9°C at shallow coast to less than 3°C at the slope (Fig. 2a), but salinity showed a little change in horizontal and vertical differences less than 1‰.

The surface sediment showed five sedimentary facies; sand, clay, mud, sand and mud mixed, and sand & clay mixed facies (Lee *et al.*, 1989). The organic carbon content within sediment was in the range of 0.20-3.44%, and these values were dependent on the various sedimen-

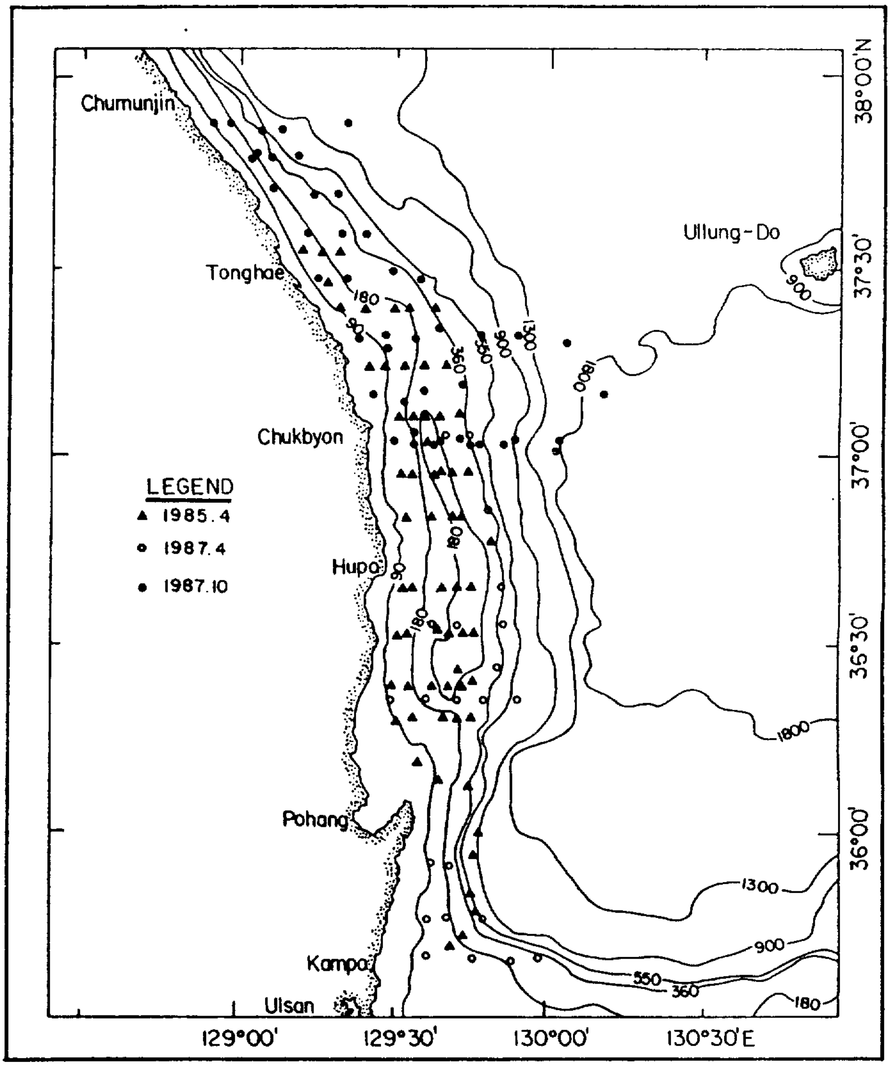

Fig. 1. Map showing the grab sampling stations in the East Sea, Korea

tary facies in our study area. Fine sediments such as silt or clay prevail on the slope area and the Hupo Basin sheltered by the Hupo Bank (Fig. 2b). However, the sediment facies on the Hupo Bank and the shelf area off Juckbyon are muddy sand or sand facies composed of mixed and coarse sediments. The primary production and standing stocks of phytoplankton in the study area was reported to be high (Shim *et al.*, 1985; Shim and Park, 1986; Park, 1989). This rich supply of organic matter may be the major contributor to the high organic content within sediments.

