# SHAWANO LAKE, SHAWANO COUNTY SEDIMENT CORE RESULTS

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In order to determine the changes in water quality that has occurred in Shawano Lake since the arrival of European settlers, a sediment core was collected by Tim Rasman using SCUBA in the deep basin on October 1, 1991. The water depth was 12.2 m and the length of the core was 64 cm. The top 20 cm was sectioned into 1 cm intervals while the remainder of the core was sectioned into 2 cm increments. There was no stratigraphy evident throughout the core with the color being dark gray to black. The core was dated and analyzed for selected geochemical and biological variables.

The core was dated using the lead-210 method and utilizing the constant rate of supply model. The mean sedimentation rate since the mid-1800's was 0.025 g $cm^{-2}$ $yr^{-1}$. This is at the top of the lower third of rates measured in 38 lakes that have been analyzed in Wisconsin (Figure 1). More important than the mean sedimentation rate is the change in the rate that has occurred since the arrival of European settlers about 150 years ago. There was an increase in the sedimentation rate from 1890 through 1910 (Figure 2) but the sedimentation rate declined and remained lower from 1920 through 1980. Since the mid-1980's, the sedimentation rate has increased and remains elevated at the top of the core.

In order to estimate how changes in watershed landuse has affected the lake; the core was analyzed for a number of elements including aluminum, potassium organic matter, calcium, iron, manganese, nitrogen, and phosphorus. The peak sedimentation rate during the 20 year period on either side of 1900 most likely was the result of disturbance in the watershed. Aluminum (Al), a proxy for detrital aluminosilicate minerals that are common in soil erosion, increased during the same time period as the sedimentation rate (Figure 2). This increase in soil erosion may have been the result of increased agricultural activity. Following the clear-cut logging during the latter part of the nineteenth century, it was common to have intensive farming as the land was cleared and subsistence farming took place. This watershed activity resulted in increased nutrients, e.g. phosphorus deposition in the lake during the first decade of the twentieth century. There was also an increase in lake productivity as indicated by the increase in organic matter in the core (Figure 2). As with the sedimentation rate, aluminum and phosphorus deposition declined from the period of 1930 through 1970. There was a short-lived period of increased erosion during the 1970's (Al) but soil erosion appears to have declined from the mid-1970s through 1990. Unlike Al, organic matter did not decline at the same rate as Al and P. Similar to Al, phosphorus (P) levels exhibited a peak during the mid-

1970's (Figure 2). The decline from 1975 through 1990 was not as great as for aluminum, indicating that phosphorus levels have remained elevated.

A further indication of the increased delivery of soil erosion materials and phosphorus is shown in Table 1. A sediment enrichment factor (SEF) of 1.0 indicates a doubling of the current accumulation rate compared with the presettlement rate. Aluminum and potassium have decreased a small amount but the phosphorus SEF was 4.3. The smaller decline in the SEF for potassium is an indication synthetic fertilizer applied in the watershed is reaching the lake. More disturbing is the high SEF for phosphorus. This indicates that phosphorus in the lake is considerably higher at the present time compared to 150 years ago.

**Table 1.** *Sediment enrichment factors. The higher the value the greater the increase in recent times compared with historical levels.*

| Aluminum | Potassium | Phosphorus |
|---|---|---|
| -0.4 | -0.1 | 4.3 |

The impact of the addition of synthetic fertilizer is shown by the ratio of aluminum to potassium. While both Al and K are found in soil clays, the decline in the ratio of Al:K is an indication that since about 1980 there has been an increase in the amount of commercial fertilizer in the watershed (Figure 3).

Both iron (Fe) and manganese (Mn) are released from the sediments when the overlying waters become devoid of oxygen. Since Mn is reduced to its soluble form at a higher oxygen level than Fe, it is released at a higher rate than iron. Typically this released Mn moves towards the deepest area of the lake and thus is deposited during fall turnover at a greater rate in the deep area of the lake. Since the sediment core was taken in this area it is possible to use the ratio of Fe and Mn in the sediment core to obtain an indication in the oxygen trend in the deep waters of the lake. From about 1900 the ratio steadily declined until about 1980 (Figure 3). This is a strong indication that during this time, the oxygen in the bottom waters declined during stratification.

