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GEOSPATIAL MANAGEMENT PROGRAMS AND PROJECTS IN THE GREAT LAKES

Report to the 2012-2015 IJC Priority Work Group on
Strengthening the Capacity to Deliver Great Lakes
Science and Information

For the International Joint Commission

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PREFACE

Programs outlined in this paper are only those geospatially linked initiatives that can be directly applicable or applied to management of resources in the Great Lakes Basin.

Information on programs was largely gathered from program websites and thus websites are outlined after the program title. In some cases program objectives and goals were taken directly verbatim from the site in order to provide the information as the program intended. In other cases information was taken from a second source, citations are used.

EXECUTIVE SUMMARY

Geospatial data and services are critical elements needed to meet the mission of monitoring and surveillance of ecosystem integrity under the Great Lakes Water Quality Agreement (GLWQA). Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing are the primary elements which fall under the geospatial data and services umbrella. Geospatial services provide the technology to create, analyze, maintain, and distribute information.

It is critical to identify and assess those programs or projects being conducted within the Great Lakes basin that address both data collection and management to inform environmental management decisions.

This paper provides a compendium of information about the purpose, goals and objective of these initiatives, as well as what the products of these programs are and how this relates to management.

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Background

The Great Lakes Water Quality Agreement (GLWQA) is the principal driving force behind monitoring and surveillance of ecosystem integrity in the Great Lakes by provincial, state, and federal agencies. The Agreement includes extensive recommendations for monitoring pollutant sources, loadings, presence, impacts and trends in various media, as well as ensuring compliance with specific environmental objectives (Richardson et al., 2012). Monitoring is also necessary to support modeling and predictive techniques and to assess the success of remedial or restorative measures. Lakewide Management Plans (LaMPs) are binational, cooperative efforts described in the GLWQA to restore and protect the health of each of the Great Lakes by reducing chemical pollutants entering the lake and by addressing the biological and physical factors impacting the lake. LaMPs require additional monitoring to assess impairment of 14 different beneficial uses — for example, fish tumors; degradation of benthos; beach closings; and restrictions on fish and wildlife consumption (Richardson et al., 2012). Responsibility for monitoring in the Great Lakes, under the GLWQA, is shared among Canadian and U.S. federal agencies, as well as the eight Great Lakes states and the province of Ontario. The U.S. General Accounting Office identified 24 government agencies that provide Great Lakes monitoring and/or research information; in addition, U.S. Municipalities and Canadian Conservation Authorities implement monitoring activities (this does not include academia and volunteer organizations) (Richardson et al., 2012). In addition, the GLWQA recognizes the importance of “the interacting components of air, land, water, and living organisms, including humans” in the Great Lakes basin ecosystem, and calls for research to determine impacts. A vital component of this effort is how these variables relate in a geospatial context.

Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing are the primary elements which fall under the geospatial data and services umbrella. Geospatial services provide the technology to create, analyze, maintain, and distribute geospatial data and information. GIS, GPS, satellite imagery and remote sensing play a vital role in National, Federal, Provincial and region long-term goals in analyzing and quantifying ecosystem health. Nationally coordinated support for geospatial services, along with regional support and infrastructure, promotes cost savings and enables improved business practices. Geospatial data can improve enable improved visualization, analysis, interoperability, modeling, and decision support. The benefits include increased accuracy, increased productivity, and more efficient information management and application support. Improved coordination and sharing of this data will further aid in standardization of practices and data collection.

Although multi-agency consultation and collaboration on geospatial projects has increased over the past decade, with so many players the potential for both real and perceived duplication of effort remains. Multiple groups investigating the causes and possible solutions of a lake's problems often benefit from working in a coordinated fashion (Richardson et al., 2012). This is particularly relevant with geospatial data that can overlap graphically and provide important regional information and insight for cumulative stressors. Standardization of data and sharing will greatly aid in providing a holistic view of the health of the Great Lakes.

The 2012-2015 Cycle IJC priority: "Strengthening the Capacity to Deliver Great Lakes Science and Information" includes several individual projects, including a project entitled "Integration and Access to Information" that is meant to provide advice about how data collected through a multitude of U.S. and Canadian initiatives might be best utilized to inform Great Lakes management decisions. The IJC has recent and relevant experience with both the GLSLR-Adaptive Management Task Team and the International Watershed Initiative illustrating the importance of documenting and communicating the purpose and intent of existing initiatives so that opportunities for collaboration and standardization will be revealed. To meet IJC priority objectives, it is critical to identify and assess those programs or projects being conducted within the Great Lakes basin that address both data collection, and data management and delivery to inform environmental management decisions. Most of these initiatives are aimed at creating geo-spatial information systems. A compendium of information about the nature and purpose of these initiatives is a critically important foundation for the Council of Great Lakes Research Managers report and could be utilized by managers of both Parties at all levels of government.

Objectives

- 1) Conduct a review of data collection and data management and delivery geospatial management programs/projects in the Great Lakes region, focusing on a) existing management programs supported by Geospatial database tools and b) the monitoring efforts that support the function and refinement of these management tools.
- 2) Develop a compendium of information about the purpose and structure of existing state, provincial, and binational data collection and data management and delivery programs/projects for the Great Lakes Basin based on the results of the above review.
- 3) Provide a report that explains the purpose and scope of each effort and compare and contrast these existing initiatives.

Deliverables

This document serves as the main deliverable of the objectives outlined above. With direction from IJC scientific authorities, and through established contacts and input from U.S. and Canadian agency representatives involved in the implementation and refinement of GIS tools in support of management decision-making information was gathered pertaining to existing programs within the Great Lakes Basin. Input from the Council of Great Lakes Research Managers will be considered, as well as input from staff of related active efforts including, but not limited to The Cooperative Science and Monitoring Initiative (CSMI), and particularly the GEOSS Great Lakes Test bed initiative.

This summary report describes GIS based management related activities and projects being conducted in the Great Lakes basin as either an ongoing monitoring program or as a grant-driven academic study. The report summarizes programs claiming to deliver management related information and to examine the range of approaches currently adopted (especially in the context of LaMPs) for gaps with special focus on near shore areas in the Great Lakes.

INTRODUCTION

Geospatial information is the cornerstone of effective ecosystem management and restoration planning at the regional level (USGS, 2013). Restoration, management, and assessment of Great Lakes Basin aquatic ecosystems require an understanding of the relations between landscape characteristics, water withdrawals and returns, streamflow, and ecological function. A science framework built on these relations may include spatial data, ecological data, and analysis. Geospatial data and services are critical elements of the necessary monitoring and surveillance for this science framework. Geospatial data includes Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing and the relating mapping and visualizations. A list of sources of GIS data for the Great Lakes can be found in Appendix A. These are agencies that supply data but are not for the most part involved in related analysis and management planning.

Of the Great Lakes, the Lake Erie watershed is the closest to achieving complete topographical modeling by using Light Detection and Ranging (LiDAR) that creates fast and accurate terrain models through airborne high resolution laser scanning imagery. One example that highlights the importance and need for geospatial information in management planning is the Lake Erie watershed is the Huron-Erie Corridor, which includes the St. Clair River, Lake St. Clair, and the Detroit River, and is a major multi-use waterway, involving commercial shipping, recreational boating, the international wildlife refuge, and intakes for the Detroit Water and Sewer Department, which provides drinking water to almost 5 million people in Detroit and surrounding communities (USGS, 2012). Geospatial information in Lake Erie can provide a useful planning tool to each of these sectors.

The use of increasingly advanced technologies in the coastal zone (notably remote sensing, web mapping and mobile application technologies, visualization techniques, and LiDAR) to support research and management has improved the quality of information geospatial data is now able to provide.

Numerous initiatives throughout the Great Lakes Basin are calling for greater coordination of GIS data collection and dissemination efforts to better establish the status and trends of Great Lakes coastal natural resources. Many of these initiatives recognize the need for a shared resource of GIS data. Examples of these initiatives range from the basinwide level, to individual lake basin programs (the LaMPs), to regional ecosystems, to local watersheds, and finally, to site-specific projects. This "nested approach" ensures that environmental impacts are being reviewed by the program working at the proper scale to address the issues (EPA, 2013).

A cornerstone of collaborative, regionally based planning is providing access to data for transparent, science-based decision-making. Geospatial information can be used for management planning regarding habitat protection, coastal wetlands, water resources, sustainable land use, conservation practices on agricultural lands (specific to buffers), and Great Lakes fisheries, among others, and goes even further and calls for data trends to be accessible via the Internet by 2006 (GLIN, 2013).

This report examines existing and ongoing Great Lakes geospatially informed programs that serve management needs. This paper examines 50 initiatives and over 60 programs. The websites for each initiative is provided from which most or all of the data was gathered. This report aims to provide only a brief introduction to the programs to summarize the program description, objectives/goals and the products and management relevance.

The report aims to be comprehensive but some programs may have been excluded based on the indirect link to management. Similarly some programs may have been missed due to their small scale operations or if they were still in their infancy.

Geospatial services provide the technology to create, analyze, maintain, and distribute geospatial data and information. GIS, GPS, remote sensing and related mapping play a vital role in the long-term goals of understanding, analyzing and quantifying ecosystem health. Knowing the spatial distribution of stressors and human benefits will help guide the effective management of Great Lakes resources.

Projects

1.0 NOAA Coastal and Marine Spatial Planning

Website: <http://www.msp.noaa.gov/>

Project Description

NOAA's Coastal and Marine Spatial Planning (CMSP) Data Registry is a web-based resource to provide access to a collection of NOAA geospatial data sets served with supporting metadata. Approximately 50 data sets are included in the registry. These data sets directly contribute to comprehensive regional marine planning. Within the CMSP Data Registry, data has been organized thematically as have been deemed as high-priority needs from regional planning communities. Some of the available data include seamless raster navigational charts, bathymetry, human uses, essential fish habitat, and boundaries for U.S. marine protected areas. NOAA data are provided in a variety of standard Web mapping service formats. These allow for a one-stop discovery, display, and download by users. Many of the mapping displays can be previewed—either individually or simultaneously in a data mash-up with other registry data sets—using ESRI's ArcGIS.com map viewer. These data are also being integrated into Ocean.Data.Gov to reach an even broader audience (NOAA, 2013 (a)).

Objectives

The primary objective of this program is to provide access to data through the CMSP data registry. Longer term goals are to develop a strategy to link national systems like the CMSP Data Registry and Ocean.Data.Gov to regional information management approaches in the ocean and coastal planning community; to identify common standards and procedures to be adopted by regional ocean governance groups; and to establish a practitioner's network of data and tool developers and contributors to Ocean.Data.Gov and the larger network of data portals (NOAA, 2013 (a)).

Products and Management Relevance

Coastal and marine spatial planning offers a comprehensive and integrated approach to managing uses and activities at the regional level. This program places sound science and the best available information at the heart of decision-making and brings federal, state, tribal, and other partners together to cooperatively to develop coastal and marine spatial plans. This process is designed to decrease user conflict, improve planning and regulatory efficiencies, decrease associated costs and delays, engage affected communities and stakeholders, and preserve critical ecosystem functions and services. The marine planning is a tool developed from the bottom up to improve collaboration and coordination among all coastal and ocean interests, and to better inform and guide decision-making that affects their economic, environmental, security, and social and cultural interests (NOAA, 2013 (a)).

2.0 Great Lakes Restoration Initiative (GLRI)

Website: <http://glri.us/>

The Great Lakes Restoration Initiative (GLRI) is a federal project funded at \$475 million and is a top priority for the agencies involved. The initiative invests in solutions to some of the most urgent threats to the Great Lakes, including toxic pollution, destruction of wetlands and habitat, polluted run-off and invasive species such as the Asian carp (Great Lakes Initiative, 2013).

President Obama unveiled the Great Lakes Restoration Initiative in his inaugural budget in 2009. Work has begun on over 300 local projects that will improve the health of the Great Lakes. Many of these projects are facilitated by the U.S. Geological Survey (USGS), as a multi-disciplinary science agency, with integration of expertise from the various USGS Science Centers and collaborating with other federal agencies. Other major contributors to GLRI projects include the U.S. Environmental Protection Agency, other federal agencies and non-federal partners through competitive grants, cooperative agreements and contracts (Great Lakes Initiative, 2013).

A task force of 11 federal agencies developed a plan to put the president's initiative into action. This action plan covers fiscal years 2010 through 2014 and addresses five urgent focus areas (Great Lakes Initiative, 2013):

1. Cleaning up toxics and areas of concern;
2. Combating invasive species;
3. Promoting nearshore health by protecting watersheds from polluted run-off;
4. Restoring wetlands and other habitats; and
5. Working with partners on outreach.

Current Great Lakes Restoration Projects that are geospatially inclusive are described below.

2.1 SharedGeo GLRI Collaborative Mapping Project

Website: <http://www.sharedgeo.org/projects/great-lakes-restoration-initiative-glri-project/>

Project Description

The SharedGeo GLRI Project supports current and historical imagery and spatial data that are related to the Great Lakes area, surrounding watersheds and wildlife habitats. The SharedGeo

GLRI project hosts 40+ TB of imagery data that are served in a fast, reliable and scalable manner. These datasets are available from nine U.S. states and the Province of Ontario. This online system is specifically designed to accommodate expansion, and can be easily replicated for use in other scenarios. In addition, metadata and services from other sources are also available and are harvested by the SharedGeo GeoNetwork node. The GeoNetwork node contains information about hundreds of data layers in the Great Lakes region (Shared Geo, 2013).

Objectives

The goal of the SharedGeo GLRI Project is to serve and share current and historical imagery and spatial data that are related to the Great Lakes area, surrounding watersheds and wildlife habitats (Shared Geo, 2013).

Products and Management Relevance

The project uses open-source tools to serve, catalog, map and distribute spatial data and has main 3 products/parts (Shared Geo, 2013):

- 1) Spatial data web services and data download tools
- 2) A spatial data catalog
- 3) A web map integration tool

The most important way SharedGeo is contributing to the Great Lakes Restoration Initiative is by providing fast and reliable imagery services to other organizations. These services can be used in for mapping applications (Shared Geo, 2013).

SharedGeo also leverages other organizations resources by harvesting their map services and metadata services into the SharedGeo GeoNetwork node and if data are available via map services, the layers can be added to Co-Map to be viewed. By using services and not local copies of data in this solution, the user is always assured they have the most up-to-date data and imagery to use in their decision making (Shared Geo, 2013).

2.2 Geospatial Information for Decision Support in AOCs and Ecosystems

Website: http://cida.usgs.gov/glri/projects/accountability/decision_support_AOCs.html

Project Description

The U.S. Geological Survey (USGS) working with county governments, the State of Michigan, and other Federal Agencies, particularly the U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA), is acquiring high-resolution elevation and Light Detection and Ranging (LiDAR) point-cloud data. The specific regions of study for this project include (in order of priority): Macomb County, St. Clair County, and Monroe County, Michigan. The imaging work is being contracted to the USGS National Geospatial Technical Operations Center (NGTOC) Commercial Partnerships Team (CPT) based in Rolla Missouri (USGS, 2013 (e)).

Objectives

The objective of the project is to complete LiDAR coverage for the Huron-Erie Corridor. Depending on funds actually available or obtained through partnerships, the project will expand to finish the Lake Erie watershed. This information will then be made available to scientists, managers, State/County/Local agencies, and the general public (USGS, 2013 (e)).

Products and Management Relevance

LiDAR is a critical data need for many Federal, State, and local agencies, as well as environmental managers and researchers. Much of the elevation data in the Great Lakes, and within the western Lake Erie watershed, is more than 30 years old and lack sufficient detail to identify areas of current or potential wetlands, develop restoration and management plans, or even delineate watersheds reliably. Further, the additional derivative products of the LiDAR, including land cover, canopy height, and biomass, among others, provide useful information for restoration and related management planning(USGS, 2013 (e)) .

2.3 Great Lakes Basin Ecosystem Team (GLBET)- Geographic Information Information System/Decision Support System (Islands)

Website: http://www.umesc.usgs.gov/management/dss/great_lakes_islands.html
(factsheet): <http://www.glc.org/gis/GLBET/IslandsDSSFactSheet.html>

Project Description

The Great Lakes contain approximately 30,000 islands, ranging in size from small boulders to more than a hundred thousand acres (USGS, 2013 (g)). These islands form are part of the world's largest freshwater system and are a unique natural resource and are a valuable are of study for coastal ecology. There are several rare natural features located on the islands of the Great Lakes, including several species of plants endemic solely to Great Lakes islands, and many U.S. Fish and Wildlife Service (USFWS) trust resources such as rare and endangered species, neotropical migrants, interjurisdictional fishes, colonial water birds, and waterfowl (USGS, 2013 (g)). The Great Lakes Basin Ecosystem Team (GLBET) Islands Committee collaborated with the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC) to gather spatial and non-spatial data on the Great Lakes islands. The Great Lakes Island Geographic Information System and Decisions support Program focuses on Great Lakes island protection. This initiative is timely in that pressures from invasive species and humans continue to increase (USGS, 2013 (g)).

Objectives

The U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC) was tasked to gather spatial and non-spatial data on the Great Lakes and create a Decision Support System (DSS) to guide future management and protection of these islands and surrounding areas (USGS, 2013 (g)).

The GLBET GIS/DSS is a tool, which helps the user answer simple questions concerning Great Lakes islands and the Great Lakes basin as a whole. The GIS/DSS facilitates decision-making for land acquisition, environmental review, management planning, and provides a valuable tool for communication and outreach (USGS, 2013 (g)).

Products and Management Relevance

The DSS facilitated decision-making for land acquisition, environmental review, management planning, and provide a valuable tool for communication and outreach. The DSS was made available from the desktop of all USFWS field stations that manage resources within the Great Lakes Basin (USGS, 2013 (g)). Managers can review the Great Lakes islands within the DSS for natural resource values and threats and for their potential for acquisition by the National Wildlife

Refuge System. The GLBET GIS/DSS is currently available as a demonstration project for the Lake Michigan watershed (USGS, 2013 (g)) (Figure 1).

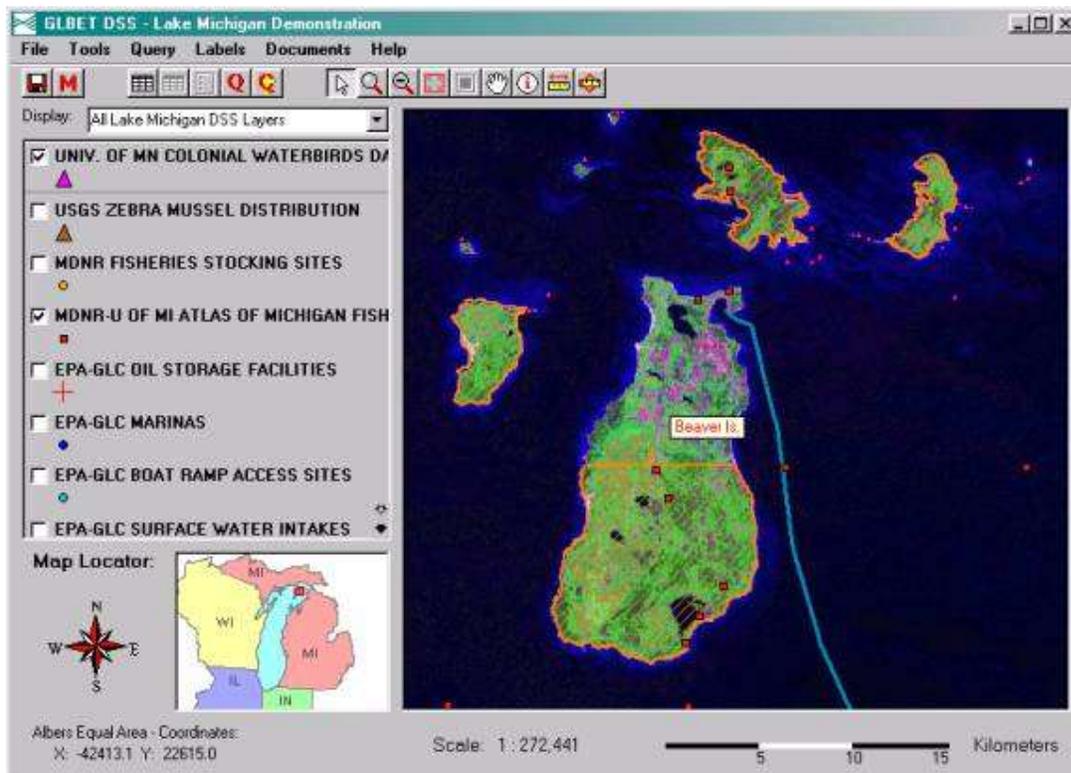


Figure 1. GLBET DSS Lake Michigan Demonstration (source: <http://www.glc.org/gis/GLBET/IslandsDSSFactSheet.html>)

The GLBET GIS/DSS will be expanded in the future to include the remaining Great Lake basins. Each individual lake basin will have its own application, which the user can install on his/her computer (USGS, 2013 (g)).

2.4 Great Lakes Basin Lake Sturgeon GIS Database

Website: http://www.umesc.usgs.gov/management/dss/great_lakes_sturgeon.html

Project Description

The Great Lakes Basin Ecosystem Team (GLBET) Lake Sturgeon Committee collaborated with the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC) to create a prototype webpage to graphically display Lake Sturgeon sampling information collected within the Great Lakes Basin. The UMESC then created a prototype web-based

Environmental System Research Institute's (ESRI) ArcIMS (Internet Map Server) Decision Support System (DSS) to display this information (USGS, 2013 (h)).

Objectives

Field staff within the Great Lakes Basin have been entering Lake Sturgeon sampling information into a database structure that will link to the National Hydrographic Dataset for display in an interactive web-based application. The database will improve upon the existing maps and database developed for the 2000 and 2002 Great Lakes Fishery Trust (GLFT) Lake Sturgeon Workshops. The long-term objective is to compile the available lake sturgeon data sources to help focus restoration and research activities on priority lake sturgeon waters (USGS, 2013 (h)).

Products and Management Relevance

The pre-existing GLFT Workshop base maps and database identifies and categorizes all known lake sturgeon waters within the Great Lakes Basin into extirpated, historic, reintroduced, and/or current lake sturgeon populations for 2000 and 2002. This collaborative GLRI project has created a metadata structure that broadens the information that can be stored and made available to researchers. Greater resolution of the degree of use or presence in a river system has been added for all populations. Where available, information is referenced for presence of adults, juveniles, and subadults, and whether spawning has been observed, egg deposition documented, and larvae captured (USGS, 2013 (h)).

This project will significantly enhance the availability of a unified, interactive web-based GIS application and meta-database of Great Lakes lake sturgeon information important to researchers and managers particularly for restoration and protection of lake sturgeon.

2.5 Great Lakes Restoration Initiative: Forecasting Potential Phragmites Coastal Invasion Corridors

Website: <https://cida.usgs.gov/glri/geonetwork/srv/en/main.home>

Project Description

Through a cooperative effort with Michigan Tech Research Institute (MTRI), a spatial analyst lab, satellite data was used (PALSAR) to create a basin-wide map of Phragmites in the Great Lakes. The mapping effort also was supported by GLRI funds from the USFWS. The basin-wide map of the US coastal zone shows variability in the distribution of Phragmites, with

certain regions (e.g., western Lake Erie, southern Lake Huron, Green Bay of Lake Michigan) supporting extensive Phragmites. This mapping product represents mature invasive Phragmites. Further, using LIDAR data that were collected as part of a NOAA GLRI project, the study was able to determine what bottomlands may be exposed under reduced lake-level scenarios (climate change) and become potential corridors for Phragmites invasion (USGS Great Lakes Science Center, 2011).

Objectives

The goals of this program were to first identify current Phragmites distribution in the Great Lakes coastal zone. Next to detect potential areas vulnerable to invasion due to influences such as altered water levels, nutrient and sediment loading, and shoreline development, and finally to communicate project results to researchers, managers, policy makers, and the general public to guide future management and restoration efforts throughout the Great Lakes basin (USGS, 2013 (i)). The objectives were to use remote sensing (LIDAR) to map the current extent of Phragmites in the Great Lakes coastal zone, and assess areas vulnerable to the spread of Phragmites under predicted climate-change scenarios and environmental influences (e.g., nutrients, hydrology, shoreline development). The third objective was to create a web-based decision-support tool to be communicated to the public and decision makers USGS Great Lakes Science Center, 2011).

Products and Management Relevance

The main product of this study was the Phragmites maps that were made available to the general public and land managers through the USGS Center for Integrated Data Analytics (CIDA) GLRI GeoNetwork. The GeoNetwork allows the graphical interpretation of these products through interactive maps. Other project-related data publicly available on the existing GeoNetwork include a study area extent, raw lidar topo-bathymetry, the proximity-weighted reduced lake-level scenarios that were derived from LIDAR, a layer showing users where LIDAR data were unavailable, a separate set of reduced lake-level scenarios made possible by NOAA (USGS Great Lakes Science Center, 2011).

The second major product was the GLRI Phragmites Decision Support Tool (DST) Mapper which is intended to provide resource managers with information to strategically develop effective Phragmites control and invasion prevention programs in the Great Lakes coastal zone (10 km inland from the shoreline) (USGS Great Lakes Science Center, 2011).

