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CONSTRUCTING A COASTAL DATA MODEL FOR PUGET SOUND: A CLASSROOM EXPERIENCE

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INTRODUCTION

Coastal zone management (CZM) requires robust geospatial information to be effective everywhere, but particularly in nearshore areas influenced by considerable land development impacting surface water runoff in watersheds that drain into coastal waters (Beatley, Brower, and Schwab 2002). Using geospatial information technologies, particularly geographic information systems technology, can help develop a shared insight about problems, challenges and solutions about how to management coastal resources (Wright and Scholz 2005). CZM applications of geographic information systems (GIS) are not new, but GIS database integration directed at exploring issues associated with nearshore management in hopes of fostering shared understanding among diverse stakeholders is still in its infancy. In this paper we take the reader through the steps we used to develop a coastal data model. We present the outcomes of the process and consider next steps for development and use of the data model in the context of a participatory web portal for improving nearshore coastal resources.

BACKGROUND

The Puget Sound is the 2nd largest estuary in the U.S. In 2005, Washington State's Governor Christine Gregoire established the Puget Sound Partnership for Nearshore Restoration. The goal of the Puget Sound Partnership (2006, p.10) is to "…ensure that Puget Sound forever will be a thriving natural system, with marine and freshwaters, healthy and abundant native species". In line with that, the goal of the Puget Sound Nearshore Partnership (2006, p.1) is to "identify significant ecosystem problems, evaluate potential solutions, and restore and preserve critical nearshore habitat." Understanding the complexities of the fish and plant life plus how human activities affect the habitat that support that life within the nearshore can be enhanced through the use of geospatial information technologies.

CZM was used as the motivating theme to teach an intermediate course in GIS within the Department of Geography at the U of Washington (Geography 460 Autumn 2006). The offering combined a set of class lectures from a previous quarter with this new perspective, but the instructor (Nyerges) concluded something more was needed to really enhance the learning experience. Consequently, the instructor and a group of honor students (other co-authors of this paper) agreed that a foundation for learning about the breadth and depth of GIS applied to CZM could come through working with a *robust GIS representation of coastal features* related to water flows from watersheds and within estuarine ecosystems. Such representations are called data models. A data model consists of the geospatial constructs for structuring data, the operations that can be performed on those structures to derive information from the data, and the rules for maintaining the integrity of data. The core of a GIS approach for managing coastal resources involves the development of a robust coastal data model, and in particular a coastal nearshore data model. As part of an ad hoc honors activity (required of honors students) we focused on the development of a coastal data model in general, and a coastal nearshore data model in particular as a basis for enhancing the learning experience. In this paper we report on the schema developed as part of this classroom experience.

CONCEPTUAL SCHEMA INTEGRATION ANALYSIS – OUR METHOD

As mentioned earlier, a data model consists of three components: 1) constructs for structuring data, 2) operations for data processing, and 3) rules that maintain the integrity of data (Codd 1981). The popular version of a GIS data model focuses only on the component one, and thus we start with that. We made use of an informal approach to schema integration analysis to synthesize the conceptual contents of the coastal data model as an approach to database design (Nyerges 1989). Conceptual schema integration analysis involves identifying, comparing, and contrasting feature classes and the geospatial data types most appropriate for characterizing those feature classes in order to develop an overall "conceptual data schema" – simply a list of feature classes and potential relationships that form the core of a database design.

Each of the three steps in our method used a different source of "community of practice" knowledge to perform conceptual schema integration. In a first step, we explored how to integrate watershed data and marine data into GIS using the ArcHydro Data Model (Whiteaker, Schneider, and Maidment 2001) and ArcMarine Data Model (Wright 2006). In a second step we identify coastal feature classes described within a textbook reader about coastal zone management (Beatley, Brower, and Schwab 2002), and add them to the feature class list for the coastal data model. In a third step we make use of the recommendations put forward by the Puget Sound (Nearshore) Partnership (2006) to further contextualize the coastal data model for anticipated use. We used these different "communities of practice" knowledge because they are all considered "vetted knowledge" and because they are convenient to us.

