LAKE ERIE MILLENNIUM NETWORK
RESEARCH NEEDS WORKSHOP 3.12

SUMMARY REPORT - DRAFT

Planning for an Integrated Habitat Classification System and Map for the Lake Erie Basin

University of Windsor, Windsor Ontario

30-31 January 2006

OVERVIEW

This workshop builds on the results from a workshop held at the F.T. Stone Laboratory in June 2005 to develop a unified, integrated, consensus-based classification system for Lake Erie terrestrial and aquatic habitats. (See project description and Workshop I summary at http://www.glc.org/eriehabitat/workshops.html). Five habitat subcommittees composed of professionals with expertise in characterizing or mapping natural habitats including terrestrial, inland lakes and rivers, wetlands, coastal margins (nearshore) and open lakes were charged with developing protocols for the classification scheme. This included an ongoing evaluation of existing classification systems, and methods for harmonizing (cross-walking) these systems across the five major environmental zones. Participants at the first workshop reviewed regional geospatial datasets that could be incorporated into this mapping exercise, and reached consensus on the limits and definitions of each habitat zone.

On January 30 – 31, 2006 a second workshop was held at the University of Windsor to summarize existing and newly developed habitat classification schemes and geospatial datasets for these five major environmental zones. The objective of the January 2006 workshop was to reach general consensus on appropriate classification schemes for each of the natural environmental zones. Progress reports from each of the environmental zone committees were presented including specific recommendations regarding the best methods for classifying habitats within each of the five natural environmental zones. Copies of the habitat subcommittee presentations are available at: http://www.uwindsor.ca/users/k/kgd/LEMN302.nsf. Workshop participants were also asked to identify critical attributes and/or types of data that, based on best professional judgment, control or regulate habitat pattern, distribution, and associated ecological functions within the Lake Erie basin.

The results of this workshop are being used to guide the development and implementation of a hierarchical classification scheme within two pilot watersheds in the Lake Erie basin – the Maumee River watershed in Ohio and the Grand River watershed in Ontario. Ultimately, these data and coverages will be used to compile and produce a suite of basinwide maps that will detail a complete mosaic of Lake Erie habitats in a common format for both the United States and Canada. This work is supported by a grant from U.S. EPA – Great Lakes National Program Office, administered through the National Fish and Wildlife Foundation.

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SUMMARY OF RESULTS

(1) Initial focus on the Physical (and Chemical) Attributes that regulate habitat.

Habitat subcommittees and workshop participants agreed that physical, chemical, and biological integrity form the basis for ecological integrity, and provides a sound framework for development of classification schemes within each of the natural environmental zones. Workshop participants agreed to first develop habitat classification schemes focused initially on physical and chemical attributes that control habitat pattern and distribution within the Lake Erie basin. This approach is based on the following rationale: 1) physical and chemical attributes of the system (landscape, energy, and hydrology) form the fundamental underpinnings of habitat structure in both terrestrial and aquatic systems; 2) restoration, protection, and monitoring efforts typically involve manipulation and assessment of physical and/or chemical conditions of a system; and 3) physical and chemical geospatial datasets are generally much more complete (both spatially and temporally) than equivalent biological datasets. Moreover, this multidisciplinary approach focuses attention on the underlying structural parameters that create and maintain habitats across the basin. More importantly, it also reduces the strong tendency of biological specialists to focus primarily on species-specific habitat, which requires knowledge of the life-stage requirements of the individual species or biological communities of interest and severely constrains our ability to develop a unified hierarchical habitat classification for the entire Lake Erie basin.

(2) Implementation of a Dynamic Habitat Classification Scheme.

Given the dynamic nature of Lake Erie basin habitats, workshop participants agreed on the need to develop a dynamic habitat classification scheme based on multiple integrated geospatial data layers that contain information on physical, chemical, and biological attributes within each of the natural environmental zones. In contrast, static classification systems map individual habitats as fixed entities that do not reflect spatial and temporal variability. The use of a dynamic classification scheme allows us to initially classify or 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 identify and map habitat areas for species, biological communities, or ecological functions of interest (Figure 1). In other words, habitats will be identified as a function of the type of inquiry or questions asked for a specific species of interest. 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.

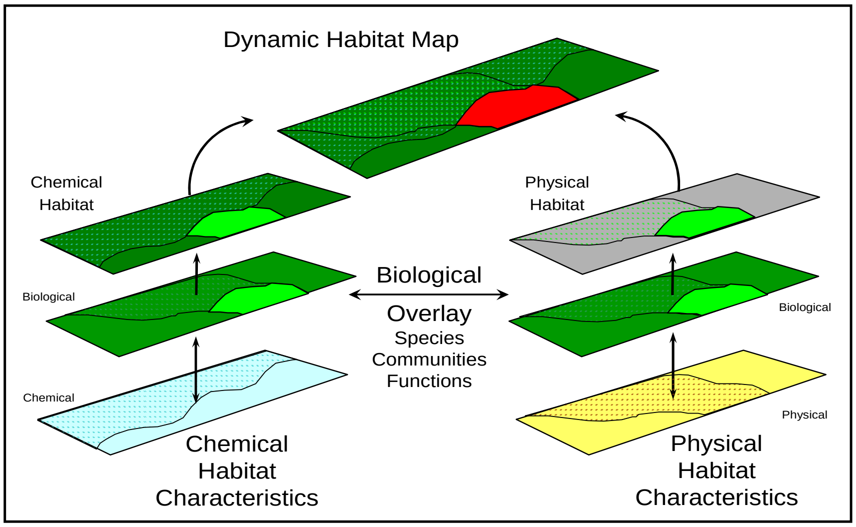

Figure 1. Dynamic habitat mapping concept. Physical and chemical attributes are overlain by biological data layers to develop physical and chemical habitat affinities. Physical and chemical habitats are then integrated and classified using statistical or geospatial analyses with biological data to generate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

(3) <u>Six Major Environmental Zones (instead of five)</u>.

During the workshop, attendees agreed that there were six rather than five natural environmental zones that are defined by landscape features and dominant physical processes. Relatively shallow water areas of the Western Basin of Lake Erie have attributes of both nearshore and open-lake offshore environmental zones. Participants agreed to subdivide the nearshore zone into a coastal margin zone extending from ordinary high water to the 3-m isobath, and a nearshore open-water zone extending from the 3-m to 15-m isobaths. Each of these zones are dominated by distinctly different processes. Moreover, the proposed boundaries are supported by limnological and biological datasets. The six natural environmental zones are:

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

Terrestrial, Inland Lakes and Tributaries, and Wetland environmental zones are typically associated with "terrestrial" or land data layers. Coastal Margin, Nearshore Open-Water, and Open-Lake Offshore environmental zones are typically associated with "aquatic" or water data layers. Note that wetland attributes are included in more than one environmental zone.

(4) <u>Classification Schemes and Environmental Attributes</u>. *What are the 4-6 physical habitat variables that act as the drivers that regulate biota (in order of importance)?*

<u>Terrestrial Environmental Zone</u>

Workshop participants generally agreed that terrestrial classification will be based on crosswalked National Land Cover (U.S. - NLCD) and Provincial Land Cover (Ontario - LCD) datasets. Crosswalk tables are being developed to integrate U.S. and Canadian land cover datasets. Key habitat classification attributes identified include:

1) **Elevation/Topography** – slope, aspect, geomorphology
2) **Land Cover** – land use, urban, agricultural, forest, wetland…
3) **Hydrology and Hydrography** –drainage network (hydrography), connectivity/fragmentation, temperature, sediment load, turbidity, nutrients
4) **Climate** – growing degree days, precipitation, temperature range and variability
5) **Soils and Geology** – type (texture, composition), depth to bedrock, permeability (infiltration),
6) **Water Use** – water intakes, outfalls, power plants, dams, diversions
7) **Atmospheric Deposition**
8) **Biota-specific habitat variables (Overlay)** – species, guild, community, function, life stage

<u>Inland Lake and Tributaries Environmental Zone</u>

Workshop participants generally agreed that the landscape/valley segment approach jointly developed by the USGS Great Lakes GAP program and the U.S. EPA STAR Wisconsin Illinois Michigan River Classification project (University of Michigan) would be used to classify inland lakes and tributaries within the Lake Erie basin. Processing protocols have already been developed and geospatial datasets already exist for much of the Lake Erie basin. The GAP/STAR project identified key framework variables that include stream or catchment size, thermal regime, stream gradient, energy (flow), and sediment/substrate characteristics. Using these variables as an initial framework, key habitat classification attributes identified include:

1) **Size -** catchment area, discharge, (stream width, stream order)
2) **Thermal Properties** (warm, cool, cold) – temperature, discharge/area, darcy (groundwater), catchment slope, surficial geology
3) **Gradient (Energy)** – substrate (texture, composition), erosion/deposition, stream power, sinuosity, width-depth ratio
4) **Flow Regime** – discharge, stream power, flow variability
5) **Soils and Geology** – substrate/bank material (texture, composition), surficial geology, depth to bedrock, bedrock type
6) **Connectivity** – dams, channelization, segment length distance
7) **Land Cover/Land Use** – riparian zone
8) **Nutrient Loading**
9) **Biota-specific habitat variables (Overlay)** – species, guild, community, function, life stage