The Mapper consists of three integrated components:

- A distribution map of large stands of existing Phragmites.
- A map of estimated Phragmites habitat suitability based on current environmental conditions.

- Corridor networks including reduced lake-level scenarios that are weighted by proximity to existing Phragmites to show likely invasion pathways.

The basin-wide map of current Phragmites distribution will be useful to natural resource managers and will provide a basis for basin-wide efforts to control Phragmites, especially in areas where preservation of native biodiversity is particularly important. This map will also aid in attempts of controlling the spread of this invasive species (USGS Great Lakes Science Center, 2011).

Wetlands with previously undiscovered stands of Phragmites will be identified, and restoration efforts can be directed at these areas. Predicting corridors for future invasion by assessing vulnerability of exposed bottomlands to expansion will allow managers to target and prioritize control efforts, especially in relation to current coastal wetland restoration efforts. Furthermore this research will help provide information about Phragmite growth under climate change conditions and allow for development of adaptive management programs (USGS Great Lakes Science Center, 2011).

2.6 Fish Habitat Enhancement Strategies for the Huron-Erie Corridor

Website: http://cida.usgs.gov/glri/projects/habitat_and_wildlife/fish_habitat_HEC.html

Project Description

The Huron-Erie Corridor (HEC) is the connecting channel between Lake Huron and Lake Erie and includes the St. Clair River, Lake St. Clair, and the Detroit River. It supports sixty-five species of fish, 16 of which are classified as threatened or endangered by state, federal, and provincial authorities; and is part of the Great Lakes flyway for migratory birds. The Detroit River International Wildlife Refuge and the Ottawa National Wildlife Refuge are located in the HEC, and the Detroit River is designated an International Heritage River System (USGS, 2013 (i)). Over the last century, fish productivity in the HEC has been greatly reduced through loss of coastal wetlands, filling and armouring shorelines, and channelization and dredging of the limestone bedrock that was spawning habitat for numerous fish species to construct the shipping channels (USGS, 2013 (j)). Thus, in 2004, the USGS Great Lakes Science Center and partners conceived the Huron-Erie Corridor Initiative (HECI) to develop science-based adaptive management strategies to help restore high fishery productivity in the corridor and develop delisting criteria for fish habitat loss BUIs. This includes developing historic maps for the HEC and ranking threats to restoration of fishery production in order to devise a plan for restoring fish productivity by creating connected fish spawning and nursery habitat. Scientists are working to address impediments to restoring ecological resiliency and function in the Corridor by developing scientific strategies intended to restore productivity of historic fish spawning grounds by measuring increases in fish egg deposition and larval transport rates, create connected fish spawning & nursery habitat, measure effects of aquatic invasive species

on native aquatic species, protect and restore coastal wetlands, and improve beach health and water quality (USGS, 2013 (j)).

Objectives

Specific objectives of the HECI include (USGS, 2013 (j)):

- developing a blueprint for restoring fish productivity by creation of connected fish spawning and nursery habitat;
- comparing historic and present fishery productivity and fish habitat;
- developing a GIS data base of historic maps for the HEC;
- addressing tribal interests in fishery resources restoration; and
- assessing and ranking threats to restoration of fishery productivity in the HEC.

The program will integrate geospatial and hydrodynamic models to estimate natural habitat attributes (geomorphology, flow regimes, depths, substrate characteristics, and bank slope; as baseline parameters for fish habitat restoration. GIS analysis and hydrologic modeling will be used to link changes in the fluvial geomorphology and hydraulic regime to natural erosion, channelization and changes in fish habitat from 1870 to 2000 in the Huron-Erie Corridor. Historic and recent data sources will be used to develop Geographic Information System (GIS) coverages of the waterway referenced to modern horizontal and vertical datums (USGS, 2013 (j)).

Products and Management Relevance

This research will assess the productivity of current habitat for fish seeks to identify remaining functional habitat fragments as well as areas where habitat restoration would produce self-sustaining populations of native fishes. The USGS will make this information research available in useful formats to stakeholders and partners. Data and information derived from previous research conducted by USGS GLSC in the Detroit River resulted in the construction to two fish spawning reefs that are used by at least 14 species of native fish species, including economically important walleye and the State- and Provincially-threatened lake sturgeon (USGS, 2013 (j)).

Scientists involved in this HEC research are already assessing how habitat assessment and restoration techniques developed in the HEC can be applied in other Great Lakes connecting channels, such as the St. Marys and Niagara rivers, and the Welland Canal. This project addresses AOC delisting goals by mapping major physical components of fish habitat, identifying missing components, and examining connectivity to surrounding habitats. This part of the project is building on an ongoing EPA funded project to meet AOC delisting goals by developing a “blueprint” for fish habitat restoration in the HEC (USGS, 2013 (j)).

2.7 Avian Botulism Geospatial Information for Decision Support

Website: http://cida.usgs.gov/glri/projects/habitat_and_wildlife/avian_botulism.html

Project Description

This study is based on the hypothesis that recent increases in the frequency of occurrence of type E avian botulism outbreaks in the Great Lakes may be associated with the presence of dreissenid mussels and specific environmental conditions created by their presence. Periodic outbreaks of type E botulism have resulted in die-offs of fish and fish-eating birds in the Great Lakes since the 1960s, but outbreaks have become more common and widespread, particularly in lakes Michigan, Erie and Ontario (USGS, 2013 (a)). This study aims to determine the presence or absence of botulism (*C. botulinum* and type E botulinum) toxin in sediments and food-chain components and to assess the pathways by which the toxin reaches the fish-eating bird populations. Further the study will use population surveys to assess waterbird distribution, with emphasis on species historically impacted by type E botulism (e.g., common loon *Gavia immer*), to examine the spatial relationships between bird distribution and carcass detection of confirmed botulism mortalities, and to analyze the relation between botulism in birds and environmental conditions at locations where toxin exposure is likely to occur (USGS, 2013 (a)).

Objectives

The primary objectives of this study are to (USGS, 2013 (a)):

1. complete development of a Förster Resonance Energy Transfer (FRET) assay for detection of botulinum neurotoxin type E (BoNT/E),
2. characterize the distribution of foraging waterbirds during botulism outbreaks,
3. carry out enhanced epidemiological investigations of ongoing outbreaks and retrospective synthesis of past outbreaks, and
4. examine the trophic pathways by which fish and birds are exposed to botulinum toxin from Great Lakes food webs and determine how the occurrence of avian botulism is related to environmental variables and food web structure.

Sampling sites were chosen in northern Lake Michigan based on preliminary bird distribution data and will span a range of environmental conditions with consideration for areas where past botulism outbreaks have occurred (e.g., near Sleeping Bear Dunes National Lakeshore).

Enhanced epidemiological investigation of current outbreaks will be carried out by increasing data collection and sampling efforts particularly when outbreaks occur. A retrospective synthesis of past outbreaks will include documenting the distribution and timing of piscivorous waterbird mortality during periods of past botulism outbreaks and combining these with environmental data in GIS. Two aerial surveys will be conducted, this high-resolution digital photography will be used to georeference and automate counting and mapping of waterbird distribution. Geo-referenced maps identifying locations of previous botulism-related bird mortality on the Great Lakes will be used with bird distribution maps, surface water conditions (currents, temperature, etc), bathymetry data, and sediment data to predict where birds may have been exposed to the type E botulinum toxin. Locations of sites that support the growth of *C. botulinum* will be determined and mapped. Analyses will follow that will determine what environmental variables and food web components are associated with the presence of *C. botulinum*. The botulism mortality maps will also be made available to the public (USGS, 2013 (a)).

Products and Management Relevance

The ultimate goal of the investigations of this study is to understand the factors that result in the proliferation of botulism toxin in the lakes so that management strategies can be developed to prevent outbreaks from occurring, which will be a great benefit to restoration efforts for Great Lakes ecosystems (USGS, 2013 (a)).

If the study is able to determine that that recent increases in the frequency of occurrence of type E avian botulism outbreaks in the Great Lakes may be associated with the presence of dreissenid mussels this could supply managers with an important adaptive management tool or provide more support efforts and research into the invasive control of mussels within the Great Lakes.

2.8 Forecast/Nowcast Great Lakes Nutrient and Sediment Loadings

Website: http://cida.usgs.gov/glri/projects/nearshore_health/forecast_loadings.html

Project Description

USGS scientists are working to collect real-time, near-real-time, and synoptic flow and water-quality data from tributaries to the Great Lakes. The work would be aligned with the proposed National Monitoring Network Design for the Great Lakes (USGS, 2013 (b)). There are currently a number of streamflow gages operating at many of the potential sites of data collection. Some already have water quality samples being collected at a number of the proposed sites. There is also real time water quality data being collected at several sites. Tributary Monitoring Sites Automated samplers, water quality multi sensor probes, and gage house and stage equipment have already been deployed at 30 of the Great Lakes National Monitoring Network sites (USGS,

2013 (b)). Water samples collected at the 30 tributary monitoring sites include suspended sediment such as nutrients (including nitrogen, nitrite, nitrite + nitrate, total nitrogen, ortho-phosphorus, and total phosphorus); chloride, and bacteria (USGS, 2013 (b)). This effort will be coordinated with the EPA, COE, FWS, States and other monitoring and modeling entities.

Objectives

The USGS will expand tributary monitoring according to the National Monitoring Network for Coastal Waters design. As outlined above, objectives of this project include (USGS, 2013 (b)):

- Nutrients and Sediment analysis using automated and manual sampling;
- The development of watershed models throughout the Great Lakes.

The importance of these efforts to monitor these sites includes:

- to provide baseline information,
- to provide support for measuring restoration progress, and
- to demonstrate the ability to reduce monitoring costs through the use of real-time sensors.

To determine the current status of the nutrient loading to each Great Lake and forecast potential future changes in loading, a GIS regional model is proposed to be developed which links results of two existing types of models (the water-quality watershed model, SPARROW (SPATIally Referenced Regression On Watershed attributes model) with the results from water-quantity models, WATER and PRMS) to estimate basin-wide loading for current conditions and for various future projections (changes in climate and land use). This model can then be integrated into a decision support tool that can be used to estimate the impact of potential land management decisions and climate change (USGS, 2013 (b)).

Products and Management Relevance

Additional models will be evaluated to design a modeling project to simulate flows and loads of sediment, phosphorus, nitrogen, and emerging contaminants and pathogens in up to three “representative” tributaries of the Great Lakes Basin. This information will provide baseline information, provide support for measuring restoration progress, and model potential load changes throughout the Great Lakes. The monitoring effort will help to make progress towards more complete implementation of the Great Lakes National Monitoring Network (NMN) for Coastal Waters tributary design and will include sampling in some embayments and drowned river mouths where tributaries discharge (USGS, 2013 (b)).

The results of this effort will support the Lakewide Management Plans, Remedial Action Plans, and State management plans (USGS, 2013 (b)). The decision support tool can further aid management decisions through incorporating climate impacts into planning.

2.9 Enhancing Great Lakes Beach Recreational Water Quality Decision Making and Beach Health Project

Website: http://cida.usgs.gov/glri/projects/nearshore_health/beach_water_quality.html

Project Description

Scientists in USGS Science Centers in the Great Lakes are involved in much of the research on cost effective ways to make beach closure decisions as well as on a more complete understanding of microbiological science relevant to making effective beach management decisions. This project is proposed to improve the knowledge of the underlying science of beaches as it relates to human health impacts and provide improved tools and techniques that can be used by the beach health management community. This work will draw on a vast amount of U.S. Geological Survey data and expertise in microbiology, hydrology, coastal processes, instrumentation, methods development, and modeling. The project is coordinated with both NOAA and USEPA efforts; and is aligned with the USGS Ocean Research Priorities Plan (ORPP) project entitled, “Improving Great Lakes Coastal Recreation Water-Quality Monitoring and Forecasting.” Funding for USGS beach projects and research in the Great Lakes comes from a variety of sources including the: Ocean Research Priority Plan, USGS; the Great Lakes Restoration Initiative, USEPA; and many state and local partner agencies and organizations throughout the region (USGS, 2013 (k)).

Objectives

The overall goal is to compile data on Great Lakes beach recreational quality in comprehensive databases and a geographic information system (GIS) that together a) facilitate the assembly of ORPP project data and outside-source data for access by team members, b) improve the scientific evaluation and interpretation of Great Lakes beach water quality, and c) enhance the communication of this information to the public (USGS, 2013 (k)). The geospatial (GIS) component is integral to each of these goals.

There are four major elements for Beach Health in the USGS GLRI— real-time assessments; pathogens and microbial source tracking; coastal processes; and data analysis, interpretation, and communication. These efforts will be coordinated with EPA and NOAA through an existing interagency team formed to coordinate federal agency efforts on beach health issues in the Great Lakes.

Products and Management Relevance

One product of this project includes a web services tool that was developed to integrate GLRI monitoring data with related ancillary data sets. This web services tool was developed to collect spatially processed meteorological, hydrodynamic, and other environmental data.

The overall mission of this work is to provide science-based information and methods that will allow beach managers to more accurately make beach closure and advisory decisions, understand the sources and physical processes affecting beach contaminants, and understand how science-based information can be used to mitigate and restore beaches and protect the public. The work proposed will improve the knowledge of the underlying science of beaches as it relates to human health impacts and provide improved tools and techniques that can be used by the beach health management community (USGS, 2013 (k)).

This program will continue to maintain and update the data assessment as a tool for beach managers to find data and inform others about their available datasets. A web interface for dataset managers to contribute and update the information about their datasets that provides information to beach data managers on best practices for creating and serving datasets will be integrated. Beach closure and advisory information based on these data sets combined with predictive models will be provided through internet-based nowcast systems as a planning tool for use by more agencies around the Great Lakes (USGS, 2013 (k)).

2.10 Lakewide Management Plan (LaMP) Web Mapping Application

Websites: <http://wim.usgs.gov/LaMP/LaMPMapper.html> and http://cida.usgs.gov/glri/projects/accountability/management_plan.html

Project Description

The USGS is providing expertise, capacity and support for the implementation of Lakewide Management Plans and the associated goals, objectives and targets for each of the Great Lakes. In support of that work, WiM has developed a Web Mapping Application to display information about projects and programs around the Great Lakes. The mapper is to compile information on areas where data are being collected, missing, or sparse, and on areas where ecosystems are vulnerable (USGS, 2013 (d)).

Objectives

Each area of the Great Lakes has been designated to an individual USGS Science Center as each lake may have different vulnerabilities and sensitivities. Each will coordinate with partners in each of the Great Lakes for support for sampling and monitoring information. For Lake Huron, emphasis focused on issues affecting fisheries and nutrient inputs, particularly in the Saginaw basin. For Lake Superior, emphasis was on support of activities with partners in compiling data and on collecting data focused on Areas of Concern, nutrients and areas with potential for mining. For Lake Michigan, efforts included continued compilation of monitoring information into the mapper specific to the near-shore framework. In Lake Erie, emphasis was placed on coordinating activities with partners and on compiling data for the mapper. For Lake Ontario,

work has consisted primarily of coordinating activities with the EPA on de-listing project at Areas of Concern sites. Activities of the Great Lakes Science Center include coordinating activities with partners in each of the Great Lakes and on support for near-shore sampling and monitoring activities (USGS, 2013 (d)).

The goal of the mapper is to focus on compilation of information that will result in recognition of areas where data are being collected, missing, or sparse, and on areas where ecosystems are vulnerable (USGS, 2013 (d)).

Products and Management Relevance

The mapper will assist decision making related to protecting and restoring ecosystems based on information as to where data is missing or sparse and where ecosystems are vulnerable. This can help managers located areas where more data collection is needed.

3.0 Great Lakes Early Detection Network (GLEDN)

Website: <http://ibis.colostate.edu/cwis438/websites/GLEDN/Home.php?WebSiteID=17>

Project Description

The Renz lab at the University of Wisconsin-Madison Department of Agronomy, in collaboration with Colorado State University (CSU) and the Midwest Invasive Plant Network (MIPN) launched the Great Lakes Early Detection Network (GLEDN). GLEDN has a number of cooperating organizations including the cattail volunteer monitoring project, EDDMaps, GISIN, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), iMapinvasives, MIPN, the National Institute of Invasive Species Science, New Invader Watch List, and Surface Water Integrated Monitoring System (SWIMS). These collaborators are all sharing data through GLEDN (Colorado State University, 2013).

GLEDN is an invasive species early detection and warning system for the Great Lakes region developed through funding provided by the National Park Service as part of the Great Lakes Restoration Initiative. GLEDN is an online system that collects invasive species reports from casual observers, verifies these reports and integrates them with others networks. The system then uses this integrated information to send customized early detection email alerts to those subscribed (Colorado State University, 2013).

Objectives

The three major efforts of GLEDN are to (Colorado State University, 2013):

- 1) Provide a tool that will allow for easy reporting of invasive populations. This tool will target casual observers as many of the existing systems do not capture this group, using an online map.
- 2) Develop an online, customizable alert system. This feature will allow the user to select what species they would like to receive alerts from and what geographic area they are interested in.
- 3) Develop a framework for data sharing across existing systems.

Products and Management Relevance

Sharing of data allows for better predictive modelling of both actual and potential spread of invasive species in the Great Lakes Region. This information, combined with the real-time email alert system could facilitate rapid response and management efforts for newly reported populations of invasive species (Colorado State University, 2013).

4.0 Invasive Species Early Detection and Distribution Mapping System

Website: <http://www.misin.msu.edu/>

Project Description

The Midwest Invasive Species Information Network (MISIN) is an evolving data aggregation effort targeting invasive species early detection and rapid response needs within the Midwest region of the United States. This effort is being led by the researchers with MSU Applied Spatial Ecology and Technical Services, MSU Invasive Species Initiative at Michigan State University and the Michigan Natural Features Inventory (Michigan State University's Applied Spatial Ecology and Technical Services Laboratory, 2013).

Objectives

The goal of this regional resource is to assist both experts and citizen scientists in the detection and identification of invasive species in support of the successful management of invasive species (Michigan State University's Applied Spatial Ecology and Technical Services Laboratory, 2013).

Products and Management Relevance

The products of this program will further assist with the needed development of a regional network of data providers dedicated to the survey and management of invasive alien species.

The Midwest currently lacks effective collaborative mechanisms for dealing with regional scale emerging invasive species issues. However, if invasive species data could be easily gathered by many observers, readily aggregated and disseminated in real-time, synergistic relationships between resource managers would occur, resulting in improved efficiency and better decision making at regional and national scales. This invasive species data effort is being designed so that it can easily be scaled up to meet the regional needs of the Great Lakes basin and the Midwest region (Michigan State University's Applied Spatial Ecology and Technical Services Laboratory, 2013).

5.0 The Great Lakes Regional Environmental Information System (GLREIS)

Website: <http://www.cse.msu.edu/~chengb/research/ENFORMS/glreis.html>

Project Description

The Consortium for International Earth Science Information Network (CIESIN), in cooperation with the U.S. EPA, has developed an environmental information system providing public access to information, data and data utilities relevant to the Great Lakes Region. The Great Lakes Regional Environmental Information System (GLREIS) utilizes the online forum to provide a user-friendly interface to "guides to information", documents, databases, and several CIESIN-developed software applications that facilitate data identification, acquisition, and utility. The "guides" provide descriptions of data sets, organizations and initiatives pertaining to the Great Lakes. CIESIN-developed applications include the CIESIN Gateway, several map servers, the Land Transformation Model and a Decision Support System (Michigan State University, 2013).

Objectives

The CIESIN Gateway is a distributed information system that provides the capability to locate and retrieve metadata and data from a "virtual archive" of globally distributed data servers. The Gateway speeds the task of locating and acquiring metadata and data by providing a parallel search capability (Michigan State University, 2013).

Products and Management Relevance

The map servers provide interactive mapping of user-selected U.S. Census population and housing variables, and select EPA Great Lakes National Program Office (GLNPO) GIS coverages and databases (Michigan State University, 2013).

The Decision Support System (DSS) prototype provides analysis tools including modeling, simulation, and visualization for water quality management at the watershed level. One of the tools available through the DSS is the Land Transformation Model (LTM). The LTM analyzes how past decisions on land-use have influenced present land-use patterns. By integrating variables pertaining to socioeconomics, ecological succession, pollution potential, hydrology, and ecosystem integrity within a GIS framework, future land-use change can be projected (Michigan State University, 2013).

6.0 The Cooperative Science and Monitoring Initiative (CSMI)

Website: http://cooperativescience.net/?page_id=53

Project Description

The Cooperative Science and Monitoring Initiative (CSMI) was created as the result of a need to coordinate science in support of management of the Great Lakes. This coordination includes enhanced monitoring and research field activities which are conducted in one lake per year, tied to the needs of the Lakewide Management Plan (LaMP) committees. These activities include sample analysis, data interpretation, reporting, and LaMP data needs compilation. The Lake Ontario LaMP committees determined that data were needed on: status of the lower food web as detection for ecological change; extent of decoupling of nearshore to offshore movement of materials, specifically nutrients and pollutants; lake-wide lake trout assessment as an indication of progress towards restoration; and development of whole system ecological models (Richardson et al, 2012).

Objectives

The Cooperative Science and Monitoring Initiative (CSMI) was developed to help coordinate science programs on the Great Lakes, as well as undertake programs to address issues identified by the Lakewide Management Plan (LaMP) management teams and their partners. The Lake Ontario Nearshore Study will be described in this report. The general goal of the Lake Ontario Nearshore Study was to focus research and monitoring on better understanding the structure and function of the nearshore zone to provide guidance for the management of this valuable resource (Makarewicz and Howell, 2012).

The Lake Ontario Lakewide Management Committee determined to undertake the following nearshore issues: describe the gradient from nearshore/offshore in regard to phosphorus, suspended solids, other nutrients and tracers of watershed input within the nearshore under the influence of three different land use patterns (urban, agriculture, and undeveloped); estimate the abundance (biomass) of *Cladophora*, dreissenid mussels, cyanobacteria, and round gobies; describe the thermal, light, and nutrient regimes to the extent needed to support numerical modeling of *Cladophora* growth and other selected biological processes; describe the role of physical processes, such as prevailing coastal flow regimes, the spring thermal bar and hypolimnetic upwellings, on movement of materials from nearshore to the offshore; document the importance of tributaries (including smaller tributaries) locally to the nearshore zone by describing the inputs of nutrients and sediments to the nearshore (Richardson et al., 2012). Intensive sampling of seven 100-km² nearshore sites and a lake circumnavigation using geospatially linked, continuous-measuring sensors allowed for unprecedented detail on the structure of the nearshore of Lake Ontario in the post-dreissenid era (Makarewicz and Howell, 2012).

Products and Management Relevance

The results of this study produced 23 manuscripts that describe the wide variability in nearshore nutrients, suspended solids, and organic wastewater correlated with proximity to the shoreline and among geographic areas (Makarewicz and Howell, 2012).

This collaborative approach helps bring together federal, provincial and state agencies, as well as other partners, to work on issues in the Great Lakes based on a rotational cycle, where one lake is the primary focus for the year and provides enhanced science delivery by combining efforts. Addressing important gaps allows for more effective and efficient adaptive management decision making. Use of these data by management will allow for an evaluation of transport of materials from the nearshore to the offshore and inform adaptive and remedial efforts.

7.0 Great Lakes Observing System (GLOS)

Website: <http://glos.us/>

Project Description

The Great Lakes Observing system works to coordinate users, collectors, and providers of Great Lakes data at various scales to identify needs for data, information, and products; identify gaps; and avoid duplication. GLOS (2013) aims to establish technology standards to improve data management and exchange as well as improve regional networks of observing and monitoring activities. The data provided is intended to support the region's need for modeling, and other data tools or products. The Great Lakes Observing System is a coordinated network of people, equipment and technology working together to provide data about the Great Lakes in a variety of formats and applications

Objectives

GLOS helps improve data access and integration by providing the Integrated Ocean Observing System (IOOS) and other international standards-based data management services. The GLOS Data Management team works to:

- Establish protocols to improve data retrieval, standardization, storage and delivery.
- Coordinate and facilitate the distribution of data and information to and from GLOS, other observing systems, and data users.
- Engage users and develop customized products that are easy to access and user-friendly.

GLOS provides two primary services to the Great Lakes region: 1) coordinating users and collectors/providers of Great Lakes data at various scales to identify needs for data, information, and products; identify gaps; and avoid duplication.; 2) provide data services to support identified user needs for raw and processed data, modeling, and other data services.

Products and Management Relevance

GLOS products include applications that integrate model output and historic, event-collected, and real-time into user friendly outputs.

Once data is submitted to GLOS, it becomes publicly available to the larger Great Lakes community, benefiting data users and decision makers in the Great Lakes managing:

- navigation and shipping
- public safety/rip currents
- alternative energy
- water quality issues

Three important products of GLOS include GLATOSWeb, the Boaters Forecast Tool and The Huron to Erie Connecting Waterways Forecasting System described below.