In order to further understand the nutrient history of a lake, biological remains are examined. Generally, the most useful are diatoms. These are special types of algae that typically live under a wide range of environmental conditions. Unfortunately diatoms were not preserved in the sediments of Shawano Lake. This occasionally happens in larger, relatively shallow lakes. This also happened in Lake Noquebay, Marinette County. Other biological remains that were preserved in Shawano Lake sediments were chlorophyll and zooplankton. The chlorophyll found in the core is an indication of past levels of algae. The increased sedimentation rate around 1900 only resulted in a very small increase in algal levels (Figure 2). There was a small increase about 1950, but by far the largest increase occurred around 1970. Although the peak concentration occurred in 1980, levels have remained high since 1980, and are considerably elevated compared to historical times.

Zooplankton remains are used to reconstruct changes in submerged aquatic plant coverage and sometimes fish predation. Only the group Cladocera are preserved in the sediments but these zooplankters are very informative. In the Shawano Lake core, the dominant zooplankter was *Bosmina longirostris* (Figure 4). This species inhabits the pelagic zone and is frequently the dominant fossil in lakes. In this core, species that inhabit the littoral zone (*Alona* spp. and *Chydorus* spp.) are also well represented. Starting around 1880 there is a decline in *B. longirostris* and an increase in *Alona* spp. This likely indicates that the macrophyte community expanded at this time. This expansion continued and it appears to have stabilized around the mid-1950s. *Chydorus sphaericus* can be found in the littoral zone but also is common in the pelagic zone when filamentous algal species occur in the open water. Typically these filaments are blue-green algae. Therefore it appears that blue-green algal blooms have become more common since 1975. Since the frequency of *C. sphaericus* is highest in the surface sediments it is likely that algal blooms are more common at the present time than at any other time in the last 150 years.

**Summary**

- A sediment core was collected from the deepest area of the lake. The core covers the time period just prior to European settlement until 1991.
- Soil erosion in the watershed peaked during the period 1890-1910. The current rate of soil erosion is similar to the pre-settlement level.
- While phosphorus deposition was elevated around 1910, the current rate is over 5 times the pre-settlement rate. This is due in part to the use of synthetic fertilizers in the watershed.
- Dissolved oxygen levels in the bottom waters have been declining since 1890.
- The extent of macrophyte coverage began to increase around 1880 and at the present time it remains much higher than historical levels.
- The level of algae at the present time is much higher than historical levels. The frequency of algal blooms began to increase about 1970 and currently is higher than at any other time during the last 170 years.

