Carbon Cycling in the Watershed and Lakes

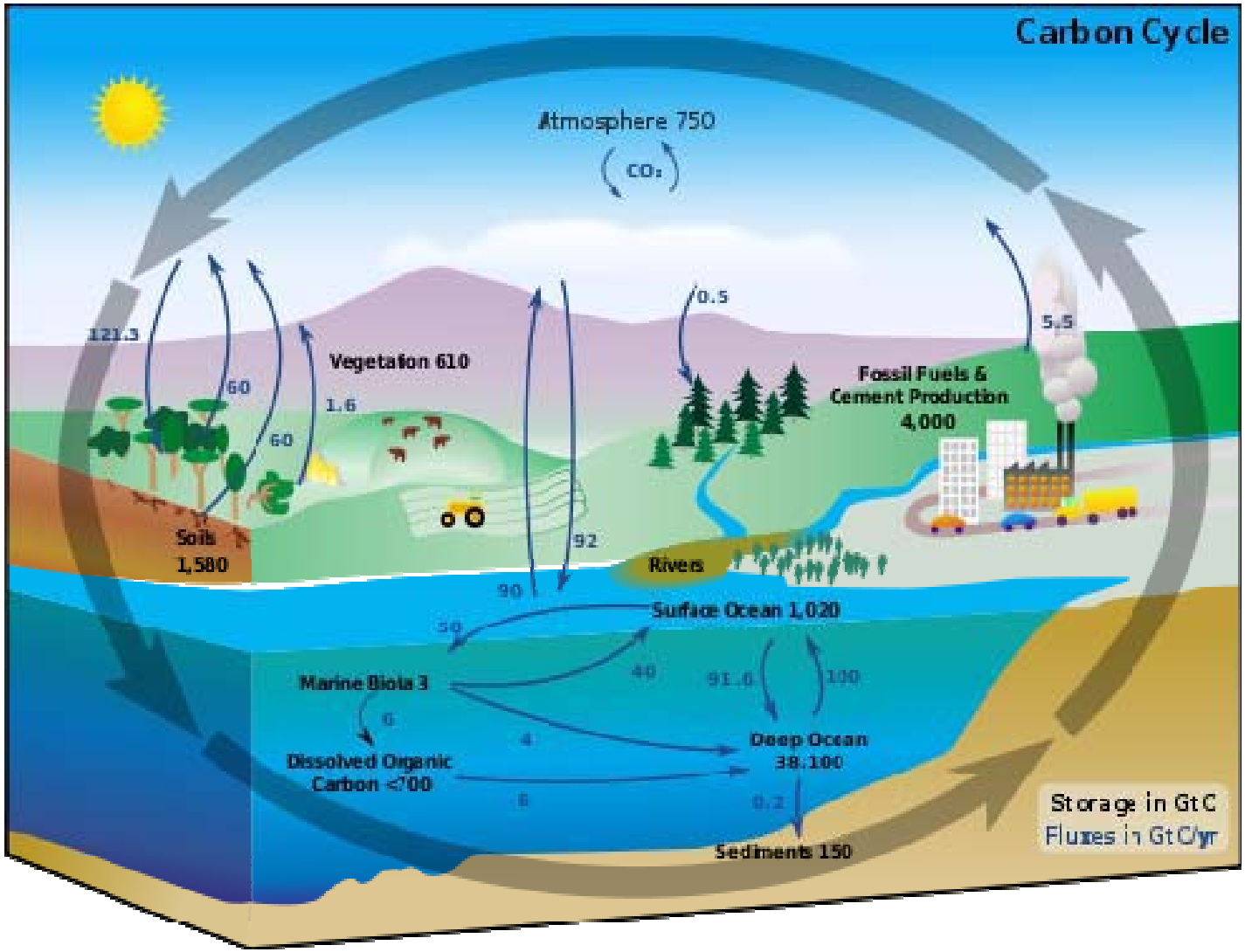
Bopi Biddanda,

Scott Kendall, Eric Strickler, Angie Defore, Maggie Weinert,
Deb Dila, Kaitlyn Driza and Kate Coveney

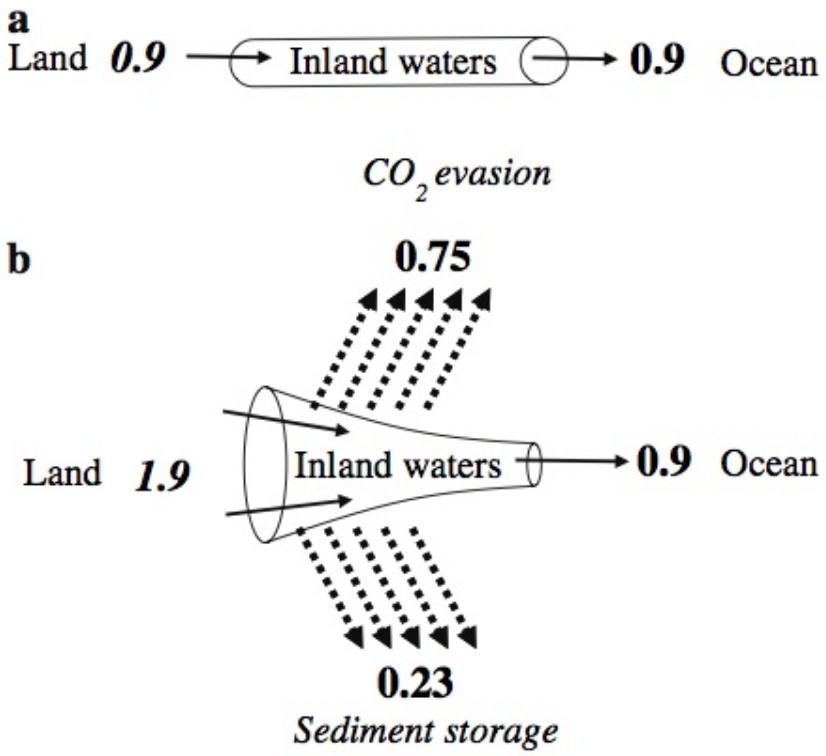
Annis Water Resources Institute and Lake Michigan Center

Grand Valley State University, MI

Carbon Cycle



Reevaluation of the Role of Inland Waters



a) Traditional view of carbon transport from terrestrial environment to oceans, b) Modern view of carbon transport showing inland waters as reactive sites of carbon metabolism (Cole et al. 2007).

Muskegon Lake - fed by Muskegon River (background) flowing into Lake Michigan (foreground). www.co.muskegon.mi.us

Freshwater ecosystems are major sites of C processing!

