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Coupling of GIS and time dependent 2-D Sediment Transport Modeling
GIS와 연동된 2차원 퇴적물이동 모델링

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1. INTRODUCTION

The Kyunggi Bay (125-128E, 36-38N) is a macro-tidal bay in the western central port of Korean Peninsula(Fig.1). The Bay characterizes its feature as wide tidal flats, deep tidal channels and tidal sand ridges running in parallel to tidal flows. The macro-tidal range (up to approximately 8.6m) and consequent strong tidal currents erode the bottom sediment and selectively transport to the low-energy area forming tidal ridges or tidal flats.

The tides in the Bay are mostly of semi-diurnal types with increasing tidal range toward the shoreline. The main flows o f flood d irect t oward n orth-east w hile t he ebb currents flow south-westward. Relatively strong currents occur along the spatially distributed channels, implying spatial nonhomogeneity in sediment characteristics.

2. MOTIVATION

Due to the public awareness and fishermen's interest, the potential environmental impacts of undersea sand mining has been drawn attention. The motivation of the study is how we could balance the positive and negative impacts arising from the undersea sand mining in the Bay.

3. GOALS OF THE STUDY

The goals of the study is to quantity the sediment transport processes due to the undersea sand mining, to predict the recovering processes of the sand pits, and to provide time-varying distributions of environmental parameters in the GIS system that is coupled with ecological impact assessment.

4. UNDERSEA SAND MINING IN KOREA

Since the early 1990s, Korea has been established a few new satellite cities in mid-western area. These public works brought high demands of construction materials particularly the concrete sands which were in short supply from land sources.

Since then, many mining companies got permission to mine the undersea sands to supply the construction materials. The most of sand mining has been operated in the tidal sand ridges in Kyunggi Bay. The annual production of underwater sands in Kyunggi Bay estimates approximately as 15 million cubic tons that account for approximately 70% of sand material necessary for Seoul metropolitan area. The total amount of undersea mined sands takes about 20% of nation-wide sand demand in Korea.

5. FIELD OBSERVATION

A prototype field experiment has been conducted in an undisturbed area where the sediment types are favored by dredging company. The purpose of setting the test site is to measure the major hydrodynamic and sediment parameters affected by the mining operations, and their progressive variation in time and space, including the dispersion of surface b enthic p lumes, a nd t he r ecovery status of the pit in the seabed. Through the filed experiment, the sediment flux(source concentration at the source cell) and the sediment size has been measured for modeling control parameters. The temporal variation of the mining pit has been observed to estimate the recovering rate of the disturbed seabed.

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6. MATHEMATICAL MODELING

The Mathematical description of the physical and sediment transport processes are performed by means of 1-D, 2-D and 3-D models. The 1-D model is to estimate the vertical variation of concentration profile due to the surface and benthic plumes. The 2-D and 3-D models predict the tides and tidal currents and dispersion of suspended materials released in the surface and benthic boundary layer.

The model grid was set at horizontal dimension of approximately 150 meters to resolve the strong tidal currents along narrow channels in the model area. The very fine bathymetric map was compiled by using the digital navigation chart of the NORI. An example application was presented for continuous release of suspended materials of 0.1308mg/ℓ in concentration and of 0.0625mm in grain size at the source cell.

7. INTEGRATION OF ARCGIS WITH HYDRODYNAMICS & SEDIMENT TRANSPORT MODEL

The spatial accuracy in the application of 3-D environmental models has increased dramatically over the past decade due to the benefits of high computational resources, and accurate location of input /calibration data obtained through field measurement using DGPS, and immediate data transmit through the internet. So it seems extremely advantageous to handle the spatial data associated with environmental models with georeferencing tool such as ArcGIS 8.1.

In this study, the integration of hydrodynamic and sediment transport models is accomplished with the use of the ArcGIS 8.1 and the ArcIMS3.1.