Sampling methods and data analysis

Benthic fauna were collected by van Veen grab from three cruises performed by T/V Hanbada of Korean Maritime University, Pusan in April of 1985 and 1987, and in October of 1987 (Fig. 1). In the cruise of 1985, the sampling stations were selected mainly on the shallower shelf and shelf break located between 36°N and 37°30'N. From total 65 stations, single grab sample (at 42

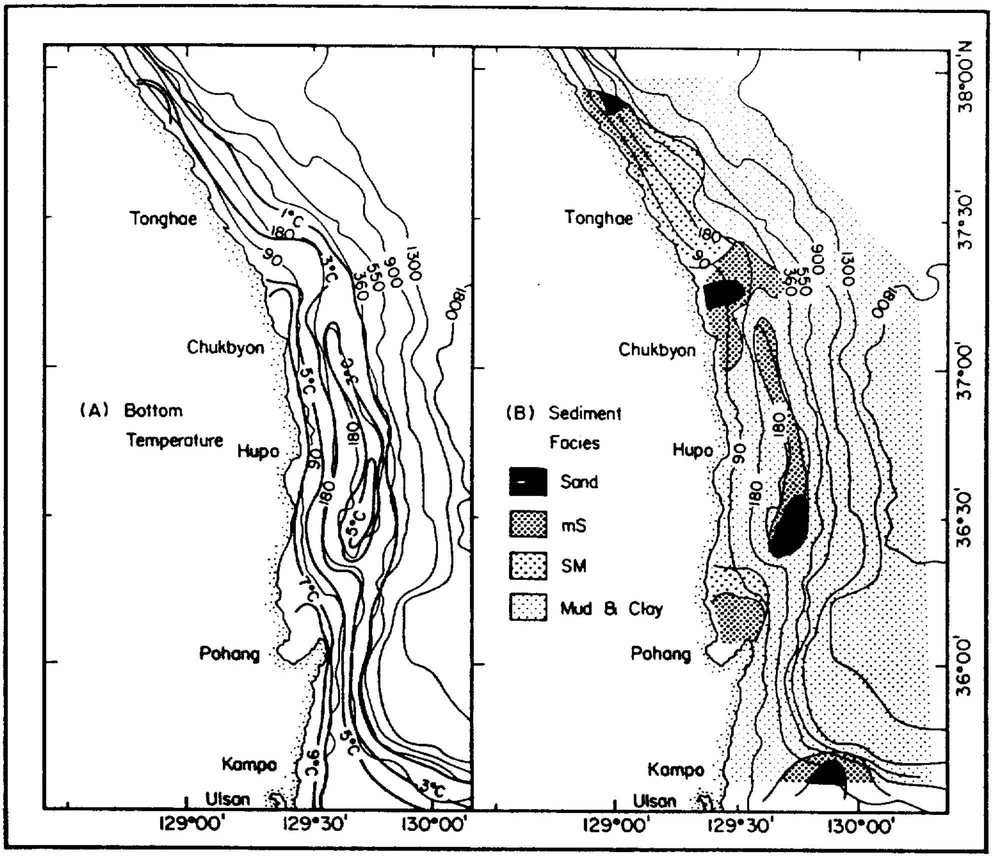

Fig. 2. (A) The isotherms of the bottom temperature drawn by the temperature data measured at near bottom from 1961 to 1983 by FRDA 1986). (B) The surface sediment facies redrawn from the results of Lee *et al.* (1989).

sts.) or duplicate samples (at 23 sts.) were taken. In April of 1987, 22 samples were taken in the shelf region and at the outer edges of the previous sampling stations in the depth range of 400-500 m in order to cover the upper slope region. A larger grab sampler (0.3 m^2) was employed at two sites, St. 735 and St. 736 in the Hupo Basin and the slope region respectively in addition to the conventional small grab sampler (0.1 m^2). We also used a rather larger grab (0.2 m^2) during the autumn cruise of 1987 at the 10 stations in the continental slope. Except for 6 stations where duplicate samplings were impossible due to the bottom condition, all samples per station were with a biting area of 0.2 m^2.

Among benthic fauna sieved through 1×1 mm mesh screen and fixed with 10% formalin, only polychaete worms were treated in the present study. The duplicate samples were counted separately, but they were pooled for the estimation of mean density and species richness per station. Thus all the abundance data were converted into the values with the sample size of 0.2 m^2. The distribution type of each species in terms of biogeography was given based on the literatures (Uschakov, 1955; Uschakov and Wu, 1965; Imajima and Hartman, 1964; Hartman, 1968; 1969).

Bottom temperature of each station in the shelf of upper slope area shallower than 300 m could be directly determined from the result of FRDA (1986), and those at the deeper station were estimated to be lower than 1.0℃ by extrapolating the annual data of FRDA. The total

Table 1. Dominant species of polychaetes selected by their importance values in the East Sea (southwestern Japan Sea).

