Korean Journal of Polar Research
Vol.2, No.2, p.61~71, December 1991

Preliminary Study on the Macrobenthic Community of Maxwell Bay, South Shetland Islands, Antarctica

In-Young Ahn and Young-Chul Kang

Polar Research Center, Korea Ocean Research & Development Institute,
Ansan, P.O.Box 29, Seoul 425-600, Korea

남극 남쉐틀란드군도 맥스웰만의 대형저서동물군집에 관한 기초연구

안인영 · 강영철

한국해양연구소 극지연구센터

Abstract : Macrobenthic faunas were grab-sampled from 11 stations in Maxwell Bay, South Shetland Islands, Antarctica February 4 through 6, 1989. Substrate type is varied, ranging from mud to gravelly muddy sand. Biomass ranges from 0.3 to 154g wet wt per $0.1m^2$ (79 inds. x $0.1m^{-2}$). The highest biomass occurred in muddy bottom on the bed slope at a depth of 342m and the lowest in anoxic muddy bottom of the central deep basin (400~500m). Polychaetes are the most abundant faunal group, comprising 68% of the total biomass. Echinoderms are the next commonly occurring group, making up 22% of the total biomass. Bivalves comprise 5% of the samples in terms of numbers but form only 1.4% of the total biomass due to their small body sizes. Species composition seems to be related to the sediment type. In muddy bottom the deposit-feeders such as the tube-building polychaete *Maldane sarsi antarctica* are well represented. On the other hand, in sandy bottom of Bransfield Strait benthic fauna is more diverse although only a few individuals were sampled for each of the majority of the species. The large polychaete species *Pista spinifera* and *Neoamphitrite affinis antarctica*, the mobile epifauna such as decapods, amphipods, isopods and pycnogonids, the deposit-feeding holothuroids, and the suspension-feeding cirripedes occur in sandy bottom.

Key words : Antarctica, Maxwell Bay, Bransfield Strait, soft bottom, macrobenthos, polychaetes, echinoderms, biomass, species composition

요약 : 남극 남쉐틀란도군도 맥스웰만의 연성 저질에 서식하는 대형저서동물들을 1989년2월4일부터 2월6일에 걸쳐, 11개의 정점에서 채니기로 채집하였다. 저질의 형태는 니질(mud)에서 자갈이 섞인 니사질(muddy sand)에 이르기까지 다양하다. 생물량은 채니기당($0.1m^2$) 0.3~154g으로 평균값은 45g(79개체)/$0.1m^2$이다. 생물량은 만 안쪽 수심 342m의 니질의 경사면에서 가장 높고, 수심 400~500m의 무산소성 니질(anoxic mud)로 덮여있는 중앙의 골에서 가장 낮다. 갯지렁이류가 가장 많이 출현하며 습중량이 총생물량의 68%에 이른다. 극피동물이 다음으로 많이 출현하며 총생물량의 22%에 달한다. 이매패류는 개체수로는 총채집개체의 5%에 달하나 크기가 작아 습중량은 1.4%에 불과하다. 종조성은 저질의 형태와 관련이 있는 것으로 보이는데, 만 안쪽 니질에서는 소형의 갯지렁이류인 *Maldane sarsi antarctica*가 우점하며, 만 바깥쪽 브랜스필드해협의 니사질에서는 대형의 갯지렁이류인 *Pista spinifera*와 *Neoamphitrite affinis antarctica*, 십각류, 단각류, 등각류, 따개비 그리고 해삼류등이 다양하게 출현한다.

주요어 : 남극, 맥스웰만, 브랜스필드해협, 연성저질, 대형저서동물, 갯지렁이류, 극피동물, 생물량, 종조성

Introduction

The littoral and shallow sub-littoral zones in Antarctic waters are subject to fluctuating environmental conditions caused by the ice abrasion and by the inflow of icemelt water. In deeper water, however, benthic environment is characterized by stable and uniform physical regime, and benthic communities exhibit high diversity and biomass comparable with those in other areas of the world's oceans (reviewed by Picken, 1985a).

Antarctic benthic samples have been amassed since the earliest voyages of exploration (reviewed by Dell, 1972), but our understanding about taxonomy, systematics and biogeography is unsatisfactory. The qualitative and quantitative description of the benthos is still continuing (reviewed by Picken, 1985b).

