LAKE EUTROPHICATION AND THE INFLUENCE OF ROAD SALT

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A Presentation to the Two Rivers Coalition
December 8, 2010

What is Eutrophication?

- A natural process: over 1000's of years lakes become nutrient rich, fill in with sediments and become marshes and dry land
- "Cultural"or "anthropogenic" eutrophication: same process but speeded enormously due to input of nutrients - typically phosphorous (P), sometimes nitrogen (N)
- Can influence lakes, rivers, streams, estuaries – especially problematic in poorly mixed, slow moving water

Causes

- Addition of "limiting" nutrient (P, N) stimulates organic matter productivity (photosynthesis)
- Thick algal blooms develop, decreasing sunlight penetration
- Lack of sunlight kills submerged aquatic vegetation (less oxygen input at depth, less fish/shellfish habitat)

Eutrophication

Photo from: Rutgers New Jersey Agricultural Experimental Station
Cooperative Extension of Salem County

Consequences

- Increased organic matter production decreases dissolved oxygen (DO) concentrations

$$CH_2O + O_2 = CO_2 + H_2O$$

- Drawdown of oxygen can lead to hypoxic (<2 mg/L or ppm DO) or anoxic (<0.2 mg/L or ppm DO) water

- Hypoxia or anoxia kills fish ("healthy" water has ~8 mg/L DO; fish begin to die at ~2 mg/L DO)

