Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

Reassessment
of the
Action Plan for Reducing, Mitigating and Controlling Hypoxia in the Northern Gulf of Mexico (2001)

USEPA Science Advisory Board
Hypoxia Advisory Panel

Sept 6-7, 2006
Washington DC

Action Plan for Reducing, Mitigating and Controlling Hypoxia in the Northern Gulf of Mexico (2001)

An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico (2000) [link]

Topic 1: Characterization of Hypoxia
Topic 2: Ecological and Economic Consequences of Hypoxia
Topic 3: Flux and Sources of Nutrients in the MARB
Topic 4: Effects of Reducing Nutrient Loads to Surface Waters within the MRB and GOM
Topic 5: Reducing Nutrient Loads, especially Nitrate-Nitrogen to Surface Water, Groundwater and the GOM
Topic 6: Evaluation of Economic Costs and Benefits of Methods for Reducing Nutrient Loads to the GOM

Coastal Goal: By the year 2015, reduce the 5-year running average areal extent of the Gulf of Mexico hypoxic zone to < 5,000 sq km
Within Basin Goal: To restore and protect the waters of the 31 States and Tribal lands within the MARB
Quality of Life Goal: To improve the communities and economic conditions across the MARB, in particular the agriculture, fisheries, and recreation sectors
Integrated Assessment of Hypoxia in the Northern Gulf of Mexico (2000)

- Primary obstacle to reducing model uncertainties … is lack of a sufficiently comprehensive database
- Existing database not designed to quantify load-response relationships – *new monitoring approaches needed*
- Comprehensive monitoring programs alone will not be sufficient for developing, calibrating and validating quantitative WQ models – *relevant and targeted research needed*
- Future modeling should include linkages of WQ/Eutro and hydrodynamics, expansion of spatial domain, and refinement of temporal and spatial resolution – *new integrated, multimedia modeling constructs needed*

Research & Management Highlights 2001-2006

Gulf Science

Lower Basin Science and Management

Upper Basin Science and Management
Long Term Trends

Since mid 1980s, the 5-yr running average size of hypoxic zone has hovered around 15,000 km²

Annual riverine nutrient flux and nutrient ratios poorly related to mid summer size of hypoxia

USGS sites: MSR @ St Francisville and AR @ Melville
http://co.water.usgs.gov/hypoxia/hypoxia_new.htm

Gulf Science

Topics/Issues Addressed
- Characterization and Long-Term Trends of Hypoxia
- Characterization of Nutrient and Organic Matter Loads
- Physical Oceanographic Processes
- Water Column Processes
- Benthic Processes
- Modeling Applications

Multiple lines of evidence from multiple sources are consistent with the general pattern of coastal eutrophication observed in other U.S. systems and around the world

- Long-term increases in nutrient loads to the Louisiana continental shelf (LCS) has resulted in excess primary production and ultimately bottom water hypoxia

- Increased concentrations of nitrate-nitrogen delivered to the Gulf is the predominant factor contributing to excess primary production and increased bottom water hypoxia

- Management strategies for LCS hypoxia should include nitrogen as well as phosphorus since both nutrients (and their ratio) are important in primary productivity and biogeochemical processes
Gulf Science

Temporal characteristics of hypoxia are fairly well known, except for timing of development in spring.

Density stratification is key – disruption of pycnocline by weather events is not uncommon. Hypoxia can develop in 9-18 day following stratification.

Atchafalaya River fw discharge and nutrients may have relatively larger influence on hypoxia across the LCS, at least equivalent to MSR.

Statistical models suggest that spring/early summer nutrient fluxes (primarily NOx) are good predictors of mid summer size of hypoxia.

Increased N loads have altered N:P ratios such that P limitation occurs in the near-field at certain times of the year, including the spring bloom period.

Gulf Science

Fairly complete description and basic understanding of physical oceanography.

Winds stress and fw discharge dominate physical processes influencing hypoxia.

Along shelf currents reverse during summer.

Elevated Chl and production in the LCC (along inshore edge of hypoxic zone) may be significant source of organic matter to LCS bottom waters.

Biogeochemical and physical processes vary spatially (along and across shelf) and temporally (seasonal) in the region where hypoxia develops – thus mechanisms of hypoxia development, sources of nutrients driving production and OM fueling respiration are expected to vary along the LCS.

Current monitoring of fw discharge, sediment and nutrient loads/concentrations not adequate to resolve monthly (or shorter) time scale processes influencing hypoxia.
Below pycnocline and benthic processes (aerobic & anaerobic respiration) contribute to seasonal depletion of bottom water O2 and maintenance of hypoxic bottom waters – yet available information is surprisingly small

Abundant unconsolidated ‘mobile muds’ may be important in the transport and reactivity of organic matter and nutrients derived from the river plume and associated plankton processes – resuspension may stimulate decomposition and biogeochemical cycling

Terrigenous sediments deposited from the MSR plume are thought to be high in [Fe] and [Mn] – the influence on sulfide and phosphate flux is unclear

Development of a sediment diagenesis model for LCS provides a useful tool for understanding benthic biogeochemical processes

Hypoxia modeling

Existing Gulf hypoxia models range from simple regression models to complex 3-D simulation models, and include different aspects of physics, chemistry and biology.

