Coastal Informatics:
Web Atlas Design and Implementation

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Information Science REFERENCE

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Printed at:	Lightning Source

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Coastal informatics : web atlas design and implementation / Dawn Wright, Ned Dwyer, and Valerie Cummins, editors.
p. cm.
Includes bibliographical references and index. Summary: "This book examines state-of-the-art developments in coastal informatics (e.g., data portals, data/ metadata vocabularies and ontologies, metadata creation/ extraction/ cross-walking tools, geographic and information management systems, grid computing) and coastal mapping (particularly via Internet map servers and web-based geographical information and analysis)"-- Provided by publisher. ISBN 978-1-61520-815-9 (hardcover) -- ISBN 978-1-61520-816-6 (ebook) 1. Coasts--Geographic information systems. 2. Coastal mapping. 3. Management information systems. I. Wright, Dawn J., 1961- II. Dwyer, Ned. III. Cummins, Valerie, 1974- GC10.4.R4C63 2010
526.0914'6--dc22

2009052431

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Chapter 9
Wisconsin, USA

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ABSTRACT

Simply stated, a coastal web atlas (CWA) is a means of organizing, presenting, and sharing spatial data for the coast. Once in place, a CWA can function as a coastal spatial data infrastructure and a platform for developing coastal management decision support tools. While Wisconsin has been actively applying geospatial technologies to coastal issues since 1994, development of a CWA is in its infancy. Wisconsin Sea Grant has learned much about key components of a CWA during the past decade through its role leading four coastal spatial data integration projects. Several technical and institutional issues surfaced as the projects moved from discovery, acquisition, and integration of spatial data from multiple sources to analyze regional coastal issues to the development of interoperable web mapping services and spatial data catalogs. These issues are associated with the following research topics: web portal design and evaluation, choosing appropriate web mapping technologies, GIS cartography, domain spatial data infrastructures, geospatial data archives, and spatial ontologies. Building the Wisconsin Coastal Atlas will provide insight on these important research topics.

INTRODUCTION

While Wisconsin has long been applying geospatial technologies to coastal issues, the process of implementing a coastal web atlas (CWA) is only beginning. The past 15 years has seen the development of many coastal GIS applications and experimentation with multiple platforms for web mapping and spatial data catalogs. The Wisconsin Coastal GIS Applications Project (http://coastal.lic.wisc.edu/) has yielded many benefits, but it has not taken full advantage of current "Web 2.0" technologies that promote information sharing and collaboration. The emergence of an international effort to promote interoperable CWAs provides a good reason to re-examine coastal GIS in Wiscon-

DOI: 10.4018/978-1-61520-815-9.ch009

sin. It is now a good time to extend coastal GIS beyond a campus research and outreach project to a broader platform for discovering, accessing, integrating, and utilizing geospatial data about the Great Lakes coasts. This chapter will explore the evolution of coastal GIS in the state, examine the benefits and drawbacks of the different web mapping/spatial data catalog-portal approaches that have been developed, and share the strategy that will be used to build a Wisconsin Coastal Atlas.

WISCONSIN COASTAL GIS APPLICATIONS PROJECT (1994-2009)

Since 1994, the University of Wisconsin Sea Grant Institute has actively supported the application of geospatial technologies to better understand coastal issues facing the Great Lakes. The Wisconsin Coastal GIS Applications Project, a collaborative project between University of Wisconsin-Madison (UW) Sea Grant and the Land Information and Computer Graphics Facility at UW, was the vision of Allen H. Miller, then Assistant Director for Outreach at UW Sea Grant and a pioneer in the modernization of land records in Wisconsin. An important mission of the project was to leverage the sizeable investment in local government land information systems in Wisconsin (over $160 million since 1991) to support decision-making about Great Lakes coastal management.

