State of the Lakes Ecosystem Conference 1998

BIODIVERSITY INVESTMENT AREAS
Aquatic Ecosystems

Aquatic Biodiversity Investment Areas in the Great Lakes Basin:
Identification and Validation

Version 3

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Notice to Readers

This paper on Biodiversity Investment Areas is one of three such papers that were prepared for discussion at SOLEC 98 and have been modified based on comments received at the conference. The idea of Biodiversity Investment Areas originated at SOLEC 96 for the Nearshore Terrestrial Ecosystem. This work has continued and been expanded to include Aquatic Ecosystems and Coastal Wetland Ecosystems. The authors of these papers have drawn information from many experts.

Executive Summary

Here, we report on initial efforts to identify and validate candidate aquatic biodiversity investment areas (ABIAs) across the Great Lakes Basin Ecosystems. The ABIA concept is linked to its terrestrial shorelands counterpart, Lands by the Lakes, reported at SOLEC'96 and placed in context with other national and international biodiversity initiatives. The working definition of an ABIA used in this study is: **a specific location or area within a larger ecosystem that is especially productive, supports exceptionally high biodiversity and/or endemism and contributes significantly to the integrity of the whole ecosystem**.

A conceptual framework is presented as the basis for developing scientifically defensible methods for identifying and validating ABIAs. The framework is focused on three dimensions where the three main axes represent biodiversity, spatial units, and habitat features in discrete elements. Paired intersections of the axes represent the distribution of biodiversity (biodiversity and spatial units), the characterization of spatial units, or locations, by the overlaying of many habitat features (spatial units by habitat features), and the niches of individual species and life stages (biodiversity by habitat features). In this preliminary assessment of ABIAs, attention has been concentrated on freshwater fishes.

To augment the implementation of the conceptual framework, a survey of Great Lakes experts was undertaken to establish a preliminary list of candidate ABIAs. The candidate ABIAs provide broad geographical coverage across the basin and many types of spatial units have been included. The survey approach has many subjective elements resulting from the varying abilities and experience of the experts consulted, the uneven distribution of prior observations and assessment, and the lack of quantifiable criteria for identification. This list of candidates will be compared with the areas identified via the application of scientific models based on the conceptual framework.

The methodology for a quantitative approach to the identification of ABIAs namely, Habitat Supply Analysis (HSA), is described. This approach is being implemented with the aim of providing a complete assessment for fish ABIAs in the Lake Erie Basin ecosystem (lake, tributaries, and connecting channels) at SOLEC 2000. Meanwhile aspects of the approach are illustrated with results from prototype studies.

The conceptual framework and the components of the habitat supply methodology are used to formulate a comprehensive scheme of status indicators for ABIAs. ABIAs can be classified according to their class (healthy, damaged, lost, and missing), relative level of potential importance as a biodiversity investment areas (low, medium, and high), and their current status (as a percentage) derived from a composite assessment of the many habitat features characterizing the spatial units making up an ABIA. The ABIA classes are matched by ABIA management strategies: healthy – conservation, damaged – restoration, lost – creation, and missing – enhancement. The missing class represents new opportunities to enhance, reproduce, and connect existing ABIAs in overall efforts to restore the integrity of Great Lakes Basin ecosystems.

The next steps toward the creation of a comprehensive ABIA system are outlined.

1. Introduction

Identification of Biodiversity Investment Areas has become a preferred approach to conservation of biodiversity. In contrast to a species-by-species approach, focus on geographical areas provides conservation planning with a way of protecting threatened habitats, communities, and ecological processes on which a wide range of species depend. Strategic identification and protection of a fundamental set of Biodiversity Investment Areas thus results in the preservation of both known and unknown endangered or rare species and genetic diversity within species.

The Nature Conservancy (TNC, 1994) proposed the use of Natural Heritage programs to identify critical areas for maintenance of biodiversity in the Great Lakes Region. This approach was implicitly hierarchical and promoted the view that understanding and managing threats to regions of biodiversity required assessment of essential ecological systems that sustained biodiversity resources. This concept of identifying regions of high biodiversity was applied to terrestrial ecosystems within the Great Lakes basin (Reid and Holland, 1996). Regions of high biodiversity were classified using a landscape-scale analysis of ecologically significant bioregions and constituent ecosystems. Recently, The Nature Conservancy has attempted to consolidate this landscape-scale approach with hierarchical aquatic ecosystem classification for protection of aquatic biodiversity (Lammert *et al.* 1997). The proposed classification systems rely on nested spatial hierarchies, which relate climate influenced ecological provinces to large-scale biological and ecological patterns. Within an ecological province, geology and landforms entrain zoogeography and aquatic ecosystem patterns. In practice, this classification system depends on well-characterized plant communities to demarcate ecoregional provinces. Although aquatic ecosystems are climate and landscape influenced, their ecosystems are dominated by higher frequency dynamic processes. As Steele (1974) suggests, animals in aquatic ecosystems are the analog for plants in terrestrial ecosystems in terms of persistent biomass structure. Unlike plants, however, most aquatic animals are mobile, and the regulatory structures of aquatic ecosystems become inextricably linked to life-cycle ambits of dominant animal species. Consequently, a hierarchical classification of ecoregional provinces, based solely on landscape features, may prove too static to capture the important processes that regulate biodiversity resources in large-scale aquatic ecosystems such as the Great Lakes.

The basic challenge in developing a workable ABIA framework for aquatic ecosystems is to capture both static and dynamic regulatory components. Because fish biomass constitutes over half of the standing biomass of most lake ecosystems (cf. Kitchell *et al.* 1979), the approach we propose here is based on the relation of habitat structure to fish diversity and production. From the level of microhabitat description, this approach is quite compatible to landscape approaches (e.g. Lammert *et al.* 1997; Seelbach *et al.* 1997). It differs, however, in that it provides a biological connection of microhabitat structure to the regulation of ecosystem structure and function through the utilization of these habitat structures by fish throughout their life cycles.

1.1 Background

The importance of preserving the earth's biological diversity (biodiversity) was formally recognized in the Convention on Biological Diversity at the United Nations Conference on Environment and Development (UNCED) in 1992. Canada and the United States of America were among 138 countries that ratified the convention recognizing the importance of biological diversity to humanity's economic and social development. Biodiversity refers to the variety of organisms and the diversity of physical environments in which they occur and is recognized at genetic, species, ecosystem and sometimes

landscape levels of organization (U.S. Congress 1987, Noss, 1990). Preserving biological diversity is important because it:

- Provides opportunities for sustainable economic development
- Nurtures human welfare, and
- Enables the ecosystems to adapt to change

and for:

- The aesthetic values of natural ecosystems
- The contribution of land- and water-scapes to the emotional and spiritual well-being of today's highly urbanized human populations
- The cultural identity of many indigenous peoples
- The ethical reason that the earth supports many other life forms that warrant our respect, whether or not they are of benefit to humans (EPA, 1997).

Preserving and restoring habitats have been identified as the best strategies for preserving biodiversity (Arico, 1995; Gray, 1997). In 1996, SOLEC oversaw the designation of **Biodiversity Investment Areas (BIAs)** (See web-site 1.1). in the nearshore terrestrial environment of the Great Lakes. These **BIAs** were defined as clusters of places, called ecoregions, that have exceptional biodiversity value. Biodiversity value was assigned to an ecoregion based on characteristic shoreline types, significance of natural communities, existing representation in parks/protected areas, presence of a priority unprotected feature, land use, trend in shoreline health and, health of associated ecological communities. The purpose of identifying these areas was to draw attention to those nearshore terrestrial sections of shoreline with the greatest concentrations of biodiversity values. The United States and Canada, through the Binational process, decided to expand this effort to identifying similar areas for nearshore, offshore, tributary and coastal wetland environments in the Great Lakes Basin for SOLEC 1998.

1.2 Objectives and Approach

The objective of this study was to identify and, eventually, provide a scientifically defensible basis for the selection of, Aquatic Biodiversity Investment Areas (**ABIAs**) in the Great Lakes. An ABIA is defined as **a specific location or area within a larger ecosystem that is especially productive, supports exceptionally high biodiversity and/or endemism and contributes significantly to the integrity of the whole ecosystem**. These areas can be large (e.g.. a specific tributary and its receiving waters or a whole lake basin) or small (e.g. a coastal wetland, an offshore reef, an embayment, or a segment of shoreline). This definition is similar to but does not completely overlap that used for 'biodiversity hotspots' (Reid 1998). Hotspots are areas with high biodiversity and/or high incidence of endemics or rare species. The ABIA definition reaches beyond the idea of hotspots to encompass consideration of centres of high levels of natural, self-sustaining productivity and ecological integrity of ecosystems as envisaged in the successive versions of the Canada-U.S. Great Lakes Water Quality Agreement.

Fish biodiversity was chosen as the initial indicator of overall biodiversity for the assessment of ABIAs in the Great Lakes. Fish communities are well known to be excellent indicators of overall ecosystem integrity and health (Lyons *et al.*, 1995). Furthermore, preserving fish biodiversity is compatible with conservation of individual endangered species and populations (Lyons *et al.*, 1995). There is also evidence that high biodiversity areas for one taxonomic group are similar for other groups (Reid 1998).

This study of ABIAs in the Great Lakes Basin was developed in three phases. In the first phase, a conceptual, and methodological, framework was developed as a basis for placing the ABIA idea into an appropriate ecological and scientific context (Section 2 below). In the second phase, a survey approach was adopted as a means of identifying ABIAs. This survey is regarded as a short-term strategy for designating ABIAs. In the third phase, a scientifically defensible method of validating the identification of ABIAs is described and preliminary indication of its potential to accurately identify these areas is reported. It is regarded as a long-term strategy for identifying ABIAs (Section 4 below). In Section 5, the strength and weaknesses, and advantages and disadvantages of the different identification strategies are assessed along with the operational status of the ABIA concept. The report concludes with a set of recommendations for the future.

1.3 Context

This and similar efforts in SOLEC 1998 to identify and designate biodiversity investment areas (BIAs) parallel and complement other ecosystem management efforts in the Great Lakes Basin and beyond.

These related efforts include the overarching concepts of the Ecosystem Approach and their practical implementation in the Remedial Action Plans (RAPs) for designated Areas of Concern (AOCs) and Lakewide Management Plans (LaMPs) to be developed for each Great Lake under the terms of successive revisions of the Great Lakes Water Quality Agreement. The scope of that agreement has been progressively expanded from a focus on water quality issues to the widest consideration of ecosystem health throughout the basin, including the lands, the waters, the air, the peoples, the economic activities, etc. The BIA efforts complement the Ecosystem Approach in recognizing that conservation and restoration of biodiversity requires the conservation, restoration, and, where necessary because of past indifference or neglect, creation of habitats and ecosystems.

The Great Lakes Fishery Convention Act (1955) and the Strategic Great Lakes Fishery Management Plan (SGLFMP, 1980 And revised 1997) recognize the important role of fishery and other agencies in management and conservation of fisheries, fish productivity, and the ecosystems supporting them. Part of SGLFMP commits the signatory agencies to the development of complementary sets of fish community and environmental objectives for each Great Lake. In the recent revision of SGLFMP, the agencies recognized that those objectives have to be developed in the context of ecosystem management. This study of ABIAs, focused on fish biodiversity, is based on concepts consistent with the goals of the SGLFMP objective setting.

Beyond the Great Lakes Basin, the 1996 reauthorization of the Magnuson Fishery Conservation and Management Act, now known as the Magnuson-Stevens Act, with respect to federally managed marine fish stocks in the United States required that ‘essential’ habitats for these stocks be identified as a major step toward increasing the management of habitat as a requisite component of stock management. The National Marine Fisheries Service, U.S. Department of Commerce, is responsible for completing essential habitat plans. These activities, that bring stock and habitat management closer together, parallel the ABIA assessment process. Similarly in Canada, the 1986 Policy for the Management of Fish Habitat, while lacking a clear mandate for the conservation of fish biodiversity per se, directs agencies to develop area fish habitat management plans as a basis for managing future threats from development activities and for ensuring that the requisite natural, self-sustaining productivity of habitats supporting fish production and harvests be maintained.

2. Conceptual Framework

As the arenas of ecosystem management are often made more complicated through the use of terms such as biodiversity, integrity, health, *even* ecosystem, etc., whose meanings or interpretations are often contentious, this section presents an attempt to ground the BIA, and particularly the ABIA, ideas on current ecological science, especially aquatic ecosystem science.

2.1 For Biodiversity Investment Areas in the Great Lakes Basin

Biodiversity Investment Areas (BIA) are geographical regions rich in critical habitat for a number of species. Reid and Holland (1996) identified 19 BIAs representing important large core areas of shoreline habitat in the Great Lakes region. The ecoregions represented by these BIAs have characteristic sets of climate and physical features that develop unique assemblages of plants and animals. For shoreline BIAs, plant communities are important indicators of status and serve as benchmarks for restoration. Extending the BIA concept into lakes requires a change of indicators. Because watershed processes influence the structure of aquatic communities, some correspondence between identified shoreline BIAs and Aquatic Biodiversity Investment Areas (ABIAs) is bound to occur. However, plants are much less important regulators of community structure in aquatic ecosystems, and physical and chemical factors are correspondingly more important determinants of local biodiversity. The central challenge of identifying ABIAs within the Great Lakes is thus finding a set of criteria that demarcate habitat structures that are important to maintenance of lake-wide biodiversity and that regulate structure and productivity of lake ecosystems.

2.2 For Fish Biodiversity in the Great Lakes Basin

Like plants in terrestrial systems, animal communities provide persistent structure for aquatic ecosystems. One way to differentiate ABIAs is to evaluate habitat through effects on fish abundance and distribution. Figure 2.1 represents a conceptual framework with which to organize identifying characteristics of ABIA sites. The framework consists of three primary axes: Spatial Units (or Locations), i.e., landscape features that together comprise an ABIA; Habitat Attributes, i.e., qualities that describe these spatial units such as water chemistry, temperature, depth, substrate type, etc.; and Fish Species by Life Stage. All three axes are categorical. Intersection cells represent the suitability of a particular Spatial Unit within a specific ABIA for a particular life history stage of a single species of fish. Projections onto planes of the axes are integrated summaries of Habitat Attributes. An ABIA is thus defined as a set of specific Spatial Units with their associated Habitat Attributes. The intersection of the Fish Species/Life Stage and Spatial Unit axes indicate the fish biodiversity supported by that ABIA, and the intersection of each Fish Species/Life Stage with Habitat Attribute axes represents the niche space.

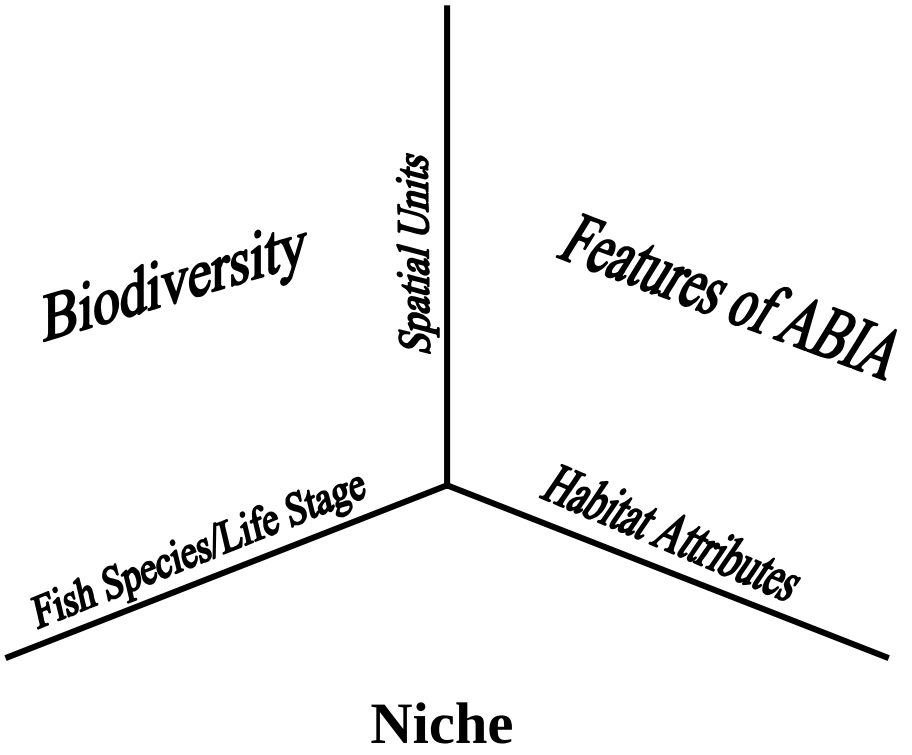
An advantage of the ABIA framework in Figure 2.1 is its reliance on readily discernable axis components. Spatial Units are specific geographical features such as tributaries, embayments, beach littoral zones, wetland littoral zones, pelagic zones, submerged reefs, and profundal regions that together comprise an ABIA. Each Spatial Unit may have subcategories but identification by location, and hierarchical organization, limits category overlap. Furthermore, no two ABIAs will be the same. ABIAs may have the same types of Spatial Units (ex. beach and embayment) but the Habitat Attributes that describe these Spatial Units will be unique to a geographical location and hence an ABIA. Selection of Habitat Attributes, for use in the framework, depends on relevance to fish abundance and distribution.

These attributes will include a range of physical, chemical, and biological characteristics, but the attributes chosen must allow consideration of current, potential, and desired state of the ABIA. Assessment of ABIAs can be conducted through an aggregate consideration of the habitat requirements of all fish species and life stages. The methodology to enable this approach will be outlined in section 4 below.

More focused assessments of economically important, rare and endangered species or invading species is also feasible, especially where more detailed knowledge of life stage habitat requirements (niche) is available. Such analyses will not be described in this report but such assessments are under development and will be reported later. Those assessments will allow for a more explicit consideration of the spatial and temporal interconnections and interactions between locations serving different life stages of particular species. The framework provides the basis for tracking habitat constraints throughout the life cycle of a species. Thus locations that serve as corridors connecting essential habitats for consecutive life stage may in a static analysis not appear to be critical or limiting. However, if the connection is broken or disrupted, the value of the adjacent ABIAs may be diminished or lost.

The use of fish abundance and distribution data to identify ABIAs and to indicate status of in-lake habitat is conceptually appealing and more scientifically defensible than approaches that rely too heavily on intuition. Although habitat constraints are only one of several factors that regulate aquatic community structure, a growing body of evidence suggests that availability of habitat can have important effects on both biodiversity and relative abundance of economically important fish. Because of their ability to exert a "top-down" control on aquatic ecosystems, species composition and abundance of fish influence the diversity and structure of other species. For example, excessive abundance of detritivorous species, like Carp, can have a deleterious effect on littoral aquatic vegetation. Through effects on reproduction and survival of early life history stages and through effects on growth and survival of juvenile and adult fish, habitat limitations have the potential to limit the productive capacity of aquatic ecosystems, their ability to respond to invasion of exotic species, and their overall stability. The framework in Figure 2.1 thus lends itself to diagnostic analysis of factors contributing to loss of fish productivity as well as restoration analyses that would indicate levels of habitat availability that would provide various desired levels of abundance and distribution of fish.

Figure 2.1. Conceptual framework for the identification and validation of aquatic biodiversity investment areas (ABIAs), linking biodiversity, habitat attributes, and spatial units.



3. Identification of Candidate Aquatic Biodiversity Investment Areas (ABIAs)

A mail-out questionnaire was the first approach used to identify Aquatic Biodiversity Investment Areas (ABIAs). The following sections describe this approach and the results.

3.1 Survey Methodology

Seven hundred experts in Great Lakes ecology from Canada and the United States were identified using the SOLEC mailing list database. A questionnaire (Appendix 1) was prepared and mailed to those experts. Recipients were also asked to copy and further distribute the questionnaire to other experts in their organization or group, experts who may not have been included in the original mailing list.

