UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

19 FEB 2014

REPLY TO THE ATTENTION OF:

Mr. Roger Eberhardt
Acting Deputy Director, Office of the Great Lakes
Michigan Department of Environmental Quality
525 West Allegan
P.O. Box 30473
Lansing, Michigan 48909-7773

Dear Roger:

Thank you for your February 4, 2014, request to remove the "Restrictions on Fish and Wildlife Consumption" Beneficial Use Impairment (BUI) from the Deer Lake Area of Concern (AOC) in Michigan. As you know, we share your desire to restore all of the Great Lakes AOCs and to formally delist them.

Based upon a review of your submittal and the supporting data, the U.S. Environmental Protection Agency hereby approves your BUI removal request for the Deer Lake AOC. In addition, EPA will notify the International Joint Commission of this significant positive environmental change at this AOC.

We congratulate you and your staff, as well as the many federal, state, and local partners who have worked so hard and been instrumental in achieving this important environmental improvement. Removal of this BUI will benefit not only the people who live and work in the Deer Lake AOC, but all the residents of Michigan and the Great Lakes basin as well.

We look forward to the continuation of this important and productive relationship with your agency and the local coordinating committee as we work together to fully restore all of Michigan's AOCs. If you have any further questions, please contact me at (312) 353-4891, or your staff may contact John Perrecone, at (312) 353-1149.

Sincerely,

Chris Korleski, Director
Great Lakes National Program Office

cc: Dan Wyant, Director, MDEQ
Jon W. Allan, MDEQ, Office of Great Lakes
Rick Hobrla, MDEQ, Office of Great Lakes
Stephanie Swart, MDEQ, Office of Great Lakes
Stephen Locke, IJC
Wendy Carney, EPA, GLNPO
John Perrecone, EPA, GLNPO
Mark Loomis, EPA, GLNPO

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
OFFICE OF THE GREAT LAKES
LANSING

JON W. ALLAN
DIRECTOR

February 4, 2014

Mr. Chris Korleski, Director
Great Lakes National Program Office
United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard (G-17J)
Chicago, Illinois 60604-3507

Dear Mr. Korleski:

The purpose of this letter is to request the United States Environmental Protection Agency (USEPA), Great Lakes National Program Office's (GLNPO) concurrence with the removal of the Restrictions on Fish and Wildlife Consumption Beneficial Use Impairment (BUI) for the Deer Lake Area of Concern (AOC). The Michigan Department of Environmental Quality (MDEQ) has assessed the status of this BUI in accordance with the state's *Guidance for Delisting Michigan's Great Lakes Areas of Concern* and recommends that this final BUI be removed from the list of impairments in the Deer Lake AOC.

We have made minor changes to the document since the original submittal in November 2013. The edits are located on page 8 of the enclosed Removal Recommendation. All other documentation necessary for removal of the Restrictions on Fish and Wildlife Consumption BUI for the Deer Lake AOC has also been enclosed.

We value our partnership and look forward to working with the GLNPO on delisting this AOC. If you need further information concerning this request for the Deer Lake AOC, please contact Ms. Stephanie Swart, Office of the Great Lakes at 517-284-5046, or at swarts@michigan.gov, or you may contact me.

Sincerely,

Roger Eberhardt
Acting Deputy Director
517-284-5035

Enclosures
cc: Mr. Jon W. Allan, MDEQ
Mr. Richard Hobrla, MDEQ
Ms. Stephanie Swart, MDEQ
cc/enc: Mr. Marc Tuchman, USEPA
Mr. John Perrecone, USEPA

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Lynelle Marolf, Deputy Director, Office of the Great Lakes

FROM: Rick Hobrla, Chief, Great Lakes Management Unit

DATE: November 15, 2013

SUBJECT: Removal of the Restrictions on Fish and Wildlife Consumption Beneficial Use Impairment for the Deer Lake Area of Concern

The Department of Environmental Quality, Great Lakes Management Unit, Areas of Concern (AOC) Program staff request concurrence with the recommendation to remove the Restrictions on the Fish and Wildlife Consumption Beneficial Use Impairment (BUI) in the Deer Lake AOC. This request is made in accordance with the process outlined in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern*.

Attached is a Removal Recommendation documenting restoration and justifying removal of this BUI. Also attached is a draft letter to Mr. Chris Korleski, Director, Great Lakes National Program Office, United States Environmental Protection Agency, requesting removal of the BUI. The re-designation was discussed by the Deer Lake Public Advisory Council and the community at a meeting on November 5, 2013. As part of their continued support for this BUI removal recommendation, the Deer Lake Public Advisory Council submitted a letter on November 5, 2013.

Attachments
cc: Stephanie Swart, Office of the Great Lakes

Removal Recommendation
Restrictions on Fish and Wildlife Consumption Beneficial Use Impairment
Deer Lake Area of Concern

Issue

The Michigan Department of Environmental Quality (MDEQ), Office of the Great Lakes, Areas of Concern (AOC) program recommends removal of the Restrictions on Fish and Wildlife Consumption Beneficial Use Impairment (BUI) in the Deer Lake AOC. This recommendation is made with the support of staff from the MDEQ Water Resources Division, the Michigan Department of Community Health (MDCH), and the Deer Lake Public Advisory Council (PAC). This recommendation is made in accordance with the process and criteria set forth in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern* (Guidance) (MDEQ, 2008).

Background

Deer Lake is a 1,010-acre impoundment located in central Marquette County near the center of Michigan's Upper Peninsula. The Deer Lake AOC includes a portion of Carp Creek, Deer Lake, and the Carp River. Carp Creek flows into Deer Lake at the middle of the South Basin. Deer Lake flows into the Carp River via the dam at the North Basin impoundment. The AOC terminates as the Carp River flows into Lake Superior near the city of Marquette, Michigan (Figure 1).

Historic mining practices resulted in mercury contamination to the Deer Lake basin from Ropes Creek and Carp Creek. According to the 1987 Remedial Action Plan (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 Michigan Department of Natural Resources (MDNR).

Two BUIs -- Eutrophication or Undesirable Algae as well as Bird or Animal Deformities or Reproduction Problems -- have been assessed and removed (Swart, 2011a; Swart, 2011b). One BUI remains for the Deer Lake AOC: Restrictions on Fish and Wildlife Consumption. Additional historical information can be found in Attachment B and a timeline of activities in the AOC can be found in Attachment C.

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:

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 associated 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.

The attached excerpt from the *Guidance* (pages 14-18) includes the rationale for the delisting criteria (Attachment A).