Despite the increasing human activities in Maxwell Bay, no qualitative or quantitative studies on benthic communities of the bay have been reported yet. This paper presents preliminary data on the abundance and species composition of benthic macrofauna and the nature of sediment environment in Maxwell Bay.

Environment

Maxwell Bay is a typical U-shaped fjord characterized by a deep sill (Park et al., 1989) and a relatively small amount of freshwater input (Chang et al., 1990). Geographic location of Maxwell Bay and Bathymetric contours in the bay are shown in Fig. 1. The bay is about 18km long and 6 to 14km wide, and surrounded by King George Island and Nelson Island which belong to South Shetland Islands. To the northwestern end of the bay, between King George and Nelson Islands, lies Fildes Strait which is 400 ~800m wide and connected to Drake Passage. The mouth of the bay is open to Bransfield Strait. Water

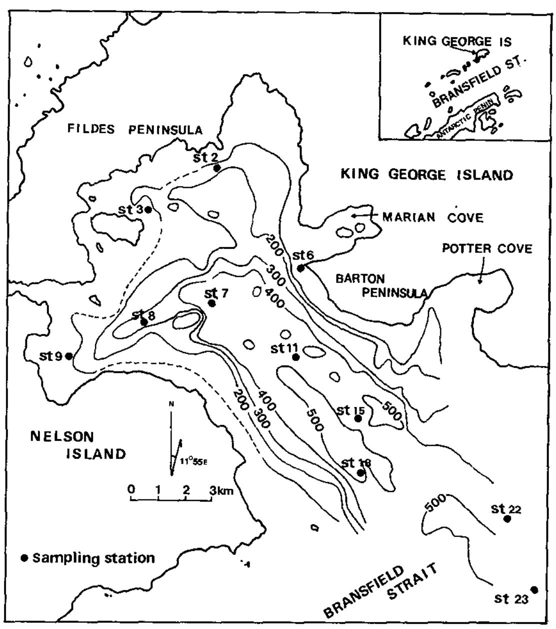

Fig. 1. Geographic location of Maxwell Bay and the sampling stations in the bay. Bathymetric contours are drawn based on the information given by Instituto Hidrografico de la Armada de Chile(1989).

depth gently increases from the coastline to 200m depth, but sharply increases from 200m to 400m. The central part of the bay is relatively flat, ranging from 400m to 500m in depth. The surface layer of the bay was frozen during the preceding winter, from the late July to the mid-September, 1988. As spring progressed sea ice melted, and fresh water input occurred. Druing the sampling period water temperature ranged from -0.1℃ to 1.5℃, decreasing with depth. Salinity varied from 33.5‰ to 34.6‰, gradually increasing with depth. However, at the head of the bay the surface temperature was lower than that at 5~10m, and the salinity sharply dropped toward surface due to thawing of sea ice (Chang et al., 1990). Mean air temperature was 2.5℃ in February, 1989. Details of meteorological observation at King Sejong Station was described in Lee et al.(1990).

Materials and Methods

Eleven stations were selected for benthos sampling at various points in Maxwell Bay (Fig.1). Samples were collected with a van Veen grab which covered an area of 0.1m² to a sediment depth of 20cm. One sample was taken at each station aboard M/V Cruz de Froward February 4 through 6, 1989. Subsamples (ca. 500ml) for grain size analysis were scooped from the top 5cm of each undisturbed grab sediment. The rest of the sediment was sieved through 1-mm-mesh screen in order to extract macrofauna. Extracted animals were fixed in 10% formalin and transported to the lab in King Sejong Station, King George Island. Animals were sorted into major faunal groups. Polychaetes were identified, if possible, to species. Biomass was expressed in terms of wet weight. Wet weight was determined to the nearest 0.1g from the preserved samples. Polychaete tubes and bivalve shells were included in the measurement of wet weight.