The project has passed through several phases since its inception (see Figure 1). The first phase focused on the use of GIS "teaching models" to address specific coastal issues in specific places, such as shoreland zoning, coastal erosion, floodplain management, and water quality (Rink *et al.,* 1998). The models were used in numerous workshops and classes, translated into on-line GIS tutorials, and disseminated to thousands worldwide. The second phase examined the use of GIS for integrated coastal management – moving from specific local issues to complex regional issues. This phase included an early demonstration of how digital parcel mapping, tax assessment databases, and other spatial data could be acquired from local governments and aggregated to support regional-scale analysis and mapping (Hart, 2000). The third phase explored the use of GIS for "dynamic and distributed" coastal management. The result was a system where custodians, whether they be local, regional, state, federal, academic, or non-profit entities, maintain and provide access to the most current spatial data and multiple remote users can access and integrate data in real-time from multiple sources. The fourth phase showed the value of visualization and virtual globe tools to promote a more intuitive understanding of coastal issues (Stone *et al*., in press).

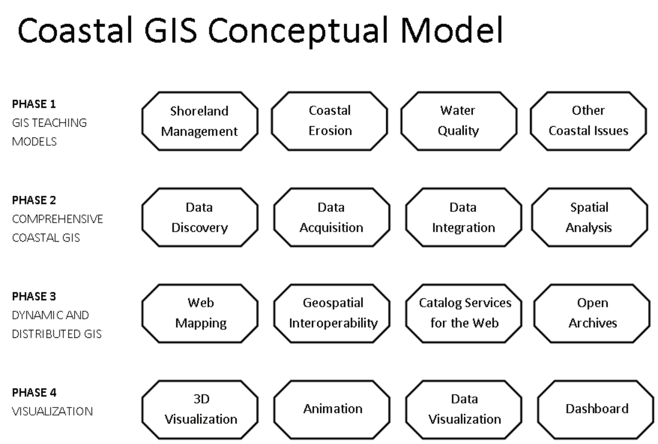
LESSONS LEARNED FROM FOUR COASTAL DATA INTEGRATION PROJECTS

The following section explores four data integration efforts undertaken as components of the broader Wisconsin Coastal GIS Applications Project and examines the issues and obstacles faced as one moves from discovery, acquisition, integration, and analysis of spatial data from multiple sources to the development of interoperable web mapping services and spatial data catalogs.

Lake Michigan Potential Damages Study

The centerpiece of the second phase of the Wisconsin Coastal GIS Applications Project (use of GIS for integrated coastal management) was an extensive effort to discover, acquire, and integrate local government spatial data to analyze coastal erosion hazards for the Lake Michigan coast of Wisconsin. This work was a component of the Lake Michigan Potential Damages Study, a multi-year project funded by the U.S. Army Corps of Engineers to examine the impacts of extreme variations

Figure 1. The four phases of the Wisconsin coastal GIS applications project



in Great Lakes water levels on coastal property. Multiple spatial data sets were acquired from land information offices in eleven coastal counties in 1998. These included parcels, tax assessment data, planimetric and topographic mapping, land use, and digital orthophotos. Several institutional issues surfaced during the process of acquiring the spatial data. These included the actual cost of acquiring the data, the time required to obtain the data from the moment the initial requests were made, and restrictions placed on sharing and use of the data. Several technical issues arose during the process of integrating the data. These included lack of metadata provided by data custodians, as well as dealing with multiple and confusing data formats and map projections (Hart, 2000).