The questionnaire required an ABIA nomination, a detailed description of the site and, attributes of the site that made it a good candidate for an ABIA. Recipients were asked to complete a separate questionnaire for each nomination. An ABIA was defined as a specific location, or area within a larger ecosystem, that is especially productive, supports exceptionally high biodiversity and/or endemism and contributes significantly to the integrity of the whole ecosystem. The questionnaire required the nominator to:

- Identify the candidate as specifically as possible
- Indicate its general position in a lake or connecting channel basin
- Describe the main spatial units using elements in a generic classification scheme, supplemented with commentary where needed
- Select up to 3 items from a list of possible reasons for the candidacy
- Indicate at the life stage, species and community level supported by the site
- Add any addition comments or explanation

Most respondents completed the check-off portions of the questionnaire and many provided commentary information, often supplemented with other printed material. The results from the questionnaires were compiled in a GIS compatible database and mapped using ArcView® application by ESRI Corporation. Geographical coordinates for candidate sites were obtained where available from two web-sites (1.2 and 1.2). Otherwise, coordinates were read from large-scale paper maps.

3.2 Survey Results

To date, 168 sites have been nominated as ABIAs by 92 experts (Appendix 2 – Detailed Summary of ABIA Survey Responses). Thus, the response rate was approximately 11.5 percent, a rate considered typical for mail-out questionnaires.

The sites are distributed throughout the Great Lakes Basin (Figure 3.1). Most of the sites (74 %) are in the lakes compared to the connecting rivers and most sites are in the upper lakes (Figure 3.2).

Most of the sites were selected because they exhibit a number of important attributes. The majority of sites were indicated to support 'high biodiversity' (49%), to be 'very productive' (48%) and have 'high habitat diversity' (33%) (Figure 3.3). The next most frequently selected attributes described the sites as 'critical for rare species' and 'critical for economically important species'.

The majority of sites were characterized by more than one location feature (Appendix 2). The most common location features, characterizing the sites, were 'tributary' (66%), 'wetland' (65%) and/or 'embayment' (36%) (Figure 3.4). 'Shorelands', 'nearshore reefs', and 'islands' were the next most frequently selected features.

39 of the 168 ABIA nominations are located within Areas of Concern (AOCs) designated by the International Joint Commission (Table 3.1).

3.3 Evaluation

Questionnaires, completed by experts, provided valuable information about the location, characteristics and attributes, and significance of potential ABIAs. Although expert nominations can provide supporting evidence for validating ABIA selection models, used explicitly, they do not provide scientifically robust results because of several methodological shortcomings. These shortcomings include:

- Low response rate of experts to the request for ABIA nominations (11%)
- Uneven distribution of experts throughout the Great Lakes resulting in a biased geographical distribution of ABIAs
- The competence of the experts to identify ABIAs cannot be assessed or compared.

Other shortcomings arise because some areas have been studied more intensively than others. This discrepancy increases the likelihood that intensively studied sites will be nominated more frequently than lesser-studied areas. For example, the AOCs represent a small proportion of the total area of the Great Lakes Basin but 23 percent of ABIAs were located in AOCs. Also, the constant flux in the pool of Great Lakes experts results in a loss of 'institutional memory' of sites that may have been studied in the past but that are no longer being studied. This may also affect the likelihood of a site being nominated. Furthermore, not every site that is nominated by experts would be considered a good ABIA candidate. An example of this last point, is the nomination of NIPSCO Dean Mitchell Generating Station discharge outlet in Illinois as an ABIA. The warm water from this discharge outlet attracts a number of fish species but the site itself is not characterized by habitat features that support sustainable aquatic biodiversity. Some of the shortcomings might be addressed by amending the questionnaire to gather additional data. However, the shortcomings of the expert nomination process for selection of ABIAs, highlight the need for the development of a scientifically defensible approach.

Table 3.1. Tabulation of ABIAs associated with designated Great Lakes' Areas of Concern**.**

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
2	Humber Bay Marshes	Ontario	Wetland	High Productivity High Habitat Diversity High Connectivity Value	It is a well developed wetland in an urban setting.	It has important recreational and educational value. Active feeding site for colonial waterbirds and wading birds. There is a presence of fur bearing mammals and seasonal fish spawning. Fish found in the area include rainbow trout, rainbow smelt, white sucker.	Mr. C. Gonsalves (Emery Creek Environmental Association)
3	Nipigon River/Nipigon Bay	Superior	Tributary Embayment	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species High Habitat Diversity	It is at Nipigon which is east of Thunder Bay.	This is a high productivity area and is world renowned for speckled trout. It is widely used by resident and non-resident anglers and commercial fishermen. River has a high biodiversity of fish species and a remnant population of brook trout. It is the last refuge for coaster brook trout, recovering Lake Sturgeon and walleye population,and the biggest tributary to Lake Superior.	Mr. Joe Coghlan (OFAH) Mr. Bob Thomson (Lake Superior Management Unit, OMNR) Mr. Ed Iwachewski (OMNR - Centre for Northern Forest Ecosystem Research)
4	Presque Isle Bay and Associated Wetlands	Erie	Wetland Embayment Beach	High Biodiversity Critical for Rare Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature	Sandspit arcs back towards mainland to form large, shallow embayment with aquatic plant beds, emergent marsh, shallows, beaches and mussel beds.	There are rare sp. including bowfin, spotted gar, Iowa darter, lake sturgeon, e. sand darter, Great Lakes muskellunge. Approximately 20 species of freshwater mussels and several rare fish; productivity is likely high and species diversity including peninsula is one of highest for Lake Erie; including plants and habitats in general.	Mr. Roger Kenyon (Pennsylvania Fish and Boat Commission) Mr. Charles Bier (Western PA Conservancy)
8	St. Lawrence River	St. Lawrence	Tributary Wetland Embayment Shorelands Islands	High Biodiversity High Productivity Critical for Economically Important Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature	It is located in the Massena/Cornwall area. Three tributaries, the Grouse, Rarquette, and the St. Regis Rivers flow into the St. Lawrence which flow through the St. Regis Mohawk Reservation. It is the migratory route for economic species such as american eel, also growth habitat for eel.	It is the main nursery and migratory habitat for eels that are the basis of a commercial fishery - also member of the predatory fish community.	Mr. Shawn Martin (St. Regis Mohawk Tribe) Dr. Peter Hodson (School of Environmental Studies, Queen's University)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
31	Thunder Bay	Huron	Tributary Wetland Reef Nearshore Embayment Pelagic Shorelands	High Biodiversity Rare Habitat Feature	There are shipwrecks located here. Some of the last remaining Great Lakes shoreline wetland habitat.	It should be considered as a marine sanctuary.	Mr. Alfred Beeton (Great Lakes Research Laboratory) Dr. Dave Fielder (Michigan DNR)
32	Black River draining into Prince Edward Bay	Ontario	Tributary Wetland	High Biodiversity High Productivity Rare Habitat Feature High Connectivity Value	There is a lengthy low relief tributary with extensive emergent/submergent vegetation. Somewhat degraded due to agricultural land use.		Dr. Charles Minns (Dept. of Fisheries and Oceans)
33	Cootes Paradise and Hamilton Harbor	Ontario	Wetland Embayment	High Biodiversity High Productivity High Connectivity Value	It is undergoing restoration, and surrounded by urbanization and upstream agricultural stresses.	It is a critical part of a sequence of connected streams, wetland, bay, open lake, shore areas and open lake pelagic.	Dr. Charles Minns (Dept. of Fisheries and Oceans)
39	Saginaw Bay	Huron	Tributary Wetland Reef Nearshore Embayment	High Biodiversity High Productivity Critical for Economically Important Species High Habitat Diversity	Very large stands of emergent grass wetlands and nearshore rocky bottom that are highly productive which support a rich and diverse flora and fauna. It is in East Central Michigan. Saginaw Bay offers a huge variety of habitat types.	Saginaw Bay supports a rich flora and fauna through high rates of primary productivity and very protected shallow waters among the emergent grasses. It is the largest warm-water embayment in Lake Huron. Saginaw Bay and tributaries support extremely valuable sport fisheries for a variety of species, principally yellow perch and recovering walleye populations. The bay also supports a commercial fishery for whitefish, yellow perch and other species. The bay is home to a huge variety of species from warm water to cold water.	Dr. Russell Moll (Michigan Sea Grant) Mr. James Baker (Michigan DNR) Dr. Dave Fielder (Michigan DNR)
54	Maumee River	Erie	Tributary Embayment Shorelands	Critical for Economically Important Species		Reproductive habitats for life stages are linked by physical processes and function as a unit. Reproductive center - these habitats are critical/essential in that they exist no where else in space or time for this stock.	Mr. David Davies (Ohio Division of Wildlife)
63	St. Clair River Delta/Lake St Clair	Erie	Wetland Embayment Shorelands Islands	High Biodiversity High Productivity Critical for Rare Species Rare Habitat Feature High Connectivity Value	It has submergent and emergent macrophytes, and shallow, warm and productive waters. Migratory route for valuable fish populations from lakes Erie and Huron.	One of the last remaining stretches of natural shoreline, spawning and nursery ground for numerous fish species. Most diverse native plant, vertebrate, and invertebrates community in Great Lakes.	Dr. Tim Johnson (Ontario Ministry of Natural Resources) Mr. Robert Haas (Michigan DNR)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
67	St. Louis River	Superior	Tributary Wetland Embayment	High Productivity Critical for Rare Species Critical for Endangered Species	It is a large commercial harbor; area of concern with high value habitat and the largest US tributary to Lake Superior.	Contains a common tern nesting site; walleye spawning area for western Lake Superior; sturgeon restoration; significant remaining wetlands.	Ms. Karen Plass (St. Louis River Citizens Action Committee)
68	Humbug Marsh, Detroit River	Erie	Wetland	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species Critical for Endangered Species Rare Habitat Feature High Connectivity Value	Last remnant Great Lakes coastal marsh on the 32-mile Michigan shoreline of the Detroit River.	Migration route for the 117 species of fish that inhabit the Great Lakes; for the 27 species of waterfowl that frequent Michigan's coastal wetlands; the more than 17 species of raptors, including eagles, hawks, and falcons; the more than 48 species of non-raptors, including loons, warblers, neotropical songbirds, cranes, and cattle egrets, and numerous species of butterflies that migrate annually from Canada to the southern United States and South America.	Dr. Bruce Manny (U.S. Geological Service)
73	St. Mary's River	Huron	Wetland Reef Nearshore Islands	High Biodiversity High Habitat Diversity High Connectivity Value	The St. Mary's offers not only a variety of habitat but also some unique environmental conditions.	The river offers a blend of many habitat types.	Dr. Dave Fielder (Michigan DNR)
114	Milwaukee River Estuary		Tributary Shorelands	High Biodiversity Critical for Economically Important Species Rare Habitat Feature	It is approximately 1200 acres in size, has high angling pressure, and a walleye restoration project is ongoing. There is high zebra mussel impact, and a yellow perch nursery area. (lower Milwaukee River and the outer and inner harbors, Milwaukee, WI)	It is an area of high public interest, and is an urban location with a high degree of change over the past 10 years.	Mr. Jim Thompson (Wisconsin DNR)
117	Severn Sound	Huron	Tributary Wetland Shorelands Islands	High Biodiversity High Productivity High Habitat Diversity	There are extensive fringing wetlands, islands, and submerged reefs.	There are shallow, nutrient rich waters, combined with geological transition zones that create conditions for the development of a complex fish community.	Mr. Arunas Liskauskas (Ontario MNR)
121	Bay of Quinte	Ontario	Tributary Shorelands	High Biodiversity High Habitat Diversity Critical for Economically Important Species High Connectivity Value	This is a very significant breeding area. Millhaven Creek is a possible salmonid spawning area. There are large beds of aquatic macrophytes and also pelagic habitat. Over 5000 ha of wetlands are within 3.2 km of the shoreline.	It is very important to the fisheries of Eastern Lake Ontario. Important sport (e.g. walleye) and commercial fisheries. There are sturgeon, walleye, and other fish that spawn in the tributaries and also it is important for waterfowl and other aquatic birds.	Mr. Jack Odette (OFAH) Mr. Andy Smith (OMNR)
124	McVicar' Creek	Superior	Tributary	High Habitat Diversity	McVicar's Creek is in the city of Thunder Bay.	This is very important spawning habitat and should be maintained in the future.	Mr. Joe Coghlan (OFAH)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
151	Bluffers Park	Ontario	Reef Nearshore Embayment	High Productivity High Habitat Diversity	It is a major embayment complex. There is an existing mosaic of habitat components including extensive areas of submerged aquatic vegetation, deep water areas, warm water thermal habitat, open coast shoreline of beaches headland, and are important spawning areas for pelagic forage fish and one section provides lake trout spawning habitat.	A significant embayment complex that provides important sheltered warm water habitat. Focus of restoration activities that are treating storm water and developing important wetland habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
152	Convex shoreline profile offshore from the East Point Waterfront area	Ontario	Pelagic Profundal	High Productivity High Habitat Diversity	It is the only convex shoreline profile along the Toronto waterfront, and is somewhat rare along the north shore of Lake Ontario. The convex shoreline profile is a major attraction and is an important habitat for pelagic fish.	The convex shoreline profile attracts a variety of pelagic fish.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
153	Highland Creek Coastal Marsh	Ontario	Tributary Wetland	High Productivity High Habitat Diversity	There is a wetland complex, corridor area to the highland creek watershed, moderate areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, creek mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	The moderate wetland complex provides important sheltered warm water habitat. The focus of restoration activities is to treat storm water and develop important wetland habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
154	Rouge River Coastal Marsh	Ontario	Tributary Wetland	High Productivity High Habitat Diversity	There is a wetland complex, a corridor area to the Rouge River watershed, extensive areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, river mouth and marsh which are important spawning areas, and significant opportunities for restoration exist.	There is an extensive wetland complex that provides important sheltered warm water habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
155	Duffin's Creek Coastal Marsh	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex, and there are extensive areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, river mouth and marsh which are important spawning areas, and there are significant opportunities for restoration activities.	The extensive wetland complex provides important sheltered warm water habitat and it is the only location for brook silverside on the Toronto Waterfront, which has a limited distribution.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
156	Frenchman's Bay Coastal Marsh	Ontario	Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex, and extensive areas of submerged aquatic and emergent wetland vegetation. It is a warm water thermal habitat, and the river mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	There is an extensive wetland complex that provides important sheltered warm water habitat. It is the only location for brook silverside on the Toronto Waterfront.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
157	Carruther's Creek Coastal Marsh (Shoal Point Marsh)	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex with a corridor area to the Carruther's Creek watershed, and there are extensive areas of submerged aquatic and emergent wetland vegetation. It is a warm water thermal habitat and the river mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	The extensive wetland complex provides important sheltered warm water habitat with significant productivity within the marsh.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
158	Colonel Sam Smith Park	Ontario	Wetland Reef Nearshore Embayment	High Biodiversity High Productivity High Habitat Diversity	There are restoration activities including modification to the boat basin shoreline to diversify and improve fish production, the creation of a wetland complex, and open coast shoreline modification which provides lake trout spawning shoals. It is a diverse warm water fish community, with bass and pike.	It is a significant sheltered warm water habitat and it provides high productive capacity for warm and cold water species. It is somewhat isolated from water quality impacts of the city.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
159	Mimico Creek Estuary (Humber Bay Park Complex)	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	It is a major restoration area, and activities will develop an important estuary wetland complex.	It is a significant sheltered warm water habitat, and restoration activities will provide improved productive capacity for warm water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
160	Humber Bay Shores (Humber Bay Park Complex)	Ontario	Wetland Reef Nearshore	High Productivity High Habitat Diversity	There are major restoration activities that will develop an important mosaic of habitat components including islands. There are areas of submerged aquatic vegetation, cobble beaches, a wetland complex, and specific spawning areas for bass and northern pike.	It is a significant sheltered warm water habitat, and has open coast habitat and shoreline diversification. Restoration activities will provide improved productive capacity for warm and cold water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
162	Humber River Marsh	Ontario	Tributary Wetland Embayment	High Biodiversity High Productivity High Habitat Diversity	It is a major coastal wetland complex and corridor. The existing mosaic of habitat components includes sheltered backwater lagoons, extensive areas of emergent wetland vegetation, and an estuary corridor.	It is a significant coastal marsh complex with significant sheltered warm water habitat. There is a corridor connection between the lake and river habitats. The Humber marshes have significant productive capacity and local biodiversity for warm water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
163	Toronto Bay (Toronto Inner Harbour)	Ontario	Embayment	High Productivity High Habitat Diversity	It is a major embayment complex. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, deep water areas, warm water thermal habitat, and river discharge.	It is a significant embayment complex that provides important sheltered warm water habitats, which are the focus of planned restoration activities.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
164	Toronto Islands (Toronto Inner Harbour)	Ontario	Embayment Shorelands Islands	High Biodiversity High Productivity High Connectivity Value	This is a major embayment complex. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, sheltered lagoons, deep water areas, warm water thermal habitat, and critical spawning juvenile and adult habitat.	It is a significant embayment complex that provides important sheltered warm water habitat, and is a centre of productivity and biodiversity that supports and feeds adjacent habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
165	Tommy Thompson Park	Ontario	Reef Nearshore Embayment	High Biodiversity High Productivity High Connectivity Value	This is a major landform with extensive natural shorelands and embayments. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, sheltered lagoons, deep water areas, warm water thermal habitat, and critical spawning juvenile and adult habitat.	This is a significant embayment complex that provides important sheltered warm water habitat, and is the centre of productivity and biodiversity that supports and feeds adjacent habitats. It has excellent potential for restoration of critical habitats. There is functional nearshore spawning of lake trout on the open coast where the 10 m depth contour intersects the shore.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
166	Open coast shoreline from Ashbridges Bay Park (Toronto) to Carruther's Creek (Durham Region)	Ontario	Shorelands Beach	Critical for Economically Important Species High Connectivity Value	There is a major open coast landform with extensive areas of natural beach and various shoreline protection works (groynes, beach headlands, revetments). Existing mosaic contains open coast habitat, sand, cobble, and gravel beaches, headland, groynes, and revetments. Restoration activities are focused at providing nearshore reefs and maintaining the beach profile.	This is a significant open coast shoreline with extensive sand gravel and cobble beaches. It is the centre of productivity and biodiversity for pelagic forage fish species that supports and feeds the economically important pelagic salmonids. The open coast shoreline is extensively utilized by juvenile salmonids and adult salmonids that utilize the shoreline during coldwater periods and staging into the tributaries that connect to the lakes. It has excellent potential for restoration of critical open coast habitat.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
167	Headwaters of Etobicoke Creek north of Mayfield Road, west of Hurontario Street	Ontario	Tributary	High Biodiversity	There are several small tributaries with permanent flow.	It is a remaining tributary in watershed with rural land use and it still supports a healthy diversity of fish species. It is an eventual seed source for the rest of the watershed.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
169	Main Humber River/Niagara Escarpment to Humber Bay on Lake Ontario	Ontario	Tributary	High Biodiversity High Productivity Critical for Rare Species	Includes the Main Humber subwatershed and associated tributaries north of junction with east Humber.	It is a highly diverse habitat which supports high biodiversity. Nominated as a heritage river.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
170	Little Rouge Creek (subwatershed of the Rouge River watershed)	Ontario	Tributary	High Biodiversity High Productivity Critical for Rare Species		There is an opportunity to protect large areas of riparian habitat due to public ownership (federal and provincial) and thus the protection of aquatic communities.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
171	East Duffins Creek	Ontario	Tributary	High Biodiversity Critical for Economically Important Species	It is a subwatershed of Duffins Creek watershed.	It is principally a cold water stream with potential to support Atlantic salmon.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
172	East Don River in the Don River watershed	Ontario	Tributary	High Habitat Diversity	Located from Oak Ridges Moraine to the confluence with the west Don including the tributaries.	Has high potential to rehabilitate for a variety of sensitive fish species. It is a diverse habitat transition from ORM to near Lake Ontario.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
173	Lake Wilcox	Ontario	Tributary	High Biodiversity High Productivity Critical for Economically Important Species	It is a kettle lake on Oak Ridges Moraine.	It is a kettle lake in an urbanizing area. There is an opportunity to preserve and rehabilitate the habitat and species and link to community outreach.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)

