Gulf of Mexico Hypoxia
Causes, Consequences, Correctives

Boesch & Rabalais begin monitoring (1985)
NOAA-funded study crystallized issue (1990-95)

Public Policy Development

- EPA convened Federal Principals (1996)
- CENR initiates scientific assessment (1997)
- HABHRCA Bill signed into Law (1998)
- Integrated Assessment completed (2000)
- Action Plan delivered to Congress (2001)

How did we get from “here” to “there”?

Dr. Donald Scavia
University of Michigan
Commissioned Technical Papers

Characterize hypoxia distribution, dynamics, and causes.
Nancy Rabalais, LUMCON.

Ecological and economic consequences of hypoxia.
Robert Diaz, VIMS; Andrew Solow, WHOI.

Sources and loads of nutrients.
Donald Goolsby, USGS.

Effects of reducing nutrient loads.
Patrick Brezonik, Univ. of Minn.; Vic Bierman, Limno-Tech.

Methods for reducing nutrient loads.
William Mitsch, Ohio State University.

Economic costs and benefits of reducing loads.
Otto Doering, Purdue University.

Over 50 academic and agency scientists
Independent Peer Review

Dr. Donald Boesch
University of Maryland

Dr. Jerry Hatfield
Agricultural Research Service

Dr. George Hallberg
Cadmus Group

Dr. Fred Bryan
Louisiana State University

Dr. Sandra Batie
Michigan State University

Dr. Rodney Foil
Mississippi State University

3-5 reviews for each report

Public Comment after Peer Review
Received and responded to 34 sets
http://www.nos.noaa.gov/Products/pubs_hypox.html

Integrated Assessment Team

Don Pryor, Don Scavia
National Oceanic and Atmospheric Administration

Mary Belefski, Larinda Tervelt, John Wilson
U.S. Environmental Protection Agency

Herb Buxton, Don Goolsby
U.S. Geological Survey

Howard Hankin, Tim Strickland, Fred Swayder
U.S. Department of Agriculture

Tom Pullen
U.S. Army Corps of Engineers

Mark Anderson
Office Science and Technology Policy
Integrated Assessment was based on the 6 peer reviewed reports and public comments; Plus 16 additional sets of comments on the draft IA.
http://www.nos.noaa.gov/Products/pubs_hypox.html

Gulf of Mexico Hypoxia
Causes, Consequences, Correctives

Reviewed Potential Causes

- Intrusion from deep water.
- Organic carbon loads.
- Long-term Climate Change.
- Changes in Land-use and N loads.
Potential Causes

Intrusion of deep offshore waters

An Old Deepwater Source?

1996 data: < 2.0 mg/l at 5-30 m depth

1935 data: < 4.3 mg/l at 250-600 m depth
River organic carbon load

While lots of carbon leaves the river, only the particulate fraction can get to hypoxic zone.

N load produces ca. 15 X more oxygen depletion. (1N ~ 7C plus recycling)

Most hypoxic-zone sediment organic carbon is of marine origin.

Result from Consensus Meeting:
Organic carbon is a relatively small factor.
Potential Contributing Factors

Climate-induced flow changes

Nitrogen Flux to the Gulf

Goolsby, et al
Water Discharge Trends

92-Yr annual average water discharge

Goolsby, et al

15% flow increase.
300% increase in Nitrate flux.

Potential Contributing Factors

Landscape changes/Nutrient load
Nitrate Flux to the Gulf

Million Metric Tons


Goolsby, et al

Nitrogen loads

Where does it come from?

Effects of reducing it?

Means to reduce it?
Nitrogen Source Distribution

Nitrate Yields

TN Yields Delivered from Agriculture

Hypoxia has increased since the 1950’s.
River N load is main driver of hypoxia
P considerations ---
N load is > 3X that of 1950’s.
90% of nitrate inputs from non-point sources.
74% of nitrate is from agricultural non-point sources.
56% of nitrate enters system north of Ohio River.

Will system respond to N reduction?
Effects of Reduced N Loads

Stream Water Quality Changes

- Brezonik et al.

