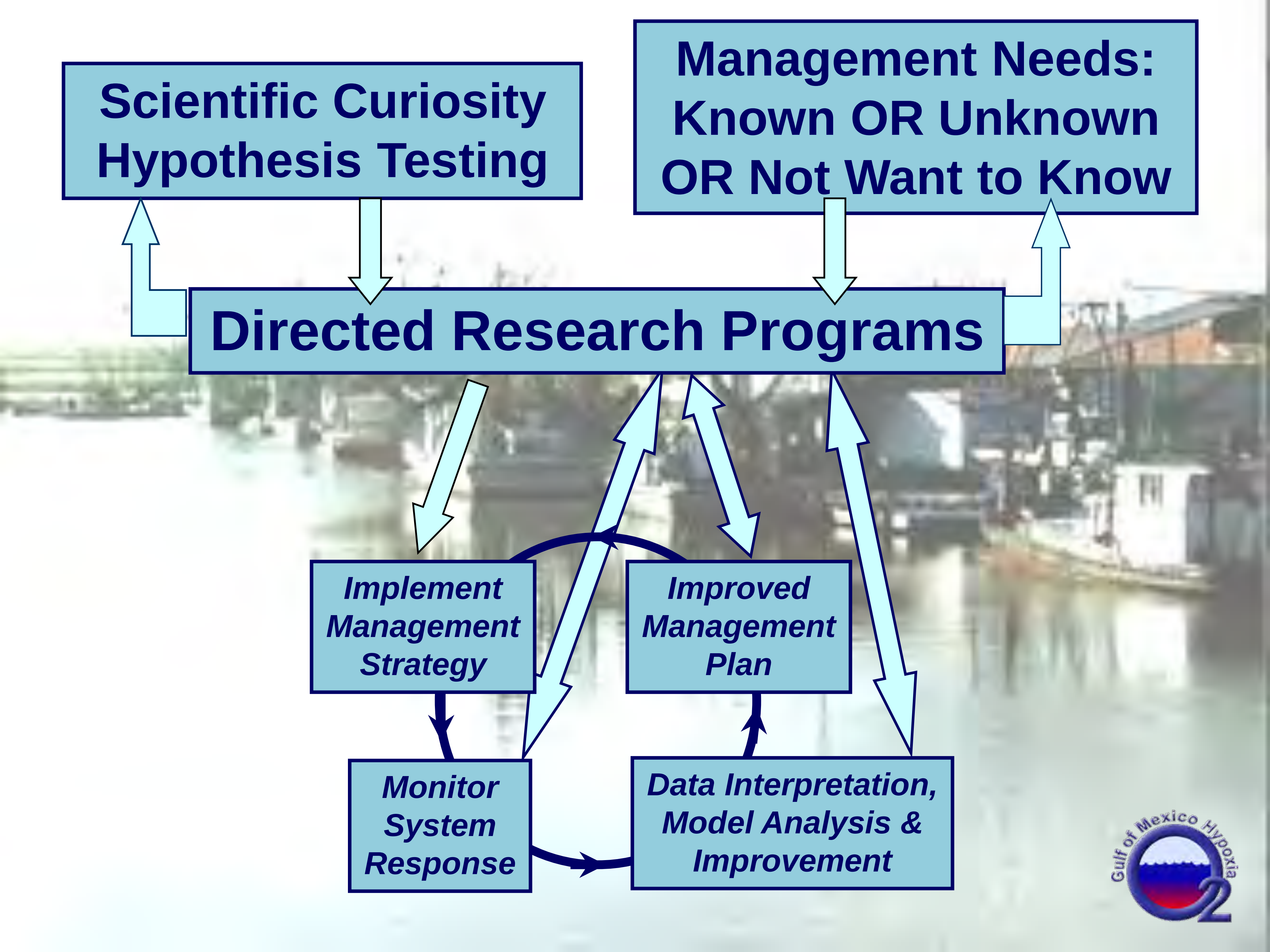
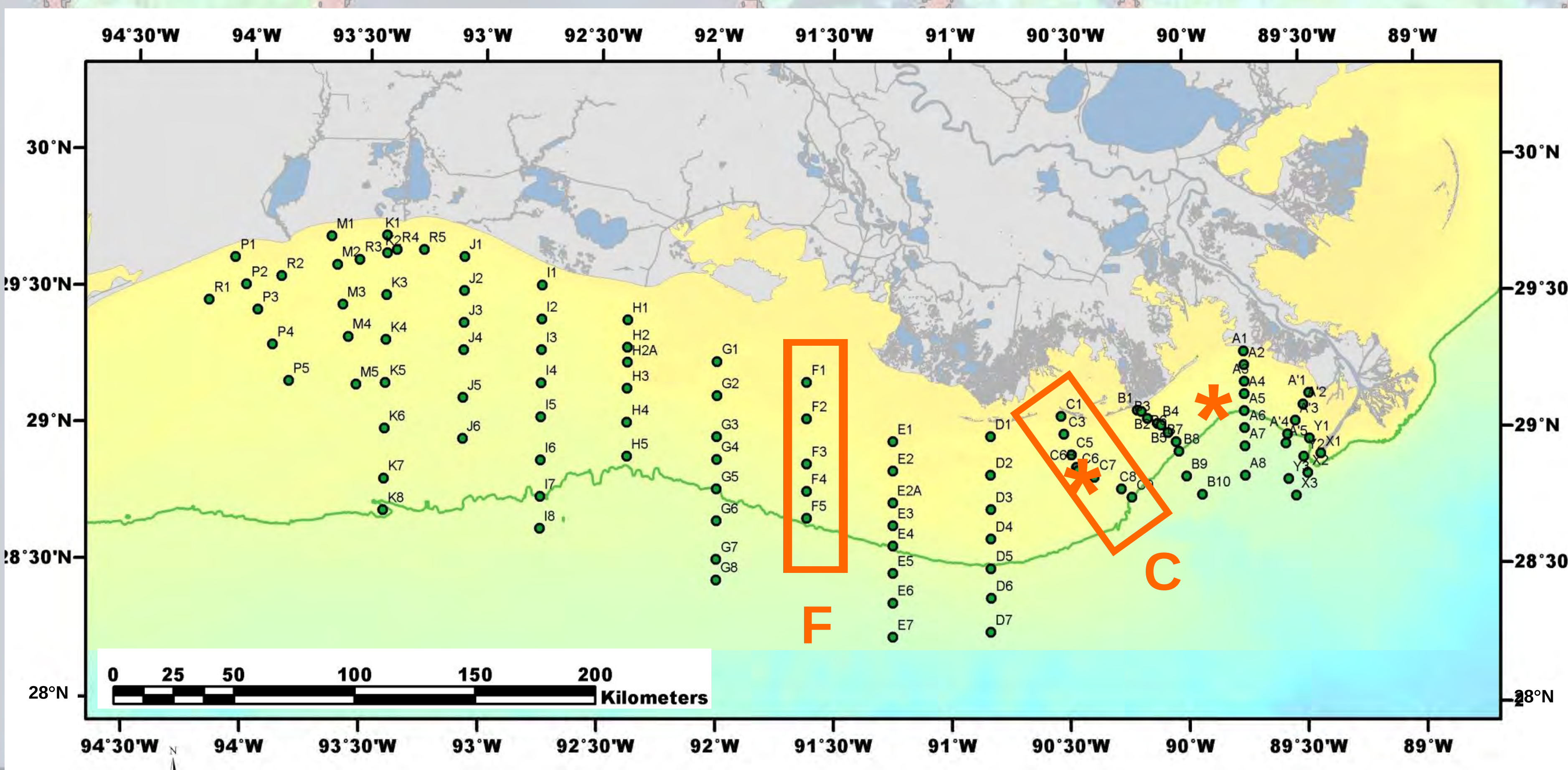
Science of the Causes of Hypoxia

Nancy Rabalais et al.

In support of overview of diversions and hypoxia, and context for refining science needs; July 14, 2014


Scientific Curiosity
Hypothesis Testing
Management Needs:
Known OR Unknown
OR Not Want to Know
Directed Research Programs
Implement Management Strategy
Improved Management Plan
Monitor System Response
Data Interpretation, Model Analysis & Improvement
Gulf of Mexico Hypoxia
O2

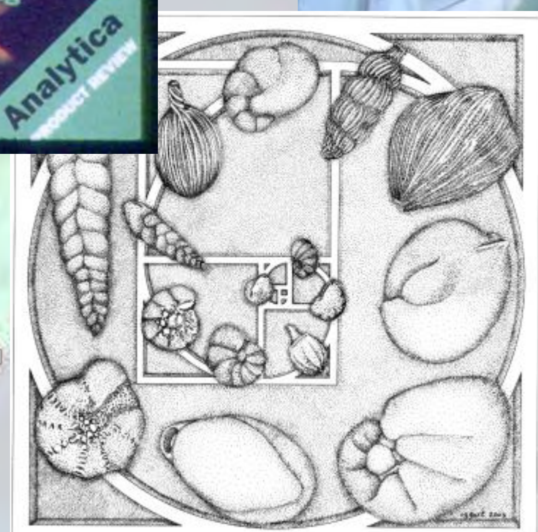
- **Mid-summer shelfwide**
- **Monthly/bimonthly along transects C & F**
- **Deployed oxygen meters**

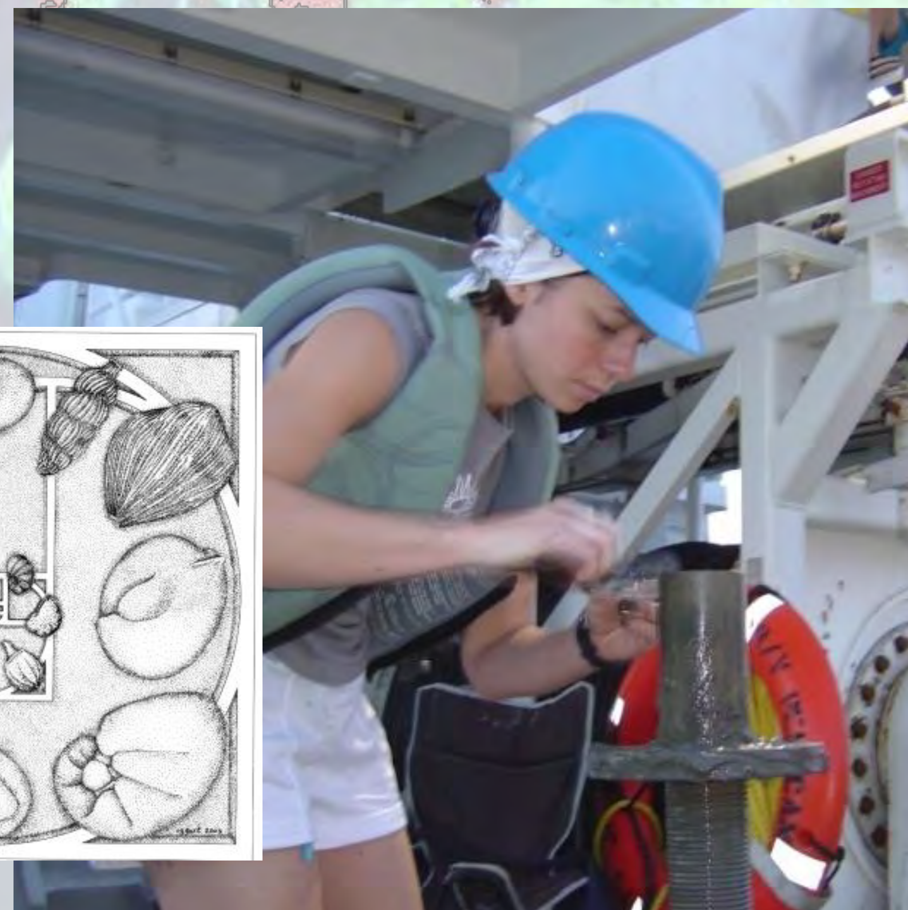


Important Factors for Hypoxia	Unimportant (or Minimal) Factors for Hypoxia
• Stratification • Currents • Winds, waves • Nutrient-enhanced primary production • High flux of surface carbon to the seabed • Oxygen consumption exceeds oxygen resupply • Directly proportional to N load • N+P is most limiting, N alone more than P alone	• Deep-water oxygen minimum layer • Allochthonous river carbon • Ground water • Wetland erosion • Estuarine nutrients • Mississippi River mainstem and deltaic levees • Reduced suspended sediments • Upwelled nutrients • Climate (not as yet)

