



# Effects of phosphorus limitation on oxygen dynamics in the Mississippi and Atchafalaya river plumes

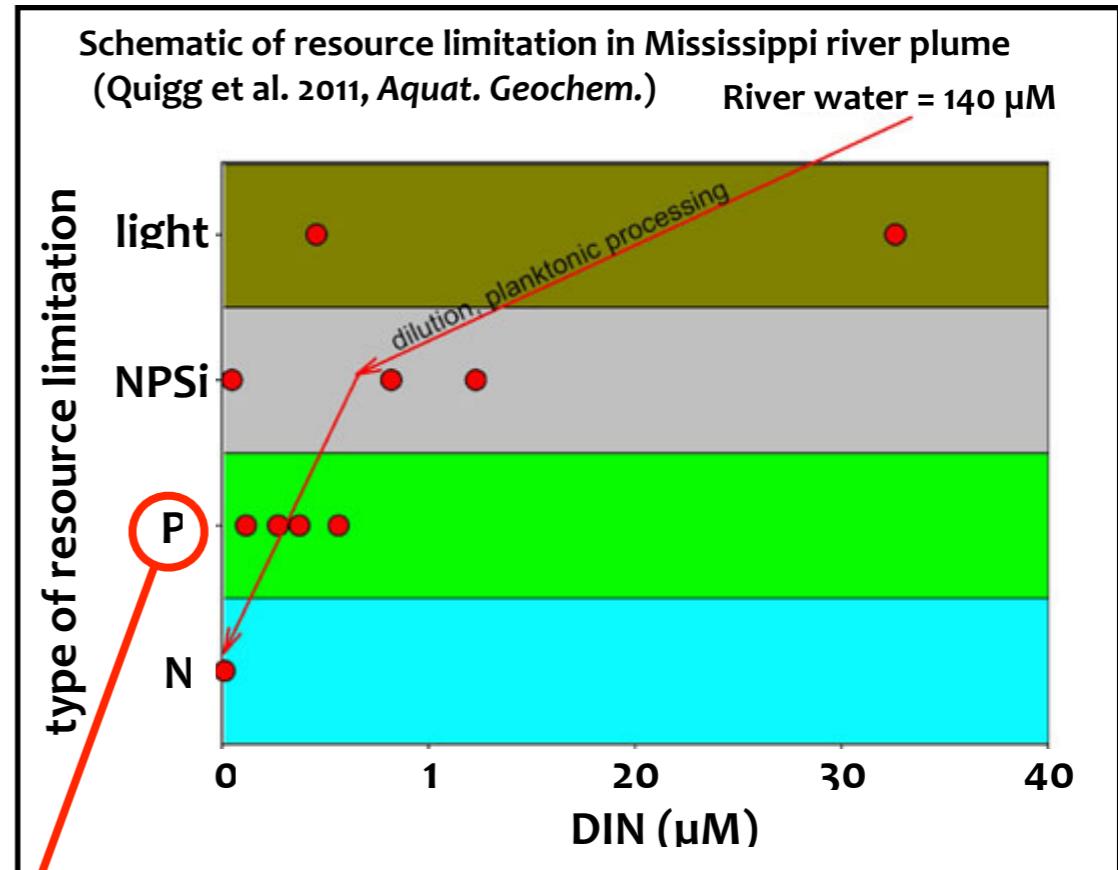
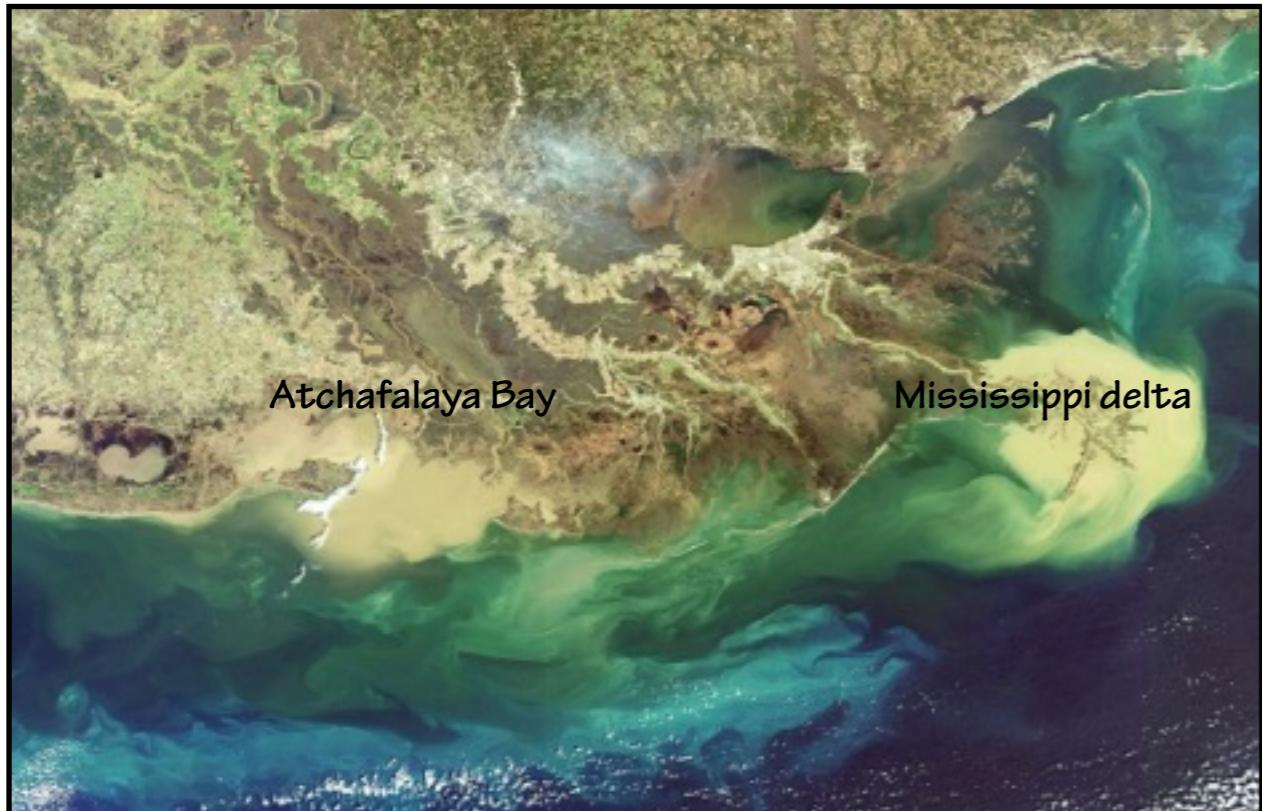
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<sup>1</sup> Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

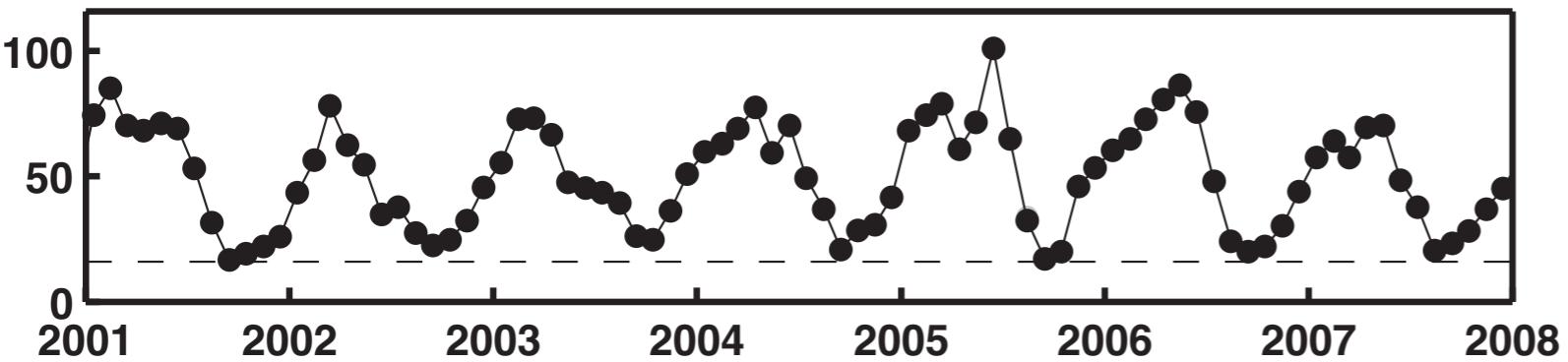
<sup>2</sup> Department of Oceanography, Texas A&M University, College Station, Texas, USA