7.1 GLATOSWeb

GLATOSWeb compiles acoustic telemetry project information. Scientists have been implanting Great Lakes fish with transmitters and have been tracking fish movement through a network of receivers placed on the bottom of the lakes. The purpose of GLATOS is to help scientists and the public learn more about Great Lakes acoustic telemetry projects and their contribution to research. The GLATOSWeb tool was developed in partnership with the Great Lakes Fishery Commission (GLFC) and the US Geological Survey (USGS). The fish tagged for tracking include lake trout, sea lamprey, walleye, and lake sturgeon.

7.2 The Boaters' Forecast Tool

The Boaters' Forecast Tool provides recreational boaters information on water currents and depth. The easy to use, web-based format was customized to address information needs specific to boaters in the Great Lakes, including information on marina and boat launch locations. The tool was developed in partnership with New York Sea Grant, and the NOAA's Great Lakes Environmental Research Laboratory (GLERL). The Boaters' Forecast Tool, allows boaters to access NOAA's modeling output along with real-time data and other information of interest to harbour communities.

7.3 The Huron to Erie Connecting Waterways Forecasting System

The Huron to Erie Connecting Waterways Forecasting System provides predicted forecasts of water levels and currents through the Huron to Erie Corridor. The tool has varying applications, which include guiding spill response, aiding search and rescue efforts, beach health management, and finding the source of fish kills, among others. This information is available through nowcasts every three hours and forecasts every 12 hours for currents and water level for St. Clair River, Lake St. Clair, and Detroit River.

The fully integrated, bi-national observing system will provide products and services to decision-makers, resource managers and other data users (GLOS (a), 2013).

8.0 The Great Lakes Observing System Enterprise Architecture (GLOS-EA)

Website (summary sheet): http://www.limno.com/pdfs/GLOSEA_Exec_Summ_091511.pdf

Project Description

A comprehensive, collaborative, and consensus-based enterprise architecture design process has been conducted under the direction of NOAA-Great Lakes Environmental Research Laboratory (GLERL). The project brought together multi-disciplinary experts to identify and recommend specific actions and investments that will achieve an integrated, comprehensive, and sustainable observing system enterprise for the Great Lakes. This Great Lakes Observing System Enterprise will provide ready access to vital real-time and historical information to support decision-making by managers and users. Building on the components of the existing system, the NOAA Great Lakes Environmental Research Lab and key regional partners including the US Geological Survey, US EPA, the Integrated Ocean Observing System, and the Great Lakes Observing System (GLOS) initiated the development of a conceptual design and implementation plan of an enterprise architecture (GLOS, 2013 (a)).

Objectives

This project's goal is to exemplify that which is the definition of an observing system; a comprehensive enterprise that includes sensors, a network that gathers data, a data management and communications system, models and other tools that process data, and the information portals and user interfaces that make processed data.

Products and Management Relevance

Documents that have been completed under this project include a Design Report, Concept of Operations Report, Trade Study Report, and Implementation Plan. The documents also include the results of information-gathering efforts conducted in the early phases of the project that describe the current state of user needs, data management and communication systems and modeling in the Great Lakes (GLOS, 2013 (a)). This will provide ready access to vital real-time and historical information to support decision-making by managers.

9.0 The Great Lakes Test Bed Initiatives

Website (factsheet):

<http://glos.us/sites/default/files/documents/Great%20Lakes%20Testbed%20Factsheet.pdf>

Project Description

The Great Lakes Test bed is working to support the development of a geospatial portal for the seamless access to observational data. In conjunction with the Great Lakes Observing System (GLOS), a coordinated observing system in the Great Lakes Region, the Test bed will provide institutional mechanisms for ensuring the necessary level of coordination, strengthening and supplementing the numerous existing Great Lakes information integration efforts that will reinforce and support partners' contributions to the Global Earth Observation System of Systems (GEOSS). The Great Lakes Test bed is an initiative of the Canadian and U.S. partners of the Group on Earth Observations (GEO). The Great Lakes Test Bed Initiative is led by the U.S. Geological Survey and Environment Canada, with support from the International Joint Commission. This group also includes participation from the Coordinating Committee on Great Lakes Basic Hydraulic & Hydrologic Data, and other groups that are already addressing data integration such as Fisheries and Oceans Canada (DFO), National Ocean and Atmospheric Administration (NOAA), U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA). This project proposes to utilize, enhance, and expand existing efforts to coordinate the aggregation, integration, and communication of Great Lakes data to such a point that it can be included in the GLOS data discovery portal (GLOS, 2013 (b)).

Objectives

The goal is promoting interoperability, collaborating to promote the convergence of observation networks, systems and sensors. While Canada and the US have many similarities in the way they collect and process data, significant differences still occur for some variables. A recommendation was made to establish trans-boundary sites with comprehensive integrated measurements to provide an assessment of the data products on each side of the border and their uses for water resources management (GLOS, 2013 (b)). The Great Lakes region was chosen as one of the first test beds for this initiative. The Test bed group will investigate the potential for data activities in four focus areas in the Great Lakes Basin: 1) Ice cover, 2) Water levels, 3) Groundwater, and 4) Beaches.

Products and Management Relevance

The Great Lakes Test bed will utilize, enhance, and expand existing efforts to coordinate the aggregation, integration, and communication of Great Lakes data to be included in the GLOS data discovery portal (GLOS, 2013 (b)).

Federal, state, provincial and local government agencies with an interest in data integration and access are able to participate in the Test Bed; informing their needs as consumers of integrated data, related services, and product outputs for resource managing and decision-making.

10.0 Great Lakes Information Network (GLIN)

Website: <http://gis.glin.net/>

Project Description

The Great Lakes Commission (GLC), with support from the National Oceanic and Atmospheric Administration (NOAA), is designing a metadata clearinghouse that will provide decision-makers and researchers with detailed overviews of data and information specific to the use and management of Great Lakes resources.

Objectives

The project will collect standardized descriptions for approximately 2,000 coastal spatial data sets from local, regional, state/provincial, and federal sources, including several current basin-wide projects looking at coastal wetlands, water resources, lake levels and ecosystem health studies such as beach monitoring and human health issues (GLIN, 2013).

The data directory will be built into the Great Lakes Information Network (GLIN). The interface will feature a search function for locating data by topic and a map interface for location data geography.

Two secondary objectives of the GLIN Data Directory project are (1) to encourage the use of standardized metadata and (2) to provide uniform base data for the Great Lakes basin, compliant with federal standards and easy to access.

The GLC will assimilate into the GLIN Data Directory approximately 2,000 coastal spatial data sets from the local, regional, state/provincial, and federal level within the categories of (GLIN, 2013):

- political/administrative boundaries
- demographics
- transportation
- utilities and infrastructure
- agriculture and landuse/land cover
- surface hydrology and hypsography/bathymetry
- soils, geology, and groundwater
- digital raster graphics/line graphics, satellite imagery, and digital orthophotography

Products and Management Relevance

The GLIN Data Directory is a data indexing system that will provide resource management decision-makers and researchers with overviews of geospatial data and information relevant to the use and management of Great Lakes resources. With coastal areas under pressures from many angles, tools for resource managers and policy makers are critical for ecological conservation and the development of sustainable practices. The GLIN Data Directory answers the need for a central data depot with data descriptions and all relevant information on each data set the directory indexes (GLIN, 2013).

11.0 The Great Lakes GIS Online Project

Website: <http://www.glakesonline.nos.noaa.gov/>

Project Description

Great Lakes Online is a product that provides users with the latest information from NOAA's observing network in the Great Lakes. Real-time water level and meteorological data are provided to users via the Internet or an interactive telephone response system.

Objectives

The Great Lakes GIS Online project builds upon GLIN to provide Internet-based access to, and online mapping capability for a variety of consistent spatial data layers covering the Great Lakes Basin (NOAA, 2013 (c)).

Products and Management Relevance

Based on GLIN's formula for building online partnerships among U.S. and Canadian agencies and organizations, the Great Lakes GIS Online project will provide a solid foundation for interagency spatial data sharing and collaboration. Managers and decision-makers will have the opportunity to gather data from one all-encompassing source (NOAA, 2013 (c)).

12.0 Satellite Lake Quality Analysis

Website: <http://www.lakeanalysis.com/>

Project Description

Water Satellite provides satellite image analysis of land and water resources. Using algorithms that measure the unique spectral reflectance of specific minerals and organisms, they can identify the concentrations in parts per billion of blue-green algae (cyanobacteria), aquatic vegetation (chlorophyll-a) and phosphorus in water, phosphorus on land in parts per million and temperature of water (Blue Water Satellite Inc., 2013).

Objectives

LakeAnalysis.com is a division of Blue Water Satellite, Inc. and utilizes Blue Water Satellite technology to provide entire water-body analysis. Satellite imaging technology is used to detect the presence, location, and concentration of blue-green algae and aquatic vegetation blooms, as well as the phosphorus that causes them to bloom (Blue Water Satellite Inc., 2013).

Products and Management Relevance

Blue Water Satellite's ability to detect levels of phosphorus, both in water and in surface soils, can aid in early detection and help managers prevent blue-green algae and aquatic vegetation blooms from taking over the lake. The information can also be used by management or researchers to determine which portions of the lake are clean/safe and which are possibly dangerous or toxic. Using this base it is also possible to assess water quality improvements and

or deterioration by making comparisons to lakes in the past (Blue Water Satellite Inc., 2013). This information can be highly valuable to determine where to focus remediation programs.

13.0 Upper Great Lakes Study Adaptive Management

Website: <http://ijc.org/iuglsreport/>

Project Description

In March 2007, the International Joint Commission (IJC) initiated a five-year, \$17.5million, International Upper Great Lakes Study (IUGLS) to examine the management of water levels and flows in the upper Great Lakes (IJC, 2012).

Objectives

The purpose of the adaptive management strategy is to inform decision-making processes through an improved understanding of:

1. How the system is changing, both in terms of hydro-climatic changes and in terms of the physical changes of the system;
2. How the Superior regulation plan is performing over-time and whether adjustments are required as more is learned;
3. When the regulation plan may no longer be meeting its intended objectives due to changing conditions; and
4. The limitations of the regulation plan and what risks emerge which cannot be addressed through regulation alone.

(IJC, 2012)

The study identifies climate risk and decision scaling and defines coping zones particularly for coastal areas and the impacts on recreational boating and tourism, commercial navigation, municipal and industrial water uses, hydropower and the ecosystem (IJC, 2012).

Products and Management Relevance

Following consultation with climate experts and resource managers in the upper Great Lakes basin, the Study adopted a decision-scaling approach to defining climate risk as the first step in scoping an adaptive management strategy. Decision-scaling the decision-scaling approach begins with stakeholders to identify vulnerabilities or risks. It determines their domain of vulnerabilities and then assesses whether conditions that would produce the identified vulnerabilities are possible or plausible based on the available climate science (IJC, 2012).

The information presented in this report provides decision makers with important information regarding future water levels in Lake Superior as well as adaptive management strategies.

14.0 Great Lakes GIS (includes LEGIS, LMGIS, LHGIS, LOGIS, LSGIS)

Website:

http://ifrgis.snre.umich.edu/projects/GLGIS/support_docs/html/GLGIS/GLGIS_project_history.htm

Project Description

The Institute for Fisheries Research, University of Michigan, and Michigan Department of Natural Resources (DNR) aim to facilitate sharing of data and holistic management of the Great Lakes basin, the Great Lakes GIS (GLGIS) project of assembling GIS-based classifications of aquatic ecological. This will include map-delineated spatial units and associated habitat and biological attribute data for terrestrial, tributary rivers, nearshore, and offshore ecosystems. This system would serve as the base map on which to compile and view landscape-scale inventory of Great Lakes Basin aquatic resources. This project will be done for each of the Great Lakes (Lake Erie GIS (LEGIS), Lake Michigan GIS (LMGIS), Lake Huron GIS (LHGIS), Lake Ontario GIS (LOGIS) and Lake Superior GIS (LSGIS)). The prototype for this project, the Lake Huron GIS, was initiated by members of the Great Lakes Fishery Commission's Lake Huron Technical Committee. The GLGIS has been generously funded by the U.S. Fish and Wildlife Service through the Great Lakes Fish and Wildlife Restoration Act, the U.S. Environmental Protection Agency, the Michigan Department of Natural Resources, and the Great Lakes Fishery Commission (UM IFR, 2013).

Objectives

The objectives of this program include:

- 1.) Develop seamless, standardized, habitat-based GIS projects for the Great Lakes.
- 2.) Develop a collaborative plan and establish institutional arrangements for long-term data sharing, development, distribution, training and maintenance of GLGIS databases.

The primary objective of the GLGIS Project is to integrate data from each lake basin into a common database to provide an inventory of basin-wide aquatic resources. Additionally, many new layers and tools are also being developed to ensure that the DSS is a powerful tool for analysis of whole-system responses to management alternatives. These goals will be accomplished by compiling digital maps and ecological classifications of Great Lakes habitats; and creating an inventory of available data and more fully develop the overall Great Lakes Aquatic Habitat GIS (UM IFR, 2012).

Products and Management Relevance

GLGIS will provides resource scientists and managers with a centralized collection of spatially referenced data that span jurisdictional (i.e., state, federal, tribal, and local agencies) and habitat boundaries (i.e., nearshore, tributary, connecting channels, offshore, inland lakes, and terrestrial). The GLGIS also affords end-users a spatial perspective, as ecosystem processes can be investigated in a spatial context (i.e., through the use of maps and spatial operations) and a temporal perspective, as the GIS interface allows for examination of phenomena through time (UM IFR, 2013).

In addition to integrating existing data from federal, state, provincial, tribal, and non-governmental organizations, this information system will also provide a means of inventorying and monitoring basin habitat (e.g. terrestrial, tributary, nearshore, and offshore systems) and serves as a tool for science inquiry and a comprehensive resource for Great Lakes basin resource managers. The final product enables decision-makers to more effectively plan holistically for the basin's future, monitor its status, target protection and restoration efforts, and address key habitat issues (UM IFR, 2013).

15.0 Great Lakes Environmental Center (GLEC)

Website: http://www.glec.com/capabilities/technical_services/GIS_mapping.php

Project Description

The Great Lakes Environmental Center (GLEC) and their GIS sector provide a range of specialized GIS services, from map exhibits supporting environmental assessments to terrain and bathymetric analyses. GLEC's GIS practice is integrated with GLECs expertise in environmental surveys/assessments, aquatic/terrestrial ecology, and environmental toxicology, lending value spatially integrated ecologically informative outputs. GLEC has capabilities to combine 2D and 3D geospatial and GIS/CAD information with (GLEC, 2013):

- Environmental Data Management
- Geostatistical Analysis
- Terrain and Bathymetric Mapping
- Environmental Survey Support
- Land Use Analysis
- Watershed/Wetland Delineation
- Preliminary Radio Frequency Analysis

Objectives

The strategic plan of the U.S. EPA calls for a survey and report on the condition of the Nation's lakes, rivers and streams. GLEC is the lead contractor for this effort. In support of this project, EPA asked GLEC to construct nine unique ecoregions for the conterminous U.S. and then analyze and report on each ecoregion's physiographic, ecological, and anthropogenic characteristics (GLEC, 2013).

GLEC's GIS sector combined and modified existing detailed ecoregions into the nine new ecoregions, and then overlaid pertinent spatial data such as hydrography, climate, habitat, land cover, census data, pollution, and industrial and agricultural activity. The ecoregion map provides a logical backdrop for the probability-based water quality survey (GLEC, 2013).

Products and Management Relevance

As a product of this study, the nine aggregate ecoregion map has been published in EPA's Wadeable Streams Assessment report and will be included in a comprehensive report to the U.S. Congress on the health of the nation's waters. Important spatial data such as hydrography, climate, habitat, land cover, census data, pollution, and industrial and agricultural activity can provide managers with new information in informing planning and management decisions (GLEC, 2013).

16.0 NOAA Coastal Geospatial Data Project

Website: <http://coastalgeospatial.noaa.gov/>

Project Description

NOAA's National Coastal Assessment and Data Synthesis (CA&DS) provides a systematic framework that integrates data such as eutrophication conditions, pollutant sources and loadings, population, sediment contamination, and others that are consistently formatted using a hierarchical set of spatial units defined by the Coastal Assessment Framework (CAF). The CAF encompasses nearly 83 percent of the land areas within the contiguous United States and includes the drainage basins of nearly all of the nation's rivers (NOAA, 2013 (b)).

Objectives

The Coastal Assessment Framework was developed in the mid-1990s by NOAA's Special Projects Office to allow characterization of entire watersheds in the U.S., both coastal and upstream portion, with a nested hierarchy of spatial units for the small and large-scale coastal resource data analyses needed to effectively manage the nation's diverse data resources.

Products and Management Relevance

The CAF includes coastal and estuarine drainage areas along the nation's coasts and upstream fluvial drainage areas (Figure 2). The CA&DS system is intended to provide the coastal stewardship community a capability to access, synthesize, assess, and apply nationwide data sets to priority coastal issues such as estuarine eutrophication, essential fish habitat, coastal monitoring, and sustainable development. The data available through this web site was originally compiled in the late 1990's. While there are no current plans to update this project much of the data may still be relevant (NOAA, 2013 (b)).

Geospatial information available for download include:

- Shellfish Harvest Classification
- Physical and Hydrologic
- Agricultural Census
- Agricultural Pesticides Use
- Fertilizer Use
- Land Use / Land Cover
- Socioeconomics
- Population and Population Density (1970-2000)
- Estuarine Eutrophication
- Estuarine Living Marine Resources
- Pollution Sources

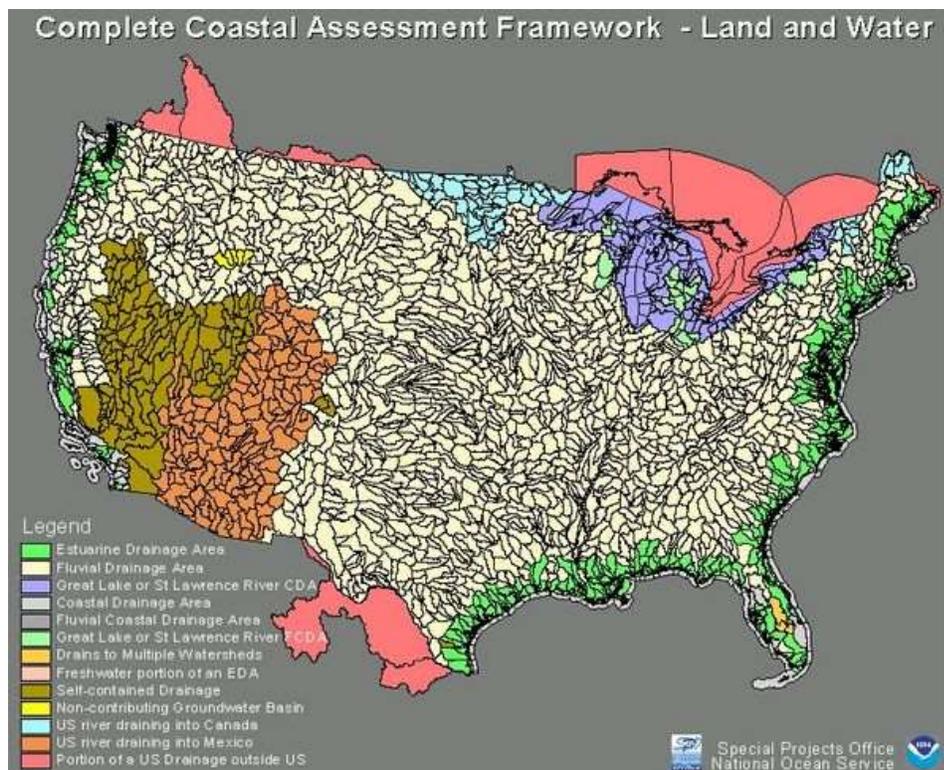


Figure 2. NOAA Coastal Assessment Map

17.0 Wisconsin Coastal Atlas

Website: <http://wicoastalatlus.net/>

Project Description

The Wisconsin Coastal Atlas (WCA) is a new initiative to provide access to maps, data, and tools to support decision-making about the Great Lakes. The project team for the Wisconsin Coastal Atlas includes staff from the University of Wisconsin Sea Grant Institute, the Land Information and Computer Graphics Facility, the Wisconsin State Cartographer's Office, the Robinson Map Library, the UW Cartography Lab, the Space Science and Engineering Center, and the Department of Urban and Regional Planning at UW-Madison. Project partners include state and federal government agencies, non-profit organizations, as well as coastal regional planning commissions, counties, municipalities, and tribal governments.

The Wisconsin Coastal Atlas provides a web-based portal that catalogs, integrates, presents, and shares distributed sources of geospatial data and supports development of a coastal spatial data infrastructure for Wisconsin. The initial focus of the atlas is on coastal hazards, but it is built with an open architecture that allows addition of new tools and components over time. Design of the atlas is based on the successful Oregon Coastal Atlas and advanced through collaboration with the Oregon Coastal Management Program and Oregon State University. The project also tackles research topics that address the science needed to effectively build and link coastal web atlases (University of Wisconsin Sea Grant Institute, 2013).

Objectives

The objective of the Wisconsin Coastal Atlas is to provide access to maps, data, and tools to support decision-making about the Great Lakes. It provides a resource to support a better understanding of coastal issues, to share coastal data, and to inform decision-making about sustainable use of the Great Lakes (University of Wisconsin Sea Grant Institute, 2013).

Projects are expanding on this initial project. One such project will incorporate satellite imagery and open-water observations in order to 1) communicate water quality trends in Green Bay, 2) reduce conflicts between recreational fishermen and trap nets in Lake Michigan, and 3) improve the safety of water sports on the Great Lakes. The project will develop and apply social-science methods to evaluate and improve the effectiveness of spatial decision support tools and establish a webinar series to promote the development of a Great Lakes Coastal Atlas Network.

Products and Management Relevance

One product of this program is a gallery of web mapping interfaces that provides customized perspectives related to specific coastal issues in Wisconsin. Users can search for geospatial data through interfaces that connect to catalogs maintained by other coastal data custodians. The atlas

serves as a gateway to spatial decision support tools relevant to Great Lakes management and provides access to educational resources about coastal issues in Wisconsin.

WCA is intended for use by coastal resource managers, planners, researchers, educators, tourists, citizen scientists, and coastal residents. At the state level, the Wisconsin Department of Natural Resources is interested in how the atlas will enable the analyses needed to implement the Wisconsin Great Lakes Strategy and the Great Lakes Compact (University of Wisconsin Sea Grant Institute, 2013). The atlas could be used as a tool to help citizens make sound decisions regarding coastal development (i.e. in floodplains).

18.0 Great Lakes Regional Aquatic GAP (GLGAP)- “Watershed Modeling for Stream Ecosystem Management”

Website: http://cida.usgs.gov/glri/projects/accountability/watershed_modeling.html

Project Description

The USGS Great Lakes Regional Aquatic GAP (GLGAP) project has cooperated with state and federal natural resource agencies, Universities, and The Nature Conservancy to map and classify aquatic habitats, define fish distributions, and identify gaps in the distribution and conservation of fish species and their habitats for lotic systems of the US Great Lakes watershed (USGS, 2013 (f)).

Objectives

The project will generate a consistent basin-wide data framework consisting of a unified stream classification system linking landscape, hydrologic, and biologic information to stream networks. Streamflow for gauged and ungauged watersheds in the basin will be estimated. These estimates will be combined with landscape, ecological, and other hydrologic data to classify streams (USGS, 2013 (f)).

Products and Management Relevance

GLGAP results consist of regionally consistent spatial data components that include landscape characterization of inter-confluence stream reaches and associated watersheds with more than 300 habitat variables, empirical models to predict fish species abundance for more than 130 fish species, empirical models to predict summer stream temperature, a hierarchical aquatic habitat classification framework, a fish-based lotic habitat classification, and a central relational

database to store results. These results have been achieved for all lotic habitats within the U.S. Great Lakes-St. Lawrence River Basin and for a limited number of nearshore Great Lake areas (USGS, 2013 (f)).

This program will provide information for managers to assess the status of stream ecosystems and prioritize locations to focus stream restoration efforts. Managers can use this information for planning and management of game and non-game species including stocking, diseases, and invasive species and thus for protecting and enhancing aquatic systems for recreational use. Further to this information can be used for assessing disturbance of aquatic ecosystems and provide tools for planning adaptive management strategies (USGS, 2013 (f)).

This information can also be used to assess the health of aquatic ecosystems, provide tools for use in stream ecosystem and watershed restoration, planning, and management; help identify areas in need of protection, conservation, enhancement, and restoration; and provide information for policy makers to make informed decisions on topics that relate to stream ecosystem health (USGS, 2013 (f)).

Many of these results have already been adopted by state natural resource agencies for use by natural resource managers and policy makers to better understand, manage, and conserve aquatic natural resources. These tools and data extend the ability to plan and identify priorities for conservation goals (USGS, 2013 (f)).

19.0 Canadian Wind Atlas

Website: www.windatlas.ca/

Project Description

Using its numerical atmospheric models and Canadian Digital Elevation Data (CDED) from the GeoBase Web portal, Environment Canada pioneered a Canadian Wind Energy Atlas in October 2004. The Canadian Wind Energy Atlas is a contribution from the EOLE Project, a research project hosted by Environment Canada (RPN); initiated in year 2000. Most of the results are based on WEST (Wind Energy Simulation Toolkit), a system developed for the project (Environment Canada, 2013).

