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I . Executive Summary

Since its formal endorsement by the Binational Executive Committee in 2002, the Lake Huron Binational Partnership ("the Partnership") has coordinated lakewide environmental activities in the Lake Huron basin. The United States Environmental Protection Agency, Environment Canada, Michigan's Departments of Environmental Quality and Natural Resources, and Ontario's Ministries of Environment and Natural Resources form the core of the Partnership by providing leadership and coordination. A flexible membership is being promoted on an issue-by-issue basis, which is inclusive of other agencies and levels of government, Tribes/First Nations, non-government organizations, and the public.

The approach in Lake Huron differs from the Lakewide Management Plans (LaMPs) of Lakes Superior, Michigan, Erie and Ontario in that there has been no formal binational designation of lakewide beneficial use impairments, nor extensive lakewide modeling of chemical loadings. This alternative approach focuses on pollution reduction activities in areas of obvious importance, such as Areas of Concern (AOCs), and directly pursues on-the-ground activities to protect areas of high-quality habitat, which are abundant within the Lake Huron basin. In addition, existing stakeholder and agency forums are used as much as possible to support the goals of the Partnership. The Partnership maintains a close association with the Remedial Action Plan efforts in AOCs, the Great Lakes Fishery Commission's Lake Huron and Lake Huron Technical Committees, the State of the Lakes Ecosystem Conference, and domestic efforts that support the Partnership.

This 2006-2008 Action Plan provides updated information on environmental trends, identifies priority issues, and promotes management activities to be pursued over the next two-year cycle. Consistent with an adaptive management approach, the Action Plan tracks progress on issues identified in the previous cycle, including advancements in addressing nearshore nutrients and pathogens through Canada's South-East Shore Working Group, and has been expanded to address emerging issues, such as the recent disruptions in Lake Huron's aquatic food web.

Over the past two-year cycle, the Partnership has successfully used a streamlined approach to coordinate the many environmental activities impacting Lake Huron. We look forward to expanding on our past efforts and advancing the binational protection and restoration of the Lake Huron ecosystem.

II. Introduction

The Lake Huron Basin

The Lake Huron drainage basin is defined by an expansive watershed and abundance of shoreline habitat. Lake Huron has over 30,000 islands and, as a result, has the longest shoreline of any lake in the world. One of these islands, Manitoulin Island, is the largest island of any freshwater lake on Earth. Lake Huron's drainage basin is larger than any other Great Lake, and its relatively undisturbed nearshore areas support a high diversity of aquatic and riparian species of importance to the Great Lakes region. Over 40 species of rare plants, five rare reptile species, and 59 fish species are found in the coastal wetlands of Lake Huron. Lake Huron's coast remains diverse and has retained significant remnants of historic fish and wildlife habitat. Saginaw Bay, Georgian Bay and the North Channel support some of the most extensive high quality coastal habitat in the Great Lakes region.

The U.S.-Canada border divides the main basin of Lake Huron almost in half. The Canadian portion of the Lake, including Georgian Bay, is wholly within the Province of Ontario. The U.S. portion is entirely within the State of Michigan. The drainage basin on the Ontario side (86,430 square kilometers or 33,500 square miles) covers twice the area, has approximately five times the shoreline, and roughly 300,000 fewer residents than in Michigan. While the Lake Huron watershed is home to about 2.5 million people, both sides of Lake Huron have relatively low human population densities. The Lake Huron basin contains no major metropolitan areas. The largest urban centers in the basin are Sudbury and Sarnia on the Ontario side and Saginaw and Bay City on the Michigan side. With populations under 100,000, these urban areas are relatively small compared to urban areas in the more populous Great Lake basins.

Lake Huron is the third largest freshwater lake in the world in terms of area, and the sixth largest in volume. Its average depth is 59 metres (195 feet). The average retention time for water in Lake Huron is 22 years. This long retention time makes Lake Huron, and the other Great Lakes, susceptible to the build up of persistent toxic substances that can bioaccumulate in fish, fish-eating wildlife, and humans.

In 1987, as part of an effort to clean up the most polluted areas in the Great Lakes, Canada and the United States identified five Areas of Concern (AOCs) in the Lake Huron basin: Spanish Harbour (Ontario), Severn Sound (Ontario), Collingwood Harbour (Ontario), Saginaw Bay (Michigan), and the St. Marys River, which connects Lakes Huron and Superior (a binational AOC). Canada and Ontario have recognized Spanish Harbour as an "Area in Recovery" where all remedial actions have been implemented and the environment will take some time to recover. Severn Sound was delisted as an AOC in 2003, and the Collingwood Harbour AOC, was delisted in 1994. The causes of impairment within the remaining AOCs continue to be addressed; fish and wildlife habitat, fish and wildlife populations, and environmental quality are subsequently recovering.

Rocky shores associated with the Precambrian shield cover the northern and eastern shores; limestone dominates the shores of Manitoulin Island and the northern shore of the Bruce Peninsula; and glacial deposits of sand, gravel, and till predominate in the remaining portions of the shore. Mining of limestone, nickel, uranium, copper, platinum and gold has been an important activity in the northern portion of the Lake Huron basin. The Lake Huron basin is also heavily forested in the northern region, and more urbanized in the southernmost portion of the lake. Much of the "thumb" area of Michigan, along the Bruce Peninsula and the southeast shore of the main basin is dominated by agricultural land use (e.g., field crops) and supports many beef and dairy farms.

Though residential land use makes up a small percentage of current total land use in the Lake Huron basin, much of the recent development has occurred along the coast. In the past 20 years, and as more people begin to retire, there has been increasing development pressure for cottages and year-round retirement properties in rural areas. Undoubtedly, the next 20 years will bring more development to the coastal regions of the basin, especially as urban populations continue to grow and more people desire to live in less densely populated areas.

The Partnership

In 2002, the federal, state and provincial agencies that manage binational environmental activities under the Great Lakes Water Quality Agreement (GLWQA) formally endorsed the formation of a Lake Huron Binational Partnership ("the Partnership") to prioritize and coordinate environmental activities in the Lake Huron basin. The United States Environmental Protection Agency (USEPA), Environment Canada (EC), Michigan's Departments of Environmental Quality (MDEQ) and Natural Resources (MDNR) and Ontario's Ministries of Environment (OMOE) and Natural Resources (OMNR) form the core of the Partnership, by providing leadership and coordination. However, the Partnership emphasizes the importance of maintaining a flexible membership, which is inclusive of other agencies and levels of government, Tribes/First Nations, non-government organizations (NGOs), and the public on an issue-by-issue basis.

The Partnership builds upon the efforts that were begun by the MDEQ's Office of the Great Lakes during the Lake Huron Initiative ("the Initiative"). The Initiative developed an Action Plan for Lake Huron in 2000 and updated in 2002 which outlined priority programs and initiatives to address use impairments, critical pollutants, habitat and biodiversity. In 2004, the Lake Huron Binational Partnership produced a binational Action Plan which builds on many of the activities from the Initiative and further develops priorities for binational and domestic action. This document updates the 2004 report.

The Partnership facilitates information sharing and priority setting for binational environmental protection and restoration activities of importance in the Lake Huron basin and promotes cooperation and collaboration towards shared objectives that are unachievable by individual agencies alone. Public consultation is an important component of the Partnership's activities in the Lake Huron basin, particularly on a project-specific level. Those individuals and organizations which have a direct interest in an issue are encouraged to participate or provide input to project direction and implementation. The agencies in the Partnership work with existing mechanisms and groups, as much as possible, to consult with and provide outreach information to the public. For example, a series of stand-alone fact sheets were produced on the following topics: The Lake Huron Binational Partnership, Contaminants in Fish, Contaminants in Wildlife, Developing Environmental Objectives for Fish Communities, Lake Huron GIS, and Changes in the Lake Huron Fish Community. In addition, two fact sheets were developed on domestic activities in support of the Partnership, including The Canadian South-East Shore Working Group and Phosphorus Concentrations in Saginaw Bay, Michigan.

The Partnership has developed an action-oriented process for identifying priority issues and efforts needed to ensure a healthy Lake Huron basin and watershed. The binational work plan includes U.S., Canadian, and joint actions that focus on short term project implementation and longer-term priority setting goals.

The Issues

The participants of the Partnership have agreed upon three binational issues to focus on:

- Contaminants in fish and wildlife,
- Biodiversity and ecosystem change, and
- Fish and wildlife habitat.

These key issues were given priority for immediate action, while other issues will be tracked and added as the Partnership pursues an iterative process of updating and expanding activities over time. The types of activities which address the binational issues include:

- Documenting status and trends of contaminants in fish and wildlife, chemicals causing fish consumption restrictions. The identification of potential sources and implementation of reduction measures.
- Determining the scope and causes of observed changes in ecosystem structure and function. The impact of invasive species on food web dynamics, fish communities and biodiversity.

- Evaluating, protecting, and restoring critical habitat such as wetlands, fish spawning areas, and nesting sites for waterbirds.

While these topics are being addressed binationally, other issues are the subject of Canadian or U.S. domestic activities. These include the restoration of beneficial uses in the AOCs, and other local issues, such as fouling of beaches by algae and bacteria. The Partnership facilitates the sharing of information between countries on these domestic issues.

The Lake Huron basin's size and the complexity of jurisdictions on both sides requires coordination among existing basinwide natural resource programs and local initiatives in areas of common interest. While governmental agencies are in a position to provide leadership, success depends on leveraging both governmental and NGO involvement and resources. In order to streamline activities and minimize costs, the Partnership interacts closely with representatives of these existing programs. One example of the collaborative effort is the Partnership's close ties to the Great Lakes Fishery Commission's (GLFC's) Lake Huron Technical Committee (LHTC). The LHTC has representation on the Partnership committee, informing the Partnership of the LHTC activities and recommendations, such as the Environmental Objectives document developed for Lake Huron fishery. Success also requires collectively engaging local governments whose authority and local decision making has a significant impact on the sustainability of local natural resources and communities throughout the Lake Huron basin.

III. Fish and Wildlife Contaminants

Introduction

Contaminant concentrations in fish from Lake Huron have been monitored over time in order to address human and wildlife health concerns. Because certain contaminants bioaccumulate and biomagnify in the food chain, fish are excellent indicators of pollutants in the aquatic ecosystem. Contaminant monitoring programs have been developed and implemented to monitor contaminant concentrations in the edible portions of sport fish and in whole fish as a way to monitor human and wildlife health respectively.

The MDEQ, the OMOE, and EPA's Great Lakes National Program Office (GLNPO) collect and analyze many species of sport fish from the Great Lakes, including the Lake Huron watershed, to determine whether chemicals are present in quantities that may be of concern to those eating sport-caught fish. Contaminants such as mercury, toxaphene, dioxins, and polychlorinated biphenyls (PCBs) can accumulate in fish, wildlife and humans and could be harmful to a developing fetus, young child or breastfeeding infant. MDEQ and OMOE determine the available fish contaminant information and place advisories on the consumption of specific species of fish depending on the levels of contaminants found. GLNPO provides Great Lakes sport fish contaminant information to the states to be incorporated into State issued advisories.

Long-term (>25 yrs), basinwide, monitoring programs that measure whole body concentrations of contaminants in top predator fish (e.g., lake trout and/or walleye) and in forage fish (e.g., smelt) are conducted by a collaborative effort through GLNPO's Great Lakes Fish Monitoring Program, and EC's Fish Contaminants Surveillance Program (previously maintained by the Canadian Department of Fisheries and Oceans (DFO)). Since the late 1970s, concentrations of historically regulated contaminants such as PCBs, DDT and mercury have generally declined in most monitored fish species. The concentrations of other contaminants, both currently regulated and unregulated, have demonstrated either slowing declines or, in some cases, increases in selected fish communities. The changes are often lake-specific and relate both to the specific characteristics of the substances involved and the biological composition of the fish community.

Contaminant Trends in Whole Fish

Since the 1970s, there have been declines in the levels of many persistent, bioaccumulative and toxic (PBT) chemicals, such as PCB, DDT, dieldrin, dioxins, and furans, in the Great Lakes basin due to bans on the use and/or production of these harmful substances and restrictions on their emissions. Present concentrations of contaminants, such as PCBs and DDT, show general declines in Lake Huron, with some year to year fluctuation. Though PBT chemicals continue to be a significant concern, dramatic declines are no longer detected, likely due to changes in the environment and reduction in the sources of contaminants. Continuing sources of contaminants are primarily from sediments contaminated by historic and current direct discharges (e.g., industrial, municipal and tributary), atmospheric deposition, and land runoff.

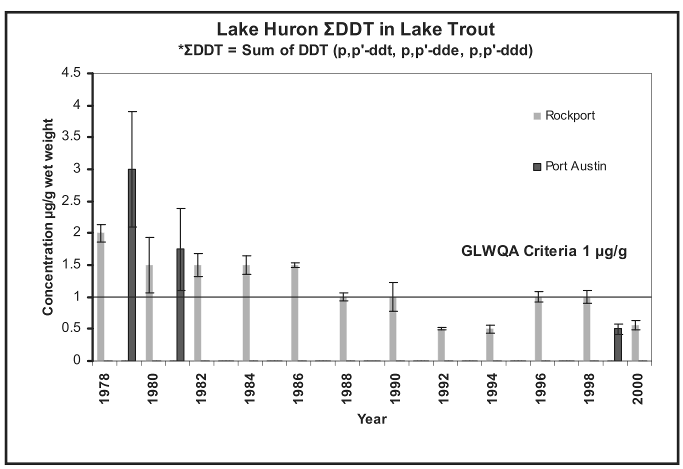


Figure 3.1. Total DDT in Lake Huron lake trout. Source: GLNPO – Great Lakes Fish Monitoring Program 2005.

Pesticides such as DDT, Toxaphene, Mirex, Chlordane and Aldrin/Dieldrin have been banned from use in the U.S. and Canada; however, they are still cycling within the environment through runoff, sediment

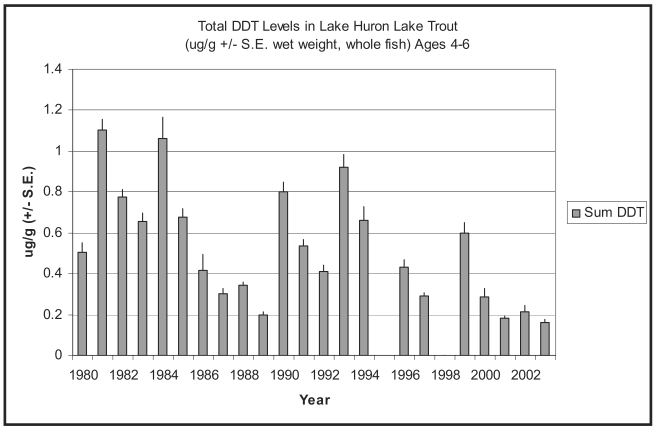


Figure 3.2. **Total DDT levels in Lake Huron lake trout. Source: DFO, Great Lakes Laboratory for Fisheries & Aquatic Sciences 2005.**

resuspension and long range atmospheric transport. The large surface area of Lake Huron, like the other Great Lakes, has made it particularly vulnerable to atmospheric deposition of contaminants.

Both GLNPO (Figure 3.1) and DFO (Figure 3.2) lake trout data show a general decline in total DDT concentrations over time. Both programs have observed large fluctuations in total DDT concentrations in the early years of analysis followed recently by a relatively consistent year-to-year decline. Likewise, total DDT concentrations in Lake Huron rainbow smelt also fluctuated between years, but they exhibit a recent downward trend. GLNPO and DFO observed that concentrations of total DDT in Lake Huron lake trout has consistently remained at or below the GLWQA criteria since 1988 and 1984, respectively. Total DDT concentrations in Lake Huron smelt have never been observed to be above GLWQA criteria.

Both GLNPO (Figure 3.3) and DFO (Figure 3.4) lake trout data show a general decline in concentrations of PCBs over time. Concentrations in recent DFO lake trout samples were the second lowest ever recorded for the program. PCB concentrations in DFO rainbow smelt have fluctuated considerably over time. Total PCB concentrations in lake trout observed by both GLNPO and DFO remain above the GLWQA criteria. PCB concentrations in smelt have consistently remained below GLWQA criteria since 1997.

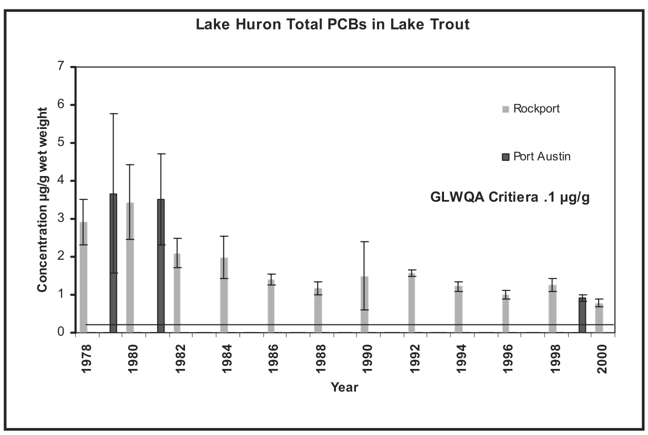


Figure 3.3. **Total PCBs in Lake Huron lake trout. Source: GLNPO – Great Lakes Fish Monitoring Program 2005.**

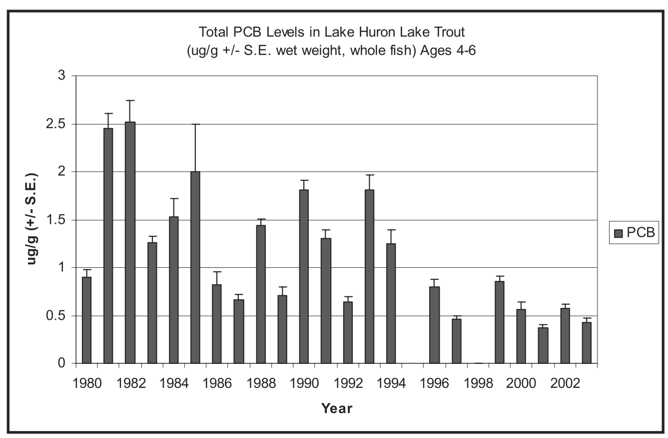


Figure 3.4. **Total PCB levels in Lake Huron lake trout. Source: DFO, Great Lakes Laboratory for Fisheries & Aquatic Sciences 2005.**

Mercury concentrations in DFO smelt have fluctuated considerably between 1979 and 2003 (Figure 3.5). Rainbow smelt collected in 2003 had the highest lakewide concentration recorded since 1984. Mercury levels in Lake Huron rainbow smelt have never been observed to be above the GLWQA criteria.

Contaminant Trends in Sport Fish

In most areas of Ontario, contaminant levels have been declining due to bans on harmful substances and restrictions on emissions. Ontario sport fish contaminant analyses are based on the dorsal fillet section of the fish, not the whole fish fillet as in Michigan. The Ontario advisories are published biennially in the Guide to Eating Ontario Sport Fish (Guide). Fish consumption can be unrestricted (maximum eight meals per month), restricted to four, two or one meal per month, or totally restricted (“do not eat”).

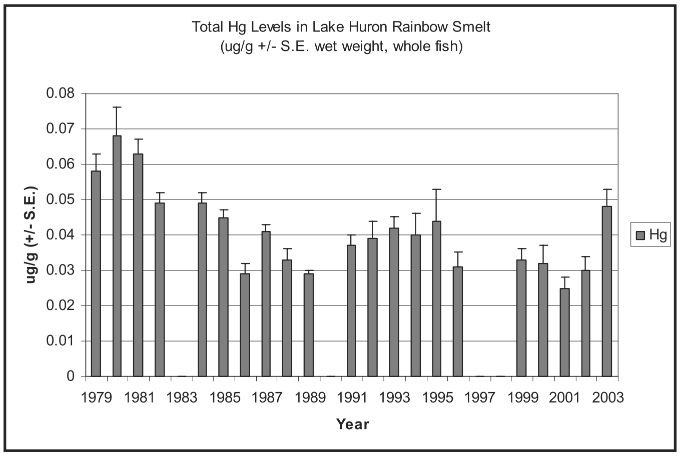


Figure 3.5. Total Mercury in Lake Huron rainbow smelt. Source: DFO, Great Lakes Laboratory for Fisheries & Aquatic Sciences 2005.

PCB levels in sport fish declined significantly in Lake Huron between 1976 and 1990. However, from 1990 to the present, levels have remained stable. The lakewide average PCB levels for five year intervals in a typical (55 cm) lake trout are shown in Figure 3.6. In the late 1970s, concentrations exceeded the "do not eat" consumption limit of 1,220 ng/g for the general population. Current PCB concentrations are within the 4 meal per month range (153-305 ng/g) for both the general and sensitive populations (i.e., women of child-bearing age and children under 15). However, dioxins, furans and dioxin-like PCBs (dl-PCB) are responsible for the majority of the consumption restrictions on lake trout from Lake Huron in the 2005-06 Guide.

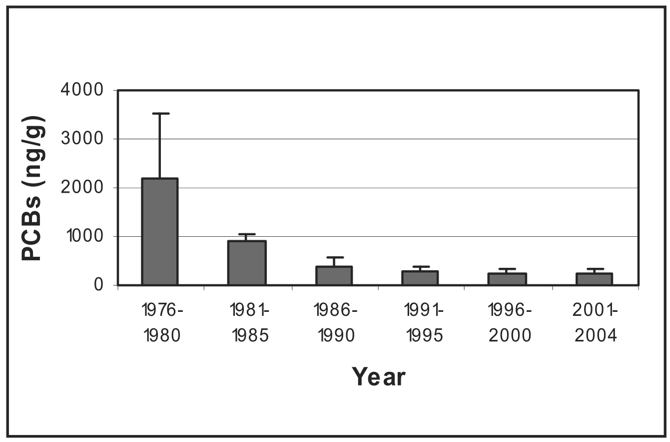


Figure 3.6. PCB concentrations in 55 cm Lake Huron lake trout. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

Figure 3.7 shows the lakewide average dioxin/furan/dl-PCB toxic equivalent (TEQ) concentrations in 55 cm lake trout. The dioxin/furan TEQs (light bars in the figure) have declined considerably between 1990 and 2001. For the 2005-06 Guide, dl-PCBs were included in the guideline for dioxins and furans. Analysis for dl-PCBs began in 1997 (dark bars in the figure), and have been included in the total TEQ since that time. This has resulted in a significant increase in fish consumption restrictions based on total TEQs (dioxins, furans and dl-PCBs) in all of the Ontario waters of the Great Lakes. It is too early to determine if dl-PCB levels have changed significantly from 1997. Continued monitoring of the lake for these contaminants is necessary in order to determine such trends. Total TEQs for 55 cm lake trout from all years exceed the first level of consumption restriction (1.62 pg/g) resulting in a four meal per month consumption restriction. More recent levels exceed the "do not eat" consumption restriction guideline of 12.96 pg/g.

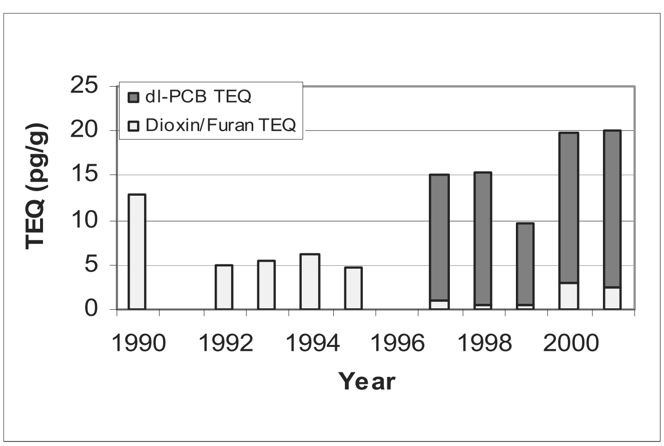


Figure 3.7. Dioxin/furan/dl-PCB TEQs in 55 cm Lake Huron lake trout. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

In Figure 3.8, the mean lakewide mercury levels are compared in multiple year categories. The mercury concentrations in walleye declined considerably between 1977 and 1986. Over the past 20 years, however, mercury levels have been relatively stable, ranging from 0.20 to 0.30 ug/g. In Ontario, the unlimited consumption limit for mercury is 0.26 ug/g for the sensitive population and 0.61 ug/g for the general population. Although mercury concentrations in 45 cm walleye have exceeded the guideline for the sensitive population in the past, mercury is not a cause for restrictions in this size of walleye in more recent years. Larger sized walleye as well as other similar species (e.g., northern pike) are restricted for mercury in Lake Huron.

