

# Long Term Topographic Changes in the Haeundae Region

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**Abstract :** The coastal zone has got settled as an important space topologically and geographically. As such, it provides value according to the uses to which is applied. However, by the excessive development and the shortage of the management, the coastal zone including coastline, beach, bank, tideland and river mouth has been destroyed. Therefore, the ability to detect coastal topographical change has emerged as an important issue. Generally, the monitoring of coastal topographical change is accomplished through aerial photography, direct survey, or the use of topographical mapping. Such data collection makes possible a systematic and scientific analysis. Therefore above all things, accurate data of the costal zone should be collected for the analysis. In this study, we collected data through the sounding and the beach survey and analyzed the topographical change in Haeundae region during long term. As a result, we could acquire not only the coastal depth data but also the data from the GPS surveys. And we examined the feasibility of manufacturing variable thematic maps and surveys and examined these data as the available data when detecting the topographic change quantitatively through the long term monitoring. If the database on the coastal zone are constructed based on data to collect continuously through these studies and are applied to coastal management with GIS technology, it is estimated that the effective monitoring method of the coastal zone, the scientific analysis of causes on the coastal erosion, the real countermeasure on erosion and so on could be provided.

**Keywords:** Sounding, GPS Survey, Topographic Change

## . Introduction

The coastal zone is the region to connect the shore and the ocean. The coastal zone functions as the buffer which protects the shore from the ocean. And it has got settled as an important space topologically and geographically because of the susceptibility in the change of the environment. As such, it provides value according to the uses to which is applied. Keeping pace with the present industrial structure to encourage the export, it is made full use of an industrial location to aggregate densely a population and industrial facilities or a tourist resort including the sand beach and cliffs.

But the environment of the coastal zone has been largely changed because of the excessive development and the shortage of the management. As a result, the coastal zone including coastline, beach, bank, tideland and river mouth has been destroyed.

As a countermeasure on the destruction, the Korean Ministry of Maritime Affairs and Fisheries devised comprehensive plans to prevent the coastal erosion such as coastal improvement projects, the establishment of private organization for the effective management, the development and the construction of monitoring system. Data on coastal, topographical and sounding surveys are necessary to devise a plan and enforce a plan. But existing estimates of lost sand are unlikely to be accurate and studies on the measurement and the prevention of sand loss are rare within Korea.

Son il et al. conducted the leveling and demonstrated the disproportion between supply and removal of deposits has brought about coastal erosion. But field surveys such as the leveling are auxiliary methods, not substantial methods. Though field surveying data are precise, they are ineffective and uneconomic in case of monitoring the coastal zone during a long term. Unlikely field surveys, aerial photos are useful to interpret the change of the coastal topography quantitatively during a long term. So studies on photogrammetry have been carried out widely within Korea. Example of these include 'Coastline change on the Haeundae Beach using digital aerial photo(Choi Chul Uong et al., 2001)' and 'Reliability Examination of Analyzed for Shoreline Change Using Aerial Images(Jung Seung Jin et al., 2003)'. Outside Korea, various GPS techniques applied to precise surveys and navigations mainly are introduced in association with sounding instruments or photogrammetry instruments for monitoring the coastal zone. M. El-Raey et al. detected the volume change applying Landsat MSS images and profiles obtained from hydrographical survey, not as of old. R.L. Shrestha et al. collected data on the coastline annually using airborne laser swath mapping technique and compared these with GPS surveying results.

As above, various studies on basic monitoring through analyzing causes of the coastal topographic change or countermeasures to prevent the coastal erosion have been conducted. However, above all things, accurate data of the costal zone should be collected. Therefore, in this paper, we monitored Haeundae beach, Korea using results obtained from the sounding and the beach survey.

## **. Marine topographic change for 25 years**

### **1. Acquisition of spatial data on marine topography from sounding**

To examine the change of the Haeundae marine topography for 25 years, we received sounding results surveyed in 1980, 1994 and 2005 that the South Sea Oceanographic Research Office, of National Oceanographic Research Institute of Korea owns.

