An Integrated Habitat Classification and Map of the Lake Erie Basin: Final Report

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Abstract

This project, funded by U.S. EPA – Great Lakes National Program Office, developed an integrated habitat classification and map for the Lake Erie basin that can be used to assist the Lake Erie Lakewide Management Plan (LaMP) in developing a bi-national inventory of the status and trends in the quantity and quality of fish and wildlife habitats in the basin. The integrated habitat map will be used to track improvements in habitat quantity and quality resulting from preservation, conservation, and restoration efforts and to guard against further loss or degradation from land use alterations.

The project grew out of the Lake Erie LAMP long term habitat vision and strategy developed by the LAMP Technical Workgroup and the Lake Erie Millennium Network (LEMN) www.lemn.org for long-term preservation and restoration of ecological integrity in the Lake Erie basin.

Specifically, this project was designed to: 1) develop and implement a unified, consensus based classification of six Lake Erie habitat zones from data available in existing mapping projects; and 2) develop a geospatial database that integrates classification systems at relevant scales into map layers and eventually into a single, integrated GIS habitat map of the Lake Erie basin for the United States and Canada. This project addresses the need for a unified, consensus based habitat classification system and inventory, which is a fundamental prerequisite to managing and conserving critical habitats and maintaining ecological integrity within the Lake Erie basin. This report summarizes the content of the web site, www.glc.org/eriehabitat.

Introduction

This project, funded by U.S. EPA – Great Lakes National Program Office, developed an integrated habitat classification and map for the Lake Erie basin that can be used to assist the Lake Erie Lakewide Management Plan (LaMP) in developing a bi-national inventory of the status and trends in the quantity and quality of fish and wildlife habitats in the basin. The integrated habitat map will be used to track improvements in habitat quantity and quality resulting from preservation, conservation, and restoration efforts and to guard against further loss or degradation from land use alterations.

Specifically, this project will: 1) develop and implement a unified, consensus based classification of six Lake Erie habitat zones from data available in existing habitat mapping projects; and 2) develop a geospatial database that integrates classification systems at relevant scales into map layers and eventually into a single, integrated GIS habitat map of the Lake Erie basin for the United States and Canada. This project addresses the need for a unified, consensus based habitat classification system and inventory, which is a fundamental prerequisite to managing and conserving critical habitats and maintaining ecological integrity within the Lake Erie basin.

The Principal Investigator for the project is Dr. Lucinda Johnson from the Natural Resources Research Institute, University of Minnesota Duluth. Other members of the binational project team include: Dr. Jan Ciborowski and Dr. Scudder Mackey from the University of Windsor; Mr. Ric Lawson and Dr. Roger Gauthier from the Great Lakes Commission; Dr. Nick Mandrak from Fisheries and Oceans Canada; Mr. Dan Button from the U.S. Geological Survey; and Mr. Tom Hollenhorst from the Natural Resources Research Institute, University of Minnesota Duluth.

In early June 2005, an Experts Workshop was held at the Franz Theodore Stone Laboratory on Gibraltar Island to identify existing geospatial datasets within the Lake Erie basin and assess habitat classification schemes currently in use within the basin. Subgroups were established to further identify geospatial datasets and explore classification schemes within six natural and semi- natural habitat zones, including terrestrial; inland aquatic; coastal wetland; coastal margin; nearshore; and open water areas of the basin. These experts form the core of a Habitat Working Group that continues to provide guidance to the project team during the testing and validation phase of the project. A dynamic classification scheme will be tested in two pilot watersheds – the Maumee River watershed in northwestern Ohio and the Grand River watershed in southern Ontario.

A second workshop, held in January 2006 reviewed and reached consensus on zone boundaries and an integrated hierarchical habitat classification scheme based on recommendations from each of the habitat zone subgroups. Geospatial coverages and linkages between those coverages were identified and compiled along with a list of critical attributes based on physical, chemical, and biological components for each of the six environmental zones. Ongoing sub-group discussions guided the development of processing algorithms to further develop the classification protocols for each of the environmental zones.

The project team is collaborating with ongoing habitat assessment projects in the basin, including the University of Michigan's Institute for Fisheries Research Great Lakes GIS project, intended to provide fisheries resource managers with comprehensive geospatial datasets, and ongoing U.S. Geological Survey Aquatic GAP and U.S. EPA STAR projects designed to evaluate the biological diversity of aquatic species and their habitats. The project team has also developed a strategy to apply the comprehensive classification scheme to the entire Lake Erie basin, and has developed a binational habitat map data exchange website to include links to geospatial metadata and habitat coverages in the basin (www.glc.org/eriehabitat). The Lake Erie habitat classification and mapping project will serve as a model for developing a comprehensive basinwide habitat classification system and inventory for the entire Great Lakes basin.

Project Team

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Technical Workgroups

As part of this project six natural and semi-natural habitat zones have been identified. The habitat zones include terrestrial; inland aquatic; coastal wetland; coastal margin, nearshore; and open water. Recognized experts from each of these habitat zones have been asked to participate in technical working groups. The technical working groups are charged with identifying data sources, habitat classifications schemes and agreeing on mapping protocols.

Terrestrial - forests, woodlots, grasslands, palustrine wetlands, and abandoned agricultural fields within the lake Erie watershed.

Inland Lakes and Streams - streams, palustrine wetlands, and inland lakes within the watershed.

Wetlands - coastal, riparian, and palustrine wetlands.

Coastal Margin - embayments and nearshore - water depths 3 m or less.

Nearshore Open-Water - water column and substrate - water depths 3 meters to 15 meters.

Open Water - water column and the substrate - water depths 15 meters and greater.

