Summary of Gulf Hypoxia Science Symposium

Presentation of USEPA Science Advisory Board Hypoxia Advisory Panel

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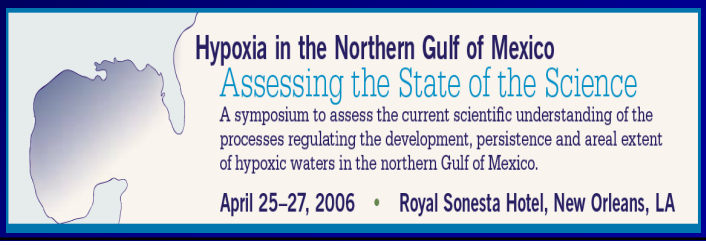


EPA and NOAA Co-Organizers

Invited Scientists

33 authors contributing to 6 technical presentations and synthesis manuscripts

25 panelists providing critical independent comments/discussion

6 Federal Agencies and 18 academic institutions represented

~ 150 total registrants

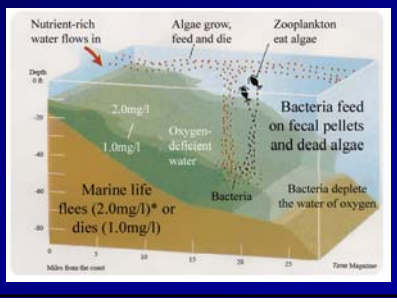
Topics/Issues Addressed

- Characterization and Long-Term Trends of Hypoxia (Lead: N Rabalais)
- Characterization of Nutrient and Organic Matter Loads (Lead: E Turner)
- Physical Oceanographic Processes (Lead: S DiMarco)
- Water Column Processes (Lead: M Dagg)
- Benthic Processes (Lead: J Morse)
- Modeling Applications (Lead: D Justic)

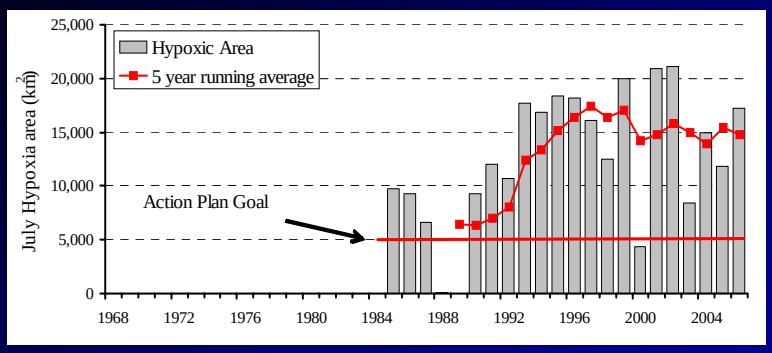
Summary Conclusions

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

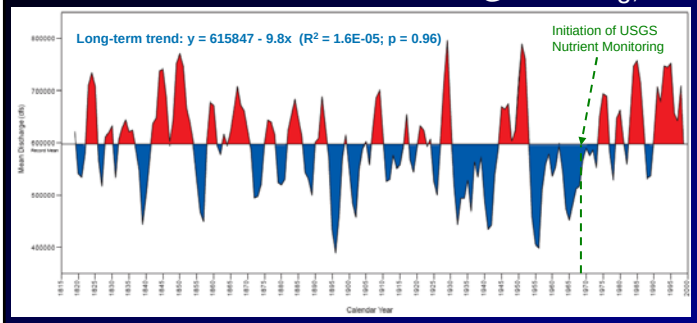


Long Term Trends



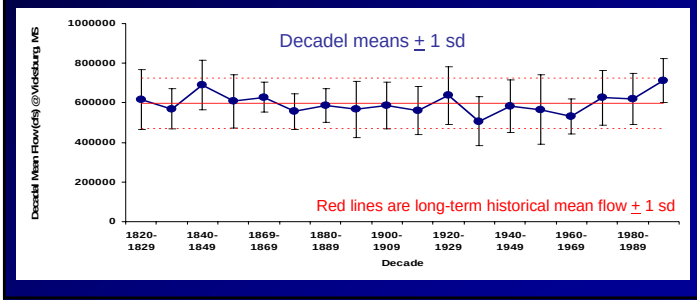
Since mid 1990s, the 5-yr running average size of hypoxic zone has hovered around 15,000 km^2