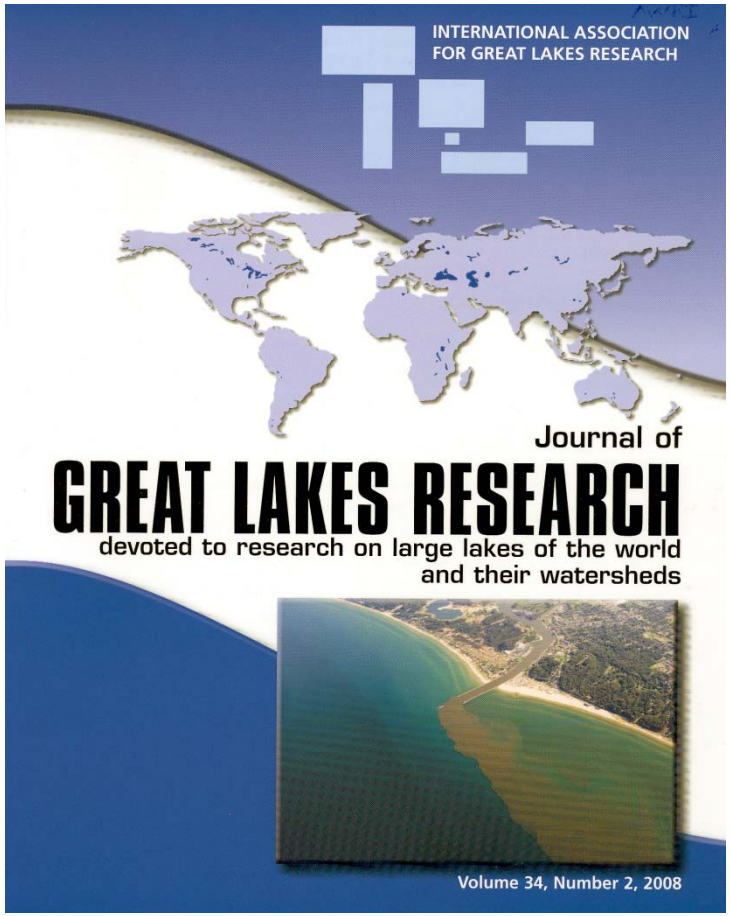
River to lake gradient

Visible trophic level changes occur along the Land to Lake gradient!