Workshop Summaries:

June 6 - 7, 2005, Stone Laboratory, Gibraltar Island

Workshop I Summary

Workshop Presentations

January 30 - 31, 2006, University of Windsor

Workshop II Executive Summary

Workshop II Full Summary

Workshop Presentations

Dynamic Habitat Classification Concept

Physical habitat can be defined as a combination of a range of physical and energy characteristics that meet the needs of a species and/or biological community for a given life stage, and can be delineated geographically (Mackey 2005). This definition is a fundamental underpinning of the dynamic habitat classification approach, where the intersection of appropriate physical, chemical, and biological characteristics needed to support the needs of a specific species, biological community, or ecological function can be used to identify and delineate potential “habitat”. Physical and energy characteristics are a function of the landscape surface (geomorphology), the materials that make up the landscape (geology and hydrology), and the physical, chemical, and biological processes that act on the landscape. Areas with similar physical and energy characteristics can be grouped into distinct natural habitat zones.

Given the complex and dynamic nature of Lake Erie basin habitats, a dynamic habitat classification scheme was developed based on multiple integrated geospatial data layers that contain information on physical, chemical, and biological attributes within each of the natural environmental zones. For a given species or biological community, there are a range of physical, chemical, and biological attributes that when grouped together, meet the needs of a specific organism or community for a given life stage. Areas where all of these environmental characteristics intersect can be used to identify and delineate potential habitat.

This approach allows us to identify and group physical and chemical attributes that may influence habitat distribution and function. Appropriate biological datasets and/or screens can then be compared with these attributes to develop physical-biological-habitat linkages and to assess habitat utilization.

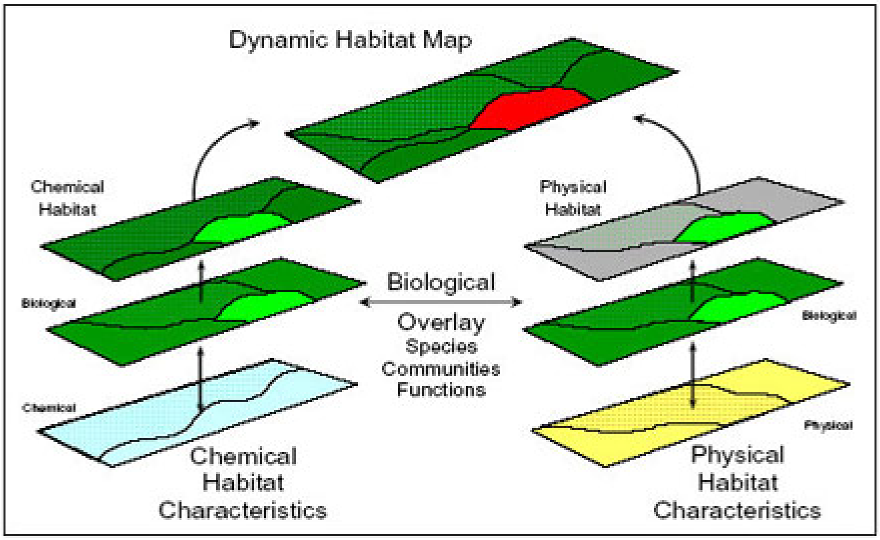

Figure 1. Dynamic habitat mapping concept. Physical and chemical attributes are overlain by biological data layers to develop physical and chemical habitat affinities. Physical and chemical habitats are then integrated and classified using statistical or geospatial analyses with biological data to generate dynamic habitat maps (or polygons) as a function of the species, community, or ecological function of interest. (Scudder Mackey – University of Windsor)

In aquatic systems, static classification systems map individual habitats as fixed entities that do not reflect spatial and temporal variability. The dynamic habitat classification approach addresses this limitation by considering both the three-dimensional and dynamic nature of aquatic habitats. Moreover, a dynamic approach preserves the original geospatial data layers for future inquiries and allows for periodic updates as new data become available. The linkage of these geospatial data layers and associated classification schemes at regional scales creates a *defacto* high-level hierarchical classification scheme across the entire basin.

Lake Erie Habitat Zones

Habitat Zone Concept – Landscape characteristics and the dominant physical processes acting on those landscapes can be grouped into areas with similar environmental characteristics. These areas with similar environmental characteristics are called **habitat zones**.

For Lake Erie, six natural habitat zones were defined based on landscape features and dominant physical processes. The six natural habitat zones are:

Land Data Layers	Water Data Layers
Terrestrial (forests, woodlots, grasslands, palustrine wetlands, and agricultural fields by watershed)	**Nearshore Open-Water** (water column and substrate - water depths 3 m to 15 m)
Coastal Margin (shoreline, water column and substrate in embayments - water depths 3 m or less)	**Wetlands** (coastal, riparian, and palustrine wetlands)
Inland Lakes and Tributaries (streams, rivers, palustrine wetlands, and inland lakes)	**Offshore** (water column and substrate - water depths 15 m and greater)

These maps and associated meta-data are all available from the data catalog (link)

Watersheds - Detailed watersheds for Lake Erie were delineated for both the Canadian and US sides of the basin using elevation data and ESRI's ArcHydro data model. A total of 1,075 watersheds were delineated for streams and interfluves draining directly to Lake Erie and Lake St. Clair. These watersheds were ordered from west to east allowing them to be agglomerated to represent larger drainage areas. Lakeward habitat zones were queried from bathymetry data.