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 and there is not a suitable comparison site with similar characteristics. 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 inland lakes in Michigan due to mercury contamination of fish tissue. The specific MDCH fish consumption advisories for Deer Lake are in Attachments G and H. Please refer to the MDCH *Eat Safe Fish Guide* for any fish consumption restrictions at www.michigan.gov/eatsafefish.

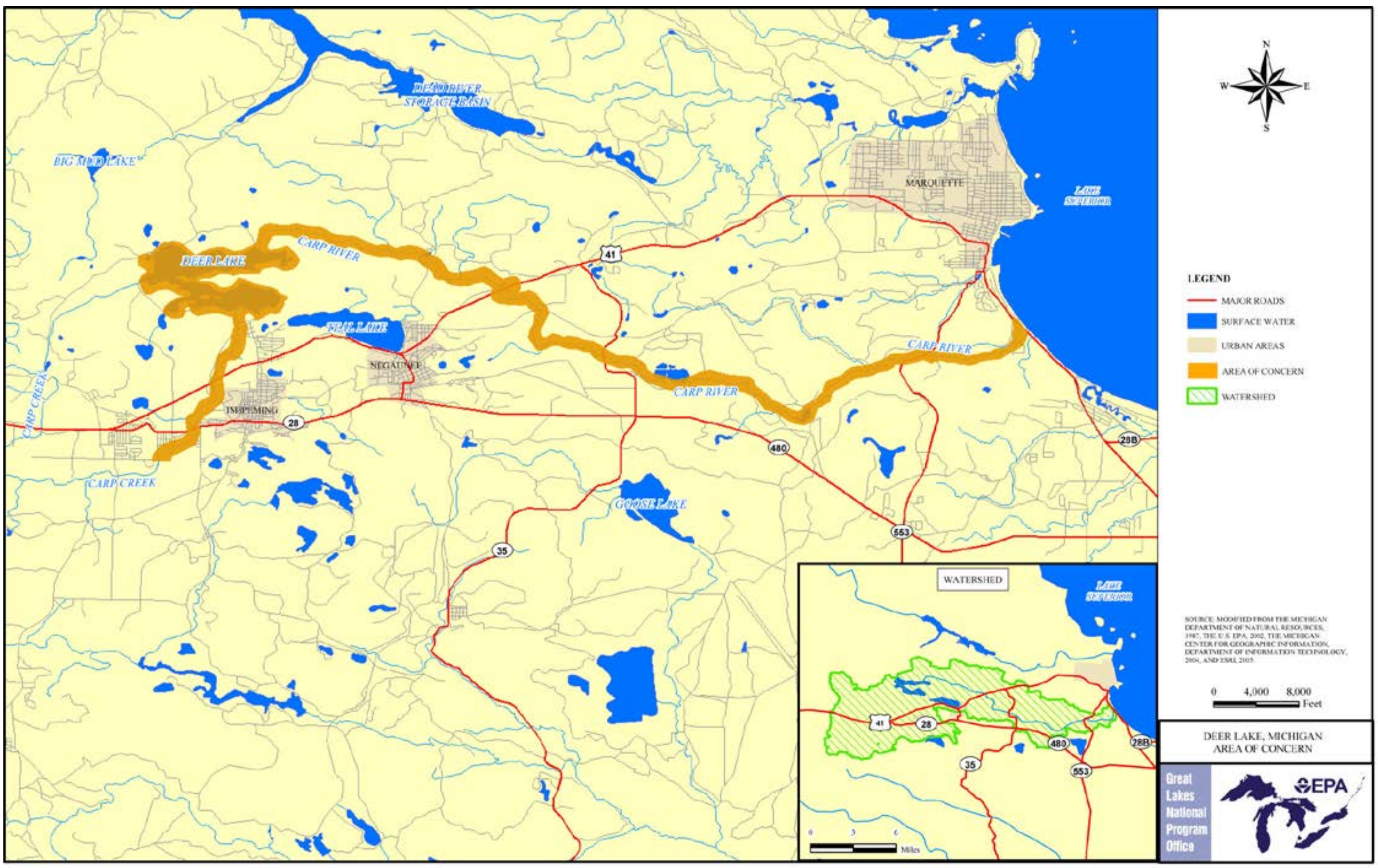

Figure 1. Deer Lake AOC Boundary

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 tailings from this process remained in the watershed. The Cleveland-Cliffs Iron Company (now Cliffs Natural Resources [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. A 2006 Amendment to Consent Judgment 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 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 MDCH. The assessments were designed to focus specifically on Tier 3 of the Guidance described on page 1, analysis of trend data. The full scope and methods can be found in Attachment E.

Fish Tissue Assessment

Fish tissue concentrations of mercury have declined over the last 20 years in Deer Lake fish 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. Therefore, the assessment data below strongly support this BUI removal recommendation based on the established criteria (Attachment A).

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).

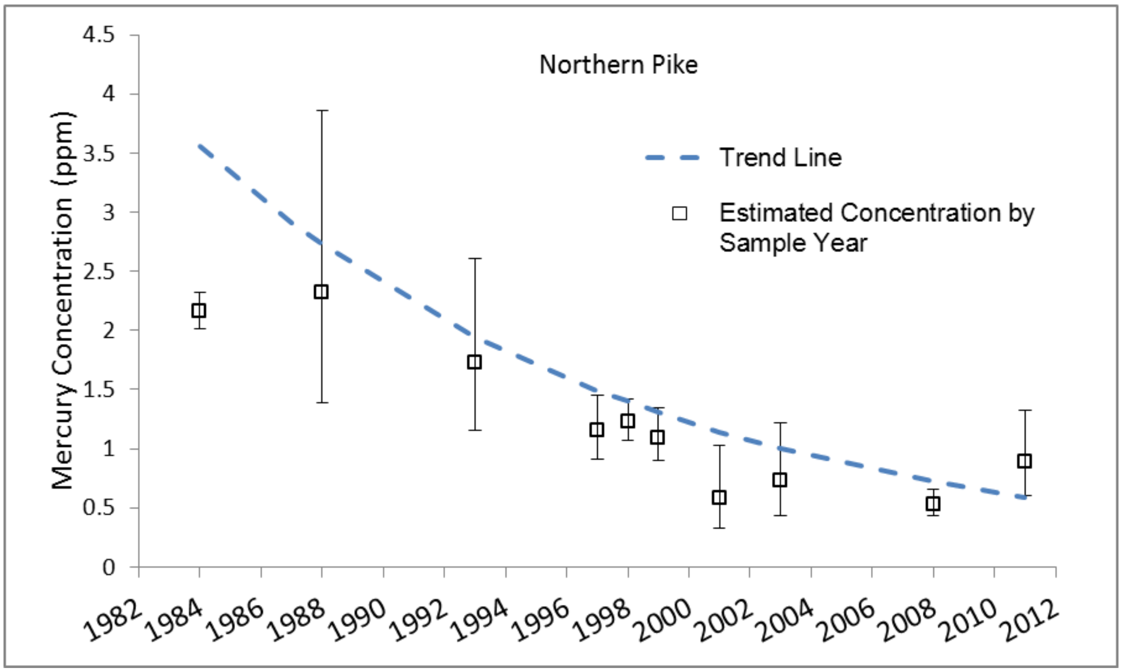

Figure 2. Temporal trend and estimated mercury concentrations in standard sized northern pike collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

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).