8. CONCLUSIONS

1. Digital navigation charts benefits the preparation of high resolution bathymetry data for fine scale mathematical models.
2. The continuous monitoring and measurement of changing seabed due to undersea sand mining are essential part of sediment transport study.
3. Prediction of hydrodynamic and sediment transports models is easily enhanced by more field observed data.
4. Interfacing the ArcGIS to hydrodynamic models benefits the pre - and past – processing and decision making tasks.

9. FUTURE WORK

1. Further improvement of more robust and accurate models to predict the change in seabed features.
2. Field measurement of the recovery period of the pits in the seabed.
3. Seam less editing of the model I/O on GIS tools using the VBA tool.
4. Vertical representation of the 3-D model results using 3D analyst module.

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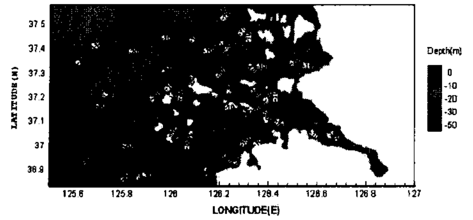

Fig. 1. The bathymetry was reproduced by using the digital navigation chart of the NORI.

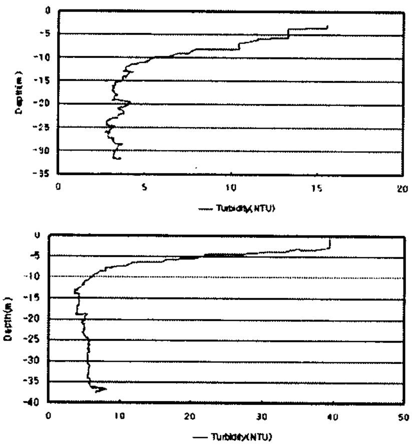

Fig. 2. Observed concentration profiles of suspended materials sampled at different points away from the mining site.

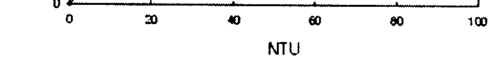

Fig 3. Comparison of directly sampled concentration (PPM) and YSI measured concentration (NTU) : y=0.2987+1.2317x, R^2=0.997.

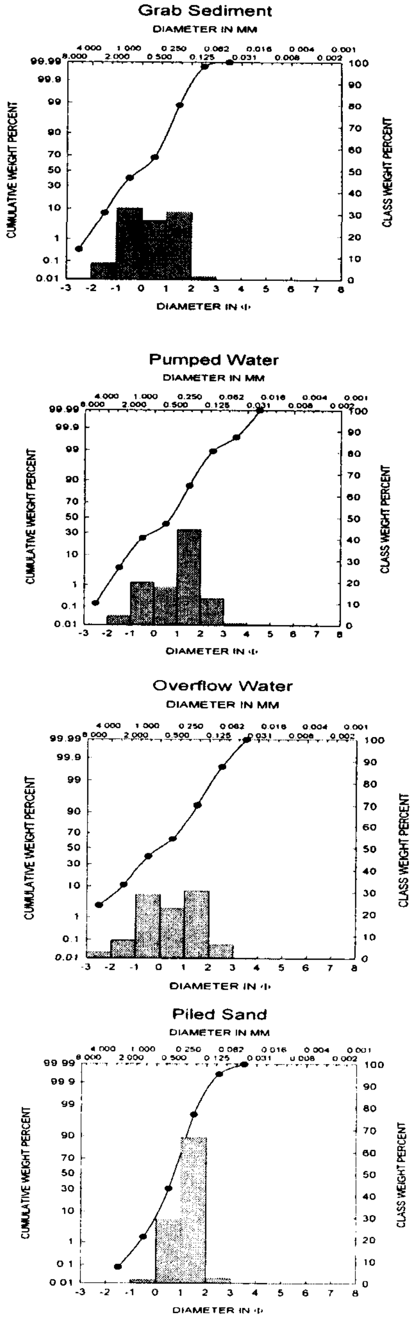

Fig. 4. The grain size distributions of the samples obtained in the process of dredging operation : bottom sediment, pumped sediment, piled sample in the barge and over spilling water.

