STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

RICK SNYDER
GOVERNOR

DAN WYANT
DIRECTOR

May 16, 2014

Dr. Susan Hedman
Regional Administrator
United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard (R-19J)
Chicago, Illinois 60604-3507

Dear Dr. Hedman:

The Michigan Department of Environmental Quality (MDEQ) is pleased to provide the enclosed final Delisting Report for delisting of the Deer Lake Area of Concern (AOC). This remarkable milestone in the AOC program was prepared in consultation with the Deer Lake Public Advisory Council (PAC) and state and federal agencies. This letter requests that the United States Environmental Protection Agency (USEPA) proceed with the necessary steps to delist the AOC.

In 1981 a Michigan Department of Community Health (MDCH) fish consumption advisory classified all fish in Deer Lake, Carp Creek, and the Carp River as "do not eat," due to high mercury levels. By 1987, the USEPA named Deer Lake as an AOC under the Great Lakes Water Quality Agreement with three beneficial use impairments: eutrophication or undesirable algae; bird or animal deformities or reproductive problems; and restrictions on fish and wildlife consumption. These impairments resulted from mercury inputs and nutrient loading. Over decades, through the efforts of state, local, and federal governments and the local PAC, causes for the impairments have been controlled, and all three beneficial uses have been restored and removed through the process and criteria established in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern*.

The MDEQ values this partnership and looks forward to working with the USEPA toward similar success in other Michigan AOCs. If you would like further information concerning this request for the Deer Lake AOC, please contact Ms. Stephanie Swart, Office of the Great Lakes (OGL), MDEQ, at 517-284-5046 or swarts@michigan.gov.

Sincerely,

Dan Wyant
Director
517-284-6700

Enclosure

cc: Mr. Scott Hicks, United States Fish and Wildlife Service
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Deer Lake Area of Concern
Final Delisting Report

Deer Lake, facing west in the south basin Photo: Stephanie Swart

Great Lakes Management Unit
Office of the Great Lakes
Michigan Department of Environmental Quality

March 28, 2014

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and

Michigan Department of Community Health, Environmental Health Division
Michigan Department of Environmental Quality, Water Resources Division
Michigan Department of Natural Resources, Fisheries Division

This document should be cited as follows:

Michigan Department of Environmental Quality. 2014. Final Delisting Report Deer Lake Area of Concern.

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APPENDICES

ATTACHMENTS

GLOSSARY

ACJ – Amended Consent Judgment
AIS – Aquatic invasive species
AOC – Area of Concern
BUI – Beneficial Use Impairment
CESC – Cliffs Electric Services Company
CJ – Consent Judgment
CNR – Cliffs Natural Resources
DDT – Dichlorodiphenyltrichloroethane
FCMP – Fish Contaminant Monitoring Program
GLWQA – Great Lakes Water Quality Agreement
GLRI – Great Lakes Restoration Initiative
IJC – International Joint Commission
LAMP – Lakewide Action and Management Plan
LOEL – Lowest Observable Effect Level
LSBP – Lake Superior Binational Partnership
MDCH – Michigan Department of Community Health
MDEQ – Michigan Department of Environmental Quality
MDNRE – Michigan Department of Natural Resources and the Environment
MDNR – Michigan Department of Natural Resources
NPDES – National Pollutant Discharge Elimination System
OGL – Office of the Great Lakes
PAC – Public Advisory Council
PCB – Polychlorinated biphenyl
ppm – Parts per million
RAP – Remedial Action Plan
USEPA – United States Environmental Protection Agency
USFWS – United States Fish and Wildlife Service
WWTP – Wastewater treatment plant
WQS – Water quality standards
WRD – Water Resources Division

1. INTRODUCTION

In 1981, a Michigan Department of Community Health (MDCH) fish consumption advisory indicated that all fish in Deer Lake, Carp Creek, and the Carp River were recommended “do not eat” due to high mercury levels (MDNR, 1987). The Deer Lake Area of Concern (AOC) was designated in 1985 and a Remedial Action Plan (RAP) was written by the Michigan Department of Natural Resources (MDNR) in 1987. Over the next 33 years state, local, and federal governments and academic researchers have described known problems, identified actions and studies needed to further define and remediate those problems, and carried out those actions in order to remove the Beneficial Use Impairments (BUIs).

As the lead agency for AOC coordination, the Michigan Department of Environmental Quality (MDEQ) is responsible for developing quantifiable targets to measure progress toward restoring the AOC. Working closely with members of the Deer Lake Public Advisory Council (PAC), U.S. Environmental Protection Agency (USEPA), and other partners, the MDEQ has determined that management actions are sufficiently complete to support delisting of the Deer Lake AOC.

This document serves as a final delisting report and provides the rationale to support the delisting decision. All BUIs have been removed and are procedurally decoupled from this delisting document. Each BUI Removal Package is summarized herein. The focus of this report is summarizing the efforts of all parties to remove the three Beneficial Use Impairments (BUIs) for the AOC: Restrictions on Fish and Wildlife Consumption, Eutrophication or Undesirable Algae, and Bird or Animal Deformities or Reproductive Problems.

2. BACKGROUND

2.1 Great Lakes Approach to Restoring Beneficial Uses

There are two agreements between the United States and Canada that form a governing framework for monitoring and improving the Great Lakes internationally. The 1909 Boundary Waters Treaty created the International Joint Commission (IJC) and the first Great Lakes Water Quality Agreement (GLWQA) signed in 1972. In 1987 amendments to the 1978 GLWQA were adopted by the federal governments of the United States and Canada and established guidelines for identifying geographical AOCs based on the presence of conditions that “caused or is likely to cause impairment of beneficial use or of the area’s ability to support aquatic life” (Canada and U.S., 2012). Annex 2 of the Amendments listed 14 BUIs which are caused by a detrimental change in the chemical, physical, or biological integrity of the Great Lakes system (Canada and U.S., 2012). The Annex directed the two countries to identify AOCs that did not meet the objectives of the GLWQA. RAPs addressing the BUIs were to be prepared for all 43 AOCs identified. The BUIs provided a tool for describing effects of the contamination, and a means for focusing remedial actions.

The scope of the AOC program is based on the concept that each area had at least one BUI; one that set the area apart from other sites with lesser contamination in the state that were not designated an AOC.

When AOCs were originally designated, no specific quantitative criteria for listing or delisting these areas were developed. The IJC issued general listing and delisting guidelines in 1991, and the U.S. Policy Committee adopted general guidance on the process for AOC delisting in 2001

(USEPA, 2001). However these efforts were not specific enough for use in determining restoration of individual BUIs by either the State of Michigan or the U.S. federal government. In response to the need for specific BUI restoration criteria, the MDEQ developed the *Guidance for Delisting Michigan's Great Lakes Areas of Concern* (Guidance) (2008). The purpose of the document is to: 1) provide guidance to AOC program participants about Michigan's process for delisting AOCs; and 2) identify specific quantitative or qualitative criteria which Michigan uses to determine when BUIs have been restored. The criteria for each BUI include four main components: Significance in Michigan's Areas of Concern, Restoration Criteria and Assessment, Rationale, and State of Michigan Programs and Authorities for Evaluating Restoration.

2.2 Deer Lake Area of Concern

The Deer Lake AOC is located in Marquette County in Michigan's central Upper Peninsula. The AOC includes Carp Creek from the old Ishpeming Township Wastewater Treatment Plant (at the end of Southwood Drive) downstream to the 1,010-acre Deer Lake impoundment and the Carp River from the dam at the north basin of Deer Lake to Lake Superior near the city of Marquette (Figure 1).

Deer Lake was originally listed as an AOC because of a 1981 Michigan Department of Community Health (MDCH) "do not eat" fish consumption advisory which indicated that all fish in Deer Lake, Carp Creek, and the Carp River were too heavily contaminated with mercury to be safe for consumption (MDNR, 1987). Historic mining practices resulted in mercury contamination to the Deer Lake basin from Ropes Creek and Carp Creek. The MDNR and later the MDEQ proceeded with the RAP process and identified the BUIs affecting the integrity of the Deer Lake AOC (MDNR, 1987). The MDEQ later updated the RAP in 2011 as part of the Stage 2 GLWQA process to indicate the actions necessary to address the causes and sources of the BUIs (MDEQ, 2011).

Mercury inputs to the Deer Lake AOC primarily came from mining activities in the surrounding area. The Ropes Gold and Silver Mine, located northwest of Deer Lake, used a mercury amalgamation process to concentrate gold (MDEQ, 1987). The leftover material or tailings from this process remained in the watershed. The Cleveland-Cliffs Iron Company (now Cliffs Natural Resources [CNR]) disposed of assay reagents containing mercury down laboratory drains that led to the city of Ishpeming's wastewater treatment plant, and Carp Creek. In 1970 the city of Ishpeming, in order to cope with wet weather events, diverted Partridge Creek from their storm water system into Cliffs Shaft Mine tunnels beneath the city. The diverted water picked up mercury, including some that may have come from used dynamite blasting caps, and transported it into Carp Creek. As a result of these inputs, CNR entered into a consent judgment with the State of Michigan in 1984, and later an amended consent judgment (ACJ) in 2006. The consent judgment and ACJ were intended "to facilitate the long-term maintenance of completed remedial measures addressing mercury in the Deer Lake impoundment ("Deer Lake"), provide funding for additional remedial measures and minimize discharges of mercury from the Cliffs Shaft Mine to Carp Creek" (ACJ, 2006).

One of the selected remedies, noted in the 1987 RAP, was to cease drawdown of the Deer Lake impoundment (MDNR). This effort would, assist in the decrease of microbial methylation of mercury in the sediments according to previous research (MDNR, 1987). A secondary remedy was to allow the lake to naturally attenuate as mercury-laden sediments were covered by uncontaminated sediment (MDNR, 1987). As part of the requirements of the ACJ, CNR maintains the dam at a minimum water level of at least 1,385 feet above sea level. There is currently a valve at the base of the dam that draws surface waters down toward the lake bottom, oxygenating the hypolimnion, which may further reduce the ability for sulfate reducing bacteria to convert mercury into biologically available methylmercury (ELM, 2005).

3. ROLES

3.1 Michigan Department of Environmental Quality

The MDEQ Office of the Great Lakes (OGL) is the lead agency for coordination of BUI assessments, development of RAPs, and management actions at the Deer Lake AOC. The MDEQ coordinates communication, sampling, and on the ground restoration between the federal, state and local partners. Once the Deer Lake AOC is delisted, the MDEQ programs will remain responsive to environmental concerns and activities in the area, as they are for other non-AOC sites throughout the State of Michigan.

3.2 U.S. Environmental Protection Agency

The USEPA has primary responsibility for oversight and funding of the AOC program in the Great Lakes under the GLWQA. The USEPA also works with the PAC and the State of Michigan to identify key needs for the AOC, including management actions necessary for delisting. This includes responsibility for approving the removal of BUIs and providing recommendations to the U.S. Department of State that AOCs be delisted. The USEPA funded and assisted in implementing Phases 1 and 2 of the Partridge Creek Diversion project providing $8 million in GLRI funding to the city of Ishpeming.

3.3 Local Government

The city of Ishpeming is a member of the PAC for the Deer Lake AOC. In addition, they have contributed toward management actions that have resulted in BUI removals, including upgrading the wastewater treatment plant in 1985 and funding $700,000 of Phase 1 of the Partridge Creek diversion project.

3.4 Public Advisory Council

Public involvement is a key component of the AOC program in Michigan. Each AOC has a PAC, or equivalent group/organization. The Deer Lake PAC was organized to “provide local leadership required for developing and carrying out a RAP that will identify environmental problems, establish water use goals, and recommend actions that will restore the AOCs beneficial uses” (DLPAC, 2002). The PAC has managed support grants and other grants in order to accomplish goals in the AOC. The PAC plays an important role in facilitating stakeholder participation in the decisions affecting Michigan’s AOC program and is represented on a Statewide Public Advisory Council. The Deer Lake PAC meets quarterly and they have reviewed all formal documents for the AOC. The PAC voted to support each of the BUI removals, as well as this Delisting Report. In addition, as part of the delisting process a public meeting will be held in the region of the AOC.

After over 30 years of focusing on BUI removals and mercury contamination within the Deer Lake AOC, the PAC will likely continue its involvement with Deer Lake, transitioning into the Deer Lake Association. The Deer Lake Association will remain in contact with other local environmental organizations, local government, and state agencies. The most important function of the association will be to serve as a unifying voice and a steward for the lake.

4. BENEFICIAL USE IMPAIRMENT OVERVIEW

The Deer Lake AOC had three of the 14 possible Beneficial Use Impairments: Bird or Animal Deformities or Reproduction Problems, Eutrophication or Undesirable Algae, and Restrictions on Fish and Wildlife Consumption. These three BUIs were designated based on a decision process which included a review of the original RAP and confirmation with the Deer Lake PAC. The other eleven beneficial uses were determined to not be impaired at the Deer Lake AOC. All three of the designated BUIs have been removed for this AOC through the process established in the *Guidance* (2008). Specific information on each of the three BUIs is included below.

4.1 Bird or Animal Deformities or Reproduction Problems

Action

This BUI was removed by the MDEQ and the USEPA in September 2011. The complete Removal Recommendation can be obtained by going to the OGL's Deer Lake page at https://www.michigan.gov/en/egle/about/Organization/Water-Resources/aoc/deer-lake-aoc-delisted.

Summary

The Deer Lake AOC Technical Committee recommended the removal of the Bird or Animal Deformities or Reproduction Problems BUI based on the collective review of the related documentation per the process outlined in the *Guidance* (MDEQ, 2008). This recommendation was made by the Deer Lake Technical Committee, comprised of staff from the USEPA, United States Fish and Wildlife Service (USFWS), Clemson University's Institute of Environmental Toxicology, MDEQ staff, and members of the Deer Lake PAC.

Background

The original 1987 RAP identified bald eagle (*Haliaeelus leucocephalus)* reproduction problems as a concern (MDNR, 1987). Since bald eagles are piscivorous, it was suggested that the elevated concentration of mercury in the fish was the cause of the reproductive failure in the bald eagles. A fish sample taken from Deer Lake at the same time, indicated traces of DDT and PCBs as well as high levels of mercury (MDNR, 1987).

Removal Criteria

According to the Guidance the restoration criteria for the Bird or Animal Deformities or Reproduction Problems BUI in the Deer Lake AOC requires that:

Approach 1 – Observational Data and Direct Measurements of Birds and Other Wildlife

- Evaluate observational data of bird and other animal deformities for a minimum of 2 successive monitoring cycles in species identified in the RAP as exhibiting these problems. If deformity or reproductive problem rates are not statistically different than inland background levels (at a 95 percent confidence interval), or no reproductive or deformity problems are identified during the two successive monitoring cycles, then the BUI is restored. If the rates are statistically different, it may indicate a source from either within or from outside the AOC. Therefore, if the rates are statistically different or the amount of data is insufficient for analysis, then:

- Evaluate tissue contaminant levels in egg, young, and/or adult wildlife. If contaminant levels are lower than Lowest Observable Effect Level (LOEL) for that species or are not statistically different than inland control populations (at a 99 percent confidence interval), then the BUI is restored.

Where direct observation of wildlife and wildlife tissue data is not available, the following approach will be used:

Approach 2: Fish Tissue Contaminant Levels as an Indicator of Deformities or Reproductive Problems

- If fish tissue concentrations of PCBs, dioxins, DDT, or mercury (as determined in the RAP) contaminants of concern in the AOC are at or lower than the LOEL known to cause reproductive or developmental problems in fish-eating birds and mammals, the use impairment is restored.

OR

- If fish tissue concentrations of PCBs, dioxins, DDT, or mercury in the AOC are not statistically different than the associated Great Lake (at 95 percent confidence interval), then the BUI is restored. In the connecting channel AOCs, either the upstream or downstream Great Lake may be used for comparison.

The attached excerpt from the Guidance (pages 23-28) includes the rationale for application of the removal criteria to this BUI (Appendix 3).

Analysis

Elevated levels of mercury in fish were discovered in 1980 as part of an investigation by the Callahan Mining Company related to reopening the Ropes Gold Mine. At that time, the elevated levels of mercury in the fish were believed to have been primarily caused by discharges of mercury originating from the Cleveland-Cliffs Iron Company assay labs. These labs discharged wastewater through the old Ishpeming Wastewater Treatment Plant (WWTP) (MDNR, 1987).

The 1987 RAP indicated that the elevated concentration of mercury in fish was the cause of the reproductive failure in the bald eagles. Neither direct organochloride nor mercury data from the nesting pair of eagles at Deer Lake were collected. However, mercury may not have been the cause of the reproductive failures since there were elevated levels of other chemicals present in fish collected at the site. A sample of fish from Deer Lake found traces of DDT and PCB contamination (MDNR, 1987). The information in the RAP regarding the reasons for reproductive failure in the pair at Deer Lake is limited and mostly observational. Dr. William Bowerman, ecotoxicologist and eagle specialist indicated that as bald eagles molt, mercury is shed through their feathers, and a direct connection has not been made between mercury in fish and bald eagle reproductive failures (Bowerman, 2006). Additionally, bald eagles have a large range and are migratory and thus could have ingested contaminants anywhere in their range or migration route.

On a national level, bald eagle populations in the United States were at very low levels in the 1960s. The USFWS census data from that time indicated that only 417 pairs of bald eagles were present in the United States in 1963. Habitat destruction, disturbance, and contaminants, specifically persistent organochlorine compounds such as DDT, were identified as the likely causes of the low bald eagles numbers during that time. DDT thins the shells of the eggs causing the adult birds to crush their eggs leading to reproductive failures. The chemical was banned in 1972. Since then, bald eagles have recovered enough to be listed as ‘threatened’ rather than ‘endangered’ by the USFWS.

The USFWS goal for bald eagle recovery in the northern states was 1200 occupied breeding areas distributed over a minimum of 16 states with an average annual productivity of 1.0 young per occupied nest. The USFWS goal was achieved in 1991 with 1,349 occupied breeding areas distributed over 20 states. In 1998, the Lake Superior Binational Program (LSBP) recommended a five-year productivity average of greater than 1.0 young bald eagle per occupied territory as the target indicator of ecosystem health. The rationale for this indicator is that bald eagle populations in north central Wisconsin, the Superior and Chippewa National Forests in Minnesota, and the inland areas of Michigan retained the core of the bald eagle population during the “DDT years” and continue to have healthy-appearing and stable populations. The productivity rates in these areas range from 1.0 to 1.3 young/occupied territory. The success of the breeding pairs in Deer Lake can be favorably compared to USFWS regional goals.

The USFWS began observing the bald eagles at Deer Lake in 1963, and from 1964 to 1996 no eaglets were observed (Best, 2011). According to USFWS wildlife biologist David Best, the eagle pair has now been successfully reproducing since 1997. The eagles have been using two primary nesting sites (Figures 2 and 3), but there may be other nests surrounding Deer Lake. Documentation by the USFWS indicates that bald eagles have successfully fledged an average of 1.73 young per year for the period 1997 through 2011 (Appendix 4). The Deer Lake pair has produced 25 fledglings during the past 14 breeding seasons (six in the last four) which is well above the suggested target of 1.0 by the USFWS and greater than 1.0 by the LSBP as an indicator of ecosystem health. Furthermore, USFWS information has not indicated deformities in the bald eagles nesting at Deer Lake. The USFWS continues to monitor bald eagles at Deer Lake.

Since field data exists, the first approach in the Guidance for assessing BUI restoration was used (Appendix 3). Based on multiple years of observation of the nesting pair at Deer Lake and the lack of reproductive problems, the Guidance BUI removal criteria were met. The complete nest survey information going back to 1963 can be found in Appendix 4.

Figure 2. Deer Lake AOC 2011 nest site. Photo courtesy of Matt Schroderus, Ishpeming, Michigan.

Figure 3. Deer Lake AOC 2007 breeding season fledglings. Photo courtesy of Matt Schroderus, Ishpeming, Michigan.

The removal of the Bird or Animal Deformities or Reproduction Problems BUI was also discussed with the Deer Lake PAC at their regular meeting in September 2007. The PAC passed a motion supporting the removal of the Bird or Animal Deformities or Reproduction Problems BUI at the meeting. A public meeting was held in September 2007 to discuss the removal of this BUI with the community. The community expressed their support for removal of this BUI. In recognition of their continued support for this BUI removal, the PAC unanimously passed a motion at their August 11, 2011 meeting and submitted a letter (Attachment A).

4.2 Eutrophication or Undesirable Algae

Action

This BUI was removed by the MDEQ and the USEPA in September 2011. The complete Removal Recommendation can be obtained by going to the OGL's Deer Lake page at https://www.michigan.gov/en/egle/about/Organization/Water-Resources/aoc/deer-lake-aoc-delisted.

Summary

The Deer Lake AOC Technical Committee recommended the removal of the Eutrophication or Undesirable Algae BUI based on the collective review of the related documentation per the process outlined in the *Guidance* (MDEQ, 2008). This recommendation was made by the Deer Lake Technical Committee, comprised of staff from both the USEPA, and the MDEQ, and members of the Deer Lake PAC.

Background

The original 1987 RAP identified eutrophication as a concern in Deer Lake due to hypereutrophic conditions caused primarily by excessive nutrient loadings (MDNR, 1987). The major nutrient sources included historic discharges of untreated municipal wastewater from the city of Ishpeming and Ishpeming Township to Carp Creek prior to 1964. These untreated wastewater discharges were replaced by three primary wastewater treatment plants that discharged partially treated municipal wastewater to Carp Creek from both the city of Ishpeming and Ishpeming Township from 1964 until

1985. These historic municipal wastewater discharges resulted in greatly elevated nutrient concentrations in Deer Lake (USEPA, 1975; Bills, 1977; Ludwig, 1981).

Removal Criteria

According to the Guidance, the restoration criteria for the Eutrophication or Undesirable Algae BUI in the Deer Lake AOC requires that:

- no waterbodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the most recent Clean Water Act *Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report* (Integrated Report), which is submitted to USEPA every two years.

The attached excerpt from the Guidance (pages 33-34) includes the rationale for application of the removal criteria to this BUI (Appendix 5).

Analysis

In 1975, as part of a national study, the USEPA determined that Deer Lake was eutrophic (USEPA, 1975). A 1977 study by Northern Michigan University determined that Deer Lake was hypereutrophic (Bills, 1977). At that time, the winter dissolved oxygen content of Deer Lake was less than the level recommended for fish survival (USEPA, 1986 and 2000).

In the 1800's the city of Ishpeming discharged untreated wastewater to Carp Creek and Partridge Creek. Beginning in the 1930s, soap manufacturers began using "builders" to improve the cleaning efficiency of soap powders and detergents. The most common "builder" that was used to prevent soap scum was a complex phosphate (EAI, 2006). Phosphate (an ionic form of phosphorus) is one of the limiting nutrients in many Michigan water bodies, and was later determined to be an important source of eutrophication (Schindler, 1974). Consequently, phosphate (as part of wash water) was being discharged from the city and contributing to the eutrophication of Deer Lake. Beginning in 1972, the phosphate content of laundry detergents, which had been as great as 15 percent by weight since the late 1930s, was decreased to 8.7 percent by weight. By 1977, based on eutrophication concerns; the State of Michigan decreased the maximum phosphate content of laundry detergents to 0.5 percent by weight (EAI, 2006). In 1973, Michigan promulgated administrative rules to enforce water quality standards, which required a maximum monthly effluent concentration for total phosphorus and limits on nutrients to prevent excess plant growth which may become injurious to the designated uses of the surface waters of the state (MDEQ, 1994).

In 1964, three primary WWTPs were built in the city of Ishpeming and Ishpeming Township. An enhanced secondary municipal wastewater treatment plant replaced the three primary treatment plants in 1985, and nutrient loading to Carp Creek and Deer Lake decreased significantly. By 1995, after the plant upgrade, Deer Lake was described as mesotrophic or moderately nutrient-enriched, and the annual loading of nutrients to Deer Lake decreased, see Table 1 (Kerfoot, 1995). The WWTP's National Pollutant Discharge Elimination System (NPDES) permit discharge point is to Carp Creek near the intersection of Washington Street and North Washington Street in Ishpeming. The WWTP has a limit (0.8 mg/l and 8.8 lbs/day) for total phosphorus as part of its NPDES discharge permit.

Table 1: Nutrient loading change after Ishpeming WWTP upgrades.

Nutrient	1975 Annual loading data from Primary WWTPs	1998 Annual loading data from Enhanced Secondary WWTP	Percent Change
Phosphorus	15,960 lbs/yr[1]	1,711 lbs/yr[2]	89 percent decrease[3]
Nitrogen	69,090 lbs/yr[1]	3,051 lbs/yr[4]	95 percent decrease

[1] Data from USEPA (1975)
[2] Data from Kotajarvi (1998)
[3] The USEPA (1975) estimated that an 80 percent decrease in phosphorus loading from the municipal wastewater treatment plants would reduce the incidence and severity of nuisance algal blooms as well as provide additional protection for downstream Lake Superior.
[4] Data are from D'Itri *et al.* (1993)

In 1989, winter monitoring by the MDNR demonstrated that Deer Lake had begun recovering from eutrophication. Dissolved oxygen concentrations below the ice were sufficient to support fish growth and survival (USEPA, 1986) to a depth of 12 feet. Additional monitoring by CNR in 1999 and 2000 documented further recovery where dissolved oxygen concentrations were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 18 feet.

Deer Lake is not on the Category 5 list of impaired waters in the 2010 Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report (MDNRE, 2010*)* due to nutrients or excessive algal growths thereby meeting the restoration criteria outlined in the *Guidance*.

A timeline of Deer Lake AOC eutrophication and recovery, as well as additional technical support documents, can be found in Appendices 2, 6, and 7.

The removal of the Eutrophication or Undesirable Algae BUI was discussed with the Deer Lake PAC at their regular meeting in September 2007. The PAC passed a motion supporting the removal of the Eutrophication or Undesirable Algae BUI at that meeting. A public meeting was held in September 2007 to discuss the removal of this BUI with the community. The community expressed their support for removal of this BUI. In recognition of their continued support for this BUI removal, the PAC unanimously passed a motion at their August 11, 2011, meeting and also submitted a letter of support (Attachment A).

4.3 Restrictions on Fish and Wildlife Consumption

Action

This BUI was removed by the MDEQ and the USEPA in February 2014. The complete Removal Recommendation can be obtained by going to the OGL's Deer Lake page at https://www.michigan.gov/en/egle/about/Organization/Water-Resources/aoc/deer-lake-aoc-delisted.

Summary

The MDEQ, Office of the Great Lakes, AOC program recommended removal of the Restrictions on the Fish and Wildlife Consumption BUI in the Deer Lake AOC. This recommendation was made with the support of staff from the MDEQ Water Resources Division, the MDCH, and the Deer Lake PAC.

This recommendation is made in accordance with the process and criteria set forth in the *Guidance* (MDEQ, 2008).

Background

Historic mining practices resulted in mercury contamination to the Deer Lake basin from Ropes Creek and Carp Creek. According to the 1987 RAP, mercury contamination led to a fish consumption advisory in 1981 by MDCH for all species in the Carp River, Carp Creek, and Deer Lake (MDNR). A timeline of activities in the AOC can be found in Appendix 1. Additional historical information can be found in Appendix 2.

Removal Criteria

The *Guidance* has three tiers which serve as removal criteria for the Restrictions on the Fish and Wildlife Consumption BUI, the third of which applies to the Deer Lake AOC. This BUI is considered restored when:

- The fish consumption advisories in the AOC are the same or less restrictive than the associated Great Lake or appropriate control site.

OR, if the advisory in the AOC is more stringent than the associated Great Lake or control site:

- A comparison study of fish tissue contaminant levels demonstrates that there is no statistically significant difference in fish tissue concentrations of contaminants causing fish consumption advisories in the AOC, compared to a control site.

OR, if a comparison study is not feasible because of the lack of a suitable control site:

- Analysis of trend data (if available) for fish with consumption advisories shows similar trends to other appropriate Great Lakes trend sites.

The attached excerpt from the *Guidance* (pages 14-18) includes the rationale for the removal criteria to this BUI (Appendix 8).

Tier 3 of the *Guidance* is applicable to Deer Lake, as the fish advisory for the lake is more stringent than that of Lake Superior (Tier 1), and there is not a suitable comparison site with similar characteristics (Tier 2) since there was no impoundment in the area representative of the geomorphic conditions in Deer Lake. The BUI was evaluated based on an analysis of trend data for fish with consumption advisories as compared to other appropriate Great Lakes trend sites. The research supporting the recommendation to remove the Restrictions on Fish Consumption BUI demonstrates that there is a strong decreasing trend in fish tissue concentrations of mercury over the last 20 years as a result of elimination of primary sources of mercury to the lake.

It is expected that fish consumption advisories will remain in place for Deer Lake for the foreseeable future, as they do for all lakes and rivers in Michigan due to the air deposition of mercury in inland waters. The specific MDCH fish consumption advisories for Deer Lake are in Attachments B and C. Please refer to the MDCH *Eat Safe Fish Guide* for any up-to-date fish consumption restrictions at www.michigan.gov/eatsafefish.

Analysis

Mercury inputs to the Deer Lake AOC primarily came from mining activities in the surrounding area. The Ropes Gold Mine, located northwest of Deer Lake, used a mercury amalgamation process to concentrate gold (MDNR, 1987). The leftover materials or tailings from this process remained in the watershed. The Cleveland-Cliffs Iron Company (now known as CNR) disposed of mercury reagents down drains that led to the city of Ishpeming's wastewater treatment plant, and Carp Creek. In 1970, the city of Ishpeming, in order to cope with wet weather events, diverted Partridge Creek from their storm water system into Cliffs Shaft Mine tunnels beneath the city. The diverted water picked up mercury, some of which came from used blasting caps, and transported it into Carp Creek. Ropes Gold Mine is no longer operational and other mining practices no longer take place. The controllable legacy mercury in the system has been remediated through source control and lake management activities.

The last controllable source of mercury to the lake, Partridge Creek, has been diverted from the Cliffs Shaft Mine into the city's storm water system. Water from the shaft mine will continue in a limited discharge into Carp Creek until the system reaches equilibrium. The diversion did not completely separate Partridge Creek from the shaft mine in order to accommodate extreme flood events. As part of the ACJ, CNR will monitor the discharge to Carp Creek on a quarterly basis. A 2006 ACJ commits CNR to maintaining Deer Lake at a minimum of 1,385 feet above sea level. This water depth has been determined to be the most effective long-term remedial approach for Deer Lake. At this depth methylmercury production is curtailed in sediments and thereby a bioavailable source of mercury to fish is minimized (ACJ, 2006).

An interoffice memo by the MDEQ estimated the total mercury load to Deer Lake via Carp Creek to be 241 grams per year (g/yr) and the estimated total from the surrounding watershed to be 314 g/yr (Staron, 2004). Approximately 46 percent of the load is the result of direct and indirect atmospheric deposition, while approximately 54 percent is from local sources.

The city of Ishpeming and the city of Negaunee's wastewater treatment plants each have a 12-month rolling average mercury limit of 10 nanograms per liter for discharge to Carp Creek. The largest remaining point source of mercury to the Deer Lake AOC was Partridge Creek, with an estimated 22.7 percent of the annual mercury load (Staron, 2004).

The MDCH, CNR, and MDEQ have monitored mercury in fish in the Deer Lake AOC since 1984 (Bohr, 2013a). The evaluation of the Deer Lake AOC also informs the Fish Contaminant Monitoring Program for the MDEQ in conjunction with the MDCH. The assessments were designed to focus specifically on Tier 3 of the Guidance described on page 15, analysis of trend data. The full scope and methods can be found in Attachment E.

<u>Fish Tissue Assessment</u>

Fish tissue concentrations of mercury have declined over the last 20 years in the Deer Lake fish species for which data is available. This includes northern pike, walleye, white sucker and yellow perch. The tissue concentrations are never expected to be zero given the atmospheric deposition of mercury to all inland lakes and rivers in the state. Therefore, the assessment data below strongly support this BUI removal recommendation based on the established criteria (Appendix 8).

Northern Pike

Mercury concentrations in northern pike declined between 1984 and 2011 at an average annual rate of 6.9 percent based on multiple regression results (Attachment E). In a standard sized 24-inch northern pike, estimated mercury concentrations declined from 2.3 parts per million (ppm) in 1988 to 0.9 ppm in 2011 (Attachment E). The estimated mercury concentration in a standard size northern pike has been stable since 2001.

Changes in mercury concentrations were also measured in northern pike collected in the Carp River Basin, downstream from Deer Lake. A t-test comparing similar sized northern pike showed that the mercury concentration in the 2011 samples (mean = 0.42 ppm) were significantly less than the concentrations measured in the 1999 samples (mean = 0.64 ppm) (Attachment E).

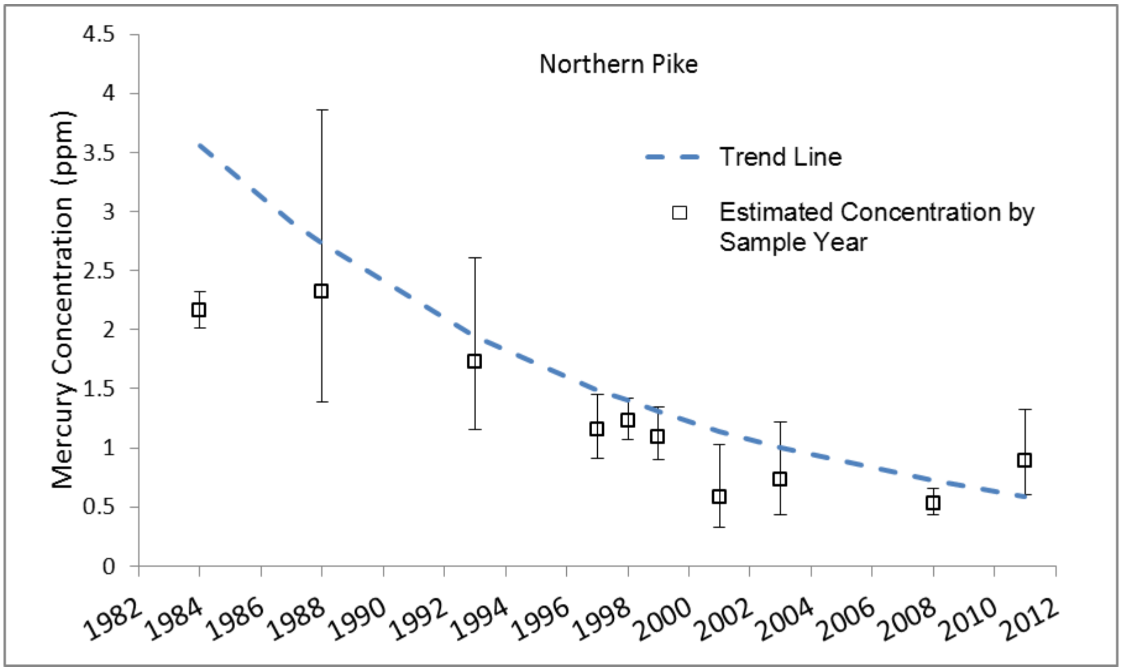

Figure 2. Temporal trend and estimated mercury concentrations in standard sized northern pike collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

Walleye

Walleye mercury concentrations have declined between 1990 and 2011 at an average annual rate of 3.8 percent based on multiple regression results (Attachment E). The estimated mercury concentration in a standard sized 18-inch walleye declined from a peak of 1.12 ppm in 1997 to 0.99 ppm in 2011. Although it appears that concentrations may have increased slightly from 1990 to 1997, there was no significant trend. In fact, this period was followed by a decline of 2.7 percent per year from 1997 to 2011 (Attachment E).