Wetlands Environmental Zone

Workshop participants generally agreed that the hydrogeomorphic wetland classification developed by the Great Lakes Coastal Wetlands Consortium (GLCWC) and modified by Great Lakes Environmental Indicators (GLEI) stressor-response work, would be used for coastal wetlands. It was also agreed that the National Wetland Inventory classification system developed by Cowardin *et al.* (1979) would be applied to inland and riparian wetlands. It was recognized that at finer scales it may be necessary to incorporate additional biological information (especially vegetative coverages in response to changing water levels) into the classification scheme where data are available. Key habitat classification attributes identified include:

1) **Elevation/Topography** – bathymetry, slope, water depth,
2) **Land form and Geomorphology** – location relative to lake or river, other wetlands; connectivity; protected/unprotected (exposure and potential for seiche influence)
3) **Hydrology -** water depth; lake levels; range of variability; source waters
4) **Soil and Substrate** – type (texture, composition); permeability (infiltration)
5) **Water Quality** – nutrients; dissolved oxygen; thermal characteristics
6) **Vegetation** (submergent, emergent) – type; distribution; density
7) **Biota-specific habitat variables (Overlay)** – species, guild, community, function, life stage

Coastal Margin and Nearshore Environmental Zones

A formal habitat classification scheme has not yet been developed for coastal margin or nearshore environmental zones. The physical characteristics of coastal margin and nearshore zone habitats will likely be classified based on some combination of relative energy, substrate and substrate stability, water quality, and shoreline characteristics. The nearshore open-water classification scheme will share common elements with the Open-Lake Offshore classification scheme, and geospatial integration will be required at regional scales. Key habitat classification attributes identified include:

1) **Elevation –** bathymetry, slope, water depth, lake levels
2) **Substrate** – type (texture, composition), stability, contaminants
3) **Energy** (high, medium, low) **-** wave climate, fetch distance, water depth
4) **Water Mass Characteristics** – flow, circulation patterns, water chemistry (nutrients, contaminants), temperature, dissolved oxygen
5) **Turbidity/Sedimentation** – light penetration/attenuation
6) **Shoreline Type –** upland elevation/topography, surficial geology, depth to bedrock, bedrock type, land cover, protected/unprotected (shore protection)
7) **Biota-specific habitat variables (Overlay)** – species, guild, community, function, life stage

Open-Lake Offshore Environmental Zone

The Ohio Department of Natural Resources (ODNR) and Ontario Ministry of Environment (OMNR) have proposed a preliminary classification scheme based on a combination of bathymetry, substrate, thermal, hydraulic (gyres and riverine outwelling), and ecological parameters. Researchers at the Institute for Fisheries Research at the University of Michigan have attempted to use cluster analyses to combine bathymetry, slope, substrate, and thermal characteristics into zones of affinity for Lake Erie. Significant data gaps exist in the hydraulic and outwelling data, and the habitat subcommittee recommended that additional modeling work be done to better understand regional water circulation patterns and the relative importance of riverine contributions to Lake Erie water mass characteristics. Key habitat classification attributes identified include:

1) **Elevation** – bathymetry, slope, water depth, lake levels
2) **Circulation Patterns** – upwelling, outwelling, gyres
3) **Thermal Structure** – vertical and lateral
4) **Dissolved oxygen** (water quality)
5) **Substrate** – type (texture, composition), stability, contaminants
6) **Wind and Wave Climate** -
7) **Light attenuation** – turbidity
8) **Regional lakebed structure -** cross-lake moraines
9) **Biota-specific habitat variables (Overlay)** – species, community, function, life stage

(5) <u>"Super variables" identified that apply to more than one environmental zone</u>. *Are there common physical classification attributes among habitat subcommittees that will let us use common data sets across zones? Which attributes are unique to specific units?*

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. Table 1 summarizes "common" environmental variables or datasets that were identified during the workshop discussion. Attributes for each environmental zone are crosswalked into super variables on the left side of Table 1.

Table 1. Common Environmental Attributes

	Land Data Layers			Water Data Layers		
"Super variables"	**Terrestrial**	**Inland Lakes & Tribs**	**Wetlands**	**Coastal Margin**	**Nearshore**	**Offshore**
Elevation	Topography	Bathymetry	Bathymetry	Bathymetry	Bathymetry	Bathymetry
Slope	Land Surface	Water Surface	Bottom Slope	Bottom Slope	Bottom Slope	Bottom Slope
Energy		Stream Power	Wave/Currents	Wave/Currents	Wave/Currents	Wave/Currents
Climate	Degree Days	Temperature	Temperature	Thermal Stratification	Thermal Stratification	Thermal Stratification
Hydrography/ Geomorphology	Drainage Network	Drainage Network	Wetland/ Shoreline	Shoreline	Lakebed Structure	Lakebed Structure
Hydrology/Hydraulics	Precipitation Runoff Infiltration	Flow Regime/ Water Source	Water Levels/ Flow Regime/ Water Source	Water Levels/ Circulation/ Outwelling	Water Levels/ Circulation/ Outwelling	Water Levels/ Circulation/ Outwelling
Geology	Soils/Surficial Materials/ Bedrock	Substrate/ Stability/ Bedrock	Substrate/ Bedrock	Substrate/ Stability/ Bedrock	Substrate/ Stability/ Bedrock	Substrate/ Stability/ Bedrock
Turbidity	Point and Non-Point Sources	Suspended Sediment Load/ Turbidity	Turbidity/Light Attenuation	Turbidity/Light Attenuation	Turbidity/Light Attenuation	Turbidity/Light Attenuation
Water Chemistry	Point and Non-Point Sources	Nutrients/ Contaminants	Nutrients/ Contaminants	Nutrients/ Contaminants	Nutrients/ Contaminants	Nutrients/ Contaminants
Vegetation	Land Cover	Submergent/ Emergent	Submergent/ Emergent	Submergent/ Emergent	Submergent	Submergent
Land Cover	All	Riparian/ Upstream	Riparian/ Upstream	Riparian/ Shoreline Type		

To avoid duplication and/or inconsistencies, integrated geospatial datasets were identified that are applicable to more than one natural environmental zone. In many cases, this requires crosswalking of data attributes from multiple sources to create the integrated geospatial datasets. "Integrated" or "common" geospatial datasets have attributes that are internally consistent across multiple environmental zones. "Common" geospatial datasets identified during the January workshop are listed below:

Common "Land" Variables or Geospatial Datasets

1) **Elevation/topography**
2) **Hydrography** (rivers, wetlands, lakes)
3) **Land cover**
4) **Soils, surficial materials, depth to bedrock, bedrock**

Common "Water" Variables or Geospatial Datasets

1) **Bathymetry and shoreline** (higher resolution coastal margin)
2) **Substrate characterization and distribution** (higher resolution coastal margin)
3) **Hydraulics/water circulation** (nearshore open-lake and open-lake offshore)
4) **Wind and wave climate/fetch** distances
5) **Thermal characteristics** (surface temperature, stratification)

(6) Data gaps, scaling issues, and dataset integration/crosswalking.

Terrestrial Environmental Zone

Project team members from the University of Minnesota – Duluth Natural Resources Research Institute (NRRI) have been working to crosswalk Canadian and U.S. land cover datasets. Coverages are similar, and it is anticipated that crosswalk tables will be completed shortly for terrestrial land cover datasets for both the Maumee and Grand River pilot watersheds.

Inland Lakes and Tributaries Environmental Zone

ArcHydro protocols have been applied to the Grand River and it is likely that the GAP/STAR processing protocols developed for the inland tributaries can likely be applied to Ontario geospatial datasets. The USGS Aquatic GAP Program has already started to prepare Maumee River watershed datasets for GAP/STAR analyses. The project team will work with the USGS to complete the GAP/STAR analyses within the Maumee River watershed.

Wetlands Environmental Zone

Workshop participants identified serious data gaps in the wetlands datasets. Specifically, the National Wetland Inventory (NWI) datasets for Ohio are incomplete and may not be in appropriate digital formats. The USGS and ODNR are assessing ways to complete digitization of the Ohio Lake Erie NWI datasets. At a recent meeting, $250,000 was allocated by ODNR to develop NWI digital coverages at a 1-2 m resolution. Also, there are "unevaluated" wetlands in Ontario that need to be evaluated, classified and integrated into the Ontario PLC database

Workshop participants noted that in some areas, the NWI datasets may be out-of-date as they were based on imagery taken during the 1970's and 1980's - more than 30 years ago. Continued development, altered flow regimes (hydrology and connectivity), and impacts of invasive plant species may have significantly altered or changed the location and distribution of wetlands within the past 30 years. Validation of NWI datasets may be required.

