Phosphorus Loading to Lake Erie from the Maumee and Sandusky Rivers: Knowns and Unknowns

> Western Lake Erie Conference Otsego Park March 12, 2009

Dr. David B. Baker National Center for Water Quality Research Heidelberg University, Tiffin, OH



Point Source Loading to Lake Erie

Direct PS Indirect PS Point Source



Lake Erie Nonpoint Source Phosphorus Loads



Reduced till and no-till programs

How has the lake responded to reduced TP loads? Lake Erie Total Phosphorus Loading by Major Source Lake Huron Atmosheric Point Source Nonpoint Source Unspecified 30,000 Total Phosphorus, metric tons 25,000 Excellent improvements Deteriorating conditions since through the 20,000 the mid-1990s mid-1990s 15,000 10,000 5,000 0 1967 1972 1977 1982 1987 1992 1997 2002 Water Year

Average Phosphorus Load metric tons/yr	Percent of total
5,604	60.8%
1,908	20.7%
628	6.8%
1,080	11.7%
9,220	100%
	Average Phosphorus Load metric tons/yr 5,604 1,908 628 1,080 9,220

*Data from Dave Dolan, U. Wisconsin, Green Bay

What are the geographical sources of these loads?









Conclusions

- 1. The Western Basin is the major port of entry of phosphorus loading to Lake Erie.
- 2. Agricultural runoff from the Maumee and Sandusky rivers is the major source of phosphorus entering the Western Basin.
- 3. The Western Basin in the major source of phosphorus entering the Central Basin of Lake Erie.

Have agricultural pollution abatement programs in Northwestern Ohio really worked?



Streams carry two types of phosphorus:

Particulate Phosphorus Attached to suspended sediments. 70-85%

Dissolved Phosphorus

Dissolved in the stream water (mostly phosphate)

15-30%

Agricultural pollution control efforts have focused on reducing particulate phosphorus.

- 1. no-till and reduced till agriculture
- 2. Buffer strips
- 3. Conservation Reserve Program





Next four slides

Trends in dissolved reactive phosphorus loading

- **1. Maumee River**
- 2. Sandusky River

Trends in bioavailable phosphorus loading

- 3. Maumee River
- 4. Sandusky River









Why has the dissolved reactive phosphorus export from the Maumee and Sandusky rivers increased so much?

This was predicted to accompany adoption of conservation tillage by Terry Logan and others back in the 1970s?

- 1. Phosphorus stratification in soil (build up at surface)
- 2. More broadcast applications of phosphorus.
- 3. Increased surface runoff (streams becoming flashier)
- 4. Increased soil phosphorus levels in general
- 5. Hotspots of DRP runoff from manure application practices
- 6. (and the list goes on)

Some research at the linking cropland issues to tributary loading of dissolved phosphorus.









What is the environmental impact of phosphorus stratification?



There are many research needs at the landlake interface –

These are logistically complicated research tasks.

We need local help and advice to implement these research programs.

In July and August 2003, three major runoff events occurred in the Maumee River (left). That summer had the most severe blue-green algal blooms that have been observed in recent years.





LANDSAT 7 Image

March 3, 2006



Research to start on connecting the dots.



LANDSAT 7 Image





Schematic illustration of sampling network for LaGrangian sampling. Exact placement of stations will be affected by storm size and logistic considerations.





In particular, we need help in lining up charter boats that would be available to help implement this kind of sampling program.

Our grant has funds to support charter boat help.

For more information, contact:

Dave Baker

dbaker@heidelberg.edu

419 448-2941


Conclusions

- 1. The Western Basin is the major port of entry of phosphorus loading to Lake Erie.
- 2. Agricultural runoff from the Maumee and Sandusky rivers is the major source of phosphorus entering the Western Basin.
- 3. The loading of dissolved reactive phosphorus has increased in both rivers since the mid-1990s.
- 4. Bioavailable phosphorus inputs are now at their highest levels since the onset of monitoring in the mid 1970s.
- 5. Research is now underway regarding the significance and control of DRP runoff from these watersheds.