Rank	Species Name	No. of indiv.	Dominance (%)	Frequency (St. No.)	% of Occurrence
1	*Chaetozone setosa*	1274	13.32	72	56.69
2	*Aglaophamus malmgreni*	639	6.68	96	75.59
3	*Ampharete arctica*	561	5.87	78	61.42
4	*Terebellides horikoshii*	529	5.53	79	62.20
5	*Tharyx* sp.	457	4.78	55	43.31
6	*Magelona pacifica*	692	7.24	7	5.51
7	*Nephtys schmitti*	298	3.12	74	58.27
8	*Lumbrineris japonica*	319	3.34	70	55.12
9	*Nothria holobranchiata*	333	3.48	53	41.73
10	*Terebellides kobei*	308	3.22	48	37.80
11	*Sternaspis scutata*	177	1.85	53	41.73
12	*Prionospio malmgreni*	199	2.08	32	25.20
13	*Maldane cristata*	160	1.67	39	30.71

particulate organic matter (POM) within sediment was determined in percentage value by the ignition loss at 550℃ for 4 hr. Sedimentary data used in the present paper were from the results of Lee *et al.* (1989), who analyzed them using the same bottom sediments taken simultaneously for benthic fauna sampling. Shannon-Wiener's diversity index (H ') and equitability index (J) were calculated.

To see whether any relationship exists between polychaete worms and abiotic factors, the Spearman's rank correlation coefficient was calculated by using the abundance data of the most frequent 10 species. Major abiotic factors used in the calculation were depth, bottom temperature, mean grain size, clay content, total organic matter in sediment, and sorting values. To avoid many double zero matches, only pairs without double zero values were considered in the calculation of correlation coefficients.

RESULTS

A total of 112 taxa in 36 polychaete families were encountered from 127 sampling stations on the shelf and slope region of the East Sea (Appendix 1). The most important species in the study area was *Chaetozone setosa,* which occurred at 72 stations and accounted for 13.3% of total polychaetes (Table 1). *Magelona pacifica, Aglaophamus malmgreni, Ampharete arctica, Terebellides horikoshii,* and *Tharyx* sp. were also dominant species, each accounted for more than 5.0% of total abundance. *Aglaophamus malmgreni,* however, showed the highest value in the occurrence frequency reaching up to 76% (96 sts.) of total sampling stations. Species which occupied more than 50% of total sampling stations were only frequently ocurred 5 species as follows: *Terebellides horikoshii* (79 sts.), *Lumbrineris japonica* (70 sts.). About 21 species were collected at only one sampling station, and 16 species appeared at only two stations. These rare species accounted for 1.6% of total abundance.

The biogeographical classification of each species, despite limitation of accurate assignment based solely on the literature data, gave us some information on the distribution patterns of polychaetes in terms of zoogeography. Total five zoogeographical groups were emerged from our polychaete data (Table 2): arctic-boreal, amphiboreal, North Pacific, subtropical or southern, and cosmopolitan species. North Pacific sp cies are further divided into three groups, that is, widely distributed North Pacific, amphipacific, and North-West Pacific species. Polychaete worms pertinent to the North-West

Table 2. Zoogeographical composition of polychaete worms on the southwestern shelf and slope area of the East Sea.

Zoogeographic Types	No. of Species	%	No. of Individuals	%
Arctic-boreal (I)	26	23.21	3428	35.85
Amphiboreal (II)	9	8.04	267	2.79
North Pacific (IIIa)	5	4.46	74	0.77
Amphipacific (IIIb)	8	7.14	1112	11.63
North-West Pacific (IIIc)	34	30.36	2596	27.15
Subtropic (IV)	8	7.14	530	5.53
Cosmopolitan (V)	22	19.64	1556	16.27

Pacific provinces constituted the most dominant group which comprised 34 species (30.4%), and accounted for 27% of total abundance (Table 2). The next dominant group was the species assigned to the arctic-boreal provinces; 26 species and 36% of total abundance. The cosmopolitan species were also a major component; 22 species and 16% of total polychaetes. Those known as a subtropical or southern species were 8 species (5.5% of total abundance). This result indicates that the study area should be more influenced by the cold water masses than the southern warm water masses.

The mean density and number of species per station were estimated to be 75.3 ± 53.4 indiv./0.2 m^2 and 14.2 ± 5.3 species/0.2 m^2 respectively. The spatial distribution of polychaete abundance and species numbers are shown in figure 3. High polychaete density and species richness were seen in the shallow regions while deep region including shelf break and slope sus-