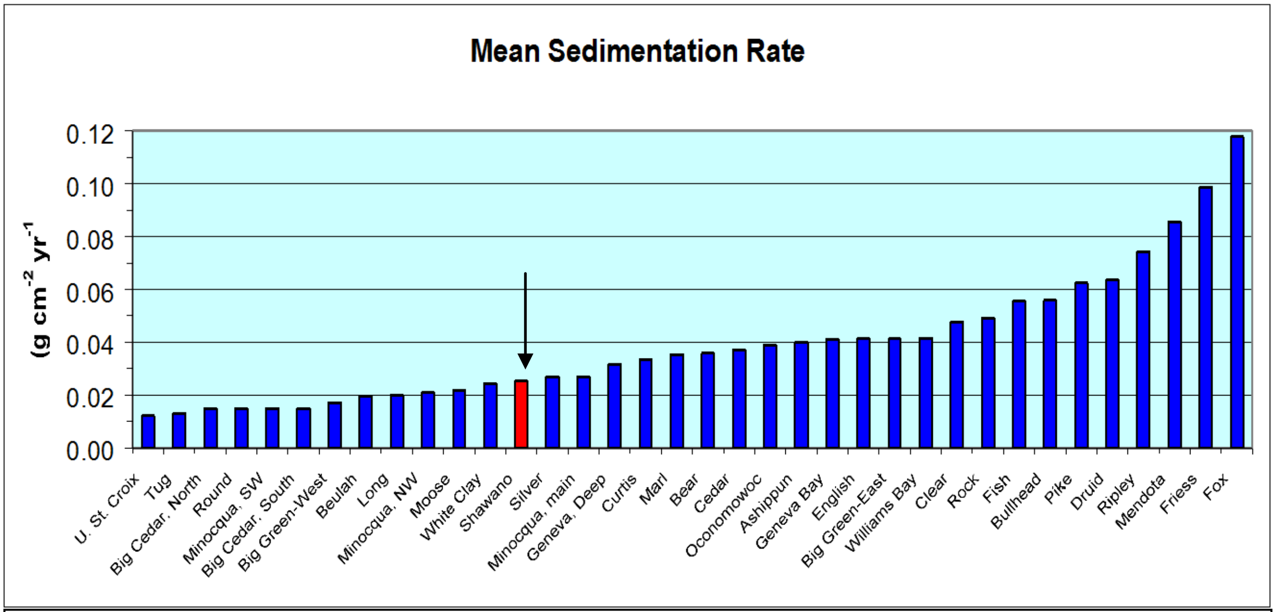


**Figure 1.** Mean sedimentation rate for 38 Wisconsin lakes. The arrow points to Shawano Lake which has a mean sedimentation rate of 0.025 g cm$^{-2}$ yr$^{-1}$.

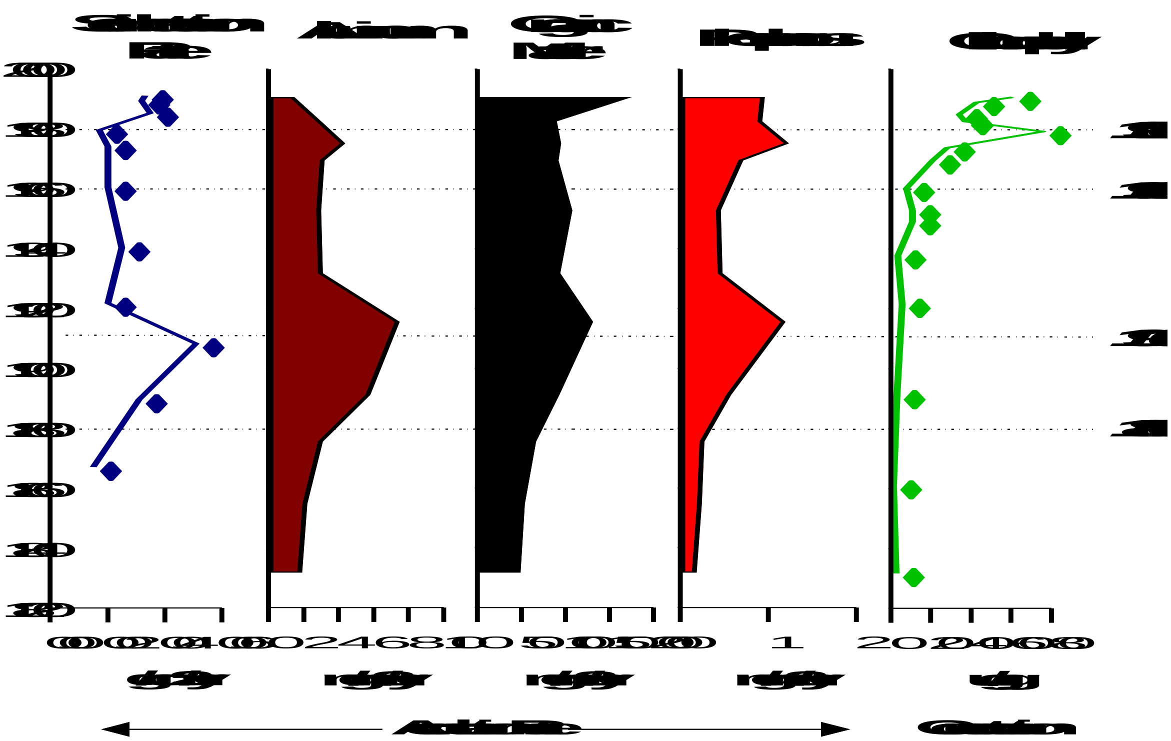

**Figure 2.** Accumulation rate for sediment and other geochemical variables. Aluminum represents soil erosion while organic matter is an indication of lake productivity. The high organic matter point at the top of the core does not necessarily mean a high productivity rate but reflects the lack of breakdown of the organic matter which occurs after deposition. Chlorophyll is an indication of the trend in the algal community.

