



Zooplankton Biomass

Formerly Indicator # 116

Overall Assessment

Status: Undetermined

Trend: Undetermined (changing)

Rationale: Changes in community structure are occurring in Lake Michigan, Lake Huron, and Lake Ontario consistent with both oligotrophication and invasive species impacts. Consequences for fish communities are as yet unresolved.

Lake-by-Lake Assessment

Lake Superior

Status: Good

Trend: Unchanging

Rationale: Stable summer zooplankton community is dominated by large calanoid copepods.

Lake Michigan

Status: Undetermined

Trend: Undetermined (changing)

Rationale: Summer biomass of cladocerans and cyclopoid copepods has been declining since 2004. Summer mean size of zooplankton has increased due to increases in large calanoids. Current (2006) community is indicative of cold, unproductive system.

Lake Huron

Status: Undetermined

Trend: Undetermined (changing)

Rationale: Total summer biomass has declined dramatically since 2003 due to fewer *Daphnia*, bosminids, and cyclopoid copepods. Summer mean size of zooplankton is increasing. Current (2006) community is indicative of cold, unproductive system.

Lake Erie

Status: Undetermined

Trend: Undetermined

Rationale: Variable biomass and composition of summer crustacean zooplankton community in each basin. Most diverse zooplankton community in the Great Lakes. No trends apparent between 1998 and 2006.

Lake Ontario

Status: Undetermined

Trend: Undetermined (changing)

Rationale: Lowest percentage of calanoid copepods of all Great Lakes. Total summer biomass has declined since 2004 due to a decline in cyclopoid copepods. Invasive *Bythotrephes* might be influencing community size and spatial distribution.

Purpose

- The Zooplankton Populations indicator assesses characteristics of the zooplankton community over time

and space, and will be used to infer changes over time in vertebrate or invertebrate predation, system productivity, energy transfer within the Great Lakes, or other food web dynamics.

- Measures used to characterize the zooplankton community are total crustacean biomass and composition, average crustacean length, and ratio of calanoids to cladocerans + cyclopoids.
- Zooplankton Populations indicator is used in the Great Lakes indicator suite as a State indicator in the Aquatic dependent Life category.

Ecosystem Objective

Maintain the biological integrity of the Great Lakes and support a healthy and diverse fishery as outlined by the Goals and Objectives of the LaMPs and Great Lakes Fishery Commission. This indicator supports Annex 2 of the GLWQA. The relationship between the measures tracked in this indicator and the above ecosystem objectives are not fully worked out. As such, precise quantitative goals for this indicator do not yet exist.

Planktivorous fish often feed size selectively, removing larger cladocerans and copepods. High densities of planktivores therefore can result in a reduction of the mean size of zooplankton in a community. Mills *et al.* (1987) have found that mean crustacean zooplankton size > 0.8 mm were associated with predator:panfish ratios > 0.2 . Their work, however, was conducted in small, warm water lakes where cladocerans, rather than calanoid copepods, are likely to dominate. The universality of this relationship remains unclear at this time. In particular, there are questions regarding its applicability to systems with large numbers of calanoid copepods, systems impacted by predaceous cladocerans and dreissenids, and situations where the size structure of the crustacean zooplankton community is primarily a consequence of food type or availability rather than predation.

Gannon and Stemberger (1978) found that cladocerans and cyclopoid copepods are more abundant in nutrient enriched waters of the Great Lakes, while calanoid copepods dominate oligotrophic communities. They reported that areas of the Great Lakes where the density of calanoid copepods comprises over 50% of the summer crustacean zooplankton community (or the ratio of calanoids to (cyclopoids + cladocerans) is greater than 1) could be classified as oligotrophic. As with individual mean size though, clear objectives have not presently been defined.

Ecological Condition

Summer biomass of crustacean zooplankton communities in the offshore waters of Lake Superior has remained at a relatively low but stable level since at least 1998 (Figure 1). The plankton community is dominated by large calanoid copepods (*Leptodiatomus sicilis* and *Limnocalanus macrurus*) that are characteristic of oligotrophic, cold water ecosystems. Since 2003 the biomass of cladocerans and cyclopoid copepods in Lake Huron has declined dramatically, with total biomass very similar to that of Lake Superior as of 2006. Data from 2005 and 2006 suggest that a similar decline may now be occurring in Lake Michigan, although this has been offset somewhat by an increase in the biomass of *L. macrurus*. Summer communities in both lakes have become increasingly similar to that of Lake Superior, with both composition and magnitude characteristic of a cold oligotrophic system. Cyclopoid abundance has also begun to show evidence of decline in Lake Ontario. Mechanisms for these declines are not known at this time, although evidence has recently been presented for reductions in primary production as a driving factor in the changes in Lake Huron (Barbiero et al. 2011). Other possible causes include exotic species interactions or fish predation pressure.

