GIS Mapping for Marine Scientific Monitoring Information after Oil Spill Accident

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Abstract:

Most of coastal region of Taean in Korea were seriously damaged by 'Hebei Spirit' oil spill accident in December 7, 2007. To evaluate this oil contaminant status, marine scientific monitoring has been done continuously in the field oil pollution, marine ecosystem, and marine environment. For the management and use of these monitoring results, several kinds of data were collected and keyed into database. This paper is aimed to use and understand the monitoring results effectively using GIS. Therefore, two kinds of GIS thematic maps were made; MOP(marin oil pollution) thematic map for the comparison of temporal and spatial variation of the monitoring data and MFMOP (monitoring frequency for marine oil pollution) dasymetric map for monitoring frequency to understand how many monitoring activities were done on the spatial basis. MOP thematic maps were made using 5 types of map template such as graduated symbols, graduated colors, charts, contours, and 3-D perspective views. MFMOP dasymetric maps were made on the spatial scales of 2x2 km and 10x10 km grid.

1. INTRODUCTION

On December 7, 2007, a barge carrying a crane hit the oil tanker 'Hebei Spirit' offs the shores of the western coast in Taean. The oil spill incident caused the spill of an estimated 12,547 tons of three different types of crude oil. There have been marine science researches conducted on a continuous basis to assess the influence of the oil spill on marine environment and ecosystem from the time of incident to the present, based on 50 items for investigation in 3 fields; oil pollution field, marine ecosystem field and marine environment field. The necessity of systematic management data in various fields and the interpretation of overall results for the conditions of pollution is required. Therefore, it is urgent to set up measures to efficiently manage the data and easily identify conditions of pollution inspected in other fields. The GIS (geographic information system) technology provides users efficient information and furthermore enables them to identify spatio-temparal change of spatial oil pollution by providing coordinate-based spatial information and attribute simultaneously. Particularly, the GIS thematic map gives the above-mentioned benefits by providing structure and pattern of spatial distribution for a certain subject.

This study mainly focused on build GIS DB based on monitoring data collected from researched conducted by 2010 since the incident, and to efficiently provide measures for systematic pollution data management and monitoring performance information through a production of the MFMOP dasymetric map using monitoring frequency of data and the MOP thematic map using pollution information monitored.

2. SCOPE AND METHODOLOGY

The 'Hebei Spirit' oil spill incident occurred at 11km away from Mallipo beach in the Taean peninsula, Chungnam-do, South Korea. The oil spilled took a toll on the southwestern coast of Korea due to tidal current and strong northwester during winter season. The study area is selected suffering from the incident in the 73km range covering from Garorim bay located north of Taean to Anmyeon-do in the south as the subject of study (Figure 1).

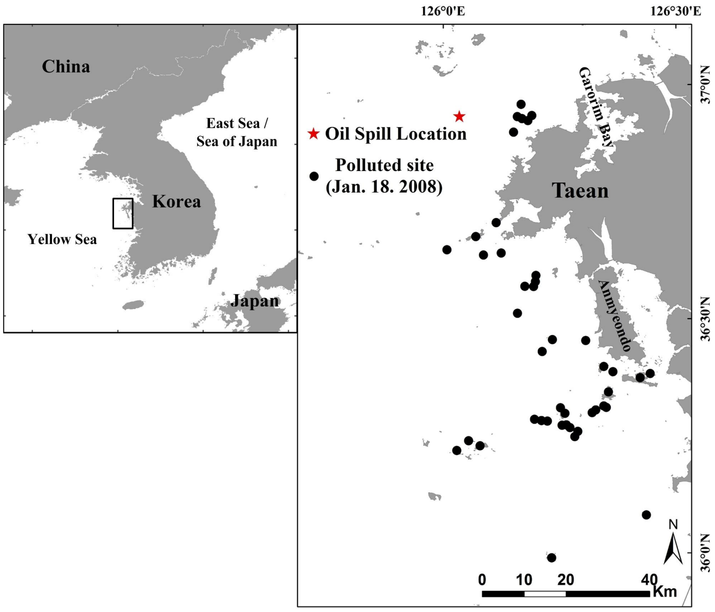

Figure 1: Study area

This study used the data of oil pollution field, marine ecosystem field and marine environment field inspected from December 2007, the time of beginning of the incident, to December 2010. The oil pollution were inspected in 4 items; seawater, sediment, marine biota and toxicity in intertidal zone and subtidal zone. Marine ecosystem field has 3 items; pelagic ecosystem, benthos on intertidal and subtidal zone, and Nektic ecosystem. Marine environment field were inspected in 3 items seawater quality, marine geology and heavy metal in sediment. The total number of data collected for 4 years is shown in the Table 1; monitoring were conducted in total 7,802 stations; 4,689, 2,011 and 1,102 in oil pollution field, marine ecosystem field and marine environment field, respectively.