Table 3.1 continued

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
174	Morningside Park and Colonel Danforth Park	Ontario	Tributary	High Biodiversity High Habitat Diversity	They are tributaries in public parks in the middle and lower reaches of the watershed.	There is an opportunity to preserve and rehabilitate the river processes and associated fish species.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)

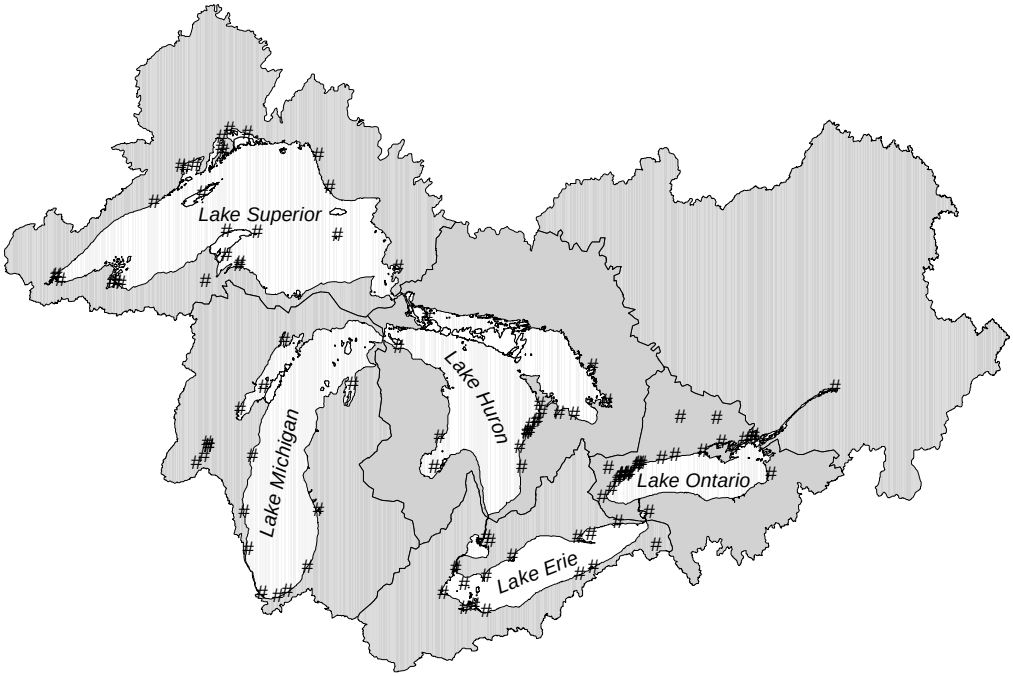


Figure 3.1. A map of the Great Lakes and their drainage basins showing the distribution of candidate ABIAs identified by experts in survey responses.

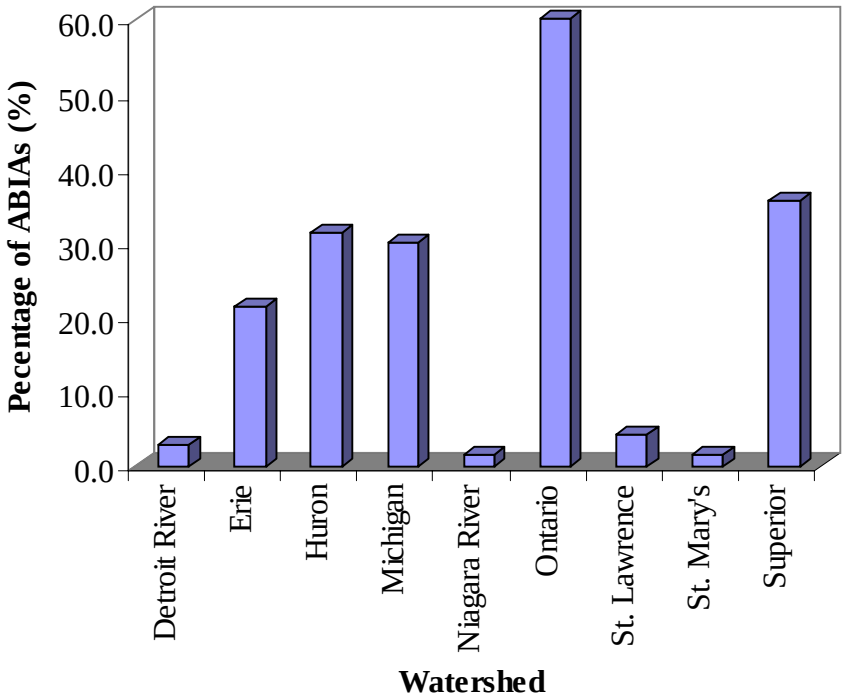


Figure 3.2. The percentage frequency distribution of candidate ABIAs among the Great Lakes and connecting channels.

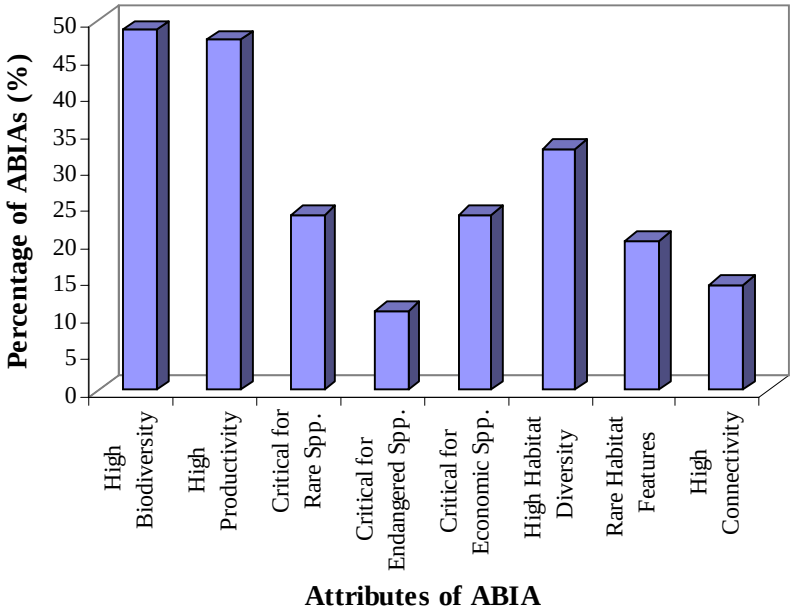


Figure 3.3. The percentage frequency of occurrence of various selection criteria among candidate ABIAs.

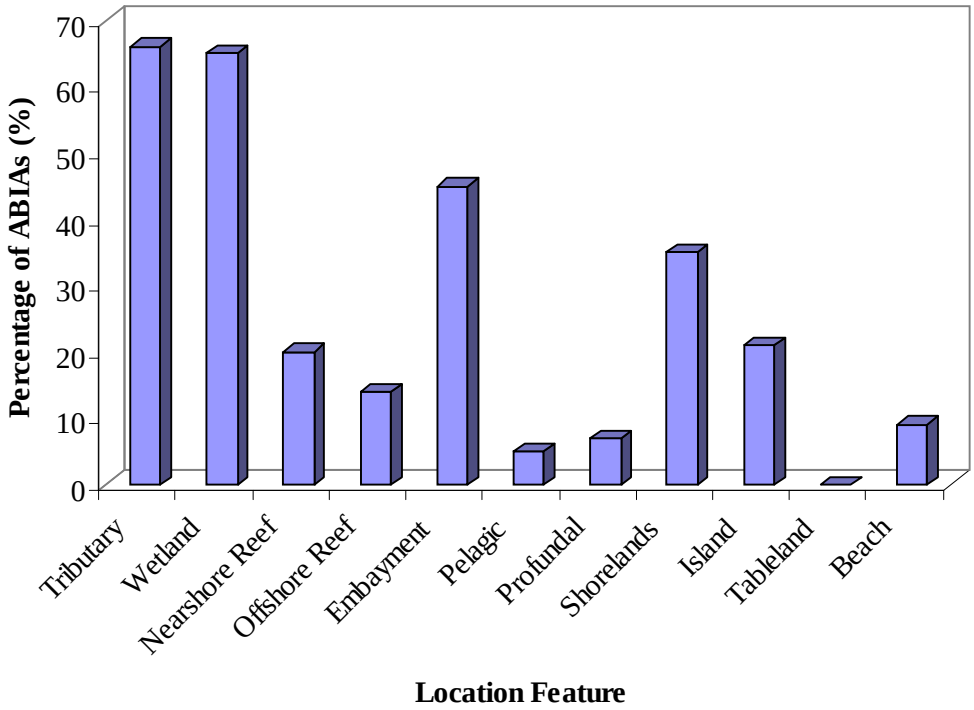


Figure 3.4. The percentage frequency of various spatial unit types among the candidate ABIAs.

4. Validation of Candidate ABIAs Using Habitat Supply Analysis

The conceptual framework (Section 2 above) provided the template for a method of identifying ABIAs for all biodiversity and, particularly, for fish biodiversity. In this section, an approach to translating the conceptual framework into an operational tool is described. Prototype results illustrate what might be expected when a habitat supply analysis is completed for the Lake Erie Basin. A science-based, reproducible methodology will:

- Decrease reliance on a limited and changeable pool of experts able to recognize ABIAs
- Allow the identification of ABIAs in more remote and less studied areas of the Great Lakes, and
- Contribute to the development of more extensive mapping of BIAs in the Great Lakes basin and beyond
- Once ABIAs are identified, efforts can be taken to conserve and/or restore these areas as needed to attain overall ecosystem management goals and objectives.

4.1 Habitat Supply Analysis

Habitat Supply Analysis (HSA) is a data synthesis and integration methodology that enables implementation and testing of the conceptual framework described earlier. The three primary surfaces, defined by the axes of the conceptual matrix (Figure 2.1), may be visualized as elements in an equation that predicts locations of high biodiversity from the product of fish habitat suitability models and the characterization of locations using a range of habitat attributes. The primary objective of the HSA portion of this project is to test the powers of fish species/life stage-habitat attribute suitability models. These models are used, in combination with GIS-based representations of the Habitat Attributes of each Spatial Unit, to predict observed patterns of Fish Species/Life stage in each Spatial Unit. The predicted patterns of Fish Species/Life stage in each Spatial Unit represent the biodiversity at an ABIA.

Application of this HSA approach, to validating the identification of ABIAs, does not preclude other methodologies for identifying ABIAs or other applications of HSA. Indeed HSA, as applied to fish, is envisioned as the central resource for information and assessment in the development and implementation of Area Fish Habitat Management Plans (AFHMPs). Such plans can provide:

- A habitat inventory in a GIS-based information system with analytical capabilities.
- An overview and context for planning biodiversity and habitat conservation and restoration priorities.
- A means of identifying key habitat features and significant locations.
- A direct link to fishery resource management wherein habitat objectives are marshalled in support of fisheries objectives.
- A solid guide for development activities and regulatory actions by conservation authorities and local governments. If you have a colour-coded map, you can get that consideration built into local planning documents and guidelines.
- A context in which site-specific activities can be assessed.

The current project, to validate the ABIAs identified by experts, is consistent with the wider applicability of AFHMPs.

The present HSA approach is consistent with, and derives elements and concepts from, a number of previous efforts to address conservation and protection of natural ecosystems. Previous efforts include the HEP-HSI approach of USFWS (USFWS 1981, Terrell *et al.* 1982) and GAP analysis (Scott *et al.*, 1993).

4.2 Components of Habitat Supply Analysis for ABIAs

There are four main components in the application of HSA:

1) Fish species/Life stage-Habitat Attribute Suitability Modelling,
2) Habitat Attribute-Spatial Unit Mapping,
3) Spatial Unit-Fish species/Life stage Suitability Mapping (Biodiversity Mapping), and
4) Comparison of Biodiversity Maps with the Distribution of ABIAs.

Implementation of these steps is planned for both a generic assessment of fish species biodiversity and a specific assessment of the suitability of habitat to fish species of special interest. The sequence described below is given in detail for the generic assemblage assessment. This same sequence would be followed for a species level assessment.

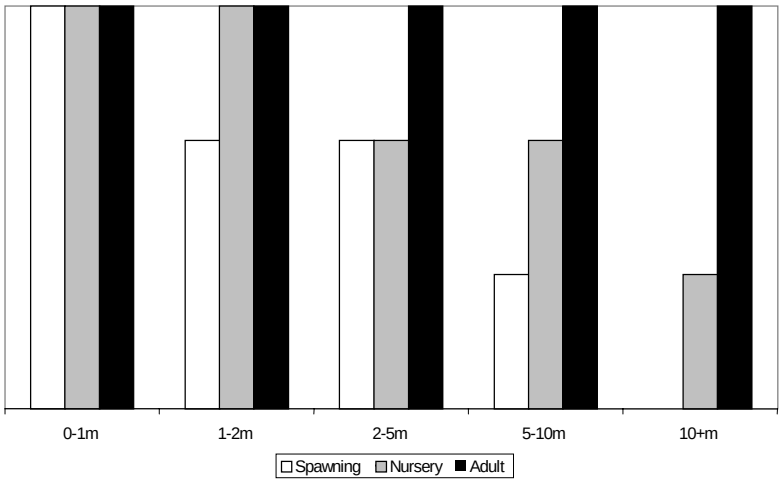
4.2.1 Fish species/Life stage-Habitat Attribute Suitability Modelling

The approach to habitat attribute suitability index modelling is based on the Defensible Methods approach developed by Minns *et al.* (1996, 1997, 1998a,b). At present, the modelling scheme has only been implemented for lacustrine fish habitat but a corresponding scheme for streams is under development. Concepts in the modelling approach are applicable to any taxon or grouping of biodiversity in any ecosystem type. The approach to modelling lacustrine fish habitat suitability index values has several steps that address the suitability of habitat to fish proceeding hierarchically from; various life stages of individual fish species; individual fish species; groups of fish and; fish assemblages.

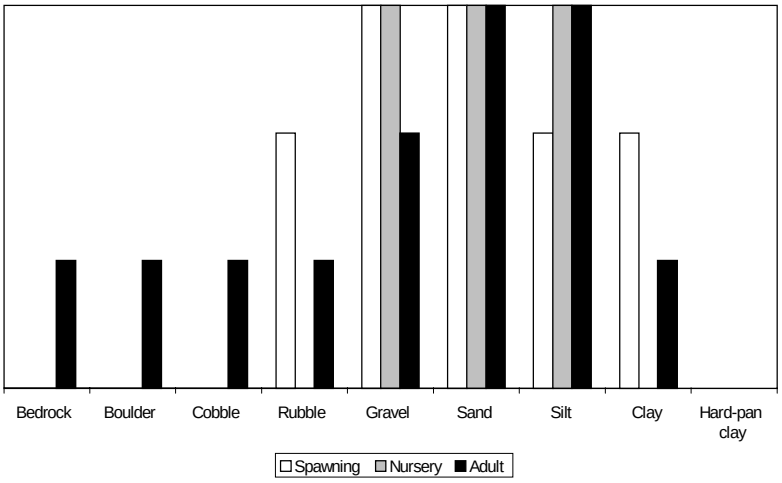
<u>Life stage suitability</u>:

- Simple suitability ratings are assembled by habitat attribute (Depth, substrate, and cover) for each life stage of each species in the assemblage being considered. Ratings of nil, low, medium, or high for each category of each attribute are rendered on a numerical scale as 0.0, 0.33, 0.67, and 1.0. Sample ratings for yellow perch, *Perca flavescens,* are shown in Figure 4.1. Aggregate assessments by life stage of habitat preference across the whole fish assemblage present in the Great Lakes show the high importance of shallow waters with softer substrates like sand and silt and with vegetation present (Figure 4.2).
- The suitability index value, of combinations of one category per habitat attribute across the set of attributes, is computed as the product of the simple independent suitability values. This creates a matrix, or cube, of suitability values (Figure 4.3).

A)



B)



C)

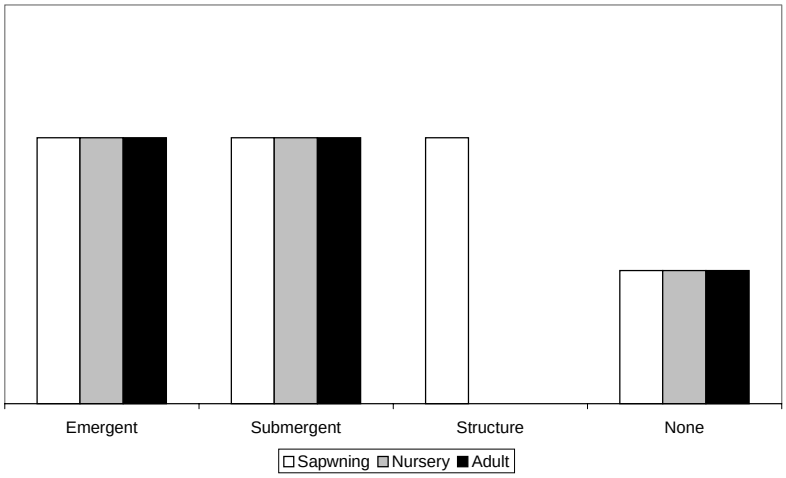
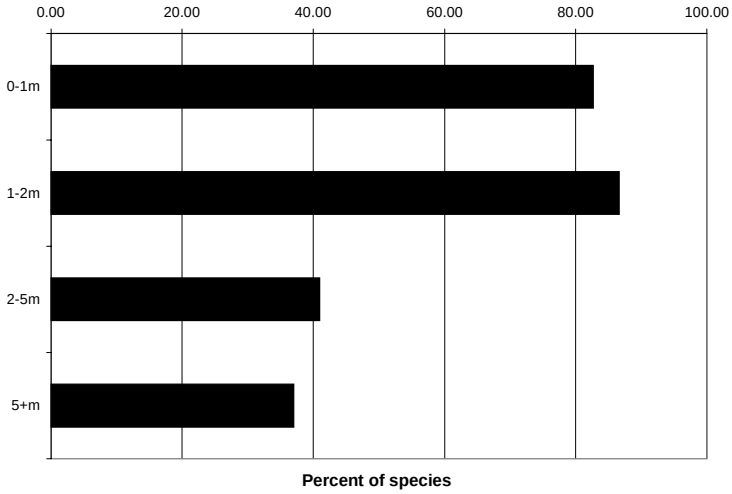


Figure 4.1. Habitat suitability ratings compiled for yellow perch, *Perca flavescens*, by habitat attribute: A) depth, B) substrate, and C) cover for each life stage. (Source: Lane *et al.* 1996 a,b,c).

