

Benthos Diversity and Abundance

Formerly Indicator # 104

Overall Assessment

Status: Fair

Trend: Unchanging or Deteriorating

Rationale: Based on the benthic community, the trends in the trophic condition of the lakes are mixed in the period from 1998 through 2009. Some near shore sites are becoming more eutrophic while some off-shore, deep water sites more oligotrophic.

Lake-by-Lake Assessment

Lake Superior

Status: Good

Trend: Unchanging

Rationale: All sites in Lake Superior were classified as oligotrophic based on the oligochaete community index since 1997.

Lake Michigan

Status: Good

Trend: Unchanging

Rationale: Most sites in Lake Michigan have a trophic index value below 0.6 indicating an oligotrophic condition. Since 2002 nearshore sites on the eastern side of the southern basin and in southern Green Bay have oscillated between meso- and eutrophic. Since 2006 only the nearshore site near the Kalamazoo River outlet and one Green Bay site were above 1.

Lake Huron

Status: Undetermined

Trend: Undetermined

Rationale: Most sites in Lake Huron have been below 0.6 over the past decade; since 2006 all but two sites would be considered oligotrophic. The site in Saginaw Bay oscillates between mesotrophic and eutrophic. The nearshore site located on the eastern shore near the outlet of Saugeen River in Ontario, Canada has been eutrophic since 2008 and has very high densities of oligochaetes, the highest densities of all of all sites sampled in Lake Huron. The majority of the sites have been coming increasingly oligotrophic, potentially causing problems for the food web; therefore, the status of Lake Huron is undetermined.

Lake Erie

Status: Poor

Trend: Unchanging

Rationale: Most sites sampled over the past decade in Lake Erie were above 1.0 and would be classified as eutrophic. Since 2000 sites in the eastern basin tended to be more eutrophic than the central or western basin sites; however, in 2008-2009 all sites in the western basin were classified as eutrophic. Sites in the central basin tended to be the least eutrophic.

Lake Ontario

Status: Fair

Trend: Deteriorating

Rationale: All of the off-shore deep water sites in Lake Ontario would be classified as oligotrophic since 2003. Nearshore sites however have tended toward mesotrophic and eutrophic, and since 2003 western basin sites along the southern shore of Lake Ontario have become increasingly eutrophic.

Purpose

- The purpose of this analysis is to assess trends in the benthic community composition over time with respect to trophic status of the Great Lakes.

Ecosystem Objective

With respect to the benthos of the Great Lakes, the ecosystem objective is that the composition of benthic community in the Great Lakes should remain relatively constant over time and space and be comparable to unimpaired waters with similar depth and substrate conditions. One estimate of benthic community status is based on Milbrink's Modified Environmental Index (1983) which uses oligochaete diversity, trophic classifications, and abundances to compute the trophic status of a body of water. Trophic classifications are based on individual species responses to organic enrichment. This indicator supports Annex 2 of the Great Lakes Water Quality Agreement.

Ecological Condition

Annex 2 of the Great Lakes Water Quality Agreement states that there should be no impairment of Great Lakes benthos. SOLEC uses the oligochaete based trophic condition index (Milbrink, 1983; a modification of Howmiller and Scott, 1977) to assess trophic status of each site. The trophic condition index is calculated based on known organic enrichment tolerances and abundances of oligochaete taxa (see attached summary of calculation procedure). The index ranges from 0 – 3: scores less than 0.6 (the lower line in Figure 1) indicate oligotrophic conditions; scores above 1 (the top line in Figure 1) indicate eutrophic conditions; and, scores between 0.6 and 1.0 suggest mesotrophic conditions. Scores approaching 3 indicate high densities of oligochaetes dominated by the pollution tolerant *Limnodrilus hoffmeisteri* and *Tubifex tubifex*.

During the study period of 1998 through 2009 we observed a consistent difference in trophic conditions between Lakes and a few trends within Lake basins. Averaged across the study period, Lake Erie was consistently and significantly more eutrophic than all the other Lakes followed in order of increasing oligotrophication by Lakes Ontario, Michigan, Huron and Superior. Lakes Huron and Superior had significantly lower average trophic index scores than the other three Lakes. Summarized by Lake, we observed no significant trends in trophic condition over the study period. Summarized by Lake basin, there were a few trends noted: increasing eutrophication in the eastern and central basins of Lake Erie, in the southern basin of Lake Michigan, and in the western basin of Lake Ontario. In Lakes Ontario and Michigan these trends are driven by increasing OTI scores for nearshore sites.