Table 1: The number of monitoring station as each fields

Category	Total num. of station in Oil pollution field	Total num. of station in Marine ecosystem field	Total num. of station in Marine environment field	Total number of station
2007	602	14	85	701
2008	1996	719	825	3,540
2009	843	523	96	1,462
2010	1248	755	96	2,099
Total	4,689	2,011	1,102	7,802

Figure 2 shows the process of map production using monitoring data. The raw data in the 3 fields collected from December 2007 to December 2010 is in an excel file. First, creating the GIS point data using raw Excel data for producing the thematic map. Raw excel data was built to DB in mdb format, and saved the point data created in GIS DB for enabling correction and control. The procedures of making the MFMOP dasymetric map are as follows. First, create a regular grid; 2x2km for managing monitoring stations in detailed area and 10x10km for managing wide monitoring stations, within the extent of the subject area. Second, create individual point objects by dividing monitoring station in a form of point built into data by field and time. Last, calculate the number of point overlapped by using join count function after performing spatial join for regular grid created and point data classified. The procedures of making the MOP thematic map are as follows. First, classify attributes of items of monitoring data (number/quantity, cycle of monitoring and intertidal/subtidal). Second, produce 5 map templates and define a template appropriate for expressing them by attribute of data. Third, define standardized legend in consideration of the distribution of data histogram. Lastly, enable to produce the standardized and unified MOP thematic map by defining marginal element. This study used ArcGIS 9.3 of ESRI as a tool for building GIS DB and GIS mapping.

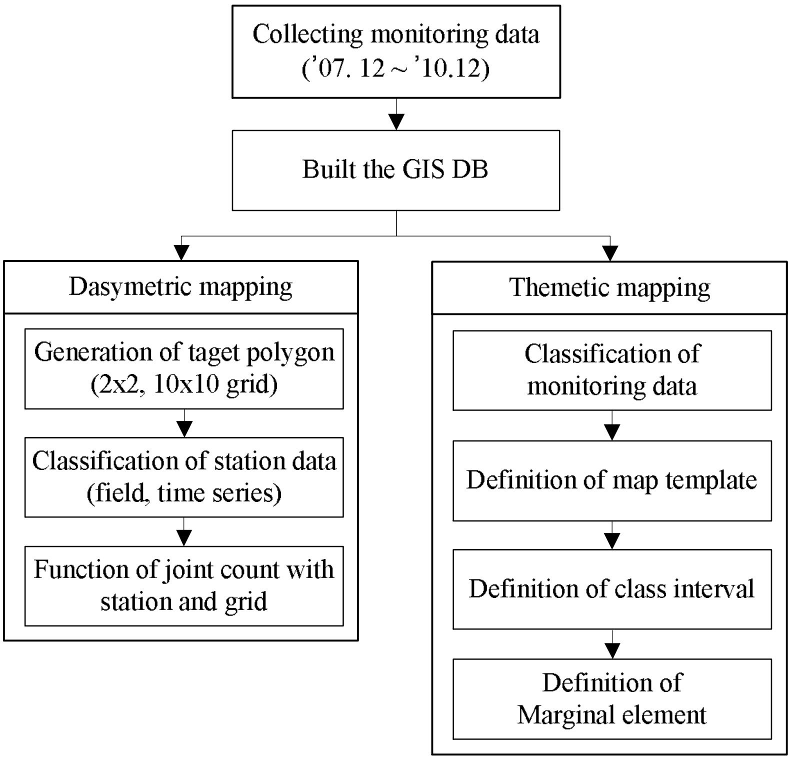

Figure 2: GIS Mapping process

3. RESULTS

(1) Making the MFMOP dasymetric map

Figure 3 is the MFMOP dasymetric map using monitoring station in the oil pollution field in 2010. The red zone shows high monitoring frequency, and the sky blue zone is where monitoring was conducted once or twice in a year. It shows that the monitoring frequency in intertidal zone is higher than intertidal zone where the influence of oil pollution is still remains. a) is the map in 2x2km grid, displaying detailed area for monitoring and frequency in intertidal zone, whereas b) is the map in 10x10km grid, showing the scope of monitoring and density of frequency for wide area.