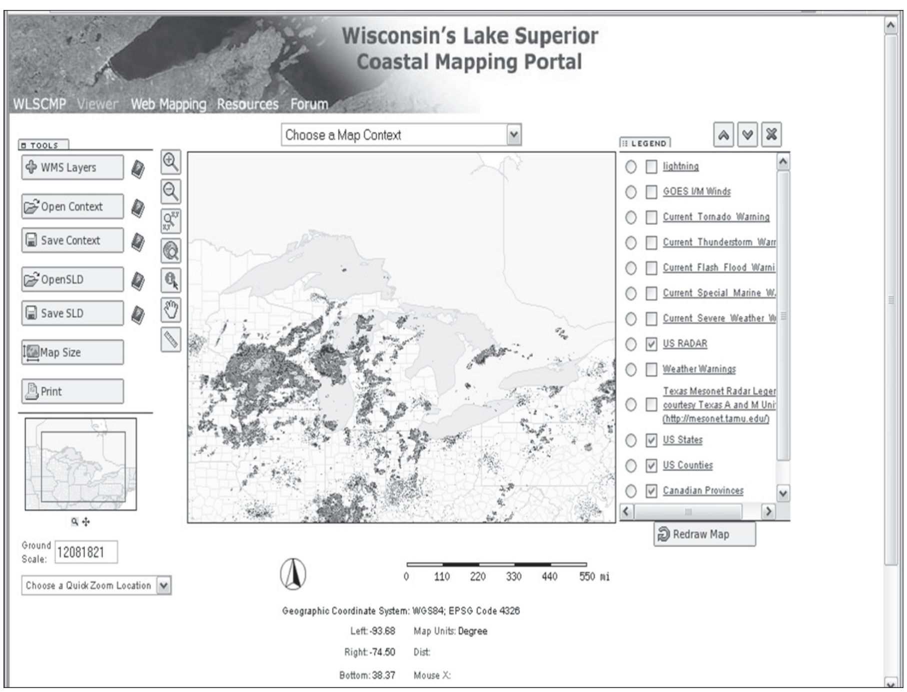
With an integrated spatial database for the Lake Michigan coast in place, it was then possible to attempt to conduct the coastal erosion analyses that were formulated at the beginning of the study. These involved specific spatial queries such as determining the assessed value of land and improvements within the jurisdiction of shoreland zoning regulations. While at the time of the study, it was not possible to fully complete all the analyses due to gaps in the availability of local data, it was recognized that a valuable, integrated spatial database had been compiled that could be used to analyze a variety of regional-scale coastal issues. A resulting problem was that many of the data sets (parcels, topography, planimetric features, and imagery) needed to be updated on a regular basis to reflect the changing nature of the coast. Also, it was difficult to make the data available to others. Several organizations involved in state and regional coastal issues on the Great Lakes were interested in access to the integrated coastal data, but, as researchers and outreach specialists, it was difficult to fulfill the role of a spatial data librarian.

Lake Superior Coastal Mapping Portal

As the Lake Michigan Potential Damages Study wound down in 2000, the Open Geospatial Consortium (OGC) was implementing standards to promote geospatial interoperability and software emerged that allowed integration of spatial data from distributed sources. An opportunity emerged to move the focus of the Wisconsin Coastal GIS Applications Project to the Lake Superior coast of Wisconsin and test whether it was possible to build a "dynamic and distributed" coastal GIS. The NOAA Coastal Services Center provided funding to collaborate with local governments and other coastal data custodians to author interoperable web mapping services and build a web-mapping portal that integrated these services to support coastal management decision-making along the Lake Superior coast. The project team was influenced by the Gulf of Maine Ocean Observing System (GoMOOS), who had developed the cutting edge Gulf of Maine Mapping Portal (http://www.gommap.org/). GoMMaP was constructed using Minnesota MapServer (http://www.mapserver.org/), an open-source web map server software initiated at the Department of Forest Resources at the University of Minnesota, and Chameleon (http://chameleon.maptools.org/) – an open source environment for developing web mapping applications launched by DM Solutions Group, a geospatial consulting group based in Ottawa, Canada.