- Effects of Reduced N Loads
- Stream Water Quality Changes
- LM = Lower Mississippi
- UM = Upper Mississippi
- MS = Missouri
- OH = Ohio

Bierman et al.

Effects of Reduced N Loads

Gulf Hypoxia Changes

- Bierman et al.
## Two key ways to reduce loads:

- **Decrease N loss from land**
- **Increase Denitrification**

## Agricultural Non-Point Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Nitrogen Reduction (1000 MT/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm N management</td>
<td>900 - 1,400</td>
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<tr>
<td>Alt. crop systems</td>
<td>500</td>
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<tr>
<td>Tertiary treatment</td>
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</table>

Mitsch et al
Doering et al
Increasing Denitrification

Nitrogen Reduction
(1,000 MT/yr)

- Wetlands: 300
- Riparian Buffers: 300
- Coastal Diversion: 50

Mitsch et al

Costs-effectiveness of Actions

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Doering et al
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Doering et al

### Gulf of Mexico Hypoxia

**Causes, Consequences, Correctives**

Action Plan was based on Integrated Assessment, Public Comments on IA, and Public Meetings

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

Mississippi River/Gulf of Mexico Watershed Nutrients Task Force

January 2001
Mississippi River/Gulf of Watershed Nutrient Task Force

**States:** Arkansas, Illinois, Iowa, Louisiana, Minnesota, Mississippi, Missouri, Tennessee, Wisconsin

**Tribes:** Mississippi Band of Choctaw Indians, Prairie Island Indian Community

**Feds:** EPA, USDA, NOAA, DOI, Army Corps, DOJ, OSTP, CEQ

Task Force met 7 times to hear science, industry, and public views for Action Plan.

**Key Task Force Agreements**

- Recognized need to **reduce N loads.**
- **Sub-basin** scale for strategies.
- Actions will also help **fresh waters.**
- **Incentives** not regulations.
- New actions will require **new funds.**
- Existing programs (e.g. WRP, CRP)
Gulf Action Plan: GOALS

Coastal. By 2015, reduce hypoxia below 5,000 km².

Basin. Restore and protect the waters of Basin States and Tribes.

Communities. Improve social and economic conditions in the Basin.

Hypoxia Goal

Reaching this goal requires 30% reduction in Nitrogen load.
### Action Plan 11 Actions

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<th>Action</th>
<th>Target Date</th>
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<td>1. Ask for money</td>
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<td>2. Sub-basin Committees</td>
<td>Summer 2001</td>
</tr>
<tr>
<td>3. Develop Research Plan</td>
<td>Fall 2001</td>
</tr>
<tr>
<td>4/5. Expand monitoring</td>
<td>Spring 2002</td>
</tr>
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<td>6. Sub-basin Strategies</td>
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<td>7. Evaluate Corps projects</td>
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<td>8. Reduce points sources</td>
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<td>10. Implement BMPs</td>
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<td>11. Reassessment</td>
<td>Dec. 2005</td>
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### 11. Reassessment:

By December 2005, and every five years thereafter,

... assess the nutrient load reductions achieved and the response of the hypoxic zone, water quality throughout the Basin, and economic and social effects.

Based on this assessment, the Task Force will determine appropriate actions to continue to implement this strategy or, if necessary, revise the strategy.
Adaptive Management

Actions

1. Ask for money Dec 2000
2. Sub-basin Committees Summer 2001
3. Develop Research Plan Fall 2001
4/5. Expand monitoring Spring 2002
6. Sub-basin Strategies Fall 2002
7. Evaluate Corps projects Dec. 2002
8. Reduce points sources Jan. 2003
9. Restore wetland/buffer Spring 2003
10. Implement BMPs Spring 2003
11. Reassessment Dec. 2005
Long-term biological signals

- Ostracods
- Glaucnite
- Biogenic Silica

Rabalais, et al.
Landscape/Nutrient Changes

Artificially drained land in Mississippi Basin

Estimated N fertilizer use in Mississippi Basin

Goolsby, et al