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Characteristics of Recent Foraminifera and Surface Sediments in Gomso-Bay Tidal Flat, West Coast of Korea: Potential for Paleoenvironmental Interpretations

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곰소만 조간대의 현생 유공충과 표층 퇴적물의 특성: 고환경 해석에 적용 가능성

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The line-SW is located in the mouth of Gomso Bay (20 km long and 5~8 km wide), west coast of Korea. This area is composed of sand flat, mud flat, sand shoal and chenier. The differences of physical, geological and geomorphic conditions in subenvironments of the bay may control and produce distingtive foraminiferal populations and assemblages. This study investigates whether five a priori subenvironments (five local zonations) in Gomso-Bay tidal flat can be distinguished from each other on the basis of total (living plus dead) foraminiferal assemblages.

Seventy-four species (67 benthic; 7 planktonic) were recorded in total assemblages of surface sediments from 10 stations. *Ammonia beccarii tepida, Discorbis candeiana, Elphidium etigoense* and *Eponides nipponicus* were most dominant species in living and total assemblages. The relative abundance (%) of living population was high at upper flat and decreased from upper to lower flat. The low percentages of living populations in middle to lower flat are probably influenced by the decreasing reproduction of foraminifera caused by high energy condition and addition of dead species from offshore. The occurence of planktonic foraminifera in middle to lower flat (5.3~6.6%) indicates introduction of planktonic foraminifera from offshore by storm and/or tidal current. The relatively high numbers of species in lower middle to lower flat are probably caused by a mixing of faunas from these areas and offshore. The high numbers of total individuals per 50 m*l* of sediment in upper flat indicate that this area is a relatively stable environment where waves and currents are protected by the chenier.

Five biofacies of the total foraminiferal assemblages were established on the basis of dominant species (those representing more than 20% of the total assemblages in any station) in the five *a priori* subenvironments recognized along the Line-SW transect in Gomso-Bay tidal flat. Five biofacies are potentially useful in paleoenvironmental interpretation in late Quaternary Gomso-Bay tidal deposits.

한국 서해안 곰소만(길이 20 km, 폭 5~8 km) 입구에 위치한 측선-SW에는 사질 조간대, 니질 조간대, 조간대 사주, 쉐니어(chenier) 등이 잘 발달되어 있다. 만내 각 소환경에서의 물리적, 지질적 및 지형적 요인의 차이는 아마도 특징적인 유공충 분포를 나타내리라 생각된다. 본 연구는 곰소만 조간대에서 지형적인 고도차에 의해 세분될 수 있는 5개의 지역적인 소환경이 유공충의 전체군집에 의하여 서로 구분될 수 있는가를 조사하는 것이다.

연구지역에서 채취된 10개의 표층 퇴적물에서 총 74종(저서 유공충: 67종; 부유성 유공충: 7종)의 유공충이 확인되었다. 연구지역에는 *Ammonia beccarii tepida, Discorbis candeiana, Elphidium etigoense* 및 *Eponides nipponicus*의 4종이 살아있는 군집과 전체군집내에서 널리 분포하고 있다.

살아있는 개체의 상대적인 비율(%)은 상부조간대에서 높게 나타나며 하부조간대로 하부조간대로 갈수록 감소

한다. 중부조간대와 하부조간대에서 살아있는 개체의 비율이 낮은 이유는 물리적인 에너지가 외해쪽으로 증가하여 유공충의 생산성이 감소하며, 또한 외해로 부터 죽은 개체가 유입되어 죽은 개체수가 증가하기 때문인 것으로 해석된다. 중부와 하부 조간대에서 발견되는 부유성 유공충의 존재는(5.3~6.6%) 외해에서 태풍이나 조류에 의해 유입된 것으로 추정된다. 중부조간대 하부와 하부조간대에서 상대적으로 종의 수가 많은 것은 아마도 이 지역의 종들이 서로 혼합되어진 결과일 것이다. 시료 50 ml 당 전체 개체수가 상부조간대에서 높게 나타나는 것은 쉐니어가 파랑과 조류를 막아주어 이 지역이 상대적으로 안정된 환경을 유지하여 유공충의 생산성이 높기 때문이다. 곰소만 조간대(Line-SW)에서 풍부하게 나타나는 유공충(전체군집에서 20% 이상이 어느 한 지점에서 나오는 종)을 기준으로 하여 5개의 생물상(biofacies)이 분리되었다. 5개의 생물상은 제4기 후반의 곰소만 조간대 퇴적물의 고환경을 해석하는데 잠재적으로 유용할 것으로 사료된다.

