Gulf of Mexico Hypoxia

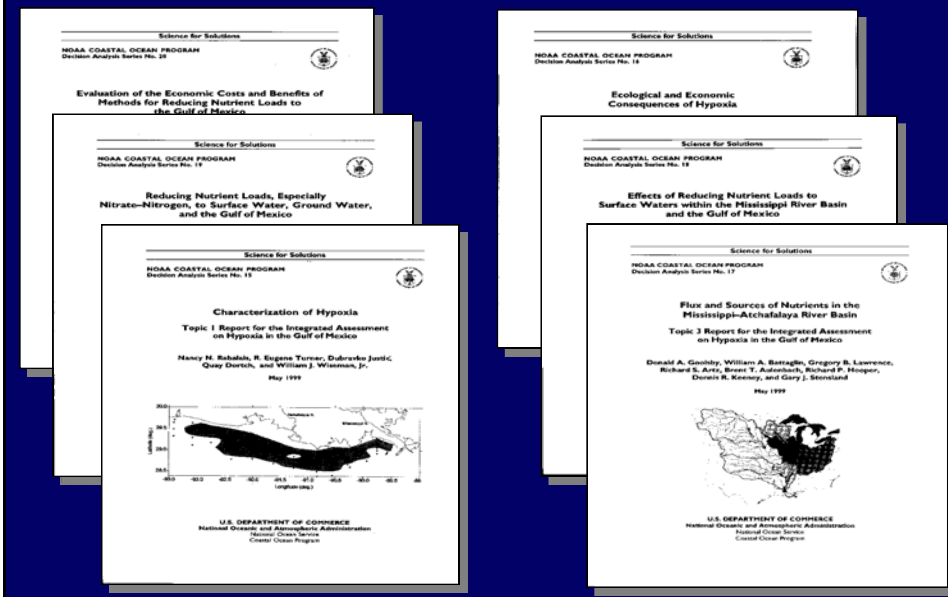
Causes, Consequences, Correctives

Public Policy Development

- Boesc… & Rabalais begin monitoring (1985)
- NO… …ed study crystallized issue (1990-95)
- …terest raised (1993-1995)
- NGOs pet… & LA for action (1995)
- EPA convene… …rincipals (1996)
- CENR initiates s… …ment (1997)
- HABHRCA Bill signe… (1998)
- Integrated Assessme… …ted (2000)
- Action Plan delivered to Congress (2001)

How did we get from “here to there”?

Commissioned Technical Papers



Technical Background Reports

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 B ... and

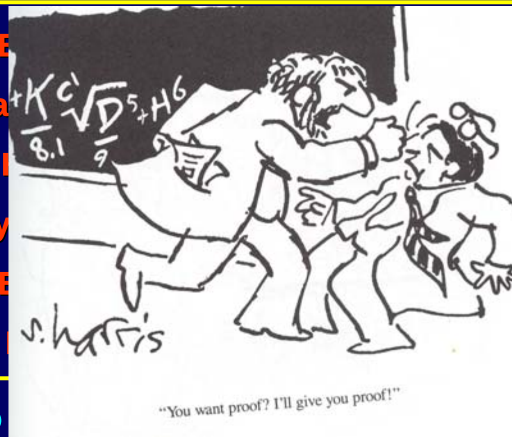
Dr. Jerry Ha ... rch Service

Dr. George ...

Dr. Fred Bry ... iversity

Dr. Sandra B ... versity

Dr. Rodney ... niversity



3-5 ... ort

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

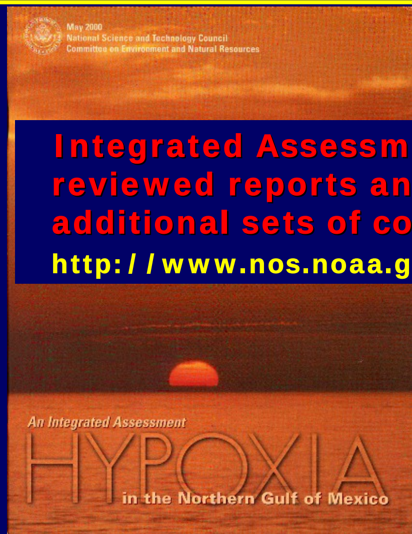
Herb Buxton, Don Goolsby
U.S. Geological Survey