# 1. Resource limitation



DIN:DIP ratio in the Mississippi River



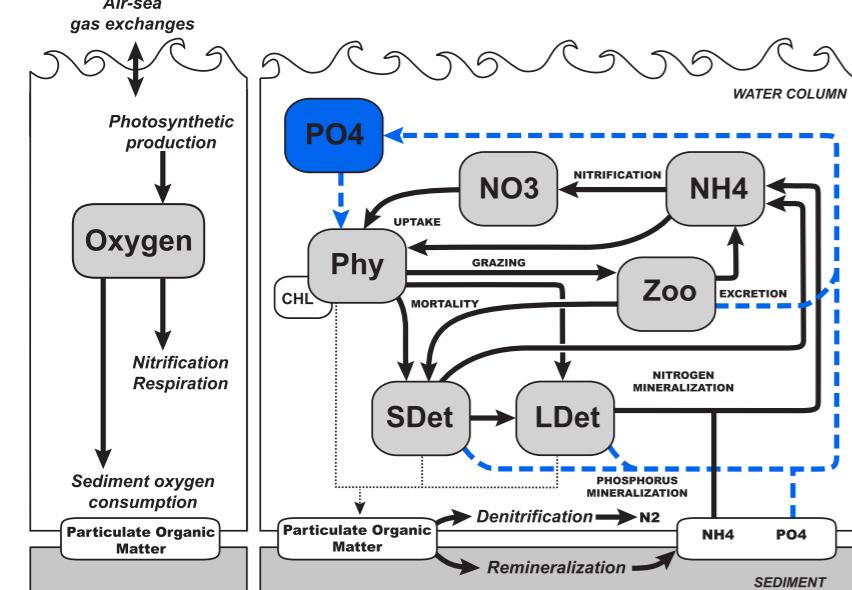
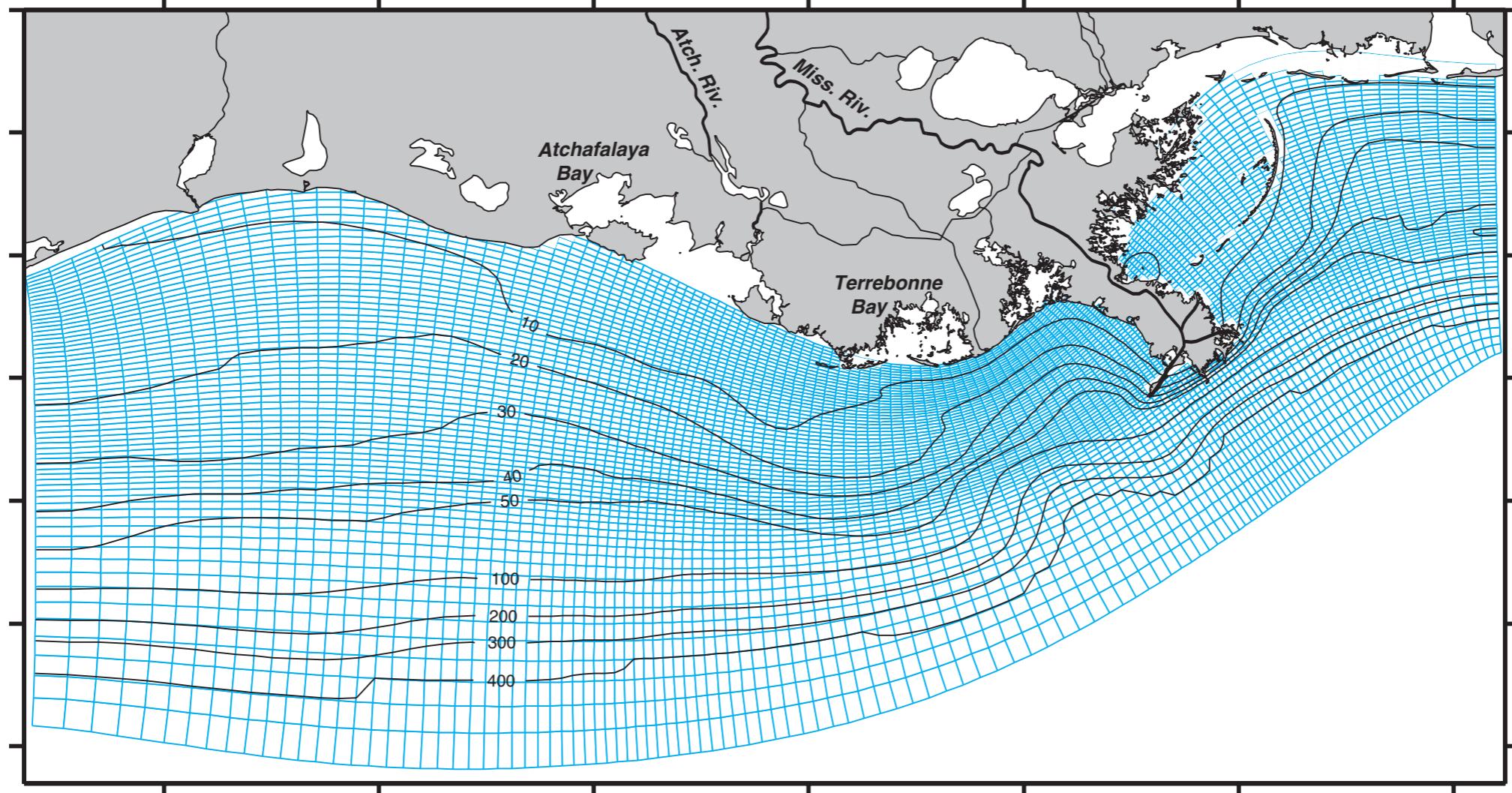
- ⇒ DIN:DIP well above Redfield in spring
- ⇒ Several independent measures have shown P-limitation on the shelf
- Coincides with:
  - Peak in primary production
  - Development of summer hypoxia

## 2. Objectives

- Simulate P-limitation on the Louisiana shelf;
- Determine if and how P-limitation influences:
  - ⇒ primary production
  - ⇒ depositional flux of particulate organic matter
  - ⇒ bottom water  $O_2$
- Assess if P-limitation is likely to expand or contract hypoxia
- Evaluate the consequences of varying river inputs

