Slide 1

Hypoxia in the Gulf of Mexico

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Slide 2

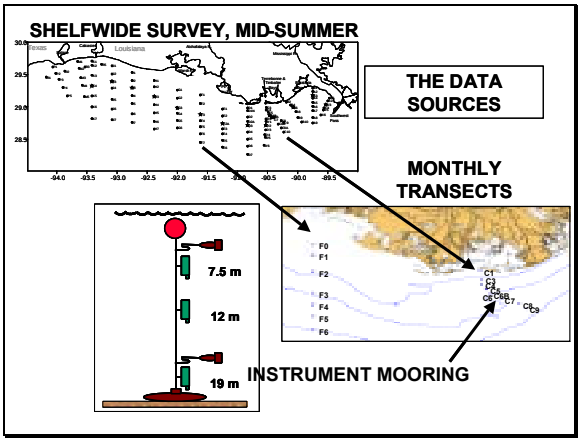
- Distribution and dynamics of hypoxia
- What are the proximal causes?
- What are the ultimate causes?
- What has changed over time?
- What are the consequences?
- What are the solutions?

Slide 3

Slide 4

Slide 5

Slide 6



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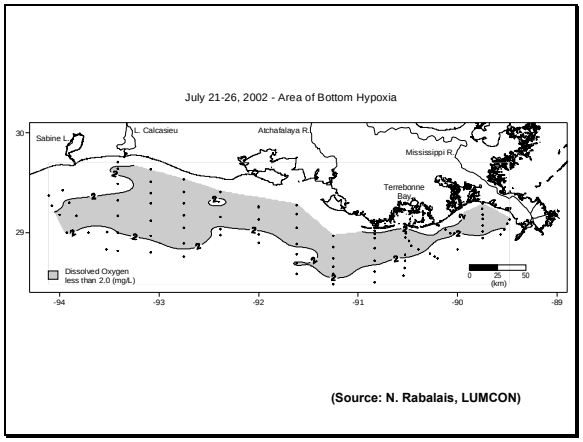
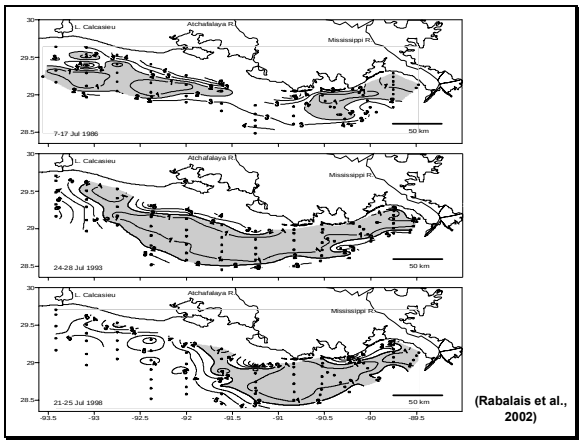


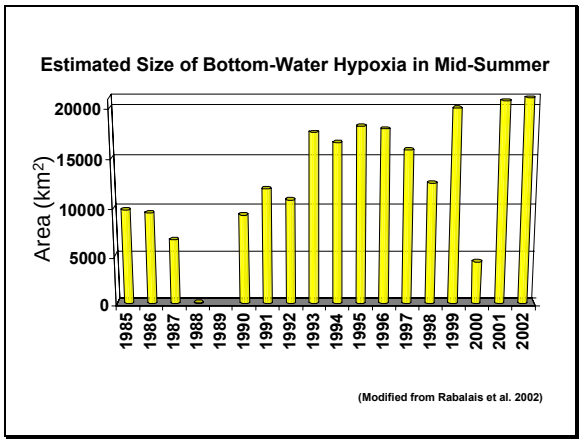
(Source: N. Rabalais, LUMCON)

Slide 8



(Rabalais et al., 2002)

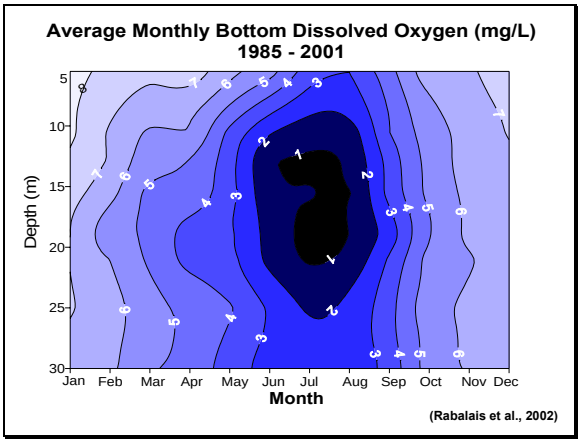
Slide 9



(Modified from Rabalais et al. 2002)

Slide 10

Slide 11



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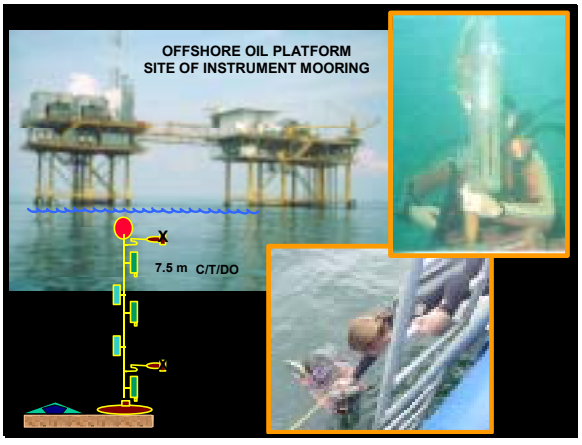