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

Gulf of Mexico Hypoxia
Causes, Consequences, Correctives



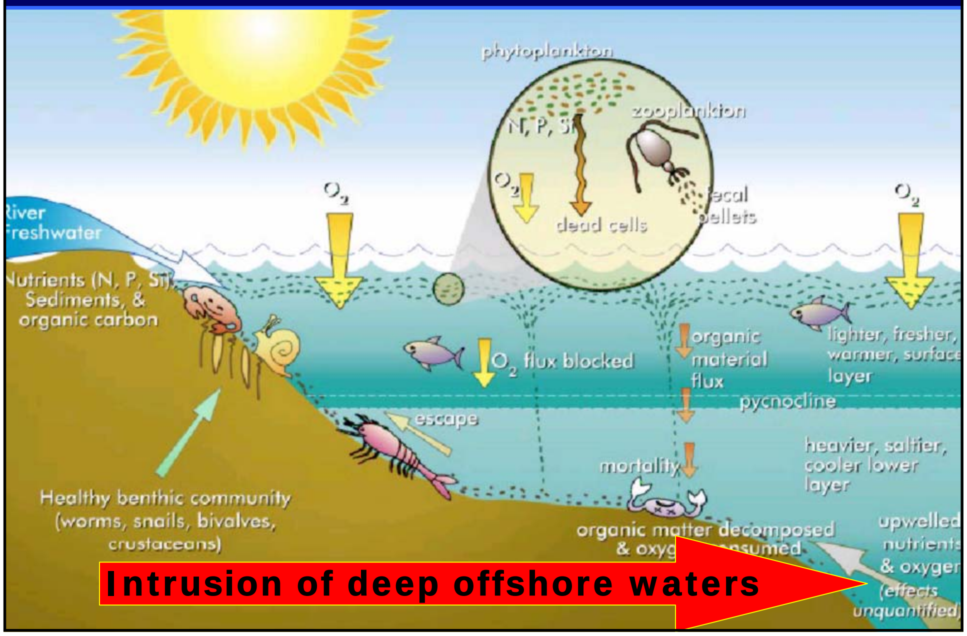
Integrated Assessment was based on the 6 peer reviewed reports and public comments; Plus 16 additional sets of comments on the draft IA.

http://www.nos.noaa.gov/Products/pubs_hypox.html

Reviewed Potential Causes

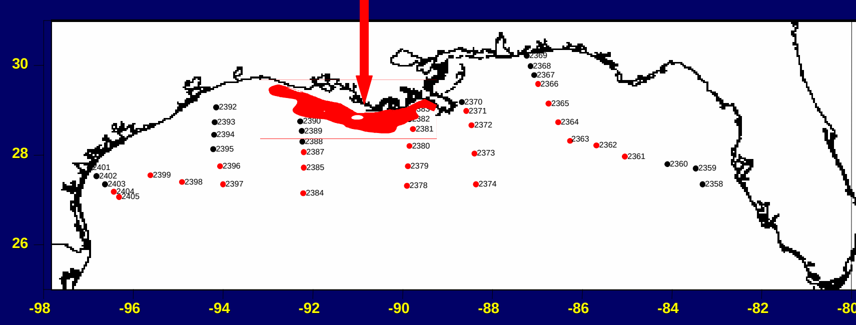
- Intrusion from deep water.
- Organic carbon loads.
- Long-term Climate Change.
- Changes in Land-use and N loads.