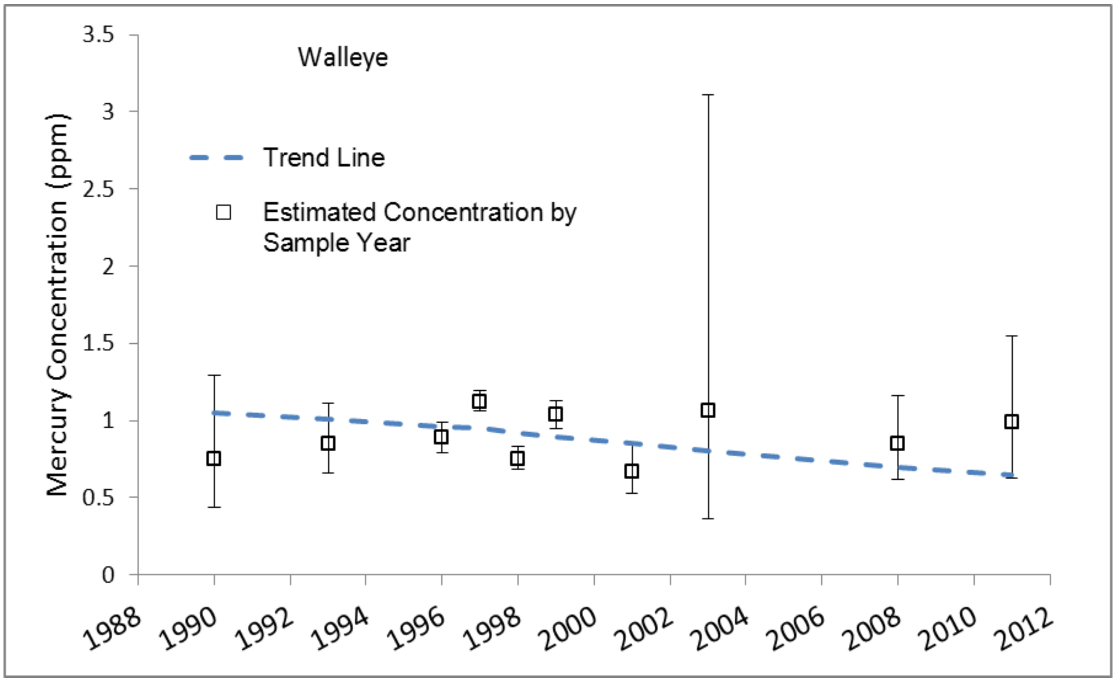

Figure 3. Temporal trend and estimated mercury concentrations in a standard sized walleye collected from Deer Lake, Marquette County, Michigan, from 1990 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

The Restrictions on Fish and Wildlife Consumption BUI was removed based on declines in fish tissue mercury for northern pike and walleye. White sucker and yellow perch were not sampled regularly; although they are included as the results suggest declines in mercury concentrations.

White Sucker

Mercury concentrations in white sucker collected from Carp Creek and Deer Lake declined at an average annual rate of 2.5 percent (Attachment E). The estimated mercury concentration in standard sized 15-inch white suckers declined from 0.41 ppm in 1984 to 0.15 ppm in 2011 (Attachment E).

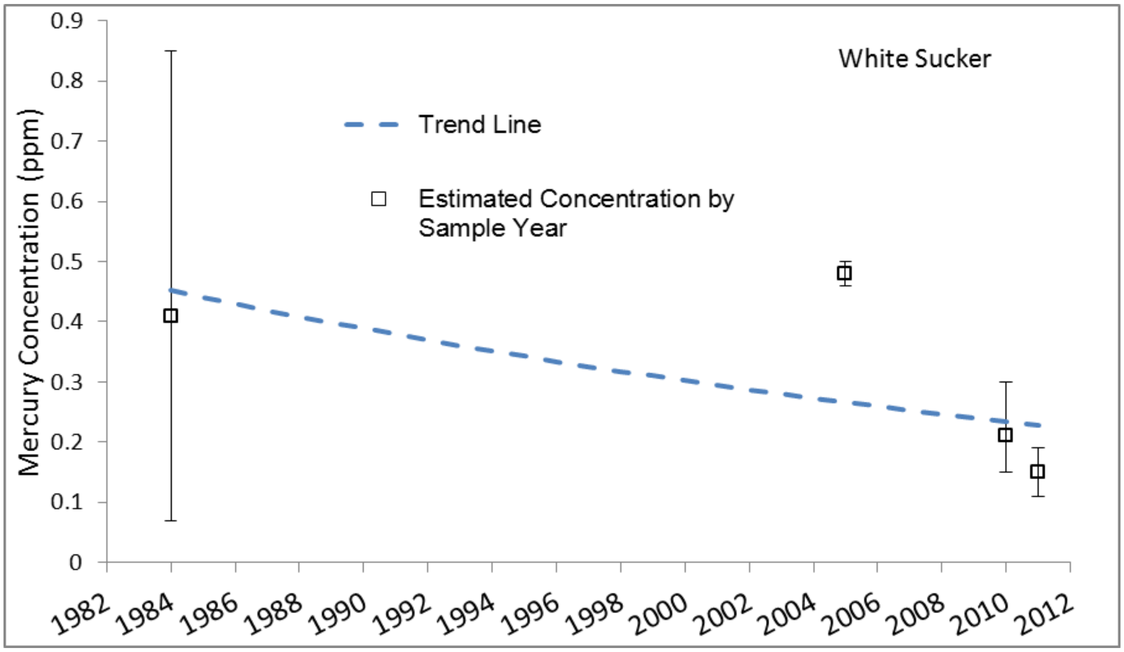

Figure 4. Temporal trend and estimated mercury concentrations in 15-inch white sucker collected from Carp Creek and Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

Yellow Perch

Yellow perch mercury concentrations declined between 1984 and 2011 at an average annual rate of 6.7 percent (Attachment E). The estimated mercury concentration in a standard-sized 10-inch yellow perch declined from a peak of 1.65 ppm in 1984 to 0.34 ppm in 2011 (Attachment E).

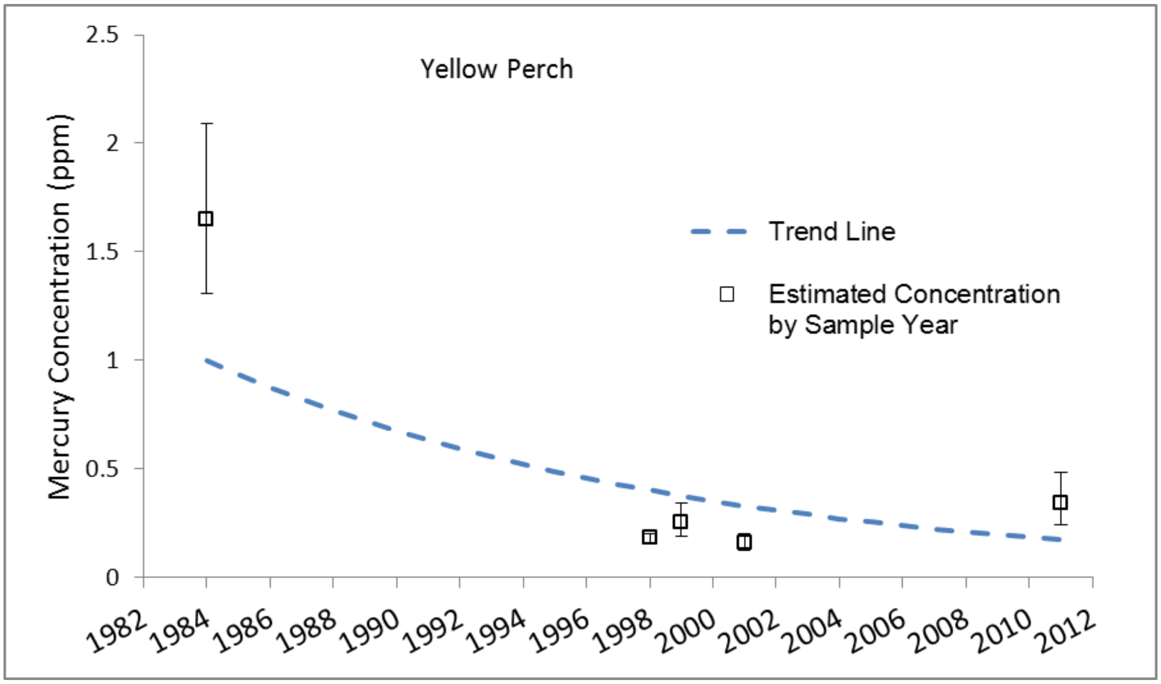

Figure 5. Temporal trend and estimated mercury concentrations in standard sized yellow perch collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

Based on sample size, concentrations of mercury decreased in northern pike by 61 percent, in walleye by 12 percent, in white sucker by 63 percent, and in yellow perch by 79 percent from 1984 to 2011 (Attachment E). Concentrations of mercury in fish with consumption advisories appear to have stabilized since 2000 (Attachment E).

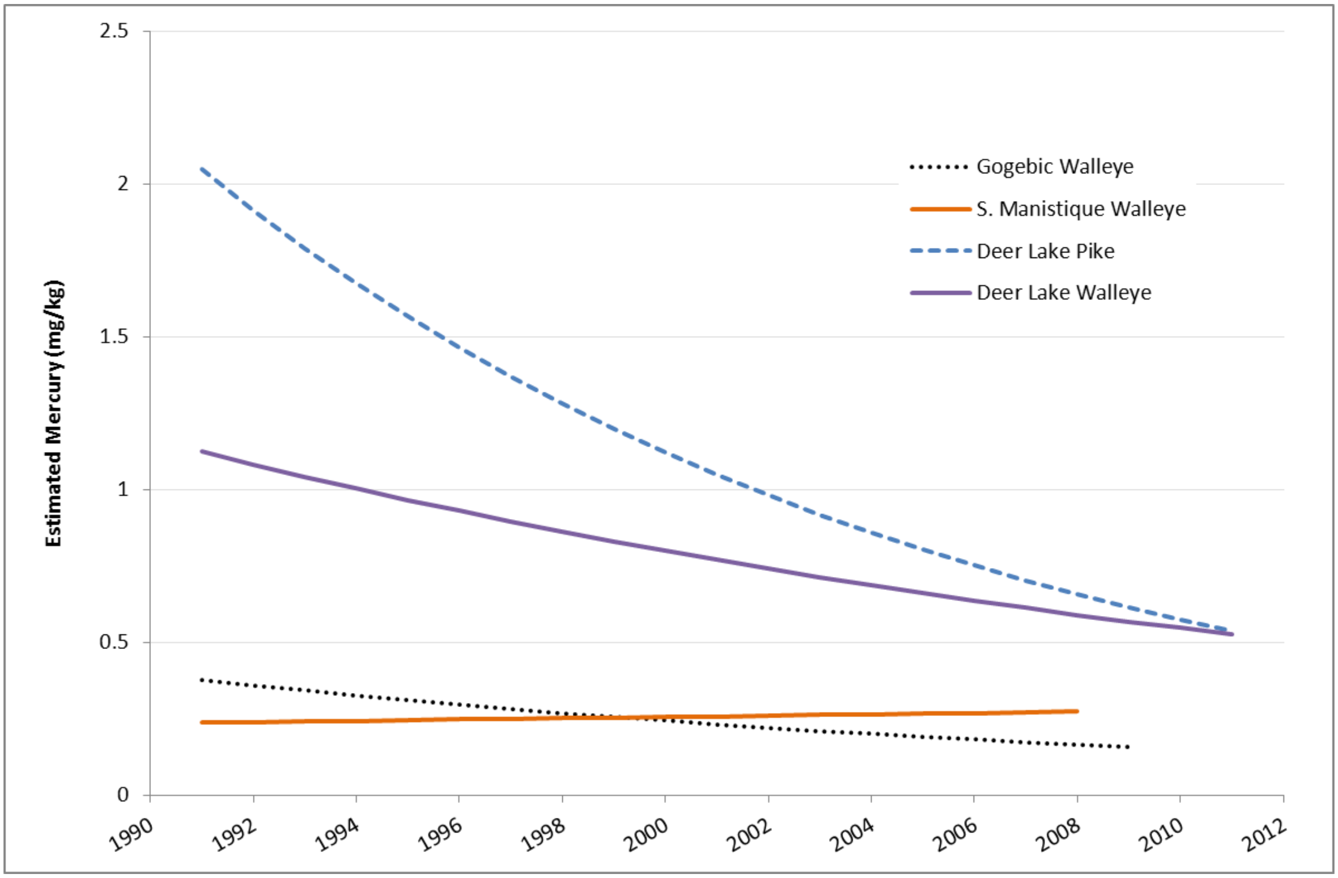

Figure 6. Comparison of Deer Lake pike and walleye trends to the same for Lake Gogebic walleye and Manistique walleye (Bohr, 2013b).

Trends in walleye for Deer Lake are similar to walleye from the Great Lakes trend sites of Lake Gogebic and South Manistique Lake (Figure 6) (Bohr, 2013b; Attachment F). The lakes were selected as they are the only inland lake trend sites in the Upper Peninsula and they have trend data for walleye. In addition, they are relatively close to the AOC and are more likely to have atmospheric inputs and other regional influencing factors similar to Deer Lake. The Deer Lake walleye slope is similar to Lake Gogebic and both are improving more so than Manistique, with the note that there is no significant trend for Manistique at this time. Since there is a significant decrease in mercury in pike, a comparison to another Great Lakes trend site is not warranted.

Conclusions

Mercury concentrations declined in northern pike and walleye from 1984 to 2011, with northern pike showing the most dramatic decline. Both northern pike and walleye were collected regularly over the period and the size of the data sets provides confidence in the conclusions. Yellow perch and white sucker were not sampled regularly; although the results for those species suggest declines in mercury concentrations, the data sets are too small to be a basis for the BUI recommendation. The results for yellow perch and white sucker have been included for reference and because they are included in the fish consumption advisory. In comparison to other Great Lakes trend sites, mercury concentrations in the Deer Lake AOC have declined at a rate comparable to Lake Gogebic and at a higher rate than South Manistique Lake (Attachment E). There are no longer significant point sources of mercury to the Deer Lake AOC. Management of the dam and water levels will continue to limit mercury from becoming bioavailable.

Mercury concentrations in Deer Lake fish with consumption advisories from 1984 to 2011 had declined at rate similar to or higher than other Great Lakes trend sites. Therefore, this BUI met the criteria for removal, according to the *Guidance* criteria outlined on page 15.

5. POST-DELISTING RESPONSIBILITIES AND MONITORING

The objective of post-delisting monitoring is to ensure that restoration objectives continue to be met. As part of the Amended Consent Judgment, CNR will maintain the dam at a height to prohibit methylation of mercury (ACJ, 2006). In addition, CNR will maintain signage around the lake informing anglers of the mercury in the fish. CNR will also monitor fish, water, and sediment at Deer Lake until 2034 and provide those results to the MDEQ (ACJ, 2006). CNR will monitor the mercury concentrations of Partridge Creek to ensure the newly constructed diversion is functioning properly. The MDEQ, as part of the Fish Contaminant Monitoring Program, will continue to collect fish from Deer Lake for mercury testing. Sediment samples will be collected by the USEPA in 2014 to confirm depth of sediment cover and mercury levels. The USFWS will continue to monitor bald eagle nesting activities at Deer Lake.

Other non-AOC issues will be addressed as part of other programs within the MDEQ and MDNR. The MDEQs National Pollution Discharge Elimination System permits program has responsibilities for point source dischargers to Carp Creek and the Carp River. The MDNRs fisheries management program routinely conducts population surveys in Deer Lake and Carp Creek to determine health of the fishery. The MDNR has held several public meetings to incorporate comments from the public and local stakeholders as to future management of the Deer Lake fishery. The State of Michigan's multi-departmental Aquatic Invasive Species Program (AIS) will continue to implement the State AIS Management Plan and work with local partners to prevent, monitoring, and control AIS in waters of the state. The MDEQs Water Resources Division (WRD) conducts basin cycle monitoring inland lakes and streams throughout the state, these efforts will track the health of Deer Lake, Carp Creek, and the Carp River. The next survey will take place in 2015. The WRD also works with various partners on non-point sources, wetlands, inland lakes/streams, and watersheds. The Michigan Coastal Zone Management Program supports sustainable and resilient coastal development and protection of sensitive ecological and cultural resources within the coastal zone.

The MDEQ-OGL participates in the Lake Superior Binational Program (LSBP), which includes the development of the Lakewide Action and Management Plan (LAMP). MDEQ staff will continue to offer support to local partners in bridging the gap between local needs and binational, lakewide planning, including: implementing relevant LAMP priorities; identification of Great Lakes funding and technical resources; and communicating information in both directions. Local governments and organizations may consider participating in the Lake Superior Binational Forum, the public stakeholder group that advises the federal, state, provincial, and tribal and First Nation governments that comprise the LSBP.

The MDCH is preparing educational materials for the AOC on eating fish safely. These materials include a new tri-fold brochure for eating safe fish in Marquette County and signage for posting around Deer Lake and the Carp River. MDCH will also continue to work with area stakeholders, including the local health department and fishing associations, in order to provide local distribution of outreach materials and sustainable Eat Safe Fish educational opportunities.

6. PUBLIC INVOLVEMENT IN THE DELISTING PROCESS

The Deer Lake PAC and the MDEQ have consistently worked to both inform the affected communities in the AOC and to seek their input with regard to remedial activities and BUI removals. The same holds true during the process of delisting the AOC. At least one public meeting in the Deer Lake community was held to present evidence supporting each BUI removal and to seek public comment. The Deer Lake PAC held a public meeting on November 5, 2013 where they agreed to begin the delisting process, which includes reviewing and voting on the Final Delisting Report.

7. RECOMMENDATION TO DELIST

7.1 Restoration and Removal of the Beneficial Use Impairments

The goal of the AOC program, as defined under the GLWQA, is to ensure that the AOCs are improved to the point where their environmental conditions are equal to other non-AOC locations across the Great Lakes. Those conditions may not be pristine, but are consistent with the ambient environmental conditions elsewhere in the Great Lakes.

The Deer Lake AOC had only three BUIs: (1) bird or animal deformities or reproductions problems, (2) eutrophication or undesirable algae, and (3) restrictions on fish and wildlife consumption. The BUIs were a result of mercury inputs and nutrient loading. Mercury inputs and nutrient loading have now been controlled and all three BUIs have since been removed.

7.2 Delisting Recommendation

The restoration of this AOC is a significant success story in the overall restoration and protection of the Great Lakes. The change from a highly contaminated and hypereutrophic lake and river to a lake and river with successfully reproducing bald eagle, fish that can be safely consumed within limits, and oligotrophic conditions is a result of long-term and substantial commitments from many partners over three decades. This progress and positive change has resulted in this recommendation to delist the Deer Lake AOC.

All three BUIs have been removed, and environmental conditions in the Deer Lake AOC are comparable to non-AOC locations in the Great Lakes. The MDEQ, with the concurrence of the Deer Lake PAC, recommends delisting the Deer Lake AOC.

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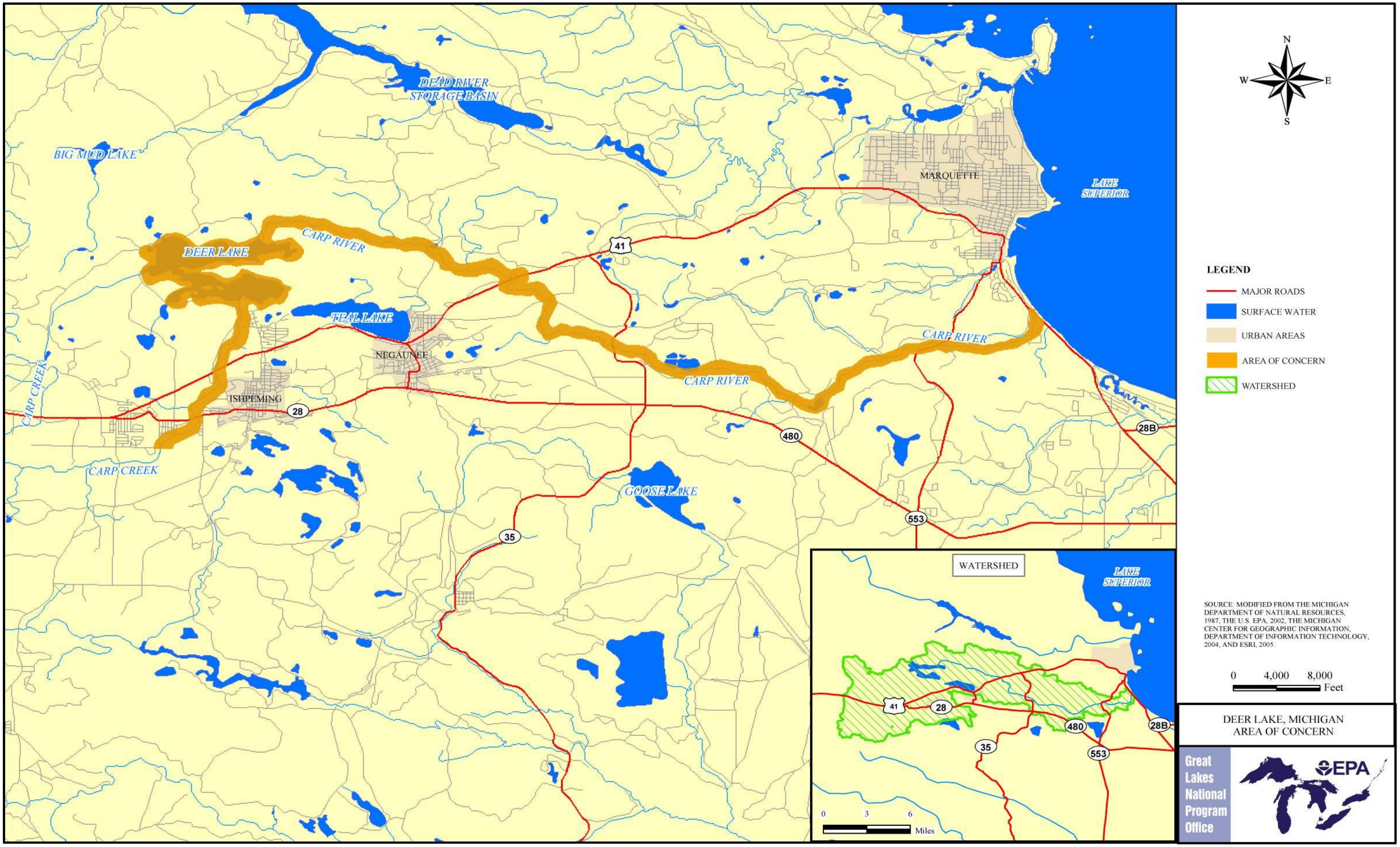

Figure 1. Deer Lake Area of Concern Boundary

APPENDIX 1

Deer Lake – A history of mining and the Deer Lake AOC

Mark Loomis, Deer Lake Task Force Lead
USEPA Great Lakes National Program Office

Iron Mining:

1844 – William Burt surveys area by Teal Lake, identifies potential iron deposits with compass magnets.

1846 – Jackson Mining Company files mining claims for iron ore near Teal Lake after talking with Chippewa chief (Marji-Gesick).

1847 – Cleveland Iron Company is formed on signing of Articles of Association on November 9, 1847.

1848 – Cleveland Iron Company opens Little Mountain Mine. Cliffs shaft mine began as number of smaller mines to the west of Teal Lake, developed by people attracted to area by Jackson Company's activities.

1855 – Locks at Sault Ste. Marie open. Railroads connect Ishpeming and Negaunee mines to harbor in Marquette, Michigan – ore moved through locks to Detroit, Toledo, and Cleveland (then to Pittsburgh).

1865 – Iron Cliffs Company formed by S. Tilden.

1868 – Cliffs company is 1st mine in the region to use dynamite.
Iron Cliffs Company based in Cleveland opens Barnum Mine, an open pit on the same ore body as the Little Mountain. The two companies (Cleveland Iron Company and Iron Cliffs Company) open a number of other open pits (Cleveland, Incline, Sawmill, New York).

1877 – The "New Barnum" mine started when Iron Cliffs Company drills hole "A" – March 15, 1877.

1877 – June, Iron Cliffs drills hole "B", ore discovered ~400 feet below surface.

1879 – Iron Cliffs company uses diamond drilling to determine ore body continued west under the city of Ishpeming.

1880 – Alternatively proposed date of sinking shafts north of Barnum mine. The Cliffs Shaft mine was
1882 sited entirely by diamond drill testing; there was no outcrop of the ore body as was the case in most Marquette range mines.

1891 – Cleveland-Cliffs Iron Company is formed on May 7, 1891 with the merger of Iron Cliffs Company and the Cleveland Iron mining Company.
As the new mine workings went deeper, the earlier mines were connected underground and their ore hoisted through the A and B shafts of the opposite ends of the Cliffs Shaft Site.
The earlier open pit mines to the east of the city are now being mined from below and provided natural ventilation for the mine, with fresh air entering through their workings and rising through A and B shafts.

1897 – Barnum Pit mine closes.

1919 – Egyptian revival designed concrete shafts are constructed at A and B to replace the aging wooden structures. Cleveland-Cliffs president William G. Mather recommended that the new shafts incorporate architectural beauty because of the mine's proximity to Ishpeming.
George W. Maher (consulting architect from Chicago) designed shafts. Concrete was colored by the high iron content of the local gravel and originally had a light brown and pink variegated color. They became the only concrete structures, for an iron mine, to be used as shaft houses, in the United States.
Sometime after 1926, Cleveland-Cliffs needed to expand to keep the company working because the Republic Mine was inactive. Cliffs shaft is a geological puzzle of faults and cross faults. Drilling discovers the Bancroft vein just north of Euclid street and under Lake Bancroft. They also open the south-east vein. A lease was taken out by the Oliver Mining Company, formerly the Lake Superior Iron Company, for holdings just south of Division Street. More ore was also discovered to the Cooper Lake Road area to the west.

1955 – 174 feet "C" shaft Koepe lift is installed. A and B shafts are retired from active mining.

This was the first Koepe friction hoist installed in the western hemisphere, using German and Swedish technology. The mine was now 1250 feet below the surface with very extensive drifts running for miles in all directions.

1967 – Cliffs Shaft Mine "Barnum Mine" ends production. This was the largest and longest operating underground, direct-shipping, hard ore mine in the Lake Superior Region and the U.S., producing 28.9 million tons of ore from 1848-1967 (contested 1868-1972).

Gold Mining:

1845 – D. Houghton identifies gold and copper deposits, also shows probability of iron deposits is high.

1877 – Julius Ropes of Ishpeming finds serpentine group with gold-bearing quartz 15 miles west of Ishpeming.

1880 – Ropes discovers promising quartz vein.

1881 – Ropes finds quartz vein "leaders" that are the base of the Ropes Gold Mine – spring 1881.

July 1881 – The Ropes Gold and Silver Mining Company starts active mining.

1883 – The Curry Mine shaft begins.

1884 – 25-stamp mill is erected in November.

1888 – 50-stamp mill starts. Ropes mine is ~500 feet deep and $125,000 in gold/silver concentrates have been taken out. Average yield of rock is ~$4/ton, erected in November.

1888 – NY Times article reports "no great rush of miners to Ishpeming." This is a shaft mine and only a dozen or so men can work at a time. There are no placer mines here; quartz mining requires miners, supplies, and months of pre-production investment. Also, land is owned by companies and private holders, so there is no squatter claim potential like in the west.

1897 – Ropes Gold Mine closes - The Ropes Mine ran for 14 years and produced $645,792 in gold and silver, but was never able to pay a dividend to its stockholders. Fifteen levels had been developed to 813 feet. The gold was shipped and extracted by the mercury amalgamation process and gravity separation.

1900 – Corrigan, McKinney and Co. purchased the mine property and, using the newly-developed cyanide leaching process, reclaimed nearly $200,000 in gold from the tailings during **1900-1901**. Additional gold was gleaned from scraps of mercury amalgam recovered throughout the mill buildings.

1970s – Callahan Mining Co. purchases the mine property. The mine changed hands numerous times without further production until the inflation of the 1970s drove up gold prices enough to prompt Callahan Mining Co. to purchase the property and invest in exploration and rehabilitation of the mine.
Improved metallurgical methods and higher gold prices in the 1970's and 1980's attracted a $20 million redevelopment project to the Ropes Mine which again began producing gold in the fall of 1985. The reopened mine produced until 1989 when a combination of low gold prices, poor ore grade, and a collapse of rock in the production shaft prompted its shutdown.

1983 – Callahan Mining resumed mining with the sinking of a truck decline to 900 feet depth.

1984 – A new shaft was sunk with workings reaching 1548 feet depth. Ore rock was trucked to the ore dressing plant of the retired Humboldt Iron Mine for gold extraction. Operations continued despite the collapse of the uppermost levels in 1987.

1985 – Callahan Mining Co. begins producing gold.

1989/1990 – Ropes Gold Mine closed due to declining ore values and a cave-in that resulted in extensive underground damage. This prompted the closing of the only profitable gold mine in Michigan history.

The AOC:

1877 – Iron Cliffs company used diamond drilling to determine ore body and continued west under the city of Ishpeming. Shafts "A" and "B" are started. This begins the use of dynamite in the mine under the city. Mercury from the dynamite blasting caps accumulates in mine workings.

Mercury is still in the now submerged mine shafts and is the main source of contamination for Partridge Creek.

1882 – 1897 Liquid (elemental) mercury was used to recover gold from ore at the Ropes Gold Mine (located on Deer Lake, west of the north basin). Mercury amalgam was also recycled for gold.

Early – 1880's The Carp River is impounded to form Deer Lake. The water is taken from the reservoir and used for mining operations. Over the years, the location of the dam has shifted as mining operation needs changed. Deer Lake has been in place since this time, resulting in the accumulation of mercury contaminated sediments.

1891 – The surface mine pit east of the city is connected to underground mine workings associated with shafts "A" and "B." This created the direct hydrologic connection between surface waters (future Partridge Creek) and contaminated groundwater (groundwater infiltrated the underground mines after closure in the 1960s).

1897 – Ropes Gold mine closes. W.H. Rood erected several large vats and attempted to reclaim the gold in tailings using a cyanide process. This work only lasted a few years.

1929 – 1981 Mercury salts were used in iron ore assays in laboratories of the Cleveland Cliffs Iron Company. Mercury-containing wastewater from the lab was discharged to the wastewater treatment system (which was inadequate). This discharge ended up in Carp Creek and then Deer Lake.

1929 – 1963 All wastewater generated in the city of Ishpeming and Ishpeming Township is discharged without treatment through combined sanitary and storm sewers into Carp Creek. This had direct impact on the Eutrophication BUI.

1967 – Following closure, the Cliffs Shaft mine (underneath the city of Ishpeming) fills with groundwater. Because of the low oxygen conditions, mercury methylates into a more bioavailable form.

1970 – Prior to this time, Partridge Creek flowed westerly into the east-side of the city. It was then directed through the city's storm sewer and re-emerged on the west-side of the city. In 1970, due to flooding and overflow concerns, the city was allowed to divert Partridge Creek into a mine pit on the east side of town. The water then flowed through the now flooded historic mine workings where it accumulated mercury and became contaminated. Then on the west-side of the city, two 24" wells were installed to help re-create Partridge Creek with the mercury contaminated mine water.

1986 – An enhanced Secondary Wastewater Treatment Plant replaced the three primary treatment plants in April 1986. This construction significantly reduced nutrient loading (a major factor in the AOCs Eutrophication BUI) by 86 percent.

1987 – Deer Lake AOC Remedial Action Plan is developed. Natural attenuation is selected as a remedy for Deer Lake. Over time, mercury contaminated sediments have accumulated in Deer Lake. Studies showed that the mercury in these sediments was not bioavailable so long as the bottom of the reservoir had high oxygen levels. The high oxygen levels keep the mercury from methylating, thereby reducing its bioavailability. Therefore, the solution to control mercury was to maintain a bottom draw dam, which forces oxygen rich water at the surface down to the bottom of the reservoir. Additionally, natural sediments will attenuate or build up to cover the mercury contaminated sediments.

2004 – A study by the MDEQ shows that over 67.4 grams of mercury per year enters the AOC from Partridge Creek. This is over 21 percent of the total mercury load to the AOC.

2010 – The city of Ishpeming receives FY2010 Great Lakes Restoration Initiative grant to conduct Phase 1 of the Partridge Creek diversion.

September – 2011 The MDEQ, in conjunction with USEPA and the PAC, recommends removal of two BUIs: 1) Eutrophication or Undesirable Algae and 2) Bird or Animal Deformities or Reproduction Problems.

2012 – The city of Ishpeming receives a FY2012 GLRI grant to conduct a portion of Phase 2 of the Partridge Creek diversion. Because of cost constraints, the project was divided into two portions, the open channel areas and the closed culvert/sewer areas.

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APPENDIX 2

Deer Lake AOC Historical Background

Historic mining practices resulted in mercury contamination to Deer Lake basin from Ropes Creek and Carp Creek. The "Ropes" Goldmine operated at various times from 1882 through 1991 along Ropes Creek. Gold recovery in the Ropes Mine from 1882-1897 used a mercury amalgamation process to concentrate the gold mined there. Gold processed from the Ropes Mine from 1900-1901 used a cyanide leaching process and additional gold was recovered from scraps of mercury amalgam recovered throughout the Ropes Mill buildings. Mining activity resumed from 1983-1991, but the ore was trucked off-site and out of the basin to the Humboldt Iron Mine for extraction. Throughout the earlier activities, the gold mine tailings from the Ropes Mine were deposited into Ropes Creek watershed. The mine closed in 1979. During the course of investigations by Ecological Research Services, Inc. for the Callahan Mining Company pursuant to the reopening of the Ropes Gold Mine in 1983, high levels of mercury were discovered in fish tissue, sediments, and the water column in Deer Lake (MDNR, 1987).

Investigations by the MDNR determined that Cleveland-Cliffs Iron Company, now Cliffs Natural Resources, labs disposed of assay reagents containing mercury down the drains. These wastewaters drained through the Ishpeming WWTP to Carp Creek. Cliffs immediately stopped the practice in 1981 when it was determined that their labs were the major continuing mercury source. The 1984 Consent Judgment (CJ) committed both the State of Michigan and Cliffs to a restoration plan which included drawing down the level of the Deer Lake Reservoir, eliminating the contaminated fish, slowly refilling the reservoir, and monitored recovery. The 1984 CJ is Appendix B of in the *1987 Remedial Action Plan for Deer Lake Area of Concern* (MDNR, 1987). The 2006 amendments to the 1984 CJ are intended to facilitate the long term maintenance of the completed remedial measures, provide funding for any additional remedial measures, and minimize discharges from Cliffs Shaft Mine to Carp Creek.