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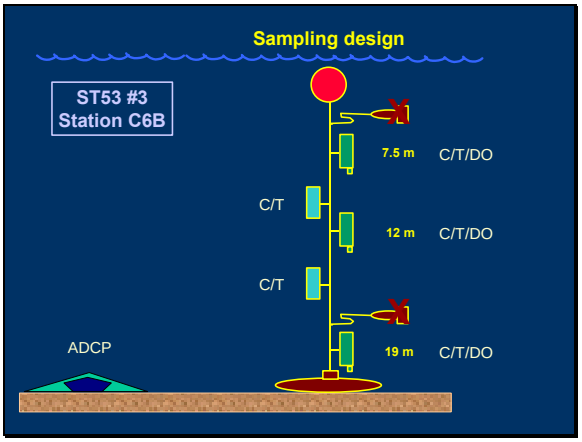

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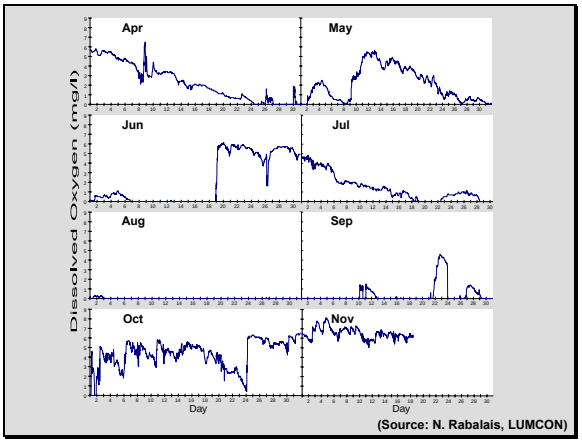

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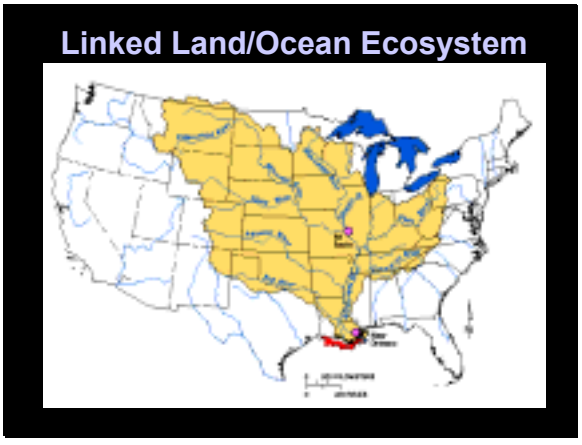

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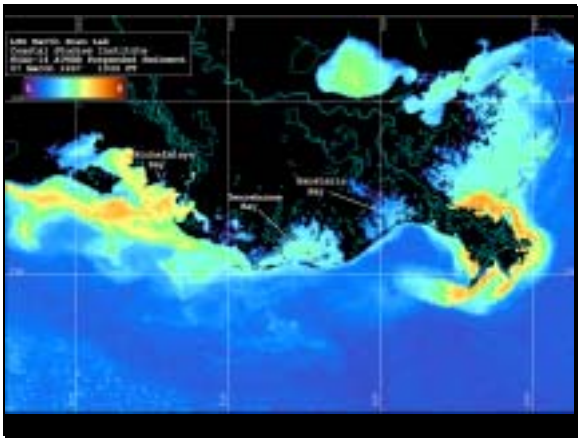

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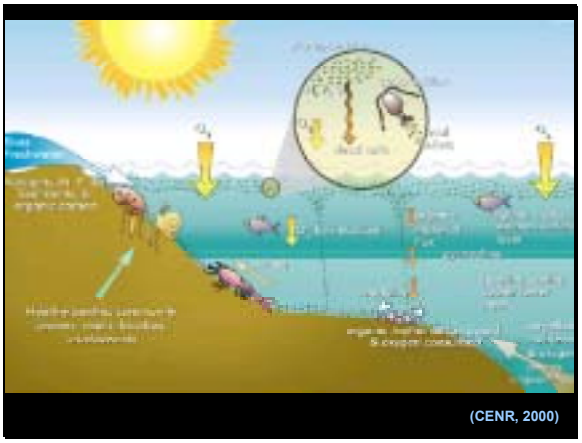

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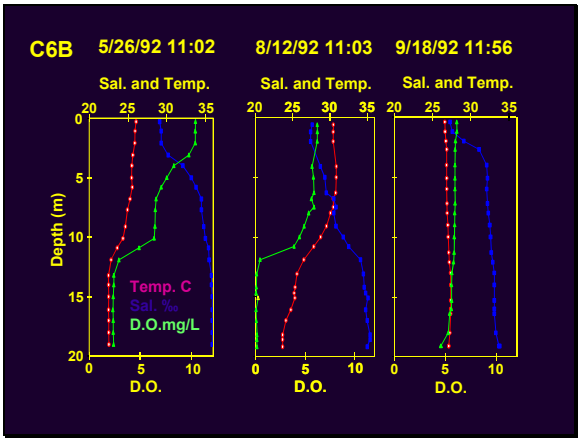
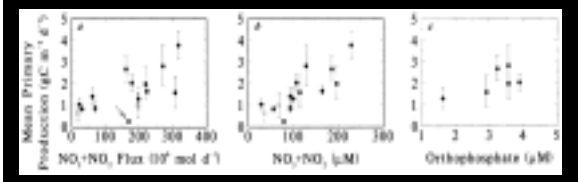