(Source: N. N. Rabalais, LUMCON)

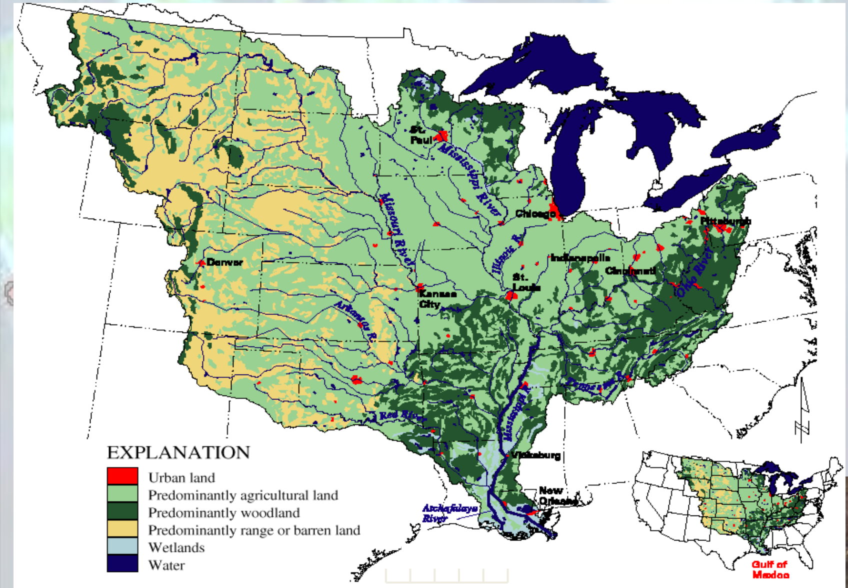
Coastal hypoxia is **NOT** natural and began to appear mostly after the 1950s