Disparities have been noted in the coastal wetland classification between the U.S. and Canada. U.S. and Canadian inland and riparian wetland datasets also need to be consolidated, compared, and crosswalked.

Coastal Margin and Nearshore Environmental Zone

NRRI staff have been testing protocols to extend watershed boundaries into coastal margin and nearshore zones of Lake Erie. It may be possible to delineate watershed zones of influence and link watershed processes to coastal margin and nearshore zones.

Substrate data are not available for the mouth of the Grand River (Ontario) or adjacent coastal margin and nearshore areas. With the exception Ohio, there are significant gaps in coastal margin and nearshore substrate data. Additional data are needed fill these data gaps and will require substantial field effort.

The coastal margin, nearshore, and offshore committees have recommended that a unified substrate map be created for the entire Lake Erie basin. Standard classification schemes are needed with respect to texture, composition, hardness, and stability before integration into the habitat map. The project team has developed a standardized set of substrate descriptors that can be crosswalked and used to create a unified substrate map (i.e., a common substrate dataset) for all of Lake Erie.

Open-Lake Offshore Environmental Zone

Significant gaps exist in our understanding of open-lake circulatory patterns and interactions with tributary flows, including outwelling and upwelling events. Datasets are sparse and incomplete. The habitat subcommittee recommended that additional hydrodynamic modeling work be used to develop a better understanding of regional water circulation patterns and the relative importance of riverine contributions to water mass characteristics within the nearshore and open-lake offshore areas of Lake Erie.

Scaling Issues

Workshop participants suggested that in providing information and data to users, that the resolution of the data provided be hierarchically related to the scale of the request, i.e. whole basin requests will generally yield coarse-scale data while site-specific requests may yield finer-scale data. This hierarchical scaling approach could also be used when implementing the dynamic classification scheme, i.e. whole basin classifications would be performed using coarse-scale datasets while site-specific classifications would be performed using fine-scale datasets.

(7) <u>Restrictive data sharing policies are a major impediment to implementation of a basinwide habitat classification system and map</u>.

Development of a binational habitat map and classification scheme requires access and ability to distribute (i.e. serve) geospatial information and derivative products to a broad range of potential users. Current geospatial data ownership, access, and release mechanisms in Canada place severe restrictions on our ability to access, use, and distribute many critical Canadian geospatial datasets. This is a legal/policy issue that will have to be managed by the Canadian Federal and Provincial governments.

A data sharing agreement must be negotiated that describes what data will be shared, how it will be used, and the ways that it can (or can not) be shared or distributed to other entities who are not party to the data sharing agreement. Typically, the agreement is between a supplier and a user, and the data are restricted to the use for which the specific agreement was made. Generally, whoever creates something has copyright; if one makes changes to original data, the original owner still has copyright. Moreover, ownership will still rest with original data holders, but they can license products for unrestricted use of the derived product. There may be potential costs associated with access and use of these data as well. Workshop participants identified several key issues and agreed to pursue multiple strategies to get around this potential problem.

1) For the short term, initial data access and data sharing may be possible through existing data sharing or loan agreements with project partners. It may also be possible to use data summaries and or derivative products produced by project partners to generate preliminary habitat coverages. An alternative strategy would be to have the project team provide the “cookie cutter” tools and protocols to project partners who would then use those tools to generate derivative products that could be shared and distributed under existing agreements.
2) For the long term, major users (who have yet to be identified but will probably be governmental agencies) will require access to raw data layers with unrestricted ability to share and distribute derivative products. This will require a broad, comprehensive data sharing agreement. What constitutes raw or derivative data will have to be clearly defined in the agreement. Ideally, there should be no cost associated with access to these geospatial data layers.
3) Comprehensive data sharing agreement should be for an extended period of time (say 10 years) and be renewable. A long-term agreement is necessary due to the importance of these datasets to continuing indicator and monitoring work by the Lake Erie LaMP, the Great Lakes Fishery Commission, U.S. EPA., Environment Canada, and other resource management and protection agencies.
4) For infrequent users, there is a need to develop independent data sharing agreements to permit access to raw data layers and/or derivative products (boilerplate agreement?). Data could be accessed through the Ontario Geospatial Data Exchange and/or through individual agencies or organizations party to a comprehensive data sharing agreement. Suggestion was made to develop a web-based agreement that is digitally signed before accessing or downloading “proprietary” datasets.

Unfortunately, there are no single “go to” entities or agencies tasked to develop these data sharing agreements. Individual pairwise data sharing agreements will likely have to be developed between potential suppliers and users of geospatial data. However, there is an ongoing effort to develop an Ontario Geospatial Data Exchange (OGDE), which currently has more than 180 members including all of the Provincial ministries. OGDE is comprehensive but has taken a long time to develop. However, the OGDE does not currently have Federal support. OGDE members are trying to add U.S. members, but it has taken more than 2 years to add New York State and negotiations are currently stalled. Workshop participants generally supported implementation of the OGDE and identified several opportunities and/or entities that could assist with our efforts to develop comprehensive data sharing agreements. Potential partners/supporters include:

- Great Lakes Regional Exchange (Great Lakes Commission)
- Lake Erie LaMP
- Great Lakes Fisheries Commission
- International Joint Commission
- Conservation Authorities
- Environment Canada
- Transport Canada
- Provincial Agencies
- U.S. EPA
- U.S. Army Corps of Engineers

It was agreed that inquiries will be initiated with Environment Canada and U.S. EPA to identify key contacts and to discuss the importance of resolving geospatial data sharing issues with respect to this project. Letters will also be sent to the Lake Erie LaMP, the International Joint Commission, and the Great Lakes Fisheries Commission to seek support for development of a comprehensive data sharing agreement between project partners as part of this project.

(8) Products and Dissemination Strategies.

The project design currently identifies the Great Lakes Commission as the primary clearinghouse for geospatial datasets and associated classification tools or protocols developed by the project team. In some respects, the Commission may end up mirroring the functions of the OGDE in Ontario. Workshop participants recommended that source data holders retain responsibility for maintenance and updating of geospatial datasets, but the Commission through the Great Lakes Data Exchange could act as a clearinghouse/server for these geospatial datasets and tools assuming appropriate data sharing agreements are in place.

Workshop participants also discussed the potential users of the products generated from this project. It is anticipated that the primary users will be member agencies and institutions directly involved with implementation of the Lake Erie LaMP and associated indicator suites. This would include major Federal, State, and Provincial resource management and protection agencies, binational and regional commissions, and associated academic institutions. Secondary users may include also include various academic researchers, NGO's, and other interested parties.

Instead of a single "Lake Erie habitat map", it is anticipated the project team will provide initial tools and protocols to begin implementation of a dynamic habitat classification system that can be accessed and manipulated by the end user to produce a suite of derivative map products according to need. This will require development of linkages to appropriate underlying geospatial datasets and associated metadata (subject to data sharing agreements); access to attribute crosswalk tables, classification rules and associated processing tools; and protocols to build coverages and produce and print derivative map products.

The types of products that would meet the needs of these users range from a suite of fixed map products (i.e. layered maps) in a traditional summary report format (downloadable) to a fully interactive online system that allows users the flexibility to access, download, and manipulate geospatial datasets at multiple scales. Workshop participants recommended development of a nested distribution system that provides different levels of information and functionality to different user groups according to need. However, it became clear that implementation of this strategy would require a multi-year effort requiring resources well above and beyond what is available under the current U.S. EPA grant. Given the pilot nature of this project and time and resource limitations, it was suggested that initial products (or deliverables) should be a geospatially-based habitat classification system, crosswalk tables upon which the habitat classification is based, and a suite of derivative map products focused on the two pilot watersheds to illustrate the potential power and utility of a dynamic habitat classification system. Moreover, where datasets allow, it may be possible to provide regional whole-lake products for specific environmental zones.

(9) Next Steps.

Project team members Tom Hollenhorst (NRRI University of Minnesota) and Scudder Mackey (University of Windsor) will work with habitat subcommittee members to continue to compile critical geospatial datasets, apply classification protocols, and develop crosswalk tables (identified during this workshop) to generate a suite of test products (maps and coverages) for each of the natural environmental zones within the pilot watershed areas. These products will be shared with the habitat subcommittees for evaluation and review late spring 2006.

An advisory group was established to assist Tom and Scudder on technical/data processing issues. Members of the technical advisory group include Christine Geddes (IFR), Connie Livchak (ODNR), Mike Robertson (LIO), Jana Stewart (USGS), Li Wang (UMich), Brian Huberty (USFWS), Krista Holmes (USGS), Jenn Vincent (EC), Minako Kimura (UMich), and Chris Castiglione (USGS). These individuals will be contacted either individually or as a group to provide guidance with respect to specific data processing issues and/or concerns as the project progresses. Moreover, this advisory group will assist with outstanding issues related to implementation, distribution, and serving of the hierarchical databases.