Results

Sediment Type and Sampling Depth

Bottom Substrate is varied from mud to gravelly muddy sand (Table 1). Sediment tends to become coarser toward the coast and also toward Bransfield Strait. Stations 22 and 23 are located at Bransfield Strait and bottom sediment is characterized by relatively high content of sand. These two stations are separated from the other stations in Maxwell Bay by a sill at a depth of 430m. Station 6, which is shallow and close to land, is subject to ice scour, and its sediment consists of nearly 60% of sand and gravel. The central basin is covered with 92~94% of mud, and anoxic mud was sampled at stations 7 and 11. Sampling depth ranged from 40 to 498m.

Table 1. Depth and substrate composition of the sampling stations in Maxwell Bay. Subsamples (ca. 500ml) for grain size analysis were taken from the top 5cm of the undisturbed grab sediment. Stations are rearranged in order of sediment grain size (coarse to fine).

St.	Depth(m)	Gravel(%)	Sand(%)	Mud(%)
23	425	2.56	64.94	32.5
6	40	10.29	47.07	42.64
22	440	0.19	26.95	72.86
9	80	0.08	19.85	80.07
8	342	1.29	17.4	81.31
18	520	0	10.66	89.34
2	150	3.33	7.14	89.53
3	90	0.9	8.8	90.3
15	498	0.32	6.5	93.18
11	470	0	7.39	92.61
7	440	0.24	6.41	93.35

Abundance and Species Composition of Macrofauna

Biomass shows a considerable variation among the stations, ranging from 0.3 to 154g wet wt (3 to 422 ind.) per $0.1m^2$ (Table 2 and Fig. 2). The mean values of wet weight and number of individuals are 45g x $0.1m^{-2}$ and 79 inds. x $0.1m^{-2}$, respectively. Biomass is the highest at muddy bottom of St. 8 (342m), moderately high at muddy bottom of St. 2 (150m) and in sandy bottom of Sts. 22 (440m) and 23 (425m) in Bransfield Strait. Anoxic muddy bottom of Sts. 7 and 11 (440 and 470m) and muddy bottom of St. 18 at the central basin (520m) are almost devoid of macrofauna.

Polychaetes are the most abundant fauna, comprising 69% of total wet weight and 74% of total number, and occur in all stations except St. 11

Table 2. Abundance and species composition of macrofaunal communities in Maxwell Bay. Values are the biomass for each species or faunal group (g wet wt/$0.1m^2$). The numbers in parentheses are the number of individuals for the same sample. + : present but less than 0.1g

Species	Stations										
	2	3	6	7	8	9	11	15	18	22	23
POLYCHAETES											
Maldane sarsi antarctica	25.6(57)	13.2(34)			124.1(400)						
Potamilla antarctica	29.7(22)	4.8(8)	9.7(5)		3.8(2)					13.1(37)	
Pista spinifera										15.9(2)	13.8(5)
Neoamphitrite affinis antarctica											16.4(2)
Polychaete sp. A					17.7(3)	4.6(4)					28.1(15)
Others	4.5(1)	2.5(5)		0.8(1)	2.8(1)	2.1(18)		0.5(5)	5.3(1)	0.5(16)	
ECHINODERMS											
Echinoidea		0.5(5)						5.8(51)			
Ophiuroid sp. A	1.6(2)	11.2(3)	10.4(4)			0.9(1)		13.5(3)		7.3(4)	
Ophiuroid sp. B		0.4(7)	0.2(8)		0.6(6)					0.4(2)	0.4(7)
Holothuroid sp. A										16.6(1)	37.3(1)
Holothuroid sp. B										3.6(7)	
Crinoidea										+(1)	
MOLLUSKS											
Bivalves	1(2)	1(1)		0.2(2)	+(3)	2.3(2)	0.3(4)	1.6(21)	0.2(4)	+(2)	0.4(5)
Gastropods										+(1)	0.3(2)
Scaphopods					+(3)			0.4(9)	+(1)	+(1)	+(4)
CRUSTACEANS											
Decapods											1.2(2)
Amphipods										+(1)	+(7)
Isopods											+(4)
Cirripedes											+(2)
Pycnogonids										0.1(3)	+(2)
ASCIDIANS	14.8(1)		8.7(2)								
BRYOZOANS	2.1(3)	1.2(3)			+(2)	3.2(4)					0.7(3)
COELENTERATES											
Primnoella sp.					5.4(2)						
Total wet weight	79.3	34.8	29	1	154.4	13.1	0.3	21.8	5.5	57.5	98.6
Total No. of ind.	88	66	19	3	422	29	4	89	6	78	61

