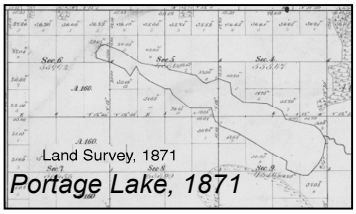
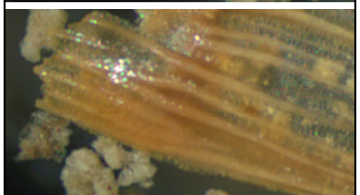
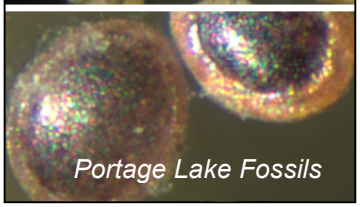
Science Museum of Minnesota

St. Croix Watershed Research Station

A Paleoecological Investigation of Portage Lake, Hubbard Co., MN







Issue: Portage Lake is threatened by excess nutrients. Can the sediments tell us about the historical condition of the lake, when it changed, and how it can be improved?

Portage Lake

- ✓ Portage Lake is located in Hubbard County, Minnesota. It is a 422 acre reservoir with a maximum depth of 17 ft and a well-developed shoreline. Portage Lake was dammed in 1937 with water levels currently maintained at about 5 ft above the natural outlet. A similar shaped lake basin was present before damming of Portage Lake but likely experienced greater variation in water levels. In May 2008, a 2.1 m core was recovered from the east basin of Portage Lake to determine the lake's ecological history.

Sediment core analysis

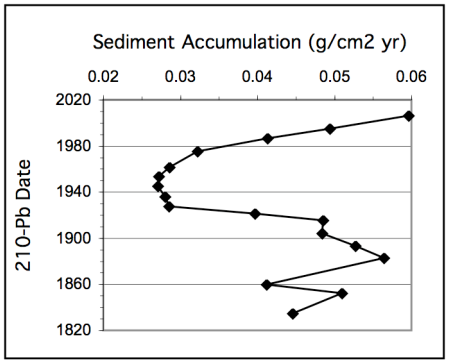
- ✓ Sediments in lakes provide a record of physical, chemical, and biological clues for determining how and when a lake has changed.
- ✓ To establish a date-depth relationship for a core, we use natural (Lead-210) or man-made (Cesium-137) radioisotopes. This tells us the approximate year that a layer of sediment was deposited.
- ✓ The Portage Lake core was analyzed for changes in geochemical and biological clues including inorganics (mineral matter), carbonates, organics, phosphorus, biologically produced silica, and macrofossils. Each provides information on lake history:
  Inorganics – a measure of the mineral matter in the core. Inorganics may increase with erosion or rising water levels
  Carbonates – carbonates accumulate due to input of hard groundwater and as a natural product of plant and algae photosynthesis
  Organics – a measure of biological material in a core from the breakdown of plant, algae, and animal remains
  Phosphorus – a measure of all types of phosphorus in a core, generally increases when nutrient loading and plant/algae production increase
  Biogenic silica – a measure of the amount of historical diatom growth; diatom accumulation normally increases with increased nutrients
  Macrofossils (plant, algae, animal) – many organisms leave identifiable remains in sediments that we use to determine their abundance and when they appear or disappear. Plants fossils can be charcoal (forest fires) or aquatic plants leaves (wild rice leaves) and seeds, algae can be free-floating species (*Pediastrum*) or attached (*Chara*), animal remains can be zooplankton (e.g., *Bosmina*), insects (e.g., chironomids) or even fish.
- ✓ Portage Lake presented a special challenge because its sediments were unsuitable for some paleoecological work that is regularly done on MN lakes; the sediment core did not contain well-preserved diatoms necessary for historical reconstruction of open water total phosphorus concentrations.

Our research shows...

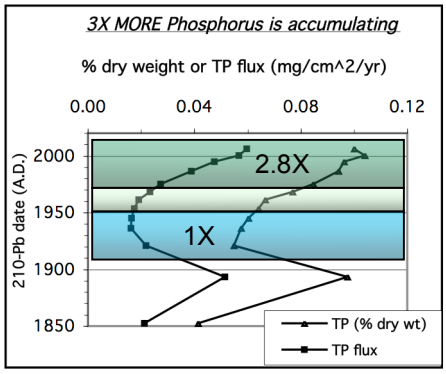
- ✓ Core dating shows that sediments that are deeper than 50 cm in the east basin were deposited before Euroamerican settlement. Approximely 50 cm of sediment have accumulated in the last 125 years.