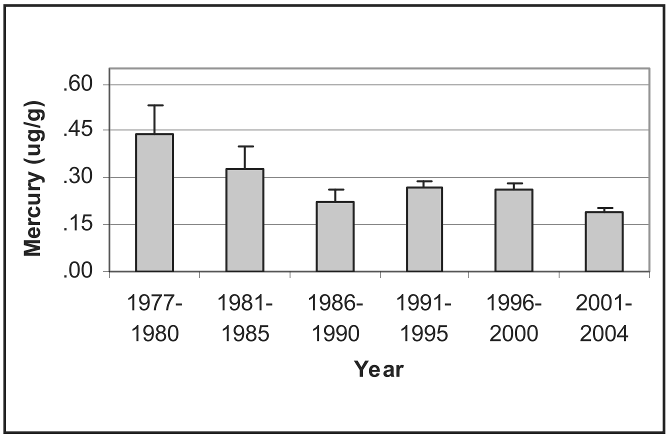


Figure 3.8. Mercury concentration in 45 cm Lake Huron walleye. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

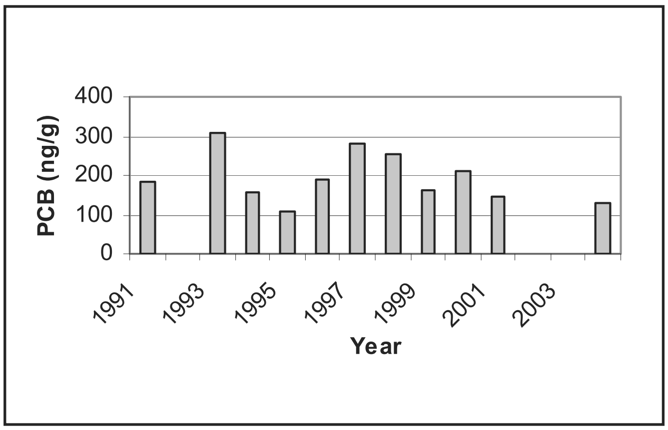


Figure 3.9. PCB concentration in 55 cm Georgian Bay lake trout. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

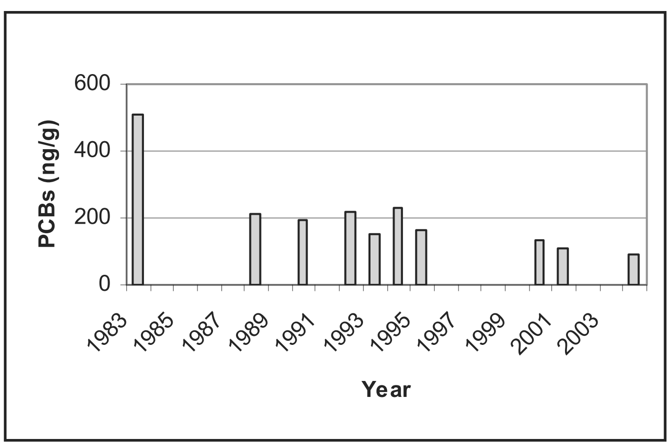


Figure 3.10. PCB concentration in 55 cm North Channel lake trout. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

PCB levels in Georgian Bay are generally lower than in Lake Huron. Figure 3.9 shows PCB concentrations in typical sized lake trout collected from Georgian Bay. Concentrations in these fish meet or exceed the four-meal-per-month restriction level (153 ng/g) in all years except for 1995 and 2004. Dioxin and furan levels in lake trout from Georgian Bay between 1993 and 2001 range from 0 to 5 pg/g. Again, the addition of dl-PCBs to the TEQ has resulted in increased consumption restrictions and the consumption of 55 cm lake trout is restricted to zero meals per month, as listed in the 2005-06 Guide.

Toxaphene concentrations in 55 cm lake trout from Georgian Bay exceeded the consumption guideline (235 ng/g) between 1995 and 1997. Since that time, toxaphene levels in Georgian Bay have decreased and are not listed as a cause of any consumption restrictions in the 2005-06 Guide.

Overall, the proportion of consumption restrictions for fish from Georgian Bay (30%) is much less than those for Lake Huron (50%). In the North Channel, the proportion of fish consumption restrictions (40%) is also lower than in Lake Huron. The PCB levels in lake trout in the North Channel have declined since 1983 (Figure 3.10). Recent levels are below the consumption restriction guideline. Toxaphene levels in 55 cm lake trout from the North Channel exceeded the consumption guideline in 1988 but have decreased considerably since that time, and are now below detection.

Fish Consumption Advisories

Individual Great Lakes States, Tribes and the Province of Ontario issue specific consumption advisories for how much fish is safe to eat for a wide variety of contaminants. Fish consumption advisories are based on guidelines developed through research and review of toxicological data, and differ by fish species, size and location. Recently, Health Canada has revised their Tolerable Daily Intakes (TDIs) for PCBs and dioxins, which has increased the frequency of consumption restrictions caused by PCBs and dioxins, and decreased the frequency of those caused by toxaphene and mirex/photomirex.

In comparison to the other Great Lakes, such as Lake Ontario, contaminant concentrations are relatively low in Lake Huron. Nevertheless, fish consumption advisories exist for the open lake

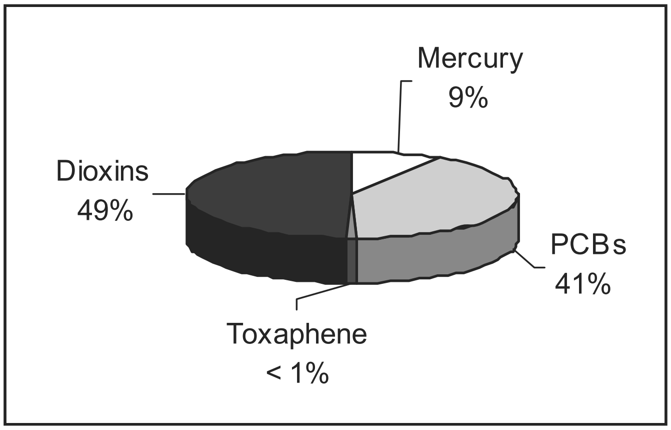


Figure 3.11. Causes of consumption advisories for the Lake Huron watershed. Source: OMOE, Sport Fish Contaminant Monitoring Program, 2005.

and all Areas of Concern (e.g., St. Marys River, Saginaw Bay, and the Spanish Harbour). On the Ontario side, fish restrictions have increased due to revisions in the consumption guidelines. Advisories differ by species, size and location, so it is important to check advisories in effect for the appropriate area.

In the Ontario waters of Lake Huron (including Georgian Bay, North Channel, and St. Marys River), generally, the restrictions on trout, salmon, carp and channel catfish are caused by dioxins/furans/dl-PCBs as well as PCBs (Figure 3.11). The restrictions on other species (e.g., walleye and northern pike) are usually caused by mercury. In total, over 40% of the advisory given for sport fish from Lake Huron results in some level of consumption restriction.

In the Michigan waters of Lake Huron (including Saginaw Bay and the St. Marys River), generally, the restrictions on trout, salmon, carp, channel catfish, burbot, northern pike, walleye, white bass, white suckers, white perch and yellow perch are caused by PCBs. The other restrictions are caused by chlordane, dioxins, and/or mercury.

Based on the most recent information, the current status of sport fish consumption advisories for both Ontario and Michigan are as shown below:

PCBs – In Michigan waters, almost every sample collected from Lake Huron exceeded the trigger level used by the Michigan Department of Community Health (MDCH) to issue sport fish consumption advisories for the protection of women of child bearing age and children under 15. Sport fish consumption advisories cover 15 species of Lake Huron fish. In addition, fish from several Lake Huron tributaries are covered by sport fish consumption advisories due to elevated concentrations of PCBs. The status is similar in the Ontario waters with PCBs causing many of the consumption restrictions.

Toxaphene – Past toxaphene concentrations in several species of Lake Huron fish including lake trout, lake whitefish and brown trout have been above the OMOE sport fish consumption advisory trigger level. However, recent levels of toxaphene are at or below detection, and cause less than one percent of the consumption restrictions in Lake Huron.

Dioxins - Lake trout, lake whitefish, chinook salmon, rainbow trout and carp have dioxin/furan/dl-PCB concentrations that exceed the trigger level used by both the MDCH and the OMOE, resulting in the issuance of sport fish consumption advisories on both the U.S. and Ontario sides of Lake Huron. In addition, fish from the Saginaw River watershed are covered by advisories due to elevated concentrations of dioxin.

Chlordane - Concentrations of chlordane in Lake Huron lake trout on the U.S. side occasionally exceed the sport fish consumption advisory trigger level (Figure 3.12). In Ontario, levels of chlordane are very low and do not cause any fish consumption restrictions.

Mercury - Only the methylated form of mercury bioaccumulates in fish tissue and a number of characteristics influence the methylation of mercury in the aquatic environment. Mercury methylation occurs more readily in inland lakes than in the Great Lakes. Therefore, sport fish consumption advisories due to elevated levels of mercury are more prevalent in fish from inland lakes

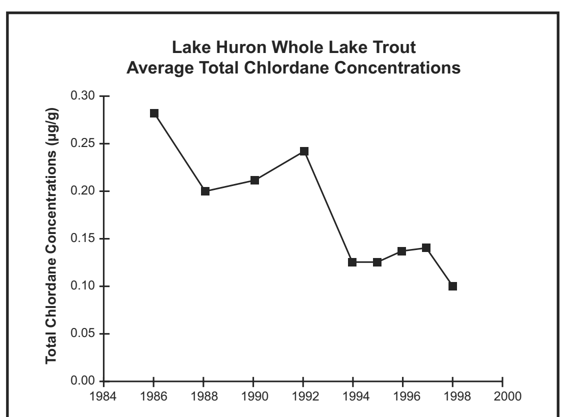


Figure 3.12: Lake Huron Whole Lake Trout Average Total Chlordane Concentrations graph. Source: DeVault et al. 1996 and USEPA unpublished data.

within the Lake Huron watershed, rather than in fish collected from Lake Huron. Nevertheless, consumption of some species in Lake Huron, such as yellow perch, walleye, rock bass and northern pike, is restricted due to mercury contamination.

DDT/PBB - Concentrations of DDT and PBB rarely exceed sport fish consumption advisory trigger levels in Lake Huron fish. The only area of the Lake Huron watershed where concentrations are elevated is the Pine River located in the Saginaw River watershed.

Additional Information

For more information regarding the fish consumption advisory programs in Michigan and Ontario go to the following web sites:

Michigan:

www.michigan.gov/mdch-toxics click on "Michigan Fish Advisory"

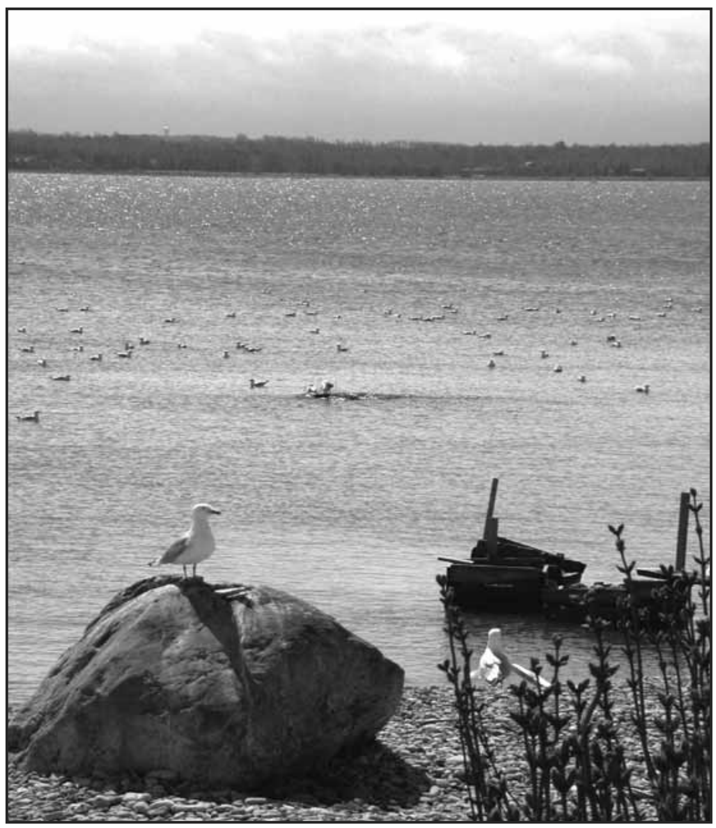
Ontario:

http://www.ene.gov.on.ca/envision/guide/

Contaminants in Lake Huron Wildlife

Introduction

In the early 1970s, fish-eating birds nesting in the Lake Huron basin, such as eagles, herring gulls, double-crested cormorants, suffered eggshell thinning, which led to breeding failure and a decline in population levels. Much of the reproductive failure was caused by exposure to various contaminants in the fish that they ate. By the 1990s, concentrations of many persistent toxic contaminants, such as PCBs, had been greatly reduced and most fish-eating bird populations recovered. However, some problems associated with contaminants continue to occur in a small percentage of the bird populations in localized areas. It is important to analyze contaminants over time (temporal) and at various locations (spatial) to identify potential problem areas and sources.



Gull Photo: Environment Canada

The Canadian Wildlife Service (CWS) of EC has been monitoring contaminant levels in herring gull eggs at up to 15 Great Lakes sites since 1974. The three Lake Huron sites are: Channel-Shelter Island (in Saginaw Bay), Double Island (off Blind River), and Chantry Island (off Southampton) (Figure 3.13). The program tracks temporal and spatial trends in contaminant levels and effects in this top avian aquatic predator.

The MDEQ began a similar annual gull egg monitoring project in 1999 that augmented the CWS work. Michigan sites include the outer Saginaw Bay, Alpena, St. Ignace and Sault Ste. Marie. MDEQ data are reviewed each year and new contaminant parameters are considered for analysis.

Figure 3.13. Location map of the three Lake Huron herring gull monitoring sites.

In addition to herring gull egg monitoring, the CWS occasionally measures contaminants in eggs from double-crested cormorants, ring-billed gulls, black-crowned night-herons, great black-backed gulls, and several species of terns.

Contaminant Trends in Fish-Eating Birds

Contaminants levels have declined dramatically at all three CWS Lake Huron sites since 1974, although the rates of decline for some compounds slowed during the 1990s. In spite of these declines, PCB and dioxin levels in gull eggs from Channel-Shelter Island continued to remain elevated compared to the other Great Lakes sites. While major point sources of chemical contaminants are not found on the Canadian side of Lake Huron, atmospheric deposition, agricultural runoff, re-suspension of sediments and leaching of soils from landfill sites contribute to the steady state that has been evident since the 1990s. Year-to-year fluctuations in contaminant levels result from changes in food type and abundance, which may be affected by the severity of winter on the Great Lakes.

High concentrations of brominated diphenyl ethers (BDEs) in Great Lakes herring gulls have recently been identified as a concern. BDEs are known to impact thyroid function and growth in some wildlife. Total BDE in herring gull eggs sampled from Double and Chantry Islands in 2000 were low (308-320 ug/kg) in comparison to other Great Lakes sites (1400 ug/kg in Green Bay), largely due to their remoteness from large urban/heavy industrial centres.

Gull Egg Photo: Environment Canada

In general, the CWS monitoring of contaminants in eggs from double-crested cormorants, ring-billed gulls, black-crowned night herons, great black-backed gulls, and several species of terns has indicated that levels of contaminants from Lake Huron sites were lower than other Great Lakes sites.

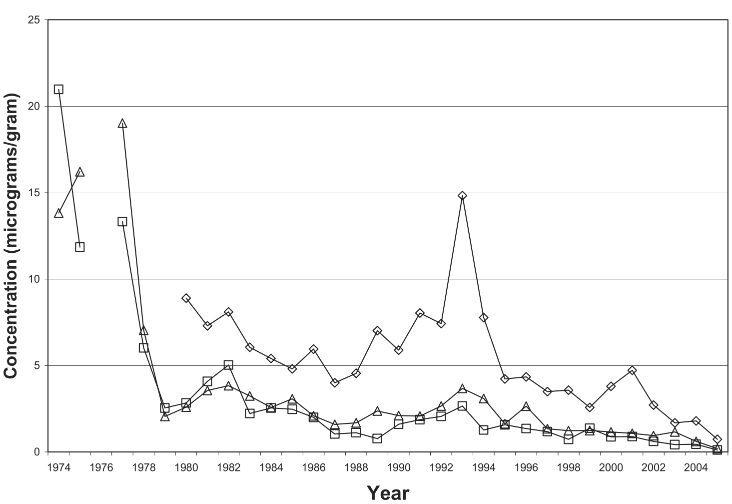


Figure 3.14. DDE concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island. Source: Canadian Wildlife Service 2005.

Figures 3.14 through 3.19 indicate trends in the levels of contaminants in herring gull eggs at the three CWS Lake Huron sites:

Monitoring of waterfowl hunted from Georgian Bay and Sault Ste. Marie found that organochlorines, PCBs and mercury concentrations in pectoral muscle were low and did not pose a risk to wildlife. One exception was a common merganser taken from Sault Ste. Marie, which had the highest PCB concentrations of all waterfowl and game birds collected across Canada from 1987 to 1995. The reason for these high levels is unknown.

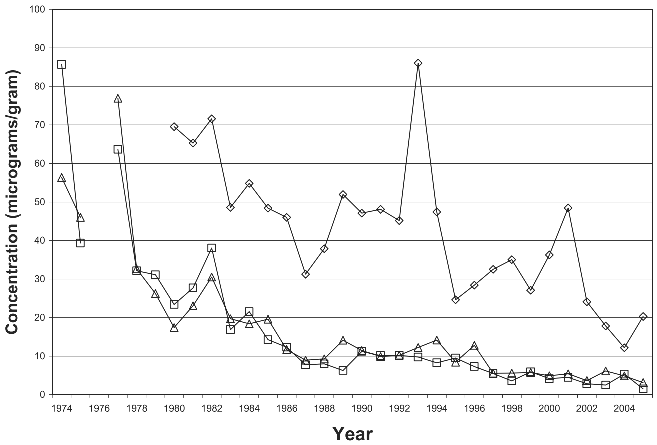


Figure 3.15. **PCB 1254-1260 concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island.**
Source: Canadian Wildlife Service 2005.

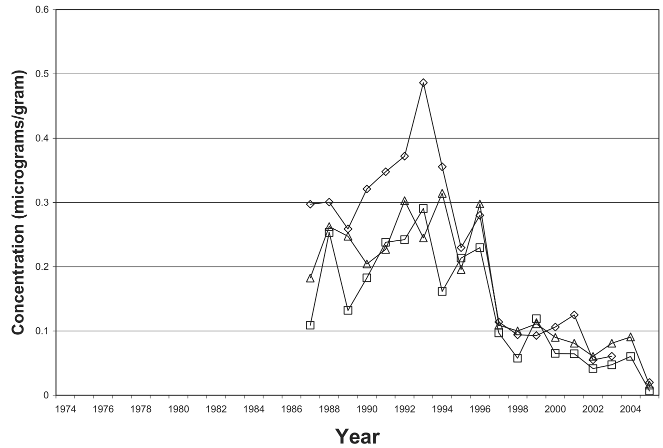


Figure 3.16. **Total Chlordane concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island.**
Source: Canadian Wildlife Service 2005.

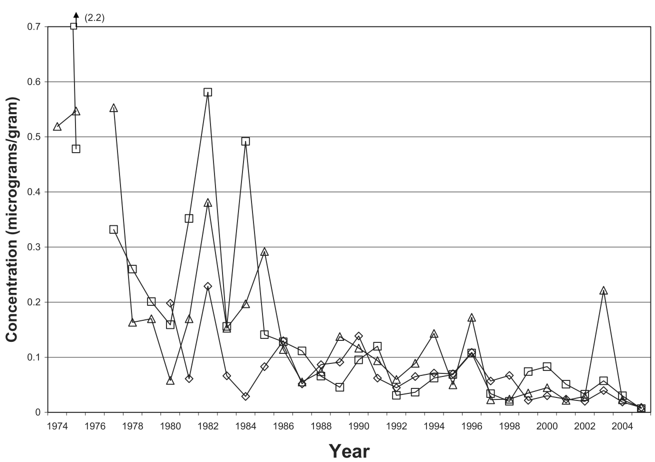


Figure 3.17. **Mirex concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island.**
Source: Canadian Wildlife Service 2005.

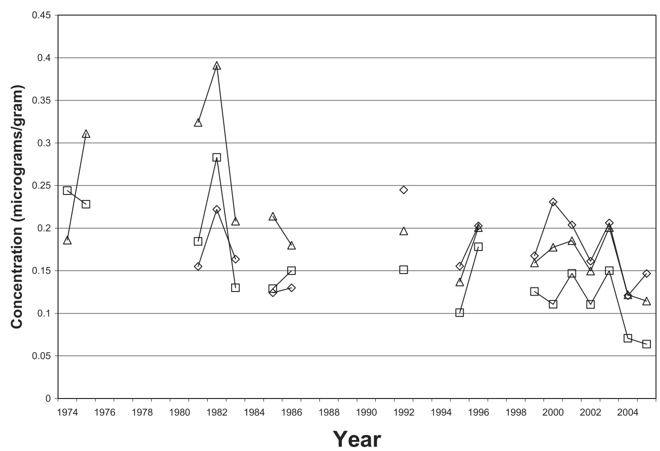


Figure 3.18. **Mercury concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island.**
Source: Canadian Wildlife Service 2005.

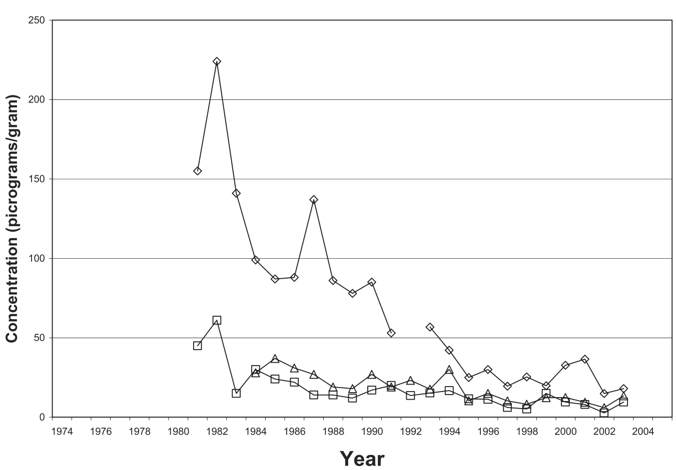


Figure 3.19. **2378-TCDD concentrations in herring gull eggs at Channel-Shelter Island, Double Island and Chantry Island.**
Source: Canadian Wildlife Service 2005.

Legend:

□ Chantry Island

Δ Double Island

◇ Channel Shelter Island

Bald Eagles/Osprey

Bald eagles are a very sensitive top level predator and are often considered the ultimate contaminant indicator species. Because eagles are returning to the Great Lakes region, levels of contaminants in their blood can be used as an indicator of contaminant trends. In recent years, elevated levels of contaminants have been found in some eaglet blood samples taken from Georgian Bay and Lake Huron watersheds (e.g., Saginaw River, Shiawassee Cutoff) although the 1999-2001 samples were significantly lower than in 1987-1992.