Inquiries will be initiated with Environment Canada and U.S. EPA to identify key contacts and to discuss the importance of resolving geospatial data sharing issues with respect to this project. Letters will also be sent to the Lake Erie LaMP, the International Joint Commission, and the Great Lakes Fisheries Commission to seek support for development of comprehensive data sharing agreement(s) between project partners as part of this project.

The Great Lakes Commission will establish a project website on their server to provide project information and updates. Eventually this site will serve as a primary link and clearinghouse for geospatial datasets and associated classification tools or protocols developed for the Lake Erie Binational Habitat Map project. It is likely that the technical advisory group will also be consulted to provide guidance as to how best to develop an operational strategy for online dissemination of project data, tools, and products.

HABITAT SUBCOMMITTEE SUMMARIES
AND BREAKOUT SESSION DISCUSSIONS

<u>Terrestrial Habitat subcommittee Update</u> (Tom Hollenhorst – University of Minnesota)

The objective of the Lake Erie Binational project is to develop an integrated habitat classification and map of the Lake Erie basin. Based on a prior workshop and contributions by habitat subcommittee members, there is good participation and a high level of interest from both sides of the lake. The terrestrial environmental zone categories include land cover, elevation, watershed and subwatershed boundaries, population, etc. Even though the project is focused on two pilot watersheds, the project team is attempting to incorporate data from a broader geographic area that may include the entire Lake Erie basin. Early in the process the terrestrial habitat subcommittee identified watersheds as the framework upon which the terrestrial habitat analyses will be based. To incorporate potential external edge effects, the project study area will include a 20 to 40 km buffer zone adjacent to the surface-water boundary of the Lake Erie basin.

As initial base data layers, the project team is currently using geospatial datasets acquired and developed during the Great Lake Environmental Indicators project (GLEI). Based on habitat subcommittee discussions and results from the June workshop, it was agreed that the National Land Cover Dataset (NLCD) coverages and equivalent Ontario PLC coverages will be the primary land cover dataset used for terrestrial habitat classification and analyses. Under the GLEI project, an enhanced NLCD coverage was developed that corrects inaccuracies in the original NLCD (early 1990's) and incorporates new land cover data through 2001. In Ontario, provincial land cover data are available based on information from the mid-1990's. Ontario is planning to update their PLC coverages through acquisition of Quickbird satellite imagery. This is an ongoing process and may not be available for use in this project. A new NLCD is under development and will include a canopy cover data layer, but may not be available in time for use in this project. When available, it will be possible to do change detection and analyses by comparing old and new NLCD and Ontario PLC datasets.

Moreover, there are differences in attribute names and descriptions between the NLCD and Ontario PLC datasets. NRRI staff are working to harmonize those datasets by developing crosswalk tables that will result in an integrated land cover dataset for both the U.S. and Ontario land cover datasets (Figure 2). Preliminary crosswalking and resulting coverages show that agriculture has significantly altered the landscape across the basin, particularly in southern Ontario and the southwestern portion of the Lake Erie basin. Additional land cover attribute data may become available from other sources, and will be incorporated into the integrated datasets as it becomes available.

Terrestrial - Summary Break-out Group Discussion and Recommendations

Present: Tom Hollenhorst, Dave Ewert, Adam Yates, Mike Robertson

Integrated coverages show that 75 to 80 percent of Lake Erie is surrounded by agricultural and urban land cover, basically the only two major types of land cover in the region (Figure 2). In southern Ontario, very little forest and grassland cover is present. Also in southern Ontario, there is an ongoing regional effort to use post 2002 aerial photography to develop updated land cover datasets rectified to SOLRIS data classes at a half hectare resolution. These updated datasets will be compared with existing land cover datasets to detect land cover changes and trends. New high-resolution land cover datasets are also coming online at a 1:10,000 scale. The second phase of this effort will be fine-tuning and validating the land cover datasets and resolving GIS issues.

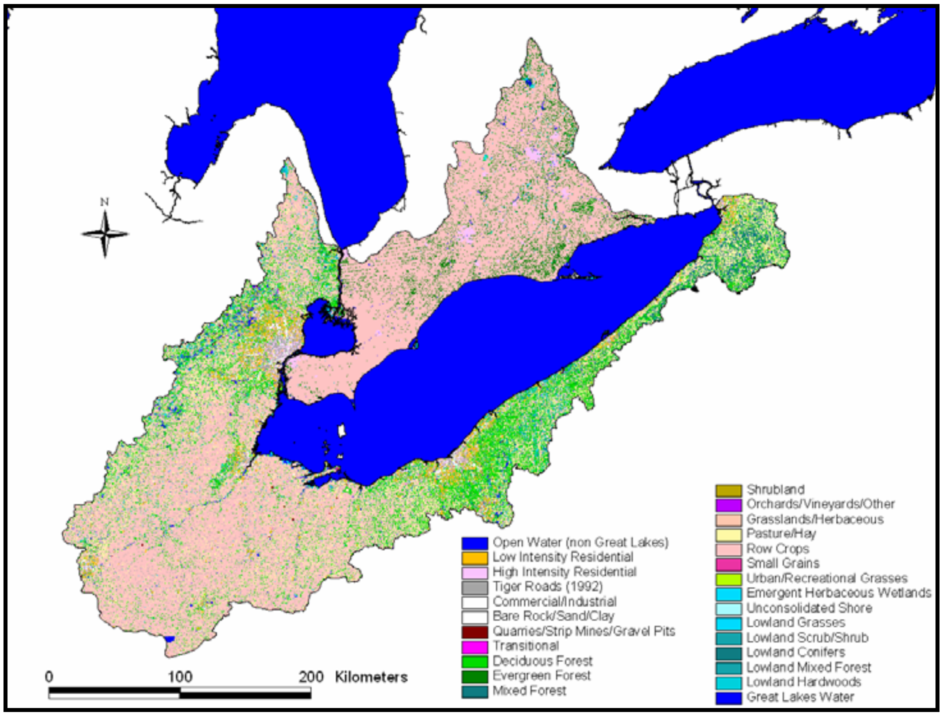

Figure 2. Integrated LCD coverage for the Lake Erie Basin based on crosswalk tables. Agriculture is the dominant land cover in southern Ontario and in the southwestern portion of the Lake Erie basin (Tom Hollenhorst – University of Minnesota).

The primary physical controls on terrestrial habitat include agriculture (land cover pattern and distribution), erosion and sedimentation (altered flow regimes), and nutrients and pesticides (contaminant sources and loadings). In general, urban areas have flashier drainage systems and increased nutrient and contaminant loadings. The drainage network and hydrology are corridors/vectors for collection and transport of nutrients, contaminants, and sediments. Other related variables are climate (temperature, growing degree days), precipitation, and soils. Digital elevation models are also important as change in elevation controls gradient and energy of system. Consumptive use and/or extraction/diversion of water (municipal water intakes, wastewater treatment plants, and power plants) may also be important.

Connectivity and fragmentation are major drivers controlling the distribution of terrestrial habitats as well. The consensus approach is to overlay land cover data on elevation to determine relative importance of variables. Key terrestrial variables listed in order of importance are:

1. Elevation (slope, aspect)
2. Land use/changes in hydrology
   - nutrients, sediments, temperature,
   - habitat connectivity/fragmentation
3. Climate – growing degree days
   - precipitation
   - extreme temperatures, high max and lows
4. Soils and Geology
   - particle/Soil type
   - soil permeability

- depth to Bedrock
- texture

5. Water Use (quantity and location)
   - intakes, outfalls
   - power plants, dams
6. Point Source
   - contaminants
   - nutrients
7. Atmospheric Deposition

<u>Inland Lakes and Rivers Habitat subcommittee Update</u> (Nick Mandrak – Fisheries and Oceans Canada, Li Wang – University of Michigan, Jana Stewart – USGS GAP Program)

The inland lakes and tributaries habitat subcommittee was asked to define environmental zone boundaries at the June workshop, and concerns were raised about fuzzy boundaries with terrestrial, wetland, and nearshore environmental zones. The habitat subcommittee also recognized that many riverine classification systems are species or habitat-specific and combine both physical and biological elements into the classification. This leads to the development of numerous highly "specialized" classification systems that are seldom suitable for regional or basinwide analyses. Consequently, the habitat subcommittee recommended using the GAP/STAR model as a template to develop a regionally applicable riverine classification scheme for Lake Erie. This model requires identification of the appropriate geospatial datasets to classify each habitat type within riverine environments. The habitat subcommittee identified critical data gaps, and found that the riverine geospatial datasets are not as complete in Canada as in the U.S., and that additional GIS data coverages may be needed to apply the GAP/STAR model in Ontario.