Long Term Trends in Flow:
1817-1998 MSR @ Vicksburg, MS



Long-term annual mean flow =~600,000 cfs (~ ±25%)

(Poore, et al., 2006. USGS Bulletin 2187)



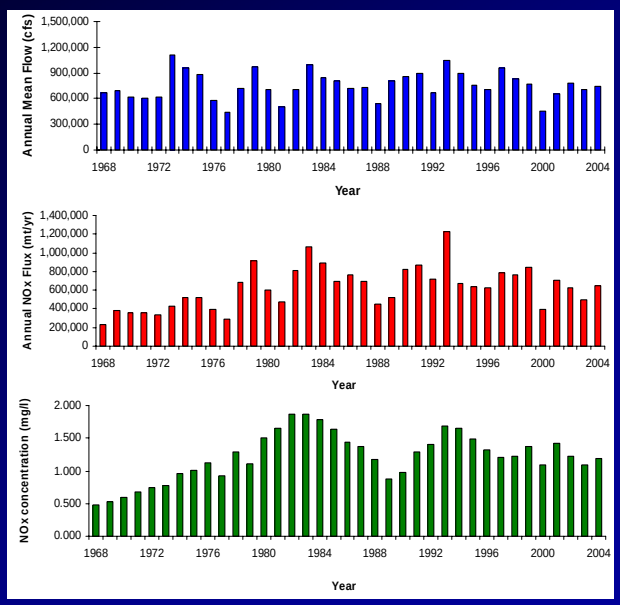
1990's mean flow is highest on record, but within 1 sd of long-term mean flow

Long Term Trends in Flow, Load, & Conc

MSR annual mean discharge (cfs)

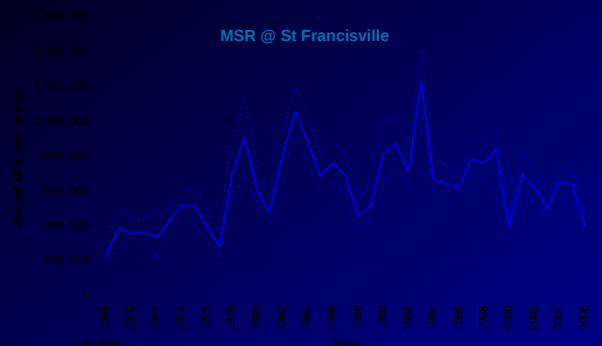
MSR annual mean nitrate flux (mt/yr)

MSR annual mean nitrate concentration (mg/L)



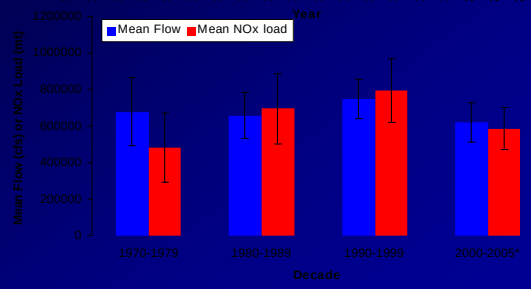
USGS Estimator flux: MSR @ St Francisville and AR @ Melville
http://co.water.usgs.gov/hypoxia/html/nutrients_new.html

Long Term Trends



USGS Loadest flux

Annual mean NO_3+NO_2 flux (mt/yr) ± 95% confidence interval

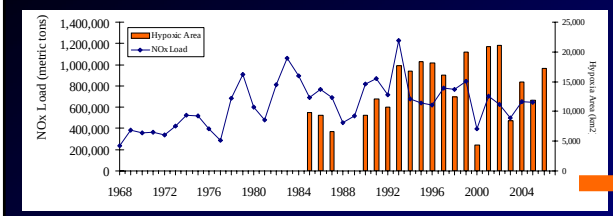


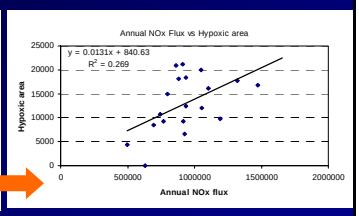
Decadal mean flow (cfs) and decadal mean NO_3+NO_2 flux (mt/yr) ± 1 sd