The Canadian Wind Atlas offers the possibility to browse through the results of the numerical simulations that were run on all of Canada in order to determine its wind energy potential. The Wind Energy Atlas web site features colour maps representing the average wind velocity and power on the whole country (Figure 3), as well as corresponding geophysical characteristics and access to the meteorological data. Also offered are an overview of the methodology used to

generate the different simulation maps, and a download section where data files can be obtained for those who wish to run custom simulations (Environment Canada, 2013).

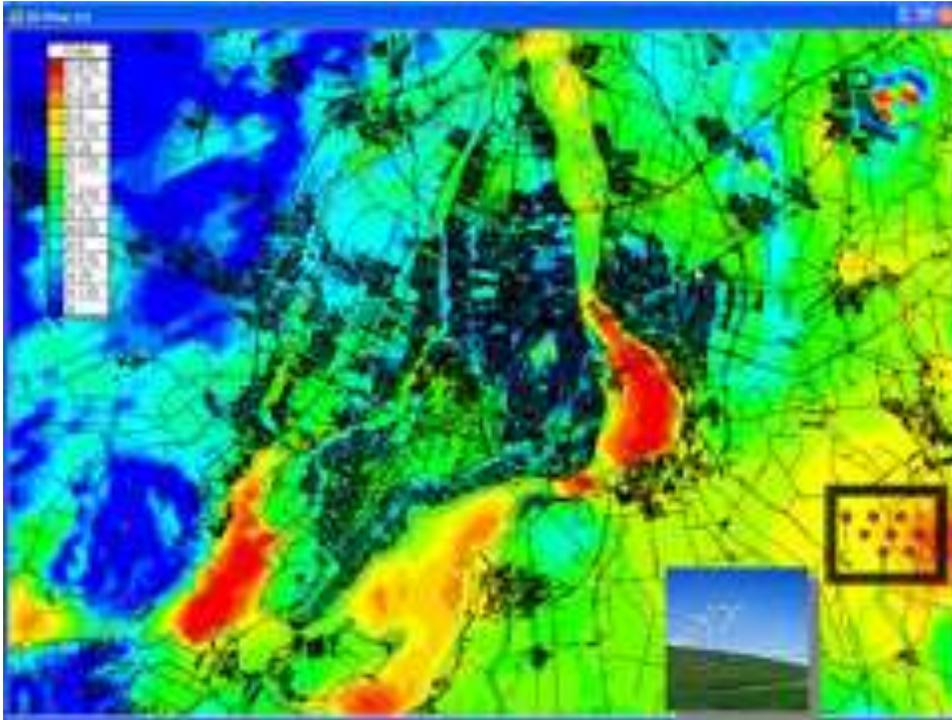


Figure 3. Sample Colour Coded Wind Atlas Map (Source: Environment Canada Wind Atlas)

Objectives

The goal of the wind atlas is to provide a high-resolution map (5 km grid) that covers the Canadian landmass and is based on wind climate data. Environment Canada's Wind Energy Atlas web site aims at developing new meteorological tools to be used by Canada's wind energy industry. The AnemoScope Wind Energy Simulation Toolkit was produced through the joint efforts of Environment Canada's Recherche en Prévision Numérique division and the Canada Hydraulics Centre at National Research Council Canada. AnemoScope and is the world's first software application in the field of wind energy production.

Products and Management Relevance

Consultants, the industry and the general public can find data about wind potential, which may be highly relevant to managers wishing to develop renewable energy sources.

20.0 Great Lakes Environmental Assessment and Mapping (GLEAM) Project

Website: www.greatlakesmapping.org

Project Description

The Great Lakes Environmental Assessment and Mapping Project (GLEAM) evaluates multiple stressors affecting the Great Lakes ecosystem. GLEAM merges spatial data layers representing all major categories of stressors to the Great Lakes, ranging from climate change and land-based pollution to invasive species, into a single map of cumulative stress. The synthesis of this information into a single map enhances the ability to manage and restore the Great Lakes ecosystem (Great Lakes Mapping, 2013).

Objectives

The GLEAM project included four main steps. First, they mapped the intensity of stressors across the Great Lakes (1 km² resolution). Second, weightings of relative impact of each stressor by habitat type was developed, based on a survey of Great Lakes experts. Third, a cumulative stress (CS) map was derived by summing all of the stressors. Finally, regions as identified as highly valued recreational, biological, and economic opportunities were mapped (Great Lakes Mapping, 2013).

Great Lakes stressors included seven categories:

- Aquatic habitat alterations
- Climate change
- Coastal development
- Fisheries management
- Invasive species
- Nonpoint source pollution
- Toxic chemical pollution

Products and Management Relevance

This research builds new tools to integrate spatial information for environmental management decisions in the Great Lakes. We aim to build maps to visualize and understand environmental impacts (or stressors) on the lakes and benefits humans enjoy from the lakes (or ecosystem services). For example, a high resolution map of cumulative ecosystem stress to guide restoration, conservation, and management efforts was developed (Figure 4). This map merges data for all major categories of environmental stressors to the Great Lakes, ranging from climate change to pollution to invasive species (Great Lakes Mapping, 2013).

Mapping of important ecosystem services provided from the Great Lakes (recreational, etc.) allow for an enhanced understanding of cumulative stress at these locations. These areas are important since under high cumulative stress they may not be able to provide the current services as the same level. The locations of beaches, marinas and important bird-watching sites to represent high-value recreational activities are used (Great Lakes Mapping, 2013).

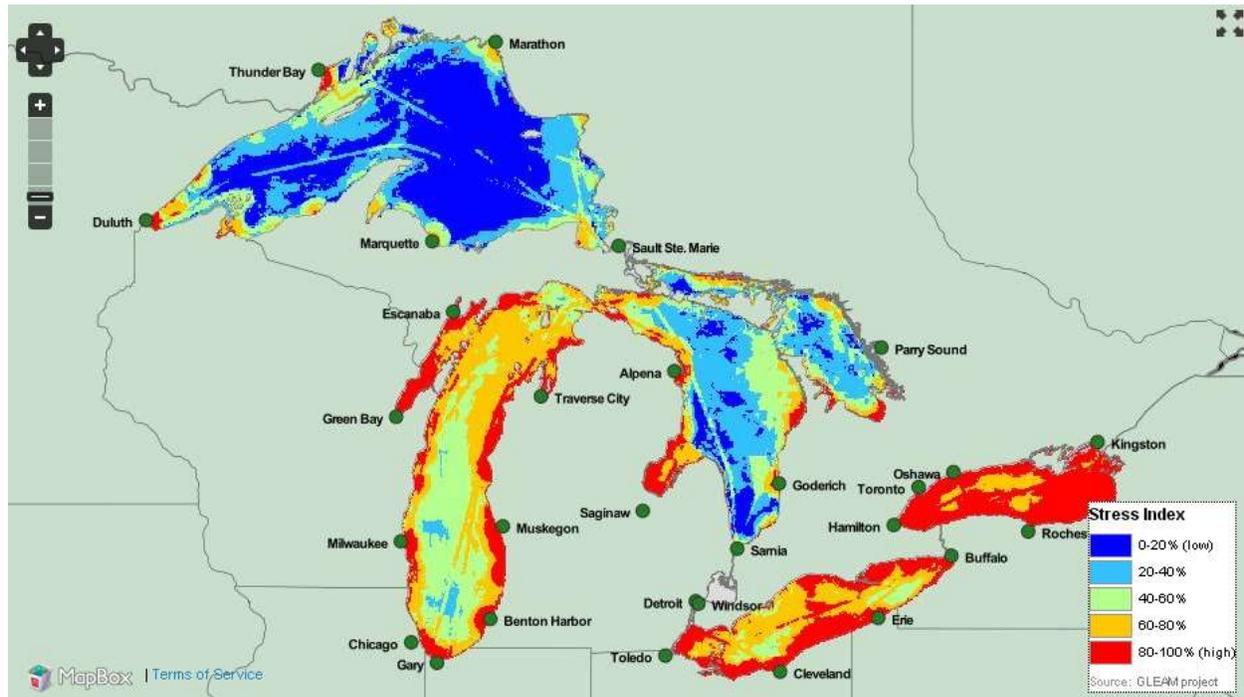


Figure 4. Great Lakes Stress Index Map, source: GLEAM project

The final map can be used to assess stressor impacts at locations with significant human benefits and to evaluate conservation and restoration opportunities.

21.0 Lake Michigan Nearshore Monitoring (NEMO)

Website: <http://wi.water.usgs.gov/lmmcc/>

Project Description

Since its formation in 1999, the Lake Michigan Monitoring Coordination Council (LMCC) has been instrumental in providing technical and coordination support to the Lakewide Management Plan (LaMP) for Lake Michigan. The LMMCC supports coordination of monitoring and research activities conducted in all resource components (tributaries, embayments, beaches, wetlands,

groundwater, open lake, and airshed) of Lake Michigan (Lake Michigan Monitoring Coordination Council National Monitoring Network – Lake Michigan Pilot, 2007).

Objectives

The goals of this program are:

- Understand and inventory nearshore monitoring activities (developing a web mapper);
- coordinate implementation of a nearshore network;
- identify monitoring gaps;
- coordinate database approach;
- develop a nearshore conceptual model;
- integrate data reporting.

Products and Management Relevance

Examples of Lake Michigan nearshore activities and products include:

- USEPA National Coastal Assessment
- University and State near shore Buoys
- University and Federal near shore biology research
- USEPA Triaxus tows of nearshore zone
- USGS GLRI tributary, river mouth, beach, and near shore monitoring (9 projects)
- State and local tributary and river mouth (embayments) monitoring
- UWM sensors on Ferry crossings

(Lake Michigan Monitoring Coordination Council National Monitoring Network – Lake Michigan Pilot, 2007).

22.0 Great Lakes Coastal Resilience Planning Guide

Website: <http://greatlakesresilience.org/>

Project Description

The Great Lakes Coastal Resilience Planning Guide provides educational resources and practical, process-driven approaches to mapping, analyzing, reporting and visualizing specific coastal hazard topics (Great Lakes Resilience, 2013).

Objectives

The Great Lakes Coastal Resilience Planning Guide is designed for state and local officials engaged in coastal management, planning, mitigation and development issues to allow:

- examination of how recent and ongoing trends in short-term and long-term climate conditions affect hazards and their impacts on land, water and resources
- investigation on how different hazards management alternatives respond to and affect changing conditions (Great Lakes Resilience, 2013).

Products and Management Relevance

The Great Lakes Coastal Resilience Planning Guide includes information for hazard management and planning through coastal flood maps. Shoreline change is explored through dynamic coastal processes such as bluff recession and erosion prediction. The Guide also provides information on habitat conservation, restoration and mitigation planning as well as coastal infrastructure planning such as shoreline protection, ports, harbours and transportation.

23.0 Geographic Decision-Support System (GDSS) “Geomatics to the Rescue of the American Eel”

Website: <http://www.nrcan.gc.ca/science/story/3563>

Project Description

There has been a significant decline in the American eel population in Canada and the United States over the past 30 years. This population decline is particularly evident in the Great Lakes and St. Lawrence River basin. Fisheries and Oceans Canada, in collaboration with the Quebec Department of Natural Resources and Wildlife and the Ontario Ministry of Natural Resources, has developed a geographic decision-support system (GDSS) for evaluating sites where the American eel no longer has free access to its natural habitat (Trentin and Dupont, 2011).

Objectives

The goal of this program was to develop a geographic decision-support system (GDSS) for evaluating sites where the American eel no longer has free access to its natural habitat. To determine the cause of the decline and identify the action to be taken, researchers have turned to geomatics and data from the GeoBase National Hydro Network. The GDSS is helping to determine where fish ladders should be installed to facilitate eel movement past dams and to promote the species' recovery (Trentin and Dupont, 2011).

Products and Management Relevance

According to Fisheries and Oceans Canada, the use of geomatics is now critical to allowing a visual analysis of the impact of the various dam construction scenarios.

For now, the GDSS computer tool is still in the development stage and pilot projects are underway to document three rivers — one in Quebec, one in Ontario and one in the Maritimes. The next step will be to fine tune the features of the Web tool. Additional data provided by the National Hydro Network will also be added to document other watersheds that are considered priorities. In the near future, the geographic decision-support system will be used not only to determine priorities for action for eels, but also for other migratory fish species (Trentin and Dupont, 2011).

24.0 Measuring Risk of Water Contamination Indicators

Website (Geobase article):

<http://www.geobase.ca/geobase/en/action/agriculture.html;jsessionid=002F929004670929634BD633960C24A8>

Project Description

Agriculture and Agri-Food Canada (AAFC) initiated the development of agri-environmental indicators to measure the efficiency of agricultural management practices and to provide an objective, science-based assessment of environmental sustainability. Indicators to measure the risk of water contamination by phosphorus and coliforms were developed. This approach enables the integration of data on source contamination, contamination transport, and the factors connecting source contamination and transport (GeoBase, 2013).

Objectives

One important factor connecting agricultural land and water bodies is the measure of saturation excess runoff. Saturation excess runoff is the point at which runoff will occur once the soil is so saturated that it can no longer hold water (GeoBase, 2013). Total rainfall amount and landscape factors such as soil depth (i.e., available water storage capacity), upland-watershed area, and local topography are the factors determining whether or not a particular area in a watershed will generate runoff. To evaluate this, a Topographic Index (TI) was computed for all agriculturally classified watersheds in Canada using the GeoBase Canadian Digital Elevation Data (CDED) and National Hydro Network (NHN) data.

Products and Management Relevance

The project provided the risk indicators with a connectivity factor representing the propensity of developing runoff on agricultural land. Results show that the highest TI values are found in regions where topography tends to be hilly and where agriculture is primarily located in river valleys. The lowest values are found in flat areas. This information is particularly important where there is localized high TI values found where agriculture is found close to important water bodies such as lakes or major rivers (GeoBase, 2013).

25.0 Earth Observation for Sustainable Development of Forests (EOSD)

Website: <http://cfs.nrcan.gc.ca/pages/337>

Project Description

The Canadian Forest Service, in partnership with the Canadian Space Agency, is using space-based earth observation (EO) technologies to create products for forest inventory, forest carbon accounting, monitoring sustainable development, and landscape management. The Earth Observation for Sustainable Development of Forests (EOSD) initiative will work in partnership with the Provinces and Territories and develop a land cover map of the forested area of Canada. This program will aid in providing forest measuring and monitoring system that responds to key policy drivers related to climate change and to report upon sustainable forest development of Canada's forest both nationally and internationally (NRCAN, 2013).

Objectives

EOSD will develop techniques for change monitoring, biomass estimates and automated processing to aid in production. Inputs from EOSD will be an important data source in the National Forest Carbon Accounting Framework and will also be used to enhance Canada's new plot-based National Forest Inventory. Initially EOSD, working with the provinces, territories, universities and industry, will work to develop a national map of the forested land cover of Canada with the long term goal of producing not only land cover maps, but maps of forest change over time, and biomass. The National Forest Information System will be used to integrate and synthesize applicable data and products and make them accessible to a wide range of users through the web. Spatial information will be produced with the aid of automation that can be used for analysis, visualization, and integration with other national spatial data sets (NRCAN, 2013).

The long term goals of the EOSD Project for all of Canada's forest lands are (NRCAN, 2013):

- To produce earth observation data sets and derived products which can be used as input to national and global forest inventories and as geospatial information on forest cover change, forest productivity, forest carbon stocks, and carbon and water exchange;
- To enhance the use in education and by academia of remote sensing as a primary information tool for monitoring the sustainable development of forests and changes in forest carbon stocks;
- To develop and apply operational information systems for providing government, industry, academic and public access to spatial knowledge of sustainable use of forests

Products and Management Relevance

EOSD products include a land-cover map of forested areas of Canada that will be produced using Landsat TM data. Change monitoring methodologies and systems will be developed that will provide spatially explicit maps of major forest changes on a 5 to 10 year basis and more subtle changes on a sample basis with annual imagery. With a combination of remotely sensed data and forest inventories techniques, procedures are being developed to map the forest biomass of Canada from EOSD and using these maps to fill gaps in the national biomass inventory. The EOSD project will use space-based earth observation technologies to create products to support the measurement and monitoring of the sustainable development of Canada's forest as well as to support reporting requirements related to climate change (Kyoto Protocol) and landscape management. This will include monitoring of disturbance and change, reforestation, afforestation, and deforestation are essential elements (NRCAN, 2013).

26.0 Great Lakes Aquatic Habitat Framework (GLAHF)

Website: <http://ifrgis.snre.umich.edu/projects/GLAHF/glahf.shtml>

Project Description

A Great Lakes aquatic habitat database and classification framework will be developed that integrates key habitat components to address local, lake-wide, and basin-wide restoration and management needs. This spatial framework will cover the entire Great Lakes basin but will focus on coastal and nearshore systems. The Great Lakes Aquatic Habitat Framework (GLAHF) will provide a spatially referenced, comprehensive database framework that links available inventory, assessment, and monitoring data with restoration and management plans and policies across multiple spatial and temporal scales (Institute for Fisheries Research (IFR) of the Michigan Department of Natural Resources and Environment and the University of Michigan, 2013 (a)). GLAHF has been funded by the Great Lakes Fishery Trust.

Objectives

This framework will facilitate the integration of key habitat components for the purpose of addressing lakewide and basinwide management, research, and conservation issues with the flexibility to identify data gaps, incorporate new local data, and address emerging issues. The aquatic habitat database will consist of available geo-referenced physicochemical and biological data covering all Great Lakes habitat with particular focus on coastal and nearshore areas for the U.S. and Canada as the core database components. The database will link major coastal habitat features such as wetlands, reefs, coastal watersheds, and rivermouths with terrestrial watershed and open water systems (Institute for Fisheries Research (IFR) of the Michigan Department of Natural Resources and Environment and the University of Michigan, 2013 (a)).

Products and Management Relevance

This tool will provide managers with a consistent geographic framework that has the capability to link, map, integrate, and track habitat classifications, assessments, indicator development, ecological forecasting, monitoring, and restoration activities across the Great Lakes.

27.0 Groundwater Geoscience Program

Website: <http://www.nrcan.gc.ca/earth-sciences/about/current-program/groundwater-geoscience/3042>

Project Description

The Groundwater Geoscience Program assesses aquifers and makes the data available through the Groundwater Information Network. The extent of Canada's groundwater supply (aquifers) is being assessed. This Groundwater Geoscience Program is built on the successes of the two previous phases of the program: 2002-06 Groundwater Program, and the Groundwater Mapping Program 2006-09. Up to 2009, 12 of the 30 key regional aquifers had been mapped and evaluated. In this third phase of the program, approved for the period of 2009 to 2014, the mapping and assessment of seven additional aquifers have been initiated and is to be completed by 2014. The Groundwater Geoscience Program activities will be jointly developed with partners, with other federal departments as well as provincial governments (NRCAN, 2011).

Objectives

The Groundwater Geoscience Program is to establish a defensible and useful scientific data framework which can be used by authorities responsible for managing groundwater on a regular basis. These management activities may also include scientific cooperation and shared management in the case of transboundary aquifers crossing the Canada/United States border (NRCAN, 2011).

Products and Management Relevance

The program seeks to increase the cooperation with the provinces, territories, and universities, as well as with the U.S. federal and state agencies in developing groundwater knowledge by providing a robust scientific database, information and models to support responsible management of the aquifers in making informed decisions for groundwater resources (NRCAN, 2011).

28.0 Fish Species at Risk Research and Assessment in Southern Ontario (Mapping Species at Risk)

Website: <http://www.dfo-mpo.gc.ca/science/publications/annualreport-rapportannuel/>

Project Description

The Great Lakes Laboratory for Fisheries & Aquatic Sciences (GLLFAS) research division of the Department of Fisheries and Oceans (DFO) Science has collected fish and mussel distribution data within Ontario to update historical records and to obtain an accurate picture of the current distribution of Species At Risk (SAR). In 2003, a useful mapping tool was developed for a project carried out by Habitat Management and its partners, with funding from the national Species at Risk Act (SARA) program (Department of Fisheries and Ocean (DFO) Canada, 2013).

Objectives

The project's goals were to:

- assemble and validate fish and mussel distribution data in Ontario
- develop a web-mapping application for Ontario Great Lakes Area (OGLA) staff related to species at risk
- develop an atlas with supporting documentation for partners
- update a web-mapping application with valid, current data

Products and Management Relevance

GLLFAS and Oceans and Habitat (OGLA) collaborated to develop the tool (a series of maps) for OGLA and partner agencies, including Conservation Authorities, Ontario Ministry of Natural Resources, and Ontario Ministry of Transportation. Each map uses a 3-colour scheme based on SARA status, to represent the presence of extirpated, endangered and threatened species currently (DFO, 2013).

In June 2006 a draft version of the mapping tool was distributed to OGLA partners as an "atlas" of 143 maps and in June 2007 Version 1 was officially released. This project will continue throughout the coming years as risk status changes for different species and as new distribution data are collected (DFO, 2013).

29.0 NowCOAST

Website: <http://nowcoast.noaa.gov>

Project Description

NOAA's nowCOAST is a GIS-based web mapping portal providing integrated, one-stop access to on-line, real-time coastal environmental observations and NOAA forecasts for any region in the coastal United States. Updated at regular intervals throughout the day, nowCOAST has the ability to display near real-time meteorological and oceanographic surface observations across the continental United States as well as across the world (NOAA, 2013 (e)).

Objectives

The objective of NowCOAST is to provide users with displays of the latest surface weather and ocean observations, satellite cloud imagery, weather radar reflectivity mosaics, sea surface temperature analyses and gridded forecasts. It also supplies geo-referenced hyperlinks to thousands of web sites providing current observations from meteorological, oceanographic, river, and water quality observing networks and NOAA forecast products from the top of the watershed to the high seas (NOAA, 2013 (e)).

NowCOAST Web mapping portal contains links to a variety of NOAA and non-NOAA Web sources of real-time coastal observations and NOAA forecasts.

Products and Management Relevance

NowCOAST's surface observations are plotted directly on the map at the geo-referenced location of the observation point. In addition to these observations, near real-time imagery is also displayed on the map viewer. Both Infrared and Visible Satellite Imagery are displayed on nowCOAST. An on-map visualization is also available that shows a mosaic of NCEP's Sea Surface Temperature Analysis. Recently, gridded forecast fields obtained from the National Digital Forecast Database have also been added. Forecasts out to three days are available for Maximum Temperature, Minimum Temperature, Wind Speed & Direction, Significant Wave Height and Quantitative Precipitation Amount. The portal also includes hyperlinks to meteorological, oceanographic, and river observations from in-situ and remote-sensing platforms from observing networks operated by federal and state agencies and regional ocean observing systems. These networks include but are not limited to airway stations, climate reference stations, fixed buoys, coastal platforms, river gages, Doppler weather radars, high frequency current radars, radiosondes, and wind profilers (NOAA, 2013 (e)).

The forecast products that nowCOAST links to include 1) forecast "guidance" from NOAA's computer-based estuarine, oceanographic, river, and weather prediction models and 2) worded marine weather and general weather forecasts for geographic areas. In addition, the portal includes links to NOAA's astronomical tidal predictions for sites along the coast.

NowCOAST is designed to be a planning aid to assist recreational and commercial mariners, coastal managers, HAZMAT responders, coastal ocean modelers and marine educators to discover and display real-time information for their particular needs and geographic area of interest. Thus, nowCOAST supports the NOAA Integrated Ocean Observing System (IOOS) Program's vision "to provide continuous, integrated data on our open oceans, coastal waters, and Great Lakes...to support the information needs of government, environmental managers, scientists, business and the public" (NOAA, 2013 (e)).

30.0 Water Resources Information Program (WRIP)

Website: <http://www.mnr.gov.on.ca/en/Business/WRIP/index.html>

Project Description

The Water Resources Information Program (WRIP) developed by the Ontario Ministry of Natural Resources (MNR) ensures that information about Ontario's water resources is accessible, accurate and useable. The Water Resources Information Program encourages information sharing among agencies with a responsibility for water, provides leadership, and guidance in information management practices, develops data improvement solutions, architecture and standards and acts as a focus point for water-related information in Ontario (MNR, 2013).

Objectives

Geospatially linked goals of WRIP include:

- merge two water flow data layers
- update watershed boundaries
- provide derivative products using ArcHydro (see below)
- provide water-related base data needed for data analysis

(MNR, 2013)

Products and Management Relevance

Some of the products of WRIP include:

- The "Arc Hydro Surface Water Data Model Framework" is a product that has been used in the Quality Checking (QC) Process for improving the datasets that WRIP manages.
- A Digital Elevation Model (DEM) is a 3 dimensional model of the Earth's topography that captures the terrain, water surface and drainage. Water Resources Information Program's (WRIP) Digital Elevation Model I (DEM1) was created as part of the Provincial Watershed Project. This version focused on source data error detection (for contour and stream network data) and applying a global drainage condition when generating the DEM.
- WRIP DEM2 significantly enhances the DEM1 product by additionally including lake boundaries and digital terrain model elevation points in the DEM surface generation. Field verification, to further determine the accuracy of this elevation surface, is ongoing.
- DEM2 is used in surface hydrology, groundwater, and data improvement among others. Derivative products from DEM2 such as WRIP's Enhanced Flow Direction (EFDIR) can be used to create consistent watersheds that honour the hydrology for the majority of the province, and act as a base data layer for the Arc Hydro data model.
- Lflow, is in development and is to be a data collection and analysis package, to provide a standard data collection, storage and analysis environment for low streamflow data. Lflow will serve as a foundation for integrating, analyzing and sharing low streamflow data easily and consistently. Lflow is being developed around a standard low streamflow measurement methodology established by the Geological Survey of Canada.

