V. Aquatic and Coastal Habitat

The Lake Huron Binational Partnership has identified degradation and loss of historical habitat in tributaries, near shore, and coastal wetland habitats as major stressors to the Lake Huron ecosystem. Although many of the ecosystems have been fragmented and others nearly eliminated, the Lake Huron basin exhibits a high level of diversity in its natural environments. The basin's coastal marshes, islands and rocky shorelines, sand dunes, alvars, tributaries, savannahs and prairies contain features that are either unique to, or are best represented within the Lake Huron watershed. The health of the lake and its biological diversity is directly related to the health of each of these habitat components.

Coastal Wetlands

Coastal wetlands are intermediate zones linking the open waters of the Great Lakes with their watersheds. Despite being fundamentally important to assure the biological diversity and health of the Great Lakes ecosystem, coastal wetland area and quality is declining (Ingram, 2004; Mayer et al., 2004). However, knowledge of coastal wetland functions and their socio-economic and ecological importance has improved and recent scientific attention has raised the profile of coastal wetlands providing a current picture of the health, integrity and the potential for management (Krieger *et al.*, 1992; AEHMS, 2004).

Four basic wetland types are found in the Great Lakes basin: swamps, marshes, bogs and fens. Fens, or meadow marshes, commonly occur in Lake Huron and are identified as globally imperiled (Natural Heritage Information Centre, 1995). Swale complexes are also found along the shores of Lake Huron between dunes or ridges. Coastal wetlands can also be separated into lacustrine, riverine, or barrier-protected systems based on their dominant hydrologic source and connectivity to the lake (Albert et al., 2003).

Coastal wetlands have important ecological, economic and social functions and values. Those connected with the lake and tributary system perform important functions for Lake Huron through their contributions to hydrology, deposition of sediments, particle entrapment, nutrient retention, storage and exchange to recipient waters. Other functions include provision of habitat and the foundation for a complex food web. These wetland functions provide crucial societal values: water quality improvement, flood attenuation, shoreline protection, human food and recreational use, landscape diversity and carbon storage (Loftus et al., 2004; Mayer et al., 2004).

Estimates on the number of fish species utilizing coastal wetlands for spawning, nurseries and food sources vary from 59 (Prince et al., 1992; Jude and Pappas, 1992) to over 90% of the approximately 200 fish species in the Great Lakes (Liskauskas et al., 2004). A rich variety of amphibians and reptiles require these wetlands for breeding, development, foraging, hibernation and refuge (Hecnar et al., 2002; Hecnar, 2004). Important staging and nesting areas are provided for waterfowl and other avian species during the reproductive and migration seasons (Prince et al., 1992).

<u>Coastal Wetland Distribution and Inventories</u>

The Great Lakes Coastal Wetland Consortium (GLCWC) identified 1255 Lake Huron wetlands for Ontario totaling 16,086 hectares (9,749 acres); the greatest amount of coastal wetlands relative to other Great Lakes on the Canadian shoreline. An additional 800 wetlands were identified on the Michigan shoreline totaling 44,335 hectares (109,554 acres) (Figure 5.1). The true wetland area for Ontario is expected to be much higher; however, photo coverage is required to permit inventory for remote areas of the North Channel and Georgian Bay (Ingram, 2004). The wide distribution of wetlands in these areas lends itself to the use of remote sensing technology to obtain an inventory and identify environmental impacts due to human-related and natural alterations. McMaster University researchers are using IKONOS satellite imagery and ground truthing to more accurately delineate and map wetlands in eastern Georgian Bay.

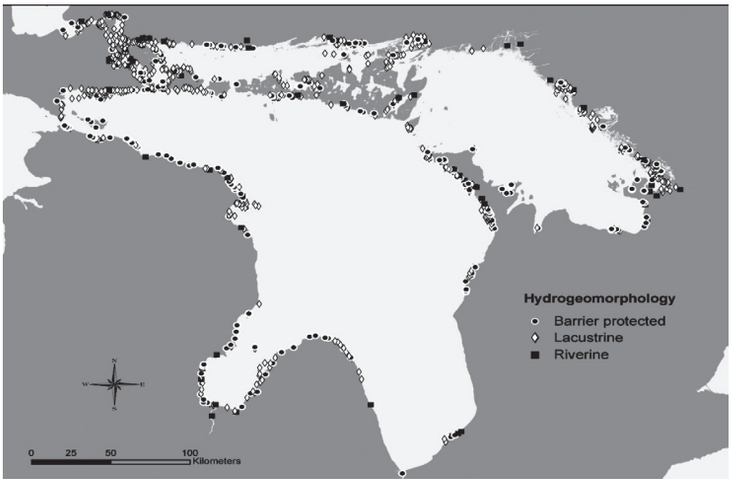

Figure 5.1. Distribution of Lake Huron coastal wetlands by hydrogeomorphic type.