Visible Mesoscale River Runoff into Lake Michigan

Grand River

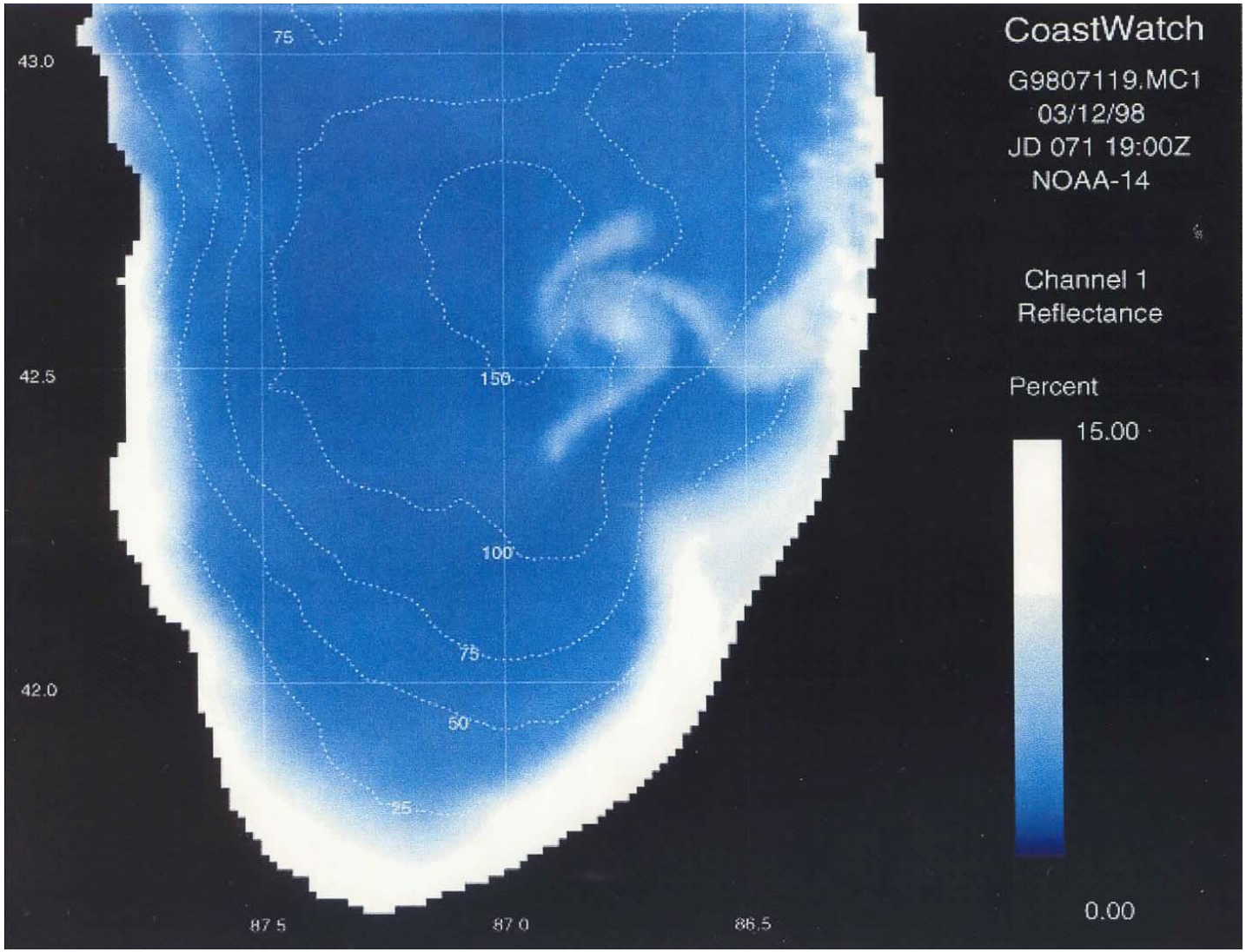
Photo credit: Marge Beaver, Muskegon



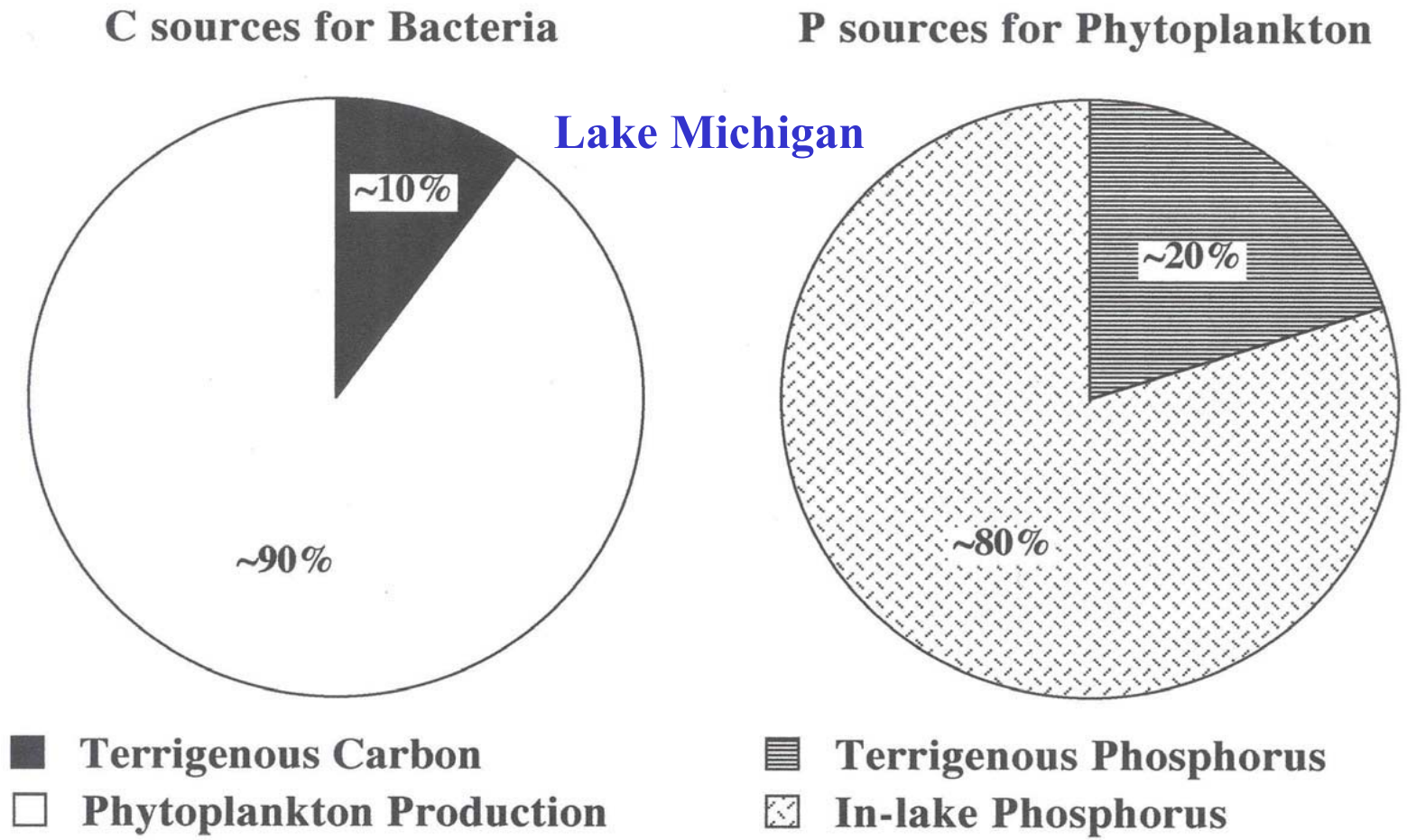
Johengen et al. JGLR, 2008

Rivers link Land-derived C & Nutrients to the Lake via Aquatic Microbes!

Massive Sediment Resuspension event 3/98
Total Suspended Matter (surface reflectence) in Surface Waters

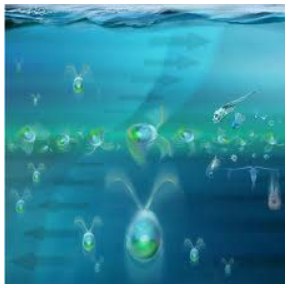


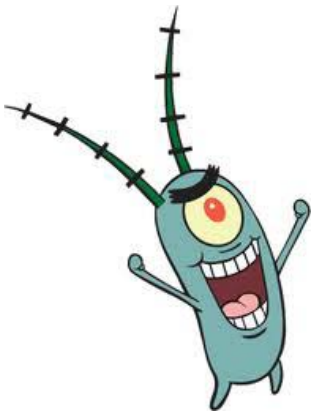
Aquatic microorganisms link terrestrial organic matter and nutrients to aquatic productivity (Biddanda and Cotner, 2002).



Toast to a Lake Brew

When rain runs down-river to the lake
Where wicked winds stir the lot
You know the brew is in the coastal pot!





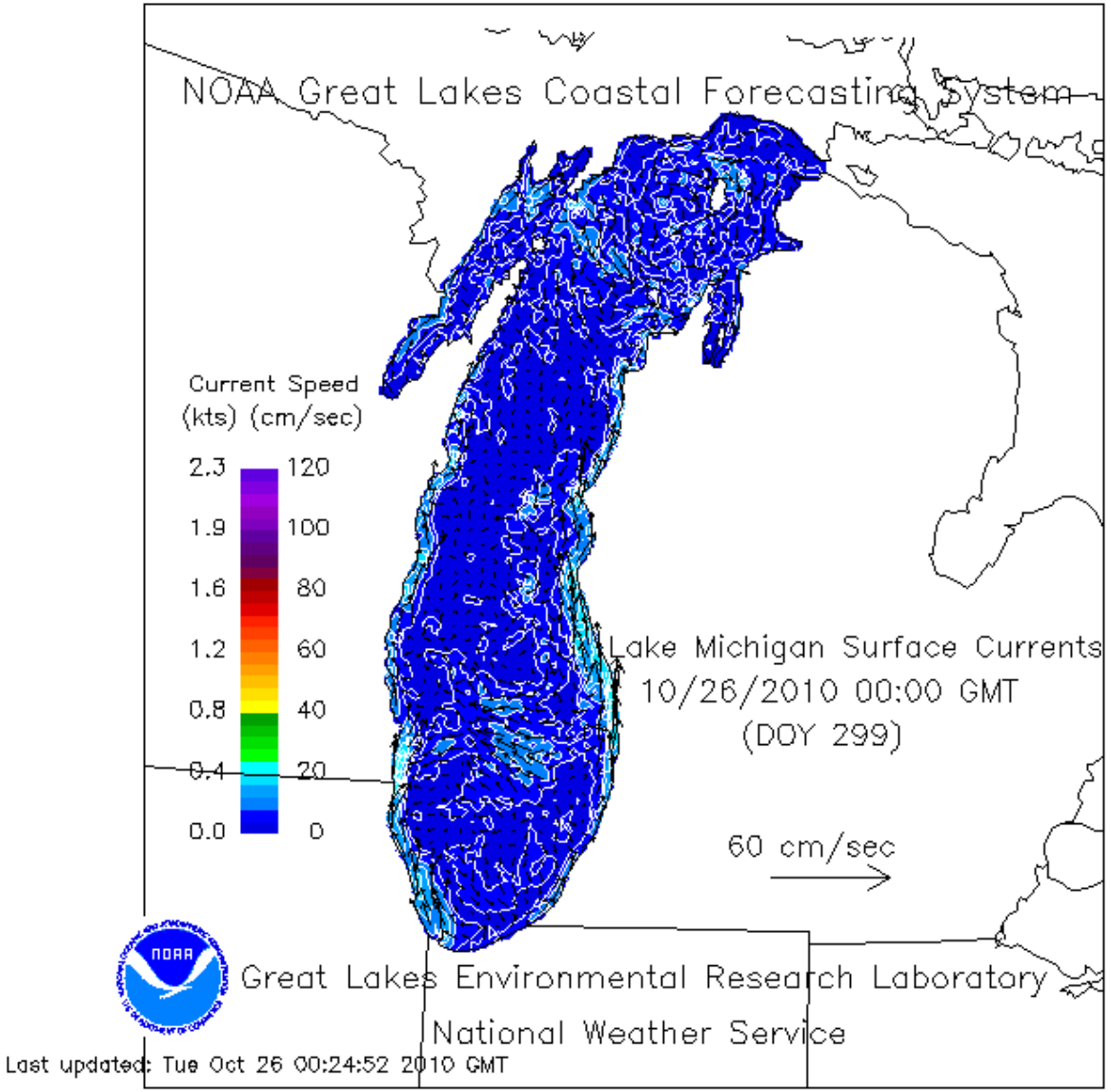
As plankton go nuts over N and P
With little light in which to see
Animals dine on resuspended waste
Production and respiration peak in haste!