The Lake Superior Coastal Mapping Portal (http://maps.aqua.wisc.edu/lscmp/) includes a rudimentary catalog of interoperable web mapping services and allows users to select a "context file" in the mapping interface that groups services by theme and/or geography. For example, portal users can select a combination of services (point observations, NEXRAD radar, etc.) that display weather conditions for the entire Great Lakes (see Figure 2) or a different combination of services that integrate local spatial data for the four Wisconsin counties that border Lake Superior. While the LSCMP served as an early testbed showing the potential of integrating web mapping services in Wisconsin, it suffered from slow performance and maintenance issues. The Chameleon interface that was developed proved to be poorly suited to maintain an operational catalog of interoperable web mapping services.

Figure 2. Lake Superior coastal mapping portal map interface

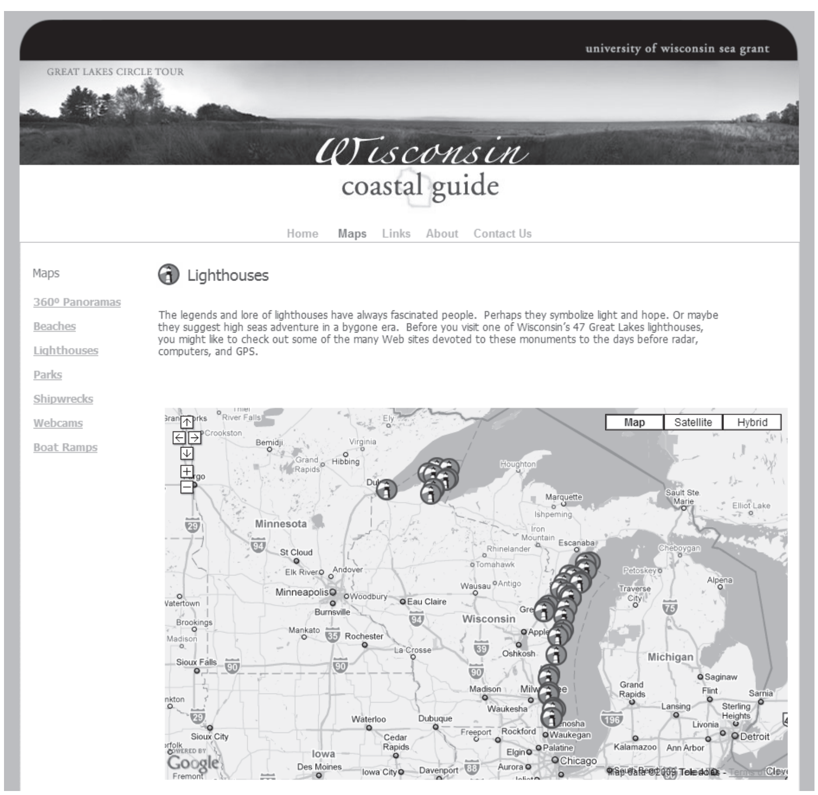


Wisconsin Coastal Guide

A third project initiated in 2005 allowed UW Sea Grant to test new approaches to web mapping. The Wisconsin Coastal Guide (http://www.wisconsin-coastalguide.org/) is an interactive web-mapping site that supports coastal heritage tourism along the Great Lakes Circle Tour route in Wisconsin and was funded by the Wisconsin Coastal Management Program. The Great Lakes Circle Tour is a scenic driving route circumnavigating all of the Great Lakes. The route, which is marked by distinctive signs, tends to follow busy state and federal highways and sometimes veers away from the lakes. The Wisconsin Coastal Guide shows the designated driving route, but also includes local roads and coastal attractions such as lighthouses, shipwrecks, boating access, beaches, and parks (see Figure 3). Panorama photos have been taken for nearly all of the public access sites to the Great Lakes. The primary mapping interface utilizes the Google Maps Application Programming Interface (API) (http://code.google.com/apis/maps/). When users click on the icon for a specific coastal attraction, a dialog box appears with more information, including links to external web sites with rich content about the attraction. A user can, for example, click on a lighthouse and gain access to any of the independently maintained web sites that provide detailed historical information and photos about Great Lakes lighthouses.