The natural Deer Lake basin covered approximately 90 acres. The original impoundment was formed in 1887 to provide a steady source of water for the Ropes Goldmine operations and did little to change the size of the lake. The second higher dam was built in 1912 by the Cliffs Electric Services Company (CESC) as a hydropower storage reservoir, increasing the reservoir to approximately 602 acres to provide energy and to augment winter water flows to the Cliffs iron ore processing operations in Marquette. A third higher dam was built just below the second in 1942 by the CESC, inundating the second dam, creating the current reservoir to enhance the reservoir's operational capacity. This dam remains in place and is the operating outlet for the Deer Lake reservoir. A large butterfly valve was installed for water flow control at the base of this dam. This valve now helps to control anoxic conditions in the north basin by operating as a bottom draw on the dam. Opening the valve as the lake begins to thermally stratify allows anoxic waters in the north basin to flow out the lake bottom keeping dissolved oxygen levels in the hypolimnion higher, instead of allowing all of the flow to exit through the notch at the top of the dam. The notch at the top of the dam is set to maintain the water level in the lake at 1,385 feet above sea level. The water level was agreed to between the state and the Cliffs in the 2006 amendments to the CJ. This level was agreed to be the optimal level needed to minimize the mercury methylation from the contaminated sediments remaining within the lake.

AOC Designation

In 1985, the Great Lakes Water Quality Board recommended an AOC designation for Deer Lake to the International Joint Commission. This recommendation was based on the fish consumption advisory issued by the Michigan Department of Community Health (MDCH) in 1981 for the Deer Lake reservoir that was expanded in 1982 to include Carp Creek and the Carp River. The fish consumption advisory was driven by high levels of mercury in fish tissues, water, and sediment as described in the 1987 Deer Lake RAP (MDNR, 1987).

Elevated levels of mercury in fish were discovered by Ecological Research Services, Inc. through work for the Callahan Mining Company as part of the investigation into the feasibility of reopening of the Ropes Gold Mine. The elevated levels of mercury in the fish were believed to have been primarily caused by discharges of mercury originating from the Cliffs assay labs. These labs discharged wastewater through the old Ishpeming WWTP (MDNR, 1987). Mercury discharges were curtailed in 1981 when the problem was identified (MDNR, 1987).

APPENDIX 3

2008 Guidance for Delisting
Michigan's Great Lakes Areas of Concern

Bird or Animal Deformities or Reproduction Problems

Significance in Michigan's Areas of Concern (AOC)

Seven of Michigan's AOCs are listed as either impaired or unknown status for bird and animal deformities (e.g., crossed bills) or reproductive problems (e.g., egg shell thinning), including: River Raisin, St. Clair River, Detroit River, Saginaw River/Bay, St. Marys River, Deer Lake, and Kalamazoo River.

In Saginaw River/Bay, Deer Lake, and Kalamazoo River, past studies have indicated elevated toxic chemical concentrations (e.g., mercury or PCBs) and/or some deformities in birds and other animals. In the other AOCs which list this BUI, the status is either unknown or inconclusive. In most cases, studies on bird and animal deformities have not been done. The species historically impacted are fish eating birds or animals such as bald eagles, herring gulls, common terns, mink, or otter. The contaminants associated with these impacts are primarily the persistent bioaccumulative toxics: PCBs, dioxins, DDT, and mercury.

Michigan Restoration Criteria and Assessment

Restoration of this BUI will be demonstrated using two approaches, depending on availability of data in a particular AOC. The first approach evaluates restoration based on field assessment of birds and/or other wildlife in those AOCs where Michigan Department of Environmental Quality (MDEQ) or other State-approved bird and wildlife data are available.

The second approach will be applied in those AOCs where bird and other wildlife data are not available, and uses levels of contaminants in fish tissue known to cause reproductive or developmental problems as an indicator of the likelihood that deformities or reproductive problems may exist in the AOC.

<u>Approach 1 – Observational Data and Direct Measurements of Birds and Other Wildlife</u>

- Evaluate observational data of bird and other animal deformities for a minimum of 2 successive monitoring cycles in species identified in the RAP as exhibiting these problems. If deformity or reproductive problem rates are not statistically different than inland background levels (at a 95 percent confidence interval), or no reproductive or deformity problems are identified during the two successive monitoring cycles, then the BUI is restored. If the rates are statistically different, it may indicate a source from either within or from outside the AOC. Therefore, if the rates are statistically different or the amount of data is insufficient for analysis, then:

- Evaluate tissue contaminant levels in egg, young, and/or adult wildlife. If contaminant levels are lower than the Lowest Observable Effect Level (LOEL) for that species or are not statistically different than inland control populations (at a 95 percent confidence interval), then the BUI is restored.

Data for a comparison study must come from a control site which is agreed to by the MDEQ, in consultation with Michigan Department of Natural Resources (MDNR). It will be chosen based on physical, chemical, and biological similarity to the AOC and the 2 sites must be within the same USEPA Level III Ecoregions for the Conterminous U.S.

Where direct observation of wildlife and wildlife tissue data is not available, the following approach will be used:

<u>Approach 2: Fish Tissue Contaminant Levels as an Indicator of Deformities or Reproduction Problems</u>

- If fish tissue concentrations of PCBs, dioxins, DDT, or mercury (as determined in the RAP) contaminants of concern in the AOC are at or lower than the LOEL known to cause reproductive or developmental problems in fish-eating birds and mammals, the use impairment is restored.

OR

- If fish tissue concentrations of PCBs, dioxins, DDT, or mercury in the AOC are not statistically different than the associated Great Lake (at 95 percent confidence interval), then the BUI is restored. In the connecting channel AOCs, either the upstream or downstream Great Lake may be used for comparison.

Fish of a size and species to be prey for the wildlife species under consideration must be used for the tissue data.

Rationale

Practical Application in Michigan

Bird and other animal deformities and reproductive problems have a particular challenge related to criteria for restoration:

- Most of the species involved are only part year residents in an AOC, or have a home range that may include locations outside an AOC. This makes it difficult to attribute deformities or reproductive problems to a specific location. The 2 approaches of the criteria address this.
- There is also a wide variation in how this use impairment was originally determined in Michigan's AOCs. Some AOCs had empirical data and some had anecdotal information.
- Many fish-eating birds and animals, such as eagles, are long-lived birds. Long after remedial actions have occurred and a site is restored, it is possible for reproductive effects to remain apparent.
- It is very difficult to determine actual prevalence of deformities and reproductive problems. Fox and Bowerman (in press), provide examples of this last point and detail issues with assessments of this BUI.
- In some AOCs with this BUI, the species monitored under MDEQ's wildlife monitoring program do not reside there, so no direct wildlife data are available.

Given the above practical considerations, the statewide criteria for this BUI uses two approaches – one for AOCs where wildlife data are available, and a second approach where direct wildlife information is not available. In the latter case, contaminant levels in fish tissues are used as an indicator of potential deformities or reproductive problems in the fish-eating species which have historically been impacted by contaminants (e.g., eagles, herring gulls, mink, and otter). Even in the absence of direct wildlife data, if contaminant levels in fish tissue are high, it indicates that the possibility for deformities or reproductive problems in fish-eating wildlife may be higher.

The contaminants of concern are PCBs, dioxins, DDT, and mercury and each AOC with this BUI may have one or more contaminants present. Assessment in each AOC will be based on the relevant contaminant(s).

The State will consider restoration of this BUI on a case-by-case basis for AOCs with circumstances that may not fit exactly into the process outlined above.

1991 International Joint Commission (IJC) General Delisting Guideline

When the incidence rate of deformities or reproductive problems in sentinel wildlife species do not exceed background levels in inland control populations.

The IJC general delisting guideline for the BUI is presented here for reference. The Practical Application in Michigan subsection above describes application of specific criteria for restoration based on existing Michigan programs and authorities.

State of Michigan Programs/Authorities for Evaluating Restoration

Michigan assesses water bodies throughout the state on a 5-year basin rotation plan according to the MDEQ's "Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters" (MDEQ, 1997) and "Michigan Water Quality Strategy Update" (MDEQ, 2005). Each year, a set of targeted watersheds is sampled at selected sites defined by the National Pollutant Discharge Elimination System (NPDES) permitting program for conventional and toxic pollutants, and biological and physical habitat/morphology indicators. The set of watersheds sampled rotates each year, with each major watershed in the state revisited every 5 years (see Appendix 1 for maps of the basin rotations). One element of the strategy is wildlife contaminant monitoring.

Wildlife plays an important role in monitoring water quality and ecosystem health and can be used to monitor for spatial and temporal trends in contaminant concentrations. Specific life stages may be sampled to provide discrete time units for determination of temporal trends. Specific geographic regions or watersheds may be targeted for the determination of spatial trends.

The specific objectives of the wildlife contaminant monitoring are to:

1. Determine contaminant levels in wildlife that may be exposed to contaminants from surface waters of the state.

2. Assess whether contaminant levels in fish are changing with time.

3. Evaluate the overall effectiveness of MDEQ programs in protecting wildlife from toxic contaminants.

4. Determine whether new chemicals are bioaccumulation in wildlife.

The wildlife contaminant monitoring element currently consists of two components that, in combination, provide data necessary to achieve these objectives. These components include bald eagle and herring gull egg monitoring. The bald eagle project began in 1999 and has continued each year since then. Sample collection and analysis of herring gull eggs began in 2002. Wildlife is analyzed for bioaccumulative contaminants of concern, including mercury, PCBs, and chlorinated pesticides (e.g., DDT/DDE/DDD).

Data are reviewed each year to determine whether there are additional new parameters of concern for which wildlife should be analyzed.

Another element of the State's monitoring strategy applicable to this BUI is enhanced and improved Fish Contaminant Monitoring Program (FCMP). Fish contaminant data are used to determine whether fish from waters of the state are safe for human and wildlife consumption, and as a surrogate measure of bioaccumulative contaminants in surface water. Fish tissues are analyzed for bioaccumulative contaminants of concern. These include mercury, PCBs, chlorinated pesticides (e.g., DDT/DDE/DDD), dioxins, and furans. More recently, some fish tissues have been analyzed for polybrominated biphenyl ethers (PBDEs) and perfluorooctane sulfonate (PFOS).

Fish contaminant studies needed for the assessment of this BUI restoration will be arranged by MDEQ as part of the Michigan FCMP. Timing and study design will be determined by the MDEQ based on available resources.

Some local AOC communities also have programs for monitoring water quality and related parameters which may be applicable to this BUI. If an AOC chooses to use local monitoring data for the assessment of BUI restoration, the data can be submitted to the MDEQ for review. If the MDEQ determines that the data appropriately address the restoration criteria and meet quality assurance and control requirements, they may be used to demonstrate restoration success.

APPENDIX 4

United States Fish and Wildlife Service Bald Eagle Survey Data 1963-2011

Year	Nest Occupied?	Eaglets Fledged
1963	N	0
1964	Y	0
1965	Y	0
1966	Y	0
1967	Y	0
1968	Y	0
1969	Y	0
1970	N	-
1971	Y	-
1972	N	-
1973	Y	0
1974	Y	0
1975	Y	0
1976	Y	-
1977	Y	-
1978	Y	-
1979	Y	-
1980	Y	0
1981	N	-
1982	N	-
1983	N	-
1984	Y	0
1985	N	-
1986	N	-
1987	-	-
1988	N	-
1989	-	-
1990	-	-
1991	N	-
1992	-	-
1993	-	-
1994	-	-
1995	-	-
1996	-	-
1997	Y	1
1998	Y	2

1999	Y	2
2000	Y	1
2001	Y	2
2002	Y	2
2003	Y	1
2004	Y	2
2005	Y	2
2006	Y	2
2007	Y	2
2008	Y	0
2009	Y	2
2010	Y	2
2011	Y	2

*This data is comprised of surveys of multiple nesting locations around Deer Lake. Not all nesting locations were necessarily sampled each year.

APPENDIX 5

2008 Guidance for Delisting
Michigan's Great Lakes Areas of Concern

Eutrophication or Undesirable Algae

Significance in Michigan's Areas of Concern (AOC)

Eight of Michigan's AOCs are listed as impaired due to eutrophication, including: River Raisin, Rouge River, Clinton River, Saginaw River/Bay, St. Marys River, Deer Lake, Muskegon Lake, and White Lake.

Michigan Restoration Criteria and Assessment

This Beneficial Use Impairment will be considered restored when:

- no waterbodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the most recent Clean Water Act Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report (Integrated Report), which is submitted to the United States Environmental Protection Agency (USEPA) every two years.

In addition, the MDEQ is in the process of developing nutrient criteria for state surface waters which will be adopted into Michigan's Water Quality Standards (WQS). The MDEQ will evaluate restoration of this BUI consistent with the nutrient criteria when the nutrient criteria are approved by the USEPA and adopted into rule.

Rationale

Practical Application in Michigan

The MDEQ regulates water pollution under the authority of Part 31 of the Natural Resources Environmental Protection Agency (NREPA), P.A. 451 of 1994. The AOC restoration criteria are consistent with the state's WQS, and how the State identifies waters for inclusion on the Clean Water Act section 303(d) list, which is submitted to USEPA every two years. If a waterbody exhibits growths of undesirable algae in quantities which interfere with a water body's "designated uses" as identified in rules R323.1060 and R323.1100 of the Michigan WQS (e.g., inhibits swimming due to the physical presence of algal mats and/or associated odor; inhibits the growth and production of warm water fisheries, and/or other indigenous aquatic life and wildlife), the waterbody is included on Michigan's Section 303(d) list.

1991 International Joint Commission (IJC) General Delisting Guideline

When there are no persistent water quality problems (e.g., dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.

The IJC general delisting guideline is presented here for reference. The Practical Application in Michigan subsection above describes application of specific criteria for restoration based on existing Michigan programs and authorities.

State of Michigan Programs/Authorities for Evaluating Restoration

Michigan assesses water bodies throughout the state on a 5-year basin rotation cycle according to the MDEQ's "Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters" (MDEQ, 1997) and "Michigan Water Quality Strategy Update" (MDEQ, 2005). Each year, a set of targeted watersheds are sampled at selected sites for conventional and toxic pollutants, and biological and physical habitat/morphology indicators. The set of watersheds sampled rotates each year, with each major watershed in the state revisited every 5 years. Two particularly relevant elements of the strategy are expanded and improved water chemistry monitoring and the lake monitoring program. One of the specific objectives of these programs is to determine whether nutrients are present in surface waters at levels capable of stimulating the growth of nuisance aquatic plants/algae/slimes.

Under the water chemistry monitoring program, water samples generally are analyzed for nutrients, conventional parameters (i.e., temperature, conductivity, suspended solids, pH, dissolved oxygen), total mercury, and trace metals (i.e., cadmium, chromium, copper, lead, nickel, zinc). A much smaller number of samples are analyzed for organic contaminants such as PCBs and base neutrals. Other parameters may be included as appropriate at specific locations, including observations of nuisance algae in AOCs with this impairment. Nutrients and conventional parameters may also be monitored at sites where biological data are collected during routine watershed assessments. Data are reviewed each year to determine whether additional parameters should be added, removed, or analyzed at a greater or lesser frequency.

Some local AOC communities also have programs for monitoring water quality and related parameters which may be applicable to this BUI. If an AOC chooses to use local monitoring data for the assessment of BUI restoration, the data can be submitted to the MDEQ for review. If the MDEQ determines that the data appropriately address the restoration criteria and meet quality assurance and control requirements, they may be used to demonstrate restoration success.

APPENDIX 6

Deer Lake AOC Timeline of Eutrophication and Recovery
Diane Feller, PAC Chair

Summary of activities within the Deer Lake watershed which either contributed to the degradation of or improvements in water quality:

- 1869 – Untreated sewage entered Partridge Creek, which historically flowed through what is now the city of Ishpeming, and was transported to Carp Creek.
- 1881 – Partridge Creek was dredged and widened between Main and First Streets in the city of Ishpeming to reduce flooding during heavy rains.
- April, 1890-1964 – The city of Ishpeming purchased the Carp Creek dam from the Deer Lake Iron and Lumber Company and removed it to allow floodwater and sewage that accumulated in Carp Creek during heavy rains to enter Deer Lake (LaFayette, 1977).
- 1896 – The falls on Carp Creek were blasted to lower the channel six feet and prevent sewage in the stream from "backing up" into the city of Ishpeming during high flows (Dobson, 2005).
- 1900 – Partridge Creek had been diverted into a sewer pipe beneath Third, Bank, and Front Streets in the city of Ishpeming. Brick caissons were built in the ground along the creek channel to drain surface water and lateral sewers. The creek channel was filled and a school was built in a filled portion of the old creek just west of Pine Street. (Dobson, 2005).
- 1900 and 1929 – Ishpeming constructed combined (sanitary and storm) sewers which discharged to Carp Creek. Sewage eventually flowed into the Deer Lake reservoir.
- 1929 – The city of Ishpeming constructed a large (78 inch diameter) sewer main from Front Street (beneath Division Street) to the Carp River.
- 1930s – Soap manufacturers began using "builders" to improve the cleaning efficiency of soap powders and detergents.
- 1947 – The laundry detergent "Tide," which contained the "builder" sodium tripolyphosphate was introduced throughout the United States. Tide and other "built" detergents gained widespread acceptance, and by 1953, the amount of detergent sold exceeded the amount of soap that was sold (EAI, 2006).
- 1963 – Sanitary sewers were constructed in the primary residential area of Ishpeming township.
- 1964 – Three primary (solids removal) WWTPs with chlorination were built.
    - Ishpeming township "A" Plant discharged to Carp Creek near the intersection of Copper Street and Southwood Drive in West Ishpeming.
    - The city of Ishpeming WWTP discharged to Carp Creek near the intersection of Poplar Street and North Road in Ishpeming.
    - Ishpeming township "B" Plant discharged to Carp Creek near the west end of Elm Street in Ishpeming.
- 1970 – The Michigan Water Pollution Control Board determined that the three primary WWTPs were inadequate, and recommended replacement.
- 1970 – At approximately this time, Partridge Creek was re-routed from the sewer main into mine workings (Cliffs Shaft Mine and others) beneath the city of Ishpeming, and back into Carp Creek.
- 1972 – The phosphate content of laundry detergents, which had been as great as 15 percent by weight since the late 1930s, had gradually decreased to 8.7 percent by weight.
- 1973 – The State of Michigan promulgated Administrative Rules to enforce water quality standards.
- 1975 – As part of a national study, USEPA determined that the Deer Lake reservoir was was eutrophic.
- 1977 – A study by Northern Michigan University determined that Deer Lake was

hypereutrophic (Bills, 1977). During the winter the dissolved oxygen content of the entire reservoir was less than the level recommended for fish survival (USEPA, 1986 and 2000).

- 1977 – Based on eutrophication concerns, the State of Michigan decreased the maximum phosphate content of laundry detergents to 0.5 percent by weight.
- 1984 – Construction began on a new enhanced secondary (removal of solids, organic carbon nitrogen and phosphorus) WWTP to replace the three primary WWTPs.
- 1986 – The new Ishpeming Area Joint WWTP, which is an enhanced secondary WWTP, began treating sanitary wastewater from the city of Ishpeming and Ishpeming township (MDNR, 1987). The enhanced secondary WWTP discharges to Carp Creek near the intersection of Washington Street and North Washington Street in Ishpeming.
  1986 – The city of Ishpeming completed separation of storm and sanitary sewers. Storm and sanitary sewers in Ishpeming township were not combined, and did not need to be separated.
- 1989 – Winter monitoring by the DNR demonstrated that Deer Lake had begun recovering from eutrophication. Dissolved oxygen concentrations below the ice were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 12 feet.
- 1993 – A study by Michigan State University, the MDNR and the Tokyo University of Agriculture determined that The Enhanced Secondary WWTP significantly decreased nutrient loading to the Deer Lake AOC, relative to the three Primary WWTPs that were replaced (D'Itri *et al*., 1993).
- 1995 – A study by Michigan Technological University determined that Deer Lake was mesotrophic (Kerfoot and Harting, 1995).
- 1999 and 2000 – Winter monitoring by Cleveland-Cliffs Iron Company documented additional recovery from eutrophication since 1989. Dissolved oxygen concentrations were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 18 feet.

APPENDIX 7

Technical Information on the Recovery of Deer Lake from Hypereutrophication

Deer Lake PAC Technical Committee

What is eutrophication?

Eutrophication is the process of nutrient enrichment in a water body. The main nutrients involved are phosphorus, nitrogen and sometimes carbon. For many lakes, phosphorus is the key nutrient involved in eutrophication (MDEQ, 2004). The amount of nutrients typically determines the biological productivity of a water body. Oligotrophic lakes have low concentrations of nutrients and have relatively low productivity. Mesotrophic lakes contain moderate amounts of nutrients and have moderate productivity. Eutrophic lakes contain high concentrations of nutrients, are highly productive, and can have water quality problems from the high productivity. Hypereutrophic lakes contain excessive amounts of nutrients that diminish water quality, aquatic habitat and aesthetic values.

Why is hypereutrophication a problem?

Hypereutrophication can result in several water quality problems that impair beneficial uses of the affected water body, including:

- Nuisance plant growth. Weeds in shallow water; algae blooms decrease
- water clarity. Some cyanobacteria blooms can produce potent toxins.
- Sand and gravel sediments are covered with muck (decaying algae).
- Dissolved oxygen is depleted as the excessive plant growth dies and sinks and is consumed by bacteria. Dissolved oxygen depletion can occur in the bottom water during summer in eutrophic lakes. In hypereutrophic lakes, the dissolved oxygen depletion can occur through the entire water column, especially during the winter months beneath ice cover; and
- Changes to fishery and other aquatic communities. Sensitive coldwater species such as trout, walleye, and mayflies decline or even disappear, while tolerant warm-water species such as catfish, bass, and sludge worms increase until they dominate the aquatic community.

What are the nutrient sources for the Deer Lake AOC?

The watershed is primarily forested. The main sources of phosphorus, which is a key nutrient enrichment in aquatic systems, include:

- Municipal sewage,
- weathering soils and bedrock in the watershed, and
- Storm water runoff.
- Historically, phosphorus resulted from the widespread use of phosphate “builders” to enhance the performance of laundry detergents from the 1930s into the 1970s likely contributed large amounts of phosphorus to local municipal sewage systems. Also, the primary wastewater treatment plants of that time were not efficient at removing phosphorus, so significant amounts of that nutrient entered the Deer Lake reservoir from municipal wastewater.

What measures have been taken to address nutrient sources?

- Phosphorus regulations for laundry detergents. Starting in the 1930s, the phosphate content of "built" laundry detergents was 15 percent by weight. In 1972, the phosphate content of laundry detergents had gradually decreased to 8.7 percent by weight. Based on eutrophication concerns, the State of Michigan passed legislation decreasing the maximum phosphate content of "built" laundry detergents to 0.5 percent by weight on October 1, 1977.
- Enhanced Secondary wastewater treatment. The original three municipal wastewater treatment plants (WWTPs) in the Deer Lake AOC used Primary treatment. Primary treatment typically involves the use of a bar screen and a grit chamber to remove large and small debris, respectively. A primary clarifier is also used to remove small particles and scum. Secondary treatment adds a biological process that uses bacteria to remove organic material that would create a significant biochemical oxygen demand (BOD) in the receiving water body if it were not removed. Enhanced Secondary treatment adds a process for removal of nitrogen and phosphorus as well as BOD removal. The current Ishpeming Area Joint WWTP uses enhanced secondary treatment for municipal wastewater.
- Separation of storm and sanitary sewers. In older cities such as Ishpeming, it was common to combine sanitary and storm sewers and treat all wastewater prior to discharge. During storm events the large amount of storm water could overwhelm the WWTPs and needed to be diverted. Municipal wastewater was also diverted during these storm events, so untreated sanitary wastewater entered Carp Creek during storms. The city of Ishpeming separated the sanitary and storm sewers in the early 1980s. Municipal wastewater is no longer diverted around the WWTP during storm events, so nutrients are removed from sanitary sewage at all times.

What changes in the Deer Lake AOC demonstrate that these remedies have been successful?

- Nutrient loading from municipal wastewater sources decreased significantly when the new enhanced secondary WWTP replaced the three primary WWTPs in 1986 (Table B-1). Phosphorus loading from the three primary WWTPs was calculated to be 15,960 lbs per year (USEPA, 1975). Phosphorus loading from the enhanced secondary WWTP has been measured at a yearly average of 1,711 lbs between 1987 and 1997 (Kotajarvi, 1998). Nitrogen loading from the three primary WWTPS was 69,090 lbs per year (USEPA, 1975). Current nitrogen loading from the enhanced secondary WWTP is 3,051 lbs per year. The improvements in wastewater treatment, combined with phosphorus regulation of laundry detergents, have decreased phosphorus (89 percent) and nitrogen (95 percent) loading to the Deer Lake AOC.

Table C-1. Historic and current phosphorus budgets for the Deer Lake reservoir.

Phosphorous Sources for Deer Lake	Early 1970s loading (lbs/yr)	Current loading (lbs/yr)
Precipitation[1]	140	140
Watershed[1]	2,770	2,770
City of Ishpeming WWTP	11,300[1]	1,711[2]
Ishpeming Twp. WWTP "A"	3,660[1]	0
Ishpeming Twp. WWTP "B"	1,000[1]	0
Turnover	> 1,279[3]	≤ 400[4]
Total	> 20,149	≤ 5,021

[1] Data from USEPA (1975)
[2] Data from the Ishpeming Area WWTP, which receives municipal wastewater from the city of Ishpeming and Ishpeming township (Kotajarvi, 1998)

[3] Data for the South Basin of Deer Lake from Bills (1977) were used to calculate the amount of phosphorus that was released from sediments during anoxic (oxygen- depleted) conditions in late summer and late winter. No data for the North Basin are available; hence, this value represents a minimum estimate.

[4] Data from the PAC monitoring program were used to calculate the amount of phosphorus that was released from sediments during anoxic (oxygen-depleted) conditions in late summer (anoxic conditions no longer occur during the winter). Phosphorus concentrations vary with local weather and seasons. This value represents the maximum value that was measured, which occurred in 2004 following an unusually long, hot summer that resulted in atypically large phosphorus releases, and cyanobacteria blooms in several Michigan lakes (Alexander, 2004).

Based on work by Vollenweider (1968, 1975) the USEPA has acknowledged that excessive phosphorus loading can lead to eutrophication in the current *Quality Criteria for Water* (USEPA, 1986). However, the USEPA has not promulgated a national criterion for phosphorus. Vollenweider (1975) has calculated phosphorus loading thresholds that are based on the ratio of mean depth to hydraulic residence time. The Deer Lake reservoir has a mean depth of 3.84 meters and a hydraulic residence time of 0.377 years, which equals a value of 10.19 m/year. For lakes with a mean depth to residence time of 10 m/year, Vollenweider predicts that eutrophic conditions will occur when the phosphorus load exceeds 0.63 $g/m^2/yr$. In the early 1970s, phosphorus loading was greater than 20,149 pounds per year and the average size of the Deer Lake reservoir at that time was 906 acres. These values equaled a loading rate greater than 2.50 $g/m^2/yr$, which was more than four times greater than the eutrophic threshold. In the early 1970s, the Deer Lake reservoir was clearly hypereutrophic.

The State of Michigan Water Quality Standard Rule 323.1060 for plant nutrients has set a maximum monthly average effluent concentration of 1.0 mg phosphorus per liter for point sources. The National Pollutant Discharge Elimination System (NPDES) permit (MI0044423) for the Ishpeming Area Joint WWTP has a phosphorus limit of 0.08 mg/L, which is slightly more restrictive than R 323.1060. The Ishpeming Area Joint WWTP has remained in compliance with its NPDES permit since April 1986; therefore, it is also meeting the State Standard set by R 323.1060.

The current phosphorus load of ≤5,021 pounds per year for the 1,010-acre Deer Lake (Table B-1) equals a loading rate ≤0.56 $g/m^2/yr$. The current phosphorus budget for the Deer Lake AOC is less than Vollenweider's eutrophic threshold of 0.63 $g/m^2/yr$, but is greater than the oligotrophic rate of 0.32 $g/m^2/yr$. Based on the phosphorus budget, the Deer Lake reservoir should become mesotrophic when the reservoir reaches equilibrium with the current loading. A study by Michigan Technological University described the Deer Lake reservoir as mesotrophic nine years after the new enhanced secondary WWTP became operational (Kerfoot and Harting, 1995).

Water clarity has increased, as shown by deeper secchi depths. Water clarity is affected by the amount of algae in lakes. Shallow secchi depths occur during algae blooms. The USEPA (1975) estimated that an 80 percent decrease in phosphorus loading from the municipal wastewater treatment plants would reduce the incidence and severity of nuisance algal blooms as well as provide additional protection for downstream Lake Superior. Secchi depth data are available from the 1970s (USEPA, 1975; Bills, 1977) and the PAC has measured secchi depths on a weekly basis through the summer months during 2002-2006. These secchi depths are presented in Figures C-1 and C-2 below. Secchi depths in both basins have improved (are deeper) since the 1970s. Water clarity in Deer Lake has increased, which indicates that algal blooms have decreased in response to lower nutrient loads.

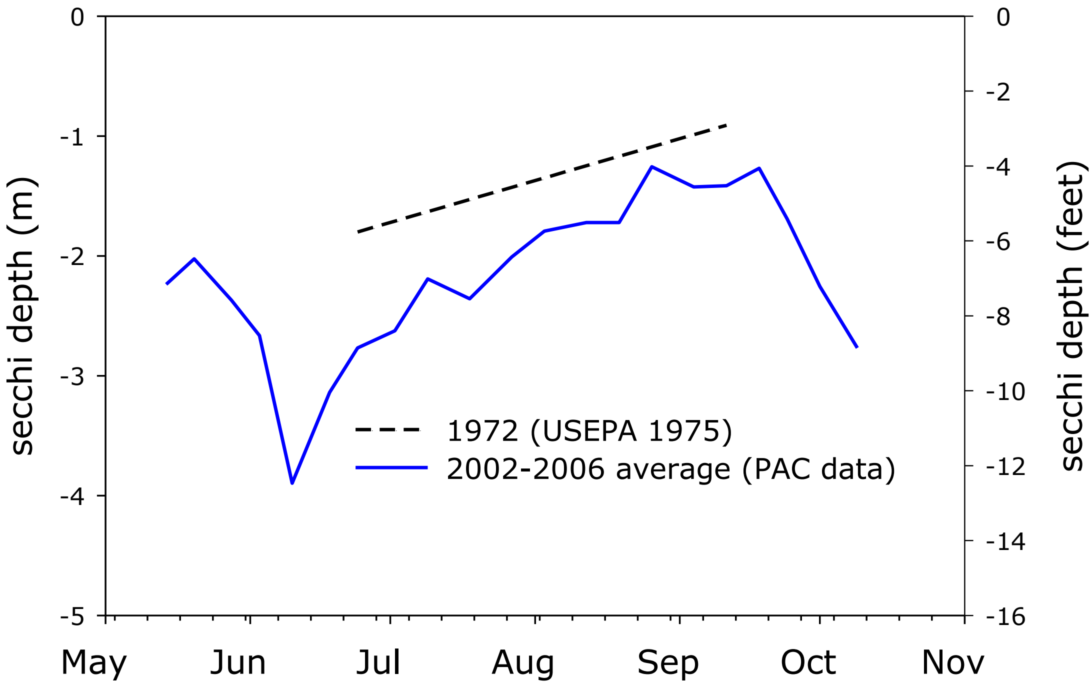


Figure C-1. Historic and current water clarity in the North Basin of the Deer Lake reservoir. The deeper position of the solid line is indicative of greater water clarity.

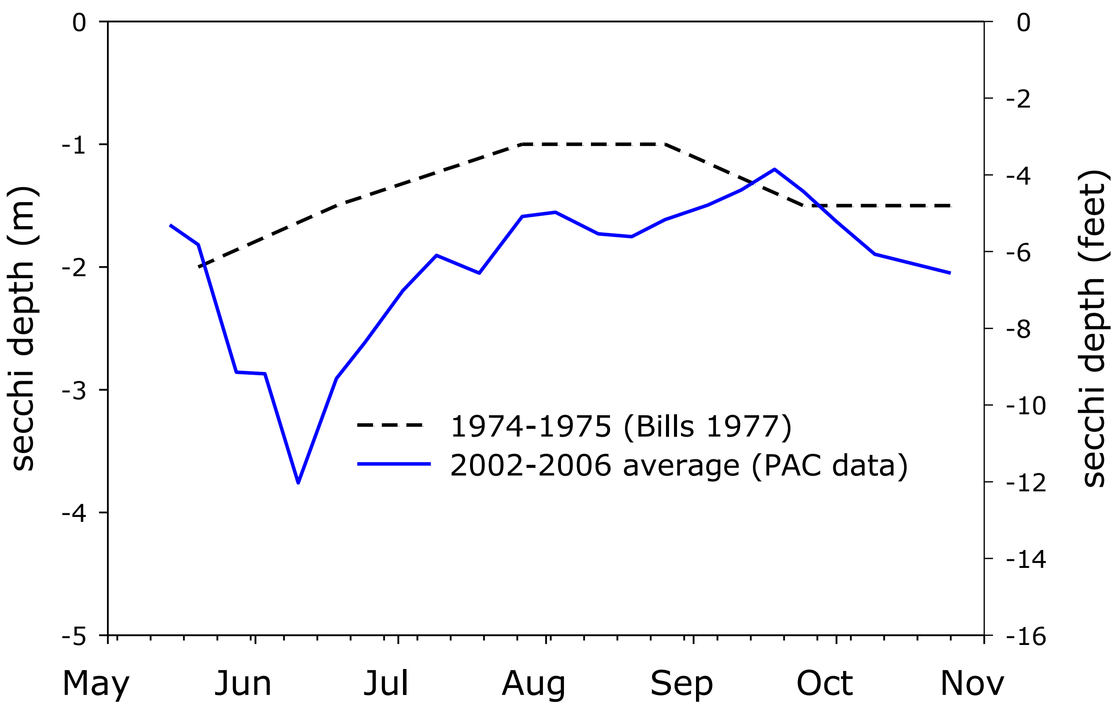


Figure C-2. Historic and current water clarity in the South Basin of the Deer Lake reservoir. The deeper position of the solid line is indicative of greater water clarity.

- One of the methods to determine the trophic status of a lake is the Trophic State Index (TSI). The TSI is based on the amount of plant material that exists in a water body (Carlson, 1977). TSI "scores" range from 0 to 100, and can be calculated from several factors, including: phosphorus, weight of algae, *chlorophyll a* (an algae pigment) or secchi depth. TSI "scores "are interpreted as summarized in Table B-2 (Carlson and Simpson, 1996).

One common method for calculating TSI "scores" is to use *Chlorophyll a* concentrations in the water body. *Chlorophyll a* is the primary pigment that algae uses to capture sunlight for photosynthesis. Therefore, *Chlorophyll a* concentrations are directly related with to algal biomass and primary productivity. The original equation for calculating a TSI based on *Chlorophyll a* (Carlson, 1977), which is used in the DEQ Cooperative Lake Monitoring Program (Bednarz, 2007) is:

$$TSI(Chl_a) = 10\left[6 - \frac{2.04 - 0.68 * \ln Chl_a}{\ln 2}\right]$$

Table C-2. Expected conditions in north temperate lakes, and corresponding Trophic State Index (TSI) values from Carlson and Simpson (1996).