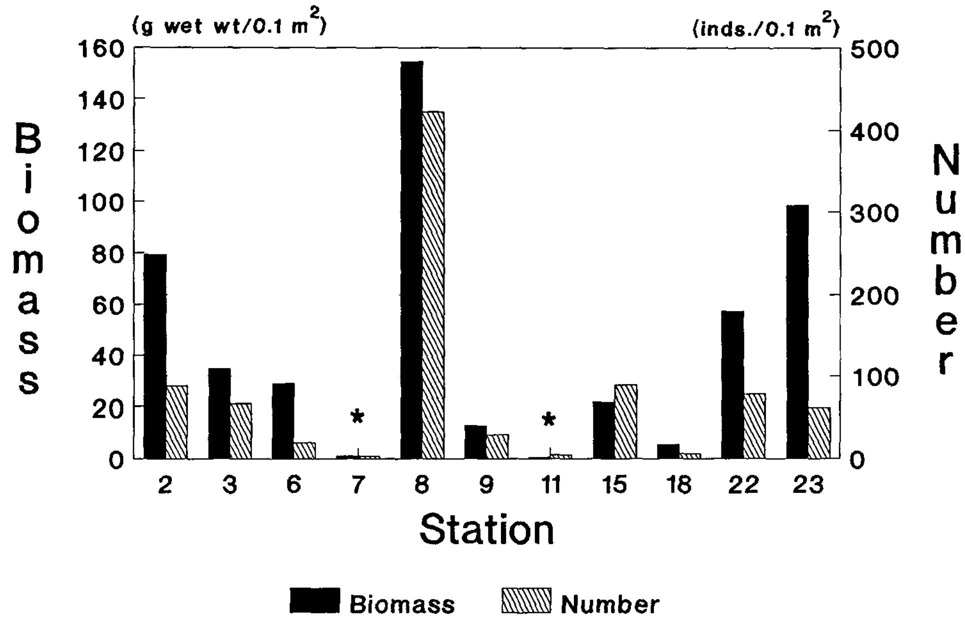

Fig. 2. Biomass of macrobenthic fauna in terms of wet weight and number of individuals per grab ($0.1m^2$)in the sampling stations of Maxwell Bay. * : Black mud was sampled.

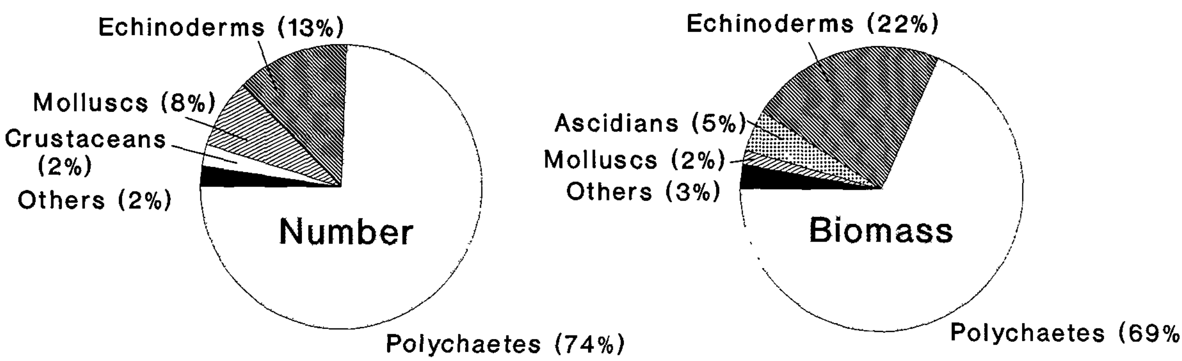

Fig. 3. Major components of the macrobenthic infaunal community of Maxwell Bay in terms of number and wet weight.

(Table 2 and Fig. 3). Echinoderms are the next commonly occurring group, forming 22% of the total biomass and about 89%, 49%, 39%, 37% and 35% of the biomass at stations 15, 22, 23, 6 and 3. Bivalves were sampled at 7 out of 11 stations but form only 2% of total biomass due to their small body sizes. Only three ascidians were sampled from 2 stations but they comprise 5% of the total biomass because of their large body size.