As an alternative to the Google Maps interface, links are provided to Keyhole Markup Language (KML) files for each of the coastal features, as well as other reference layers such as the Great Lakes Circle Tour route and oblique aerial photos of the coast. In addition, a KML file was created that combines all the coastal features and reference

Figure 3. Wisconsin coastal guide Google maps interface



layers (see Figure 4). Users who have downloaded virtual globe applications such as Google Earth (http://earth.google.com/) or NASA World Wind (http://worldwind.arc.nasa.gov/) find they have much improved ability to navigate the Circle Tour and explore coastal attractions. The main drawback is that users need to download very large files to install these "thick software clients" on their computer. This may not be a problem for those with high bandwidth and administrative privileges on their computer, but there are computer users without these advantages. Another benefit to this approach is that KML is now an OGC standard that promotes interoperability. Providing a stable URL to the KML files promotes their use in other web mapping applications. As an example, the Wisconsin Coastal Guide KML files have been used in the HarborView web-mapping application (http://glos.us/hview/) developed by the Great Lakes Observing System (GLOS). HarborView is an interactive web-mapping site that integrates weather and current Great Lakes observations with coastal attractions to promote safe and pleasurable recreational boating (see Figure 5). This initial foray into the world of mapping mashups has been beneficial in promoting coastal heritage tourism, but showed how little guidance exists on deciding among the various approaches to developing web-mapping interfaces.

Wisconsin Coastal Data Catalog

Influenced by a presentation on the International Coastal Atlas Network interoperability prototype and coastal erosion use case at the Coastal Zone '07 conference in Portland, Oregon, UW Sea Grant decided to explore adoption of some of the supporting technologies for a CWA in Wisconsin. Most of this effort involved installing and customizing GeoNetwork (http://geonetwork-opensource.org/), an open source geospatial catalog software developed by the United Nations.

The Wisconsin Coastal Data Catalog (http://speedy.ersc.wisc.edu:8080/geonetwork/) was populated with spatial data sets developed for the Lake Michigan Potential Damages Study in Ozaukee County, Wisconsin. These included mapping of coastal bluff tops and toes in 1956 and 1999, and coastal orthophotos for the same time periods. Metadata was included for each of the data sets. The GeoNetwork interface allows a user to search for data using a variety of techniques; view an abstract, key words, and a display graphic of the data set; access the detailed metadata; view layers in an interactive web mapping application;

Figure 4. Wisconsin coastal guide combined KML file in Google Earth

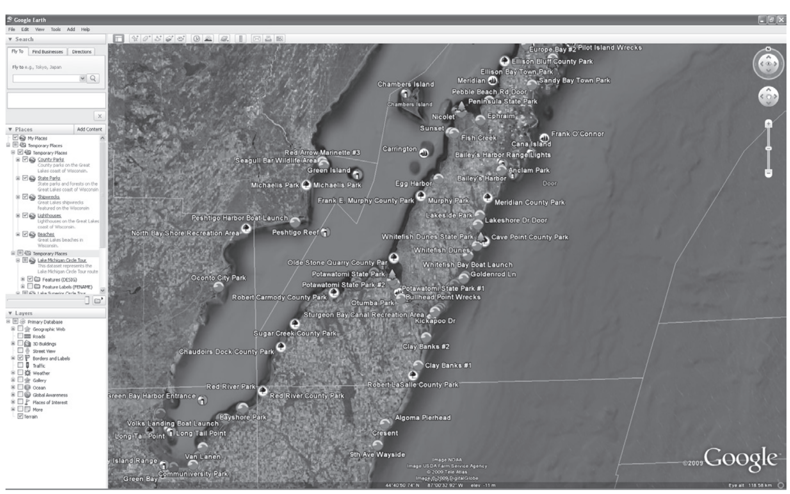
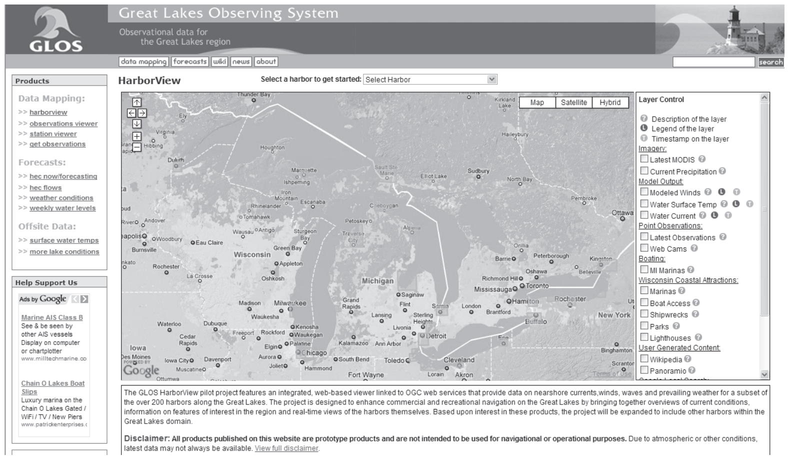