As Fig. 1, we overlaid results obtained from sounding with digital maps issued by National Geographic Information Institute of Korea in 2000 and generated original survey drawings of Haeundae. We extracted marine digital elevation model(DEM)s from original survey drawings using Intergraph MTA&InRoads software, as raster data consisted of grids are more useful to compute the depth of the water, the area and the volume than vector data.

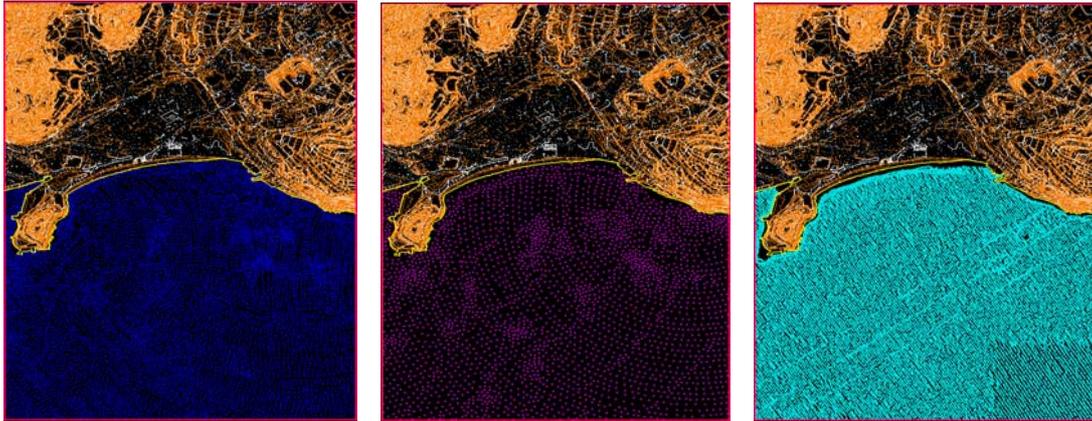


Fig. 1 Original survey drawings of Haeundae beach (1980, 1994, 2005)

## 2. Analysis of marine topographic changes using sounding

### 2.1. Visible analysis

We derived each isobaths from marine DEMs and overlaid these with marine DEMs. As a result of the visual analysis, the erosion generally has happened up to 300m away from the beach including Dongback island and Mipo. And reef zones are clearly evident on several places.

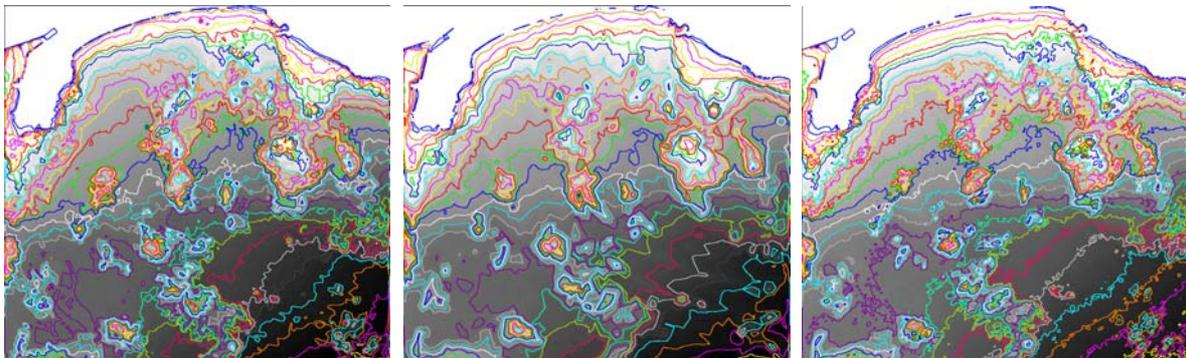


Fig. 2 Isobaths of Haeundae beach (1980, 1994, 2005)

