The Lake Huron Binational Partnership

Phosphorus in Saginaw Bay - Is It Still a Problem?

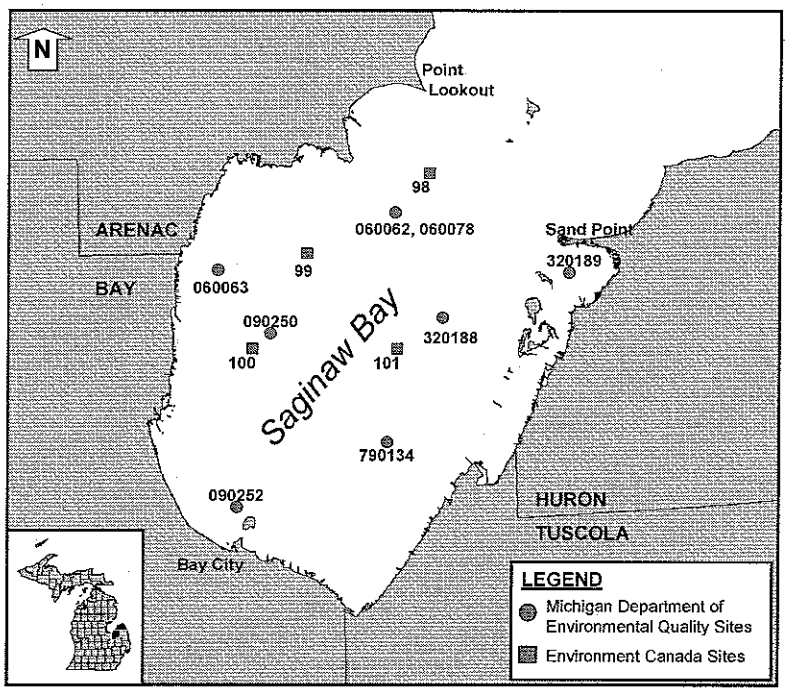
About the Bay[1]

Saginaw Bay is a large estuary and embayment of Lake Huron on the eastern coast of the state of Michigan that extends southwest 82 kilometers from Lake Huron to the mouth of the Saginaw River in Bay City, Michigan. The bay is essentially divided into inner and outer bay regions, marked by a constriction extending from Point Lookout on the western shoreline to Sand Point on the eastern shoreline (Figure 1).

Although the respective surface areas are similar, the inner bay is relatively shallow and only contains approximately 30 percent of the bay's total water volume[2], with a mean depth of 4.6 meters. The outer bay has a mean depth of 15 meters.

Saginaw Bay has a drainage basin seven times larger (ca. 21,000 km^2) than the immediate area of the bay[2]. The Saginaw River, located near the southwestern end of the bay near Bay City, is the dominant source of surface drainage into the bay, accounting for approximately 70 percent of the total drainage of tributaries to the bay and drawing from 80 percent of the bay's total basin area. Consequently, the inner bay is heavily impacted by occasionally large seasonal inputs from the Saginaw River. Saginaw River daily discharge rates vary by season, ranging from 28 million cubic meters per day in the spring to 2.4 million cubic meters per day in the fall[3]. The outer bay is primarily influenced by Lake Huron.

Figure 1. Map of Saginaw Bay showing Michigan Department of Environmental Quality and Environment Canada Monitoring Stations.



The Phosphorus Problem[4]

Generally, the Great Lakes are *phosphorus limited*, meaning that the amount of phosphorus determines the basic productivity of the lake. Higher levels of phosphorus support increased plant growth and greater productivity. Scientists classify lakes based on the level of productivity. In 1979, the International Joint Commission described Lake Huron as *oligotrophic*,or having low productivity[5]. Saginaw Bay was described as *eutrophic*, or having high productivity.

During the 1970s and 1980s, the Saginaw River added nearly two metric tons of total phosphorus per day to the bay, the largest contribution of phosphorus to the Great Lakes by any river in Michigan. The total phosphorus concentration in

the inner bay increased 10-fold from below 0.005 mg/L in 1971[6] to 0.047 mg/L in the spring of 1978[7]. The added phosphorus increased the growth of nuisance blue-green algae that was likely responsible for the foul odors and poor taste of drinking water withdrawn from the bay.

Supplement to Annex 3 of the 1978 Great Lakes Water Quality Agreement

Total Phosphorus Target for Saginaw Bay

The average concentration of total phosphorus should be 15 µg/l or less.

Control of phosphorus inputs was the principal pollution control strategy adopted under the 1972 Great Lakes Water Quality Agreement between the United States and Canada. The 1987 Supplement (Annex 3) to the 1978 Great Lakes Water Quality Agreement led to specific targets for total phosphorus in the bay (0.015 mg/l). The targets represent planning guides to reduce phosphorus loading into Saginaw Bay. The phosphorus target load for Saginaw Bay is 440 metric tonnes per year for the purpose of alleviating drinking water taste and odor problems[8].