(MNR, 2013)

Given the variety of stakeholders and partners it works with to improve water information management, the Water Resources Information Program (WRIP) works in close cooperation with stakeholders or partners. Provincial government ministries, municipalities and conservation authorities are just some of the agencies that rely on water-related information to create maps, conduct geographic analysis and support decisions about the province's water resources (MNR, 2013).

31.0 Coastal Wetland Survey- Great Lakes Coastal Wetlands Consortium

Website: <http://www.glc.org/wetlands/>

Project Description

As part of Phase II of the Great Lakes Coastal Wetlands Consortium program, a binational team completed a comprehensive Great Lakes Coastal Wetlands Inventory. This dataset, a collaborative effort between Canada and the United States, is a basinwide digital coastal wetland inventory of all the Great Lakes coastal wetlands classified using the Consortium's classification scheme. The coastal wetland inventory is available for all eight states that surround the five Great Lakes: Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin and the Canadian Great Lakes area (Great Lakes Commission, 2013 (b)).

Objectives

The main goal of this program was to supply the best coastal wetland data currently available and incorporating a standard classification process; the binational inventory provides a standard reference for the Great Lakes wetland community.

The Inventory consists of wetland polygons and points, along with extensive attribute data, compiled from the best existing data sets throughout the basin. All the data have been standardized and the polygons have been stitched together into one seamless GIS.

The mapping of the U.S. coastal wetlands was done using geographic information systems (GIS) by the U.S. Geological Survey, Water Resources Discipline (USGS WRD) in Columbus, Ohio. The Michigan Natural Features Inventory (MNFI) identified and classified all coastal wetland complexes. Canadian Wildlife Service - Environment Canada, in cooperation with Ontario Ministry of Natural Resources, constructed the map for the Canadian coastal wetlands (Great Lakes Commission, 2013 (b)).

Products and Management Relevance

The inventory is the most broadly accessible, comprehensive binational collection of coastal wetlands in the Great Lakes Basin and will serve as the framework for long-term monitoring of coastal wetlands.

This inventory has been used in a variety of studies. For example a 2010-2012 effort “Monitoring the Status and Trends of Ecosystem Health of Great Lakes Coastal Wetlands: An Intensification of the National Effort” by the Environmental Protection Agency and the Michigan Department of Natural Resources and Environment. This project is intended to implement the EPA’s National Assessment protocols, in addition to the Great Lakes Coastal Wetlands Monitoring Plan developed by the Great Lakes Coastal Wetland Consortium (GLCWC) to evaluate the status and trends of Great Lakes coastal wetlands (Great Lakes Commission, 2013 (b)).

32.0 Shared Information Management and Delivery System

Website (project summary): <http://www.greatlakeslcc.org/wp-content/uploads/2011/03/Great-Lakes-Info-System-Project-Summary.pdf>

Project Description

Proposed overall architecture of a Great Lakes Information Management and Delivery system is to support strategic habitat conservation to support biological planning, conservation design, conservation delivery, and outcome based monitoring of the adaptive management framework that guides strategic habitat conservation (Upper Midwest & Great Lakes Landscape Conservation Cooperative, 2013). The Nature Conservancy and U.S. Geological Survey, working with a broad network of scientists, natural resource professionals, agency staff, and non-profit colleagues, are in the process of designing and developing a shared Great Lakes information management and delivery system to help support the mission of the Upper Midwest/Great Lakes (UMGL) Landscape Conservation Cooperative (LCC).

Objectives

The goal of this project is to develop demonstration projects that provide a foundation for a shared, web-based, Great Lakes information management and delivery system to support strategic habitat conservation (Upper Midwest & Great Lakes Landscape Conservation Cooperative, 2013).

The objectives include:

- Illustrate the ability to develop a Great Lakes Information Management and Delivery system (i.e., Proof of Concept).
- Illustrate the benefits of an intuitive information management and delivery system and generate support for expanding the information system across the Great Lakes.
- Identify obstacles and solutions for the incremental development and long term maintenance of the information system.

The information management and decision support systems are constructed around the decision making process itself.

Products and Management Relevance

Designing a Shared Great Lakes Information Management & Delivery System to Support Strategic Habitat Conservation Project is intended to operationally support the concept of strategic habitat conservation, which is an adaptive management framework focused on informing decisions to help get the right conservation practices to the right places. These conservation decisions require the integration of relevant ecological and socioeconomic data and knowledge and also decision tools that are presently highly fragmented and difficult to assemble across the Great Lakes (Upper Midwest & Great Lakes Landscape Conservation Cooperative, 2013).

33.0 USGS Great Lakes Shared Science Center

Website: <http://www.glsc.usgs.gov/>

Project Description

The Great Lakes Science Center (GLSC) is a biological research center of the U.S. Geological Survey (USGS). The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. GLSC research spans a range of topics including: fish populations and communities; aquatic habitats; nearshore, coastal, terrestrial, and wetland communities; and the biological processes that occur in the complex Great Lakes ecosystem. Long-term data sets gathered by Center researchers are powerful tools for studying Great Lakes processes on broad spatial and temporal scales.

The GLSC responds to research and information needs of federal agencies of the United States, especially needs of the Department of Interior's U.S. Fish and Wildlife Service (USFWS) and National Park Service (NPS), and needs of Canadian federal agencies, eight states, the Province of Ontario, and Native American tribes found within the Great Lakes basin.

Objectives

The Center's science plan focuses on developing forward-looking approaches to the development of effective research and monitoring programs and indicators of ecosystem change in offshore, coastal, and terrestrial ecosystems. The science plan also addresses theme areas of

critical need such as the role of thiamine deficiency in aquatic ecosystems, initiatives to improve biological resources within the Huron-Erie Corridor, and emerging issues such as aquatic and terrestrial invasive species.

Major strengths of the GLSC include the long-term databases of forage fish, benthic invertebrate, and zooplankton populations and associated information in each of the Great Lakes that have been maintained by Center researchers over more than fifty years of surveys. These continue to be an important source of information on the dramatic changes that have occurred, and continue to occur, in the Great Lakes ecosystem. Other significant databases, such as the commercial catch in U.S. waters of the Great Lakes (maintained by the Center since 1920), are also housed at the GLSC.

Products and Management Relevance

These databases have grown in content, quality, utility, and accessibility to provide managers in the region with reliable and unbiased information necessary for making management decisions. Many Center research studies build on these databases, adding community and ecosystem context to the picture of population trends documented by fish assessments. Predictive models are constructed by Center scientists, anticipating needs of Great Lakes managers. GLSC researchers are increasingly undertaking cross-lake collaborations with other GLSC researchers and collaborative efforts with researchers and resource managers outside of the USGS to produce the syntheses necessary to understand ecological trends and predict how humans might influence future ecological states.

34.0 NOAA Medium Resolution Shoreline

Website: <http://coastalgeospatial.noaa.gov/shoreline.html>

Project Description

NOAA's Medium Resolution Digital Vector Shoreline is a high-quality, Geographic Information System-ready, general-use digital vector data set created by the Strategic Environmental Assessments (SEA) Division of NOAA's Office of Ocean Resources Conservation and Assessment. Compiled from hundreds of NOAA coast charts, this product comprises over 75,000 nautical miles of coastline, representing the entire coterminous United States of America (NOAA, 2013 (f)).

Objectives

The Medium Resolution Digital Vector Shoreline incorporates the entire conterminous United States coastline as four major regions, each of which has a number of sub-regional shoreline section files (Figure 4). Each of these files in-turn were developed from a series of NOAA nautical charts. All charts have been edge-matched such that adjoining arcs connect, regardless of original nautical chart scale. The Great Lakes Coasts, including all five lakes in their entirety and the St. Lawrence River/Seaway to Ogdensburg, New York is included as a region comprising the digital shoreline (NOAA, 2013(f)).

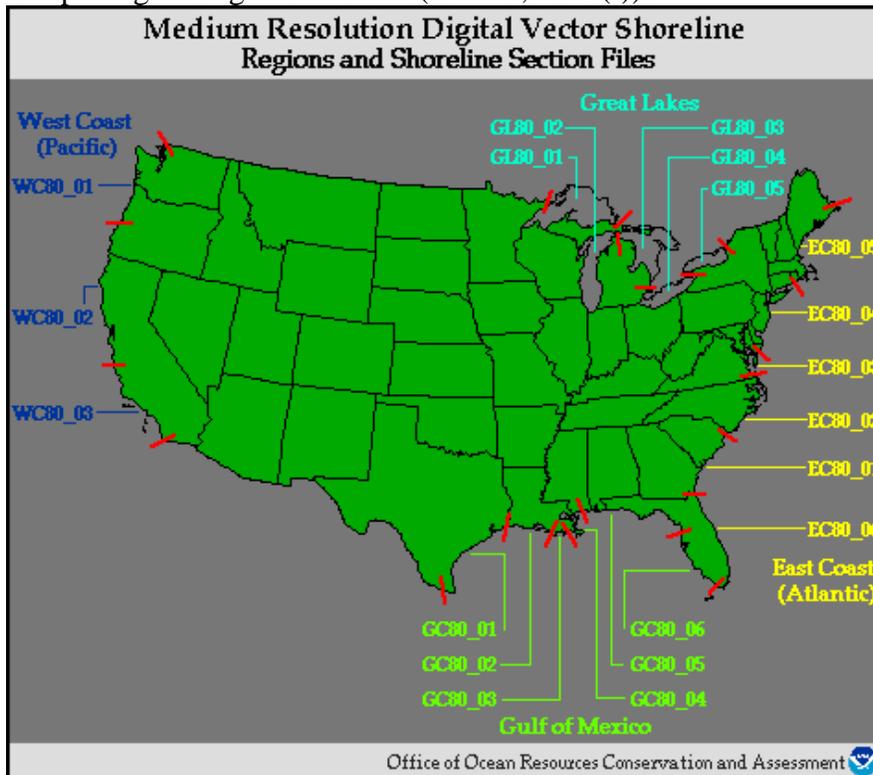


Figure 4.0 Locations of each sub-regional shoreline. Source: NOAA, 2013(f)

Products and Management Relevance

The product is designed for use by a broad audience. Potential users include government agencies, universities, research institutions, and individuals in the private sector.

35.0 Great Lakes Maritime Information System

Website: <http://www.utoledo.edu/research/ITI/shortseashipping.html>

Project Description

The Great Lakes Maritime Information Delivery System initiative was created to aid in expanding regional freight information resources for the Upper Midwest. This program was developed through a Partnership between The Great Lakes Maritime Research Institute and the Toledo University Intermodal Transportation Institute. The initiative was based on the Upper Midwest Freight Corridor Study by the Mississippi Valley Freight Corridors Coalition to establish a regional approach for improving freight transportation in the Upper Midwest (University of Toledo, 2013).

Objectives

The goals of this initiative are to establish multi-state, multi-jurisdictional partnership of public and private sector stakeholder interests and to study short- and long-term issues surrounding anticipated increases in freight movement and impacts on the region's infrastructure and economic health (University of Toledo, 2013).

The main elements of the system include:

- Detailed data repository for vessel movements, port functions commodity flows, economic activity, environmental impacts, etc.
- An Internet-based GIS data viewer (Citrix Metaframe Delivery)
- An Internet-based information delivery site for prepared maps, tables, graphics, text, etc.
- An information clearinghouse and centralized data facility to furnish links to other information resources, (private firms, government agencies, universities, etc.)
- A data exchange to support user inquiries and furnish information on demand

The GIS Repository contains a variety of collected data including:

- Intrastate Employment patterns for each commodity type
- Population and Socioeconomic data representing market demand within the region
- Port Locations—U.S. (National Transportation Atlas)
- Waterway Network—Great Lakes and Inland
- Waterways (Army Corps of Engineers)
- Navigation Facilities, Locks, *etc.*
- Port Operations Data such as Tonnages, Commodities transshipped (Lake Carriers Assn.), Vessels Serviced, Equipment, *etc.*
- Baseline 2002 commodity flows through the Saint Lawrence Seaway and Great Lakes System
- Freight Analysis Framework estimated from 2002 Commodity Flow Survey Data. This data set provided the research team with a skeleton framework upon which to add subsequent flow data as it is obtained.

(University of Toledo, 2013).

Products and Management Relevance

The products of this work so far include basic prepared maps for viewing and download among a variety of jurisdictions: county, congressional district, etc. with analysis and specialized functions in the database for advanced users.

This project will continue data collection, and management and Information Delivery Efforts and pursue opportunities for adopting automated data acquisition technologies--including Advance and real-time vessel movement monitoring (AIS). Other data expected to be added to the GIS repository include:

- Advance Vessel Schedule Information including ETAs and ETDs
- Actual Arrival and Departure Data
- Vessel Traffic Analysis
- Historical Vessel Movement
- Port and Terminal Utilization Studies

This data will greatly assist managers in assessing and planning for vessel movements, port functions commodity flows, economic activity, and associated environmental impacts (University of Toledo, 2013).

36.0 Automatic Identification System (AIS)

Website: <http://www.greatlakes-seaway.com/en/commercial/transiting/ais/index.html>

Project Description

Automatic Identification System (AIS) is a communications protocol developed under the aegis of the International Maritime Organization (IMO), International Telecommunication Union (ITU) and International Electrotechnical Commission (IEC) (The St. Lawrence Seaway Management Corporation and Saint Lawrence Seaway Development Corporation, 2013).

Using Global Positioning System (GPS) technology, any vessel equipped with an AIS transponder transmits its exact location to the Seaway's Traffic Control Center and, in addition, to other ships on the waterway equipped with an AIS display. The location of each vessel is continuously tracked and displayed on a computer generated map of the Seaway, together with its speed and course (The St. Lawrence Seaway Management Corporation and Saint Lawrence Seaway Development Corporation , 2013).

Complementing this information, the Seaway's TMS broadcasts other pertinent data such as local wind speed and direction, water levels and flows, ice conditions, availability of the next lockage, and safety-related messages as dictated by circumstances. The end result is a tightly integrated navigation aid that enhances the ability of each ship captain and/or pilot to navigate the Seaway safely and efficiently. An AIS transponder is mandatory on all commercial vessels transiting through the Seaway's traffic sectors (from the St. Lambert Lock in Montreal to mid-

Lake Erie) (The St. Lawrence Seaway Management Corporation and Saint Lawrence Seaway Development Corporation, 2013).

Objectives

In 2002, the St. Lawrence Seaway enhanced navigation safety and efficiency by implementing the universal Automatic Identification System (AIS), and integrating it with the Seaway's Traffic Management System (TMS). The project was successfully completed by a team that included the U.S. Saint Lawrence Seaway Development Corporation, the Canadian St. Lawrence Seaway Management Corporation, various marine transportation interests, and technical assistance from the U.S. Volpe Transportation Systems Center. Water levels, weather data and lockage order-of-turn for each lock within the Seaway are now broadcast in real-time (The St. Lawrence Seaway Management Corporation and Saint Lawrence Seaway Development Corporation, 2013).

Products and Management Relevance

The importance of AIS to shipowners is that it enhances safety (especially under adverse weather conditions) through real-time ship-to-ship communications of vessel locations, speeds and courses. It also has the potential to reduce transit through better traffic management, and enhanced scheduling of lock passages.

There are numerous benefits of AIS for Seaway Management including:

- efficient traffic management, with continuous monitoring of vessel location and speed under all weather conditions
- enhanced scheduling of lockages and vessel tie-ups
- faster response times in the event of an accident/incident, coupled with more accurate information concerning hazardous cargoes
- the ability to monitor all vessel speeds in real-time to ensure compliance with Seaway speed limits
- greater coordination in the scheduling of ship inspections
- enhanced monitoring of vessels for safety and security purposes
- Enhances navigation via the provision of timely and accurate environmental information, broadcasted through AIS channels by the Seaway's TMS

(The St. Lawrence Seaway Management Corporation and Saint Lawrence Seaway Development Corporation, 2013).

37.0 Real-Time Environmental Coastal Observations Network (RECON)

Website: <http://www.glerl.noaa.gov/res/recon/>

Project Description

Real-time Environmental Coastal Observations Network (RECON) is run by NOAA GLERL with co-investigators from the Lake Erie Center, University of Michigan, University of Wisconsin-Milwaukee, Thunder Bay National Marine Sanctuary, Wisconsin Sea Grant, National Undersea Research Program (NURP), University of Michigan Space Physics Research Lab and Ohio Supercomputer Center.

The RECON project will provide national data national using commercial networking standards to provide real-time whole water column observations of physical, chemical, and biological variables in coastal areas few, if any, environmental observations. The RECON project will also include the development of autonomous underwater vehicle technology and deployment of real-time in situ biological and chemical sensors, including fisheries acoustics for biomass estimation. On-water observation networks will include the development of fiber optic cabled and high-bandwidth wireless systems utilizing advanced database management systems. The project will establish a test bed for observing system network design studies and develop enhanced verification capabilities (National Oceanic and Atmospheric Administration and Great Lakes Environmental Research Laboratory [NOAA GLERL], 2013) (a).

Objectives

The goal of the RECON project is to develop a national network of low cost coastal buoys capable of seabed to sea-surface observations. The RECON system has been designed with a built-in capability to add buoy observation sites to meet regional and national integrated observing system requirements. In addition to advancing NOAA's scientific real-time data acquisition capability, the project is making relevant data accessible to the public and educational institutions through a web-based data interface. Permanent and portable wireless internet observation systems will be deployed at six sites for scientific data collection and continued engineering development in Lakes Huron and Erie (NOAA GLERL, 2013) (a)).

Long term goals include collection of long-term data sets for physical, biological, chemical, and meteorological parameters in the Great Lakes, to deploy observations systems on portable, low cost buoys and fixed platforms of opportunity, and to implement a high bandwidth, wireless Ethernet-based system. It is aimed that the data will be secure and provided in real-time.

Products and Management Relevance

The RECON system currently in place in the Great Lakes has national and regional applications. This wireless Internet observation system, with shore stations at four coastal locations covering approximately 800 square miles of sea surface, uses commercially available networking equipment allowing straightforward integration into a nationwide network. Each system collects

meteorological data and provides sub-surface measurements of chemical, biological, and physical parameters. The system is designed to allow controlled access to multi-institutional users through surface buoys and sub-surface sensor guest ports located on an underwater hub (NOAA GLERL, 2013) (a).

The observation network currently provides environmental data to state, federal, and university researchers, educators and resource managers. The need for development of regional coastal observing systems has been highlighted by a number of studies. Continual assessment of the status and trends in coastal environments permits identification of perturbations that may signal changes in the ecosystem, puts current trends into an historical framework, allows for the ability to differentiate true environmental change from variance and provides a context to assess the impact of predicted changes (NOAA GLERL, 2013) (a).

38.0 CoastWatch Great Lakes Program Great Lakes Node

Website: <http://coastwatch.glerl.noaa.gov/>

Project Description

Coast Watch Great Lakes Program Great Lakes Node provides near real-time and archived data from satellite observations as well as in-situ data from throughout the Great Lakes. Satellite data is obtained from NOAA Advanced Very High Resolution Radiometer (AVHRR) and Geostationary Operational Environmental Satellites (GOES) observations, while the in-situ observation stations consist of platforms, buoys, gauges, and ship reports from a number of different organizations (National Oceanic and Atmospheric Administration and Great Lakes Environmental Research Laboratory [NOAA GLERL], 2013(b)).

Objectives

GLERL is the regional node for the NOAA CoastWatch program, providing access to near real-time and retrospective satellite observations and in-situ Great Lakes data.

Products and Management Relevance

A digital map of the Great Lakes surface water temperature and ice cover which is produced daily at the GLERL through the NOAA CoastWatch program. The Great Lakes Surface Environmental Analysis (GLSEA) is stored as a 512x512 pixel map in GIF format, suitable for viewing on PCs and workstations with readily available software (NOAA GLERL, 2013)(b). This allows managers to see real-time data and make informed decisions based on this.

39.0 The Lower Niagara River Lake Sturgeon Study

Website: http://www.fws.gov/midwest/sturgeon/lowergl_page.htm

Project Description

The lower Niagara River lake sturgeon study is a collaboration between the Service's Northeast Fishery Center and the Lower Great Lakes Fish and Wildlife Conservation Office, to assess the health and status of the lake sturgeon population in the lower Niagara River and locate their spawning habitat. Combining a genetic analysis with this information will supply a population viability analysis to estimate the future population size of lake sturgeon in the lower Niagara River (U.S. Fish and Wildlife Service, 1999).

Objectives

The objective of this study is to estimate the lower Niagara River lake sturgeon population and track their movement in order to identify locations of spawning nurseries.

Since fall of 2010, over 300 individual fish have been tagged and released. Age analysis of these fish from fin spine samples indicate that most fish in the lower Niagara River are between 13 and 16 years old. The movements of 72 lake sturgeon implanted with radio transponder tags have been tracked using a combination of stationary radio-receivers and mobile tracking, which identified the locations of possible spawning grounds and migration behaviour (U.S. Fish and Wildlife Service, 1999).

Using GIS mapping software, the lake sturgeon tracking data will be overlaid with data collected from a GLRI-funded sidescan sonar project, mapping the river substrate to provide important information on habitat in the lower Niagara. In 2012 blood samples were collected from all sturgeon captured prior to spawning season, to identify sex and spawning stage by measuring hormone levels (U.S. Fish and Wildlife Service, 1999).

Products and Management Relevance

With the addition of some upcoming genetic analysis, the above information will be combined into a population viability analysis to estimate the future population size of lake sturgeon in the lower Niagara River. This will help managers in assessing the health of the important lake sturgeon community and locate spawning locations in order to better protect the species and improve population numbers (U.S. Fish and Wildlife Service, 1999).

40.0 Coordinate GIS databases

Website: <http://ifrgis.snre.umich.edu/>

Project Description

The GIS Working Group at Institute for Freshwater Research (IFR) is the primary unit developing geographic information system (GIS) tools for assisting management of aquatic ecosystems for the Fisheries Division of the Michigan Department of Natural Resources and Environment (MDNRE).

Major projects address the development of GISs and related databases on Great Lakes and inland waters of Michigan and the region.

Objectives

GIS projects include:

- Great Lakes Fisheries GIS. Ecosystem management of Great Lakes fisheries requires analysis of multiple, spatially explicit factors. A comprehensive GIS can facilitate analysis of factors influencing fish abundances, distributions, and harvest in the Great Lakes, and help provide information to managers as they make decisions.
- Digital Water Atlas. The purposes of this project are to develop spatially explicit information describing the natural resources of Michigan's inland waters and to develop applications to support assessment of resource status and management options. The objective is to provide resource managers and other agencies with desktop access to such comprehensive information and applications.
- Michigan Rivers Inventory. This long-term, collaborative research effort focuses on development of a regional, spatially explicit, inventory framework; a collaboratively managed research database; and scientific models and methods for studying the large-scale ecology of Michigan's rivers.
- Geographic Distribution Maps of Michigan Fishes. Maps show locations of fish collections by species. The database for these maps consists of approximately 160,000 georeferenced records for collections made from 1823 to 2002.
- National Hydrography Dataset - High Resolution. The NHD contains spatial information about surface waters and the drainage network. IFR personnel are preparing high-resolution (1:24,000) versions of this dataset for 12 USGS Cataloging Units in Michigan that contain portions of the Huron-Manistee, Hiawatha, and Ottawa National Forests.

- **Ecological Classification of Rivers for Environmental Assessment.** The goal is to couple landscape-based modeling from regional data sets and land-transformation models with a valley segment ecological classification. Objectives include completion of a GIS-based river segment classification and provision of a comprehensive status and risk assessment of river systems across Michigan, Illinois, and Wisconsin.

(Institute for Fisheries Research (IFR) of the Michigan Department of Natural Resources and Environment and the University of Michigan, 2013 (b))

Products and Management Relevance

The purposes of these projects are to develop spatially explicit information describing the natural resources to develop applications to support assessment of resource status and management options. The data is to provide resource managers and other agencies with desktop access to geospatially relevant data (UM IFR, 2013 (b)).

41.0 Great Lakes Wind Collaborative

Website: <http://www.glc.org/energy/wind/>

Project Description

The Great Lakes Wind Collaborative (GLWC) proposes to develop a web-based geospatial decision support system to facilitate informed wind development in the eight state Great Lakes region (IL, IN, MI, MN, NY, OH, PA, and WI). This decision support system will integrate relevant ecological, geophysical and socio-economic geospatial datasets that can be applied to evaluate alternate wind development scenarios based on user inputs and thereby enable more informed decisions about the suitability of locations for wind facilities, in onshore and offshore environments. The major participants in this project are Great Lakes Wind Collaborative, Great Lakes Commission, Pangaea Information Technologies, Ltd., and Bluewater Geospatial (Great Lakes Commission, 2013) (c)).