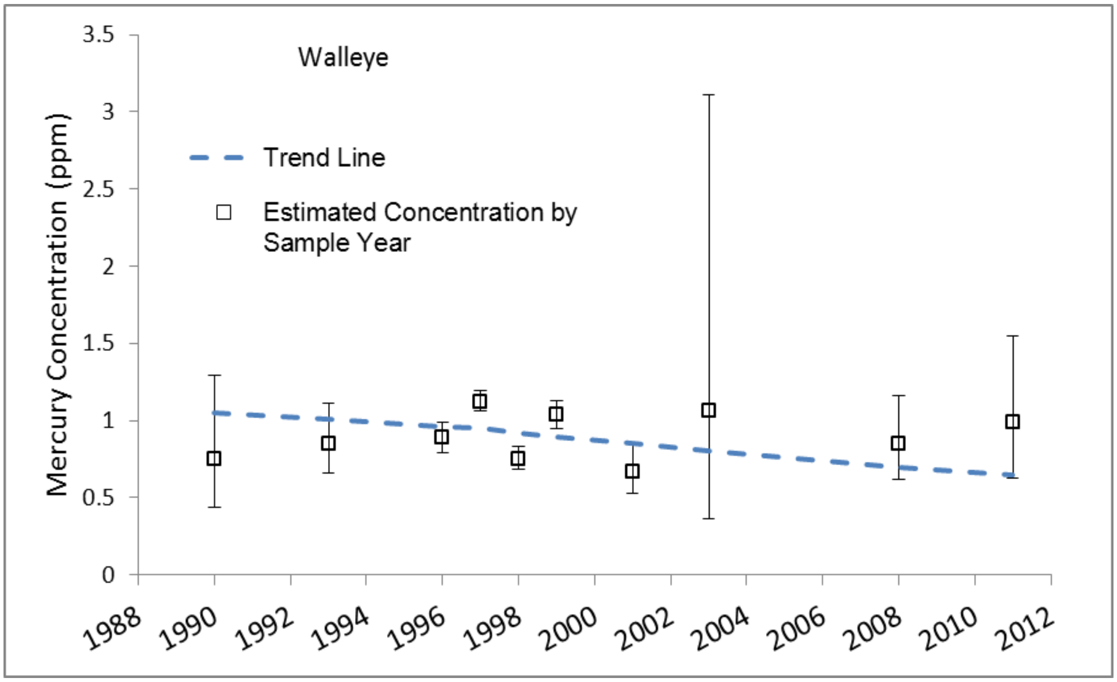

Figure 3. Temporal trend and estimated mercury concentrations in a standard sized walleye collected from Deer Lake, Marquette County, Michigan, from 1990 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

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).

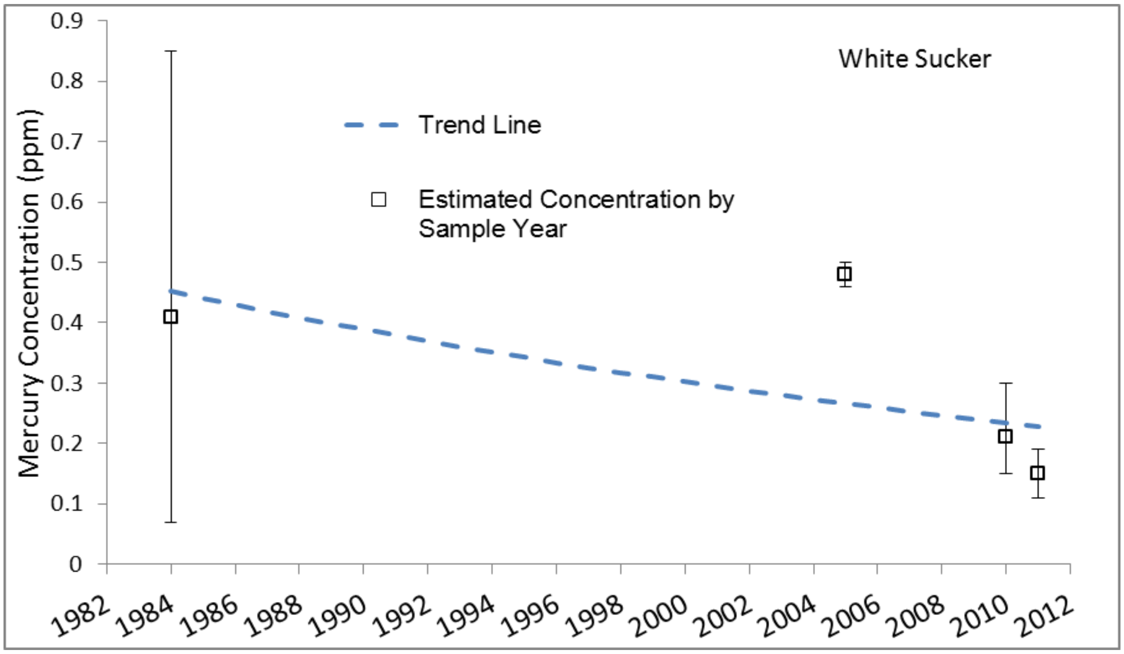

Figure 4. Temporal trend and estimated mercury concentrations in 15-inch white sucker collected from Carp Creek and Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

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).