Integrated Habitat Zone Map

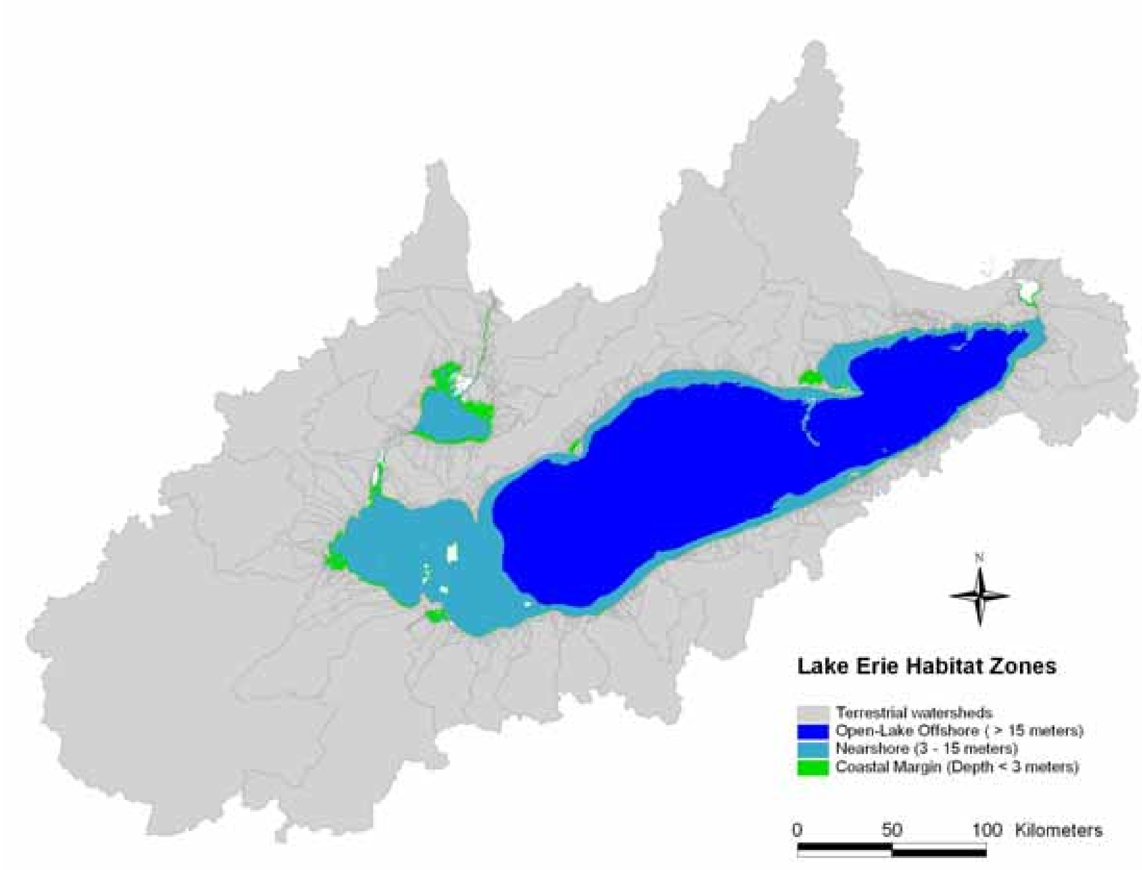

Figure 2. Lake Erie habitat zones, representing 6 distinct terrestrial and aquatic habitats in the basin.

Lake-ward Habitat Zones

Coastal Margin

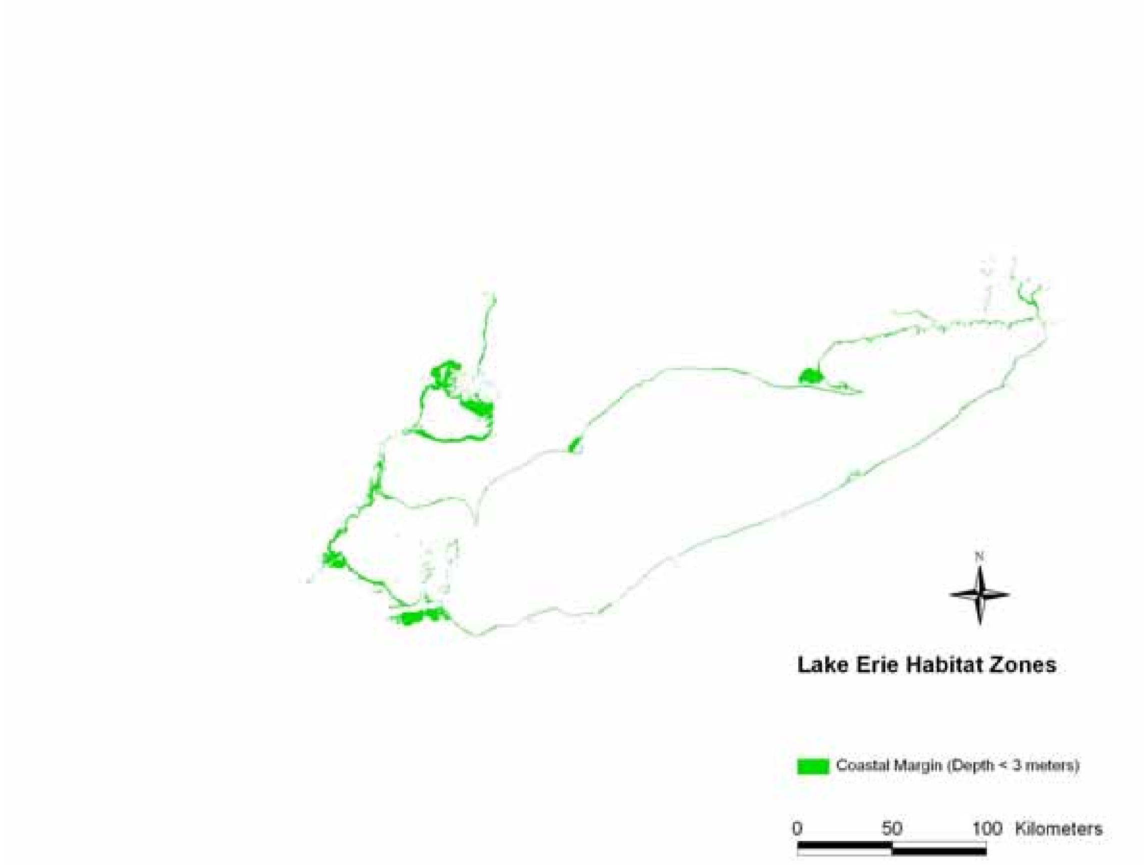

Figure 3. Lake Erie Basin, coastal margin habitat zone.