In Lake Erie, the most eutrophic conditions were found in the eastern basin, which tended to increase up until about 2003 and remain between 2.0 and 2.5 through 2009. There was a similar trend in the data for central basin although the OTI scores were less eutrophic. The western basin varied substantially but no trends were obvious.

Lake Huron sites were mostly classified as oligotrophic since 2007. In the period from 1998 through 2001, the southernmost site was classified as mesotrophic or eutrophic but has been consistently oligotrophic since 2002 (one minor exception in 2006). The Saginaw Bay site was extremely eutrophic from 1997 through 2001, improved to mesotrophic, but has trended towards eutrophic again starting in 2007. One site in the central basin, HU96B (44m) off Southampton, Ontario, near the outlet of the Saugeen River, was very eutrophic in 2004, 2008 and 2009 (Figure 1). At this site counts of dreissenids were about 50 /m² in 2004 and increased to 2,800/m² in 2008; counts of

oligochaetes (mature and immature) increased from 450/m² in 2000, 1,700/m² in 2004, and 11,560/m² in 2009.

Most sites in Lake Michigan were classified as oligotrophic. The exceptions were the nearshore sites along the southern and central Michigan basins' eastern coast (near the Grand and Kalamazoo River outlets) and along the western coast near Green Bay. The sites in Green Bay have been consistently mesotrophic to mildly eutrophic.

Deepwater sites in Lake Ontario have been classified as oligotrophic throughout the study period. Average scores in the western basins showed a trend toward increasing eutrophication since 2001, primarily due to increasingly eutrophic nearshore sites along the southern shore.

Management Challenges/Opportunities

The Milbrink Environmental Index is a good tool to assess changes in organic enrichment in sediments and detect changes in the trophic status of the benthic community. Some nearshore sites across the Lakes are becoming increasingly eutrophic. Some of these changes may be related to terrestrial inputs from large rivers. However, many of the recent changes in the benthic community have been due to invasive species, especially dreissenid mussels. Likely consequences have been the loss of the native amphipod *Diporeia* sp. from many sites in the lower Lakes and changes in the relative abundances of other species. For example, our analysis has shown a trend toward decreasing densities of Sphaeriidae clams in Lakes Michigan, Huron and Ontario which could be related to direct competition with dreissenid mussels. In addition, some researchers have found that Oligochaeta densities may increase with presence of dreissenid mussels because the oligochaetes can feed off the dreissenid feces and pseudofeces (although others have found no changes or decreasing densities of oligochaetes; see Soster et al. 2011). Although our analyses did not detect significant upward trends in the abundances of oligochaetes over time, these changes may and have likely occurred on a site-by-site basis (nearshore Lake Huron and Ontario sites). If dreissenid mussels resulted in an increase in the numbers of oligochaetes, this could result in an elevated Milbrink's index indicating organic enrichment causes of community change instead of impacts due to invasive species. Additional indices need to be developed that can track changes in the benthic community independent of changes due to trophic status and more accurately assess trends in the benthic community.

Comments from the author(s)

The oligochaete indicator used for SOLEC (Indicator #104) assesses trophic status of the Lakes and may suggest pressures due to organic enrichment. Some nearshore sites and sites near large river mouths do show increasing eutrophication across all five Lakes. This suggests that pollution abatement mitigation in the upland watersheds could help to improve water quality and sediment conditions at these sites. Other pressures not accounted for in the oligochaete trophic index include invasive species, regional climate change, water level changes, toxic or other contaminants, and other unforeseen changes to the ecosystem. Recent changes due to invasive species, especially the invasive dreissenid mussels, pose severe threats to the ecosystem function. Incorporating indicators to track community composition changes due to new invasive species are needed to better track benthos changes as invasive species pressures change throughout the basin.

Dreissenid populations are expected to have altered the ecology of all four lower Lakes and may be part of the cause of the suspected oligotrophication of Lake Huron and other changes such as algae blooms and *Cladophora* fouling of beaches. However, the Milbrink's trophic index did not detect Lake Huron oligotrophication using the benthic community as indicator taxa. This suggests a need for development of additional indices that can better track changes in the benthic community composition with respect to other changes that are occurring in the Lakes. Additional environmental variables are needed to enable the development of additional benthic community indicators that together with the Milbrink's index will better assess the lake condition based on trends in the benthic

community.