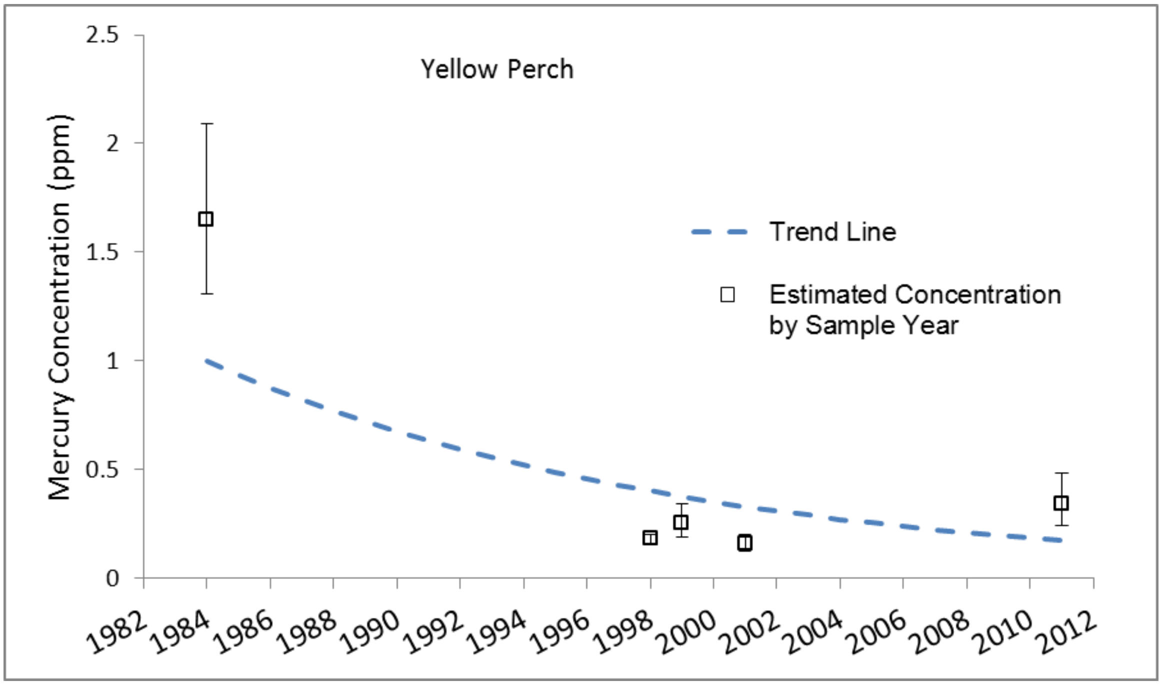

Figure 5. Temporal trend and estimated mercury concentrations in standard sized yellow perch collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95 percent confidence intervals (Bohr, 2013a).

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).

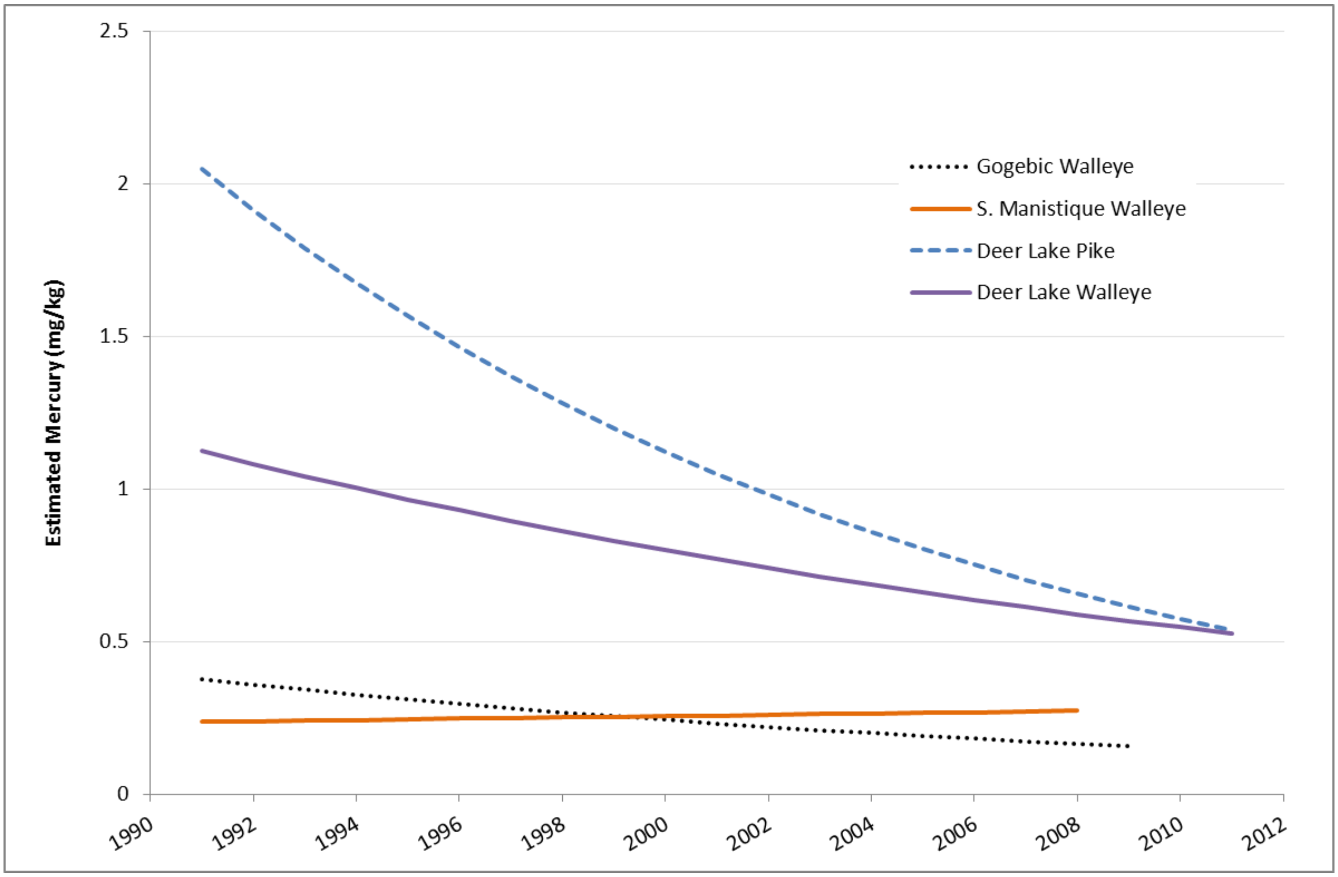

Figure 6. Comparison of Deer Lake pike and walleye trends to the same for Lake Gogebic walleye and Manistique walleye (Bohr, 2013b).

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 meets the criteria for removal, according to the *Guidance* criteria outlined on page 1 of this report.

Recommendation

Based upon review of the data and technical input from the MDCH, MDEQ's Water Resources Division staff, and USEPA staff, the MDEQ AOC program staff recommends removal of the Restrictions on Fish and Wildlife Consumption BUI in the Deer Lake AOC. The data and this Removal Recommendation were shared and discussed with the Deer Lake PAC, which provided a letter of support (Attachment D).