A)



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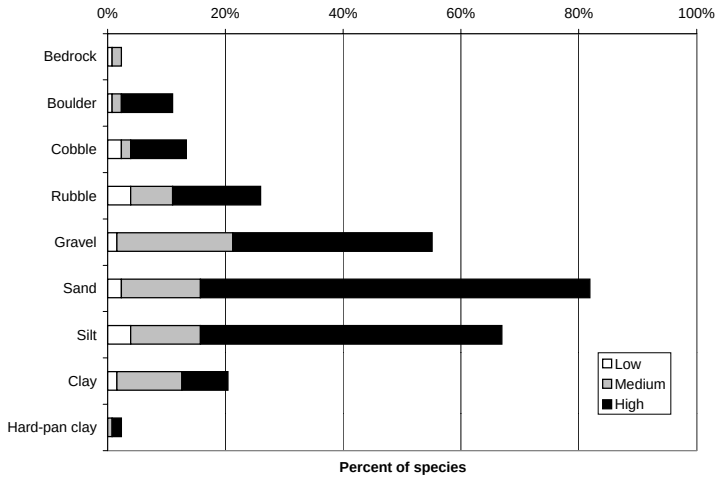

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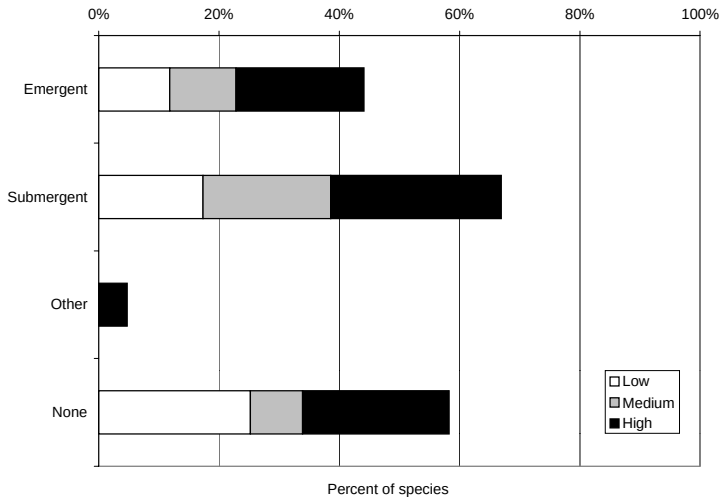

Figure 4.2. Aggregate use of habitat attributes A) depth, B) substrate, and C) cover by young-of-the-year of all fish species using lacustrine habitat in the Great Lakes. (Source: Lane *et al.* 1996 a,b,c).

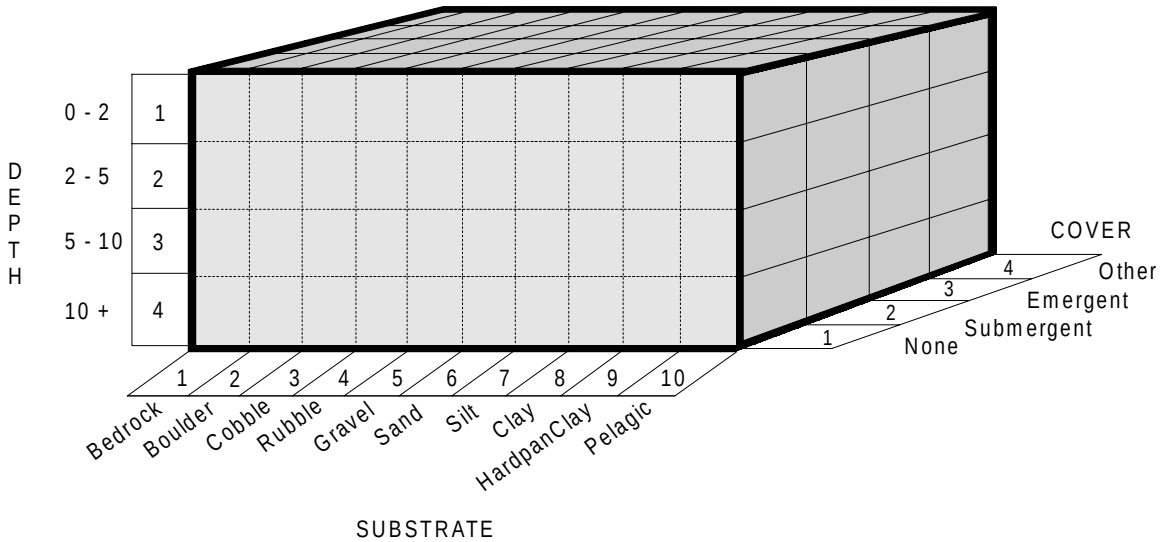

Figure 4.3. The matrix of combinations for the three habitat attributes, depth, substrate, and cover, used to estimate suitability values for the adult life stage of Great Lakes fish species.

Species suitability:

- For each species, the suitability matrices for the three life stages are weight-summed using a set of weights that sum to one.
- A fixed set of weights is used for all species in each application of Defensible Methods. For the default approach, all weights are equal which assumes that there is no a priori way of knowing the relative importance of different life stages without a detailed assessment of the habitat-limited bottlenecks in a population's dynamics and productivity.
- Each species matrix is then rescaled, such that the sum of suitability values across all combinations of categories, cells in the matrix, equals 1. This provision ensures that that each species can only contribute 1 to any group suitability matrix.

Group suitability:

- Groups of fish species are formed using criteria that reflect either ecological life style preferences, e.g. thermal (warm-, cool-, and cold-water) or trophic (piscivore, and non-piscivore), or human use preferences, e.g., commercial, sport and forage species, or other reasonable criteria. In site-specific applications of Defensible Methods, a combination of thermal and trophic groupings has been used which usually results in six groups of species.
- The matrices for species in a group are summed and then rescaled so the maximum cell value is 1. Thus the group suitability matrix expresses relative suitability among cells but ensures that pools of group matrices are not influenced by differences in the number of species making up a group.

Assemblage suitability:

- Matrices from the groups are sum-weighted using a set of group weights that sum to 1. The group weights depend on the priorities of fishery management agencies and users and fundamental properties of the target ecosystem (size, maximum depth, nutrient status, etc.).

The suitability value matrices obtained at any of the 4 levels in the hierarchy of calculations can be used to evaluate the suitability of habitats in one or many locations.

As might be expected, for a modelling scheme based on combining habitat preferences for many species, the suitability values obtained for group and assemblage are correlated with integrated fish community measures such as species richness, abundance and biomass. In Severn Sound, an analysis of combined fish community and habitat assessment data collected in the littoral zone showed that fish measures for warmwater and coolwater groups, for the assemblage, and for Index of Biotic Integrity were significantly correlated with corresponding Defensible Methods-based habitat suitability indices (Table 4.1, Figure 4.4)(Minns, *et al.* in preparation).

Table 4.1. Pearson correlation coefficients between Defensible Methods suitability indices and fish community measure for standard survey transects in Severn Sound. [Values in bold-face are significant at P=0.05 after Bonferroni correction.]

Defensible Methods Indices			Fish Capture Variables		
Thermal Category	Trophic Status	Life Stage	Species Richness	Density	Biomass
Warmwater	Non-piscivores	Adult	0.249	**0.383**	0.243
		YoY	**0.389**	**0.522**	**0.389**
		Spawning	0.171	0.265	0.180
	Piscivores	Adult	0.162	0.142	0.144
		YoY	0.208	0.198	0.182
		Spawning	0.172	0.139	0.157
Coolwater	Non-piscivores	Adult	**0.449**	**0.428**	**0.408**
		YoY	**0.456**	**0.460**	**0.374**
		Spawning	0.244	0.183	0.250
	Piscivores	Adult	0.120	0.133	0.100
		YoY	0.152	0.159	0.122
		Spawning	0.127	0.136	0.107
Coldwater	Non-piscivores	Adult	Insufficient Catch for Correlation		
		YoY		“	
		Spawning		“	
	Piscivores	Adult		None Caught	
		YoY		“	
		Spawning		“	
Composite Index Score vs Total Fish Variables			**0.396**	**0.442**	**0.319**

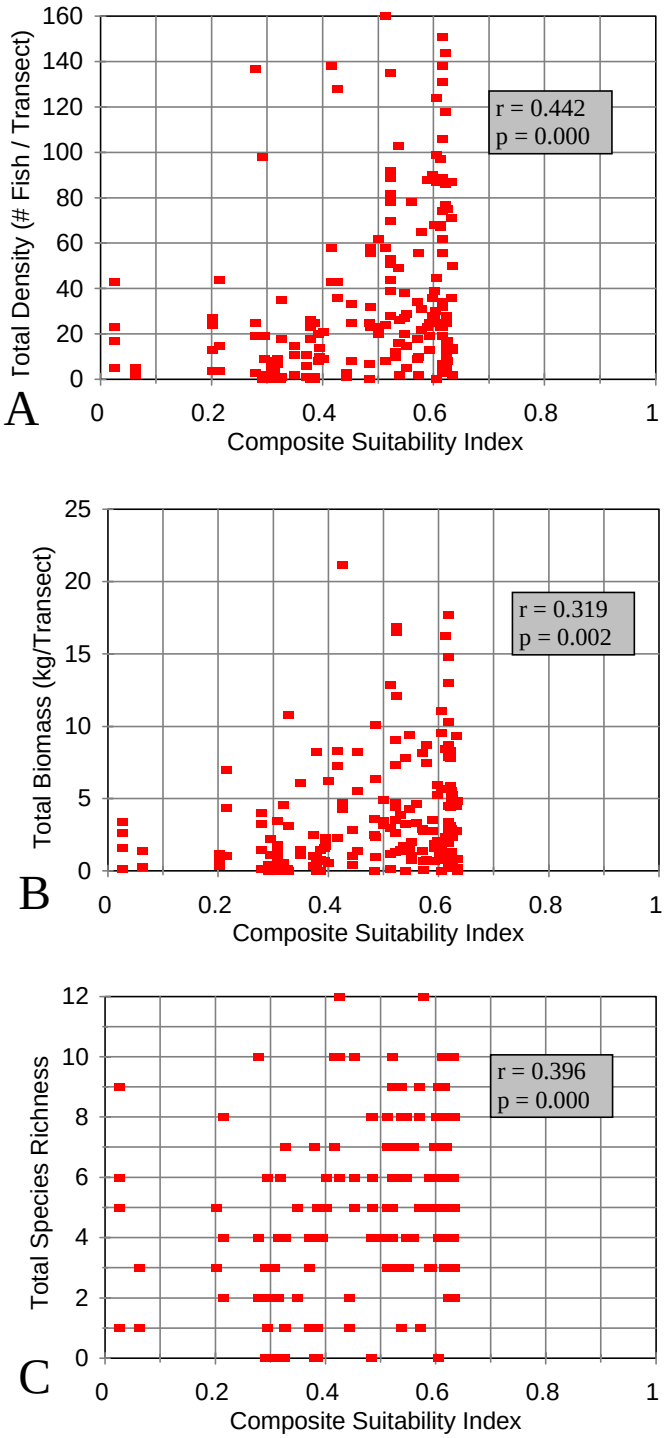

Figure 4.4. Graphs showing the relationships, and their statistical significance, between direct measures of the fish community (A - density, B - biomass, and C – species richness per standard electrofishing transect sample) composite habitat suitability index values obtained using the Defensible Methods approach of Minns *et al.* (1995) for littoral areas in Severn Sound, Georgian Bay.

This approach, which takes into account depth, substrate and cover, can be extended to other habitat attributes. At present, modelling for thermal and light habitat is under way for some species. Suitability maps for temperature and light will be developed separately. Shifting from physical habitat which is treated using 2-dimensional models to dynamic habitat attributes with 3- and 4-dimensional features poses a significant analytical challenge.

4.2.2 Habitat Attribute-Spatial Unit Mapping

To apply the suitability models to ecosystems and to identify those areas and locations with higher or lower suitability for supporting fish biodiversity, the habitat attributes used in the development of the suitability values must be mapped across locations. The spatial extent of the required map coverage will depend on the objectives of the assessment exercise. For the ABIA project, the Great Lakes Basin is the target area but assembling map coverage of habitat attributes for that whole region is not possible at present. Instead, Lake Erie and its basin have been selected for the initial test of the predictive power of habitat suitability models (see Section 4.3 below).

Separate map layers are prepared for each habitat attribute in a geographical information system (GIS). The map layers are then intersected, or overlaid, to identify spatial polygons with unique combinations of habitat attributes. The overlay step brings the maps of all habitat attributes into a single map layer. Differences in polygon boundaries are incorporated to produce a map with many polygons. Each overlay polygon has one category from each habitat attribute identified. This combined map is known as a unique conditions map. For example, if depth, substrate and vegetation map layers are overlaid, there might be spatial polygons in sheltered nearshore locations with depth in the range 0 to 1 metres; substrate consisting of sand (60%), silt (30%), and clay (10%); and submerged vegetation cover of 60%.

4.2.3 Spatial Unit-Fish Species/Life stage Suitability Mapping

Linking the Fish Species/Life stage-Spatial Unit suitability index models to Habitat Attribute-Spatial Unit mapping requires three steps:

1) The overlay of separate habitat attribute maps to obtain a unique conditions map,
2) Development of a series of correspondence tables linking the categorical elements for each attribute in the suitability models and the habitat attribute-spatial unit maps, and
3) Attachment of suitability values to each unique polygon in the overlay map.

Completion of these steps results in the production of a series of location suitability maps.

The correspondence tables linking Fish Species/Life stage-Habitat Attribute suitability matrices to Spatial Unit-Habitat Attribute maps is necessary because it is difficult to obtain the same classification schemes for all sources of data. For instance, while substrate suitability values are specified for discrete categories of substrate (e.g. sand, boulder, clay), field mapping of substrate may identify either new categories representing mixtures of the discrete categories (e.g. sandy-gravel, silty-clay, etc.) or proportions of discrete substrates present (e.g. 30% gravel+60% sand+10% silt, etc.). If the field data consists of categories representing mixtures, the correspondence tables must indicate the expected proportional composition, based on expert opinion of by inference from available compositional data, e.g. sandy-gravel = 70% gravel+30% sand. Similar approaches are used for other habitat attributes. Once

the proportions have been established in the correspondence tables, weighted suitability values can be computed for field-based map categories.

With the suitability models and correspondence tables in place, the assignment of suitability values to polygons in the overlay map is straightforward. Life stage, species, group and assemblage suitability values can be assigned to overlay map polygons and suitability maps generated. The suitability maps can be analyzed in several ways:

1) The maps can be classified by assigned non-overlapping ranges of suitability to categories, e.g. 0.0-0.3 low, 0.3-0.7 medium, 0.7-1.0 high,
2) Areas in particular suitability ranges can be determined,
3) Weighted-suitable areas, the sum of area multiplied by suitability across all polygons, can be computed as an area equivalent measure of habitat supply.

4.2.4 Comparison of Suitability Maps with the Distribution of ABIAs

The comparison of ABIA nominations with biodiversity maps will be a straightforward process. The candidate ABIAs can be classified into a series of classes depending on the criteria used to identify them. The suitability maps are developed with a continuous scale from 0 to 1 but can be reclassified into categorical maps with ranges of suitability from poor through to excellent. ABIA and Suitability class values can be cross-tabulated with the expectation that ABIAs will be more strongly associated with high suitability classes or values.

4.3 Outline of Approach for Lake Erie Basin

Work has begun on a habitat supply analysis for fish biodiversity in the Lake Erie Basin and results will be reported at SOLEC 2000. Lake Erie was selected because 1) Pilot-scale mapping activities have already been undertaken (Minns *et al.* 1997, 1998); 2) Much effort is going into the definition of fish habitat suitability models linked to population models for several key fish species in the lake; and 3) Significant changes are occurring in the ecosystem with major habitat impacts.

The habitat supply analysis for Lake Erie will cover all aquatic habitats in the lake, in the tributaries, and in the connecting channels. The many habitat feature maps will be compiled from existing sources rather than from new, expensive data collection programs. There are sufficient extant data, or where necessary the means to infer or extrapolate, to provide a substantive test of the predictive power of this approach to the identification of ABIAs in the Great Lakes Basin.

4.4 Sample of Expected Results

Several previous studies have provided preliminary evidence of the feasibility of the habitat supply analysis approach in Lake Erie, in Long Point Bay on Lake Erie, and in Severn Sound on Georgian Bay. These pilot projects illustrate the potential of this approach.

In a prototype for the Lake Erie HSA, Minns and Bakelaar (1998 in press) used available bathymetric and substrate data and an inferred map of submerged vegetation cover in conjunction with the Defensible

Methods approach described in section 4.2 above to predict habitat suitability maps in the Canadian waters of Lake Erie. Suitability maps were developed for major groupings of fish based on thermal and trophic preferences and for selected species (Figure 4.5). These maps are based on physical habitat considerations alone and thermal habitat was not considered. The maps show limited areas of suitable habitat for coldwater non-piscivores in the central and eastern basins of the lake and extensive areas for walleye throughout the lake. The habitat supply analysis work currently under way in support of the SOLEC and other efforts is a direct outcome of that work.

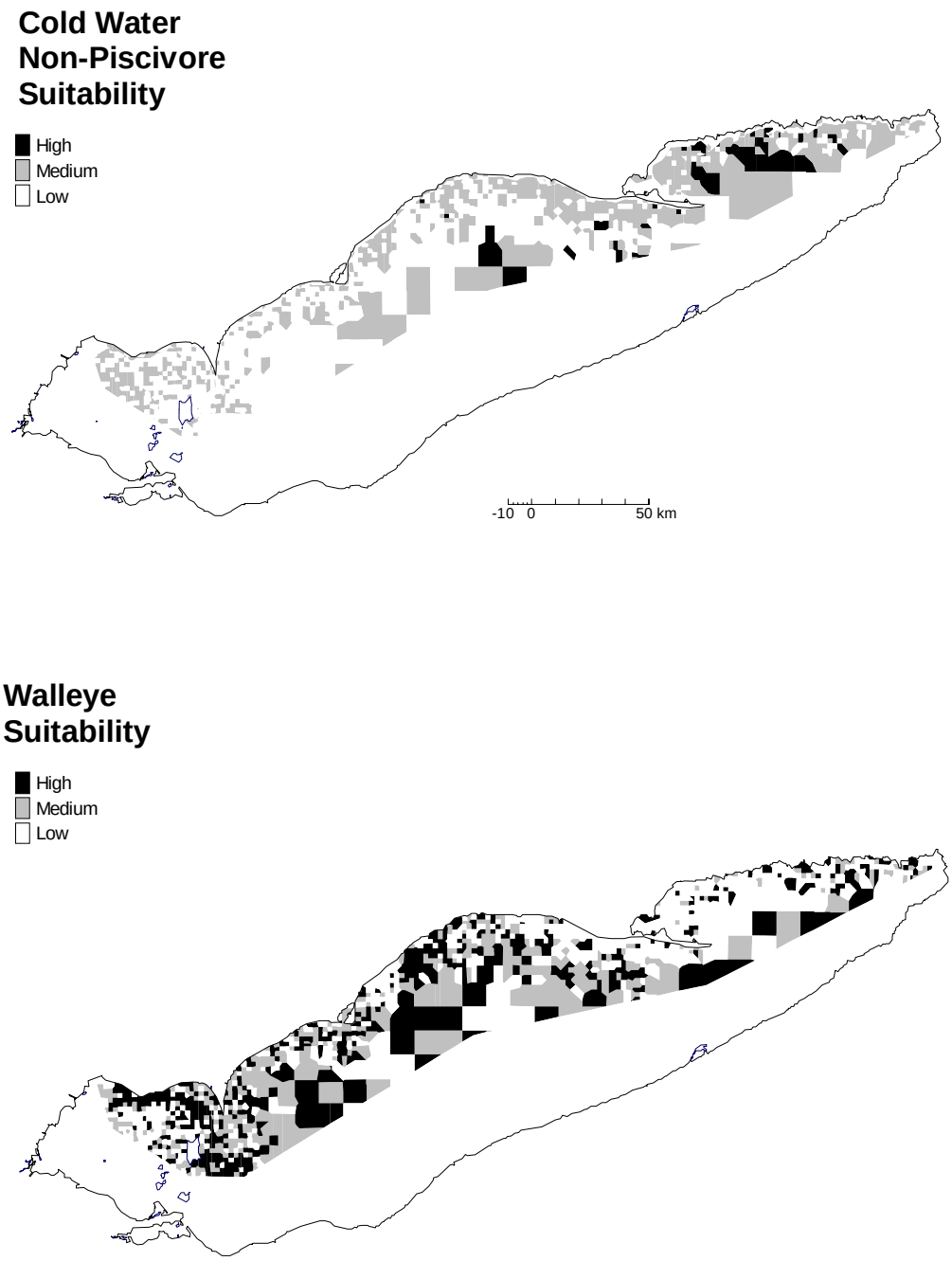

Figure 4.5. Habitat suitability index maps based on Defensible Methods ratings of physical habitat attributes without reference to thermal habitat for A) coldwater non-piscivorous fishes and B) walleye (*Stizostedion vitreum vitreum*) in the Canadian waters of Lake Erie.[Source: Minns and Bakelaar, 1998 in press].