Potential Causes



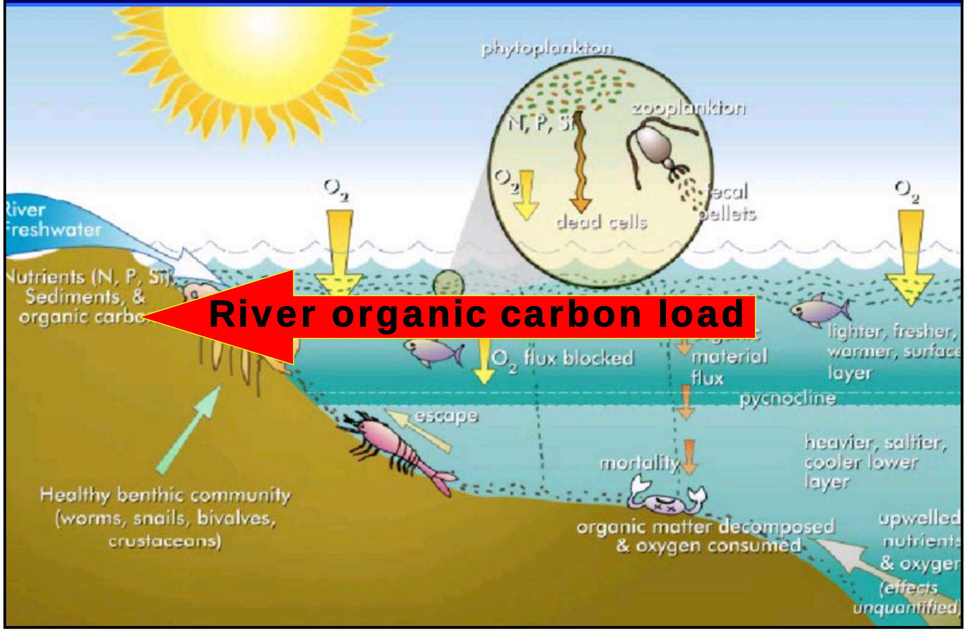
An Old Deepwater Source?

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



- 1935 data: <4.3 mg/l at 250-600 m depth

Potential Contributing Factors



Organic Carbon

A significant contribution?

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

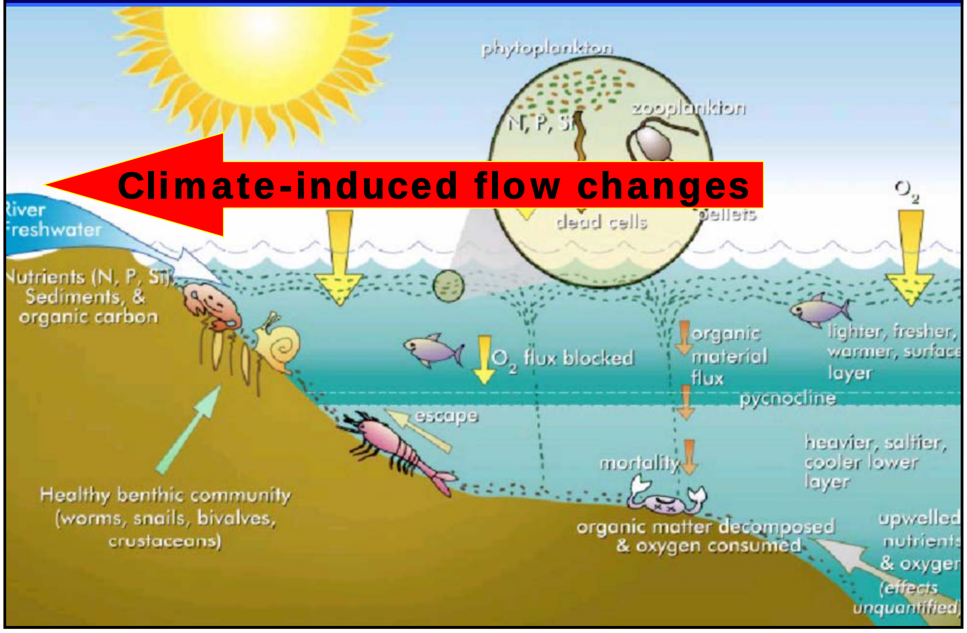
N load produces ca. 15 X more oxygen depletion. (1N ~ 7C plus recycling)