Calculation of Oligochaete Trophic Index (OTI)

To evaluate trends in the benthic community of the Great Lakes, SOLEC uses an Oligochaete Trophic Index (OTI). The OTI was initially described by Mosley and Howmiller (1977) with subsequent modifications by Howmiller and Scott (1977), Milbrink (1983), and Lauritsen et al. (1985). The SOLEC indicator primarily follows Milbrink’s formula; however since there are different interpretations of the formula we have defined our process below in an attempt to clarify the calculations going forward. Milbrink classifies Tubificids and Lumbriculids oligochaetes into four ecological classes relative to trophic status of the lake. The values range from 0 indicating intolerant of enrichment (oligotrophic conditions) to 3 indicating tolerant of enrichment (highly eutrophic conditions). The index is calculated as:

$$c * [(1/2 * n_0 + n_1 + 2 * n_2 + 3 * n_3) / (n_0 + n_1 + n_2 + n_3)]$$

where n₀, n₁, n₂, and n₃ indicate the abundances of organisms in each of the four trophic categories (see attached table) and c is a density coefficient that scales the index to absolute densities of Tubificids and Lumbriculids. The c coefficient is as follows (Milbrink 1983):

- c=1 if n > 3,600
- c=0.75 if 1,200 > n < 3,600
- c=0.5 if 400 > n < 1,200
- c=0.25 if 130 > n < 400
- c=0 if n < 130

There are several parts of the OTI calculation that are open to interpretation so we have included a clarification of how we interpreted these points below:

- we only used lumbriculids and tubificids to calculate the index;
- all immature lumbriculids were classified as *Stylo-drilus heringianus* (Styheri);
- the c coefficient was estimated from abundances (n) of mature and immature lumbriculids and tubificids;
- Milbrink (1983) assigned the tubificid *Tubifex tubifex* (Tubtubi) dual classifications depending on the dominance of Styheri or *Limnodrilus hoffmeisteri* (Limhoff). We formalized the dual classifications as follows: if the ratio of abundances of n₀ oligochaetes to n₃ oligochaetes (Limhoff) > 1 then Tubtubi is classified as a 3; if the ratio is < 1 then Tubtubi is classified as a 0; however, if the ratio is close to one (0.75 to 1.25) then Tubtubi is a 3 if c ≥ 0.5 and a 0 if c < 0.5;
- if Limhoff density is zero and n₀ is relatively high and/or total density is low, then Tubtubi is 0, otherwise 3; and,
- if the total density of oligochaetes is zero, then the index is zero.

Trophic classifications were obtained from literature for the Great Lakes and are shown in Table 1.

Assessing Data Quality

Insert “x” under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable

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1. Data are documented, validated, or quality-assured by a recognized agency or organization		x				
2. Data are traceable to original sources		x				
3. The source of the data is a known, reliable and respected generator of data		x				
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin				x		
5. Data obtained from sources within the U.S. are comparable to those from Canada						x
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report		x				
Clarifying Notes:						

Acknowledgments

Authors:

Dr. Catherine Riseng, University of Michigan, Ann Arbor, MI, criseng@umich.edu
 Glenn Carter, University of Michigan, Ann Arbor, MI, carterg@umich.edu
 Dr. Kurt Schmude, University of Wisconsin – Superior, Superior, WI
 Dr. Sara Adlerstein, University of Michigan, Ann Arbor, MI
 Dr. Rick Barbiero, CSC and Loyola University, Chicago, IL

Information Sources

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

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List of Tables

Table 1: Trophic classifications for select mature lumbriculids and tubificids taken from Howmiller and Scott (1977), Milbrink (1983) with additions from Kreiger (1984), Lauritsen et al. (1985). If Milbrink classifications differed from Howmiller and Scott, Howmiller and Scott was used.