More recently, Minns *et al.* (1998 in revision) undertook a more limited study of the Long Point Bay area in Lake Erie, taking advantage of a detailed aerial remote sensing study to map nearshore habitats in 1994. A suitability model was used to assess habitat supply for three life stages in northern pike (*Esox*

lucius, L.) and the supply estimates were used with Minns *et al.*'s (1996) population model for pike to predict potential biomass and production in the Bay area. There were also efforts in the Long Point study to assess thermal habitat in 4-dimensions, daily over the year by area grid and depth. The thermal and physical indices have yet to be combined. The suitability maps obtained for the Long Point area illustrate the potential for assessing the importance of contiguity (Figure 4.6). The dark areas represent fifty percent of the weighted suitable area, i.e., the product of area and suitability by unique habitat area, with the greatest suitability values. The higher quality habitats for each life stage do not overlap much but rather are intermingled thereby minimizing the distances as organisms pass from one life stage to the next.

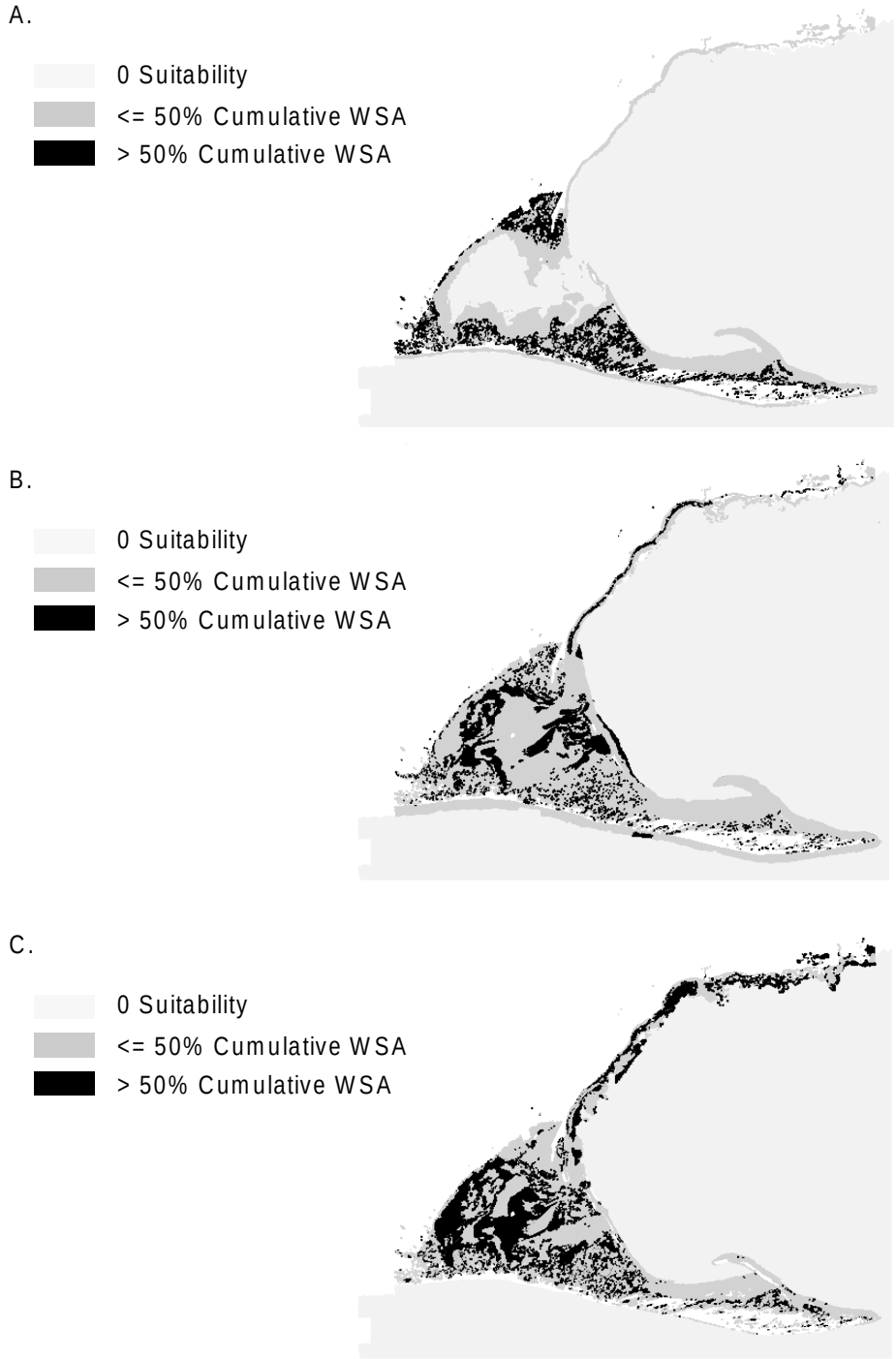

Figure 4.6. Habitat suitability maps based on Defensible Methods ratings of physical habitat attributes without reference to thermal habitat for three life stages of northern pike, *Esox lucius*: A) spawning, B) yoy or nursery, and C) adult in the Long Point region of Lake Erie.

The third example from Severn Sound illustrates how the suitability maps that identify ABIAs might be used to guide local planning and development (Minns *et al.* in preparation). The nearshore habitat of the whole shoreline of Severn Sound on Georgian Bay was mapped over several years. The habitat data were assembled in a GIS and habitat suitability mapping performed (Figure 4.7). The figure shows a small portion at the mouth of Matchedash Bay. The suitability maps are being combined with wetland maps, maps identifying rare habitat features, and local knowledge of important fish habitats, to produce a colour-coded nearshore map. Areas are coded red, yellow, or green according to their importance as fish habitat. The colour scheme coordinates with a planning and development guidance document and the combined product will be used in local and regional planning offices to province first-cut guidance and direction for proposed development activities. Red areas have a higher fish biodiversity investment values and the types and scope of development allowed will be more restricted than in green areas. Green areas are often sites where past neglect and ignorance led to a loss of habitat value and now represent important sites for habitat enhancement or creation.

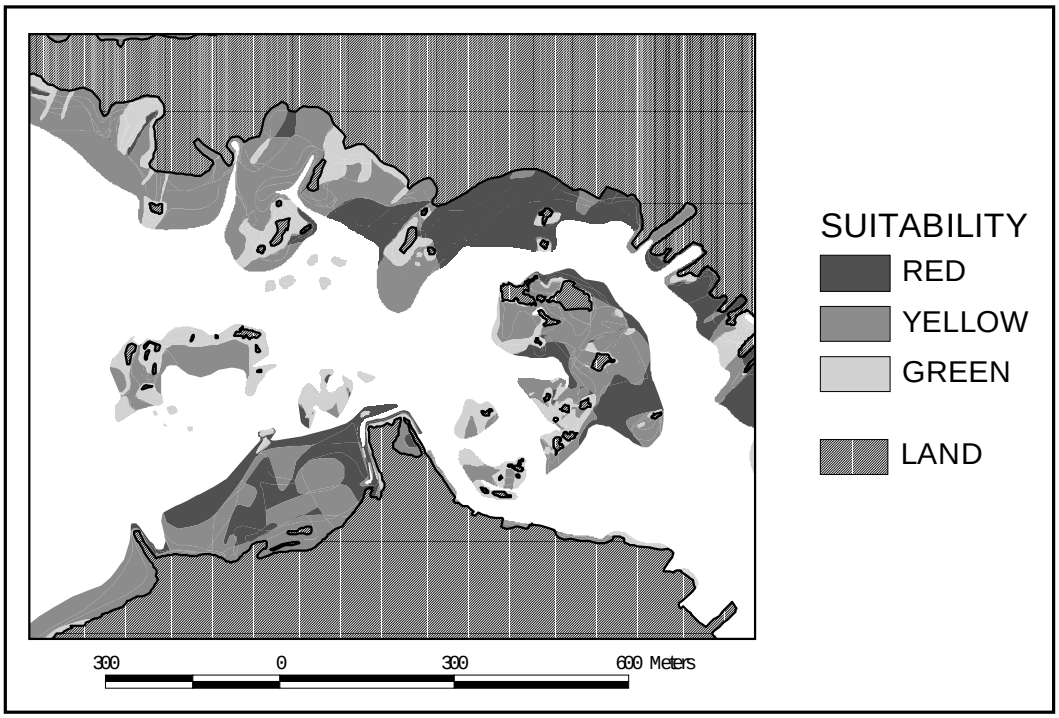

Figure 4.7. Habitat suitability maps based on Defensible Methods ratings of physical habitat attributes for part of Matchedash Bay, Severn Sound on Georgian Bay.

5. Status Indicators for ABIAs

Habitat Supply Analysis identifies areas within the Great Lakes that have the potential to support high biodiversity. In actuality, these areas may not be supporting levels of biodiversity that equal their potential. Consequently, the following schema has been proposed to classify ABIAs according to their current level of production and biodiversity. These classifications are:

- **Healthy** ABIAs – These are ecosystem locations that are relatively intact and functioning **Conservation** efforts should be concentrated at these sites.
- **Damaged** ABIAs – These are locations that are damaged or degraded but that still retain the inherent capacity to support biodiversity and ecosystem functions if stressors are removed or ameliorated. **Restoration** efforts should be concentrated at these sites.
- **Lost** ABIAs – These are sites where past actions have led to their complete loss thereby, eliminating important contributors to biodiversity maintenance. **Creation** efforts should be directed to these sites where feasible.
- **Missing** ABIAs – These are sites where, because of their position in a sequence of locations or their contiguity to other locations, **enhancement** of habitat features would locally increase biodiversity and directly contribute to larger scale ABIA objectives.

Because of the high degree of connectivity among locations in aquatic ecosystems and the high level of mobility of many of the target biodiversity elements, it is unlikely that there are any areas that are not to some degree an ABIA. Thus within the four classes of ABIA, levels such as Low, Moderate, and High will be needed to distinguish the degree of actual or potential biodiversity investment contribution among locations (Table 5.1). Areas that are rated low may still be essential to the overall functioning of the ecosystem even if the relative contribution to maintenance of biodiversity and natural productivity appears to be low. For example, some locations may only be used on a transient basis as migration corridors between other locations supporting functions such as reproduction, rearing, or foraging. Such an ABIA classification scheme may have the most practical significance as a basis for priorizing conservation, restoration, creation, and enhancement activities. Furthermore, this scheme should ensure that no further loss or degradation of status in any ABIA occurs and, that necessary restoration, creation and enhancement activities will be used to achieve gains in status for some ABIAs.

Table 5.1. Hypothetical organization for the assessment of class, potential, and status based on evaluation of habitat features conditions across spatial units, or locations.

Spatial Units	Habitat features 1	2	3	4	…	Analysis (HSA)	Class	Potential	Status
Wetland	H	M	M	H		➜	Damaged	High	60%
Reef	H	H	H	H	…	➜	Healthy	Medium	95%
Bay	H	L	M	H		➜	Lost	Medium	0%
Reef	M	L	M	L		➜	Damaged	Low	70%
Stream	L	L	L	H		➜	Missing	High	20%
Etc.	…					…	…		

Implementation of this classification scheme requires that all locations be assigned a class and a status or level. Various units can be used to quantify the coverage in each class by level combination. For example, lengths of streams and rivers, lengths of shoreline, areas of lake or wetland, etc., can be used as indicators. Change in class or level can be reported on a location specific basis or in aggregate for a region, a whole lake basin, or for the Great Lakes basin as a whole.

In this classification scheme, given that habitat impairment has been identified in nearly all AOCs, those candidate ABIAs identified in the survey would probably be classified as Damaged and then assigned status on their relative biodiversity contribution in a local and regional context. Many of the coastal wetlands, that have been lost to infilling, would be classified as Lost whereas other wetlands, that have been cut off from the lakes by dyking, would classified as Damaged. In AOCs and other areas where habitat creation has been undertaken, potential sites for islands and reefs might be classified as Missing once the opportunity has been noted. Such a location may be withdrawn from a Damaged-Low combination, banked as Missing-High while the means of effecting the changes are planned, and then re-entered as Healthy-High once the enhancement activity has successfully occurred.

Without a detailed analysis of habitat supply and effects on individual species, any assessment of status of the ABIAs in the Great Lakes with these criteria is premature. However, it is possible to illustrate the type of status assessment that will be possible by reviewing the contributions of the proposed framework to existing evaluations of habitat status. In a recently completed assessment of the state of Lake Erie, the Lake Erie Commission (1998) rated the aquatic habitat quality of Lake Erie shorelines and river mouths

within Ohio. Using a Qualitative Habitat Evaluation Index (QHEI), they found that the overall shoreline rated only fair on a scale of poor, fair, good, and excellent and that the overall score for river mouth QHEI was poor (Tables 5.2 and 5.3).

Table 5.2. Average QHEI scores for Lake Erie shores with equivalent grade scores. Grades are A: excellent, B: good; C: fair, and D: poor. Data courtesy of R. Thoma, Ohio EPA.

Lake Erie shoreline regions

Area	QHEI	Grade
Lucus Co.	49.1	**D**
Ottawa Co.	49.0	**D**
Erie Co.	56.0	**B**
Lorain Co.	55.6	**B**
Cuyahoga Co.	51.0	**C**
Lake Co.	53.4	**C**
Ashtabula Co.	52.1	**C**
Sandusky Bay	48.5	**D**
Lake Erie Islands	63.2	**A**
Lake shore average	53.4	**C**

Table 5.3. Average QHEI scores for Lake Erie tributaries. Lacustuary scores with lacustuary habitat grades, dam locations and miles of free flowing stream below dams. The overall tributary habitat grade is also given. Tributary habitat grades are calculated using the lacustuary QHEI grade and the amount of free flowing stream (below dams) that is available to spawning fish from Lake Erie. Grades are A: excellent, B: good; C: fair, and D: poor. Data courtesy of R. Thoma, Ohio EPA.

River system	Lacustuary QHEI	Tributary grade	Lacustuary habitat grade	Dam location*	Miles of free flowing stream below dam
Maumme R.	50.9	C	**B**	32.2	17.4 mi.
Portage R.	54.2	C	**D**	20.8	5.8 mi.
Sandusky R.	43.6	D	**F**	18.0	2.3 mi.
Huron R.	52.1	C	**D**	14.6	4.3 mi.
Vermilion R.	48.0	D	**C**	23.7	21.8 mi.
Black R.	49.9	D	**C**	No dam	N/A
Cuyahoga R.	34.0	F	**D**	20.7	13.9 mi.
Chagrin R	53.7	C	**D**	4.8	3.4 mi.
Grand R.	52.4	C	**B**	30.9	26.7 mi.
Ashtabula R.	48.2	D	**C**	No dam	N/A
Conneaut Cr.	41.0	D	**C**	20.4	18.9 mi.
Average	47.2	D	**D**	N/A	N/A

* Dam location given as number of miles upstream of the confluence of the tributary with Lake Erie. This distance includes the portion of river affected by Lake Erie water levels.

Table 5.4 is a re-classification of the river mouth QHEI results using the proposed ABIA status classes. All of the tributaries in Ohio fall into a degraded class. With finer analysis of habitat structures within the tributaries, it becomes clear that there are some major losses of habitat (principally caused by dams or shoreline hardening). These losses in specific locations result in the following assessment by the Lake Erie Commission: "Currently, only three of nine lakeshore areas and two of the 11 river mouths possess habitat suitable to support healthy biological communities." The contrast between the only two river mouths that support healthy biological communities, namely the Grand River and Maumee River, is also instructive. Unlike the Grand River, the Maumee River outlet is continuous with an extensive coastal wetland complex that serves as a nursery area for river-run fish species such as walleye. While walleye are known to spawn in both the Maumee and Grand Rivers, the Grand River is not a major contributor to walleye recruitment in Lake Erie. The primary rivers are the Maumee and Sandusky. Despite its degraded status, the Sandusky River because of its proximity to nursery area would thus be a prime candidate for restoration efforts. The Grand River, in contrast, contributes less to lake-wide biodiversity and productivity because nursery habitat is limited or missing entirely. The Grand River in Ohio, therefore, would be a candidate for enhancement of missing habitat features.

Table 5.4. ABIA status of river mouth habitats on the Ohio shore of Lake Erie, based on the results of R. Thoma, Ohio EPA.

River system	Lacustuary habitat grade	Miles of free flowing stream below dam	ABIA Class
Maumme R.	**B**	17.4 mi.	Degraded
Portage R.	**D**	5.8 mi.	Degraded
Sandusky R.	**F**	2.3 mi.	Degraded
Huron R.	**D**	4.3 mi.	Degraded
Vermilion R.	**C**	21.8 mi.	Degraded
Black R.	**C**	N/A	Degraded
Cuyahoga R.	**D**	13.9 mi.	Degraded
Chagrin R	**D**	3.4 mi.	Degraded
Grand R.	**B**	26.7 mi.	Degraded
Ashtabula R.	**C**	N/A	Degraded
Conneaut Cr.	**C**	18.9 mi.	Degraded
Average	**D**	N/A	Degraded

6. Conclusions and Recommendations

While this report is an interim report of a work-in-progress, it is already possible to drawn several conclusions and make some recommendations that will affect how this work proceeds in preparation for SOLEC'2000.

- **Conceptual Framework:**
  - Accept that the terrestrial BIA scheme created for SOLEC 1996 is not directly transferable into an ABIA scheme because of key structural and functional differences between terrestrial and aquatic ecosystems.
  - Recognize that the three axis model linking biodiversity, habitat attributes and spatial units provides a strong basis for integrating ecosystem assessments and has many potential applications when translated into an operational methodology.

- **Surveying for Candidate ABIAs:**
  - Recognize the subjective nature of candidate areas identified by experts in a non-quantitative context.
  - Continue to gather candidate ABIAs recommended by experts around the Great Lakes Basin as a means of clarifying the concept of ABIAs and as a test-bed for the quantitative approach (HSA).
  - Expand the scope of information gathered in the survey approach.
  - Implement method of gathering survey data using an Internet web-site.
  - Implement a semi-automated method for updating the candidate database and updating the web-site.

- **Habitat Supply Analysis:**
  - Complete the prototype application of the HSA approach for the Lake Erie Basin for fish species assemblages using the aggregate Defensible Methods approach to suitability modelling and compare the results with the survey-based candidate ABIAs.
  - Carry through the development of habitat supply data for individual species using more detailed suitability models and link the supply results via density dependent functions to population models.
  - Pursue analysis of contiguity issues arising for sequences of life stages within species and for interaction between species in assemblages and communities.

- **Status Indicators:**
  - Develop further the class, potential, status approach to indicators for ABIAs drawing on the Lake Erie HSA to derive quantitative results and to identify habitat management strategies.