Assumptions, limitations and/or shortcomings of existing models are known and documented

Existing models provide scientific rationale for a N load reduction target of 30 - 45% to achieve Action Plan target of 5,000 km²

Existing models are sufficient for estimating P load reductions

Further model developments and improvements should occur along multiple fronts, and address

hydrodynamic processes
open boundary conditions
benthic-pelagic coupling and vertical flux
sediment processes
multiple nutrients (N, P, Si)
model domain
biogeochemical processes
Upper Mississippi River Sub-basin Workshop
(Illinois, Iowa, Minnesota, Missouri, and Wisconsin; plus Indiana and Ohio
15 science panels comprised of 75 nutrient/water quality researchers)

Importance of hydrology/land-use
Potential of improved water management
Wetlands buffer strips
N management (rate, timing, forms, additives)
Fertilizer- and manure-P management
Erosion control
Use of cover crops/living mulches/perennials
Avoiding actions with unintended side effects
Field- and watershed-scale tools for planning
Evaluation of management changes
Upper Mississippi River Sub-basin Workshop
Current Understanding

In tile-drained landscapes:
- N losses greater
- Carrier - subsurface drainage water
- Dominated by NO₃ form
- Occur with sustained flows
- Usually in spring at time with little ET/nutrient uptake

In “rolling” landscapes with good surface drainage:
- P losses greater
- Carriers - runoff water and sediment
- Usually dominated by P in sediment
- Occur with “flashy” rainfall-runoff events
- Year around, worse in spring with less vegetative cover

Potential relative reductions in nitrate leaching in Corn Belt for specific corn/soybean management changes

<table>
<thead>
<tr>
<th>Practice</th>
<th>Change</th>
<th>Relative Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-fertilizer on corn</td>
<td>Reduce from 150 to 125 lb/ac</td>
<td>****</td>
</tr>
<tr>
<td>Timing of fertilizer application</td>
<td>No fall N-fertilizer applications</td>
<td>**</td>
</tr>
<tr>
<td>Cropping</td>
<td>switch to perennials</td>
<td>******************</td>
</tr>
<tr>
<td>Buffer strips</td>
<td>1-5% of area</td>
<td>-</td>
</tr>
<tr>
<td>Tillage</td>
<td>plow to long-term, continuous no-till</td>
<td>**</td>
</tr>
<tr>
<td>Wetlands</td>
<td>1-5% of area</td>
<td>**********</td>
</tr>
</tbody>
</table>

Little to no expected impact -
Minor expected impact **
Intermediate Expected impact ****
Big expected impact **********
Huge expected impact ***************
Upper Mississippi River Sub-basin Workshop

Conclusions

- Soil nutrient levels must be sufficient for good crop growth
- Whenever excess water moves, nutrient losses will occur
- Nutrient impairment problems are not mainly due to "excess nutrients", but historic changes in land-use and hydrology
- Some improvement in in-field nutrient management possible, but off-site practices also needed
- No easy answers: improvements will be incremental
- Targeting/site-specific design necessary
- Economics must play a role, especially in considering land-use changes
- Must avoid promotion of wrong practices (e.g., to reduce organic matter/soil quality with too low N rates on corn)
- Care must also be taken in "promising too much;" variability in weather dominates both short- and long-term outcomes

Lower Mississippi River Sub-basin Workshop

(Arkansas, Kentucky, Louisiana, Mississippi, Missouri, Tennessee)

Topics/Issues Addressed

- Nutrient trends in the Lower Mississippi River Sub-basin
- Status of Nutrient Monitoring in the Lower MRB
- Major Municipalities and Point Sources
- Agricultural Management and Practices
- Role of Wetlands in Nutrient Filtration and Uptake
- Distributary Region of the River – Obstacles and Opportunities
- Future Trends – Climate Change, Energy, Fertilizer Prices, River Management
Lower Mississippi River Sub-basin Workshop
Current Understanding

Substantial loss of USGS monitoring stations in early and mid 90s – No monitoring of LMR between Cairo, IL and St. Francisville, La

Summary of information from Municipalities of New Orleans and Baton Rouge
• New Orleans utilizing wetland assimilation of wastewater, nutrient loading will be reduced, and restoration of a cypress swamp is planned in a degraded area east of New Orleans, which can serve as a wetlands buffer both for nutrient uptake and hurricane protection
• Louisiana “industrial corridor”: One refinery has reduced nitrate emissions by at least 50%, through source reduction and biological plant operation. Ongoing reduction efforts continue

Loosheatchie River: site of an innovative joint effort of several small but growing municipalities to reduce nutrient inputs from wastewater treatment plants. Potential for nutrient trading.

Conservation tillage had less sediment in runoff water; leaving crop residue and winter cover in place will significantly reduce accelerated erosion.

A pilot project is underway with farmers, crop advisers, industry, and government agencies to improve cotton fertilization BMPs

Lower Mississippi River Sub-basin Workshop
Conclusions

Although the lower Mississippi River Basin is a smaller geographic area than the Upper MRB, it has a pretty high nitrate yield per unit area

Results from 1996-2000 indicate that although the Yazoo River was contributing about 2.8 percent of the annual flow, its contributions to the annual flux of total nitrogen and total phosphorous in the Mississippi River were 1.4 percent and 3.4 percent respectively

Subsurface drainage with deep chiseling showed reduction in surface runoff, sediment loss, phosphorous loss, nitrate loss. Conservation tillage showed significant reduction in sediment loss.

Seasonally flooded fields show reduced winter erosion and reduced losses of nutrients and chemicals

P and N have different removal mechanisms; significant differences in denitrification rates between restored and natural forested wetlands, with higher rates for the latter. Swamps can show nitrate reduction of 100%, total N reduction of 80%, and total P reduction of 87%.

Estuaries assimilate a large portion of nutrient inputs; higher nutrient reductions would be possible by removing spoilbanks along oil access canals, allowing greater marsh-water interaction.

Global climate change would interfere with nutrient management and eutrophication control efforts; the 20% increase in MS River discharge predicted by some models could offset nitrate reduction efforts.

Discussions are underway involving potential modifications to the management of the Mississippi River’s active delta to achieve coastal restoration goals.