Then as rivers slow and winds subside
The placid lake takes it in stride
Returns to its native serene state of blue
And is ready for another dose of home-brew!

–Bopi Biddanda

IAGLR, May 2009; ASLO Bulletin 2009.

Storm of October 2010

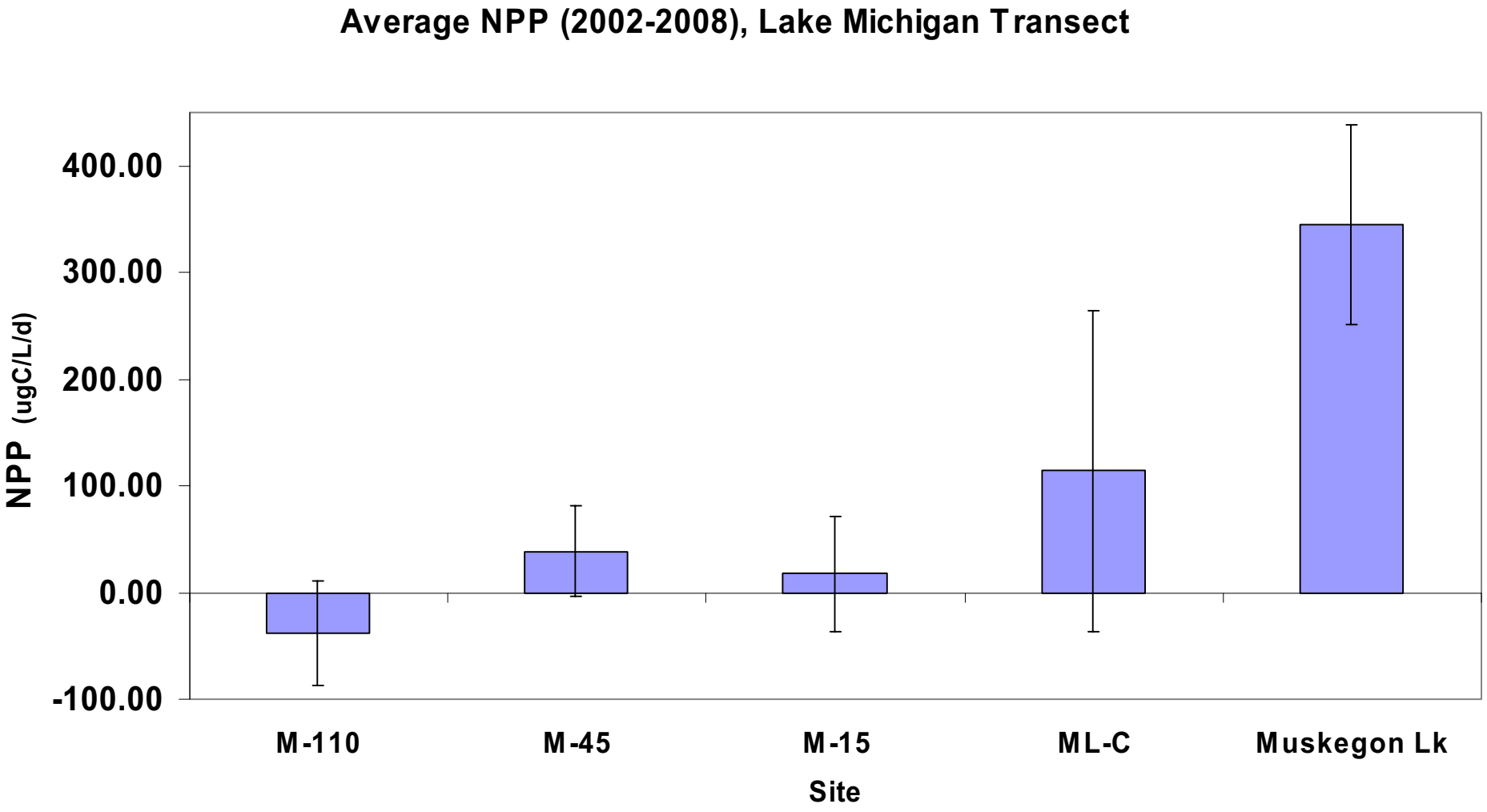


Methods

- Respiration (R) and Production (P) were measured by tracking changes in dissolved oxygen concentrations in BOD bottle incubations under *in situ* conditions over a daily cycle.
- R = Dark bottles
- NPP = Light Bottles
- GPP = R + NPP