Exposure to heavy metals has been identified as a concern for bald eagles. Several bald eagles found dead in the last few years in Ontario have had elevated levels of both mercury and lead in their bodies. The life span of an adult bird, the length of time birds use a given nest site, and the age of new breeding birds are other important factors which will ultimately determine how reproductively successful nesting bald eagles are on the shores of Lake Huron.

Ospreys are often used as local indicators in areas where there are few or no bald eagles. During 1991-1993, DDE concentrations in osprey eggs and blood samples were significantly higher in Georgian Bay than at inland sites in Ontario (Martin et al. 2003). Mean concentrations of DDE were lower than the critical value (4.2 ug/g) associated with significant eggshell thinning, however, 20% of eggs from Georgian Bay were above this level. In terms of heavy metals, all samples taken from the St. Marys River and Georgian Bay (1991-1993) had mercury levels below those expected to cause adverse effects on reproduction. With the exception of the Georgian Bay osprey sampled, the osprey population on the Canadian side of Lake Huron does not appear to be affected by the current level of contaminants.

Other Wildlife

Otter Photo: U.S. Fish and Wildlife Service

Snapping turtles are ideal indicators of contaminant exposure due to their sedentary nature, their position as a top predator in the food chain, and their ability to accumulate high levels of contaminants over the course of their long lives. Geographic variation in contaminant levels has been shown to be similar to the variation reported for herring gull eggs at Great Lakes sites. Mink and otter are also sensitive indicators of mercury in the aquatic environment, as both live in wetland habitat near the shoreline and consume various amounts of fish in their diet. Mink are one of the most susceptible mammals to PCBs, resulting in reproductive problems and death. Trends in mink populations have followed those of fish-eating birds; the population began to decline in the mid 1950s and was lowest in the early 1970s, but recovered somewhat in the 1980s. Because otter have a lower rate of reproduction they are more susceptible to contaminants, and as a result, populations have been slower to recover.

Total mercury concentrations in otter tissues from near Parry Sound were higher than those in mink tissues, possibly due to their more fish-based diet compared to mink. Mercury levels in otter hair were within the range found in studies in southern Ontario. Levels reported for Lake Huron otter were well below those where negative impacts could have been expected.

Mink Photo: U.S Environmental Protection Agency

Conclusions

In summary, wildlife information has indicated that PCBs, chlordane, dioxins and DDT are a concern in the Lake Huron basin although, with the exception of Saginaw Bay

(PCBs, dioxin), concentrations are low compared to the other Great Lakes. Concentrations have declined significantly since the early 1970s, but still remain at levels associated with deformities and reproductive effects in several local watersheds in Michigan, especially Saginaw Bay. Data collected on the Ontario side of Lake Huron indicated that wildlife species contaminant concentrations were generally not at levels of concern, although sporadic elevated measurements support the need for continued ongoing monitoring.

Gull Photo: Environment Canada

IV. Aquatic Ecosystem

Aquatic Ecosystem Change

Since French explorer Étienne Brûlé first saw Lake Huron in 1612, the lake ecosystem has undergone many changes. Among the most significant changes to the fish community have been the invasion of rainbow smelt (*Osmerus mordax*) in the 1920's, followed by alewife (*Alosa pseudoharengus*) and the sea lamprey (*Petromyzon marinus*) in the 1930s. Sea lamprey predation and overfishing led to the collapse of lake trout (*Salvelinus namaycush*) by the 1950's in most of Lake Huron (although two remnant stocks barely survived). With no predators to control alewife and smelt populations their numbers exploded and nuisance die-offs of alewives commonly littered beaches during the 1960s.

The turnaround came with sea lamprey control in the 1960s which allowed the survival of stocked Pacific salmon (*Oncorhynchus spp*.), lake trout and other predators. Restocking controlled both smelt and alewife populations, prevented nuisance alewife die-offs and resulted in exceptionally good fishing.

The original Lake Huron ecosystem had lake trout as the main predator together with burbot (*Lota lota*) in the deeper waters, and walleye (*Sander vitreus*) being the main nearshore area predator. The historic prey base was dominated by lake herring (or cisco) (Coregonus artedii) and a number of other species of deepwater ciscos (*Coregonus spp*.) including the bloater (*Coregonus hoyi*), with sculpins (*Cottus spp. and Myoxocephalus quadricornis*), lake whitefish (*Coregonus clupeaformis*) and round whitefish (*Prosopium cylindraceum*) contributing to a lesser extent.

The historic Lake Huron off-shore ecosystem had fewer predator species (dominated by the then very abundance lake trout) and many more prey fish species. The current ecosystem has many more predator species (although their total biomass is lower then that of lake trout before their near extinction) and both predators and prey are dominated by introduced species. Many of the original deepwater cisco species in Lake Huron are extirpated (Refer to the section divider for illustration of aquatic system).

In the 1990s the invasion of zebra and quagga mussels (*Dreissena polymorpha, Dreissena bugensis*) changed the Lake Huron ecosystem significantly and had negative impacts on native species. Lake Huron again saw dramatic changes to its ecosystem starting in 2003. The following summary will outline some of the more significant recent changes.

Lower Trophic Levels

Up to 1998, there was a good balance of size and species of zooplankton. In recent years, zooplankton abundance and species diversity has declined to the lowest levels recorded. The most significant changes started to occur in 2003 when cladocerans, specifically large daphnia, disappeared and larger bosmina started disappearing. By 2005, almost all sizes of daphnia and bosmina were gone and copepods in the sub-order cyclopods were severely reduced in abundance. These changes were occurring more rapidly in the northern area of the main basin. Limnocalanus spp. (*calanoid copepods*) were still in high abundance in 2005 but these species tend to stay near the bottom of the lake and are not available to most fish. Any changes to another important fish food, mysis (*Mysis relicta*), were unfortunately not monitored since this species only comes up from the lake bottom at night and the study design did not target this species.

The most likely causes for the observed declines of zooplankton are:

1. invasion of exotic dreissenid mussels
2. invasion of exotic cladocerans mainly the spiny water flea (*Bythotrephes cederstromi*)
3. increased fish predation

Any potential negative impact by dreissenid mussels on native zooplankton would have to be through competition for primary productivity. The status of primary productivity is measured by phytoplankton abundance but has not shown any significant declines in the offshore waters of the main basin of Lake Huron. But whether the source of this primary productivity has changed to forms not usable to photoplankton (as in bluegreen or filamentous algae) is unknown. Thus we cannot be sure if the decline in zooplankton abundance is related to reduction in food source.

The second potential cause for native zooplankton declines is through competition for food with exotic cladocerans (specifically spiny water flea). However, this seems unlikely given that spiny water flea abundance has not increased significantly during the period of native zooplankton decline. Given that the study design conducts sampling only twice a year, it is possible that some changes in spiny water flea abundance could be missed. Recent anecdotal accounts indicate that the spiny water flea has increased in the diet of lake whitefish in Georgian Bay and this may indicate an increase in their abundance in that basin. The status of zooplankton may be different in Georgian Bay and the North Channel of Lake Huron compared to the main basin, especially in light of differences in fish abundance and growth, however similar zooplankton studies are unfortunately not conducted on those basins.

The observed changes and timing of zooplankton declines are, however, consistent with a predation effect since adult fish prefer larger cladocerans (mainly daphnia and bosminids) and calanoid copepods while larval fish prefer small nauplii (juvenile copepods), cyclopods and bosminids (*cladocerans*). The first sign of major declines of zooplankton in 2003 also coincided with a very large year class of alewives which may have exerted high predation pressure on zooplankton. Despite the very low levels of abundance of the major forage fish species of Lake Huron as a whole after 2003 (rainbow smelt, lake herring, alewives and bloater), zooplankton has shown no signs of recovery. If fish are driving the declines in zooplankton abundance it must be because they have changed their feeding patterns and are targeting zooplankton at a higher rate due to a drop in the availability of the benthic invertebrate diporeia (*Diporeia hoyi*).

Lake Huron has been the least studied of all the Great Lakes for benthic invertebrates; however, some comparative data are available from the early 1970s and 2000 from across the main basin. All major benthic invertebrate groups (diporeia, oligochaeta, sphaeriidae and chironomidae) declined in abundance from the early 1970s to 2000. Benthic invertebrates declined by approximately 50% in deep waters and 75% in nearshore areas over this period. The most severe declines were seen in the amphipod diporeia where large areas of the lake were devoid of this species by 2000. In 2003, sampling was repeated at 87 sites. Comparisons between the 2000 and 2003 datasets showed diporeia declined by an additional 57% in just three years. Samples collected in southern Georgian Bay from 2000 to 2003 have shown similar declines in diporeia abundance. Some additional data collected on the benthic communities in Saginaw Bay from 1987-2000 has revealed that the decline in diporeia began during 1992-1993 approximately the same time that zebra mussels invaded the area. A decline of diporeia in other areas of the Great Lakes also coincided with the arrival of zebra mussels. Although zebra mussels are implicated in the decline of diporeia the exact mechanism is unknown. Only a few pockets of diporeia have remained in the main basin of Lake Huron and they appear associated with upwelling areas characterized by cooler water temperatures.

Diporeia has a much higher caloric value than other food items with one individual being the equivalent energy of hundreds of other zooplankton. Many pelagic forage fish species in Lake Huron (including rainbow smelt, alewife and bloater) have traditionally utilized diporeia in their diet. When diporeia numbers drastically declined in the 2000s fish had to seek other prey items. Declines in zooplankton abundance which following the decline of diporeia might indicate a change of fish feeding habitats to an increased plankton diet to compensate for decreases in benthic food availability. Fish may have changed their diet to target first mysis or cladocerans and then, later, to copepods. The current zooplankton structure of the main basin of Lake Huron is now very similar to the much less productive waters of Lake Superior.

Dreissenid mussels have had a significant impact on the Great Lakes by removing planktonic algae and thus making nearshore, shallower waters clearer. They have had both direct and indirect effects on native species. Dreissenid mussels have established themselves in most areas of Lake Huron. From 2000 to 2003, zebra mussels were relatively stable in abundance in areas sampled while quagga mussels showed an increase. Quagga mussels are closely related to zebra mussels but can tolerate much deeper depths and are colonizing water below 30 m, locations that were not previously impacted by zebra mussels.

As quagga mussels expand and diporeia and other zooplankton continue to decline there are likely to be continued and escalating impacts on fish populations in Lake Huron. Changes in the magnitude and species composition of available benthic and planktonic food has the potential to alter competitive outcomes amongst prey fish. This will likely result in decreases in the survival and growth of planktivores and lower recruitment of larval fish. These changes could influence the relative success of different prey fish species and indirectly affect those of predator fish species.

Prey Fish

Alewife

Next to rainbow smelt, the alewife was typically the most common prey in Lake Huron. In 1998, there was a near collapse of alewives, as adult abundance declined to very low numbers. Milder winters from 1997 to 1999 resulted in higher survival of young alewives which buffered the population from high predation levels. In 2003, there were very low adult numbers of alewives but an extremely large year class was produced (Figure 4.1).

Despite this large year class, 90% of the young fish were less than 86 mm total length at the end of the summer, the size considered the minimum necessary to survive the winter. The 2003 year class was so abundant that competition for food sources appears to have lowered their growth and the fish were small entering the winter. The decline of diporeia has also reduced the availability of high quality abundant food for fishes including alewives, and a reduction in alewife condition was noted when zebra mussels moved into Saginaw Bay and diporeia concurrently declined.

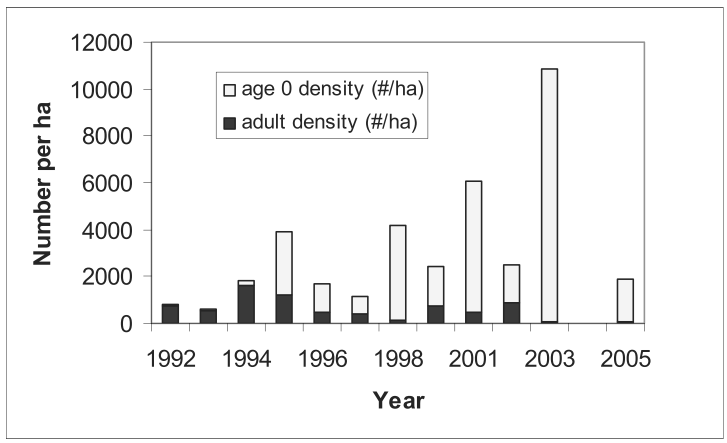


Figure 4.1. Alewife abundance in fall bottom trawls 1992-2005. Source: USGS data.

Climate, food web changes and salmonid predation are likely factors in the major decline in alewives since 1997. In the past several years the Great Lakes climate has experienced the widest variation in winter severity over the past 20 years. Alewives tend to suffer lower mortality when mild winters prevail during their first year; and this appears to affect their abundance for the rest of their lives. After 1995, alewife populations also experienced significant increases in predator consumption rates, principally due to increasing Chinook salmon reproduction. While alewives in 1984 reached the age of 8 years, despite increases in abundance, they only survived until ages 3 to 4 by 2000-2002.

Consecutive recruitment failures have continued since 2003. Studies in 2004 and 2005 reveal a 99% decline in alewife abundance from 2002. There was a slight increase in age 0 alewives observed in bottom trawls in 2004, but this was due to a few high catches in the north of the lake. Adult abundance increased slightly in 2005, but their numbers remain very low compared to pre-2003 levels. Some young-of-the-year alewives will likely mature as yearlings in 2006, but spawning stock biomass continues at all-time lows and alewife abundance is expected to remain low in 2006.

Given the poor survival of recent year classes the future of alewives is uncertain. However, it's very likely that they originally invaded the upper lakes with few individuals and they have shown they can produce strong year classes during years with relatively low adult abundance. Diet studies of lake trout in the northern and north-central main basin have shown alewives remain a common food item. This indicates that pockets of alewives still exist in Lake Huron although not in areas vulnerable to bottom and mid-water trawling and hydroacoutic studies. Therefore their resurgence is possible but given the extremely low numbers of adults and the low availability of zooplankton as prey, it is unlikely that adult alewives will recover, at least for some time, to their former abundance.

Rainbow Smelt

Young of the year rainbow smelt were at a record high abundance in assessment studies in 2005 but they were very small in size. There has been a steady decline in adults since 1992. Adult abundance increased slightly in 2004 but declined again in 2005. While the 2004 increase of adults was likely due to recruitment of the 2003 year class, the 2005 decline was probably due to increased predation pressure. Adult smelt biomass in the range of 6 kg/ha is not replacing former adult alewife biomass which typically ranged 10-24 kg/ha. Adults are also much smaller than they were in the past. Few fish are greater than 150 mm where 200 mm adults were common in the 1970s and 1980s. The lack of availability of larger prey items, including smelt, could affect the growth rates and maximum sizes attained by predator fish.

Bloater

The native bloater has been increasing in abundance the past two years (2004 and 2005), with the 2005 year class being the strongest on record since 1992. Historically, their abundance has been much lower than smelt or alewives (less than 0.2 kg/ha). Bloater will therefore not significantly offset the increased predation demands resulting from the declining abundance of alewives. Adult bloaters are currently considered scarce compared to the population cycles that saw them increasing in the 1980s and peaking in the mid 1990s.

Lake Herring

Despite both anecdotal and observed abundance increases in lake herring in some areas of the lake (most notably Georgian Bay and the North Channel through index netting), neither bottom or mid-water trawling assessment documented these changes. Possibly some small lake herring were misidentified as bloater (work is currently being conducted to confirm the small fish identification), also lake herring may not be as susceptible to these gear types as bloaters.

Sculpins, sticklebacks and trout-perch

Sculpins, sticklebacks (*Pungitius pungitius, Gasterosteus aculeatus*) and trout-perch (*Percopsis omiscomaycus*) are at lower abundance than during the previous decade. Numbers have remained consistently low since 2002.

Prey Fish Conclusions

Prey biomass in Lake Huron has declined 65% since 2001, almost totally a result of the drastic decline of alewife (Figure 4.2).

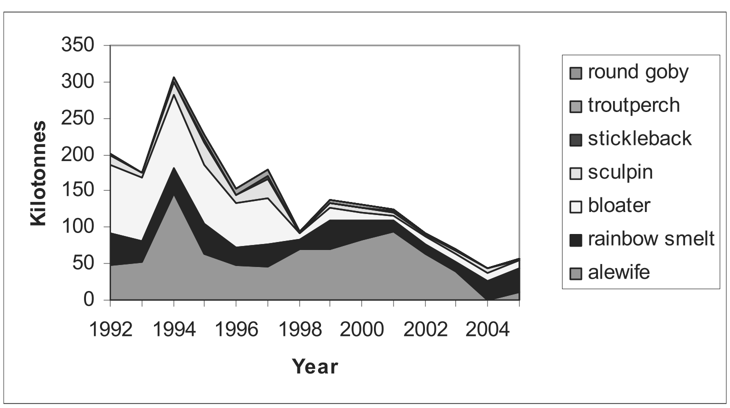


Figure 4.2. Estimated prey biomass in Lake Huron from fall bottom trawl surveys 1992-2005. Source: USGS data.

While species counts and composition are decreasing, some prey fish are changing their depth preferences. Although there was a slight increase in prey biomass in 2005, strong smelt and bloater recruitment has not yet resulted in more adults. Similar to changes in zooplankton, Lake Huron is becoming more like Lake Superior in regards to its prey base.

Lake Huron managers are hopeful that recent declines in alewives will allow for the expansion of the native bloater and lake herring. This will provide a more stable, better adapted prey base and will hopefully provide larger sized prey that can support larger sized predator fish. A continued reduction in alewife abundance would also reduce the detrimental impacts of alewives through predation on young predators and the effects of early mortality syndrome.

Predator Fish

Chinook Salmon

Chinook were first stocked into Michigan waters of Lake Huron in 1968 and in 1985 in Ontario waters. Stocking has varied between years, peaking in 1989 at over 5 million fingerlings but averaging 4.0 million from 1986 to 2004 (Figure 4.3). Chinook salmon became the dominant predator in Lake Huron through the 1980s and 1990s. During this period, they fed mainly on non-native forage fish (alewives and smelt are their preferred diet items). Lake trout are abundant in the lake due to stocking, but they exert less predation pressure on the prey base than Chinook salmon. The abundance of both alewives and smelt can fluctuate significantly between years which can drastically influence growth rates and survival of Chinook salmon.

Balancing predator numbers with available prey has always been a difficult task in the Great Lakes. In the 1980s, Lake Michigan Chinook salmon consumption rates exceeded their prey availability and resulted in reduced growth rates and an outbreak of bacterial kidney disease (BKD) in the stressed fish. This resulted in a decline in predator abundance for a number of years. Lake Ontario had concerns of a similar fate when they observed a declining prey base in the 1990s and in response reduced their stocking rates.

By interagency agreement, Lake Huron stocking levels of predator species were capped at 1990 levels in 1991 (8.33 million salmonids) until such time as more information was available on the predator versus prey balance. In 1998, catch rates were very high and the condition (or plumpness) and growth for Chinook were very low due to the low abundance of alewives as prey. Stocking was subsequently reduced by nearly 20% in 1999 as a result of the development of a computer model named the "Consume" model that indicated prey consumption demand appeared to be exceeding prey availability. Bioenergetics modeling confirmed that Chinook salmon were the dominant predator in the lake. A large year class of alewives produced in 1998 provided a good food source for Chinook salmon in 1998 and 1999, and growth rates increased averting a situation similar to Lake Michigan. Starting in 2003, very limited numbers of adult alewives were available and when the huge 2003 year class had very poor survival over the winter of 2003/2004 few alewives were available in 2004. This resulted in record low average sizes of Chinook salmon that were in very poor condition with many exhibiting signs of chronic malnutrition. Most Chinook salmon stomachs observed in the main basin of Lake Huron were empty in 2005. When present, food items were dominated by rainbow smelt and sticklebacks. Despite concerns that declines in growth would result in disease outbreaks similar to the situation that occurred in Lake Michigan, to date BKD levels have remained relatively low and stable.

Ongoing low abundance of alewives in 2005 resulted in the lowest catch and harvest rates on record for Chinook salmon in the main basin. Prior to 2005, catch per unit effort of Chinook salmon was higher in years of low alewife abundance.

Growth, condition and catch rates of Chinook salmon in Georgian Bay and the North Channel from 2000 to 2005 did not decline to the same levels observed in the main basin. This indicates that forage base status differs among the basins of Lake Huron. Hydroacoustic surveys conducted by the United States Geological Survey (USGS) in 2004 and 2005 revealed that Georgian Bay and the North Channel had the highest densities of prey fish biomass in Lake Huron. Smelt appear to be much more abundance in these two basins, which has likely been sustaining Chinook salmon and limiting declines in growth rates

Historically, little was known of the levels of natural reproduction of Chinook salmon in Lake Huron. In the 1980s, some wild fish were observed, mainly in Georgian Bay and the North Channel, and studies of young of the year fish in the early 1990s indicated that less than 30% of the Chinook salmon were wild in Michigan waters.

In the late 1960s until the early 1990s, the number of Chinook salmon caught by anglers was proportional to the number of fish stocked. This started to change by the mid 1990s, and even though stocking numbers were stable or declining catch rates increased. Use of the "Consume" model in the late 1990s, made it apparent that the level of natural reproduction of Chinook salmon in Lake Huron was a critical unknown and could have a significant impact on predator demand. Initial estimates used in the model were 20% to 50% natural production depending on the basin, but these were only very rough estimates provided by management agencies.

Because of the uncertainty of the estimated levels of natural reproduction and the potential significant influence on predator demand, a joint international study was designed and initiated in the early 2000s. From 2000 to 2003, all Chinook salmon stocked into Lake Huron were marked. Lake Michigan also contributed to the study since movement of Chinook salmon between Lakes Huron and Michigan has been documented. Assessment consisted of sampling fish from around the lake during June to August, prior to when the fish would be homing back to their natal streams. This time period was chosen to assure estimates of wild fish were not biased by sampling elevated concentrations of stocked fish homing to areas where they were originally stocked.

Results collected in 2003 to 2005 were surprising and consistent between years. In Michigan waters, 82% of the Chinook salmon were unmarked and presumed wild. The number was even higher in Georgian Bay, at 98% and 86% in the North Channel. It is presumed that the majority of the natural reproduction in Lake Huron is from Ontario waters since most of the cold water streams in the State of Michigan have been dammed and are inaccessible for spawning.

In the 1990s, the spawning run of Chinook salmon in all areas of the lake were mainly fish aged 3 to 5. Today the run is dominated by age 2 and 3 fish and no age 4 and 5 fish are seen. A shorter life span was once a disadvantage in that fish would be spawning at smaller sizes with fewer eggs resulting in less likelihood of their young surviving and contributing to future generations. Today it is an advantage to spawn early and be able to contribute some energy to reproduction, since living longer and contributing energy to growth could result in little energy remaining for reproduction resulting in fewer or very poor quality offspring.

With no strong year classes of alewives in the foreseeable future the future state of Chinook salmon in Lake Huron appears poor.

Lake Trout

Lake trout were the original dominant predator in the Lake Huron ecosystem. Unsustainable harvest practices and sea lamprey predation led to their demise in the main basin of Lake Huron in the 1940s and their almost complete disappearance in Georgian Bay and the North Channel by the mid 1950s. Two small remnant populations survived in Iroquois Bay and Parry Sound.

Efforts to rehabilitate this species and return the lake to some semblance of its historic balance have resulted in the stocking of over 70 million pure strain lake trout by 2005 (Figure 4.3).

Half of the current stocking occurs in the main basin, with the other half split between Georgian Bay and the North Channel. Initially, stocking was done nearshore but recently more offshore stocking has occurred.