Phosphorus Monitoring[1,6]

The Michigan Department of Environmental Quality (MDEQ) has conducted seasonal monitoring of Saginaw Bay water quality at seven monitoring stations since 1993. Environment Canada (EC) has conducted ship-based water quality monitoring in the Great Lakes since the late 1960s. Four stations in each of the inner and outer Saginaw Bay have been included in this program since 1985. Inner bay station locations are shown for both of these monitoring programs in Figure 1.

The MDEQ conducts sampling at a monthly frequency from ice-out through November, weather permitting. All seven stations are sampled at approximately 1 meter depth; station 060062 is also sampled at mid-depth (data from both depths at this station are averaged for analysis). EC typically conducts two monitoring cruises per year, one in the spring (late April – early May) and one in the summer (August). In recent years, cruises are conducted approximately every second year.

Figure 2 shows the average total phosphorus concentration from inner bay sites each spring as measured by the two monitoring programs. Both data sets show considerable year-to-year variability in the results. The MDEQ data are generally higher, probably because some sites are located closer to shore-based nutrient sources. The EC data set shows that the long-term (20-year) trend has been slightly declining phosphorus concentrations, from about 0.018 mg/L in the mid-1980s to about 0.01 to 0.015 mg/L total phosphorus in recent years. For comparison, the average concentrations of total phosphorus in the open waters of Lake Huron during the spring over the past two decades have been in the range of 0.004 to 0.005 mg/L[6].

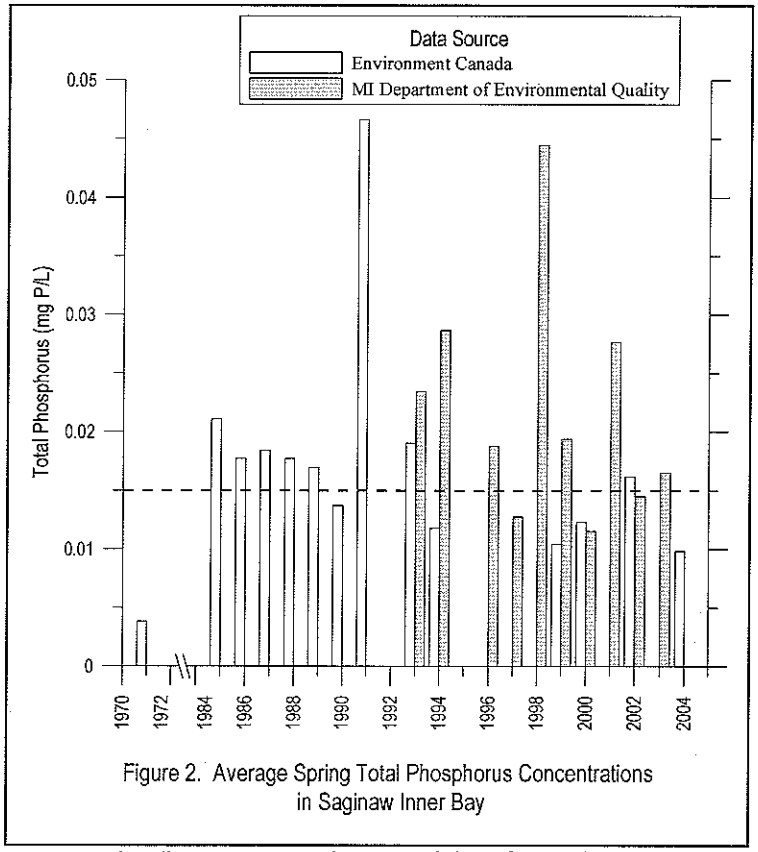


Figure 2. Average Spring Total Phosphorus Concentrations in Saginaw Inner Bay

A linear regression model of total phosphorus concentrations over time shows that total phosphorus has decreased in Saginaw Bay at a rate of approximately 0.005 mg/L per year. However, the regression is not statistically significant for either data set (EC slope 1985 – 2004 = -0.0056 mg/L per year, R^2= 0.31; MDEQ slope 1993 – 2003 = -0.0052 mg/L per year, R^2 = 0.09). The most recent (spring 2004) EC data are the lowest on record. Continued monitoring will assist in determining if this declining trend will continue in the years to come.

Figure 3 shows the distribution of station average data by year. Data from the majority of stations in all years have been characterized by total phosphorus concentrations at or exceeding the target of 0.015 mg/L. When these results are considered along with those of chlorophyll *a* monitoring, they indicate that Saginaw Bay may currently be classified as a *mesotrophic* (mid-productivity) to *eutrophic* (high productivity) waterbody.

Phosphorus Modeling of Saginaw Bay

The most recent report by the MDEQ on Great Lakes tributaries estimated that the Saginaw River has a mean flow of 6.4 million cubic meters per day, and a phosphorus loading rate of 227 metric tonnes of phosphorus per year[9]. The loading from the Saginaw River alone therefore represents about 52% of the target load for the entire Bay.