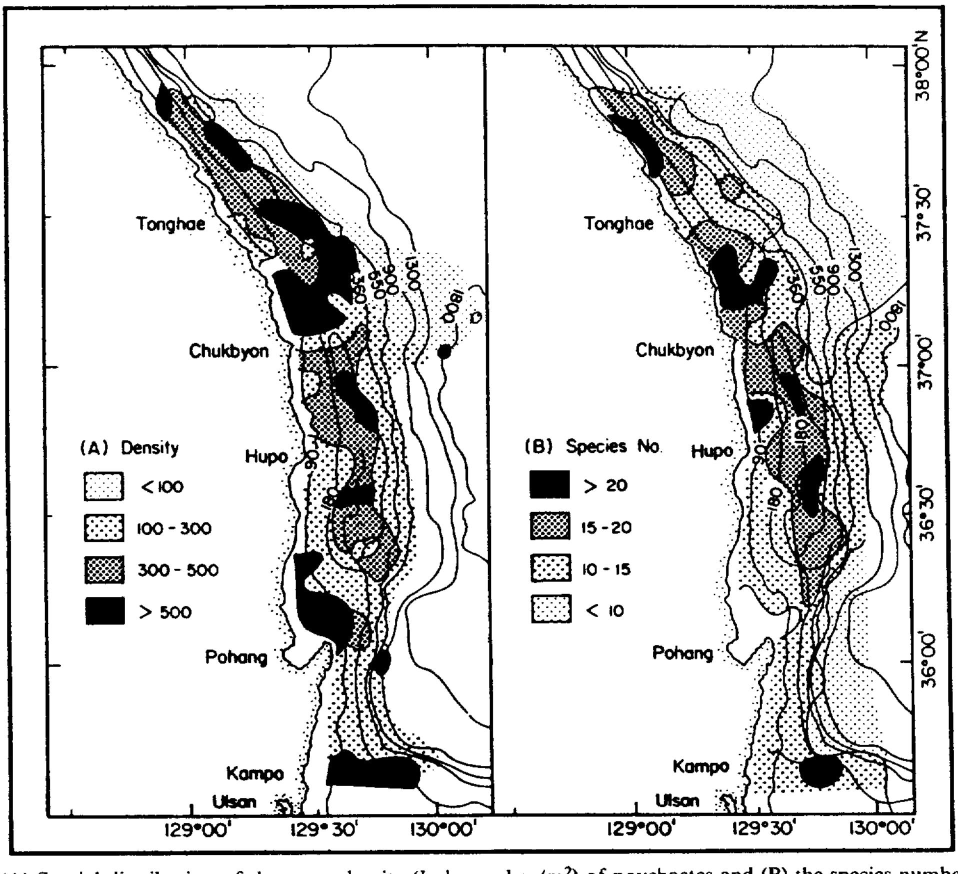

Fig. 3. (A) Spatial distribution of the mean density (Ind. number/m^2) of poychaetes and (B) the species number per 0.2 m^2 in the study area.

Table 3. Mean density, species number and diversity of polychaete worms along the water depth gradient on the continental shelf and slope area of the East Sea. The value in a parenthesis is the standard deviation of each parameters.

Depth (m)	No. of Stations	Density (ind./m²)	Species (No.)	Diversity (H ′)	Temperature (°C)
43-100	9	822	17.1	2.02	6.9
(77±14)		(614)	(7.4)	(0.61)	(1.7)
101-150	32	374	15.6	2.35	4.9
(125±13)		(159)	(5.5)	(0.38)	(2.2)
151-200	17	352	14.7	2.30	3.11
(170±16)		(167)	(4.1)	(0.27)	(0.96)
201-300	32	367	12.7	2.07	1.99
(240±27)		(154)	(4.6)	(0.40)	(0.69)
301-400	11	406	12.9	1.83	1.11
(362±27)		(224)	(3.5)	(0.43)	(0.43)
401-600	12	326	11.0	1.70	0.50
(467±38)		(183)	(3.8)	(0.61)	(0.04)
601-1000	9	127	9.9	1.97	0.16
(817±150)		(61)	(3.6)	(0.45)	(0.04)
1001-2000	5	193	9.6	1.74	0.10
(1720±260)		(161)	(4.4)	(0.50)	(0.01)

tained lower density and species richness. To see whether polychaete density and species richness change along the depth gradient in this study area, 8 depth categories were established in a rather arbitrary scale from depth data. We first examined the overall density, species richness, and species diversity along the arbitrary depth categories (Table 3). At shallow depth, a severe density variation was seen, but from 100 m to 600 m depth, there was no significant density change (ANOVA, at $p=0.05$). The density of the seventh category (i.e. 600 m-1,000 m) was different from those of all shallow depth categories. In the case of species number and diversity, any significant difference was not found between depth categories except species diversity between group 2 and 6 ($H'=2.35$ vs. 1.70), even though these values showed a gradual decrease with depth.