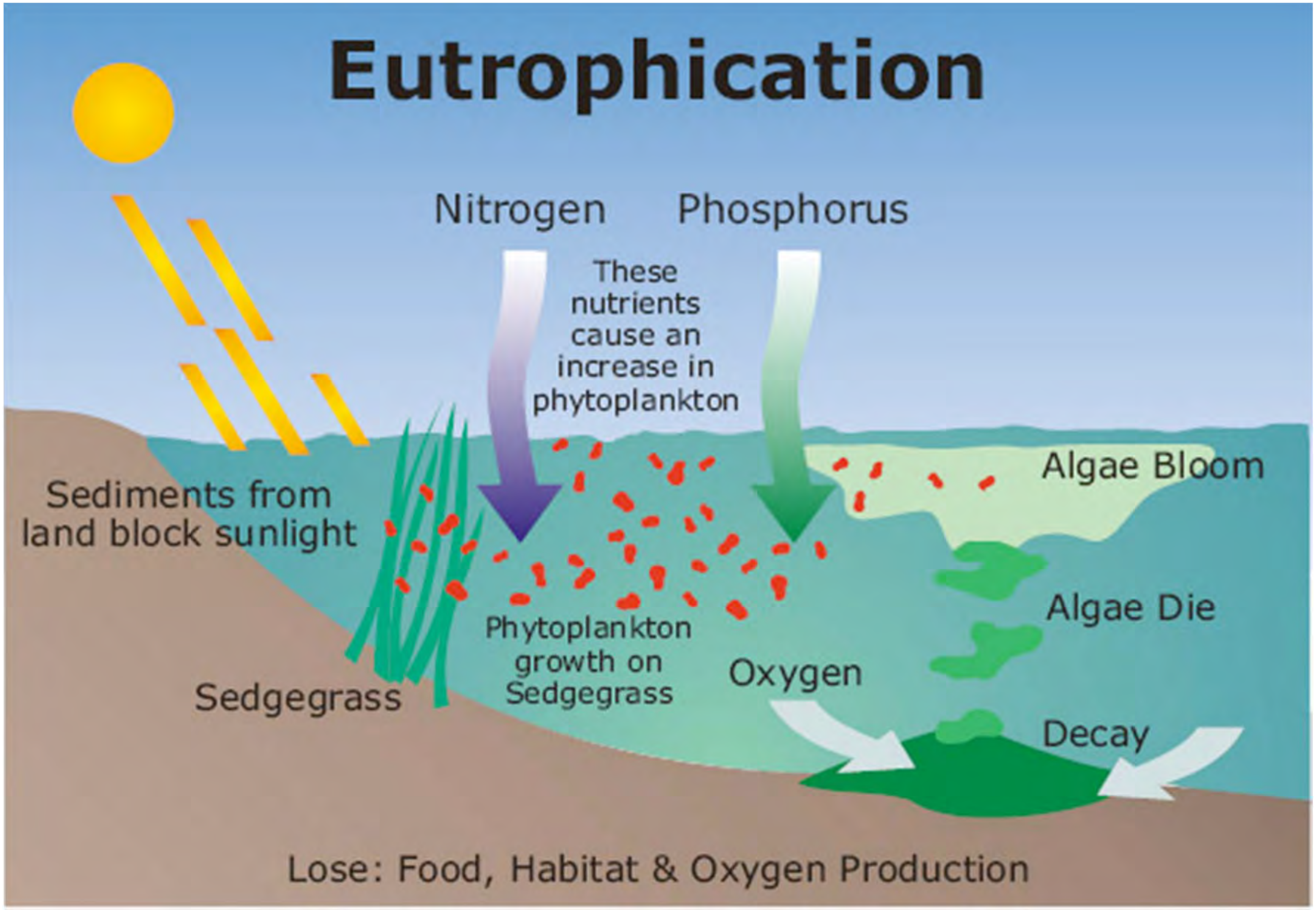