Of the polchaetes, the tube-building *Maldane sarsi antarctica* is the most dominant species, forming 33% of total biomass and comprising 80%, 38% and 32% of the total biomass at stations 8, 3 and 2, respectively (Table 3 and Fig.4). Another polychaete species *Potamilla antarctica* is the next abundant species, making up about 12% of the total biomass and about 38%, 33% and 23% of the biomass at stations 2, 6 and 22, respectively.

Table 3. Structure of macrobenthic communities in Maxwell Bay with the species or faunal groups listed in order of biomass (high to low). The biomass values from 11 stations were pooled together. Numbers in the parentheses are the number of individuals for the same species or faunal group. P:polychaetes, E:echinoderms, C:crustaceans, Co:coelenterates, M:mollusks, A:ascidians, +:present but less than 0.1g or 0.1%.

Species	Biomass		
	g wet wt.	%	cumulative %
Maldane sarsi antarctica(P)	162.9(491)	32.9	32.9
Potamilla antarctica(P)	61.1(74)	12.3	45.2
Holothuroid sp. A(E)	53.9 (2)	10.9	56.1
Polychaete sp. A(P)	50.4 (22)	10.2	66.3
Ophiuroid sp. A(E)	44.9 (17)	9.1	75.4
Pista spinifera (P)	29.7 (7)	6.0	81.4
Neoamphitrite affinis antarctica (P)	16.4 (2)	3.3	84.7
Ascidian sp. A(A)	14.8 (1)	3.0	87.7
Aglaophamus sp.(P)	13.0 (5)	2.6	90.3
Ascidian sp. B(A)	8.7 (2)	1.8	92.1
Bryozoans	7.2 (15)	1.5	93.6
Bivalves(M)	7.0 (46)	1.4	95.0
Echinoidea(E)	6.3 (56)	1.3	96.3
Primnoella sp.(Co)	5.4 (2)	1.1	97.4
Holothuroid sp. B(E)	3.6 (7)	0.7	98.1
Sabellaria sp.(P)	3.0 (6)	0.6	98.7
Ophiuroid sp. B(E)	2.0 (30)	0.4	99.1
Polychaete sp. B(P)	1.4 (16)	0.3	99.4
Decapods(C)	1.2 (2)	0.2	99.6
Nicomache lumbricalis(P)	0.8 (1)	0.2	99.8
Polychaete sp. C(P)	0.6 (15)	0.1	99.9
Scaphopods (M)	0.4 (18)	0.1	100.0
Gastropods(M)	0.3 (3)	+	
Polychaete sp. D(P)	0.2 (5)	+	
Pcynogonids(C)	0.1 (5)	+	
Amphipods(C)	+ (8)	+	
Isopods(C)	+ (4)	+	
Cirripedes(C)	+ (2)	+	
Crinoidea(E)	+ (1)	+	