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

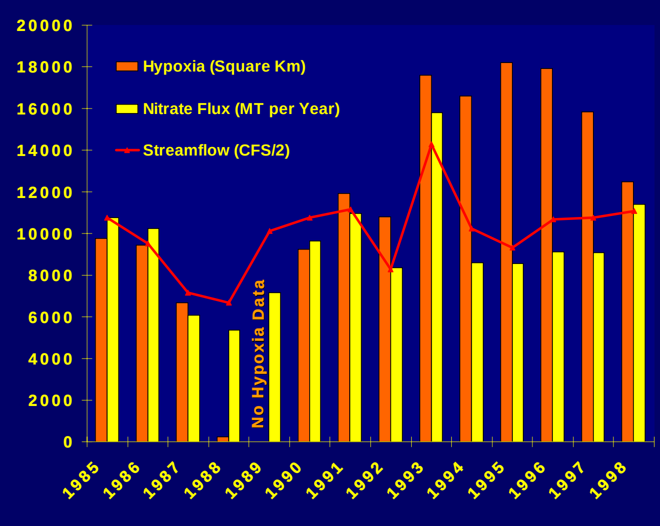
Result from Consensus Meeting:

Organic carbon is a relatively small factor.

Potential Contributing Factors



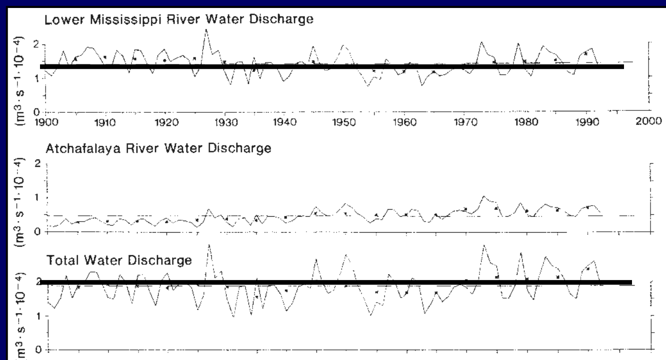
Nitrogen Flux to the Gulf



Goolsby, et al

Water Discharge Trends

92-Yr annual average water discharge

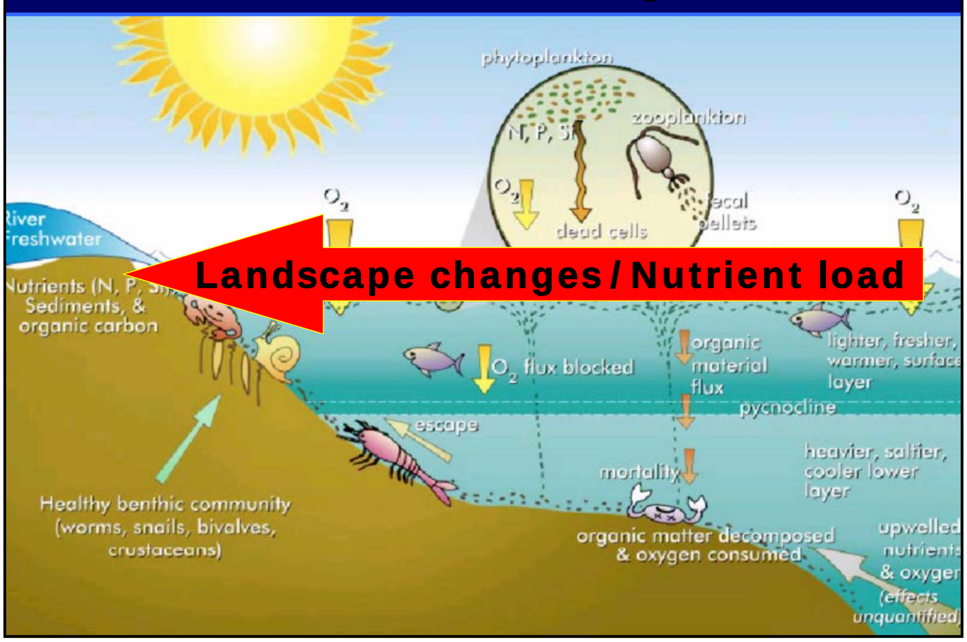