Prepared by: Stephanie Swart, AOC Coordinator
Great Lakes Management Unit
Office of the Great Lakes
Michigan Department of Environmental Quality
September 26, 2013

Attachments

A – Restrictions on Fish and Wildlife Consumption; pages 14-18 of the *Guidance for Delisting Michigan's Great Lakes Areas of Concern*
B – Deer Lake AOC Historical Background
C – Deer Lake – A History of mining and the Deer Lake AOC
D – Deer Lake PAC letter supporting BUI removal, November 5, 2013
E – Temporal Trends in Deer Lake Fish Tissue Mercury Concentrations 1984-2011, J. Bohr
F – A Summary of Contaminant Trends in Fish from Michigan Waters, draft April 4, 2013, J. Bohr
G – MDCH Eat Safe Fish in AOCs Fact Sheet
H – MDCH letter supporting BUI removal, July 30, 2013

References

Amendment to Consent Judgment. 2006. State of Michigan in the Circuit Court for the County of Marquette, Case Number 82-14767. Honorable John R. Weber, Circuit Court Judge. Signed November 7, 2006.

Bohr, J. 2013a. Temporal Trends in Deer Lake Fish Tissue Mercury Concentrations 1984-2011. Water Resources Division, MDEQ, Lansing, Michigan.

Bohr, J. 2013b. A Summary of Contaminant Trends in Fish from Michigan Waters. April 4, 2013 draft. Water Resources Division, MDEQ, Lansing, Michigan.

ELM Consulting, LLC. 2002. Mercury Source Characterization for Deer Lake, Marquette County, Michigan. Prepared for Cleveland-Cliffs Iron Company.

International Joint Commission. 2012. Protocol Amending the Agreement between the United States of America and Canada on Great Lakes Water Quality 1978, as amended on October 16, 1983 and November 18, 1987.

MDEQ. 2011. Stage 2 Remedial Action Plan for the Deer Lake Area of Concern. Office of the Great Lakes, MDEQ, Lansing, Michigan.

MDEQ. 2008. *Guidance for Delisting Michigan's Great Lakes Areas of Concern,* revised. MI/DEQ/WB-06-001.

MDNR. 1987. Remedial Action Plan for the Deer Lake River Area of Concern. Great Lakes and Environmental Assessment Section, Surface Water Quality Division, MDNR, Lansing, Michigan.

Staron, M. 2004. Interoffice Memo. Annual Mercury Loading Estimates to Deer Lake via Carp Creek Watershed. Surface Water Assessment Section, Water Bureau, MDEQ, Lansing, Michigan. September 17, 2004.

Swart, S. and S. Baker. 2011a. Briefing Paper Removal Recommendation Bird or Animal Deformities or Reproduction Problems Beneficial Use Impairment Deer Lake Area of Concern.

Swart, S. and S. Baker. 2011b. Briefing Paper Removal Recommendation Eutrophication or Undesirable Algae Beneficial Use Impairment Deer Lake Area of Concern.

Attachment A

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 U.S. EPA 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.

Attachment B

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 Michigan Department of Natural Resources (MDNR) determined that Cleveland-Cliffs Iron Company, now Cliffs Natural Resources (Cliffs) assay labs practiced disposal, down the lab drains, of mercury reagent laden wastewater. These wastewaters drained through the Ishpeming Wastewater Treatment Plant (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 (MDCM) 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).

Attachment C

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

Version 2
8/2/2012

Mark Loomis, Deer Lake Task Force Lead
U.S. EPA 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 - 1882 Alternatively proposed date of sinking shafts north of Barnum mine. The Cliffs Shaft mine was 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 U.S.

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 (CSOs) 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 AOC's Eutrophication BUI) by 86%.
1987 – Deer Lake AOC Remedial Action Plan is developed. Natural attenuation is selected as 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% of the total mercury load to the AOC.

2010 – 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 EPA GLNPO and the local public advisory Council, recommends removal of two BUIs: 1) Eutrophication or Undesirable Algae and 2) Bird and Animal Deformities or Reproductive Issues.

2012 – City of Ishpeming receives 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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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

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
JUNE 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 primary 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, the Great Lakes National Program Office, and the 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 containing blasting cap residues from the mines and waste 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 near 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 WWTP ended in 1981 although other less significant inputs from the watershed continued. A study conducted in 2000 by Michigan State University estimated that mercury concentrations in Deer Lake surficial sediments would return to background levels around 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 Nawakwa Lake which have similar watershed 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 were 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.

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 in mercury with an average annual rate of decline of 6.9% between 1984 and 2011.

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

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

7. Mercury concentrations in Deer Lake fish have declined at a rate comparable to the rate of decline 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 gillnets.

A total of 44 brook trout (*Salvelinus fontinalis*), 1 brown bullhead (*Amieurus nebulosis*), 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 on one date in 2011. White sucker were collected from Carp Creek or 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.

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

Deer Lake AOC fish tissue samples were analyzed for total mercury by the Michigan Department of Natural Resources Environmental Laboratory between 1984 and 1988 and by the Michigan Department of Community Health Analytical Chemistry Laboratory after 1988. Both of these analytical laboratories have quality assurance programs and used peer-reviewed methods of sample digestion and quantification. Total mercury is referred to as “mercury” throughout the report.

MDEQ fish contaminant results are entered in an Access database and are available on-line 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 data set. 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 data sets 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.

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 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 in 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 28.9 inches (mean length 23.6) 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 indicated 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 a temporal trend somewhat suspect.

Yellow Perch

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 furthest from being normally distributed and the variance was not homogenous across the data set. In addition, as with the white sucker data set, yellow perch were not adequately sampled for a lengthy period of time leaving a 14-year data gap between 1984 and 1998.

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 (Bohr 2013). Two inland lakes in the Upper Peninsula are monitored as part of the temporal trend 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 concentrations 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.

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 conclude this we need to make several assumptions:

1. Fish growth rates have been stable over the period of study. Changes in growth rate can alter mercury concentrations in fish (Harris and Bodaly 1998; Trudel and Rasmussen 2006).

2. The food web has been stable over the period of study. Changing the length of the food chain of a predator fish will affect the amount of mercury accumulated by that species (Johnston et al. 2003).
3. Water chemistry and other in-lake physical processes affect mercury methylation rates (Mattieu 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.