### 3. Model description

Circulation model



Model: ROMS v3.0

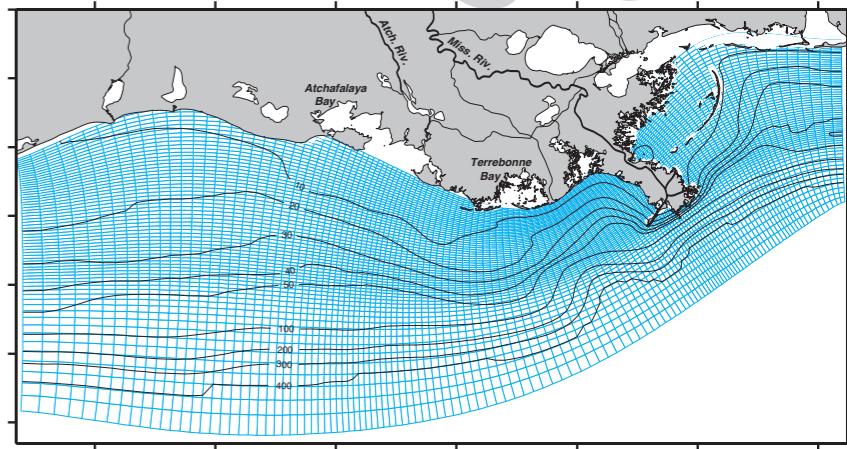
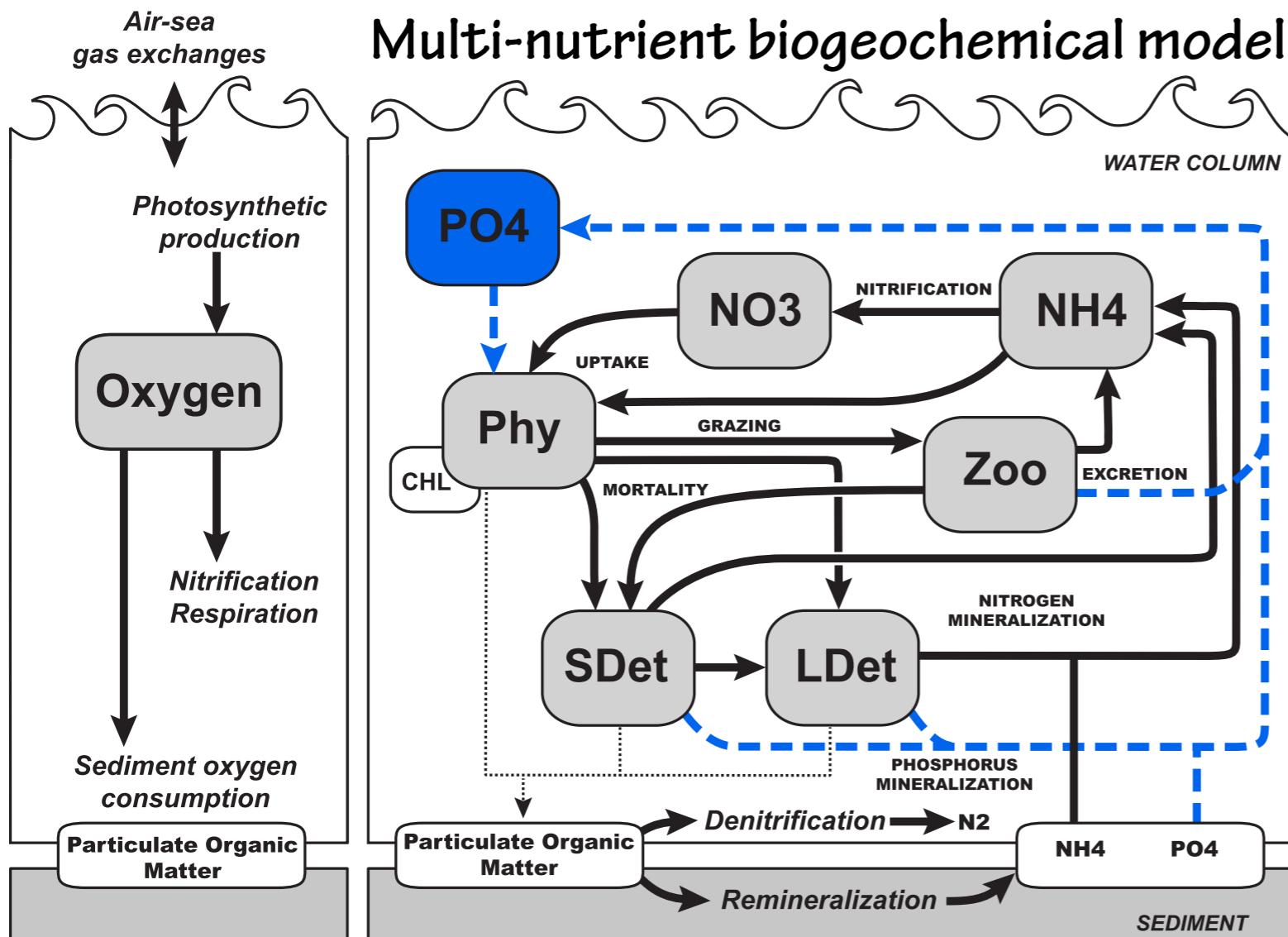
Resolution: 3-5 km in horizontal, 20 vertical layers

Forcing: 3-hourly NCEP NARR winds;  
climatological surface heat and freshwater fluxes

River inputs: daily measurements of freshwater input by U.S. Army Corps of Engineers;  
monthly estimates of nutrient and particulate matter loads from USGS

Horizontal boundary conditions: climatology for biology and physics

### 3. Model description



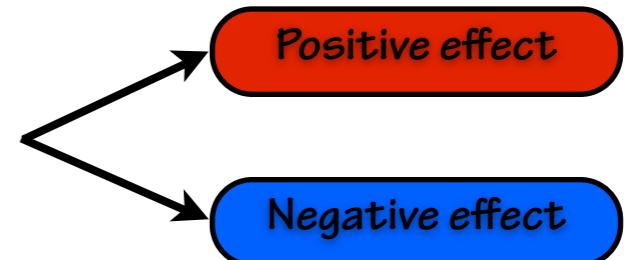
#### Characteristics

- Pelagic ecosystem model
- Multi nutrient
- O<sub>2</sub> dynamics
- Instant bottom remineralization

#### Simulations

- 7 years (2001-2007)
- 2 versions:
  - ⇒ Control with P
  - ⇒ N-only

Effect = Control - N-only



## 4. Nutrient-limitation

(comparison with observations from  
Sylvan et al. 2006, EST)

