The News from Saginaw Bay

Where the mussels are strong, the walleye are good looking, and all the phosphorus is above average

Craig A. Stow
NOAA Great Lakes Environmental Research Laboratory
Ann Arbor, MI

5 year study 2008-2013
NOAA Center for Sponsored Coastal Ocean Research
1974 Report
- Many problems, minimal data

1978 Great Lakes Water Quality Agreement
- 440 metric ton/year Total Phosphorus target
- 15 µg/L total phosphorus “target”
- 3.6 µg/L chlorophyll a “target”
- 3.9 m secchi depth

Mesotrophic state

Early phosphorus reduction efforts
- Targeted point sources

Emphasis shifted to toxic contaminants

1991 - zebra mussels discovered in bay

1991-96 - NOAA GLERL research

Project beginning

Status of TP load and other targets was unclear

Muck resurgent problem
- Cladophora growth catalyzed by mussels

Mussels last surveyed in 96 - fairly dense, zebras

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In 1972 the United States and Canada signed the Great Lakes Water Quality Agreement (GLWQA) to protect the aquatic environment common to the two countries, known geologically as the Laurentian Great Lakes. This agreement expressed the intent of each country to restore and enhance the quality of a water resource that represents 20% of the world’s surface fresh water. The GLWQA was revised in 1978 and is currently undergoing an extensive review.

One of the major thrusts of the agreement has been to solve the problem of eutrophication and its environmental consequences. The first GLWQA and its 1978 revision set forth as overall policy of reducing phosphorus loading and addressing the problem of eutrophication. Eutrophication is a process by which increases in the population of certain algae, encouraged by the presence of excess phosphorus in a lake, lead to the depletion of oxygen in the water and the consequent deterioration of the lake.

The impressive size of the Great Lakes has not been enough to shield them from many of the water quality problems that have resulted from the tremendous human population explosion within their basin (Table 1). Over the past 180 years the population residing within the Great Lakes basin has risen from approximately 300,000 to more than 40 million.

The municipal, industrial, and commercial use of this water resource during the development of urban society has led to a concomitant deterioration of Great Lakes water quality; so has the extensive agricultural cultivation of the surrounding land. This is particularly the case in the lower Great Lakes basins (involving 59% and 56% of land in the Lake Erie and Lake Ontario basins, respectively). Several studies have linked the chemical and biological deterioration of the Great Lakes to population growth within the basin (1-3).

The importance of the Great Lakes was recognized long before the signing of the Boundary Waters Treaty of 1909. The most significant provision of this treaty, which is still in force today, is the establishment of the International Joint Commission (IJC). Among the responsibilities of the IJC is that of undertaking investigations into the problems of specific boundary waters on the request of either the United States or Canada. These studies, designed to formulate recommendations to the two governments, are known as “Reference Studies.”

Since its inception the IJC has issued more than 50 Reference Studies; some of its more important work, however, has been done according to the functions given to it under the GLWQA. Two international boards have been established to assist the IJC in its work relating to the GLWQA: the Great Lakes Water Quality Board and the Science Advisory Board.

By the mid- to late 1960s members of the Great Lakes research and regulatory communities had documented serious eutrophication problems in the lower Great Lakes and had found cause for concern in parts of Lakes Michigan and Huron. They were particularly concerned with this phenomenon in the large embayments of Green Bay and Saginaw Bay. At about the same time scientists in general had begun to agree that the most effective means of controlling eutrophication in lakes is to reduce phosphorus levels. On the basis of this conclusion and the 1970 annual report of the IJC, the 1972 GLWQA set forth water quality objectives and recommended measures to control discharge of phosphorus that finds its way
Estimated TP Load vs. Time
(Saginaw River only)

### Total Phosphorus and Chlorophyll

<table>
<thead>
<tr>
<th>N</th>
<th>Average</th>
<th>6.6</th>
<th>9.5</th>
<th>6.5</th>
<th>6.0</th>
<th>2.3</th>
<th>1.8</th>
<th>0</th>
<th>0</th>
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</thead>
</table>

**Chlorophyll a (µg/L):**

- **River plume 1991-96**
- **Non-plume 1991-96**
- **Outer bay 1991-96**
- **River plume 2008-10**
- **Non-plume 2008-10**
- **Outer bay 2008-10**

**Transect data unavailable**
### Secchi Depth

<table>
<thead>
<tr>
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<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>149</td>
</tr>
<tr>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>193</td>
<td></td>
</tr>
</tbody>
</table>