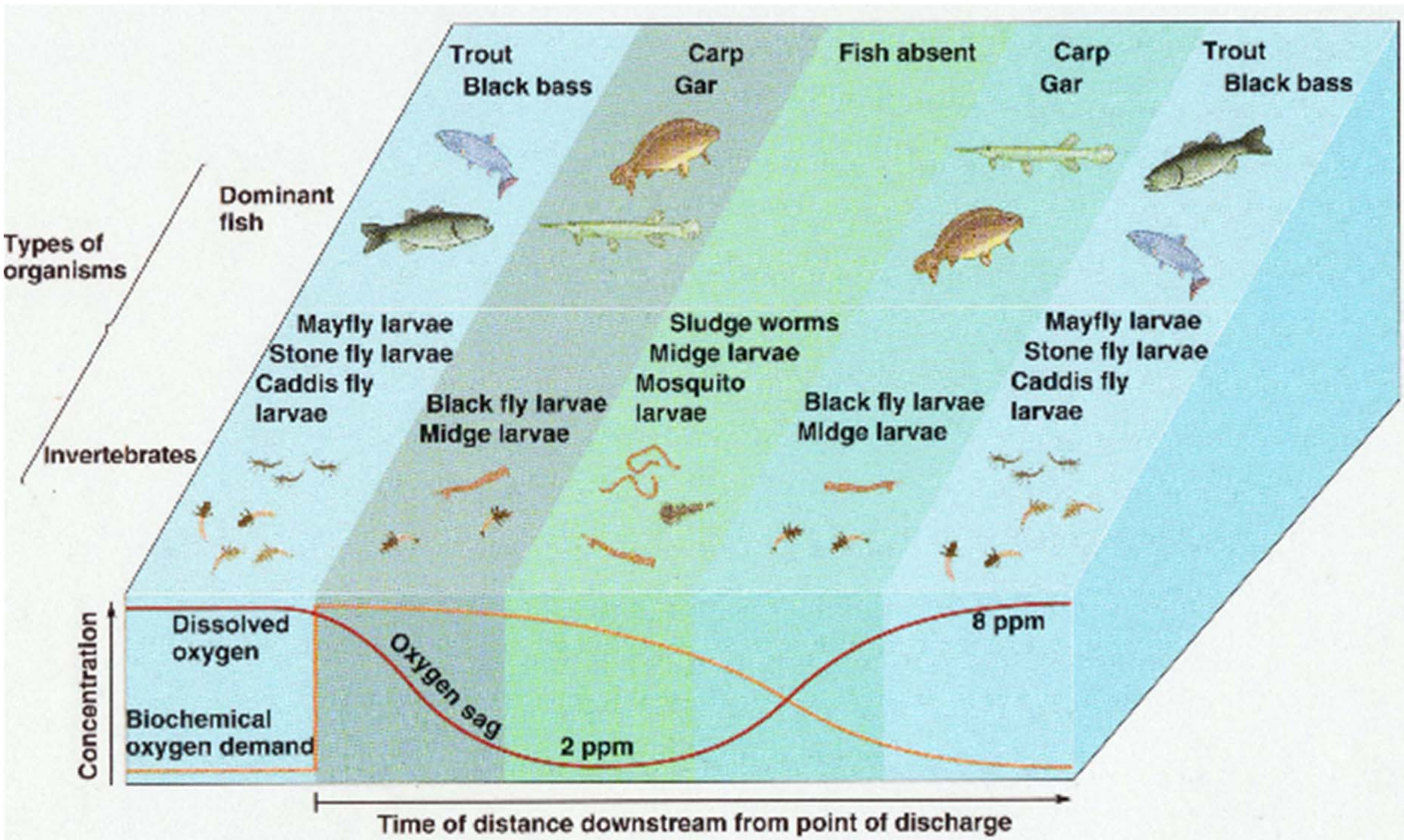