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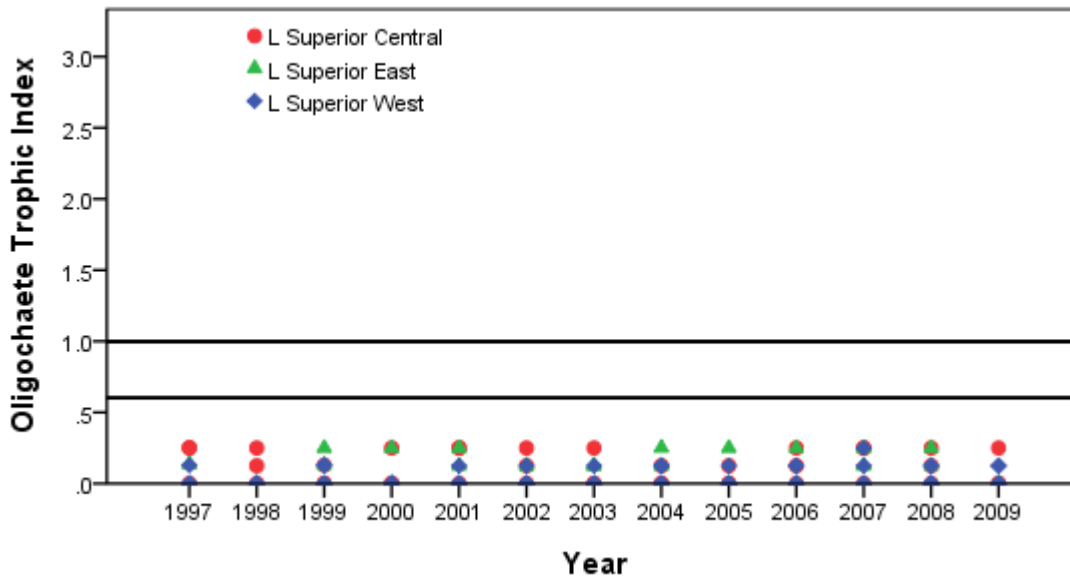
Figure 1. Scatterplot of the index values for Milbrink's (1983) Modified Environmental Index, applied to data from GLNPO's 1998 through 2009 summer surveys. Values ranging from 0 to less than 0.6 indicate oligotrophic conditions; values from 0.6 to 1.0 indicate mesotrophic conditions; and values greater than 1.0 indicate eutrophic conditions. Index values for taxa were taken from literature (Barbour et al. 1994, Howmiller and Scott 1997, Krieger 1984, Milbrink 1983). Data points represent the average of triplicate samples taken at each sampling site; immature specimens were included in the analysis for calculation of overall density used to establish the coefficient *c* but only mature specimens were used to calculate the number belonging to each ecological group of oligochaetes (see attached description of index calculation).

Figure 2. Map of the Great Lakes showing the trophic status at each sampling site calculated for 2009. Trophic status was based on the modified trophic index for oligochaete worms from Milbrink (1983). One site in the western basin of Lake Superior had no oligochaetes and two sites had only Enchytraeidae in the samples. Given that there were no oligochaetes and previous years had indices <0.2, these sites were shown as oligotrophic.