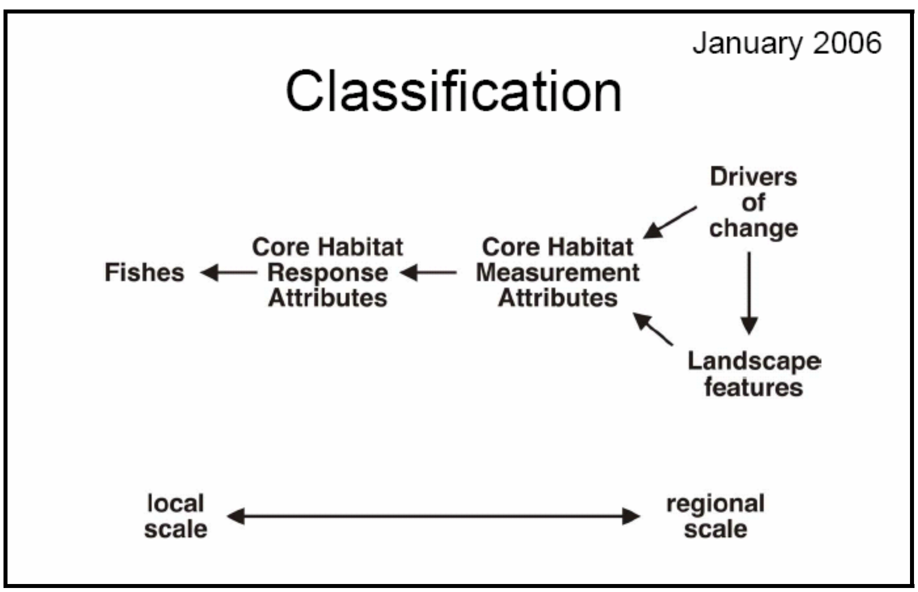

Figure 3. Flow chart illustrating how measures used to develop and define habitat classification systems are affected by scale.

The habitat subcommittee also agreed that the Great Lakes Water Quality Agreement (GLWQA) integrity elements (physical, chemical, and biological integrity) provide a fundamental framework upon which habitat classification schemes can be based. The ultimate goal is to link landscape features and drivers of change to the biota (fish in this case) in order to predict the distribution and function of habitats within riverine and inland lake systems at multiple scales (Figure 3). Moreover, participants emphasized that critical linkages to fish (or other organisms) could potentially be made by any combination of terrestrial or aquatic environmental parameters.

The project team will build on ongoing work by the USGS GAP and EPA STAR grant teams. Currently, 1:100,000 scale NHD coverages are being used for these analyses (1:24,000 NHD coverages are not available in all states). Land cover data are available at a 30 m resolution. The fundamental analysis unit is the stream segment, which is defined by the line segment between channel confluences. Analyses are focused on five different scales - within channel, local riparian, local watershed, upstream riparian and upstream watershed scales. Riparian zones are defined by buffer zones twice the stream width: (60 m buffer for a 30 m stream). The approach and tools are geospatial and a suite of processing algorithms has been developed to simplify and standardize data manipulation and processing. A centralized database has been created to hold habitat characteristics and associated biological datasets (the primary focus is on fish). Analyses in New York, Wisconsin, Minnesota, and Illinois are nearly complete. Initial steps have been completed in Ohio but work may not be completed due to funding limitations. Based on these data and statistical analyses, three key variables were identified: the first being stream or catchment size; the second being thermal characteristics; and the third is a combination of stream gradient, energy, and sediment characteristics (Figure 4).

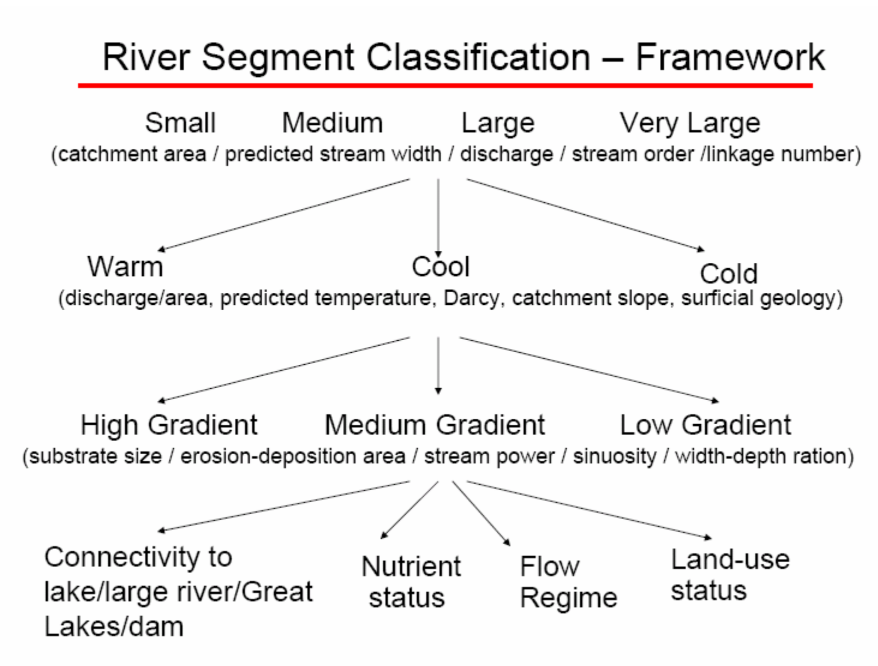

Figure 4. Primary variables found to have a statistically significant relationship to fish and aquatic habitats in riverine systems. Parameters in parentheses could be considered to be drivers of change. (Li Wang – University of Michigan)

Inland lakes and rivers – Summary Break-out Group Discussion and Recommendations
Present - Li Wang, Jana Stewart, Les Stanfield, Minako Kimura, Nick Mandrak

The habitat subcommittees used Figure 4 (above) from Li Wang's presentation to guide discussion. Primary physical drivers are stream or watershed size, temperature, slope or gradient, and associated hydrogeomorphic landscape factors. A fundamental assumption is that landscape features drive (or create) habitat, which in turn regulates the distribution of the biota. The subheadings in parentheses (in Figure 4) describe the drivers that control the three fundamental factors identified by the GAP/STAR project team. Many of these drivers are landscape parameters or can be derived from landscape parameters. The habitat subcommittee discussed several combinations of parameters and suggested that watershed or catchment size is a more appropriate measure than stream order or stream size. Moreover, it was recognized that the thermal characteristics of a stream are influence by several parameters, including: source water and riparian cover, which may require data on ground and surface hydrology and riparian canopy analyses that are not generally included in current U.S. or Ontario land cover datasets.

The objective is to identify data and parameters that can best predict aquatic and fish habitat distributions. Minns and Wichert 2005 have reviewed the evolution in our understanding of the most important factors that should be used to characterize fish habitat. The accuracy of those predictions will be, in part, a function of the scale at which one is operating at. The habitat subcommittee also agreed on the need to focus on all habitats, not just fish habitat (i.e., summarize the physical and chemical attributes that would have to be overlaid to define the preferred areas of taxa other than only fishes), and that classification systems should be based on natural (not only anthropogenic) environmental parameters. Although anthropogenic factors can influence and alter habitat distribution, the presence or intensity of human disturbances should not form the basis for a habitat classification system. Key riverine and inland lake parameters are summarized in Figure 4, and are listed below:

1. Size
   - catchment area, discharge
   - stream width, stream order
2. Thermal Properties (warm, cool, cold)
   - temperature
   - discharge/area
   - darcy (groundwater)
   - catchment slope,
   - surficial geology
3. Gradient (Energy)
   - substrate (texture, composition)
   - stream power, erosion/deposition
   - sinuosity, width-depth ratio
4. Flow Regime
   - discharge, stream power
   - flow variability
5. Soils and Geology
   - substrate/bank material (texture, composition),
   - surficial geology, depth to bedrock, bedrock type, porosity
6. Connectivity

- dams, channelization
- segment length distance

7. Land Cover/Land Use
   - riparian zone
   - adjacent and upstream land cover
8. Nutrient Loading

<u>Wetland Habitat subcommittee Update</u> (Ric Lawson – Great Lakes Commission)

Habitat subcommittee consensus was reached during the June workshop to use the hydrogeomorphic classification scheme (HGM) for coastal wetlands developed for the Great Lakes Coastal Wetlands Consortium (GLCWC) by groups in the US and Canada. This classification would then be merged with GLEI wetland approach developed for the U.S. Great Lakes coastline. The two systems are compatible but some differences exist and datasets will have to be crosswalked and merged. Wetlands are so dynamic that it is difficult to build a consistent wetland classification system based exclusively on biological components. The GLCWD identified 3 fundamental hydrogeomorphic classes – lacustrine, riverine, and barrier protected wetlands, within which were nested a total of 10 subclasses. Coastal wetland classification coverages are available for most of the U.S. Lake Erie coastline and are based on data derived from the National Wetland Inventory (NWI) dataset and State wetland mapping efforts. In Ontario, preliminary wetland classifications were based initially on "evaluated" wetlands. "Unevaluated" wetlands have now been added to the coverages. There are two complete wetland datasets that when crosswalked should provide a comprehensive data layer of coastal wetlands for the entire Lake Erie basin. Follow up discussions confirm that is desirable to augment the HGM classification system by also incorporating some biological attributes (especially emergent vegetation classes) for finer-scale classification and mapping efforts. This is especially important from the context of accounting for marked year-to-year changes in water level, to which emergent macrophyte species rapidly respond. Consensus was reached to use the NWI classification system from Cowardin *et al.*1979 for inland and riparian wetlands in both the U.S. and Canada.