Diagram from: Lincoln.ne.gov

Oxygen "Sag" Curve in a River

BOD = biological oxygen demand; a good measure of quantity & quality of organic matter production



From: Chiras

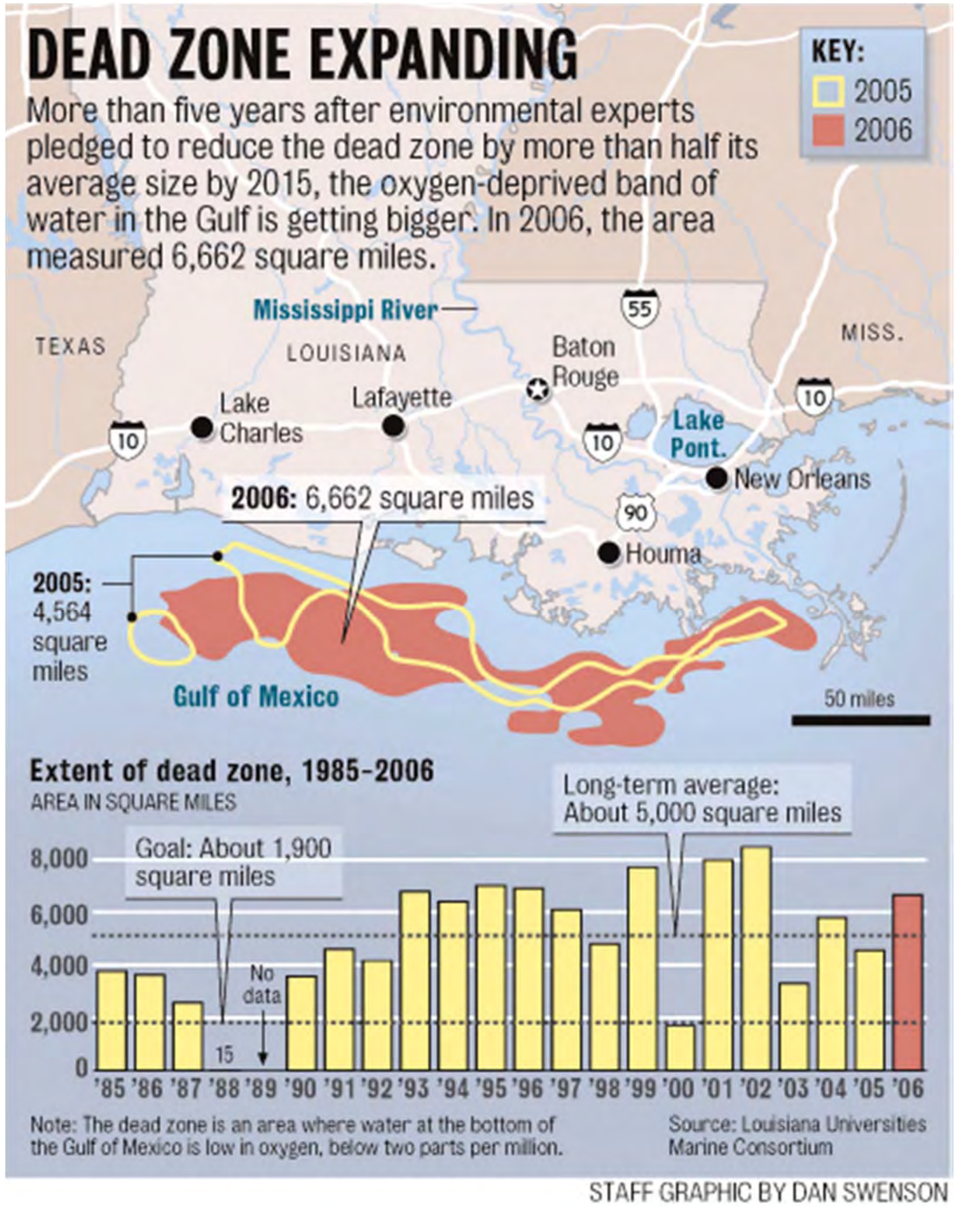
Hypoxia in Kalamazoo River

Photo taken in the 1950's showing a massive fish kill in the Kalamazoo River

http://www.wmich.edu/geology/gem/dataclearing/photos.html

Gulf of Mexico Hypoxia & Dead Zone

- **Causes**
  - Physical Environment (quiescent waters; low winds, little water mixing)
  - Nutrient Enrichment: organic matter, nitrogen, phosphorous from agricultural runoff into Mississippi & Atchafalaya Rivers
- **Consequences**
  - Largest hypoxic zone in the U.S.
  - 16,000-20,000 km^2 since 1993 (up to size of New Jersey; largest in summer)



Graphic from article by Bruce Eggler, New Orleans Times – Picayune June 9, 2007

Lake Erie

- Mostly "dead" in 1960's, $8 billion spent to reduce point source sewage input (mostly removing P) as part of the 1972 Great Lakes Water Quality Agreement

- Lake has been recovering (no algal blooms in 1980's) – but slowly due to persistent cycling of P, even after P loading is greatly reduced

- Recently (1990's), increases in P loading and large algal blooms are occurring again, possibly also linked to zebra/quagga mussels

