Reducing Nitrogen Removal Uncertainty for Operation of Mississippi River Sediment Diversions: Nitrate Reduction Rates In Turbulent Flow Conditions

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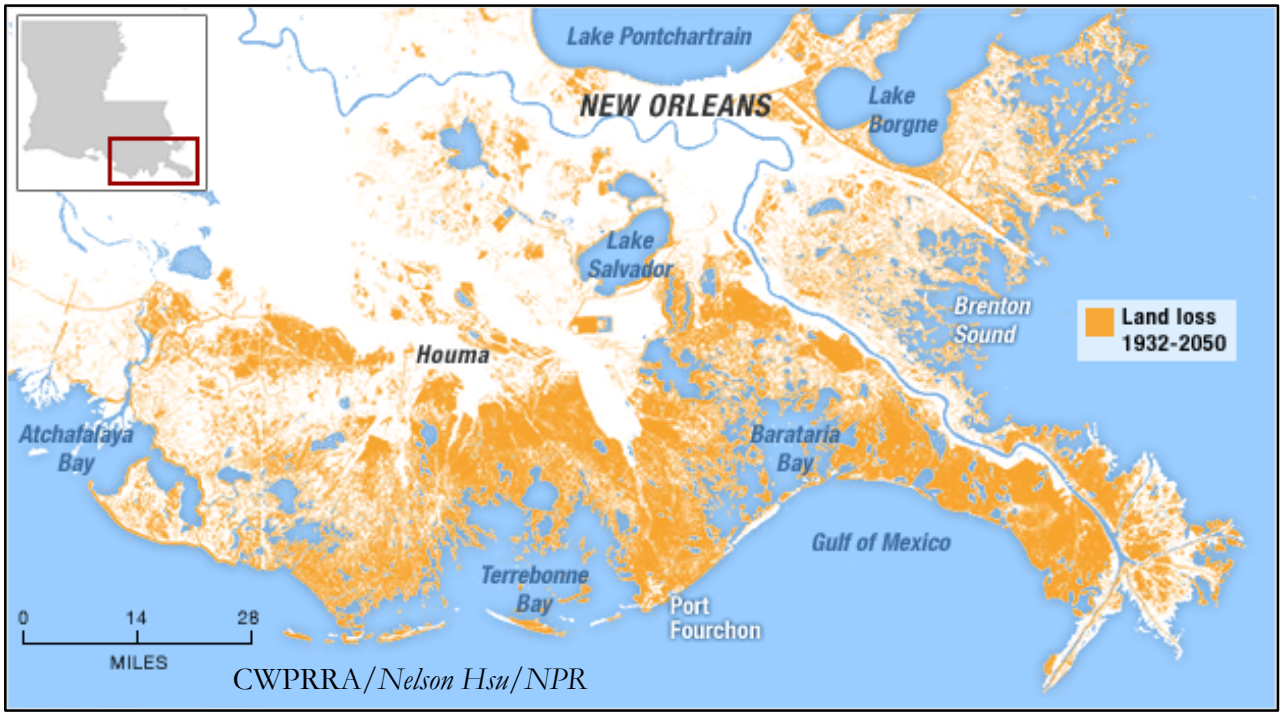
Louisiana Coastal Land Loss

- Between 1932 and 2016, Louisiana lost 4833 km^2 (1866 mi^2) of coastal land

- Wetland loss rate: ~30 km^2 yr^{-1} (11.6 mi^2)



Sea Level Rise + Subsidence

- Global sea level rise: 3.2 mm each year
- Relative sea level rise: 10 mm per year

Current rates of marsh accretion are not sufficient to maintain pace with relative sea level rise