Objectives

The ultimate objective of this project is to create an Online Wind Mapping Toolkit for the Great Lakes Wind Region. This project will address the need for high-resolution spatial data of habitat and/or migration corridors for avian and bat species of concern in regions of high potential wind development. The specific objectives of this project include:

1. Inventory and aggregate relevant ecological, geophysical and socio-economic geospatial datasets.

2. Develop a web-based, spatially-enabled decision support system wind mapping toolkit that will help decision makers identify areas where siting wind facilities might be most (or least) suitable within the Great Lake region. Specific features of the toolkit include:
 - a. A web-based map viewer, the Great Lakes Wind Atlas;
 - b. An open source design to ensure future expansion,
 - c. Query functionality that enables users to analyze impacts of wind development scenarios;
 - d. Access to new GIS data products through Open Geospatial Consortium (OGC) Services; and
 - e. Metadata files to accompany all geospatial data products to identify data quality and history.
3. Build awareness among the wind community of the mapping toolkit and continue its development.

(Great Lakes Commission, 2013) (c)).

Products and Management Relevance

This project will augment the ability of decision-makers across the Great Lakes region to respond to information requests, develop sound regulatory decisions, and improve regional planning and coordination by providing the highest available resolution data and an online mapping tool that enables use of that data to evaluate wind development scenarios. The project also addresses the regional need for Great Lakes offshore data that is consistent, accurate and robust data for the Great Lakes region (Great Lakes Commission, 2013) (c)). This project prepares the region for making informed future decisions relating to offshore wind power.

42.0 GIS for Integrated Ecosystem Assessments of Great Lakes Aquatic Resources

Website: <http://ciler.snre.umich.edu/research/project/development-gis-databases-integrated-ecosystem-assessments-ieas-great-lakes-aquatic>

Project Description

A priority research area for NOAA's ecosystems observations program is to generate and manage data and information necessary for conducting Integrated Ecosystem Assessments (IEAs) and risk analyses. A Geographic Information System (GIS) database for Great Lakes aquatic habitats will facilitate IEAs and aid managers to assess threats to coastal resources and understand ecosystem structure and function (Cooperative Institute for Limnology and

Ecosystems Research [CILER], 2013). The primary investigator for this project is NOAA GLERL with co-investigators from the University of Michigan.

Objectives

The ultimate goal of this project is to provide geospatial information that will allow for increase number of habitat acres conserved or restored; and increase number of protected species that reach stable or increasing population levels.

The project proposes to refine an existing GIS database for Great Lakes aquatic habitats to include the wealth of data collected by NOAA GLERL on physical and biological data.

The Great Lakes GIS project (GLGIS) now includes GIS databases for each Great Lake, but lacks several recent databases including: satellite imagery of chlorophyll a and turbidity for all Great Lakes, benthos densities and species composition in Lake Huron, Lake Michigan and Lake Erie for recent years, data on fish, zooplankton and dissolved oxygen in Lake Erie; biota and physical characteristics of Saginaw Bay; and distributions at depth. This project aims to incorporate these data into the spatial framework of the GL GIS, revise existing ecoregion classifications of aquatic habitat, and assign variables to spatial units (CILER, 2013)

Products and Management Relevance

Management directed towards long-term sustainability of aquatic resources should be based on a fundamental understanding of functional relationships between species and their critical habitats on the appropriate spatial and temporal scales. While GIS-based ecological classifications have been developed for many terrestrial and riverine systems in the Great Lakes basin, to date there has been little development of ecoregions directed at the Great Lakes themselves. Advances in hydro-acoustic and remote-sensing technology have encouraged collection of spatially-explicit estimates of fish production, primary and secondary production, and abiotic factors (i.e. wind, currents, temperature) in the Great Lakes. Examination of these data sets, along with analysis of historic fisheries data will facilitate understanding of patterns in distribution and abundance of important sport fishes and their prey. Ecological classification of nearshore and offshore habitat regions will establish reference conditions for monitoring aquatic species and their habitats at the relevant spatial scales. Development of habitat suitability models for selected aquatic species will address knowledge gaps that hinder species management and restoration (CILER, 2013).

Enhancing the Great Lakes GIS for an IEA of coastal anthropogenic stressors will aide development of operational management plans to provide and enhance habitat for aquatic species of greatest conservation need. Development and attribution of ecological habitat classifications with physical, chemical and biological data will facilitate forecasts of impacts from invasive species, climate change or land use change on Great Lakes habitats and species. Development of an IEA will facilitate scenario generation. Scenarios can give

representations of possible future change to the ecosystem, and can aid identification of priority conservation targets, ecosystem attributes and management plans (CILER, 2013).

This program provides a standard, basin-wide platform for inventory, classification, and holistic management of aquatic species and their habitats. Development of aquatic habitat databases and maps will eliminate information gaps for aquatic species, landscape features, ecological processes, and threats (invasive species) and aid in management and restoration strategies (CILER, 2013).

43.0 EPA's "Surf your Watershed"

Website: <http://www.epa.gov/surf>

Project Description

EPA's "Surf Your Watershed" Internet Site, which houses the Agency's first comprehensive assessment of U.S. watersheds, allows the public to locate, use, and share environmental information on a particular watershed or community. Providing the public with this information is an extremely important step in improving our nation's water quality and protecting the health of the public. A particular watershed can be selected by using maps or searching by State, Indian Tribe, County, or zip code. A search can also be based on local stream names, water bodies, or even large-scale ecosystems. At the state or watershed level, there is information regarding protection efforts, environmental/public health conditions, fish advisories, drinking water, land use, population, Superfund sites, and effluent dischargers. The public also will be able retrieve the overall score for a watershed, reflecting condition and vulnerability, additional information provided by states, and links to public and volunteer organizations working to protect and restore water at the regional, State, and watershed level (Environmental Protection Agency [EPA], 2013).

Objectives

The driving force behind Surf Your Watershed is to get environmental information into the hands of citizens and groups active in protecting and managing the environment.

Products and Management Relevance

The Great Lakes Computer Center provides a database to support regional information systems including Great Lakes Envirofacts, which consists of EPA facility information in an easily accessible format, RAPIDS, and the database of the Lake Michigan Mass Balance (EPA, 2013). The public is now able to easily search Great Lakes Envirofacts website. This allows for managers interested in promoting lake health to promote citizen engagement through directing them to pertinent information found on the "surf your watershed" website.

44.0 Lake Huron Cooperative Science and Monitoring Initiative

Website: http://www.glerl.noaa.gov/res/projects/csmi_lake_huron/csmi_lake_huron.html

Project Description

In the spring of 2012, GLERL scientists initiated an intensive research effort in Lake Huron, partnering with the U.S. Geological Survey Great Lakes Science Center (USGS-GLSC), the U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office, the Michigan Department of Natural Resources (DNR), the University of Michigan, and Environment Canada. The field campaign, entitled “2012 Lake Huron Coordinated Science and Monitoring Initiative (CSMI),” is sponsored by EPA and NOAA in part through the Great Lakes Restoration Initiative. The research will help scientists understand the structure and function of the Lake Huron ecosystem - from bacteria to fish - and clarify the impacts of stressors such as invasive species, climate change, nutrient loading, and overfishing (Great Lakes Environmental Research Laboratory and National Oceanic and Atmospheric Administration [GLERL NOAA], 2013).

Objectives

In order to gain the necessary data (bacteria, fish populations, invasive species, nutrient loading, etc.) the Lake Huron field campaign has employed an impressive fleet of vessels to carry out intensive cruises through the waters of the Thunder Bay National Marine Sanctuary off Alpena, MI in April, July, and September 2012. Sampling will also be conducted aboard EPA and Environment Canada research vessels lake-wide across Lake Huron.

Products and Management Relevance

The 2012 Lake Huron CSMI will serve as the foundation for GLERL to establish a long-term ecological research program in Lake Huron in hopes of yielding long-term data sets on nutrients, benthic organisms, phytoplankton, zooplankton, and fish to allow scientists to study their impacts and stressors. The long-term ecological research program in Lake Huron will integrate long-term observations on biological, chemical, and physical variables with process-based laboratory experiments to help develop new concepts and modeling tools to explore changes in the lake (GLERL NOAA, 2013).

45.0 Southern Ontario Land Resource Information System (SOLRIS)

Website (factsheet): http://library.queensu.ca/webdoc/maps/guides/SOLRIS_FAQ_APR2008.pdf

Project Description

The Southern Ontario Land Resource Information System (SOLRIS) is a landscape-level inventory of natural, rural and urban areas. SOLRIS follows a standardized approach for ecosystem description, inventory and interpretation known as the Ecological Land Classification (ELC) for southern Ontario.

SOLRIS is a series of GIS and image analysis protocols that map current land cover from recent remote sensing images. This initiative is currently mapping land cover (including wetlands) in southeastern Ontario, with plans to map the entire Ontario portion of the Mixed Wood Plains ecozone and includes a specific focus on wetland mapping (Queens University, 2008).

Objectives

The SOLRIS inventory is a compilation of data from various sources including topographic maps, aerial photos and satellite imagery. Computer modelling, visual interpretation and field validation were used to create a seamless inventory for Southern Ontario. SOLRIS was developed to support landscape-scale planning initiatives in southern Ontario such as Source Water Protection, Biodiversity Conservation, Natural Heritage Planning, and State of Resources Reporting (Queens University, 2008).

Products and Management Relevance

SOLARIS is an important tool for planning initiatives specific to biodiversity conservation, natural heritage and how these may change over time.

46.0 Early Detection Distribution Mapping System (EDDMapS)

Website: <http://www.eddmaps.org/>

Project Description

EDDMapS is a web-based mapping system for documenting invasive species distribution. It is fast, easy to use and doesn't require Geographic Information Systems experience. Launched in 2005 by the Center for Invasive Species and Ecosystem Health at the University of Georgia, it was originally designed as a tool for state Exotic Pest Plant Councils to develop more complete distribution data of invasive species.

Objectives

EDDMapS goal is to maximize the effectiveness and accessibility of the immense numbers of invasive species observations recorded each year. As of March 2013, EDDMapS has over 1.9 million records. EDDMapS combines data from other databases and organizations as well as volunteer observations to create a national network of invasive species distribution data that is shared with educators, land managers, conservation biologists, and beyond.

Products and Management Relevance

EDDMapS documents the presence of invasive species. A simple, interactive Web interface engages participants to submit their observations or view results through interactive queries into the EDDMapS database. EDDMapS encourages users to participate by providing Internet tools that maintain their personal records and enable them to visualize data with interactive maps (EDDMapS Early Detection & Distribution Mapping System, 2013)

Users simply enter information from their observations into the standardized on-line data form, which allows specific information about the infestation and images to be added. Data entered is immediately loaded to the Website, allowing real time tracking of species. Being able to see the current data of a species as it moves into a new area helps to facilitate Early Detection and Rapid Response programs (EDRR). EDRR programs help stop or control an invasive species before it becomes an unmanageable problem.

All data is reviewed by state verifiers to ensure all data is accurate. The data is made freely available to scientists, researchers, land managers, land owners, educators, conservationists, ecologists, farmers, foresters, state and national parks.

Early detection, rapid assessment and rapid response is a critical second defense against the establishment of invasive populations. Having the information that this program provides increases the likelihood that localized invasive populations will be found, contained, and eradicated before they become widely established and can slow range expansion, and avoid the need for costly long-term control efforts. This data will become the foundation for a better understanding of invasive species distribution around the world (EDDMapS Early Detection & Distribution Mapping System, 2013)

47.0 Lake Superior Biodiversity Conservation Assessment

Website: <http://www.natureconservancy.ca/en/where-we-work/ontario/our-work/lake-superior-assessment.html>

Project Description

Developing the Lake Superior Biodiversity Assessment was identified by the bi-national Lake Superior Lakewide Action and Management Plan (LAMP) as an important tool to better integrate biodiversity objectives into current lake management, and to support implementation of the Great Lakes Water Quality Agreement. A project team from the Lake Superior LAMP first reviewed existing information. The assessment of biodiversity target health and the ranking of threats were done through the Conservation Action Planning framework (Nature Conservancy Canada, 2013).

Objectives

Seven conservation targets were selected that encompass the biodiversity of Lake Superior. These include aquatic coastal, tributary and watershed based habitats that have many species nested within them. The health of these biodiversity targets was assessed based on SOLEC indicators, with some modifications. The overall viability assessment for Lake Superior is “good” - the lake is in a state of health that is within the natural range of variation, but some management intervention may be required for some elements. The biodiversity conservation targets that had the lowest viability included watersheds and tributaries (Nature Conservancy Canada, 2013). While nearshore and embayments are in “good” health, they are approaching the threshold for “fair”. For many of the coastal habitats (aquatic and terrestrial), and watersheds there is a high degree of regional variation in target condition (Nature Conservancy Canada, 2013). To better illustrate these regional differences, stress indices were mapped for watersheds (GLEI 2013), lake waters (GLEAM 2013) and coastal areas (analysis done for this project) (Nature Conservancy Canada, 2013).

Products and Management Relevance

This information will be used by the Lake Superior LAMP to develop ecosystem objectives and strategies to support both lake-wide and place-based conservation in 2013 (Nature Conservancy Canada, 2013).

48.0 Agricultural Resource Inventory (AgRI) Mapping

Website: <http://www.omafra.gov.on.ca/english/landuse/gis/portal.htm>

Project Description

The AgRI mapping project has provided an extensive Geographic Information Systems (GIS) digital polygon framework and corresponding database for field-specific cropping and tillage system information (Ontario Ministry of Agriculture and Food, 2013). A number of watersheds were the core regions of focus for this AgRI mapping work including the Fairchild Creek Watershed (a tributary of the Grand River), Rondeau Bay Watershed (on the coast of the Lake Erie basin) and coastal watersheds in central Huron County (between the Bayfield and Maitland Rivers) in the Lake Huron Basin (Ontario Ministry of Agriculture and Food, 2013). Collaborators on this project include Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and Ministry of Natural Resources (MNR).

Objectives

The goal of this project was to provide a Geographic Information Systems (GIS) framework and corresponding database for field-specific cropping and tillage system information for a number of watersheds in the Great Lakes Basin. Detailed, seamless digital polygon frameworks for the rural landscape in these regions were developed. High resolution orthoimagery from the 2006 Southwestern Ontario Orthoimagery Project (SWOOP 2006) was used as the base for this digitization effort. Individual polygons were developed for all farmsteads, farm fields, roadways, ditches, rough land areas and riparian areas within the study regions. A GIS data model was developed to incorporate crop (crop type, planting direction, row spacing, etc.) and tillage (type: conventional, conservation, no-till; direction, etc.) information. Field mapping with "windshield" observations from all public-access roadways in these study regions was conducted for the 2008 and 2009 cropping seasons, and the data was then entered into the AgRI GIS database (Ontario Ministry of Agriculture and Food, 2013).

Products and Management Relevance

Data provided "ground truth" calibration for the AgRI remote sensing methods development project. Data was also used as the input for the Water Erosion Prediction Project (ArcGeoWEPP) model to produce maps of soil loss under current management practices in the Rondeau Bay watershed.

Accurate maps of field crops and tillage management systems in Ontario's agricultural landscape for specific cropping seasons provide valuable information for both production and environmental management programs. They are essential components of watershed-specific, comprehensive agricultural resource inventory (AgRI) information that aids OMAFRA in its Canada-Ontario Agreement (COA) commitments, particularly for evaluating non-point source pollutant reductions associated with various farm management practices (Ontario Ministry of Agriculture and Food, 2013).

Summary

It is clear that there are numerous geospatial management projects throughout the Great Lakes. These projects cover many different aspects of Great Lakes issues including inventorying species, biodiversity assessments, wetland surveying, invasive species detection, coastal planning, and various other ecosystem components. In addition, shipping, and transport was discussed as is highly relevant in the Great Lakes Region.

There is an increasing need by Great Lakes managers to have access to geographically based data to improve management decisions. Currently, the literature on Great Lakes data compilation is scattered and is not readily available to managers in an easy, standardized and accessible way.

However, many of the activities of the initiatives discussed share the goal to fill this gap through the mission and objectives of facilitating a shared database. If these groups can work together to help identify needs, develop strategies and coordinate resources for meeting those needs and engaging Canadian and US Federal partners it is possible to improve the database, and fill in missing gaps.

A summary of programs discussed is available in Appendix B.

Conclusion

Natural resource managers today are presented with unprecedented challenges that threaten the continued protection, conservation and management of land, water and wildlife, from impacts of climate change to habitat fragmentation and invasive species. Science-driven partnerships aimed at addressing these large scale natural resource stressors, continues to advance the pool of science-based research necessary for land use managers, policy makers and others to make decisions that support long-term sustainability of the Great Lakes.

The role of geographic information systems (GIS) in environmental problem-solving and communications continues to expand at a rapid pace. In the study of environmental and ecosystem dynamics, virtually all critical data have a spatial component. Geographic information systems represent a series of processes and tools, whereby complex data are linked to geologically referenced features. The ability to manipulate data through spatial analysis and database queries, and display visual results is a highly useful tool for managers and decision makers. Managing and displaying data through GIS distills complex trends, correlations and relationships into accessible information.

Sometimes the greatest challenge to harmonising datasets is finding them. This is where it becomes increasingly necessary to facilitate the formulation of standards, the sharing of data, and, ultimately, a more collaborative, open and connected network of coastal GIS applications. Even in areas where standards and data-sharing protocols are in force, the increasingly rich and diverse database of many coastal regions leaves to GIS practitioners the task of determining the best available representation of coastal phenomena. Because the land-sea interface is a complex area, the scale of biophysically distinct areas in the coastal zone often necessitates a spatial resolution that has traditionally been difficult or expensive to acquire. GIS practitioners working in the coastal zone were until recently either limited to a few data sources or required to adapt the scale and resolution of their work to the quality of readily available data. The challenge of acquiring high-quality data has been somewhat ameliorated by the increasing availability of quick-deploying sensors such as active laser sensors like LiDAR (Light Detection and Ranging) or active satellite sensors with specialised uses in the aquatic.

Involving stakeholders such as scientists, managers, regulators, legislators, resource users and members of the public in both the formulation and the output of GIS goes beyond the technical and presents intercultural and interpretive challenges. GIS practitioners must keep the needs of stakeholders and future users in mind and have responded by creating innovative visualisations, interfaces and forums for participation in the course of applying GIS to management.

Researchers and practitioners are increasingly taking an interdisciplinary, integrative approach to applying GIS in the planning and decision making. As the body of work in this area grows, so too does our understanding of aquatic processes and the role of humans in perturbing and managing these systems. GIS has much to contribute to Integrated Management, and GIS practitioners have many more challenges to face in constructing truly integrative spatial information systems particularly in coastal regions.

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APPENDIX A:

Maps and GIS Agencies (Data Sources)/ Organizations in the Great Lakes

Maps and GIS Agencies (Data Sources)/ Organizations in the Great Lakes

Adapted from GLIN (source: <http://gis.glin.net/resources.php>)

| Agency/Organization | Programs and Products |
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| Federal | |
| U.S. Environmental Protection Agency (EPA) | Great Lakes Atlas; includes information about physical characteristics, natural processes, people, concerns, joint management and new directions (mirrored on Environment Canada's site) |
| U.S. Environmental Protection Agency | Geographic Information Systems |
| Center for Emerging Technologies | Government Information Exchange Search for topics at all U.S. federal government web sites. |
| Federal Geographic Data Committee | National Spatial Data Infrastructure (NSDI) The NSDI encompasses policies, metadata standards, and procedures for organizations to cooperatively produce and share geographic data. |
| National Imagery and Mapping Agency | U.S. Imagery and Maps National Imagery and Mapping Agency (NIMA) has developed a standard digital dataset (Digital Terrain Elevation Data (DTED®) Level 0) as well as other datasets. DTED® Level 0 elevation post spacing is 30 arc second (nominally one kilometer). |
| Natural Resources Canada | Canada Centre for Remote Sensing A national program in remote sensing in cooperation with other agencies of the Government of Canada, provincial governments, industry and Canadian universities. GeoGratis - GeoGratis is a portal provided by the Earth Sciences Sector of Natural Resources Canada which provides geospatial data at no cost and without restrictions via your Web browser. |
| Natural Resources Conservation Service | NRCS GIS and Data Sites |
| U.S. Army Corps of Engineers | Geospatial Data Clearinghouse Node |
| U.S. Fish and Wildlife Service | GIS-Decision Support System (DSS) Committee The Core Group formed by the committee examines the role that geospatial data, technologies, and analyses plays in the implementation of an ecosystem approach to management in the Great Lakes basin. |
| U.S. Geological Survey | Geography Information - USGS Geography (formerly Mapping) provides scientific information to describe and interpret America's landscape by mapping the terrain, monitoring changes over time, and analyzing how and why these changes occurred. |
| Environment Canada | Atlas of Canada - Various maps on the topics of Environment, People & Society, Economic, Historical, Reference Maps, Climate Change, Freshwater, Health. Canadian Ecodistrict Climate Normals 1961-1990 - GIS database of Climate Normals for Ecodistricts. Geobase - The GeoBase portal provides access to geospatial data at no cost, i.e. Administrative Boundaries, Canadian Digital Elevation Data, Canadian Geodetic Network, Geographical Names of Canada (toponymy), Landsat-7 Orthoimage, National Road Network. GeoConnections Discovery Portal - The GeoConnections Discovery Portal enables Geographic Information Systems' users, developers, data and service suppliers to find, evaluate, visualize, and publish Canadian geospatial data products and services. |

| Agency/Organization | Programs and Products |
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| GeoBase is a federal, provincial and territorial government initiative | GeoBase- undertaken to ensure the provision of, and access to, a common, up-to-date and maintained base of quality geospatial data for all of Canada. Through the GeoBase portal, users with an interest in the field of geomatics have access to quality geospatial information at no cost and with unrestricted use. |
| Provincial/State | |
| Illinois | |
| Chicago Region Clearinghouse Cooperative | A multi-organizational spatial data Clearinghouse for the greater Chicago Region (including participants from Northwest Indiana). |
| Illinois Geographic Information Council | To provide the leadership necessary to effectively and efficiently integrate Geographic Information Management Technology (GIMT) on a statewide basis, ensuring that GIMT is used as a strategic resource for the State of Illinois. |
| Inside Illinois | Run by the state of Illinois, it has information for everyone, providing a growing selection of useful information and maps. |
| Indiana | |
| Indiana Spatial Data Portal Indiana University | This site provides access to over 400 Gigabytes of Indiana GIS data. Most datasets are available to the public for download and have no use restrictions. |
| Lake Rim GIS Center for Geospatial Data Analysis at the Indiana Geological Survey (IGS) | The Coastal Coordination Program, Indiana Department of Environmental Management, and Indiana Geological Survey collaborated to develop the Lake Michigan Lake Rim Geographic Information System (GIS). One of the goals for the Lake Rim GIS is to facilitate public access to and analysis of environmental data for Indiana's coastal region. |
| Michigan | |
| Census and statistical data for Michigan State of Michigan | Provides Census and demographic data on items such as geography, population and housing, social and economic data. They offer services in spatial technology, business intelligence, and data transport tools. |
| GIS Management Unit | Wayne County's GIS initiative. It contains the general information and a map gallery. |
| Michigan Geological Mapping Michigan Department of Environmental Quality (DEQ) | A cooperative effort to map in detail the surface formations and understand their relationships and characteristics. |
| Spatial Data Library Michigan Department of Natural Resources (DNR) | Providing easy access to GIS data in support of holistic ecosystem management. |
| Minnesota | |
| Interagency Information Cooperative | Enhancing the access and use of forest resources data in Minnesota. |
| Land Management Information Center | Minnesota Planning offers services to improve the effective use of geographic information in Minnesota. |
| New York | |
| New York State GIS Clearinghouse | The Clearinghouse, operated by the New York State Library, was established to disseminate information about New York's Statewide GIS Coordination Program and to provide access to the New York State GIS Metadata and Data Repository. |
| Ohio | |
| Geographic Information Systems Ohio Environmental Protection Agency (EPA) | The GIS Unit provides geo-referenced data, geographical analysis and map products to the Division of Surface Water. |

| Agency/Organization | Programs and Products |
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| LearnGIS Ohio EPA, Division of Surface Water | This online tutorial will introduce you to Geographic Information Systems (GIS) and lead you through GIS concepts, from the basics to advanced analysis. You'll also find numerous applications of GIS in water resource management. |
| OGRIP - Ohio Geographically Referenced Information Program | OGRIP is an organization whose goals are to encourage the creation of digital geographic data of value to multiple users, foster the ability to easily determine what geographic data exists and foster the ability to easily access and use this data. |
| Ontario | |
| Land Information Ontario | The Ontario government established Land Information Ontario (LIO) to harmonize and standardize land information management in the province. |
| Pennsylvania | |
| Geographic Data Center | Pennsylvania's Department of Environmental Protection's GIS site. |
| Quebec | |
| GENIE Network Environnement Canada | The Green Lane Quebec region's GENIE network (Georeference Environmental Network for Information Exchange) uses the Internet to facilitate cooperation between the various intervenors during an environmental emergency. |
| Wisconsin | |
| DNR Geographic Information Systems (GIS) Wisconsin Department of Natural Resources (DNR) | Geographic Information System (GIS) technology is in use at the DNR to enable timely, efficient, and effective access to information about the state's land, water, and air resources. |
| Wisconsin State Cartographer's Office | Great mapping and GIS references for the state of Wisconsin. |
| Independent | |
| Great Lakes Commission | GIS Program This project will ensure quick and efficient access to accurate Great Lakes spatial data for the widest possible group of interested parties and will provide a solid foundation for interagency spatial data sharing and collaboration across the binational region. |
| Clark Labs | Idrisi Project Clark Labs is a non-profit research organization within the Graduate School of Geography at Clark University. Activities undertaken by the Labs include: the development, distribution and support of the raster Geographic Information System and Image Processing software IDRISI and the vector digitizing and editing software CartaLinx. |
| Institute for Geospatial Research & Education (IGRE) Eastern Michigan University | The Institute's Mission is to support the public and private implementation and use of geospatial technology. |
| Lake Superior Decision Support Project | The Lake Superior Decision Support Project is an effort to develop GIS-based decision support applications focused on the Lake Superior Basin. The site maintains several data layers within a 50 kilometer buffer of Lake Superior. |
| Minnesota GIS/LIS Consortium | The Minnesota GIS/LIS Consortium is a forum for communicating information to, and improving cooperation among, those interested in Geographic Information Systems (GIS) and Land Information Systems (LIS) in the State of Minnesota. |
| National States Geographic Information Council NSGIC GIS Inventory | The purpose of NSGIC is "to encourage effective and efficient government through the coordinated development of geographic information and technologies to ensure that information may be integrated at all levels of government." |

| Agency/Organization | Programs and Products |
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| PaMAGIC - Pennsylvania Mapping and Geographic Information Consortium | To provide "the Citizens of Pennsylvania will have a coordinated, flexible, and integrated geographical information infra-structure to support better decision making and more efficient use of limited resources." |
| Wisconsin Land Information Association | Promoting Land Information Systems and Land Records Moderization. |
| Wisconsin Coastal Atlas | Wisconsin Coastal Atlas- provides access to maps, data, and tools to support decision-making about the Great Lakes. It provides a web-based "geo-portal" that catalogs, integrates, presents, and shares distributed sources of geospatial data and supports development of a "coastal spatial data infrastructure". The initial focus of the atlas is on coastal hazards, but it is built with an open architecture that allows addition of new tools and components over time. |
| Commercial | |
| Autodesk - GIS Product Index | Best known for their AutoCAD software, they have also come out with a suite of GIS applications. |
| Caliper | GIS software company specializing in transportation. |
| Environmental Systems Research Institute, Inc. (ESRI) | One of the leading GIS software companies, ESRI is responsible for programs such as Arc/Info, ArcView and MapObjects. |
| ERDAS | One of the leading provider of Geographic Imaging products and related services. Their main products include ERDAS IMAGINE and ArcView Image Analysis. |
| Geographic Data Technology (GDT) | GIS software company specializing in niche market applications. |
| Intergraph GIS | Once known for marketing Microstation, they have since developed GeoMedia as their own GIS software package. |
| MapInfo | MapInfo is a leading software supplier that produces several GIS applications including MapInfo Professional, MapMaker and MapX. |
| PCI Geomatics | A leading developer of geomatics software and solutions based on its remote sensing, digital photogrammetry, spatial analysis, and cartographic editing programs. |
| Space Imaging | Provides a various types of imagery, including different resolutions of satellite images to synthetic aperture radar. |