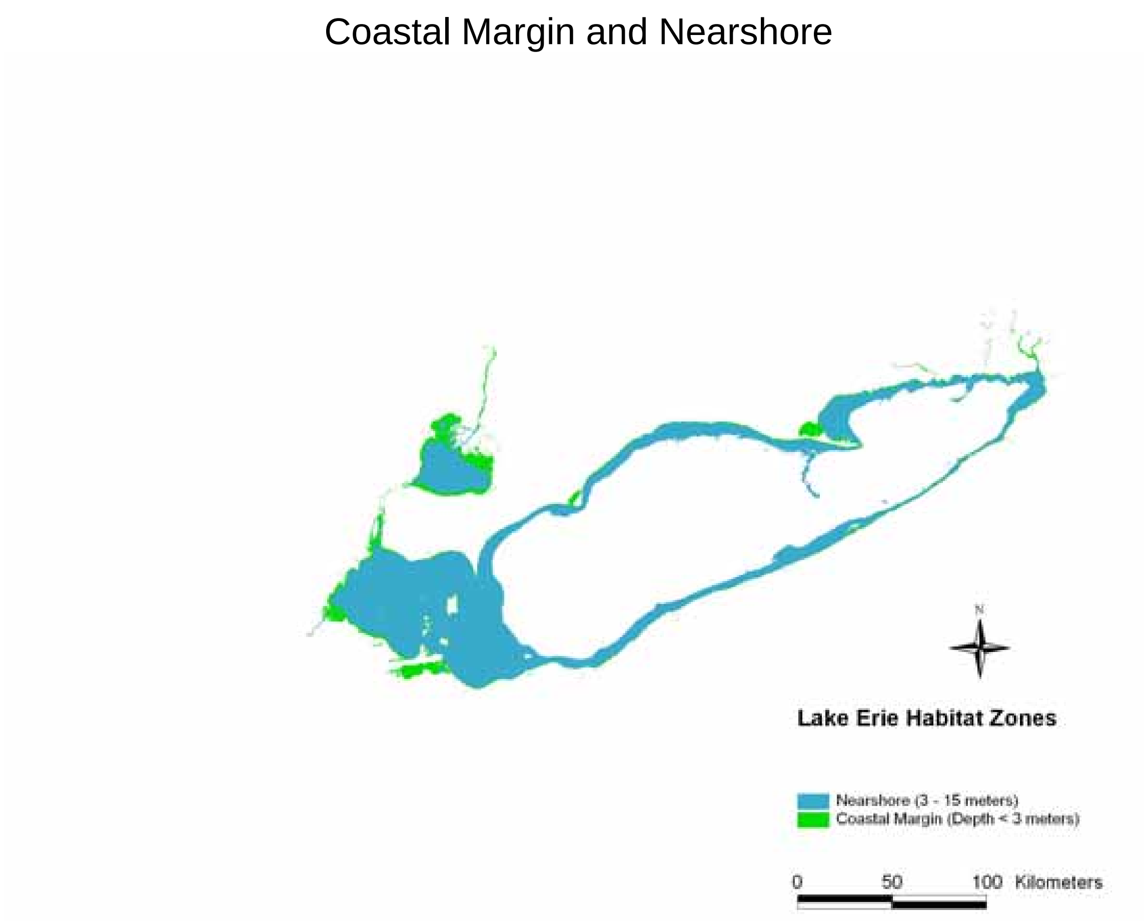

Figure 4. Lake Erie Basin coastal margin and nearshore habitat zones.

Coastal Margin, Nearshore and Open-lake

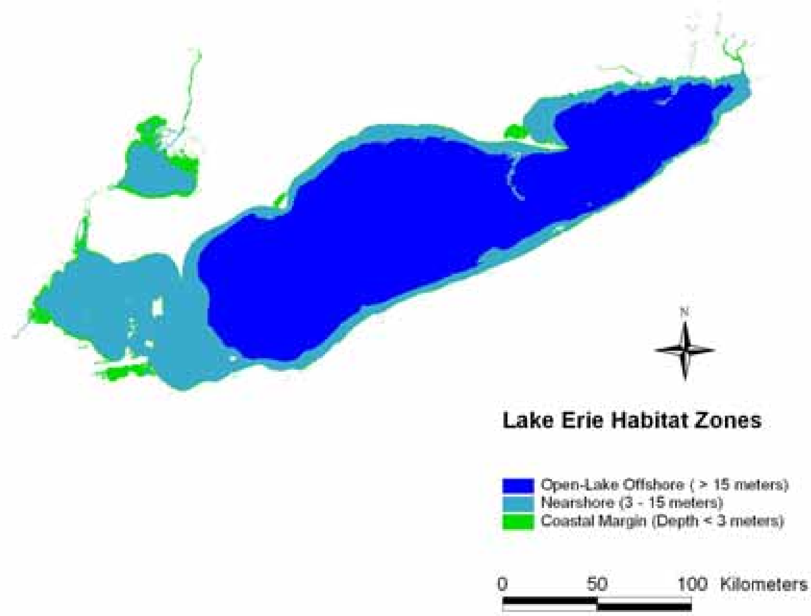

Figure 5. Lake Erie Basin coastal margin, with near shore and open lake habitat zones.