7. Acknowledgements

This work was undertaken with the support and encouragement of the Habitat Advisory Board of the Great Lakes Fishery Commission. Financial contributions and equivalent support came from U.S. Environmental Protection Agency, Environment Canada, Great Lakes Fishery Commission, Fisheries and Oceans Canada. We especially want to note the continuing advice and encouragement given by Dr. Kent Fuller with U.S. E.P.A and Dr. Harvey Shear with Environment Canada. We want to note the assistance and support of members of the Lake Erie Committee and their Environmental Objectives task group. We thank Roger Thoma with Ohio Environment Protection Agency for his help with the data and advice. We want to recognize the contributions of Carolyn Bakelaar and Peter Brunette, GIS Consultants, in the map- and web-related aspects of the project activities. Many other individuals and agencies have assisted the project team with data and information acquisition. We thank all those in the Great Lakes community who have responded to the request for candidate ABIAs, including those not yet incorporated into the database and web-site.

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1.3 http://mapping.usgs.gov/www/gnis/gnisform.html

9. Appendices

Appendix 1. English and French versions of the mail-out questionnaire for ABIA nominations.

SOLEC '98 Questionnaire to Identify

Aquatic Biodiversity Investment Areas in the Great Lakes Basin

Who are you and who do you represent?			
Name:		Position:	Agency:
Address:			
Phone:	Fax:	Email:	

Candidate Aquatic Biodiversity Investment Area (ABIA)			
What is the location? (Please be as specific as possible):			
Great Lakes Basin unit (✓ one):		Main feature (✓ up to 3):	Other location features:
Lakes: ❍ Superior ❍ Michigan ❍ Huron ❍ St. Clair ❍ Erie ❍ Ontario	River: ❍ St. Mary's ❍ St. Clair ❍ Detroit ❍ Niagara ❍ St.Lawrence	❍ Tributary ❍ Wetland ❍ Reef nearshore ❍ Embayment ❍ Reef offshore ❍ Pelagic ❍ Island(s) ❍ Profundal ❍ Tableland ❍ Shorelands ❍ Beach	Briefly describe... _____ _____ _____ _____ _____ _____
Why is this a candidate ABIA?			
Checklist (✓ up to three):		Biodiversity (name):	Other criteria:
❍ High biodiversity ❍ High productivity ❍ Critical for rare spp. ❍ Critical for economic spp. ❍ Critical for endangered spp. ❍ High habitat diversity ❍ Rare habitat features ❍ High connectivity value		Community (i.e. fish, bird, etc.): _____ Sub-community (i.e. cold water, warm water, etc.): _____ Species: _____ _____ _____ Life stage(s): _____ _____ _____	Briefly describe... _____ _____ _____ _____ _____ _____ _____ _____ _____

Please **FAX** or **MAIL** your response(s) to: Attn: Dr. Heather A. Morrison
Great Lakes Laboratory for Fisheries and Aquatic Sciences, DFO
PO Box 5050, 867 Lakeshore Road, Burlington, Ontario L7R 4A6 CANADA
Phone: (905)-336-4497 **FAX (905)-336-6437** Email: morrisonh@dfo-mpo.gc.ca

SOLEC'98 Questionnaire d'identification des
Zones d'Investissement dans la Biodiversité Aquatique de la région des Grands Lacs

Qui êtes-vous et qui représentez-vous?		
Nom:	Poste:	Agence:
Adresse:		
Téléphone:	Télécopieur:	Adresse électronique:

Candidat à la Zone d'Investissement dans la Biodiversité Aquatique (ZIBA)			
Où est-elle située ? (Soyez aussi précis que possible):			
Élément dans le bassin des Grands Lacs (Cochez-en une seule):		Caractéristique principale (Cochez-en 3 au maximum):	Autres caractéristiques de l'endroit:
Lacs: ❍ Supérieur ❍ Michigan ❍ Huron ❍ St. Clair ❍ Érié ❍ Ontario	Rivières: ❍ St. Mary's ❍ St. Clair ❍ Détroit ❍ Niagara ❍ Le Saint-Laurent	❍ Affluent ❍ Marécages ❍ Récif frangeant ❍ Baie ❍ Récif-barrière ❍ Pélagique ❍ Ile(s) ❍ Benthique ❍ Table de terre ❍ Littoral ❍ Plage	Décrivez brièvement... _____ _____ _____ _____ _____ _____
Pourquoi est-ce un candidat ZIBA ?			
Liste de contrôle (Cochez-en 3 au maximum):		Biodiversité (nom):	Autres critères:
❍ Biodiversité élevée ❍ Productivité élevée ❍ Essentielle pour les espèces rares ❍ Essentielle pour les espèces commerciales ❍ Essentielle pour les espèces menacées ❍ Diversité élevée de l'habitat ❍ Caractéristiques rares de l'habitat ❍ Importante valeur de rapports		Communauté: _____ _____ Sous-communauté:_____ _____ Espèces: _____ _____ _____ Stade(s) de développement:_____	Décrivez brièvement... _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Veuillez **TÉLÉCOPIER** ou **POSTER** votre/vos réponse(s)à l'attention de: Dr. Heather Morrison, Great Lakes Laboratory for Fisheries and Aquatic Sciences, DFO, Boîte Postale 5050, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, CANADA.
Téléphone: (905) 336-4497 **Photocopieur: (905) 336-6437** Adresse électronique: morrison@dfo-mpo.gc.ca
N.B. *Un candidat par page. Envoyez plusieurs feuilles, agrafez-les si nécessaire.*

Appendix 2. Descriptions of sites within the Great Lakes basin that have been nominated as Aquatic Biodiversity Investment Areas (ABIAs).