TSI	Attributes	Fisheries
0-30	*Oligotrophic*: Clear water, oxygen throughout the year in the hypolimnion.	Salmonid fisheries.
30-40	Hypolimnia of shallower lakes may become anoxic.	Salmonid fisheries in deep lakes only.
40-50	*Mesotrophic:* Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
50-70	*Eutrophic:* Anoxic hypolimnia, macrophyte problems possible. Blue-green algae dominate; low water transparency; algal scums	Warm-water fisheries only. Bass may predominate.
70-100	*Hypereurophic* (light-limited productivity): Dense algae and macrophytes. Algal scums block sunlight, few macrophytes survive.	"Rough" fish (carp and bullheads) dominate; summer fish kills possible.

Chlorophyll a concentrations in the Deer Lake reservoir have decreased since the 1970s (Table B-3). The TSI "scores" that are based on *Chlorophyll a* have also decreased. In 1972, the TSI "scores" based on *Chlorophyll a* were 62 (eutrophic) for the North Basin and 65 (eutrophic) for the South Basin. In 2002, the TSI "scores" based on *Chlorophyll a* were 44 (mesotrophic) for the North Basin and 36 (between oligotrophic and mesotrophic) for the South Basin.

Table C-3. Historic and recent *Chlorophyll a* concentrations and TSI (*Chl a*) scores for the Deer Lake reservoir.

Data/Test	North Basin	South Basin
June 24, 1972 *Chlorophyll a*[1]	31.6 µg/L	54.5 µg/L
June 24, 1972 TSI (*Chl a*)	62	65
June 18-21, 2002 *Chlorophyll a*[2]	4.1 µg/L	1.8 µg/L
June 18-21, 2002 TSI (*Chl a*)	44	36

[1] Data are mean values from two depth-integrated water samples (USEPA, 1975).
[2] Data are volume-weighted means from Table 7 of Manolopoulos and Hurley (2005).

Another common method for calculating TSI "scores" is to use secchi depth data. As discussed above, secchi depth is a measure of water clarity. Algae growth will create turbidity and decrease secchi depth. Therefore, low secchi depths are indicative of algal biomass and primary productivity. The original equation for calculating a TSI based on secchi depth (Carlson, 1977*)* is:

$$TSI(SD_a) = 10\left[6 - \frac{\ln SD}{\ln 2}\right]$$

Secchi depths in the Deer Lake reservoir have increased since the 1970s (Table C-4). The TSI "scores" based on secchi depth have decreased. In 1972, the TSI "scores" based on late June secchi depth were 51 (eutrophic) for both basins of the Deer Lake reservoir. The TSI "scores" based on late June secchi depths for 2002 through 2006 were 41 (mesotrophic) for the North Basin and 40 (between oligotrophic and mesotrophic) for the South Basin. The TSI "scores" vary slightly between the *Chlorophyll a* and secchi depth methods, however, the conclusions (eutrophic in the past, mesotrophic in the present) are the same regardless of which technique is used.

Table C-4. Historic and recent Secchi depths and TSI (SD) scores for the Deer Lake reservoir.

Date/Test	North Basin	South Basin
June 24, 1972[1]	1.8 m	1.8 m
June 24, 1972 TSI (SD)	51	51
June 24, 2002-2006[2]	2.8 m	2.5 m
June 24, 2002-2006 TSI (SD)	41	40

[1] Data from USEPA (1975).

[2] Data are mean values for secchi depths measured between June 20, and 28, of the years 2002-2006 in the PAC monitoring program. These dates are within four days of June 24.

- Dissolved oxygen concentrations in Deer Lake during late winter have improved significantly since the 1970s. The end of winter is a time when dissolved oxygen conditions can be diminished in hypereutrophic lakes because: 1) there has been no direct contact between the water column and the atmosphere for five months. Oxygen has been delivered with tributary waters but there has been no diffusion from the atmosphere; and 2) snow cover on the lake blocks much of the sunlight penetration, so in-lake production of oxygen from photosynthesis has been minimal for several months. Therefore, by late winter, respiration and other processes that consume oxygen have continued under the ice and snow, while the processes that produce oxygen have been minimal.

In 1975 and 1982 dissolved oxygen concentrations were depleted throughout the entire Deer Lake reservoir (Figures C-3 and C-4). Based on the data collected by Bills (1977), there was insufficient oxygen for fish survival in the water column in much of Deer Lake; however, the reservoir supported a perch and pike fishery. The dissolved oxygen profile for 1989 showed a significant improvement in comparison with the 1975 and 1982 profiles. Most of the water column in the South Basin contained enough oxygen for fish survival. In 1999 and 2001 there was continued improvement in the dissolved oxygen content of the lower part of the water column of the South Basin. In the North Basin most of the water column contained sufficient oxygen for fish survival (Figure C-3). In 2005 and 2006 dissolved oxygen concentrations had increased even more in the deep waters of both basins.

Both the MDEQ (1994) and the USEPA (1986) have promulgated water quality standards for dissolved oxygen in fresh waters (USEPA, 1986). The State of Michigan Water Quality Standard supersedes the USEPA criteria. The USEPA criteria are based on worst-case scenarios for waste load allocation, and are included here for reference purposes because they contain information about how dissolved oxygen concentrations affect aquatic communities. The three water quality standards presented in this document are:

- The Michigan Water Quality Standard for dissolved oxygen in inland, non-trout lakes is 5.0 mg/L throughout the epilimnion during stratification (R 323.1065). This standard will protect fish survival and productivity (growth) as described by USEPA (1986, 2000). Like most north temperate lakes, the Deer Lake reservoir is stratified during the summer (typically mid-June through early October) and during the winter (late October through late April). In the winter, the lake is stratified, but there is no defined epilimnion (upper, wave-mixed layer) so the interpretation of the 5.0 mg/L standard in the deep water of winter-stratified lakes is unclear.
- The 7-day mean minimum USEPA Criterion for dissolved oxygen in freshwater is 4.0 mg/L, which will protect fish survival, but the growth of sensitive species of fish and invertebrates may be impaired (USEPA, 1986); and
- The one-day minimum USEPA Criterion for dissolved oxygen in freshwater is 3.0 mg/L. The 3.0 mg/L criterion is based on protecting the survival of sensitive fish species during brief exposures to low dissolved oxygen. Dissolved oxygen concentrations less than 3.0 mg/L can be lethal to sensitive species of fish and invertebrates (USEPA, 1986). In lakes and reservoirs, fish will typically avoid areas that have low dissolved oxygen and will survive.

The dissolved oxygen profiles in Figures C-3 and C-4 document the improvements in winter conditions in the Deer Lake reservoir over a thirty-year period. Currently, the Michigan dissolved oxygen Standard of 5.0 mg/L is met in all but the deepest areas of the reservoir even during the extreme conditions of late winter stratification. Most of the volume of Deer Lake is favorable for the survival and growth of aquatic life during worst-case conditions.

The current dissolved oxygen profiles in the Deer Lake reservoir are very similar to those observed in other central Upper Peninsula lakes (Figures C-5 and C-6). Michigan and other States commonly use information from other water bodies within an ecoregion as reference information regarding the condition of a subject water body. With specific reference to the AOC process, the Michigan Guidance (MDEQ, 2008) recommends using water bodies within the same USEPA Level III Ecoregion. The Deer Lake reservoir lies within *Ecoregion 50. Northern Lakes and Forests* (USEPA, 2003), which covers all of Northern Michigan and Wisconsin, and most of Northern Minnesota (Omernik, 1987). The geographic scale of the Level III Ecoregions is too large to be practical for the purpose of selecting lakes that are very similar to the Deer Lake reservoir. Therefore, the much smaller scale Ecoregion Subsection that is described by the US Forest Service (Albert, 1995) and is used for wetland mitigation banking in Michigan (MDEQ, 2003) was used to identify lakes to compare with the Deer Lake reservoir for this document.

The Deer Lake Reservoir is within the Michigamme Highland (IX.2) Ecoregion Subsection, which is characterized by: large areas of exposed Precambrian bedrock; acidic, sandy soils; hardwood or coniferous forests in upland areas and coniferous forests in wetland areas (Albert, 1995). DO profiles were measured in selected Michigamme Highland lakes during the peak of stratification in winter (Figure C-5) and summer (Figure C-6). Of the selected Mighigamme Highland lakes, only Goose Lake (and Deer Lake) received nutrients from municipal sewage. Craig Lake is located within a wilderness area. The remaining Michigamme Highland lakes have typical lakeshore development and watershed land use for the region, and represent typical (reference) conditions for the Deer Lake reservoir.

Currently, dissolved oxygen profiles during peak winter and summer stratification are similar in Deer Lake reservoir and other Michigamme Highlands lakes (Figures C-5 and C-6). At the peak of winter stratification, nearly all Michigamme Highland lakes have some dissolved oxygen depletion below a depth of 4 meters (13 feet); only Lake Michigamme maintains dissolved oxygen concentrations above 5 mg/L throughout the full water column.

Lake Michigamme is much larger and deeper than the other lakes, which provides greater nutrient absorption capacity. The most oxygen depletion in both summer and winter occurred in Craig Lake, which is a wilderness lake.

At the peak of summer stratification, the epilimnia of four Michigamme Highland lakes (plus both basins of Deer Lake) showed some oxygen depletion, while the epilimnia for the other five lakes maintained dissolved oxygen concentrations above 5 mg/L (Figure C-6). The epilimnia of Beaufort Lake, Craig Lake, both basins of Deer Lake, Greenwood Reservoir, and Lake Independence (which were not stratified) maintained 5 mg/L dissolved oxygen concentrations in at least the upper 4 meters (13 feet) of the water column. Teal Lake and Fish Lake exhibited the most consistent dissolved oxygen concentrations throughout the epilimnia, which indicates they were very well-mixed. Teal and Fish Lakes are among the smallest lakes sampled and would have been most easily mixed by wind-driven waves.

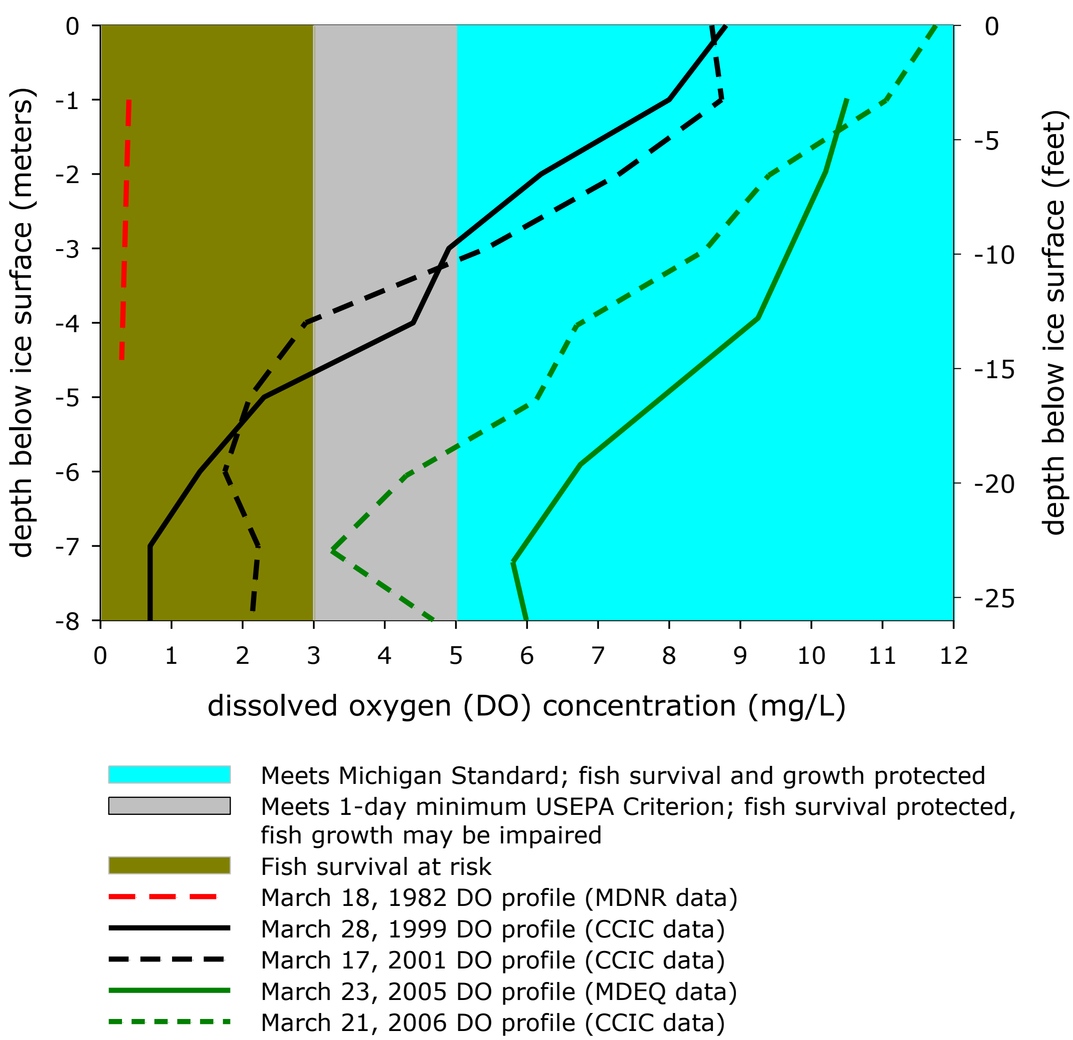
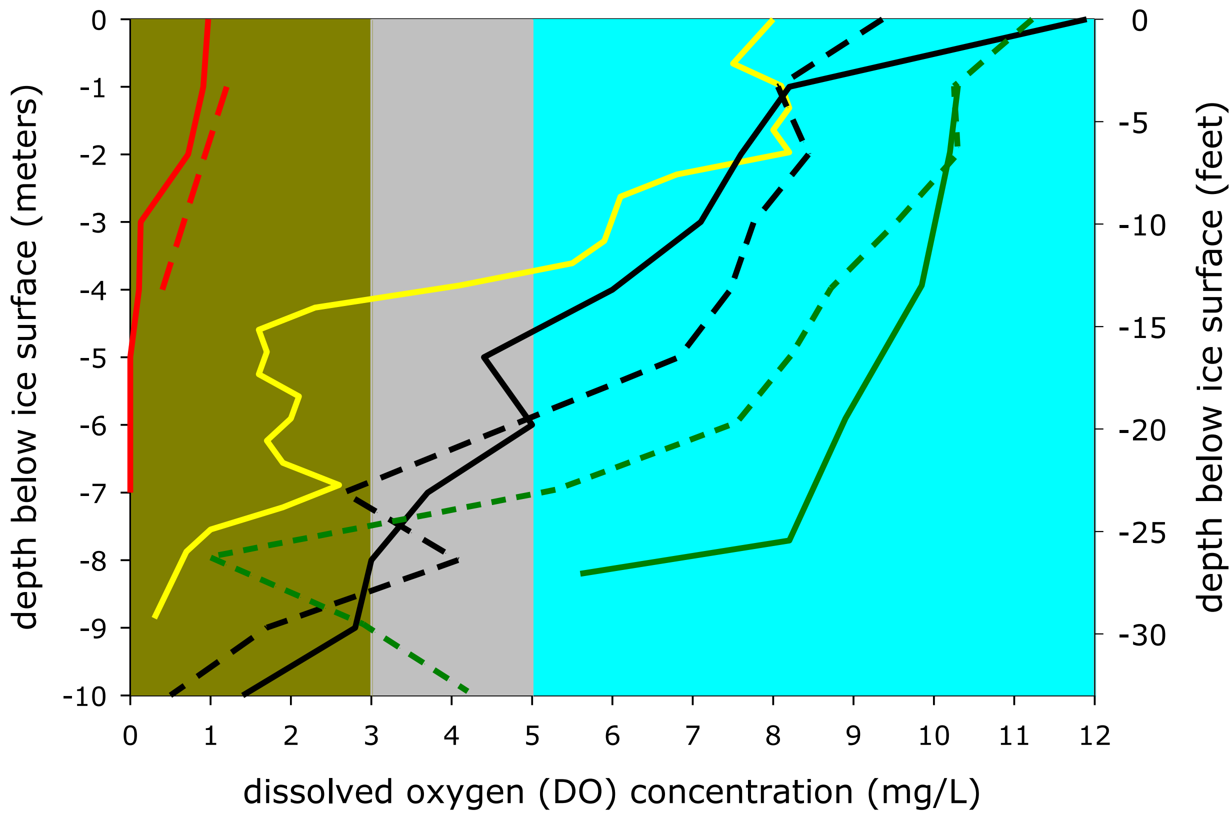


Figure C-3. Historic and recent winter dissolved oxygen profiles in the North basin of the Deer Lake reservoir.



Meets Michigan Standard; fish growth & survival are protected
Meets 1-day minimum USEPA Criterion; fish survival protected, fish growth may be impaired
Fish survival at risk
February 23, 1975 DO profile (Bills 1977 data)
March 18, 1982 DO profile (MDNR data)
April 3, 1989 DO profile (MDNR data)
March 27, 1999 DO profile (CCIC data)
March 17, 2001 DO profile (CCIC data)
March 22, 2005 DO profile (MDEQ data)
March 21, 2006 DO profile (CCIC data)

Figure C-4. Historic and recent winter dissolved oxygen profiles in the South basin of the Deer Lake reservoir.

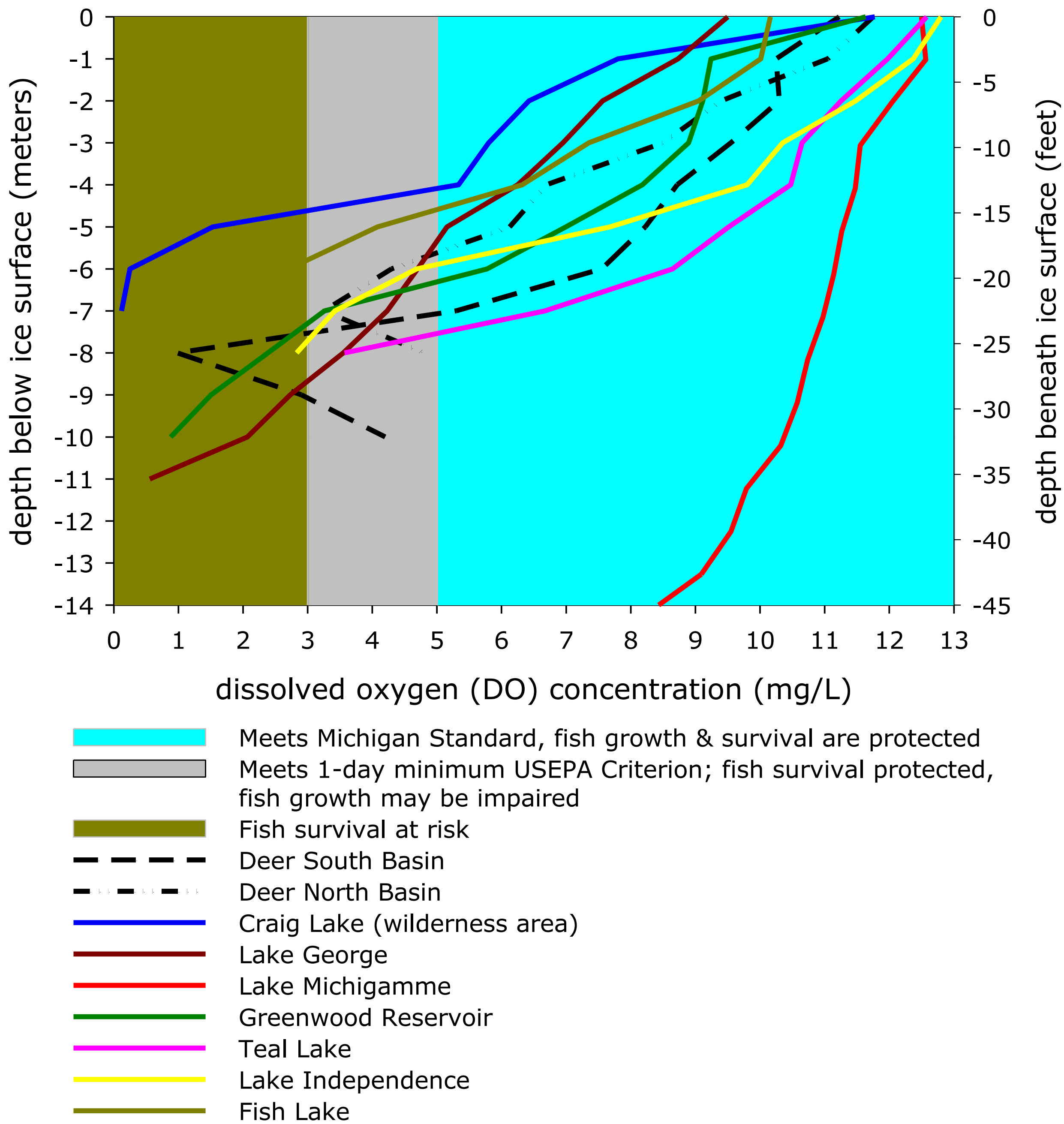


Figure C-5. Dissolved oxygen profiles in March 2006 for the Deer Lake reservoir and other large lakes in the Michigamme Highland (IX.2) Ecoregion Subsection.

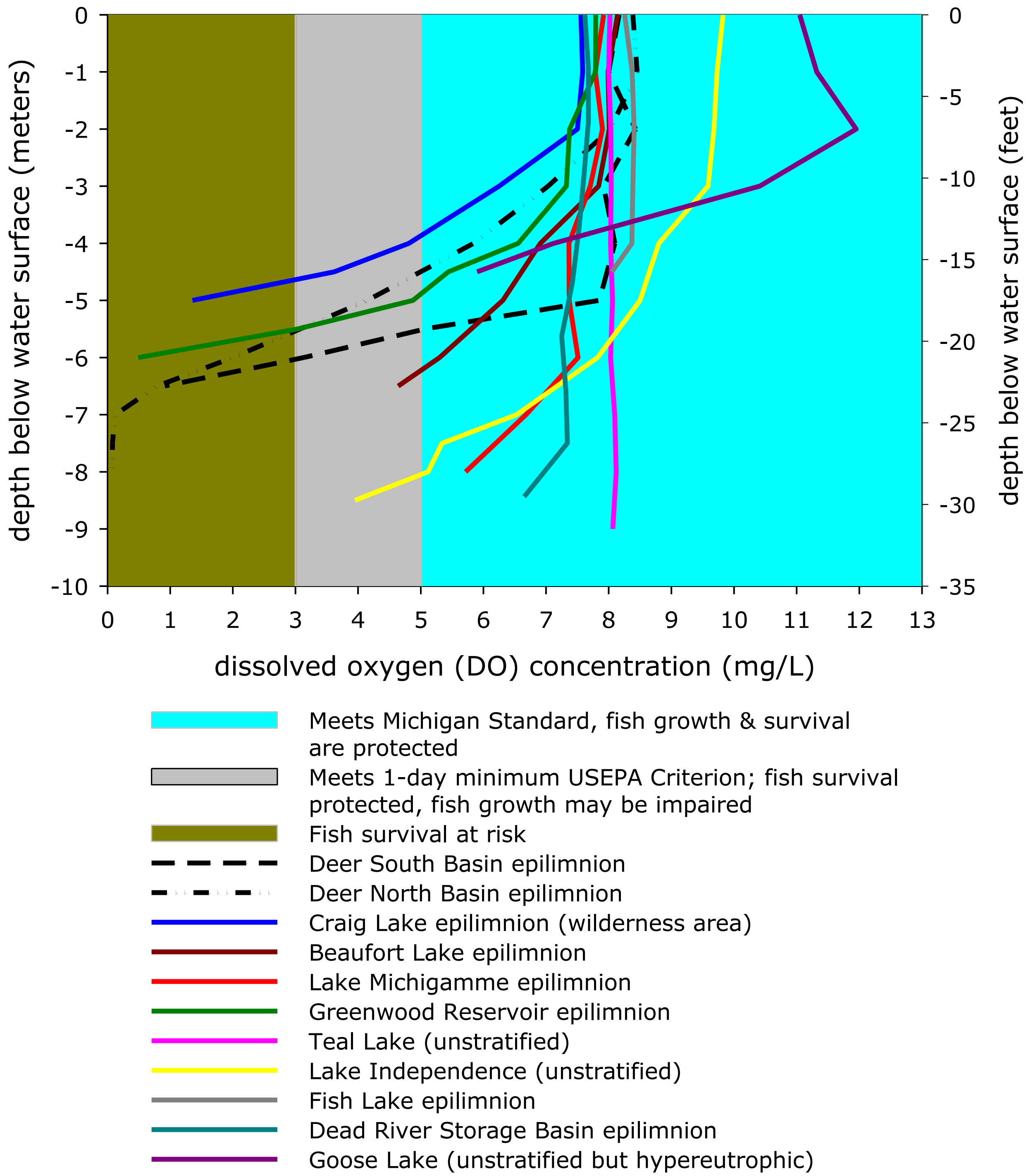


Figure C-6. Epilimnetic dissolved oxygen profiles in September 2006 for the Deer Lake reservoir and other large lakes in the Michigamme Highland (IX.2) Ecogegion Subsection.

APPENDIX 8

2008 Guidance for Delisting
Michigan's Great Lakes Areas of Concern

Restrictions on Fish and Wildlife Consumption

Significance in Michigan's Areas of Concern

Fish and wildlife consumption advisories in Michigan are determined by the Michigan Department of Community Health (MDCH) based on levels of contaminant concentrations in fish or wildlife tissue. Currently all of Michigan's 14 AOCs have consumption advisories for specific contaminants in certain species of fish. No AOCs have advisories for wildlife consumption. Fish consumption advisories range from no human consumption to restrictions on consumption for specific amounts of fish for certain human populations.

Almost all fish consumption advisories are based on levels of polychlorinated biphenyls (PCBs) or mercury which exceed MDCH guidelines. Excessive levels of dioxin result in fish consumption advisories in the Saginaw River/Bay/River AOC and in the Detroit River AOC. Excessive chlordane is causing fish consumption advisories in the White Lake AOC. Other non-AOC locations in Michigan also have various consumption advisories for these contaminants. There is a statewide consumption advisory for certain fish in all inland lakes due to mercury contamination.

Michigan Restoration Criteria and Assessment

The restoration criteria for this BUI uses a tiered approach for evaluating restoration success. This BUI will be considered restored when:

1. The fish consumption advisories in the AOC are the same or less restrictive than the associated Great Lake or appropriate control site.

OR, if the advisory in the AOC is more stringent than the associate Great Lake or control site:

2. A comparison study of fish tissue contaminant levels demonstrates that there is no statistically significant difference in fish tissue concentrations of contaminants causing fish consumption advisories in the AOC compared to a control site.

OR, if a comparison study is not feasible because of the lack of a suitable control site:

3. Analysis of trend data (if available) for fish with consumption advisories shows similar trends to other appropriate Great Lakes trend sites.

When comparison studies (per #2 above) are used to demonstrate restoration of a BUI, the studies will:

- Be designed to control variables known to influence contaminant concentrations such as species, size, age, sample type, lipids and other relevant variables from the examples in the MDEQ's Fish Contaminant Monitoring Program (FCMP).

- Include a control site which is agreed to by the MDEQ, in consultation with the PAC. It will be chosen based on physical, chemical, and biological similarity to the AOC, and the 2 sites must be within the same USEPA Level III Ecoregions for the Conterminous U.S. (see references). When a single control site cannot be found, sites may be pooled for comparisons. Where mercury concentrations in fish tissue cause waterbody specific advisories in lakes, the comparison may be made to the concentrations causing the general inland lake advisory.

- Use fish samples collected from the AOC and control site within the same time frame (ideally 1 year).

- Evaluate contaminant levels in the same species of fish from the AOC and the control site to avoid problems with cross-species comparisons. In addition, fish used for comparison studies should be the same species as the consumption advisory.

If there is no statistically significant difference (alpha = 0.05) in fish tissue concentrations of contaminants causing advisories in the AOC compared to a control site, then the BUI has been restored. If there is a significant difference between the AOC and the control site in the comparison study, then an impairment still exists.

If a comparison study is not practical for the AOC due to the lack of an appropriate control site, then trend monitoring data (if available) can be used to determine restoration success (as per approach #3 above). This is likely to be the approach used to evaluate this BUI in the connecting channel AOCs, where there are not appropriate control sites for a comparison study, and where MDEQ has substantial trend monitoring data. If MDEQ trend analysis of fish with consumption advisories shows similar trends to other appropriate MDEQ-approved Great Lakes trend sites, this BUI will be considered restored. If trend analysis does not show similarity to other appropriate Great Lakes trends sites, then an impairment exists.

No AOCs have advisories for wildlife consumption. However, if a wildlife restriction is issued at a later time within an AOC with the Fish and Wildlife Consumption BUI, the process for assessing restoration of the wildlife restriction will be similar to the process outlined above for fish consumption.

Rationale

Practical Application in Michigan

Restoration of the fish consumption advisory BUI is based on comparison of fish consumption advisories and tissue concentrations in the AOC with the associated Great Lake or other appropriate control site, not whether or not fish advisories exist in the AOCs or control site.

Comparison of advisories or tissue concentrations to a control site is used because some fish consumption advisories are issued statewide or are due to sources outside an AOC. Because the existence of an advisory may not be due to contaminant sources in an AOC, it should not preclude removal of this BUI. A more stringent advisory in the AOC than the associated Great Lake is an indication that there may be an ongoing contaminant issue within the AOC. In this case, additional source assessment may be conducted to determine whether there are sources of contamination within the AOC (e.g., caged fish studies).

The MDEQ will consider restoration of this BUI on a case by case basis for AOCs with circumstances that do not fit exactly into the evaluation steps outlined above.

1991 IJC General Delisting Guideline

When contaminant levels in fish and wildlife populations do not exceed current standards, objectives, or guidelines, and no public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels in fish and wildlife must not be due to contaminant input from the watershed.

The IJC general delisting guideline for the BUI is presented here for reference. The Practical Application in Michigan subsection above takes the general guideline and applies specific criteria for restoration based on existing Michigan programs and authorities.

State of Michigan Programs/Authorities for Evaluating Restoration

Michigan assesses water bodies throughout the state on a 5-year basin rotation plan according to the MDEQ's "Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters" (MDEQ, 1997) and the "Michigan Water Quality Strategy Update" (MDEQ, 2005). Each year, a set of targeted watersheds are sampled at selected sites defined by the National Pollutant Discharge Elimination System (NPDES) permitting program for conventional and toxic pollutants, and biological and physical habitat/morphology indicators. The set of watersheds sampled rotates each year, with each major watershed in the state revisited every 5 years (see Appendix 1 for basin rotation maps). One element of the State's monitoring strategy is the enhanced and improved FCMP.

The specific objectives of the FCMP are to:

1. Determine whether fish from the waters of the state are safe for human consumption.

2. Measure whole fish contaminant concentrations in the waters of the state.

3. Assess whether contaminant levels in fish are changing with time.

4. Assist in the identification of waters that may exceed standards and target additional monitoring activities.

5. Evaluate the overall effectiveness of MDEQ programs in reducing contaminant levels in fish.

6. Identify waters of the state that are high quality.

7. Determine if new chemicals are bio-accumulating in fish from Michigan waters.

The FCMP element consists of several components that, in combination, provide data necessary to achieve these objectives. These include:

- Edible fish portion monitoring to support the establishment or delisting of fish consumption advisories;
- Native whole fish trend monitoring;
- Periodic evaluations to expand and improve the State's fish trend monitoring network; and
- Caged fish monitoring for source/problem identification.

Fish contaminant data are used to determine whether fish from waters of the state are safe for human and wildlife consumption, and as a surrogate measure of bioaccumulative contaminants in surface water. Fish tissues are analyzed for bioaccumulative contaminants of concern. These include mercury, PCBs, chlorinated pesticides (e.g., DDT/DDE/DDD), dioxins, and furans. More recently, some fish tissues have been analyzed for polybrominated biphenyl ethers (PBDEs) and perfluorooctane sulfonate (PFOS). Data are reviewed each year to determine whether there are additional new parameters of concern for which the fish should be analyzed.
Fish contaminant studies needed for the assessment of this BUI restoration will be arranged by MDEQ as part of the Michigan FCMP. Timing and study design will be determined by the MDEQ based on available resources.

Some local AOC communities also have programs for monitoring water quality and related parameters which may be applicable to this BUI. If an AOC chooses to use local monitoring data for the assessment of BUI restoration, the data can be submitted to the MDEQ for review. If the MDEQ determines that the data appropriately addresses the restoration criteria and meets quality assurance and control requirements, they may be used to demonstrate restoration success.

Deer Lake Area of Concern
Public Advisory Council
490 Deer Lake Road
Ishpeming, Michigan 49849

August 15, 2011

Ms. Stephanie Swart, AOC Coordinator
Office of the Great Lakes
Michigan Department of Environmental Quality
525 West Allegan Street
Lansing, Michigan 48909

Re: Support for BUI Removals – Eutrophication or Undesirable Algae and Bird or Animal Deformities or Reproduction Problems

Dear Ms. Swart:

The purpose of this letter is to indicate the continued support of the Deer Lake Public Advisory Council (PAC) for the removal of the Eutrophication or Undesirable Algae and the Bird or Animal Deformities or Reproduction Problems Beneficial Use Impairments (BUIs) for the Deer Lake Area of Concern (AOC). At a meeting on August 11, 2011 the PAC unanimously passed a motion supporting the removal of these BUIs. The Deer Lake PAC has been involved in the review of the available information for both BUIs and is in agreement with the July 18, 2011 Bird or Animal Deformities or Reproduction Problems BUI document and the August 2, 2011 Eutrophication or Undesirable Algae BUI document.

If you have any questions regarding our support of the removal of these BUIs please do not hesitate to contact us. We value our partnership with the AOC Program and look forward to continuing good work at Deer Lake and hearing the good news on the BUI removals.

Sincerely,

Diane K Feller

Diane Feller, PAC Chair
Deer Lake Area of Concern
(906) 486-9967

cc: Mr. Pete Nault, Vice Chair, Deer Lake PAC
Ms. Michelle Jarvie, Secretary, Deer Lake PAC

Eat Safe Fish from Michigan's Areas of Concern

Michigan's AOCs in 2012

Areas of Concern (AOCs)

In the 1980s, the United States and Canadian governments identified 43 places in the Great Lakes region that had severe, long-term environmental problems. These places are called *Areas of Concern*.

People in federal, state, and provincial government environmental remediation programs are working to address the problems in these areas. Funding and expert guidance are provided to AOCs to help local groups, known as Public Advisory Councils (PACs), work on these environmental problems, as well.

Beneficial Use Impairments (BUIs)

These environmental problems are called *beneficial use impairments.* There are 14 categories of BUIs, originally named in the U.S.-Canadian Great Lakes Water Quality Agreement. However, a place does not have to have all 14 problems to be called an AOC.