2015
LSU Coastal
Sustainability Studio


2100
LSU Coastal
Sustainability Studio

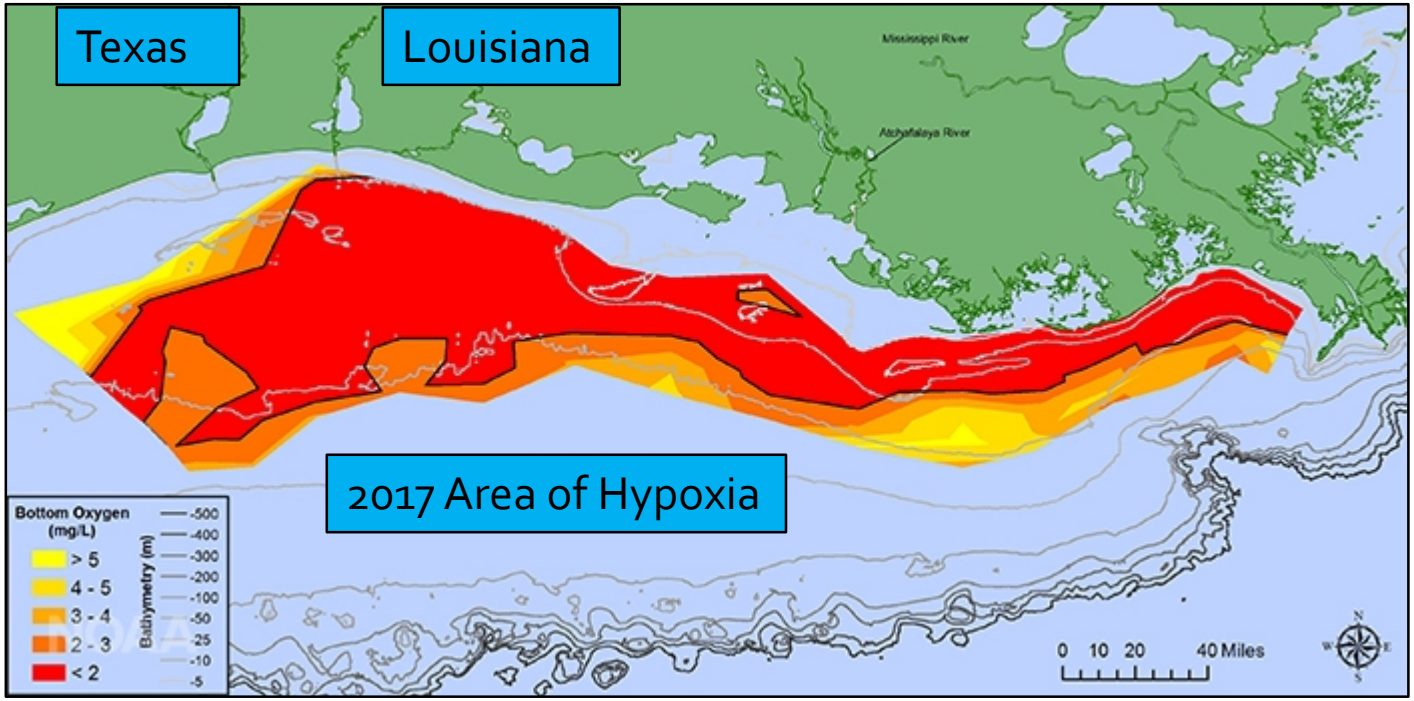
Sediment Diversions

- Divert sediment from the Mississippi river to coastal wetlands
- Can build new land and aid existing wetlands

Concern: Nitrate Loading

- Will deliver significant amounts of nitrate, possibly degrading water quality in receiving basins
- 1.5 million metric tons