Data gaps and limitations exist in Ohio where the NWI has not been converted into appropriate digital formats. Moreover, unevaluated wetlands along the Ontario shoreline should be evaluated and incorporated into the integrated coastal wetland coverages. Considerable discussion ensued about the reliability and age of the NWI datasets. Portions of the NWI are based on 1970's and early 1980's vintage aerial photography, which may be more than 30 years out-of-date. Additional validation of the NWI datasets may be necessary. Next steps include: 1) finalization of the process to harmonize and crosswalk the U.S. and Canadian coastal, inland, and riparian wetland coverages, 2) filling the Ohio wetland data gap, and 3) evaluating the "unevaluated" wetlands in Ontario.

Wetlands - Summary Break-out Group Discussion and Recommendations

The wetland habitat subcommittee discussed the fact that many catalogued wetlands no longer exist and that consideration needs to be given to the historical context of wetlands. In addition to controlling variables, there should be consideration of the potential for wetlands to be in a place and/or acknowledge wetland loss as part of the overall wetland habitat assessment. It is unclear how to incorporate this concept into a dynamic classification scheme, even though it may possible to identify appropriate ranges of controlling variables (or conditions) to create a wetland "potential" map that identifies not only historical wetland sites but other sites where wetland restoration could be possible.

The habitat subcommittee also discussed how the wetland environmental zone will be integrated into the coverages as an independent layer between the terrestrial, inland lakes and rivers, and coastal margin/nearshore environmental zones. It is unclear that if wetland maps are to remain intact, how they will fit into the data structure and be incorporated into the regional overlays. This is of particular concern due to scaling and resolution issues, especially when considering the disparate scales and resolution of the terrestrial, inland lakes and rivers, and coastal margin/nearshore environmental zones. Are the scales and resolutions of the two other zones going to match wetland needs? Moreover, wetland boundaries may intersect multiple environmental zones (i.e. cross watershed boundaries) and it is unclear how these cases will be handled in the data layers. The subcommittee also recognized that the dynamic classification scheme being developed will delineate ecotones, which are particularly apparent in the case of wetlands. Key wetland variables identified are listed below:

1. Topography
   - bathymetry (water depth)
   - slope
2. Hydrology
   - flow Regime
   - range of variability
3. Soil and Substrate
4. Water Quality
   - nutrients (stagnant, human influenced)
   - contaminants
5. Landscape structure
   - connectivity (between wetlands, watersheds, lake)
   - distribution, pattern, fragmentation

<u>Coastal Margin and Nearshore Open-Water Habitat subcommittee Update</u> (Scudder Mackey – University of Windsor)

Physical habitat can be defined as combination of a range of physical and energy characteristics that meet the needs of a species, guild, 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 a meet the needs of a specific species, guild, biological community, or ecological function can be used to identify and delineate potential "habitats" (Figure 5). The dynamic habitat classification approach addresses the three-dimensional nature of aquatic habitats and the dynamic nature of these habitats as well. This approach can be applied to coastal margin, nearshore, and offshore open-lake environmental zones as well.

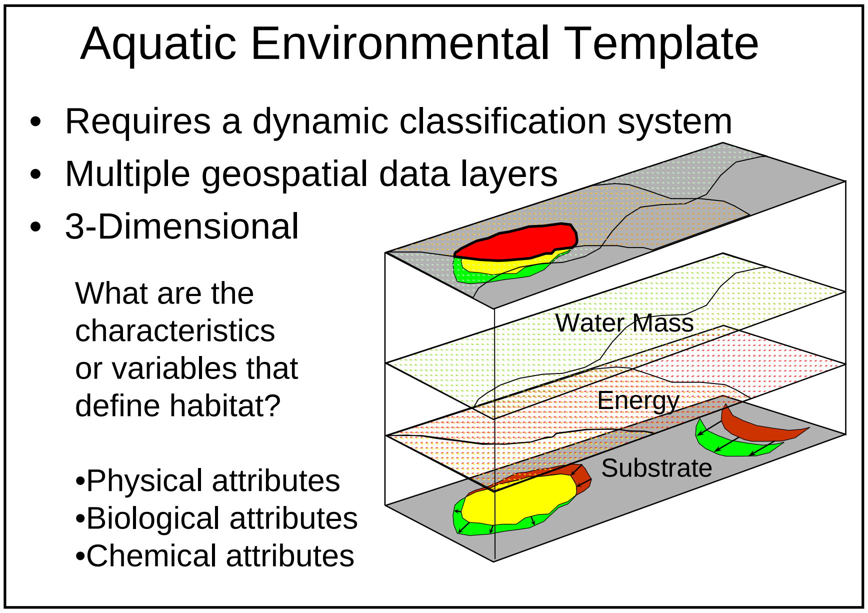

Figure 5. Three-dimensional aquatic habitat environmental template based on fundamental components – energy, substrate, and water mass characteristics. (Scudder Mackey – University of Windsor)

Initially, the coastal margin/nearshore zone was defined as extending from ordinary high water (OHW) to the 10-m isobath and/or a maximum distance from shore of 4 km. Within the western basin, the coastal margin/nearshore zone extended from OHW to the 5-m isobath and/or a maximum distance from shore of 4 km. Typically, the shoreward limit would be defined by the intersection of the OHW with a beach, bluff, revetment, seawall, or other shoreline feature. At the June workshop, the 4 km distance limit was dropped and the 10-m isobath was adopted for the entire lake basin. However, this definition does not adequately address major processes and habitat characteristics that are unique to coastal margin areas of the western basin, which are thought to influence the distribution and function of important biological attributes in the western basin (primarily fisheries-related variables). Accordingly, the habitat subcommittee recommended that the nearshore zone be subdivided into two separate environmental zones – a **coastal margin zone** and a separate **nearshore open-water zone** (Figure 6.).

The coastal margin zone would extend lakeward from the OHW mark to the 3-m isobath. This zone is generally dominated by high-energy littoral processes and is directly influenced by anthropogenic modifications to the shoreline. Substrates are generally coarser-grained than those found in deeper water and may be highly unstable. The nearshore open-water zone would extend from the 3-m isobath lakeward to the 15-m isobath. This zone would be dominated by processes more characteristic of the open-lake, but would also be subject to higher wave energies and associated littoral or nearshore processes during major storm events. Substrates are generally finer-grained but may be reworked during storm events. Anthropogenic impacts are generally indirect and may be associated with outwelling zones and/or zones of influence from tributary flows into Lake Erie. The 15-m isobath approximates where the thermocline intersects the sediment/water interface (thermal stratification). Waters shallower than 15 m are well within the photic zone and biological productivity is higher than in deeper water areas, which also influences fish community distributions.

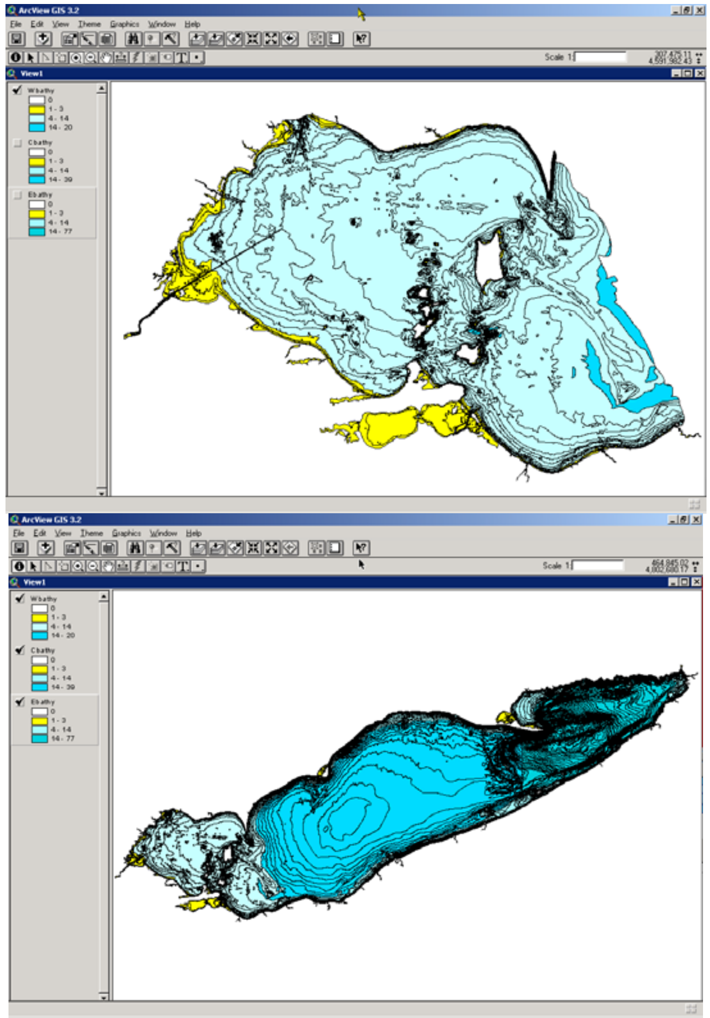

Figure 6. Revised coastal margin and nearshore open-water boundaries for the Western Basin and Lake Erie. Coastal margin (yellow), nearshore open-water (light blue), and offshore open-water (dark blue). (Scudder Mackey – University of Windsor)