Lake trout in Parry Sound, a location of one of the two remnant stocks, has been deemed rehabilitated. This

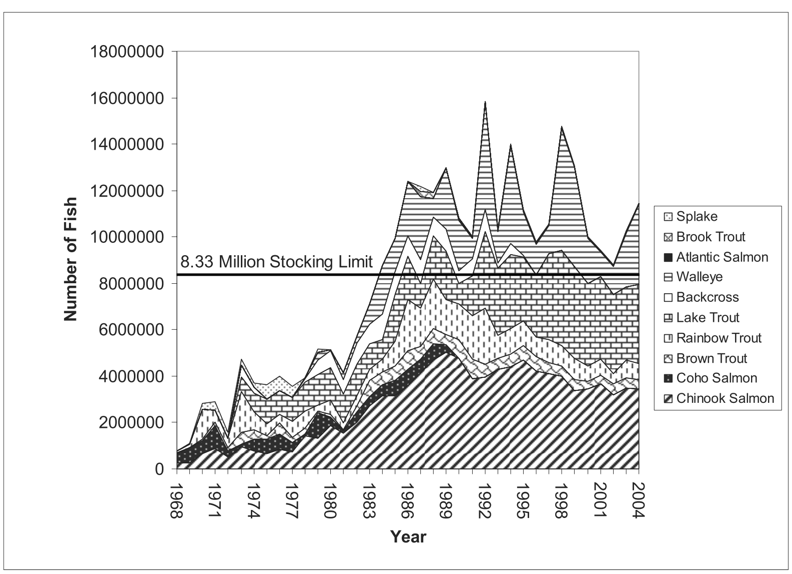


Figure 4.3. Number of predators stocked into the Lake Huron basin, 1968-2004.

Section IV

6

was accomplished through a combination of stocking and strict harvest controls. Lake trout natural reproduction has been observed in ten other locations in Lake Huron at various levels of abundance but to date no other locations have been fully rehabilitated.

Until recently the majority of observations of natural reproduction had been in embayment areas (Owen Sound, South Bay, Iroquois Bay, Parry Sound, Thunder Bay). Since 1984, a total of 231 wild young-of-the-year lake trout have been caught in MDNR bottom trawls in Thunder Bay, MI. The highest catch was in 1990 at 43 fish but numbers steadily declined through the 1990s and 2000s and no young of the year fish were caught in 2002 or 2003. In 2004, 11 were caught and another 12 in 2005. In addition, 22 wild young of the year lake trout were also incidentally captured by USGS bottom trawling during prey assessment surveys in 2004 and an additional 11 in 2005. All the USGS fish were captured in the main basin over a wide area. This was considered a significant development given that only five young of the year were caught in the previous 32 years of conducting this work. All of these fish were captured at northern sites (ten near Detour Island and 13 near Alpena). The capture of several yearling lake trout in 2005 indicates that at least some of the 2004 year class had survived their first winter.

The only other year that wild lake trout were observed in any number in the USGS bottom trawls was in 1986. Peak years in the MDNR trawling in Thunder Bay were 1986-1990, when a total of 137 wild juveniles were taken. These fish were from years when alewife abundance was relatively low and lake trout spawning stock was high. The decline in alewife in 2004 and 2005 in addition to higher abundances of adult lake trout and lower sea lamprey predation associated with increased control all likely played a role in the recent observation of lake trout natural reproduction. Alewives appear to limit natural reproduction of lake trout through both direct predation on fry and early mortality syndrome. Early mortality syndrome is caused by a low thiamine (vitamin B) condition in adult female lake trout (and other fish species with high proportions of alewife in their diet) which results in poor quality eggs. Thiaminase, an enzyme that breaks down thiamine is found in high levels in the guts of alewives. Lake trout with a high proportion of alewives in their diet can accumulate thiaminase. This results in low thiamine levels in lake trout eggs and significant reductions in hatching success and survival. .

Thiamine levels in lake trout eggs have been monitored in Lake Huron at several locations since 1996. In 2004, many areas of the lake (particularly Georgian Bay and South Bay) showed declines in the number of lake trout exhibiting thiamine concentrations below the level of lethal and secondary effects. This suggests that these lake trout are finding alternative food sources to alewives. The situation in the main basin of Lake Huron in 2004 was not as encouraging. Although some areas showed slightly increased thiamine levels they were still much lower than Georgian Bay and in some locations thiamine levels had even declined further. Studies indicate that 85% of the diet of offshore lake trout in the main basin still consisted of alewives.

Although the rehabilitation of lake trout has proven to be a long and difficult process, some success has been achieved and the demise of alewives appears to provide an excellent opportunity to build on the accomplishments achieved to date. The successful rehabilitation of lake trout in Lake Superior has provided the proof that rehabilitation of this native species in the Great Lakes is attainable.

Percids (Walleye and Yellow Perch)

Walleye historically were the dominant near-shore predator in Lake Huron. They are found in discrete populations in all three basins. Many localized populations are in various states of reduced abundance compared to historic levels. These declines are attributed to both high fishing pressure and habitat alterations. Since the majority of walleye populations spawn in rivers and require clean cobble spawning grounds they are very vulnerable to habitat degradation.

Saginaw Bay historically had the largest abundance of walleyes in Lake Huron but their numbers declined in the 1940s due to year class failures attributed to habitat loss, pollution, and to a lesser extent alewife predation. Key requirements for rehabilitation have been improvement of water quality under provisions of the Clean Water Act and stocking. Walleye year class strengths have been monitored in Saginaw Bay since the mid 1980s. A larger year class was detected in 1998, a year of low adult alewife abundance, but the 2003 year class was extraordinary large at almost five times the previous 1998 record (Figure 4.4).

Only 28% of the large 2003 year class could be attributed to stocked fish. Ideal climatic conditions and low alewife abundance are credited for this large year class. Similar large year classes were observed in Lakes Erie and Michigan in 2003. However, since very impressive year classes also occurred in 2004 and 2005 in Saginaw Bay that cannot be attributed to favorable climatic conditions, the lack of alewife appears the common influence for the ongoing reproductive success of walleye. Subsequent monitoring has indicated that these large year classes of walleye have not survived their first over-winter mortality period as well as past year classes. Still it appears that strong year classes have been established, but none greater than that achieved by the 1998 year class.

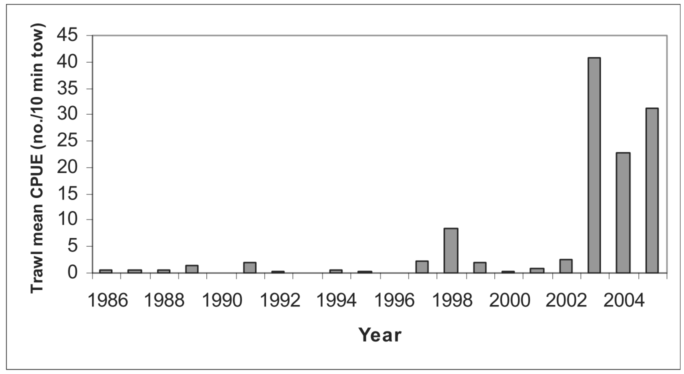


Figure 4.4. Walleye age class strengths in Saginaw Bay 1986-2005. Source: MDNR data.

Yellow perch (Perca flavescens) in Lake Huron have traditionally been an important species for both angling and commercial harvest and as prey, particularly for walleye. They also experienced an unprecedented large year class in 2003 (Figure 4.5).

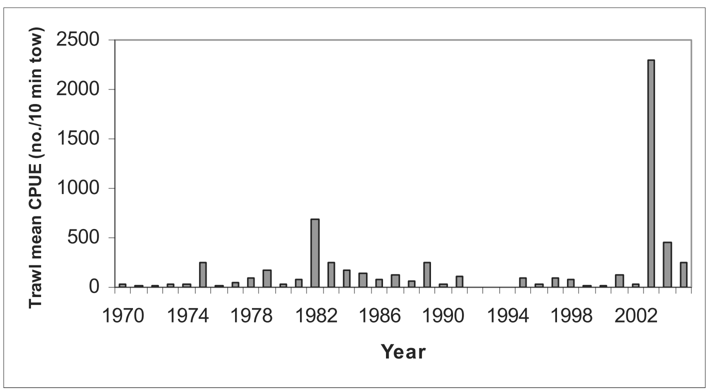


Figure 4.5. Yellow perch year class strengths in Saginaw Bay 1970-2005. Source: MDNR data.

In 2004 and 2005, their year class strength was much reduced compared to 2003 but still amongst the historic highest. Over-winter survival of recent year classes of yellow perch has been poor. Presumably the large year classes were competing with each other for limited food resulting in reduced fitness heading into winters. Predation pressure by predators, particularly walleye, was also a likely factor in the poor survival of the 2003 and 2004 yellow perch year classes. There has been some improvement in growth of young-of-the-year yellow perch in 2005. That year class may survive better as a result.

Reductions in alewife abundance seem to be benefiting reproduction of native walleye and yellow perch. It is speculated that good year classes of both species are likely to continue if alewives are maintained at low numbers. This will hopefully provide a window of opportunity for the walleye population of Saginaw Bay and other areas of Lake Huron to make significant advancements in rehabilitation. Managers will need to be cognizant of other limiting factors on the population and ensure that increased exploitation does not limit the potential for rehabilitation.

Coregonids (lake whitefish, bloater, lake herring, shortjaw cisco)

Lake whitefish are the most abundant and widely distributed member of the off-shore benthic community, occupying all areas of Lake Huron. They are the most sought after commercial fish species and have accounted for greater than 80% of the total commercial yield since 2000. Commercial yield of lake whitefish has declined from it's peak in 1998 but harvest is still substantial and currently is higher than at any other time in the last two centuries (Figure 4.6).

Recent declines in the market price of lake whitefish has contributed to a drop in commercial fishing effort and yield. Declines in both mean weight at age and condition began in the late 1980s and early 1990s and continued through 2002. The mean weight at age appears to have stabilized or slightly increased in 2003 and 2004. Declines in lake whitefish growth are likely related to the reduction of diporeia as a diet item, which has resulted in reduced lipid content in whitefish. Dreissenid mussels and mysis (another deep water amphipod) are now the principal components of their diet.

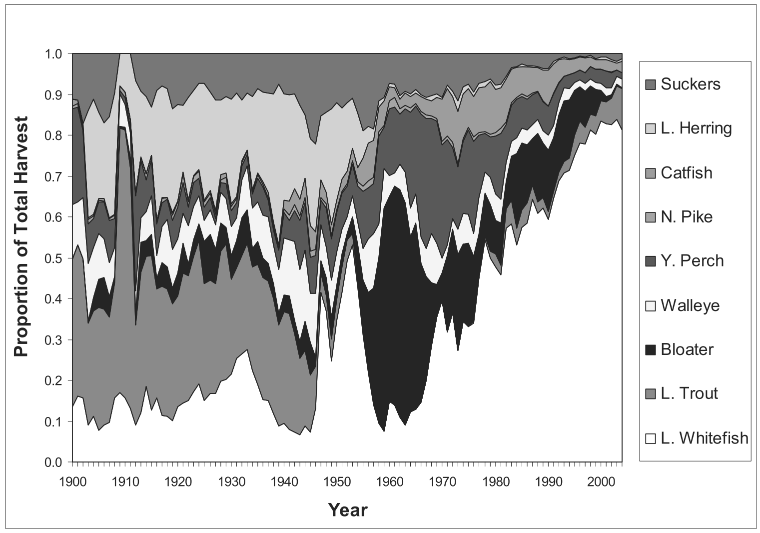


Figure 4.6. Commercial Harvest of Major Species in Lake Huron, 1900 to 2004.

In recent years lake whitefish have changed their distribution and are found in deeper water, possibly a result of an increase in water transparency likely related to the dreissenid invasion. Since 1997, large floating plumes of green algae (*Cladophora spp*.) have fouled commercial gear reducing catchability of lake whitefish. This increase in cladophora is probably related to increased water clarity as well. The change in distribution has led to increased numbers of lake trout being caught incidentally when the commercial fishery is targeting lake whitefish; this has been particularly evident since 2000.

Bloater and the shortjaw cisco (*Coregonus zenithicus*) are the only two remaining deepwater ciscoes currently found in Lake Huron. The shortjaw cisco is considered endangered and is only located in limited areas in Georgian Bay. The commercial catch of bloaters declined dramatically in Lake Huron during 2000 to 2004 (Figure 4.6). The reductions in catch occurred concurrently with observed declines in abundance and recruitment. In 2003 and 2004, there have been slight increases in abundance of adult bloaters from strong year classes produced from 1997 to 2000.

Lake herring are found in all three basins of Lake Huron but their distribution is restricted. They are common in the St. Marys River, North Channel, in waters between the straits of Mackinac and Drummond Island, and in eastern Georgian Bay. Lake herring are not found in Michigan waters south of the Straits of Mackinac, but they are occasionally caught in the Ontario waters of the southern main basin. Unlike lake whitefish, growth rates of lake herring, based on mean weight-at-age, appear to be more stable during 1991-2004. Abundance of lake herring appears to be slowly increasing in its core habitat of Georgian Bay and the North Channel and in the southern main basin. Managers are hopeful that increases in lake herring abundance will occur in the absence of alewives.

Saginaw Bay was traditionally a prime area for lake herring but very few are seen there today even when they appear to be increasing in other areas of the lake. Lake Huron managers are currently reviewing options for re-introducing this species to the Saginaw Bay and Thunder Bay areas through stocking and promoting their increase in abundance in other areas of the lake through harvest control.

Fishery Management Goals

Fish Community Objectives (FCO) for Lake Huron were developed in 1995, and in most cases, reflected yield targets by species based on historic commercial fishery landings from 1912-1940. An emerging realization is that historic harvests, and even current levels for some species, may not be sustainable in the long-term. Historic commercial fishery practices such as switching to different targeted species, fishing different fish stocks, changes in fishing effort and fishing power may all have masked the steady decline of fish populations over this historic time period.

In addition, the current ecosystem may not be as productive as in the past because non-native prey species are not as efficient in utilizing the primary and secondary production of the lake as were historic species, such as the diversity of ciscos that once inhabited the lake. The introduction of non-native species such as zebra and quagga mussels and the spiny water flea may also divert much of the primary and secondary production of the lake to different pathways, making it unavailable to top predators.

Non-native salmonids which feed almost exclusively on alewife and smelt are likely less efficient at utilizing productivity than indigenous lake trout. Lake trout has a much more varied diet and would historically have utilized some portion of the available benthic prey, in addition to forage fish, to support their population size.

Taken in context, historic yield can provide an idea of what a fully recovered fish community might sustain rather than a specific target. The GLFC currently facilitates the publishing of State of the Lake Reports for each of the Great Lakes on a five year rotation. A critical review of the lake status relative to FCOs is currently being conducted, and FCOs will be updated as required.

Revised FCOs will need to address such issues as - can rehabilitation of native species occur in the presence of alewife? If not, the lake may not be able to support both healthy populations of exotic salmonids and native predators. The number of changes the lake is currently undergoing makes strategic planning particularly difficult. The types of changes being seen in Lake Huron are not being witnessed in any of the other Great Lakes. Are the changes currently occurring in Lake Huron permanent? Is primary productivity of the lake going to continue to be low? If the introduction of additional exotic invaders is not stopped, this will continue to limit predictive capacity and sound strategic planning for the lake.

To better facilitate the cooperative management of fisheries resources a framework for inter-jurisdictional coordination of fisheries management based upon an ecosystem context was developed. This "ecosystem approach" to fisheries management recognizes that the resources of the Great Lakes must be managed as a whole, that healthy fish communities require functioning, diverse habitats and clean water. In order to support the FCOs, Environmental Objectives (EOs) are being developed to describe the biological, chemical and physical needs of these desired fish communities. The rehabilitation of Saginaw Bay, which once accounted for a significant proportion of lakewide yield of fish species, and making stream habitats currently blocked by man-made barriers available to migrating fish, rank as key targets for future habitat work.

Traditionally, the impacts of industrialization and human population density on Lake Huron have not been as great as some of the other Great Lakes. However, given that Lake Huron is vulnerable to future potential anthropogenic impacts due to its close proximity to highly populous areas and its popularity as a destination for millions of cottagers, tourists and anglers; timely strategic planning to protect and enhance habitat is very important. The mounting development pressures on Lake Huron from improved highways, increases in year round residents, and diminishing resources in other locations, will likely increase harvest and development pressure and strain the achievement of resource sustainability. Continued vigilance is needed to insure that future development on Lake Huron is done in a sound ecologically sustainable manner while efforts to seek solutions to existing problems continue to occur.

With multiple resource agency input, the development of Draft EOs was initiated in 2002 and the current version is undergoing critical review. The draft EOs provide a summary of the major environmental impediments to achieving FCOs in Lake Huron.

A summary of the Draft EOs is provided below:

Spawning and Nursery Habitats

Maintain, protect and restore the integrity and connectivity of wetland spawning, nursery and feeding areas throughout the Lake Huron basin. Coastal wetlands throughout Lake Huron provide critical spawning, nursery and feeding habitat for a variety of fish species. Northern pike (*Esox lucius*) and muskellunge (*Esox masquinongy*) spawn exclusively in wetland areas whereas other species such as yellow perch, walleye, and minnow species use these areas as nursery and feeding sites. Historical losses of Lake Huron wetlands through drainage, infilling and other physical alterations have been significant. Many remaining wetlands are degraded or no longer accessible due to shoreline armoring. Spawning and nursery wetland habitats identified as priority areas in the draft Environmental Objectives are: Saginaw Bay, St. Marys River, Les Cheneaux Islands, Eastern Georgian Bay and North shore of North Channel.

Protect and restore connectivity and functionality of tributary spawning and nursery areas throughout the Lake Huron Basin. The Lake Huron watershed is the largest of the Great Lakes with numerous rivers and streams draining into the basin. The principal spawning and nursery habitats for a variety of species, including lake sturgeon (*Acipenser fluvescens*), walleye, pacific salmonids, and suckers (*Catostomus spp*.) are found in these tributaries. Unfortunately, rivers and streams are some of the most altered and disrupted habitats in the Lake Huron basin. Many of the watersheds draining into Lake Huron have barriers to upstream access and have flow regimes that have been altered as a result of watershed land-use changes or hydro-electric generation needs. Spawning and nursery tributary habitats identified as priority areas in the draft Environmental Objectives are: Saginaw Bay watershed, St. Marys River, Garden River, Mississagi River, Spanish River, Moon River, Severn River, Nottawasaga River, Saugeen River, Au Sable River and Thunder Bay River.

Protect and restore reef spawning areas throughout the Lake Huron Basin. Lake Huron is a deep oligotrophic lake with a fish community that was historically dominated by deep dwelling species such as lake trout, whitefish and ciscoes. Most of these species utilize offshore or nearshore reefs for spawning purposes. Nearshore and offshore reefs are one of the most common habitat features throughout the Lake Huron basin. For the most part these habitats have not been physically altered to the same extent as other habitat types, however, the colonization of these habitats by invasive species such as zebra mussels and round goby (*Neogoblus melanostomus*) has accelerated in recent years and may in time degrade the quality of these habitats. Spawning and nursery reef habitats identified as priority areas in the draft Environmental Objectives are: Saginaw Bay, Manitoulin Island, Western shore of Bruce Peninsula (including Fishing Islands complex), Georgian Bay, Thunder Bay, Drummond Island, Mackinaw Island, Six Fathom Bank and Yankee Reef.

Shoreline Processes

Protect and rehabilitate nearshore habitats and reestablish the beneficial structuring forces of natural water exchanges, circulation, and flow that they provide. The alteration of nearshore areas due to human activities has been widespread throughout the Lake Huron basin but has been most pronounced in the populated areas in the southern part of the basin. Shoreline straightening, infilling, dredging, and other such activities alter nearshore currents, increase erosion and deposition of fine sediments and leads to the loss of habitat diversity. Since a majority of fish species inhabiting the basin use nearshore areas at some point in their life-cycle, altering these areas results in the loss of fish production and change in fish community structure. Priority areas identified in the draft Environmental Objectives for protection and rehabilitation are Saginaw Bay, Central and south-east shore of main basin, St. Marys River, Southern Georgian Bay, Thunder Bay, Les Cheneaux Islands and Eastern Georgian Bay/North Channel.

Food Web Structure and Invasive Species

Protect and where possible enhance or restore fish community structure and function by promoting native species abundance and diversity and avoiding further invasive species introductions. Fish communities throughout the Lake Huron basin have undergone substantive change over the last century. Historically, the offshore fish communities were characteristic of a large, deep oligotrophic lake with lake trout and burbot being the dominant predators, and a variety of cisco species being the dominant prey species. In the nearshore waters, a relatively greater diversity of predators (walleye, northern pike, muskellunge, bass (*Micropterus spp.)*) were present as well as benthivores (sturgeon, suckers, channel catfish (*Ictalurus punctatus*)) and forage fish (herring, yellow perch, cyprinids). A variety of factors have been implicated in the loss or extinction of species in the basin and prominent among them is the proliferation of invasive species such as lamprey, alewife, rainbow smelt, and zebra mussels. Priority areas identified in the draft Environmental Objectives for protection and enhancement and rehabilitation of fish community structure are the main basin, Saginaw Bay, St. Marys River, Les Cheneaux Islands and Severn Sound.

Water Quality

Protect and restore water quality throughout the Lake Huron basin and especially in the AOCs in order to avoid reductions in fish production and reduce or remove contaminant burdens from the fish community. Water quality throughout the Lake Huron basin has shown gradual improvement since the early 1970's. Some localized nutrient enrichment problems exist in Saginaw Bay and southeastern main basin and in northeastern Manitoulin Island. Acid rain and heavy metal contamination is still a localized issue in some parts of the North Channel and Georgian Bay. Consumption restrictions due to contaminant levels are in place throughout the basin for a variety of fish species. Priority areas identified in the draft Environmental Objectives for protection and restoration of water quality are Saginaw Bay, St. Marys River, Severn Sound, Southern Georgian Bay, central and northern Georgian Bay, North Channel, and southeast main basin.

Invasive Species

Lake Huron has been dramatically and forever changed by the invasion of non-native species, which have decimated native fish populations, and in some cases, permanently impacted fish communities. Invasive species are defined as species that do not originate in the Lake Huron ecosystem and have been introduced either intentionally or accidentally. Invasive species threaten the diversity and abundance of native species and the ecological stability of infested waters.

The introduction of invasive species into Lake Huron has altered or disrupted existing relationships and ecological processes. This disruption can cause significant changes to the Lake Huron ecosystem such as alterations of food webs, nutrient dynamics, reproduction, sustainability, and biodiversity. Invasive species have few natural enemies such as pathogens, parasites and predators. Without coevolved parasites and predators, they out-compete and even displace native populations. Not only do invasive species compete with native species for food and habitat, they may also increase cycling of persistent bioaccumulative chemicals in the food chain. For example, research has shown that zebra mussels and round gobies are contributing to the cycling and bioaccumulation of PCBs.

The recent invasion of zebra and quagga mussels, round gobies, the spiny water flea, white perch (*Morone americana*) and ruffe (*Gymnocephalus cemuus*) into Lake Huron heightens the uncertainty for expectations from the ecosystem.

The following is a description of a number of invasive species having a significant impact on the Lake Huron aquatic ecosystem.

Sea Lamprey - The sea lamprey has been a serious problem in the Great Lakes for more than 50 years. An adult lamprey can consume, and subsequently kill, up to 40 pounds of fish in just 12 to 20 months. The St. Marys River, which flows between Lake Superior and Lake Huron has become the most important spawning area for lampreys in the Great Lakes. By the1990s the St. Marys River was producing more sea lampreys than all other Great Lakes spawning tributaries combined.

Successful rehabilitation of Lake Huron lake trout populations has been hindered because of the high number of sea lamprey. Without question, the sea lamprey problem in northern Lake Huron, with increased lamprey production from the St. Marys River, is the most severe impediment to a healthy fish community in the lake.

Cost-effective sea lamprey control on the St. Marys, once thought to be impossible, may now be within reach because of a special program developed by biologists and research scientists working under the direction of the GLFC. During 1998 and 1999, more than 840 hectares of the St. Marys River were treated with Bayluscide 3.2% Granular Sea Lamprey Larvicide. Additional treatments of sea lamprey "hot-spots" in the river have been conducted in more recent years. The larvicide treatments reduced the number of larval sea lampreys in the river by nearly 45%. Enhanced trapping and release of sterile male lampreys in the river reduced the reproduction potential by an estimated 92%. Although the GLFC's fish community objective for sea lamprey (75% reduction) was not met for the year 2000, the objective for 2010 (90% reduction) is attainable. However, funding for sea lamprey control remains at approximately 65% of that needed to fully fund the program.