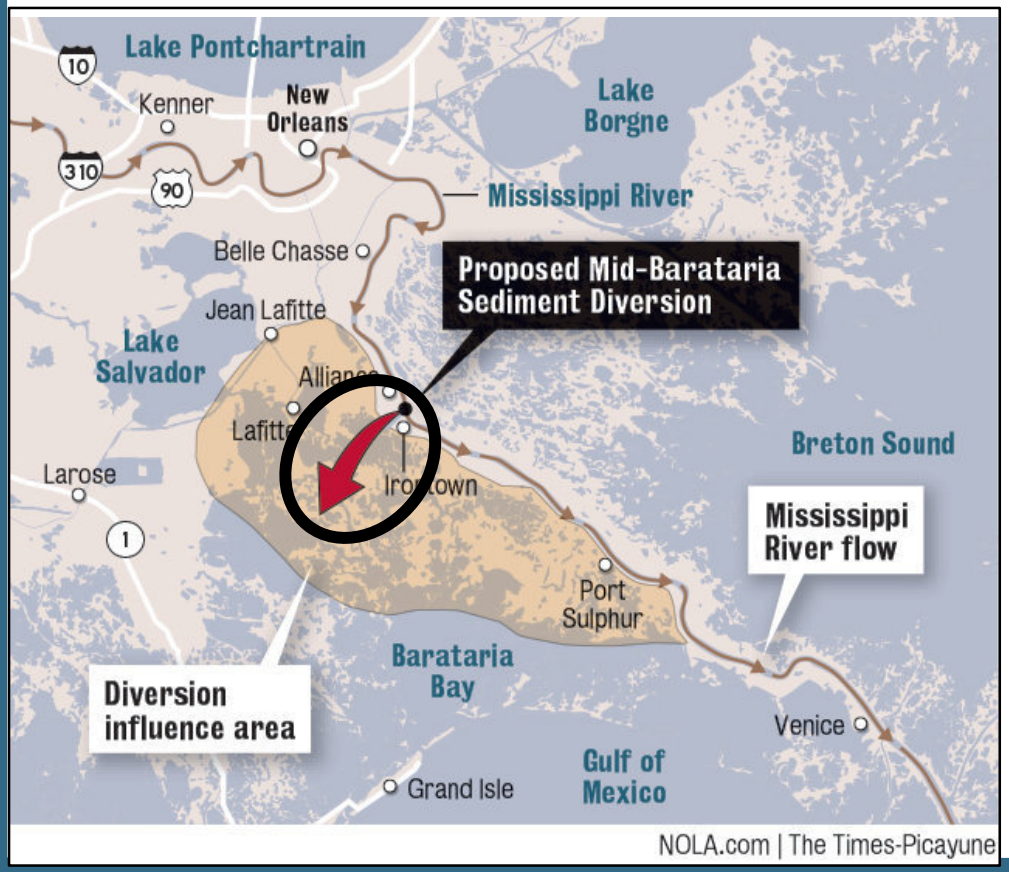
- $5 billion+ devoted to diversions



Fate of Nitrate?

A paucity of data on nitrate reduction rates near diversion outfall

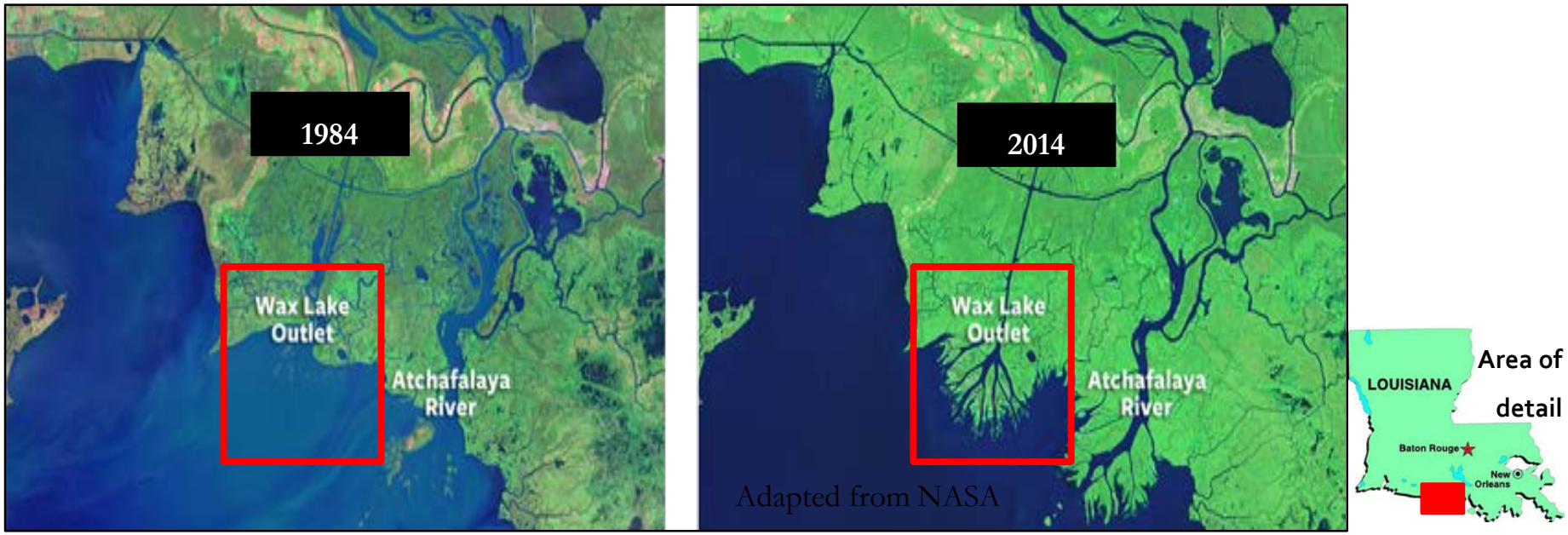
- Where turbulent conditions and sediment suspension occurs