The proportion of calanoid copepods in Lake Superior has remained fairly stable at 70%, indicating oligotrophic conditions (Figure 2). Summer zooplankton communities in Lake Michigan and Lake Huron have shown an increasing proportion of calanoid copepods in recent years, which suggests an improved trophic state. Primary production, and in particular the spring phytoplankton bloom, has indeed declined notably in both lakes coincident

with the changes in the zooplankton communities. In the case of Lake Michigan, this has been due both to an increase in *L. macrurus*, and a decline in cladoceran populations. The increased proportion of calanoids in Lake Huron has resulted primarily from substantial declines in both cladoceran and cyclopoid copepod populations. Lake Ontario has the lowest proportion of calanoids, followed closely by the nutrient enriched western basin of Lake Erie. Values for the central and eastern basins of Lake Erie are at intermediate levels and exhibit considerable interannual variation.

Mean length of crustacean zooplankton in the offshore waters of the Great Lakes is generally greater in the spring than during the summer (Figure 3). In the spring, mean zooplankton size in all of the Great Lakes is near or above 0.8 mm. Mean length in Lake Superior declines during the summer due to the production of immature copepodids, but it is still above the criterion. Summer mean lengths in Lake Huron and Lake Michigan remain high and have begun to show increases in recent years, most likely due to the increased importance of *L. macrurus* noted above. In Lake Erie and Lake Ontario, the mean length of zooplankton declines considerably in the summer. Whether this decline is due to predation pressure or to the increased abundance of bosminids (0.4 mm mean length) and immature cyclopoids (0.65 mm mean length) is unknown.

Management Challenges/Opportunities

Changes in the zooplankton communities of Lake Huron and Lake Michigan, and to a lesser extent Lake Ontario, are consistent with reductions in nutrient levels, which have been seen in all three lakes, and could represent a consequence of nutrient reduction activities, perhaps compounded by effects of dreissenid mussels. The reductions in cladocerans in the former two lakes, along with recent declines in *Diporeia* populations, could represent a decreasing food base for forage fish and in turn require adjustments in fish stocking goals. However, exact mechanisms of these declines, and the relative strength of bottom-up versus top-down forcings, have yet to be fully determined.

An important threat to the zooplankton communities of the Great Lakes is posed by invasive species. The continued proliferation of dreissenid populations can be expected to impact zooplankton communities through the alteration of the structure and abundance of the phytoplankton community, upon which many zooplankton depend for food. Predation from the exotic cladocerans *Bythotrephes longimanus* and *Cercopagis pengoi* may also have an impact on zooplankton abundance and community composition. Invasive predatory cladocerans have been shown to have had a major impact on zooplankton community structure in the Great Lakes (Barbiero and Tuchman 2004).

Comments from the author(s)

Currently the most critical need is for the development of quantitative, objective criteria that can be applied to the zooplankton indicator. The applicability of current metrics to the Great Lakes is largely unknown, as are the limits that would correspond to acceptable ecosystem health.

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
1. Data are documented, validated, or quality-assured by a recognized agency or organization		x				
2. Data are traceable to original sources		x				

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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: Richard P. Barbiero, CSC, Chicago, IL, gloetri@sbcglobal.net

Contributors: Mary Balcer, University of Wisconsin-Superior, Superior, WI
 Glenn J. Warren, Great Lakes National Program Office (USEPA), Chicago, IL
 Ora Johannsson, Department of Fisheries and Oceans Canada, Burlington, Ontario Canada

Information Sources

Barbiero, R.P., Lesht, B.M., and Warren, G.J. 2011. Evidence for bottom-up control of recent shifts in the pelagic food web of Lake Huron. *J. Great Lakes Res.* 37:78-85.

Barbiero, R.P., and Tuchman, M.L. 2004. Changes in the crustacean communities of Lakes Michigan, Huron, and Erie following the invasion of the predatory cladoceran *Bythotrephes longimanus*. *Can. J. Fish. Aquat. Sci.* 61:2111-2125.

Gannon, J.E. and Stemberger, R.S. 1978. Zooplankton (Especially Crustaceans and Rotifers) as Indicators of Water Quality. *Trans. Amer. Micros. Soc.* 97, 16–35.

Johannsson, O.E., Dumitru, C., and Graham, D.M. 1999. Examination of zooplankton mean length for use in an index of fish community structure and application in Lake Erie. *J. Great Lakes Res.* 25:179-186.

Mills, E.L., Green, D.M., and Schiavone, A. 1987. Use of zooplankton size to assess the community structure of fish populations in freshwater lakes. *N. Am. J. Fish. Manage.* 7:369-378.

Insert Names, Affiliations and Contact Information

List of Figures

Figure 1. Average composition of crustacean zooplankton biomass at Great Lakes offshore stations, 1998-2006, sampled in August of each year. Samples were collected with 153 µm mesh net tows to a depth of 100 m or the bottom of the water column, whichever was shallower.

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office

Figure 2. Average percentage of calanoid copepods (by abundance) in crustacean zooplankton communities from Great Lakes offshore stations sampled in August/September for 1998-2006 (excluding 2000). Samples were collected with 153 μm mesh net tows to a depth of 100 m or the bottom of the water column, whichever was shallower. Line at 50% level is the suggested criterion for oligotrophic lakes.

