Phytoplankton Populations

Formerly Indicator # 109

Overall Assessment

Status: Undetermined

Trend: Undetermined (changing)

Rationale: Reductions in the spring bloom are occurring in Lake Michigan, Lake Huron, and to a lesser extent in Lake Ontario, consistent with both oligotrophication and invasive species impacts. Cyanobacterial blooms are occurring with greater frequency in the western basin of Lake Erie.
**This assessment is based on historical conditions and expert opinion. Specific objectives or criteria have not been determined.*

Lake-by-Lake Assessment

Lake Superior

Status: Good

Trend: Unchanging

Rationale: Changes in phytoplankton community size or seasonality, as measured by satellite-estimated chlorophyll a, have not been detected in Lake Superior. Current communities are indicative of an oligotrophic system.

Lake Michigan

Status: Fair

Trend: Undetermined (changing)

Rationale: A notable reduction in the spring bloom and a consequent diminution in seasonality has been seen in Lake Michigan. Lower levels of primary production could be reducing resource availability to higher trophic levels.

Lake Huron

Status: Fair

Trend: Undetermined (changing)

Rationale: The spring bloom largely disappeared in 2003; reductions in chlorophyll have been seen across all seasons since 2005. Coincident declines in zooplankton and benthos suggest impacts on higher trophic levels.

Lake Erie

Status: Poor

Trend: Deteriorating

Rationale: While highly variable, no trends in chlorophyll have been noted for Lake Erie since the last report (2003). However, blooms of cyanobacteria, in some cases toxic, appear to have increased in frequency in the western basin in recent years.

Lake Ontario

Status: Fair

Trend: Undetermined (changing)

Rationale: There is some indication of declines in spring chlorophyll in the past ten years.

Other Spatial Scales
Insert other spatial scales information including Status, Trend and Rationale if available.

Purpose

- To directly assess phytoplankton species composition, biomass, and primary productivity in the Great Lakes
- To indirectly assess the impact of nutrient and contaminant enrichment and invasive non-native predators on the microbial food-web of the Great Lakes

Ecosystem Objective
Desired objectives are phytoplankton biomass size and structure indicative of oligotrophic conditions (i.e. a state of low biological productivity, as is generally found in the cold open waters of large lakes) for Lakes Superior, Huron and Michigan; and of mesotrophic conditions for Lakes Erie and Ontario. In addition, algal biomass should be maintained below that of a nuisance condition in Lakes Erie and Ontario, and in bays and in other areas wherever they occur. There are currently no guidelines in place to define what criteria should be used to assess whether or not these desired states have been achieved.

Ecological Condition
This indicator assumes that phytoplankton populations respond in quantifiable ways to anthropogenic inputs of both nutrients and contaminants, permitting inferences to be made about system perturbations through the assessment of phytoplankton community size, structure and productivity. Internally consistent time series data on phytoplankton community size and composition have not been available since 2000. In their absence, assessments made in this report have been based on estimates of chlorophyll derived from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite imagery as well as on literature sources.

Major changes have occurred in the phytoplankton community of several Great Lakes since SOLEC 2003. The spring phytoplankton bloom in Lake Huron, which is the major episode of primary production in the lake, virtually disappeared in 2003 (Barbiero et al. 2011). Dramatic declines in cladoceran populations were seen that summer, along with overall declines in crustacean biomass (Barbiero et al. 2009). Declines in the spring bloom were also seen in Lake Michigan (Fahnenstiel et al. 2010, Barbiero et al. in prep.) along with similar changes in zooplankton communities. Causal links, if any, between the reductions in the spring bloom and the coincident reductions in cladoceran biomass are not fully worked out at present. These changes represent a trend towards oligotrophication in Lakes Huron and Michigan, with the offshore waters of these two lakes now closely resembling those of Lake Superior in many respects (Barbiero et al. in prep.). While this trend can be viewed in a positive light from a conservation perspective, it likely also represents an overall reduction in the carrying capacity of the two lakes.

In the western basin of Lake Erie, a number of large blooms of the nuisance cyanobacterium *Microcystis* have occurred since the last report (Vincent et al. 2004), and there is evidence that such blooms are becoming a yearly occurrence (Chaffin et al. 2011).

There is some evidence that the chlorophyll declines seen in Lake Ontario in the 1980s (Johengen et al. 1996) have continued in the past ten years (GLNPO, unpublished data), albeit at a reduced rate.

No assessment of “ecosystem health” is currently possible on the basis of phytoplankton data, since reference criteria and endpoints have yet to be developed.

Management Challenges/Opportunities

The two most important potential future pressures on the phytoplankton community are changes in nutrient loadings and continued introductions and expansions of non-native species. Increases in the magnitude and/or bioavailable fraction of phosphorus loading might result in both increases in phytoplankton community size, as well as shifts in phytoplankton community composition away from diatoms and towards other, potentially nuisance, taxa. Conversely, reductions in phosphorus loading might be expected to have the opposite effect. Continued expansion of dreissenid mussel populations could further reduce nutrient concentrations in offshore waters and contribute to the oligotrophication already seen in some of the lakes.

Comments from the author(s)

A highly detailed record of phytoplankton biomass and community structure has accumulated, and continues to be generated, through regular monitoring efforts. However, problems exist with internal comparability of these data. While efforts are currently underway to rectify this situation, consistent long-term data extending beyond 2000 are not currently available.

While the use of phytoplankton data to assess "ecosystem health" is conceptually attractive, there is currently no objective, quantitative mechanism for doing so. Reliance upon literature values for nutrient tolerances or indicator status of individual species is not recommended, since the unusual physical regime of the Great Lakes makes it likely that responses of individual species to their chemical environment in the Great Lakes will vary in fundamental ways from those in other lakes. The use of species-level phytoplankton data to assess 'ecosystem health' will require the development of an objective, quantifiable index specific to the Great Lakes.

Given the current lack of comparable, long-term data, the difficulties involved in interpretation of such complex data mentioned above, as well as the limited temporal window afforded by a biannual monitoring program, it is important to identify alternate sources of appropriate data to help monitor trends in phytoplankton. In this context, the use of remote sensing technologies has great potential to enhance our ability to detect trends in chlorophyll concentrations in the Great Lakes. While there is currently not universal agreement as to the applicability of standard chlorophyll algorithms to the Great Lakes, particularly in cases in which absolute concentrations are of interest, satellite imagery has shown promise in the detection of chlorophyll trends in the Great Lakes (e.g., Kerfoot et al., 2010; Barbiero et al., 2011).

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	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: Information has been drawn from a number of sources, including the peer-reviewed scientific literature and unpublished SeaWiFS satellite data. The validity of SeaWiFS imagery for quantifying chlorophyll concentrations in the Great Lakes has not been fully worked out as of yet, and therefore any conclusions based on this data should be approached with some caution. Quantification of data quality is typically not treated in detail in the scientific literature.						

Acknowledgments
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Information Sources

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Last Updated
State of the Lakes Ecosystem Conference (SOLEC) 2011