INTRODUCTION

The ecological studies of recent foraminifera have added to their value as paleoenvironmental indicators (Phleger, 1960; Murray, 1973; Boltovskoy and Wright, 1976). Culver and Banner (1978) have shown that the distribution of foraminifera can be related to grain-size distributions because both are affected by the waves, currents and tides. The distribution of foraminifera is also affected by other ecological parameters including temperature, salinity, elevation, pH, disolved oxygen, predation, water depth and exposure (Phleger, 1960; Murray, 1973; Boltovskoy and Wright, 1976). Although the ecology of modern foraminifera of Yellow Sea coast has been studied, no previous work on foraminiferal ecology has been done in Gomso Bay. Quantitative studies of Yellow Sea coast have been done at Gyunggi Bay (Chang and Lee, 1982, 1983), Asan Bay (Chang and Lee, 1984) and southern Yellow Sea (Cheong, 1991). These studies related foraminiferal distributions to ecology and divided areas into faunal zones or biofacies. The modern tidal flat of Gomso Bay has different depositional environments including sand flat, intertidal sand shoal, chenier and mud flat. Since these environments have different physical, geological and geomorphic parameters, it is believed that the differences in these parameters may control and produce distingtive foraminiferal populations and assemblages. For this research, five different local zonations (5 *a priori* subenvironments) have been identified in Gomso-Bay tidal flat based on elevation. This study focused on the relationship between foraminiferal distributions and five different zonations. The purpose of this study is to investigate quantitatively whether different zonations of Gomso-Bay tidal flat are characterized by different foraminiferal assemblages, and to determine whether these assemblages can be used as paleoenvironmental indicators in late Quaternary Gomso-Bay deposits.

AREA OF INVESTIGATION

Gomso Bay is 20 km long and 5~8 km wide, and exhibits a variety of subenvironments. The sedimentary environments of this region include tidal channel, sand flat, intertidal sand shoal, mud flat and chenier. A broad tidal flat lies on the southern part of the bay. A deep, large tidal channel runs parallel to the northern rocky coast and connected to the tributary network of meandering channels on the extensive southern tidal flat (Fig. 1).

The surfacial sediments on the tidal flat (Fig. 2) consist of silt and sandy silt on the middle to upper tidal flat, mud on the bottoms of tidal tributaries, and sand and silty sand on the middle to lower tidal flat (Lee *et al.*, 1994). Gomso Bay has semidiurnal tides with average tidal range of 433.8 cm (spring, 589.8 cm; neap, 277.8 cm; National Geography Institute, 1981) The study area is a part of Gomso Bay at its mouth (Line-SW) (Fig. 1). The vertical profile of the Line-SW is shown in Fig. 3. The elevation of line-SW was precisely measured using an electronic optical distance-measuring instrument. Based on differences in elevation, five different local zonations (5 *a priori* subenvironments) have been distinguished within the Line-SW (Fig. 3). The tidal flat of the Line-SW is divided into five subenvironments (upper, lower upper, upper middle.

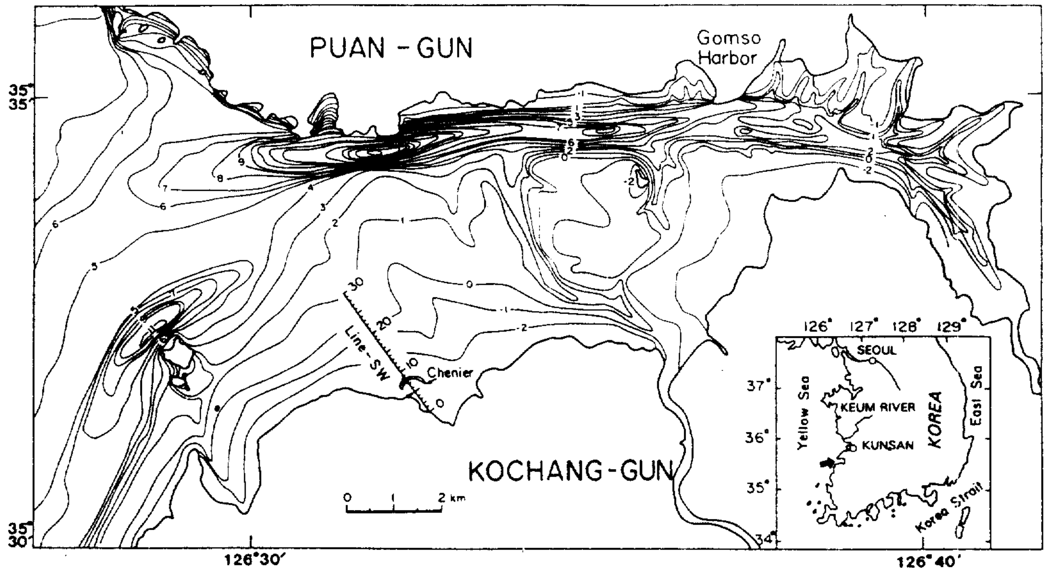

Fig. 1. Location map of Gomso Bay (inset) showing bathymetry and transect (Line-SW) levelled at 100 m in intervals. Bathymetry (relative to mean sea level) is from National Geography Instituе (1981); minus indicates elevation above mean sea level.