Landward Habitat Zones

Terrestrial Watersheds

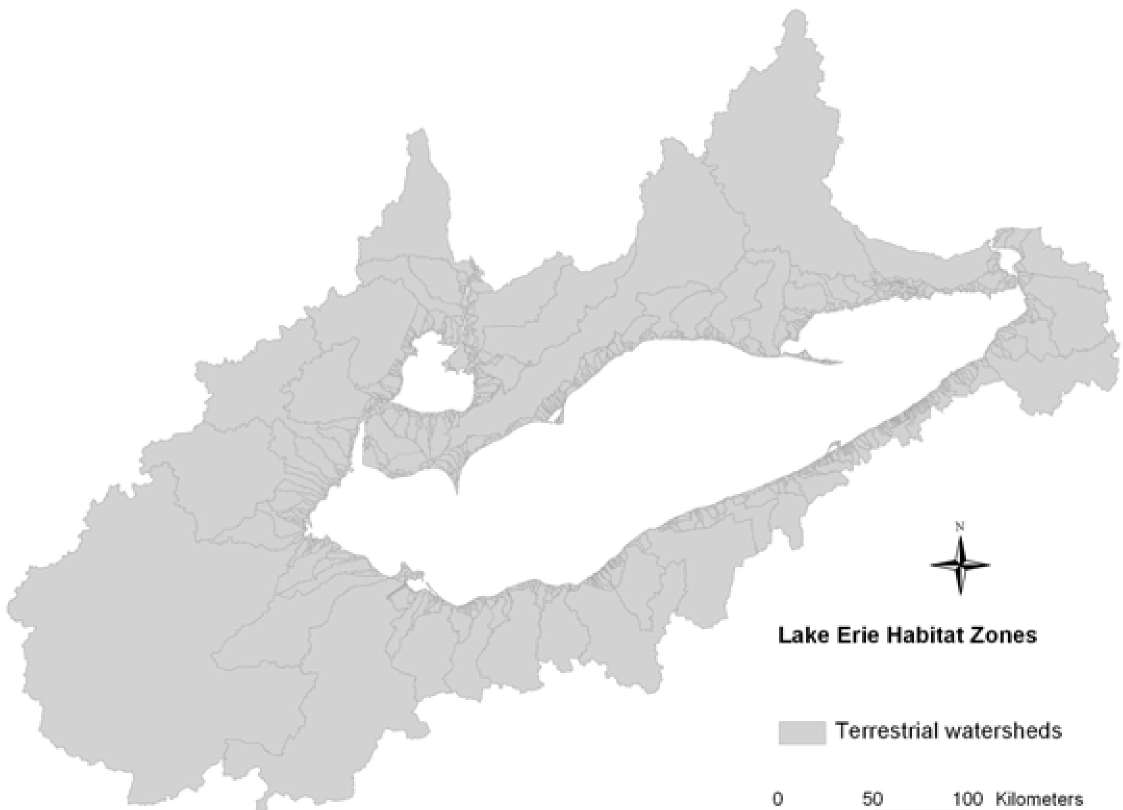

Figure 6. Lake Erie Basin, riverine watersheds.

Inland Tributaries (with Shreve Stream Link number)