Objective:

Determine rates and spatial variability of nitrate reduction in turbulent surface water environments

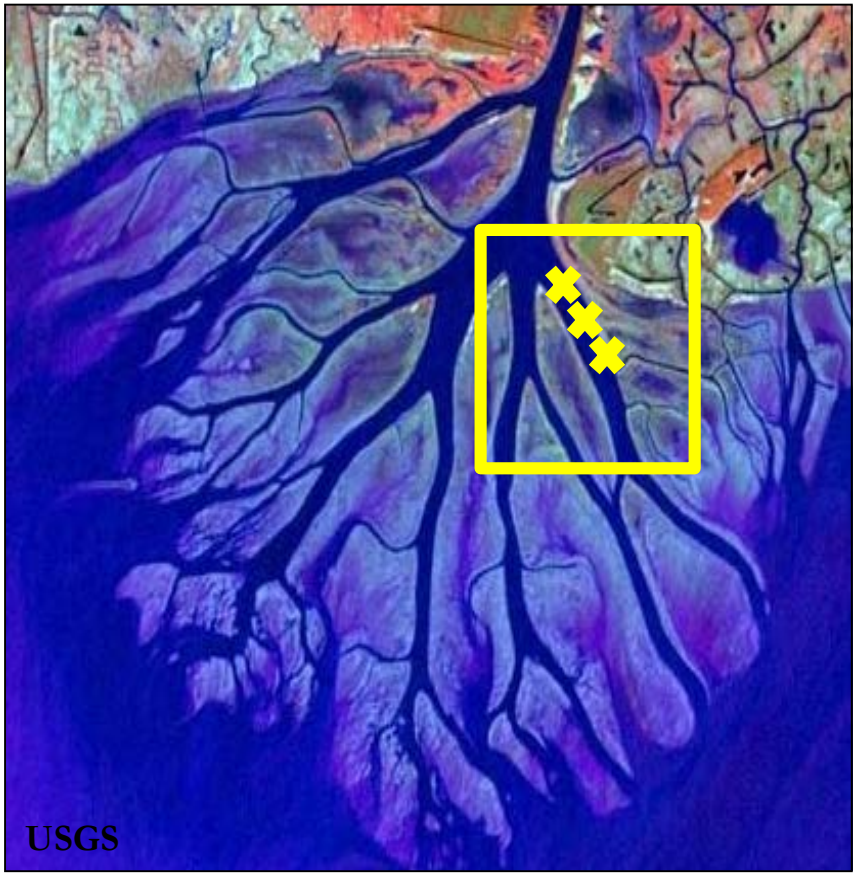
Study Site: Wax Lake Delta



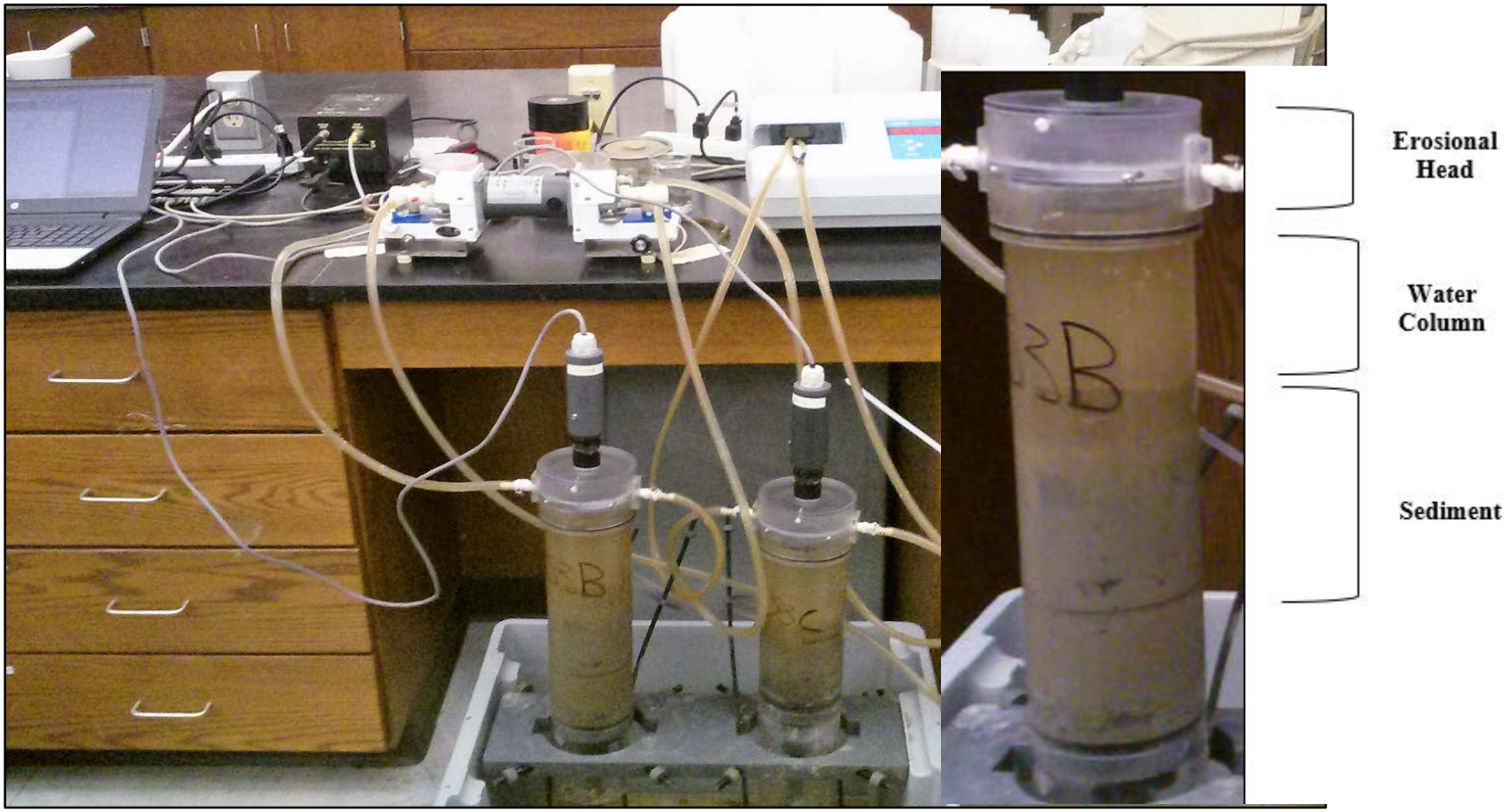
- A 12,000 acre growing delta on the coast of Louisiana
- Receives diverted sediment from the Atchafalaya river
- Sediment delivery to the delta is similar to sediment delivered by diversions

Sampling Design

- Three sites in the mudflats of Wax Lake Delta
- Twelve intact cores collected at each site
  - Nine for evaluating nitrate reduction under turbulent conditions
  - Three for soil physiochemical analysis



Gust Erosion Microcosm System (GEMS)



- Mimics shear stress conditions on core surface sediment
- Manipulates shear stress by controlling spinning rate of erosional heads on the water column of sediment cores