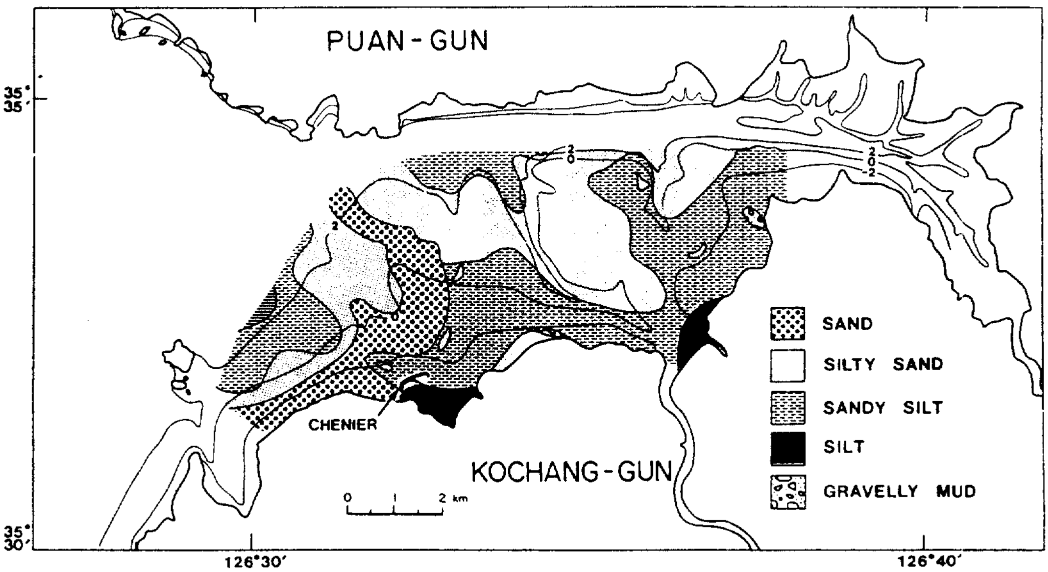

Fig. 2. Distribution of surface sediments in Gomso tidal flat. Silt and sandy sit dominate on the middle to upper tidal flat, whereas sand and silty sand dominate on the middle to lower tidal (from Lee *et al.*, 1994).

lower middle, and lower flat) on the basis of MHWL (mean high water level), MNHWL (mean neap high water level), MSL(mean sea level) and MNLWL (mean neap low water level) (Wang and Eisma, 1988).

MATERIALS AND METHODS

Surface sediments for sedimentological analysis were sampled at 28 stations along the Line-SW tran-

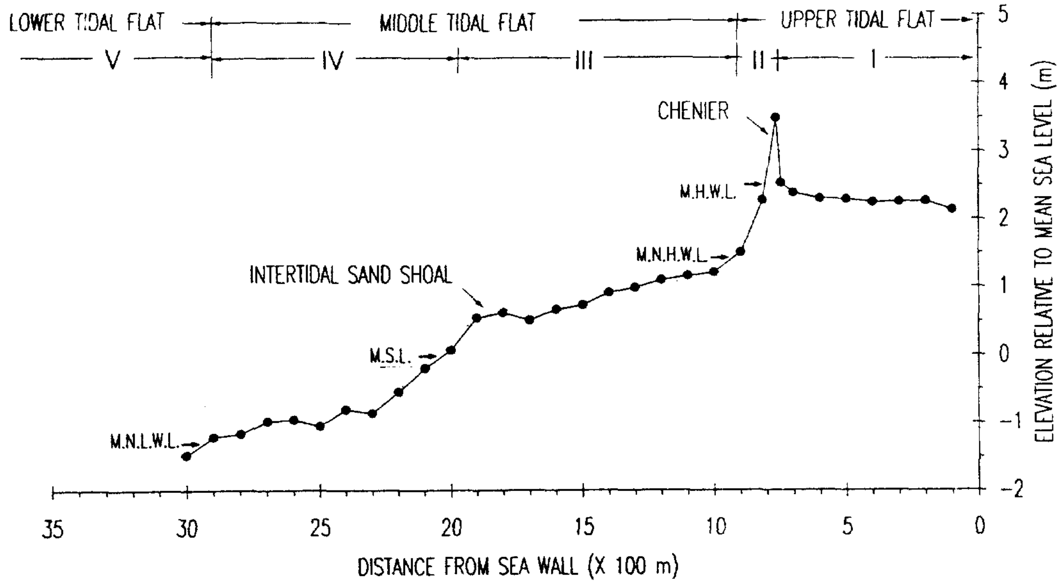

Fig. 3. Elevation of Line-SW transect crossing the outer part of Gomso-Bay tidal flat. The tidal flat is divided into five zones based on MHWL (mean high water level). MNHWL (mean neap high water level). MSL (mean sea level) and MNLWL (mean neap low water level): I: upper, II: lower upper flat, III: upper middle flat. IV: lower middle flat. V: lower flat, Note a chenier located at upper tidal flat above MHWL, and interidal sand shoal near MSL.

sect on April, 1992. The sand and mud fractions were separated by wet sieving through a 63 micron stainless-steel sieve after removing organic materials and carbonates with 10% H_2O_2 and 0.1 N HCl. Grain-size distribution were determined using standard sieving (Folk, 1980) and Sedigraph 5000D at half phi intervals. A computer program calculated moment statistics. Moment statistics was used to determine sediment type, mean and sorting.

Surface samples for foraminiferal analysis were collected at 10 stations along the Line-SW transect on March, 1993. Samples were taken during low water when the sea bed was exposed. The upper one cm of sediment was scraped to produce subsamples of approximately 50 ml. The sample was preserved immediately in plastic bottle with a buffered formalin solution (5%, buffered with Hexamine to pH 8 or 9) in the field. Foraminiferal samples washed over a 63 micron sieve to remove silt, clay and formalin on the same day of collection, and stored in 50% isopropyl alcohol.