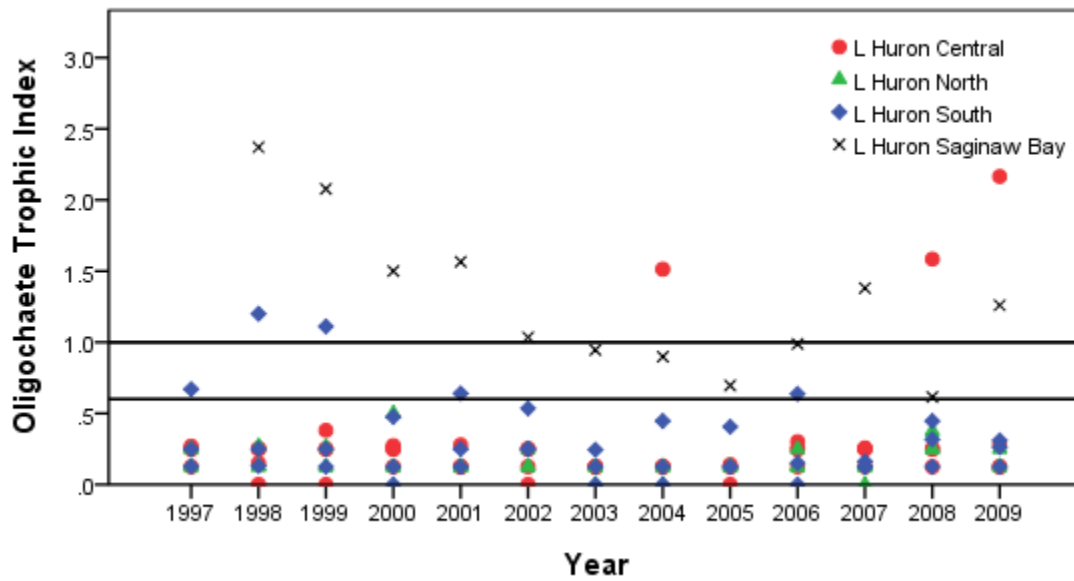
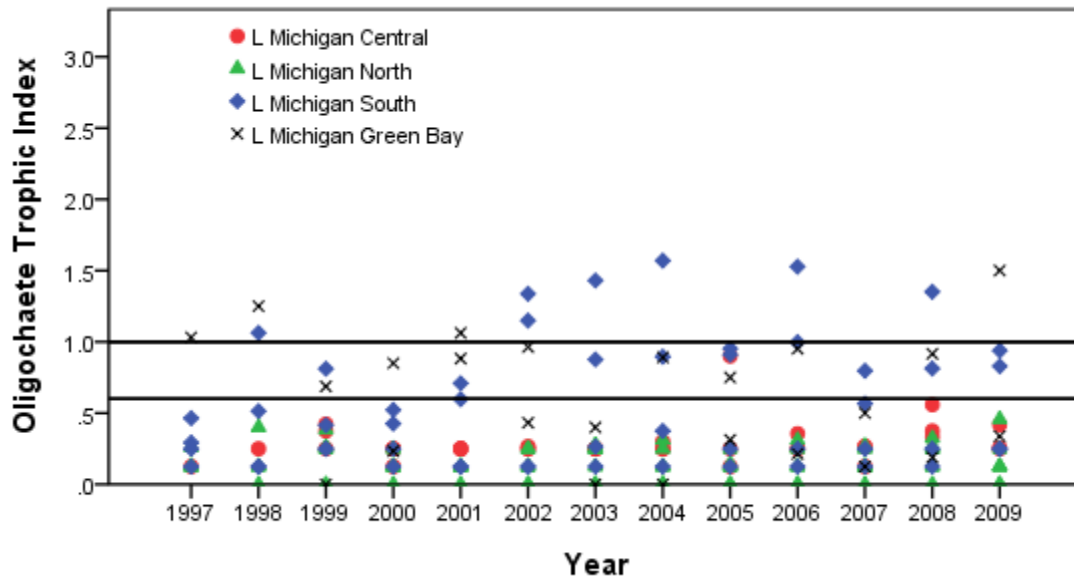
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SPECCODE	GENUS	SPECIES	Trophic Class	Source	Comment
RHYCOCC	Rhyacodrilus	coccineus	0	Howmiller and Scott 1977	Same classification as Krieger 1984 & Lauritsen et al. 1985
TASAMER	Tasserkidrilus	americanus	0	Howmiller and Scott 1977	formerly <i>T. kessleri</i> in both Lauritsen et al. 1985 and Kreiger
LIMPROF	Limnodrilus	profundicola	0	Howmiller and Scott 1977	Same classification as Krieger 1984 & Lauritsen et al. 1985
RHYMONT	Rhyacodrilus	montana	0	Kreiger 1984	Same classification as Lauritsen et al. 1985
RHYSP	Rhyacodrilus	spp.	0	Kreiger 1984	Same classification as Lauritsen et al. 1985
SPINIKO	Spirosperma	nikolskyi	0	Kreiger 1984	Same classification as Lauritsen et al. 1985
STYHERI	Stylodrilus	heringianus	0	Howmiller and Scott 1977	General agreement from all sources for this taxon
TASSUPE	Tasserkidrilus	superiorensis	0	Kreiger 1984	Same classification as Lauritsen et al. 1985
AULAMER	Aulodrilus	americanus	1	Howmiller and Scott 1977	Classification based on Aulodrilus sp.
AULLIMN	Aulodrilus	limnobius	1	Milbrink 1983	
AULPIGU	Aulodrilus	pigueti	1	Milbrink 1983	
ILYTEMP	Ilyodrilus	templetoni	1	Kreiger 1984	Same classification as Milbrink 1983 & Lauritsen et al. 1985
ISOFREY	Isochaetides	freyi	1	Kreiger 1984	Same classification as Lauritsen et al. 1985
SPIFERO	Spirosperma	ferox	1	Howmiller and Scott 1977	Same classification as Kreiger 1984 & Lauritsen et al. 1985
AULPLUR	Aulodrilus	pluriseta	2	Milbrink 1983	
LIMANGU	Limnodrilus	angustipenis	2	Howmiller and Scott 1977	
LIMCERV	Limnodrilus	cervix	2	Howmiller and Scott 1977	same as Milbrink 1983
LIMCECL	Limnodrilus	cervix/claparedeianus	2	Howmiller and Scott 1977	same as Milbrink 1983
LIMCLAP	Limnodrilus	claparedeianus	2	Howmiller and Scott 1977	same as Milbrink 1983
LIMMAUM	Limnodrilus	maumeensis	2	Howmiller and Scott 1977	
LIMUDEK	Limnodrilus	udekemianus	2	Howmiller and Scott 1977	same as Milbrink 1983
POTBEDO	Potamothrix	bedoti	2	Milbrink 1983	
POTMOLD	Potamothrix	moldaviensis	2	Milbrink 1983	Same classification as Lauritsen et al. 1985
POTVEJD	Potamothrix	vejovskyi	2	Milbrink 1983	Same classification as Lauritsen et al. 1985
QUIMULT	Quistadrilus	multisetosus	2	Howmiller and Scott 1977	
LIMHOFF	Limnodrilus	hoffmeisteri	3	Milbrink 1983	Differs from classification in Lauritsen et al. 1985
TUBTUBI	Tubifex	tubifex	0 or 3	Milbrink 1983	Depends on densities of LIMHOFF and STYHERI and total oligochaete density