Also we compared the distribution pattern of 13 dominant species along the depth categories (Table 4). From Table 4, a specific depth range was apparent and there were approximately three types in their abundance distribution along the depth gradient. One group composed of those occurred at shallow depth categories in-

Table 4. Mean individual numbers per 0.2m² of dominant polychaetes along the water depth in the East Sea. (Sp1: *Chaetozone setosa*, Sp2: *Aglaophamus malmgreni*, Sp3: *Ampharete arctica*, Sp4: *Terebellides horikoshii*, Sp5: *Tharyx* sp., Sp6: *Magelona pacifica*, Sp7: *Nephtys schmitti*, Sp8: *Lumbrineris japonica*, Sp9: *Nothria holobranchiata*, SP10: *Terebellides kobei*, Sp11: *Sternaspis scutata*, Sp12: *Prionospio malmgreni*, Sp13: *Maldane cristata*, n: number of sampling sites)

Depth (m)	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8	Sp9	Sp10	Sp11	Sp12	Sp13
43-100	3.6	—	0.7	0.9	1.3	76.8	0.1	1.3	0.7	0.7	0.4	6.3	8.0
(n=9)	(6)		(3)	(3)	(7)	(6)	(1)	(3)	(4)	(1)	(3)	(4)	(4)
101-150	3.1	2.6	2.9	4.5	3.3	—	2.3	2.2	6.8	1.8	0.7	3.2	1.7
(n=32)	(16)	(20)	(24)	(19)	(10)		(17)	(22)	(19)	(13)	(12)	(13)	(17)
151-200	9.8	4.5	6.9	4.2	3.4	—	3.2	4.0	2.1	4.2	2.7	0.8	0.6
(n=17)	(7)	(14)	(12)	(11)	(5)		(11)	(8)	(9)	(10)	(7)	(6)	(6)
201-300	8.0	8.8	9.6	7.1	2.4	—	3.3	4.7	1.8	5.2	2.9	0.6	0.4
(n=32)	(12)	(29)	(25)	(27)	(9)		(21)	(25)	(11)	(19)	(22)	(5)	(6)
301-400	36.7	6.6	1.1	2.0	3.5	—	2.0	0.7	1.0	0.5	0.3	0.1	—
(n=11)	(10)	(11)	(4)	(5)	(10)		(9)	(4)	(6)	(3)	(2)	(1)	
401-600	25.6	5.7	1.5	3.0	10.8	—	2.1	1.3	0.6	—	0.5	0.4	0.1
(n=12)	(11)	(10)	(7)	(9)	(7)		(10)	(7)	(3)		(3)	(3)	(1)
601-1000	11.6	5.0	0.7	1.3	1.9	—	2.1	0.7	0.1	0.4	0.2	—	0.8
(n=9)	(7)	(9)	(2)	(3)	(5)		(6)	(1)	(1)	(2)	(3)		(5)
1001-2000	9.8	5.0	0.2	1.6	3.5	—	0.4	—	—	—	0.2	—	—
(n=5)	(3)	(3)	(1)	(2)	(2)		(1)				(1)		

Table 5. Distributional patterns of dominant species in relation to some environmental factors. Four dominant species whose occurrence frequency was less than 50 sts. were excluded in the Spearman's rank correlation analysis, and the coefficients were calculated based on the data excluded double-zero matches. (*: 0.10<p<0.05, **: p<0.05)

Species \ Factors	n	Depth (m)	Temp. (℃)	Org. (%)	Clay (%)	Mz (ϕ)	Sort (ϕ)
Chaetozone setosa	72	0.35 (**)	-0.37 (**)	—	0.22 (*)	0.22 (*)	—
Aglaophamus malmgreni	95	—	—	—	—	—	0.20 (**)
Ampharete arctica	78	—	—	—	-0.19 (*)	-0.21 (*)	—
Terebellides horikoshii	79	—	—	—	—	—	—
Tharyx sp.	55	—	—	—	—	—	—
Nephtys schmitti	76	-0.23 (**)	0.22 (*)	—	—	—	—
Lumbrineris japonica	70	—	—	—	-0.25 (**)	-0.24 (**)	0.29 (**)
Nothria holobranchiata	53	-0.41 (**)	0.33 (**)	—	—	—	—
Sternaspis scutata	53	—	—	—	0.27 (*)	—	—

Table 6. Regional comparison on the mean densities of polychaete worms reported in soft bottoms around Korean waters.

Study area	Density (indiv./m²)	References
I. Estern coasts		
1) Shelf and slope of the East Sea	300 (30-2,020)	present study
2) Shelf area off the southeastern coast	300 (20-1,830)	Choi & Koh, 1988
3) Ulsan Bay	860	Yi *et al.*, 1982
II. Southern coasts		
1) Busan coast	550	Lee, 1976
2) Kwangyang Bay	490 (10-2,985)	Choi & Koh, 1984
	600	KORDI, 1985
III. Western coasts		
1) Eastern Yellow Sea	400	Lee, 1987a
2) Karolim Bay	540-1,100	KORDI, 1981

cluding *Magelona pacifica, Nothria holobranchiata, Prionospio malmgreni,* and *Maldane cristata.* These species showed their maximum abundance at the shelf area. Next group was composed of those showed their maximum density at the intermediate depth range from the shelf-break to the upper slope (150 m-300 m), e.g., *Ampharete arctica, Terebellides horikoshii,* and *Nephtys schmitti.* The third group was composed of those having a rather broad occurrence range but their maximum densities at deeper area from 300 m to 600 m. *Chaetozone setosa, Aglaophamus malmgreni,* and *Tharyx* sp. were typical species of this group (Table 4).