In order to distinguish the living and dead foraminifera, the sample was stained for 6 to 8 hours with 0.1 g of rose Bengal (Walton, 1952) and washed over a 63 micron sieve. The washed sample was soap-floated to separate and concentrate foraminifera from quartz grains (Harris and Sweet, 1989). Sand-sized and soap-floated samples were dried in an oven at 40~60°C. If a soap-floated sample contained more than 300 specimens, it was split into smaller aliquots with microsplitter. The floated sample was re-wetted, picked live and dead foraminifera, sorted into different morphologic groups, and identified using reference literatures.

RESULTS AND DISCUSSION

Characteristics of Surface Sediments

Sediment characteristics of surface sediments in the Line-SW are illustrated by statistical parameters (Table 1). Distribution of sediment within the Line-SW changes generally seaward from fine to coarse. The general sediment patterns in the study area are as follows: (1) very poorly sorted, fine-grained mud-

Table 1. Texture and grain-size characteristics of surface sediments along the Line-SW transect

Environment	Station	Texture (%)				Sediment Type	Mean (phi)	Sorting (phi)
		Gravel	Sand	Silt	Clay			
UPPER TIDAL FLAT(I)	SW-02		4.3	75.1	20.6	Silt	6.62	2.38
	SW-04		7.4	69.7	22.9	Clayey silt	6.78	2.34
	SW-05		5.3	80.7	14.1	Silt	5.88	1.72
	SW-06		11.3	70.6	18.1	Clayey silt	6.14	2.48
	SW-07		39.9	40.6	19.5	Sandy silt	5.20	3.19
Chenier	SW-08	6.3	93.1	0.7		Gravelly sand	0.75	1.15
LOWER TIDAL FLAT(II)	SW-09		53.9	38.5	7.6	Silty sand	4.07	2.21
UPPER MIDDLE TIDAL FLAT(III)	SW-10		68.0	28.7	3.3	Silty sand	3.56	1.67
	SW-11		81.5	16.5	2.0	Sand	3.19	1.41
	SW-12		90.5	7.9	1.6	Sand	2.88	1.27
	SW-13		97.1	7.9		Sand	2.97	0.71
	SW-14		97.1	2.9		Sand	2.61	0.70
	SW-15		96.5	2.6	0.5	Sand	2.60	1.07
	SW-16		94.2	4.7	1.1	Sand	2.59	1.19
	SW-17		93.5	5.5	1.0	Sand	2.04	1.26
	SW-18		99.6	0.4		Sand	1.79	0.40
Intertidal sand shoal	SW-19		99.4	0.6		Sand	2.36	0.48
LOWER MIDDLE TIDAL FLAT(IV)	SW-20		98.2	1.8		Sand	2.64	0.49
	SW-21		97.9	2.1		Sand	2.54	0.54
	SW-22		98.2	1.8		Sand	2.61	0.61
	SW-23		97.2	2.9		Sand	2.60	0.57
	SW-24		95.2	4.8		Sand	2.91	0.56
	SW-25		93.9	6.1		Sand	3.02	0.63
	SW-26		91.2	8.8		Sand	3.03	0.67
	SW-27		93.2	6.0	0.9	Sand	3.01	0.84
	SW-28		83.6	15.6	0.9	Sand	3.32	1.03
	SW-29		62.9	36.0	1.1	Sand	3.84	1.03
LOWER TIDAL FLAT(V)	SW-30		72.8	25.6	1.6	Silty sand	3.71	1.20

dy sediment in upper flat; (2) poorly to well sorted sand bodies in middle flat; (3) poorly sorted silty sand in lower flat.

The upper flat between the chenier (shelly sand ridge) and sea wall (SW2, 4~7) is composed of a very poorly to poorly sorted (1.72~3.19ϕ) silty sediment with a mean size of medium silt (Mz=5.20~6.78ϕ). This area is characterized by a small patch of flora *Salicornia* sp. and *Sueda japonica*. The chenier (shelly sand ridge), about 860 m long and 30~60 m wide, lies parallel to the shore, approximately 700 m seaward from the sea wall (Fig. 3). The chenier (SW8) is composed of 93% sand and shell fragments with samll amount of subangular granules which is poorly sorted (1.15ϕ) producing a mean size of coarse sand (Mz=0.75ϕ). The lower upper flat between mean high water level and mean neap high water level occurs on the sea side of the chenier. The lower upper flat (SW9) consists of very poorly sorted silty sand with a mean size of coarse silt (Mz=4.07ϕ). The upper middle flat (SW10~19) between mean neap high water level and mean sea level is characterized by sand facies that are poorly to well sorted (0.40~1.67ϕ), and has a mean size of very fine to medium sand (Mz=1.79~3.56ϕ). The lower middle flat (SW20~29) between mean sea level and mean neap low water level is also characterized by sand facies. The most of this area except SW28 and SW29 contains a relatively high percent sand (more than 90%), that is well to moderately sorted (0.49~0.84ϕ), and has a mean size of very fine to fine sand (2.54~3.03ϕ). The lower part of this area (SW29) and the lower flat below the level of mean neap lower water (SW30) are composed of silty sand that is poorly sorted (1.03~1.20ϕ) and have a mean size of very fine sand (3.71~3.84ϕ). The tidal sands on middle to lower flat were probably transported from the extensive offshore sand bodies which cover the entire eastern third of Yellow Sea shelf and nearshore (Lee *et al.* 1988, 1994).