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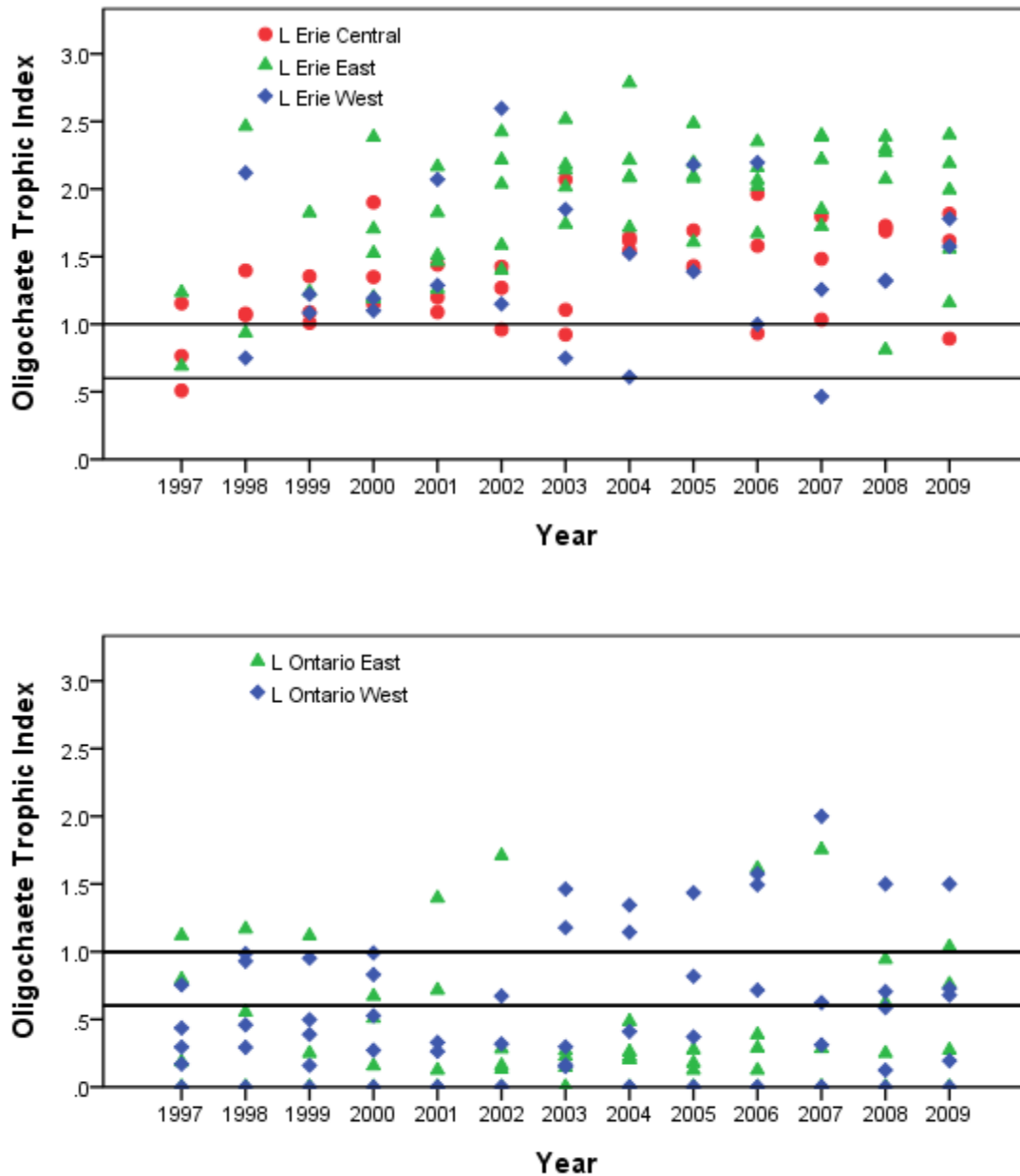