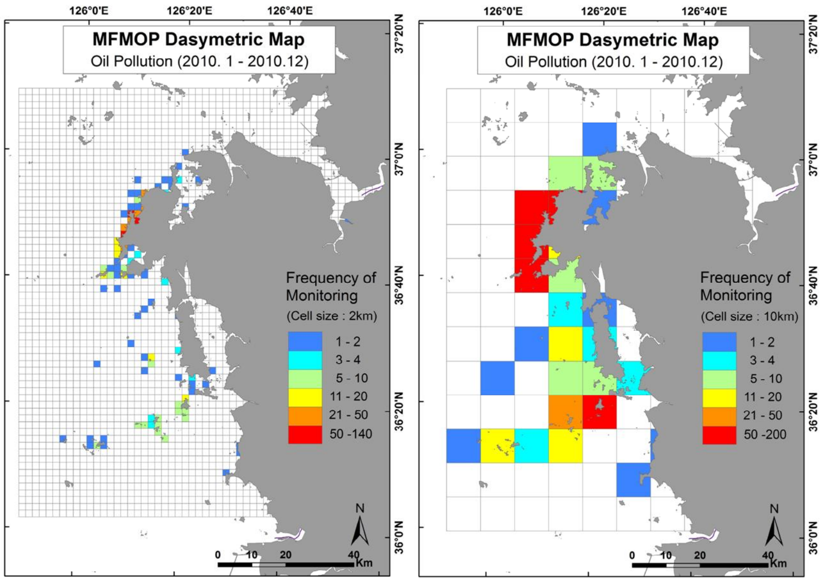

Figure 3: 2 types MFMOP (monitoring frequency for marine oil pollution) dasymetric map in oil pollution field

(2) Making the MOP thematic map

The monitoring data should be expressed in a form suiting the attribute of the data. As lots of data built in various fields cannot be produced in the GIS map in the same pattern, we enabled the data to be expressed in their own attribute. Therefore, we built 5 GIS map templates which are a representative form of expression of GIS as shown in Table 2. In addition, considering the attribute of approximately 50 monitoring data, we classified each of them in the type (Mitchell, 1999). We defined marginal element of the map as follows; defining the coordinate system as WGS84 coordinate system and inserting title, date of monitoring, unit of data, legend of data, direction (north arrow), scale bar, et cetera, all which are necessary for the map.

Table 2: Define the GIS map template

Type	feature	Attribute	Advantage	Disadvantage
Graduated symbols	Locations, Lines, Areas	Counts/Amounts, Ratios, Ranks	Intuitive-people associate symbol size with magnitude	May be difficult to read if many features on map
Graduated colors	Areas, Continuous phenomena	Counts/Amounts, Ratios, Ranks	Make it easy to read patterns and feature values	Colors not intuitively associated with magnitude
Charts	Locations, Areas	Counts/Amounts Ratios	Shows categories as well as quantities	May present too much information, obscuring pattern
Contours	Continuous phenomena	Amounts, Ratios	Easy to see rate of change across an area	May make it hard to read patterns and individual feature values
3-D perspective views	Continuous phenomena, Locations, Areas	Counts/Amounts Ratios	High visual impact	May make it hard to read values of individual feature

Figure 4 illustrates the MOP thematic map produced. Figure 4-a) is the graduated symbols map and is an outcome of the monitoring for bedrock intertidal macrozoobenthos in subtidal zone. We brought previously-built station data into the basic map, produced histogram for the whole data for producing legend on the map for each attribute data, and granted them data level. The data was set in 5 levels and classified by density of data based on maximum value and minimum value. Figure 4-b) shows the graduated symbols map for marine environment restoration area. For identification, we distinguished the area from other areas with different a color. Chart map is divided into 2 types. Figure 4- c) is the bar chart map showing the result of monitoring for PAHs in intertidal zone which enables to compare monitoring outcome by station of 15, 16, Alkylated PAHs. Figure 4-d) is the pie charts map displaying the ratio of composition of phytoplankton in subtidal zone. The ratio of dominating 4 species and other ones form 100% in total. Figure 4-e) is the contour map for monitoring data for 16PAHs in subtidal sediment. Raster data was created from point data by using IDW interpolation for making the contour map. In addition, in case of the contour map, standardized section level method through an analysis of histogram for expressing spatially successive phenomenon was used. Figure 4-f) is a production of the 3-D perspective views map for 16PAHs data and Alkylated PAHs data in respect of intertidal sediment on the coast of Taean near the spot of accident. We could express monitoring stations gathered in beaches.