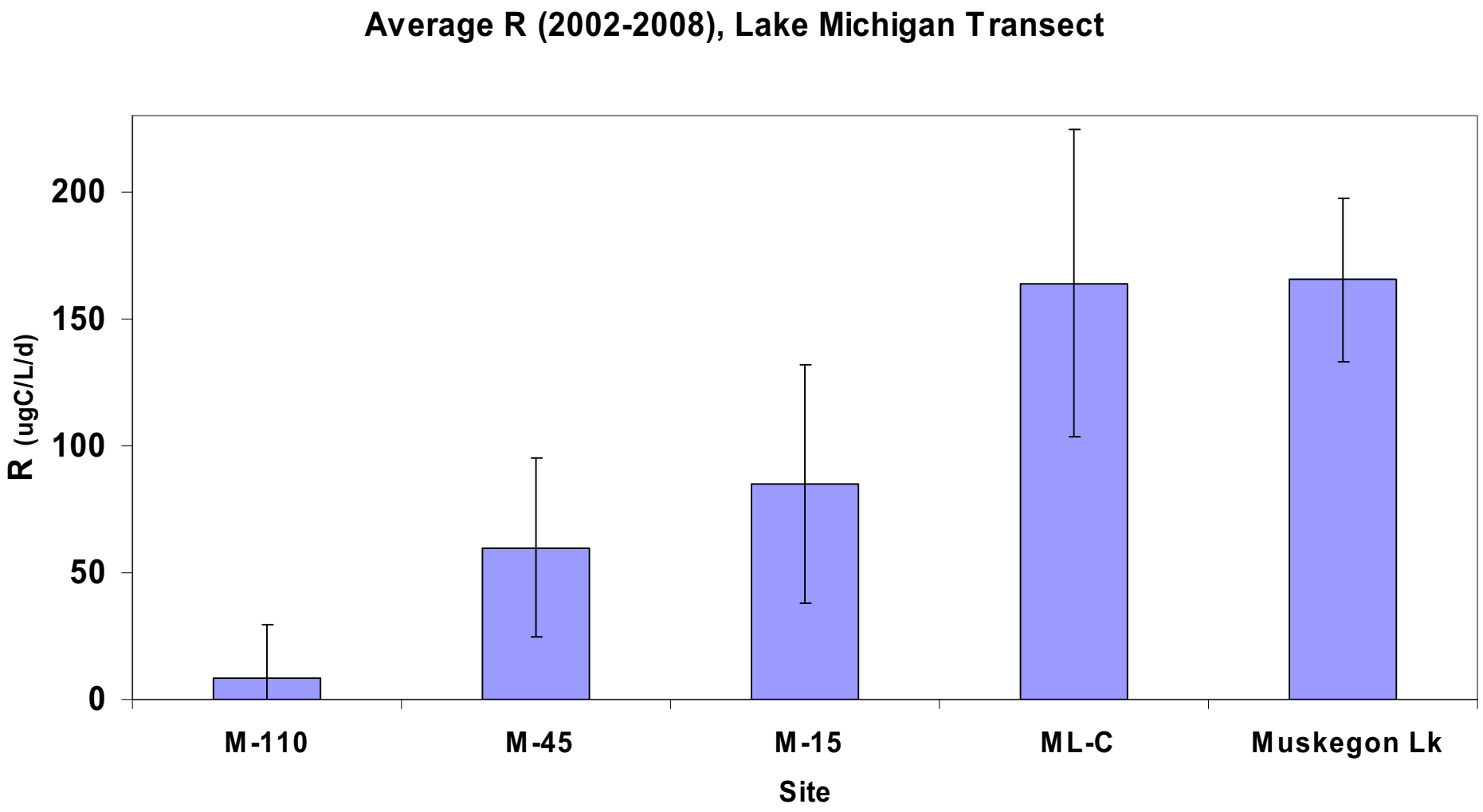
Controls, Light and Dark Bottles

Plankton Metabolism: Land to Lake Gradient in Lake Michigan



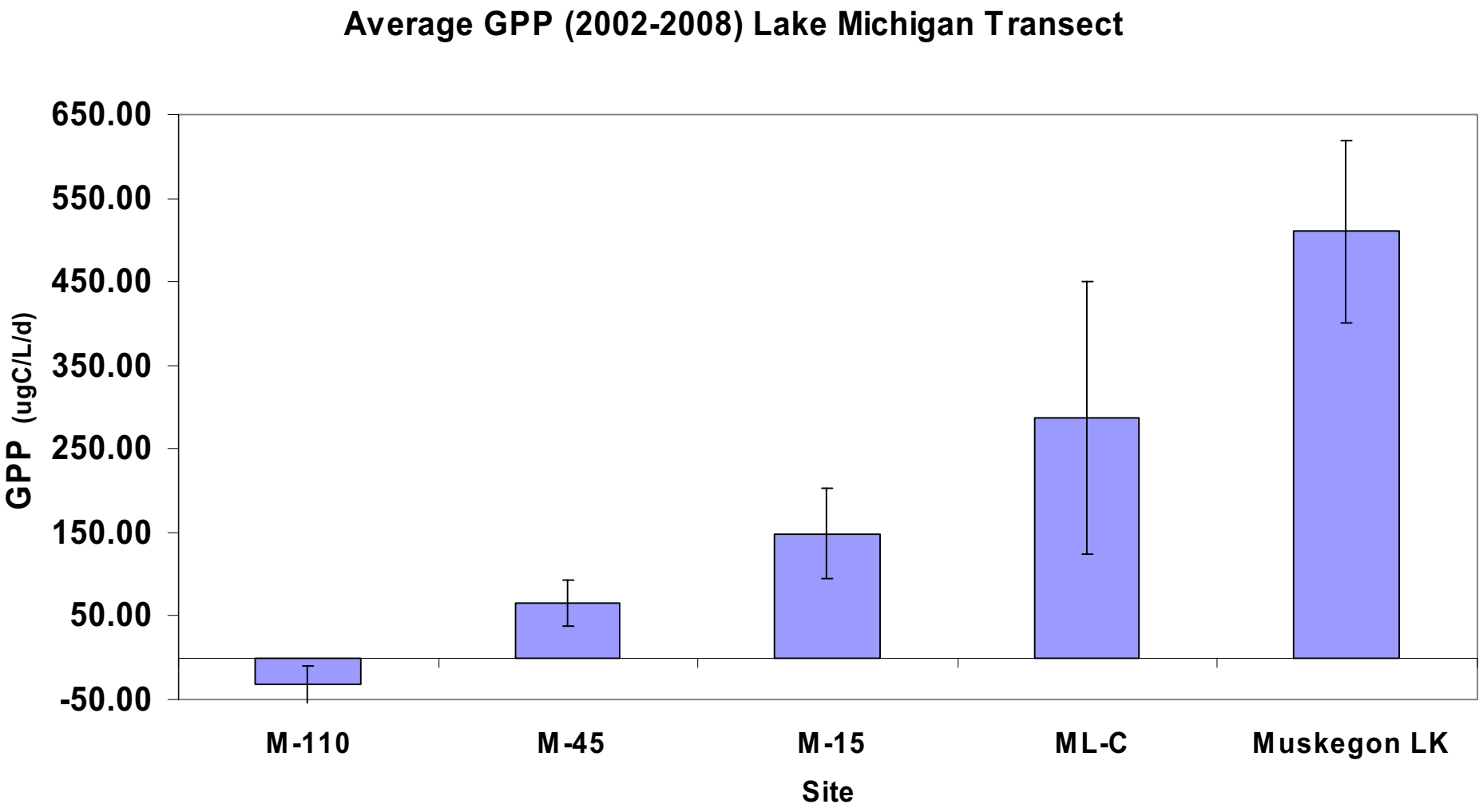
Decreasing Net Primary Production Along the Land to Lake Gradient