Each BUI has goals that need to be met in order to be removed from the AOC's list of problems. Once all BUIs are removed from the list, the AOC is considered to be no longer impaired and can be *delisted,* or removed from the list of AOCs.

The 14 BUIs that an AOC can have are:

- Restrictions on Fish and Wildlife Consumption
- Tainting of Fish and Wildlife Flavor
- Degraded Fish and Wildlife Populations
- Fish Tumors or Other Deformities
- Loss of Fish and Wildlife Habitat
- Degradation of Benthos
- Degradation of Aesthetics
- Beach Closings
- Added Costs to Agriculture or Industry
- Restrictions on Dredging Activities
- Eutrophication or Undesirable Algae
- Restrictions on Drinking Water Consumption or Taste and Odor Problems
- Bird or Animal Deformities or Reproductive Problems
- Degradation of Phytoplankton and Zooplankton Populations

Over the years, several BUIs have been removed from Michigan's AOCs, as citizens, industries, and government joined together to improve our state's environmental health. In fact, after decades of hard work, some Michigan AOCs only have one or two BUIs remaining and are getting closer to being delisted.

Restrictions on Fish Consumption BUI

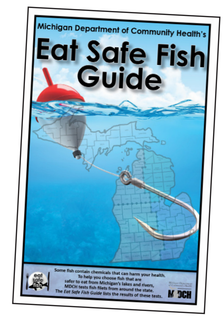
If an AOC has a ***Restrictions on Fish Consumption BUI***, it means that the fish from the affected lake or river at one time had higher levels of chemicals than fish in similar lakes or rivers in the Great Lakes region.

In most cases, the process to remove the Fish Consumption BUI is fairly direct. Chemical levels in fish from the AOC are compared to levels in fish from outside of the AOC. The BUI can be removed from the AOC's list of problems when:

- the levels of chemicals found in fish from the AOC are the same or less than fish from a similar location that is not an AOC, or
- the levels of chemicals in fish from the same lake or river have decreased over time. This process is used if there isn't a similar enough location outside of the AOC to use as a comparison.

Each AOC has their own process for BUI removal in place. The final decision to remove the BUI depends on the process that the PAC and the Michigan Department of Environmental Quality agree upon.

Michigan Department of Community Health *Eat Safe Fish Guide*



The ***Eat Safe Fish Guide*** is put out by the Michigan Department of Community Health (MDCH). This guide lists all of the fish species that have been tested from lakes and rivers throughout Michigan. MDCH tests only the filet of the fish for chemicals like PCBs, dioxins, and mercury. They use this information to develop the safe fish eating guidelines printed in the *Eat Safe Fish Guide*.

Fish with chemicals in their bodies are not just found in AOCs, but also in the other thousands of lakes and rivers throughout Michigan. If you eat a lot of Michigan fish, are young and/or have health problems, you can use the *Eat Safe Fish Guide* to find fish that are lower in chemicals and safer for you to eat. You can get a free copy of the *Eat Safe Fish Guide* from MDCH by calling 1-800-648-6942 or visiting www.michigan.gov/eatsafefish.

BUIs and Eat Safe Fish Guidelines are NOT the same.

- ***Fish Consumption BUIs*** compare chemical levels in fish from the AOC to chemical levels in fish that are not in an AOC. When these levels are similar - meaning the amount of chemicals in fish from the AOC are little different than those from other lakes and rivers in the state that are not in an AOC - then the BUI can be removed.
- The ***MDCH Eat Safe Fish Guide*** helps you find safer fish to eat from Michigan lakes and rivers. MDCH tests filets of fish for chemicals from locations all around the state. The *Eat Safe Fish Guide* can help you find safer fish to eat in lakes and rivers throughout Michigan, not just in the AOC.

When the Fish Consumption BUI is removed from an AOC's list of problems, fish from the lake or river will still be tested and listed in the ***MDCH Eat Safe Fish Guide*** for some time after.

Michigan lakes and rivers are improving thanks to federal and state environmental rules and the hard work of the US Environmental Protection Agency, the MDEQ, and the PACs, but it will take many years for these chemicals to leave the ecosystem and the fish.

To learn more about AOCs & BUIs:

MDEQ - Office of the Great Lakes

517-335-3168

www.michigan.gov/aocprogram

To learn more about eating safe fish:

MDCH - Division of Environmental Health

1-800-648-6942

www.michigan.gov/eatsafefish

ATTACHMENT C

STATE OF MICHIGAN
DEPARTMENT OF COMMUNITY HEALTH
LANSING

RICK SNYDER
GOVERNOR

JAMES K. HAVEMAN
DIRECTOR

July 30, 2013

Stephanie Swart, Deer Lake AOC Coordinator
Michigan Department of Environmental Quality
525 West Allegan
Lansing, Michigan 48909

Dear Ms. Swart:

The Michigan Department of Community Health (MDCH) concurs with the findings presented in the Michigan Department of Environmental Quality's (MDEQ) staff report entitled *"Temporal Trends in Deer Lake Fish Tissue Mercury Concentrations"* (June 2013). The MDEQ's analysis demonstrates long-term temporal declining trends of mercury concentrations in fish tissue samples and meets the third removal criterion for the Restrictions on Fish Consumption Beneficial Use Impairment (BUI) cited in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern*.

> "Analysis of trend data (if available) for fish with consumption advisories shows similar trends to other appropriate Great Lakes trend sites."

The MDCH, therefore, supports the MDEQ in their efforts to remove the Fish Consumption BUI for Deer Lake.

In addition, MDCH will relax the fish consumption guidelines for Deer Lake in the 2013-2014 *Eat Safe Fish Guide* from the most restrictive *Do Not Eat Any Species* category to the *Limited* category for northern pike, walleye, and perch. MDCH recognizes that healthy adults may safely eat one or two meals per year of fish in the *Limited* category, but cautions that women of childbearing age, young children, or adults with a chronic health condition should not eat these fish.

Carp River and Carp Creek have historically carried a *Do Not Eat* fish advisory for most species of fish. MDCH has also relaxed consumption recommendations for both of these waterbodies.

MDCH is appreciative of the funding provided by the Environmental Protection Agency's Great Lakes Restoration Initiative that financed these assessments. MDCH also lauds the continued efforts of the MDEQ to remediate Michigan's Areas of Concern.

Sincerely,

David R. Wade, Ph.D.
Director, Division of Environmental Health

ATTACHMENT D

Deer Lake Area of Concern
Public Advisory Council
490 Deer Lake Road
Ishpeming, Michigan 49849

November 5, 2013

Ms. Stephanie Swart, AOC Coordinator
Office of the Great Lakes
Michigan Department of Environmental Quality
525 West Allegan Street
Lansing, Michigan 48909

Re: Support for Beneficial Use Impairment (BUI) Removal – Restrictions on Fish and Wildlife Consumption

Dear Ms. Swart:

The purpose of this letter is to indicate the continued support of the Deer Lake Public Advisory Council (PAC) for the removal of the Restrictions on Fish and Wildlife Consumption BUI for the Deer Lake Area of Concern (AOC). At a meeting on November 5, 2013 the PAC unanimously passed a motion supporting the removal of these BUIs. The Deer Lake PAC has been involved in the review of the available information for both BUIs and is in agreement with the September 26, 2013 Restrictions on Fish and Wildlife Consumption BUI document.

If you have any questions regarding our support of the removal of this last BUI please do not hesitate to contact us. We value our partnership with the AOC Program and look forward to continuing good work at Deer Lake and moving forward in the delisting process.

Sincerely,

Diane K Feller

Diane Feller, PAC Chair
Deer Lake Area of Concern
(906) 486-9967

cc: Mr. Pete Nault, Vice Chair, Deer Lake PAC
Mr. Rob Beranek, Secretary, Deer Lake PAC

MI/DEQ/WRD-13/018
REVISED DECEMBER 27, 2013

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
AUGUST 2013

STAFF REPORT

TEMPORAL TRENDS IN DEER LAKE FISH TISSUE MERCURY CONCENTRATIONS 1984-2011

INTRODUCTION

Deer Lake is a 900 acre impoundment of the Carp River in Marquette County near Ishpeming, Michigan (Figure 1). Carp Creek is a tributary to the Deer Lake impoundment. The Carp Creek, Deer Lake, Carp River system was designated as an Area of Concern (AOC) by the International Joint Commission, Great Lakes National Program Office, and State of Michigan, in part, because of elevated levels of mercury in fish tissue. The Michigan Department of Public Health (now the Department of Community Health) issued a "no consumption" advisory for fish from Carp Creek, Deer Lake, and the Carp River in 1981. The "no consumption" advisory remains in effect for Deer Lake but has been relaxed for selected species from Carp Creek and Carp River.

Iron mining activities were the major source of mercury to the Deer Lake system. Mercury contained in blasting caps residues from the mines and reagents from the mine laboratory were released into the sewer system or washed into Carp Creek and ultimately into Deer Lake (Michigan Department of Natural Resources (MDNR), 1987). In addition, wastes from gold mining activity on the northwest shore of Deer Lake contributed mercury to the system. Over time, the contaminant built up to high levels in the Deer Lake sediments and aquatic biota.

Major mercury discharges from the Ishpeming Wastewater Treatment Plant ended in 1981 although there were also significant inputs from the watershed [illegible]. A study conducted in 2000 by Michigan State University estimated that mercury concentrations in Deer Lake surficial sediments would return to background levels in the year 2024 as existing sediments are gradually buried through natural processes (Fett et al., 2003).

Mercury in fish from the Deer Lake AOC has been monitored frequently since 1984. Concentrations of mercury in fillets of walleye and northern pike from Deer Lake collected in 1999 were higher than in fillets from those species collected from Greenwood Reservoir and [illegible] Lake, which have similar water and limnological characteristics (Day, 2000). Monitoring results since 1999 suggest that mercury concentrations in Deer Lake fish have been gradually declining. The purpose of this report is to determine the statistical significance of changes in fish tissue mercury concentration over the monitoring period.

SUMMARY

1. Fillet samples of brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011 [illegible] 201 fillets [illegible] analyzed for total mercury.
2. Northern pike were collected from Deer Lake on 11 dates, walleye on 10 dates, and yellow perch on 8 dates; these data were sufficient for the evaluation of temporal trends in Deer Lake fish tissue mercury concentration.

The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

Mercury concentration generally increases with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average rate of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations in a standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in a standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were less sufficient to evaluate temporal trends but samples of those species were collected regularly over the time period; conclusions based on those species are not final. Data for other species from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collections was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to mercury contamination and historically have had significantly higher concentrations of mercury. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

The MDEQ fish contaminant results are entered in an Access database and are available online at (the link provided was broken and has been removed). The results used for this report are included in Appendix A.

3. Mercury concentrations in northern pike, walleye, white sucker, and yellow perch have all declined over the period of study.

4. Northern pike showed the most dramatic decline with an average annual rate of decline of 6.9% between 1984 and 2011.

Mercury concentration generally increases with fish age. Since fish increase in length with age, the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

5. Mercury concentrations in northern pike, walleye, and yellow perch from Deer Lake appear to have stabilized since about 2000.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the dataset. An exponential decay rate model was used to obtain estimates of average annual rates of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

6. Mercury concentrations in northern pike collected from the Carp River Basin in 2011 were lower than concentrations in northern pike collected there in 1999.

7. Mercury concentrations in Deer Lake fish have declined at a rate comparable to the declining trend observed in walleye from Lake Gogebic, and at a higher rate than observed in walleye from South Manistique Lake.

METHODS

Fish were collected by the MDNR or the Michigan Department of Environmental Quality (MDEQ) from Deer Lake on 14 dates from 1984 through 2011, from Carp Creek on 2 dates (August 2005 and August 2010), and from the Carp River on 8 dates from 1984 through 2011. Fish were collected using electrofishing gear, fyke nets, and gill nets.

In addition, mercury concentrations in fish of standard length were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration at a given fish length, and can be used to predict the concentration in a given size fish. The mercury concentration in standard size northern pike, walleye, white sucker, and yellow perch was estimated for each year these species were collected.

A total of 4 brook trout (*Salvelinus fontinalis*), 1 brown bullhead (*Ameiurus nebulosus*), 169 northern pike (*Esox lucius*), 153 walleye (*Sander vitreus*), 53 white sucker (*Catostomus commersonii*), and 80 yellow perch (*Perca flavescens*) were collected from the Deer Lake AOC by state agencies and analyzed as fillet samples between 1984 and 2011 (Tables 1 through 5). Northern pike were collected from Deer Lake on 11 dates between 1984 and 2011, from the Carp River at the Carp River Basin on 3 dates, and from the Carp River at Eagle Mills on 2 dates. Walleye were collected from Deer Lake on 10 dates between 1990 and 2011; 2 walleye were collected from the Carp River at the Carp River Basin in 2011. White sucker were collected from Carp Creek on 2 dates, from Deer Lake on 4 dates between 1984 and 2011 and from the Carp River in 1984, 2004, and 2011. Yellow perch were collected from Deer Lake on 8 dates between 1984 and 2011; 1 yellow perch was collected from the Carp River near Eagle Mills in 1984 and 1 was collected from the Carp River at the Carp River Basin in 2011.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends; samples of these species were not collected regularly over the time period, conclusions based on these species are not strong. Data for other species or from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size for northern pike; this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collections was 17.5 inches, 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size for yellow perch.

The fish were processed as standard edible portions in accordance with the Great Lakes Environmental Assessment Section Procedure 31. Standard edible portions are skin-on fillets for walleye, white sucker, yellow perch, and brook trout and skin-off fillets for northern pike. Each sample was individually wrapped in aluminum foil, appropriately labeled, and frozen until analyzed.

The fish tissue samples were analyzed for total mercury by the MDEQ Environmental Laboratory or the Michigan Department of Community Health Analytical Chemistry Laboratory. Both of these analytical laboratories have quality assurance programs and used peer-reviewed methods for sample digestion and quantification. Total mercury is referred to as "mercury" throughout the report.

Deer Lake AOC fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is located as part of the Deer Lake AOC, fish in Deer Lake have been more directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in their fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

Mercury concentration generally increases with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each
species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations in a standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in a standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of those species were not collected regularly over the time period; conclusions based on those species are not strong. Data for other species or from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

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Mercury concentrations generally increase with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The lengths of fish collected will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithm in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations at a standard length were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration at a given size fish. The mercury concentrations at standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of these species were not collected regularly over the time period, or collected based on those species were not strong. Data for other species from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for this species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for this species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been more directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in their fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

RESULTS

Northern Pike

Mercury concentrations in Deer Lake northern pike declined between 1984 and 2011 at an average annual rate of 6.9% based on the multiple regression results (Figure 2, Table 6). The estimated mercury concentration in 24-inch northern pike declined from a peak of 2.3 parts per million (ppm) in 1988 to an estimated 0.9 ppm in 2011, an overall change of -61%. The estimated mercury concentration in standard size northern pike has been relatively stable since 2001. A mercury concentration versus fish length regression line based on the data collected between 2001 and 2011 yields an estimated mercury concentration of 0.64 ppm for a 24-inch Deer Lake northern pike. This represents a change of -72% from the peak concentration observed in 1988.

A change in mercury concentrations was also measured in northern pike collected downstream of Deer Lake at the Carp River Basin. Eight northern pike ranging in length from 22.5 to 27.3 inches (mean length 24.6) were collected in 1999 and 11 fish ranging from 21.4 to 26.9 inches (mean length 23.7) were collected in 2011. A t-test comparing the northern pike of equivalent size showed that the mercury concentration in the 2011 samples (mean = 0.42 ppm) was significantly less ($p<0.001$) than the concentration measured in the 1999 samples (mean = 0.64 ppm). Two larger fish were collected in 1999 and 1 smaller fish was collected in 2011; these were not used in the comparison to avoid biasing the result.

Walleye

Mercury concentrations in Deer Lake walleye declined between 1990 and 2011 at an average annual rate of 3.8% based on the multiple regression results (Figure 3, Table 6). The estimated mercury concentration in 18-inch walleye declined from a peak of 1.12 ppm in 1997 to an estimated 0.99 ppm in 2011, an overall change of -12%. A visual evaluation of the estimated concentrations in 18-inch walleye suggests that concentrations may have increased slightly from 1990 through 1997 after which concentrations stabilized or declined gradually. Regression analysis of the two periods independently indicates there was no significant trend from 1990 through 1997; this was followed by a decline of 2.7% per year from 1997 through 2011.

White Sucker

White sucker collected from Carp Creek were treated as part of the Deer Lake population because there is no impediment to fish movement between the water bodies and some migration is likely. Mercury concentrations in Deer Lake white sucker declined between 1984 and 2011 at an average annual rate of 2.5% based on the multiple regression results (Figure 4; Table 6). The estimated mercury concentration in 15-inch white sucker declined from 0.41 ppm in 1984 to an estimated 0.15 ppm in 2011, an overall change of -63%.

The estimated mercury concentration in a 15-inch white sucker collected in 1984 has relatively wide confidence limits largely because of the small sample size for that year (n=5). In addition, no white sucker samples were collected from Deer Lake between 1984 and 2005. Both of these factors make the evaluation of temporal trends somewhat suspect.

The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

<u>Yellow Perch</u>

Mercury concentrations in yellow perch declined between 1984 and 2011 at an average annual rate of 6.7% based on the multiple regression results (Figure 5; Table 6). The estimated mercury concentration in 10-inch yellow perch declined from a peak of 1.65 ppm in 1984 to an estimated 0.34 ppm in 2011, an overall change of -79%. The estimated mercury concentration in 10-inch yellow perch was approximately the same in 2011 as it was in 1998/1999. Statistically speaking, the yellow perch trend line is the least reliable of the 4 species evaluated because the data were further from being normally distributed and the variance was not homogeneous across the dataset. In addition, as with the white sucker data set, yellow perch were not adequately sampled for a long period of time leaving a 14-year data gap between 1984 and 1998.

Mercury concentration generally increases with fish age. Since fish increase in length with age, the length of fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

DISCUSSION

The northern pike, walleye, white sucker, and yellow perch data all indicate to varying degrees that mercury levels have declined in Deer Lake fish tissue since regular monitoring began in 1984. By comparison, the MDEQ has regularly monitored contaminant levels in fish from selected inland lakes and impoundments since 1990 to evaluate temporal trends. Of 12 inland water bodies monitored statewide, mercury concentrations in fish have increased in 1, decreased in 4, and remained unchanged in 7 (Day, 2013). Two inland lakes in the Upper Peninsula are monitored as part of this temporal trends assessment. Mercury in Lake Gogebic (Gogebic/Ontonagon Counties) walleye has declined since 1990 at a rate of 4.7% per year; this may in part be attributed to reductions in mercury emissions from a nearby copper smelting facility. No measurable temporal trend in mercury concentration in walleye from South Manistique Lake (Mackinac County) was observed over the period. Reductions in fish tissue mercury in Deer Lake compare favorably to these lakes.

In addition, mercury concentrations in standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis and fish length on the horizontal axis. The lines represent the best estimate of mercury concentration at a particular length and can be used to predict the concentration in a given size of fish. The mercury concentration in standard size northern pike, walleye, white sucker and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of those species were not collected regularly over the entire period; conclusions based on those species are not strong. Data for other species or from other parts of the AOC were not sufficient for trend analyses.

One conclusion that can be drawn from the apparent decline in fish tissue mercury is that the legacy mercury contamination in Deer Lake is becoming less available for bioaccumulation. In order to make this determination, some assumptions must be made:

1. Fish growth rates have been stable over the period of study. Changes in growth rate can alter mercury concentration in fish (Harris and Bodaly, 1998; Trudel and Rasmussen, 2006).
2. The food web has been stable over the period of study. Changes in the length of the food chain of predator fish will affect the mercury accumulated by the top species (Johnston et al., 2003).
3. Water chemistry and other lake physical processes affect mercury methylation rates (Mattlow et al., 2013) and we assume these have been stable over the period of study.

These and possibly other assumptions must be kept in mind. If in fact the availability of the legacy mercury has not changed and one or more of the assumptions is not true, fish tissue mercury could increase again if physical or biological conditions in the lake change.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

Report By: Joseph Bohr, Aquatic Biologist Specialist
Surface Water Assessment Section
Water Resources Division

The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

Mercury concentration generally increases with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in average length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations in standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of those species were not collected regularly over the time period considered. Data for other species from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

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The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

Mercury concentration generally increases with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each
species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations in a standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in a standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

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The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

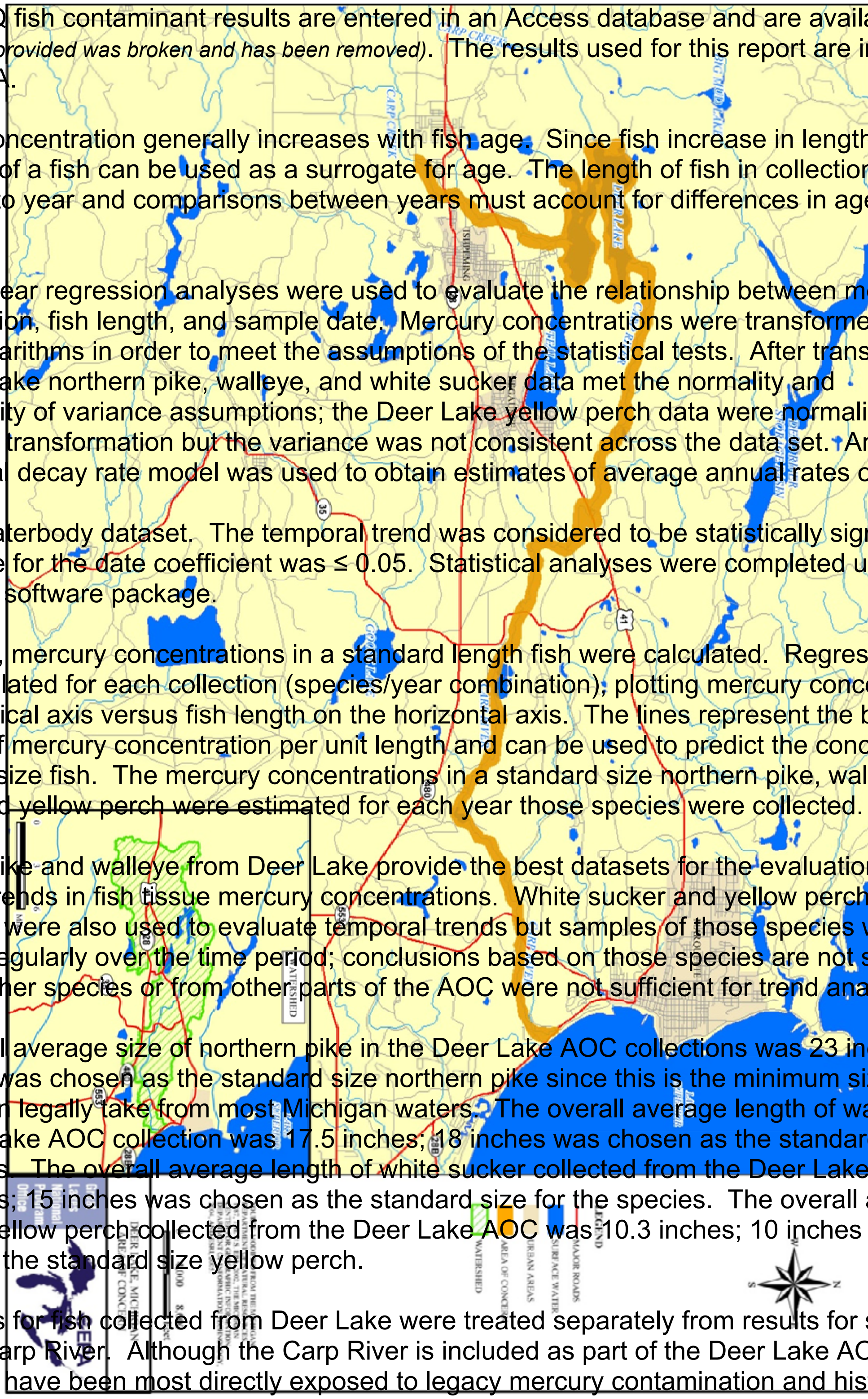

Figure 1. Map of Deer Lake Area of Concern.

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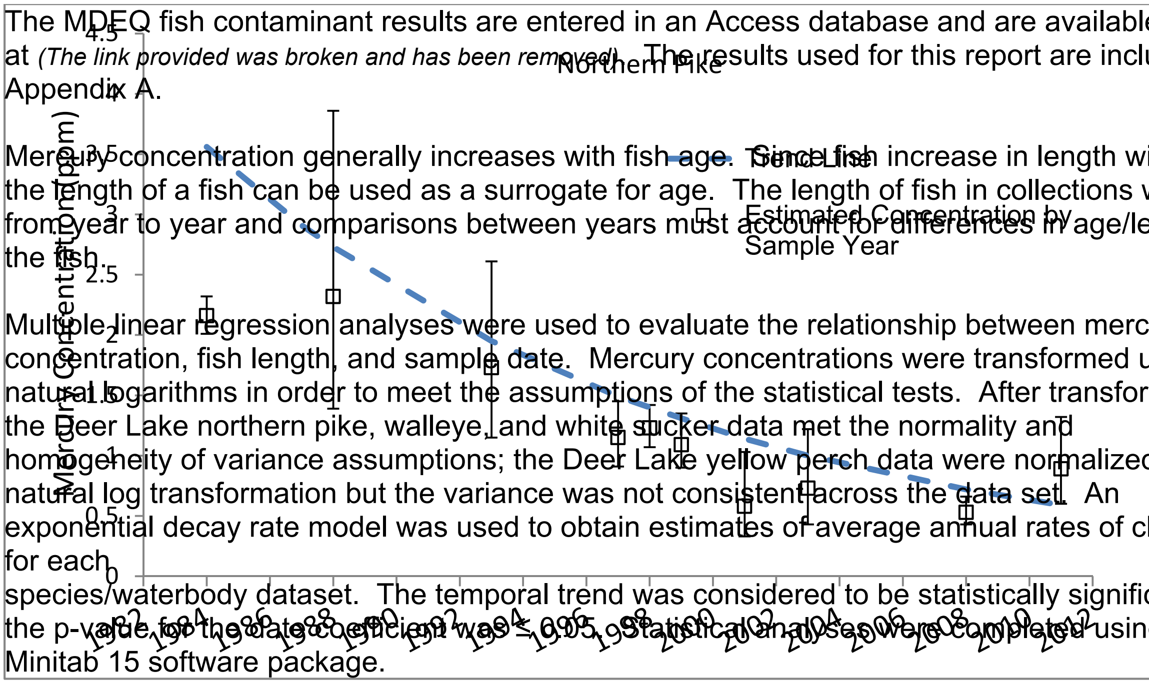
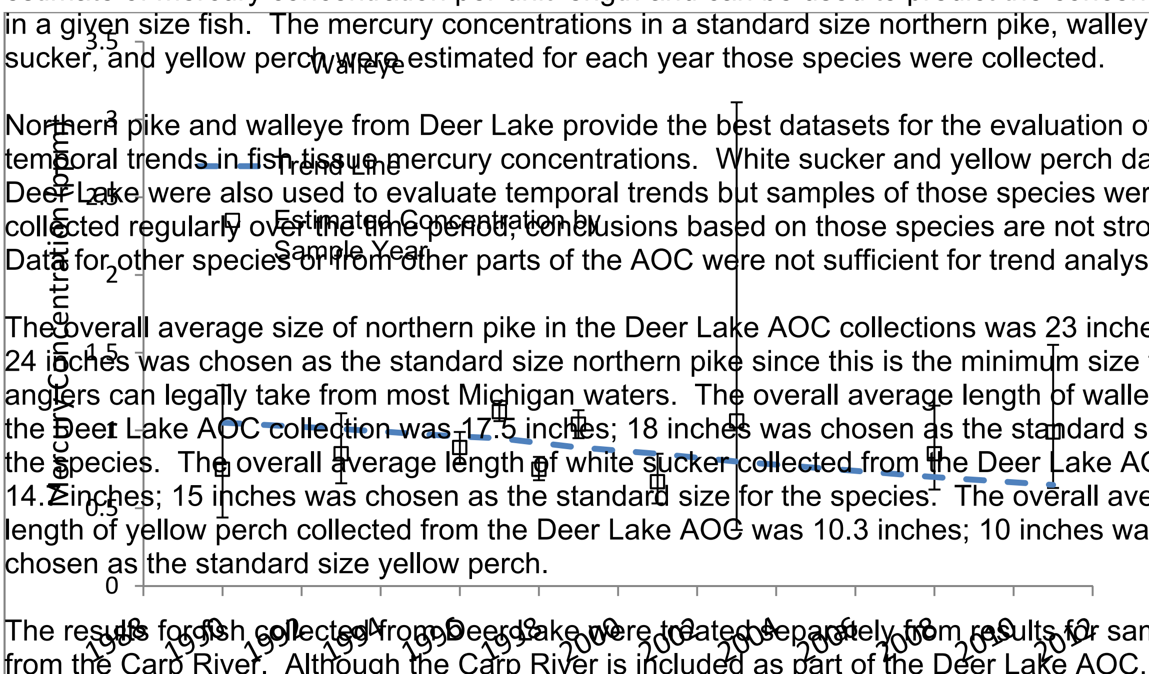


Figure 2. Temporal trend and estimated mercury concentrations in 24-inch northern pike collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

In addition, mercury concentrations in a standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in a standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of those species were not collected regularly over the time period; conclusions based on those species are not strong. Data for other species or from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.2 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.



The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

Figure 3. Temporal trend and estimated mercury concentrations in 18-inch walleye collected from Deer Lake, Marquette County, Michigan, from 1990 through 2011. Error bars represent 95% confidence intervals.

The MDEQ fish contaminant results are entered in an Access database and are available online at *(The link provided was broken and has been removed)*. The results used for this report are included in Appendix A.

Mercury concentration generally increases with fish age. Since fish increase in length with age the length of a fish can be used as a surrogate for age. The length of fish in collections will vary from year to year and comparisons between years must account for differences in age/length of the fish.

Multiple linear regression analyses were used to evaluate the relationship between mercury concentration, fish length, and sample date. Mercury concentrations were transformed using natural logarithms in order to meet the assumptions of the statistical tests. After transformation, the Deer Lake northern pike, walleye, and white sucker data met the normality and homogeneity of variance assumptions; the Deer Lake yellow perch data were normalized by the natural log transformation but the variance was not consistent across the data set. An exponential decay rate model was used to obtain estimates of average annual rates of change for each species/waterbody dataset. The temporal trend was considered to be statistically significant if the p-value for the date coefficient was ≤ 0.05. Statistical analyses were completed using the Minitab 15 software package.

In addition, mercury concentrations in a standard length fish were calculated. Regression lines were calculated for each collection (species/year combination), plotting mercury concentration on the vertical axis versus fish length on the horizontal axis. The lines represent the best estimate of mercury concentration per unit length and can be used to predict the concentration in a given size fish. The mercury concentrations in a standard size northern pike, walleye, white sucker, and yellow perch were estimated for each year those species were collected.

Northern pike and walleye from Deer Lake provide the best datasets for the evaluation of temporal trends in fish tissue mercury concentrations. White sucker and yellow perch data for Deer Lake were also used to evaluate temporal trends but samples of those species were not collected regularly over the time period; conclusions based on those species are not strong. Data for other species or from other parts of the AOC were not sufficient for trend analyses.

The overall average size of northern pike in the Deer Lake AOC collections was 23 inches; 24 inches was chosen as the standard size northern pike since this is the minimum size that anglers can legally take from most Michigan waters. The overall average length of walleye in the Deer Lake AOC collection was 17.5 inches; 18 inches was chosen as the standard size for the species. The overall average length of white sucker collected from the Deer Lake AOC was 14.7 inches; 15 inches was chosen as the standard size for the species. The overall average length of yellow perch collected from the Deer Lake AOC was 10.3 inches; 10 inches was chosen as the standard size yellow perch.

The results for fish collected from Deer Lake were treated separately from results for samples from the Carp River. Although the Carp River is included as part of the Deer Lake AOC, fish in Deer Lake have been most directly exposed to legacy mercury contamination and historically have had significantly higher concentrations of mercury in the fillets. In addition, Carp River samples have been collected a significant distance downstream of the Deer Lake dam and probably represent distinct populations.

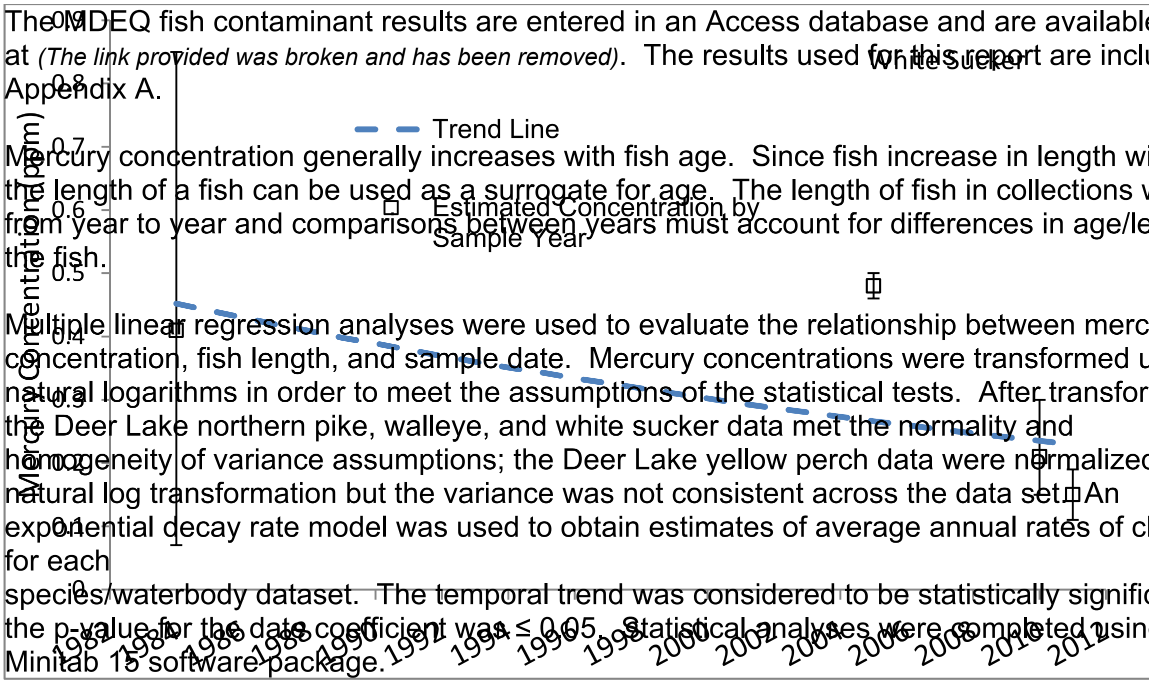


Figure 4. Temporal trend and estimated mercury concentrations in 15-inch white sucker collected from Carp Creek and Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

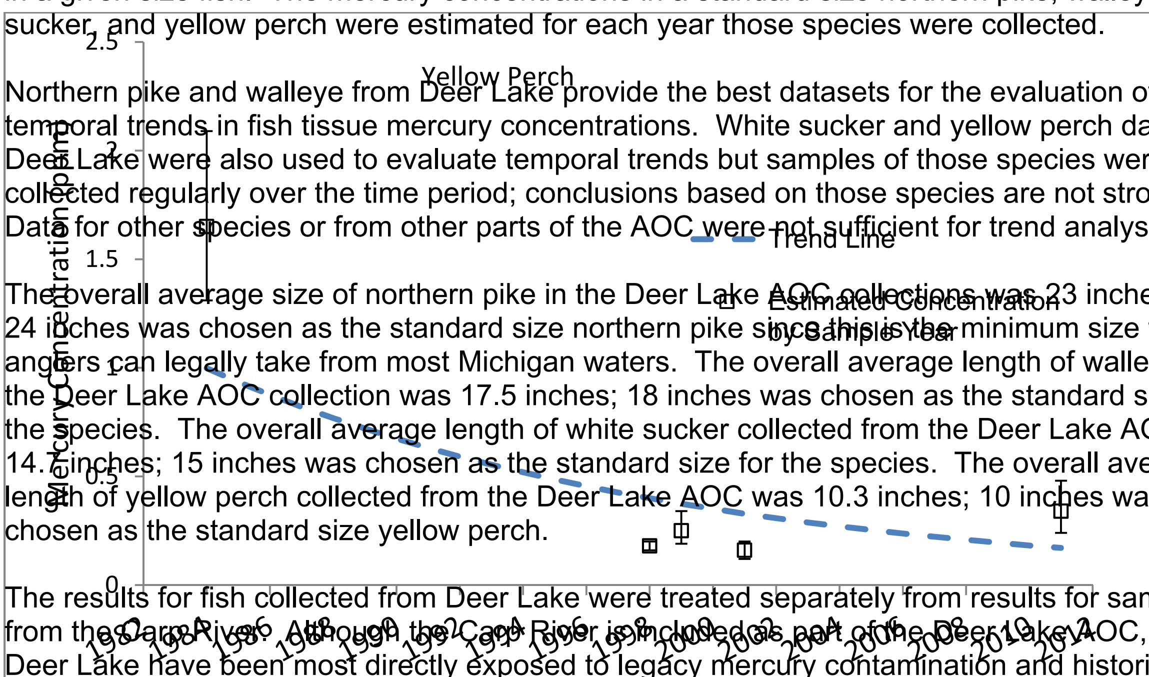


Figure 5. Temporal trend and estimated mercury concentrations in 10-inch yellow perch collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

ATTACHMENT E

Table 1. Summary of brook trout samples collected by the MDNR and MDEQ from the Deer Lake Area of Concern between 1984 and 2005.