...that Portage Lake has changed

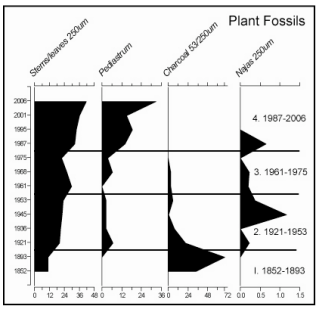
Sedimentation in Portage Lake

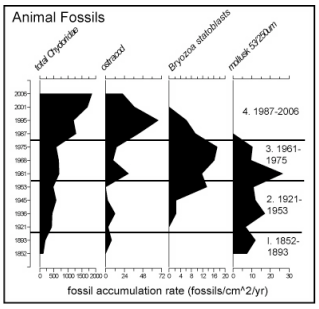


Phosphorus in Portage Lake



Fossils in Portage Lake





- ✓ Sedimentation rates (how fast sediment is accumulating) have changed in Portage Lake. The accumulation of sediments decreased with damming but increased after 1960. The decline in sedimentation rates after damming likely reflects an enlargement of the area where sediments accumulate.
- ✓ Sediments in Portage Lake are dominated by carbonates and organic fractions. Carbonates decreased in abundance and accumulation after damming, but have increased in accumulation since 1960. Organics have increased in accumulation since damming.
- ✓ Total phosphorus in the core was variable before damming but increased in concentration and accumulation after damming. This is a typical response to increased nutrient loading which has resulted in greater lake productivity. Current rates of P accumulation (1987-2006) in Portage Lake are 2.8X higher than the rate of accumulation from 1921 to 1953 and 2.2X higher than rates from 1961 to 1975.
- ✓ Macrofossils of plant, algae, and animal remains were abundant in the Portage Lake core and provide clues to the ecology of the lake.
- ✓ Four historical periods or zones (Zone 1 1852-1893; Zone 2 1921-1953; Zone 3 1961-1975; Zone 4 1987-2006) were identified from the macrofossils in the core. The major changes between zones in the core were based on abundance and accumulation of charcoal, the green alga *Pediastrum*, testate amoeba, bryozoans, and chydorid and bosminid zooplankton.
- ✓ The most recent sediments, Zone 4 (1987-2006), are surprisingly the most different from the other stratigraphic zones. Plant macrofossils are abundant in Zone 4 and there is higher abundance of the green alga *Pediastrum* (possibly in response to increased nutient loading) and loss of seeds from the macrophyte *Najas*. Animal communities also show changes, especially loss of several historically abundant groups (mollusks and bryozoans). Testate amoeba, ostracodes, and total bosminids and chydorids have peaks in abundance. The shifts in these animal groups indicate significant ecological changes in Portage Lake that are likely a result of changes in water clarity, loss of well-structured macrophyte beds, and/or shifts in food web structure potentially related to changes in fish communities.
- ✓ A resounding body of evidence in the sediments indicates that Portage Lake has changed. From our perspective, these changes likely reflect the interactive effects of nutrient loading and food web shifts.

How can we use this information?

- ✓ Excess nutrients, especially phosphorus and nitrogen, cause unsightly algae blooms, nuisance plant growth, and deplete oxygen levels. It's unsightly and creates poor conditions for swimming, fishing, and boating.
- ✓ Most of the changes recorded in the Portage Lake sediment core are indicative of increased nutrient availability and increased lake productivity, although fisheries manipulations may have also affected the food web. Addressing these problems in shallow lakes such as Portage is a challenge due to internal nutrient loading and introduction of exotic species (curly leaf pondweed), which impact nutrient availability.
- ✓ The greatest changes in Portage Lake appear to be since the mid-1980s and suggest that efforts to develop a full nutrient budget for the lake (including both external and internal sources), continued control of exotics, and careful consideration of further fisheries and food web manipulations would provide additional information and measures to improve the lake's water quality.

Funding Partners
Portage Lake Association
Minnesota Pollution Control Agency

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