Goolsby, et al

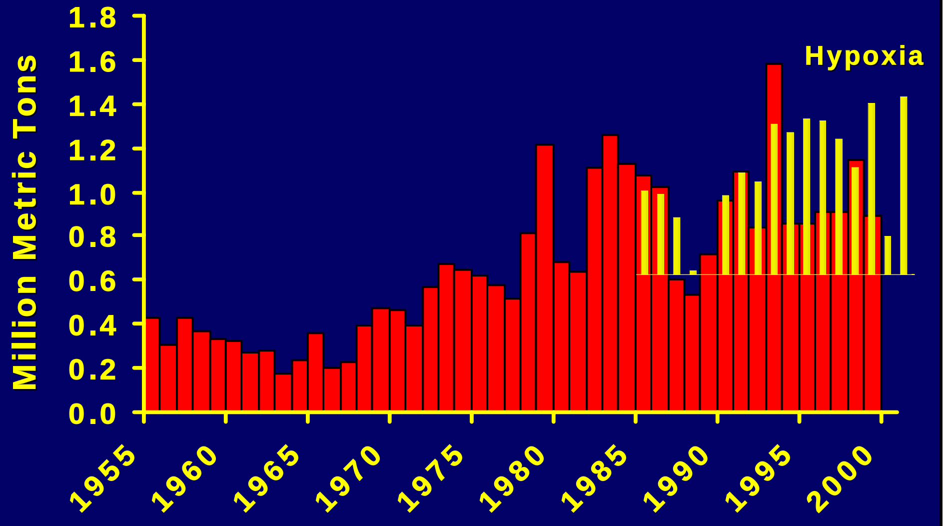
15% flow increase.

300% increase in Nitrate flux.

Potential Contributing Factors



Nitrate Flux to the Gulf



Goolsby, et al

Nitrogen loads

Where does it come from?

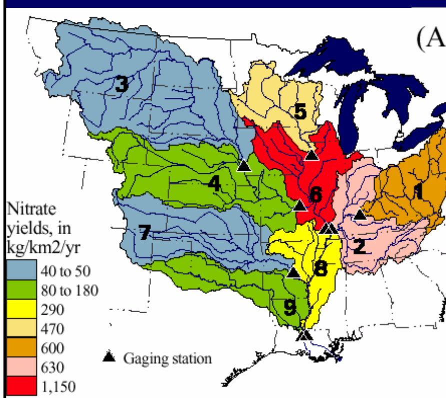
Effects of reducing it?

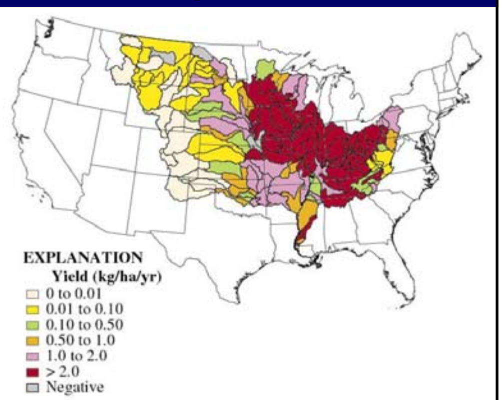
Means to reduce it?