Water Body	Location	Collection Date	N	Length (Inches)			Mercury Concentration (ppm)		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Carp Creek	u/s Deer Lake	25-Aug-05	10	6.8	8.0	10.3	0.2	0.3	0.6
Carp River	Carp River Basin	20-Aug-99	10	7.3	9.0	12.2	0.1	0.2	0.2
Carp River	Eagle Mills	23-Jul-93	10	6.7	8.8	11.8	0.1	0.2	0.3
Carp River	Landfill Rd.	18-Aug-04	4	10.6	10.9	11.2	0.2	0.2	0.3
Carp River	M-35	27-Sep-84	1	9.5	9.5	9.5	0.4	0.4	0.4
Carp River	M-35	17-Aug-04	9	7.2	9.7	14.1	0.1	0.2	0.3

Table 2. Summary of northern pike samples collected by the MDNR and MDEQ from the Deer Lake Area of Concern between 1984 and 2011.

Water Body	Location	Collection Date	N	Length (Inches)			Mercury Concentration (ppm)		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Deer Lake	Marquette County	09-Oct-84	16	10.6	19.0	30.3	0.8	1.7	3.2
Deer Lake	Marquette County	26-Oct-87	18	12.6	15.7	17.6	2.1	3.1	4.4
Deer Lake	Marquette County	06-Oct-88	19	17.5	20.4	24.2	0.7	2.0	3.7
Deer Lake	Marquette County	14-Sep-93	10	20.5	26.4	33.9	0.5	2.0	2.6
Deer Lake	Marquette County	02-Oct-97	13	20.2	24.8	34.0	0.5	1.7	5.7
Deer Lake	Marquette County	09-Oct-98	20	16.9	21.9	35.6	0.3	1.3	10.5
Deer Lake	Marquette County	04-May-99	18	19.3	27.4	34.6	0.4	2.1	5.9
Deer Lake	Marquette County	01-May-01	6	22.6	25.0	27.0	0.4	0.7	1.5
Deer Lake	Marquette County	03-May-03	5	25.0	28.5	38.3	0.7	1.1	2.2
Deer Lake	Marquette County	14-Sep-08	5	20.9	25.1	33.8	0.3	0.8	2.1
Deer Lake	Marquette County	03-May-11	10	22.4	31.1	41.6	0.7	2.8	5.5
Carp River	Carp River Basin	20-Aug-99	10	22.6	26.6	36.8	0.5	0.7	1.1
Carp River	Carp River Basin	04-Aug-10	1	19.8	19.8	19.8	0.3	0.3	0.3
Carp River	Carp River Basin	29-Sep-11	12	18.5	23.2	28.8	0.3	0.4	0.5
Carp River	Eagle Mills	06-Oct-88	3	10.0	11.1	11.6	0.6	0.7	0.7
Carp River	Eagle Mills	23-Jul-93	3	22.8	25.2	27.2	1.2	1.6	2.2

Table 3. Summary of walleye samples collected by the MDNR and MDEQ from the Deer Lake Area of Concern between 1990 and 2011.

Water Body	Location	Collection Date	N	Length (Inches)			Mercury Concentration (ppm)		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Deer Lake	Marquette County	02-Nov-90	16	10.0	11.4	13.4	0.6	0.7	0.9
Deer Lake	Marquette County	14-Sep-93	10	10.6	16.4	20.5	0.3	0.8	1.7
Deer Lake	Marquette County	02-Oct-96	10	16.2	18.5	20.3	0.6	1.0	1.4
Deer Lake	Marquette County	02-Oct-97	10	16.7	18.8	23.0	1.0	1.2	1.3
Deer Lake	Marquette County	09-Oct-98	20	15.1	18.8	21.7	0.3	1.0	1.5
Deer Lake	Marquette County	04-May-99	35	14.6	18.6	23.6	0.4	1.2	1.7
Deer Lake	Marquette County	01-May-01	12	15.4	18.8	23.0	0.2	0.8	1.1
Deer Lake	Marquette County	03-May-03	5	18.2	19.1	19.9	0.6	1.1	1.5
Deer Lake	Marquette County	14-Sep-08	22	13.7	15.9	18.4	0.1	0.4	0.9
Deer Lake	Marquette County	03-May-11	11	19.0	20.0	21.3	0.9	1.3	1.6
Carp River	Carp River Basin	29-Sep-11	2	19.1	19.5	19.8	0.5	0.5	0.6

Table 4. Summary of white sucker samples collected by the MDNR and MDEQ from the Deer Lake Area of Concern between 1984 and 2011.

Water Body	Location	Collection Date	N	Length (Inches)			Mercury Concentration (ppm)		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Carp Creek	u/s Deer Lake	25-Aug-05	7	7.5	10.6	15.8	0.2	0.3	0.6
Carp Creek	u/s Deer Lake	04-Aug-10	10	10.9	15.6	18.7	0.1	0.2	0.4
Carp River	Carp River Basin	29-Sep-11	10	12.6	16.0	19.8	0.1	0.3	0.5
Carp River	M-35	27-Sep-84	1	11.1	11.1	11.1	0.3	0.3	0.3
Carp River	M-35	17-Aug-04	10	8.5	11.1	13.6	0.1	0.2	0.4
Deer Lake	Marquette County	09-Oct-84	5	15.7	18.2	19.7	0.4	0.5	0.8
Deer Lake	Marquette County	03-May-11	10	12.0	17.6	21.5	0.1	0.3	0.7

Table 5. Summary of yellow perch samples collected by the MDNR and MDEQ from the Deer Lake Area of Concern between 1990 and 2011.

Water Body	Location	Collection Date	N	Length (Inches)			Mercury Concentration (ppm)		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Carp River	Carp River Basin	29-Sep-11	1	7.9	7.9	7.9	0.1	0.1	0.1
Carp River	M-35	27-Sep-84	1	8.0	8.0	8.0	1.0	1.0	1.0
Deer Lake	Marquette County	09-Oct-84	20	6.9	8.3	10.0	0.6	1.2	2.2
Deer Lake	Marquette County	06-Oct-88	1	9.4	9.4	9.4	0.7	0.7	0.7
Deer Lake	Marquette County	02-Oct-97	1	8.2	8.2	8.2	0.2	0.2	0.2
Deer Lake	Marquette County	09-Oct-98	15	8.5	10.3	12.0	0.2	0.2	0.4
Deer Lake	Marquette County	04-May-99	13	9.8	12.0	14.0	0.2	0.5	0.9
Deer Lake	Marquette County	01-May-01	11	9.3	11.4	13.7	0.1	0.3	0.6
Deer Lake	Marquette County	12-Apr-10	2	8.5	9.4	10.2	0.2	0.2	0.2
Deer Lake	Marquette County	03-May-11	15	9.6	11.4	12.6	0.2	0.4	0.8

Table 6. Regression statistics for northern pike, walleye, white sucker, and yellow perch collected from Deer Lake, Marquette County, between 1984 and 2011.

Northern Pike

Regression Equation ln Hg = 4.79 - 0.000183 Date + 0.0873 Length (Inches)

Predictor	Coefficient	SE of Coefficient	T-Value	P
Constant	4.79	0.625	7.66	<0.001
Date	-0.000183	0.000021	-8.77	<0.001
Length (Inches)	0.0873	0.00956	9.14	<0.001
	S=0.55	R^2=42.3%		

Walleye

Regression Equation ln Hg = 1.26 - 0.000104 Date + 0.133 Length (Inches)

Predictor	Coefficient	SE of Coefficient	T-Value	P
Constant	1.26	0.5238	2.4	0.018
Date	-0.000104	0.000015	-6.86	<0.001
Length (Inches)	0.133	0.0103	13	<0.001
	S=0.37	R^2=54.5%		

White Sucker

Regression Equation ln Hg = - 0.024 - 0.000069 Date + 0.0869 Length (Inches)

Predictor	Coefficient	SE of Coefficient	T-Value	P
Constant	-0.0241	0.9855	-0.02	0.981
Date	-0.000068	0.000023	-2.97	0.006
Length (Inches)	0.08686	0.01998	4.35	<0.001
	S=0.44	R^2=52.3%		

Yellow Perch

Regression Equation ln Hg = 3.91 - 0.000179 Date + 0.158 Length (Inches)

Predictor	Coefficient	SE of Coefficient	T-Value	P
Constant	3.91	0.7073	5.53	<0.001
Date	-0.000179	0.0000245	-7.32	<0.001
Length (Inches)	0.158	0.0455	3.48	<0.001
	S=0.58	R^2=42.3%		

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Brook Trout	2005013-F008	2005013-S08	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	M	6.8	30	F	0.23	
Brook Trout	2005013-F009	2005013-S09	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	M	7	40	F	0.23	
Brook Trout	2005013-F010	2005013-S10	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		7.1	50	F	0.27	
Brook Trout	2005013-F011	2005013-S11	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		7.1	40	F	0.21	
Brook Trout	2005013-F012	2005013-S12	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		7.1	40	F	0.31	
Brook Trout	2005013-F013	2005013-S13	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	7.8	50	F	0.20	
Brook Trout	2005013-F014	2005013-S14	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	7.9	60	F	0.34	
Brook Trout	2005013-F015	2005013-S15	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	8.5	75	F	0.36	
Brook Trout	2005013-F016	2005013-S16	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	10.3	195	F	0.57	
Brook Trout	2005013-F017	2005013-S17	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	M	10.2	175	F	0.35	
Brook Trout	1999003-F001	1999003-S01	Carp River	Carp River Basin	1999003	20-Aug-99		7.3	30	F	0.15	
Brook Trout	1999003-F002	1999003-S02	Carp River	Carp River Basin	1999003	20-Aug-99		7.9	40	F	0.14	
Brook Trout	1999003-F003	1999003-S03	Carp River	Carp River Basin	1999003	20-Aug-99		7.9	40	F	0.10	
Brook Trout	1999003-F004	1999003-S04	Carp River	Carp River Basin	1999003	20-Aug-99		8.1	50	F	0.14	
Brook Trout	1999003-F005	1999003-S05	Carp River	Carp River Basin	1999003	20-Aug-99		8.2	65	F	0.15	
Brook Trout	1999003-F006	1999003-S06	Carp River	Carp River Basin	1999003	20-Aug-99		8.4	75	F	0.17	
Brook Trout	1999003-F007	1999003-S07	Carp River	Carp River Basin	1999003	20-Aug-99		8.8	80	F	0.18	
Brook Trout	1999003-F008	1999003-S08	Carp River	Carp River Basin	1999003	20-Aug-99		10	110	F	0.17	
Brook Trout	1999003-F009	1999003-S09	Carp River	Carp River Basin	1999003	20-Aug-99		11	185	F	0.17	
Brook Trout	1999003-F010	1999003-S10	Carp River	Carp River Basin	1999003	20-Aug-99		12.2	230	F	0.15	
Brook Trout	93074-F001	93074-S01	Carp River	Eagle Mills Pump House	93074	23-Jul-93		6.7	40	F	0.16	
Brook Trout	93074-F002	93074-S02	Carp River	Eagle Mills Pump House	93074	23-Jul-93		7.3	60	F	0.16	
Brook Trout	93074-F003	93074-S03	Carp River	Eagle Mills Pump House	93074	23-Jul-93		7.5	60	F	0.12	
Brook Trout	93074-F004	93074-S04	Carp River	Eagle Mills Pump House	93074	23-Jul-93		7.5	70	F	0.12	
Brook Trout	93074-F005	93074-S05	Carp River	Eagle Mills Pump House	93074	23-Jul-93		7.9	90	F	0.20	
Brook Trout	93074-F006	93074-S06	Carp River	Eagle Mills Pump House	93074	23-Jul-93		8.1	90	F	0.11	
Brook Trout	93074-F007	93074-S07	Carp River	Eagle Mills Pump House	93074	23-Jul-93		8.1	100	F	0.15	
Brook Trout	93074-F008	93074-S08	Carp River	Eagle Mills Pump House	93074	23-Jul-93		11.4	270	F	0.22	
Brook Trout	93074-F009	93074-S09	Carp River	Eagle Mills Pump House	93074	23-Jul-93		11.6	300	F	0.15	
Brook Trout	93074-F010	93074-S10	Carp River	Eagle Mills Pump House	93074	23-Jul-93		11.8	330	F	0.31	
Brook Trout	2004009-F001	2004009-S01	Carp River	Landfill Rd.	2004009	18-Aug-04		10.6	180	F	0.23	
Brook Trout	2004009-F002	2004009-S02	Carp River	Landfill Rd.	2004009	18-Aug-04	F	10.6	210	F	0.20	
Brook Trout	2004009-F003	2004009-S03	Carp River	Landfill Rd.	2004009	18-Aug-04	F	11.1	270	F	0.25	
Brook Trout	2004009-F004	2004009-S04	Carp River	Landfill Rd.	2004009	18-Aug-04	F	11.2	260	F	0.27	
Brook Trout	84012-F007	84012-S05	Carp River	M-35	84012	27-Sep-84		9.5		F	0.40	
Brook Trout	84012-F008	84012-S06	Carp River	M-35	84012	27-Sep-84		6.1		W	0.20	
Brook Trout	84012-F009	84012-S06	Carp River	M-35	84012	27-Sep-84		6.3		W	0.20	
Brook Trout	84012-F010	84012-S07	Carp River	M-35	84012	27-Sep-84		5.2		W	0.10	
Brook Trout	84012-F011	84012-S07	Carp River	M-35	84012	27-Sep-84		5.9		W	0.10	
Brook Trout	2004010-F001	2004010-S01	Carp River	M-35	2004010	17-Aug-04		7.2	60	F	0.23	
Brook Trout	2004010-F002	2004010-S02	Carp River	M-35	2004010	17-Aug-04		8.5	80	F	0.16	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Brook Trout	2004010-F003	2004010-S03	Carp River	M-35	2004010	17-Aug-04		8.6	150	F	0.07	
Brook Trout	2004010-F004	2004010-S04	Carp River	M-35	2004010	17-Aug-04		8.8	110	F	0.12	
Brook Trout	2004010-F005	2004010-S05	Carp River	M-35	2004010	17-Aug-04		9.7	140	F	0.16	
Brook Trout	2004010-F006	2004010-S06	Carp River	M-35	2004010	17-Aug-04		9.9	150	F	0.16	
Brook Trout	2004010-F007	2004010-S07	Carp River	M-35	2004010	17-Aug-04		9.9	170	F	0.26	
Brook Trout	2004010-F008	2004010-S08	Carp River	M-35	2004010	17-Aug-04		10.5	210	F	0.17	
Brook Trout	2004010-F009	2004010-S09	Carp River	M-35	2004010	17-Aug-04		14.1	560	F	0.13	
Brook Trout	88067-F004	88067-S04	Deer Lake	Marquette County	88067	06-Oct-88		7.2		W	0.11	
Northern Pike	1999003-F011	1999003-S11	Carp River	Carp River Basin	1999003	20-Aug-99	F	22.6	1044.2	Fs	0.59	
Northern Pike	1999003-F012	1999003-S12	Carp River	Carp River Basin	1999003	20-Aug-99	M	23.7	1316.6	Fs	0.60	
Northern Pike	1999003-F013	1999003-S13	Carp River	Carp River Basin	1999003	20-Aug-99	F	24	1225.8	Fs	0.51	
Northern Pike	1999003-F014	1999003-S14	Carp River	Carp River Basin	1999003	20-Aug-99	M	24	1362	Fs	0.56	
Northern Pike	1999003-F015	1999003-S15	Carp River	Carp River Basin	1999003	20-Aug-99	F	24.2	1316.6	Fs	0.77	
Northern Pike	1999003-F016	1999003-S16	Carp River	Carp River Basin	1999003	20-Aug-99	F	24.9	1679.8	Fs	0.59	
Northern Pike	1999003-F017	1999003-S17	Carp River	Carp River Basin	1999003	20-Aug-99	F	25.8	1861.4	Fs	0.66	
Northern Pike	1999003-F018	1999003-S18	Carp River	Carp River Basin	1999003	20-Aug-99	M	27.3	2043	Fs	0.86	
Northern Pike	1999003-F019	1999003-S19	Carp River	Carp River Basin	1999003	20-Aug-99	F	33	3768.2	Fs	1.06	
Northern Pike	1999003-F020	1999003-S20	Carp River	Carp River Basin	1999003	20-Aug-99	F	36.8	5902	Fs	1.13	
Northern Pike	2010261-F001	2010261-S01	Carp River	Carp River Basin	2010261	04-Aug-10	M	19.8	850	Fs	0.28	
Northern Pike	2011207-F014	2011207-S14	Carp River	Carp River Basin	2011207	29-Sep-11	M	18.5	660	Fs	0.33	
Northern Pike	2011207-F015	2011207-S15	Carp River	Carp River Basin	2011207	29-Sep-11	M	21.4	980	Fs	0.39	
Northern Pike	2011207-F016	2011207-S16	Carp River	Carp River Basin	2011207	29-Sep-11	F	21.9	1120	Fs	0.28	
Northern Pike	2011207-F017	2011207-S17	Carp River	Carp River Basin	2011207	29-Sep-11	F	23.4	1300	Fs	0.43	
Northern Pike	2011207-F018	2011207-S18	Carp River	Carp River Basin	2011207	29-Sep-11	F	22.8	1340	Fs	0.41	
Northern Pike	2011207-F019	2011207-S19	Carp River	Carp River Basin	2011207	29-Sep-11		21.9	1200	Fs	0.49	
Northern Pike	2011207-F020	2011207-S20	Carp River	Carp River Basin	2011207	29-Sep-11	F	23.1	1340	Fs	0.46	
Northern Pike	2011207-F021	2011207-S21	Carp River	Carp River Basin	2011207	29-Sep-11	M	22.8	1480	Fs	0.46	
Northern Pike	2011207-F022	2011207-S22	Carp River	Carp River Basin	2011207	29-Sep-11	M	24.1	1580	Fs	0.42	
Northern Pike	2011207-F023	2011207-S23	Carp River	Carp River Basin	2011207	29-Sep-11	M	23.6	1480	Fs	0.49	
Northern Pike	2011207-F024	2011207-S24	Carp River	Carp River Basin	2011207	29-Sep-11	F	25.6	1840	Fs	0.46	
Northern Pike	2011207-F025	2011207-S25	Carp River	Carp River Basin	2011207	29-Sep-11	F	28.8	2580	Fs	0.31	
Northern Pike	88068-F005	88068-S05	Carp River	Eagle Mills Pump House	88068	06-Oct-88		11.6	130	Fs	0.64	
Northern Pike	88068-F006	88068-S06	Carp River	Eagle Mills Pump House	88068	06-Oct-88		10	100	Fs	0.73	
Northern Pike	88068-F007	88068-S07	Carp River	Eagle Mills Pump House	88068	06-Oct-88		11.6	100	Fs	0.63	
Northern Pike	93074-F011	93074-S11	Carp River	Eagle Mills Pump House	93074	23-Jul-93		22.8	1160	Fs	2.22	
Northern Pike	93074-F012	93074-S12	Carp River	Eagle Mills Pump House	93074	23-Jul-93		25.6	1860	Fs	1.32	
Northern Pike	93074-F013	93074-S13	Carp River	Eagle Mills Pump House	93074	23-Jul-93		27.2	2340	Fs	1.18	
Northern Pike	84011-F001	84011-S01	Deer Lake	Marquette County	84011	09-Oct-84		13.8		Fs	1.00	
Northern Pike	84011-F002	84011-S02	Deer Lake	Marquette County	84011	09-Oct-84		12.2		Fs	1.00	
Northern Pike	84011-F003	84011-S03	Deer Lake	Marquette County	84011	09-Oct-84		13		Fs	1.00	
Northern Pike	84011-F004	84011-S04	Deer Lake	Marquette County	84011	09-Oct-84		11.4		Fs	0.90	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Northern Pike	84011-F005	84011-S05	Deer Lake	Marquette County	84011	09-Oct-84		10.6		Fs	0.90	
Northern Pike	84011-F006	84011-S06	Deer Lake	Marquette County	84011	09-Oct-84		11		Fs	0.90	
Northern Pike	84011-F007	84011-S07	Deer Lake	Marquette County	84011	09-Oct-84		11		Fs	0.80	
Northern Pike	84011-F008	84011-S08	Deer Lake	Marquette County	84011	09-Oct-84		10.6		W	0.80	
Northern Pike	84011-F009	84011-S09	Deer Lake	Marquette County	84011	09-Oct-84		9.8		W	1.00	
Northern Pike	84011-F010	84011-S10	Deer Lake	Marquette County	84011	09-Oct-84		11		W	1.10	
Northern Pike	84011-F011	84011-S11	Deer Lake	Marquette County	84011	09-Oct-84		23.2	1100	Fs	2.10	
Northern Pike	84011-F012	84011-S12	Deer Lake	Marquette County	84011	09-Oct-84		20.9	800	Fs	1.70	
Northern Pike	84011-F013	84011-S13	Deer Lake	Marquette County	84011	09-Oct-84		21.3	800	Fs	1.70	
Northern Pike	84011-F014	84011-S14	Deer Lake	Marquette County	84011	09-Oct-84		21.3	1000	Fs	1.70	
Northern Pike	84011-F015	84011-S15	Deer Lake	Marquette County	84011	09-Oct-84		24.4	1400	Fs	2.70	
Northern Pike	84011-F016	84011-S16	Deer Lake	Marquette County	84011	09-Oct-84		26.4	1700	Fs	2.60	
Northern Pike	84011-F017	84011-S17	Deer Lake	Marquette County	84011	09-Oct-84		30.3	2400	Fs	2.70	
Northern Pike	84011-F018	84011-S18	Deer Lake	Marquette County	84011	09-Oct-84		25.6	1700	Fs	2.30	
Northern Pike	84011-F019	84011-S19	Deer Lake	Marquette County	84011	09-Oct-84		26.8	2100	Fs	3.20	
Northern Pike	87099-F010	87099-S10	Deer Lake	Marquette County	87099	26-Oct-87		15.7	319	Fs	2.60	
Northern Pike	87099-F011	87099-S11	Deer Lake	Marquette County	87099	26-Oct-87		15	273	Fs	3.30	
Northern Pike	87099-F012	87099-S12	Deer Lake	Marquette County	87099	26-Oct-87		14.1	227	Fs	2.30	
Northern Pike	87099-F013	87099-S13	Deer Lake	Marquette County	87099	26-Oct-87		14	273	Fs	2.10	
Northern Pike	87099-F015	87099-S15	Deer Lake	Marquette County	87099	26-Oct-87		14.5	227	Fs	2.30	
Northern Pike	87099-F016	87099-S16	Deer Lake	Marquette County	87099	26-Oct-87		12.9	137	Fs	2.40	
Northern Pike	87099-F017	87099-S17	Deer Lake	Marquette County	87099	26-Oct-87		12.6	137	Fs	2.40	
Northern Pike	87099-F018	87099-S18	Deer Lake	Marquette County	87099	26-Oct-87		13.8	227	Fs	2.30	
Northern Pike	87099-F019	87099-S19	Deer Lake	Marquette County	87099	26-Oct-87		17.6	364	Fs	4.10	
Northern Pike	87099-F020	87099-S20	Deer Lake	Marquette County	87099	26-Oct-87		17.3	501	Fs	3.60	
Northern Pike	87099-F021	87099-S21	Deer Lake	Marquette County	87099	26-Oct-87	F	17	501	Fs	4.40	
Northern Pike	87099-F022	87099-S22	Deer Lake	Marquette County	87099	26-Oct-87		17.3	501	Fs	3.70	
Northern Pike	87099-F023	87099-S23	Deer Lake	Marquette County	87099	26-Oct-87		17.2	546	Fs	3.20	
Northern Pike	87099-F024	87099-S24	Deer Lake	Marquette County	87099	26-Oct-87		16.4	319	Fs	3.90	
Northern Pike	87099-F025	87099-S25	Deer Lake	Marquette County	87099	26-Oct-87		16.4	364	Fs	3.80	
Northern Pike	87099-F026	87099-S26	Deer Lake	Marquette County	87099	26-Oct-87		17.3	501	Fs	3.30	
Northern Pike	87099-F027	87099-S27	Deer Lake	Marquette County	87099	26-Oct-87		16.6	364	Fs	3.20	
Northern Pike	87099-F028	87099-S28	Deer Lake	Marquette County	87099	26-Oct-87		17	501	Fs	2.10	
Northern Pike	88067-F006	88067-S06	Deer Lake	Marquette County	88067	06-Oct-88		22.8	1060	Fs	2.60	
Northern Pike	88067-F007	88067-S07	Deer Lake	Marquette County	88067	06-Oct-88		23.6	1220	Fs	1.61	
Northern Pike	88067-F008	88067-S08	Deer Lake	Marquette County	88067	06-Oct-88		24.2	1200	Fs	2.40	
Northern Pike	88067-F009	88067-S09	Deer Lake	Marquette County	88067	06-Oct-88		22	840	Fs	3.73	
Northern Pike	88067-F010	88067-S10	Deer Lake	Marquette County	88067	06-Oct-88		21.7	860	Fs	1.64	
Northern Pike	88067-F011	88067-S11	Deer Lake	Marquette County	88067	06-Oct-88		21.3	960	Fs	1.60	
Northern Pike	88067-F012	88067-S12	Deer Lake	Marquette County	88067	06-Oct-88		20.5	860	Fs	2.89	
Northern Pike	88067-F013	88067-S13	Deer Lake	Marquette County	88067	06-Oct-88		21.9	1040	Fs	2.47	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Northern Pike	88067-F014	88067-S14	Deer Lake	Marquette County	88067	06-Oct-88		21.5	900	Fs	1.09	
Northern Pike	88067-F015	88067-S15	Deer Lake	Marquette County	88067	06-Oct-88		17.5	460	Fs	2.65	
Northern Pike	88067-F016	88067-S16	Deer Lake	Marquette County	88067	06-Oct-88		18.9	560	Fs	0.71	
Northern Pike	88067-F017	88067-S17	Deer Lake	Marquette County	88067	06-Oct-88		19.1	620	Fs	1.54	
Northern Pike	88067-F018	88067-S18	Deer Lake	Marquette County	88067	06-Oct-88		18.7	600	Fs	0.79	
Northern Pike	88067-F019	88067-S19	Deer Lake	Marquette County	88067	06-Oct-88		18.5	580	Fs	0.74	
Northern Pike	88067-F020	88067-S20	Deer Lake	Marquette County	88067	06-Oct-88		19.1	620	Fs	1.36	
Northern Pike	88067-F021	88067-S21	Deer Lake	Marquette County	88067	06-Oct-88		18.5	500	Fs	2.68	
Northern Pike	88067-F022	88067-S22	Deer Lake	Marquette County	88067	06-Oct-88		18.9	640	Fs	2.47	
Northern Pike	88067-F023	88067-S23	Deer Lake	Marquette County	88067	06-Oct-88		19.7	760	Fs	2.68	
Northern Pike	88067-F024	88067-S24	Deer Lake	Marquette County	88067	06-Oct-88		19.5	730	Fs	2.14	
Northern Pike	93083-F001	93083-S01	Deer Lake	Marquette County	93083	14-Sep-93		23.8	1220	Fs	2.44	
Northern Pike	93083-F002	93083-S02	Deer Lake	Marquette County	93083	14-Sep-93		23.6	1200	Fs	2.60	
Northern Pike	93083-F003	93083-S03	Deer Lake	Marquette County	93083	14-Sep-93		30.5	2560	Fs	2.10	
Northern Pike	93083-F004	93083-S04	Deer Lake	Marquette County	93083	14-Sep-93		20.5	1020	Fs	0.49	
Northern Pike	93083-F006	93083-S06	Deer Lake	Marquette County	93083	14-Sep-93		22.4	800	Fs	2.60	
Northern Pike	93083-F007	93083-S07	Deer Lake	Marquette County	93083	14-Sep-93		22.8	1140	Fs	2.06	
Northern Pike	93083-F008	93083-S08	Deer Lake	Marquette County	93083	14-Sep-93		28.3	2100	Fs	1.79	
Northern Pike	93083-F019	93083-S19	Deer Lake	Marquette County	93083	14-Sep-93	M	33.9	4120	Fs	2.04	
Northern Pike	93083-F020	93083-S20	Deer Lake	Marquette County	93083	14-Sep-93		29.5	2500	Fs	2.45	
Northern Pike	93083-F021	93083-S21	Deer Lake	Marquette County	93083	14-Sep-93		28.3	2180	Fs	1.92	
Northern Pike	97070-F001	97070-S01	Deer Lake	Marquette County	97070	02-Oct-97	M	31.1	2951	Fs	3.19	
Northern Pike	97070-F002	97070-S02	Deer Lake	Marquette County	97070	02-Oct-97	F	30	1861.4	Fs	2.58	
Northern Pike	97070-F003	97070-S03	Deer Lake	Marquette County	97070	02-Oct-97	F	24.1	1135	Fs	1.14	
Northern Pike	97070-F004	97070-S04	Deer Lake	Marquette County	97070	02-Oct-97	F	22.4	998.8	Fs	0.61	
Northern Pike	97070-F005	97070-S05	Deer Lake	Marquette County	97070	02-Oct-97	F	23.2	998.8	Fs	0.72	
Northern Pike	97070-F006	97070-S06	Deer Lake	Marquette County	97070	02-Oct-97	F	21.8	908	Fs	0.73	
Northern Pike	97070-F007	97070-S07	Deer Lake	Marquette County	97070	02-Oct-97	M	21.5	908	Fs	0.54	
Northern Pike	97070-F008	97070-S08	Deer Lake	Marquette County	97070	02-Oct-97	M	22.3	817.2	Fs	0.92	
Northern Pike	97070-F020	97070-S20	Deer Lake	Marquette County	97070	02-Oct-97	M	20.2	635.6	Fs	1.17	
Northern Pike	97070-F021	97070-S21	Deer Lake	Marquette County	97070	02-Oct-97	M	21	771.8	Fs	0.83	
Northern Pike	97070-F022	97070-S22	Deer Lake	Marquette County	97070	02-Oct-97	M	21	771.8	Fs	0.97	
Northern Pike	97070-F023	97070-S23	Deer Lake	Marquette County	97070	02-Oct-97	M	30.1	1543.6	Fs	5.74	
Northern Pike	97070-F024	97070-S24	Deer Lake	Marquette County	97070	02-Oct-97	F	34	3904.4	Fs	3.30	
Northern Pike	1998024-F036	1998024-S36	Deer Lake	Marquette County	1998024	09-Oct-98	F	16.9	408.6	Fs	0.49	
Northern Pike	1998024-F037	1998024-S37	Deer Lake	Marquette County	1998024	09-Oct-98	F	18.4	499.4	Fs	0.33	
Northern Pike	1998024-F038	1998024-S38	Deer Lake	Marquette County	1998024	09-Oct-98	F	19.1	635.6	Fs	0.37	
Northern Pike	1998024-F039	1998024-S39	Deer Lake	Marquette County	1998024	09-Oct-98	F	19.6	681	Fs	0.35	
Northern Pike	1998024-F040	1998024-S40	Deer Lake	Marquette County	1998024	09-Oct-98	F	19.6	635.6	Fs	0.74	
Northern Pike	1998024-F041	1998024-S41	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.6	635.6	Fs	0.99	
Northern Pike	1998024-F042	1998024-S42	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.4	726.4	Fs	0.90	