For the preliminary data on the relationship between polychaetes and environmental factors, the Spearman's rank correlations were calculated using the abundance data of ten dominant species whose occurrence frequency was more than 50 stations to reduce the bias from few data and to include more diverse habitat conditions (Table 5). Among 6 environmental factors, organic content within sediment showed no significant correlation. Most species showed a siginificant correlation with one or two factors. The densities of *Nephtys schmitti,* and *Nothria holobranchiata* were negatively correlated to water depth or positively to bottom temperature, while that of *Chaetozone setosa* was positively related to water depth. In terms of sedimentary properties, *C. setosa* and *Sternaspis scutata* were related with fine sediments, but *Lumbrineris japonica* and *Ampharete arctica* with coarse sediments.

DISCUSSION

The most common species, showing high values in both mean density and occurrence frequency, are different from those reported by Lee and Chin (1989) in the eastern Yellow Sea. The representative species of the Yellow Sea were *Spiophanes bombyx, Goniada maculata, Ampharete arctica, Nephtys caeca, Nothria iridescens,* and *Clymenella koreana.* In our study area, the most common species are *Chaetozone setosa, Aglaophamus malmgreni, Magelona pacifica, Ampharete arctica, Terebellides horikoshii, Tharyx* sp., *Nothria holobranchiata, Lumbrineris japonica,* and *Nephtys schmitti.* Only *A. arctica* was common in both regions. Especially, *Chaetozone setosa* and *Terebellides horikoshii* were rare or not found in the Yellow Sea. Some typical polychaetes in mixed or sandy sediments of the Yellow Sea such as *Goniada maculata, Nephtys caeca* and *Sphiophanes bombyx* were completely replaced to the typical muddy species in the East Sea, e.g. *Aglaophamus malmgreni, N. schmitti,* and *Tharyx.* sp. Dominant polychaete worms in the present study area are also different from those in the coastal enbayments of Korea. For example, the dominant species of the Ulsan Bay were *Cirratulus cirratus, Lumbrineris longifolia,* and *Magelona japonica* (Yi *et al.*, 1982); Those in the coast of Pusan were *L. longifolia* and *M. japonica* (Lee, 1976); *Prionospio pinnata* in the Masan Bay (Hong and Lee, 1983); *L. longifolia* and *Lagis bocki* in the Kwangyang Bay (Choi and Koh, 1984).

We mainly compared our results with the benthic communities in the Yellow Sea because of their similar scale and proximity in areal aspect. The discrepancy in faunal composition between these two areas may be due to their specific environmental conditions. The main differences in environmental factors are in sedimentary facies and in the depth range and thereby in the temperature range. The bottom sediment of the Yellow Sea is composed mainly of sand except some deep area of mud. This sedimentary facies well reflects the dominance of motile species, e.g., *Goniada maculata, Nephtys caeca,* and *Lumbrineris cruzensis* which are typical species of unstable sandy sediments. In contrast to this, the sedimentary facies of the East Sea is mainly muddy facies consisting of silt and clay except some sites in the Hupo Bank. In the muddy facies of this study area, large polychaetes possing tubes occupied a high proportion in numerical abundance. The water depth and bottom temperature of the Yellow Sea is shallower and higher than those of the East Sea, respectively. Most of the Yellow Sea is in the depth range of less than 100 m, and the temperature of the cold water in the central part of the Yellow Sea (308 Line of FRDA) fluctuated from 4 ℃ to 10 ℃ in winter and summer respectively (Lee, 1987a). In the southern Yellow Sea, the bottom water has been in the constant temperature of 12 or 13 ℃ (313 Line of FRDA). However, the annual mean temperature of bottom water in the southern East Sea is in the range of 0 ℃ to ca. 9 ℃ and closely dependent on the depth. The thermal effect of the East Korean Warm Current (EKWC) is very restricted along the shallow coastal area and partly at the Hupo Bank (Fig. 2).

Spatial difference in faunal density was severe, and polychaete densities of sampling stations were in a wide range from 30 indiv./m^2 to 2,020 indiv./m^2. However, mean density of polychaete worms is in the similar level or slightly lower than those from previous researches (Table 6). The spatial distribution of polychaete density showed a negative correlation with the water depth and the mean density decrease along the depth gradient (Table 3). This trend is well coincided with the commonly known depth-density or depth-biomass relations of benthic fauna (Rowe, 1981; 1983; Lampitt *et al.,* 1986; Kojima and Ohta, 1989). The exponential decrement in both faunal density and biomass with depth was frequently explained by the amount of food supply through vertical or horizontal transports (Kojima and Ohta, 1989). However, our result showed that the organic matter in the sediment was nearly not related with the specific polychaete density of some dominant species (Table 5). The food supply in our study area may not play a limiting factor for the distribution of polychaete worms. The higher correlation between mean densities of dominant species and water depth or temperature, and the specific depth ranges suggest that the density decrement of polychaetes with depth should be, at least in the case of our study area, more related to the gradients in bottom temperature and sediment grain size (such as mean phi and sorting value) than organic matter.