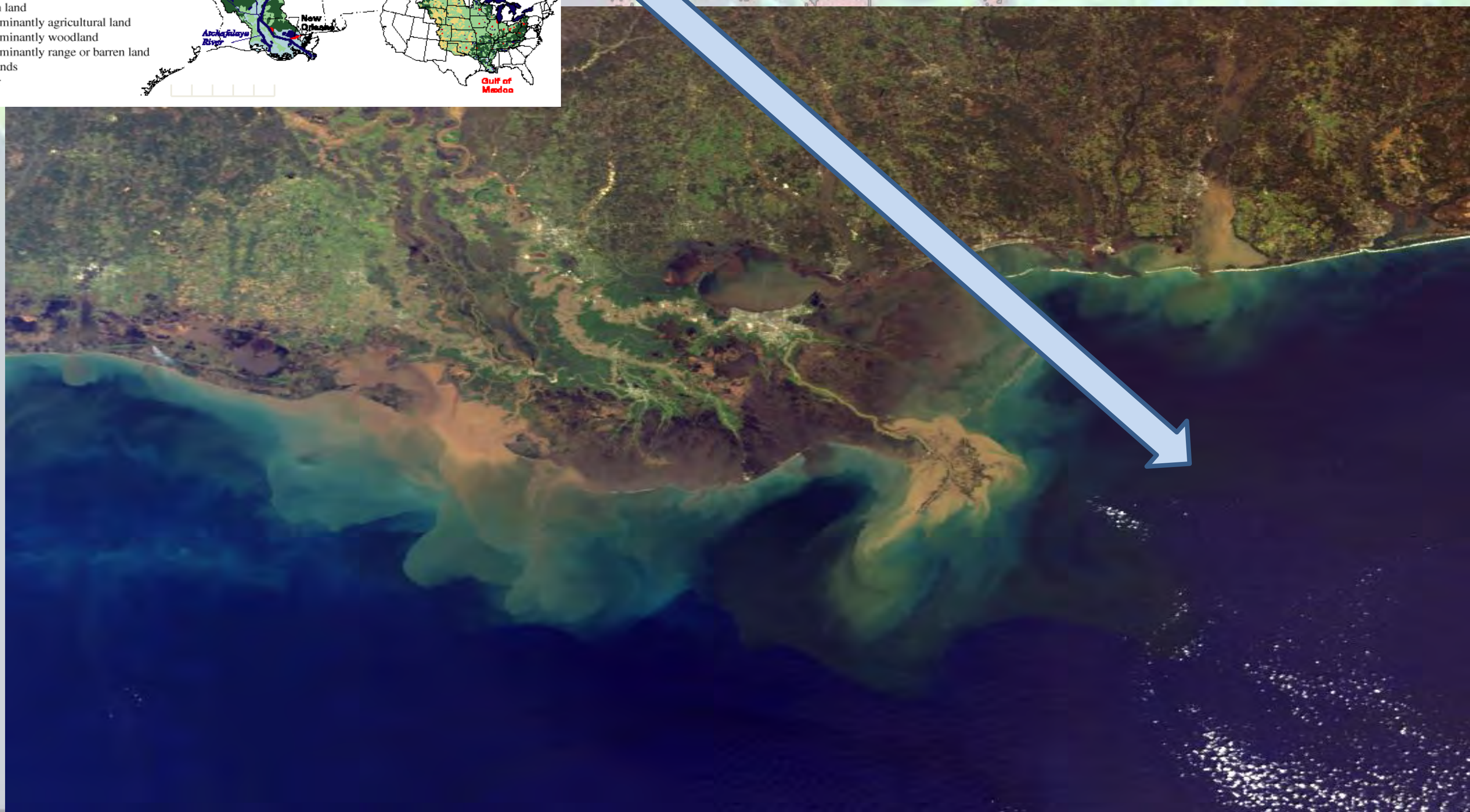




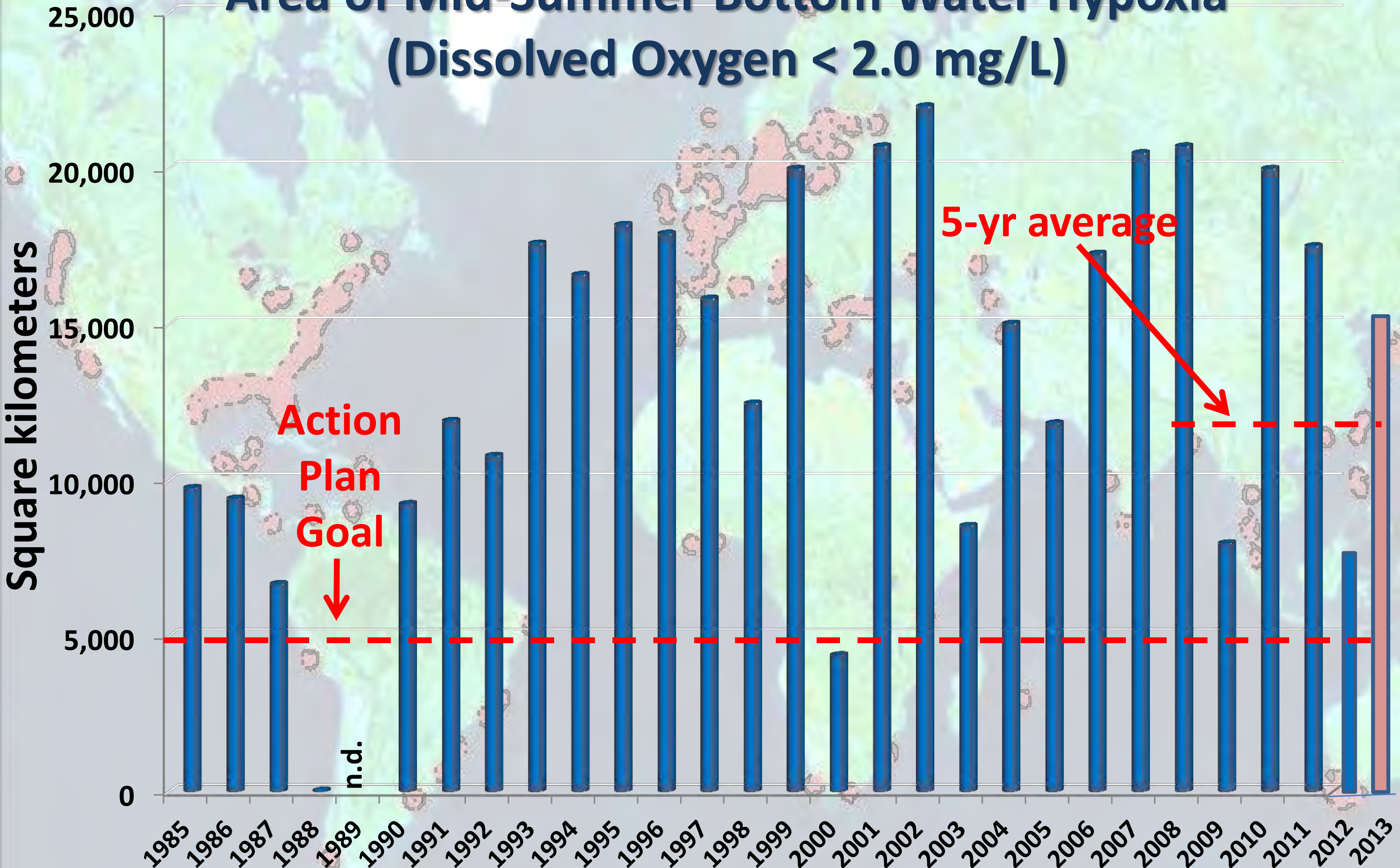
Gulf of Mexico Hypoxia O2

Linked Land, River, Ocean Ecosystem



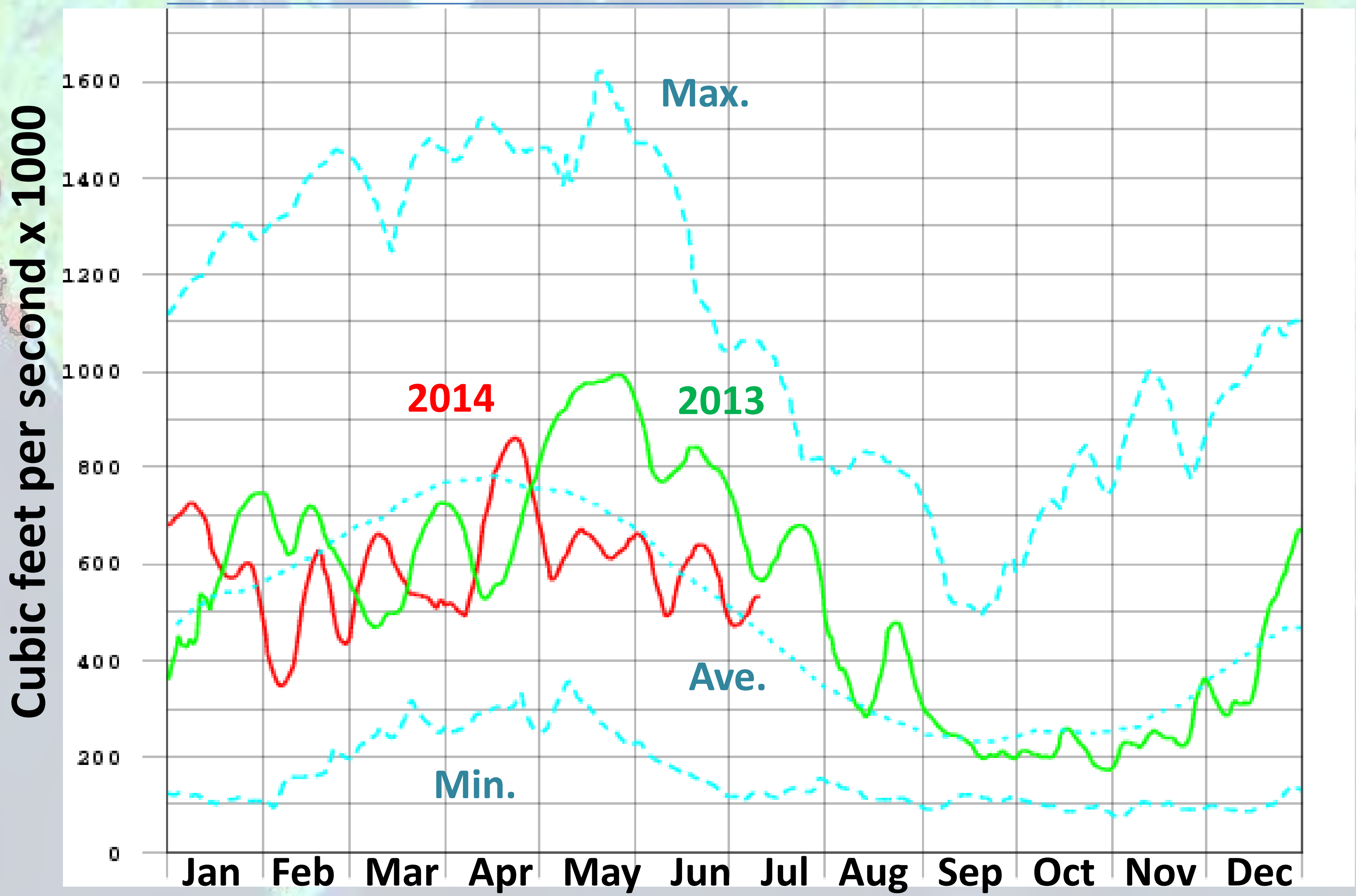


Area of Mid-Summer Bottom Water Hypoxia (Dissolved Oxygen < 2.0 mg/L)



Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University
Funded by: NOAA, Center for Sponsored Coastal Ocean Research

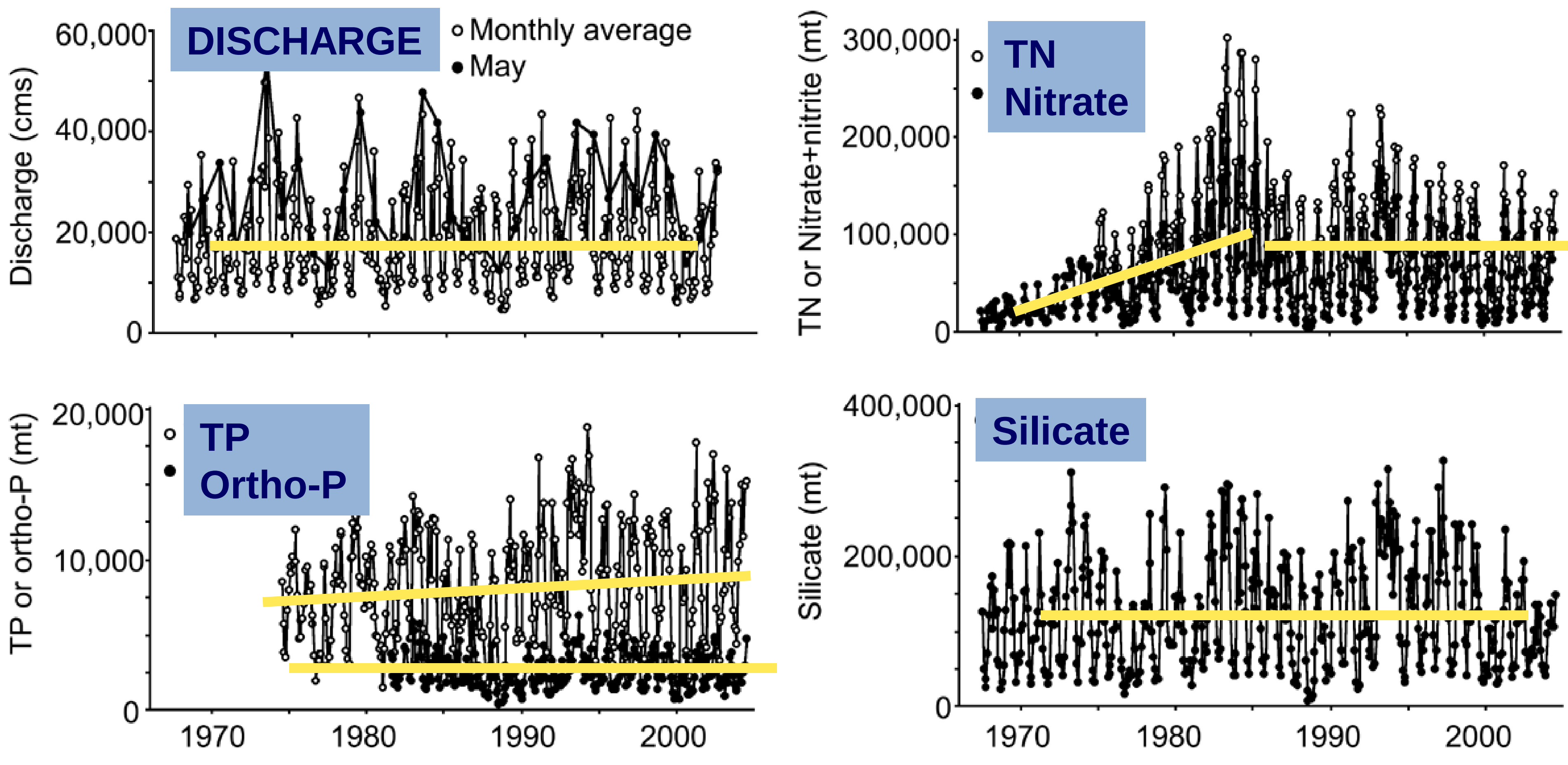
Mississippi River Discharge at Tarbert Landing, 1935-July 2014



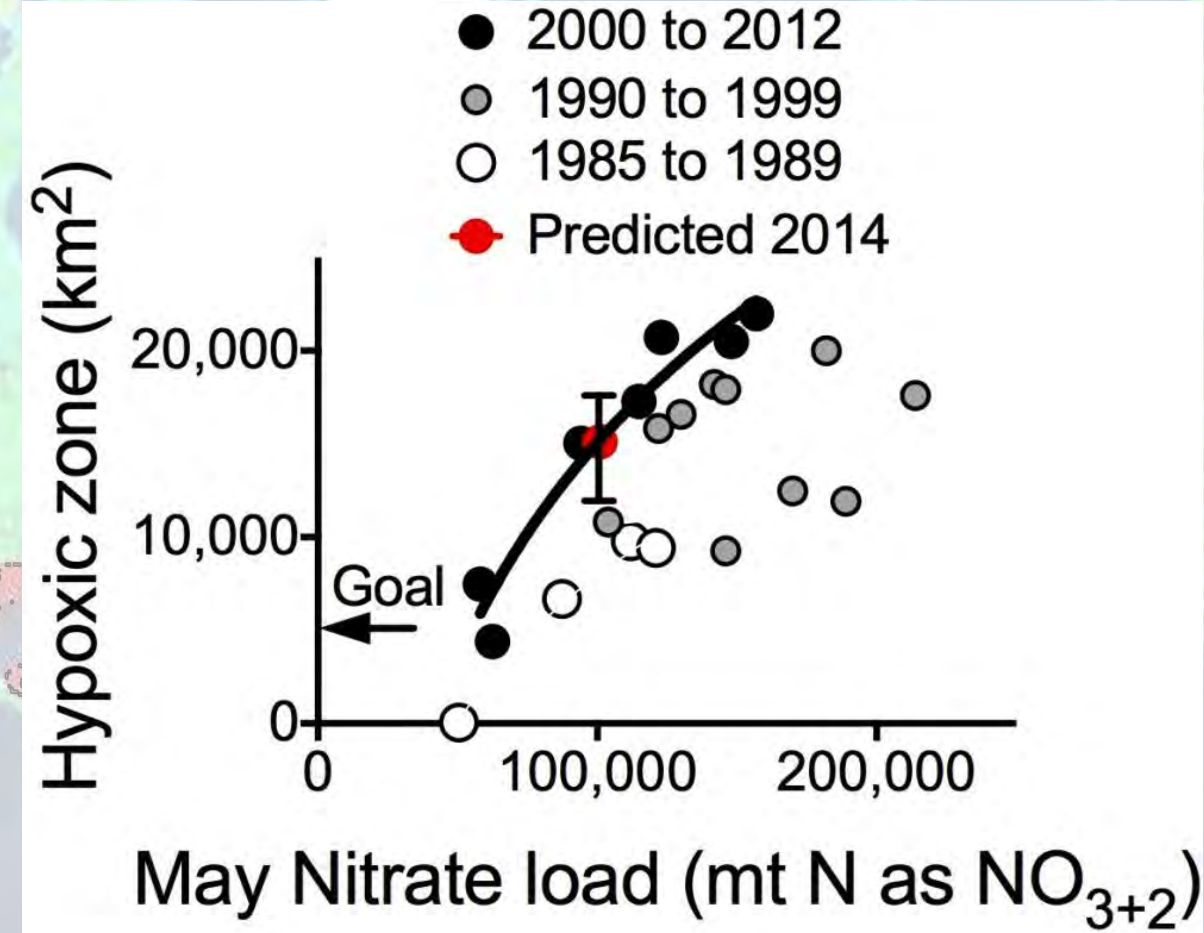
http://rivergages.mvr.usace.army.mil/WaterControl/Districts/MVN/tar.gif