Plankton Metabolism: Land to Lake Gradient in Lake Michigan



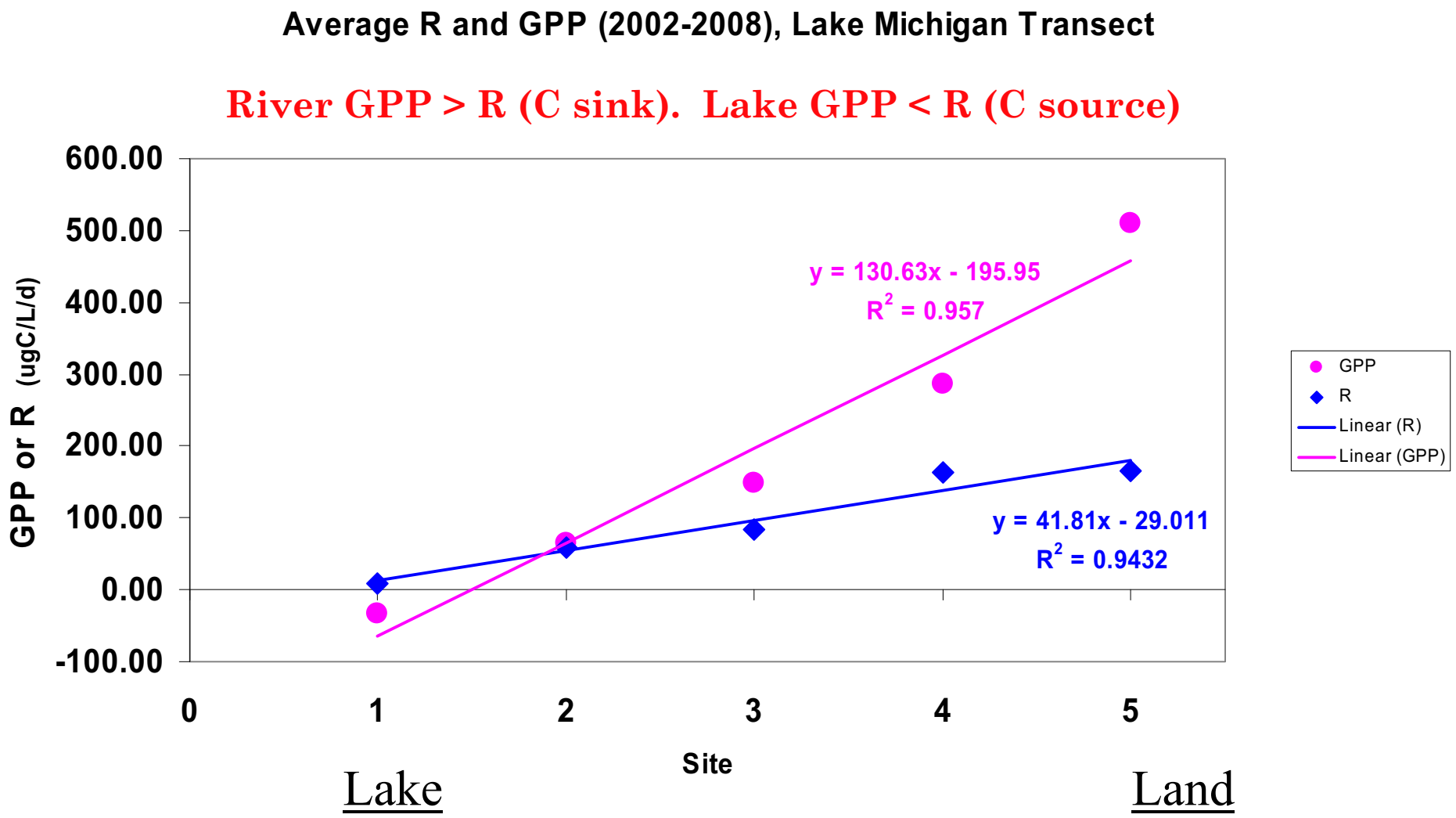
Decreasing Plankton Respiration Along the Land to Lake Gradient

Plankton Metabolism: Land to Lake Gradient in Lake Michigan



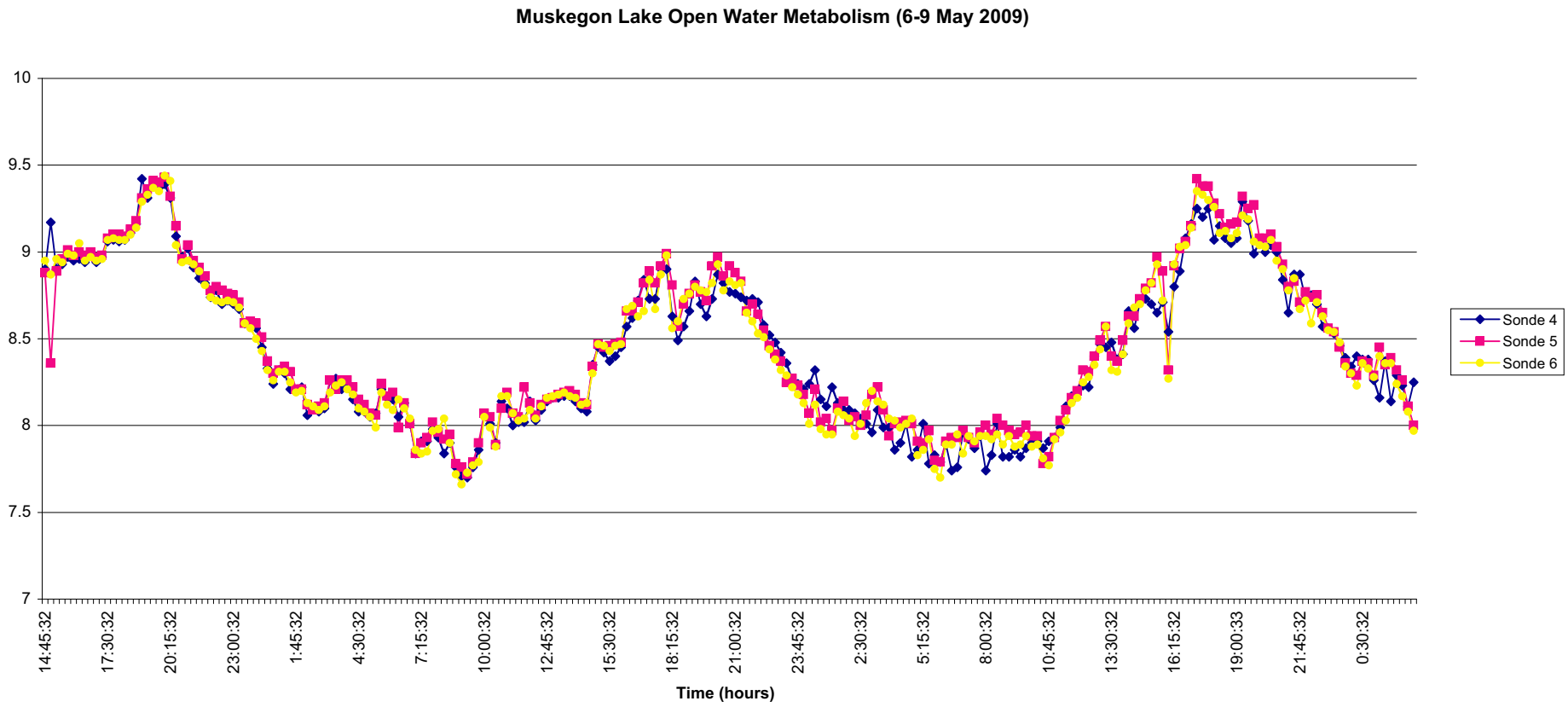
Decreasing Gross Primary Production Along the Land to Lake Gradient

