The Role of Midwestern Agriculture in Gulf of Mexico Hypoxia
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What is hypoxia?

- Hyp = low
- Oxia = oxygen
- Hypoxia = low oxygen
  - defined as less than 2 ppm oxygen dissolved in water
  - most aquatic organisms will die with prolonged exposure
Hypoxia in the Gulf of Mexico

- Seasonal (appears in summer)
- Associated with phytoplankton bloom (single-celled marine plants)
- N is limiting nutrient in marine waters
  - adding N should increase phytoplankton growth
    - could increase hypoxia; depends on conditions
  - similar effect to P added to fresh water
GOM Hypoxia Since 1993
Source: Rabalais, Turner, and Wiseman

1993
1994
1995
July 23-27, 1996
July 23-29, 1997
Bottom Water Hypoxia
July 22-26, 2000
Hypoxia in July 2004

The hypoxic zone is closer than normal to the Louisiana coast this year (persistent winds from south). As a result, shrimp trawlers did not have success.
Area of Mid-Summer Bottom Water Hypoxia (Dissolved Oxygen < 2.0 mg/L)

Long-Term Average

Action Plan Goal

5-Year Average

Source: N. Rabalais, LUMCON
Average Monthly Bottom Dissolved Oxygen (mg/L) 1985 - 2001

(Rabalais et al., 2002)
Hypoxia and N fertilizer

- N fertilizer use
  - started after World War II
  - increased until 1980
  - pretty much level since 1980
- Mississippi River N
  - increased from 1950-1980 then leveled off
- Hypoxic zone in the Gulf
  - only measured since 1985
Figure 1. Estimated nitrogen fertilizer use in the United States, and nitrate concentrations in the Mississippi River at St. Francisville, LA., 1955–95.
Size of the hypoxic zone

- Only measured since 1985
- Size related to N going down the river but not to N use (fairly constant)
- N going down the river related mostly to flow differences from year to year
y = -7E-09x² + 0.0188x - 6440.8

R² = 0.4796
Hypoxia Area in Gulf of Mexico & Mississippi River Water Flow Rate

Hypoxia Area, square miles

Average Annual Water Flow (cubic feet/second)

\[ y = -0.00x^2 + 0.05x - 14,151.17 \]

\[ R^2 = 0.42 \]
EPA Action Plan

• Developed by Mississippi River/Gulf of Mexico Watershed Nutrient Task Force
• Issued for public comment by EPA summer 2000
• All voluntary
• Targets:
  – *Initially:* reduce N load to Gulf by 30%
  – *Now:* reduce 5-year average size of hypoxic zone to below 5000 square kilometers
    • Use “adaptive management” (i.e. whatever works)

http://www.epa.gov/msbasin/actionplan.htm
Reducing N load by 30%

- Total N load to Gulf is about 1.8 million tons/year
- Increase since 1950 about 1 million tons/year
- 30% reduction = 0.5 million tons/year
- annual fertilizer N use about 7 million tons/year
Annual N Inputs to Mississippi Basin
Approximated from Goolsby. USGS. 1999. CENR Report #3

Million metric tons


Soil Mineralization
Fertilizer
Legume & Pasture
All manure
Atmospheric ammonia
Atmospheric nitrate
Municipal & industrial
Reducing N load by 30%

• Time lag between N management changes and improvement in water quality?
  – Water (and N) leaching from fields may take a long time to reach rivers
  – Lots of talk about N runoff but main losses appear to be via leaching and re-emergence in springs, seeps, etc.
Fertilizer N Use Efficiency on Corn has Increased 32% since 1980
Ways to reduce N movement to surface waters

• Reduce fall N fertilizer applications
• Reduce fertilizer N over-applications
  – match rate to crop need to minimize unused N
• Reduce manure N over-applications
• Some suggest increased wetlands to remove N, but much more expensive per unit reduction
Reducing N overapplication can be tricky

Oran 2000 Optimal N Rates

How do you fertilize this field?
N applications based on color can meet crop needs precisely

Variable-rate sidedressing demonstrations in 2004: N rates were reduced by an average of 45 lb N/acre compared to rates used by producers in the same fields.
Hypoxia and agriculture: Summary

- Gulf hypoxic zone size varies from year to year; 2000 smallest since 1989 (drought)
- EPA has adopted an Action Plan
- They are seeking federal funding for voluntary programs to reduce N loading of the Mississippi River
- Their target is to reduce the size of the hypoxic zone to less than 5000 square kilometers (5-year average) by reducing N loading to the Gulf
- Reducing N loading:
  - Reduced fall N fertilizer applications
  - Reduced over-application of fertilizer & manure N
- There may be a time lag between adoption of effective practices and reduced N delivery to the Gulf