300% increase in N load

80% due to NO_3^- concentration ↑
20% due to discharge ↑



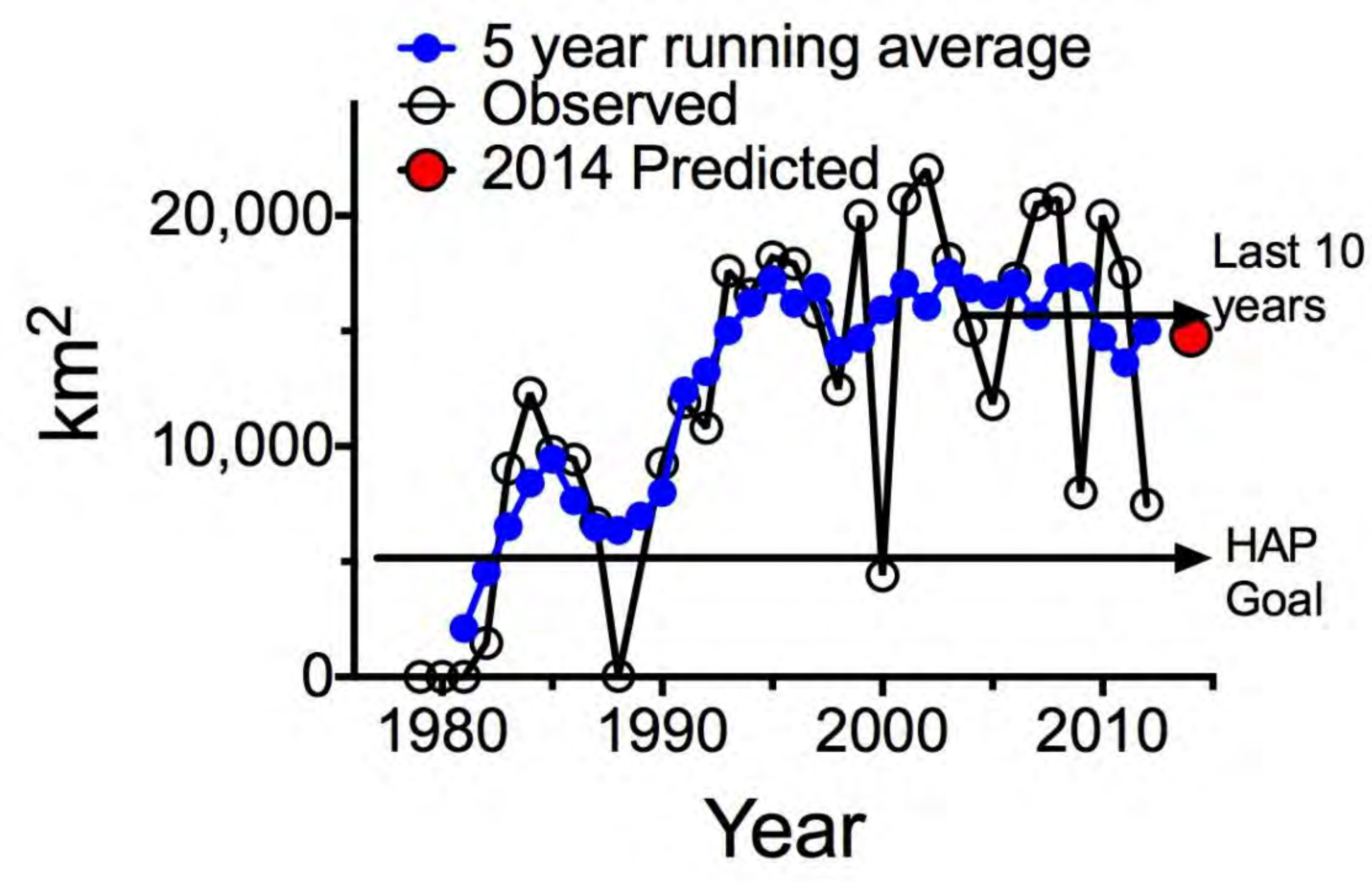
Turner et al. 2007



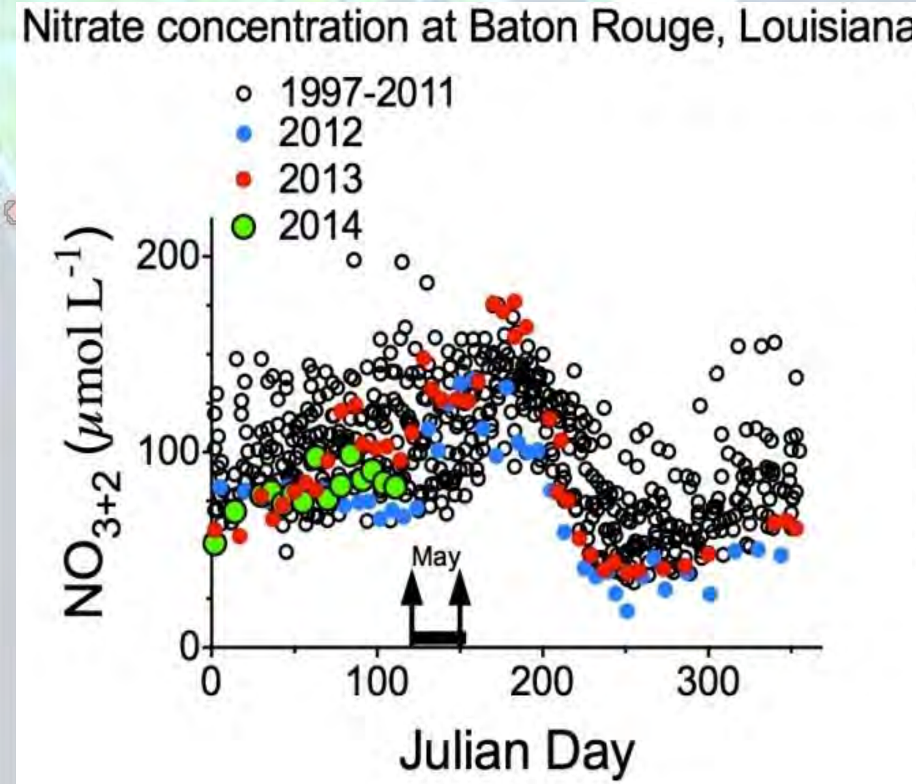
Modified from Turner et al. 2012

The relationship between nitrate+nitrate loading in May and the size of the hypoxic zones from 1985 to 2012. The 2014 predicted size is indicated with the red dot (with a 95% confidence interval.)

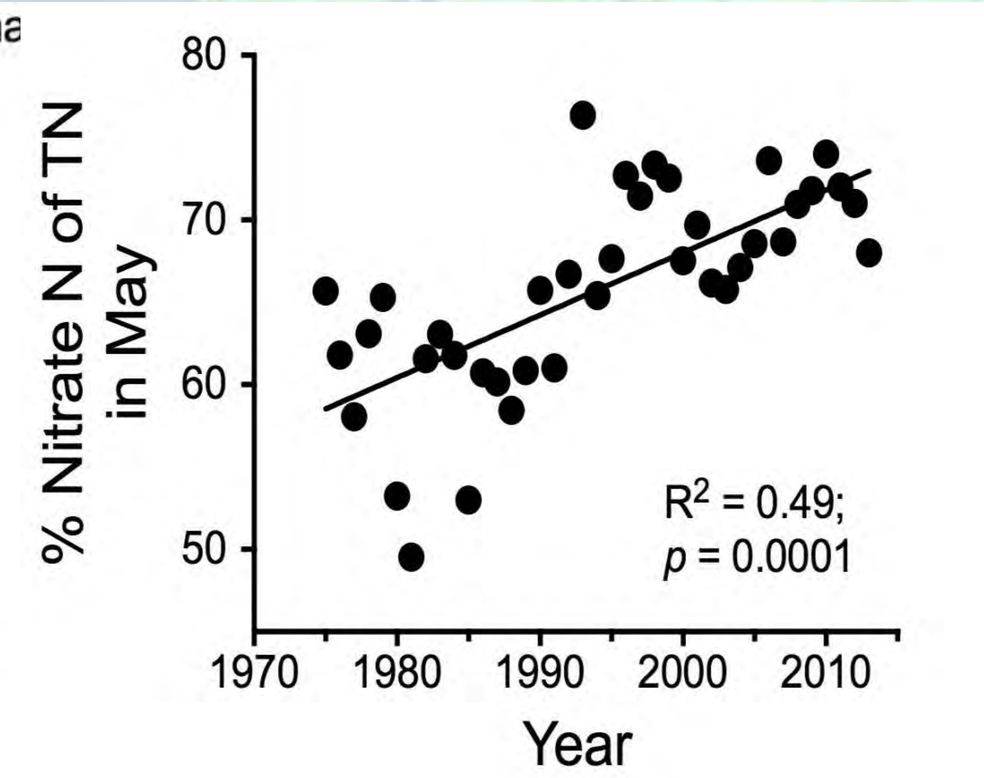
A area of bottom-water hypoxia is much larger now than historically at the same NO_{3+2} loading. Mitigating high nutrient loads will be more difficult now than in the past.



Turner and Rabalais, 2014 Hypoxia Forecast



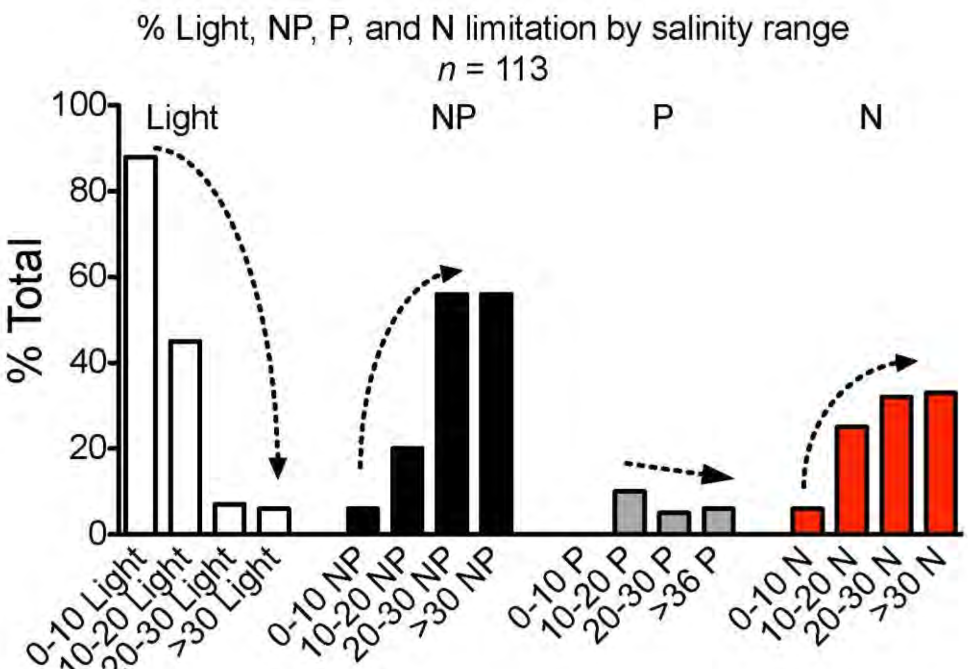
The concentration of nitrite+nitrate (NO2+3) at Baton Rouge, La from 1997 to May 2014.