Integrating ArcHydro and ArcMarine Data Models – First Step

The ArcHydro Data Model describes geospatial and temporal data about surface water resource features in watersheds (Whiteaker, Schneider, Maidment 2001). The data model addresses three issues. First, it addresses the principal water resource features on a landscape. Second, it offers a description about how water moves from feature to feature, that is through multiple connective networks. Third, the data model provides for a description of time patterns of water flow and water quality associated with water channels.

The ArcMarine Data Model represents a new approach to spatial modeling using improved integration of many important features of the ocean realm, both natural and manmade (Wright 2006). The model considers how marine and coastal data can be most effectively integrated in 3 and 4D space and time and includes an approach towards a volumetric model to represent the multidimensional and dynamic nature of ocean data and processes.

Drawing the two data models together to examine what is in common resulted in recognizing that even the idea of "shoreline" is not common between the two data models. Although a "shore zone" can be constructed, it was not explicitly evident in either one. This result heightened our interest about what should be included in a coastal data model. We concluded that feature classes from both are useful, but many more would be needed if we were to really focus on "coastal features". Understanding the similarities and differences in the ArcHydro and ArcMarine data models leads to a better understanding of how to develop a coastal data model. However, to gain a better sense of what feature categories should be considered, we developed a follow-on activity using a second source of information.

Feature Classes from a Coastal Zone Management Book – Second Step

A collection of feature classes and several attributes were compiled from a text reader about coastal zone management, assuming this textbook reader was evidence of another form of expert knowledge. Students used one of the two course textbooks (*Coastal Zone Management* - Beatley, Brower, and Schwab 2002), to compile a more comprehensive list of feature classes. We argue that authors of a textbook are themselves experts in a topic, and that topic is peer reviewed by other experts familiar with the topic. Because this particular text is published by Island Press, a well known environmental publisher, we expect the slant on the information is more environmentally-oriented. However, because the book was used as a reader in the GIS course, we know from experience that it has reasonably well-balanced perspective as it speaks to sustainability issues about economic, social, and ecological aspects of communities.

Puget Sound Nearshore Partnership – Third Step

On October 13th, 2006, the Puget Sound Partnership (2006) executive committee released recommendations for focusing efforts in the Puget Sound area. These recommendations are useful to a) identify fundamental theme for improving the health of Puget Sound, b) identifying features that can corroborate the list identified from reviewing Beatley, Brower, and Schwab (2002) as well as those in the integration of the ArcHydro and ArcMarine Data Models, and c) identify primary and secondary processes that encourage a type of GIS data analysis to derive information as a basis for decision support to restore the Sound.

When building a data model, GIS analysts must also consider the GIS data processing operations to be supported as part of an application. In this case, the processes and applications involving coastal nearshore features. We used the feature themes and processes collated from the Nearshore Partnership recommendations to identify still more features.

RESULTS OF SCHEMA ANALYSIS FOR A PROPOSED COASTAL DATA MODEL

Feature classes identified in steps 1, 2, and 3 are collected together in Table 1. The feature classes are grouped into feature datasets (bold-face text in left column). Along with the list of features and grouping, we identify the most likely geospatial data type to act as a database representation. The resulting table provides a target for the conceptual schema of a coastal data model. Clearly, not all features would be used in all applications, so it is important to identify which feature classes and processes are to be manipulated by what data operations.

The next step in the project is to selectively detail applications as identified by the Nearshore Partnership. This next step is proceeding on several fronts, including working with members of the Science Team of the Puget Sound Nearshore.