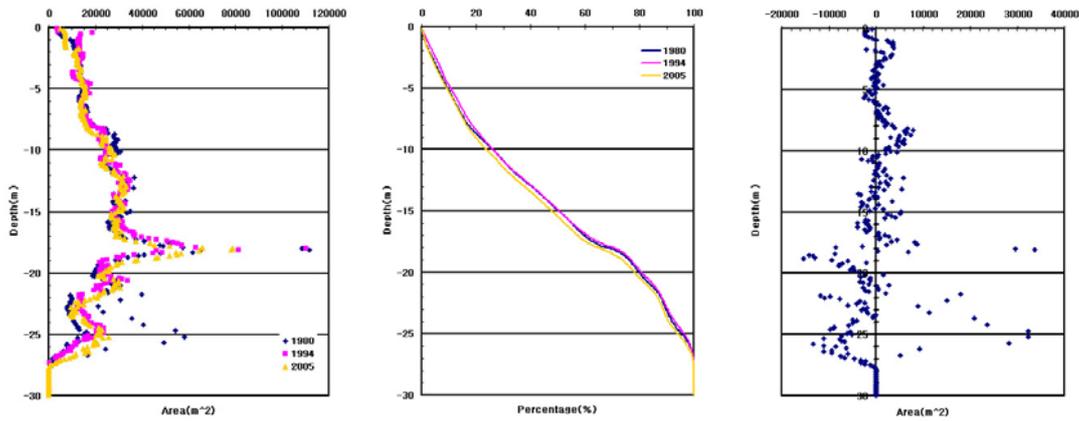
### 2.2 Quantitative Analysis of marine topographic change by depths of water

As a result of statistical analysis of marine DEMs, total volume of marine topography is 89763216 and has gained in quantity as 2207884 for 25 years. But the mean depth of water and total area are -14.8906m, 6028168 and have diminished in quantity as 0.39m, 11028 .

The area by the sounding indicated that the increase was generated at 0~1m, decrease at 1~5m, increase at 5~6m, decrease at 6~10m, increase at 10~11m, decrease at 11~13m and decrease above 13m during 25 years. The initial sounding section to exhibit the decrease is 1m~5m and the maximum sounding showing the decrease is 1.5m in which tourists mainly bathe. If the area of this sounding decreases continuously, Haeundae will loss its value as sightseeing resort.

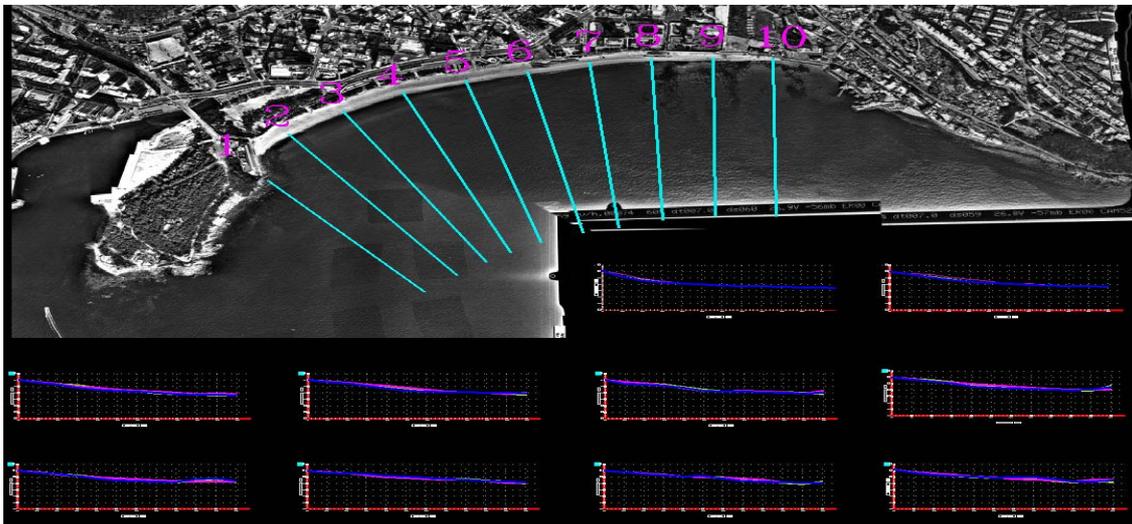
**Table 1 Statistical summary of surveyed data in the region**