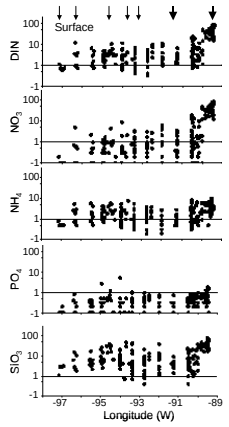
Slide 19

Nitrogen, phosphorus (and silica) are essential for the growth of phytoplankton. Most often, however, problems with an overabundance of nutrients in marine systems are the result of excess nitrogen rather than phosphorus.



(Lohrenz et al., 1997)

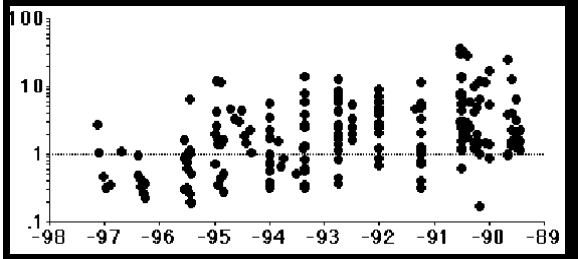
Slide 20



(Rabalais et al., 2002)

Slide 21

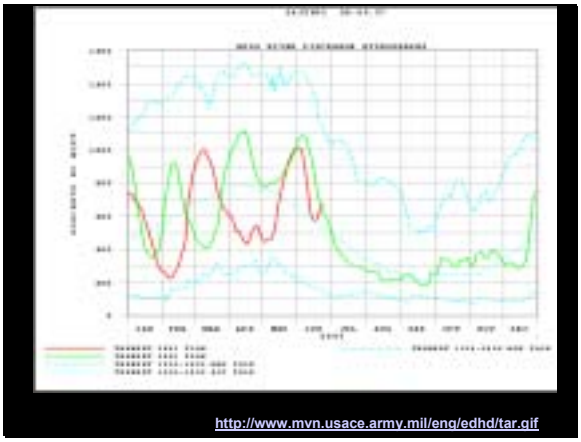
Surface Chlorophyll a (µg/l)



Longitude (W)

(Rabalais et al., 2002)

Slide 22



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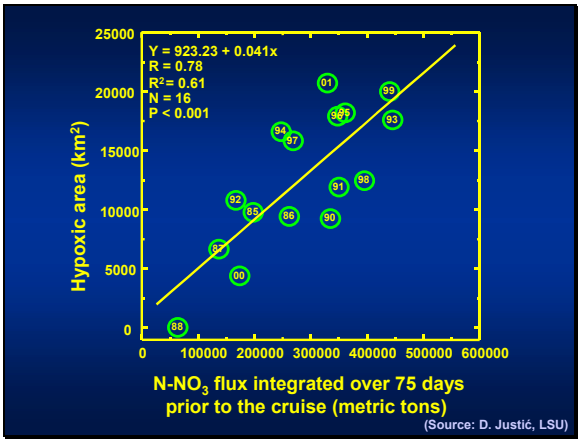

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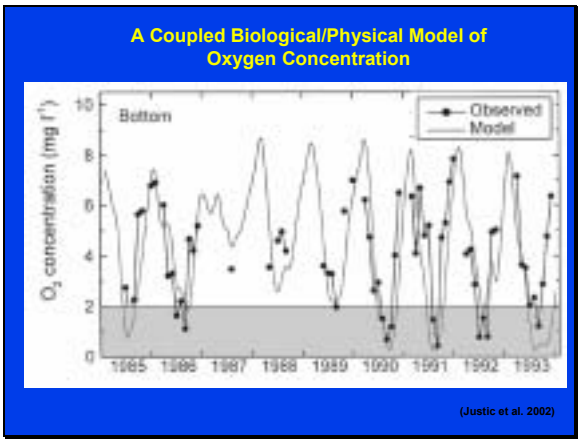
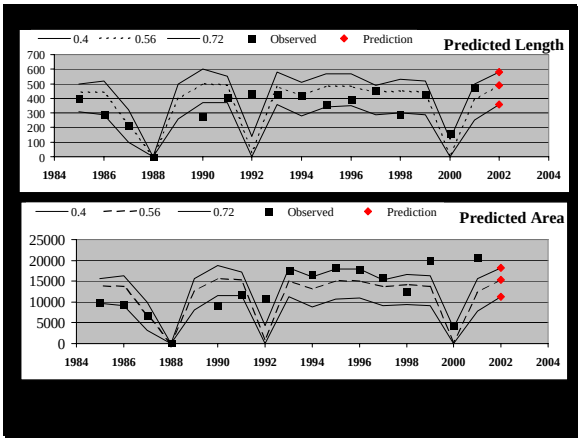