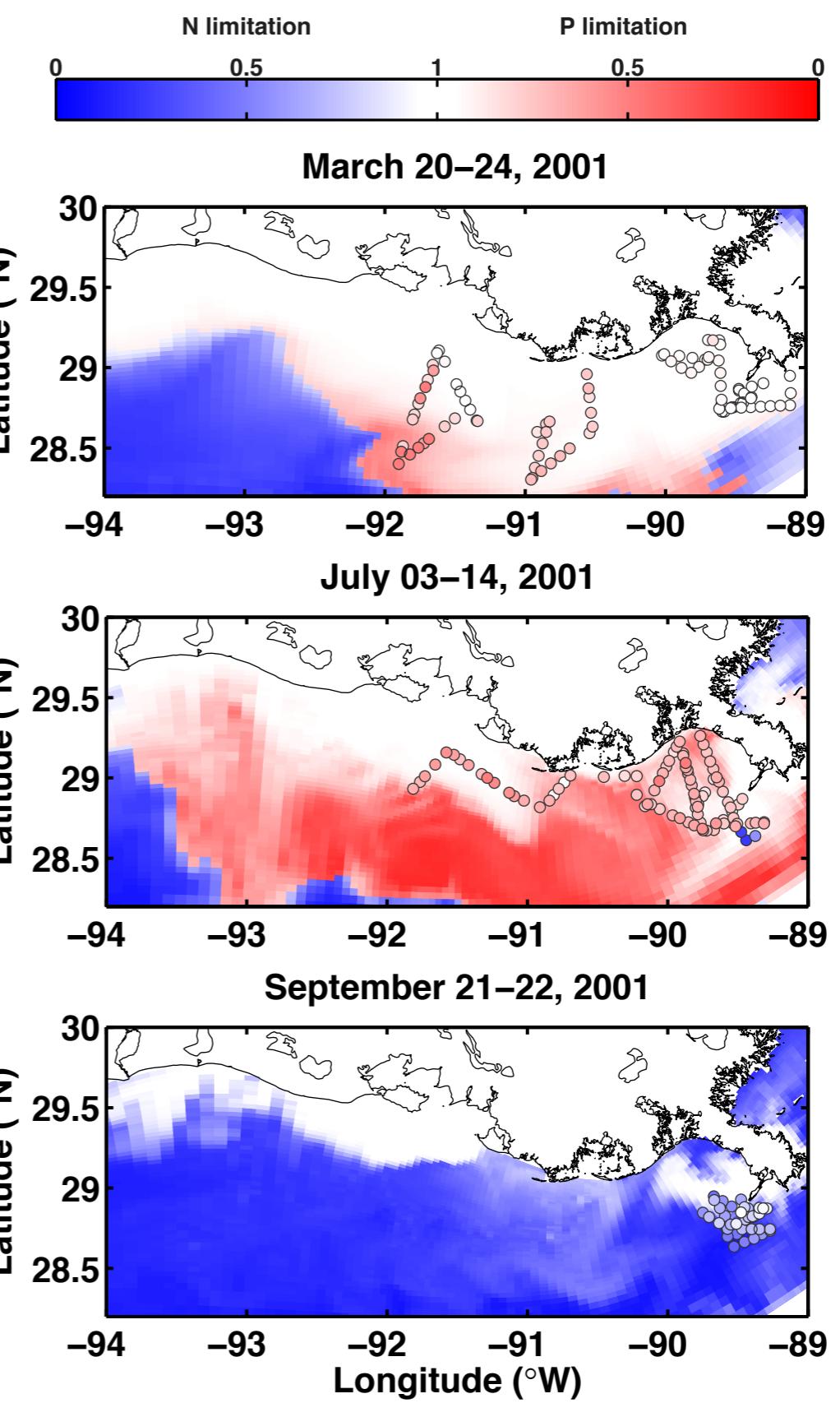
No nutrient limitation



P-limitation



N-limitation

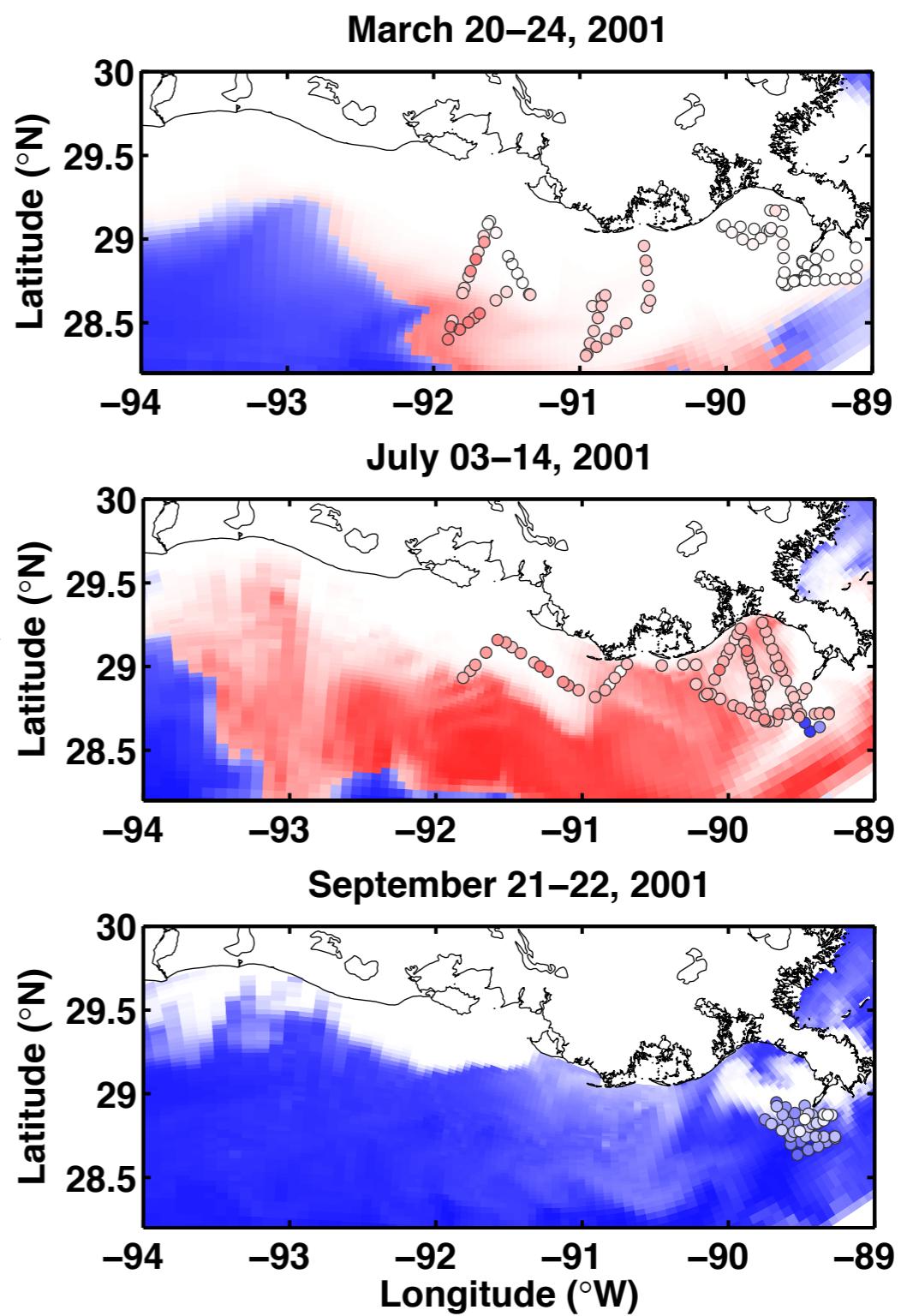
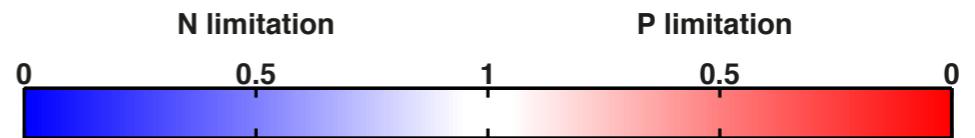


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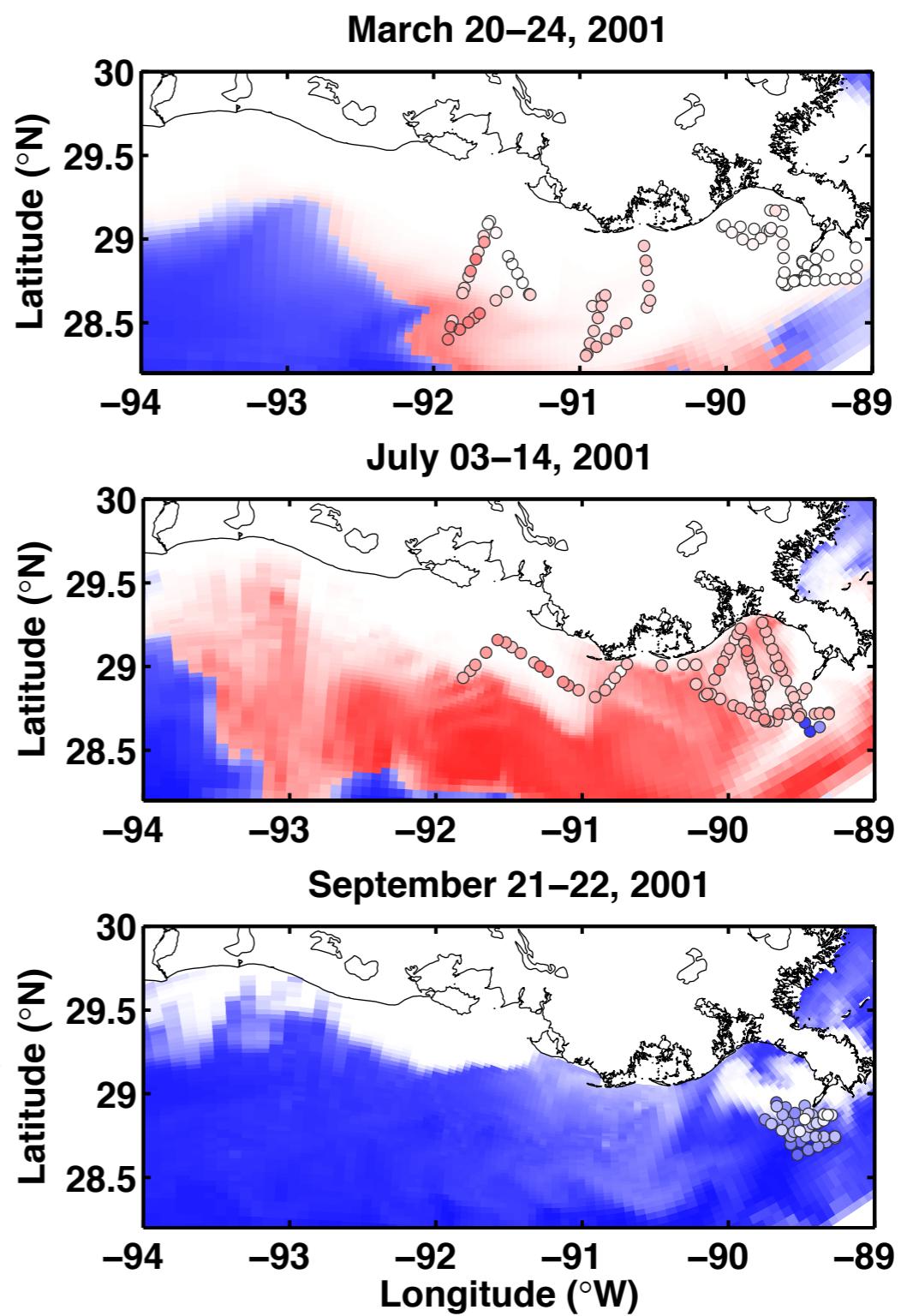
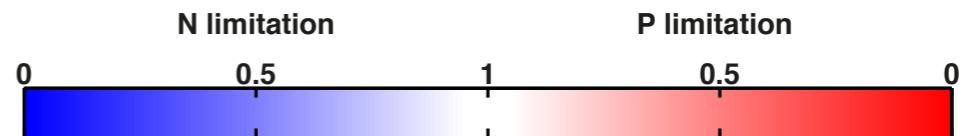
### P-limitation