Coastal Wetland Stressors

Coastal wetlands experience continual stress from natural and anthropogenic influences. While present lake levels are within the range of historic natural variation, global warming and human activities could potentially result in a trend towards even lower water-level cycles (Jalava et al., 2005). Exploitation of wetland soils exposed above the low water line is yet another management concern (Albert and Minc, 2004). Other deleterious impacts to wetland habitat include diking, draining, filling, road construction, non-native species, marinas, boat channel dredging, and non-point source pollution.

Coastal Wetland Status and Indicators of Health

While a small fraction of pre-settlement wetlands remain (Krieger et al., 1992), no comprehensive estimate of wetland loss is available for the Canadian and U.S. sides of Lake Huron. Large scale wetland loss has not occurred in northern Lake Huron and Georgian Bay because of is sparse population and its highly irregular, and in some cases remote shoreline. However, cottage, marina, and subdivision development continue to pressure wetlands.

Various indicators have been proposed to track improvement or deterioration of wetlands throughout the Great Lakes (Ingram, 2004; Lawson, 2004), with those of Chow-Fraser and colleagues (2006) used extensively in Lake Huron. McMaster University researchers evaluated more than 100 wetlands throughout the Bruce Peninsula, eastern Georgian Bay and the North Channel using a Water Quality Index to rank wetlands according to the degree of anthropogenic disturbance. Habitat quality was calculated using scores for Wetland Fish, Zooplankton and Macrophyte Indices (Chow-Fraser et al. 2006). Compared with 93 other Great Lakes coastal wetlands, Georgian Bay and the North Channel are in the "very good" to "excellent" categories. Most wetlands showing signs of degradation are in southeastern Georgian Bay are "moderately degraded".

Lake Huron Coastal Wetland Priority Management Areas

Priority coastal wetland management areas and attributes are provided below. Additional information and wetland-relevant fish community objectives can be found in the Great Lakes Fishery Commission's Environmental Objectives for Lake Huron (Liskauskas et al., 2004).

Saginaw Bay

Saginaw Bay is recognized as a rich biological resource representing the largest freshwater coastal wetland area in the United States. Historically, Saginaw Bay contained one of the largest wetland/lake prairie complexes in the

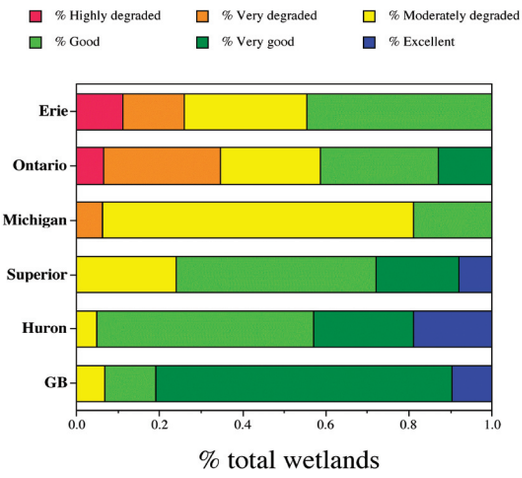

Figure 5.2. Comparison of Great Lakes coastal wetland health.

Great Lakes region and supported the largest population of yellow perch, walleye, northern pike and muskellunge populations. It continues to be important for yellow perch, smallmouth bass, largemouth bass, black crappie, sunfish, rock bass, and channel catfish. Massive land use changes since the mid-1880s have significantly altered the quantity, diversity and quality of wetland. Reports indicate that only 6070 hectares (15,000 acres) of the nearly 14973 hectares (37,000 acres) of emergent vegetation around Saginaw Bay remain today. The upper watershed development is causing sedimentation and contamination of sediments. The area still experiences shoreline development pressure and wetland loss and is impacted by exotic species. Many of the remaining coastal wetlands are no longer connected to the lake.

A restoration strategy has been developed for Saginaw Bay which focuses on preserving coastal marsh areas and upland buffers. It clearly identifies vulnerable areas so that governmental agencies, local conservation/environmental organizations and concerned citizens can monitor their status, enhance enforcement of existing laws and conduct educational programs.

Les Chenaux Islands

This area contains extensive coastal wetlands and has experienced some historic loss. The area supports a diverse fish community and is critical habitat for yellow perch and northern pike. Stressors include nutrient enrichment problems and shoreline development pressures. Priority actions consist of continued wetland monitoring and evaluation.