Round Goby - The round goby are a small fish that feed chiefly on bivalves, amphipod, crustaceans, small fish, and fish eggs. Consumption studies of fish suggest round gobies might have a detrimental impact on native species through competition for food and predation on eggs and young fish. To help control the expansion of the goby into other waterways, river barrier systems are being implemented along with aggressive public education programs. Unfortunately, no effective measures have been found to decrease established populations of goby. Goby have continued to spread in Lake Huron and have been found in increasing numbers in the diets of lake trout, walleye, and burbot. There are concerns that this could increase contaminant levels in predators. In addition, although the mechanisms are not well understood gobies are implicated in recent outbreaks of botulism. Concerns also exist that gobies will out-compete native fishes, especially sculpins, and predate on the eggs and young of other fish, reducing both the diversity and density of prey and predators in the lake.

Eurasian Ruffe - The Eurasian ruffe was first identified in 1995 in Thunder Bay near Alpena, Michigan. Ruffe adapt well to various environments, mature quickly, and spawn over an extended period of time. Ruffe populations initially grew in number, yet they did not spread from the Thunder Bay region of Lake Huron. Fortunately, they have not been detected in Thunder Bay since 2003. Hopefully, this species will disappear from Lake Huron.

Spiny Water Flea - The spiny water flea was first discovered in Lake Huron in 1984 and is believed to have entered the waters of the Great Lakes through discharged ballast water. The spiny water flea has now colonized all offshore areas of the lake. Although its average length is rarely more than 1.5 cm, this predacious zooplankter can have a profound effect on a lake's plankton community.

Zebra and Quagga Mussels - Zebra mussels reproduce rapidly and are able to form dense layered colonies of over one million per square metre. Zebra mussels are a serious threat to the Lake Huron ecosystem because they have tremendous filtering capacity for sediments and phytoplankton. In many regions of the Great Lakes zebra mussels have had severe impacts on many native unionids and are of special concern to threatened and endangered species of bi-valves. Also, zebra mussels are a serious concern because they contribute to the cycling of contaminants by removing PCBs from the sediments and reintroducing them into the food web. Quagga mussels are similar to zebra mussels in many respects but they do prefer deeper water. They therefore have the potential to detrimentally impact aquatic species that use the deeper portions of the lake.

Other Aquatic Nuisance Species - Eurasian watermilfoil (*Myriophyllum spicatum*) is one of the most common species found in Saginaw Bay. Populations have thrived since the introduction of zebra mussels that contributed to higher water clarity. Eurasian watermilfoil is detrimental to Lake Huron because it reroutes nutrients from plankton, depriving energy to the fish community. Purple loosestrife is a perennial wetland plant that is impacting Lake Huron wetland ecosystems by out-competing native vegetation and changing the structure, function and productivity of the wetlands they invade. The plant can form dense monoculture stands sometimes hundreds of hectares in size. The fishhook water flea (*Cercopagis*), is one of the most recent invasive species to Lake Huron. Fishhook water fleas are a problem because, like the spiny water flea, they get tangled in the lines of both recreational and commercial fishery nets and have a large appetite for zooplankton. Further, ecological disruptions have not been completely determined, therefore, the fishhook water fleas are being closely monitored.

V. Aquatic and Terrestrial Habitat

The Partnership has identified degradation and loss of historical habitat in tributaries, nearshore, and coastal wetland habitats as a major stressor to the Lake Huron ecosystem, and one of three binational priorities to be given immediate action. 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, 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. The following sections provide an overview of the major habitat resources of the Lake Huron watershed, the stresses and threats to these resources and, in general terms, their status and conservation needs.

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 over the mostly qualitative and descriptive understanding of just a few years ago. 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, also known as meadow marshes, commonly occur in Lake Huron and are identified as globally imperiled communities (Natural Heritage Information Centre, 1995). Water-filled depressions found between dunes or ridges, known as swale complexes, are also found along the shores of Lake Huron. Coastal wetlands are also 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 for microbe and invertebrate species, providing the foundation for a complex food web. These wetland functions translate into crucial societal values including, improvement to water quality, flood attenuation and shoreline protection, human food, recreational use, landscape diversity and carbon storage (Loftus et al., 2004; Mayer et al., 2004).

Coastal wetlands provide a variety of niches that fulfill the habitat requirements of a range of flora and fauna; some of which are species at risk. 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).

Coastal Wetland Distribution and Inventories

The most comprehensive data for Lake Huron coastal wetlands was completed by the Great Lakes Coastal Wetland Consortium through a binational initiative. The binational team identified 1,255 Lake Huron wetlands for Ontario totaling 16,085.81 hectares (9,748.74 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 some 44,334.95 hectares (109,553.60 acres) (Figure 5.1).

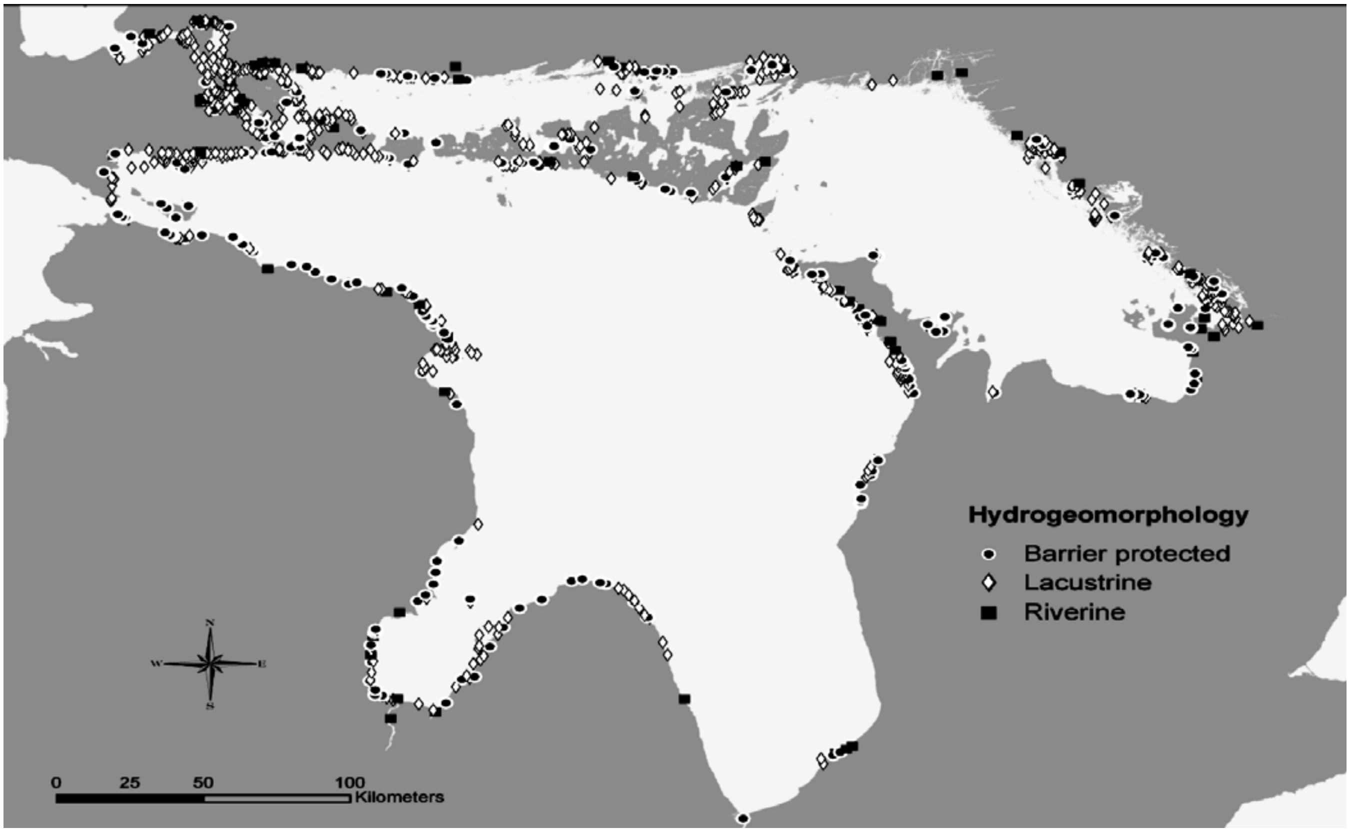


Figure 5.1. Distribution of Lake Huron coastal wetlands by hydrogeomorphic type.

The true wetland area for Ontario is expected to be much higher; however, photo coverage is required for the 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 a wetland inventory and to identify environmental impacts due to human-related and natural alterations. The results of an investigation by McMaster University researchers using IKONOS satellite imagery and ground truthing information, revealed an overall vegetation accuracy of 97% within a small wetland in Twelve-Mile Bay in July 2004.

Coastal Wetland Stressors

Coastal wetlands experience continual stress from natural and anthropogenic influences. While wetlands can benefit from minor fluctuations in water level by encouraging a more diverse plant community, certain direct and indirect stresses can have negative and irreversible consequences to wetland structure and function. There are also concerns that decreasing Great Lakes water levels can affect the shoreline ecosystem and coastal wetlands of Lake Huron and Georgian Bay. 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 or U.S. sides of Lake Huron. Loss of wetlands on a large scale has not occurred in northern Lake Huron and Georgian Bay because of its remoteness. However, environmental stressors such as cottage, marina, and subdivision development continue to impact other Lake Huron coastal wetlands. The need for binational wetland indicators to assess these and other stressors arose during a series of State of the Lake Ecosystem Conferences (SOLEC).

Indicator metrics have been proposed and are currently being evaluated using macroinvertebrate, fish, plant, amphibian, bird community dynamics, wildlife contaminants, water chemistry, sediment loading and landscape attributes. These indicators will not only be used to assess the level of an identified stressor, but will be used to track improvements to, or deterioration of, the Lake Huron's coastal wetlands (Ingram, 2004; Lawson, 2004; Chow-Fraser et al., 2006).

From 2003 to 2005, 71 wetland complexes throughout eastern Georgian Bay and the North Channel were inventoried and assessed multiple times by McMaster University researchers, providing temporal information for wetland integrity. A Water Quality Index was used to rank wetlands according to the degree of human-induced disturbances. Except for two wetlands, all others were ranked in the "good" to "excellent" categories. Compared with 93 other Great Lakes coastal wetlands, Georgian Bay and the North Channel are disproportionately represented in the "very good" to "excellent" categories. Most of the wetlands that show signs of degradation are located in southeastern Georgian Bay; these wetlands have been identified as "moderately degraded." In addition, the quality of fish habitat was assessed by calculating scores for Wetland Fish, Zooplankton and Macrophyte Indices. Scores were generally indicative of very good to excellent habitat (Chow-Fraser et al. 2006).

Lake Huron Coastal Wetland Priority Management Areas

Examples of priority coastal wetland management areas and attributes are provided below. Additional information and wetland-relevant fish community objectives can be found in the GLFC's Draft EOs 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 Great Lakes region. The Bay also supported the largest population of yellow perch, walleye, pike and muskellunge populations. Today, wetlands in the Bay support populations of smallmouth bass, largemouth bass, black crappie, sunfish, rockbass, and channel catfish. However, massive land use changes since the mid-1880s have significantly altered the quantity, diversity and quality of wetland. Reports indicate that only 6,070 hectares (15,000 acres) of the nearly 14,973 hectares (37,000 acres) of emergent vegetation around Saginaw Bay remain today. In addition, shoreline and upper watershed development is causing wetland loss, sedimentation and contamination of sediments. Many of the remaining coastal wetlands are no longer connected to the lake and are being impacted by non-native species.

A restoration strategy, which focuses on preserving coastal wetlands and upland buffers, has been developed for Saginaw Bay. It clearly identifies vulnerable wetland areas that are important to preserving the integrity of the Bay and that are in need of protection.

Les Chenaux Islands

The Les Chenaux archipelago contains extensive coastal wetlands, which have experienced some historic wetland loss. The area supports a diverse fish community and provides critical habitat for the Lake Huron yellow perch population. The major stressors to the coastal wetlands include nutrient enrichment problems associated with both localized point and non-point sources, and historic and on-going shoreline development pressures. Priority actions at this time consist of continued wetland monitoring and further evaluation of known stressors.

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

Coastal wetlands are interspersed throughout these northern shorelines, many of which still require assessment. This northern region of Lake Huron supports a diverse warm and coolwater fish community. For example, muskellunge, northern pike, bass, black crappie, and sunfish utilize the coastal wetlands as habitat and for spawning. Unfortunately, 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 (Environment Canada and Ontario Ministry of Natural Resources, 2003). Wetland area in southern Georgian Bay has decreased since 1951, including 68% in Severn Sound and 18% in Penetanguishene/Hog Bay (Severn Sound Remedial Action Plan, 1993). Currently, the Severn

Sound and Magnetawan Rivers are under intense recreational and development pressures. Impacts from exotic species are also becoming more prominent. Priorities in these areas include additional inventories, monitoring and recovery. Alternatively, the Spanish River delta wetlands are currently recovering from historic environmental impacts and are a site of muskellunge recovery.

St. Marys River

The St. Marys River is listed by the State of the Lakes Ecosystem Conference (SOLEC) as the top Shoreline Biodiversity Investment Areas in the Great Lakes. This is due to the large areas of undeveloped land and coastal wetlands in the southern portion of the river. The St. Marys River area has a wide range of habitat types including significant embayments and emergent wetlands providing spawning, nursery, and feeding grounds for a number of native and introduced species. These wetlands provide habitat for fish, waterfowl and wildlife, and recreational opportunities.

ALVARS

Alvar communities of the Lake Huron basin warrant special interest because of their rarity and unique assemblages of flora and fauna. Alvar conservation is also an International Joint Commission (IJC) desired outcome of Biological Community Integrity and Diversity. 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.

Grassland and pavement alvars are classified as provincially and globally imperiled by The Nature Conservancy (TNC - 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 hydological 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

Local, regional and international conservation initiatives are underway which identify and protect alvar sites in the Great Lakes basin. One of the most significant is the International Alvar Conservation

Initiative (IACI). The initiative is coordinated by the Great Lakes Program of TNC (U.S.) and operated through an Alvar Working Group. The Working Group includes Ontario and Michigan government agencies, universities, Ontario Nature, TNC (Canada), Natural Heritage Programs, and scientists (Reschke et al., 1999).

Alvar habitats across the Lake Huron basin are at risk. 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). 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, La Cloche Island, Peninsula and Carden Plains. 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).

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 3,000 to 4,000 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, beach dunes and perched dunes are the two major dune types along the shore of Lake Huron. Beach dunes consist mostly of sand and develop on the low-lying shores of Lake Huron, while perched dunes sit on a plateau above the shore and consist of sand as well as other loose material (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 drops. 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 systems in turn provide important habitat for many unique and specialized species at risk. Many dune plants have evolved special adaptations to the extreme heat to nutrient deficient soil. In addition to seed production, some species send out horizontal root stems which develop into new plants.

Threatened plant species of the Lake Huron dunes include Houghton's goldenrod, which exists only along the northern shores; dwarf lake iris and Pitcher's thistle, both of which grow in sand dune systems (Jalava, 2004). The federal, state and provincial endangered piping plover is known to nest along the northern Michigan shoreline. In addition, the prairie warbler, a rare bird in Michigan, is known to nest in shrubs on foredunes of Lake Huron, as far north as Rogers City. 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 uninformed and 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 unimpacted areas (Peach, 2005). Some human related threats to dunes include:

- Dune removal or alteration due to cottage development and cottage parking;
- Damage to plants and habitat from foot traffic;
- Habitat fragmentation from human caused breaches and blow-outs to dunes;
- Invasion by 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 that there will be 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 over the last few years to help them gain a better understanding and appreciation for the conservation of beach and dune systems. A Beach and Dune Guidance Manual was developed for the Town of Saugeen Shores, to help inform and educate town employees about the form, function and vulnerabilities of the dune systems along their waterfront (Peach, 2003). The Michigan Natural Features Inventory, partnering with the Michigan Coastal Zone Management Program, has 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 the dunes along the Michigan coast (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 km (3,827 miles). Most of these islands are found in the North Channel and Georgian Bay. Swamps, bogs and fens are common on the islands, and most of the Great Lake coastal meadow marshes are found among the coastal islands (Jalava et al., 2005). The Thunder Bay/Misery Bay Archipelago also hosts a wide 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.

The modern configuration of the Lake Huron islands has existed for approximately the past 5,000 years and consists of limestone islands in the west, and a mix of limestone and granite islands in the east. Due to their isolation, Lake Huron islands are important conservation areas that support distinctive flora and fauna and unique landscape features such as dunes, alvars and provide habitat conditions similar to those that existed prior to European settlement (Vigmostad, 1999). While islands have historically been important to fish, birds and other wildlife, this is now intensified as mainland habitats have experienced significant fragmentation and loss to human development.

Islands provide important stopover sites and refugia for many migratory bird species. According to Ewert et al. (2004), 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. According to a survey in 1999, 156 Georgian Bay islands support colonial waterbird colonies (Jalava et al., 2005). Approximately 160,000 nesting pairs of colonial waterbirds were counted in surveys conducted by the Canadian Wildlife Service (CWS) from 1998-2001 (Hughes, 2004). As previously stated, islands provide habitat for endangered species and provide fish spawning and nursery areas (Manny and Kennedy, 2004). Islands support unique plant communities that differ from their mainland counterparts. Lake Huron islands also support diverse assemblages of both 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

Lake Huron islands are more sensitive to human influence than the mainland and need special protection to conserve their natural features and values. Many species of island nesting birds are sensitive to human disturbance, which if high enough, may cause them to abandon the colony for the year. Because little is known about the Lake Huron islands as a collection or their conservation status, well-documented stresses continue to degrade these important ecosystems (Ewert et al., 2004; Jalava et al., 2005).

The following are documented threats to Lake Huron island ecology and integrity:

- Development of islands;
- Shoreline hardening;
- Introduction of non-native species;
- Boat wakes and mooring ;
- Increased human access and non-sustainable recreation;
- Potential effects of climate change to island ecology, and;
- Transfer of ownership from government to private owners.

Island Conservation

Lake Huron islands represent a unique opportunity to protect a resource of local, regional significance because many islands remain intact. In the 1995 Canada-U.S. workshop to assess the Great Lakes Islands and during the 1996 SOLEC, the natural biological diversity of islands was emphasized and awarded global significance. A number of significant scientific island conservation approaches are currently being implemented, such as the Great Lakes Basin Ecosystem Team's Great Lakes Islands Committee. This Committee completed an overall assessment of the islands for protection and restoration efforts and developed action plans.

TRIBUTARIES

Over 10,000 km (6,213 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 it's associated nearshore ecosystem with water and nutrients, and provides important fish and wildlife habitat (Crosbie and Chow-Fraser, 1999). The tributaries, in turn, depend on upland vegetation to regulate the nutrients (energy) and material entering the waterways. Species that inhabit tributary habitat depend upon the oxygenation of water, 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 also 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 watershed will ensure that critical habitat is available, thus preserving the genetic diversity of fish and wildlife in the Lake Huron basin.

Factors affecting Lake Huron Tributaries

Historically, Lake Huron was connected to a diverse array of stream and inland lake habitats. 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 (Figure 5.2). Water quality deteriorated steadily through the 1970s, as point sources of domestic and industrial waste proliferated. In warm water streams in the southern part of Lake Huron, lake fish populations are excluded from tributaries and habitat, many of which have 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 to bottom-

Figure 5.2 Distribution of dams in the Lake Huron watershed.

dwelling invertebrates. Excessive sediments can also damage estuarine marshes. Sediment loading, concomitant with the bound contaminants, has buried many historically important spawning habitats, and has altered the community dynamics of contaminant 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 (i.e., fish that live in the open waters and use tributaries for spawning). In many situations, below-dam habitat is degraded by altered hydrology and increased water temperatures, which influence water quality; the physical habitat, including the distribution of aquatic plants; and suspended sediments.

Apart from dams, obstructions and sedimentation, other 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, industrial, and commercial land uses. High levels of nutrients from fertilizers and other chemicals, along with excessive soil erosion threaten the water quality, thus impact habitat for fish and 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 re-established in order for Lake Huron to achieve its full potential for fish and wildlife production. Priority management areas have been drafted by the GLFC's Draft EOs for Lake Huron. Additional information and fish community objectives relevant to tributary habitat can be found in the GLFC's Draft EOs for Lake Huron.

LAKE HURON HABITAT PROTECTION, RESTORATION AND CONSERVATION

As described in the previous sections, many different efforts to protect, restore, and conserve important habitat are ongoing in the Lake Huron watershed. A variety of forums have developed habitat-specific conservation plans for the key environmental components of the Lake Huron ecosystem. These plans represent the critical thinking of governmental managers, technical experts, and informed stakeholders. The 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. 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.

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VI. Areas of Concern

Areas of Concern in Lake Huron

In 1987, four AOCs (Collingwood Harbour, Severn Sound, Spanish Harbour, and Saginaw River/Bay) were identified within the Lake Huron watershed, as well as the binational St. Marys River. Collingwood Harbour and Severn Sound in Canada were delisted in 1994 and 2003, respectively. Monitoring is ongoing in the AOCs to ensure that environmental quality is maintained. Each of the remaining AOCs is being addressed through on-going programs, as described below.

For more information on AOCs, see the following websites:

http://gldev.on.ec.gc.ca/water/raps/map_e.html

http://www.epa.gov/glnpo/aoc/index.html

Spanish Harbour, Ontario

At the Spanish Harbour AOC, all recommended actions were completed and in 1999, the area was the first in the Great Lakes to be recognized as being an "Area in Recovery". Heavy metal contamination in the river and harbour are being monitored for natural recovery. Results from recent surveys (2003 and 2005) have been compiled into draft reports. Some follow-up sediment and fish analyses are planned for 2006 to fully explore the presence of dioxin in the Whalesback Channel. Data is being used to refine previous modeling efforts to offer some predictions to estimate the recovery period. At the same time, new developments in scientific risk assessment techniques have illustrated the need to revisit the delisting criteria. For example, reviews and revisions of the benthos criteria will be completed in 2006.

A six year muskellunge reintroduction program involving many partner organizations has been completed and final assessments are being compiled. Young of the year muskie have been caught in Spanish Harbour for the first time in many years. See the Action Plan for more details of OMNR projects.

Saginaw River/Bay, Michigan

The Saginaw Bay watershed is one of Michigan's most diverse areas. The watershed is 14,016 square km (8,709 square miles) in size and is America's largest contiguous freshwater coastal wetland system. The watershed's rich resources support agriculture, manufacturing, tourism, outdoor recreations, and a vast variety of wildlife. The watershed is also affected by a variety of urban and rural environmental stressors, including industrial discharge, nonpoint source pollution, and habitat degradation. The Saginaw River/Bay AOC boundary extends from the head of the Saginaw River (at the confluence of the Shiawassee and Tittabawassee Rivers) to its mouth and includes the entire Saginaw Bay area.

The first Saginaw River/Bay Remedial Action Plan (RAP) completed in 1988 identified sediment contaminated with organic compounds (e.g., dioxins, furans and PCBs), fish consumption advisories, degraded fisheries and loss of significant recreational values as the major reasons for the AOC designation. Following substantial remedial progress within the AOC, the RAP was updated in 1994. The 1994 RAP identified and described 12 beneficial use impairments (BUIs) known to occur in the Saginaw River/Bay AOC. In 2001, the Measures of Success report provided a list of targeted conditions that were viewed as important steps toward delisting the designated BUIs in the AOC. The RAP priorities identified included remediation of contaminated sediment, nonpoint pollution control, coastal wetland protection, and habitat restoration. The MDEQ, in cooperation with the Partnership for Saginaw Watershed, is proposing to update the next RAP report in 2007 to document recent remedial actions and BUI assessments conducted in the AOC.