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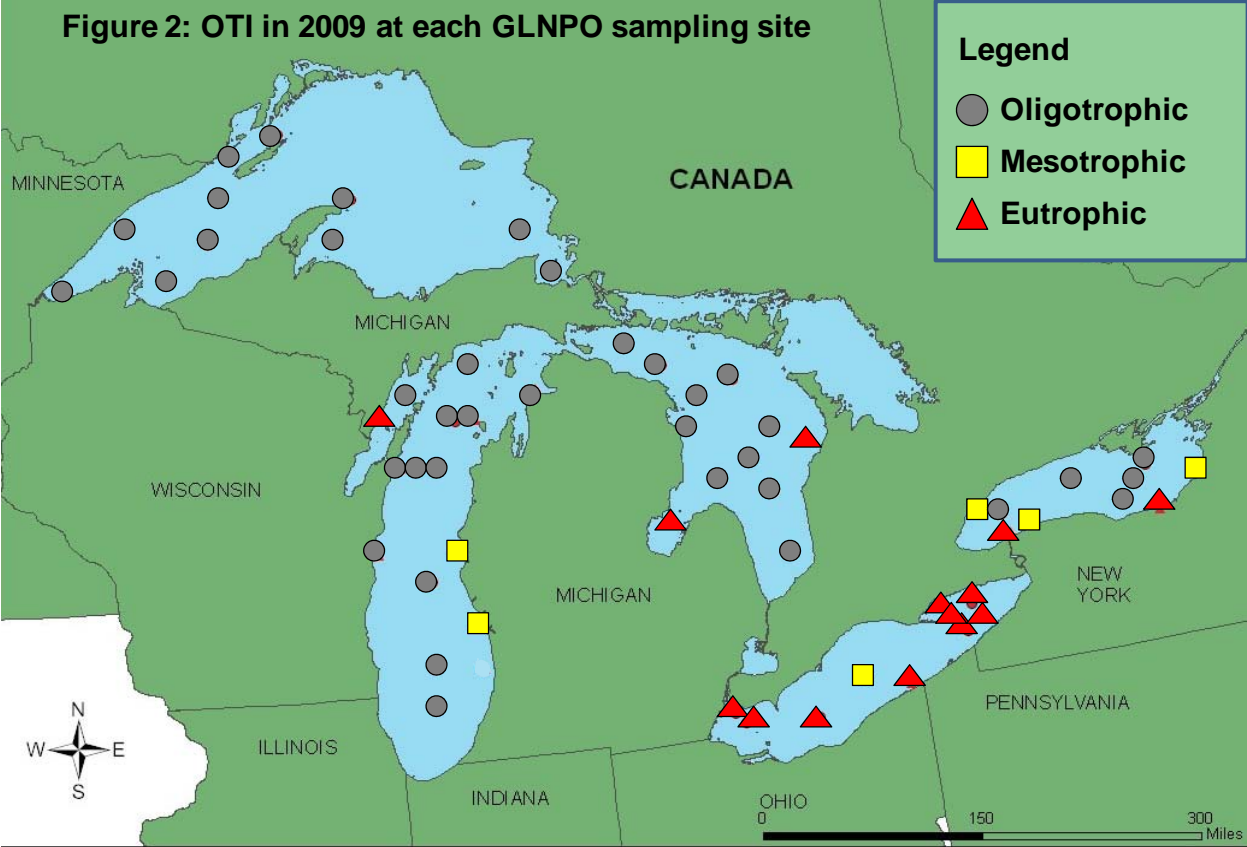


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Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2011