Nitrogen Source Distribution

Nitrate Yields

TN Yields Delivered from Agriculture





Goolsby, et al

Alexander, et al

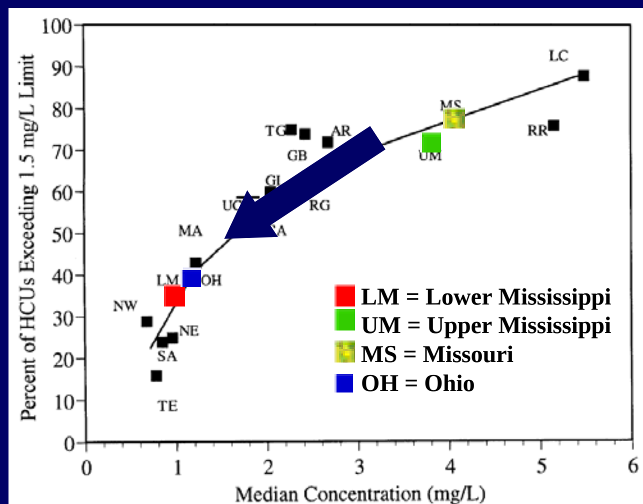
Summary of Causes

- 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

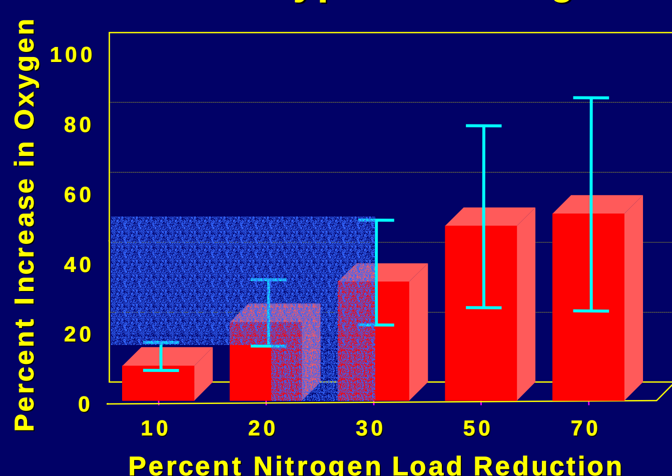
Stream Water Quality Changes



Brezonik et al.

Effects of Reduced N Loads

Gulf Hypoxia Changes



Bierman et al.

Two key ways to reduce loads:

Decrease N loss from land

Increase Denitrification

Agricultural Non-Point Sources

	Nitrogen Reduction (1000 MT/yr)
Farm N management	900 - 1,400
Alt. crop systems	500
Tertiary treatment (point sources)	20

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

	Unit Cost $/kg N
Edge-of-Field Losses	
20%	0.88
40%	3.37
Reduce Fertilizer Use	
20%	0.69
45%	2.85
Wetlands	
1M acres	6.06
5M acres	8.90
Riparian buffers:	
19M acres	26.03
Coastal diversions	~6
Tertiary treatment	~40

Doering et al

Costs-effectiveness of Actions

	Unit Cost $/kg N	Net Cost $/kg N
Edge-of-Field Losses		
20%	0.88	→ 0.80
40%	3.37	3.25
Reduce Fertilizer Use		
20%	0.69	0.67
45%	2.85	2.81
Wetlands		
1M acres	6.06	- 2.19
5M acres	8.90	→ 1.00
Riparian buffers:		
19M acres	26.03	
Coastal diversions	~6	
Tertiary treatment	~40	

Doering et al

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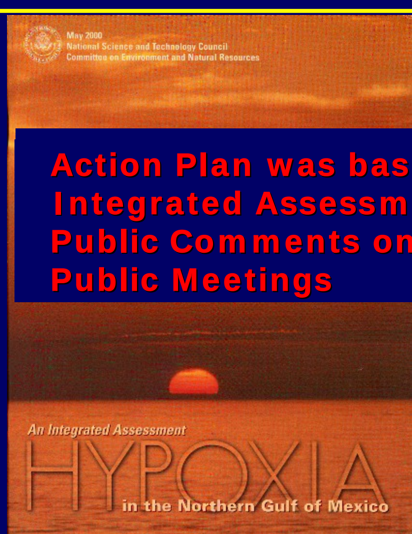
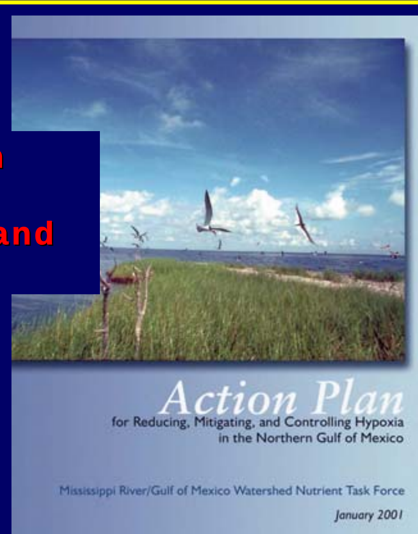