Bruce Peninsula, Eastern Georgian Bay and North Shore of North Channel

Wetlands are interspersed throughout these shorelines and still require assessment. The area supports a diverse warm and cool water fish community. Muskellunge and northern pike utilize these coastal wetlands for spawning. The area also supports a high diversity of smallmouth bass, largemouth bass, black crappie, sunfish and rock bass. More than half of the wetlands along the central coast, the western coast of the Bruce Peninsula and southern Georgian Bay have suffered recent losses (EC and OMNR 2003). Wetland area in southern Georgian has decreased since 1951 (Severn Sound -68%; Penetanguishene/Hog Bay -18%) (Severn Sound Remedial Action Plan, 1993). Severn Sound and Magnetawan Rivers are under intense recreational and developmental pressure. Impacts from exotic species are becoming more prominent. The Spanish River delta wetlands are currently recovering from historic environmental impacts and are a site of muskellunge recovery. Priorities include additional inventories, monitoring and recovery of these wetlands.

Alvars

Alvar communities of the Lake Huron basin warrant special interest because of their rarity and unique assemblages of flora and fauna. Alvars are naturally open areas of thin soil over flat limestone or dolostone with grassland, savanna and sparsely vegetated rock barrens (Catling and Brownell 1995). The limestone on which most of Lake Huron alvars are found was deposited about 450 million years ago and overlies the granite and quartzite of the Precambrian shield. The Bruce Peninsula and Manitoulin Island sites are distinctive in having species associated with fen-like wetlands on cool limestone pavements (Brownell and Riley, 2000). The Bruce Peninsula, Manitoulin Island and Maxton Plains, on Michigan's Drummond Island, rank as the largest, most intact and least disturbed alvars in the world (Rescheke et al., 1999).

A number of endemic species have evolved to survive only in this environment and are restricted to alvar sites in the Lake Huron region (Brownell and Riley, 2000). Forty-three plant species regarded as rare in Ontario occur on alvars (Rescheke et al., 1999). A list of more than 300 species from groups including beetles, leafhoppers, sawflies and butterflies have also been identified (Bouchard and Wheeler, 1997). Alvars offer other significant interests such as their genetic diversity, natural history recreation, education and biological research.

Distribution and Factors Affecting Alvar Habitat

Many alvar species have a worldwide distribution restricted to the Great Lakes shores and are of global, regional, state/provincial significance. Lake Huron alvar communities are scattered in an arc that follows the Niagara Escarpment from upper Michigan through southern Ontario and to northwestern New York. The Great Lakes contain 95% of the world's alvars, with 64% occurring in Ontario and 15% in Michigan State.

Grassland and pavement alvars are classified as provincially and globally imperiled by The Nature Conservancy (Catling and Brownell 1995). More than 90% of the original extent of alvars has been lost and much of the remaining alvar ecosystem has been degraded due to a variety of anthropogenic factors including:

- Loss to quarries and collection of glacial boulders, rubble and slabs for landscaping;
- All-terrain vehicles and disruption of local hydrological patterns;
- Intensive grazing resulting in species loss and invasion of non-native plants;
- Collection of "at risk" plants and old-growth cedars by bonsai collectors;
- Logging of trees from alvar savannas, and
- Rural development, trailer parks and cottage construction (Rescheke et al., 1999).
- Lake Huron Alvar Conservation

Alvar conservation is an International Joint Commission (IJC) desired outcome of Biological Community Integrity and Diversity. Local, regional and international conservation initiatives are underway to identify and protect Great Lakes basin alvars. One of the most significant is the International Alvar Conservation Initiative (IACI). The initiative is coordinated by the Great Lakes Program of The Nature Conservancy (U.S.) and operated through an Alvar Working Group (Reschke et al., 1999).

Two comprehensive reports have been published providing a conservation blueprint for alvars in the U.S. and Canada. Ontario Nature coordinated Ontario activities of the IACI to produce 'The Alvars of Ontario' (Brownell and Riley, 2000). Additional information and priority action recommendations can be found in the technical report 'Conserving Great Lakes Alvars' compiled on behalf of the Alvar Working Group by Reschke and colleagues (1999). A natural-features gap analysis was conducted and areas most in need of protection relative to the amount of existing alvars in Ontario were identified as follows: Manitoulin, North Channel and La Cloche Island and Peninsula and Carden Plain.