Ongoing remedial efforts continue to address contaminated sediments and floodplain soils within the watershed. For example, in an effort to better understand the distribution of dioxin at the macro (system wide) and micro (hotspot) scale the MDEQ, along with other agencies and the private sector, have collected soil, sediment, and ecological data in the AOC. Once finalized, the assessment reports will help address possible trends in sediment concentrations, and target where future potential remediation may need to occur (personal communication, Art Ostaszewski, MDEQ WHMD).

The 1998 $28.2 million Natural Resources Damage Assessment (NRDA) settlement funded the removal of contaminated sediments, including post-evaluation monitoring, and provided matching funds to protect and restore coastal wetlands in the Saginaw Bay watershed. Portions of this settlement have been used as a match for several North American Wetland Conservation Act (NAWCA) grant projects. For example, the U.S. Fish and Wildlife Service (USFWS) completed the Tobico Marsh restoration project in November of 2004. Restoration work completed in the 900-acre wetland complex improved northern pike spawning opportunities, and modifications to the flap gate at Tobico Lagoon will help to keep water out during high lake levels, minimizing flooding risks to nearby residences. Ducks Unlimited, along with a large coalition of conservation partners, has also obtained NAWCA funding and NRDA matching funds to implement a variety of conservation activities (e.g., GIS mapping coastal wetlands) and wetland restoration projects throughout the Saginaw River watershed.

Binational Area of Concern: St. Marys River

The St. Marys River is a 112 km (70-mile) connecting channel between Lakes Superior and Huron, and is subject to many activities under the binational RAP. Accomplishments on the Canadian side have included:

- Process improvements at the Algoma Steel mill;
- The addition of secondary treatment at the East End Water Pollution Control Plant;
- Installation of sewage overflow tanks;
- Rehabilitation of the sewer system in areas of high infiltration;
- The development of wetland protection strategies;
- The recovery of walleye populations;
- The design of habitat features in the city's waterfront development, and;
- Installation of an activated sludge treatment facility to reduce the oxygen demand and suspended solids in the discharge water of the St. Marys Paper mechanical pulp mill.

Another accomplishment has been the Environmental Management Agreement between Algoma Steel, EC, and the OMOE, which has resulted in many improvements to both air and wastewater discharges from the plant.

Current RAP projects on the Canadian side include: development of a strategy for contaminated sediment in the Bellevue Marine Park area; review of delisting criteria; wastewater characterization study; and the coastal wetland assessment and protection program. Future challenges include long-term sea lamprey control efforts to reduce the impact on Lake Huron fisheries, and the finalization and implementation of an overall sediment management plan for the St. Marys River. This management plan applies the recently completed Canada-Ontario Contaminated Sediment Assessment Framework to identify the areas of contamination within the river which require management actions. Currently, the two contaminated areas causing the most concern are the Bellevue Marine Park area and the Algoma Slip. However, some improvements in benthic communities and sediment toxicity have occurred in the Algoma slip as a result of navigational dredging.

Priorities on the Michigan side of the St. Marys River are: additional cleanup of the Cannelton Tannery Superfund site, sea lamprey control, elimination of combined sewer overflows, and remediation of contaminated soil and sediment at the decommissioned manufactured gas plant downstream of Sault Edison power plant. The Cannelton Superfund site was restored for re-use by the city of Sault Ste. Marie and its citizens. Additional remediation is proposed that may allow the site to support light industry, residential homes, or park areas. Certain use restrictions will apply to various parts of the site to prevent contamination from affecting human or ecosystem health. The sea lamprey control efforts will help reduce impact on fisheries in northern Lake Huron and Lake Michigan. This will be a long-term, continuing effort since the opportunistic lamprey can take quick advantage of any lapse in larvae and adult control measures. Combined sewer separation in Sault Ste. Marie, Michigan, has already eliminated the worst of the occasional overflows of sewage to the St. Marys River. Continued work on this will eventually stop all potential for untreated sewage entering the river. Consumers Energy is conducting remediation work at the site of a decommissioned manufactured gas plant downstream of Sault Edison power plant. Permits for landbased soil erosion work and deep water dredging were issued by MDEQ in summer of 2005. Landbased investigations and remedial actions are ongoing, with approximately 5,000 cubic yards removed from the shoreline areas of the site in 2005. River-based sediment investigations are complete, and in-water dredging started in the fall of 2005. Consumers completed the first phase of that work with an estimated 2,500 cubic yards of contaminated sediment and tar removed from the river.

In addition to the above projects, there have been a number of activities carried out cooperatively. For example, the St. Marys River Fisheries Task Group, of which the OMNR and the MDNR) are members, implemented a 12 month angler fish harvest survey in May of 2005 (second in a series). The survey, which collects information on angler activity and fish species status, is an important tool in the sustainable management of the St. Marys River fishery. Numerous other monitoring projects have been carried out by U.S. and Canadian agencies, both jointly and separately, which have focused on sediment assessment, water quality, benthos, fish, and wetlands.

Binational cooperation has not been restricted to government agencies. The general public, for example, participated in three workshops on contaminated sediment issues organized by the Binational Public Advisory Council, from November 2004 to April 2005. The workshops provided information on the progress and current status of the cleanup of contaminated sediments within the St. Marys River AOC, and provided citizens and other stakeholders on both sides of the border a means of expressing their concerns about specific remediation plans.

VII. Other Issues

Lake Water Levels

Great Lakes water levels fluctuate as the result of several natural factors and are also influenced by human activities. Three types of water level fluctuations occur on the Great Lakes: short-term (lasting from less than an hour to several days), seasonal (one-year), and long-term (multi-year). Wind generated waves are superimposed on all three categories of water level fluctuations (Department of Fisheries and Oceans 2006a). Unlike the other Great Lakes, water levels in Lake Huron (and Lake Michigan, since they share the same level) are approaching historic lows. (Figure 7.1).

As indicated in Figure 7.1, lake levels in Lakes Michigan and Huron were above Chart Datum (176.0 metres International Great Lakes Datum [IGLD] 1985) from 1967 to 2000, with record high lake levels reported in 1986. In 2000, lake levels dropped to this reference point, and have since fluctuated around this height. Current lake levels are well below long-term averages for Lake Huron (Department of Fisheries and Oceans 2006c). Cyclic water level fluctuation is a natural occurrence, but it remains to be seen whether the current lows signal the beginning of a longer trend, or are just another phase in the Lake's periodic swing between high and low water level phases.

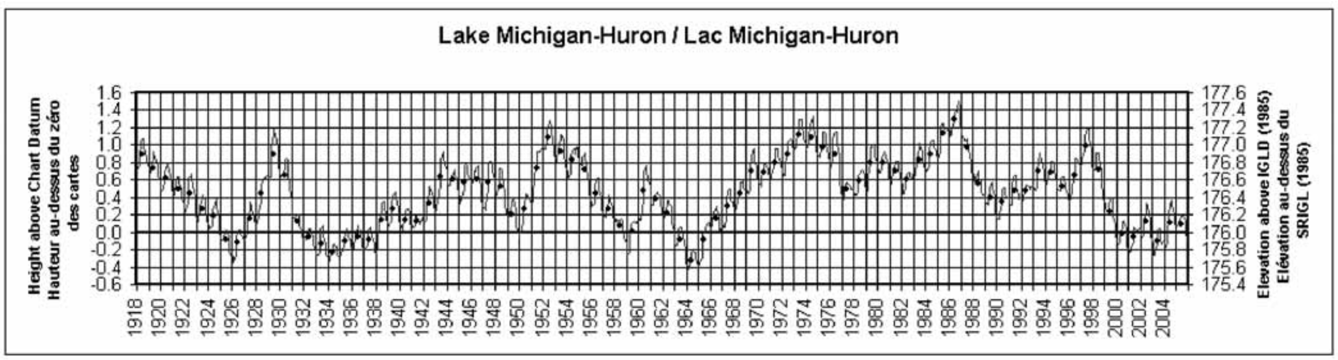

Figure 7.1. A graphical representation of the historical monthly and yearly mean water levels from the coordinated water level gauging network for Lakes Michigan and Huron.
Source: Department of Fisheries and Oceans 2006b.

Natural water level fluctuations are beneficial to coastal wetland habitat and help to maintain the diversity of flora and fauna communities. Extreme or extended periods of high or low water levels, however, can compound the effects of natural lake processes and cause undesirable results. For example, high water levels are of concern for those that live along the shoreline, because high water levels can combine with other factors, such as storms, to cause serious flood and erosion problems.

On the other hand, lower lake levels pose safety concerns for boaters, increased costs to commercial shipping, and wetland loss. Low water levels also generate water quality concerns where, in areas of warm and shallow water, there may be increased bacterial and algal growth along the shoreline. However, many shoreline property owners have welcomed the recent lower water levels, since it has exposed increased amounts of shoreline and has reduced the potential for property damage from erosion. Others are very concerned about exposed shorelines and the loss of existing wetlands, which are being dried out as water levels drop. The low water levels that have recently occurred in Lakes Huron and Michigan are not being observed to the same extent in the other Great Lakes. This situation created a novel regulatory issue.

On the Michigan shoreline, receding water levels exposed shoreline and mud flats, which were subsequently colonized by emergent wetland vegetation. This represents natural restoration that has not existed for many years, and represents a substantial increase in essential wetland habitat for fishes and waterfowl. However, some property owners, accustomed to sandy beaches and open lake, regard the new wetlands with disfavor and have attempted to secure beach grooming permits. Several cases of unpermitted vegetation removal led to enforcement actions. The State of Michigan's

Wetlands Protection and the Great Lakes Submerged Lands, parts of Michigan's Natural Resources and Environmental Protection Act, were recently amended to permit property owners to carry out limited vegetation beach maintenance, except in areas designated as Environmental Areas by the MDEQ, where threatened or endangered species may be impacted, or in designated critical dune areas. The recent amendments to the Michigan law designated Saginaw Bay as a pilot area, which allows riparian property owners in the Bay area to remove certain types of vegetation from exposed bottomlands, after receiving an expedited letter of approval from the MDEQ. Vegetation removal in this pilot area is typically limited to 50% of a property owner's shoreline, or 100 ft, whichever is greater. A permit from the U.S. Army Corps of Engineers is still required for mechanical removal of vegetation. Unless extended by the Michigan Legislature, the law dealing with beach maintenance will expire June 3, 2006.

At the same time in some Canadian waters, particularly in Georgian Bay and the North Channel, where different shoreline conditions exist, many wetlands have been significantly reduced in size through drying. This has reduced availability of critical spawning habitat for fish species, such as northern pike, muskellunge and smallmouth bass. Currently, research is being conducted to assess impacts of these low water levels and compare the current situation to the historic state.

Botulism

Botulism is a foodborne disease of vertebrates caused by a commonly found bacterium, Clostricium botulinum. Since 1998, outbreaks in Ontario waters have left dead fish, waterbirds, and mudpuppies on beaches. These organisms are affected by the extremely potent neurotoxin produced by the bacteria which lives on and in the bottom sediments of the lakes, as well as the soil in the uplands. In 1998 and 1999, the outbreaks were observed on beaches between Sarnia and Goderich. Since then, the outbreaks have been concentrated around the Point Clark area and as far north as Saugeen Shores. A common loon that had been banded as an adult in western Lake Superior was found dead during an outbreak in the fall of 2004, near Point Clark, Ontario. In 2005, only a few botulism outbreaks were reported, including a few loons in the Saugeen Shores area, and an incident where numerous mudpuppies were reported south of Goderich. Lakes Ontario and Erie continued to report numerous bird mortalities due to suspected botulism outbreaks.

Botulism outbreak events typically begin in mid to late summer and can continue up to the end of December, often coinciding with movement of migratory birds moving south for the winter. The mechanism responsible for recent outbreaks is not well understood. Scattered outbreaks have occurred as recently as the 1960's, but they did not persist at that time. It is believed that there may now be links with nearshore algae blooms; increases in benthic organisms due to the invasion of zebra mussels, quagga mussels and round gobies; or other unknown factors. The potential causes of the outbreaks are being investigated in all of the affected Great Lakes to determine the mode of transmission up the food chain, as well as, risks to native wildlife populations.

Cormorants

Cormorants are fish-eating birds implicated in decreases in nearshore fish populations throughout the Great Lakes. Cormorant abundance was increasing in the middle of the 20th century, but began a sharp decline in the 1960s due to reproductive failure induced by contaminants. Recent declines in pesticides such as DDT and an increase in available prey fish (primarily exotic species such as alewives), have allowed cormorant populations to increase. Breeding colonies are now established on many offshore islands in Lake Huron. Many groups perceive cormorants as a direct threat to fisheries and have called for cormorant control. This is a complex issue because cormorant effects on local fisheries appear to vary greatly among breeding colonies. However, cormorants clearly have an effect on island vegetation; their excrement has denuded vegetation. This has affected other bird species such as herons that also nest on vegetated island.

Cormorant management is contentious because there has been disagreement on the absolute need for control measures, the level of control needed, and which control method should be used. Some stakeholders view shooting or trapping as inhumane. Inducing nest failure through egg-oiling is only slightly less controversial, but it requires several years of control before numbers are reduced. This is undesirable to stakeholders who want immediate action. Some control measures have been implemented, but a basinwide plan has not yet been developed. In Ontario waters, the OMNR is currently conducting an extensive study to determine cormorant impacts on fish populations in Georgian Bay and the North Channel. Egg oiling is being conducted as part of this study, but any wider-scale control efforts will proceed only if a significant negative effect of cormorants on fish populations can be demonstrated.

Beaches and Bacterial Contamination

The beaches of Lake Huron draw thousands of tourists and cottagers annually to its shoreline. Lake Huron beaches are concentrated mostly in the southern half of the main basin, from Port Huron to Saginaw Bay in the Michigan, and from Sarnia to Sauble Beach in Ontario. There are also significant beach areas in Nottawasaga Bay and Severn Sound in southern Georgian Bay, on southern Manitoulin Island, and several small beaches near Thessalon and Blind River in the North Channel.

County health departments in Michigan and Ontario regularly monitor levels of Escheria coli (E.coli), a bacterial indicator organism, in waters adjacent to public beaches and compare their E. coli levels against State or provincial water quality standards. When E. coli levels exceed these guidelines, public health advisories notify the public that, beaches are posted (Ontario) with signs advising against swimming, or closed (Michigan) for swimming. Health departments will continue to sample the beach for E. coli until levels fall within acceptable levels, before the public is notified the beach is safe for swimming.

E.coli lives in the digestive systems of humans and other warm-blooded animals. Most strains are not dangerous, but they can indicate the presence of other disease-causing bacteria. There are a variety of sources that contribute bacteria and other pathogens to the surface water. The sources of E. coli include:

- Illicit waste connections to storm sewers or roadside ditches;
- Septic systems;
- Combined and sanitary sewer overflows;
- Storm (rain) runoff;
- Wild and domestic animal waste, and;
- Agricultural runoff.

The current amount of time each year on average that beaches are posted on the Canadian side of Lake Huron is very low (around 3%), or between 2 and 3 days per swimming season (depending on the length of the season). For the period from 1999 to 2003, beaches in the North Channel were never posted, and beaches in Georgian Bay were rarely posted. Beaches in southeastern Lake Huron, particularly from Point Clark south to Sarnia, have advisories posted more often. The frequency and duration of postings in some areas of southeastern Lake Huron suggests a chronic bacterial contamination problem (Lake Huron Science Committee, 2004).

In the Michigan portion of the Lake Huron basin there are 130 public beaches. Intensive monitoring of Michigan beaches on the Lake Huron shoreline began in 2001. In 2005, 91 public sites were monitored in 12 counties. As a result of the monitoring, 21 closure events were reported at 14 different beaches in 4 counties (Arenac, Bay, Huron, and St. Clair) totaling 125 days. Monitoring of Lake Huron beaches on the Michigan shoreline over the last six years is shown below in Table 7.1. The percentage of samples exceeding the E. coli standard in the Michigan ranges from 2.2 to 4.9%.

Table 7.1. Results of E. coli monitoring of beaches in the Michigan portion of Lake Huron.

Year	Number of Beaches Monitored	Number of Samples	Number of Samples Exceeding Standard	Percent of Samples Exceeding Standard
1999	0	0	-	-
2000	1	1	0	-
2001	28	318	7	2.2
2002	42	568	15	2.6
2003	54	778	22	2.8
2004	50	753	24	3.2
2005	50	690	34	4.9

Under Section 303(d) of the U.S. federal Clean Water Act, Michigan is required to identify waters that are not attaining water quality standards. Table 7.2 identifies specific areas within the Lake Huron watershed of Michigan that are identified as being impaired by pathogens.

Table 7.2. Areas in the Michigan portion of the Lake Huron watershed identified as being impaired by pathogens. Source: MDEQ, 2006.

Major Drainage Basin	Impaired Area
Eastern Upper Peninsula	Kinross Lake Beach, St. Marys River
Thunder Bay River	Lake Huron Starlite Beach
Au Gres-Rifle River	Saginaw Bay Singing Bridge Beach
Kawkawlin-Pine River	Saginaw Bay Brissette Beach Township Park, Kawkawlin River Boat Launch Beach, Saginaw Bay Wenona Beach, Saginaw Bay City State Recreation Area Beach, Saginaw Bay South Linwood Township Park Beach
Birch-Willow River	Lake Huron Forester County Park Beach, Lake Huron Kraft Road Beach
Tittabawassee River	Cedar River Campground Beach, Tittabawassee River
Shiawassee River	Shiawassee River Cole Park Beach, Bad River, Ringwood Forest County Park Beach, Holly Drain/Three Mile Creek
Flint River	Burdick Drain, C.S. Mott Lake Bluebill Beach, Potters Lake
Cass River	Cass River Heritage Park, Duff Creek and S. Br. Cass River Beach, Cass River Beach

Beaches and Algal Fouling

Increased biological productivity in the Saginaw Bay, primarily due to eutrophication, has resulted in an increase in organic debris washing up on area swimming beaches. This organic debris consists of decomposing algae, aquatic plants, and small invertebrate animals. The smell and unsightliness of this beach debris prompted citizen complaints and concern about recreational activities at Saginaw Bay recreational areas.

On the Canadian side of Lake Huron, there have been periodic complaints of algae fouling the southeastern shoreline (Lake Huron Centre for Coastal Conservation, 2004). Reports have ranged geographically from Sarnia to north of Kincardine. The washed algae on the shore, and subsequent decay, can be aesthetically unpleasant if present in large amounts. Additionally, the shore fouling is perceived as an indicator of deteriorating water quality.

In 2003, the OMOE and EC conducted surveys from Southampton to Bayfield to examine the fouling of shoreline by the green algae Cladophora. This species of algae is frequently implicated in fouling episodes in the Great Lakes (e.g. Higgins et al., 2006). The shallow lake bottom (<2m) had no or little visible growth of Cladophora at most locations visited, suggesting that ambient levels of nutrients were limiting the growth of Cladophora. Very localized areas where it was present in greater densities suggested that growth was a response to phosphorus enrichment in the immediate area.

There have also been complaints of shore fouling by charaphytes (green algae of the order Charales). During the 2003 survey, charaphytes were frequently observed growing in low density on the shallow lakebed and washed up on the shoreline in limited amounts. As a group, charaphytes are typically associated with oligotrophic (nutrient-poor) waters. Although there have been recent and large fouling events by this, there is little reference to it in previous Great Lakes studies of nuisance algae. The reasons for this seemingly recent phenomenon are not known, and will be the subject of future studies.

Aquaculture

In Lake Huron, rainbow trout are stocked into floating pens at small size, fed prepared diets, and harvested when they reach marketable size. Currently these operations occur only in Ontario waters of Lake Huron and are mostly located in the North Channel. Aquaculture operations support high fish concentrations that produce fecal material, which can degrade water quality and alter benthic environments below pen rearing facilities. Proper placement of these facilities is critical, but aesthetic concerns can arise even in areas with suitable water circulation.

Additional concerns regarding these operations include the introduction of unwanted organisms, diseases, and parasites from shipments of eggs or young fish, although none of these issues have been documented at Lake Huron operations. Rainbow trout were introduced into Lake Huron well over 100 years ago and have become naturalized. Escaped pen reared fish typically would not represent a new introduction; however, interactions between pen reared and naturalized rainbow trout are unknown. Despite these problems the industry provides a desired product with significant economic benefits, and is working with various levels of government to develop technologies and best management practices to ensure ecological sustainability.

Climate Change

Global climate change may be affecting Lake Huron by altering water levels. If current trends continue, further reductions in water level can be expected, and would exacerbate navigation and beach vegetation issues. A wide range of fisheries issues could occur if Lake Huron experienced additional warming:

- Expansion of the near-shore fish community into deeper areas;
- Increases in fish populations that are presently temperature limited (particularly alewife), and;
- Range expansion of both native and introduced fishes that are presently restricted to Lake Erie are possible.

Global climate change may also cause greater demand for fresh water, and any reduction or loss of fresh water in other regions of North America, would heighten water demand and place greater pressure on Great Lakes states to allow water withdrawal and/or diversion. While this might benefit the region's economy, potential ecological, economic, and social issues will need to be considered.

Low Level Contaminants

Recent advances in chemical detection techniques have revealed the presence of low concentrations of chemical contaminants that were previously not known to be present. Studies in other aquatic systems have detected a wide range of chemicals including the following: personal care products (e.g., soaps and perfumes), human and veterinary drugs (e.g., antibiotics), natural and synthetic hormones, plasticizers, insecticides, fire retardants, and caffeine. Concentrations of these chemicals almost never exceed standards set for drinking water, but there are no standards for many substances because their presence was not known. The primary concern with low-level contaminants is that they may serve as endocrine disrupters that affect growth, maturation, and reproduction of aquatic organisms. The problem is so new that many basic questions are unanswered.

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VIII. Action Plan

Introduction

The Lake Huron Binational Partnership is an action-oriented process for identifying priority issues and implementing efforts needed to ensure a healthy Lake Huron and sustainability of each country's portion of the basin. The Partnership promotes cooperation and collaboration towards shared objectives that can not be accomplished by individual agencies alone. The following Action Plan identifies projects that the Partnership believes are important for the protection and restoration of the Lake Huron ecosystem. However, a comprehensive list of all of the localized and binational natural resource management efforts in the Lake Huron basin is beyond the scope of this document. Consistent with an adaptive management approach, the Action Plan also tracks progress on issues identified in the previous cycle, including advancements in addressing nearshore nutrients and pathogens through Canada's South-East Shore Working Group, and expands to address emerging issues, such as the recent disruptions in Lake Huron's aquatic food web. The Action Plan includes government agency (U.S. and Canadian), individual, and other partnership projects that are currently being implemented in the basin to address both short-term and longer-term priority actions.

Canadian Watershed

In order to address binational priorities as well as issues on the Canadian side of the Lake Huron basin, a federal/provincial working group was established in 2002. A number of needs were met by the working group such as information sharing, partnering on projects as well as work planning and reporting under the requirement of the Canada-Ontario Agreement (COA). This group has since expanded to include other government and non-government organizations who will work together to coordinate activities within the Canadian basin. A Southeast Shore working group functions as a subcommittee to the federal/provincial group and focuses specifically on the bacteria and algae fouling issues at Lake Huron's beaches along the shore from Southampton to Sarnia.

U.S. Watershed

Federal, State, Tribal, and local agencies have made considerable progress toward protecting and restoring the Lake Huron watershed. Loadings of persistent, bioaccumulating chemicals continue to be addressed, populations of native species show signs of recovery, and communities are actively managing land-use to protect natural resources. The U.S effort relies on a close association with existing binational and domestic forums, and pursues innovative on-the-ground projects through the use of open and competitive grants.