	Surveyed Points	Grid Size	Mean Sounding	Area	Volume
1980	11245	2 x 2	-14.4978 m	6039196	87555332
1994	3772	2 x 2	-14.2976 m	6048012	86471876
2005	21257	2 x 2	-14.8906 m	6028168	89763216
Change			0.392784 m	11028	-2207884



**Fig. 3 Changes in the area and the volume by sounding**

**2.3 Equal interval analysis of the marine topography**



**Fig. 4 Cross section of the sounding survey (Blue : 1980, Green : 1990, Pink : 2000)**

To analyze the equal interval changes in topography for 25 years, we constructed cross sections from marine DEMs. We derived cross sections at 160m intervals from Chosun Beach Hotel, overlaying data from 1980, 1994 and 2005. We then computed the depth of erosion and accumulation at intervals. Results are Fig. 4 and Table 2. As indicated by Fig. 4, there were generally accumulation in 1994 and erosion in 2005. In case of the center to supply sand

intensively and the east (Mipo), erosion appears subtly and accumulation appears in some places. However, in case of west (Chosun Beach Hotel), erosion appears obviously.

**Table 2. Erosion and accumulation by section (E:Erosion, A: Accumulation)**

			1	2	3	4	5	6	7	8	9	10	
0	80-90	E										0.0892	
		A	0.1812	0.4744									
	90-00	E	0.137	0.6598									0.0866
		A											
80-00	E		0.1854									0.1758	
	A	0.0442											
100	80-90	E							0.1164	0.0098		0.1852	
		A	0.601	1.26	0.8648	0.0928	1.1136	0.6948			0.4958		
	90-00	E						0.6678	0.6882		0.1076		
		A	0.5594	1.4232	0.046	0.717	0.0704			0.3102		1.2068	
	80-00	E							0.8046	0.3004			
		A	1.1604	2.6832	0.9108	0.8098	1.184	0.027			0.3882	1.0216	
200	80-90	E								0.2176		0.3638	
		A	0.0534	0.9024	1.4636	1.5948	0.5002	1.5424	1.0942		0.0658		
	90-00	E			0.0826		1.172		0.2302	0.8406	0.3052		
		A	0.3284	1.2106		0.3134		0.1273				0.3638	
	80-00	E					0.6718			1.0582	0.2352	0.3638	
		A	0.3818	2.118	1.381	1.9082		1.6702	0.864				
300	80-90	E	0.0016		0.3076		0.187			0.055		0.8814	
		A		0.144		0.4126		0.325	0.5186		1.0896		
	90-00	E		0.415						0.698	0.3518	0.1648	
		A	0.0696		0.8358	1.0086	0.1314	0.9656	0.6782				
	80-00	E		0.276			0.0556			0.753		1.0462	
		A	0.068		0.5282	1.427		1.2906	1.3028		0.7378		
400	80-90	E	0.1464	0.3248	0.4346			0.0762	0.004			1.7684	
		A				0.1206	0.1916			0.3086	0.4366		
	90-00	E								0.5068			
		A	0.4016	0.816	1.1006	0.2064	0.1492	0.873	0.9178		1.1478	0.6202	
	80-00	E								0.1982		1.1482	
		A	0.2552	0.4912	0.666	0.333	0.3408	0.7968	0.9138		1.5944		
500	80-90	E	0.2298	0.2716	0.5924	0.8632		0.5974	0.4438		0.9714		
		A					0.0836			0.1306		0.445	
	90-00	E					0.0544		2.1528	0.6878			
		A	0.5362	0.6502	1.504	0.0916		0.86			0.7758	1.1234	
	80-00	E				0.7716			2.5964	0.5572	0.1956		
		A	0.297	0.3898	0.9098		0.0292	0.2626				1.5684	