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Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Northern Pike	1998024-F043	1998024-S43	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.4	726.4	Fs	0.97	
Northern Pike	1998024-F044	1998024-S44	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.4	726.4	Fs	0.89	
Northern Pike	1998024-F045	1998024-S45	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.7	908	Fs	0.65	
Northern Pike	1998024-F046	1998024-S46	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.8	817.2	Fs	0.94	
Northern Pike	1998024-F047	1998024-S47	Deer Lake	Marquette County	1998024	09-Oct-98	M	22.2	817.2	Fs	0.79	
Northern Pike	1998024-F048	1998024-S48	Deer Lake	Marquette County	1998024	09-Oct-98	F	22.2	862.6	Fs	0.97	
Northern Pike	1998024-F049	1998024-S49	Deer Lake	Marquette County	1998024	09-Oct-98	M	22.3	908	Fs	0.95	
Northern Pike	1998024-F050	1998024-S50	Deer Lake	Marquette County	1998024	09-Oct-98	M	22.5	953.4	Fs	0.72	
Northern Pike	1998024-F051	1998024-S51	Deer Lake	Marquette County	1998024	09-Oct-98	F	22.7	862.6	Fs	0.91	
Northern Pike	1998024-F052	1998024-S52	Deer Lake	Marquette County	1998024	09-Oct-98	F	22.7	862.6	Fs	1.21	
Northern Pike	1998024-F053	1998024-S53	Deer Lake	Marquette County	1998024	09-Oct-98	F	22.7	862.6	Fs	0.95	
Northern Pike	1998024-F054	1998024-S54	Deer Lake	Marquette County	1998024	09-Oct-98	F	22.8	908	Fs	0.75	
Northern Pike	1998024-F055	1998024-S55	Deer Lake	Marquette County	1998024	09-Oct-98	F	35.6	2996.4	Fs	10.47	
Northern Pike	1999006-F049	1999006-S49	Deer Lake	Marquette County	1999006	04-May-99	F	19.5	760	Fs	0.35	
Northern Pike	1999006-F050	1999006-S50	Deer Lake	Marquette County	1999006	04-May-99	F	20.5	530	Fs	1.06	
Northern Pike	1999006-F051	1999006-S51	Deer Lake	Marquette County	1999006	04-May-99	M	19.3	930	Fs	0.54	
Northern Pike	1999006-F052	1999006-S52	Deer Lake	Marquette County	1999006	04-May-99		22.4	770	Fs	1.09	
Northern Pike	1999006-F053	1999006-S53	Deer Lake	Marquette County	1999006	04-May-99	F	22.4	820	Fs	1.35	
Northern Pike	1999006-F054	1999006-S54	Deer Lake	Marquette County	1999006	04-May-99	F	23	1060	Fs	0.81	
Northern Pike	1999006-F055	1999006-S55	Deer Lake	Marquette County	1999006	04-May-99	F	27.4	1440	Fs	1.07	
Northern Pike	1999006-F056	1999006-S56	Deer Lake	Marquette County	1999006	04-May-99	F	28.3	2060	Fs	2.24	
Northern Pike	1999006-F057	1999006-S57	Deer Lake	Marquette County	1999006	04-May-99	F	27.2	1910	Fs	1.40	
Northern Pike	1999006-F058	1999006-S58	Deer Lake	Marquette County	1999006	04-May-99	M	26	1420	Fs	1.89	
Northern Pike	1999006-F059	1999006-S59	Deer Lake	Marquette County	1999006	04-May-99	F	27.4	1780	Fs	1.49	
Northern Pike	1999006-F060	1999006-S60	Deer Lake	Marquette County	1999006	04-May-99	F	32.3	3480	Fs	5.87	
Northern Pike	1999006-F061	1999006-S61	Deer Lake	Marquette County	1999006	04-May-99	F	30.7	3280	Fs	2.06	
Northern Pike	1999006-F062	1999006-S62	Deer Lake	Marquette County	1999006	04-May-99	F	30.9	2820	Fs	3.64	
Northern Pike	1999006-F063	1999006-S63	Deer Lake	Marquette County	1999006	04-May-99	F	32.3	3360	Fs	2.81	
Northern Pike	1999006-F064	1999006-S64	Deer Lake	Marquette County	1999006	04-May-99	F	34.3	4600	Fs	3.23	
Northern Pike	1999006-F065	1999006-S65	Deer Lake	Marquette County	1999006	04-May-99	F	34.6	4270	Fs	3.44	
Northern Pike	1999006-F066	1999006-S66	Deer Lake	Marquette County	1999006	04-May-99	F	34.6	4920	Fs	2.90	
Northern Pike	2001008-F024	2001008-S24	Deer Lake	Marquette County	2001008	01-May-01	F	22.6	980	Fs	0.65	
Northern Pike	2001008-F025	2001008-S25	Deer Lake	Marquette County	2001008	01-May-01	M	24.1	1290	Fs	0.41	
Northern Pike	2001008-F026	2001008-S26	Deer Lake	Marquette County	2001008	01-May-01	M	23.4	1150	Fs	0.56	
Northern Pike	2001008-F027	2001008-S27	Deer Lake	Marquette County	2001008	01-May-01	M	26.2	1950	Fs	0.49	
Northern Pike	2001008-F028	2001008-S28	Deer Lake	Marquette County	2001008	01-May-01	M	27	2060	Fs	1.50	
Northern Pike	2001008-F029	2001008-S29	Deer Lake	Marquette County	2001008	01-May-01	F	26.9	2320	Fs	0.73	
Northern Pike	2003161-F001	2003161-S01	Deer Lake	Marquette County	2003161	03-May-03		38.3	6084	Fs	2.16	
Northern Pike	2003161-F007	2003161-S07	Deer Lake	Marquette County	2003161	03-May-03		25	880	Fs	1.10	
Northern Pike	2003161-F008	2003161-S08	Deer Lake	Marquette County	2003161	03-May-03		25.2	1179	Fs	0.79	
Northern Pike	2003161-F009	2003161-S09	Deer Lake	Marquette County	2003161	03-May-03		26.8	1663	Fs	0.66	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Northern Pike	2003161-F010	2003161-S10	Deer Lake	Marquette County	2003161	03-May-03		27	1610	Fs	0.81	
Northern Pike	2008211-F001	2008211-S01	Deer Lake	Marquette County	2008211	14-Sep-08	M	20.9	1030	Fs	0.34	
Northern Pike	2008211-F002	2008211-S02	Deer Lake	Marquette County	2008211	14-Sep-08	F	21.5	1000	Fs	0.40	
Northern Pike	2008211-F003	2008211-S03	Deer Lake	Marquette County	2008211	14-Sep-08	M	23.8	1440	Fs	0.60	
Northern Pike	2008211-F004	2008211-S04	Deer Lake	Marquette County	2008211	14-Sep-08	M	25.4	1730	Fs	0.53	
Northern Pike	2008211-F005	2008211-S05	Deer Lake	Marquette County	2008211	14-Sep-08	F	33.8	4370	Fs	2.08	
Northern Pike	2011212-F041	2011212-S41	Deer Lake	Marquette County	2011212	03-May-11	F	22.4	1000	Fs	0.65	
Northern Pike	2011212-F042	2011212-S42	Deer Lake	Marquette County	2011212	03-May-11	F	25.8	1300	Fs	0.65	
Northern Pike	2011212-F043	2011212-S43	Deer Lake	Marquette County	2011212	03-May-11	M	25.2	1060	Fs	1.30	
Northern Pike	2011212-F044	2011212-S44	Deer Lake	Marquette County	2011212	03-May-11	M	26.7	1560	Fs	1.50	
Northern Pike	2011212-F045	2011212-S45	Deer Lake	Marquette County	2011212	03-May-11	F	32.4	3040	Fs	1.80	
Northern Pike	2011212-F046	2011212-S46	Deer Lake	Marquette County	2011212	03-May-11	F	33	3280	Fs	3.80	
Northern Pike	2011212-F047	2011212-S47	Deer Lake	Marquette County	2011212	03-May-11	F	34.1	3380	Fs	3.50	
Northern Pike	2011212-F048	2011212-S48	Deer Lake	Marquette County	2011212	03-May-11	F	35	4300	Fs	4.70	
Northern Pike	2011212-F049	2011212-S49	Deer Lake	Marquette County	2011212	03-May-11	F	34.4	4100	Fs	4.20	
Northern Pike	2011212-F050	2011212-S50	Deer Lake	Marquette County	2011212	03-May-11	F	41.6	4000	Fs	5.50	
Walleye	2011207-F001	2011207-S01	Carp River	Carp River Basin	2011207	29-Sep-11	F	19.1	1280	F	0.45	
Walleye	2011207-F002	2011207-S02	Carp River	Carp River Basin	2011207	29-Sep-11	F	19.8	1540	F	0.56	
Walleye	87099-F001	87099-S01	Deer Lake	Marquette County	87099	26-Oct-87		6		W	2.30	
Walleye	91032-F001	91032-S01	Deer Lake	Marquette County	91032	02-Nov-90		11	454	F	0.79	
Walleye	91032-F002	91032-S02	Deer Lake	Marquette County	91032	02-Nov-90		10.6	227	F	0.56	
Walleye	91032-F003	91032-S03	Deer Lake	Marquette County	91032	02-Nov-90		10	204	F	0.57	
Walleye	91032-F004	91032-S04	Deer Lake	Marquette County	91032	02-Nov-90		12.5	341	F	0.66	
Walleye	91032-F005	91032-S05	Deer Lake	Marquette County	91032	02-Nov-90		10.6	227	F	0.72	
Walleye	91032-F006	91032-S06	Deer Lake	Marquette County	91032	02-Nov-90		11.6	272	F	0.63	
Walleye	91032-F007	91032-S07	Deer Lake	Marquette County	91032	02-Nov-90		11.5	318	F	0.65	
Walleye	91032-F008	91032-S08	Deer Lake	Marquette County	91032	02-Nov-90		11.4	272	F	0.66	
Walleye	91032-F009	91032-S09	Deer Lake	Marquette County	91032	02-Nov-90		12.5	318	F	0.85	
Walleye	91032-F010	91032-S10	Deer Lake	Marquette County	91032	02-Nov-90		13.4	454	F	0.66	
Walleye	91032-F011	91032-S11	Deer Lake	Marquette County	91032	02-Nov-90		12.1	318	F	0.64	
Walleye	91032-F012	91032-S12	Deer Lake	Marquette County	91032	02-Nov-90		11.7	409	F	0.60	
Walleye	91032-F013	91032-S13	Deer Lake	Marquette County	91032	02-Nov-90		10.9	227	F	0.72	
Walleye	91032-F014	91032-S14	Deer Lake	Marquette County	91032	02-Nov-90		10.7	227	F	0.55	
Walleye	91032-F015	91032-S15	Deer Lake	Marquette County	91032	02-Nov-90		12	295	F	0.75	
Walleye	91032-F016	91032-S16	Deer Lake	Marquette County	91032	02-Nov-90		10	182	F	0.84	
Walleye	93083-F009	93083-S09	Deer Lake	Marquette County	93083	14-Sep-93		16.1	560	F	0.55	
Walleye	93083-F010	93083-S10	Deer Lake	Marquette County	93083	14-Sep-93		20.1	1180	F	0.92	
Walleye	93083-F011	93083-S11	Deer Lake	Marquette County	93083	14-Sep-93		13.8	400	F	0.40	
Walleye	93083-F012	93083-S12	Deer Lake	Marquette County	93083	14-Sep-93		20.5	1400	F	1.09	
Walleye	93083-F013	93083-S13	Deer Lake	Marquette County	93083	14-Sep-93		13	300	F	0.62	
Walleye	93083-F014	93083-S14	Deer Lake	Marquette County	93083	14-Sep-93		10.6	160	F	0.25	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Walleye	93083-F015	93083-S15	Deer Lake	Marquette County	93083	14-Sep-93		14.6	480	F	0.49	
Walleye	93083-F016	93083-S16	Deer Lake	Marquette County	93083	14-Sep-93		18.1	940	F	1.71	
Walleye	93083-F017	93083-S17	Deer Lake	Marquette County	93083	14-Sep-93		19.3	1400	F	1.07	
Walleye	93083-F018	93083-S18	Deer Lake	Marquette County	93083	14-Sep-93		18.1	1880	F	0.72	
Walleye	96008-F001	96008-S01	Deer Lake	Marquette County	96008	02-Oct-96	M	16.2	580	F	0.79	
Walleye	96008-F002	96008-S02	Deer Lake	Marquette County	96008	02-Oct-96	M	16.6	610	F	0.82	
Walleye	96008-F003	96008-S03	Deer Lake	Marquette County	96008	02-Oct-96	F	17.7	780	F	0.79	
Walleye	96008-F004	96008-S04	Deer Lake	Marquette County	96008	02-Oct-96	M	17.8	720	F	0.63	
Walleye	96008-F005	96008-S05	Deer Lake	Marquette County	96008	02-Oct-96	M	17.9	670	F	0.80	
Walleye	96008-F006	96008-S06	Deer Lake	Marquette County	96008	02-Oct-96	M	19.1	990	F	1.09	
Walleye	96008-F007	96008-S07	Deer Lake	Marquette County	96008	02-Oct-96	M	19.6	830	F	1.09	
Walleye	96008-F008	96008-S08	Deer Lake	Marquette County	96008	02-Oct-96	F	19.7	990	F	1.24	
Walleye	96008-F009	96008-S09	Deer Lake	Marquette County	96008	02-Oct-96	F	20.2	1020	F	1.18	
Walleye	96008-F010	96008-S10	Deer Lake	Marquette County	96008	02-Oct-96	M	20.3	960	F	1.38	
Walleye	97070-F009	97070-S09	Deer Lake	Marquette County	97070	02-Oct-97	M	23	1498.2	F	1.32	
Walleye	97070-F010	97070-S10	Deer Lake	Marquette County	97070	02-Oct-97	F	19.5	998.8	F	1.26	
Walleye	97070-F011	97070-S11	Deer Lake	Marquette County	97070	02-Oct-97	M	19.5	953.4	F	1.24	
Walleye	97070-F012	97070-S12	Deer Lake	Marquette County	97070	02-Oct-97	M	19.6	862.6	F	1.33	
Walleye	97070-F013	97070-S13	Deer Lake	Marquette County	97070	02-Oct-97	F	19	862.6	F	1.16	
Walleye	97070-F014	97070-S14	Deer Lake	Marquette County	97070	02-Oct-97	F	18.4	817.2	F	1.03	
Walleye	97070-F015	97070-S15	Deer Lake	Marquette County	97070	02-Oct-97	F	17.7	726.4	F	1.17	
Walleye	97070-F016	97070-S16	Deer Lake	Marquette County	97070	02-Oct-97	M	17.5	590.2	F	1.09	
Walleye	97070-F017	97070-S17	Deer Lake	Marquette County	97070	02-Oct-97	M	16.7	635.6	F	0.98	
Walleye	97070-F018	97070-S18	Deer Lake	Marquette County	97070	02-Oct-97	M	17.3	726.4	F	1.11	
Walleye	1998024-F016	1998024-S16	Deer Lake	Marquette County	1998024	09-Oct-98	M	15.1	454	F	0.32	
Walleye	1998024-F017	1998024-S17	Deer Lake	Marquette County	1998024	09-Oct-98	M	15.3	544.8	F	0.56	
Walleye	1998024-F018	1998024-S18	Deer Lake	Marquette County	1998024	09-Oct-98	F	15.7	499.4	F	0.53	
Walleye	1998024-F019	1998024-S19	Deer Lake	Marquette County	1998024	09-Oct-98	F	16.2	544.8	F	0.43	
Walleye	1998024-F020	1998024-S20	Deer Lake	Marquette County	1998024	09-Oct-98	F	16.2	590.2	F	0.37	
Walleye	1998024-F021	1998024-S21	Deer Lake	Marquette County	1998024	09-Oct-98	M	17.8	817.2	F	1.02	
Walleye	1998024-F022	1998024-S22	Deer Lake	Marquette County	1998024	09-Oct-98	M	18	771.8	F	0.58	
Walleye	1998024-F023	1998024-S23	Deer Lake	Marquette County	1998024	09-Oct-98	F	18.3	771.8	F	1.05	
Walleye	1998024-F024	1998024-S24	Deer Lake	Marquette County	1998024	09-Oct-98	M	18.4	771.8	F	1.04	
Walleye	1998024-F025	1998024-S25	Deer Lake	Marquette County	1998024	09-Oct-98	M	18.6	862.6	F	1.03	
Walleye	1998024-F026	1998024-S26	Deer Lake	Marquette County	1998024	09-Oct-98	F	20	1089.6	F	1.05	
Walleye	1998024-F027	1998024-S27	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.1	1044.2	F	1.19	
Walleye	1998024-F028	1998024-S28	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.2	908	F	1.16	
Walleye	1998024-F029	1998024-S29	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.4	1180.4	F	1.20	
Walleye	1998024-F030	1998024-S30	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.6	862.6	F	1.23	
Walleye	1998024-F031	1998024-S31	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.6	1225.8	F	1.20	
Walleye	1998024-F032	1998024-S32	Deer Lake	Marquette County	1998024	09-Oct-98	F	20.7	1271.2	F	1.20	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Walleye	1998024-F033	1998024-S33	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.3	1089.6	F	1.24	
Walleye	1998024-F034	1998024-S34	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.5	1180.4	F	1.50	
Walleye	1998024-F035	1998024-S35	Deer Lake	Marquette County	1998024	09-Oct-98	F	21.7	1225.8	F	1.52	
Walleye	1999006-F014	1999006-S14	Deer Lake	Marquette County	1999006	04-May-99	F	14.6	400	F	0.44	
Walleye	1999006-F015	1999006-S15	Deer Lake	Marquette County	1999006	04-May-99	M	15	360	F	0.94	
Walleye	1999006-F016	1999006-S16	Deer Lake	Marquette County	1999006	04-May-99	M	15.9	460	F	0.79	
Walleye	1999006-F017	1999006-S17	Deer Lake	Marquette County	1999006	04-May-99	M	16.5	490	F	1.17	
Walleye	1999006-F018	1999006-S18	Deer Lake	Marquette County	1999006	04-May-99	F	15.4	400	F	0.68	
Walleye	1999006-F019	1999006-S19	Deer Lake	Marquette County	1999006	04-May-99	M	15.7	460	F	0.72	
Walleye	1999006-F020	1999006-S20	Deer Lake	Marquette County	1999006	04-May-99	M	15.9	480	F	1.11	
Walleye	1999006-F021	1999006-S21	Deer Lake	Marquette County	1999006	04-May-99	M	15.7	460	F	0.97	
Walleye	1999006-F022	1999006-S22	Deer Lake	Marquette County	1999006	04-May-99	F	15.4	460	F	0.41	
Walleye	1999006-F023	1999006-S23	Deer Lake	Marquette County	1999006	04-May-99	M	15	430	F	0.57	
Walleye	1999006-F024	1999006-S24	Deer Lake	Marquette County	1999006	04-May-99	F	16.7	490	F	1.00	
Walleye	1999006-F025	1999006-S25	Deer Lake	Marquette County	1999006	04-May-99	F	17.3	620	F	0.93	
Walleye	1999006-F026	1999006-S26	Deer Lake	Marquette County	1999006	04-May-99	F	17.3	420	F	1.38	
Walleye	1999006-F027	1999006-S27	Deer Lake	Marquette County	1999006	04-May-99	M	16.5	520	F	1.26	
Walleye	1999006-F028	1999006-S28	Deer Lake	Marquette County	1999006	04-May-99	F	18.1	580	F	1.37	
Walleye	1999006-F029	1999006-S29	Deer Lake	Marquette County	1999006	04-May-99	M	17.3	540	F	1.46	
Walleye	1999006-F030	1999006-S30	Deer Lake	Marquette County	1999006	04-May-99	F	17.9	670	F	1.28	
Walleye	1999006-F031	1999006-S31	Deer Lake	Marquette County	1999006	04-May-99	M	19.7	920	F	1.20	
Walleye	1999006-F032	1999006-S32	Deer Lake	Marquette County	1999006	04-May-99	F	18.9	940	F	1.14	
Walleye	1999006-F033	1999006-S33	Deer Lake	Marquette County	1999006	04-May-99	F	20.5	1020	F	1.42	
Walleye	1999006-F034	1999006-S34	Deer Lake	Marquette County	1999006	04-May-99	M	19.1	750	F	1.45	
Walleye	1999006-F035	1999006-S35	Deer Lake	Marquette County	1999006	04-May-99	M	19.7	910	F	1.28	
Walleye	1999006-F036	1999006-S36	Deer Lake	Marquette County	1999006	04-May-99	F	20.5	1260	F	1.17	
Walleye	1999006-F037	1999006-S37	Deer Lake	Marquette County	1999006	04-May-99	F	19.1	850	F	1.19	
Walleye	1999006-F038	1999006-S38	Deer Lake	Marquette County	1999006	04-May-99	M	20.1	1010	F	1.51	
Walleye	1999006-F039	1999006-S39	Deer Lake	Marquette County	1999006	04-May-99	F	20.5	1120	F	1.21	
Walleye	1999006-F040	1999006-S40	Deer Lake	Marquette County	1999006	04-May-99	F	20.7	1100	F	1.40	
Walleye	1999006-F041	1999006-S41	Deer Lake	Marquette County	1999006	04-May-99	F	20.9	1190	F	1.38	
Walleye	1999006-F042	1999006-S42	Deer Lake	Marquette County	1999006	04-May-99	M	20.5	1290	F	1.12	
Walleye	1999006-F043	1999006-S43	Deer Lake	Marquette County	1999006	04-May-99	F	21.7	1160	F	1.43	
Walleye	1999006-F044	1999006-S44	Deer Lake	Marquette County	1999006	04-May-99	F	22	1580	F	1.22	
Walleye	1999006-F045	1999006-S45	Deer Lake	Marquette County	1999006	04-May-99	F	22.4	1610	F	1.45	
Walleye	1999006-F046	1999006-S46	Deer Lake	Marquette County	1999006	04-May-99	F	22.4	1720	F	1.26	
Walleye	1999006-F047	1999006-S47	Deer Lake	Marquette County	1999006	04-May-99	F	22.4	1630	F	1.23	
Walleye	1999006-F048	1999006-S48	Deer Lake	Marquette County	1999006	04-May-99	F	23.6	1760	F	1.72	
Walleye	2001008-F012	2001008-S12	Deer Lake	Marquette County	2001008	01-May-01	M	15.4	430	F	0.24	
Walleye	2001008-F013	2001008-S13	Deer Lake	Marquette County	2001008	01-May-01	M	16.1	530	F	0.80	
Walleye	2001008-F014	2001008-S14	Deer Lake	Marquette County	2001008	01-May-01	M	15.7	470	F	0.36	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Walleye	2001008-F015	2001008-S15	Deer Lake	Marquette County	2001008	01-May-01	M	16.9	630	F	0.72	
Walleye	2001008-F016	2001008-S16	Deer Lake	Marquette County	2001008	01-May-01	M	17.1	610	F	0.82	
Walleye	2001008-F017	2001008-S17	Deer Lake	Marquette County	2001008	01-May-01	M	18.3	760	F	0.97	
Walleye	2001008-F018	2001008-S18	Deer Lake	Marquette County	2001008	01-May-01	M	18.8	790	F	1.02	
Walleye	2001008-F019	2001008-S19	Deer Lake	Marquette County	2001008	01-May-01	F	19.9	970	F	0.69	
Walleye	2001008-F020	2001008-S20	Deer Lake	Marquette County	2001008	01-May-01	M	20.7	1280	F	0.86	
Walleye	2001008-F021	2001008-S21	Deer Lake	Marquette County	2001008	01-May-01	F	21.3	1340	F	1.09	
Walleye	2001008-F022	2001008-S22	Deer Lake	Marquette County	2001008	01-May-01	F	21.8	1640	F	0.97	
Walleye	2001008-F023	2001008-S23	Deer Lake	Marquette County	2001008	01-May-01	F	23	1590	F	0.99	
Walleye	2003161-F002	2003161-S02	Deer Lake	Marquette County	2003161	03-May-03		18.2	605	F	1.12	
Walleye	2003161-F003	2003161-S03	Deer Lake	Marquette County	2003161	03-May-03		18.6	604	F	1.00	
Walleye	2003161-F004	2003161-S04	Deer Lake	Marquette County	2003161	03-May-03		19	634	F	1.13	
Walleye	2003161-F005	2003161-S05	Deer Lake	Marquette County	2003161	03-May-03		19.6	832	F	0.59	
Walleye	2003161-F006	2003161-S06	Deer Lake	Marquette County	2003161	03-May-03		19.9	729	F	1.46	
Walleye	2008211-F006	2008211-S06	Deer Lake	Marquette County	2008211	14-Sep-08	M	14.7	410	F	0.28	
Walleye	2008211-F007	2008211-S07	Deer Lake	Marquette County	2008211	14-Sep-08	M	13.9	370	F	0.19	
Walleye	2008211-F008	2008211-S08	Deer Lake	Marquette County	2008211	14-Sep-08	M	13.7	375	F	0.23	
Walleye	2008211-F009	2008211-S09	Deer Lake	Marquette County	2008211	14-Sep-08		14.4	390	F	0.12	
Walleye	2008211-F010	2008211-S10	Deer Lake	Marquette County	2008211	14-Sep-08		14.4	410	F	0.11	
Walleye	2008211-F011	2008211-S11	Deer Lake	Marquette County	2008211	14-Sep-08	F	14.6	450	F	0.28	
Walleye	2008211-F012	2008211-S12	Deer Lake	Marquette County	2008211	14-Sep-08		15.6	560	F	0.45	
Walleye	2008211-F013	2008211-S13	Deer Lake	Marquette County	2008211	14-Sep-08	F	15.3	520	F	0.54	
Walleye	2008211-F014	2008211-S14	Deer Lake	Marquette County	2008211	14-Sep-08	M	15.7	550	F	0.44	
Walleye	2008211-F015	2008211-S15	Deer Lake	Marquette County	2008211	14-Sep-08	F	16.2	495	F	0.61	
Walleye	2008211-F016	2008211-S16	Deer Lake	Marquette County	2008211	14-Sep-08	F	15.4	480	F	0.22	
Walleye	2008211-F017	2008211-S17	Deer Lake	Marquette County	2008211	14-Sep-08	F	15.2	460	F	0.31	
Walleye	2008211-F018	2008211-S18	Deer Lake	Marquette County	2008211	14-Sep-08	F	15.8	560	F	0.20	
Walleye	2008211-F019	2008211-S19	Deer Lake	Marquette County	2008211	14-Sep-08	F	16.1	540	F	0.28	
Walleye	2008211-F020	2008211-S20	Deer Lake	Marquette County	2008211	14-Sep-08	F	16.2	560	F	0.62	
Walleye	2008211-F021	2008211-S21	Deer Lake	Marquette County	2008211	14-Sep-08	M	17.3	650	F	0.76	
Walleye	2008211-F022	2008211-S22	Deer Lake	Marquette County	2008211	14-Sep-08	F	16.6	610	F	0.42	
Walleye	2008211-F023	2008211-S23	Deer Lake	Marquette County	2008211	14-Sep-08	F	16.4	605	F	0.49	
Walleye	2008211-F024	2008211-S24	Deer Lake	Marquette County	2008211	14-Sep-08	F	17.7	720	F	0.72	
Walleye	2008211-F025	2008211-S25	Deer Lake	Marquette County	2008211	14-Sep-08	F	17.7	775	F	0.93	
Walleye	2008211-F026	2008211-S26	Deer Lake	Marquette County	2008211	14-Sep-08	F	17.6	780	F	0.67	
Walleye	2008211-F027	2008211-S27	Deer Lake	Marquette County	2008211	14-Sep-08	F	18.4	810	F	0.77	
Walleye	2011212-F026	2011212-S26	Deer Lake	Marquette County	2011212	03-May-11	M	19	860	F	1.30	
Walleye	2011212-F027	2011212-S27	Deer Lake	Marquette County	2011212	03-May-11	F	19.8	900	F	1.40	
Walleye	2011212-F028	2011212-S28	Deer Lake	Marquette County	2011212	03-May-11	M	19.7	1080	F	0.86	
Walleye	2011212-F029	2011212-S29	Deer Lake	Marquette County	2011212	03-May-11	F	20.4	1080	F	1.10	
Walleye	2011212-F030	2011212-S30	Deer Lake	Marquette County	2011212	03-May-11	F	19.2	920	F	0.98	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Walleye	2011212-F031	2011212-S31	Deer Lake	Marquette County	2011212	03-May-11	F	20.2	1060	F	1.30	
Walleye	2011212-F033	2011212-S33	Deer Lake	Marquette County	2011212	03-May-11	F	20.4	1060	F	1.50	
Walleye	2011212-F034	2011212-S34	Deer Lake	Marquette County	2011212	03-May-11	F	19.6	1080	F	1.20	
Walleye	2011212-F035	2011212-S35	Deer Lake	Marquette County	2011212	03-May-11	F	19.8	900	F	1.60	
Walleye	2011212-F036	2011212-S36	Deer Lake	Marquette County	2011212	03-May-11	M	20.2	1020	F	1.60	
Walleye	2011212-F037	2011212-S37	Deer Lake	Marquette County	2011212	03-May-11	F	21.3	1300	F	1.50	
White Sucker	2005013-F001	2005013-S01	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		7.5	40	Fs	0.19	
White Sucker	2005013-F002	2005013-S02	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	M	8.1	70	Fs	0.19	
White Sucker	2005013-F003	2005013-S03	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	9.3	110	Fs	0.24	
White Sucker	2005013-F004	2005013-S04	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		9	105	Fs	0.23	
White Sucker	2005013-F005	2005013-S05	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		9.4	120	Fs	0.21	
White Sucker	2005013-F006	2005013-S06	Carp Creek	u/s Deer Lake	2005013	25-Aug-05	F	15.2	580	Fs	0.42	
White Sucker	2005013-F007	2005013-S07	Carp Creek	u/s Deer Lake	2005013	25-Aug-05		15.8	710	Fs	0.56	
White Sucker	2010260-F001	2010260-S01	Carp Creek	u/s Deer Lake	2010260	04-Aug-10		10.9	220	F	0.12	
White Sucker	2010260-F002	2010260-S02	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	M	12.4	340	F	0.16	
White Sucker	2010260-F003	2010260-S03	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	M	14.4	520	F	0.27	
White Sucker	2010260-F004	2010260-S04	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	M	17.1	750	F	0.20	
White Sucker	2010260-F005	2010260-S05	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	F	16	760	F	0.26	
White Sucker	2010260-F006	2010260-S06	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	F	15.3	740	F	0.13	
White Sucker	2010260-F007	2010260-S07	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	M	16.1	980	F	0.13	
White Sucker	2010260-F008	2010260-S08	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	F	17.3	920	F	0.32	
White Sucker	2010260-F009	2010260-S09	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	F	18	1040	F	0.42	
White Sucker	2010260-F010	2010260-S10	Carp Creek	u/s Deer Lake	2010260	04-Aug-10	F	18.7	1080	F	0.34	
White Sucker	2011207-F003	2011207-S03	Carp River	Carp River Basin	2011207	29-Sep-11	F	12.6	420	F	0.09	
White Sucker	2011207-F004	2011207-S04	Carp River	Carp River Basin	2011207	29-Sep-11	F	13.1	420	F	0.12	
White Sucker	2011207-F005	2011207-S05	Carp River	Carp River Basin	2011207	29-Sep-11	F	16.1	800	F	0.27	
White Sucker	2011207-F006	2011207-S06	Carp River	Carp River Basin	2011207	29-Sep-11	F	16.5	700	F	0.32	
White Sucker	2011207-F007	2011207-S07	Carp River	Carp River Basin	2011207	29-Sep-11	F	15.5	740	F	0.14	
White Sucker	2011207-F008	2011207-S08	Carp River	Carp River Basin	2011207	29-Sep-11	F	16.1	800	F	0.20	
White Sucker	2011207-F009	2011207-S09	Carp River	Carp River Basin	2011207	29-Sep-11	F	16	840	F	0.35	
White Sucker	2011207-F010	2011207-S10	Carp River	Carp River Basin	2011207	29-Sep-11	M	16.3	900	F	0.33	
White Sucker	2011207-F011	2011207-S11	Carp River	Carp River Basin	2011207	29-Sep-11	F	17.7	1060	F	0.47	
White Sucker	2011207-F012	2011207-S12	Carp River	Carp River Basin	2011207	29-Sep-11	F	19.8	1520	F	0.29	
White Sucker	84012-F001	84012-S01	Carp River	M-35	84012	27-Sep-84		3.9		W	0.10	
White Sucker	84012-F002	84012-S01	Carp River	M-35	84012	27-Sep-84		7		W	0.10	
White Sucker	84012-F003	84012-S02	Carp River	M-35	84012	27-Sep-84		8.1		W	0.10	
White Sucker	84012-F004	84012-S02	Carp River	M-35	84012	27-Sep-84		8.5		W	0.10	
White Sucker	84012-F005	84012-S03	Carp River	M-35	84012	27-Sep-84		11.1		F	0.30	
White Sucker	2004010-F010	2004010-S10	Carp River	M-35	2004010	17-Aug-04		8.5	100	F	0.14	
White Sucker	2004010-F011	2004010-S11	Carp River	M-35	2004010	17-Aug-04		8.7	110	F	0.07	
White Sucker	2004010-F012	2004010-S12	Carp River	M-35	2004010	17-Aug-04		10.1	170	F	0.39	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
White Sucker	2004010-F013	2004010-S13	Carp River	M-35	2004010	17-Aug-04		10.2	190	F	0.23	
White Sucker	2004010-F014	2004010-S14	Carp River	M-35	2004010	17-Aug-04		11.1	220	F	0.13	
White Sucker	2004010-F015	2004010-S15	Carp River	M-35	2004010	17-Aug-04		11.4	245	F	0.22	
White Sucker	2004010-F016	2004010-S16	Carp River	M-35	2004010	17-Aug-04		11.4	265	F	0.21	
White Sucker	2004010-F017	2004010-S17	Carp River	M-35	2004010	17-Aug-04		12.2	320	F	0.14	
White Sucker	2004010-F018	2004010-S18	Carp River	M-35	2004010	17-Aug-04		13.6	420	F	0.26	
White Sucker	2004010-F019	2004010-S19	Carp River	M-35	2004010	17-Aug-04		13.3	440	F	0.21	
White Sucker	84011-F020	84011-S20	Deer Lake	Marquette County	84011	09-Oct-84		17.7		F	0.40	
White Sucker	84011-F021	84011-S21	Deer Lake	Marquette County	84011	09-Oct-84		19.7		F	0.80	
White Sucker	84011-F022	84011-S22	Deer Lake	Marquette County	84011	09-Oct-84		19.7		F	0.50	
White Sucker	84011-F023	84011-S23	Deer Lake	Marquette County	84011	09-Oct-84		18.1		F	0.40	
White Sucker	84011-F024	84011-S24	Deer Lake	Marquette County	84011	09-Oct-84		15.7		F	0.50	
White Sucker	2011212-F001	2011212-S01	Deer Lake	Marquette County	2011212	03-May-11	F	12	420	F	0.06	
White Sucker	2011212-F002	2011212-S02	Deer Lake	Marquette County	2011212	03-May-11	F	13.9	600	F	0.14	
White Sucker	2011212-F003	2011212-S03	Deer Lake	Marquette County	2011212	03-May-11	M	14.1	640	F	0.11	
White Sucker	2011212-F004	2011212-S04	Deer Lake	Marquette County	2011212	03-May-11	F	15.7	1000	F	0.11	
White Sucker	2011212-F005	2011212-S05	Deer Lake	Marquette County	2011212	03-May-11	M	17	1000	F	0.34	
White Sucker	2011212-F006	2011212-S06	Deer Lake	Marquette County	2011212	03-May-11	F	19.7	1700	F	0.43	
White Sucker	2011212-F007	2011212-S07	Deer Lake	Marquette County	2011212	03-May-11	F	20.2	1700	F	0.39	
White Sucker	2011212-F008	2011212-S08	Deer Lake	Marquette County	2011212	03-May-11	F	20	1800	F	0.30	
White Sucker	2011212-F009	2011212-S09	Deer Lake	Marquette County	2011212	03-May-11	F	21.4	2000	F	0.70	
White Sucker	2011212-F010	2011212-S10	Deer Lake	Marquette County	2011212	03-May-11	F	21.5	2360	F	0.53	
Yellow Perch	2011207-F013	2011207-S13	Carp River	Carp River Basin	2011207	29-Sep-11	M	7.9	90	F	0.13	
Yellow Perch	88068-F001	88068-S01	Carp River	Eagle Mills Pump House	88068	06-Oct-88				W	0.51	
Yellow Perch	88068-F002	88068-S02	Carp River	Eagle Mills Pump House	88068	06-Oct-88				W	0.57	
Yellow Perch	88068-F003	88068-S03	Carp River	Eagle Mills Pump House	88068	06-Oct-88				W	0.53	
Yellow Perch	88068-F004	88068-S04	Carp River	Eagle Mills Pump House	88068	06-Oct-88				W	0.54	
Yellow Perch	84012-F006	84012-S04	Carp River	M-35	84012	27-Sep-84		8		F	1.00	
Yellow Perch	84011-F025	84011-S25	Deer Lake	Marquette County	84011	09-Oct-84		9.4		F	1.50	
Yellow Perch	84011-F026	84011-S26	Deer Lake	Marquette County	84011	09-Oct-84		9.3		F	1.40	
Yellow Perch	84011-F027	84011-S27	Deer Lake	Marquette County	84011	09-Oct-84		9.6		F	1.40	
Yellow Perch	84011-F028	84011-S28	Deer Lake	Marquette County	84011	09-Oct-84		9.1		F	1.80	
Yellow Perch	84011-F029	84011-S29	Deer Lake	Marquette County	84011	09-Oct-84		10		F	1.60	
Yellow Perch	84011-F030	84011-S30	Deer Lake	Marquette County	84011	09-Oct-84		10		F	2.20	
Yellow Perch	84011-F031	84011-S31	Deer Lake	Marquette County	84011	09-Oct-84		9.8		F	1.90	
Yellow Perch	84011-F032	84011-S32	Deer Lake	Marquette County	84011	09-Oct-84		9.6		F	1.50	
Yellow Perch	84011-F033	84011-S33	Deer Lake	Marquette County	84011	09-Oct-84		9.8		F	0.70	
Yellow Perch	84011-F034	84011-S34	Deer Lake	Marquette County	84011	09-Oct-84		9.1		F	1.50	
Yellow Perch	84011-F035	84011-S35	Deer Lake	Marquette County	84011	09-Oct-84		8.7		W	1.40	
Yellow Perch	84011-F036	84011-S36	Deer Lake	Marquette County	84011	09-Oct-84		8.5		W	0.50	
Yellow Perch	84011-F037	84011-S37	Deer Lake	Marquette County	84011	09-Oct-84		5.9		W	0.60	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Yellow Perch	84011-F038	84011-S38	Deer Lake	Marquette County	84011	09-Oct-84		5.9		W	0.60	
Yellow Perch	84011-F039	84011-S39	Deer Lake	Marquette County	84011	09-Oct-84		5.5		W	0.50	
Yellow Perch	84011-F040	84011-S40	Deer Lake	Marquette County	84011	09-Oct-84		5.7		W	0.50	
Yellow Perch	84011-F041	84011-S41	Deer Lake	Marquette County	84011	09-Oct-84		5.9		W	0.60	
Yellow Perch	84011-F042	84011-S41	Deer Lake	Marquette County	84011	09-Oct-84				W	0.60	
Yellow Perch	84011-F043	84011-S41	Deer Lake	Marquette County	84011	09-Oct-84				W	0.60	
Yellow Perch	84011-F044	84011-S42	Deer Lake	Marquette County	84011	09-Oct-84		5.1		W	0.30	
Yellow Perch	84011-F045	84011-S42	Deer Lake	Marquette County	84011	09-Oct-84				W	0.30	
Yellow Perch	84011-F046	84011-S42	Deer Lake	Marquette County	84011	09-Oct-84				W	0.30	
Yellow Perch	84011-F047	84011-S42	Deer Lake	Marquette County	84011	09-Oct-84				W	0.30	
Yellow Perch	84011-F048	84011-S43	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.90	
Yellow Perch	84011-F049	84011-S44	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.60	
Yellow Perch	84011-F050	84011-S45	Deer Lake	Marquette County	84011	09-Oct-84		7.3		F	0.60	
Yellow Perch	84011-F051	84011-S46	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.90	
Yellow Perch	84011-F052	84011-S47	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.70	
Yellow Perch	84011-F053	84011-S48	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.70	
Yellow Perch	84011-F054	84011-S49	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	1.40	
Yellow Perch	84011-F055	84011-S50	Deer Lake	Marquette County	84011	09-Oct-84		6.9		F	0.80	
Yellow Perch	84011-F056	84011-S51	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.60	
Yellow Perch	84011-F057	84011-S52	Deer Lake	Marquette County	84011	09-Oct-84		7.1		F	0.60	
Yellow Perch	87099-F002	87099-S02	Deer Lake	Marquette County	87099	26-Oct-87		3	11.4	W	2.10	
Yellow Perch	87099-F003	87099-S03	Deer Lake	Marquette County	87099	26-Oct-87		8.2	137	W	1.30	
Yellow Perch	87099-F004	87099-S04	Deer Lake	Marquette County	87099	26-Oct-87		8.7	182	W	3.80	
Yellow Perch	87099-F005	87099-S05	Deer Lake	Marquette County	87099	26-Oct-87		8.8	113	W	3.10	
Yellow Perch	87099-F006	87099-S06	Deer Lake	Marquette County	87099	26-Oct-87		8.5	182	W	2.80	
Yellow Perch	88067-F001	88067-S01	Deer Lake	Marquette County	88067	06-Oct-88		5.9		W	1.05	
Yellow Perch	88067-F002	88067-S02	Deer Lake	Marquette County	88067	06-Oct-88		5.9		W	0.96	
Yellow Perch	88067-F003	88067-S03	Deer Lake	Marquette County	88067	06-Oct-88		9.4		F	0.71	
Yellow Perch	97070-F019	97070-S19	Deer Lake	Marquette County	97070	02-Oct-97	M	8.2	90.8	F	0.24	
Yellow Perch	1998024-F001	1998024-S01	Deer Lake	Marquette County	1998024	09-Oct-98	F	8.5	136.2	F	0.17	
Yellow Perch	1998024-F002	1998024-S02	Deer Lake	Marquette County	1998024	09-Oct-98	F	9.5	181.6	F	0.15	
Yellow Perch	1998024-F003	1998024-S03	Deer Lake	Marquette County	1998024	09-Oct-98	F	9.5	181.6	F	0.21	
Yellow Perch	1998024-F004	1998024-S04	Deer Lake	Marquette County	1998024	09-Oct-98	F	9.8	227	F	0.18	
Yellow Perch	1998024-F005	1998024-S05	Deer Lake	Marquette County	1998024	09-Oct-98	F	9.9	272.4	F	0.17	
Yellow Perch	1998024-F006	1998024-S06	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.2	272.4	F	0.20	
Yellow Perch	1998024-F007	1998024-S07	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.6	317.8	F	0.19	
Yellow Perch	1998024-F008	1998024-S08	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.4	272.4	F	0.17	
Yellow Perch	1998024-F009	1998024-S09	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.6	272.4	F	0.17	
Yellow Perch	1998024-F010	1998024-S10	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.1	272.4	F	0.20	
Yellow Perch	1998024-F011	1998024-S11	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.4	272.4	F	0.18	
Yellow Perch	1998024-F012	1998024-S12	Deer Lake	Marquette County	1998024	09-Oct-98	F	10.7	317.8	F	0.19	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Yellow Perch	1998024-F013	1998024-S13	Deer Lake	Marquette County	1998024	09-Oct-98	F	11	272.4	F	0.16	
Yellow Perch	1998024-F014	1998024-S14	Deer Lake	Marquette County	1998024	09-Oct-98	F	11	317.8	F	0.18	
Yellow Perch	1998024-F015	1998024-S15	Deer Lake	Marquette County	1998024	09-Oct-98	F	12	363.2	F	0.35	
Yellow Perch	1999006-F001	1999006-S01	Deer Lake	Marquette County	1999006	04-May-99	M	9.8	210	F	0.20	
Yellow Perch	1999006-F002	1999006-S02	Deer Lake	Marquette County	1999006	04-May-99	F	10	250	F	0.18	
Yellow Perch	1999006-F003	1999006-S03	Deer Lake	Marquette County	1999006	04-May-99	M	10.2	280	F	0.39	
Yellow Perch	1999006-F004	1999006-S04	Deer Lake	Marquette County	1999006	04-May-99	F	10.2	290	F	0.39	
Yellow Perch	1999006-F005	1999006-S05	Deer Lake	Marquette County	1999006	04-May-99	M	10.4	240	F	0.17	
Yellow Perch	1999006-F006	1999006-S06	Deer Lake	Marquette County	1999006	04-May-99	M	11.4	370	F	0.63	
Yellow Perch	1999006-F007	1999006-S07	Deer Lake	Marquette County	1999006	04-May-99	F	12.8	460	F	0.64	
Yellow Perch	1999006-F008	1999006-S08	Deer Lake	Marquette County	1999006	04-May-99	F	13	520	F	0.66	
Yellow Perch	1999006-F009	1999006-S09	Deer Lake	Marquette County	1999006	04-May-99	F	13.2	590	F	0.67	
Yellow Perch	1999006-F010	1999006-S10	Deer Lake	Marquette County	1999006	04-May-99	F	13.6	560	F	0.71	
Yellow Perch	1999006-F011	1999006-S11	Deer Lake	Marquette County	1999006	04-May-99	F	13.4	700	F	0.63	
Yellow Perch	1999006-F012	1999006-S12	Deer Lake	Marquette County	1999006	04-May-99	F	14	780	F	0.93	
Yellow Perch	1999006-F013	1999006-S13	Deer Lake	Marquette County	1999006	04-May-99	F	13.6	580	F	0.59	
Yellow Perch	2001008-F001	2001008-S01	Deer Lake	Marquette County	2001008	01-May-01	F	9.3	170	F	0.16	
Yellow Perch	2001008-F002	2001008-S02	Deer Lake	Marquette County	2001008	01-May-01	M	9.6	210	F	0.14	
Yellow Perch	2001008-F003	2001008-S03	Deer Lake	Marquette County	2001008	01-May-01	M	10.2	230	F	0.16	
Yellow Perch	2001008-F004	2001008-S04	Deer Lake	Marquette County	2001008	01-May-01	M	10.2	240	F	0.14	
Yellow Perch	2001008-F005	2001008-S05	Deer Lake	Marquette County	2001008	01-May-01	M	10.7	240	F	0.18	
Yellow Perch	2001008-F006	2001008-S06	Deer Lake	Marquette County	2001008	01-May-01	M	11	320	F	0.16	
Yellow Perch	2001008-F007	2001008-S07	Deer Lake	Marquette County	2001008	01-May-01	M	12	340	F	0.58	
Yellow Perch	2001008-F008	2001008-S08	Deer Lake	Marquette County	2001008	01-May-01	F	12.2	460	F	0.39	
Yellow Perch	2001008-F009	2001008-S09	Deer Lake	Marquette County	2001008	01-May-01	F	13.1	500	F	0.46	
Yellow Perch	2001008-F010	2001008-S10	Deer Lake	Marquette County	2001008	01-May-01	F	13.7	510	F	0.52	
Yellow Perch	2001008-F011	2001008-S11	Deer Lake	Marquette County	2001008	01-May-01	F	13.2	610	F	0.52	
Yellow Perch	2010205-F001	2010205-S01	Deer Lake	Marquette County	2010205	12-Apr-10	F	8.5	138	F	0.19	
Yellow Perch	2010205-F002	2010205-S02	Deer Lake	Marquette County	2010205	12-Apr-10	F	10.2	266	F	0.25	
Yellow Perch	2011212-F011	2011212-S11	Deer Lake	Marquette County	2011212	03-May-11	F	9.6	240	F	0.44	
Yellow Perch	2011212-F012	2011212-S12	Deer Lake	Marquette County	2011212	03-May-11	M	10.1	260	F	0.23	
Yellow Perch	2011212-F013	2011212-S13	Deer Lake	Marquette County	2011212	03-May-11	F	10.8	260	F	0.40	
Yellow Perch	2011212-F014	2011212-S14	Deer Lake	Marquette County	2011212	03-May-11	M	11	300	F	0.28	
Yellow Perch	2011212-F015	2011212-S15	Deer Lake	Marquette County	2011212	03-May-11	F	11.2	400	F	0.31	
Yellow Perch	2011212-F016	2011212-S16	Deer Lake	Marquette County	2011212	03-May-11	F	12	480	F	0.29	
Yellow Perch	2011212-F017	2011212-S17	Deer Lake	Marquette County	2011212	03-May-11	F	11.5	380	F	0.30	
Yellow Perch	2011212-F018	2011212-S18	Deer Lake	Marquette County	2011212	03-May-11	F	10.9	340	F	0.46	
Yellow Perch	2011212-F019	2011212-S19	Deer Lake	Marquette County	2011212	03-May-11	F	12	460	F	0.35	
Yellow Perch	2011212-F020	2011212-S20	Deer Lake	Marquette County	2011212	03-May-11	F	11.5	420	F	0.29	
Yellow Perch	2011212-F021	2011212-S21	Deer Lake	Marquette County	2011212	03-May-11	F	11.5	460	F	0.49	
Yellow Perch	2011212-F022	2011212-S22	Deer Lake	Marquette County	2011212	03-May-11	F	12	440	F	0.39	