Abundance of Foraminifera

Fourteen living benthic species were identified in the study area. The relative abundance (%) for the living and total (living plus dead) assemblages are listed in Appendix. The number of living individuals per 50 m*l* of sediment varies from 3 to 2,072 specimens over the study area. Generally, the number of living individuals was low at upper middle flat (SW18), whereas the greatest number of living individuals occurred in upper flat (SW4) where *Elphidium etigoense* dominated.

Seventy-four species (67 benthic; 7 planktonic) were recorded in total assemblages of surface sediments from 10 stations. The number of total (living plus dead) individuals per 50 ml of sediment varies from 14 to 2,512 specimens. Generally, low specimen numbers occured in lower upper flat (SW9), whereas the high number of specimens occured in upper flat (SW4) where *Eiphidium etigoense* dominated with 95.2% of total assemblge. Four species, *Ammonia beccarii tepida, Discorbis candeiana, Elphidium etigoense and Eponides nipponicus*, were widely distributed in living and total assemblages over the study area.

Fig. 4 is plots of relative abundance (%) of living population, relative abundance (%) of planktonic foraminifera, number of species of the total assemblage (S), number of individuals per 50 m*l* in the total assemblage (N), mean grain size (Mz) and elevation against 10 stations along the Line-SW. The relative abundance (%) of living population changed with distance from shoreline. The percentages of living populations decreased from upper to lower flat. The low percentages of living population in middle to lower flat are influenced by the decrease of foraminiferal reproduction caused by high energy condition and the addition of dead specimens from offshore. The highest values of living population occured in the upper flat (SW4). The sediment substrate characterizing this area is clayey silt (Mz=6. 78ϕ) covered by patches of living Elphidium etigoense. Chang and Lee (1982, 1984) reported that Elphidium etigoense is dominant species in muddy sediment at the vicinity of Inchon and Asan Bay.

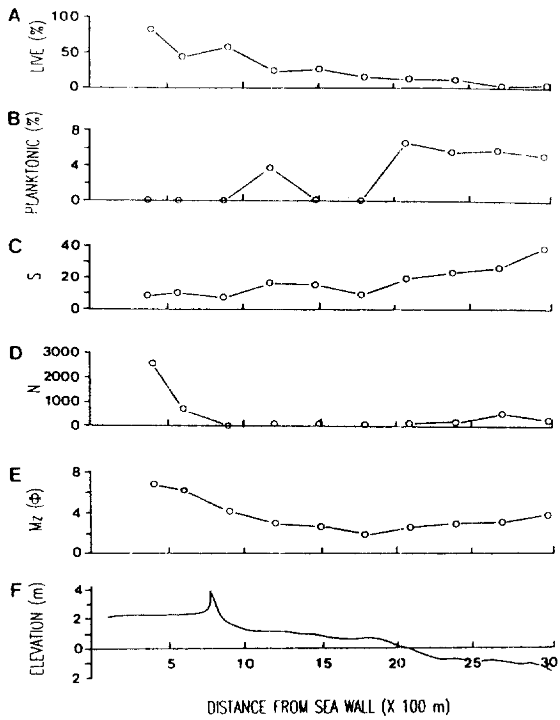

Fig. 4. Plots of A) percentages of living population, B) percentages of planktonic foraminifera, C) number of species of the total assemblage (S), D) number of individuals per 50 ml of sediment in the total assemblage, E) mean grain size and F) elevetion (m) against individual smpling stations in the Line-SW.

The planktonic foraminifera are rarely occurred in upper and upper middle flat, but occurred relatively high percentages in lower middle to lower flat (5.3~6.6%). The occurrence of planktonic foraminifera in lower middle to lower flat is probably transported from offshore by storm and/or tidal current (Cooper, 1961). The general pattern of number of species (S) increases from upper to lower flat. The lower middle to lower flat has relatively high number of species (19~39 species). This is probably caused by a mixing of faunas from middle, lower tidal flat and offshore. The high numbers of total individuals per 50 m*l* of sediment (N) occured in upper flat (SW4, 6). The high numbers of specimens in upper flat indicate that this area is a relatively stable environment where waves and currents are protected by the chenier.

Relationships between dominant species of total assemblages and subenvironments

Living and total (living plus dead) benthic foraminiferal assemblages are useful for ecological interpretations (Murray, 1973; Buzas, 1968; Scott and Medioli, 1980). There are different opinions as to whether living or total assemblages should be used as short- or long-term environmental indicators. Murray (1973) mentioned that the relative abundances of living and dead individuals of foraminifera within a single sample are generally different, and counts of dead foraminiferal assemblages are often higher than living ones due to production and postmortem changes. Therefore, he concluded that only living benthic foraminiferal population represented the environmental conditions.