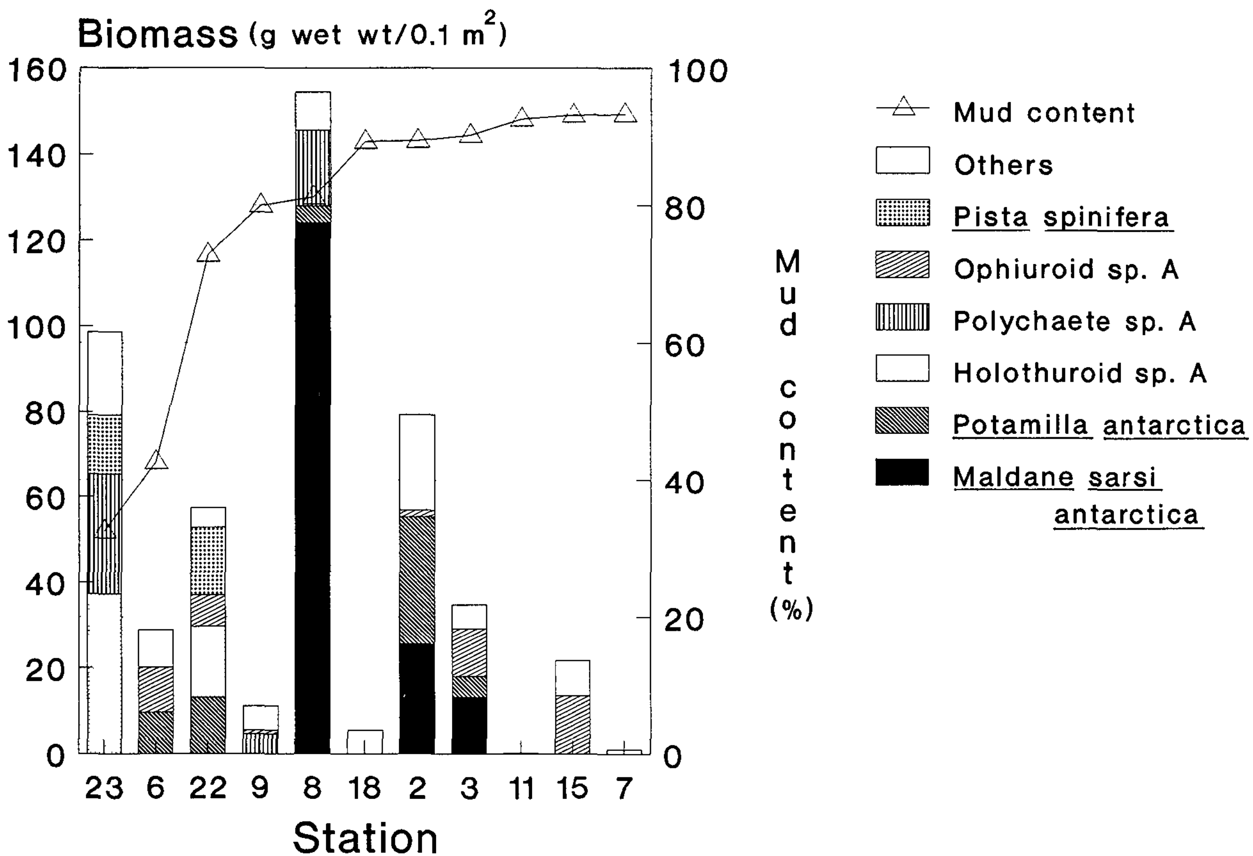

Fig. 4. Composition of dominant macrobenthic species at the sampling stations of Maxwell Bay. Stations are rearranged in order of sediment grain size (coarse to fine). Black mud was sampled from Sts. 7 and 11.

Discussion

Stations 22 and 23 in Bransfield Strait are separated from the rest of the stations in Maxwell Bay by a sill at a depth of 430m. The substrates at these stations are strikingly different from those of the stations in the bay at similar depths. Coarser sediment at the stations 22 and 23 reflects stronger water movement in Bransfield Strait than in Maxwell Bay. In contrast, anoxic mud at the stations 7 and 11 implies restricted water circulation in the central basin of the bay.

St. 6 is shallow and close to land, thereby subject to repidly fluctuating environment conditions caused by melt-water inflow from surrounding icefield and by breakup of drifting icebergs. The sediment consists of muddy sand mixed with substantial amount of terrigenous gravel particles.

The mean biomass value of 45 g (79 inds.) x $0.1m^2$ is comparable to those at the shallow mobile substrates (3~35m) at Signy Island, South Orkney Islands (Hardy, 1972), but one order of magnitude lower than those in Arthur Harbor (Lowry, 1975) and two to three orders of magnitude lower than those in the shallow shelf areas (20~40m) in McMurdo Sound, Ross Sea (Dayton and Oliver, 1977) (Table 4).

Due to the lack of replicates and the inadequacy of van Veen grab in sampling mobile epifauna and deep-burrowing infauna, it is rather difficult to evaluate the data quantitatively. However, the following speculation can be made. The lack of fauna at the stations of the central basin appears due to the anoxic condition of bottom sediment, and the low biomass at the stations near the coast seems to be due to the ice abrasion or due to freshwater inflow. During the sampling period ice floes were observed in the bay, and the substrates at shallow depths were frequently scourced by drifting ices.