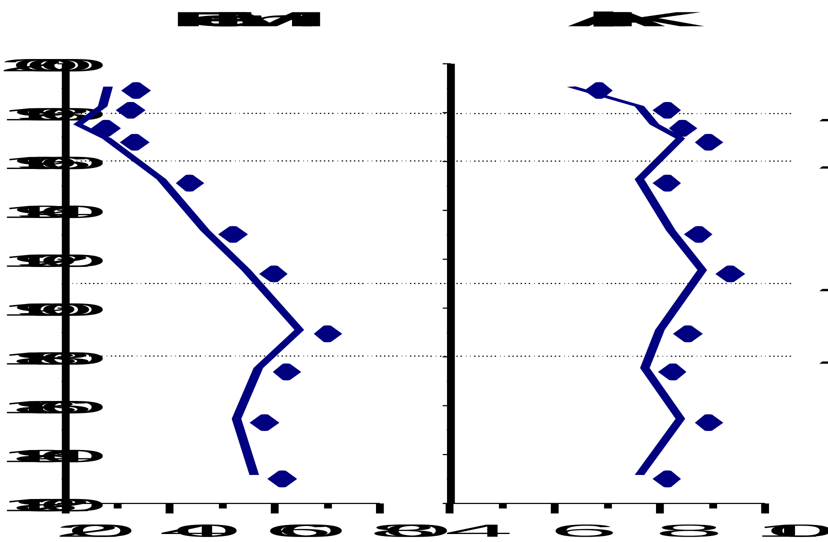

**Figure 3**. A decrease of the Fe:Mn ratio is an indication of a reduction of oxygen levels in the bottom waters. A decrease in the Al:K ratio is an indication of increased input of synthetic fertilizers.

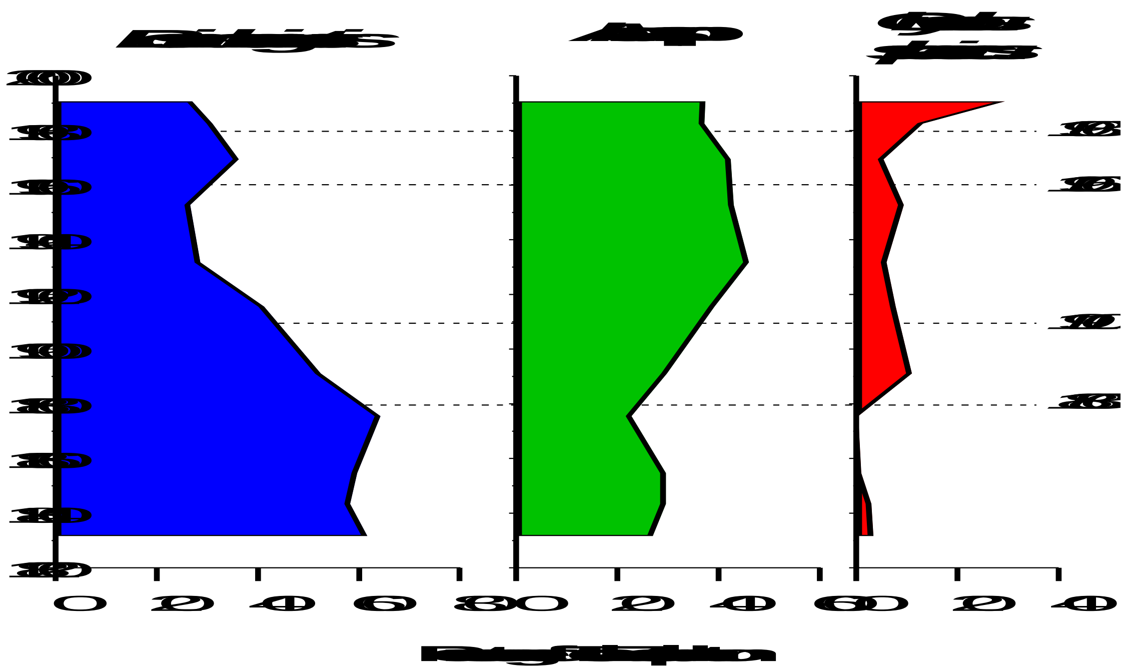

**Figure 4**. Profiles of cladoceran zooplankton. *B. longistrostris* is found in the open water while *Alona* is found in the littoral zone and is an indication of changes in the macrophyte community. *C. sphaericus* is found in the littoral zone but increases in the presence of algal blooms in the open waters of the lake.