However, Parker and Athearn (1959), Buzas (1968), Matera and Lee (1972) and Scott and Medioli (1980) investigated seasonal variations in living foraminiferal populations in coastal areas. Buzas (1968) illustrated that the living benthic population at a particular time could not be used as an environmental indicator. His study showed that the low-density living populations were randomly distributed, while the most abundant species were aggregated due to asexual reproduction. Scott and Medioli (1980) investigated living and total assemblages over a three year period in a Nova Scotia salt marsh. They found that while living populations are highly variable due to climatic or micro-environmental changes, the total assemblages did not change significantly over time. These studies suggest that the total benthic foraminiferal assemblages are reliable to interpret environmental conditions over relatively long period of time.

In this study, total foraminiferal assemblages were used for recognization of biofacies in order to interpret the long-term environmental conditions. Five

Table 2. Five biofacies for total foraminiferal assemblages in the five subenvironments of the Line-SW. The forami niferal assemblages were dominant species those which represent more than 20% of the total assemblage in any station.

Biofacies	Sample No.	Assemblage
Upper flat	SW 4,6	*Elphidium etigoense*
Lower upper flat	SW 9	*Discorbis candeians* *Elphidium asiaticum*
Upper middle flat	SW 12, 15, 18	*Ammonia beccarii tepida* *Elphidium etigoense*
Lower middle flat	SW 21, 25, 27	*Ammonia beccarii tepida* *Eponides nipponicus*
Lower flat	SW 30	*Ammonia beccarii tepida*

biofacies for total foraminiferal assemblages (Table 2) were recognized by the distribution of dominant species in the five *a priori* subenvironments of Gomso-Bay tidal flat. Dominant species represent more than 20% of the total assemblage in any station within a priori subenvironments. The dominant species in the Line-SW were *Ammonia beccarii tepida, Discorbis candeiana, Elphidium asiaticum, Elphidium etigoense* and *Eponides nipponicus*. The five biofacies in the Line-SW are as follows; I. upper flat: *Elphidium etigoense* assemblage, II. lower upper flat: *Discorbis candeiana-Elphidium asiaticum* assemblage, III. upper middle flat: *Ammonia beccarii tepida-Elphidium etigoense* assemblage, IV. lower middle flat: Ammonia beccarii tepida-Eponides nipponicus assemblage, and V. lower flat: *Ammonia beccarii tepida* assemblage.

The upper flat (SW4, 6) was dominantly composed of *Elphidium etigoense*. This species consisted of 85~95% of the total assemblage (Fig. 5). The protected muddy substrate (89~93% mud) probably produced a peak density of *Elphidium etigoense*. This biofacies can be distinguished from the other biofacies based on the abundance of *Elphidium etigoense*.

The lower upper flat (SW9) was characterized by *Discorbis candeiana* and *Elphidium asiaticum* (Fig. 6). This biofacies had only a few foraminifers (14 specimens per 50 ml). This area occurred on the front of the chenier and consisted of very poorly sorted silty sand. The high wave and tidal influence

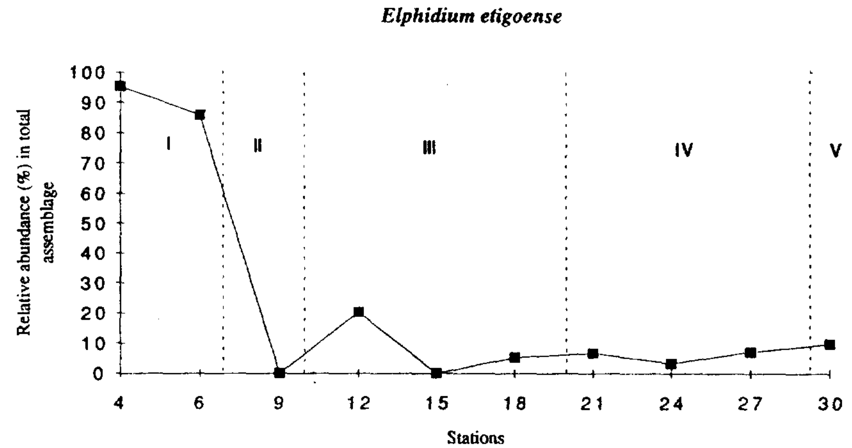

Fig. 5. Relative abundance (%) of *Elphidium etigoense* in total assemblages at 10 stations in the Line SW. Subenvironment I is the upper flat (stations 4, 6). Subenvironment II is the lower upper flat (station 9). Subenvironment III is the upper middle flat (stations 12, 15, 18). Subenvironment IV is the lower middle flat (stations 21, 24, 27). Subenvironment V is the lower flat (station 30).

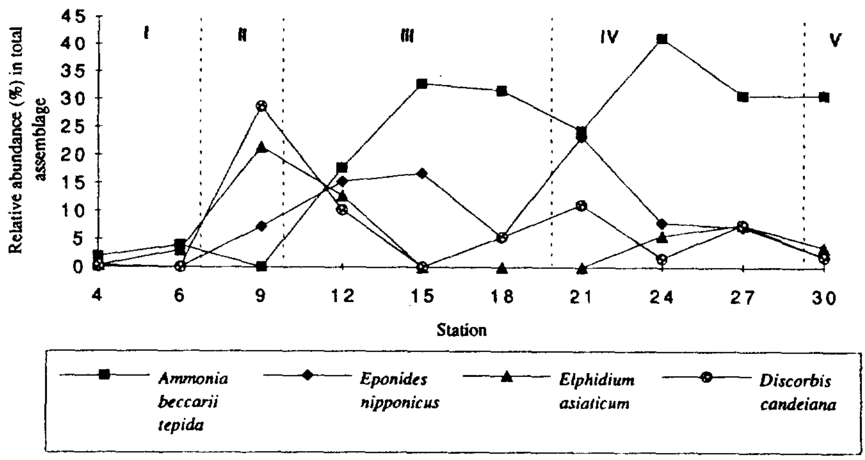

Fig. 6. Relative abundance (%) of *Ammonia beccarii tepida*. *Eponides nipponicus*. *Elphidium asiaticume*, and Discorbis *candeiana* in total assemblages at 10 stations in the Line-SW. See Fig. 4 for subenvironments.

is probably responsible for the sparsity of foraminiferal specimens.