Table 1. Coastal Data Model Features/Processes and Potential Geospatial Data Types

Features/Process	Geospatial Data Types				
	Raster	Point	Line	Polygon	Network
Physical/Natural Shoreline					
2Barrier Islands				X	
2Estuaries				X	
2Coastal Marshes				X	
2Coral Reefs				X	
2Rocky Shores			X		
2Bluffs			X		
2Wetlands				X	
12Habitats		X	X	X	
2Soil Composition	X				
2Land Cover	X				
Human Infrastructure/Impact					
12Pollution and toxic containments	X			X	X
2Land Use and Zoning				X	
2Building Code				X	
2Ports			X	X	
2Ferry Systems/Water Taxi			X		
2Present Buildings/Structures		X		X	
2Roads Network			X		X
3Sewage Utility Piping Network			X		X
2Sea Walls			X	X	
Dynamic Natural Phenomena					
12Tides	X		X		
12Currents			X		
2Winds Patterns/Flow			X		
2Erosion and Accretion	X				
2Migratory Animals (e.g. birds)					X
Water and Water Bodies					
12Catch Basins/catchments	X			X	
12Watershed areas				X	
12Streams/Rivers/Water Flow			X		
Underwater Topography					
12Continental Shelf/Slope	X				
12Water Depth/Slope	X				
12Canal Shape/Depth/Slope	X				
3Critical Area Ordinances (CAO) Spaces				X	
3Freshwater sources/treatment plants for freshwater		X		X	
3Waste Treatment locations		X		X	

Key:

1 - Step 1 features compiled from ArcHydro and Arc Data Model information
2 - Step 2 features compiled from textbook information
3 - Step 3 features compiled from Nearshore Task Force information

CONCLUSION

We conclude that development of a coastal nearshore data model definitely enhances a student's appreciation for the underpinnings of GIS information technology. Constructing suitable data models for GIS applications are the foundation of those applications. Once understanding the character of data models, GIS analysts can more readily develop GIS applications. Data models are what enable and limit GIS applications. Although we undertook this exercise in a classroom setting, we hypothesize that participatory data model development might also enhance stakeholder understanding about what is known about nearshore resources.

Data models constructed using participatory processes naturally lead to analyses performed from participatory perspectives. Such data models can form the foundation of analytic-deliberative decision processes that draw together diverse stakeholders into a discussion about how to improve precious resources. Research about the development and use of participatory GIS to support broad-based analytic-deliberative decision processes, somewhat like the decision processes for prioritizing what habitats to improve, is currently underway at the U of Washington, but it focuses on transportation improvement (see www.pgist.org). Such research is being considered for how it might improve the learning experience of students if we cast learning to use GIS within the context of multi-stakeholder scenarios about Puget Sound restoration.

LITERATURE CITED

Beatley, T., D. J. Brower, and A. K. Schwab 2002. *Coastal Zone Management*. Island Press. Washington D. C.

Codd, E. F. 1981. "Data models in Database Management" *SIGMOD Record* 11(2):112-114.

Nyerges, T. L. 1989. Schema Integration Analysis for GIS Database Development, *International Journal of Geographic Information Systems*, now *Intl Journal of Geographic Information Science*, 3(2):153-183.

Puget Sound Nearshore Partnership 2006. Home Page, http://www.pugetsoundnearshore.org/index.htm, accessed October 27, 2006.

Puget Sound Partnership 2006. Sound Health, Sound Future, http://www.pugetsoundpartnership.org/reports/final/final/Final_wAPPx_lr.pdf, last accessed January 26, 2007.

Whiteaker, T., Schneider, K. and Maidment, D. 2001. Applying the ArcGIS Hydro Data Model, http://www.crwr.utexas.edu/gis/gishydro01/support/schematutorial.pdf, last accessed November 15, 2006.

Wright, D. J. 2006. ArcMarine Data Model. http://dusk2.geo.orst.edu/djl/arcgis/, last accessed October 2006.

Wright, D. J. and A J. Scholz 2005. *Place Matters*. Ecotrust. Portland OR.

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