APPENDIX B

Summary of Great Lakes Geospatial Programs Informing Management

| Program | Agency/ Fundors | Purpose | Initiatives and Activities | Management Aspect |
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| NOAA Coastal and Marine Spatial Planning | NOAA | NOAA’s Coastal and Marine Spatial Planning (CMSP) Data Registry is a web-based resource to provide access to a collection of NOAA geospatial data sets served with supporting metadata. Approximately 50 data sets are included in the registry. These data sets directly contribute to comprehensive regional marine planning. | The primary objective of this program is to provide access to data through the CMSP data registry. Longer term goals are to develop a strategy to link national systems like the CMSP Data Registry and Ocean.Data.Gov to regional information management approaches in the ocean and coastal planning community; to identify common standards and procedures to be adopted by regional ocean governance groups; and to establish a practitioner’s network of data and tool developers. | The marine planning is a tool developed from the bottom up to improve collaboration and coordination among all coastal and ocean interests, and to better inform and guide decision-making that affects their economic, environmental, security, and social and cultural interests. |
| SharedGeo’s GLRI Collaborative Mapping Project | Funded by the EPA and administered by the US Fish & Wildlife Service. The project has several partners including the University of Minnesota, St. Mary’s University, Michigan Tech Research Institute and Ducks Unlimited. | The goal of the SharedGeo GLRI Project is to serve and share current and historical imagery and spatial data that are related to the Great Lakes area, surrounding watersheds and wildlife habitats. | The project uses open-source tools to serve, catalog, map and distribute spatial data and has main 3 parts: 1) Spatial data web services and data download tools 2) A spatial data catalog 3) A web map integration tool SharedGeo GLRI project hosts 40+ TB of imagery data. These datasets are viewable alongside data from nine US states and the Province of Ontario. | By using services and not local copies of data in this solution, the user is always assured they have the most up-to-date data and imagery to use in their decision making. As an example, a user might want to search for “wetlands”. This query will send a request to GeoNetwork which will query the metadata and find all wetlands related records. If those records have map layers associated with them that are available via services, the map user will then be able to view them. The map and metadata services may come from the SharedGeo server or from other organizations, but to the user it will be seamless. |
| Great Lakes Restoration Initiative: Geospatial Information for Decision Support in AOCs and Ecosystems | Endeavour to acquire high-resolution elevation and Light Detection and Ranging (LiDAR) point-cloud data for (in order of priority): Macomb County, St. Clair County, and Monroe County, Michigan. | The U.S. Geological Survey (USGS) working with county governments, the State of Michigan, and other Federal Agencies, particularly the U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey. | Much of the elevation data in the Great Lakes, and within the western Lake Erie watershed, was over 30 years old. In regions of modest relief, such as the lake plains of Monroe and Macomb County, MI, the existing 30m DEM and 10ft contours are both outdated and lack sufficient detail to identify areas of current or potential wetlands. This initiative has provided new, reliable and advanced data for this region. The imaging work was contracted to the USGS National Geospatial Technical Operations Center (NGTOC) Commercial Partnerships Team (CPT) based in Rolla Missouri. | LiDAR provides imagery data for Federal, State, and local agencies, as well as environmental managers and researchers. The images provide the necessary detail to identify areas of current or potential wetlands, develop restoration and management plans, and delineate watersheds reliably. The derivative products of the LiDAR, including land cover, canopy height, and biomass, among others, provide useful information for restoration. |

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| <p>Great Lakes Restoration Initiative: Great Lakes Islands Geographic Information System/Decision Support System</p> | <p>Great Lakes Basin Ecosystem Team (GLBET) Islands Committee and the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC)</p> | <p>To gather spatial and non-spatial data on the Great Lakes islands.</p> | <p>The UMESC was tasked to create a Decision Support System (DSS) to guide future management and protection of these islands and surrounding areas. The DSS facilitated decision-making for land acquisition, environmental review, management planning, and provide a valuable tool for communication and outreach.</p> | <p>The DSS was made available from the desktop of all USFWS field stations that manage resources within the Great Lakes Basin. Managers can review the Great Lakes islands within the DSS for natural resource values and threats and for their potential for acquisition by the National Wildlife Refuge System. The DSS presently in use on the Upper Mississippi River was used as a model for this project.</p> |
| <p>Great Lakes Restoration Initiative: Great Lakes Basin Lake Sturgeon GIS Database</p> | <p>The Great Lakes Basin Ecosystem Team (GLBET) Lake Sturgeon Committee and the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC)</p> | <p>To create a prototype webpage to graphically display Lake Sturgeon sampling information collected within the Great Lakes Basin.</p> | <p>Staff members from UMESC participated in several meetings and workshops with GLBET Lake Sturgeon committee members. The UMESC then created a prototype web-based Environmental System Research Institute's (ESRI) ArcIMS (Internet Map Server) Decision Support System (DSS) to display this information.</p> | <p>Since Lake Sturgeon is an important protected species, this web-based application can provide data on Lake Sturgeon populations within the Great Lakes for decision makers.</p> |
| <p>Great Lakes Restoration Initiative: Fish Habitat Enhancement Strategies for the Huron-Erie Corridor</p> | <p>USGS Great Lakes Science Center and partners</p> | <p>To develop science-based adaptive management strategies to help restore high fishery productivity in the corridor and develop delisting criteria for fish habitat loss BUIs. This includes developing historic maps for the HEC and ranking threats to restoration of fishery production in order to devise a plan for restoring fish productivity by creating connected fish spawning and nursery habitat.</p> | <p>The program will integrate geospatial and hydrodynamic models to estimate natural habitat attributes (geomorphology, flow regimes, depths, substrate characteristics, and bank slope; as baseline parameters for fish habitat restoration. GIS analysis and hydrologic modeling will be used to link changes in the fluvial geomorphology and hydraulic regime to natural erosion, channelization and changes in fish habitat from 1870 to 2000 in the Huron-Erie Corridor.</p> | <p>This project addresses AOC delisting goals by mapping major physical components of fish habitat, identifying missing components, and examining connectivity to surrounding habitats.</p> |
| <p>Great Lakes Restoration Initiative: Forecasting Potential Phragmites Coastal Invasion Corridors</p> | <p>USGS Great Lakes Science Center and Michigan Tech Research Institute (MTRI)</p> | <p>Use remote sensing to map the current extent of Phragmites in the Great Lakes coastal zone, assess areas vulnerable to the spread of Phragmites under predicted climate-change scenarios and environmental influences (e.g., nutrients, hydrology, shoreline development), and create a web-based decision-support tool.</p> | <p>Final Phragmites maps were made available to the general public and land managers through the USGS Center for Integrated Data Analytics (CIDA) GLRI GeoNetwork. The GeoNetwork is primarily a metadata catalog that describes the availability and structure of geospatial data sets produced by GLRI efforts but also allows the graphical interpretation of these products through interactive maps. Other project-related data publicly available on the existing GeoNetwork include a study area extent, raw lidar topo-bathymetry, the proximity-weighted reduced lake-level scenarios that were derived from LIDAR, a layer showing users where LIDAR data were unavailable, a separate set of reduced lake-level scenarios made possible by NOAA 1-m bathymetric contours, and a variety of base layers.</p> | <p>The GLRI Phragmites Decision Support Tool (DST) Mapper is intended to provide resource managers with information to strategically develop effective Phragmites control and invasion prevention programs in the Great Lakes coastal zone (10 km inland from the shoreline). The Mapper consists of three integrated components: A distribution map of large (> 0.2 ha) stands of existing Phragmites. A map of estimated Phragmites habitat suitability based on current environmental conditions. Corridor networks including reduced lake-level scenarios that are weighted by proximity to existing Phragmites to show likely invasion pathways.</p> |

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| <p>Great Lakes Early Detection Network (GLEDN)</p> | <p>University of Wisconsin-Madison with funding from Great Lakes Restoration and National Park Service</p> | <p>GLEDN is a collaboration among multiple stakeholders in the Great Lakes states (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York).</p> | <p>Invasive species data integrated throughout the region are being used to develop more comprehensive maps of current species distributions and predictions of their likely spread. The Great Lakes Early Detection Network hosts a variety of trainings on the use of our website and the use of the Global Invasive Species Information Network (GISIN) data sharing services. In addition, local and regional trainings on species identification and management are commonly provided by many of our collaborators.</p> | <p>The web-based alert system emails users when new sightings for species or areas of interest are entered into our member data management systems. As new sightings are reported, a network of professionals will be available to verify new sightings and natural resource managers will be notified to take appropriate management actions.</p> |
| <p>Invasive Species Early Detection and Distribution Mapping System</p> | <p>Ontario Ministry of Natural Resources (MNR), in collaboration with the Invasive Species Centre (ISC) and the Ontario Federation of Anglers and Hunters (OFAH), as well as other partnering agencies</p> | <p>Aim is to develop an on-line system for reporting invasive species sightings, and for viewing information on species distribution</p> | <p>Distribution Mapping System (EDDMapS) tool developed by the University of Georgia will be used for the collection and access to data. The Ontario version of EDDMapS will serve as a key tool which will be used by agencies as well as members of the public to report sightings of invasive species. The project is still in its infancy.</p> | <p>EDDMapS will allow resource managers to better determine priorities for invasive species management, to report new invaders, and detect patterns of spread.</p> |
| <p>Great Lakes Basin Ecosystem Team (GLBET)- Geographic Information System/Decision Support System</p> | <p>USEPA Great Lakes National Program Office</p> | <p>Provides refuge personnel and other interested parties the ability to answer questions related to islands within the Great Lakes basin using spatial and non-spatial data.</p> | <p>The UMESC was tasked to create a Decision Support System (DSS). The GLBET received a stand-alone desktop PC-based DSS application, designed exclusively to meet their needs. The DSS included tools to allow the user to calculate distances between islands and other features, identify features and display their attributes, view metadata related to map layers, and export the map display as a digital image. Additional funding was acquired to allow UMESC to collect detailed Lake Michigan island summary information and to program an Island Assessment Database which gives users the ability to organize information collected. This project was completed and delivered in September 2003. The DSS presently in use on the Upper Mississippi River was used as a model for this project.</p> | <p>Decision Support System (DSS) to guide future management and protection of these islands and surrounding areas. The DSS facilitated decision-making for land acquisition, environmental review, management planning, and provide a valuable tool for communication and outreach. The DSS was made available from the desktop of all USFWS field stations that manage resources within the Great Lakes Basin. Managers can review the Great Lakes islands within the DSS for natural resource values and threats and for their potential for acquisition by the National Wildlife Refuge System.</p> |

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| <p>The Great Lakes Regional Environmental Information System (GLREIS)</p> | <p>The Consortium for International Earth Science Information Network (CIESIN), in cooperation with the U.S. EPA</p> | <p>Aim was to develop an environmental information system providing public access to information, data and data utilities relevant to the Great Lakes Region.</p> | <p>GLREIS utilizes is accessible online to provide a user-friendly interface to "guides to information", documents, databases, and several CIESIN-developed software applications that facilitate data identification, acquisition, and utility. The "guides" provide descriptions of data sets, organizations and initiatives pertaining to the Great Lakes. CIESIN-developed applications include the CIESIN Gateway, several unique map servers, the Land Transformation Model (LTM) and a Decision Support System. The map servers provide interactive mapping of user-selected U.S. Census population and housing variables (STF3), and select EPA Great Lakes National Program Office (GLNPO) GIS coverages and databases. These map servers were developed using SAS and ARC/INFO, respectively.</p> | <p>The Decision Support System (DSS) prototype provides analysis tools including modeling, simulation, and visualization for water quality management at the watershed level. The LTM analyzes how past decisions on land use have influenced present land use change patterns. By integrating variables pertaining to socioeconomics, ecological succession, pollution potential, hydrology, and ecosystem integrity within a GIS framework, future land use change can be projected.</p> |
| <p>The Cooperative Science and Monitoring Initiative (CSMI)</p> | <p>Environment Canada and USEPA-GLNPO as well as other partners, such as the IJC Council of Great Lakes Research Managers (CGLRM), the Great Lakes Research Information Network (GLRIN), and the Great Lakes Fisheries Commission (GLFC)</p> | <p>CSMI was developed to help coordinate science programs on the Great Lakes, as well as undertake programs to address issues identified by the Lakewide Management Plan (LaMP) management teams and their partners.</p> | <p>This multi-agency initiative provides enhanced science delivery by combining efforts, where operationally possible, to tackle key information needs/gaps. The science is communicated to the clients for effective and efficient adaptive management decision making.</p> | <p>The Cooperative Science and Monitoring Initiative (CSMI) was created as the result of a need to coordinate science in support of management of the Great Lakes. The process includes enhanced monitoring and research field activities which are conducted in one lake per year, tied to the needs of the Lakewide Management Plan (LaMP) committees.</p> |

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| <p>Great Lakes Observing System Enterprise Architecture (GLOS-EA)</p> | | <p>This Great Lakes Observing System Enterprise will provide ready access to vital real-time and historical information to support decision-making by managers and users of this unique and invaluable resource.</p> | <p>The observing system is a comprehensive enterprise that includes sensors, a network that gathers data, a data management and communications system, models and other tools that process data, and the information portals and user interfaces that make processed data and information available to users. Their national weather forecasting systems provide examples of fully deployed and operational science-based observing systems. The monitoring, modeling and communication network operated by the U.S. National Weather Service and the Meteorological Service of Canada provide integrated real-time weather information, forecasts, and databases of historical weather and climate conditions for North America. The data from these systems are compiled and managed in databases, and evaluated using statistical methods and simulation models so that information regarding past, present and future weather and climate conditions can be communicated to and understood by users via the Internet and other broadcast media.</p> | <p>Over the next few decades, the effects of Global Climate Change are estimated to affect water levels (coastal property erosion), the frequency and intensity of precipitation events (flooding and runoff pollution), ice cover distribution and duration, and other factors. The observing system can track changes over time and provide planners in federal, state and local agencies with trend information to better understand, prepare for, and adapt to the changes. The observing system will also allow for integration and communication of information critical to improved understanding and management of the fisheries.</p> |
| <p>GEOS Great Lakes Test Bed Initiatives</p> | <p>Canadian and U.S. partners of the Group on Earth Observations(GEO)</p> | <p>Expansion of the GEO goal of promoting interoperability to include collaborating to promote the convergence of observation networks, systems and sensors. This includes creating a standard for how data is collected for multiple variables and establish trans-boundary sites with comprehensive integrated measurements to provide an assessment of the data products on each side of the border and their uses for water resources management.</p> | <p>The Testbed group will investigate the potential for data activities in four focus areas in the Great Lakes Basin: 1) Ice cover, 2) Water levels, 3) Groundwater, and 4) Beaches. Background information is being compiled to assess the needs and feasibility of data integration for each focus area to facilitate data exchange using protocols established by the Global Earth Observation System of Systems (GEOSS).</p> | <p>Having an established trans-boundary geospatial information with comprehensive integrated measurements at many sites will provide an opportunity for managers to perform standard assessments of the data products on each side of the border and their uses for water resources management.</p> |

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| <p>Great Lakes Information Network (GLIN)</p> | <p>The Great Lakes Commission (GLC), with support from the National Oceanic and Atmospheric Administration (NOAA)</p> | <p>The GLIN Data Directory is a data indexing system that will provide resource management decision-makers and researchers with overviews of geospatial data and information relevant to the use and management of Great Lakes resources</p> | <p>A state of the art metadata clearinghouse will provide decision-makers and researchers with detailed overviews of data and information specific to the use and management of Great Lakes resources. The project will collect standardized descriptions for approximately 2,000 coastal spatial data sets from local, regional, state/provincial, and federal sources, including several current basinwide projects looking at coastal wetlands, water resources, lake levels and ecosystem health studies such as beach monitoring and human health issues. The interface will feature a search function for locating data by topic and a map interface for location data geography. Two secondary objectives of the GLIN Data Directory project are (1) to encourage the use of standardized metadata and (2) to provide uniform base data for the Great Lakes basin, compliant with federal standards easy to access. The directory will encourage agencies towards metadata creation and compliance as part of meeting their missions and data dissemination goals.</p> | <p>With coastal areas under pressures from many angles, tools for resource managers and policy makers are critical for ecological conservation and the development of sustainable practices.</p> |
| <p>The Great Lakes GIS Online Project</p> | <p>GLIN, -a variety of U.S. and Canadian federal and state agencies</p> | <p>The project goal is to provide user-friendly online mapping of many of these files by developing and maintaining a state-of-the-art online mapping system.</p> | <p>The Great Lakes GIS Online project builds upon the regional Great Lakes Information Network (GLIN) to provide Internet-based access to, and online mapping capability for, a variety of consistent spatial data layers covering the Great Lakes Basin. The Great Lakes GIS Online project will provide a solid foundation for interagency spatial data sharing and collaboration across the binational region. It will provide institutionalization of a mechanism to build regional cooperation and collaboration in inter-agency spatial data sharing over the Internet. They are populating an online library with numerous data sets, including Great Lakes shoreline, soils, land use and land cover, hazardous waste sites, demographics, watersheds and transportation.</p> | <p>Data sets will provide decision makers with valuable geospatial information on soils, land use, land cover, hazardous waste sites, demographics, watersheds and transportation.</p> |
| <p>Beach Health Project</p> | <p>USGS</p> | <p>The mission is to provide science-based information and methods that will allow beach managers to more accurately make beach closure and advisory decisions, understand the sources and physical processes affecting beach contaminants.</p> | <p>The work consists of four science elements—real-time assessments; pathogens and microbial source tracking; coastal processes; and data analysis, interpretation, and communication.</p> | <p>The provided science-based information and methods from this project will allow beach managers to more accurately make beach closure and advisory decisions, understand the sources and physical processes affecting beach contaminants, and use science-based information to mitigate and restore beaches and protect the public.</p> |

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| Satellite Lake Quality Analysis | Blue Satellite and NOAA | Blue Water Satellite’s ability to detect levels of phosphorus – both in water and in surface soils – will help you prevent blue-green algae and aquatic vegetation blooms from taking over your lake. And, we cover every square inch of the earth, eliminating the shortcomings of arbitrary random location “grab” sampling. | Utilizes Blue Water Satellite technology to provide the finest in entire water-body analysis. Using patented satellite imaging technology to detect the presence, location, and concentration (in parts per billion) of blue-green algae and aquatic vegetation blooms, as well as the phosphorus that causes them to bloom out of control in the world’s lakes, streams, rivers, ponds, and reservoirs, our data saves money and can save lives. Reports are derived from pinpoint precise GIS-based data. Has been completed for Lake Erie Western Basin. | Blue Water Satellite’s ability to detect levels of phosphorus – both in water and in surface soils – will help prevent blue-green algae and aquatic vegetation blooms from taking over the lake. It can be used to determine which portions of the lake are clean/safe and which are possibly dangerous or toxic. It can be used to judge water quality improvements by making comparisons to lakes in the past, at any time you wish back to 1984. It can be used to determine where to focus remediation programs for effectiveness or ground water sampling programs for correlation. |
| Upper Great Lakes Study Adaptive Management | International Joint Commission | International Upper Great Lakes Study (IUGLS) was developed to examine the management of water levels and flows in the upper Great Lakes. | The study identifies climate risk and decision scaling and defines coping zones particularly for coastal areas and the impacts on recreational boating and tourism, commercial navigation, municipal and industrial water uses, hydropower and the ecosystem. | Following consultation with experts and managers in the upper Great Lakes basin, the Study adopted a decision-scaling approach to defining climate risk as the first step in scoping an adaptive management strategy. It determines their domain of vulnerabilities and then assesses whether conditions that would produce the identified vulnerabilities are possible or plausible based on the available climate science. |
| Great Lakes GIS (includes LEGIS, LMGIS, LHGIS, LOGIS, LSGIS) | Institute for Fisheries Research University of Michigan and Michigan DNR | OBJECTIVES: 1.) Develop seamless, standardized, habitat-based GIS projects for the Great Lakes. 2.) Develop a collaborative plan and establish institutional arrangements for long-term data sharing, development, distribution, training and maintenance of Great Lakes GIS databases. | To facilitate sharing of data and holistic management of the Great Lakes basin, GIS-based classifications of aquatic ecological units are being assembled. This will include map-delineated spatial units and associated habitat and biological attribute data for terrestrial, tributary rivers, nearshore, and offshore ecosystems. This system would serve as the fundamental base map on which to compile and view landscape-scale inventory of Great Lakes Basin aquatic resources. | The primary objective of the GLGIS Project is to integrate data from each lake basin into a common database to provide an inventory of basin-wide aquatic resources. Additionally, many new layers and tools are also being developed to ensure that the DSS is a powerful tool for analysis of whole-system responses to management alternatives. |
| Great Lakes Environmental Center | Great Lakes Environmental Center contracted by USEPA | EPA contracted GLEC to construct nine unique ecoregions for the conterminous U.S. and then analyze and report on each ecoregion’s physiographic, ecological, and anthropogenic characteristics. | GLEC’s GIS specialists combined and modified existing detailed ecoregions into the nine new ecoregions, and then overlaid pertinent spatial data such as hydrography, climate, habitat, land cover, census data, pollution, and industrial and agricultural activity. Spatial analysis techniques were then employed to extract statistics and characteristics of each ecoregion. | The ecoregion map provides a logical backdrop for the probability-based water quality survey data generated from the field sampling efforts. The nine aggregate ecoregion map has been published in EPA’s Wadeable Streams Assessment report and can be used by managers to extract relevant statistical information to inform decision making. |