The two biofacies (upper middle flat and lower middle flat) were closely related. *Ammonia beccarii tepida* and *Elphidium etigoense* were dominant at upper middle flat (SW12, 15, 18) and *Ammonia beccarii tepida* and *Eponides nipponicus* were dominant at lower middle flat (SW21, 24, 27) (Figs. 5 and 6). These areas had high percentages of sand (more than 90%) with an abundance of *Ammonia beccarii tepida*. The two biofacies are similar but the relative abundances of *Elphidium etigoense* and *Eponides nipponicus* were different.

The lower flat (SW30) was characterized by *Ammonia beccarii tepida* (Fig. 6). This area consisted of poorly sorted silty sand (73% sand). The relatively high number of species (S=39) and one dominant species, *Ammonia beccarii tepida* (30.8%), may be affected by the addition of rare species from offshore. This biofacies can be distinguished from the other biofacies based on the abundance of *Ammonia beccarii tepida*.

CONCLUSIONS

The distribution of foraminifera in late Quaternary coastal sediments is not believed to be significantly different from that of the modern species (Bandy, 1956). Thus, since the modern foraminiferal assemblages are closely related to fossil assemblages found in late Quaternary deposits, they should be useful for paleoenvironmental interpretations. The dominant foraminiferal species of total assemblages of the five *a priori* subenvironments have five well-defined assemblages (Table 2) and also are potentially useful in paleoenvionmental interpretations in late Quaternary tidal deposits of Gomso Bay. The apparent key species with limited facies range in the present-day assemblages should be facilitated facies definition. For example, *Elphidium etigoense* is key species used in the upper flat biofacies. However, such interpretations must be made with care and it is necessary to analyze the combinations of sedimentary characteristics with faunal features. The taphonomic processes from living to total to fossil assembalges result in the reduction of the tests in the substrates. On the basis of this study, modern sediment characteristics and foraminiferal data are useful for discriminating five subenvironments of Gomso-Bay tidal flat, and provide a model for paleoenvironmental interpretations in late Quaternary Gomso-Bay tidal deposits.

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APPENDIX. Relative abundance (percent frequency) for living and total (living plus dead) assemblages in surface sediments from 10 stations in the Line-SW.

Sample		SW 4	SW 6	SW 9	SW 12	SW 15	SW 18	SW 21	SW 24	SW 27	SW 30
No. of species	L	5	5	4	3	3	3	4	6	3	5
(Live/Total)	T	8	10	7	16	15	9	19	23	26	39
No. of individuals per fraction	L	259	145	8	19	18	3	11	15	8	8
picked (Live/Total)	T	314	336	14	79	67	19	90	126	240	227
Extrapolated No. of individuals	L	2072	290	8	19	18	3	11	15	16	8
per 50 ml (Live/Total)	T	2512	672	14	79	67	19	90	126	480	227
Relative abundance (%)	L	82.5	43.2	57.1	24	26.9	15.8	12.2	11.9	3.3	3.5
(Live/Dead)	D	17.5	56.8	42.9	76	73.1	84.2	87.8	88.1	96.7	96.5
Elevation (cm) (MSL datum)		224.1	229.7	149.9	109.5	73.4	61.6	-91.8	-80.8	-98.1	-148
Fraction Picked		1/8	1/2	1	1	1	1	1	1	1/2	1
ANOMALIA GLABRATA	L										
	T				1.3						
ANOMALINA GLOBULOSA	L										
	T				1.3						
AMMONIA BECCARII BECCARII	L										
	T					1.5					
AMMONIA BECCARII PARKINSONIANA	L								13.3		12.5
	T				3.8	9	21.1	3.3	6.3	1.3	4
AMMONIA BECCARII TEPIDA	L	0.8	1.4			27.8		9.1	33.3	37.5	37.5
	T	1.9	3.9		17.7	32.8	31.6	24.4	41.3	30.8	30.8
AMMONIA COMPRESSIUSCULA	L										
	T									1.3	
AMMONIA NAKAMURAI	L										
	T					3		2.2	3.2	5.8	7.9
AMMONIA sp. A	L										
	T					3					
AMMONIA sp. B	L										
	T						10.5				
AMPHICORYNA SPICATA	L										
	T							1.1	0.8		0.4
ASTRONONION ITALICUM	L										
	T										1.3
BOLIVINA FLORIDANA	L										
	T									0.8	
BOLIVINA ORDINARIA	L										
	T								1.6	2.1	
BOLIVINA ROBUSTA	L										
	T								0.8	0.8	2.6
BOLIVINA STRIATULA	L										
	T										0.4
BOLIVINA SUBSPINESCENS	L										
	T										0.4
BUCCELLA FRIGIDA	L										
	T				1.3	10.4		2.2	2.4	3.3	1.8
BULIMINA ELONGATA SUBULATA	L										
	T						5.3				0.4
BULIMINA EXILIS TENUATA	L										
	T									0.4	
BULIMINA MARGINATA	L										
	T				2.5						
BULIMINA sp. A	L										
	T										0.4
BULIMINELLA ELEGANTISSIMA	L										
	T										0.4
CANCRIS AURICULA	L										
	T		0.3			1.5			0.8		
CANCRIS sp. A	L										
	T		0.3								
CASSIDULINA CARINATA	L										
	T										1.3
CIBICIDES LOBATULUS	L										
	T										0.9
CIBICIDES REFULGENS	L										
	T									0.4	1.8