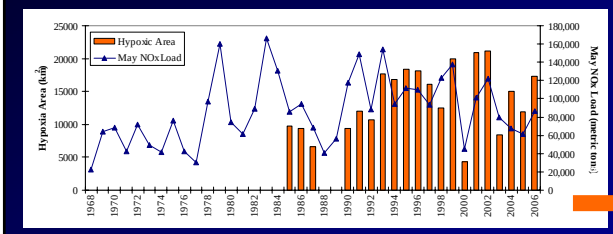
Magnitude of Variability

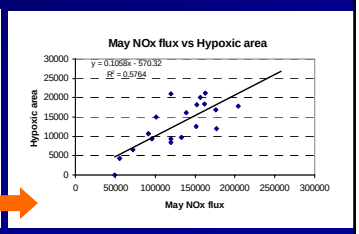
Parameter	Mean	CV (%)
Flow - Annual		
1818-1998 Mean @ Vicksburg (1817-1998)	597090 cfs	21%
1968-2005 Mean @ Tarbert Landing (+ORO)	678653 cfs	20 %
Decadal Means @ Tarbert Landing (+ORO)	619119 to 750382 cfs	14-28%
Flow – Month of May		
1968-2006 May Mean @ Tarbert Landing (+ORO)	955071 cfs	39%
1980-1996 May Mean @ Tarbert Landing (+ORO)	962653 cfs	39%
2002-2006 May Mean @ Tarbert Landing (+ORO)	844690 cfs	28%
Mid-Summer Area of Hypoxia		
1985-2006 Mean	13614 km^2	43%
2001-2006 Mean	15907 km^2	32%
Nitrate+Nitrite Flux (MSR + AR)		
1979-2006 Annual Mean	912500 mt	27%
1980-1996 Annual Mean	956941 mt	28%
2002-2006 Annual Mean	749000 mt	18%
1980-2006 May Mean	126833 mt	35%
1980-1996 May Mean	129471 mt	38%
2002-2006 May Mean	112520 mt	25%

Annual nitrate fluxes are poorly related to area of hypoxia

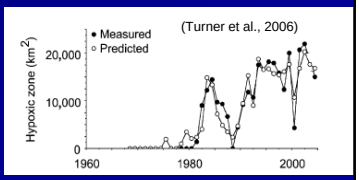








Statistical models suggest that spring/early summer nutrient fluxes (primarily May NO_3+NO_2) are good predictors of mid summer size of hypoxia



Hypoxia area (km2) = 0.0998 x May NOx flux + 672 x Year -13.4 x 105 (R^2 = 0.82)

Regression Analysis of the relationship between MSR (Tarbert Landing + ORO) Flow and mid-summer size of hypoxia (1985-2006)

Flow Parameter	R^2	*p*
May Flow	0.253	0.0201
Prior 3 mo mean (April to June) Flow	0.247	0.0218
Prior 6 mo mean (Jan to June) Flow	0.128	0.1114
Prior 9 mo mean (Oct to June) Flow	0.082	0.2084
Annual Flow	0.191	0.0309

MSR flow explains between 8 to 25% of the variability in mid-summer size of hypoxia

Current USGS monitoring of freshwater discharge as well as sediment and nutrient loads/concentrations was not designed to resolve monthly (or shorter) time scale processes influencing hypoxia

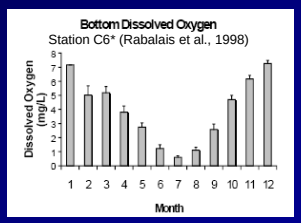
Timing and Development

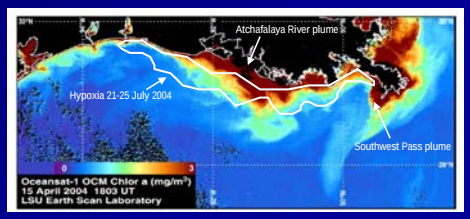
Temporal characteristics of hypoxia are fairly well known, except for timing of development in spring