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
1	Long Point	Erie	Wetland Reef Nearshore Embayment	High Biodiversity High Productivity Critical for Rare Species Rare Habitat Feature		A significant % of the total sheltered diverse aquatic vegetation area in Lake Erie is located here.	Dr. Charles Minns (Dept. of Fisheries and Oceans) Dr. Jim Sherry (Environment Canada)
2	Humber Bay Marshes	Ontario	Wetland	High Productivity High Habitat Diversity High Connectivity Value	It is a well developed wetland in an urban setting.	It has important recreational and educational value. Active feeding site for colonial waterbirds and wading birds. There is a presence of fur bearing mammals and seasonal fish spawning. Fish found in the area include rainbow trout, rainbow smelt, white sucker.	Mr. C. Gonsalves (Emery Creek Environmental Association)
3	Nipigon River/Nipigon Bay	Superior	Tributary Embayment	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species High Habitat Diversity	It is at Nipigon which is east of Thunder Bay.	This is a high productivity area and is world renowned for speckled trout. It is widely used by resident and non-resident anglers and commercial fishermen. River has a high biodiversity of fish species and a remnant population of brook trout. It is the last refuge for coaster brook trout, recovering Lake Sturgeon and walleye population,and the biggest tributary to Lake Superior.	Mr. Joe Coghlan (OFAH) Mr. Bob Thomson (Lake Superior Management Unit, OMNR) Mr. Ed Iwachewski (OMNR - Centre for Northern Forest Ecosystem Research)
4	Presque Isle Bay and Associated Wetlands	Erie	Wetland Embayment Beach	High Biodiversity Critical for Rare Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature	Sandspit arcs back towards mainland to form large, shallow embayment with aquatic plant beds, emergent marsh, shallows, beaches and mussel beds.	There are rare sp. including bowfin, spotted gar, Iowa darter, lake sturgeon, e. sand darter, Great Lakes muskellunge. Approximately 20 species of freshwater mussels and several rare fish; productivity is likely high and species diversity including peninsula is one of highest for Lake Erie; including plants and habitats in general.	Mr. Roger Kenyon (Pennsylvania Fish and Boat Commission) Mr. Charles Bier (Western PA Conservancy)
5	Credit River and adjacent waters of Lake Ontario	Ontario	Tributary	Critical for Rare Species Critical for Endangered Species	Including the headwater to the lake.	There is an OMNR project to restore the watershed, since Atlantic salmon are native to the stream.	Dr. David Noakes (University of Guelph)
6	Grand River System	Michigan	Tributary Wetland Islands	High Biodiversity High Productivity High Connectivity Value	Relatively undeveloped shoreline. Protected upstream along banks for at least twenty miles	It provides habitat for warm and cold water species, and drinking water for communities.	Mr. Mitch Deisch (City of Grand Haven)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
7	Grand River in NE Ohio	Erie	Tributary	High Biodiversity High Productivity Critical for Rare Species	It is a wild and scenic river in Ohio. Many fish and freshwater mussel species are located here.	The Grand River is under development pressure and appears to be vulnerable to degradation from urbanization.	Ms. Donna Myers (U.S. Geological Survey)
8	St. Lawrence River	St. Lawrence	Tributary Wetland Embayment Shorelands Islands	High Biodiversity High Productivity Critical for Economically Important Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature	It is located in the Massena/Cornwall area. Three tributaries, the Grouse, Rarquette, and the St. Regis Rivers flow into the St. Lawrence which flow through the St. Regis Mohawk Reservation. It is the migratory route for economic species such as american eel, also growth habitat for eel.	It is the main nursery and migratory habitat for eels that are the basis of a commercial fishery - also member of the predatory fish community.	Mr. Shawn Martin (St. Regis Mohawk Tribe) Dr. Peter Hodson (School of Environmental Studies, Queen's University)
9	Embayment south of Little Tail Point, located NW of Green Bay on Green Bay	Michigan	Embayment	High Productivity Critical for Economically Important Species		The area south of Little Tail Point on Green Bay consistently has the highest abundance of YOY yellow perch in southern Green Bay.	Mr. Brian Belonger (Wisconsin DNR)
10	Old Women Creek Estuary on south shore of Lake Erie near Huron, OH	Erie	Tributary Wetland Shorelands	High Biodiversity High Productivity Rare Habitat Feature		State nature preserve and National estuarine research reserve.	Dr. Rosanne Fortner (Ohio State Sea Grant, Ohio State University)
11	Sydenham River	Erie	Tributary	High Biodiversity Critical for Rare Species Critical for Endangered Species Rare Habitat Feature	The Sydenham River and the North Sydenham River (Bear Creek) are located in southwestern Ontario	The Sydenham River supports the richest freshwater mussel community in Canada including many rare and endangered sp. It also supports other threatened and endangered species (e.g. spiny softshelled turtle, eastern sand darter). The river should be declared an ABIA.	Dr. Janice Smith (Environment Canada, NWRI) Ms. Muriel Andreae (St. Clair Region Conservation Authority)
12	Wetland and tributary stream complex on the western shore of Green Bay in Marinette, Oconto, Brown and Shawano counties (Western Shore Coastal Zone)	Michigan	Tributary Wetland	High Productivity Critical for Economically Important Species Rare Habitat Feature	This area is a complex of interconnected tributary streams and pooled wetlands. They account for most of the wetlands associated with the Green Bay aquatic ecosystem. Range from inter-seichal to inland pooled wetlands	The entire western shore consists of wetland complexes associated with uplands in some areas. Some specific wetland systems produce in excess of 20,000 northern pike per acre.	Mr. Richard Rost (Wisconsin Dept. of Natural Resources)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
13	Point Pelee National Park, the marsh	Erie	Wetland Shorelands Beach	High Biodiversity Critical for Rare Species Critical for Endangered Species	The park is a RAMSAR International Wetland. Point on N. shore of Lake Erie - 1100 hectares of marsh plus barrier beaches and associated uplands.	There is much literature on the importance of this site.	Mr. Bill Stephenson (Parks Canada - Ontario)
14	Wolf River	Michigan	Tributary Shorelands	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species Critical for Endangered Species High Habitat Diversity	The Wolf River is located within the Menominee Reservation. Internationally known for the productive sustained yeild forest.	The Wolf River is listed as a wild and scenic river within the Menominee Reservation.	Mr. Douglas Cox (Menominee Indian Tribe)
15	Sandy Creek Estuary	Ontario	Tributary Wetland Shorelands	High Biodiversity High Productivity High Habitat Diversity	Within the eastern Lake Ontario estuary complex. Town of Ellisburg, Jefferson County, NY	There is a justaposition of stream, marsh, dune, shoreland, forest and agricultural crops.	Mr. R. Smardor (Great Lakes Research Consortium)
16	Lake Sediments						Dr. Nelson Hairston, Jr. (Cornell University)
17	South End of Chequamegon Bay	Superior	Tributary Wetland Beach	High Productivity Critical for Economically Important Species High Connectivity Value	There is groundwater upwelling.	Wetlands are important for migratory birds and cool water fishes. Ground water fed tributaries important for trout and salmon.	Mr. Thomas Busjahn (U.S. Fish and Wildlife Service)
18	Eight Inland lakes near the L. Mich. Coast of northwestern lower Michigan	Michigan	Profundal	Critical for Rare Species Rare Habitat Feature	These are deep cold water lakes.	They have coldwater stenotherms.	Dr. Daniel Mazur (U.S. EPA Region 5 DW-8J)
19	Fishing Islands off Oliphant and Red Bay on Lake Huron	Huron	Reef Offshore	Critical for Economically Important Species	There are sand shoals.	It has whitefish habitat.	Ms. Ann L. Brindle (Grey Sauble Conservation Authority)
20	Sauble Beach	Huron	Profundal	Critical for Economically Important Species		It has whitefish habitat.	Ms. Ann L. Brindle (Grey Sauble Conservation Authority)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
21	Dorans Bay	Huron	Embayment	Critical for Economically Important Species		whitefish habitat	Ms. Ann L. Brindle (Grey Sauble Conservation Authority)
22	Tank Range (near Meaford)	Huron	Profundal	Critical for Economically Important Species		It has whitefish habitat.	Ms. Ann L. Brindle (Grey Sauble Conservation Authority)
24	Wetland located along 2 miles of L. Mich. Shoreline in IL, north of the city of Waukegan and south of Wadsworth Road - within the Illinois Beach State Park.	Michigan	Wetland Shorelands Beach	High Biodiversity Critical for Rare Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature	Young dune swale topography of the sandy bed of ancient glacial Lake Chicago along the present shore of Lake Michigan.	Communities on the parallel ridges and swales illustrate primary dune succession on progressively older, ancient lakeshore line inward from Lake Michigan.	Mr. Kirby Cottrell (IL DNR)
25	Dickerson Island	St. Lawrence	Islands	High Biodiversity Rare Habitat Feature			Mr. Henry Lickers (Mohawk Council of Akwesashe)
26	Grand Traverse Bay	Michigan	Reef Nearshore Embayment Reef Offshore Shorelands	Critical for Economically Important Species High Connectivity Value		It is a critical linkage to Grand Traverse Bay watershed.	Mr. John McKinney (Michigan Sea Grant Program) Dr. Richard Schorfhaar (Michigan DNR)
27	St. Joseph River	Michigan	Tributary			An extremely degraded but previously valuable tributary.	Mr. Al Smith (Friends of the St. Joe River Assoc. Inc.)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
28	Kaministiquia River	Superior	Tributary	High Biodiversity High Productivity Critical for Rare Species	It flows through the city of Thunder Bay into Lake Superior.	It is 47 km from lake up to first barrier, with the most diverse fish community on Canadian side of Lake Superior, and a self sustaining population of Lake Sturgeon.	Mr. Ed Iwachewski (OMNR - Centre for Northern Forest Ecosystem Research) Mr. Bob Thomson (Lake Superior Management Unit, OMNR)
29	Black Bay	Superior	Tributary Wetland Embayment	High Biodiversity High Productivity Critical for Economically Important Species	On the North shore of Lake Superior between Thunder Bay and Nipigon Bay.	It is the most productive bay on Lake Superior, wide range of species, with extensive fringing wetlands	Mr. Ed Iwachewski (OMNR - Centre for Northern Forest Ecosystem Research)
30	Batchawana Bay	Superior	Tributary Wetland Embayment	High Biodiversity High Productivity Critical for Rare Species	It is near near Sault Ste. Marie.	It has extensive fringing wetlands, much lost to shoreline development, diverse aquatic community and diverse shoreline habitat.	Mr. Ed Iwachewski (OMNR - Centre for Northern Forest Ecosystem Research)
31	Thunder Bay	Huron	Tributary Wetland Reef Nearshore Embayment Pelagic Shorelands	High Biodiversity Rare Habitat Feature	There are shipwrecks located here. Some of the last remaining Great Lakes shoreline wetland habitat.	It should be considered as a marine sanctuary.	Mr. Alfred Beeton (Great Lakes Research Laboratory) Dr. Dave Fielder (Michigan DNR)
32	Black River draining into Prince Edward Bay	Ontario	Tributary Wetland	High Biodiversity High Productivity Rare Habitat Feature High Connectivity Value	There is a lengthy low relief tributary with extensive emergent/submergent vegetation. Somewhat degraded due to agricultural land use.		Dr. Charles Minns (Dept. of Fisheries and Oceans)
33	Cootes Paradise and Hamilton Harbor	Ontario	Wetland Embayment	High Biodiversity High Productivity High Connectivity Value	It is undergoing restoration, and surrounded by urbanization and upstream agricultural stresses.	It is a critical part of a sequence of connected streams, wetland, bay, open lake, shore areas and open lake pelagic.	Dr. Charles Minns (Dept. of Fisheries and Oceans)
34	Traverse Island Reef in Keweenaw Bay	Superior	Reef Offshore	High Productivity Critical for Economically Important Species High Habitat Diversity	Contains a 1/2 mile long natural spawning reef for lake trout.	There is a variety of clean boulder and rock habitat in a pollution free zone, with little human activity.	Mr. Mike Jonofrio (Keweenaw Bay Indian Community)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
35	Little Bay de Noc from the mouth of the Whitefish River to the mouth of the Ford River	Michigan	Embayment	High Biodiversity High Productivity Critical for Economically Important Species	L.B. de Noc is approx. 34000 acres. It has 3 large tributary rivers and 4 smaller streams. It supports an important walleye sport fishery and a commercial fishery for whitefish. It is also an area of high biodiversity.		Mr. Dell Siles (Michigan DNR)
36	Allouez Bay Wetland and Kakagon/Bad River Slough Complex	Superior	Wetland Embayment Shorelands	High Biodiversity Critical for Economically Important Species Rare Habitat Feature			Mr. John Brazner (US EPA)
38	Fathom Five National Marine Park located at the tip of the Bruce Peninsula	Huron	Reef Nearshore Pelagic Islands	High Biodiversity Rare Habitat Feature	Includes embayments, wetlands, nearshore communities, bird colonies, open water.	Protected area. This area is 120 km2 national marine protected area. It is part of the Niagara Escarpment World Biosphere Reserve. Already the park has played an important role in focussing research and study in a relatively undisturbed area.	Mr. Scott Parker (Parks Canada)
39	Saginaw Bay	Huron	Tributary Wetland Reef Nearshore Embayment	High Biodiversity High Productivity Critical for Economically Important Species High Habitat Diversity	Very large stands of emergent grass wetlands and nearshore rocky bottom that are highly productive which support a rich and diverse flora and fauna. It is in East Central Michigan. Saginaw Bay offers a huge variety of habitat types.	Saginaw Bay supports a rich flora and fauna through high rates of primary productivity and very protected shallow waters among the emergent grasses. It is the largest warm-water embayment in Lake Huron. Saginaw Bay and tributaries support extremely valuable sport fisheries for a variety of species, principally yellow perch and recovering walleye populations. The bay also supports a commercial fishery for whitefish, yellow perch and other species. The bay is home to a huge variety of species from warm water to cold water.	Dr. Russell Moll (Michigan Sea Grant) Mr. James Baker (Michigan DNR) Dr. Dave Fielder (Michigan DNR)
40	Big Sound Area - Parry Sound	Huron	Reef Nearshore Embayment Islands	Critical for Rare Species High Habitat Diversity High Connectivity Value		Only area outside of Lake Superior with significant natural reproduction of remnant lake trout.	Mr. John Fitzsimons (DFO)
42	Thornberry, or Crooked Creek	Michigan	Tributary	High Biodiversity Rare Habitat Feature	Site is a gravel-sand bottomed cool water stream flowing into Green Bay. This unique habitat supports one of the only inland brook trout population in Brown County, WI.	Nursery area for self sustaining inland brook trout population. Cooperative investigations between Oneida nation and USFWS and USGS.	Mr. John Koss (Oneida Nation)
43	Klydel Wetland	Niagara	Wetland	High Biodiversity High Productivity Rare Habitat Feature	Originally 102 acres - only 60-70 acres remain. Desperately needs protection from illegal development& threatened development.	Endangered wetland in urban settting. Wetland is being used as a nature area for environmental education on the 9.3 acres that is owned by North Tonawanda School District. We're trying to save the rest.	Mrs. Elizabeth Kaszubski (Citizens for a Green North Tonawanda)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
44	Big Bay Reef	Superior	Reef Nearshore Reef Offshore	High Productivity Critical for Economically Important Species Critical for Endangered Species	Identified by USCG - off Big Bay Lighthouse.	It is a productive national reef.	Mr. Mike Donofrio (Keweenaw Bay Indian Community)
45	Huron River Reef	Superior	Reef Nearshore Shorelands	High Productivity Critical for Economically Important Species Rare Habitat Feature	It is the most productive spawning reef inside Keweenaw Bay.		Mr. Mike Donofrio (Keweenaw Bay Indian Community)
46	Huron Islands	Superior	Reef Offshore Islands	High Productivity Critical for Economically Important Species High Habitat Diversity	It is a small island complex with flats surrounding it.	One of only a few lake trout spawing reefs in mgmt unit M1-4.	Mr. Mike Donofrio (Keweenaw Bay Indian Community)
47	Eagle River Shoals	Superior	Reef Offshore	High Productivity Critical for Economically Important Species Rare Habitat Feature	It is a 4 mile long reef.	They contain critical whitefish and herring habitat in mgt unit M1-3.	Mr. Mike Donofrio (Keweenaw Bay Indian Community)
48	Manitou Island	Superior	Reef Nearshore Islands	Critical for Rare Species Critical for Economically Important Species Rare Habitat Feature	There is a large island with shallow reef surrounding it.	It contains spawning and nursery habitat critical to lake trout, whitefish, & herring.	Mr. Mike Donofrio (Keweenaw Bay Indian Community)
49	North Shore of Lake Huron from Mackinac Straits to International line with Canada	Huron	Wetland Reef Nearshore Embayment Reef Offshore Shorelands Islands	High Biodiversity Critical for Rare Species Critical for Economically Important Species High Habitat Diversity Rare Habitat Feature High Connectivity Value	From Mackinal Straits to Intn'l Line, composed of Niagara Escarpment reef, sheltered waters complex. This escarpment is key to Lake trout rehabilitation - historically, 68% of catch of spawning lake trout in MI waters were from here. Lake herring is also common here (a state threatened species) It is composed of Niagara Escarpment, reef, island and sheltered waters. This escarpment is key to lake trout rehabilitation - historically 68% of spawning lake trout from MI waters were from here. Lake herring a state threatened species is also common here.	There is nesting for shore birds in Les Cheneux Islands. Islands used by cormorants, terns, gulls, & variety of other birds. There is nesting for shorebirds in Les Cheneaux Islands. Islands used by cormorants, terns, gulls and a variety of other birds.	Mr. James Johnson (Michigan Dept. Of Natural Resources) Dr. James Johnson (Michigan Department of Natural Resources)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
50	Wilmot Creek	Ontario	Tributary Wetland Shorelands	High Productivity Critical for Rare Species High Habitat Diversity	Headwaters in Oak Ridges moraine.	Provides a diversity of fish habitat suitable for many species, including atlantic salmon, supports large rainbow trout population	Mrs. Heather Conroy (Ganaraska Region Conservation Authority)
51	Ganaraska River	Ontario	Tributary Wetland Shorelands	High Productivity Critical for Rare Species High Habitat Diversity	Headwaters in Oak Ridges moraine.	It provides a diversity of habitat to supports productive fish populations.	Mrs. Heather Conroy (Ganaraska Region Conservation Authority)
52	Greater Cataraqui Marsh	Ontario	Wetland	High Biodiversity Critical for Rare Species	There is a large cattail marsh.		Mr. Chip Weselch (CWS)
53	Sandusky River	Erie	Tributary Wetland Embayment	High Productivity Critical for Economically Important Species High Connectivity Value		Reproductive habitats for life stages are linked by physical processes and function as a unit. Reproductive center - these habitats are critical/essential in that they exist no where else in space or time for this stock.	Mr. David Davies (Ohio Division of Wildlife)
54	Maumee River	Erie	Tributary Embayment Shorelands	Critical for Economically Important Species		Reproductive habitats for life stages are linked by physical processes and function as a unit. Reproductive center - these habitats are critical/essential in that they exist no where else in space or time for this stock.	Mr. David Davies (Ohio Division of Wildlife)
55	Western Basin Reef Complex	Erie	Reef Nearshore Reef Offshore Shorelands Islands	High Biodiversity High Productivity Critical for Economically Important Species Rare Habitat Feature	Remaining area of high quality nearshore habitat and biological communities along Ohio's shoreline. It is a physically complex structure; shallow, warm productive waters; macrophyte beds and diversity of substrate types.	See comments from Roseman and Mackey (attch.) It has spawning and nursery grounds for many fish species. Little undisturbed shoreline on mainland. Considerable habitat loss following colonization by zebra mussels.	Dr. Jeffrey Busch (Ohio Lake Erie Office) Mr. David Davies (Ohio Division of Wildlife) Dr. Tim Johnson (Ontario Ministry of Natural Resources)
56	Tonawanda Creek Watershed	Erie	Tributary	High Biodiversity Critical for Rare Species			Mrs. Kathryn Schneider (NY Natural Heritage Program, NYS DEC)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
57	Spooner Creek	Erie	Tributary	High Productivity	-12.8 sq mi watershed; 1.5% gradient; 14C - 15C mean Sept. temp.; wild sthd. Population, approx 6000 YOY per ha.; deep cut forested channel; spring seeps. (E.23-30) is the uppermost tributary to Cattaraugus Creek (E.23), NY's largest Lake Erie tributary, and is located just downstream of the Springville Dam	Conductivity is 370m mhos; flow (low) 1-2 cfs; private ownership; has limited public access.	Mr. Floyd Cornelius (NYS DEC, Lake Erie Unit)
58	Rondeau Bay	Erie	Embayment	High Productivity High Habitat Diversity			Mr. Jack Robinson (Lower Thames Valley County Authority)
59	Bothwells' Creek	Huron	Tributary	High Biodiversity Rare Habitat Feature	Only fall/winter spawning ground of rainbow trout in Ontario - gene pool is significantly different from general pool. (Leith R) 4 miles east of Owen Sound, on HWY#26	Unique temperature regime where winter water flows from springs stay @ 4C-7C while rest of stream freezes. Regime induces spawning in Nov-Feb period, 2-3 months before spawning period.	Mr. Doug Dodge (Ontario Ministry of Natural Resources)
60	Hammond Marina	Michigan	Embayment	High Biodiversity High Productivity	Marina protected by rip-rap shoreline.	Inside/outside (around marina) possess diverse/productive fish populations such as smallmouth bass; largemouth bass; various sunfish species; rock bass; carp; freshwater drum; johnny darters; shiners; alewife (etc.) in addition to the trout, salmon and yellow perch.	Mr. Janel Palla (Indiana Department of Natural Resources)
61	NIPSCO Dean Mitchell Generating Station	Michigan		High Biodiversity High Productivity	Heated discharge outlet of Generating station.	There is a concentration of trout and salmon species during winter/early spring months, and supports a great number of other species throughout the year.	Mr. Janel Palla (Indiana Department of Natural Resources)
62	Clay valleys/troughs off Black/Kintzele Ditch	Michigan	Reef Offshore	Rare Habitat Feature	Area offers extremely unique habitat of clay troughs ranging from 5-6 foot in height in water ranging from 15 to 30 ft. This differs from the typical sand-bottom of the lake.		Mr. Janel Palla (Indiana Department of Natural Resources)
63	St. Clair River Delta/Lake St Clair	Erie	Wetland Embayment Shorelands Islands	High Biodiversity High Productivity Critical for Rare Species Rare Habitat Feature High Connectivity Value	It has submergent and emergent macrophytes, and shallow, warm and productive waters. Migratory route for valuable fish populations from lakes Erie and Huron.	One of the last remaining stretches of natural shoreline, spawning and nursery ground for numerous fish species. Most diverse native plant, vertebrate, and invertebrates community in Great Lakes.	Dr. Tim Johnson (Ontario Ministry of Natural Resources) Mr. Robert Haas (Michigan DNR)
64	Sandusky Bay	Erie	Embayment Pelagic	High Productivity Critical for Economically Important Species	Whole bay is unusual in Great Lakes, high productivity of phytoplankton.		Dr. Robert Heath (Kent State University)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
65	White River, Pukaskwa National Park	Superior	Tributary	High Biodiversity High Productivity Rare Habitat Feature	Very productive river for Lake Superior region.	Rare river habitat for area.	Mr. Frank Burrows (Canadian Heritage Parks Canada)
66	Otter Cove, Lake Superior, Pukaskwa National Park	Superior	Tributary Wetland Embayment	High Biodiversity High Productivity Rare Habitat Feature	Cove of Lake Superior; rare feature on North shore of Superior; wetland present, rare in area.	Wetlands very rare on north shore of Superior.	Mr. Frank Burrows (Canadian Heritage Parks Canada)
67	St. Louis River	Superior	Tributary Wetland Embayment	High Productivity Critical for Rare Species Critical for Endangered Species	It is a large commercial harbor; area of concern with high value habitat and the largest US tributary to Lake Superior.	Contains a common tern nesting site; walleye spawning area for western Lake Superior; sturgeon restoration; significant remaining wetlands.	Ms. Karen Plass (St. Louis River Citizens Action Committee)
68	Humbug Marsh, Detroit River	Erie	Wetland	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species Critical for Endangered Species Rare Habitat Feature High Connectivity Value	Last remnant Great Lakes coastal marsh on the 32-mile Michigan shoreline of the Detroit River.	Migration route for the 117 species of fish that inhabit the Great Lakes; for the 27 species of waterfowl that frequent Michigan's coastal wetlands; the more than 17 species of raptors, including eagles, hawks, and falcons; the more than 48 species of non-raptors, including loons, warblers, neotropical songbirds, cranes, and cattle egrets, and numerous species of butterflies that migrate annually from Canada to the southern United States and South America.	Dr. Bruce Manny (U.S. Geological Service)
69	Baie du Dore	Huron	Wetland Embayment Islands	High Biodiversity High Habitat Diversity High Connectivity Value	100 ha shallow coastal embayment wetland opening northwest into Lake Huron, Underwood Creek Tributary, next to Douglas Point Env. Sensitive Area and Scott Point ANSO. Mean depth 2-3m; island and protective shoals. Eastern shore of Lake Huron at Point Douglas, near Tiverton, ON.	It is a provincially significant class 2 wetland, 24 vegetation communities, 50% marsh, 46% fen, 4% swamp with nursery, spawning, feeding migratory habitat for at least 50 species of fish; breeding & feeding habitat for provincially significant waterfowl, birds, reptiles, and amphibians; and more than 150 species of plants. Unique coastal habitat in eastern shore south to Sarnia.	Mr. Don Wismer (Ontario Hydro)
70	Whittlesey Creek Watershed - Bad River Watershed	Superior	Tributary Wetland	High Biodiversity Critical for Rare Species Critical for Economically Important Species Critical for Endangered Species High Habitat Diversity Rare Habitat Feature High Connectivity Value			Mrs. Laura Day (National Wildlife Federation)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
71	Isle Royale	Superior	Reef Nearshore Embayment Islands	High Biodiversity Critical for Rare Species High Habitat Diversity	Location corresponds to boundaries of Isle Royale National Park. Nearshore waters (waters, within 4 miles of the island shore encompassed by statistical grids 522-3, 619-623, 718-722, and 818-820)	This ABIA contains the only self-sustaining population of coaster brook trout in Michigan waters. Nearshore waters contain populations of humper, sisconet, and lean lake trout unique to the Great Lakes.	Mr. James W. Peck (Michigan DNR)
72	Caribou Island reef complex in Lake Superior	Superior	Reef Offshore	High Biodiversity High Productivity High Habitat Diversity	It has the most variation in depth of any area of Lake Superior. North of Grand Marais extending southwest toward Munising (statiscal grids 1137-39, 1236-39, 1335-1336, and 1435)	The community is pelagic and benthic with the most abundant populations of humper and siscowet lake trout in Lake Superior. Associated species include sculpins, burbot, and coregonines.	Mr. James W. Peck (Michigan DNR)
73	St. Mary's River	Huron	Wetland Reef Nearshore Islands	High Biodiversity High Habitat Diversity High Connectivity Value	The St. Mary's offers not only a variety of habitat but also some unique environmental conditions.	The river offers a blend of many habitat types.	Dr. Dave Fielder (Michigan DNR)
74	Fischer Creek	Michigan	Tributary Wetland Shorelands	High Biodiversity Critical for Economically Important Species	Within a state Forest.		Mr. Tom Herschelman
107	Wolf River	Michigan	Tributary	High Biodiversity High Productivity High Habitat Diversity	Wolf River flows into Lake Winnebago, and Lake Winnebago flows to Green Bay via the Fox River.	It has sturgeon spawning site & rearing areas, and walleye spawning marshes and rearing areas.	Mr. Daniel Helf (wisc. Dept. Nat. Res.)
110	Green Lake, Green Lake County, WI	Michigan	Tributary Profundal	High Biodiversity High Habitat Diversity	Green Lake is Wisconsin's deepest lake and supports a lake trout population which is rare for an inland lake this far south.		Mr. Rob McLennan (Wisconsin DNR)
111	Wolf River	Michigan	Wetland Shorelands	High Biodiversity High Habitat Diversity Rare Habitat Feature		The Wolf River bottoms are a complex of wetlands along the Wolf River. The bottoms offer unique habitat in large blocks. The wetland complex is a mix of forested, marsh, and shrub wetlands.	Mr. Daniel Helf (wisc. Dept. Nat. Res.)
112	Lakes Winneconne, Poygan, Butte des Morts, and Winnebago	Michigan	Tributary Wetland	Critical for Endangered Species High Habitat Diversity High Connectivity Value	It is a shallow lake and wetland system including Wisconsin's largest inland lake.	The Winnebago lakes support North America's largest lake sturgeon population and endangered species such as Forsters Tern.	Mr. Rob McLennan (Wisconsin DNR)
113	Rush Lake, WI	Michigan	Tributary Wetland	High Biodiversity High Productivity Rare Habitat Feature	It is a large prairie pothole lake wetland in Winnebago County, WI.	Rush Lake is the largest prairie pothole wetland in Wisconsin's Lake Michigan drainage. It has excellent biodiversity and provides critical habitat for migratory birds.	Mr. Rob McLennan (Wisconsin DNR)
114	Milwaukee River Estuary	Michigan	Tributary Shorelands	High Biodiversity Critical for Economically Important Species Rare Habitat Feature	It is approximately 1200 acres in size, has high angling pressure, and a walleye restoration project is ongoing. There is high zebra mussel impact, and a yellow perch nursery area. (lower Milwaukee River and the outer and inner harbors, Milwaukee, WI)	It is an area of high public interest, and is an urban location with a high degree of change over the past 10 years.	Mr. Jim Thompson (Wisconsin DNR)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
115	Gratiot Lake and its outlet the Little Gratiot River	Michigan	Tributary Wetland	High Biodiversity Critical for Rare Species Critical for Endangered Species	It is a glacially formed lake with about 2.5 square miles surface area. The shoreline is over 2/3 undeveloped. The depth is 70+ feet. The bottom is rocky, sandy or muddy in various locations, and there is varied emergent, submergent, and littoral vegetation. Wetlands and mixwood conifer and deciduous woodlands surround. The Little Gratiot empties into Lake Superior. Located in Eagle Harbor Township and Grant Township in Keweenaw County, MI	This is the largest inland lake in Michigan.	Ms. Bonnie Hay (Gratiot Lake Conservancy)
116	Rice Lake, Mole Lake Indian Reservation, Wolf River Watershed, Northern WI	Michigan	Tributary Wetland	High Biodiversity High Productivity Critical for Endangered Species	There are dense and healthy wild rice beds, with nesting terns and high biodiversity. It is designated as Outstanding National Resource Water (ONRW).	It is of cultural significance to the tribe, is major migration stop for waterfowl, and there are no discharges present in the entire system.	D. C. Anderson (Sokangon Chippewa Tribe)
117	Severn Sound	Huron	Wetland Shorelands Islands	High Biodiversity High Productivity High Habitat Diversity	There are extensive fringing wetlands, islands, and submerged reefs.	There are shallow, nutrient rich waters, combined with geological transition zones that create conditions for the development of a complex fish community.	Mr. Arunas Liskauskas (Ontario MNR)
118	Bronte Creek	Ontario	Tributary	High Biodiversity Critical for Endangered Species			E. J. Crossman (Royal Ontario Museum Centre for Biodiversity and Conservation Biology)
119	Long Point Bay	Erie	Wetland Embayment Shorelands	High Biodiversity High Productivity High Habitat Diversity		It has been called the most productive small mouth bass fishery in North America. Also it is very important for large mouth bass and several other Centrarchids (e.g. rock bass, bluegill, pumpkinseed).	Mr. Dave Aakney (OFAH)
120	Wilmont Creek	Ontario	Tributary	High Biodiversity High Productivity		Trout and other fish spawn in this location.	Mr. Frank Wick (OFAH)
121	Bay of Quinte	Ontario	Tributary Shorelands	High Biodiversity High Habitat Diversity	This is a very significant breeding area. Millhaven Creek is a possible salmonid spawning area.	It is very important to the fisheries of Eastern Lake Ontario.	Mr. Jack Odette (OFAH)
122	Large bay formed between Black Bay Peninsula and Sibley Peninsula	Ontario	Wetland Embayment Shorelands	High Biodiversity High Productivity High Habitat Diversity	It is large with shallow water and is near Dorion, ON.	It is a diverse fishery with many species of sport fish and forage fish, as well as marine bird nesting sites.	Mr. Neil Wiens (OFAH)
123	Black Sturgeon River		Tributary	Critical for Rare Species	This is a long, slow moving river.	It has the potential for improved sturgeon populations.	Mr. Neil Wiens (OFAH)