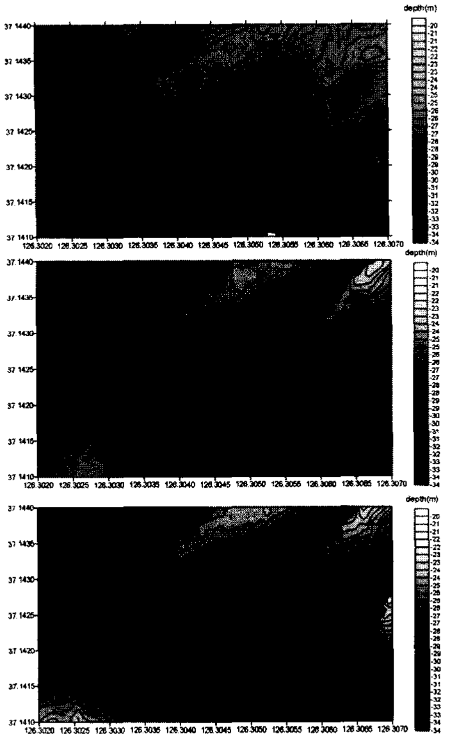

Fig. 5. The temporal variation of holes in seabed. The pit was created by test mining operation conducted in 09/07/2001, 10/12/2001, 04/19/2002.

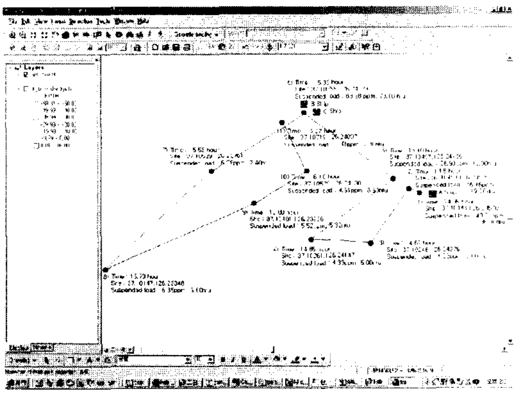

Fig. 6. The location of sampled sites and observed values of suspended materials in the undersea sand mining area.

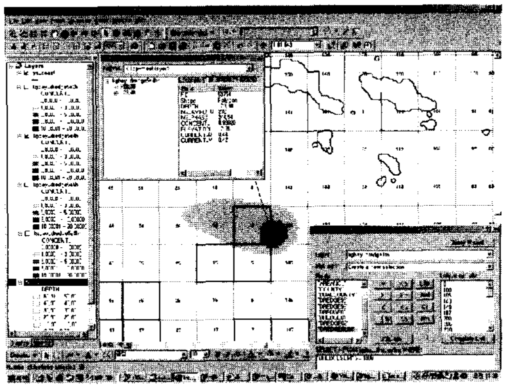

Fig.7. GIS-coupled suspended material distribution estimated by numerical modeling.

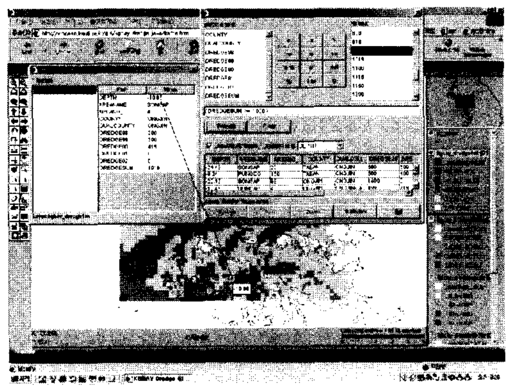

Fig. 8. A sample application of GIS Internet Map Service showing model results and general environmental parameters. A user can interact with the ArcIMS on-line.