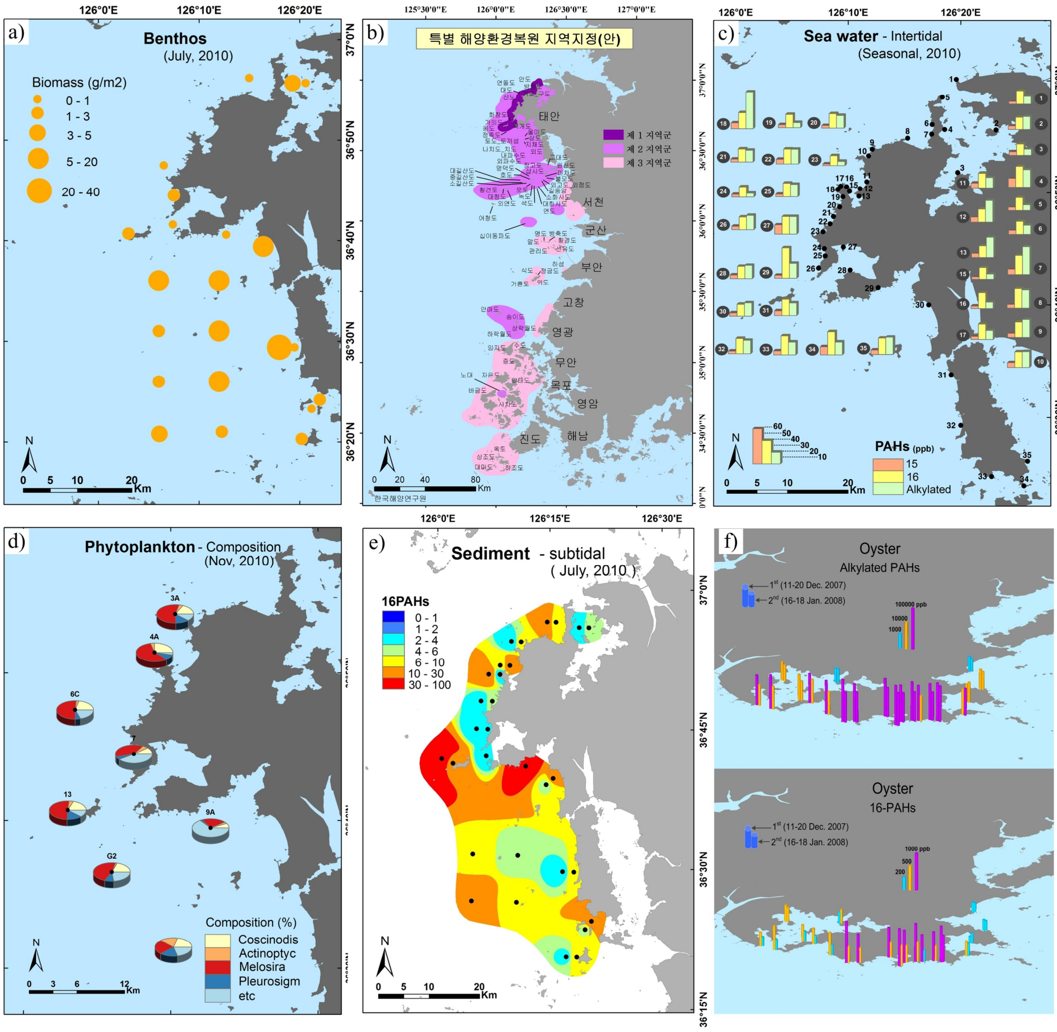

Figure 4: 5 types MOP (Marine Oil Pollution) thematic map template

4. CONCLUSIONS

In this study, producing the MFMOP dasymetric map and the MOP thematic map for efficient data management and exploratory analysis support for environment and ecosystem data inspected regarding the 'Hebei Spirit' oil spill incident occurred on the coast of Taean area in Korea in 2007. First, GIS DB was built for monitoring data accumulated for 4 years from December 2007, the time of beginning of the incident, to December 2010. The MFMOP dasymetric map for managing the performance of monitoring frequency was produced by using spatial data built. The MFMOP dasymetric map was produced on the spatial scales of 2x2 km and 10x10 km grid by performing regular grid and spatial join. In addition, 5 GIS map templates were produced for providing efficient information suiting attribute of data inspected by each item for producing the standardized MOP thematic map. Based on the map templates produced, the GIS map was produced for visibly determining damages from pollution and restoration by using mapping technology which is a basic function of GIS.

The MFMOP dasymetric map produced through this study is considered to be used as basic data for the establishment of on-site monitoring plan by year and spatial analysis for monitoring station. Moreover, the MOP thematic map will enable the comparison of the size of damages from pollution by time series by providing attribute of professional data in various fields with spatial information. There should be continuous DB-building, GIS mapping and the application of spatial analysis methodology for pollution diffusion pattern conducted.

5. Ackonwledgements

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