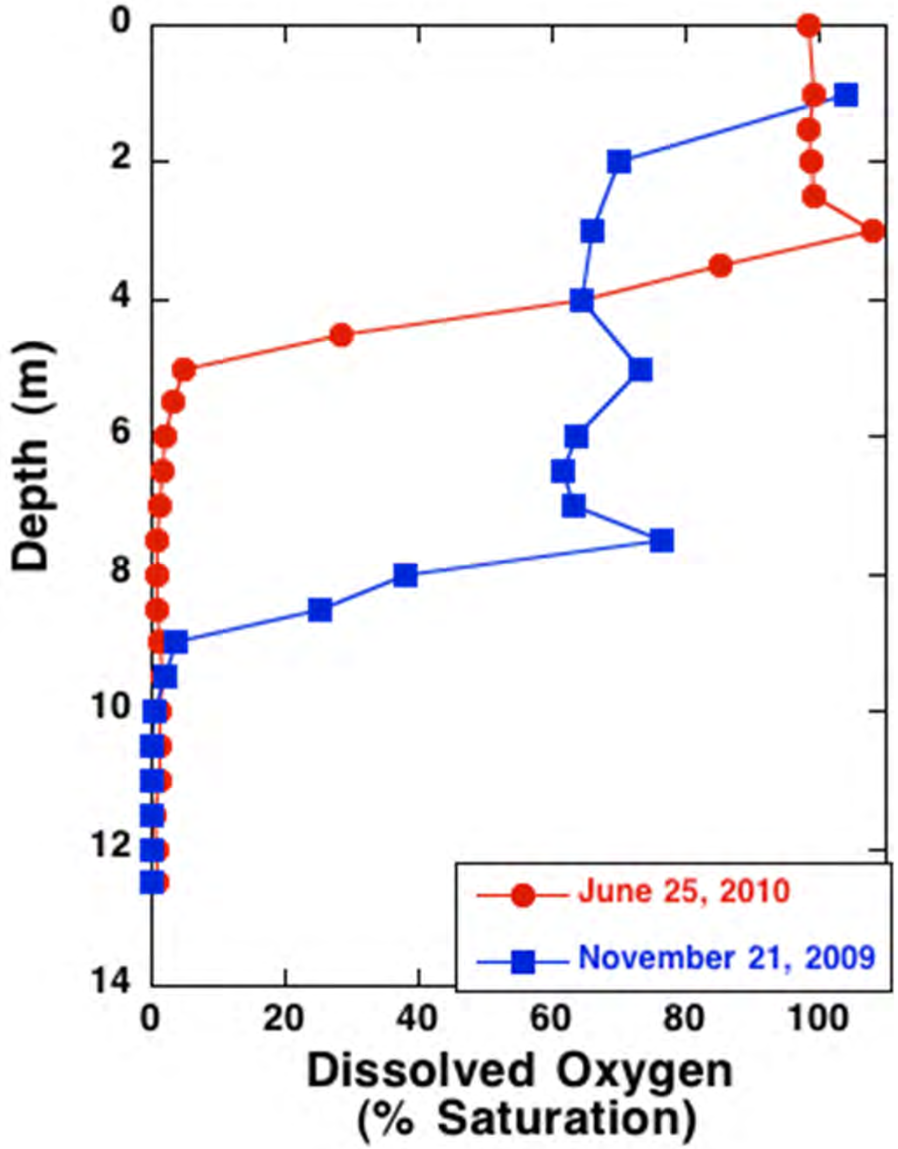
Lake Erie

Image Credit: Courtesy of MODIS Land Rapid Response Team, NASA/GSFC

Map courtesy of Ryan Sibert

Photo courtesy Lynne Heasley

Woods Lake (Kalamazoo, MI)



Major Sources of P

- Detergents
- Fertilizers
- Sewage (leaky septic tanks, treatment facilities)
- Residential runoff (lawn/leaf debris)
- Agricultural runoff
- Industrial processes