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office

Figure 3. Average individual mean lengths of crustacean zooplankton in the Great Lakes in April/May and August/September for 1998-2006 (excluding 2000). Length estimates were generated from data collected with 153 μm mesh net tows to a depth of 100 m or the bottom of the water column, whichever was shallower. Values are arithmetic averages of all sites sampled within each basin. Line at 0.8 mm was determined by Mills et al. (1987) to be associated with predator:panfish ratios > 0.2 .

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office

Last Updated

State of the Great Lakes 2009 report.

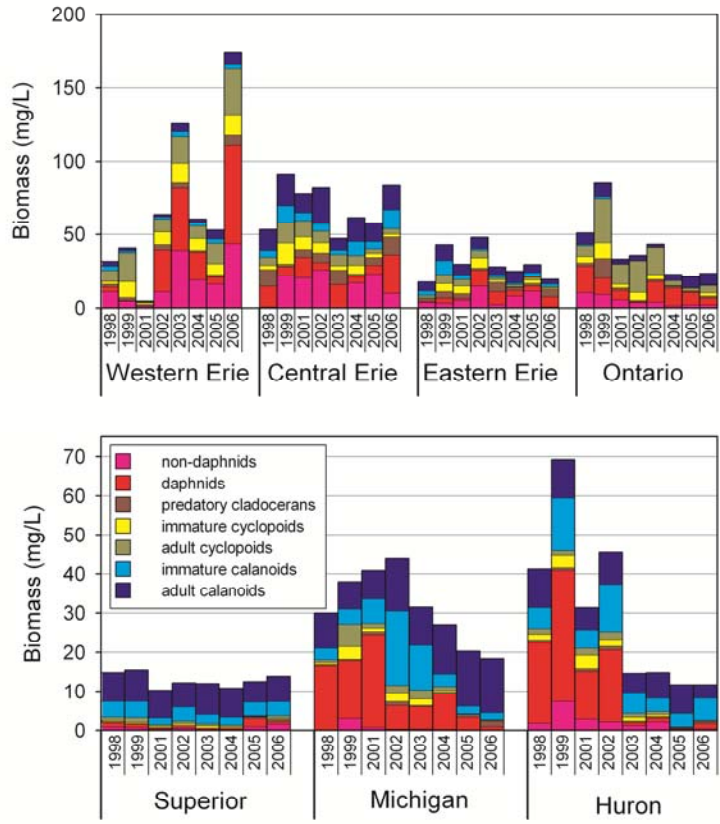


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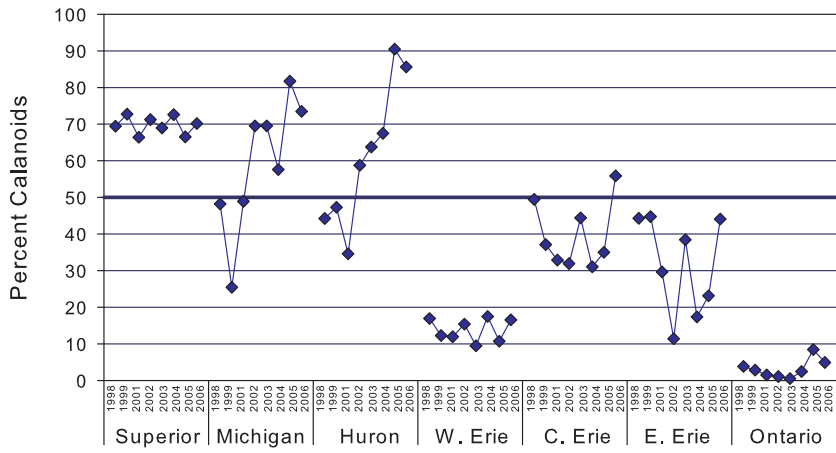


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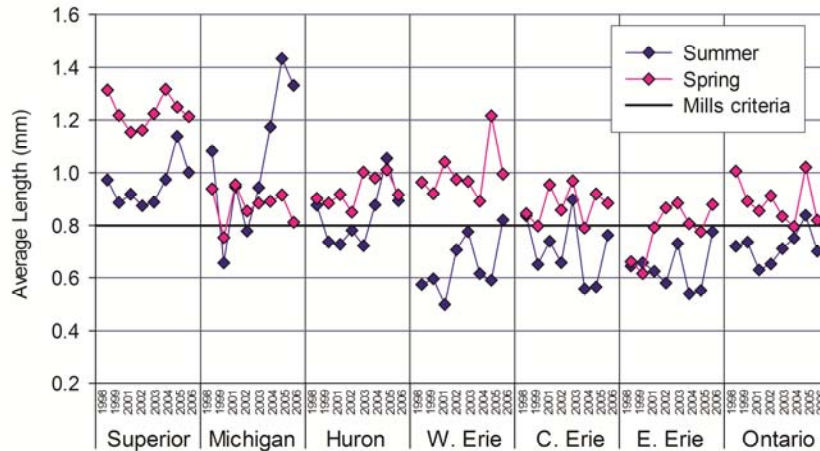


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