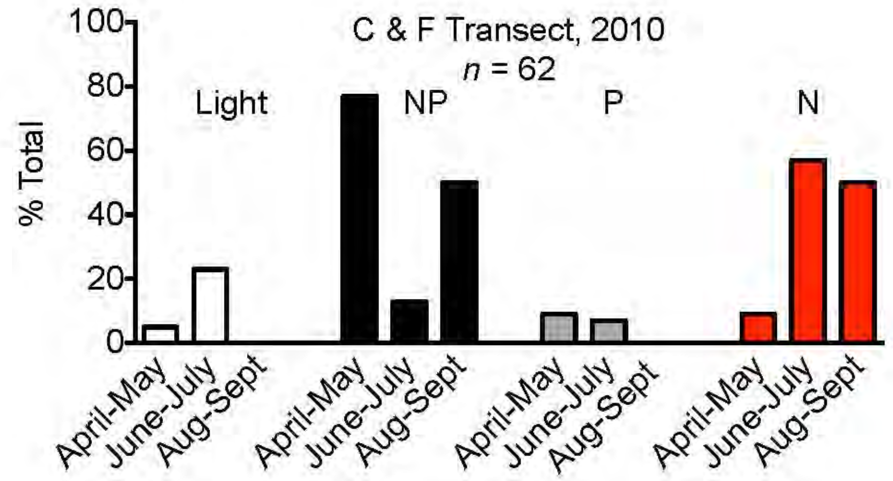
The % nitrite+nitrate load of the total nitrogen load for May in the main channel of the Mississippi River. Data source: USGS.

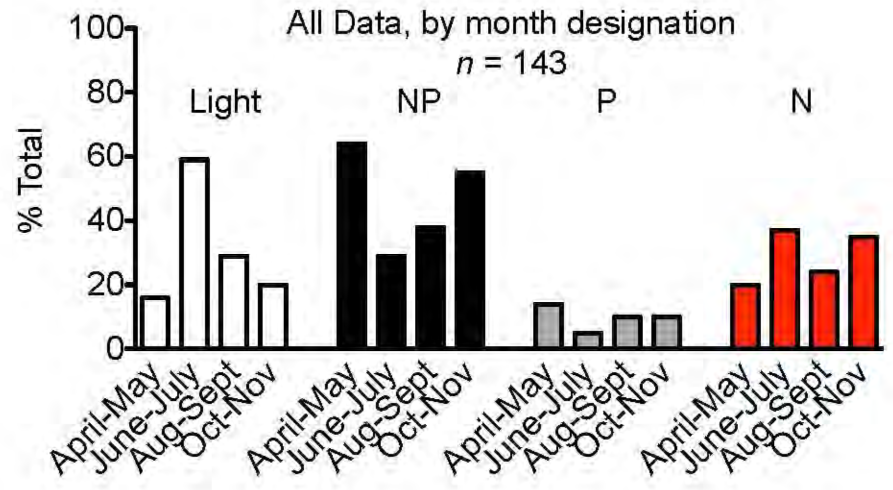
Turner and Rabalais, 2014 Hypoxia Forecast

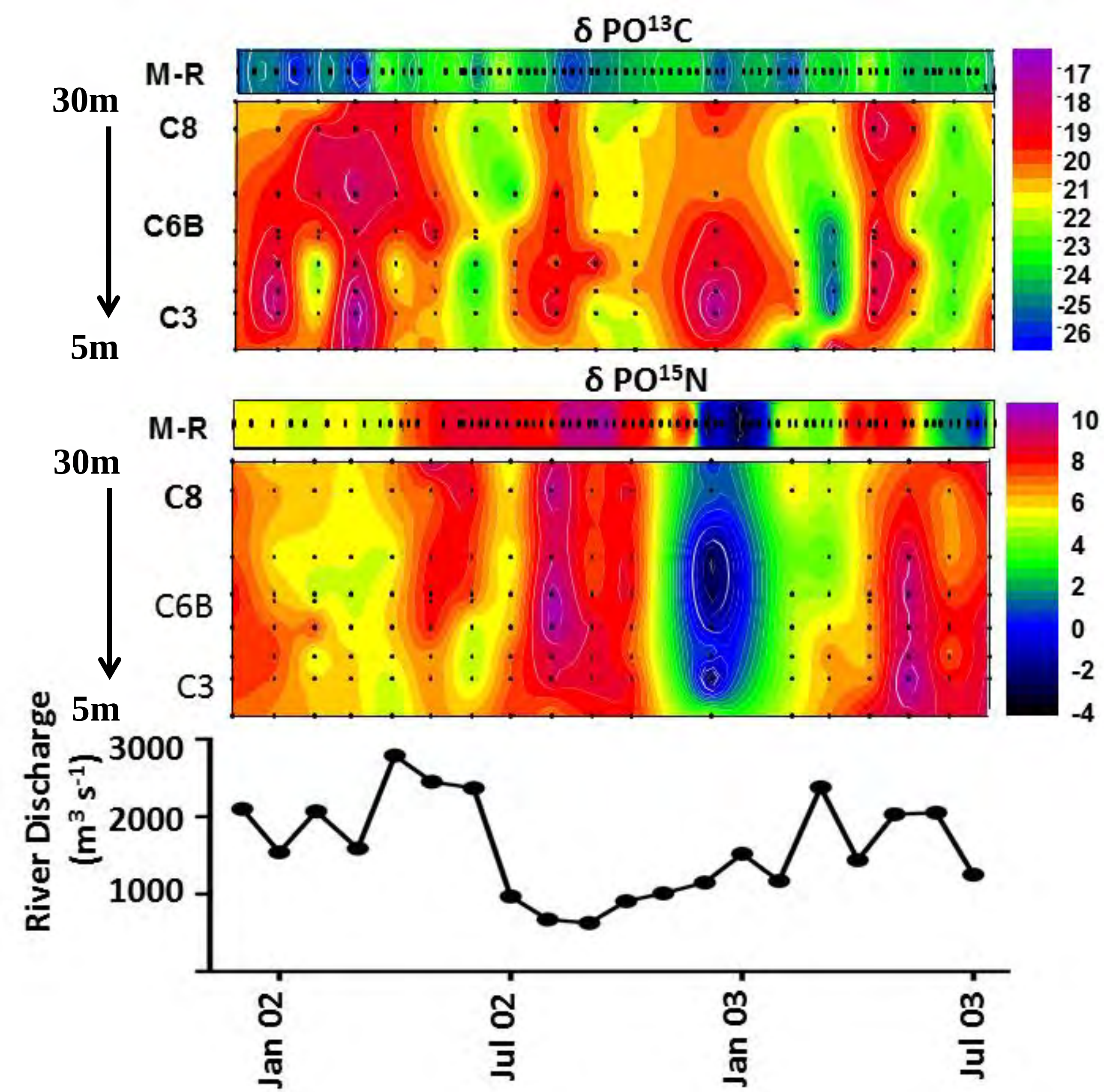
Nutrient Bioassays over Broad Spatial and Temporal Scales Identify Nutrient Limitations in the Area of Hypoxia



Turner and Rabalais 2013







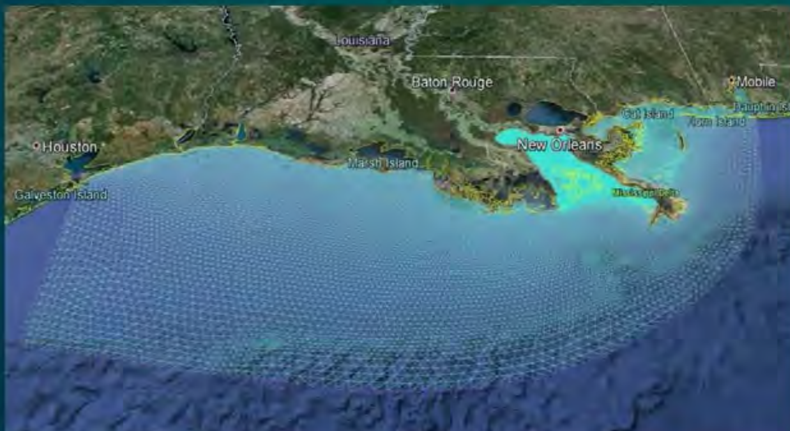
The terrestrial carbon signature (–27 to –24‰) in coastal surface waters parallels peaks in river discharge, and organic carbon offshore (–22 to –18‰) represents an atmospheric source.

The N source of particulate organic matter along the C transect is primarily from the river (–4 to 10‰) and subsequently incorporated into *in situ* production offshore.

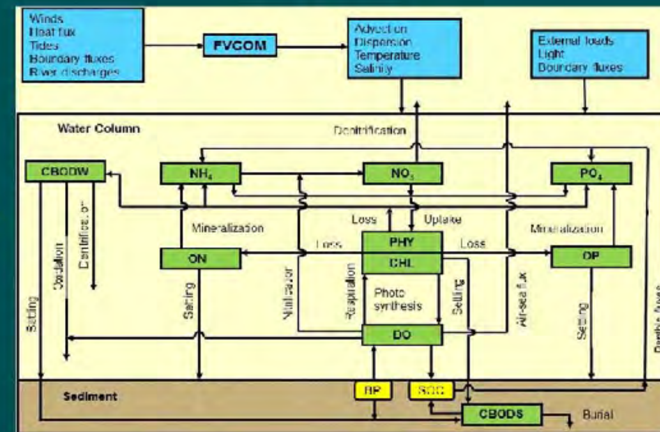
Rabalais et al. 2014. Courtesy of Björn Wissel, University of Regina, and Brian Fry, Griffith University. River data from US Geological Survey