Hindcast shows beginning in the late 1970s

Slide 25



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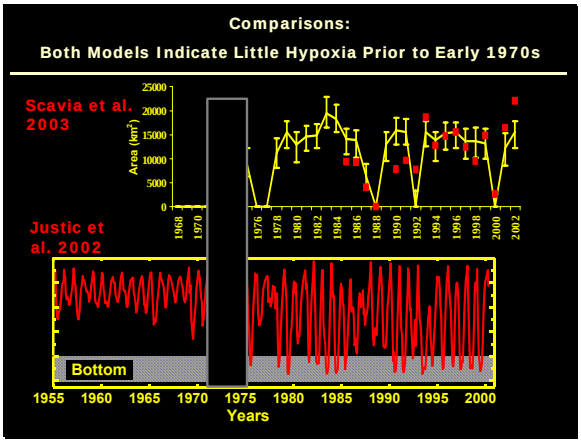

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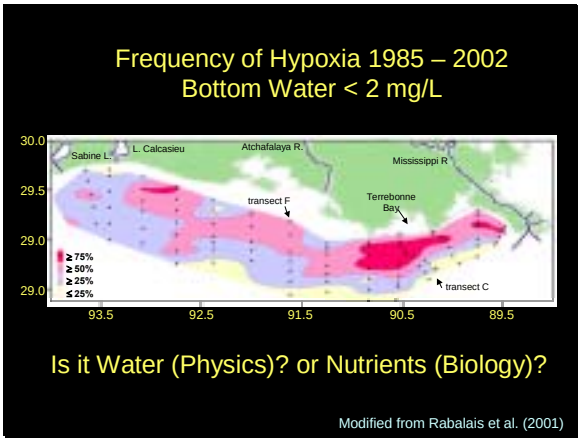


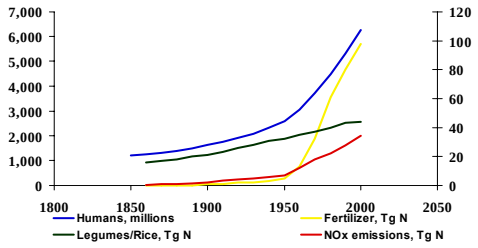
Slide 28

There are clear signals that humans have altered the global cycles of nitrogen and phosphorus over large regions and increased the mobility and availability of these nutrients to marine ecosystems.

Slide 29

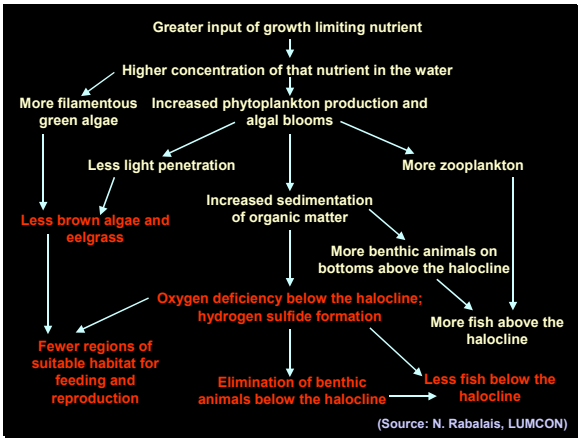
N Fixation:

Fertilizer & Legumes & Fossil Fuels



(Galloway et al. 2002)

Slide 30



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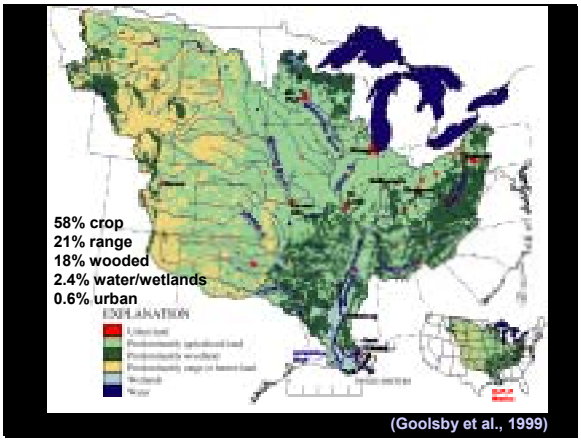
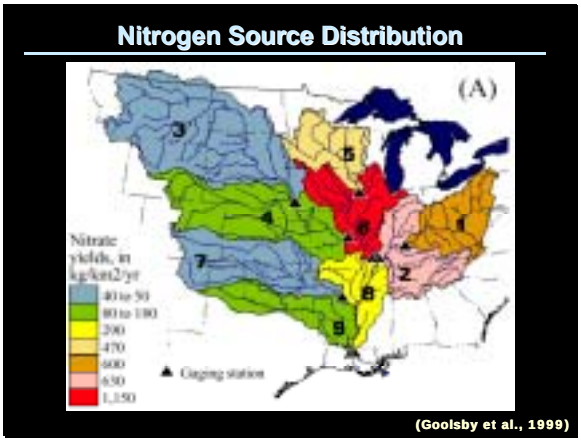


Slide 32

Nutrient concentrations and loads changed dramatically in the last half of the 20th century

- Riverine N and P tripled and doubled
- Spring nitrate peak now present
- Changes closely related to N and P fertilizer applications in watershed
- Offshore nutrient compositions shifted
- Water quality changes in nutrients, primarily, less in flow or delivery of flow

Slide 33



Wok of Don Goolsby and his team.

Used USGS stream gage network and calculated Nitrate flux at a particular station – divided by the area of it's watershed.

Nitrate Yield to be able to compare among different size watersheds

Highest Yields are from Illinois, Iowa, Indiana, southern Minnesota, and Ohio.