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

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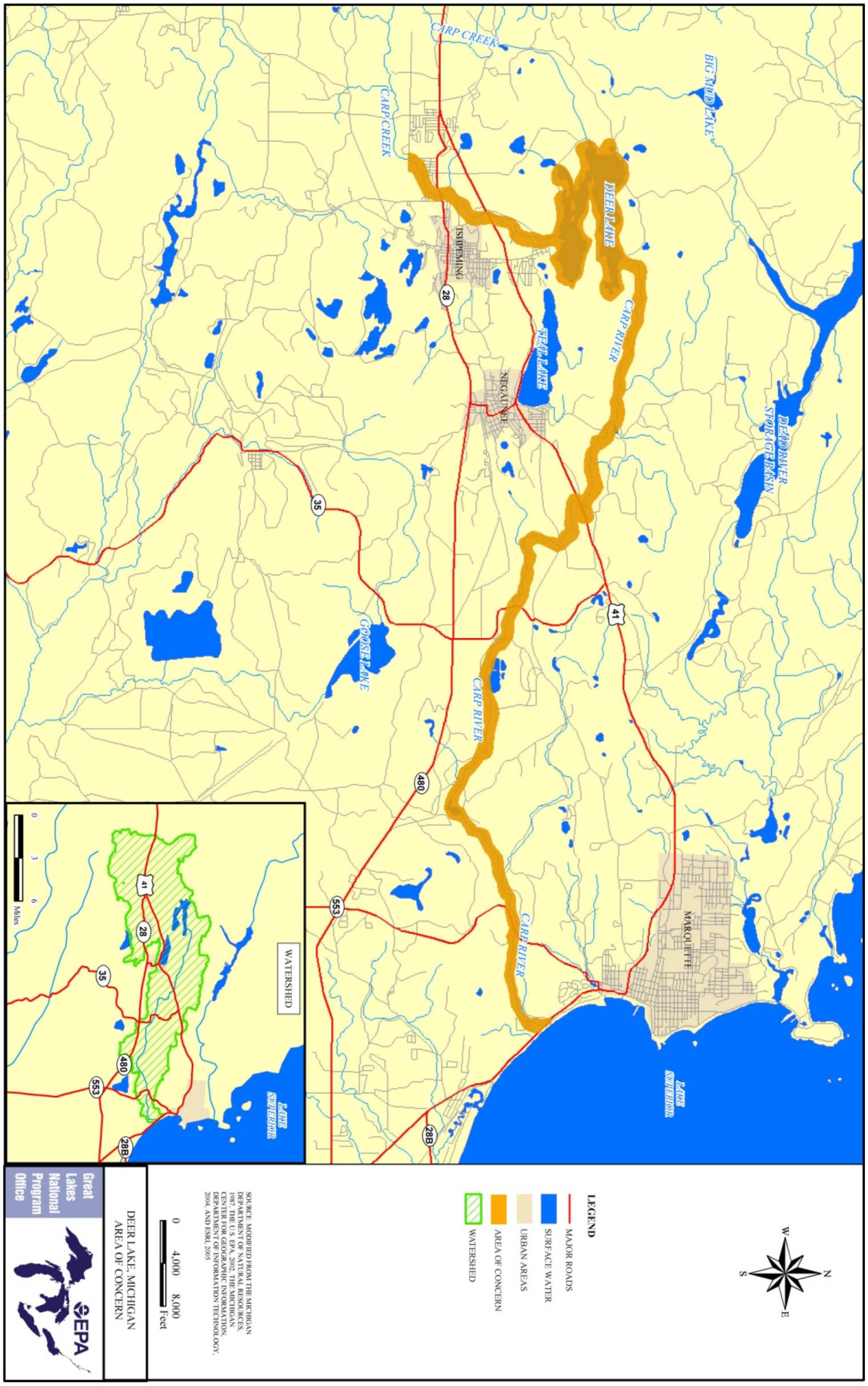


Figure 1. Map of Deer Lake Area of Concern.

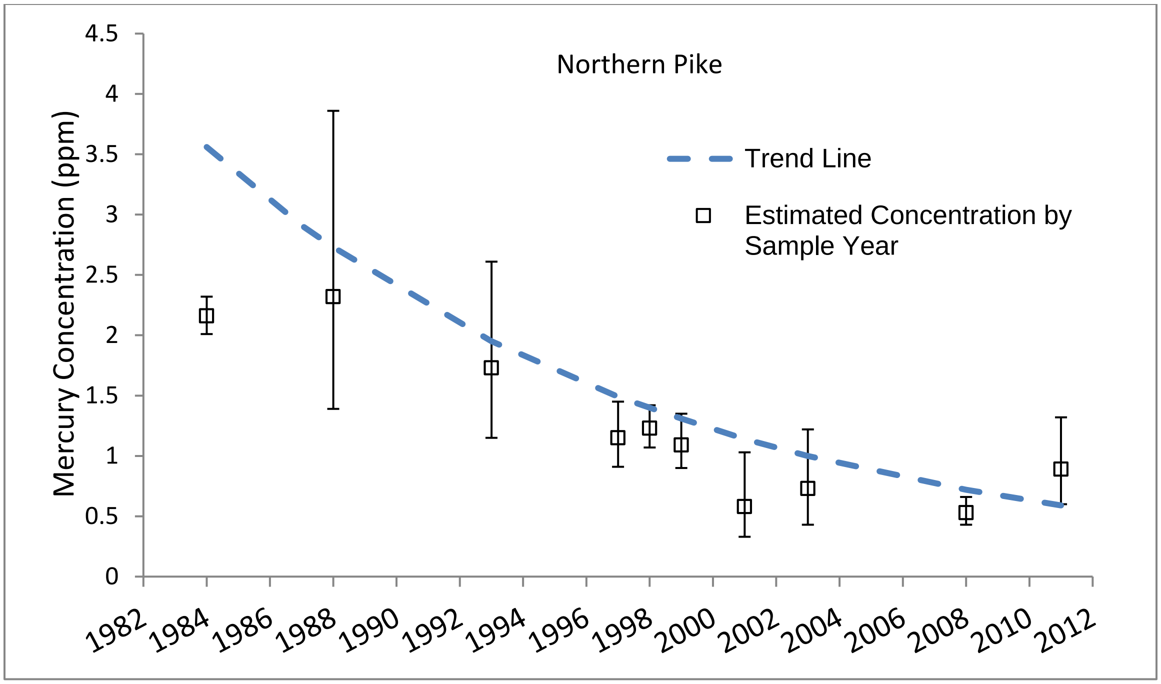


Figure 2. Temporal trend and estimated mercury concentrations in 24-inch northern pike collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