FVCOM LaTex Model

FVCOM



WASP



IBM

<u>Individual Processes</u>

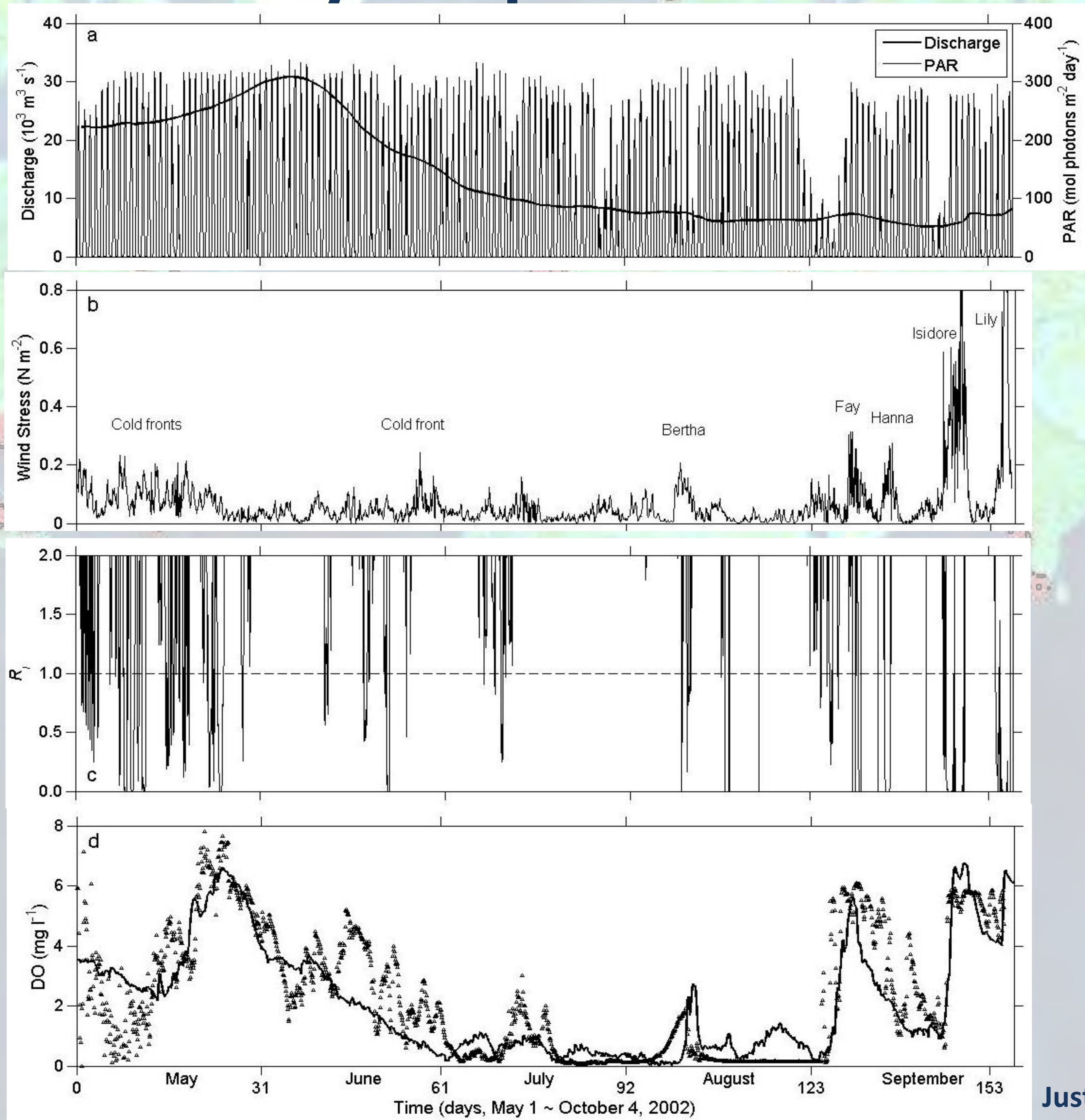
- Movement
- Growth
- Mortality
- Spawning

<u>Conditions</u>

- Dissolved O_2
- Temperature
- Salinity
- Food density
- Predator Density
- Individual Size

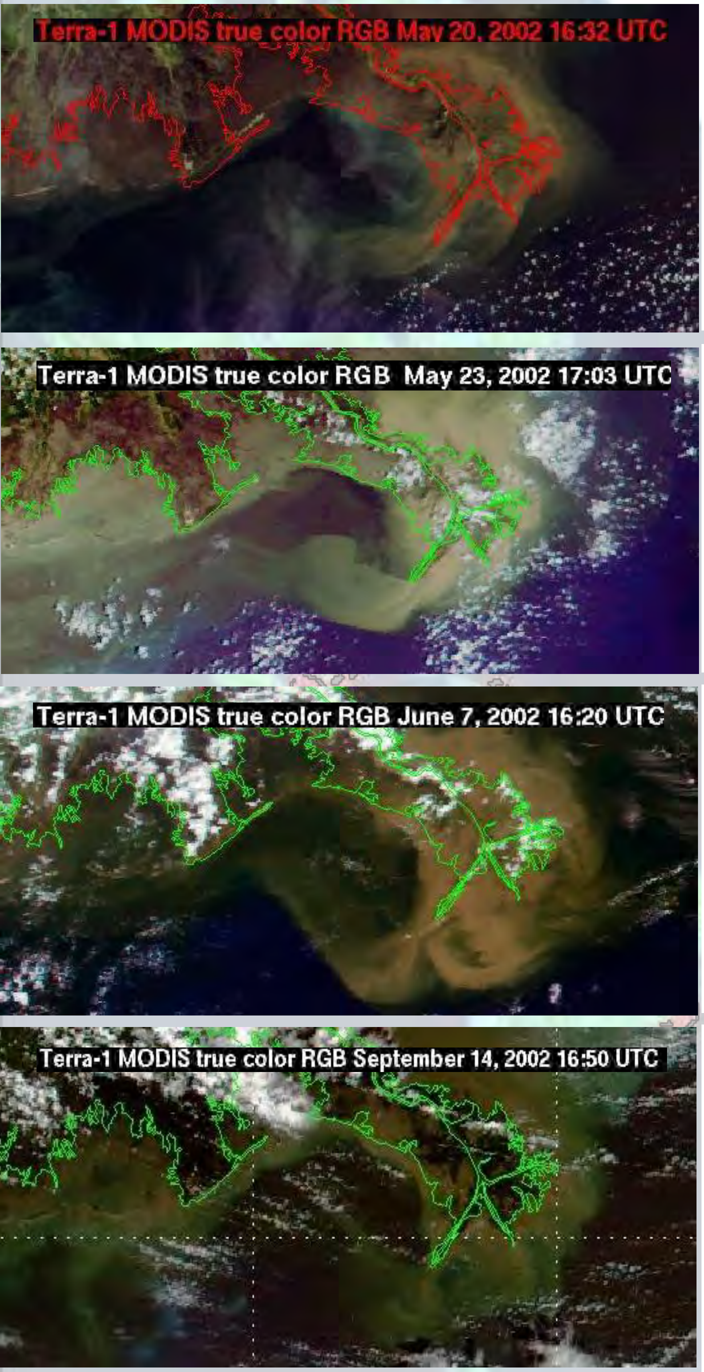
Wang and Justic (2009); Justic and Wang (2014); Rose et al. (2014)

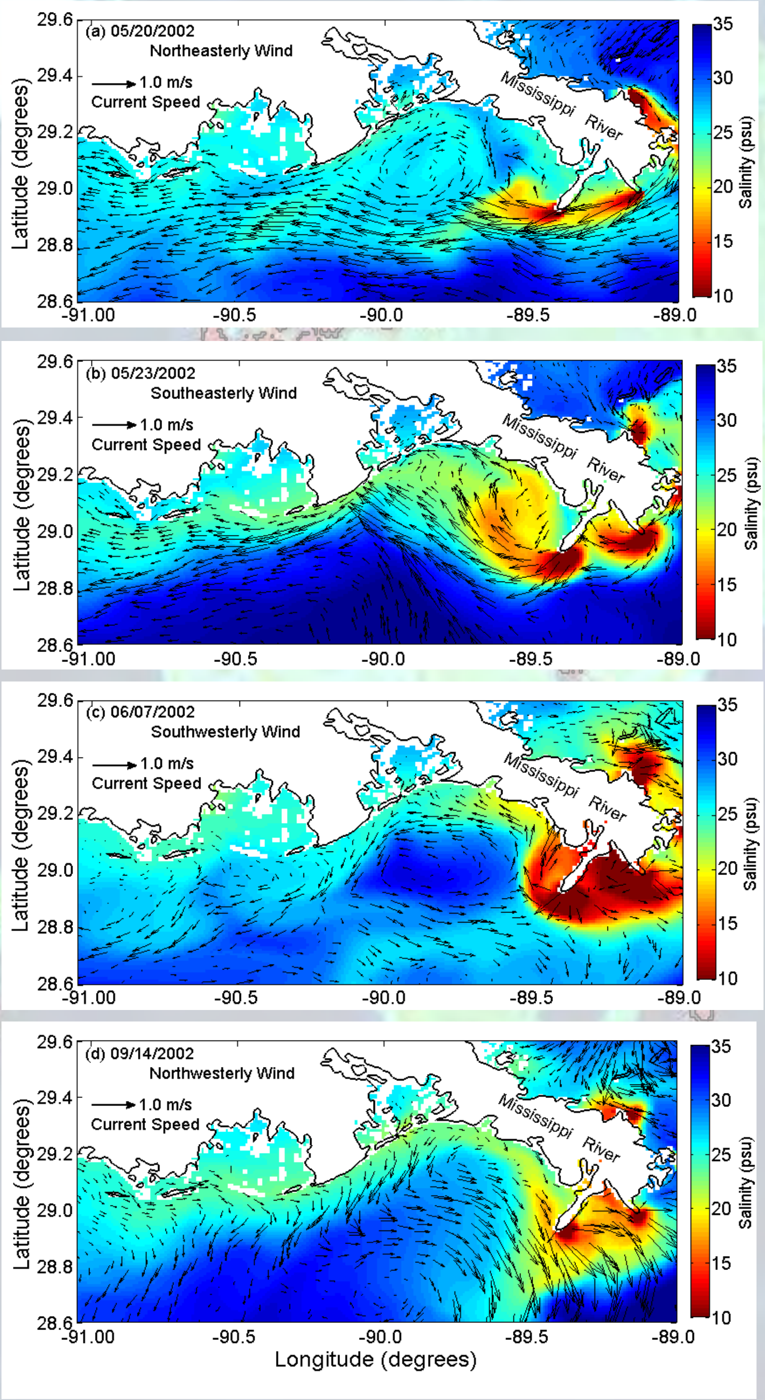
Successfully Coupled FVCOM-WASP



Bottom Meter C6C 2002

Justić and Wang, 2013





FVCOM Circulation Model and Comparison with Imagery

Excellent Results

Wang and Justić, 2009

Hypoxia in the Northern Gulf of

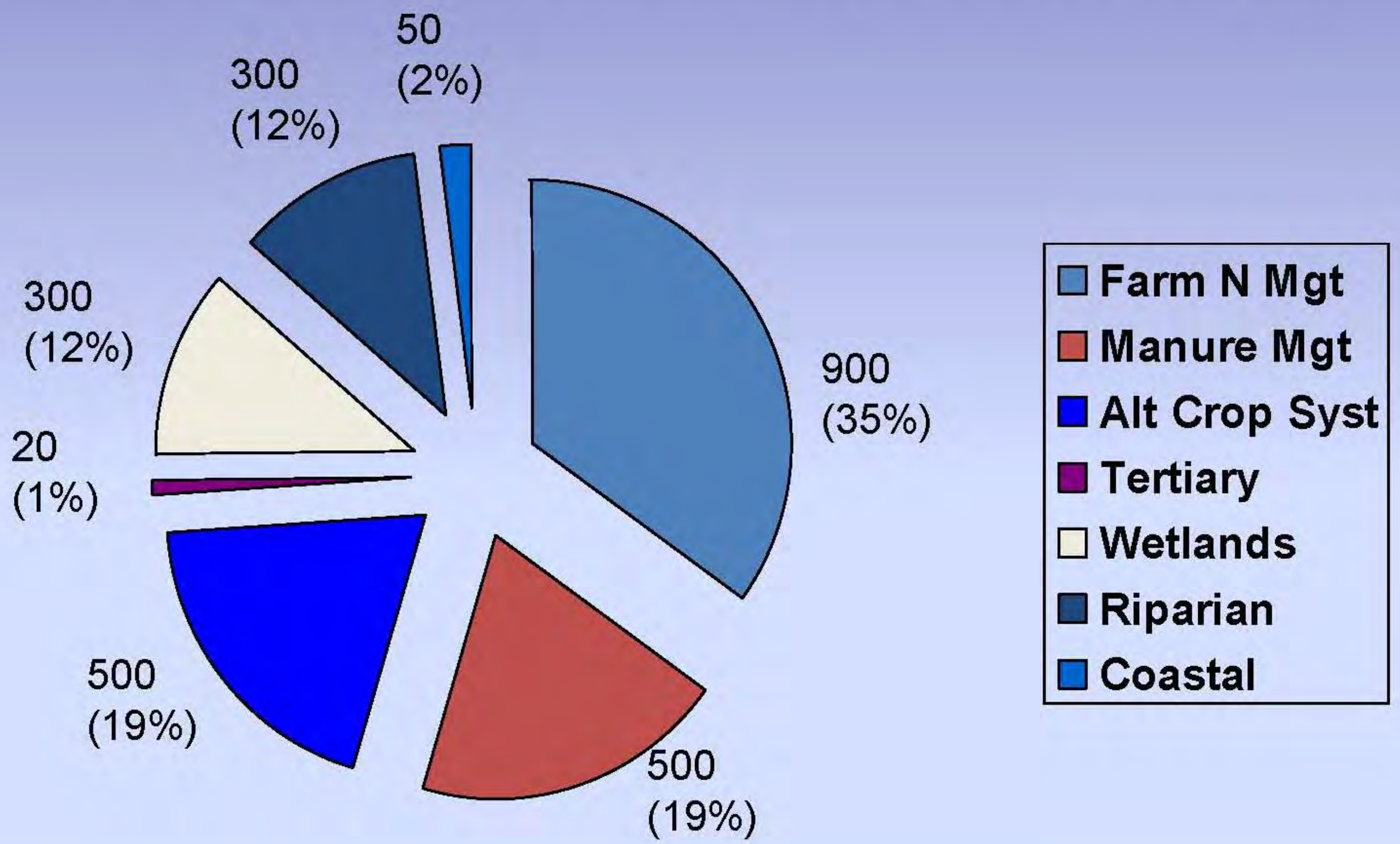
An Update by the EPA Science Advisory Board