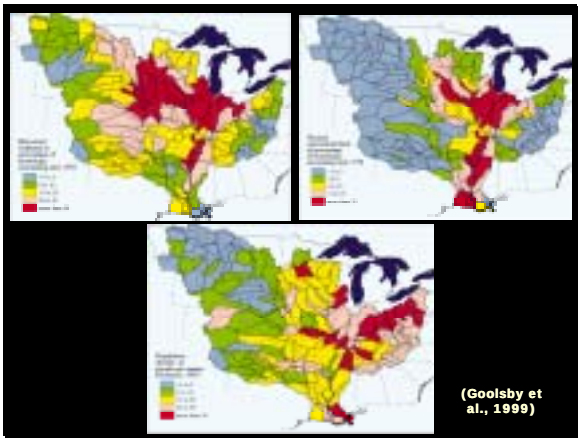
What's going on in those watersheds?

CLICK

This is the primary area of lands drained for agricultural use. Goolsby's team looked at the relationships between yield and human activities across 32 sub-basins (at a finer scale than these 9).

Next Slide shows the key results.

Slide 34



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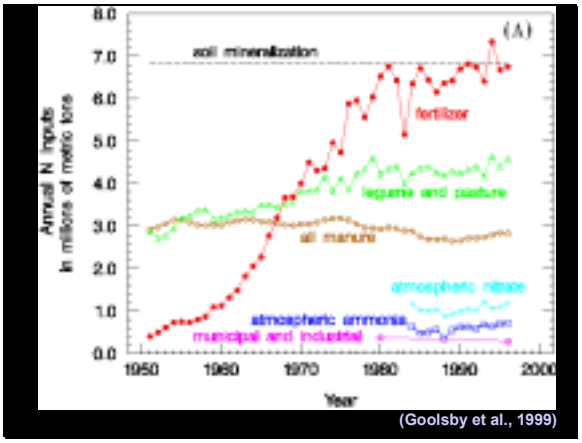

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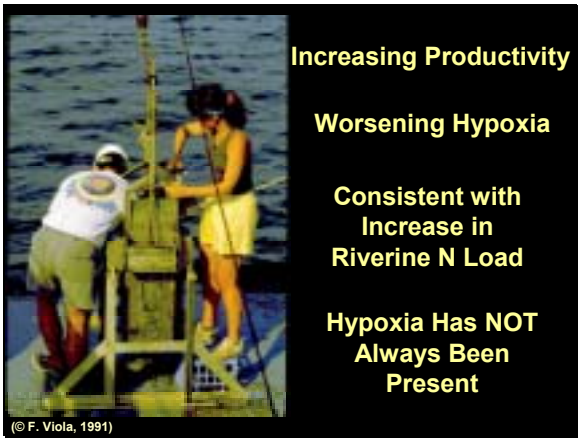
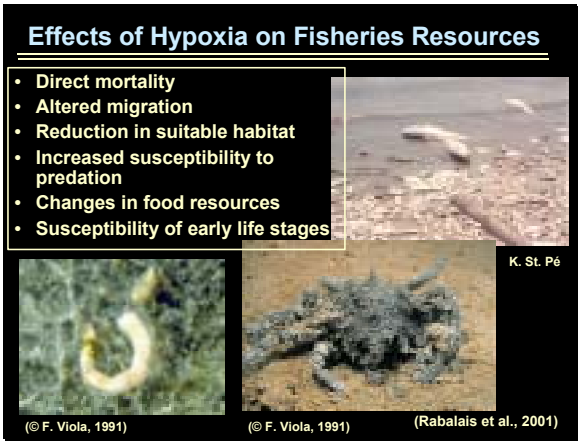


Slide 37

Slide 38



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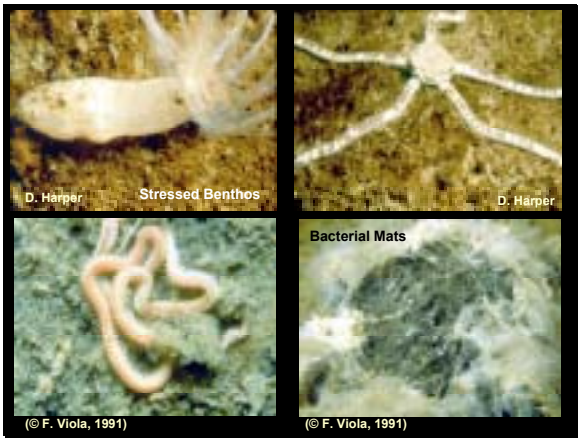
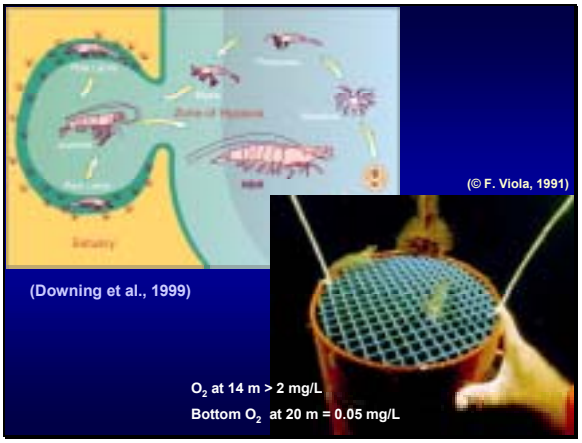
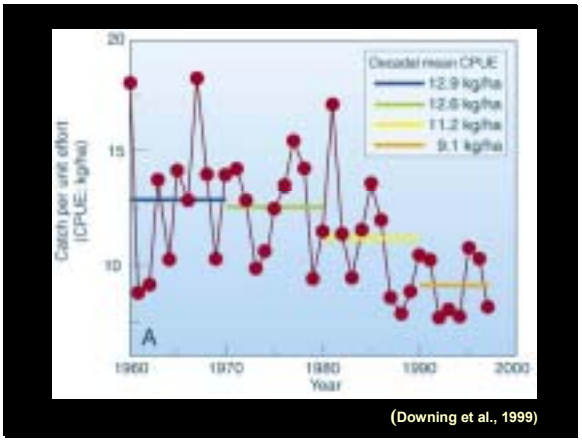