Action Plan was based on Integrated Assessment, Public Comments on IA, and Public Meetings



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)

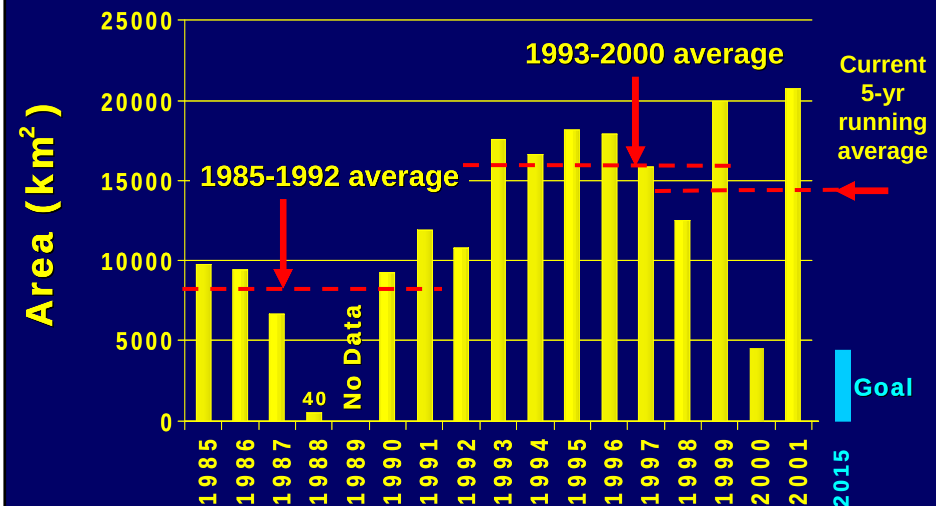
Gulf Action Plan: GOALS

Coastal. By 2015, reduce hypoxia below 5,000 km^2.

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

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

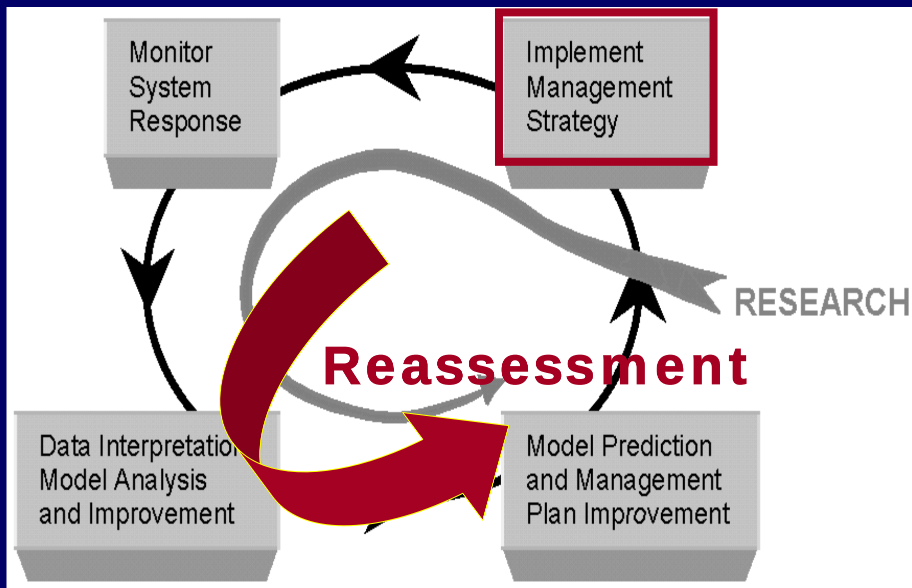
11. Reassessment:

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

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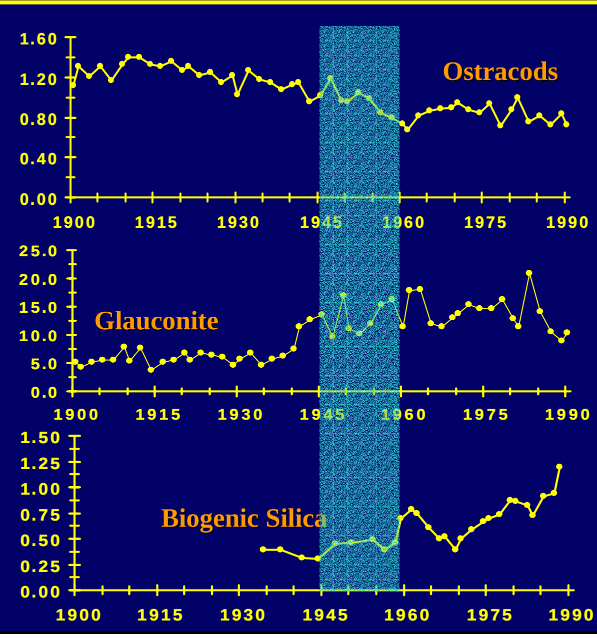
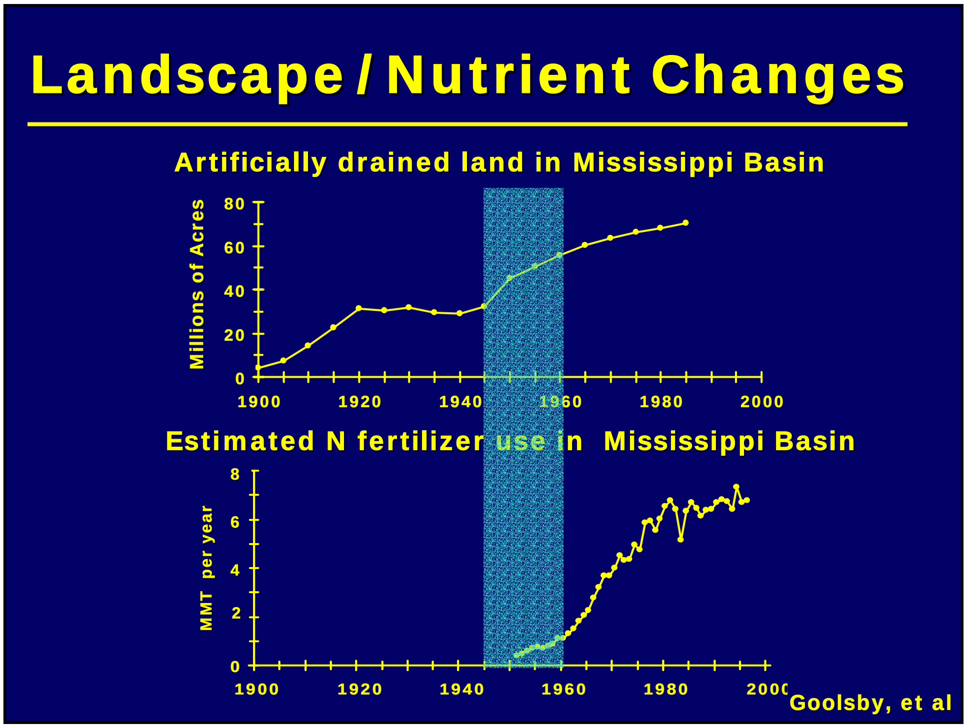
Long-term biological signals



Rabalais, et al


Landscape / Nutrient Changes
Artificially drained land in Mississippi Basin
Millions of Acres
80
60
40
20
0
1900
1920
1940
1960
1980
2000
Estimated N fertilizer use in Mississippi Basin
MMT per year
8
6
4
2
0
1900
1920
1940
1960
1980
2000
Goolsby, et al