Prevention

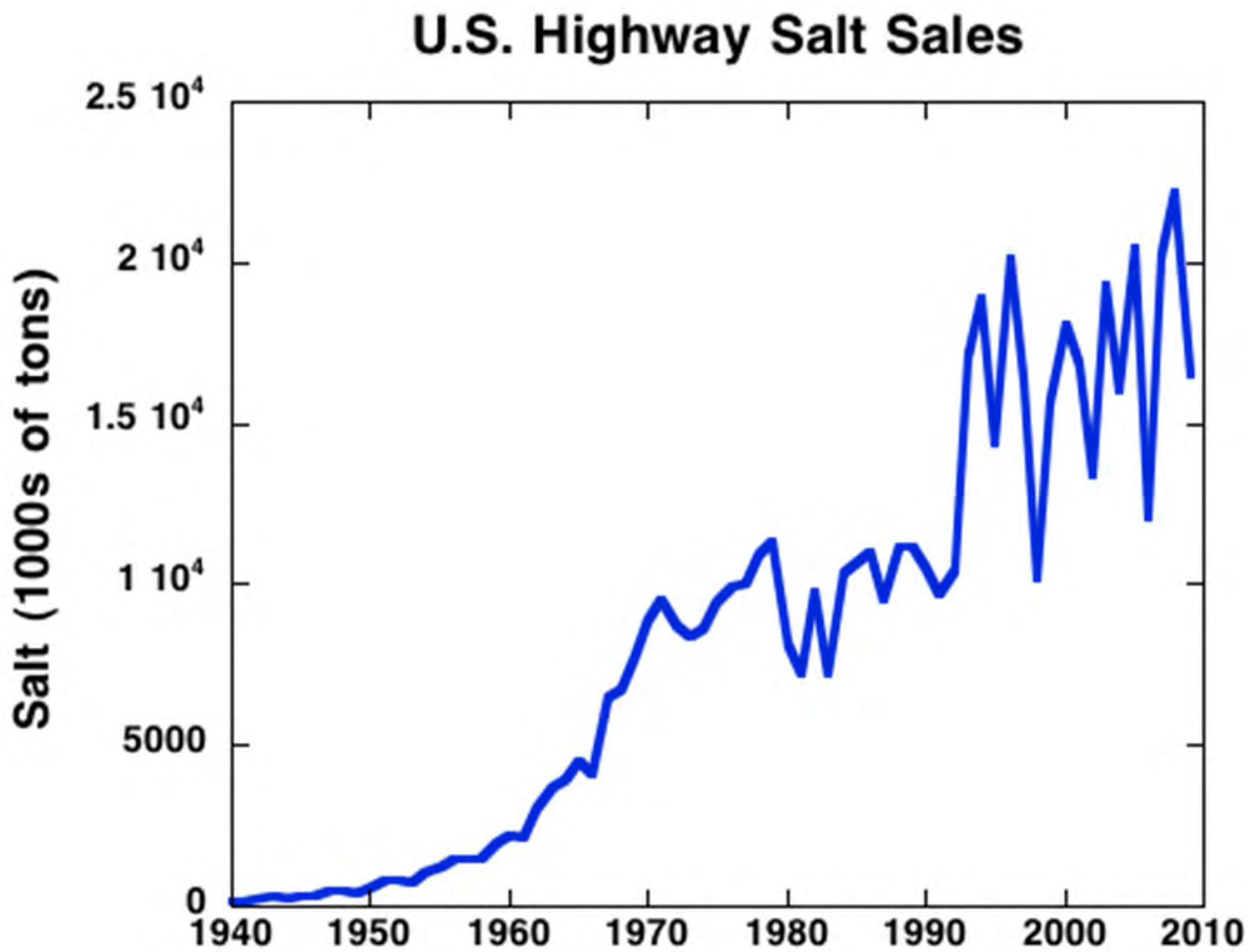
- Reduce phosphorous in sewage effluent (point source treatment)
- Reduce use of phosphorous in fertilizers, detergents
- Control residential runoff (leaf, lawn waste)
- Control agricultural runoff (no till, contour tillage, terracing, buffer strips)

Remediation Strategies

- Aeration systems
- Mechanical mixing
- Alum treatments
- Dredging
- Algicides
- Biomanipulation

Road Salt

- Sodium chloride (NaCl) used as a highway deicer since early 1940's
- Other deicers: calcium chloride, magnesium chloride, potassium acetate, calcium magnesium acetate
- Annual production of salt in U.S. : ~50 million tons
- 66% of salt use in the U.S. is for road deicing