ATTACHMENT E

Appendix A. Mercury concentrations in brook trout, northern pike, walleye, white sucker, and yellow perch collected from the Deer Lake AOC between 1984 and 2011.

Species	Fish ID#	Sample ID#	Waterbody Name	Location	Visit ID	Collection Date	Sex	Length (Inches)	Weight (g)	SampleType	Mercury (ppm)	Lab Code
Yellow Perch	2011212-F023	2011212-S23	Deer Lake	Marquette County	2011212	03-May-11	F	11.8	500	F	0.76	
Yellow Perch	2011212-F024	2011212-S24	Deer Lake	Marquette County	2011212	03-May-11	F	12.4	560	F	0.56	
Yellow Perch	2011212-F025	2011212-S25	Deer Lake	Marquette County	2011212	03-May-11	F	12.6	520	F	0.34	

ATTACHMENT F

A Summary of Contaminant Trends in Fish from Michigan Waters

The Michigan Department of Environmental Quality Water Resources Division coordinates the collection and analysis of fish from 22 locations as part of an effort to measure spatial and temporal trends in contaminant concentrations (Table 1; Figure 1). Samples are collected from each site every 2 to 5 years and analyzed as whole fish samples. Select species of adult fish are targeted for collection and analyses. Species and locations were selected to complement and avoid duplication with the USEPA's Great Lakes whole fish trend monitoring program.

Since 1990, lake trout, walleye, or largemouth bass were collected from inland lake trend monitoring sites (Table 1). In that period Lake Gogebic has been sampled 7 times, Higgins, Houghton, and Pontiac Lakes have been sampled 8 times, and Gull, Gun, and South Manistique Lakes have been sampled 9 times.

Carp were collected from 5 river impoundment trend monitoring sites since 1990 (Table 1). The River Raisin upstream of the Monroe Dam and the St. Joseph River at Chapin Lake were sampled 8 times, the Grand River upstream of the 6th Street Dam and the Muskegon River at the Croton impoundment were sampled 9 times, and the Kalamazoo River at Lake Allegan was sampled 11 times in that period.

Ten trend monitoring sites were established in the Great Lakes or connecting channels (Table 1; Figure 1). Carp were monitored at 9 locations, walleye were collected from 8 locations, and lake trout were collected from 3 locations since 1990.

Temporal trend analyses were conducted on a total of 31 data sets collected as part of Michigan's whole fish trend monitoring program. These include carp from 5 river impoundments; lake trout, walleye, or largemouth bass from 7 inland lakes; and 19 carp, walleye, or lake trout data sets from 10 Great Lake or connecting channel stations. A significant increase or decrease in at least one selected contaminant was detected in all 31 data sets.

Often strong relationships exist between lipids and organic contaminant concentrations as well as length and contaminant concentrations. Therefore, multiple linear regression analyses were used to evaluate relationships between the contaminant concentrations and these potential explanatory variables. Since the raw data often do not meet the assumptions needed for valid regression analysis the data were first transformed using the natural log of the concentration. Natural log transformed contaminant concentrations (wet weight) were used to fit the data into exponential decay rate models and obtain estimates of annual rates of change. The trend model for each subset of data was developed using an iterative process. The initial multiple linear regression model for mercury concentrations included length, weight, and collection date as explanatory variables. The model for organic contaminant concentrations used length, weight, lipids, and collection date as explanatory variables. A final multiple linear regression model was developed for each species/site and contaminant combination by successively eliminating variables that did not have a statistically significant relationship ($p<0.05$) to contaminant concentration.

Minimum detectable trends were calculated in cases where the regression model failed to detect a significant trend in contaminant concentrations. The minimum detectable trend is the smallest possible trend that could have been detected with the available data for each contaminant, species, and site. The statistical significance of slope (or trend) in a linear regression model is calculated using a t-test. The minimum detectable trend can be calculated by rearranging the t-test, establishing a desired significance level (p=0.05), and obtaining the standard error of the slope from the regression analyses. For example, a minimum detectable trend of +/-2.2% per year in Houghton Lake largemouth bass mercury concentrations (Table 2) indicates that no mercury trend was detected and the data were sufficient to detect a trend with an absolute value greater than 1.4% per year. Therefore, the absolute value of the real trend (if any) was 1.4% per year or less.

Mercury

Statistically significant changes in mercury concentrations were detected in 15 of 31 data sets (Table 2). Concentrations are increasing in at least 1 species of fish at 6 of the 7 Great Lakes or connecting channel trend sites where a trend can be detected. The average and median rates of change in these 8 data sets were +1.5% per year and +2.4% per year, respectively. The mercury concentration in Detroit River carp has declined since 1990, while walleye from the site did not exhibit a change in that period. The mercury concentration in Lake St. Clair carp also declined since 1990, but concentrations in Lake St. Clair walleye have increased in the same period.

Mercury concentrations declined in fish from 4 of 5 inland lakes or impoundments where trends could be detected, and increased in fish from the fourth site. The average and median rates of change in fish from the 5 inland waterbodies was -1.3% per year and -1.8% per year, respectively.

Minimum detectable mercury concentration trends from all inland lake, impoundment, Great Lakes, and connecting channel data sets ranged from +/-1.3% per year to +/-2.3% per year with a median minimum detectable trend of +/-1.8% per year.

Total PCBs

Statistically significant changes in total PCB concentrations were detected in 28 of 31 data sets (Table 2). Total PCB concentrations decreased in all 28 data sets where changes were statistically significant. Total PCB concentrations declined in at least 1 species from all 10 sites in the Great Lakes or connecting channels. The average and median rates of change in these data sets were 7.2% per year and 7.4% per year, respectively. Carp from Little Bay De Noc, the St. Marys River, and Thunder Bay have not yet shown a significant trend in total PCB concentrations. Minimum detectable trends ranged from +/-2.2% to +/-6.0%.

A significant downward trend in total PCB concentrations was detected in fish from all 12 impoundment and inland lake trend sites (Table 2). The average and median rates of change in fish from all 12 inland sites were -7.7% per year and -6.4% per year, respectively. The annual rate of decline ranged from 4.0% to 14.1%.

Total DDT

A statistically significant decrease in total DDT concentration was detected in 30 of 31 data sets (Table 2). Concentrations decreased in all of the Great Lakes and connecting channel data sets where a trend could be detected. The average and median rates of change in fish from these sites were both -9.0% per year. No statistically significant change in total DDT concentrations in carp from Little Bay De Noc has been measured.

Total DDT concentrations declined in fish from all 12 inland lakes and impoundments; the average and median rates of change in fish from those 11 sites were -6.5% per year and -9.0% per year, respectively.

Total Chlordane

Statistically significant decreases in total chlordane concentrations were observed in all 29 data sets (Table 2). Concentrations were consistently near or below the quantification level in walleye from Lake Gogebic and South Manistique Lake, and chlordane trend analysis was not appropriate or necessary for those data sets.

Concentrations of total chlordane declined in all 19 data sets collected from the 10 locations in the Great Lakes and connecting channels. The average and median rates of change in fish from these sites were -10.0% and -10.2% per year, respectively.

Total chlordane concentrations declined in fish from all 10 inland lakes and impoundments where analysis was appropriate. The average and median rates of change in fish from these 11 sites were -8.7 and -8.9% per year, respectively.

Dioxin TEQ

Statistically significant decreases in dioxin TEQ concentrations were measured in fish from 3 of the 4 sites where TEQ was analyzed (Table 2). Concentrations declined in lake trout from Grand Traverse Bay, Thunder Bay and Keweenaw Bay, but a significant change was not observed in carp from Saginaw Bay. The average and median rates of decline in dioxin TEQ were -8.8% per year and -9.1% per year, respectively.

Other Observations

- Lindane, terphenyl, PBB, heptachlor, and aldrin were not quantified in any of the fish sampled. However, heptachlor epoxide and dieldrin (breakdown products of heptachlor and aldrin) were quantified in most of the samples analyzed.

- In addition to heptachlor epoxide and dieldrin, several chemicals were quantified in fish consistently, indicating that they are ubiquitous in the aquatic environment. These include mercury, hexachlorobenzene, total PCB, total chlordane, and total DDT.

- All species from the Great Lakes and connecting channels tended to have higher concentrations of chlorinated organic contaminants than the same species from inland lakes.

- Average total PCB concentrations were highest in carp from the Kalamazoo River site. The Kalamazoo River has extensive areas of PCB contaminated sediments, a problem that is being addressed under state and federal programs.

ATTACHMENT F

Table 1. Whole fish trend monitoring locations, target species, and years monitored.

WATER BODY	SPECIES COLLECTED*	YEARS MONITORED
GREAT LAKES AND CONNECTING CHANNELS		
Lake Michigan		
Little Bay de Noc	Carp	1992, 94, 00, 03, 05, 07, 09
	Walleye	1992, 94, 97, 00, 02, 05, 07, 09
Grand Traverse Bay	Carp	1993, 95, 00, 03, 08, 11
	Lake Trout (D)	1990, 92, 95, 98, 01, 04, 06, 09
Lake Huron		
Saginaw Bay	Carp (D)	1990, 92, 94, 98, 01, 03, 05, 09
	Walleye	1990, 91, 92, 94, 98, 03, 05, 07, 09
Thunder Bay	Carp	1992, 94, 95, 99, 01, 04, 06, 08, 10
	Lake Trout (D)	1992, 94, 95, 98, 01, 04, 05, 07, 09
	Walleye	1991, 95, 98, 01, 05, 07, 09
Lake Superior		
Keweenaw Bay	Lake Trout (D)	1991, 93, 96, 99, 01, 04, 07, 10
Lake St. Clair		
L'Anse Creuse Bay	Carp	1990, 92, 94, 98, 02, 05, 07, 09, 11
	Walleye	1990, 92, 94, 98, 02, 05, 07, 09, 11
Lake Erie		
Brest Bay	Carp	1990, 92, 94, 97, 98, 02, 06, 08, 10
	Walleye	1990, 92, 94, 98, 04, 06, 08, 10
St. Marys River		
Munuscong Bay	Carp	1993, 95, 98, 04, 09
	Walleye	1991, 93, 95, 98, 01, 05, 07, 10
St. Clair River		
Algonac	Carp	1992, 94, 02, 05, 07, 09
Detroit River		
Grassy Island	Carp	1990, 92, 94, 96, 98, 01, 04, 07, 09, 11
	Walleye	1990, 94, 96, 98, 01, 04, 05, 11
RIVERS		
Grand River	Carp	1990, 92, 95, 00, 03, 05, 07, 09, 11
Kalamazoo River	Carp	1990, 92, 94, 97, 99, 01, 03, 05, 07, 09, 11
Muskegon River	Carp	1991, 93, 95, 97, 00, 02, 05, 07, 09
River Raisin	Carp	1991, 94, 97, 00, 04, 06, 08, 10
St. Joseph River	Carp	1991, 93, 97, 00, 02, 05, 07, 09
INLAND LAKES		
Lake Gogebic	Walleye	1992, 94, 97, 00, 02, 05, 09
South Manistique Lake	Walleye	1991, 93, 95, 98, 01, 03, 05, 07, 09
Higgins Lake	Lake Trout	1991, 95, 97, 00, 02, 05, 10, 11
Houghton Lake	Largemouth Bass	1992, 94, 98, 01, 04, 06, 08, 10
Gull Lake	Largemouth Bass	1991, 93, 95, 97, 00, 02, 05, 07, 09
Gun Lake	Largemouth Bass	1990, 92, 94, 97, 00, 02, 05, 07, 09
Pontiac Lake	Largemouth Bass	1992, 94, 97, 99, 03, 06, 08, 10

*D = dioxin and furan congeners

ATTACHMENT F

Table 2. Annual rates of change in contaminant concentrations measured in whole fish collected from fixed station trend monitoring sites. Trends using data available as of March 2013 (Most recent year = 2011).

WATER BODY	SPECIES	ANNUAL RATE OF CHANGE (%) AND PROBABILITY (p)									
		Mercury		Total PCB		Total DDT		Total Chlordane		Dioxin TEQ	
		%	p	%	p	%	p	%	p	%	p
GREAT LAKES AND CONNECTING CHANNELS											
Lake Michigan											
Little Bay de Noc	Carp	±1.9		±3.3		±3.2		-4.0	0.01		
	Walleye	2.5	0.003	-10.7	<0.001	-14.0	<0.001	-14.7	<0.001		
Grand Traverse Bay	Carp	±2.3		-9.9	<0.001	-11.2	<0.001	-10.2	<0.001		
	Lake Trout	2.0	0.002	-8.6	<0.001	-11.2	<0.001	-10.5	<0.001	-9.1	<0.001
Lake Huron											
Saginaw Bay	Carp	±1.8		-8.0	<0.001	-3.7	0.01	-8.5	<0.001	±3.1	
	Walleye	2.5	0.001	-4.3	<0.001	-7.2	<0.001	-8.9	<0.001		
Thunder Bay	Carp	4.4	<0.001	±2.2		-4.8	<0.001	-7.9	<0.001		
	Lake Trout	2.4	<0.001	-6.8	<0.001	-9.5	<0.001	-11.5	<0.001	-7.4	<0.001
	Walleye	±2.1		-7.6	<0.001	-12.8	<0.001	-16.6	<0.001		
Lake Superior											
Keweenaw Bay	Lake Trout	±1.5		-7.3	<0.001	-9.5	<0.001	-9.0	<0.001	-10.0	<0.001
Lake Erie											
Brest Bay	Carp	3.6	<0.001	-2.9	0.02	-6.8	<0.001	-7.0	<0.001		
	Walleye	1.9	<0.001	-6.6	<0.001	-10.2	<0.001	-12.7	<0.001		
Lake St. Clair											
L'Anse Creuse Bay	Carp	-2.3	0.02	-5.5	0.002	-7.4	<0.001	-7.2	<0.001		
	Walleye	2.7	<0.001	-7.2	<0.001	-13.1	<0.001	-14.0	<0.001		
St. Clair River											
Algonac	Carp	±2.3		-8.7	0.001	-7.1	0.001	-6.9	0.001		
Detroit River											
Grassy Island	Carp	-5.0	<0.001	-2.8	0.003	-2.8	<0.001	-3.7	<0.001		
	Walleye	±1.4		-8.9	<0.001	-6.5	<0.001	-13.8	<0.001		
St. Marys River											
Munuscong Bay	Carp	±1.5		±6.0		-8.4	0.001	-11.5	<0.001		
	Walleye	±1.4		-9.6	<0.001	-15.8	<0.001	-12.9	<0.001		
	Average**	1.5		-7.2		-9.0		-10.0		-8.8	
	Median**	2.4		-7.4		-9.0		-10.2		-9.1	

*± indicates that no significant trend was measured (p>0.05) and the value presented is an estimate of the minimum detectable trend.

**Average and median concentrations were calculated using only Great Lakes and Connecting Channels and species with significant trends.

Table 2. (continued)

WATER BODY	SPECIES	ANNUAL RATE OF CHANGE (%) AND PROBABILITY (p)									
		Mercury		Total PCB		Total DDT		Total Chlordane		Dioxin TEQ	
		%	p	%	p	%	p	%	p	%	p
RIVER IMPOUNDMENTS											
Grand River	Carp	±2.0		-4.0	0.003	-3.3	0.05	-6.6	<0.001		
Kalamazoo River	Carp	-1.1	0.04	-5.0	<0.001	-6.0	<0.001	-3.9	<0.001		
Muskegon River	Carp	±2.3		-12.3	<0.001	-9.5	<0.001	-12.2	<0.001		
River Raisin	Carp	-2.6	<0.001	-11.0	<0.001	-10.3	<0.001	-9.7	<0.001		
St. Joseph River	Carp	±1.4		-4.0	0.002	-9.2	<0.001	-7.1	<0.001		
INLAND LAKES											
Lake Gogebic	Walleye	-4.7	<0.001	-14.1	<0.001	-9.4	<0.001	#NA			
South Manistique Lake	Walleye	±1.3		-5.0	<0.001	-3.5	<0.001	#NA			
Higgins Lake	Lake Trout	3.6	<0.001	-5.1	<0.001	-4.9	<0.001	-8.9	<0.001		
Houghton Lake	Largemouth Bass	±2.2		-11.0	<0.001	-8.7	<0.001	-8.9	<0.001		
Gull Lake	Largemouth Bass	-1.8	0.001	-7.8	<0.001	-10.3	<0.001	-13.3	<0.001		
Gun Lake	Largemouth Bass	±2.2		-5.7	<0.001	-5.0	<0.001	-6.3	<0.001		
Pontiac Lake	Largemouth Bass	±1.5		-7.0	<0.001	-9.6	<0.001	-10.4	<0.001		
	Average**	-1.3		-7.7		-6.5		-8.7			
	Median**	-1.8		-6.4		-9.0		-8.9			

*± indicates that no significant trend was measured (p>0.05) and the value presented is an estimate of the minimum detectable trend.
**Average and median concentrations were calculated using only inland lakes and impoundments and species with significant trends.
#Trend estimates were not available because contaminant concentrations were below the analytical detection level.

ATTACHMENT F

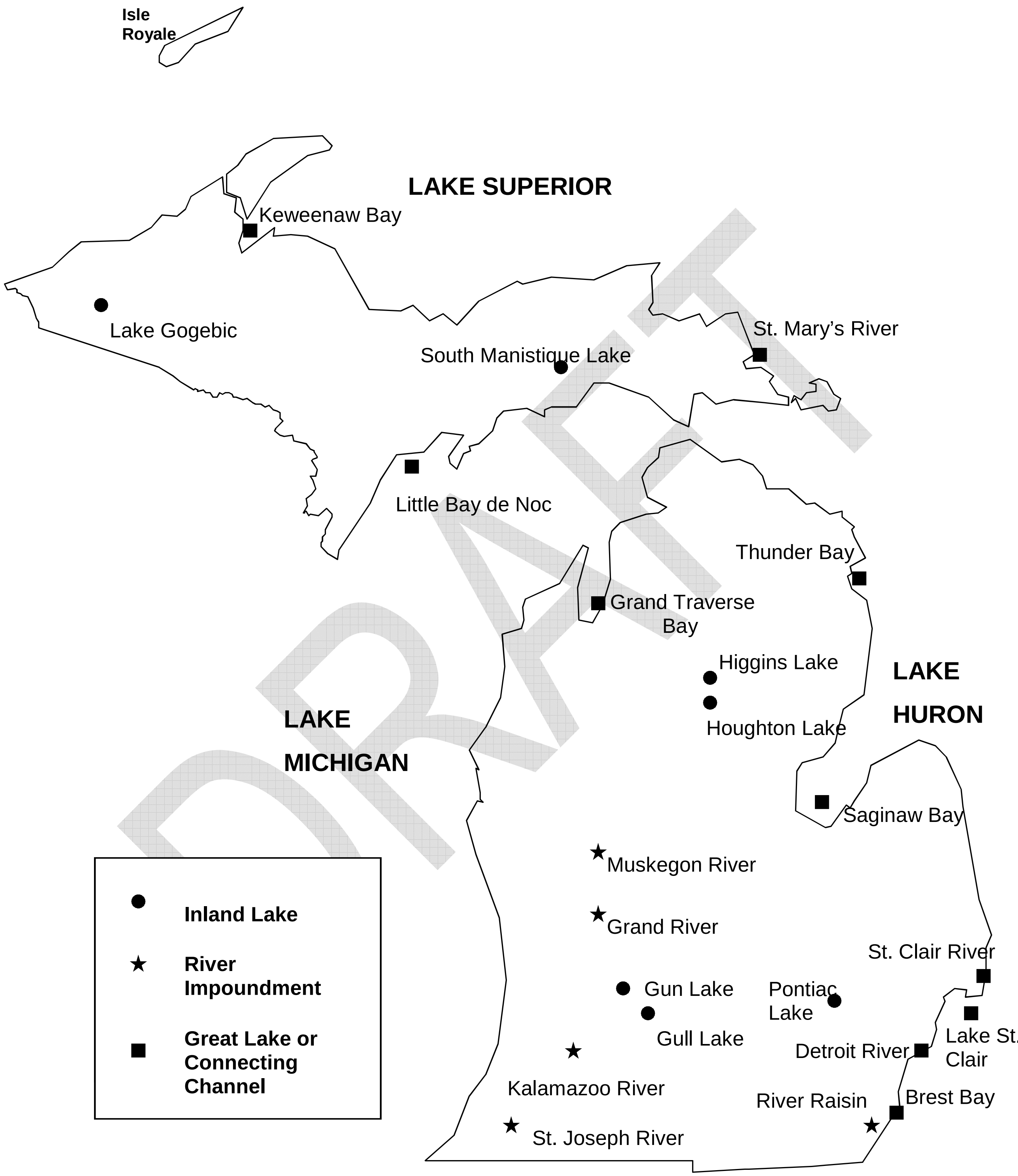

Figure 1. Whole fish trend monitoring sites.

ATTACHMENT G

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April 24, 2014

Ms. Stephanie Swart, AOC Coordinator
Office of the Great Lakes
Michigan Department of Environmental Quality
525 West Allegan Street
Lansing, Michigan 48909

Re: Support for Delisting of the Deer Lake Area of Concern

Dear Ms. Swart:

The purpose of this letter is to indicate the unanimous support of the Deer Lake Public Advisory Council (PAC) for the delisting of the Deer Lake Area of Concern (AOC). After 25-plus years, the collaborative efforts of the PAC, Michigan Department of Environmental Quality, Michigan Department of Natural Resources, U.S. Environmental Protection Agency, Cliffs Natural Resources and city of Ishpeming have achieved in the restoration of impaired uses at Deer Lake. We applaud the work that our partners have done to get the AOC to this milestone and look forward to celebrating together after confirmation of the delisting. The PAC has reviewed the delisting report and support the motion to proceed toward delisting.

If you have any questions regarding our support for the delisting of the Deer Lake AOC please do not hesitate to contact us. We value our partnership with the AOC Program and look forward to continuing to protect Deer Lake as a lake association.

Sincerely,

Diane K Feller

Diane Feller, PAC Chair
Deer Lake Area of Concern
(906) 486-9967

cc: Mr. Pete Nault, Vice Chair, Deer Lake PAC
Mr. Rob Beranek, Secretary, Deer Lake PAC