There is an alternative explanation for the lack of fauna at St. 6. Mobile epifauna and deep-burrowing infauna, such as *Laternula elliptica* which is common in shallow Antarctic waters (Hardy, 1972; Ralph and Maxwell, 1977: Fischer and Hureau, 1985), could not be adequately sampled with van Veen grab. Densely-packed siphones of *L. elliptica* were observed by SCUBA diving in the shallow waters of Marian Cove in Maxwell Bay (personal observation).

The low benthic biomass may also be related to the low level of pelagic production in this area. Primary production which was measured 1 week prior to the present study (Yang, 1990) is close to those reported in oligotrophic regions (〈$0.1gC/m^2$/day). Higher values, which are comparable to the highly productive areas in the world's ocean, such as the upwelling systems off Peru, were reported in several coastal regions and in the Vicinity of Antarctic islands (Table 5).

Table 4. Comparison of macrobenthic biomass in Maxwell Bay with those of other Antarctic shelf waters.

Site	Dominant Gr.	Biomass per sq. m.	Reference
Maxwell Bay	Polychaetes	450g (790 inds.)	This study
McMurdo Sound	Arthropods, Polychaetes	2184~145782 ind.	Dayton and Oliver (1977)
Arthur Harbor	Polychaetes, Arthropods, Bivalves	6285~7629 inds.	Lowry (1975)
Signy Is.	Polychaetes, Bivalves	300~800g	Hardy (1972)

Table 5. Comparison of the primary productivity in Maxwell Bay, which was measured 1 week prior to the present study, with those reported in other Antarctic waters.

Site	Primary productivity g $C/m^2/day$	Reference
Maxwell Bay	0.30	Yang (1990)
Gerlache St.	3.20	Reviewed by El-Sayed (1984)
Deception Is.	3.62	Reviewed by El-Sayed (1984)
Signy Is.	2.80	Reviewed by El-Sayed (1984)
Ross Sea	1.00	El-Sayed et al. (1983)

The relationship between the productivity of the water column and the benthic production has been studied in some detail at McMurdo Sound (Dayton and Oliver, 1977). Dayton and Oliver suggested that the diverse and abundant benthic biomass on the east side of the sound result from the eutrophic and organically rich water flowing above the benthos, and in contrast, the lower benthic biomass on the west side result from the oligotrophic, nutrient-poor water flowing from the permanent ice-shelf. It remains to be determined whether Maxwell Bay is oligotrophic and whether the low values of benthic biomass are directly related to the low level of food input from water column.

Species composition is greatly different between Maxwell Bay and Bransfield Strait. In Maxwell Bay deposit-feeders are well represented. The tube-building polychaete *Maldane sarsi antarctica* occurs in dense patches at the muddy stations on the bed slope of the bay, comprising 80%, 38% and 32% of the total biomass at Sts. 8, 3 and 2, respectively (Fig.4). On the other hand, in Bransfield Strait (Sts. 22 and 23) macrofauna is more diverse although only a few individuals were sampled for each of the majority of the species. The larger (>10cm in body length) polychaete species *Pista spinifera* and *Neoamphitrite affinis antarctica*, the mobile epifauna such as decapods, amphipods, isopods and pycnogonids, the deposit-feeding holothuroids, and the suspension-feeding cirripedes occur at Sts. 22 and 23.

The difference in the species composition between the two neighboring areas appears to result from the difference in sediment type. Animals in the Strait are exposed to open ocean condition and apparently to stronger current which carries away fine sediment partcles. On the other hand, the water motion may be slackened as it enters the bay, and as a result fine sediment partcles deposit on the bottom. Chang et al. (1990) reported that the hydrological features of the deep water in Bransfield Strait are greatly modified as it enters the bay. The deep sill may also cause some influence on the circulation of the deep water, thereby resulting in the different sediment environment between Maxwell Bay and Bransfield Strait at similar depths.

Ophiuroids and the polychaete *Potamilla antarctica* occur in various sediment types in both Maxwell Bay and Bransfield Strait. Another interesting thing is that small deposit-feeding bivalves, such as *Yoldia eightsi*, which is a dominant member of soft bottom macrofaunal communities in other Antarctic waters (Hardy, 1972; Lowry, 1975; Platt, 1979) are impoverished in this area.