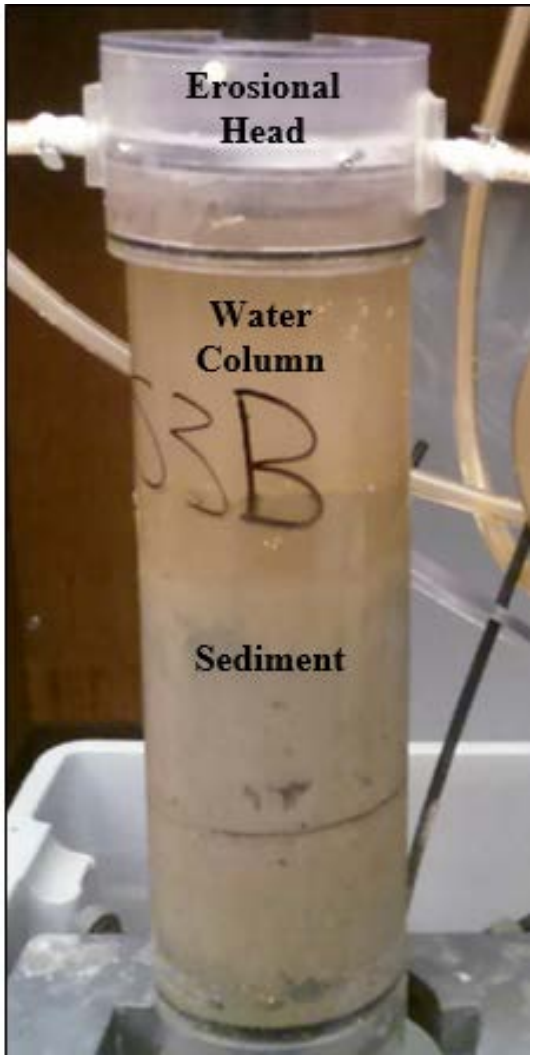
Experimental Design

Three levels of shear stress:

- **0.45 Pa (High; proximal diversion flows)**
- **0.2 Pa (Medium; distal diversion flows)**
- 0 Pa (Zero)

- 10 cm water column of a 2 mg L^{-1} NO_3-N solution

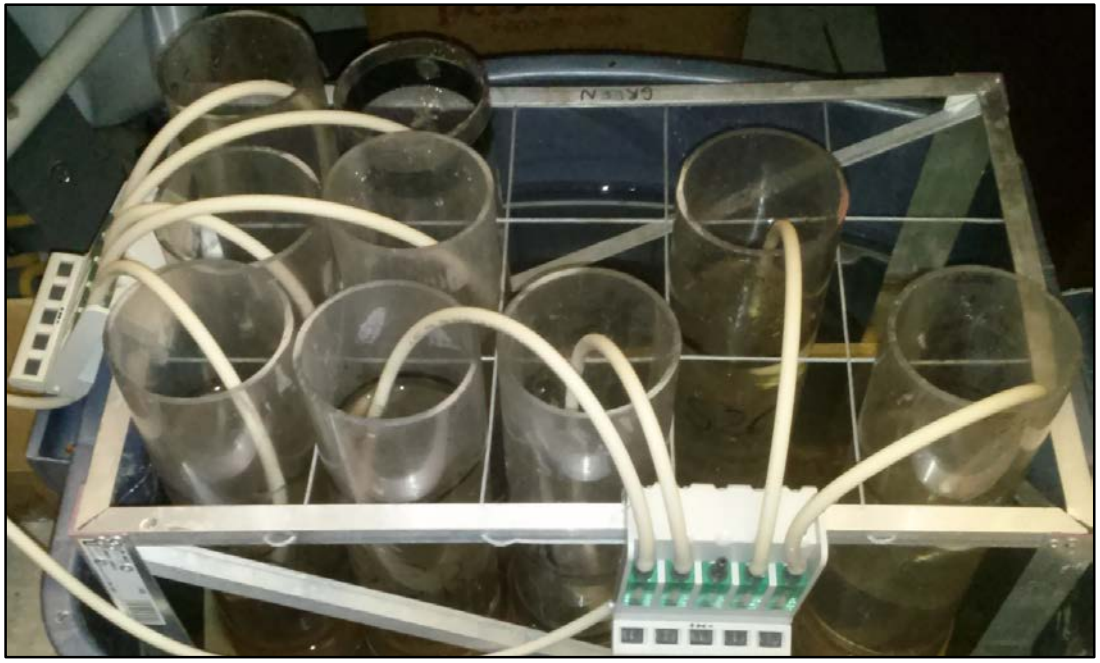
- Solution circulated through cores for 24 hours; water samples collected every 2 hours



Experimental Design

Cores with 0 shear stress:

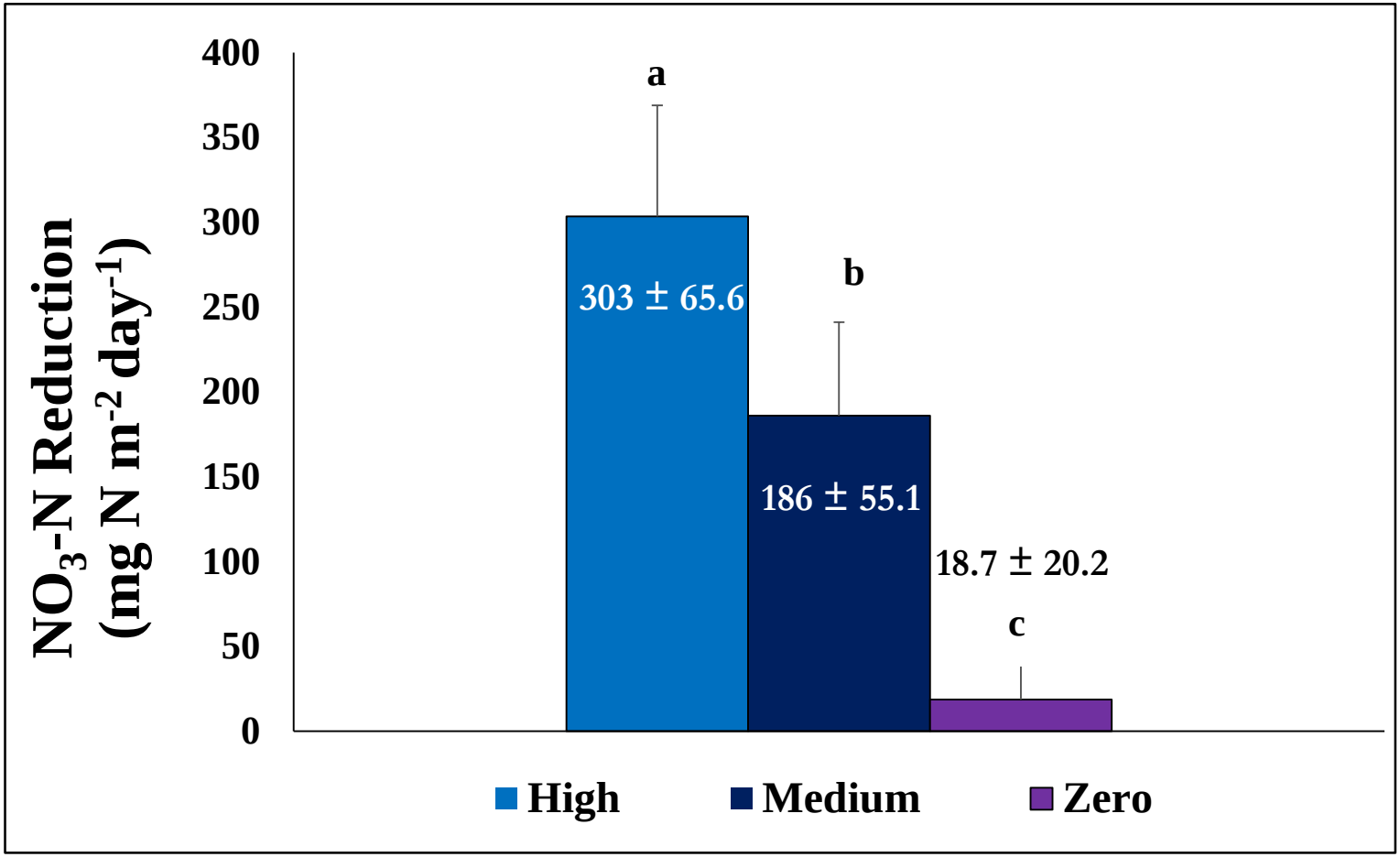
- Flooded with a 2 mg L^{-1} NO_3-N solution
- Samples were collected over 24 hours to measure NO_3^- loss