Sample		SW 4	SW 6	SW 9	SW 12	SW 15	SW 18	SW 21	SW 24	SW 27	SW 30
CRIBRONONION SUBINCERTUM	L			25							
	T			14.3							
DENTALINA YABEI	L										
	T								0.8		
DISCORBIS CANDEIANA	L	0.4		37.5	26.3		33.3	18.2	13.3		12.5
	T	0.3		28.6	10.1		5.3	11.1	1.6	7.5	1.8
ELPHIDIUM ASIATICUM	L		0.7								
	T	0.3	3	21.4	12.7				5.6	7.5	3.5
ELPHIDIUM ETIGOENSE	L	97.3	95.9		63.2		33.3	9.1	20	12.5	
	T	95.2	85.7		20.3		5.3	6.7	3.2	7.1	9.7
ELPHIDIUM EXCAVATUM	L										
	T				6.3	7.5		10	5.6	10.8	5.7
ELPHIDIUM JENSENI	L										
	T										0.9
ELPHIDIUM KUSIROENSE	L										
	T					1.5		1.1			
ELPHIDIUM OZAWAI	L										
	T		1.8								
ELPHIDIUM POEYANUM	L										
	T								2.4		
ELPHIDIUM SELSEYENSIS	L			25							
	T			14.3							
ELPHIDIUM SUBEVOLUTUM	L										
	T							1.1			
ELPHIDIUM SUBINCERTUM	L					66.7					
	T					19.4	10.5		1.6		
ELPHIDIUM sp. A	L										
	T	0.3									
ELPHIDIUM sp. B	L										
	T				1.3						
ELPHIDIUM sp. C	L										
	T					1.5					
EOEPONIDELLA PULCHELLA	L										
	T									0.4	
EPISTOMINELLA NARAENSIS	L										
	T							1.1	3.2	3.3	6.6
EPISTOMINELLA sp. A	L										
	T					1.5					
EPONIDES NIPPONICUS	L				10.5	5.6	33.3	63.6	13.3	50	25
	T			7.1	15.2	16.7	5.3	23.3	7.9	7.1	1.8
FISSURINA LAEVIGATA	L										
	T				1.3			1.1	1.6	1.3	0.9
FISSURINA MARGINATA	L										
	T				1.3					1.3	0.4
FLORILUS GRATELOUPI	L										
	T	0.3	0.3								0.9
GLOBIGERINA ATLANTISAE	L										
	T							2.2		1.3	1.3
GLOBIGERINA BULLOIDES	L										
	T								4	1.3	
GLOBIGERINITA GLUTINATA	L										
	T				1.3			2.2	0.8	2.5	3.1
GLOBOCASSIDULINA PARVA	L										
	T										0.4
GLOBOQUADRINA HEXAGONA	L										
	T									0.4	0.9
GLOBOROTALIA CRASSAFORMIS	L										
	T				2.5						
GLOBOROTALIA INCISA	L										
	T							2.2			
GLOBULINA MINUTA	L										
	T							1.1			
GYROIDINOIDES sp. A	L								6.7		
	T								0.8		
LAGENA HISPIDULA	L										
	T										0.4
NEOGLOBOQUADRINA PACHYDERMA	L										
	T								0.8	0.4	
PROTEONINA COMPRESSA	L										
	T										0.4

Sample		SW 4	SW 6	SW 9	SW 12	SW 15	SW 18	SW 21	SW 24	SW 27	SW 30
PSEUDONONION JAPONICUM	L	1.2	1.4								
	T	1.3	4.2					1.1			0.4
PULLENIA BULLOIDES	L										
	T					1.5					
PULLENIA QUINQUELOBA	L										
	T			7.1							
QUINQUELOCULINA SEMINULA	L	0.4	0.7								
	T	0.3	0.3			1.5		2.2	3.2	0.4	0.4
REOPHAX sp. A	L										
	T										0.4
ROSALINA GLOBULARIS	L										12.5
	T										0.9
ROSALINA ISABELLEANA	L										
	T										1.3
ROSALINA VILADEBOANA	L										
	T									0.4	1.8
ROSALINA sp. A	L			12.5							
	T			7.1							
TEXTULARIA sp. A	L										
	T										0.4
TROCHAMMINA CHARLOTTENSIS	L										
	T						5.3				0.4
TROCHAMMINA INFLATA	L										
	T		0.3								