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| NOAA Coastal Geospatial Data Project | NOAA | NOAA's Medium Resolution Digital Vector Shoreline is a high-quality, Geographic Information System-ready, general-use digital vector data set created by the Strategic Environmental Assessments (SEA) Division of NOAA's Office of Ocean Resources Conservation and Assessment. | The coastline data contained in this compilation are taken directly from the most up-to-date coast charts available at the time (1988-1992). Edition dates are provided as part of the descriptive information (.ATR) files. Master sheets of each of the charts were scanned and captured using CAD and GIS heads-up digitization techniques. | The product is designed for use by a broad audience and is available through this service. Potential users include government agencies, universities, research institutions, and individuals in the private sector. Digital files are available in ESRI shapefile format. |
| Wisconsin Coastal Atlas | University of Wisconsin Sea Grant College Program. | The Wisconsin Coastal Atlas is an innovative web resource that helps people better understand coastal issues, share coastal data, and inform decision-making about sustainable use of the Great Lakes. | The map gallery features a coastal overview map that provides an overview of the Wisconsin coastal zone, showing how the Great Lakes and its basin relate to coastal communities, political jurisdictions and land cover. The maps section of the Wisconsin Coastal Atlas serves as a gallery of web mapping interfaces illustrating stream gages, buoys, storm warnings, radar and satellite. The initial focus is on coastal hazards, but new themes will be added over time. | The Wisconsin Coastal Atlas is intended for use by coastal resource managers, planners, researchers, educators, tourists, citizen scientists, and coastal residents. The atlas serves as a gateway to spatial decision support tools relevant to Great Lakes management and provides access to educational resources about coastal issues in Wisconsin. |
| Great Lakes Regional Aquatic GAP (GLGAP) | USGS in cooperation with state and federal natural resource agencies, Universities, and The Nature Conservancy | Aim is to map and classify aquatic habitats, define fish distributions, and identify gaps in the distribution and conservation of fish species and their habitats for lotic systems of the US Great Lakes watershed | GLGAP results consist of regionally consistent spatial data components that can be integrated into the proposed framework and include landscape characterization of inter-confluence stream reaches and associated watersheds with more than 300 habitat variables, empirical models to predict fish species abundance for more than 130 fish species, empirical models to predict summer stream temperature, a hierarchical aquatic habitat classification framework, a fish-based lotic habitat classification, and a Central relational database to store results. These results have been achieved for all lotic habitats within the U.S. Great Lakes-St. Lawrence River Basin and for a limited number of nearshore Great Lake areas (McKenna and Castiglione, in review). | Many of these results have already been adopted by state natural resource agencies for use by natural resource managers and policy makers to better understand, manage, and conserve our aquatic natural resources. These tools and data substantially extend our ability to plan and identify priorities for conservation goals. |
| Canadian Wind Atlas | Environment Canada | The Canadian Wind Atlas offers the possibility to browse through the results of the numerical simulations that were run on all of Canada in order to determine its wind energy potential. | Provides comprehensive Geographic Coverage on land and offshore for 8 states and 2 provinces. It provides a variety of geospatial information and overlays including wind resource, transmission lines and biological features. The goal of the wind atlas is to provide a high-resolution map (5 km grid) that covers the Canadian landmass and is based on wind climate data. Environment Canada's Wind Energy Atlas web site aims at developing new meteorological tools to be used by Canada's wind energy industry. | Wind stakeholders including developers, federal, state and local regulators/reviewers, environmental NGOs, consultants and academics can use graphical displays of multiple variables to make management decisions and inform planning. |

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| <p>GLEAM</p> | <p>GLEAM brings together a diverse group of broadly-experienced academic researchers, agency staff, and representatives of basin-wide NGOs.</p> | <p>Build new tools to integrate spatial information for environmental management decisions in the Great Lakes. We aim to build maps to visualize and understand environmental impacts (or stressors) on the lakes and benefits humans enjoy from the lakes (or ecosystem services).</p> | <p>The Great Lakes Environmental Assessment and Mapping Project (GLEAM) evaluates multiple stressors affecting the Great Lakes ecosystem. GLEAM merges spatial data layers representing all major categories of stressors to the Great Lakes, ranging from climate change and land-based pollution to invasive species, into a single map of cumulative stress. The synthesis of this information into a single map enhances our ability to manage and restore the Great Lakes ecosystem. The final map can be used to assess stressor impacts at locations with significant human benefits and to evaluate conservation and restoration opportunities.</p> | <p>They use the locations of beaches, marinas and important bird-watching sites to represent high-value recreational activities. To address provisioning services, we quantify the spatial distribution and magnitude of commercial harvests, and home ports for charter fishing vessels. We also assess spawning locations for two important species in recreational and commercial fisheries: lake trout and yellow perch providing useful management information.</p> |
| <p>LMMCC Nearshore Monitoring (NEMO)</p> | <p>Network of government, university and Sea Grant scientists and managers</p> | <p>The goal of the workgroup is to coordinate and plan monitoring efforts for Lake Michigan.</p> | <p>NEMO activities and products include an inventory of current nearshore monitoring objectives and activities.</p> | <p>A comprehensive inventory of monitoring programs for the Great Lakes Basin including actively collected program metadata, and a searchable geographic database with monitoring help to support indicators proposed in the Lake Michigan LaMP.</p> |
| <p>Great Lakes Coastal Resilience Planning Guide</p> | <p>Great Lakes Resilience</p> | <p>The Guide provides educational resources and practical, process-driven approaches to mapping, analyzing, reporting and visualizing specific coastal hazard topics.</p> | <p>Provides data on: (1) Hazards Management & Planning (2) Coastal Flooding -Shoreline Change Management (3) Bluff Recession & Erosion -Habitat Conservation & Restoration Planning (4) Natural Mitigation -Coastal Infrastructure Planning (5) Ports & Harbours</p> | <p>The Guide is designed for state and local officials engaged in coastal management, planning, mitigation and development issues to allow examination of how recent and ongoing trends in short-term and long-term climate conditions affect hazards and their impacts on land, water and resources investigation on how different hazards management alternatives respond to and affect changing conditions.</p> |
| <p>Geographic Decision-Support System (GDSS) "Geomatics to the Rescue of the American Eel"</p> | <p>Fisheries and Oceans Canada, in collaboration with the Quebec Department of Natural Resources and Wildlife and the Ontario Ministry of Natural Resources</p> | <p>Develop a geographic decision-support system (GDSS) for evaluating sites where the American eel no longer has free access to its natural habitat to help deter where fish ladders should be installed to facilitate eel movement past dams and to promote the species' recovery.</p> | <p>Canada (NRCan) has offered its expertise in geomatics and has provided data from the GeoBase National Hydro Network (NHN) describing the various entities across Canada, such as lakes, reservoirs, rivers and streams, and indicating the direction of flow. Once the data are entered into the decision-support system, the gain in the area of upstream and downstream habitat following construction of a fish ladder can be calculated.</p> | <p>According to Fisheries and Oceans Canada, the use of geomatics is now critical to allowing a visual analysis of the impact of the various dam construction scenarios. Natural Resources</p> |

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| <p>“Measuring Risk of Water Contamination Indicators”</p> | <p>Agriculture and Agri-Food Canada (AAFC)</p> | <p>The development of agri-environmental indicators to measure the efficiency of agricultural management practices and to provide an objective, science-based assessment of environmental sustainability.</p> | <p>Saturation excess runoff is the point at which runoff will occur once the soil is so saturated that it can no longer hold water. Total rainfall amount and landscape factors such as soil depth (i.e., available water storage capacity), upland-watershed area, and local topography are the factors determining whether or not a particular area in a watershed will generate runoff. Indicators to measure the risk of water contamination by phosphorus and coliforms were developed using an index approach. Topographic Index (TI) was computed for all agriculturally classified watersheds in Canada using the GeoBase CDED and NHN data.</p> | <p>This approach enables the integration of data on source contamination, contamination transport, and the factors connecting source contamination and transport.</p> |
| <p>Sustainable Development of Forests (EOSD)</p> | <p>Canadian Forest Service and the Canadian Space Agency, the Earth Observation</p> | <p>Aimed at measuring and monitoring Canada's national forests.</p> | <p>As part of the EOSD project, the Canadian Forest Service used the Landsat-7 orthoimages to map and classify all of Canada's forests, a job completed in 2006.</p> | <p>The Landsat imagery was geometrically corrected (or orthorectified). This process creates images that accurately represent Canada's landmass. Once orthorectification was completed, the images were sent to partners and made available on the GeoBase portal — without charge, or restrictions. Subsequently, all partners were able to use the images to address a wide range of information needs such as for the project (EOSD).</p> |
| <p>Great Lakes Aquatic Habitat Framework</p> | <p>Institute for Fisheries Research is a cooperative unit of the Michigan Department of Natural Resources and Environment and the University of Michigan Research funded by NOAA CSCOR</p> | <p>The Great Lakes Aquatic Habitat Framework (GLAHF) is a spatial database and classification framework that integrates key habitat components to address local, lake-wide, and basin-wide restoration and management needs.</p> | <p>Current projects include:</p> <ul style="list-style-type: none"> • Great Lakes Aquatic Habitat Framework • CSCOR Great Lakes Aquatic Habitat Classification • Great Lakes GIS • Lakebed Alteration Tool • Wildlife Action Plan • Digital Water Atlas | <p>The spatial framework tool will provide managers with the first consistent geographic framework that has an essential capability to link, map, integrate, and track habitat classifications, assessments, indicator development, ecological forecasting, monitoring, and restoration activities across the Great Lakes.</p> |
| <p>Groundwater Geoscience Program</p> | <p>Natural Resources Canada</p> | <p>Assesses aquifers and makes the data available through the Groundwater Information Network. This is the third phase of the program. The two previous phases of the program: 2002-06 Groundwater Program, and the Groundwater Mapping Program 2006-09.</p> | <p>The extent of Canada's groundwater supply (aquifers) is being assessed. Up to 2009, 12 of the 30 key regional aquifers had been mapped and evaluated. In this third phase of the program, approved for the period of 2009 to 2014, the mapping and assessment of seven additional aquifers have been initiated and should be completed by 2014.</p> | <p>The Groundwater Geoscience Program is intentionally designed to establish a defensible and useful scientific data framework which can be used by provincial or local authorities responsible for managing groundwater on a regular basis, but which is also appropriate for use in a co-management regime, when necessary. These management activities may also include scientific cooperation and shared management in the case of transboundary aquifers crossing the Canada/United States border.</p> |

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| Fish Species at Risk Research and Assessment in Southern Ontario (Mapping Species at Risk) | Great Lakes Laboratory for Fisheries and Aquatic Sciences Fisheries and Oceans Canada with funding from the national SARA program. | The project's goals were to (1) assemble and validate fish and mussel distribution data in Ontario (2) develop a web-mapping application for Ontario Great Lakes Area (OGLA) staff related to species at risk (2) develop an atlas with supporting documentation for partners (4) update a web-mapping application with valid, current data | DFO Science has collected fish and mussel distribution data within Ontario to update historical records and to obtain an accurate picture (a series of maps) of the current distribution of species at risk. In 2003, a useful mapping tool was developed for a project carried out by Habitat Management and its partners. Each map uses a 3-colour scheme based on SARA status, and identifies the presence of species at risk within a stream segment. For example, red segments represent the presence of extirpated, endangered and threatened species currently listed in SARA Schedule 1. | These mapping applications are useful for determining OGLA's level of involvement in the referral process (i.e., landbased or in-water activities that could impact fish habitat). |
| Mapping pathogens in Chesapeake Bay | NOAA | The goal of this regional study is to predict the abundance or likelihood of occurrence of several pathogens in Chesapeake Bay and its tidal tributaries. | Maps of the likelihood of <i>V. vulnificus</i> , <i>V. parahaemolyticus</i> and <i>V. cholerae</i> in the Bay are routinely generated by identifying locations where the current environmental conditions are favorable to them. This is accomplished using data acquired and derived from various sources, such as hydrodynamic computer models and satellites. | Various pathogens – microorganisms which are capable of causing disease – are present in the Chesapeake Bay and pose potential threats to human health. Knowing where and when to expect these biotic risks may help mitigate their effects. |
| NowCOAST | NOAA | NowCOAST is a web mapping portal that provides spatially referenced links to thousands of real-time coastal observations and NOAA forecasts of interest to the marine community. | The portal serves as a "one-stop" website to real-time coastal meteorological, oceanographic, and hydrologic observations from a variety of Internet sites within and outside of NOAA, along with NOAA forecasts. NowCOAST covers all U.S. coastal waters including the Great Lakes. | NowCOAST is designed as a planning aid for recreational and commercial mariners, coastal managers, HAZMAT responders, marine educators, and researchers, who can discover and display real-time information for their particular needs and geographic area of interest. |
| Water Resources Information Program (WRIP) | Ministry of Natural Resources Canada | WRIP produces a variety of maps to support different projects in WRIP as well as other water-related programs in the Provincial government. | Airborne and Satellite images in digital form are used to identify features on the ground, locate objects (like wells) and measure the size of features. An example of this work includes the purchasing, enhancement and distribution of Quickbird satellite imagery to conservation authorities to assist in source water protection processes. WRIP has also produced a Provincial digital elevation model to be used in flow analysis as well as producing standardized river and stream databases for the Province and supports pilot projects in the use of web mapping technologies. | WRIP works with stakeholders to develop mapping standards that ensures that similar maps produced by different agencies will all look and communicate the same way to end users and the public. |
| Coastal Wetland Survey | Great Lakes Commission, Bi-National Team | To complete a comprehensive Great Lakes Coastal Wetlands Inventory. This dataset is a basin-wide digital coastal wetland inventory of all the Great Lakes coastal wetlands classified using the Consortium's classification scheme. | The coastal wetland inventory is available for all eight states that surround the five Great Lakes: Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin and the Canadian Great Lakes area. | The inventory is the most broadly accessible, comprehensive binational collection of coastal wetlands in the Great Lakes Basin and will serve as the framework for long-term monitoring of coastal wetlands and related decision making. |

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| <p>Shared Information Management and Delivery System</p> | <p>Upper Midwest/Great Lakes (UMGL) Landscape Conservation Cooperative (LCC).</p> | <p>Great Lakes Information Management and Delivery system is to support strategic habitat conservation including to support biological planning, conservation design, conservation delivery, and outcome based monitoring of the adaptive management framework that guides strategic habitat conservation.</p> | <p>The goal of this project is to develop demonstration projects that provide a foundation for a shared, web-based, Great Lakes information management and delivery system to support strategic habitat conservation.</p> | <p>Designing a Shared Great Lakes Information Management & Delivery System to Support Strategic Habitat Conservation Project is intended to operationally support the concept of strategic habitat conservation, which is an adaptive management framework focused on informing decisions to help get the right conservation practices to the right places.</p> |
| <p>NOAA Medium Resolution Shoreline</p> | <p>Created by the Strategic Environmental Assessments (SEA) Division of NOAA's Office of Ocean Resources Conservation and Assessment.</p> | <p>Medium Resolution Digital Vector Shoreline is a high-quality, Geographic Information System-ready, general-use digital vector data set.</p> | <p>The Medium Resolution Digital Vector Shoreline incorporates the entire conterminous United States coastline as four major regions, each of which has a number of sub-regional shoreline section files (Figure 4). Each of these files in-turn were developed from a series of NOAA nautical charts.</p> | <p>The product is designed for use by a broad audience. Potential users include government agencies, universities, research institutions, and individuals in the private sector.</p> |
| <p>Great Lakes Maritime Information on Delivery System</p> | <p>The Great Lakes Maritime Research Institute and the Toledo University Intermodal Transportation Institute.</p> | <p>The goal of this study is to supply geospatial information on issues surrounding anticipated increases in freight movement and impacts on the region's infrastructure and economic health.</p> | <p>The main elements include information on vessel movement and delivery through prepared maps, tables, graphics, text, etc. A information clearinghouse and centralized data facility to furnish links to other information resources, (private firms, government agencies, universities, etc.) will be made available.</p> | <p>This data will greatly assist managers in assessing and planning for vessel movements, port functions commodity flows, economic activity, and associated environmental impacts.</p> |
| <p>Automatic Vessel Identification System (AIS)</p> | <p>International Maritime Organization (IMO), International Telecommunication Union (ITU) and International Electrotechnical Commission (IEC).</p> | <p>Using Global Positioning System (GPS) technology, any vessel equipped with an AIS transponder transmits its exact location to the Seaway's Traffic Control Center and, in addition, to other ships on the waterway equipped with an AIS display. The location of each vessel is continuously tracked and displayed on a computer generated map of the Seaway, together with its speed and course.</p> | <p>The project was successfully completed and now AIS are mandatory on all vessels. This program expanded data gathering capacity; water levels, weather data and lockage order-of-turn for each lock within the Seaway are now broadcast in real-time data as well.</p> | <p>The importance of AIS to shipowners is that it enhances safety (especially under adverse weather conditions) through real-time ship-to-ship communications of vessel locations, speeds and courses. It also has the potential to reduce transit through better traffic management, and enhanced scheduling of lock passages.</p> |
| <p>Lakewide Management Plan (LaMP) Web Mapping Application</p> | <p>GLRI USGS</p> | <p>Developed a Web Mapping Application to display information about projects and programs around the Great Lakes. The mapper is to compile information on areas where data are being collected, missing, or sparse, and on areas where ecosystems are vulnerable.</p> | <p>The goal of the mapper is to focus on compilation of information that will result in recognition of areas where data are being collected, missing, or sparse, and on areas where ecosystems are vulnerable.</p> | <p>The mapper will assist decision making related to protecting and restoring ecosystems based on information as to where data is missing or sparse and where ecosystems are vulnerable. This can help managers located areas where more data collection is needed.</p> |

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| <p>Realtime Environmental Coastal Observation Network (RECON) Stations:</p> | <p>NOAA GLERL</p> | <p>The RECON project will provide national data using commercial networking standards to provide real-time whole water column observations of physical, chemical, and biological variables in coastal areas few, if any, environmental observations.</p> | <p>The goal of the RECON project is to develop a national network of low cost coastal buoys capable of seabed to sea-surface observations. Long term goals include collection of long-term data sets for physical, biological, chemical, and meteorological parameters in the Great Lakes, to deploy observations systems on portable, low cost buoys and fixed platforms of opportunity, and to implement a high bandwidth, wireless Ethernet-based system. It is aimed that the data will be secure and provided in real-time.</p> | <p>Continual assessment of the status and trends in coastal environments permits identification of perturbations that may signal changes in the ecosystem, puts current trends into an historical framework, allows us to differentiate true environmental change from variance and provides a context to assess the impact of predicted changes</p> |
| <p>NOAA CoastWatch Great Lakes Program</p> | <p>GLERL NOAA</p> | <p>Provides near real-time and archived data from satellite observations as well as in-situ data from throughout the Great Lakes.</p> | <p>A digital map of the Great Lakes surface water temperature and ice cover which is produced daily at the GLERL through the NOAA CoastWatch program.</p> | <p>This allows managers to see real-time data and make informed decisions based on this.</p> |
| <p>The lower Niagara River lake sturgeon study</p> | <p>Service's Northeast Fishery Center and the Lower Great Lakes Fish and Wildlife Conservation Office</p> | <p>Assess the health and status of the lake sturgeon population in the lower Niagara River and locate their spawning habitat</p> | <p>Using GIS mapping software, the lake sturgeon tracking data will be overlaid with data collected from a GLRI-funded sidescan sonar project, mapping the river substrate to provide important information on habitat in the lower Niagara. In 2012 blood samples were collected from all sturgeon captured prior to spawning season, to identify sex and spawning stage by measuring hormone levels.</p> | <p>This will help managers in assessing the health of the important lake sturgeon community and locate spawning locations in order to better protect the species and improve population numbers.</p> |
| <p>Coordinate GIS databases</p> | <p>The GIS Working Group at Institute for Freshwater Research (IFR)</p> | <p>Developing geographic information system (GIS) tools for assisting management of aquatic ecosystems.</p> | <p>Numerous projects are taking place in the GIS working group at IFR. These include A digital water Atlas, a Michigan Rivers Inventory, Geographic Distribution Maps of Michigan Fishes, a high resolution National Hydrography Dataset, and Ecological Classification of Rivers for Environmental Assessment.</p> | <p>The purposes of these projects are to develop spatially explicit information describing the natural resources to develop applications to support assessment of resource status and management options. The data is to provide resource managers and other agencies with desktop access to geospatially relevant data.</p> |
| <p>Great Lakes Wind Collaborative</p> | <p>Great Lakes Wind Collaborative, Great Lakes Commission, Pangaea Information Technologies, Ltd., and Bluewater Geospatial</p> | <p>The ultimate objective of this project is to create an Online Wind Mapping Toolkit for the Great Lakes Wind Region.</p> | <p>This project will address the need for high-resolution spatial data of habitat and/or migration corridors for avian and bat species of concern in regions of high potential wind development.</p> | <p>This project will augment the ability of decision-makers across the Great Lakes region to respond to information requests, develop sound regulatory decisions, and improve regional planning and coordination by providing the highest available resolution data and an online mapping tool that enables use of that data to evaluate wind development scenarios.</p> |

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| <p>Development of A GIS for Integrated Ecosystem Assessments of Great Lakes Aquatic Resources</p> | <p>NOAA GLERL and University of Michigan</p> | <p>A Geographic Information System (GIS) database for Great Lakes aquatic habitats will facilitate integrated ecosystem assessment and aid managers to assess threats to coastal resources and understand ecosystem structure and function.</p> | <p>The ultimate goal of this project is to provide geospatial information that will allow for increase number of habitat acres conserved or restored; and increase number of protected species that reach stable or increasing population levels. The project proposes to refine an existing GIS database for Great Lakes aquatic habitats to include the wealth of data collected by NOAA GLERL on physical and biological data.</p> | <p>This program provides a standard, basin-wide platform for inventory, classification, and holistic management of aquatic species and their habitats. Development of aquatic habitat databases and maps will eliminate information gaps for aquatic species, landscape features, ecological processes, and threats and aid in management and restoration strategies.</p> |
| <p>Surf Your Watershed</p> | <p>EPA</p> | <p>EPA's "Surf Your Watershed" Internet Site, which houses the Agency's first comprehensive assessment of U.S. watersheds, allows the public to locate, use, and share environmental information on a particular watershed or community.</p> | <p>A particular watershed can be selected by using maps or searching by State, Indian Tribe, County, or zip code. A search can also be based on local stream names, water bodies, or even large-scale ecosystems. At the state or watershed level, there is information regarding protection efforts, environmental/public health conditions, fish advisories, drinking water, land use, population, Superfund sites, and effluent dischargers. An overall score of the watershed can also be provided.</p> | <p>This allows for managers interested in lake health to promote citizen engagement through directing them to pertinent information found on the "surf your watershed" website.</p> |
| <p>2012 Lake Huron Cooperative Science and Monitoring Initiative</p> | <p>GLERL, U.S.G.S, USGS-GLSC, U.S. EPA, Great Lakes National Program Office, Michigan DNR, the University of Michigan, and Environment Canada</p> | <p>The research will help scientists understand the structure and function of the Lake Huron ecosystem - from bacteria to fish - and clarify the impacts of stressors such as invasive species, climate change, nutrient loading, and overfishing.</p> | <p>Currently large-scale sampling and monitoring is on-going.</p> | <p>The long-term ecological research program in Lake Huron will integrate long-term observations on biological, chemical, and physical variables with process-based laboratory experiments to help develop new concepts and modeling tools to explore changes in the lake.</p> |
| <p>Southern Ontario Land Resource Information System (SOLRIS)</p> | <p>Ministry of Natural Resources</p> | <p>The Southern Ontario Land Resource Information System (SOLRIS) is a landscape-level inventory of natural, rural and urban areas. SOLRIS follows a standardized approach for ecosystem description, inventory and interpretation known as the Ecological Land Classification (ELC) for southern Ontario.</p> | <p>The SOLRIS inventory is a compilation of data from various sources including topographic maps, aerial photos and satellite imagery. Computer modelling, visual interpretation and field validation were used to create a seamless inventory for Southern Ontario.</p> | <p>SOLRIS was developed to support landscape-scale planning initiatives in southern Ontario such as Source Water Protection, Biodiversity Conservation, Natural Heritage Planning, and State of Resources Reporting.</p> |

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| EDDSMapS | The Renz lab at the University of Wisconsin-Madison Department of Agronomy, in collaboration with Colorado State University (CSU) and the Midwest Invasive Plant Network (MIPN) | GLEDN is an invasive species early detection and warning system for the Great Lakes region. | GLEDN is an online system that collects invasive species reports from casual observers, verifies these reports and integrates them with others networks. The system then uses this integrated information to send customized early detection email alerts to those subscribed. | This information, combined with the real-time email alert system could facilitate rapid response and management efforts for newly reported populations of invasives. |
| Lake Superior Biodiversity Conservation Assessment | A project team from the Lake Superior LAMP and Nature Conservancy Canada | The assessment of biodiversity target health and the ranking of threats were done as an important tool to better integrate biodiversity objectives into current lake management. | Seven conservation targets were selected that encompass the biodiversity of Lake Superior. These include aquatic coastal, tributary and watershed based habitats that have many species nested within them. The health of these biodiversity targets was assessed based on SOLEC indicators, with some modifications. | This information will be used by the Lake Superior LAMP to develop ecosystem objectives and strategies to support both lake-wide and place-based conservation in 2013. |