Coastal Dunes

Lake Huron dune systems are a unique and fragile resource that provides significant recreational, economic, scientific, geological, scenic, botanical, educational and ecological benefits to basin

residents and visitors. Sand deposits forming coastal dunes along the shores of Lake Huron were laid down over the last 3000 to 4000 years, since post-glacial Lake Nipissing began to recede. They are the result of offshore sandbars, fluctuating water levels, strong winds, and stabilizing reeds and grasses that build the dune and set the stage for plant succession. Lake Huron dunes are considered rare, as many are comprised of remnant sand supplies incapable of regenerating themselves if damaged. The dune ecosystem has unique physical characteristics. In Ontario, the major dune types are, beach dunes, which consist mostly of sand and develop on the low-lying shores of Lake Huron, and perched dunes, which consist of sand as well as other loose material and sit on a plateau above the shore (Jalava, 2004; Peach, 2005). The major dune types In Michigan are dune and swale complexes, parabolic dunes and traverse dunes. Dune and swale complexes consist of a series or roughly parallel dunes that form as the water gradually drop. Parabolic dunes are defined by their U-shape and are found only in moist environments with extensive vegetation cover. Traverse dunes are believed to be originally formed in shallow bays (Albert, 2000).

Distribution

Sand dunes are found primarily along the southern shores of Manitoulin Island, the western shore of the Bruce Peninsula south to Grand Bend, and the southern portion of Georgian Bay. Smaller dunes are found on the Michigan shores of Lake Huron, mostly from Saginaw Bay northward. These dune systems support a distinct ecosystem which develops in succession from pioneer grasses to shrubs and eventually forest. These in turn support an important habitat for many unique and specialized species at risk. Dune plants have evolved special adaptations to the extreme heat as well as nutrient deficient soil. In addition to seed production, some of these plants send out horizontal root stems under the surface which develops into new growth short distances away. The root systems provide structure, making them far more durable than what appears.

Threatened plant species of the dunes include: Houghton's goldenrod (*Solidago houghtonii*), existing only along the northern shores of Lake Huron, dwarf lake iris (*Iris lacustris*) and the Pitcher's thistle (*Cirsium pitcheri*), which grows in the sand dune systems of Lakes Huron (Jalava, 2004). The federal, state and provincial endangered piping plover (*Charadrius melodus*) relies on the shoreline for nesting along the northern Michigan shoreline and successfully nested at Sauble Beach in 2007. The prairie warbler, a rare breeding bird in Michigan, nests among the shrubs on and in the lee of the foredune, as far north as Rogers City on Lake Huron. Several populations of Hine's emerald dragonflies, a U.S. federally endangered species, have recently been discovered within the marly swales near St. Ignace, Michigan (Albert, 2000).

Current Factors Affecting Dune Ecology

Lake Huron dunes have been subject to increasing degradation as more people impact the resource valued for its recreation and relaxation (Jalava, 2004). Dunes have not only become threatened by developmental pressures along the lakeshore, but also because the public are unaware of the value and function of dunes. Destruction of vegetation makes the dunes unstable, increases wind erosion and causes the coastline to recede. The fragile nature of dunes and the impacts of vehicles are well documented (Peach, 2004). Backshore areas subjected to heavy vehicle and pedestrian traffic have decreased top and root production, percent cover, and diversity of vegetation compared with unaffected areas (Peach, 2005). Some human related threats to dunes include: dune removal or alteration due to cottage development and parking; damage to plants and habitat from foot traffic and vehicles; habitat fragmentation from human caused breaches and blow-outs; non-native plant species, and impacts to dunes, including vehicle and pedestrian traffic (Jalava, 2004).

Coastal Sand Dune Conservation

Current research emphasizes the need to conserve Lake Huron coastal dunes and their biodiversity, to consider a long term vision, and understand the long term benefits achieved from protecting this resource (Peach, 2005). The Lake Huron Centre for Coastal Conservation has been working with local municipalities, community groups, schools,

and individuals to help them better understand and appreciate beach and dune systems. A "*Beach and Dune Guidance Manual*" was developed for the Town of Saugeen Shores to inform and educate town employees about the form, function and vulnerabilities of the dune systems along their waterfront, and to provide guidance to avoid negative impacts to the dunes (Peach, 2007). The Michigan Natural Features Inventory, with the Michigan Coastal Zone Management Program, produced an educational brochure entitled, "*Borne of the Wind – An Introduction to the Ecology of Michigan's Sand Dunes*" as an educational tool for protection of coast dunes (Albert, 2000).