Action Plan: Assessment of 2004-2006 Management Cycle and Identification of High-Priority Actions for the 2006-2008 Management Cycle

Activities Addressing Contaminants in Fish and Wildlife

Action	Responsible Agency	Description	Summary Status
Natural Resources Damage Assessment for Saginaw River/Bay AOC	MDEQ, USFWS	Provide follow-up activities regarding the completed contaminated sediment cleanups (PCBs) including post-evaluation in the Saginaw River by supporting the MDEQ and the USFWS implementation of the Natural Resources Damage Assessment (NRDA) settlement for Saginaw River/Bay.	The PCB-contaminated sediment removal under the NRDA has been completed and follow-up activities including post-evaluation in the Saginaw River is underway by the MDEQ and the USFWS. Post evaluation includes analysis of fish tissue under the Fish Consumption Advisory Program and analysis of caged fish (to determine if sources have been controlled) will be completed by Summer 2006.
Pine River Sediment Cleanup	MDEQ, USEPA	Complete the on-going DDT/PBB Pine River sediment cleanup including post-evaluation by supporting the MDEQ and the USEPA efforts funded through the Clean Michigan Initiative and Superfund, respectively.	The sediment remediation project in the Pine River adjacent to the Velsicol Chemical site in St. Louis, Michigan, is entering its final year. The cleanup project in the river began in 1998 as a fund-lead time-critical removal action (to address a hot spot cell in the Mill Pond area of the river) and transitioned to a fund-lead long term remedial action in 1999 (to address the remaining contaminated sediments in the river). To date, more than 650,000 cubic yards of contaminated sediment and approximately 6,000 gallons of leachate have been removed from the Pine River. The remaining work in the river will be completed by Fall 2006, and consists of removal of infrastructure associated with the river cleanup (haul roads, sheetpile), sediment removal in the EQ basin, and possible extension of the DNAPL collection trench in the area of the EQ basin.
Investigation of Dioxins in the Saginaw River Watershed	MDEQ, USEPA	Perform a screening level survey of the horizontal and vertical distribution of dioxin/furan concentrations in the Tittabawassee, Saginaw, Cass, and Shiawassee Rivers. The sample cores will provide information on the vertical distribution of the contaminants of concern and provide insight into the depositional history of the contamination.	The MDEQ has found higher than normal levels of dioxins in Tittabawassee River sediment and flood plain soil samples downstream of Midland, Michigan. The soil levels of dioxin found in repeatedly flooded areas typically exceed Michigan's soil clean up criteria and frequently exceed the U.S. Center for Disease Control's Agency for Toxic Substances and Disease Registry action level for dioxin in soil. Fish advisories for dioxin are currently in place on the Tittabawassee and Saginaw Rivers and Saginaw Bay. A wild game consumption advisory is also in place for game harvested along the Tittabawassee River downstream of Midland. In 2001, the MDEQ conducted a screening level or baseline assessment of dioxin/furans in sediments and floodplain soil in the Tittabawassee River, the main tributary to the Saginaw River AOC. Since that time, additional efforts on the part of Federal and State Agencies, along with the private sector, have resulted in the collection of additional floodplain soil, sediment, wild game, fish and other ecological data pertaining to the distribution of dioxins throughout the area. In 2004 and 2005, the MDEQ collected additional soil and sediment samples in the Saginaw River/Bay AOC, and on the Shiawassee River tributary, to the Saginaw River, to better understand the distribution of dioxin at the macro (system wide) and micro (hotspot) scale. These reports will help identify trends in sediment concentrations, and will help to target where future potential remediation may need to occur. Because of the size of the system, over 50 miles of river miles on the Tittabawassee and Saginaw alone, further characterization of river sediments and floodplain soils needs to be completed. This characterization is required as part of The Dow Chemical Company's hazardous waste operating license that was issued in June of 2003. Additional characterization of the Tittabawassee and Saginaw is also anticipated to be conducted as part of the NRDA process.

			For those residential properties in the Tittabawassee River floodplain where existing dioxin concentrations exceed or could reasonably be expected to exceed 1000 ppt TEQ in soil, Dow has begun to conduct interim response activities to begin to reduce human exposure. The final response activities for the Tittabawassee and Saginaw Rivers will be identified and implemented as part of the corrective action and NRDA process.
			For additional information on Dioxin and Dioxin in the Saginaw AOC see the links below. Dioxin Fact Sheet : http://www.michigan.gov/documents/Dioxin_Fact sheet_82359_7.pdf MDEQ Dioxin Information Page: http://www.michigan.gov/deq/0,1607,+7 135 3307_29693_21234 ,00.html
Sediment Quality in the St. Mary's River AOC	USEPA - GLNPO grant to Lake Superior State University (LSSU)	Two focus areas: 1) Little Rapids area, a candidate for restoration of open rapid habitat and has not been sampled to date, and 2) Munuscong Lake in the lower St. Mary's, which has undergone substantial hydrological manipulations and requires updated sediment sampling.	Project complete and a final report has been submitted. Both the Little Rapids and Munuscong Lake contain sites with low to moderately elevated levels of chromium and nickel. Concentrations of these compounds exceeded Threshold Effect Levels in the sampling locations. While elevated, these concentrations are below typical action levels for a remedial response. Restoration opportunities may be appropriate for these areas.
Tributary Screening for Contaminants in Sediment Along the Canadian Shoreline	EC – Ecosystem Health Division (EHD)	Sediment sampling in all Canadian tributary mouths in 2004/2005 to screen for presence of persistent contaminants. Additional intensive sampling was conducted in 2005, at the Seguin and Magnetawan Rivers to delineate contaminated zones.	Project completed. Additional sampling in 2005 confirmed contaminated sediment zones in Magnetawan and Seguin Rivers. Final report to be available in early 2006. Potential program expansion in 2007 to include all U.S. tributaries. Both the Seguin (Parry Sound) and Magnetewan rivers will be revisited in 2006 to confirm earlier data. The Lake Huron Screening report is presently undergoing internal review, and will be available in 2006.
Herring Gull Egg Contaminant Monitoring Program	EC – Canadian Wildlife Service (CWS)	The CWS to maintain annual monitoring of contaminants in Herring Gull eggs for 3 sites in Lake Huron: Chantry Island (off Southampton), Double Island (of Blind River), and Channel-Shelter island (in Saginaw Bay).	Completed annually and most recent data added to 2006 report.

Activities Addressing Nutrient and Bacteria Issues

Action	Responsible Agency	Description	Summary Status
Water Quality Surveys at Nearshore Index/ Reference Stations	OMOE - Environmental Monitoring and Reporting Branch (EMRB)	The 17 Lake Huron/Georgian Bay monitoring stations in the Great Lakes-wide suite of index and reference stations were surveyed in 2002 and 2003. The environmental information collected included, conventional water quality, persistent contaminants in surficial and suspended sediments, compositio n of benthic invertebrates, as well as selected features of habitat. It is expected that the Lake Huron/ Georgian Bay stations will be visited every 5-6 years.	The data for the environmental information has been collected and is available. A report on the findings is anticipated for completion by the end of 2006 and will be available through the OMOE's EMRB. These reference stations will be resurveyed in 2008.

Lake Huron Shoreline Water Quality Study	OMOE - EMRB	In 2003, water quality in nearshore areas of eastern Lake Huron adjacent to key tributaries was examined to help better understand tributary-nearshore linkages in eastern Lake Huron. Spatial and temporal variability in water quality in the nearshore of the lake and selected tributaries was monitored. The focus of data collections was on conventional water quality parameters including nutrients, chloride, solids, bacterial indicators and nuisance algae.	In July 2003 the OMOE conducted a survey shoreline from Southampton to Bayfield (SE Lake Huron) to examine the fouling of shoreline by algae. The study focused on the green algae, Cladophora, a species that dominates shore fouling problems around the Great Lakes (e.g., Higgins et al. 2006). Further study of algae fouling of shoreline was initiated by OMOE in 2005 and will be completed in 2006. The recent study builds upon the 2003 study and includes through-time observation of shoreline, spatially detailed studies at selected sites, and expands geographic range of locations examined (Sarnia to northern Bruce Peninsula).
Lake Huron Southeast Shore Project - a Partnership Project	OMOE – EMRB	This project is an examination of water quality in selected nearshore areas. A focus of the project is to examine possible influence of tributary discharges on nearshore conditions. A substantial field effort was conducted in 2003. Data workup, interpretation, and data reporting were completed in 2004.	In May, 2005, the OMOE released the Lake Huron Science Committee's report entitled, "Sources and Mechanisms of Delivery of E. coli (bacteria) Pollution to the Lake Huron Shoreline of Huron County". The Lake Huron South East Shores Working Group continues to provide a forum for further collaboration on research and monitoring on a range of issues, including microbial pollution affecting the Lake Huron shoreline
	EC - National Water Research Institute	An examination of the problem of eutrophication symptoms and bacterial related beach closings. The shallow nearshore zone seems to hold pollution close to shore and affects beaches. This study will establish the nearshore zone by satellite imagery, lake circulation modeling using results of satellite analysis. Land use information, public complaint information, water quality and underwater camera work will evaluate the scope of problem, symptoms and causes.	Studies have been completed and continuing work for the 2006 sampling year includes: Characterization of spatial/temporal variability of E. coli in the swash zone of specific beaches; tracking E. coli from septics, including plume characterization; characterization of E. coli discharge from groundwater to lake; and infiltration rates of E. coli through beach sand.
Georgian Bay Water Quality Survey	OMOE - EMRB	From 2003 to 2005, a large scale synoptic survey was conducted along the coastal areas of the Georgian Bay, which characterized the spatial and temporal patterns in water quality. Approximately 135 stations were sampled from Killarney to Honey Harbour, and across a spectrum of environments, to understand impacts from watershed-lake mixing, the range of natural variability, and the influence of physical parameters (e.g., depth, exposure) on water quality. The results from this study will be used to establish a baseline to which future water quality conditions can be compared and to assess the ecosystem's ability to tolerate change.	The results from this work are currently being written up and a report will be available from the EMRB at the OMOE by September of 2006.

Compliance Promotion Activities in Selected Canadian Watersheds	EC - Environmental Protection Branch	The top 10 or 11 watersheds in Ontario that have experienced the greatest amount of impact from livestock operations. The bulk of these priority watersheds are in the Lake Huron basin. In 2002, farm visits were conducted in 3 subwatershed areas in the Lake Huron basin. Future visits will promote additional compliance with best management practices for agriculture. This work is linked with the above Lake Huron Southeast Shore Project.	Completed and a new approach has been proposed for 2006/2007. See below "Adopt a Watershed" project.
Agricultural Buffer Strips in the Saginaw Bay Area	MDEQ, Michigan Department of Agriculture (MDA)	The MDEQ has been working closely with the MDA to implement a federal-state-local conservation partnership program, referred to as the Conservation Reserve Enhancement Program (CREP), to reduce significant environmental effects related to agriculture in the Saginaw Bay watershed. Eligible conservation practices include filter strips, riparian buffer strips, field windbreaks, and wetland restorations. The MDEQ and the U.S. Department of Agriculture has provided cost sharing for the implementation of Natural Resources Conservation Service approved conservation practices, monitoring, and permanent conservation easements. The success of the program will be measured in reduced sediment, phosphorus, nitrogen, pesticide, and pathogen inputs to surface waters and improved water quality in the Saginaw River and Saginaw Bay.	The Saginaw Bay CREP Program has currently completed over 37,000 acres (14,973 hectares) of installed practices and, with the currently ongoing efforts, is expected to install a total of over 45,000 acres (18,211 hectares) of conservation practices in the Saginaw Bay watershed.
Adopt a Watershed Project	EC – ECB,EP, OMAFRA, OMOE, Conservation Authorities, local watershed groups	The Adopt a Watershed project will target subwatersheds in Huron, Bruce and Lambton Counties along the Canadian Southeast shore. The program will reduce releases of harmful pollutants to watercourses and air, including nutrients, bacteria, persistent organic contaminants, pesticides, metals through education and the implementation of best management practices on farms and rural properties. Local Conservation Authorities are delivering the program with assistance from agencies for funding, design, and monitoring.	New for 2006-2008 management cycle.

Activities Addressing Fish and Wildlife Habitat/Populations

Action	Responsible Agency	Description	Summary Status
Misery Bay Community Planning	USEPA-GLNPO	Support North East Michigan Council of Government's (NEMCOG) demonstration project for the consideration of natural resource values in land use/planning in the Misery Bay area.	Completed. The final report can be found at: http://www.nemcog.org/MiseryBayInitiative.htm This pilot project helped catalyze the project described below.
Presque Isle County Green Infrastructure Project	USEPA-GLNPO	Support North East Michigan Council of Government's (NEMCOG) effort to provide ecological information and tools to local units of government, organizations and landowners in Presque Isle County. The project is an innovative partnership between NEMCOG and Michigan's Nature Features Inventory (MNFI), with guidance provided by a locally-based steering committee. The overall goal is to expand communities' abilities to incorporate natural resource information and conservation strategies into their land use planning, zoning, and land development practices. The projects will address biodiversity and ecosystem change and support the conservation of fish and wildlife habitat.	New for 2006-2008 management cycle.
Summary Report on Wildlife Habitat/ Populations and Contaminant Levels	EC	A background summary report was prepared to provide a synthesis of wildlife habitat and population information for the Canadian side of Lake Huron.	Report completed and published in 2005 as a CWS Report "*Current Status, Trends and Distributions of Aquatic Wildlife along the Canadian Shores of Lake Huron*".
Assessment and Protection of Fish Habitat and Wetlands in Selected Nearshore, Coastal and Spawning Areas of Lake Huron - Partnership Projects	OMNR -Lake Huron Unit and district offices	Nearshore Small Fish Community and Exotic Species Assessment Project to assess current small fish communities in Lake Huron and to compare the status of populations with round goby. The project will include numerous capture methods and will be conducted lakewide, including AOC's.	A survey has been conducted in the Canadian waters of the main basin, Georgian Bay, and the North Channel. Seventeen areas have been surveyed from 2003 to 2005 using COA funds. Recommendations are to survey one basin each year using base funds.
		Walleye Spawning Habitat Inventory and Assessment - Establish current status of representative spawning areas in Georgian Bay and the North Channel through the collection of information including substrate and hydrological characteristics, thermal properties, egg deposition locations and densities, observations of walleye migrations and orientations, and recruitment of walleye fry.	The assessment effort in 2004 and 2005 was focused on the Moon River walleye population and the associated habitat. Water level and water flow data collected in the project will be used to create a new Watershed Management Plan to ensure operations in the watershed will have a minimal impact on walleye recruitment.

		Lake Trout/Lake Whitefish Spawning Shoal Assessment - Identification and GIS mapping of spawning habitat to assist in habitat protection, better stocking practices, and aid in assessment.	Approximately 200 km of Southern Georgian Bay shoreline from Colpoys Bay to Christian Is. was surveyed in 2004 and 2005 using side scan sonar equipment. Data will be incorporated into a GIS database.
		Lake Sturgeon Spawning Habitat Assessment - Identification of habitat and spawning locations to determine what rehabilitation efforts are needed and if current harvest levels are sustainable.	Five major river systems (Nottawasaga, Spanish, Thessalon, Magnetawan, Serpent) were surveyed from 2003 to 2005. Spawning season occurs over a relatively long period each spring. Water level and water flow issues impact the success of sturgeon spawning.
		Evaluation of wetlands of Central Algoma - Implement a digital mapping study of wetlands using satellite imagery. Use a rapid assessment technique to provide preliminary scores for each wetland.	Wetlands in Central Algoma district have been mapped. A number of wetlands have been re-evaluated to confirm accuracy of mapping data. Information transfer to municipalities will occur in 2006-2007.
		Kagawong River Fisheries Enhancement Project - Identify problem areas for habitat enhancement and monitor reproductive success of salmon, conduct habitat enhancement work, evaluate project success in part by monitoring the reproductive success of salmon.	Habitat assessment study was done in 2003, but lack of funding in 2004 and 2005 prevented the implementation of habitat enhancement work and subsequent evaluation.
		Southern Lake Huron & Georgian Bay Coastal Wetlands and ANSIs Protection Project - Multi-pronged approach to addressing the need for current and accurate information for Natural Heritage database by targeting the most threatened coastal wetlands and ANSIs by applying rapid assessment wetland evaluations and ANSI inventories.	Nine wetlands along Southern Georgian Bay and the Bruce peninsula have been evaluated and the data has been added to Natural Resources and Values Information System (NRVIS).
Barriers to Fish Movement Project-a Partnership Project	OMNR - Lake Huron Unit and district offices	Completion of dam inventory Phase 2 in Maitland, Nottawasaga and Severn Sound areas - pending funding	Will be considered for implementation when funding is available.
OMNR Partnership Projects to Restore and Rehabilitate Watersheds in the Lake Huron Basin	OMNR - Lake Huron Unit and district offices	Ausable River Stewardship Initiative - Assist rural landowners in repairing sources of bacterial pollution and erosion on their property; enhance wildlife habitat; control erosion; inform, educate and influence sound stewardship practices on landowner property; and improve water quality/fish habitat.	Project has received COA funding from 2003 to 2005. More than 20 water quality/fish habitat improvement projects have occurred in the watershed. Over 27,000 trees have been planted and more than 27ha. of buffer has been established.
		Huronia Area Tributary Rehabilitation Program - To address eutrophication and excessive algal production. Projects include fencing, alternative livestock water sources, planting and creating buffer areas, stream rehabilitation, erosion control, stream rehabilitation, education and information promotion.	Project has received COA funding from 2003 to 2005. More than 42 water quality/fish habitat improvement projects have occurred in the watersheds. Over 36,000 trees have been planted and more than 64ha. of fragile land has been retired. Project will receive funding in 2006.

		Bayfield River Watershed Rehabilitation - To encourage and support best management practices through river clean-up, plantings, establishing buffer strips, stream rehabilitation, contaminant reduction, regulating nutrient management provisions drainage, sediment control and public education.	Project has received COA funding from 2003 to 2005. Stream crossings, buffer strip creation, cattle exclusion fencing and alternate water supplies have all been funded. Project will receive funding in 2006.
		Maitland River Watershed Rehabilitation – To encourage and support best management practices through river clean-up, plantings, establishing buffer strips, stream rehabilitation, contaminant reduction, regulating nutrient management provisions drainage, sediment control and public education.	Same as Bayfield River Watershed Rehabilitation (above).
		French River Recovery Plan - Funding to conduct fall walleye index netting to verify 2002 assessment that may have been biased due to the effects of an unknown algae, which had decreased netting efficiency.	Project was funded in the fall of 2003 to conduct the fall walleye index netting.
		Blue Jay Creek - To encourage and support best management practices through river clean-up, plantings, establishing buffer strips, stream rehabilitation, contaminant reduction, regulating nutrient management provisions drainage, sediment control and public education.	Same as Manitou River Enhancement Strategy (below).
		Manitou River Enhancement Strategy - To encourage and support best management practices through river clean-up, plantings, establishing buffer strips, stream rehabilitation, contaminant reduction, regulating nutrient management provisions drainage, sediment control and public education. These projects are also linked with activities addressing bacterial and nutrient inputs.	Project has received COA funding from 2003 to 2005. The Enhancement Strategy document was completed in 2003. More than 500-m of aquatic habitat at 9 sites have been rehabilitated, and a demonstration site has been created to increase public awareness. Project will receive funding in 2006.
Great Lakes Fishery Commission and Lake Committee Activities Supporting Partnership Goals	OMNR	Fish Stocking - MDNR, the USFWS, and OMNR -- with Community Fisheries Involvement Program (CFIP) volunteers -- stocked between 7 and 13 million fish a year in Lake Huron. Three to four million are lake trout and walleye, which were aimed specifically at rehabilitation efforts.	From 2003 to 2005 Canadian waters of Lake Huron have received 2M lake trout (OMNR), 0.5M chinook (CFIP) and 1M walleye (CFIP) annually. Similar numbers will be stocked in 2006.

		Sea Lamprey Control - The Great Lakes Fishery Commission coordinates the Sea Lamprey Control Program for all the Great Lakes. These efforts include the use of lampricide for direct mortality of sea lamprey, sea lamprey barriers to prevent spawning activity, sea lamprey traps to remove females, provide males for the sterile-male-release-technique, and provide funding and coordination to sea lamprey research.	OMNR will continue to support the lamprey program by providing marking data which is used to evaluate the effectiveness of lamprey treatments.
		Development of Environmental Objectives (EOs) supporting Fish Community Objectives - Will address the need for habitat protection and enhancement to meet the abundances and species makeup desired by fisheries managers, through either specific recommendations or the identification of information needs.	Draft EOs were created in 2004 and public consultation occurred in 2005. EOS should be finalized in 2006, with subsequent implementation.
		Assessment projects (OMNR) including: Commercial Sampling Program, Index program and Recreational Program. Ongoing annual assessment of the commercial and recreational fisheries on Lake Huron, targeting the sustainability of the resource.	These projects have occurred annually and will continue contingent upon funding. Decreased funding levels may dictate program modifications.
		Lake Huron Stewardship Councils - Provide support for functioning of two fisheries committees that assist OMNR by making management recommendations related to the fisheries of Lake Huron. Funding will mainly cover the functional costs of the committees but may also be used for educational products.	Councils have been functioning and supported with COA funding from 2003 to 2005.
Fish Passage Program	USFWS Alpena Field Research Office (FRO)	Funding and technical support, which includes information on fish habitat needs and methods to bypass barriers, is provided through this program. The goal of the program is to restore native fish and other aquatic species to self sustaining levels by reconnecting fragmented habitat.	This is an ongoing effort and will continue in the 2006-2008 cycle.
Lake Huron Aquatic Nuisance Species Surveillance and Nearshore Fish Community Monitoring	USFWS Alpena FRO	Annual surveillance (initiated in 1992) for Aquatic Nuisance Species (ANS) and monitoring population trends of nearshore fish community is conducted at northern Lake Huron ports and river mouths, as well as the St. Marys River. These efforts help locate new ANS populations, provide information on the status of established invasive species and their potential impacts on existing fish community, and establish baseline fishery data prior to potential ANS invasions.	This is an ongoing effort and will continue in the 2006-2008 cycle.

Lake Sturgeon Restoration	USFWS Alpena FRO	The Alpena FRO has led an interagency effort in the Lake Huron– Lake Erie region of the Great Lakes to determine the status and trends of lake sturgeon stocks and has relied on cooperation from state and provincial commercial fishers to compile biological data and externally tag by-caught sturgeon to develop movement and distribution information. Additional research coordinated at the Alpena FRO includes a study in the St. Clair River to determine the contribution to Lake Huron stocks and genetic profile of lake sturgeon utilizing one of the largest known spawning sites in the Great Lakes. The Alpena FRO is coordinating a multi-agency effort to standardize procedures for genetic analysis and profiling of spawning stocks from numerous Great Lakes tributaries.	This is an ongoing effort and will continue in the 2006-2008 cycle.
Lake Trout Rehabilitation	USFWS Alpena FRO	The USFWS is a critical partner in the interagency effort to restore lake trout to self-sustaining levels in Lake Huron. Lake trout stocking in U.S. waters of Lake Huron is conducted primarily by the USFWS National Fish Hatcheries and the Alpena FRO plays a critical role in monitoring the contribution of the hatchery fish to the overall rehabilitation effort by recovering and analyzing data from the lakewide recovery of coded-wire tags. Fall spawning surveys at offshore reefs in the Six Fathom Bank and Yankee Reef complex are conducted by the Alpena FRO to monitor natural reproduction that occurs at those sites.	This is an ongoing effort and will continue in the 2006-2008 cycle.
Treaty Fishery Unit	USFWS Alpena FRO	The Alpena FRO Treaty Fishery Unit fulfills Department of Interior and USFWS federal-tribal trust responsibilities by conducting activities in support of the Year 2000 Consent Decree, a 20 year fishery allocation for 1836 Treaty waters between the federal government, state of Michigan, and 5 Native American tribes. The Treaty Fishery Unit conducts fishery assessments in Lake Huron, annually performs statistical-catch-at-age modeling as part of the Modeling Subcommittee (MSC) of the Technical Fisheries Committee to determine safe harvest limits of lake trout and lake whitefish in 1836 Treaty waters, co-chairs meetings and activities of the MSC, and provides technical assistance to tribal and state resource agencies.	This is an ongoing effort and will continue in the 2006-2008 cycle.