Results: Soil Characteristics

Soil Parameter	Site 1	Site 2	Site 3	P -value
Moisture Content (%)	47.3 ± 4.71	57.2 ± 6.57	41.8 ± 3.28	>0.05
Bulk Density (g cm^{-3})	0.62 ± 0.14	0.45 ± 0.10	0.79 ± 0.11	>0.05
Total Carbon (g kg^{-1})	10.1 ± 1.70	14.1 ± 3.93	8.17 ± 0.92	>0.05
Total Nitrogen (g kg^{-1})	0.87 ± 0.10	1.30± 0.34	0.78 ± 0.06	>0.05
Total Phosphorus (g kg^{-1})	566 ± 44.08	714 ± 174.23	543 ± 36.7	>0.05
Extractable NH_4^+ (mg kg^{-1})	7.33 ± 1.5	12.6 ± 3.11	6.52 ± 0.82	>0.05

Results: Nitrate Reduction Under Turbulent Conditions



Nitrate reduction significantly increased with increasing shear stress/turbulence

Summary: Turbulent Conditions

Nitrate reduction

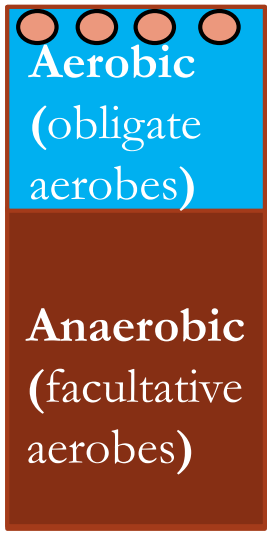
- 10x higher for r nditions
- 16x higher for h itions

Nitrate reduction rates observed were among the highest ever recorded in coastal Louisiana

Significant increases in nitrate reduction can occur by turbulent conditions

Summary: Turbulent Conditions

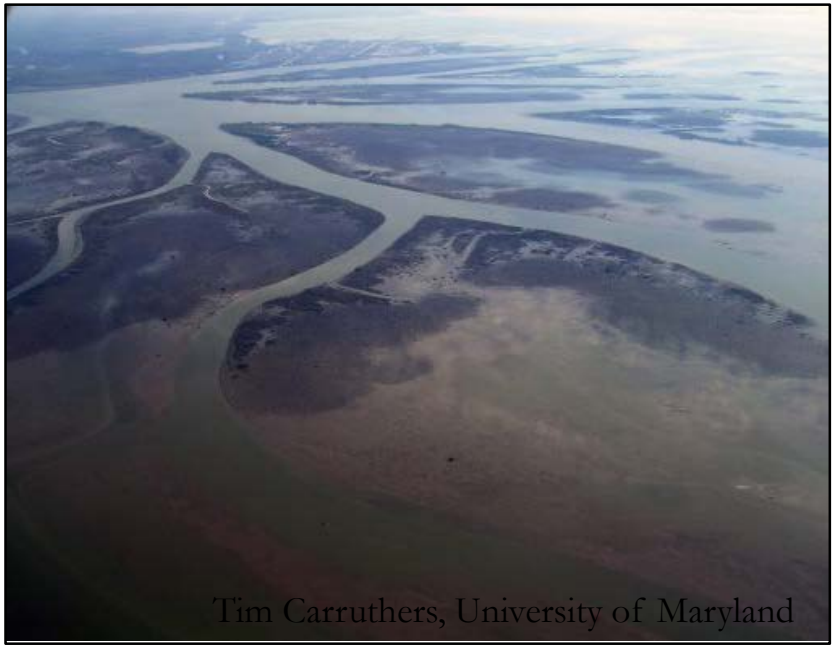
Provide increased interaction between microbes in the sediment and nitrate in the water column



Implications

- Sediment resuspension from diversions increases nitrate reduction rates
- Reduction rates are likely to increase closer to the diversion outfall
- N removal will be spatially variable and depends upon shear stress applied by diverted water

If studies in do not account for the sediment resuspension, calculated rates of nitrate reduction are likely to be underestimated.



Tim Carruthers, University of Maryland

Acknowledgements

- Louisiana Board of Regents
- Coastal Protection and Restoration Authority
- The Water Institute of the Gulf
- Aquatic Biogeochemistry Lab at UCF

CPRA
Coastal Protection and Restoration Authority of Louisiana

STATE OF LOUISIANA
UNION JUSTICE CONFIDENCE
BOARD of REGENTS

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Thank You!