- Between May and July
- Highest in July
- Mid Louisiana shelf



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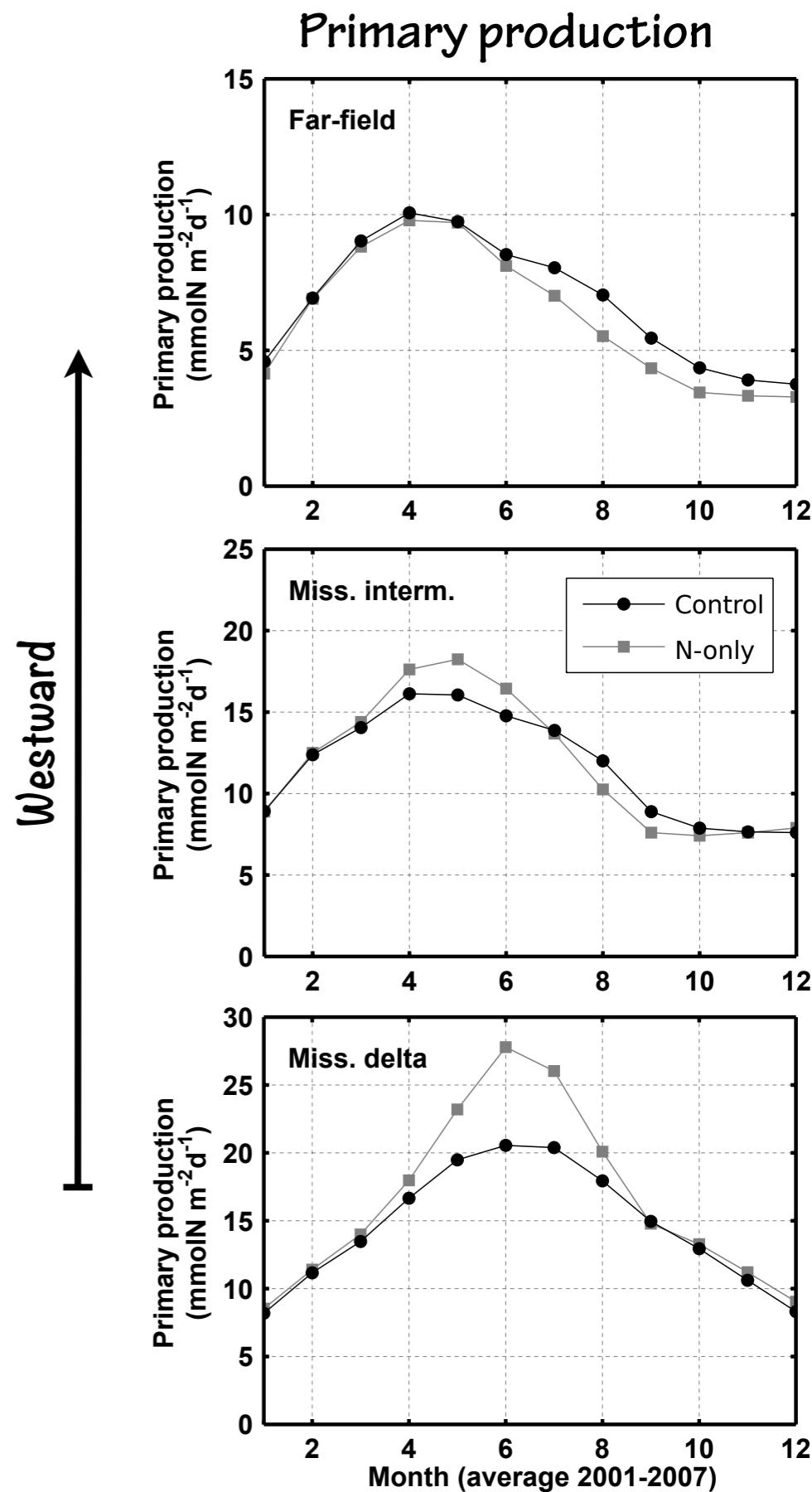
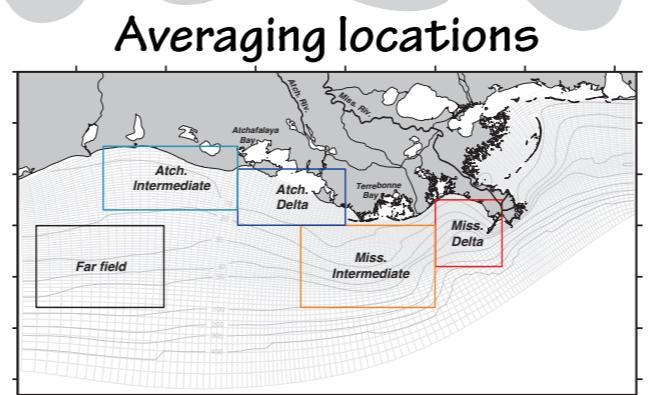


### N-limitation

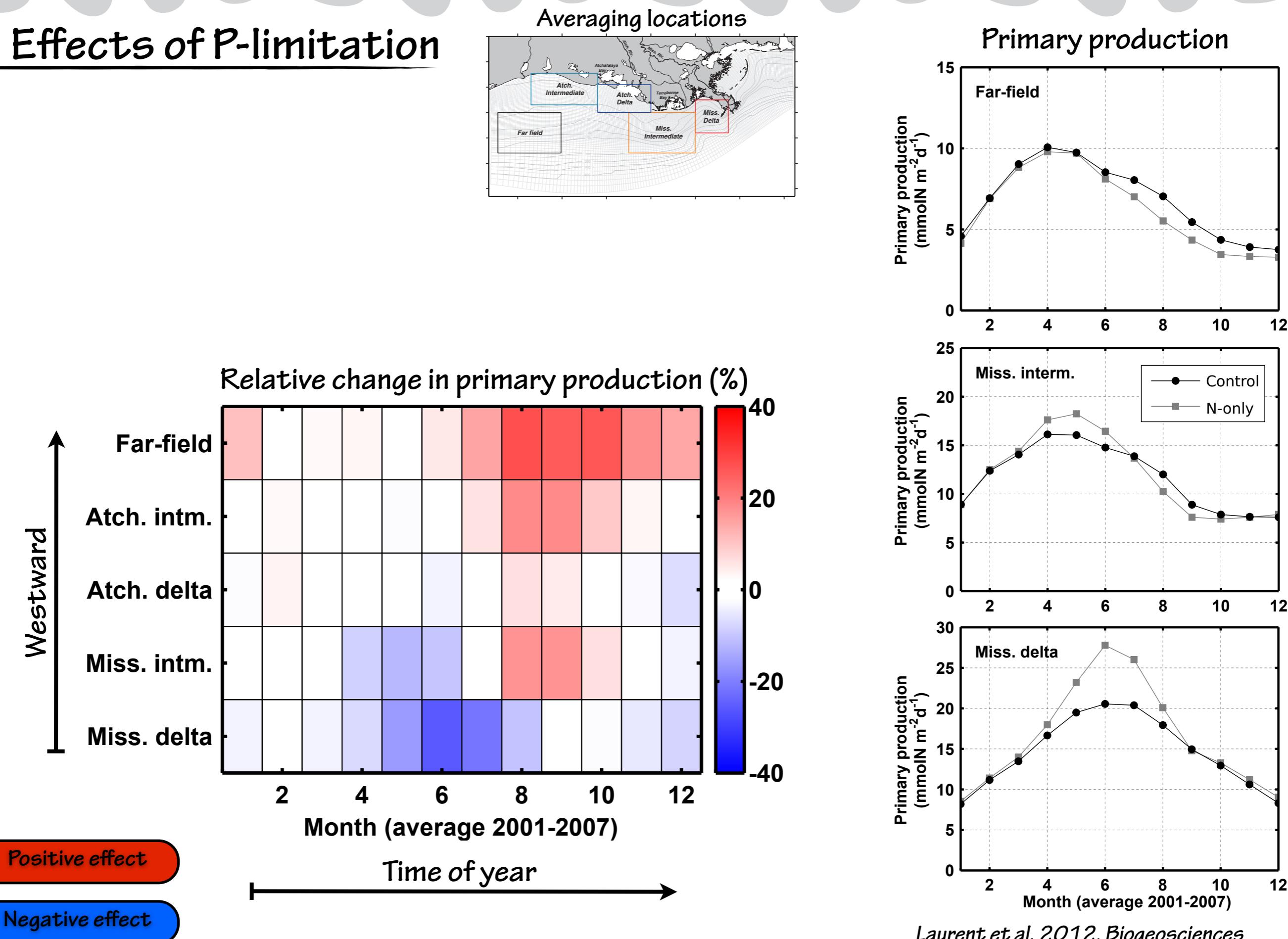
- Louisiana shelf:  
→ August-September
- Offshore



