Eutrophication in the Great Lakes: New Policy Tools for Ensuring a Thriving Great Lakes System

BORDERS IN GLOBALIZATION

Overview of the Issue

Over the past few decades, harmful algal blooms (HABs) have been on the rise in fresh (lakes, ponds, rivers and reservoirs) and brackish (seas, estuaries and lakes) waters throughout the world (O'Neil et al., 2012), as well as in the Great Lakes St. Lawrence River basin. This is particularly true in Lake Erie. This Great Lake is the most susceptible to HABs due to the fact that it is the shallowest of the Great Lakes and receives a very high level of nutrient runoff such as phosphorus (P), nitrogen (N) and organic compounds from anthropogenic sources (Rastogi et al., 2014). Massive algal blooms take place almost annually in Lake Erie (e.g. August 2014 and July 2015) and threaten sources of high quality drinking water, as demonstrated by the HAB events that rendered the city of Toledo's water undrinkable in 2014 and 2015 (Yeager-Kozacek, 2014; Messina, 2015).

HABs threaten water quality in two ways. First, HABs produce toxins and toxic by-products that result in impaired water quality; second, the development of high biomass affects co-occurring organisms and alters food web dynamics (Havens, 2008; Anderson et al., 2002). Specifically, HABs alter the clarity of the water by changing the vertical light energy distribution, where high cyanobacteria biomass causes shading and smothering that can disrupt the food chain and subsequent energy/carbon transfer to the next level within the chain. Ultimately the unutilized algal biomass will sink and decompose, smothering invertebrate and fish habitats (Pearl and Huisman, 2008) and strip oxygen from the waters upon the bloom's decomposition. Although the mechanism of HAB formation and toxicity is not fully understood, it is believed that both natural forces and anthropogenic pressures contribute to their formation (Havens, 2008).

Most Relevant Existing Policies and Legislation

There are hundreds of laws, policies and regulations in place in both Canada and the United States that address varying aspects of eutrophication. Following is a brief summary of the most relevant to the issue. In 1969, the International Joint Commission (IJC) concluded that excess phosphorus input was responsible for the eutrophication of Lake Erie and suggested immediate phosphorus input reduction. Soon after that, the 1972 amendments to the Clean Water Act (CWA) came into effect in the United States, drawing attention to issues of Great Lakes water pollution and protection. Numerous pollution control strategies were included in the CWA, including water quality criteria that set specific nutrient levels for protecting waters against over enrichment. Also, the Great Lakes Water Quality Agreement (GLWQA) between the U.S. and Canada was enacted in 1972 to tackle municipal wastewater inputs around the basin.

Through a 2012 Protocol to the GLWQA, Canada and the United States committed to combat the growing threat of toxic and nuisance algae development in Lake Erie and agreed to develop updated binational phosphorus reduction targets for Lake Erie. In February 2016, Environment Canada and the U. S. Environmental Protection Agency adopted targets to reduce phosphorus entering affected areas of Lake Erie by 40 percent. Also in 2015 Michigan, Ohio and Ontario committed to reducing the amount of phosphorus flowing into western Lake Erie by 40 percent in the next 10 years.

Stakeholders

This issue is characterized by myriad stakeholders throughout the Basin, including the following:

- Public sector: Bi-national (IJC), federal (Environment Canada, EPA), provincial (Ontario Ministry of Agriculture, Food and Rural Affairs), state (Departments of Environmental Resources or Conservation) and municipal policymakers are the backbone of this issue.
- Non-governmental organizations: Academic institutions on both sides of the border are dedicated to education and research. Civil society organizations such as Freshwater Future, the Alliance for the Great Lakes, Healing our Waters and The Nature Conservancy help coordinate advocacy and action between the public sector and citizenry.
- Private sector: Companies are interested stakeholders, including those that handle industrial sewage as well as those that benefit from having good water quality for production processes due to water consumption.
- Recreational groups and citizens connected with fisheries and aquaculture: These interests rely heavily on high quality water.
- Agricultural interests: These interests work with the Canadian Ministry of Agriculture and the U.S. Department of Agriculture as well as provincial and state governments to improve impaired waters due to agricultural runoff.
- Great Lakes citizenry: The impetus for change and the implementation of policy is based on public opinion, therefore, awareness of the HABs problem is important for action.

Policy Challenges

Dealing with eutrophication is complicated because it requires a multifaceted approach to pollution prevention and treatment. Among the most important policy challenges is the complex web of political jurisdictions and interests in this issue – federal, state, provincial and municipal – coupled with the need for public input and participation. Another challenge is better understanding the science-policy nexus related to HABs. That is, how well do current management measures address concerns highlighted by science?

Policy Alternatives and Policy Futures

The 40 percent commitments mentioned above at the binational and state-provincial levels are a good start to tackling the HABs problem in the Great Lakes. Policymakers also can avail themselves of useful tools to better understand and hence reduce HABs. For example, an opportunity exists to apply the International Organization for Standardization (ISO) 31000 risk management framework (ISO, 2009) and bowtie analysis tool (ICE/ 31010, 2009) to the HABs issue in Lake Erie. The application of these two tools has the potential to determine in a more holistic and rigorous manner whether current management strategies can adequately reduce the risk of algal blooms as a result of phosphorus loading (direct and indirect).