## . Beach topographic change for 5 years

### 1. Acquisition of spatial data on the beach from GPS survey

As construction stage of data to investigate beach topographic change, we selected surveying date based on time of high tide and made a survey using GPS from 16:00 20 August 2005 to 4:00 21 August. We selected Pukyong National University, Korea as the temporary datum point and set up the receiver. In the post process kinematic GPS method, we surveyed the coastline and the beach of Haeundae at 1 meter intervals parallel to the coastline.



Fig. 5 Field Experiment

We processed data to receive from GPS, using Trimble Geomatics Office V1.50 software. The condition of receiving GPS signals was good. After adjusting the basic line, errors of all points were within  $\pm 0.02\text{m}$  in the horizontal direction,  $\pm 0.05\text{m}$  in the vertical direction. So we could acquire excellent results.

There were not data surveyed in 2000. So we extracted the coastline and the beach from digital maps issued by National Geographic Information Institute of Korea in 2000, unlike data constructed in 2005 from GPS survey. We derived each beach DEMs from digital maps and result surveyed, using Intergraph MTA & InRoads software.

### 2. Analysis of beach topographic changes using beach surveying

#### 2.1 Visual analysis



Fig. 6 Change of coastline for 5 years

As a result of visual analysis of beach DEMs, the coastline has advanced on the left side and receded on the right, centering around Glory Condo.

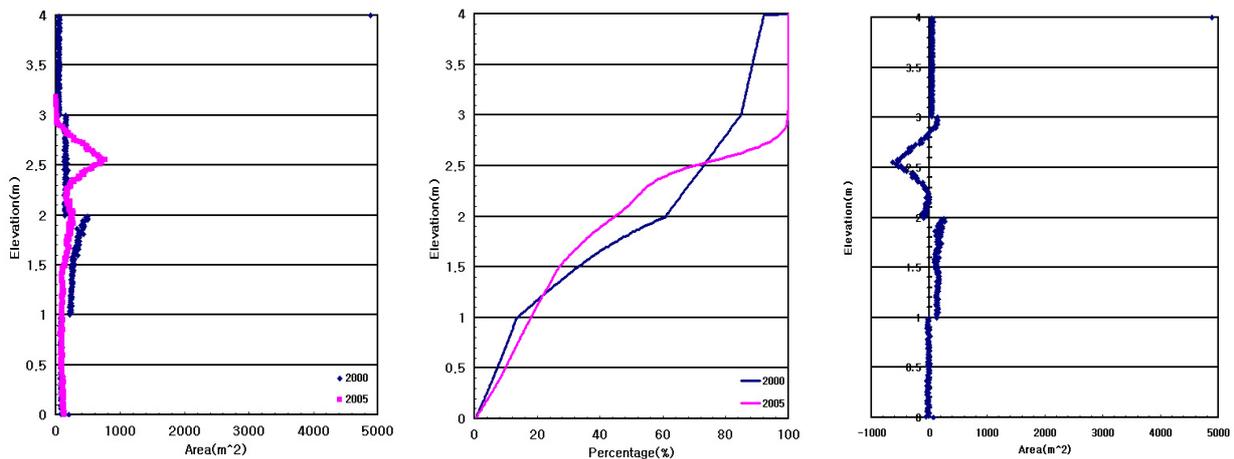
### 2.2 Quantitative Analysis of beach topographic change by elevations

As a result of statistical analysis of beach DEMs, total volume of beach topography is 106959 and has gained in quantity as 17181 for 5 years. And the mean elevation and total area is 1.89m, 56537 and have diminished in quantity as 0.08m, 6357. Though the point month of surveying was August when two months had been passed after supplying sand, the much sand has been lost.