Partners for Fish and Wildlife Program	USFWS Alpena FRO	The USFWS Partners for Fish and Wildlife (Partners) Program delivers technical assistance and funding for habitat restoration efforts on private properties. A specific focus of the program is to restore habitats for native fish and wildlife resources. The program targets wetland habitat restoration on private lands and has diversified in recent years to include riparian and in-stream habitat restoration. This partnership driven effort is delivered throughout the Lake Huron basin. The Alpena FRO delivers the program to the northern 23 counties of the lower peninsula of Michigan.	This is an ongoing effort and will continue in the 2006-2008 cycle.
Saginaw Bay Walleye Recovery Plan	MDNR Fisheries Division and collaborating partners	In 2002, the MDNR Fisheries Division presented the Saginaw Bay Walleye Recovery Plan to stakeholders for their approval and endorsement. The Saginaw Bay Walleye Recovery Plan is a science-based blue print for management actions intended to achieve a self-sustaining walleye population and restore ecological balance to the fish community. Biological benefits from the recovery plan are anticipated to extend to the greater fish community, including yellow perch. The recovery plan focuses on 1) reducing stream habitat and sediment delivery to the through collaboration with partner agencies such as MDEQ and the Natural Resources Conservation Districts as well as stakeholder watershed groups will be key to realizing this strategy, 2) achieving fish passage at key dams, 3) reef rehabilitation, and 4) increased stocking of fingerling walleye (to 2.8 million) to shift the predator/prey balance. Recovery in the Saginaw Bay will be defined as a self sustaining walleye population capable of supporting an annual yield of 1 million pounds, at a density such that growth rate of age-3 walleyes declines to 110% of the state average rate. Actions in 2004 included evaluation of 3 dams for passage or removal (working with Public Sector Consultants), seeking funding to prioritize and quantify instream habitat for walleye spawning and access, evaluating locations and seeking funding for additional walleye rearing ponds, providing the plan to stakeholder groups for improving riparian buffer zones, and continued monitoring and evaluation of the fish population.	Production of wild walleyes has greatly increased since 2003 (through 2005). This is believed to be driven mainly by the decline of alewives in Lake Huron. Three relatively strong walleye year classes have been established as a result and represent significant progress towards recovery. The recovery plan included benchmarks for making management decisions. The threshold for deciding about the future of walleye stocking (three predominantly wild year classes out of five consecutive years) was reached in 2005. The MDNR has proposed to not stock Saginaw Bay in 2006. The final decision is pending public input process. This decision criteria was part of the plan and essentially seeks to not stock as long as it appears that natural reproduction is sufficient. The strong three years of walleye juvenile production has caused biologists to revisit many of the wildly held conclusions about factors limiting walleye reproduction in the bay. It now appears that adult alewives may be the most significant factor in most years. Despite this, the MDNR feels that the provisions of the Recovery remain appropriate including those calling for habitat improvement. Walleye recovery has not yet been achieved in Saginaw Bay but recent developments are a substantial movement in that direction.

Saginaw Bay Fish Communty Assessment	MDNR Fisheries Division	To assess responses of the Saginaw Bay fish community to changing environmental and biological conditions. Monitor response of the fish community to management actions and measure effects of nonnative species and recovery of walleye population. Walleyes have been impaired by reproductive failure. The survey is done by annual gillnetting and trawling using research vessels from the Mt. Clemens and Alpena Fishery Research Stations.	Walleye partially recovered during the 1980s and 1990s, but reproduction was near zero. In 2003, 2004, and 2005 the largest year classes since the perhaps 1940s were produced from natural reproduction. The recovery of reproducing stocks is attributed to water quality improvement, broodstock established by stocking, and the decline of invasive alewives, which had been competing with and consuming walleye fry.
Fish Community Survey of the St. Marys River	MDNR, OMNR, CORA, USFWS, & other members of the St. Marys River Fisheries Task Group	To estimate trends in abundance of various fish species in the fish community of the river. Survey serves as a measure of natural reproduction, year class strength, some evaluation of walleye stocking. Survey also provides some measure of presence of exotic species. Survey is gillnet based with 44 stations being assess on a schedule (target) of approximately once every three years. First survey was completed in 1975 and a total of five such surveys have been completed.	The fish community of the St. Marys River is very diverse reflecting the varied habitat present in the river. Most species have remained relatively stable in their abundance but there is concern over mortality rates of some species. Another survey is scheduled for the late summer of 2006.
Annual Fish Community Assessments	USGS- Great Lakes Science Center (GLSC)	GLSC conducts annual bottom trawl surveys at Detour, Hammond Bay, Thunder Bay (Alpena), Ausable Point (Tawas), Harbor Beach, and Goderich (Ontario). Surveys examine abundance, size and age structure of key prey species, community composition, and prevalence of exotics. Fish collections are also sampled for analysis of contaminants, energy density, genetics, epizootics, and coded wire tags (lake trout). Recent additions to the survey include Diporeia monitoring, analyses of mechanisms regulating diet and growth of lake whitefish, re-examination of bloater (chubs) age structure, and examination of the ecological role of invasive round gobies in deepwater habitats. Fish community assessments are expanding, with hydroacoustic studies of the pelagic community beginning in 2004, and planned additional sampling of lower trophic levels in conjunction with fish surveys.	Bottom trawling and a lakewide hydroacoustic survey were completed during 2005, and both surveys are scheduled to occur again in 2006. See www. glsc.usgs.gov for annual reports on both surveys.

Colonial Waterbird Population Surveys	EC – CWS, USFWS	In 2007, the 4th decadal survey of breeding colonial waterbird populations across all of the Great Lakes will begin starting with Lakes Superior, Huron and Michigan. This project involves looking for the presence of colonially-nesting waterbirds and counting nest numbers on all the islands in each of the Great Lakes. The survey has been conducted in the 1970s, the '80s, the '90s.	Ongoing.
Lake Huron Nearshore Monitoring	MDEQ	MNFI will measure temporal and spatial trends in the nearshore biological community (benthic invertebrates and zooplankton), detect existing/spreading and newly introduced non-native aquatic species, and determine whether discernable patterns in water quality data can be detected in Lake Huron nearshore waters. The study is scheduled to begin in July of 2006.	New for 2006-2008 management cycle.

Activities to Increase Understanding of Ecosystem Change, Biodiversity and the Impact of Exotic Species

Action	Responsible Agency	Description	Summary Status
Integrated Assessment of the Microbial Food Web of the Great Lakes: Lake Huron Case Study - A Partnership Project	DFO, University of Guelph, University of Toronto, Kent State University, EC	Microbial food web study of the offshore community where nutrients are low and the microbial food web becomes an important link in the food chain. The study will provide a better understanding of the base of the food web and will help define the qualities of a "healthy ecosystem".	A 2 year study was completed and a summary report is available. Recommendations for further study are currently unfunded.
Lake Whitefish Food Web Interactions - A Partnership project	OMNR - Fish and Wildlife Branch	Study to compare bioenergetics of whitefish growth before and after the invasion of zebra mussels and spiny water flea. Will compare whitefish in locations of Lake Huron with and without Diporeia to determine the potential lakewide effects of declines of this benthic invertebrate.	Project was funded from 2003 to 2005. The first scientific paper from this study will appear in Journal of Great Lakes Research (JGLR) 32:180-193, 2006. Data analysis and report writing will continue in 2006.
Trends in the Benthic Macroinvertebrate Community of Lake Huron	NOAA-GLERL, MDNR, OMNR and National Water Research Institute (NWRI)	A benthic macorinvertebrate survey was conducted in the main basin of Lake Huron in 2003 to determine trends in major macrobenthic groups. Many of the 80 sites sampled were also sampled in 2000. Of most interest are changes in abundances of the amphipod Diporeia and dreissenid mussels (zebra and quagga).	The GLERL, in partnership with OMNR, MDNR and NWRI conducted a benthic macroinvertebrate survey throughout the main basin of the lake in 2000 and 2003 to examine recent temporal trends. There was a decline in all the major benthic taxa, but largest declines were in the amphipod Diporeia. Population abundance declined 57% between 2000 and 2003 and large lake areas are now completely devoid of this organism. In contrast, the quagga mussel population increased and is now widely distributed. The benthic macro-invertebrate study was continued in 2004 and 2005 and samples from Southern, Central and northern Lake Huron were supplied to NOAA for analysis. Project is expected to continue in 2006. Diporeia abundance continues to decline in all sample locations, zebra mussel abundance is steady and quagga abundance is increasing, especially at offshore sites.

Studies to Determine the Growth, Condition, and Energy Density of Lake Whitefish	NOAA-GLERL, MDNR, USFWS, and OMNR	This study examines the diet, condition, and growth of lake whitefish in various regions of the lake. These variables will be examined relative to abundances of the amphipod Diporeia. This important food organism is now declining and completely gone from many lake areas.	This study was completed in 2004 and should be published in 2006. OMNR has continued to make diet collections as part of the core program. OMNR expects to continue these collections in 2006. The GLERL, in partnership with MDNR, USFWS, and OMNR examined the diet, condition, and energy density of lake whitefish in various regions of the lake. Of concern is the response of lake whitefish to changes in the benthic community and the loss of the important food organism Diporeia (see "The Lower Foodweb below). Preliminary analysis indicates that quagga mussels are now a major component of fish diet while Diporeia are no longer found in the diet. This will have strong implications to the health of populations since quagga mussels are a less nutritious food source compared to Diporeia.
Changes in the Lower Food Web of Saginaw Bay	NOAA-GLERL	A large study was conducted in Saginaw Bay by the GLERL between 1990 and 1996 to assess the impact of the zebra mussel on the lower food web (nutrients, phytoplankton, zooplankton, and benthos).	While a portion of the collected data has been analyzed and published, current efforts will complete the analysis and provide an overall synthesis.
Microcystin Concentrations in Saginaw Bay	NOAA-GLERL	The resurgence of the harmful algal bloom species Microcystis sp. in Saginaw Bay is of particular concern due to its ability to produce the hepatotoxin microcystin, which is detrimental to human and ecosystem health. The GLERL, as part of the Oceans and Human Health Initiative, has mapped microcystin concentrations and Microcystis cell densities in Saginaw Bay during August 2004 and August 2005. Microcystin concentrations in excess of the World Health Organization's recommended limit for drinking water (1 µg L-1) were commonly found throughout the inner Bay.	New for 2006-2008 management cycle.

Activities at Areas of Concern

Action	Responsible Agency	Description	Summary Status
St. Marys River AOC - Can	EC – ECB, EP, CWS	Stage 2 implementation projects include completion of a fisheries assessment plan, wetland and shoreline evaluation and protection activities, and a $60M (CAN) upgrade to the Sewage Treatment Plant and sewer system improvements. The Algoma Environmental Management Agreement is undergoing an amendment to incorporate the reduction of air releases. A detailed sediment and benthos study was carried out in the fall of 2002, the report was finalized in 2004.	See also Activities Addressing Contaminants in Fish and Wildlife Section 2006-2008 activities include: development of a strategy for contaminated sediment in the Bellevue Marine Park area; review of delisting criteria; wastewater characterization study; a coastal wetland assessment and protection program and the development and implementation of an overall sediment management plan for the St. Marys River.
Saginaw River/Bay AOC	MDEQ, USEPA	Contaminated sediment studies as described in Section I. Support the continued development and evaluation of the Saginaw River/Bay Measures of Success report.	See Activities Addressing Contaminants in Fish and Wildlife Section

Spanish Harbour AOC	OMNR	Spanish River Delta Fish Community Assessment - To gather and collate a database of existing fisheries data and conduct early summer trapnetting and fall index netting to assess walleye populations. A comprehensive river and delta fish community assessment will be conducted to measure the progress of fish community recovery of the remaining species within the AOC.	Project has received COA funding from 2003 to 2005. A variety of indexing methods have been used in the Spanish River system. Preliminary results indicate Muskellunge and sturgeon recovery appears promising. Project report writing will continue in 2006.
		Coastal and River Delta Wetland Fish Community Assessment - Assess various wetlands across Lake Huron to relate fish distribution to a broad set of physical, chemical and food-web characteristics. Will develop biotic indicators of wetland health and relate to anthropogenic disturbances.	A total of 71 wetland complexes were sampled in Eastern Georgian Bay and the North Channel from 2003 to 2005. Most wetlands were ranked in the good to excellent categories, indicating that they are not showing signs of water-quality impairment.
		Whalesback Channel Integrated Management Plan Initiative - This project will coordinate First Nations and multi-stakeholder active participation in the development of a comprehensive, integrated Management Plan for species of recreational, commercial, and priority aboriginal food fishing interest in the Whalesback Channel.	Discussions have occurred from 2003 to 2005. A report summarizing available data has been prepared. Small fish survey was completed in 2004 and 2005.
		Spanish Harbour Restoration of Muskellunge Population - Financially assist with the stocking of muskellunge fall fingerling. Trapnetting assessment work to determine the status of earlier muskellunge stocking efforts.	Eight years of muskellunge stocking was completed in 2004. High flow rates prevented the effective assessment of the adult population using trap nets, however electrofishng surveys indicate natural muskellunge recruitment is occurring.
		Spanish River Delta Fish community Assessment - Coastal and river delta wetland fish community assessment.	Assessments ongoing
	EC - National Water Research Institute (NWRI), OMOE	Sediment and Benthos Assessment - A detailed sediment and benthic invertebrate study was scheduled for the fall of 2003 (with additional sampling in 2004), and included sediment chemistry, toxicity and benthic community structure.	The NWRI study was completed and a draft report is available. OMOE's EMRB collected additional samples in 2005, and further work will continue in 2006 to characterize the extent of dioxin in sediment in Whalesback Channel.
Severn Sound AOC	OMNR - Lake Huron Unit	Detailed analysis of the Severn Sound fish community, with emphasis on the walleye population. Includes walleye population estimate and small fish and exotic species assessment. This work was a commitment made as a condition under the delisting of this AOC.	Walleye spawning survey completed in 2003 and 2004. Late spring trap net fish community survey done in 2003, 2004, 2005. Walleye recruitment is occurring; however, abundance of mature walleye is still depressed. Bass production is good, but pike production remains poor, likely as a result of the low water levels. Modified fish community survey will be funded in 2006.

	OMOE	Open Water Monitoring Program - This project will monitor the environmental quality of Severn Sound open water for indicators of eutrophication. The Severn Sound Stage 3 Remedial Action Plan (RAP – SSRAP, 2002) calls for continued monitoring of open waters of Severn Sound in order to assess changes in trophic status in relation to remedial action and other ecosystem changes in the area (e.g., exotic species). Trends up to 2000 are discussed in Stage 3 RAP (SSRAP, 2002). This component of the project would support the sampling and analysis of nutrient status, phytoplankton and zooplankton community structure. This work is being conducted through a partnership with the OMOE, Severn Sound Environmental Association and Parks Canada.	This monitoring was undertaken seasonally in 2004 and 2005. Results of monitoring are available on the Severn Sound Environmental Association website at: www.severnsound.ca.
		Beach Monitoring Program - This project will monitor the environmental quality of Severn Sound swimming areas to assess quality for beach closings according to the Beach Management Protocol (MOH 1992 and 2003). The Severn Sound RAP stage 3 Report (SSRAP 2002) calls for continued assessment of swimming area quality of Severn Sound in order to assess the status of this use impairment following implementation of the Severn Sound Stormwater Management Strategy. Trends to 2000 have been discussed in (SSRAP 2002). This work is being done through a partnership with the MOE, Severn Sound Environmental Association, District Health Unit and Parks Canada.	This monitoring was undertaken seasonally for both 2004 and 2005. Results of this monitoring effort is available on the Severn Sound Environmental Association website at: www.severnsound.ca.
	SSEA, EC, OMNR, DFO, Parks Canada	Finalization and Implementation of a Fish Habitat Management Plan - The project will develop a management strategy to protect and enhance the fish habitat in nearshore areas of Severn Sound through: revising the bathymetry and shoreline layers for Severn Sound; selected surveys of nearshore vegetation and substrate conditions to update physical and biological habitat conditions; revising the fish habitat suitability classification from previous work; relating the habitat classification to the upland planning designations; and identify areas of high suitability habitat that are at risk from potential shoreline development.	New for 2006-2008 management cycle.

	SSEA, OMNR, DFO	Severn Sound Fish Habitat Management Plan This AOC was formally delisted by Canada and Ontario in January 2003. As a condition of delisting, the governments committed to undertaking a fish community assessment which was completed by OMNR. Another commitment, to be completed in 2006 is to update the fish habitat management plan and to have this incorporated into municipal Official Plans.	New for 2006-2008 management cycle.
St. Marys River AOC-U.S.	MDEQ, USEPA	St. Marys River Binational Public Advisory Council (BPAC) will be reviewing the statewide restoration criteria outlined in the Guidance for Delisting Michigan's Great Lakes Areas of Concern document. The MDEQ will work with the BPAC, the USEPA, the OMOE, and EC to refine the delisting criteria based on current U.S. and Canadian agency guidance and standards. In addition, the MDEQ has proposed to complete a RAP Update in 2006. The RAP update will be the primary tool for documenting and communicating progress on AOC restoration to the public and agencies, and will be posted on the USEPA AOC web site. The update will focus only on those remedial actions and BUIs which have been assessed during the previous two years.	New for 2006-2008 management cycle.
	MDEQ, USEPA	Contaminated sediment studies as described in Activities Addressing Contaminants in Fish and Wildlife Section.	See Activities Addressing Contaminants in Fish and Wildlife Section

Biotic Integrity and Habitat Assessment within the St. Marys River AOC	MDEQ, USEPA	LSSU is conducting a two year study to augment existing base line monitoring data (ongoing at LSSU and other organizations), to provide a mechanism to assess ecosystem health, and to provide information that may (or may not) lead to the delisting of a number of RAP beneficial use impairments (BUIs). LSSU is using multimetric indices of biotic integrity to assess habitat availability and the "health" of nine St. Marys River coastal marshes. Bio-indices will be measured (e.g., biodiversity, population genetics, and reproductive health), with a particular emphasis on upper trophic level fish. Environmental sampling and analysis of organic (total PAH and total PCB) and trace-metal contaminants in fish, sediment, and water will also be conducted. In addition, LSSU will develop a GIS database to incorporate data generated by the project to enhance evaluation and interpretation of the data collected.	New for 2006-2008 management cycle.
Saginaw River/Bay AOC	MDEQ, USEPA	The Saginaw Bay/River PAC will be reviewing the statewide restoration criteria outlined in the Guidance for Delisting Michigan's Great Lakes Areas of Concern document. The PAC compare previously developed local criteria outlined in the Measures for Success documents and make a decision by the summer of 2006, whether to: 1) accept and adopt the statewide criteria, 2) request approval from MDEQ of previously developed local criteria, or 3) develop local criteria for approval by MDEQ. In addition, the MDEQ has proposed to complete a RAP Update in 2007. The RAP update will be the primary tool for documenting and communicating progress on AOC restoration to the public and agencies, and will be posted on the USEPA AOC web site. The update will focus only on those remedial actions and BUIs which have been assessed during the previous two years.	New for 2006-2008 management cycle.

The Saginaw Bay Wetland Initiative	Ducks Unlimited, MDNR, MDEQ	The Saginaw Bay Wetland Initiative NAWCA grant was awarded to Ducks Unlimited (DU), on behalf of a coalition of, including 17 state, federal, corporate and non-profit organizations that collectively pledged over $2 million in matching funds, in February 1998. This $754,155 federal grant concluded in August 2004, and resulted in the conservation of 4,178 acres (1,691 hectares) of wetlands and associated grasslands on public and private land throughout the 22-county Saginaw Bay watershed. DU will continue its leadership role in Michigan wetlands conservation by spearheading the "Saginaw Bay to Lake Erie Coastal Habitat NAWCA Project". This successful proposal has secured $1 million of federal dollars to conserve habitat in an 18-county area that includes the coastal counties along Saginaw Bay as well as the watershed counties of Lake St. Clair and western Lake Erie.	New for the 2006-2008 management cycle.
Sault Ste. Marie Area Watershed Project	MDEQ	The Sault Ste. Marie Area Watershed Project is a non-point source pollution planning project attempting to bring together the people within the Sault Area to address water quality issues, identify pollution sources, and construct a plan to reduce those sources within the watershed project area, including the Sault city limits. The Sault Project encompasses several small "sub-watersheds" of the St. Marys River that course through the city, including Ashmun Creek, Mission Creek, Seymour Creek, Shunk Creek, and the area east to Frechette Creek.	New for 2006-2008 management cycle.

Monitoring Coordination/Data Sharing

Action	Responsible Agency	Description	Summary Status
Lake Huron Geographic Information System (LHGIS) - A Partnership Project	MDNR, USEPA-GLNPO, OMNR, and other partners	The development of the LHGIS makes all public GIS data available for wide distribution and use.	Original effort completed. Collaboration on the LHGIS is ongoing. Agencies are seeking to add all publicly-available data to the LHGIS, and are always looking for new contributors of data. For more information on the LHGIS see: http://www.glfc.org/glgis/fact_sheets/LHGIS_fact_sheet_1204.pdf To acquire the LHGIS, please contact Christine Geddes via email (cgeddes@umich.edu). For information on the Great Lakes GIS project, visit the Great Lakes GIS web site at: http://www.glfc.org/greatlakesgis/

Lake Huron State of the Lake Symposium, October 2006	EC, USEPA, Aquatic Ecosystem Health and Management Society (AEHMS)	A Lake Huron Symposium is scheduled for October 11-14, 2006, in Honey Harbour, Ontario. The purpose is to bring together Great Lakes researchers and resource managers who are focusing on different aspects of the Lake Huron ecosystem, or whose findings are applicable to addressing key management themes for the lake and its basin. Oral and poster presentations are accepted. A peer reviewed publication will be produced as a special edition of the AEHMS series.	New for 2006-2008 management cycle.
2007 Intensive Sampling Year on Lake Huron	USEPA/EC	In 2007, three water quality monitoring cruises by EC are planned for Lake Huron and Georgian Bay (one each in spring, summer and autumn). Precipitation sampling will continue at 2 sites in the Basin, including Burnt Island (the IADN Master station); and Grand Bend, a precipitation satellite site. EC will measure nutrients, major ions, trace metals and trace organics on monthly-integrated samples. Mercury and dioxin analysis will continue at the Burnt Island site. Biweekly sampling will continue at Point Edward (at the exit from Lake Huron) for nutrients, major ions, trace metals and trace organics.	A cooperative monitoring program is under development amongst all agencies involved in the Partnership. Monitoring cruises will be implemented in 2007.

Outreach Activities

Action	Responsible Agency	Description	Summary Status
Lake Huron Binational Partnership (LHBP) Fact Sheets	USEPA, EC, MDEQ	Agencies developed brochures on the LHBP and the following topics: •Changes in Lake Huron Fish Communities •Lake Huron GIS System •Contaminants in Fish •Contaminants in Wildlife •Great Lake Fishery Commission Environmental Objectives for Fish Communities •The Canadian South-East Shore Working Group •Phosphorus Concentrations in Saginaw Bay, Michigan.	Brochures complete and available at: http://www.epa.gov/glnpo/huron.html Note: Major changes in the aquatic/fish community over the last 2 years have necessitated an update to the Fish Communities brochure. This fact sheet will be updated in the 2006-2008 management cycle.

Long-Term Projects

Action	Responsible Agency	Description	Summary Status
A Framework for Sustainability for the Canadian Lake Huron Basin	EC, OMOE, OMNR, OMAFRA, First Nations, Stakeholders	A "Think Tank" workshop was held in December 2005, to develop an approach to a framework for the Canadian side of Lake Huron. The intent of the workshop was to provide a comprehensive community approach, based on best science and the use of existing and new initiatives, to promote and assist local community based projects that are focused on the improved and sustained ecosystem health of Lake Huron. Development and implementation to occur in 2006 and beyond. Important links and information sharing with U.S. counterparts will continue.	New for 2006-2008 management cycle.