Slide 40

Slide 41



Slide 42



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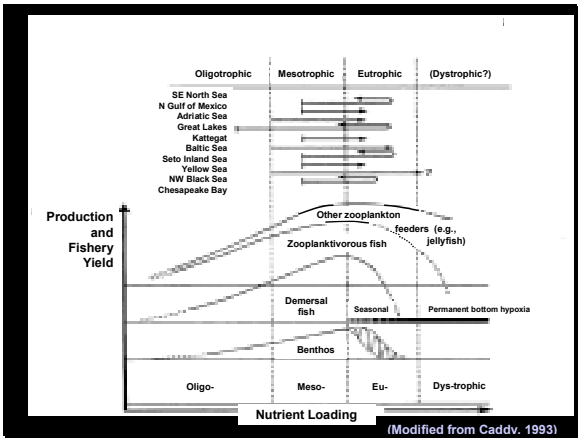


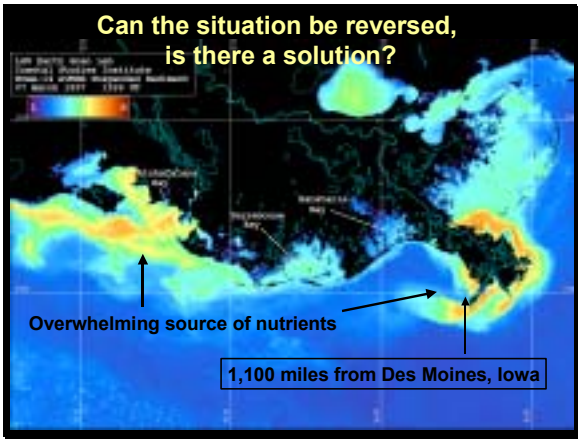
WHY DO WE CARE!
More nutrients – more primary production – more fish

CLICK
To a point. DESCRIBE THE GRAPH

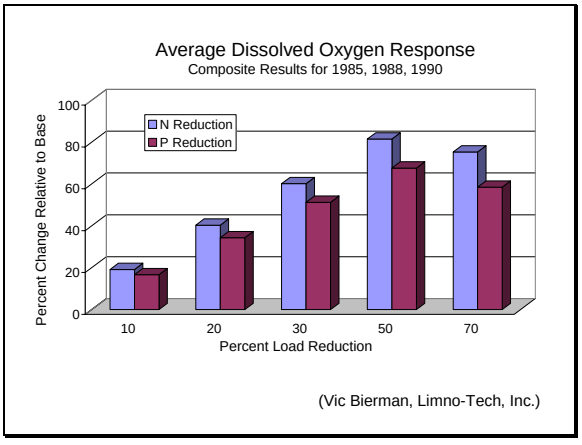
Seasonal hypoxia begins to effect benthic community and demersal fish because of lost of favored habitat
this can (and has) led to collapsed fisheries.

$64,000 question – where is the Gulf on this curve?

Slide 44



Slide 45



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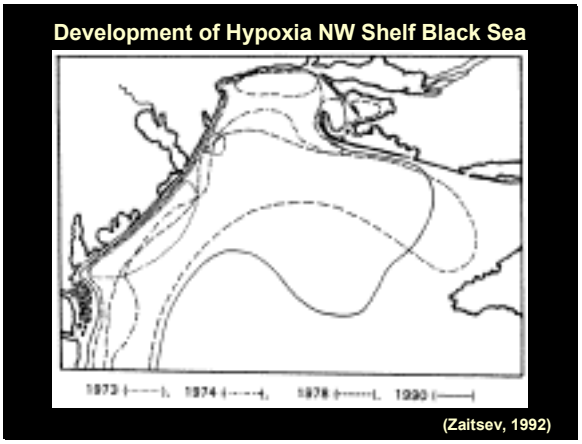

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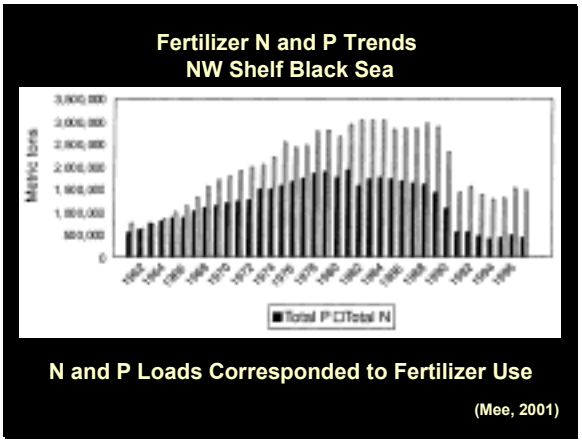