Lake Huron Islands

Lake Huron contains some of the most extensive freshwater island archipelagos in the world, with estimates exceeding 36,000 islands (Jalava et al., 2005). As a result, Lake Huron has the longest shoreline of any lake in the world, extending some 6,159 kilometers or 3827 miles. The modern configuration of the Lake Huron islands has existed for approximately the past 5000 years and can be divided into three groups: 1) limestone and dolostone islands associated with Manitoulin and Drummond Islands and the Bruce Peninsula, 2) archipelagos of nearshore Precambrian Shield islands in eastern Georgian Bay and the North Channel and, 3) the low-erodible islands in Saginaw Bay. The Thunder Bay/Misery Bay Archipelago also hosts a variety of protected limestone reefs, embayments, and beach types that are among the most important spawning and nursery sites for lake whitefish and lake trout in Lake Huron. Most of the Great Lake coastal meadow marshes are found among the gneissic islands (Jalava et al., 2005).

Due to their isolation, islands are important conservation areas that support distinctive flora and fauna and unique landscape features such as dunes, alvars, swamps, bogs and marshes (Vigmostad, 1999). While islands have always been important to fish, birds and other wildlife, this is now intensified as mainland habitats experience significant fragmentation and loss to human development. Great Lakes islands provide relatively undisturbed, and in some cases pristine, habitat conditions similar to those that existed prior to European settlement.

Islands provide stopover sites and refugia for many migratory birds. Protection of these stopover sites for landbirds may be critical as mortality rates may be much higher during migration compared to that in stationary periods (Ewert et al., 2004). According to 1999 survey results, 156 Georgian Bay islands supported colonial waterbird colonies (Jalava et al., 2005), while roughly 160,000 nesting pairs of colonial waterbirds were counted by the Canadian Wildlife Service from 1998-2001 (Hughes, 2004). Islands also provide habitat for fish spawning and nursery (Manny and Kennedy, 2004), support unique plant communities and diverse assemblages of amphibians and reptiles including the endangered eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), eastern foxsnake (*Elaphe gloydi*) and the spotted turtle (*Clemmys guttata*) (Hecnar et al., 2002).

Current Factors Affecting Island Habitat

Among the most significant threats to Lake Huron islands are (1) development, especially in the Les Cheneaux and eastern Georgian Bay region, which results in habitat loss, fragmentation, and loss of natural processes in shoreline stretches and near shore waters, and (2) spread of invasive species, particularly in Saginaw Bay where islands under public ownership are being invaded by non-native animal and plant species such as *Phragmites*, zebra mussel, and Eurasian carp that may alter ecological and trophic-level dynamics. Other threats include loss of vegetation and thus modification of ecological communities due to over browsing by deer, and potential effects of climate change. Threats related to recreation, mining, shoreline hardening, alteration of substrate in nearshore waters due to dredging, and contaminants all may have consequences to the biota and processes that maintain biota on islands. Well documented stresses continue to degrade these important ecosystems (Ewert et al., 2004; Jalava et al., 2005).

Island Conservation

The biological significance and diversity of Great Lakes islands was awarded global significance in a 1995 Canada-U.S. workshop and the 1996 SOLEC. Important scientific studies and island conservation approaches have been implemented such as the Biological Ranking Criteria for Conservation of Islands in the Laurentian Great Lakes (Ewert et al., 2004) and the Binational Collaborative for the Conservation of Great Lakes Islands.

A recent study, entitled "*Biodiversity and Conservation of Lake Huron's Islands*" provides the most comprehensive biodiversity assessment of Lake Huron islands, with over 23,000 islands mapped. While almost 50% of islands within central and northern Georgian Bay are within regulated protected areas, almost none of the islands in the East Christian Island Peninsula and Nottawasaga Bay region are protected. The most threatened island regions in Ontario include the eastern coast of Georgian Bay and the northern coast of Lake Huron along the Bruce Peninsula and Manitoulin Island (Kraus et al., 2007).

In Michigan, most islands in Saginaw Bay are under State or US government ownership, and many islands of the Thunder Bay region, near Alpena, are protected as part of the Michigan Islands National Wildlife Refuge or by Michigan Nature Association. In the northern Lake Huron portion of Michigan, a smaller proportion of islands (or parts of islands) are under public or non-governmental ownership. Round Island, near Mackinac Island, is a designated Wilderness Area by the US federal government (Kraus et al., 2007).

Kraus, et al (2007) identify some of the priority islands for biodiversity within Lake Huron for Ontario, and will soon complete a parallel analysis for the US. Based on the assessments of island values, biological significance, categorization, and ranking, the Collaborative will recommend management strategies for Great Lakes islands to preserve the unique ecological features that make islands so important. Results from a proposed threat assessment will also provide recommended management strategies to reduce the pressures on a set of priority island areas. Islands need to be integrated into both regional and local conservation and land use planning to recognize the distinctive needs and high importance of these unique systems.