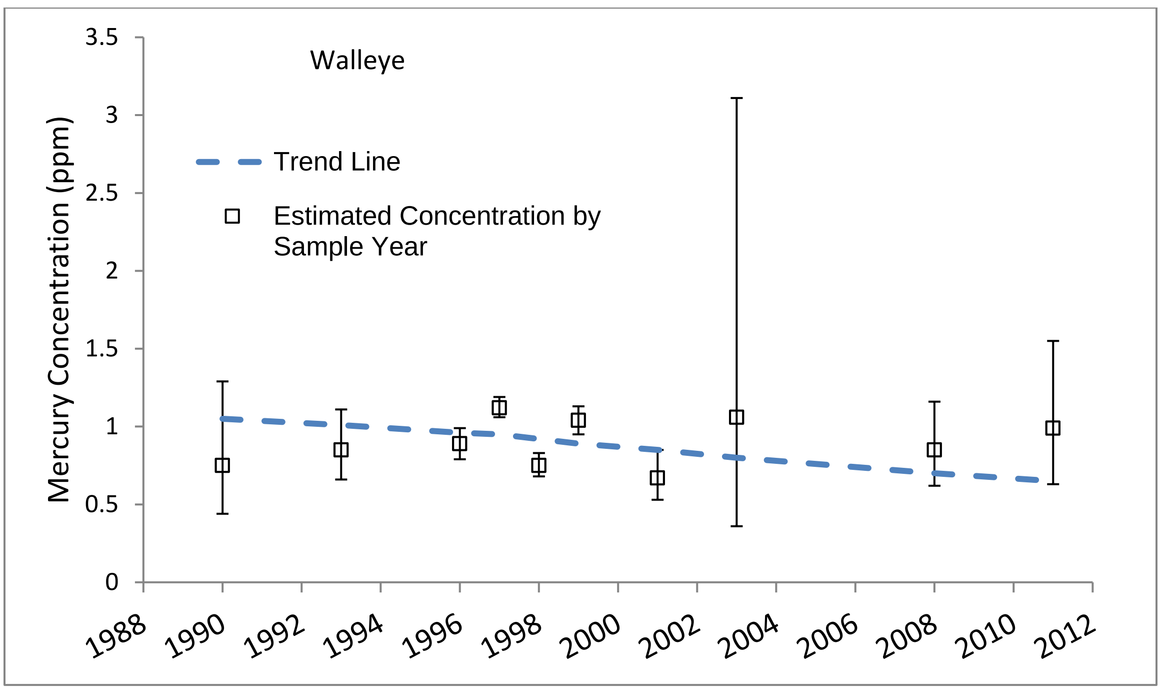


Figure 3. Temporal trend and estimated mercury concentrations in 18-inch walleye collected from Deer Lake, Marquette County, Michigan, from 1990 through 2011. Error bars represent 95% confidence intervals.

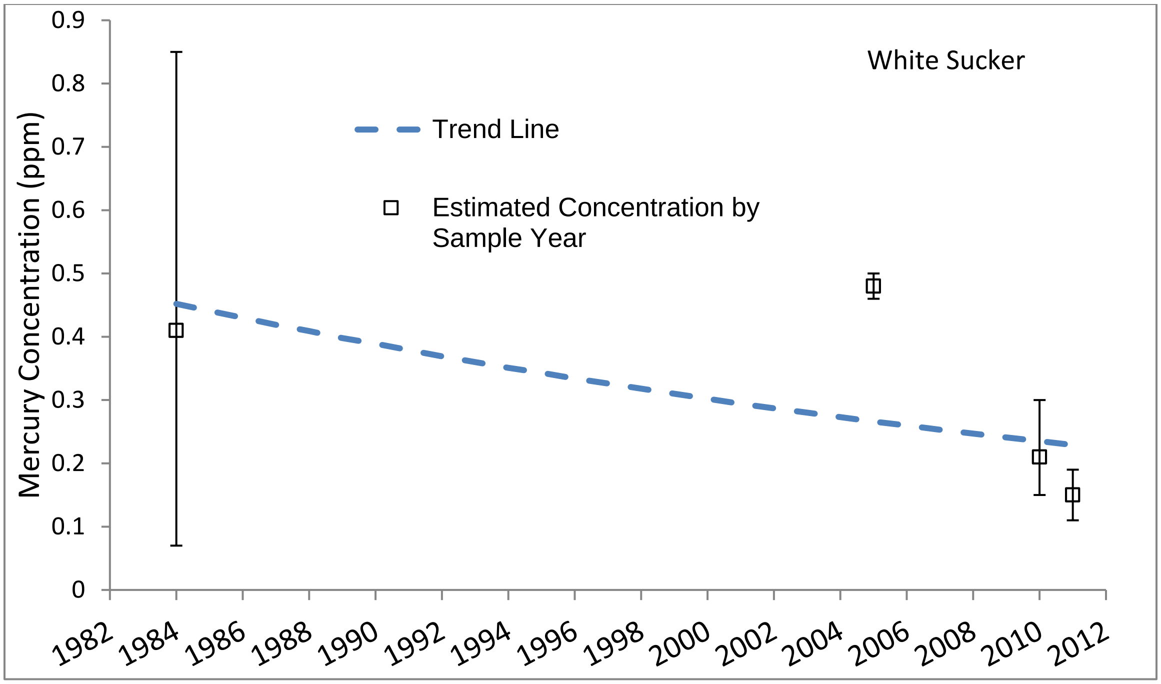


Figure 4. Temporal trend and estimated mercury concentrations in 15-inch white sucker collected from Carp Creek and Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