Sandusky R., Dissolved Reactive Phosphorus, Average Monthly Loads, 2003-2008 Water Years



Seasonal distribution of dissolved reactive phosphorus loading for the Maumee and Sandusky rivers

Maumee R. Dissolved Reactive Phosphorus, Average Monthly Loads, 2003-2008 Water Years



Much research is currently underwater regarding:

- 1. Causes of the increases in dissolved phosphorus runoff.
- 2. Best means to reduce dissolved phosphorus runoff.
- 3. Delivery of particulate phosphorus from monitoring stations to the lake.
- 4. Effectiveness of stream processing in reducing dissolved phosphorus transport through streams.
- 5. Significance of dissolved phosphorus loading from rivers for blue-green algal problems in the western basin and attached algal problems.

Questions during the discussion period.







Field Runoff in the Sandusky Watershed

The Sandusky River in Tiffin



1980 LAKE ERIE PHOSPHORUS LOADINGS

URBAN NON-POINT **RURAL** 900 MT/YR NON-POINT 8400 MT/YR POINT SOURCE 4500 LAKE ERIE LAKE HURON MT/YR AND **ATMOSPHERE** 2600 MT/YR 16,400 MT/YR

> LONG-TERM GOAL IS 11,000 MT/YR TOTAL LOADING OF PHOSPHORUS



Streams carry two types of phosphorus:

Particulate Phosphorus Attached to suspended sediments. 70-85%

Dissolved Phosphorus

Dissolved in the stream water (mostly phosphate)

15-30%

Agricultural nonpoint source phosphorus control programs in the Lake Erie Watershed focused on erosion control programs to reduce particulate phosphorus loading.

no-till crop production mulch till reduced till

buffer strips

conservation reserve program

What do trends in no-till and conservation tillage show?



Sandusky Watershed: 2008 Soil Testing Fields						
Tillage	Corn	S	Wheat			
moldboard	4.4%	7.0%	4.2%			
reduced	63.1%	7.0%	8.3%			
mulch	17.2%	7.0%	5.8%			
no-till/zone till	15.3%	78.9%	81.7%			
number of fields	203	199	120			



Have the BMPs worked?





Reducing tillage can decrease TP in runoff ...

> ...but it can increase DP in runoff.

(Sims and Kleinman. 2006. <u>Phosphorus.</u>)









0

9/10/07

8/31/07

8/21/07

0 +

8/1/07

8/11/07

In July and August 2003, three major runoff events occurred in the Maumee River (left). That summer had the most severe blue-green algal blooms that have been observed in recent years.





	% Point Source P		
Maumee	4.9%		
Sandusky	2.8%		

Why has the dissolved reactive phosphorus export from the Maumee and Sandusky rivers increased so much?

This was predicted to accompany adoption of conservation tillage by Terry Logan and others back in the 1970s?

- 1. Phosphorus stratification in soil (build up at surface)
- 2. More broadcast applications of phosphorus
- 3. Increased surface runoff (streams becoming flashier)
- 4. Increased soil phosphorus levels in general
- 5. Hotspots of DRP runoff from manure application practices
- 6. (and the list goes on)



Sandusky Watershed Phosphorus Stratification, 255 fields





Sandusky Watershed, Stratified Soil Testing Results

■ 0-2 inch ■ 0-8 in



What is the environmental impact of phosphorus stratification?





Critical Soil Test Values (standard 0-8 inch soil test)



Critical Soil Test Values (standard 0-8 inch soil test)





Relationships Between Soil Test Levels and Runoff Concentrations of DP and TP

(Sharpley et al. JEQ, 2001)

Under conservation tillage and for a given soil test P, DP concentrations are greater in runoff from more poorly drained soils. (Andraski and Bundy. 2003. U of Wisc.)