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124	McVicar's Creek	Superior	Tributary	High Habitat Diversity	McVicar's Creek is in the city of Thunder Bay.	This is very important spawning habitat and should be maintained in the future.	Mr. Joe Coghlan (OFAH)
125	Eastern Georgian Bay	Huron	Wetland Shorelands Islands	High Biodiversity High Habitat Diversity High Connectivity Value	There is a vast littoral shelf and extensive islands, submerged reefs, and fringing wetland complexes.	The geological, morphological, and biotic diversity concentrated in this littoral shelf provides conditions for the development and support of complex fish communities.	Mr. Arunas Liskauskas (Ontario MNR)
126	Humbug Marsh, Wayne County, MI	Detroit River	Wetland Embayment Islands	High Biodiversity Critical for Endangered Species High Habitat Diversity	It is between Jefferson Avenue and the Detroit Rivers, Gibraltar and Trenton, MI. It is the last remnant of coastal wetland on mainland MI shore of Detroit River. It is a fish spawning and nursery area, and flyway for migratory birds.	It is a spawning and nursery area to 40+ fish species, feeding area for bald eagles and osprey, flyway for 25+ species of waterfowl, 17+ species of raptors, and 48+ species of non-raptors. It is the migration route for 117+ species of fish, and home to endangered species.	Dr. Bruce Manny (U.S. Geological Service)
127	Bay of Quinte	Ontario	Tributary Wetland Embayment	High Biodiversity High Productivity Critical for Economically Important Species High Connectivity Value	There are large beds of aquatic macrophytes and also pelagic habitat. Over 5000 ha of wetlands are within 3.2 km of the shoreline.	Important sport (e.g. walleye) and commercial fisheries. There are sturgeon, walleye, and other fish that spawn in the tributaries and also it is important for waterfowl and other aquatic birds.	Mr. Andy Smith (OMNR)
128	Main Duck Sill, Long Point,	Ontario	Reef Offshore Profundal Islands	High Biodiversity High Productivity Rare Habitat Feature	Also important pelagic habitat of international significance.	This is an important sport fishery and an important staging area for waterfoul such as the Scaup.	Mr. Andy Smith (OMNR)
129	Apostle Islands, Kakagon-Bad River Estuaries, Fish Creek Estuary (Chequamegon Bay region)	Superior	Tributary Wetland Reef Nearshore Embayment Reef Offshore Shorelands Islands Beach	High Biodiversity Critical for Rare Species Critical for Endangered Species Rare Habitat Feature	There are rare plant communities, trumpeter swan introduction areas, endangered and threatened bird communities, and fish spawning areas.		Mr. Charles Ledin (Wisconsin DNR)
130	Little Cataraqui Marsh	Ontario	Wetland Shorelands	High Biodiversity Critical for Rare Species High Connectivity Value	It is south east of Brockville, and west of Belleville. It is part of a wetland complex which also includes Bell Swamp and Little Cataraqui Reservoir.	It is a Class 1 provincially significant wetland. ANSI area-important habitat. It has regionally significant fish spawning areas, and is important for seasonal commercial fish harvesting. It is of national significance as a waterfowl staging area and is a highly significant bird migration and river otter feeding area.	Ms. Lee Ann Hamilton (Cataraqui Region Conservation Authority)
131	Parrots Bay Marsh, South of Bayview Bay, West of Kingston and East of Belleville, ON	Ontario	Wetland Shorelands	Critical for Rare Species High Habitat Diversity High Connectivity Value	There are open water marshes and forested uplands within Parrots Bay Conservation Area. It is connected directly to Lake Ontario.	It is provincially significant as a wetland, and has fish spawning habitat. It is important for seasonal harvesting of fish, and as a feeding area for provincially significant colonial birds, waterfowl, wading birds, raptors, regionally rare bird species, and turtles. There are regionally rare plant species and high habitat value.	Ms. Lee Ann Hamilton (Cataraqui Region Conservation Authority)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
132	Bayview Bog (Lost Lake, Amherstview Swamp)	Ontario	Wetland	Critical for Rare Species High Habitat Diversity Rare Habitat Feature	Northwest of Amherstview, west of Kingston, and east of Belleville. It is a combination of upland, marsh, swamp, and fen, with many habitat types within one area.	It is a swamp-marsh-fen complex with several regionally significant tree species, vascular plants, bird species, and mammal species. It has a high proportion of native to non-native plants and has a very large heronry, high biodiversity, and many provincially significant species.	Ms. Lee Ann Hamilton (Cataraqui Region Conservation Authority)
133	Bay of Quinte	Ontario	Wetland Embayment Shorelands Beach	High Productivity Critical for Economically Important Species High Habitat Diversity	It is south of Fredericksburgh Township, immediately south of Highway 33, and on the northeast shore of Lake Ontario. It is West of Kingston, Millhaven, Bath and Sandhurst, east of Allens Point, Picton, and Belleville, and south of Napanee. Area of shoreline from Conway to Cole Point, along the Adolphus Reach	It is a Lake Ontario shoreline area of wetland and vegetated bank providing seasonal fish spawning habitat for walleye. It is an active feeding area for waterfowl and also includes an area of depositional sand beach.	Ms. Lee Ann Hamilton (Cataraqui Region Conservation Authority)
135	Clark Island, Bay of Quinte	Ontario	Wetland	High Biodiversity High Productivity Critical for Rare Species	It is north of Fredericksburgh Township, south of Anderson, southeast of Napanee, north of Sandhurst, and northeast of Lake Ontario. It is connected to Lake Ontario, and is a section of a larger wetland within Hay Bay, west of Kingston and east of Belleville.	It is an Area of Natural and Scientific Interest (ANSI) and has regionally significant areas of walleye and northern pike spawning. It is a MNR designated sensitive fish spawning area and has seasonally significant areas of commercial fish harvesting and provincially significant feeding areas for waterfowl.	Ms. Lee Ann Hamilton (Cataraqui Region Conservation Authority)
136	Baie Dore	Huron	Wetland Embayment Shorelands	High Biodiversity High Productivity Critical for Rare Species		It is the wintering grounds for significant populations of bald eagles, and the stopover for many species of ducks and geese.	Mr. Al Wilkins (Lake Huron Fishing Club)
137	Point Clark Shoals	Huron	Reef Nearshore Reef Offshore	High Productivity Critical for Economically Important Species		This is a major historic spawning shoal for lake trout and yellow perch and is crucial for lake trout rehabilitation plans of the MNR.	Mr. Al Wilkins (Lake Huron Fishing Club)
138	Douglas Point	Huron	Tributary Pelagic Profundal	High Biodiversity High Productivity Critical for Economically Important Species	There are warm water outflows from Ontario Hydro Bruce Nuclear power plants.	The warm water outflows of the power plants plus the deep surrounding waters attract and hold major numbers of fish throughout cold weather periods.	Mr. Al Wilkins (Lake Huron Fishing Club)
139	Saugeen River	Huron	Tributary	High Biodiversity High Productivity High Habitat Diversity	It is the largest tributary of the main basin of Lake Huron on the Canadian side.	This is a major spawning run of the listed species with significant natural reproduction contributing to sustaining lake populations.	Mr. Al Wilkins (Lake Huron Fishing Club)
140	Kakagon/Bad River Complex	Superior	Tributary Wetland Shorelands	High Biodiversity Critical for Endangered Species High Habitat Diversity	Tws. 48NR2W and 48NR3W, Tws. Sanborn, N. Ainland, WI. The Kakagon/Bad River Wetland Complex is a 16, 000 acre coastal estuary including Lake Superior shorelines and beaches. It is the largest of its type in the upper Great Lakes Basin.	It is of cultural importance to the Bad River Tribe for sustinance purposes. It is the largest density of breeding Bald Eagles in the Great Lakes. Lake Superior has the most diverse and largest pristine coastal wetland.	Ms. Anne Barnes (Bad River Tribe)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
141	Cheboygan River Watershed		Tributary Wetland	High Biodiversity High Productivity Critical for Rare Species Critical for Economically Important Species	There is a large assemblage of Oligotrophic lakes, trout streams, and wetlands.	There are Common Tern, Black Tern, Lake Sturgeon, Caspian Tern, Common Loon, and the American Bittern.	Mr. Scott McEwen (Tip of the Mitt Watershed Council)
142	Maitland River	Huron	Tributary	High Productivity Critical for Economically Important Species High Connectivity Value	It is the portion of the Maitland River from its mouth to Benmiller.	It is an important regional corridor for both aquatic and terrestrial species. It has important fish spawning and migration corridors, and important terrestrial corridor especially in the highly fragmented landscape of Huron County.	Mr. Geoff Peach (Lake Huron Centre for Coastal Conservation)
143	Chantry Island, coast of Southampton, ON	Huron	Reef Nearshore Islands	High Productivity Critical for Rare Species High Habitat Diversity	The island is 19 ha in size and includes a beach ridge on the east side, and coastal wetland on the west side. The reef comprises an additional 44 ha around the island.	It is the most southerly island on Huron, and a key to a number of migrating bird species. It is an important heronry as well as a stopover for Caspian Terns and several duck species. Researchers have noted 2 pairs of Egrets nesting on the island.	Mr. Geoff Peach (Lake Huron Centre for Coastal Conservation)
144	McGregor Wetland Complex/Baie du Dore	Huron	Wetland Shorelands	High Biodiversity High Productivity High Habitat Diversity	Located near Bruce Township, Bruce County, south of Port Elgin, and north of the Bruce Nuclear Power Development. It is a large wetland complex connected to Lake Huron.	It is an important coastal wetland complex in size and diversity. It is a feeding habitat for colonial waterbirds and raptors, it supports staging and production activities for waterfowl, and is an important migratory passerine area. The wetland complex has been ranked as Class 1 wetland. There are numerous rare plant species and a large herpetefaunal population.	Mr. Geoff Peach (Lake Huron Centre for Coastal Conservation)
145	Iverhuron Provincial Park, Bruce County, east of the village of Tiverton	Huron	Embayment Shorelands Beach	Critical for Rare Species High Habitat Diversity	It is located directly south of the Bruce Nuclear Power Development.	There is a significant relief dune complex with high species diversity, and it is claimed to be an important stopover location especially for neotropical migrants.	Mr. Geoff Peach (Lake Huron Centre for Coastal Conservation)
146	Minnesota Point in Duluth, MN, at the western-most end of Lake Superior	Superior	Wetland Islands Beach	Critical for Rare Species Rare Habitat Feature High Connectivity Value	It is the longest freshwater baymouth bar, and has old growth red and white pine forests (20+ acres). It is a migratory bird stopover and flyway, and there are many state-listed plant species.	There is a 7 mile long sand beach, dunes, beach grass (threatened species), and one large wetland area (1 acre) and several small pockets within the forest. It is threatened by urban expansion and much of the inland shore is shallow water habitat.	Mr. Kinnan Stauber (Park Point Community Club)
147	All shores and cliffs of Lake Superior	Superior	Tributary Wetland Shorelands	High Biodiversity High Productivity Critical for Rare Species	There are red sandstone cliffs and hemlock stands.		Ms. Judy Pratt-Shelley (Red Cliff Band of Lake Superior Chippewas)
148	All creeks and rivers running into Lake Superior	Superior	Tributary Embayment	High Biodiversity High Productivity Critical for Rare Species	Includes all rivers from the Minnesota border to White River.	This area has many productive tributaries which help to provide excellent fishing and hunting (waterfowl) opportunities as well as provide employment. There are several coastal trout breeding areas within this location.	Mr. Joe Coghlan (OFAH)

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149	Superior Sholes	Superior	Reef Offshore	High Productivity Critical for Economically Important Species High Habitat Diversity	There is an excellent population of lake trout in the middle of Lake Superior.		Mr. Ted Just (Marathon Rod and Gun Club)
150	Snye Marsh/south shore of St. Lawrence River, and part of Bainesville Bay Marsh	St. Lawrence	Wetland	High Biodiversity High Habitat Diversity	There is a Ducks Unlimited area and Eastern Habitat Joint Venture Project.		Mr. Shawn Martin (St. Regis Mohawk Tribe)
151	Bluffers Park	Ontario	Reef Nearshore Embayment	High Productivity High Habitat Diversity	It is a major embayment complex. There is an existing mosaic of habitat components including extensive areas of submerged aquatic vegetation, deep water areas, warm water thermal habitat, open coast shoreline of beaches headland, and are important spawning areas for pelagic forage fish and one section provides lake trout spawning habitat.	A significant embayment complex that provides important sheltered warm water habitat. Focus of restoration activities that are treating storm water and developing important wetland habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
152	Convex shoreline profile offshore from the East Point Waterfront area	Ontario	Pelagic Profundal	High Productivity High Habitat Diversity	It is the only convex shoreline profile along the Toronto waterfront, and is somewhat rare along the north shore of Lake Ontario. The convex shoreline profile is a major attraction and is an important habitat for pelagic fish.	The convex shoreline profile attracts a variety of pelagic fish.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
153	Highland Creek Coastal Marsh	Ontario	Tributary Wetland	High Productivity High Habitat Diversity	There is a wetland complex, corridor area to the highland creek watershed, moderate areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, creek mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	The moderate wetland complex provides important sheltered warm water habitat. The focus of restoration activities is to treat storm water and develop important wetland habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
154	Rouge River Coastal Marsh	Ontario	Tributary Wetland	High Productivity High Habitat Diversity	There is a wetland complex, a corridor area to the Rouge River watershed, extensive areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, river mouth and marsh which are important spawning areas, and significant opportunities for restoration exist.	There is an extensive wetland complex that provides important sheltered warm water habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

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155	Duffin's Creek Coastal Marsh	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex, and there are extensive areas of submerged aquatic and emergent wetland vegetation, warm water thermal habitat, river mouth and marsh which are important spawning areas, and there are significant opportunities for restoration activities.	The extensive wetland complex provides important sheltered warm water habitat and it is the only location for brook silverside on the Toronto Waterfront, which has a limited distribution.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
156	Frenchman's Bay Coastal Marsh	Ontario	Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex, and extensive areas of submerged aquatic and emergent wetland vegetation. It is a warm water thermal habitat, and the river mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	There is an extensive wetland complex that provides important sheltered warm water habitat. It is the only location for brook silverside on the Toronto Waterfront.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
157	Carruther's Creek Coastal Marsh (Shoal Point Marsh)	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	There is a wetland complex with a corridor area to the Carruther's Creek watershed, and there are extensive areas of submerged aquatic and emergent wetland vegetation. It is a warm water thermal habitat and the river mouth and marsh are important spawning areas for a variety of fish. There are significant opportunities for restoration activities.	The extensive wetland complex provides important sheltered warm water habitat with significant productivity within the marsh.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
158	Colonel Sam Smith Park	Ontario	Wetland Reef Nearshore Embayment	High Biodiversity High Productivity High Habitat Diversity	There are restoration activities including modification to the boat basin shoreline to diversify and improve fish production, the creation of a wetland complex, and open coast shoreline modification which provides lake trout spawning shoals. It is a diverse warm water fish community, with bass and pike.	It is a significant sheltered warm water habitat and it provides high productive capacity for warm and cold water species. It is somewhat isolated from water quality impacts of the city.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
159	Mimico Creek Estuary (Humber Bay Park Complex)	Ontario	Tributary Wetland Embayment	High Productivity High Habitat Diversity	It is a major restoration area, and activities will develop an important estuary wetland complex.	It is a significant sheltered warm water habitat, and restoration activities will provide improved productive capacity for warm water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

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160	Humber Bay Shores (Humber Bay Park Complex)	Ontario	Wetland Reef Nearshore	High Productivity High Habitat Diversity	There are major restoration activities that will develop an important mosaic of habitat components including islands. There are areas of submerged aquatic vegetation, cobble beaches, a wetland complex, and specific spawning areas for bass and northern pike.	It is a significant sheltered warm water habitat, and has open coast habitat and shoreline diversification. Restoration activities will provide improved productive capacity for warm and cold water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
162	Humber River Marsh	Ontario	Tributary Wetland Embayment	High Biodiversity High Productivity High Habitat Diversity	It is a major coastal wetland complex and corridor. The existing mosaic of habitat components includes sheltered backwater lagoons, extensive areas of emergent wetland vegetation, and an estuary corridor.	It is a significant coastal marsh complex with significant sheltered warm water habitat. There is a corridor connection between the lake and river habitats. The Humber marshes have significant productive capacity and local biodiversity for warm water species.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
163	Toronto Bay (Toronto Inner Harbour)	Ontario	Embayment	High Productivity High Habitat Diversity	It is a major embayment complex. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, deep water areas, warm water thermal habitat, and river discharge.	It is a significant embayment complex that provides important sheltered warm water habitats, which are the focus of planned restoration activities.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
164	Toronto Islands (Toronto Inner Harbour)	Ontario	Embayment Shorelands Islands	High Biodiversity High Productivity High Connectivity Value	This is a major embayment complex. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, sheltered lagoons, deep water areas, warm water thermal habitat, and critical spawning juvenile and adult habitat.	It is a significant embayment complex that provides important sheltered warm water habitat, and is a centre of productivity and biodiversity that supports and feeds adjacent habitats.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
165	Tommy Thompson Park	Ontario	Reef Nearshore Embayment	High Biodiversity High Productivity High Connectivity Value	This is a major landform with extensive natural shorelands and embayments. The existing mosaic of habitat components includes extensive areas of submerged aquatic vegetation, sheltered lagoons, deep water areas, warm water thermal habitat, and critical spawning juvenile and adult habitat.	This is a significant embayment complex that provides important sheltered warm water habitat, and is the centre of productivity and biodiversity that supports and feeds adjacent habitats. It has excellent potential for restoration of critical habitats. There is functional nearshore spawning of lake trout on the open coast where the 10 m depth contour intersects the shore.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)

Site #	Site Name	Watershed	Location Features	Attributes	Comments about Site	Comments about Attributes of Site	Experts
166	Open coast shoreline from Ashbridges Bay Park (Toronto) to Carruther's Creek (Durham Region)	Ontario	Shorelands Beach	Critical for Economically Important Species High Connectivity Value	There is a major open coast landform with extensive areas of natural beach and various shoreline protection works (groynes, beach headlands, revetments). Existing mosaic contains open coast habitat, sand, cobble, and gravel beaches, headland, groynes, and revetments. Restoration activities are focused at providing nearshore reefs and maintaining the beach profile.	This is a significant open coast shoreline with extensive sand gravel and cobble beaches. It is the centre of productivity and biodiversity for pelagic forage fish species that supports and feeds the economically important pelagic salmonids. The open coast shoreline is extensively utilized by juvenile salmonids and adult salmonids that utilize the shoreline during coldwater periods and staging into the tributaries that connect to the lakes. It has excellent potential for restoration of critical open coast habitat.	Mr. Gord MacPherson (The Toronto and Region Conservation Authority)
167	Headwaters of Etobicoke Creek north of Mayfield Road, west of Hurontario Street	Ontario	Tributary	High Biodiversity	There are several small tributaries with permanent flow.	It is a remaining tributary in watershed with rural land use and it still supports a healthy diversity of fish species. It is an eventual seed source for the rest of the watershed.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
168	Heart Lake in the Etobicoke Creek Watershed	Ontario	Tributary	High Biodiversity High Productivity	It is a kettle lake.	It has a diverse kettle lake habitat.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
169	Main Humber River/Niagara Escarpment to Humber Bay on Lake Ontario	Ontario	Tributary	High Biodiversity High Productivity Critical for Rare Species	Includes the Main Humber subwatershed and associated tributaries north of junction with east Humber.	It is a highly diverse habitat which supports high biodiversity. Nominated as a heritage river.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
170	Little Rouge Creek (subwatershed of the Rouge River watershed)	Ontario	Tributary	High Biodiversity High Productivity Critical for Rare Species		There is an opportunity to protect large areas of riparian habitat due to public ownership (federal and provincial) and thus the protection of aquatic communities.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
171	East Duffins Creek	Ontario	Tributary	High Biodiversity Critical for Economically Important Species	It is a subwatershed of Duffins Creek watershed.	It is principally a cold water stream with potential to support Atlantic salmon.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)

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172	East Don River in the Don River watershed	Ontario	Tributary	High Habitat Diversity	Located from Oak Ridges Moraine to the confluence with the west Don including the tributaries.	Has high potential to rehabilitate for a variety of sensitive fish species. It is a diverse habitat transition from ORM to near Lake Ontario.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
173	Lake Wilcox	Ontario	Tributary	High Biodiversity High Productivity Critical for Economically Important Species	It is a kettle lake on Oak Ridges Moraine.	It is a kettle lake in an urbanizing area. There is an opportunity to preserve and rehabilitate the habitat and species and link to community outreach.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)
174	Morningside Park and Colonel Danforth Park	Ontario	Tributary	High Biodiversity High Habitat Diversity	They are tributaries in public parks in the middle and lower reaches of the watershed.	There is an opportunity to preserve and rehabilitate the river processes and associated fish species.	Mr. Bernie McIntyre (Toronto and Region Conservation Authority)