Figure 5. GLOS HarborView web mapping application

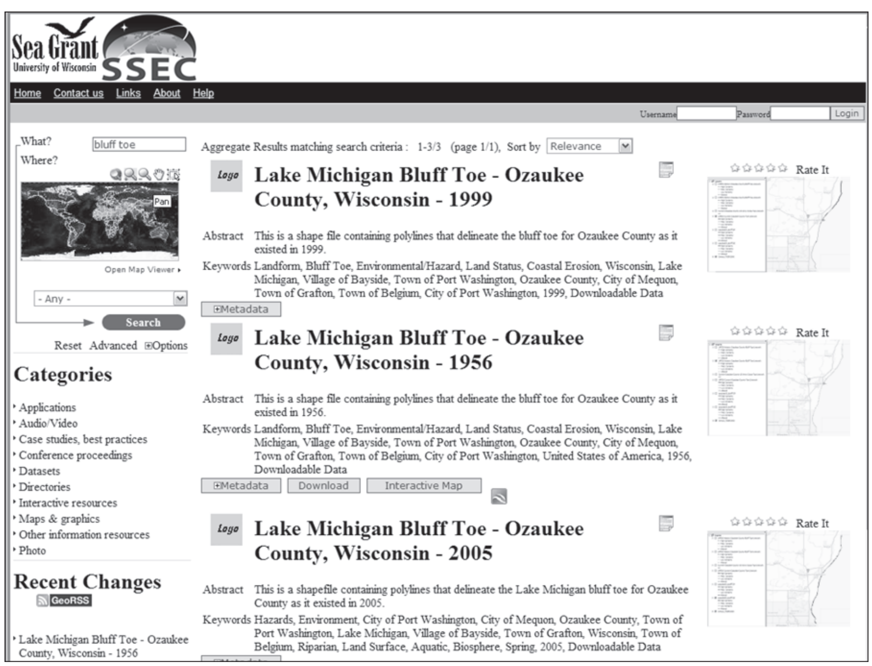


and download data in a variety of formats (see Figure 6).

GeoNetwork has many powerful capabilities. It is one of the few open-source geospatial data catalog software packages available and supports a variety of OGC interoperability protocols. Perhaps its greatest strength is the collaborative nature of the software. Because it is a web application, a remote user with credentials can login and enter information for the data sets they maintain. If some data custodians want to set up their own GeoNetwork site, communication can be established between these sites.