**Table 3 Statistical summary of surveyed data in the region**

	Surveyed Point	Cell Size	Mean Elevation	Area	Volume
1980		1 x 1	1.9737977 m	62894	124140
2005	43200	1 x 1	1.891842 m	56537	106959
Change			0.0819557 m	6357	17181

Much sand has been flowed into Haeundae beach through supplying sand from the west coast. But beach erosion has been occurred. As multistory buildings stood into the coastal zone by the excessive development and river to supply sand into the beach disappeared, it is estimated that ocean current was changed and condition that sand goes in and out the beach was destroyed. Therefore beach erosion has been occurred continuously. The area and the volume at 2~3m elevation have increased and sand has been accumulated. But area and volume at 1~2m elevation has decreased and sand has been lost.



**Fig. 7 Changes in the area and the volume by sounding**

### 2.3 Equal interval analysis of the beach topography

To analyze the equal interval changes in topography for 5 years, we constructed cross sections from beach DEMs. We derived cross sections at 100m intervals from Chosun Beach Hotel, overlaying the data from 2000 and 2005. We then computed the depth of erosion and accumulation at intervals. Results are presented in Table 4 and Fig. 8.

As the point month of surveying was August when two months had been passed after supplying sand, accumulation has generally occurred. Particularly, accumulation has clearly occurred in center of beach. Its causes are estimated that EBR Systems Corporation established minute nets composed of PVC at 30m intervals up to 2m depth of water in front of center of beach. In other words, by the installation of minute nets, the velocity of waves has been slower than old times and sand to be washed by waves has piled up. Therefore degree of erosion in the center beach is weaker than one in other regions.

But erosion has been occurred clearly in west beach (Chosun Beach Hotel). At that time to survey, there is hardly sand in front of Chosun Beach Hotel. Its causes are as follows.

First, sand to be distributed over the beach by velocity of waves and winds has been accumulated intensively in the center beach by the installation of minute nets and couldn't have reached in the west beach. Therefore erosion has been occurred clearly in west of beach.

Second, the area of Haeundae beach changes according to the season. We analyzed the area of the beach from aerial photos to be taken a photograph in the summer (May) and the winter (November) and we could know the area of beach changes according to the season. During the summer, the beach area in front of Chosun Beach Hotel is narrower and the beach area in front of Mipo is wider. But, during the winter, the beach area in front of Chosun Beach Hotel is wider and the beach area in front of Mipo is narrower.

**Table 4. Erosion and accumulation by section (E:Erosion, A: Accumulation)**

			1	2	3	4	5	6	7	8	9	10
0	00-05	E										
		A										
10	00-05	E										
		A										
20	00-05	E										
		A		0.3953								
30	00-05	E		0.4292	0.1852							
		A				0.174		0.1836				
40	00-05	E								0.0161		
		A			0.7341	0.6246	0.184	0.5925	0.5786			
50	00-05	E									0.2997	
		A			0.8753	0.7977	0.6109	0.7399	0.7146	0.5145		
60	00-05	E			0.1431						0.0431	
		A				1.1881	0.9003	0.5871	0.9227	0.283		
70	00-05	E										
		A				0.7897	0.5331		0.5944	0.4948	0.8027	