Lake Huron Reefs

Defined as bedrock exposures beneath the surface of lake Huron, these often serve as important spawning habitats for lake whitefish (as in the reef complexes of Thunder Bay and the Fishing Islands), walleye (Saginaw and Thunder Bays) and lake trout (Thunder Bay, 6-Fathom Bank reefs, Yankee Reef, Grindstone City reefs). They also have become heavily colonized by dreissenid muscles and now serve as perhaps the most productive substrate type in Lake Huron. Their heavy colonization by dreissenids could be affecting their usefulness as spawning habitat. Excessive biomass of dreissenids on some reef sites may be leading to episodic low-oxygen events that, in turn, could be favorable to *Clostridium botulinum*, leading to Type-E botulism outbreaks. There is no systematic inventory of the locations and extent of these bedrock outcroppings. A geological inventory of the lake bed would permit estimation of the location and extent of these types of habitats, improve mapping and inventory of potential spawning habitats, and help to direct biological assessments of benthic fish communities associated with reef habitats.

Tributaries

Over 10,000 km (6213.7 miles) of tributary habitat were at one time accessible to fish in Lake Huron. Two-thirds of the Lake Huron watershed is located in Canada, thus an even greater amount of tributary habitat was available to fish in Ontario waters (Liskauskas et al., 2004). Tributaries are the primary conduit for drainage of waters from the basin's landscape to Lake Huron. Tributaries supply Lake Huron and its associated nearshore ecosystem with water and nutrients, and provide important fish and wildlife habitat (Crosbie and Chow-Fraser, 1999). The tributaries, in turn, depend on upland vegetation to regulate the nutrients and solids entering the waterways, and for input

of energy and material. Biodiversity elements of tributaries depend upon the oxygenation of water and the balance of nutrients and organic materials to maintain favorable habitat conditions. Tributaries are critical spawning and nursery habitats for one-third of fishes in the Great Lakes (Liskauskas et al., 2004). Tributaries provide important habitat and migration corridors for a myriad of wildlife. Protecting and restoring the accessibility and function of tributary habitats throughout the Lake Huron basin will ensure that critical fish habitat is available as well as preserving the genetic diversity of fish and wildlife by maintaining access to these corridors.

Factors affecting Lake Huron Tributaries

Historically, Lake Huron was connected to a diverse array of stream and inland lake habitats and tributaries were important sources of cool, high quality water, as well as spawning and nursery habitats. Fish were excluded from many of these areas in the 1800's through the construction of mill dams (and later hydroelectric facilities) and water quality deteriorated steadily through the 1970's as point sources of domestic and industrial waste proliferated. In warm and cool water streams in the southern and western parts of Lake Huron, lake fish populations are exclude from tributaries and habitat has been degraded through urbanization, poor agricultural practices, and physical alteration of stream channels. Although delivery of sediments to nourish nearshore processes is an important function of tributaries, excessive loading can be damaging to stream biota, especially bottom-dwelling invertebrates. Excessive sediments can also damage estuarine marshes. Sediment loading concomitant with the bound contaminants have buried historically important spawning habitats and altered community dynamics of intolerant macroinvertebrates. While stressors such as point sources of pollution have largely been controlled during the past 25 years, many dams continue to fragment streams where historical spawning occurred for adfluvial fish (fish that live in the open waters and use tributaries for spawning) (Figure 5.3). In many situations, below-dam habitat is degraded due to the altered hydrology and increased water temperatures, influencing water quality and physical habitat including the distribution of aquatic plants and suspended sediments. Dams are almost certainly the single most important impediment to recovery of lake sturgeon, a species presently classed as Threatened by the State of Michigan.

Apart from dams, obstructions and sedimentation, the principle environmental concerns for Lake Huron tributaries are as follows: low discharge; low gradient; lack of deep habitat; lack of spawning habitat; temperature change; exploitation; fluctuating discharge and poor water quality (Michigan Department of Environmental Quality, 2002). Many Lake Huron tributaries continue to be degraded by runoff from residential, agricultural,

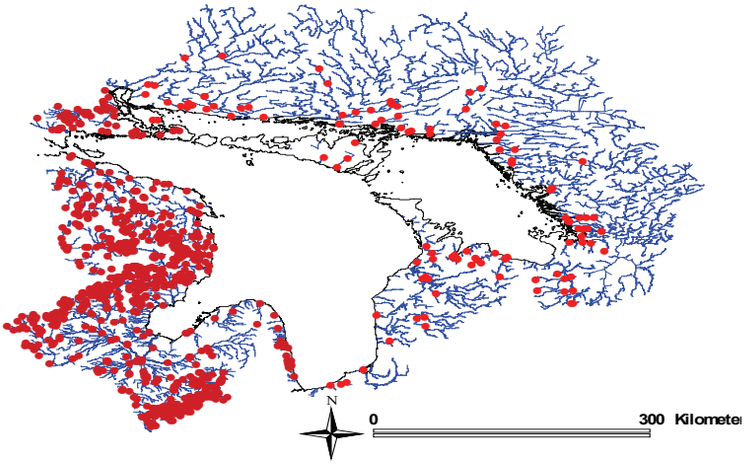

Figure 5.3. Distribution of dams in the Lake Huron watershed.

industrial and commercial land use. High levels of nutrients from fertilizers and other chemicals, along with excessive soil erosion threaten the water quality and thus impact this habitat for wildlife.