There are several problems in the sampling technique of the present study: the lack of replicates and the inadequacy of van Veen grab in sampling mobile epifauna and the large and deepburrowing infauna. Sampling techniques should be improved for the appropriate estimation of biomass. Furthermore, the interactions of benthic communities with the pelagic ecosystem should be considered in the future study. Benthic response to the highly seasonal pelagic production should be an exciting topic. In particular, autecological studies to quantify the roles of some dominant species such as *Maldane sarsi antarctica* and *Laternula elliptica* in the cycling of organic matter should prove rewarding.

Acknowledgements

We thank Mr. Ho Il Yoon for providing the sediment analysis data. We also thank the members of the second Korean Antarctic Research Team and the crews of M/V Cruz for their emotional support. This work has been conducted as a part of Korea Antarctic Research Program and supported by Ministry of Science and Technology. This work was also partially supported by Korea Ocean Research & Development Institute.

References

Anonymous, 1989. Instituto Hidrografico de la Armada de Chile. Tablas de Marea de la costa de Chile y puertos de la costa Sudamericana. I. H.A. pub. 3009:310

Chang, K.I., H.K. Jun, G.T. Park and Y.S. Eo. 1990. Oceanographic conditions of Maxwell Bay, King George Island, Antarctica (Austral Summer 1989). Korean Journal of Polar Research, 1(1):27-46.

Dayton, P.K. and J.S. Oliver. 1977. Antarctic soft-bottom benthos in oligotrophic and eutrophic environment. Science, 197:55-58.

Dell, R.K. 1972. Antarctic benthos. Adv. mar. Biol., 10:1-216.

El-Sayed, S.Z., D.C. Biggs and O. Holm-Hansen. 1983. Phytoplankton standing crop, primary productivity, and near-surface nitrogenous nutrient fields in the Ross Sea, Antarctica. Deep Sea Research, 30(8A):871-886.

El-Sayed, S.Z. 1984. Productivity of Antarctic Waters. A. Reappraisal. In: Holm-Hansen, O., L. Bolis and R. Gilles (eds.), Marine Phytoplankton and Productivity, Lecture Notes on Coastal and Estuarine Studies, No. 8, p.19-34.

Fischer, W. and J.C. Hureau. 1985. Southern Ocean. FAO Species Identification sheets for fishery purposes. FAO of the United Nations, Vol. 1, P.98.

Hardy, P. 1972. Biomass estimates for some shallow-water infaunal communities at Signy Island, South Orkney Islands, Br. Antarct. Surv. Bull., 31:93-106

Lee, B.Y., D.H. Kim and Y. Kim. 1990. A study on the climate characteristics over King Sejong Station, Antarctica (1988-1989). Korean Journal of Polar Research, 1(1):47-57.

Lowry, J.K. 1975. Soft bottom macrobenthic community of Arthur Harbor, Antarctica. Antarct. Resear. Ser. 23(1), 1-19

Park, B.K., M.S. Lee, H.I. Yoon and S.H. Nam. 1989. Marine geology and petrochemistry in the Maxwell Bay Area, South Shetland Islands. In: Huh, H.T., B.K. Park and S.H. Lee, (eds.), Antarctic Science: Geology & Biology. Korean Ocean Research & Development Institute, 85-119.

Picken, G.B. 1985a. Marine habitats - Benthos. In: Bonner, W.N. and D.W.H. Walton (eds.), Key Environments, Antarctica. Pergamon Press, 154-172.

Picken, G.B. 1985b. Benthic research in Antarctica:

past. present and future, In: Marine Biology of Polar Regions and Effects of Stress on Marine Organisms. Eds. J.S. Gray and M.E. Christianson, John Wiley & Sons Ltd., 167-184.

Platt, H.M. 1979. Ecology of King Edward Cove, South Georgia: Macro-benthos and the benthic enviromnent. Br. Antarct. Surv. Bull., 49:231-238.

Ralph, R. and J.G.H. Maxwell. 1977. Growth of two Antarctic Lamellibranchs: *Adamussium colbecki* and *Laternula elliptica* Marine Biology,42:171-175.

Yang, J.S. 1990. Nutrients, chlorophyll *a* and primary productivity in Maxwell Bay, King George Island, Antarctica. Korean Journal of Polar Research, 1(1):11-18.