Plankton Metabolism: Land to Lake Gradient in Lake Michigan



Production drops much faster than R along the Land to Lake Gradient!

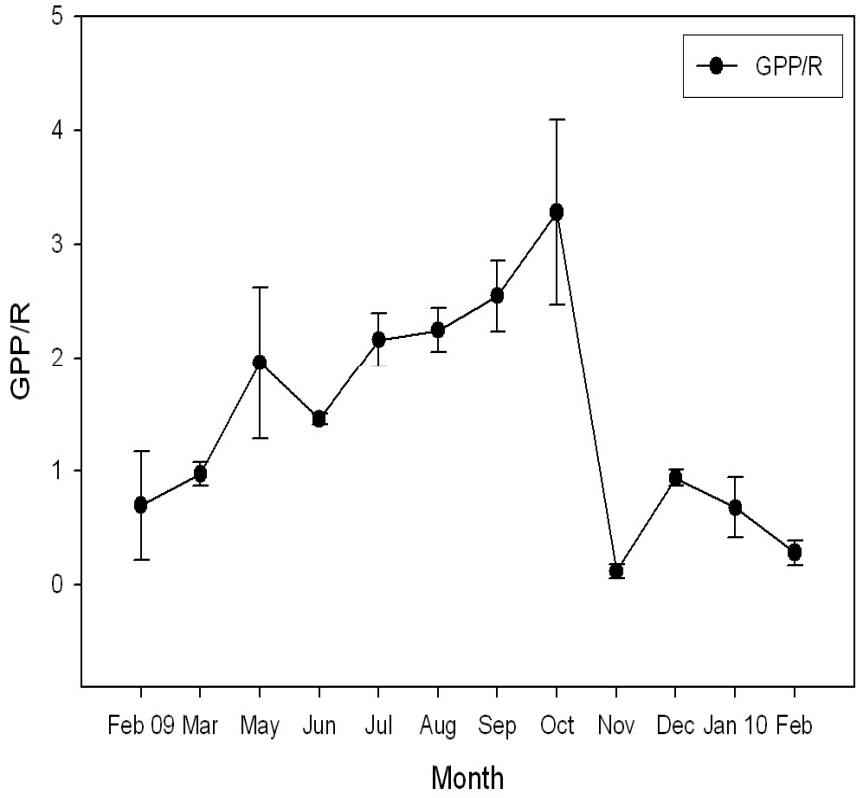
Day-Night Oxygen Cycle in Muskegon Lake May 2009

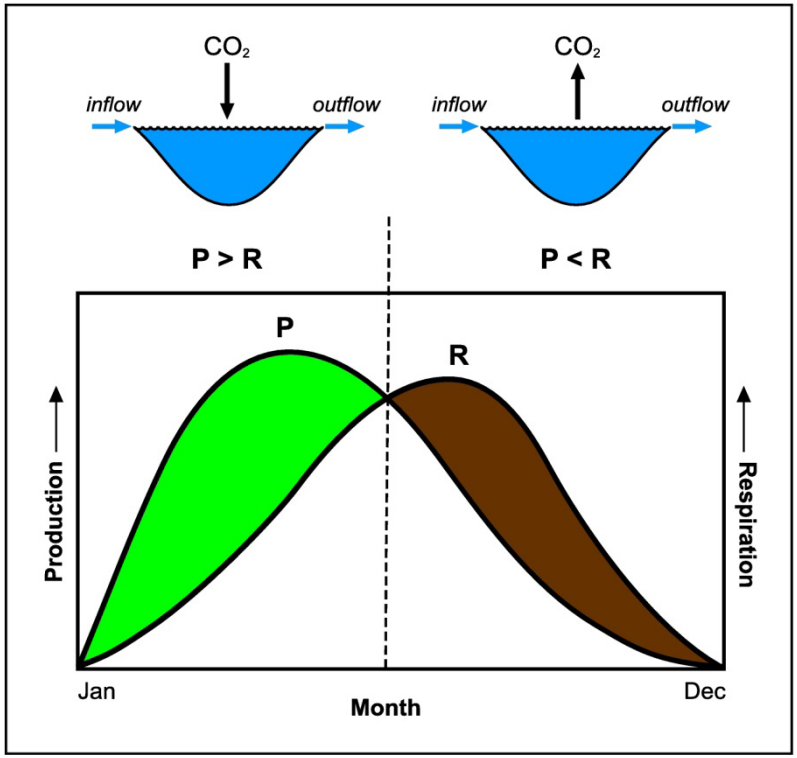


"Production and respiration are two sides of the same metabolic coin - the yin an yang of the biosphere"