Pocklington and Tremblay (1987) could identify three zoogeographic provinces distinguished by water masses based on the presence-absence data of polychaete worms in the Atlantic coast of North America. In the eastern part of the Yellow Sea, Lee (1987b) also classified the polychaete worms into five zoogeographical groups; warm water, cold water, cosmopolitan, endemic, and amphi-pacific species. The endemic species, which are confined to the northwestern Pacific including the Yellow Sea, the East Sea and other neighboring seas around the Korean Peninsula and Japanese Islands, were the most important group (29 sp. of 96 species). Cold water, cosmopolitan, and warm water groups consisted of more than 20 species. His result coincides with our data on zoogeography, and this suggests that both the Yellow Sea and the East Sea are under the influences of cold water masses, even though their origin of water masses and their formation mechanisms are different. Paik (1986) attempted the zoogeographical classification on the polychaete worms at the hard bottoms of Ullungdo, which is located at the outer margin of ou study area. Among four zoogeographical groups such as cosmopolitan, northern, temperate, and tropic groups, cosmopolitan species were the richest group (39% of total species) and any species in tropical group was not found. He discussed the effect of cold water masses existing near the Ullungdo throughout a year as a possible explanation on the absence of tropical species.

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APPENDIX 1: The species list of polychaete worms sampled on the continental shelf and upper slope of the East Sea during April of 1985 and 1987, and October of 1987.

Species Name	Fq	TI	FG	Zg
Phyllodocidae				
Anaitides maculata	10	10	CMX	I
Anaitis sp.	2	3	CMX	IIIb
Eteone longa	4	4	CMX	I
Eulalia sigeformis	8	13	CMX	IIIc
Pterocirrus macroceros	11	18	CMX	II
Aphroditidae				
Aphrodita japonica	2	4	CMJ	IIIc
Polynoidae				
Harmothoe imbricata	16	22	CMJ	I
Hartmania moorei	2	3	CMJ	
Lepidonotus squamatus	1	4	CMJ	II
Pilargidae				
Sigambra setosa	15	55	CMJ	IIIb
Syllidae				
Ehlersia cornuta	21	87	CMJ	V
Nereidae				
Nereis nichollsi	2	2	CMJ	IIIc
Tambalagamia fauveli	7	22	CMJ	IIIc
Glyceridae				
Glycera capitata	1	1	CDJ	V
G. chirori	7	16	CDJ	IIIc
Goniadidae				
Goniada maculata	28	135	CDJ	IV
Glycinde sp.	1	2	CDJ	IIIa
Nephtyidae				
Aglaophamus malmgreni	96	639	CMJ	I
Nephtys schmitti	74	298	CMJ	I
Nephtys sp.	10	78	CMJ	I
Sphaerodoridae				
Sphaerodoridium minutum	1	1	BMX	I
Euphrosinidae				
Euphrosine sp.	1	2	CMX	IIIc
Onuphidae				
Hyalinoecia tubicola	1	1	SDJ	IV
Nothria conchylega	7	16	SDJ	I
N. elegans	18	57	SDJ	V
N. holobranchiata	53	333	SDJ	IIIc
Eunicidae				
Eunice mucronata	1	20	CDJ	IIIb
Lumbrineridae				
Lumbrineris abyssalis	61	132	BMJ	IIIc
L. bifurcata	25	88	BMJ	IV
L. heteropoda	30	74	BMJ	IV
L. japonica	70	319	BMJ	IIIc
L. latreilli	45	210	BMJ	IV
L. nipponica	42	227	BMJ	IIIc
Arabellidae				
Drilonereis sp.	10	19	CMJ	IV
Orbiniidae				
Haploscoloplos elongatus	42	128	BMX	IIIb
Naineris guadricuspida	1	4	BMX	I
Phylo fimbriatus	12	36	BMX	IIIc
Paraonidae				
Aricidea jeffreysii	5	12	SMX	V
A. lopezi	2	11	SMX	IIIa
A. neosucecia nipponica	2	3	SMX	IIIc
A. ramosa	7	52	SMX	IIIa
A. uschakovi	3	6	SMX	I
Aricidea sp.	34	209	SMX	IIIc
Cossuridae				
Cossura modica	34	108	BMX	I
Aphistobranchidae				
Aphistobranchus ornatus	1	3	SDT	IIIb
Spionidae				
Laonice cirrata	39	88	IDT	V
Prionospio malmgreni	32	199	IDT	II
Pseudopolydora kempi	2	4	IDT	V
Chaetopteridae				
Phyllochaetopterus sp.	1	2	SST	IIIc
Spiochaetopterus typicus	7	9	SST	I
Magelonidae				
Magelona pacifica	7	692	SDT	IIIb
Cirratulidae				
Chaetozone setosa	72	1274	SDT	I
Tharyx sp.	55	457	SDT	V
Capitellidae				
Capitella capitata	1	1	BMX	I
Heteromastus sp.	1	2	BMX	II
Notomastus latericeus	2	3	BMX	V
Maldanidae				
Aschys auritus	2	7	BSX	IIIc
A. biceps	2	2	BSX	II
A. disparitentata	1	3	BSX	IIIc
Axiothella rubrocincta	14	44	BSX	I
Clymenella sp.	4	13	BSX	IIIc
Clymenopsis cingulata	1	2	BSX	IIIb
Clymenura aciculata	5	5	BSX	IIIc
Maldane cristata	39	160	BSX	V
Maldanella harai	1	1	BSX	IV
M. niijimense	2	5	BSX	IIIc
Nicomache lumbricalis	3	5	BSX	V
N. personata	1	4	BSX	IIIa
N. quadripinata	2	3	BSX	II
Nicomache sp.	3	3	BSX	IIIc
Notoproctus pacificus	16	207	BSX	IIIb
Petaloproctus borealis	4	6	BSX	I
Praxillella affinis	3	12	BSX	V
P. gracilis	43	151	BSX	IIIc
P. pacifica	2	4	BSX	IIIc
P. praetermissa	6	22	BSX	I
Rhodine leveni	16	32	BSX	II
Opheliidae				
Ophelina acuminata	16	33	BMX	V
Travisia forbesii	26	162	BMX	I
Scalibregmidae				
Scalibregma inflatum	25	78	BMX	V
Sternaspidae				
Sternaspis scutata	53	177	BMX	V
Oweniidae				
Myriochele gracilis	18	139	BSX	V
M. oculata	7	58	BSX	I
Owenia fusiformis	1	8	FDT	V
Flabelligeridae				
Brada villosa	18	40	SDT	I
B. nuda	2	7	SDT	IIIc