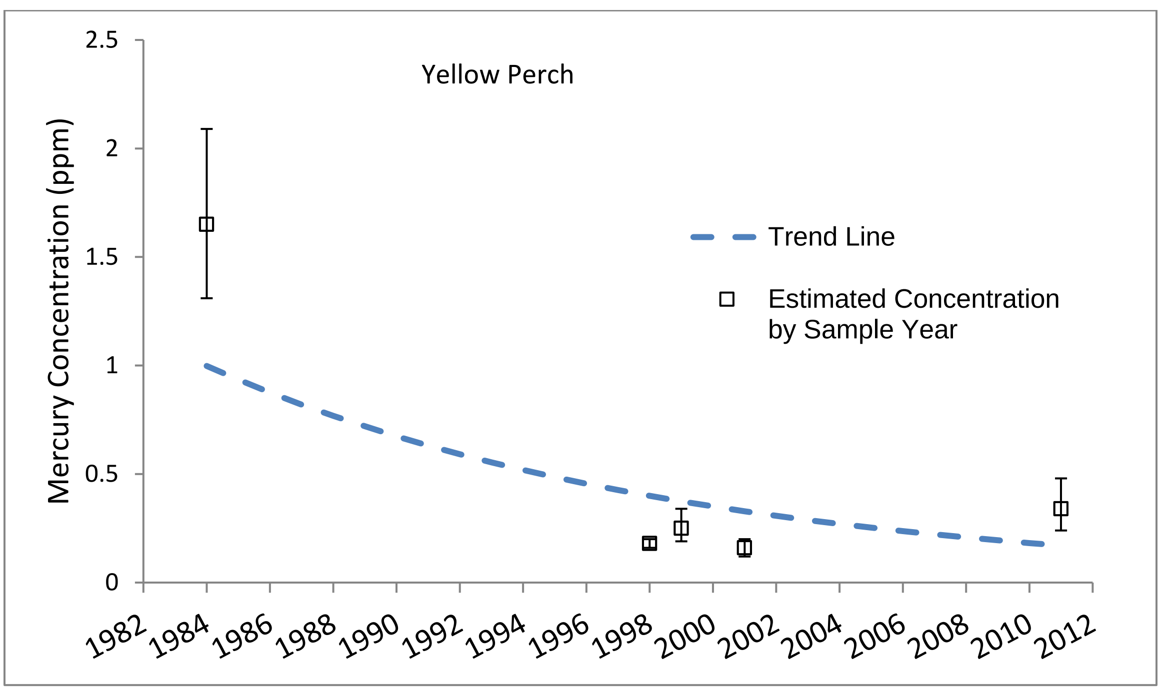


Figure 5. Temporal trend and estimated mercury concentrations in 10-inch yellow perch collected from Deer Lake, Marquette County, Michigan, from 1984 through 2011. Error bars represent 95% confidence intervals.

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

Waterbody	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.

Waterbody	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.

Waterbody	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.

Waterbody	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.

Waterbody	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 Len (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%		

APPENDIX A.

Mercury results…

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.

<u>Mercury</u>

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.

<u>Total PCBs</u>

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%.

<u>Total DDT</u>

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.

<u>Total Chlordane</u>

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.

<u>Dioxin TEQ</u>

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.

<u>Other Observations</u>

- 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.

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

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.

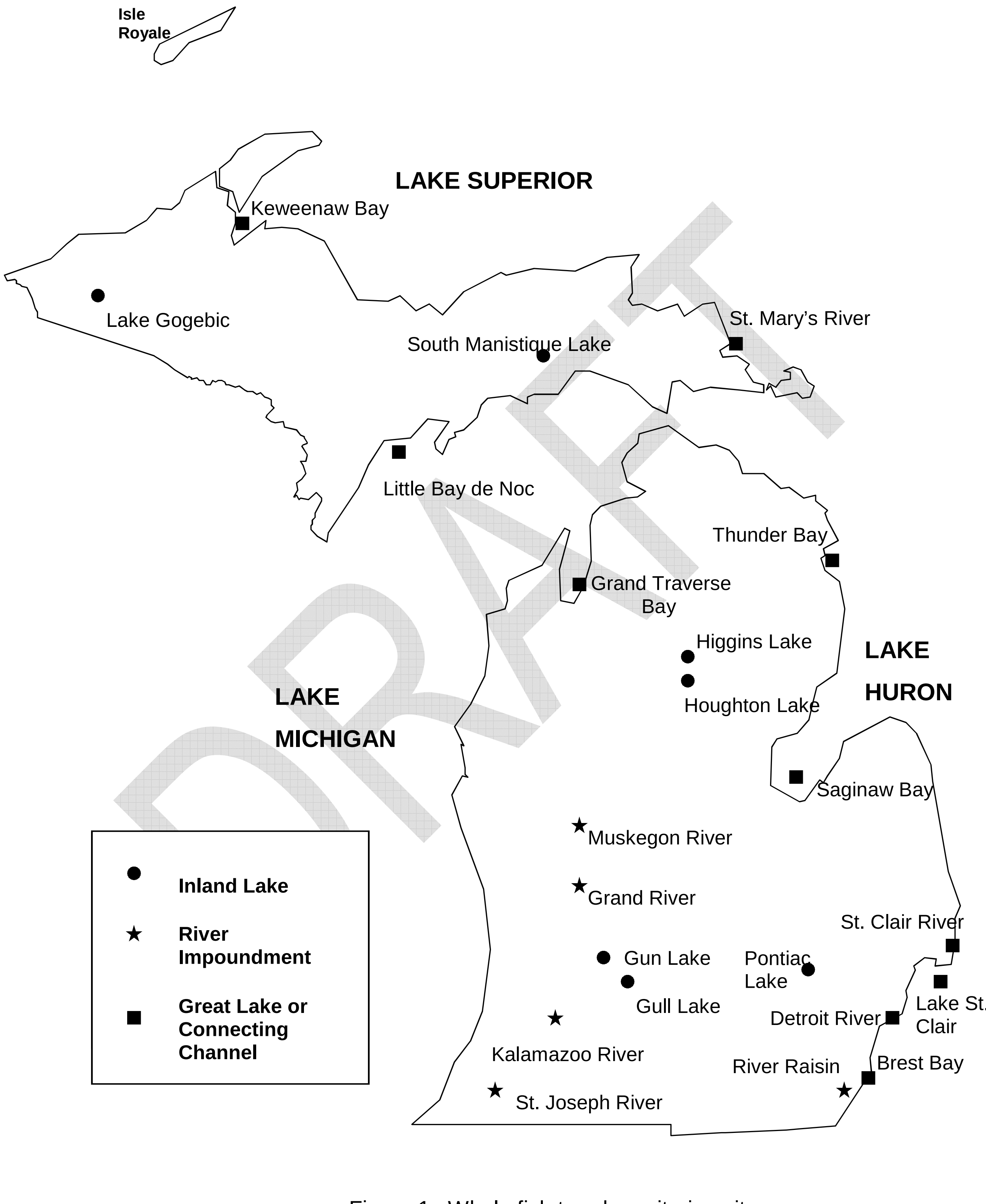


Figure 1. Whole fish trend monitoring sites.

Eat Safe Fish from Michigan's Areas of Concern

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.

Michigan's AOCs in 2012

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

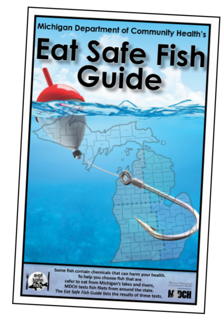
If an AOC has a ***Restrictions on Fish Consumption BUI***, it means that the fish from the affected lake or river at one time had higher levels of chemicals than fish in similar lakes or rivers in the Great Lakes region.

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

Michigan Department of Community Health

MDCH

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