There are significant spatial and temporal data gaps in the Lake Erie coastal margin and nearshore datasets. On the U.S. side, nearshore and coastal margin substrate mapping has been completed in Ohio to a distance approximately 4 km offshore at a 1:100:000 scale. Additional geospatial substrate information is available from Melissa Haltuch's M.Sc. Thesis work (Ohio State University) that integrated substrate coverages at a 1:500,000 scale from multiple sources primarily from National Water Research Institute (NWRI) and the Canadian Centre for Inland Waters (CCIW). The US Army Corps of Engineers (USACE) has completed a coarse-scale (1-km interval) evaluation of shoreline characteristics for the entire U.S. Lake Erie shoreline as part of a broad-scale potential damages study (Stewart 1999). The Nature Conservancy also produced a nearshore habitat classification map that integrates both physical and biological habitat characteristics (Higgins *et al.* 1998). Ongoing work by the USGS Aquatic GAP program has produced a series of integrated geospatial coverages for the western basin of Lake Erie as part of a pilot nearshore habitat classification and assessment project (C. Castiglione, USFWS, pers. commun.). Members of the USGS Aquatic GAP team are also participating in this project and have provided guidance and input to the coastal margin and nearshore habitat subcommittee. In Canada, the Environmental Sensitivity Atlas (1996) produced by Environment Canada contains summary shoreline information at a 1:10,000 resolution. Researchers at the Canadian Centre for Inland Waters (CCIW) are also collecting additional coastal margin and nearshore information (J. Biberhofer, Environment Canada, pers. commun.) However, high-resolution geospatial coverages are currently limited to certain areas along the Canadian Lake Erie shoreline. Important variables to consider include:

- substrate characteristics (distribution, pattern, and stability)
- kinetic energy (low, med, high)
- water mass characteristics (flow/circulation patterns)
- light penetration (turbidity, sedimentation)
- biota-specific habitat variables (function, life stage)

Coastal Margin and Nearshore Open-Water Habitat Subcommittee Discussion and Recommendations

Initial habitat subcommittee discussion focused on where to draw coastal margin boundaries with wetlands. The subcommittee noted that embayed areas often support submerged aquatic plants but should not be classified as wetlands. The lakeward limit of emergent aquatic vegetation seemed to be the most logical way to delineate the boundary between coastal wetland and coastal margin zones, especially in more open or exposed areas of the Lake.

The habitat subcommittee also identified tributary influences (mixing zones) as critical places in coastal margin and nearshore habitats. The habitat subcommittee recognized the need to interact with the offshore open-lake group to identify tributary outwelling and/or zones of influence in both the nearshore open-water and offshore open-lake environmental zones. Moreover, key physical attributes vary at a coastal margin habitats are distributed on a finer-scale at coastal margins than in the nearshore zone. Thus finer-resolution datasets will be required to classify habitats within the coastal margin zone. Ice cover and seasonal runoff were also identified as seasonally changing variables that could have a significant impact on other measured variables.

Physical data (i.e., substrate, water mass characteristics) are needed for the mouth of the Grand River, Ontario and most of the Ontario, Michigan, New York, and Pennsylvania Lake Erie shorelines. Comments were made with respect to the quality of existing data and the need to ground truth substrate data. The habitat subcommittee also recognized that a standard substrate classification scheme (identifying classes based on combinations of texture, composition, hardness, and stability) would have to be agreed to and implemented before diverse existing substrate data could be combined into a single, unified coverage. The coastal margin, nearshore, and offshore habitat classification schemes should be based on comparable substrate descriptions and maps. It would be appropriate and prudent to use the same data layers.

The habitat subcommittee did not specifically discuss creation of a formal habitat classification scheme for coastal margin or nearshore environmental zones. However, it is likely that the physical characteristics of coastal margin and nearshore zone habitats will likely be classified based on some combination of relative energy, substrate and substrate stability, water quality, and shoreline characteristics. The nearshore open-water classification scheme will also share common elements with the Open-Lake Offshore classification scheme and geospatial integration will be required at regional scales. Key habitat classification attributes identified include:

1. Elevation
   - bathymetry, water depth, lake levels
   - slope
2. Substrate
   - type (texture, composition), stability
   - contaminants
3. Energy (high, medium, low)
   - wave climate, fetch distance
   - water depth
4. Water Mass Characteristics
   - flow, circulation patterns
   - water chemistry (nutrients, contaminants), temperature, dissolved oxygen
5. Turbidity/Sedimentation
   - light penetration/attenuation
6. Shoreline Type
   - upland elevation/topography
   - surficial geology, depth to bedrock, bedrock type
   - land cover
   - protected/unprotected (shore protection)

<u>Offshore Open-Water Habitat subcommittee Update</u> (Jeff Tyson – Ohio Department of Natural Resources)

Based on discussions from the June workshop, the current boundary scheme was based on water depth and proximity to shore. Open-water boundary conditions initially established for water depths greater than 10 to 15 m were based on the location of the thermocline-sediment/water interface and associated fisheries data. The simple 7 – box water quality model (Lam *et al.* 1987) of Environment Canada commonly used to classify open water zone is based on water depth and thermal structure alone (Figure 7.). However, thermal boundaries are dynamic as the thermocline depth and intersection zones vary seasonally and in response to major storm events. The boundaries change as a function of regional hydrodynamic processes within the Lake sub-basins. Additional modeling work is needed to understand the spatial and temporal distribution of large-scale water masses that influence and structure Lake Erie offshore habitats. However, the 10 to 15-m water depth zone will likely define the nearshore-offshore boundary (see Figure 6).

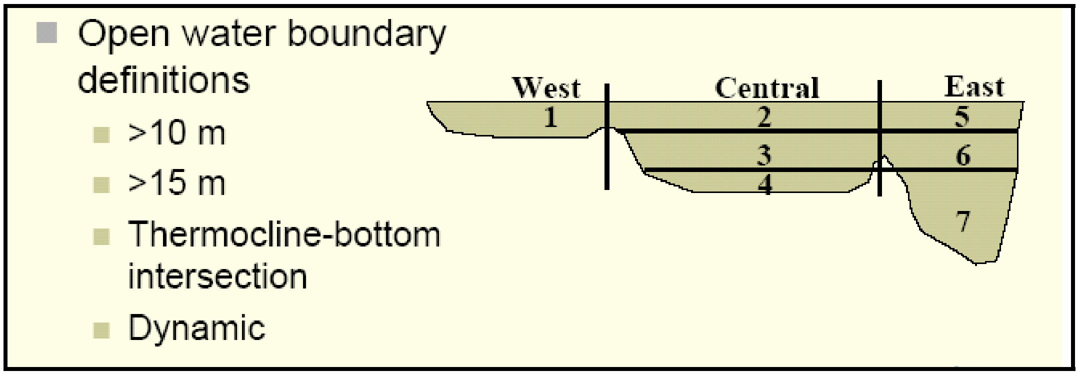

Figure 7. Simple 7-box model based on thermal characteristics and water depth used to classify water masses and offshore open-water habitats in Lake Erie. (Jeff Tyson – ODNR)

Other possible habitat classification variables include defining subzones by large-scale circulation patterns (or gyres) documented by Saylor and Miller (1987) and the influence of tributary outwelling zones on offshore water mass characteristics Recent work by Ohio Department of Natural Resources (ODNR) has resulted in a conceptual classification scheme based on a combination of bathymetry, thermal, hydraulic (gyres and riverine outwelling), and ecological parameters (J. Tyson et al. in prep., Figure 8) Researchers at the Institute for Fisheries Research at the University of Michigan have also attempted to use cluster analyses to combine bathymetry, slope, substrate, and thermal characteristics to link fish populations to structuring elements in Lake Erie (C. Geddes et al., in prep.).

