Lake Erie Trophic Status (LETS) Collaborative Study

Ohio Phosphorus Task Force
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LETS
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24 papers in special issue of JGLR

- Introductory Material (1 paper)
  Matisoff and Ciborowski (2006)
- Historical Data Sets (3 papers)
- Primary and Secondary Production and Phosphorus Cycling (10 papers)
- Benthic Processes (5 papers)
- Oxygen (4 papers)
- Management Implications (1 paper)

The Lake Erie Trophic Paradox

Classic Eutrophication Model
Excess Phosphorus —> Excess Algal Growth —> Low Oxygen in Bottom Waters —>
Undesirable consequences

Current Situation
TP Concentrations incr
TP Loadings ~ constant
Phytoplankton (chl-a) decr
HVOD no change

The historical management solution for decreasing phosphorus loadings may not work this time because of the apparent disconnects between TP loadings, phytoplankton biomass, and HVOD.
The Management Solution

Want Bottom Water Oxygen > 4ppm —>
Phosphorus Concentrations < 10 ppb —>

Reduce Phosphorus Loads

10 ppb Central Basin, 15 ppb Western Basin —>
Total Phosphorus Loading = 11,000 mta

Did it Work?

Post-GLWQA
P Loadings

Dolan & McGunagle (2005)
Central Basin Spring TP means

Rockwell et al. 2005

Phytoplankton Biomass – Central Basin

Culver et al. 2005
Central Lake Erie Chlorophyll $a$

Too little? (percid declines)

Central Basin
Hypolimnetic volumetric oxygen depletion rate (HVOD)

Burns et al. (2005)
What's wrong now?
What happened in 1989?

Dreissenid mussels happened in 1989

Recent changes in Lake Erie

Plankton community biomass, structure, dynamics (HABs)
* Microcystis (Western Basin)
* Cladophora

Western Lake Erie
10 days after power failure August 2003

OhioLink Consortium Image Server
http://dmc.ohiolink.edu/mrsid/bin/ls7

GLERL 2002
Recent changes in Lake Erie

Hypolimnetic Volumetric Oxygen Depletion

Dissolved Oxygen Concentration
Lake Erie Central Basin Hypolimnion

Recent changes in Lake Erie

Avian botulism (Eastern Basin)

G. Bortolotti
Recent changes in Lake Erie

Invasives modification of ecosystem

Recent changes in Lake Erie

Dynamic fish community structure
Possible Explanations for Changes in Trophic Processes

A. Environmental influences
B. Increased phosphorus loadings
C. Possible limits on primary production
D. Increased rates or new pathways of internal cycling (dreissenids?)

Explanations for Recent Changes

Reduced size, increased persistence of central basin hypolimnion
  * longer stratification period
  * lower lake levels
  * warmer
  * strong storms
Explanations for Recent Changes

**Increased organic carbon accumulation**
* increased P loading
* increased rates, new pathways of internal cycling
* nearshore shunt model (R. Smith et al. Univ. of Waterloo)

Explanations for Recent Changes

**Reduced primary production**
* grazing
* nutrient, trace metal limitation
* UV penetration
TP concentrations unrelated to changes in loading

Plankton biomass poorly correlated with chlorophyll a

Conroy et al. 2005
No evidence for increased ‘Dead Zone’

Burns et al. 2005

Increased DO depletion rate related to TP loadings

Rockwell 2005
Central Basin DO depletion rate related to previous year TP loading

![Graph showing Central Basin DO depletion rate related to previous year TP loading](image)

Burns et al. (2005)

Winter flood flow is major phosphorus loading mechanism

![Graph showing Winter flood flow is major phosphorus loading mechanism](image)

Dolan and McGunagle 2002
Agreement about Key Trends of Concern 1995-2000

1. Very low phytoplankton biomass in central & eastern basins
   Carrick, Charlton, Culver, Guildford, Ostrom, Smith, Twiss
   Yes   Yes   No   Yes   ?   Yes   Yes

2. Total phosphorus concentrations have been rising (last 5 yrs)
   Burns, Carrick, Charlton, Culver, Guildford, Haffner, McKay, Ostrom, Rockwell, Smith, Twiss
   Yes   ?   Yes   Yes   No   Yes   Yes
   ?   Yes   Yes   Yes

Science is not a democracy

Agreement about possible limits on primary production

Is low phytoplankton biomass in summer due to
3. nutrient limitation in subsurface epilimnetic water?
   (phosphorus or nitrogen)
   - summer 2002 (No - Twiss; Guildford)
   - spring 2003 (No – Twiss)
   - summer 2003 (Yes – Twiss)

4. trace metal limitation (iron, copper or zinc)?
   - inconclusive 2002; late summer limitation in 2003
   - picoplankton most responsive (Twiss, McKay, Guildford)

5. UV + contaminant-induced inhibition?
   - lab evidence; not evaluated in 2002
   - microbial loop more C-limited than P or N (Heath)
Summary of Findings
Dreissenid effects in central basin?

Nutrient/ Oxygen demand processes:

• TP loadings dominated by tributary discharge (regional effect reflecting climate)
• Winter discharge contributes higher TP load than summer discharge
• TP conc. & HVOD have risen through 90’s
• TP conc. & HVOD depend on previous year’s TP loading
• HVOD but not TP conc. depend on previous year’s TP
• Plankton biomass poorly correlated with chlorophyll a

Conclusions: No strong evidence of dreissenid effects on TP conc. or HVOD in central basin

Pelagic processes:

• No correlation between dreissenid distrib. & central basin hypoxia (Patterson et al. 2005; Conroy et al. 2005)
• No evidence of increased SOD (Schloesser et al. 2005; Matisoff and Neeson 2005)
• Poor correlation between dreissenid abundance & turbidity (Rockwell et al. 2005)
• Seasonal patterns of hypolimnetic production controlled by nutrients & clarity, independent of dreissenids (Carrick et al. 2005; Ostrom 2005; Guildford et al. 2005)
• Phytoplankton productivity regulated by nutrients (Guildford et al. 2005; Twiss et al. 2005; Smith et al. 2005; McKay et al.; Porta et al.)
• Microbial productivity regulation by DOC (Heath et al. 2005)

Conclusions: No strong evidence of dreissenid effects on hypoxia in central basin
Summary of Findings
Evidence of dreissenid effects in nearshore?

Pelagic processes:
• Correlation between fluorometric measures of chla and dreissenid abundance (Ghadouani and Smith 2005)
• Increased nearshore water clarity (various)

Benthic processes:
• Cladophora beds expanding; anoxic beneath (Higgins et al. 2005)
• Dreissenids stimulate Cladophora production (Davis and Hecky 2005)
• Dreissenids and Cladophora influence LOI and SOD locally (various)
• Altered zoobenthic composition and distribution (Barton et al. 2005)
• Dreissenid - goby interactions and TP increases (Barton et al. (2005); Bunnell et al. 2005))

Conclusions: Nearshore nutrient dynamics and trophic structure are regulated by local benthic-pelagic coupling and feedback loops over seasonal time scales

Summary of Findings

OFFSHORE
• Nutrient dynamics and trophic structure regulated by regional processes and annual time scales
• Weather conditions likely play a significant role

NEARSHORE
• Nutrient dynamics and trophic structure regulated by local benthic-pelagic coupling and feedback loops over seasonal or shorter time scales
• Dreissenids and local nutrient sources important