**Bar Graph:**
- **y-axis:** Secchi Depth (m)
Soluble Reactive Phosphorus

<table>
<thead>
<tr>
<th>N</th>
<th>Average</th>
<th>59</th>
<th>308</th>
<th>90</th>
<th>236</th>
<th>31</th>
<th>20</th>
<th>132</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>1.7</td>
<td>0.8</td>
<td>1.0</td>
<td>0.7</td>
<td>0.8</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

- river plume 1991-96
- non-plume 1991-96
- river plume 2008-10
- non-plume 2008-10
- outer bay 1991-96
- outer bay 2008-10
- transect plume
- transect non-plume

Saginaw Bay

Map of Saginaw Bay with locations SB1 to SB30 marked.
Mussel Surveys

~75% Quaggas
More widespread...?
Beach Muck

Cladophora
Other filamentous benthic algae
Macrophytes
Late in summer – highly degraded, undistinguishable

Good news – benthic algae tended to be P limited
Bad news – macrophytes get P from sediment
<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>Jun 7</td>
<td>Our muck problem on the beach has been more severe than in past years. We plan to use the bulldozer from Otsego Lake to help on the cleanup job.</td>
</tr>
<tr>
<td></td>
<td>Jun 14</td>
<td>Our muck problem continues to be very bad.</td>
</tr>
<tr>
<td></td>
<td>Jun 28</td>
<td>Our priority project for this week was pushing muck from the water at the beach with the bombardier and bulldozer. We have never had a more severe muck accumulation. The water’s edge is now in fair shape, and we have sand corridors through the muck piles. Swimmers now can get to and from the water.</td>
</tr>
<tr>
<td>1982</td>
<td>Jun 20</td>
<td>The prevailing NW winds have piled up the muck on our beach to the extent our bombardier tractor can’t push it. With settled water conditions we may again make some progress in clearing our swimming area.</td>
</tr>
<tr>
<td>1984</td>
<td>Aug 5</td>
<td>Muck on the beach is very thick.</td>
</tr>
<tr>
<td>1987</td>
<td>May 31</td>
<td>A lot of people are coming out to the beach in spite of the fact that lower lake levels have resulted in an increase in the amount of muck along our shore line.</td>
</tr>
<tr>
<td>1988</td>
<td>Jul 3</td>
<td>Beach continues to be very busy in spite of the low water levels that have increased our problem with the muck.</td>
</tr>
<tr>
<td>1989</td>
<td>Jun 18</td>
<td>Our mucky beach made the local papers again. See the attached article.</td>
</tr>
<tr>
<td>1990</td>
<td>May 27</td>
<td>Attached is an article from the Bay City Times concerning water quality in Saginaw Bay.</td>
</tr>
<tr>
<td>1991</td>
<td>May 19</td>
<td>We received our new four wheel drive tractor Saturday and have already put it to use raking the beach. We have an especially large amount of muck this spring.</td>
</tr>
<tr>
<td></td>
<td>May 26</td>
<td>Day use was slow because of cloudy weather and a very mucky beach.</td>
</tr>
<tr>
<td></td>
<td>Jun 9</td>
<td>Continues to be very slow due to the deplorable condition of the shoreline.</td>
</tr>
</tbody>
</table>
Recent Developments

2012 GLWQA renegotiated - calls for target load reevaluation
Development of substance objectives – also for tributaries
Adoption of Adaptive Management framework
• Intercepts differing by pre- and post-invasion periods
• Riverine TP concentration instead of TP load


Updated Model Grid for SAGEM2

New Grid Facts
- 2x2 km
- 747 active cells
- Up to 10 vertical layers (GVC)
Project Products

- $>$ 30 published journal papers
- Special Issue Journal of Great Lakes Research 20 papers – now available
- Summary Report
Summary

- TP load target not met
- TP, chlorophyll a, secchi objectives not met
- Some evidence of TP declines, reasons unclear (direct, indirect mussel effects?)
- SRP appears to be declining
- Mussel community shift, lower density, trajectory unclear
  - Possible seasonal shifts ... intriguing, implications unclear
- Cyanobacteria, *Microcystis*, microcystin present
- Monitoring gaps impede understanding
- Adaptive Management framework to integrate data, models help guide management into the future

- Process-based model (LimnoTech) and empirically-based models available (GLERL) – help address some of these questions