Soil Test Phosphorus in Relation to Manure Application Data from GLPF Stratified Soil Testing Program						
		Average Mehlic 3 P, ppm				
Manure Application	Percent of 200 fields	0-2 in	2-8 in	0-8 in	And a strength of the	
1. No known manure applications	78.5%	52	31	37	7	
2. Manure historical not recent	14.0%	67	44	50)	
3.Recent but infrequent	4.0%	53	25	32	2	
4. Recent and frequent	3.5%	133	55	75	5	

Numerous research studies are currently underway to address the problems of increased dissolved phosphorus runoff:

- 1. Great Lakes Protection Fund Sandusky Stratified Soil Testing Program (Heidelberg)
- 2. EPA Honey Creek Targeted Watershed Project (Heidelberg)
- 3. NRCS special projects in Lost Creek and Grand Lake
- 4. Environmental Defense Fund/Joyce Foundation projects
- 5. Western Lake Erie Basin multi-agency projects
- 6. Recent round of RFPs from EPA's Great Lakes National Program Office.
- 7. Recent special RFP from the Ohio Lake Erie Protection Fund.
- 8. Etc.
Adaptive Management for Lake Erie



There is lots of action on the phosphorus scene!!!

Questions?

The tributary loading data sets are available at

http://wql.data.heidelberg.edu

This site includes tutorials and an excel plotting program.

We have file of 25 scenes with linked satellite images and storm events in the Maumee and Sandusky watersheds.



LANDSAT 7 Image

March 3,

2006

Extra slides



Relationship between nitrate SEMC and storm size

Sandusky River, Nitrate Storm Event Mean Concentrations in Relation to Storm Volume, 1975-1995









Percentile distibution of 0-8 Brey 1 P, 255 fields relative to corn and soybean fertilizer recommendations



What's more important – concentrations or loads?

		TP
Detroit River	TP loads, mtons	concentration
Upper Lakes	1,080	
Point source MI	953	
Point Source Ontario	100	
Estimated NPS Delivered	1,477	
Load at mouth of Detroit R	3,610	0.02-0.05 mg/L
Maumee at Watersville	2,223	0.372 mg/L

What's more important – concentrations or loads?

Street Co.			ТР
State of	Detroit River	TP loads, mtons	concentration
	Upper Lakes	1,080	
F. K. all IN	Point source MI	953	
1245422	Point Source Ontario	100	
0.46 kg/ha	Estimated NPS Delivered	1,477	
Marriel II			
	Load at mouth of Detroit R	3,610	0.02-0.05 mg/L
1.35 kg/ha	Maumee at Watersville	2,223	0.372 mg/L

Submersible pumps continuously push stream water into sampling wells.

esticides

Nutrients



The Rock Creek stream gaging station on Heidelberg campus.

Automatic samplers collect three samples per day throughout the year.

Analytical Program at the NCWQR

- 1. Suspended solids
- 2. Total phosphorus
- 3. Dissolved reactive phosphorus
- 4. Nitrate
- 5. Nitrite
- 6. Ammonia
- 7. Total Kjeldahl Nitrogen
- 8. Chloride
- 9. Sulfate
- 10. Silica
- 11. Fluoride
- **12. Conductivity**

Seasonally pesticides Selected metals Example of data...

Sandusky River Total phosphorus 2006 water year





Do peak concentrations of TP correlate with peak discharge?



Sandusky River, Total Phosphorus Loading Rate, (kg/day)



of time with high flows and high TP concentrations.



Sandusky River, Annual Loads of Total Phosphorus





Sandusky River, Annual Discharge

Annual discharges are highly variable... relative standard deviation = 34.6%



Above example illustrates...

one river... one parameter... one year

The data set contains...

many rivers... many parameters... many years

How have the loading data been used relative to...

environmental planning?

outcome assessment? nonpoint source load reductions

BMP effectiveness

tradeoff detection

other uses (modeling, education, etc.)

What are the sources of phosphorus loading to Lake Erie? (Army Corps of Engineers, 1975)

Phosphorus sources

- **1. Point sources**
- 2. Nonpoint Sources
- **3. Atmospheric Deposition**
- 4. Upper Lake

How are these sources measured?





What are the sources of phosphorus loading to Lake Erie?

Phosphorus sources	Average annual metric tons 1998-2002	Percent
Point sources	1,970	22%
Nonpoint Sources	5,278	59%
Atmospheric	640	7%
Upper Lake	1,080	12 %
Total	8,948	

Percentile distibution of 0-8 Brey 1 P, 255 fields relative to corn and soybean fertilizer recommendations