## 5. Effects of P-limitation

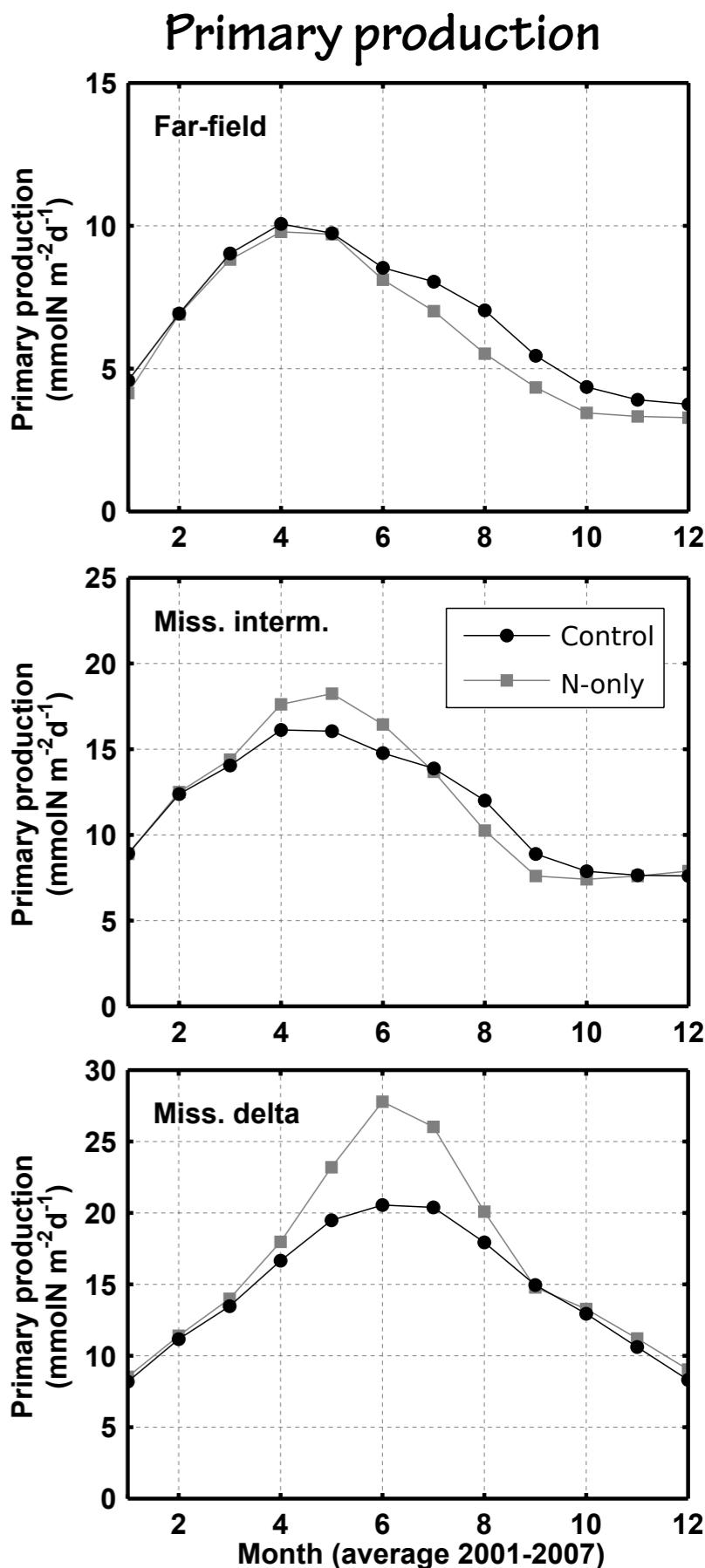
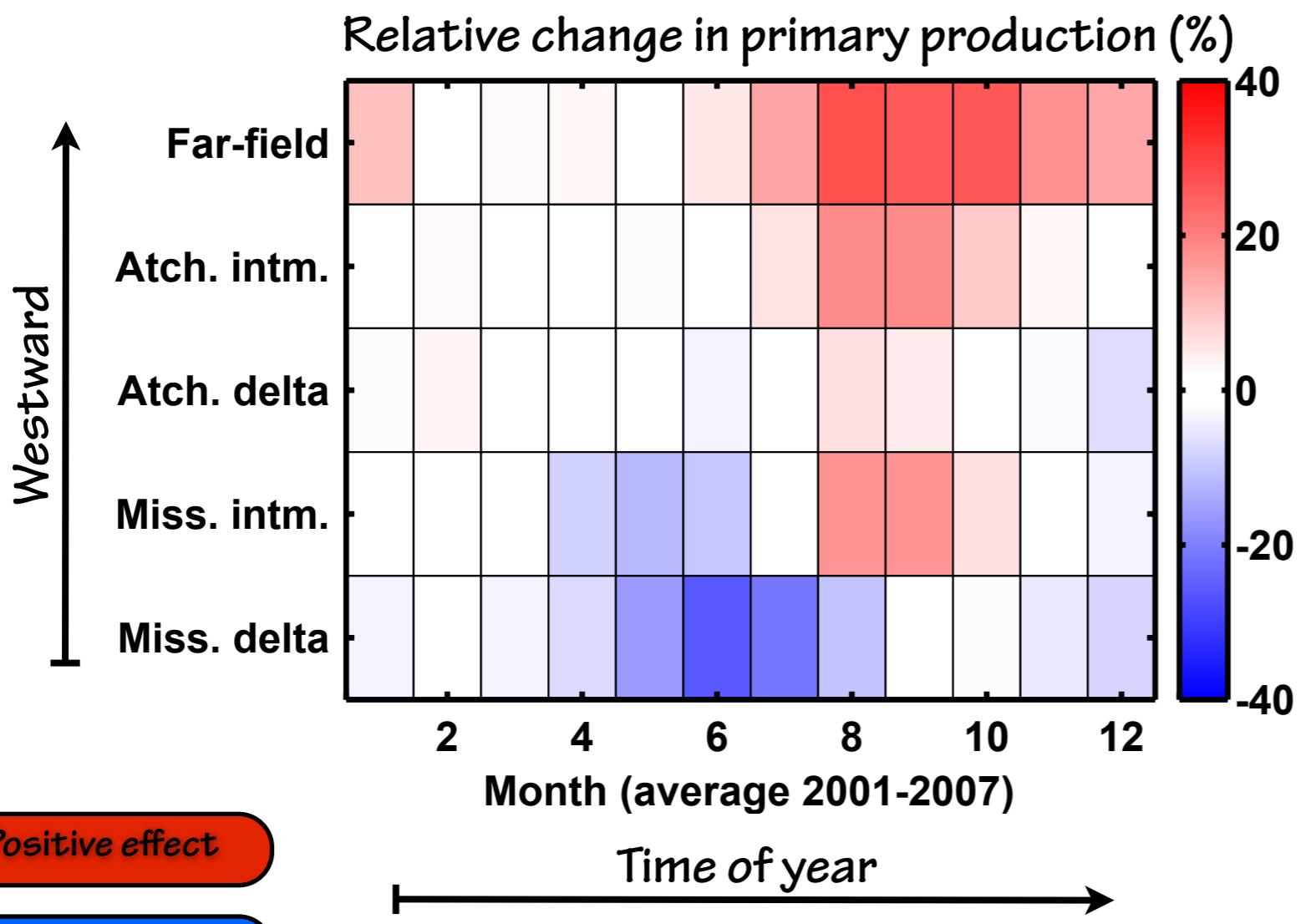