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

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





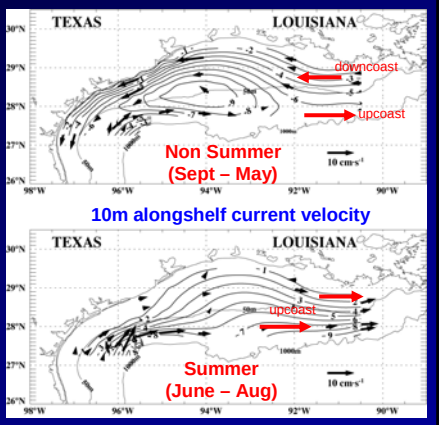
Physical Oceanography and Biogeochemistry

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

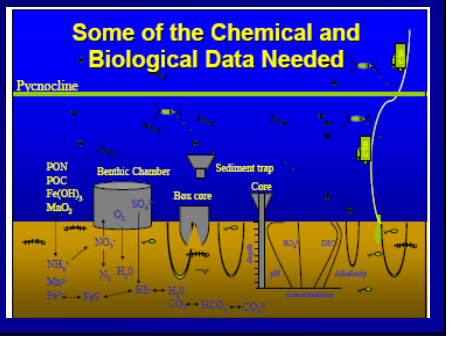
Benthic Processes

Below pycnocline and benthic processes (aerobic & anaerobic respiration) contribute to seasonal depletion of bottom water O_2 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

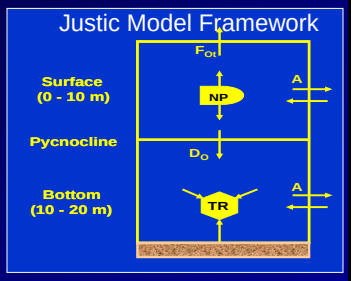
Existing Gulf hypoxia models range from simple regression models to complex 3-D simulation models, and include different aspects of physics, chemistry and biology.

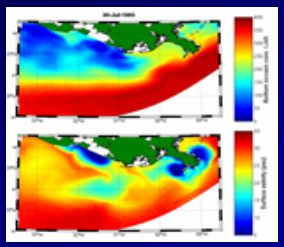
Assumptions, limitations and/or shortcomings of existing models are known and documented

Existing models provide scientific rationale for a N load reduction target of 30 - 45% to achieve *Action Plan* target of 5,000 km^2

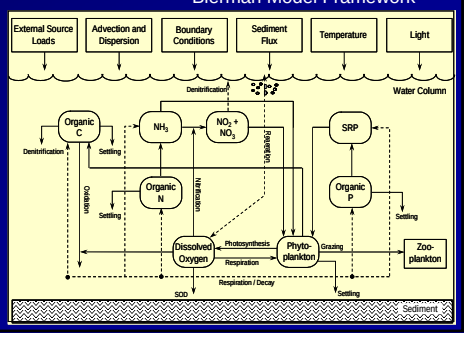
Existing models are <u>not</u> sufficient for estimating P load reductions

Justic Model Framework

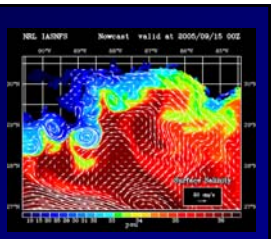
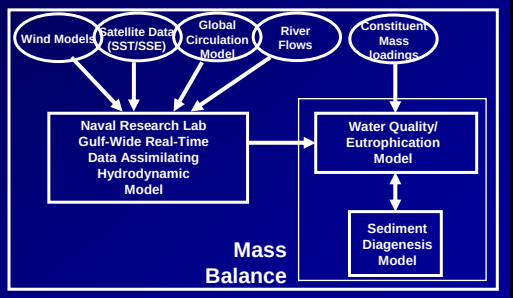
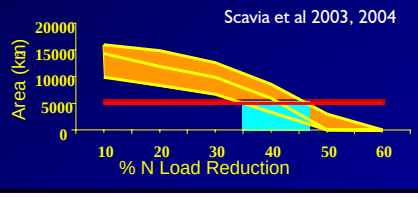
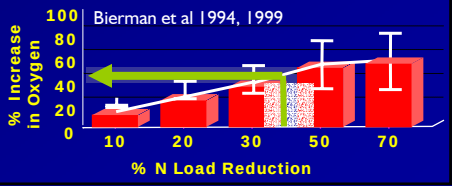




Bierman Model Framework



Hypoxia modeling

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