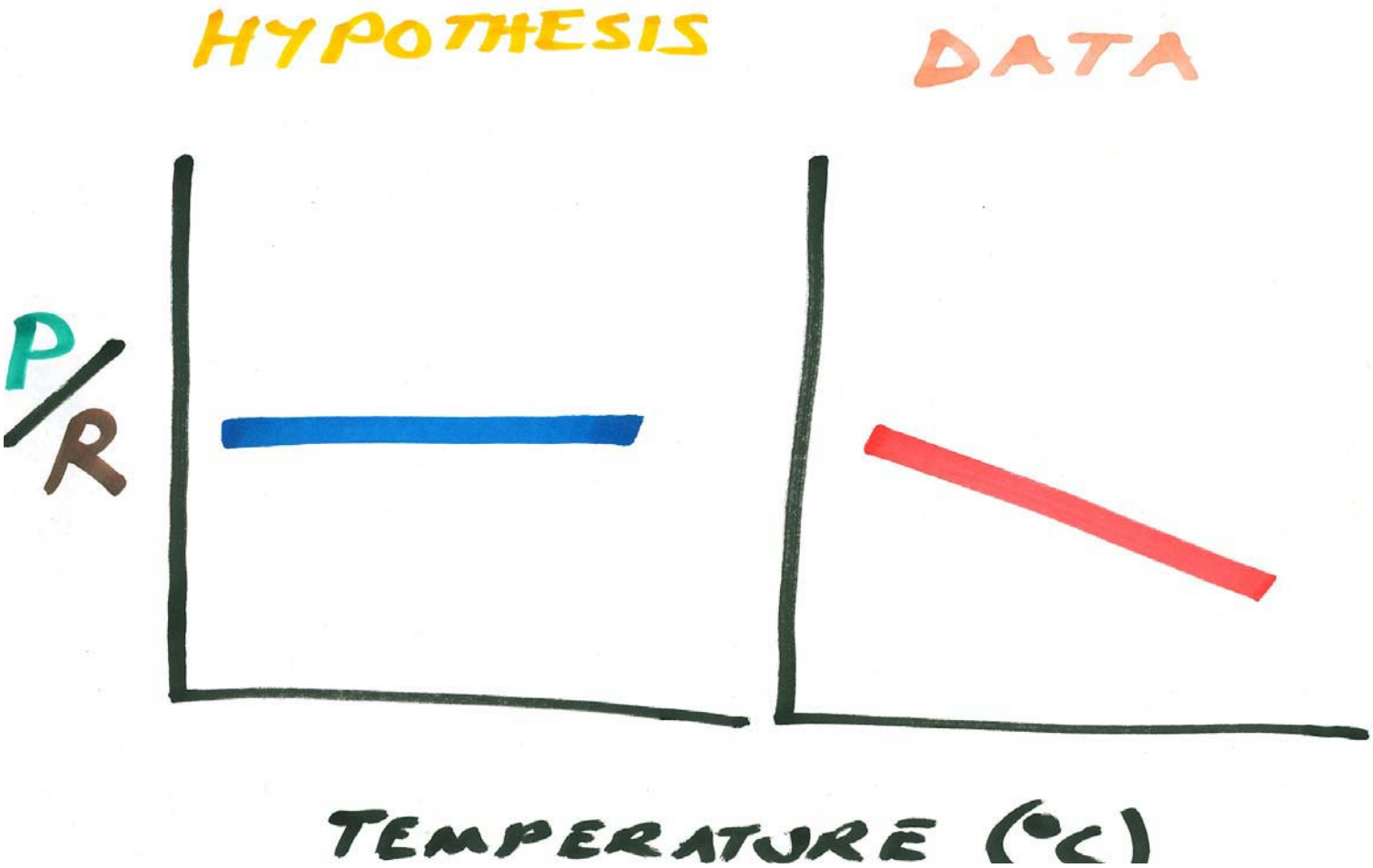
Muskegon Lake Metabolism 2008-09 Seasonal Cycle

- Predictable patterns in GPP:R ratio
  - ⬆ during the spring and summer
  - ⬇ during fall and winter





Sink to Source? Effect of Climate Warming on Plankton Metabolism in Muskegon Lake

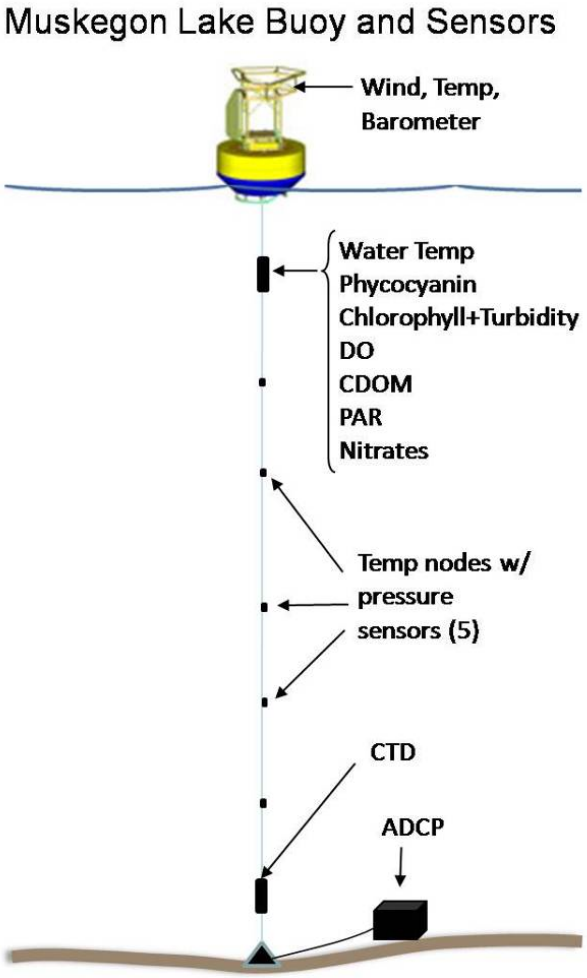


Plankton and Temperature: Schematic diagram of hypothesized results and actual findings. P refers to Gross Primary Production of Plankton and R refers to Plankton Respiration. The horizontal P/R line refers to the 1:1 line where P and R are increasing at the same rate (left). The decreasing P/R line refers to R increasing more than P as waters warm (right).

Observations

- Respiration is a major fate of current as well as past primary production in Lake Michigan.
- **Terrestrial inputs of carbon and nutrients support significant respiration and production in the Lake.**
- ***As production declines more than respiration along the Land to Lake gradient, the relative role of respiration increases - with nearshore net autotrophic systems giving way to net hetrotrophic systems offshore.***
- ***Spring-summer net autotrophy and fall-winter net heterotrophy trends are observed regularly.***
- ***As lakes warm, Respiration may exceed Production shifting lakes from sinks to sources of C***
- ***There is a need for continuous lake observatories.***

Muskegon Lake Observatory for Ecosystem Changes



Real-time Continuous Lake News!

Lake Carbon Cycle

People:

Funding: NSF, NOAA, MSGC