Data from Salt Institute

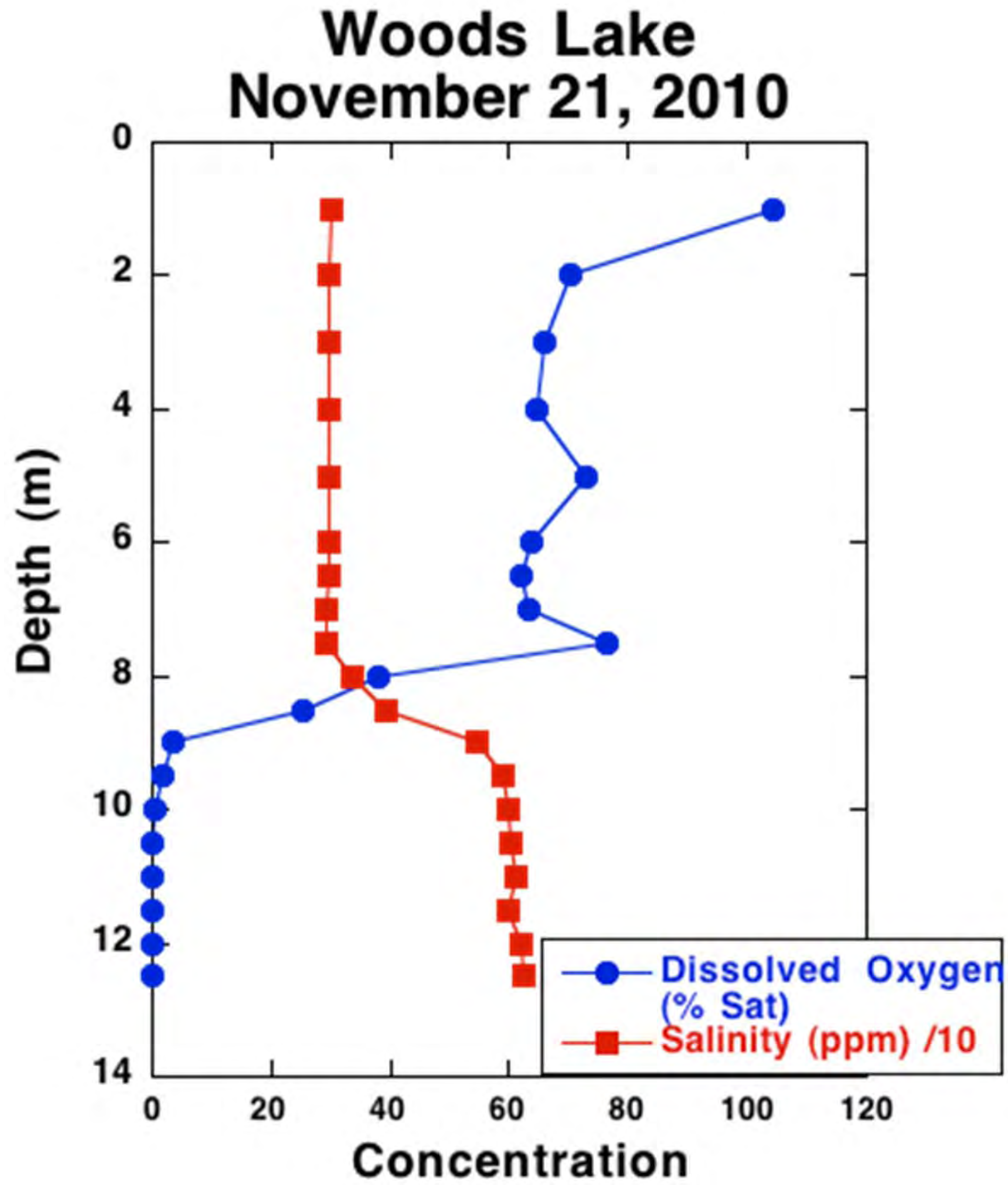
Paul Sancya / The Associated Press, 2008
Road salt is loaded at a Wayne County facility in Wayne, Mich.

Potential Consequences

- Loss of potable freshwater supplies (salinization of groundwater, surface water)
- Chronic or acute toxicity to freshwater biota
- Decreases in biodiversity
- Increases in invasive species
- Increased metal toxicity
- Changes in lake stratification