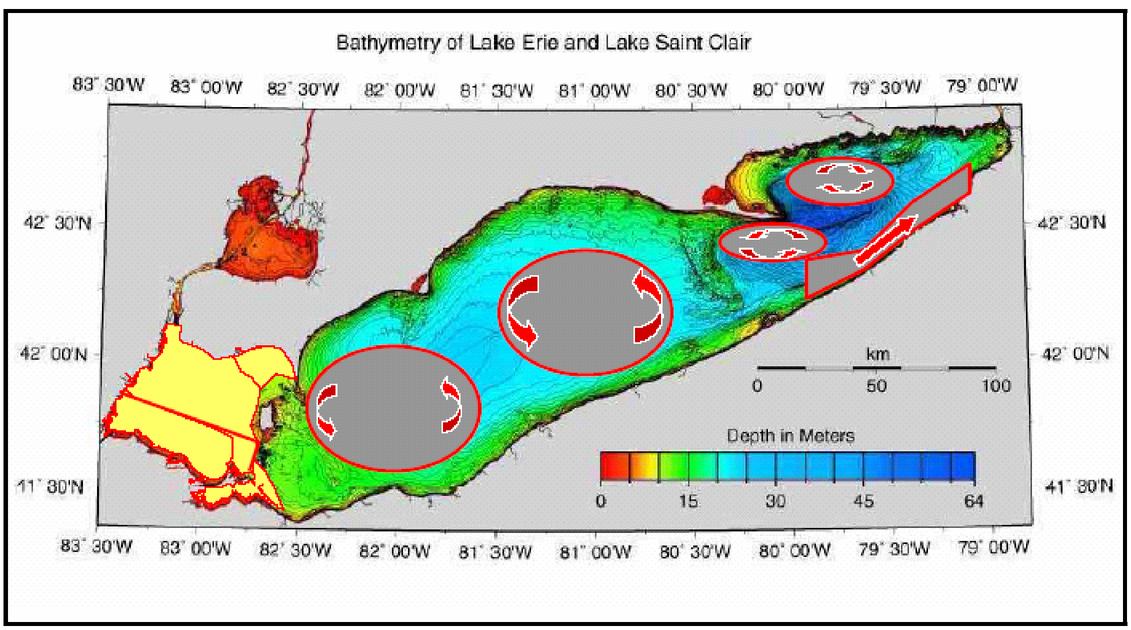

Figure 8. Conceptual classification scheme based on regional Lake Erie circulation patterns and tributary zones of influence (adapted from Saylor and Miller 1987). (Jeff Tyson – Ohio Department of Natural Resources)

Substrate characteristics may also be an important structuring variable, especially within the transition zone between nearshore and offshore environmental zones. Nearshore and coastal margin substrates are generally more dynamic and heterogeneous than offshore substrates. It was also pointed out that scaling issues are complex, and context specific (levels of resolution needed will depend on the use of the classification system). Appropriate scales of resolution have yet to be established to develop and illustrate bio-physical linkages within the offshore environmental zone. Finally, there are important resource (fish) management implications to this work. Effective protection and restoration of Lake Erie fish stocks requires a better understanding of 1) how fish use various habitats within the basin, and 2) the relative importance of those habitats to specific life stages. Currently, several Lake Erie Fishery Management units straddle major environmental subzones. It may be possible to more effectively manage the fishery resource by aligning Fishery Management units with underlying habitat structure.

Offshore Open-Lake Habitat subcommittee Discussion and Recommendation

Present: Ed Rutherford, Christine Geddes, Ram Yerubandi, Jeff Tyson, Hans Biberhofer

There was a general consensus to accept the revised boundary conditions proposed by the coastal margin and nearshore groups, with the understanding that additional hydrodynamic modelling would help to define the location and spatial and temporal variability of the boundary. Hydrodynamic modelling may also provide some insights as to the importance of mixing zones and tributary outwelling to offshore communities. Additional comments were made suggesting that lakebed bottom characteristics and structure are important elements that influence fish community distributions. For example, the Pelee/Loraine ridge (cross-lake moraine) and the Long Point Bay feature separate discrete fish stocks in the Basin. The idea of generating a set of dynamic physical and chemical data coverages that encompass the offshore zone and then overlaying biological (i.e. fisheries) datasets appealed to the habitat subcommittee. The work presented by Chris Geddes of the University of Michigan Institute for Fisheries Research highlighted several potential geospatial and biostatistical techniques (cluster analyses) that could be applied to delineate bio-physical linkages within the offshore environmental zone. The habitat subcommittee agreed that close cooperation with the coastal margin and nearshore groups would be essential if we are to develop an integrated habitat classification scheme for Lake Erie aquatic habitats. Key habitat classification attributes identified include:

1. Elevation
    - bathymetry, water depth, slope, lake levels
2. Circulation Patterns
    - upwelling, outwelling
    - gyres
3. Thermal Structure
    - vertical and lateral
4. Dissolved oxygen (water quality)
5. Substrate
    - type (texture, composition)
    - stability
    - contaminants
6. Wind and Wave Climate
7. Light attenuation
    - turbidity, sedimentation
8. Regional lakebed structure (cross-lake moraines)

FINAL COMMENTS FROM PARTICIPANTS:

Ed: like the habitat subcommittee activities; should have continuation of habitat subcommittee activities to coordinate with Tom and continue work on that; maybe can work faster in smaller groups; people are more knowledgeable; might facilitate things; then get back together or send out to everyone…

Jana: this is great; reiterate what Ed said; smaller groups are key; we need to have a common thread; have Tom on all conf calls so when we do crosswalking build off as much existing information as we can; integrate Aquatic GAP, EPA STAR as much as possible; to do it all at once without common thread will be difficult…

Chris: good effort; have had a lot of important issues raised; would be very helpful if we have a statement of purpose, even if it's general in nature; generally useful thing to have a statement designed is important; maybe a good time to start using the data we have and start to build the map; "we" being the people who will be doing the GIS work; working on IFR datasets…

Minako: great project; we want to be sure of the purpose; who will use the map and why; final flavours will depend on the purpose; we need to decide and know what the purpose is and who the users will be…

Ric: think that we've gone as far as we can in terms of how to structure, wish list, etc.; now have to put the data together and see what we have; get out of what we would like to see and get to what we can actually accomplish given what we have to work with; Tom and Scudder will help us get ready…

Ann: each of the groups would benefit from knowing what exactly the end products will be and what's expected of each group…

Les: think about articulating what the question is for each of the 5 groups; once clear, be sure that the contribution meets their needs…

Krista: realize that this stuff will bring together international groups combining data into a whole is by itself a huge project; the big picture is really the first step; then we can start to narrow it down for specific needs; use broad basin approach as a starting point…

Brian: follow up on Krista; this is a big picture and needs a big picture approach; on Monday trying to identify areas in OH area; but even a complete project wouldn't be able to answer the question that they had; data aren't there; use the product to identify data needs and then go out to get the data datasets…

Jen: not much to add; agree that we need to start building the map; focus on the purpose that is right there; keep idea in place that this is an experiment and that we have to have interim results…

Julie; initially, LaMP wanted a map to help set priorities on where we had to focus to improve habitat, and were the structuring mechanisms were to manage habitat so could work to return things to better condition prior to degradation; think that when first asked for, no one understood the amount of work that it would take; if we do stay with idea that it's a demonstration project and focus on what we can do, we (the LaMP) will take it from there; if we want to continue, we have to have product…

Jeff: hear consensus; point out that as a LaMP work group member there are lots of potential uses; want to get the product out; see people using the template for their own needs; not too worried about specific objectives…

Li: echo what Minako said; need to develop some specific questions that a classification can answer; still not clear what a boundary is; what is the terrestrial classification for? if don't know on the inside, how will we provide answers to people on the outside?

Hans: pass

Tom: monumental challenge is that there's been a lot of work done on the lake; how do we take work from different zones and link it all together? how do we link across zones?

Susan: made good headway in bringing groups together to integrate across the watershed; working across a whole lake ecosystem approach; repeat what Ed et al. said; lots of progress in small groups; have to scale down to get to common theme across different groups; do what's conceivable and don't promise too much; basic information can be used for a broad range of different things and is useful by itself…

Connie: ultimately, what we are trying to accomplish is to develop a tool that we can use to understand emergent properties; maybe that will help us find the details of how things intermingle to identify significant things; ultimately, we have to use a multiple working hypotheses approach on multiple data sets and within the two pilot watersheds to see if this has any predictive value; validation is critical before it is distributed more broadly…

Lucinda; this is an enormous contribution; everyone paid their way to come to these meetings; couldn't do this without all of your help. Thanks to everyone for attending.

LIST OF PARTICIPANTS

Hans Biberhofer	**Environment Canada**
Dan Button (absent)	**USGS**
Jan Ciborowski	**University of Windsor**
Lindsay Davidson	**University of Windsor (recorder)**
Susan Doka	**Fisheries & Oceans Canada**
Dave Ewert	**The Nature Conservancy**
Christine Geddes	**University of Michigan**
Tom Hollenhorst	**University of Minnesota - Duluth**
Krista Holmes	**Canadian Wildlife Service**
Lucinda Johnson	**University of Minnesota**
Minako Kimura	**University of Michigan**
Ric Lawson	**Great Lakes Commission**
Julie Letterhos	**Ohio EPA**
Connie Livchak	**Ohio Dept. of Natural Resources**
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Jeff Tyson	**Ohio Dept. of Natural Resources**
Jennifer Vincent	**Environment Canada**
Li Wang	**University of Michigan**
Gene Wright	**Ohio Coastal Management Program**
Adam Yates	**University of Western Ontario**
Ram Yerubandi	**Environment Canada**

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