Supports and Strengthens the Science

- N loading drives timing and extent of hypoxia
- P loads significant in watershed and Gulf of Mexico
- HAP recommends dual N & P reduction strategy

- Upper MSR and Ohio-TN sub-basins account for the 84% nitrate-N and 64% total P flux to Gulf
- Tile-drained, corn-soybean landscapes very N leaky
- *The HAP recommends* targeting the tile-drained Corn Belt region of the MARB for N and P reductions in both surface and sub-surface waters.

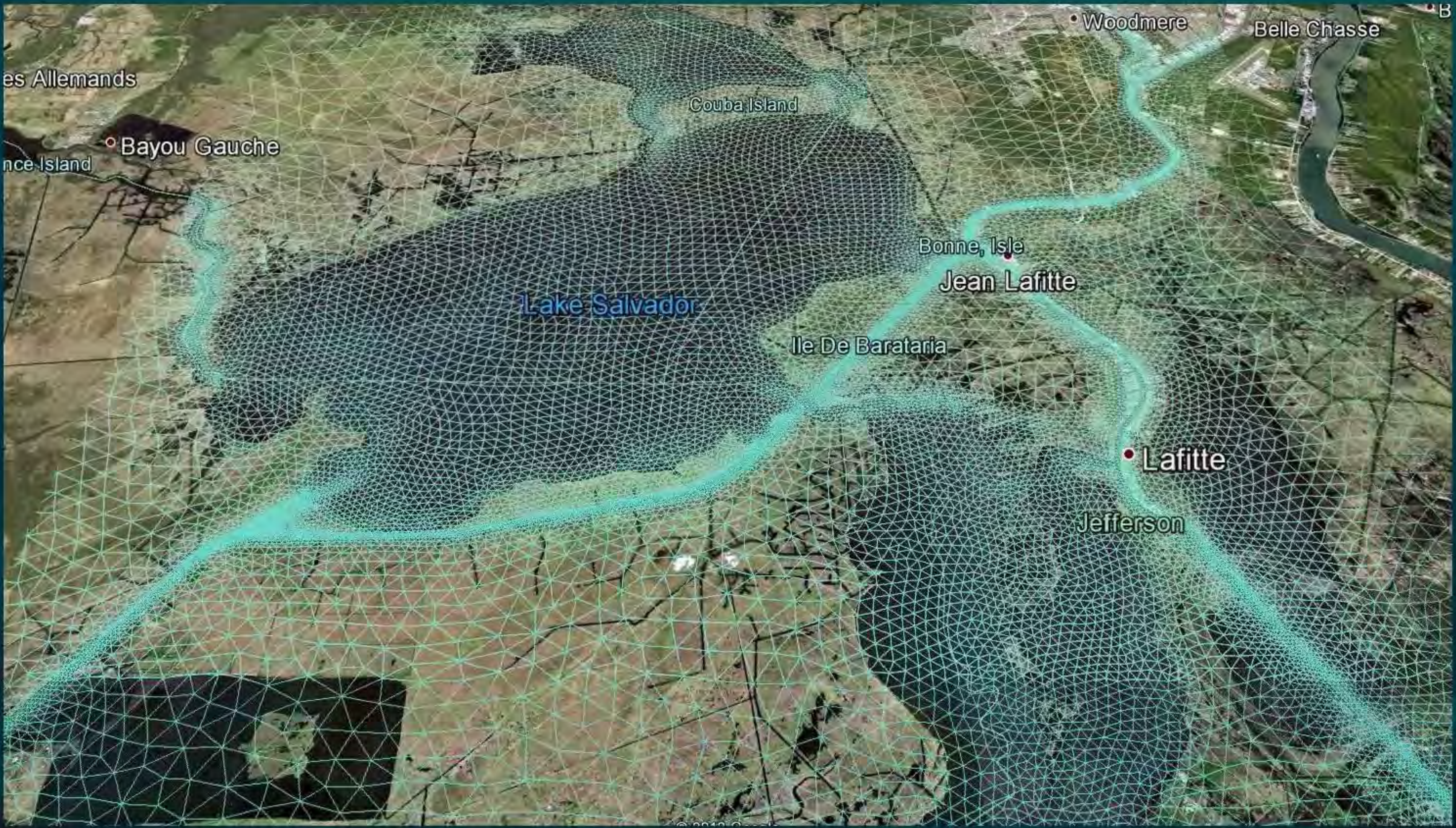
Potential N Reduction (1000 mt N/yr)



Data Source: Mitsch et al. 1999, 2001; CENR 2000

FVCOM Barataria Bay Model

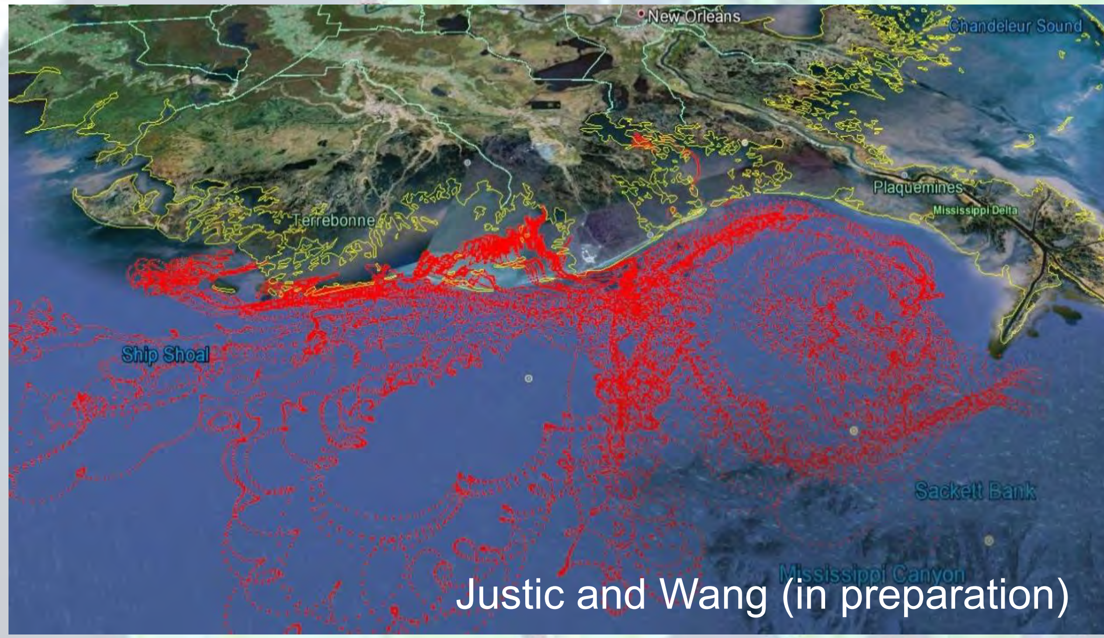
Numerical Grid - Detail



Justic and Wang (in preparation)

Surface Trajectory Modeling in the Deepwater Horizon Oil Spill

(May 29 – June 25, 2010)