## 5. Effects of P-limitation



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Westward shift with a time delay  
⇒ Primary production

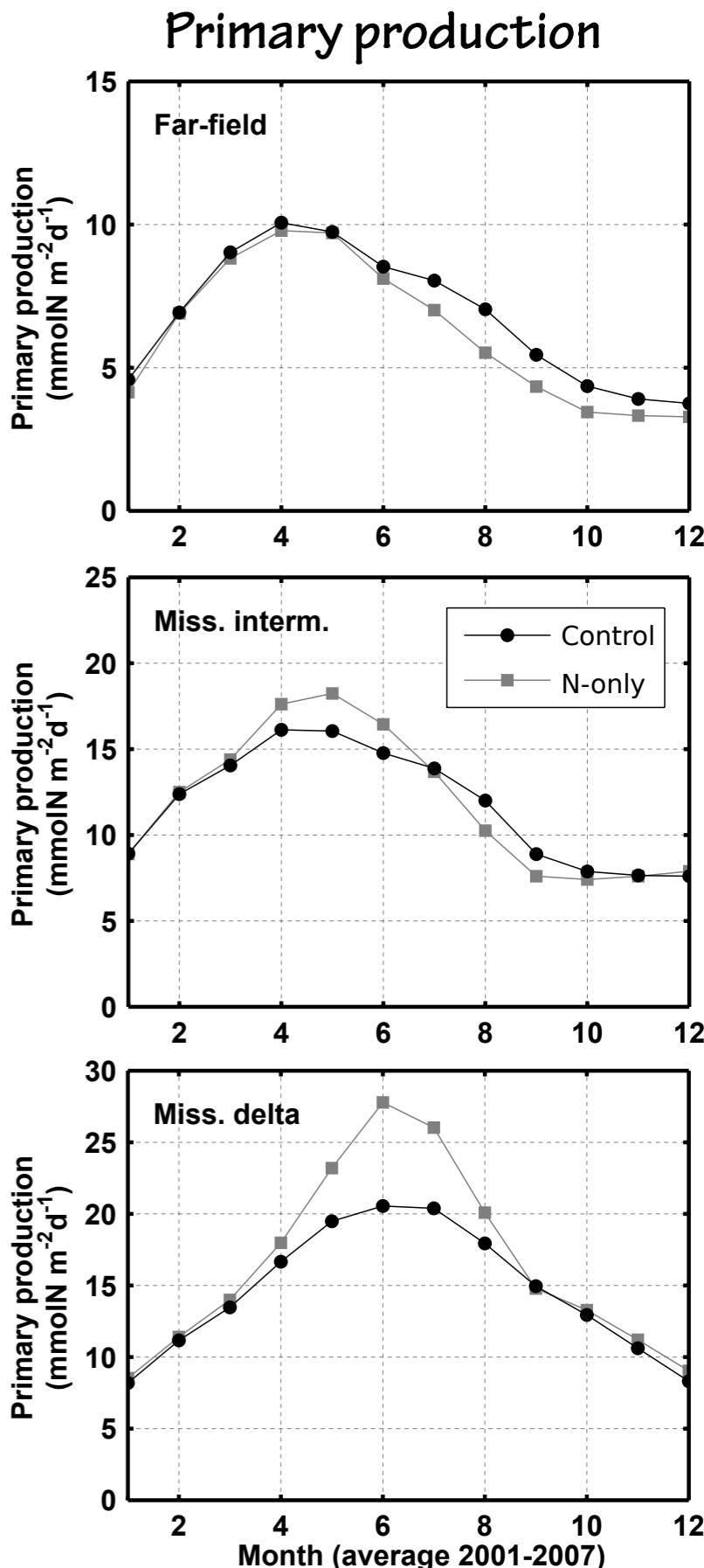
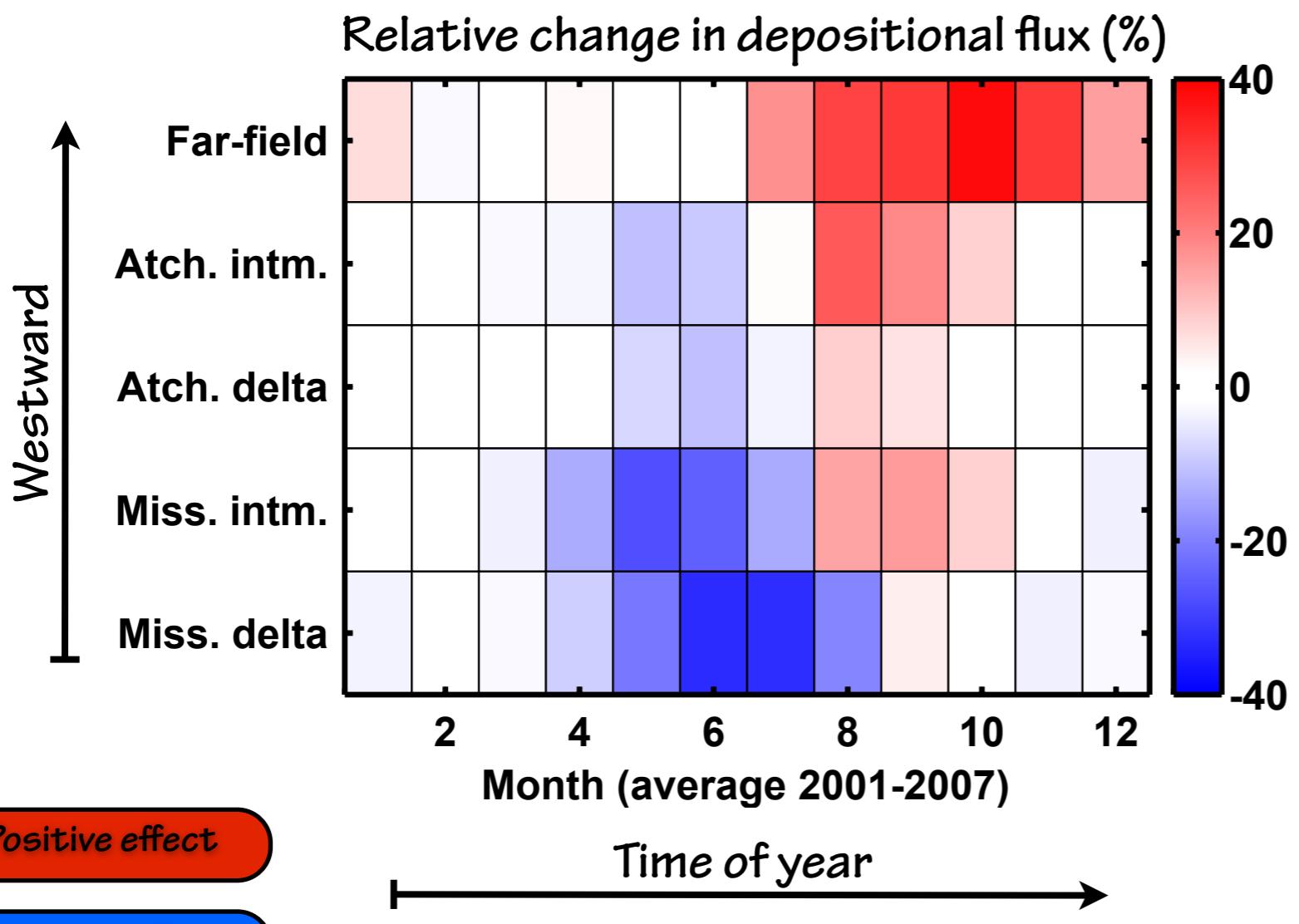