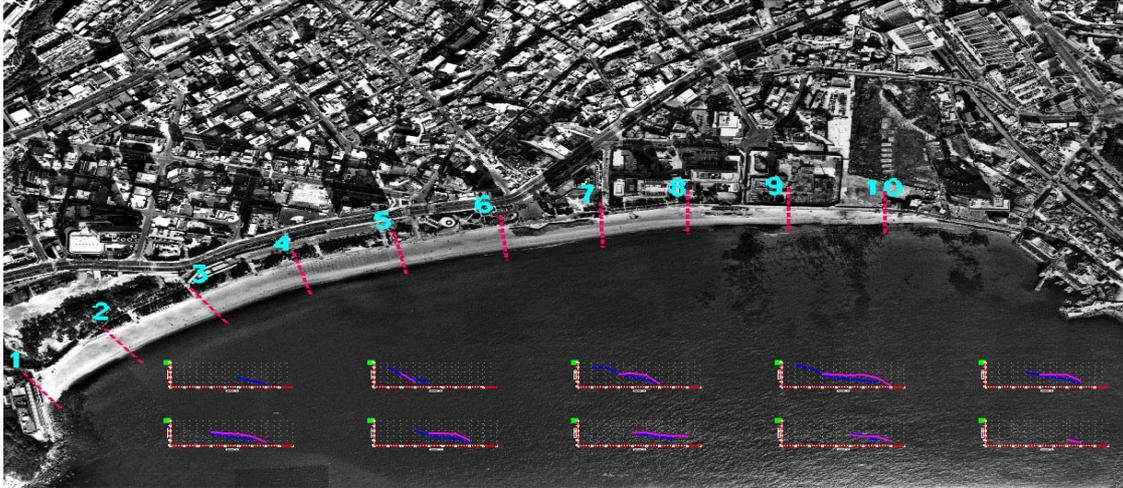


Fig. 8 Cross section of the sounding survey (Blue : 2000, Pink : 2005)



Fig. 9 Seasonal change of Haeundae beach area

Table 5 Area of beach by season

	West (Chosun Beach Hotel)	East (Mipo)
2004. 05 (summer)	16905	10541
2004. 11 (winter)	18301	9960
Change	1396	581

## . Conclusions

Based on data obtained from the sounding and the beach survey, we analyzed quantitatively the topographic change in the Haeundae region from past to present. We could acquire results as followings.

1. As a result of statistical analysis of marine DEMs, total volume of the marine topography in the Haeundae region has gained in quantity as 2207884 for 25 years. But the mean depth of water and total area have eroded in quantity as 0.39m, 11028 . The area by the sounding indicated that increase was generated at 0~1m, decrease at `1~5m,

increase at 5~6m, decrease at 6~10m, increase at 10~11m, decrease at 11~13m and decrease above 13m. The maximum sounding showing the decrease is 1.5m in which tourists mainly bathe. If the area of this sounding decreases continuously, Haeundae will lose its value as a sightseeing resort.

2. As a result of analyzing the marine topographic cross section, there were generally accumulations in 1994 and erosion in 2005. In case of the center beach to supply sand intensively and the east (Mipo) beach, erosion appears subtly and accumulation appears in some places. However, it is necessary to monitor this region for the management of the beach during the long term, as erosion appears obviously in the west (Chosun Beach Hotel) beach.

3. As a result of statistical analysis of beach DEMs, total volume, area and the mean elevation of the beach has eroded in quantity as 17181 m<sup>3</sup>, 0.08m and 6357 m<sup>3</sup> for 5 years. The area and the volume at 2~3m elevation increased and sand was accumulated. But, at 1~2m elevation, they decreased and much sand was lost. As multistory buildings stood into the coastal zone by the excessive development and river to supply sand into the beach disappeared, it is estimated that ocean current changed and condition that sand goes in and out the beach was destroyed. Therefore beach erosion has been occurred continuously.

4. We analyzed the cross section of beach. As the point month of surveying was August when two months had been passed after supplying sand, accumulation has generally occurred. By installation of minute nets in the center beach, sand to be washed by waves has piled up. Therefore accumulation has clearly occurred in the center beach. However erosion has been occurred clearly in the west beach as sand to be moved in the west beach by waves and winds has been accumulated intensively in the center beach by installation of minute nets. It is estimated that season affects erosion in the west beach. As a result of analyzing aerial photos, the area of the west beach (Chosun Beach Hotel) in the summer is narrower than one in winter as 1396 m<sup>2</sup> and the area of the east beach (Mipo) in the summer is wider than one in winter as 581 m<sup>2</sup>.

If the database on coastal erosion are constructed based on data to collect continuously through these studies and are applied to coastal management with GIS technology, it is estimated that the effective monitoring method of the coastal zone, the scientific analysis of causes on the coastal erosion, the real countermeasure on erosion and so on could be provided.

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