Bierman and Dolan[10] reported on phosphorus model calibration efforts conducted in Saginaw Bay. One of their conclusions was that wind-induced sediment resuspension was an important mechanism for re-introducing phosphorus into the water column. In the calibrated model, the resuspension mechanism was found to account for 36% and 68% of the computed spring and fall average total phosphorus concentrations, respectively. The sediments therefore act as an important pool of phosphorus, potentially available despite source reduction efforts.

Conclusions

Data obtained from monitoring conducted between 1984 and 2003 indicate mesotrophic to eutrophic conditions in Saginaw Bay. Phosphorus concentrations have been highly variable and have not significantly decreased over the nearly two-decade monitoring period. A majority of water quality measurements continue to exceed the target total phosphorus concentration of 0.015 mg/L. Further reductions in phosphorus loadings over time may be required to achieve the Great Lakes Water Quality Agreement targets.

References

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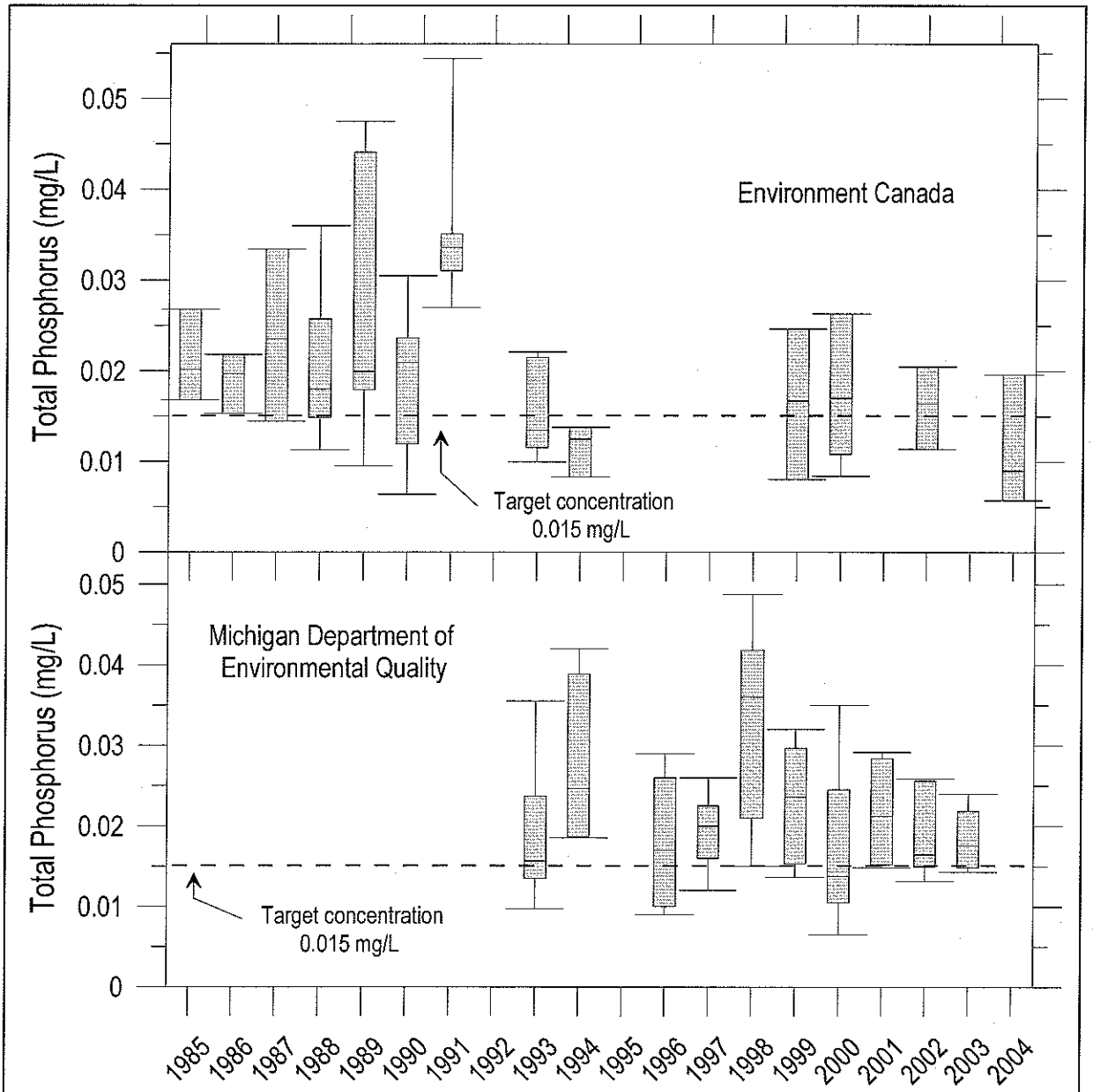

Figure 3. Box and Whisker Plot of Total Phosphorus Data by Year.
Boxes show upper and lower data quartiles; the central solid line represents the median.
Whiskers represent 1.5 times the interquartile range, up to the maximum and minimum data values.

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