Some problems were experienced during the process of installing and utilizing GeoNetwork. First, it proved difficult to customize the GeoNet-

Figure 6. Screenshot of Wisconsin coastal data catalog interface



work interface. It was difficult to modify the code that governed the appearance of the interface in the database format used by GeoNetwork. Also, importing metadata in the FGDC format did not work. GeoNetwork is better suited for importing metadata in the ISO format, while many spatial data custodians in Wisconsin maintain their metadata in FGDC format using ESRI's ArcCatalog. This issue regarding metadata uptake may affect later participation in the Wisconsin Coastal Data Catalog by local governments. Next, some of the data distribution formats supported by GeoNetwork did not work. In particular, it was not possible to view interactive maps through the GeoNetwork interface and KML files generated by the catalog did not display properly. Finally, it appears that work was still needed to successfully harvest other OGC Catalog Services for the Web (CSW) using version 2.2 of GeoNetwork. It is important to note that many of these issues could likely be solved with more programming experience at UW Sea Grant.

Despite these drawbacks, GeoNetwork still provides the best open source option for implementing a coastal spatial data catalog. It is worth watching to see if anyone "geo-enables" one of the existing open access institutional repository software environments (ePrints, DSpace, Fedora), but that may be a long way off. Over the next several months, there are plans to: (1) include outside coastal data custodians with robust interoperable web mapping services in the GeoNetwork testbed; (2) complete an ontology of Wisconsin coastal hazards terms using the Protégé software developed by Stanford University (http://protege.stanford.edu/); and (3) document other coastal data sets and reports in the Wisconsin Coastal Data Catalog. This is possible because GeoNetwork is set up to catalog more that just geospatial data. The first data sources to be cataloged include oblique aerial photos of the coast taken in 2007 and 2008 by Dr. David Mickelson, a geologist at the University of Wisconsin-Madison, and the many coastal hazards technical studies completed for the Great Lakes coast in Wisconsin during the past 20 years.

BUILDING THE CASE FOR A WISCONSIN COASTAL ATLAS

In August 2003, a retreat on the future of the Great Lakes Information Network (GLIN) was held at Wingspread near the Lake Michigan shore outside Racine, Wisconsin. Wingspread is a unique conference facility designed by Frank Lloyd Wright and operated by the Johnson Foundation. Many deliberations on important policy issues ranging from local to international have been held at Wingspread over the years. Photos on the wall show dignitaries such as Henry Kissinger engaged in serious debate. In this auspicious location, experts with an interest in the intersection of Great Lakes policy and information technology met on the tenth anniversary of GLIN to chart a course for its future. GLIN (http://glin.net/) is an innovative information portal and discussion forum for the Great Lakes that was initiated in 1991 using some of the earliest web protocols such as Gopher (Manninen, 1999). One important topic was raised multiple times during the retreat – the need for an integrated spatial database for the Great Lakes to allow exploration of what-if alternatives for Great Lakes management. The metaphor of having all the information readily available to conduct "SimGreatLakes" simulations was advanced. This is the spirit that will guide development of the Wisconsin Coastal Atlas.

A coastal web atlas is defined as "a collection of digital maps and datasets with supplementary tables, illustrations, and information that systematically illustrate the coast, oftentimes with cartographic and decision-support tools, and all of which are accessible via the Internet" (O'Dea *et al*., 2007). The Oregon Coastal Atlas (http://www.coastalatlas.net/) and the Marine Irish Digital Atlas (http://mida.ucc.ie/) are early examples of robust CWAs. In particular, the Oregon Coastal Atlas provides a good model for a CWA in Wisconsin. It was developed by the Oregon Coastal Management Program in cooperation with Oregon State University and other partners beginning in 2000. It consists of four components (maps, search, tools, learn) that enable "users to search and find data, but also to understand its original context, and put it to use via online tools in order to solve a spatial problem" (Haddad *et al.,* 2005). The atlas has been a resounding success. It now serves more than 3,500 data sets and received about 2.5 million hits in 2008 (Oregon Department of Land Conservation and Development, 2009). Moreover, the map interface has become a common framework for discussing coastal management issues (National Oceanic and Atmospheric Administration, Coastal Services Center, 2003).