Priority Management Areas for Tributary Management

The lost connectivity, altered water temperatures, water quality and hydrological flow regimes of watershed tributaries draining into the Lake Huron basin needs to be restored to more natural conditions in order for Lake Huron to achieve its full potential for fish and wildlife production.

Priority management areas have been identified by the Great Lakes Fishery Commission through the development of Environmental Objectives for Lake Huron. See section IV Fishery Management Goals (p. 31) for a list and description of issues.

Additional information and fish community objectives relevant to tributary habitat can also be found on the Great Lakes Fishery Commission's web site at www.glfc.org.

Lake Huron Habitat Protection, Restoration and Conservation

Many efforts to protect restore, and conserve important habitat is ongoing in the Lake Huron watershed. A variety of forums have developed habitat-specific conservation plans for key components of the Lake Huron ecosystem. These plans represent the critical thinking of governmental managers, technical experts, and informed stakeholders. The Lake Huron Binational Partnership recognizes the importance of this work and encourages the continuation of these efforts. While some of the watershed is managed by Federal, Provincial, and State governments, the Partnership also recognizes the key role that local governments, municipalities, and private landowners play in ensuring the functional integrity of Lake Huron and its flora and fauna. The Partnership looks forward to further developing collaborative efforts that assist non-governmental land owners in their efforts to restore and protect the Lake Huron ecosystem. Several of these activities are listed in the Action Plan of this document.

References

Albert, D. A. 2000. Borne of the Wind: An Introduction to the Ecology of Michigan Sand Dunes. Michigan Natural Features Inventory. 63p.

Albert, D.A. 2003. Between land and lake: Michigan's Great Lakes coastal wetlands. Michigan Natural Features Inventory, Michigan State University Extension, East Lansing, Mich.: Extension Bulletin E-2902. 96p.

Albert, D.A., Minc, L.D. 2004. Plants as regional indicators of Great Lakes coastal wetland health. Aquatic Ecosystem Health and Management. 7(2), 233-248

Albert, D. A., Ingram, J., Thompson, T., Wilcox, D. 2003. Great Lakes Coastal Wetlands Classification. Great Lakes Coastal Wetland Consortium.

Aquatic Ecosystem Health and Management. 2004. Coastal wetlands of the Laurentian Great Lakes: Health, Integrity and management. 7(2): 169-333.

Bouchard, P., and Wheeler, T.A. 1997, Arthropods of Alvar Habitats.

Newsletter of the Biological Survey of Canada (Terrestrial Arthropods) 16(2).

Brownell, V.R., Riley, J.L. 2000. The alvars of Ontario; Significant alvar natural areas in the Ontario Great Lakes region. Federation on Ontario Naturalists. Pp 269.

Catling, P.M. and V.R. Brownell. 1995. A review of the alvars of the Great Lakes region: distribution, composition, biogeography and protection. Canadian Field-Naturalist. 109: 143-171.

Chow-Fraser, P., McNair, S., Seilheimer, T., Wei, A., Kostuk, K., Croft, M. 2006. Ecosystem-based assessment of the quality of fish habitat in coastal wetlands of Eastern Georgian Bay and the North Channel. Project Summary Report, March, 2006.

Dept. of Biology, McMaster University, 1280 Main St. W., Hamilton ON L8S 4K1 Canada.

Crosbie, B., Chow-Fraser, P. 1999. Percentage land use in the watershed determines the water and sediment quality of 22 marshes in the Great Lakes basin. Canadian Journal of Fisheries and Aquatic Science. 56: 1781-1791.

Environment Canada and Ontario Ministry of Natural Resources. 2003. The Ontario Great Lakes coastal wetland atlas: a summary of information (1983-1997).

Ewert, D. N., DePhilip, D., Kraus, Harkness, M., Froehlich, A. 2004. Biological ranking criteria for conservation of islands in the Laurentian Great Lakes. Final report to the U.S. Fish and Wildlife Service.

Hecnar, S.J. 2004. Great Lakes wetlands as amphibian habitats: a review. Aquatic Ecosystem Health and Management, 7(2): 289-304.