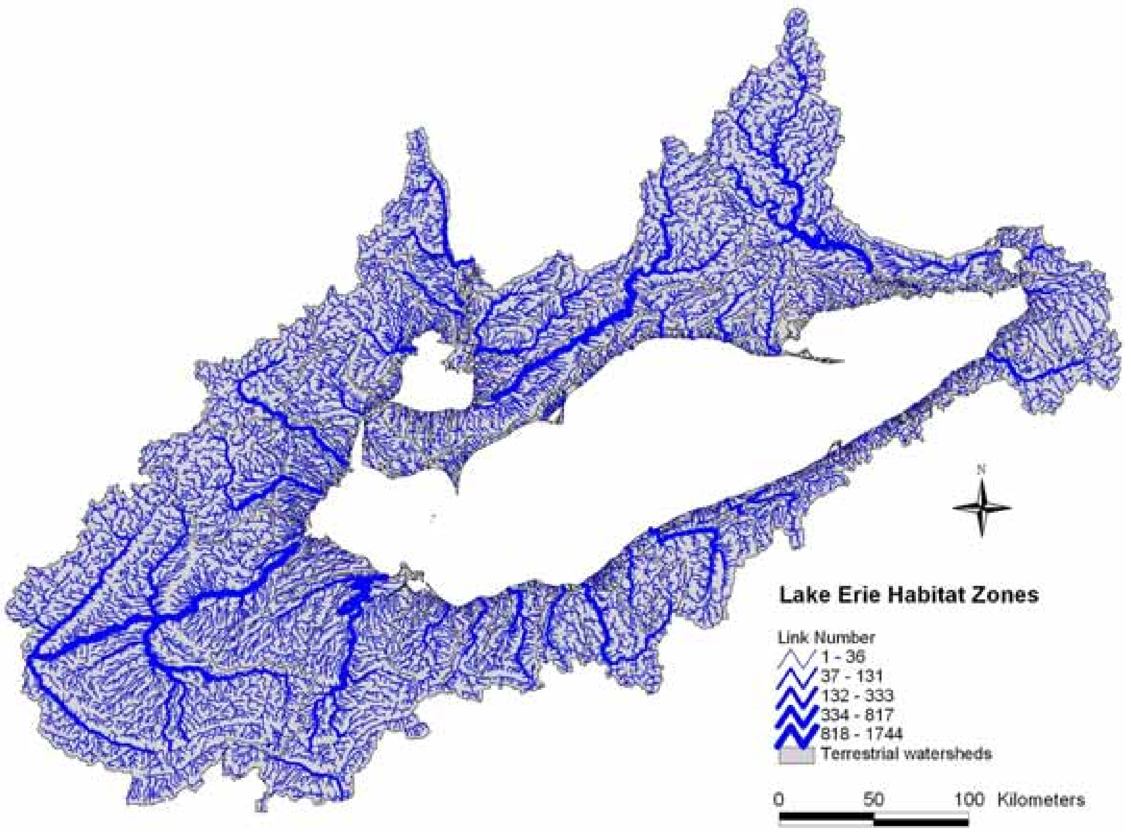

Figure 7. Lake Erie Basin, terrestrial watersheds with inland tributaries. Width of line represents the Shreve link-number, a measure that accumulates the number of first order streams in a river system.

Inland Tributaries (with Strahler Stream Order)

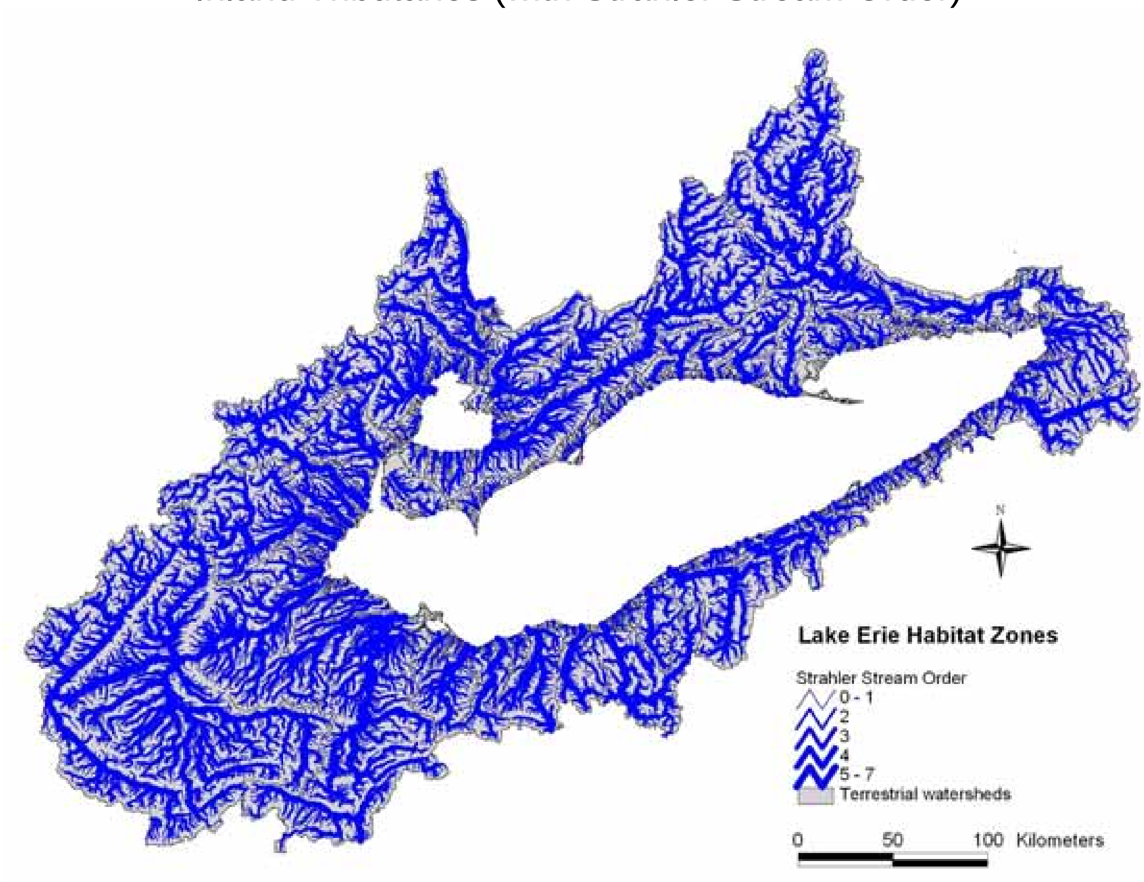

Figure 8. Lake Erie Basin tributary streams coded by stream order.

Stream order & Link Number - The watershed delineation effort also delineated stream reaches and stream order. Both Strahler stream order and Shreve stream order or link number were calculated.

Case Studies/Pilot Watersheds

We focused on two pilot watersheds, the Maumee River watershed and the Grand River watershed, to delineate high resolution watersheds and develop landscape stressor summaries. Detailed ArcHydro watershed delineations were developed for each watershed resulting in 3,485 sub-catchments for the Maumee River watershed and 1,366 sub-catchments for the Grand River watershed. Land cover, road density and human population density were summarized for each sub-catchment. Results were transformed normalized, standardized and scaled from zero to one to create a summed score for each catchment --"SumRel" that represents a relative stressor score within the basin. The ArcHydro data model was then used to accumulate these scores down the network so that each catchment's accumulated SumRel score reflects cumulative stressors flowing to that point.