In a scholarly analysis of preventative management strategies at the federal, provincial and state levels (Creed, et al., 2016), researchers undertook a "proof of concept" using the ISO risk management framework and bowtie analysis tool to examine the science-policy nexus in the case of HABs. Table 1 (Creed et al., 2016) outlines the typology of management measures used in their analysis. When applying these tools to the management measures in place in Canada and the United States at the federal, provincial and state levels, researchers found that relatively few strategies focus on "tracking" the performance of direct phosphorus source management strategies; "facilitating" (making an action or process easy or easier) for indirect phosphorus sources; and "enabling" (provide authority to reduce phosphorous). Although a first-step proof of concept, the results suggest areas that may need attention to address the current HABs problem. For example, given that so few strategies focus on tracking, perhaps a comprehensive monitoring program and the use of modelling that tracks progress and directs adaptive management are two useful policy tools that would lead to more effective outcomes. Stronger compliance and enforcement mechanisms may be needed, given that few measures actually provide the authority to reduce phosphorous levels. Thus, although the Creed (2016) analysis of preventative measures requires a second step of efficacy analysis with policy and decision makers, it illustrates an approach that provides an alternative way to focus analysis on management measures in the Great Lakes and an approach that has the potential to guide efforts around potential enhancement within current government frameworks.

Table 1. A system of management measures (modified after CEU 2008).

	Management measure	Description
Hard controls are structures that prevent or reduce the pressure, effects, or impacts	Avoidance	Spatial and temporal controls are management measures that influence where and when the human activity is allowed to occur (e.g., wintertime logging in wet areas; manure spreading during dry conditions).
	Prevention	Input controls are management measures that influence the amount or location of human activity that is permitted (e.g., riparian buffer strips for forest harvest operations and croplands).
	Mitigation	Output controls are management measures that guide how to restore damaged ecosystem components.
Soft controls are activities that enable, facilitate, or track the management measures (the Hard Controls)	Enable	Measures to ensure that authority for management is allocated and coordinated
	Facilitate	Measures that ensure education/communication to engage the public to care that we meet the policy objectives, and incentives to make it in the economic interest of people to act in ways that help achieve the policy objectives.
	Track	Measures that set management targets, improve the traceability of changes in cumulative pressures–effects–impacts, and improve the traceability of compliance to the law (regulatory measures) and the conformity to guidelines (voluntary measures) needed to assess the performance of the management system

Eutrophication will continue to be a concern for Great Lakes stakeholders. Since numerous factors contribute to the overgrowth of phytoplankton – both natural and anthropogenic – we may not see a significant drop of HAB events in the near future. However, it is imperative that stakeholders continue to focus on this issue, as reduced HABs would contribute to increased fisheries, aquaculture, strengthened ecosystem services, enhance tourism opportunities and ultimately lead toward an increase in the quality of life for residents of the Great Lakes region.

References

Anderson, D. M., Gilbert, P. M. and Burkholder, J. M. 2002. Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences. *Estuaries.* 25(4): 704-726.

Creed, I.F.,Cormier, R., Laurent, K.L., Accatino, F., Igras, J., Henley, P., Friedman, K.B., Johnson, L.B., Crossman, J., Dillon, P.J., and Trick, C.G. 2016. Formal Integration of Science and Management Systems Needed to Achieve Thriving and Prosperous Great Lakes. *BioScience (2016)* doi: 10.1093/biosci/biw030. First published online: April 13, 2016.

European Union. 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). OJ L 164, 25.6.2008.

Havens, K. E. 2008. Cyanobacteria blooms: effects on aquatic ecosystems. In: *Cyanobacterial harmful algal blooms: state of the science and research needs.* 733-747. New York: Springer Press.

International Electrotechnical Commission/ International Organization for Standardization (IEC/ISO). 2009. *Risk Assessment Techniques*. International Organization for Standardization. IEC/ISO 31010:2009.

International Standards Organization (ISO). 2009. *Risk Management Principles and Guidelines*.

International Standards Organization (ISO). 2009. *ISO 31000*:2009.

Ludsin, S. A., Kershner, M. W., Blocksom, K. A., Knight, R. L. and Stein, R. A. 2001. Life after death in Lake Erie: nutrient controls drive fish species richness, rehabilitation. *Ecol. Appl.* 11(3): 731-746.

Messina, I. 2015. Microcystin detected in raw Lake Erie water, Toledo water deemed safe to drink. *The Blade*. Retrieved on September 12, 2015 from http://www.toledoblade.com/local/2015/07/27/Microcystin-detected-in-raw-Lake-Erie-water-Toledo-water-deemed-safe-to-drink.html.

O'Neil, J. M., Davis, T. W., Burford, M. A. and Gobler, C. J. 2012. The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change. *Harmful Algae*. 14: 313-334.

Pearl, H.W. and Huisman, J. 2008. Blooms like it hot. *Science*. 320(5872): 57-58.

Rastogi, R. P., Sinha, R. P. and Incharoensakdi, A. 2014. The cyanotoxin-microcystins: Current overview. *Rev. Environ. Sci. Biotechnol*. 13(2): 215-249.

Yeager-Kozacek, C. 2014. Toxic Algae Bloom Leaves 500,000 Without Drinking Water in Ohio. *Eco Watch*. Retrieved on September 14, 2015 from http://ecowatch.com/2014/08/03/toxic-algae-bloom-500000-without-drinking-water-ohio/.