Hecnar, S.J., Casper, G.S., Russell, R.W., Hecnar, D.R., Robinson, J.N. 2002. Nested species assemblages of amphibians and reptiles on islands in the Laurentian Great Lakes. Journal of Biogeography. 29: 474-489.

Hughes, K.D. 2004 Current Status, Trends and Distributions of Aquatic Wildlife along the Canadian Shores of Lake Huron. Final Draft for Environment Canada.

Ingram, J., Holmes, K., Grabas, G., Watton, P., Potter, B., Gorner, T., Stow, N. 2004. Development of a coastal wetlands database for the Great Lakes Canadian Shoreline. Final report to the Great Lakes Commission Wetlands2-EPE-03. 2004.

Jalava, J.V., 2004. Pitcher's Thistle -Lake Huron Dune Grasslands Recovery Strategy, May, 2004. Pitcher's Thistle -Lake Huron Dune Grasslands Recovery Team. Parks Canada and Ontario Ministry of Natural Resources. ii + 32pp. + appendices.

Jalava, J.V., Cooper, W.L., Riley, J.L. 2005. Ecological survey of the eastern Georgian Bay coast. Nature Conservancy o f Canada, Toronto, and Ontario Ministry of Natural Resources, Peterborough, Ontario. 180 pp.

Kraus, D., Henson, B., Ewert, D. 2007. Biodiversity and Conservation of Lake Huron's Islands.

Jude, D.J., Pappas, J. 1992. Fish utilization of Great Lakes coastal wetlands. Journal of Great Lakes Research. 18: 651-672.

Krieger, K.A., Klarer, D.M., Heath, R.T., Herdendorf, C.E. 1992. Coastal wetlands of the Laurentian Great Lakes. Journal of Great Lakes Research. 18(4): 521-774.

Lawson, R., 2004. Coordinating coastal wetland monitoring in the North American Great Lakes. Aquatic Ecosystem Health and Management. 7(2): 215-221.

Liskauskas, A., Johnson, J., McKay, M., Gorenflo, T., Woldt, A., Bredin, J. 2004. Environmental objectives for Lake Huron: Final report of the environmental objectives working group of the Lake Huron technical committee. pp. 85.

Loftus, K.K., Smardon, R.C., Potter, B.A. 2004. Strategies for the stewardship and conservation of Great Lakes coastal wetlands. Aquatic Ecosystem Health and Management. 7(2): 305-330.

Manny, B.A., Kennedy, G. 2004. Island conservation from a fishery perspective. International Association of Great Lakes Research Conference (abstract), Waterloo, Ontario.

Mayer, T., Edsall, T., Munawar, M. 2004. Factors affecting the evolution of coastal wetlands of the Laurentian Great Lakes: an overview. Aquatic Ecosystem Health and Management. 7(2): 171-178.

Michigan Department of Environmental Quality. 2002. Lake Huron initiative action plan.

Natural Heritage Information Centre. 1995. Rate communities of Ontario: Great Lakes coastal meadow marshes. Ontario Natural Heritage Information Newsletter 2, 4-5.

Peach, G.H. 2003. Using coastal science in dune conservation and education. Abstracts - Canadian Coastal Conference. Queen's University. Kingston, Ontario, Canada. 15-17 October 2003.

Peach, G.H., 2005. Environmental impacts of vehicles on Lake Huron's beach and dune systems. Position Paper prepared by the Lake Huron Centre for Coastal Conservation.

Peach, G.H., Bowles, J. and Porter, L., 2007. Conserving a Delicate Balance: Management Plan for North Sauble Beach, Ontario, Canada. Prepared by the Lake Huron Centre for Coastal Conservation.

Public Sector Consultants Inc. 2002. Targeting environmental restoration in the Saginaw River/Bay area of concern. 2001 Remedial action plan update. Prepared for Great Lakes Commission On behalf of The Partnership for the Saginaw Bay Watershed.

Prince, H.H., Padding, P.I., Knapton, R.W. 1992. Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research. 18: 673-699.

Reschke, C., Reid, R., Jones, J., Feeney, T., Potter, H. 1999. Conserving Great Lakes Alvars. Final Technical Report of the International Alvar Conservation Initiative - on behalf of the Alvar Working Group.

Severn Sound Remedial Action Plan. 1993. An interim fish habitat management plan for the Severn Sound.

Vigmostad, K.E. (ed.) 1999. State of the Great Lakes islands. Proceedings from the 1996 U.S.-Canada Great Lakes Islands Workshop. U.S.-Canada Great Lakes Islands Project. Department of Resource Development, Michigan State University, East Lansing, MI.