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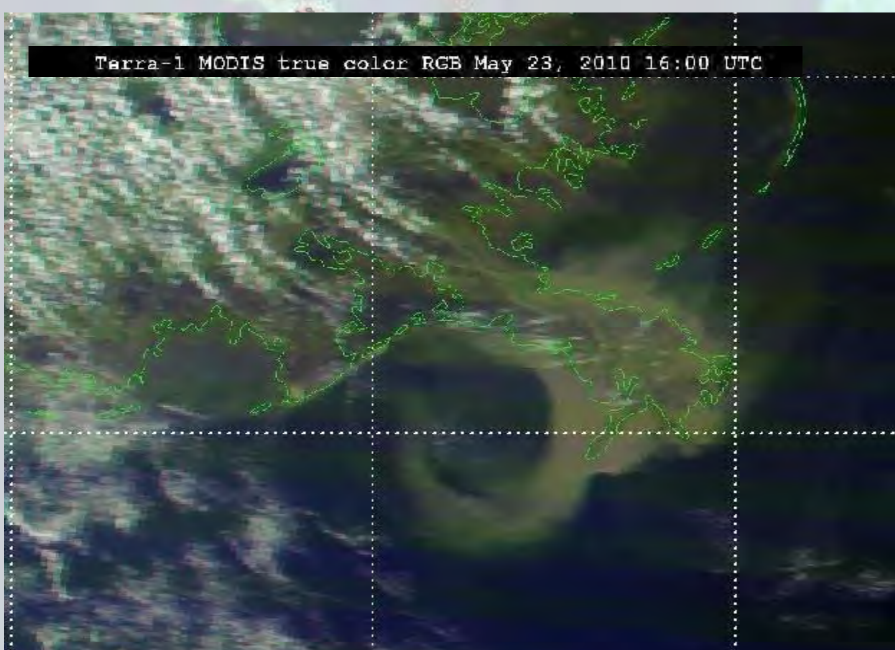
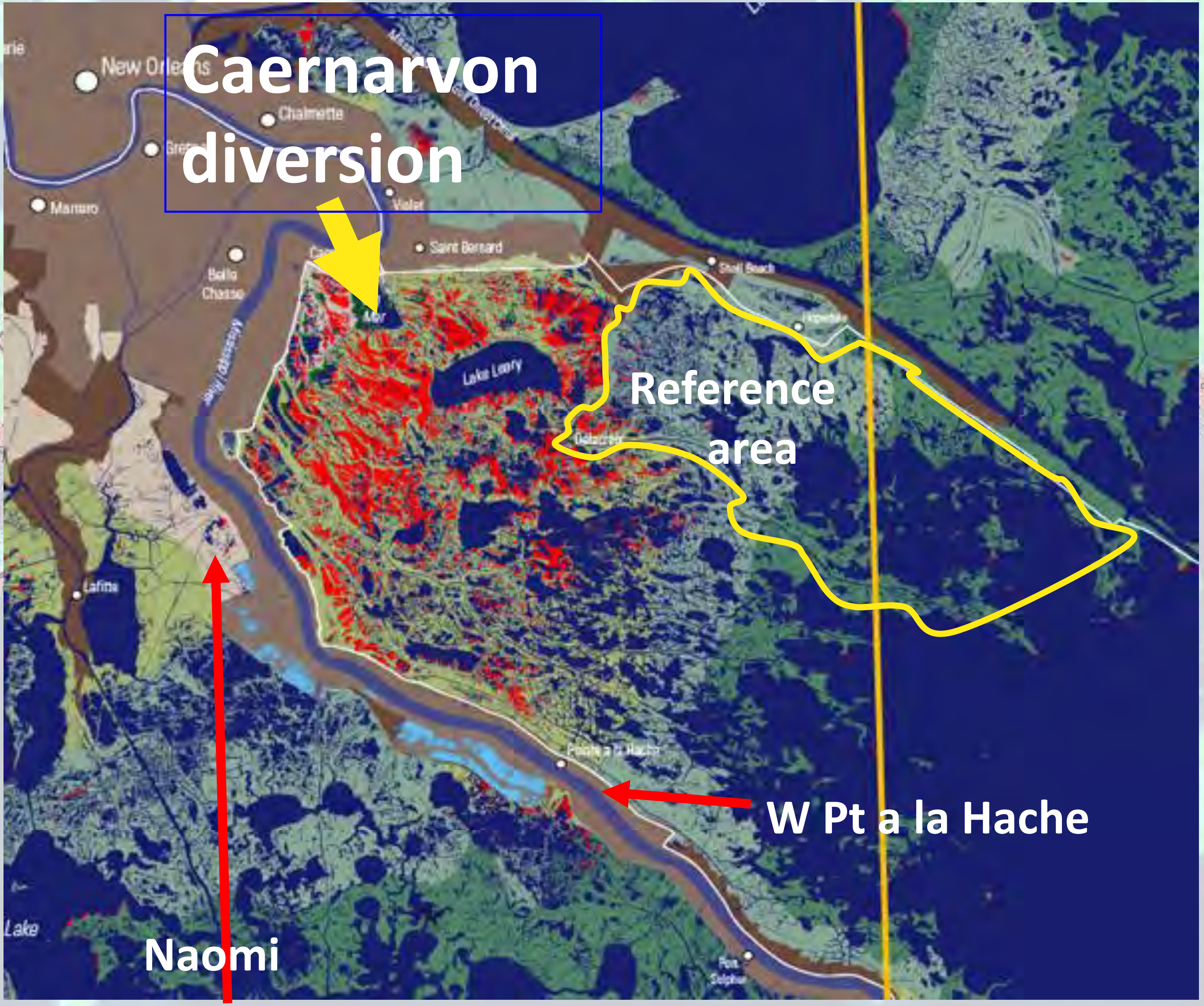



NASA Aqua MODIS May 25, 2010

Post-hurricane Land-to-water conversion



Alliance refinery

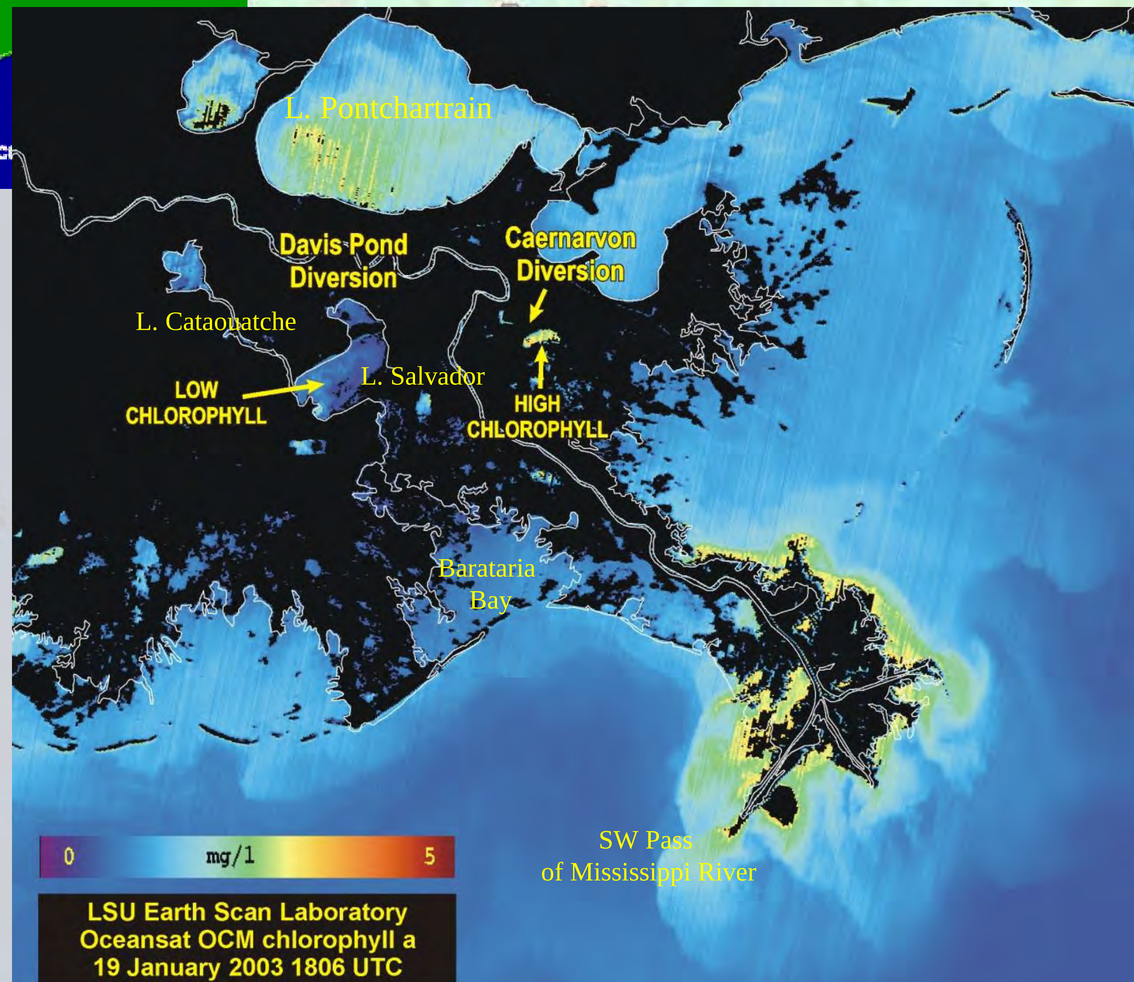
Caernarvon flow path
12 Feb 2009

55 square miles of wetlands lost

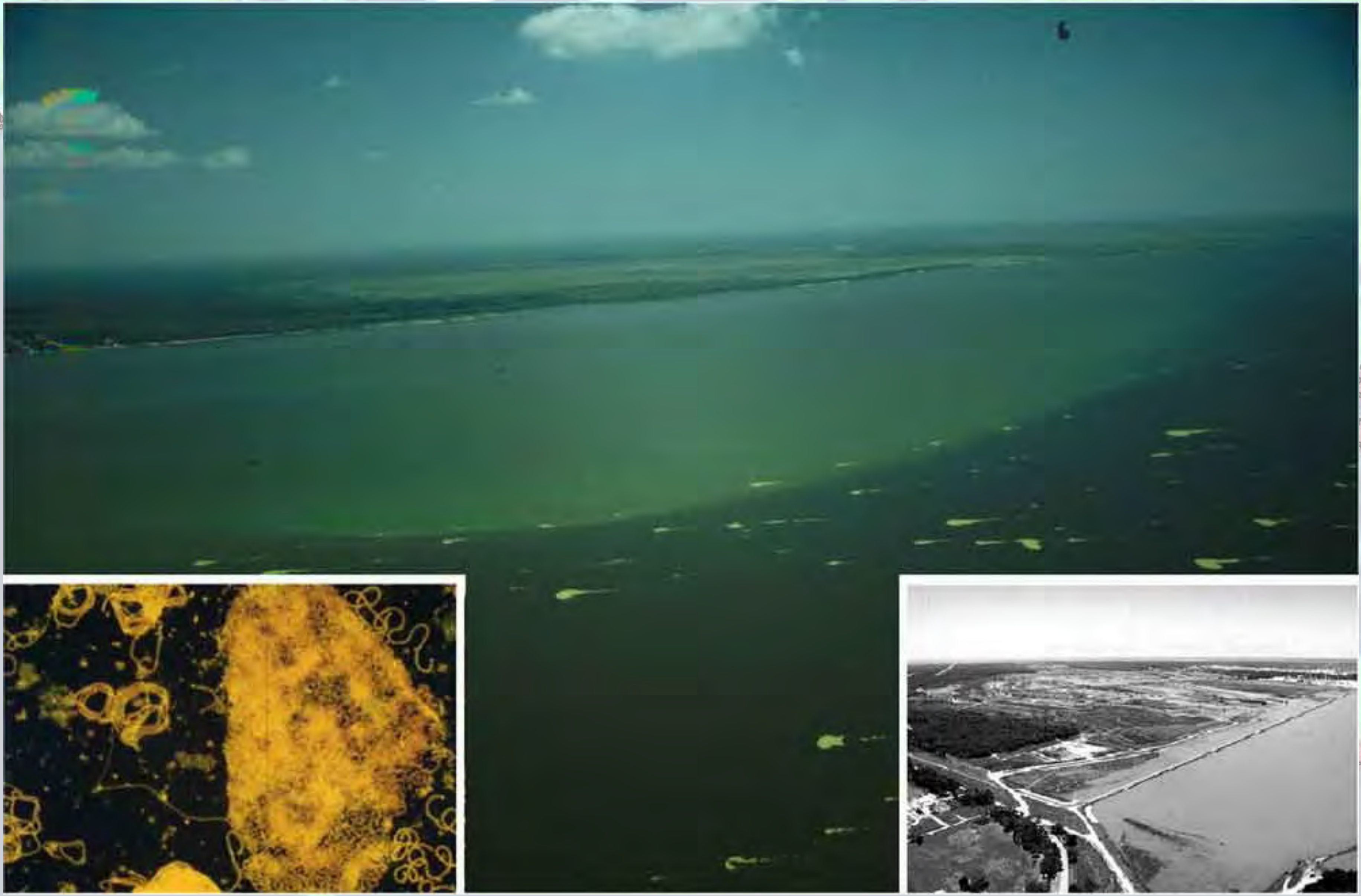
Davis Pond Diversion

Post December 31, 2003 – January 11, 2004 Diversion

40 μg/L chlorophyll in January
vs
long-term average of 5 – 10 μ g/L



Lake Pontchartrain Bloom



Photographs by R.E. Turner, LSU

nrabalais@lumcon.edu

http://www.gulfhypoxia.net