As the Wisconsin Coastal Atlas is built, there will be an effort to balance the practical needs of developing a CWA with the work that is needed to advance the most significant research issues concerning implementation and interoperability of CWAs. This includes development of a template for design and evaluation of CWA projects; promotion of sound cartographic design principles for web mapping interfaces; identifying and reducing the technical and institutional barriers to the development of domain spatial data infrastructures that draw heavily on local government data; development of an effective archive for coastal geospatial data, and; application of ontology tools to promote semantic mediation of local government spatial data sets to conduct spatial analyses of coastal issues at a regional scale.

UW Sea Grant is actively working with potential partners to communicate the vision for a Wisconsin Coastal Atlas. Development of the atlas will start in February 2010 with an initial focus on the mapping interfaces and spatial data needed to address coastal hazards on the Great Lakes. This will be synchronized with a two-year NOAA Coastal Management Fellow who will help build a Great Lakes spatial decision-support toolbox to address coastal hazards resilience and more effective implementation of comprehensive plans in coastal communities.

CONCLUSION

Wisconsin has a long history of applying geospatial technologies to Great Lakes issues. Coastal GIS projects have touched upon many of the components of a CWA, but Wisconsin currently lacks a consolidated web portal for maps, data, and decision-support tools for the Great Lakes. Funding for a two-year period starting in February 2010 has been secured to build the Wisconsin Coastal Atlas. Key project partners anticipate the benefits of the atlas. The Wisconsin Department of Natural Resources expects that an atlas will enable the analyses needed to implement the Wisconsin Great Lakes Strategy and the Great Lakes Compact. The State Geographic Information Officer sees the atlas as a template for state GIS initiatives both on and away from the coast. Completing an interoperable Wisconsin Coastal Atlas could promote development of other regional, state, and provincial CWAs. Sharing among interoperable CWAs could help realize a long-time goal of scientists and coastal resource managers – management of the Great Lakes using a whole ecosystem approach (Caldwell, 1988; MacKenzie, 1996; Sproule-Jones, 2002).

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KEY TERMS AND DEFINITIONS

Coastal Web Atlas: A collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet. Also known as web atlas, digital atlas, digital coastal atlas.

Atlas Interoperability: The ability to interrogate two or more unrelated atlas systems and potentially exchange metadata, images, vector and raster data.

Coastal and Marine Information: Both spatial and non-spatial information regarding the coastal and marine areas of a region or country.

Integrated Coastal Zone Management: A dynamic, multi-sectoral approach to managing the coast which takes into account social, economic and environmental concerns of all parties with an interest in the coastal space.

Metadata: Information that fully describes or documents a dataset, such as its geographic coverage, quality, completeness, accuracy, etc. are a "pedigree" of sorts for a data set and helps you to judge its "fitness for use" or reliability, thereby helping one to use it more appropriately and efficiently. Metadata allow a potential user, for comparative purposes, to understand how the data were collected. They also provide the all-important details of how you can actually obtain the data in question, or who best to contact. Data that do not have accompanying metadata are often hard to find, difficult to access, troublesome to integrate, and perplexing to understand or interpret.

Spatial Data Visualization: The ability to view digital data with a spatial dimension in a computer environment containing a coordinate reference system.

Web GIS: A geographical information system which can be accessed over the Internet and allow visualization and interaction with spatial data via a map as well as providing analysis functionality such as spatial analysis, querying and buffering.

Virtual Globe: A three-dimensional visual rendering of the Earth or of other planets, usually available as online software application, or as an application for the desktop. A virtual globe provides the user with the ability to navigate throughout the virtual world freely in all directions, by changing viewing angle, azimuth, and heading. A virtual globe is primarily a visualization tool (oftentimes open source) and is not completely synonymous with a geographic information system in terms of spatial analysis capabilities. Examples include Google Earth, NASA World Wind, and Microsoft Virtual Earth.