Species Name	Fq	TI	FG	Zg	Species Name	Fq	TI	FG	Zg
Flabelligera mastigophora	4	5	SDT	IIIc	*Melinnampharete gracilis*	8	12	SST	IIIc
Pherusa plumosa	6	15	SDT	V	Terebellidae				
Pectinariidae					*Artacama proboscidea*	31	65	SST	V
Amphictene moorei	6	8	BMX	IIIc	*Nicolea gracilibranchus*	2	2	SST	IV
Cistenides granulata	6	23	BMX	I	*Pista cristata*	37	111	SST	V
Sabellariidae					*P. moorei*	1	1	SST	II
Idanthyrsus armatus	1	2	FST	V	*Thelepus* sp.	2	4	SST	V
Ampharetidae					*Proclea graffi*	3	9	SST	I
Amage asiaticus	12	16	SST	IIIc	*Streblosoma bairdi*	1	6	SST	II
Ampharete acutifrons	2	3	SST	I	Trichobranchidae				
A. arctica	78	561	SST	I	*Terebellides horikoshii*	79	529	SST	IIIc
Amphicteis gunneri	23	45	SST	IIIc	*T. kobei*	48	308	SST	IIIc
A. scaphobranchiata	4	5	SST	IIIa	*T. lineata*	11	51	SST	IIIc
Amphisamytha japonica	23	74	SST	IIIc	Sabellidae				
Lysippe labiata	1	14	SST	I	*Chone* sp.	11	30	FDT	IIIc
Melinna cristata	14	38	SST	V	*Euchone analis*	8	16	FDT	I

*Abbreviation of table heading: Fq = frequencies, TI = total individual numbers, FG = feeding guilds, Zg = zoogeographic distribution types.

**Symbols used in identifying feeding guild structure: C = carnivore, B = burrowing, F = filter feeding, S = surface deposit feeding (first symbol); D = discretely motile, M = motile, S = sessile (second symbol); J = jawed, T = tentaculate, X = non-Jawed (third symbol).

***Biogeographical distribution types to which the species belong is given in the column headed by "Zg".

I = arctic – boreal; II = amphiboreal; IIIa = widely distributed North Pacific; IIIb = amphipacific; IIIc = Asiatic – North Pacific; IV = subtropical and widely distributed southern species; V = bipolar, cosmopolitan species and those of obscure geographical distribution. These assignments of species were referred mainly to Uschakov (1955), Uschakov and Wu (1965), Hartman (1968, 1969), and Imajima and Hartman (1964).