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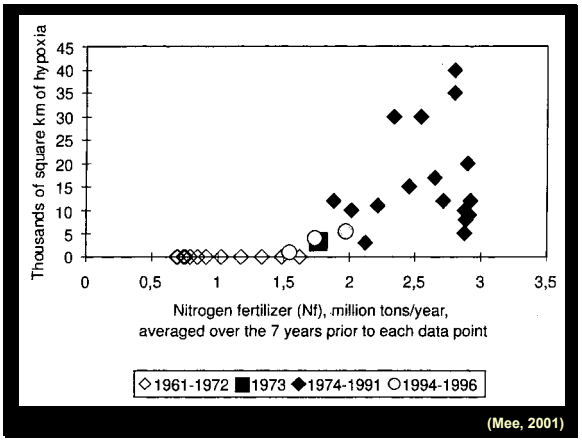

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Slide 50

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.**

- Aim to achieve a 30% reduction in N discharge to the Gulf, 5-yr running average
- Voluntary actions, incentives, education

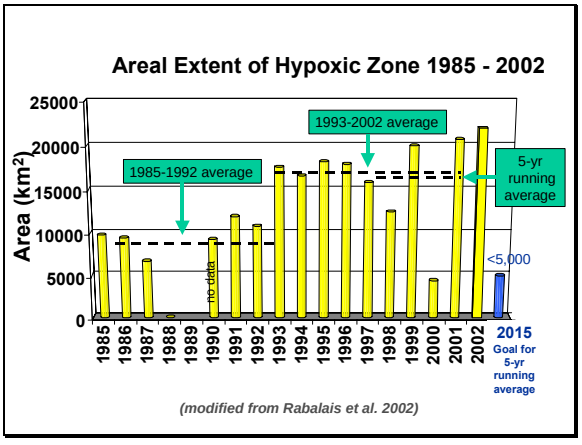
COASTAL.
By 2015, reduce hypoxia below 5,000 km^2.
DOWN FROM 15,000.

Best science indicates that to get there will require about a
30% reduction in N load to the Gulf

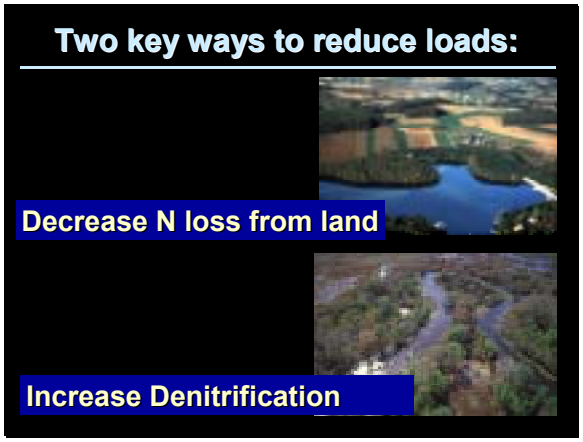
BASIN.
Restore and protect the waters of Basin States and Tribes.

COMMUNITIES.
Improve social and economic conditions in the Basin.

Slide 51



Slide 52



When all is said and done, there are two key ways to reduce loads to surface waters.

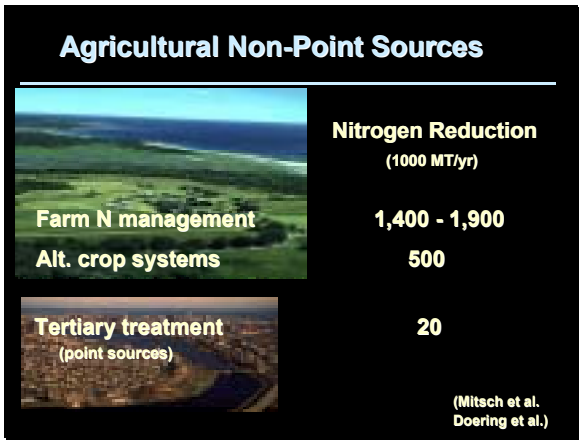
CLICK

Decrease loss from the land – primarily agricultural, non-point sources

CLICK

Increase Denitrification. – a very important natural process that removes N from the biosphere.

Slide 53



CLICK
Mitsch and Doering estimated these N loss savngs:

FARM N MANAGEMENT would save 900,000 to 1.4 Million metric tons per year
reduction in "insurance" rates of N fertilizer application,
improved manure management,
accounting for non-fertilizer nitrogen,
when calculating application rates

CROPPING SYSTEMS – perennial instead of corn and soybeans rotation on about 10% of acreage – would save about 500,000 metric tons per year.

CLICK
For comparison, if municipal treatment plants went to tertiary treatment – that would yield about 20,000 Metric tons per year.

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Increasing Denitrification

•	Nitrogen Reduction (1,000 MT/yr)
• Wetlands	300
• Riparian Buffers	300
• Coastal Diversion	50

(Mitsch et al.)