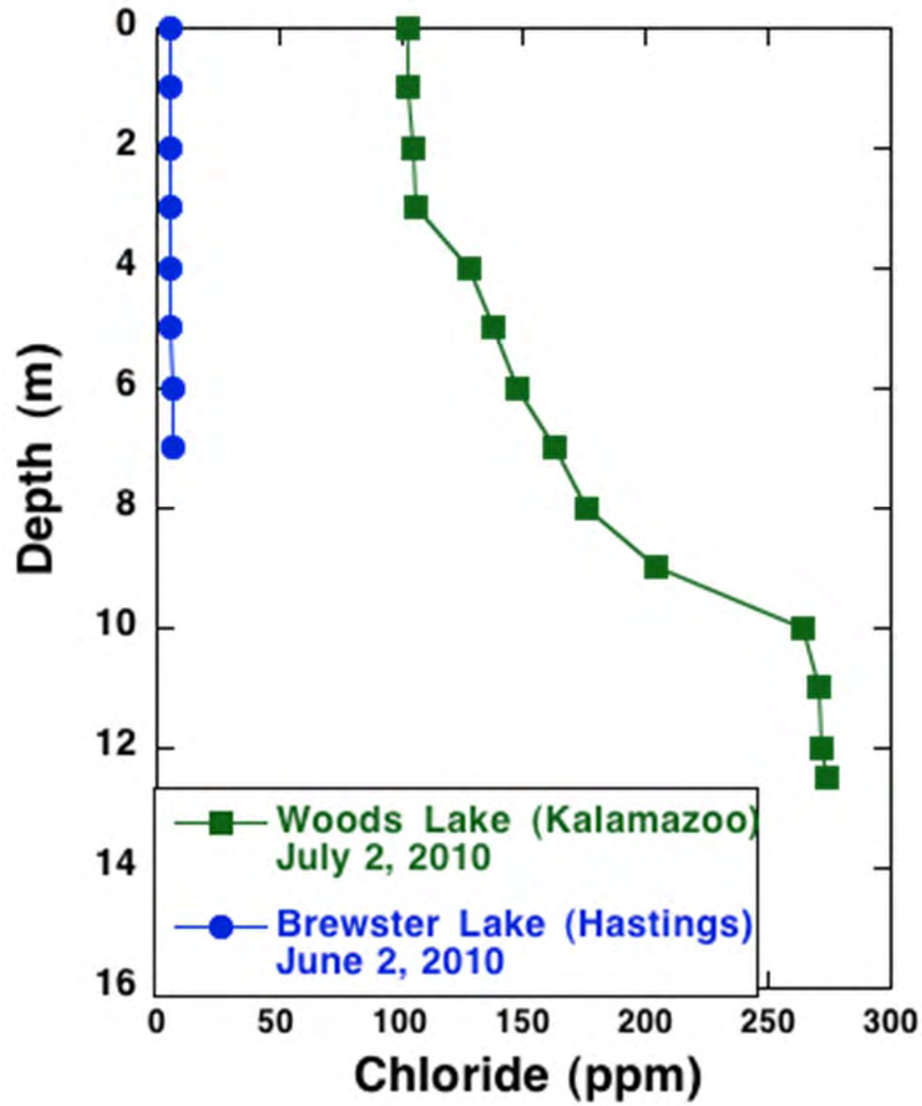
Lake Mixing

- Midwestern lakes are typically "dimictic": mix from top to bottom in the fall and spring
- Mixing occurs because of changes in temperature, density of waters
- In eutrophic lakes, mixing delivers oxygenated water to the lake bottom waters twice per year
- Mixing removes ammonia, sulfide, other potentially toxic constituents of anoxic bottom water
- Addition of road salt could theoretically slow or halt seasonal mixing



Woods Lake
November 21, 2010
Depth (m)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
Concentration
Dissolved Oxygen (% Sat)
Salinity (ppm) /10

Urban vs. Rural Lakes



Strategies

- Prevention:
  - Less use of sodium chloride salt
  - Mixing with sand
  - Use of other deicers (CMA)
- Remediation:
  - Few options, eventually mixes, dilutes

Acknowledgements

- Ryan Sibert, Christine Snyder, Andrew MacLeod, Thomas Reich, Michelle Barger, Sara Snyder, Greg Sawatzki, ENVS 4500/GEOS 5020 students
- National Science Foundation CAREER program
- National Science Foundation Geosciences Education Program
- Pierce Cedar Creek URGE program (Matt Dykstra)