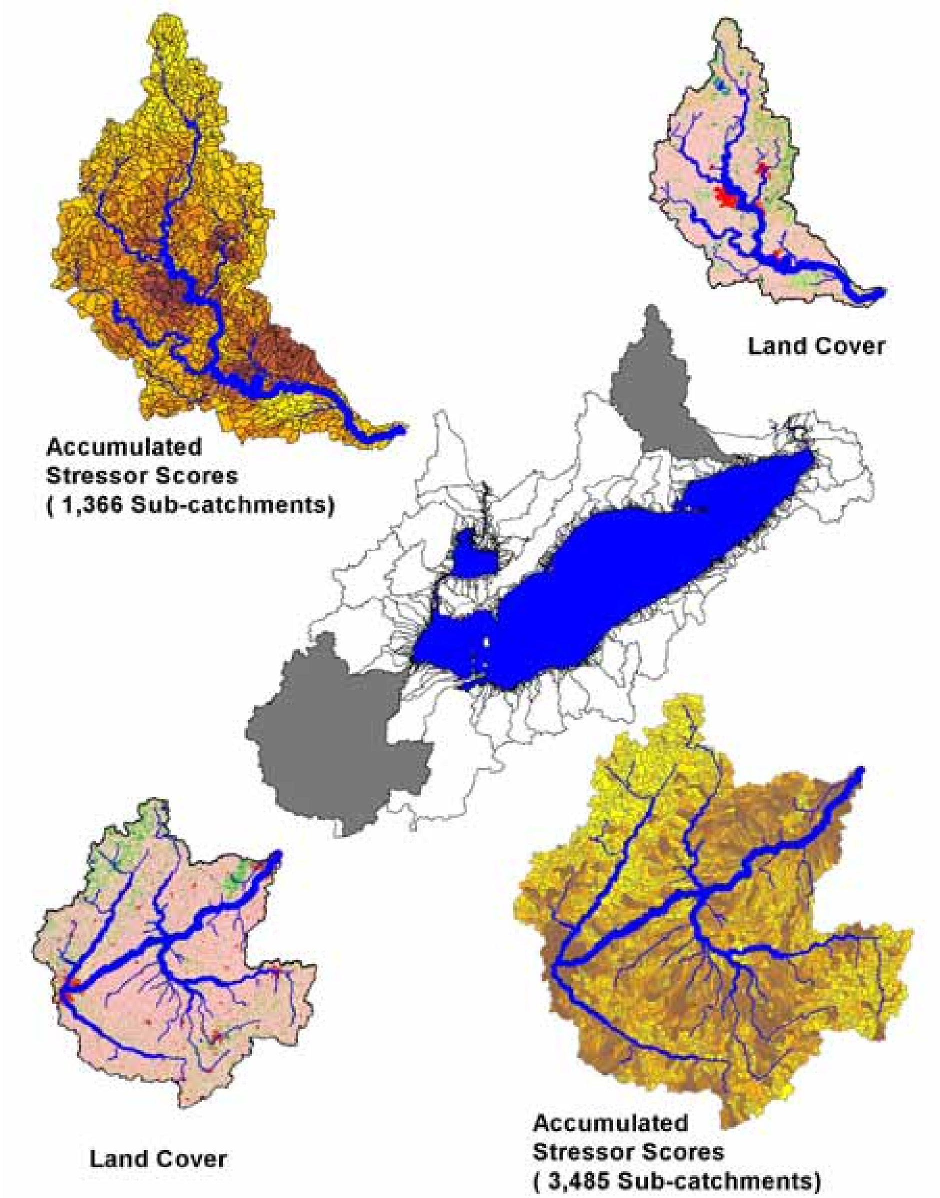

Figure 9. Landscape stressors delineated for the Grand River (Ontario) and Maumee Rivers (U.S.). The center figure depicts the high resolution watersheds delineated using ArcHydro protocols. Upper left and lower right represent maps of the stressor scores which are derived for each pilot watershed.

Data Catalog

Terrestrial, inland lakes and tributaries, and wetlands habitat subcommittees worked together to identify common variables and/or geospatial datasets that would apply to all "land-based" environmental zones and functions. Similarly, the coastal margin, nearshore, and open-lake offshore habitat subcommittees worked together to identify common variables and/or geospatial datasets that would apply to all "water-based" environmental zones and functions.

The table below summarizes "common" environmental variables or datasets that were identified during the workshop discussion. Attributes for each environmental zone are cross-walked into these common variables on the left side and the variables are linked to their descriptions and respective data sets listed below the table. Not all variables are represented with map data as of yet, but we hope to fill these gaps in the near future.

	Land Data Layers		
Super variables	**Terrestrial**	**Inland Lakes & Tribs**	**Wetlands**
Habitat Zones (combined)	Terrestrial Habitat Zone	Inland Lakes & Tributaries	Wetlands
Elevation	Topography	Bathymetry	Bathymetry
Slope	Land Surface	Water Surface	Bottom Slope
Energy		Stream Power	Wave/Currents
Climate	Degree Days	Temperature	Temperature
Hydrography/ Geomorphology	Drainage Network	Drainage Network	Wetland/ Shoreline
Hydrology/ Hydraulics	Precipitation Runoff Infiltration	Flow Regime/ Water Source	Water Levels/ Flow Regime/ Water Source
Geology	Soils/Surficial Materials/ Bedrock	Substrate/ Stability/ Bedrock	Substrate/ Bedrock
Turbidity	Point and Non-Point Sources	Suspended Sediment Load/ Turbidity	Turbidity/Light Attenuation
Water Chemistry	Point and Non-Point Sources	Nutrients/ Contaminants	Nutrients/ Contaminants
Vegetation	Land Cover	Submergent/ Emergent	Submergent/ Emergent
Land Cover	Land Cover	Riparian/ Upstream	Riparian/ Upstream