Bill Mitsch's team estimated that

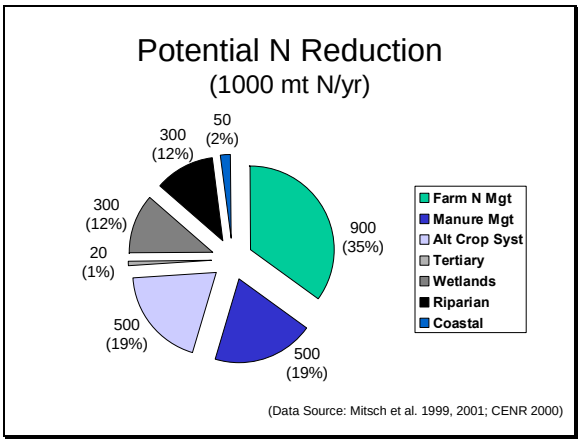
Creating and Restoring 5 Million acres of wetland will remove 300,000 Metric Tons per year.
NOTE: that is 0.7 % of the basin.

It would take 19 million acres of Riparian Buffers to remove the same amount.

They also estimated that diverting 13% of the river flow over 1.2 M acres of coastal LA would remove 50,000 metric tons per year

AND help rebuilt coastal wetlands.

Slide 55



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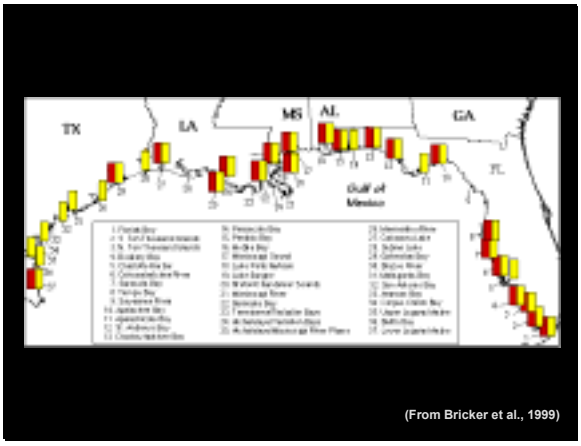

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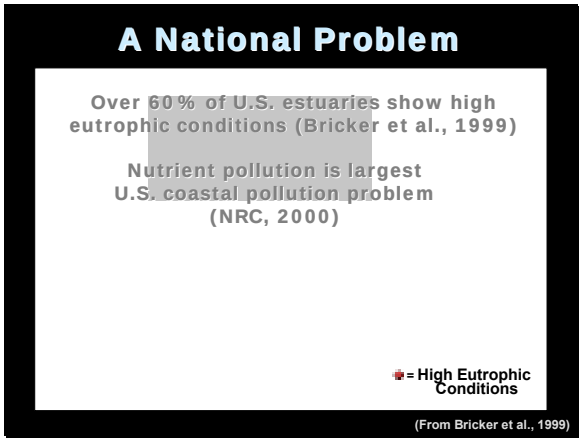


I want to close on a National Scale note.

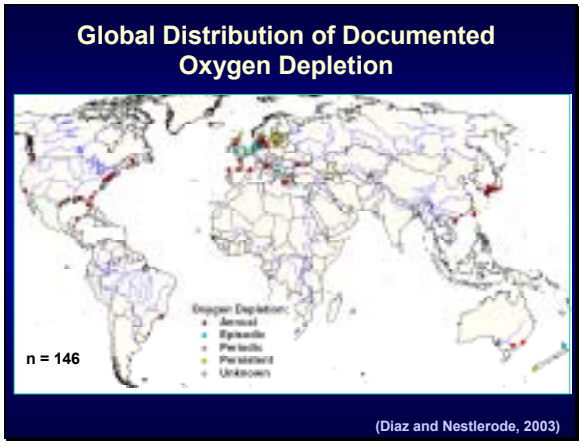
While many people are aware of nutrient pollution issues in the Chesapeake Bay, and now in the Gulf of Mexico, a recent NOAA report indicated that over 60% of our estuaries experience serious symptoms of eutrophication, including hypoxia.

GLICK

And the National Research Council, in their recent report – Clean Coastal Waters – state that Nutrient Pollution is the largest coastal pollution problem in the United States.

The problems in many of these places are similar and many of the solutions are comparable.

Slide 58



Slide 59

Hypoxia, Then & Now

44 (Diaz and Rosenberg, 1995)
50 (Science, 1998)
57 (Diaz and Rosenberg, 2000)
114 (Diaz, 2001)
146 (Diaz and Nestlerode, 2003)

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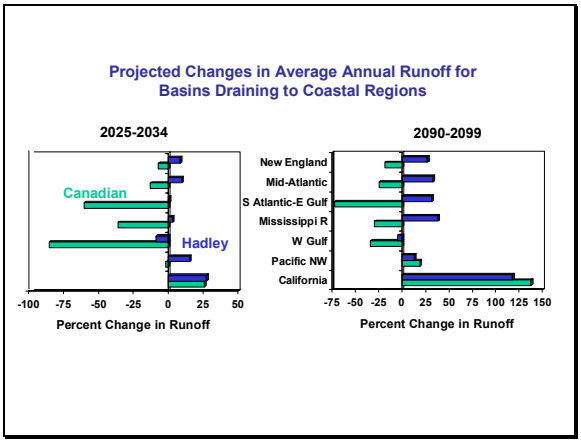

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- What do you predict with regard to distribution and severity of hypoxia, in the Gulf and elsewhere, with?
  - warming climate
  - doubled CO_2 atmospheric concentration
  - changes in freshwater inflow
  - frequency and severity of storms?
- How will fishery resources change?