	Water Data Layers		
Super variables	**Coastal Margin**	**Nearshore**	**Offshore**
Habitat Zones (combined)	Coastal Margin	Nearshore	Offshore
Elevation	Bathymetry	Bathymetry	Bathymetry
Slope	Bottom Slope	Bottom Slope	Bottom Slope
Energy	Wave/Currents	Wave/Currents	Wave/Currents
Climate	Thermal Stratification	Thermal Stratification	Thermal Stratification
Hydrography/ Geomorphology	Shoreline	Lakebed Structure	Lakebed Structure
Hydrology/ Hydraulics	Water Levels/ Circulation/ Outwelling	Water Levels/ Circulation/ Outwelling	Water Levels/ Circulation/ Outwelling
Geology	Substrate/ Stability/ Bedrock	Substrate/ Stability/ Bedrock	Substrate/ Stability/ Bedrock
Turbidity	Turbidity/Light Attenuation	Turbidity/Light Attenuation	Turbidity/Light Attenuation
Water Chemistry	Nutrients/ Contaminants	Nutrients/ Contaminants	Nutrients/ Contaminants
Vegetation	Submergent/ Emergent	Submergent	Submergent
Land Cover	Riparian/ Shoreline Type		

Integrated US/Canada Habitat Zones

Habitat zones were delineated by combining Lake Erie watersheds with isolines queried from a bathymetric grid and converted to polygons. Terrestrial areas (land, lakes, and streams) were mapped with polygons representing the coastal margin (water depths 3 m or less), nearshore areas (water depths 3 m to 15 m), and offshore areas (water depths 15 m and greater).

Combined habitat zones
shapefile | meta-data(html) | data link (map preview etc.)
Coastal margin
shapefile | meta-data(html) | data link (map preview etc.)
Nearshore areas
shapefile | meta-data(html) | data link (map preview etc.)
Offshore areas
shapefile | meta-data(html) | data link (map preview etc.)

Elevation
Canada [raster, meta-data]
United States [raster, meta-data]

Slope
Canada
United States

Energy
Canada
United States

Climate
Canada
United States

Hydrography/ Geomorphology
Canada
United States

Hydrology/Hydraulics
Canada
United States

Geology
Canada
United States

Turbidity
Canada
United States

Water Chemistry
Canada
United States

Vegetation
Canada
United States

Land Cover
Canada
United States

Map Viewer

The Lake Erie Habitat Map Viewer is an open source-based web mapping application which provides a portal for visualizing integrated Lake Erie Habitat Mapping datasets, along with other framework data layers. To enter the application and begin exploring project data, please click on the link below.

http://www.glc.org/eriehabitat/mapper.html

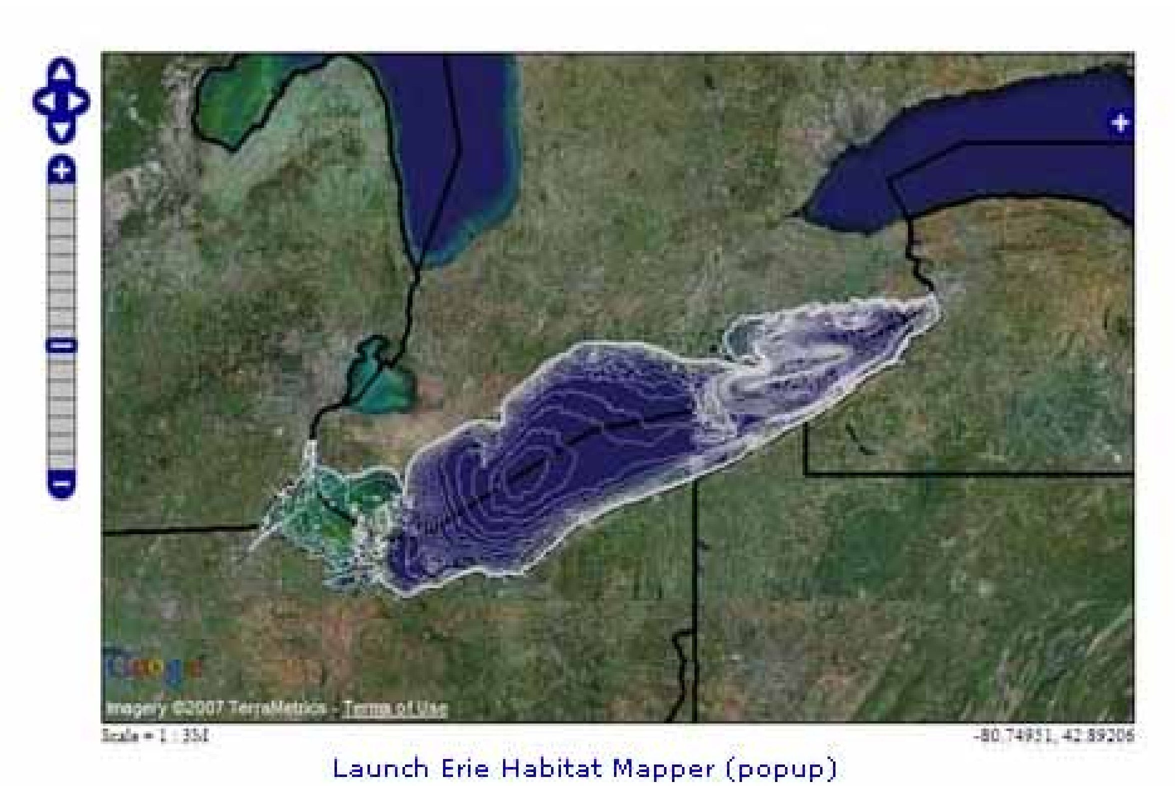

Figure 10. Lake Erie Basin map, as depicted on the web site. Users can download data, and view map images. Map query tools are under development.