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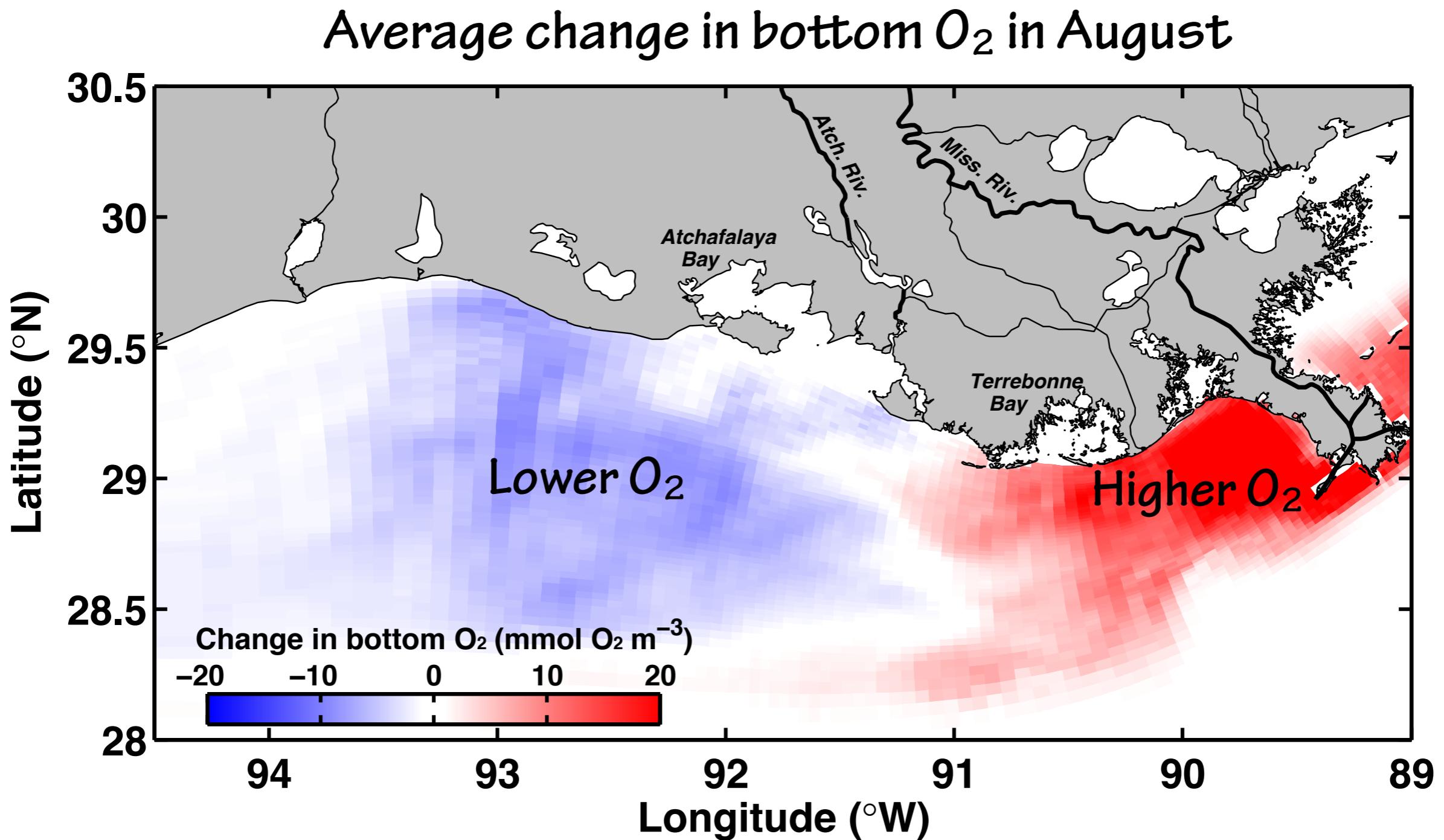
Westward shift with a time delay

⇒ Primary production

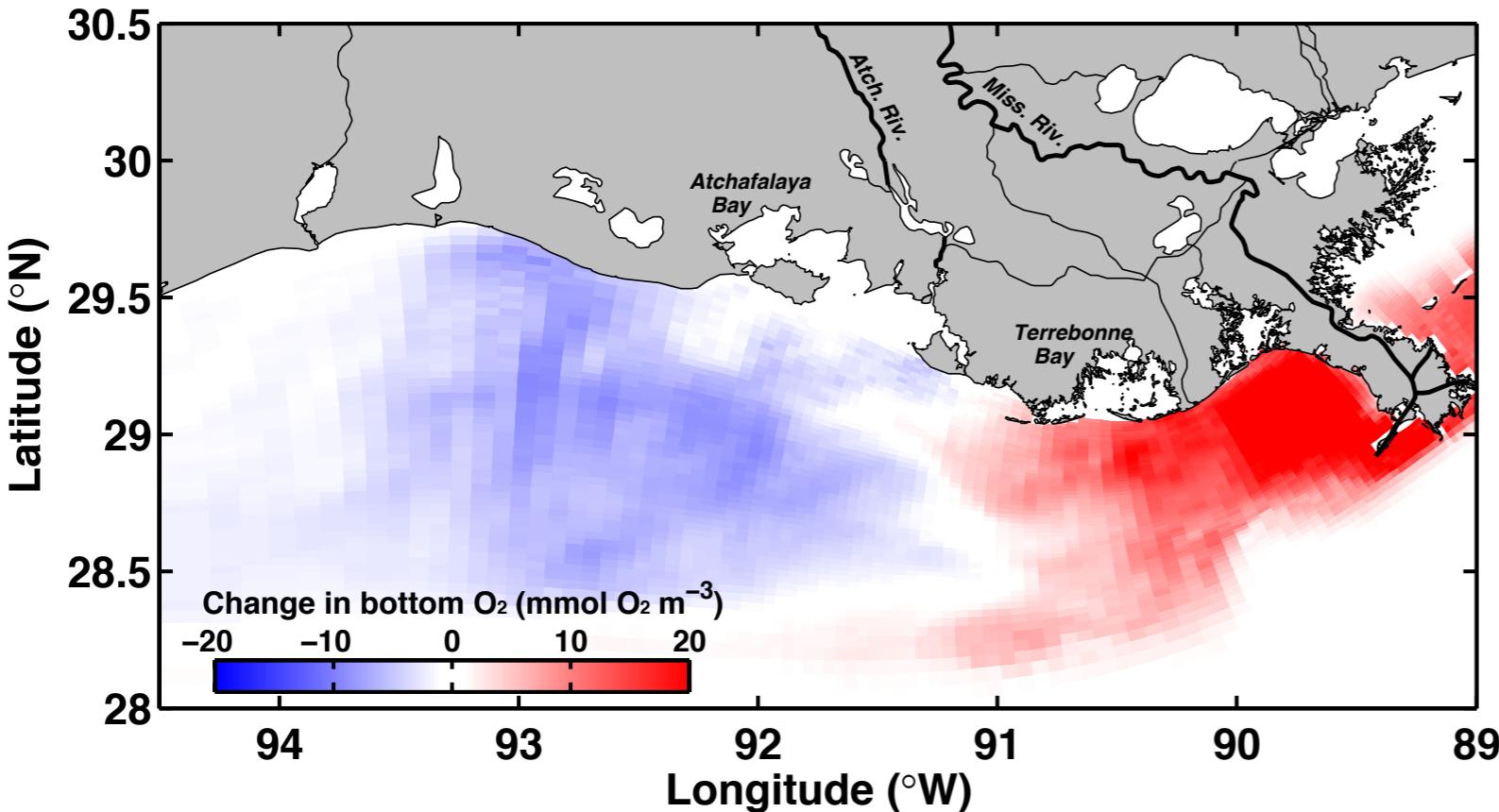
⇒ Depositional fluxes



## 6. Consequence for bottom $O_2$



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### Mississippi delta

- Significant increase in bottom  $O_2$
- Period May to July
- Delay in the onset of hypoxia

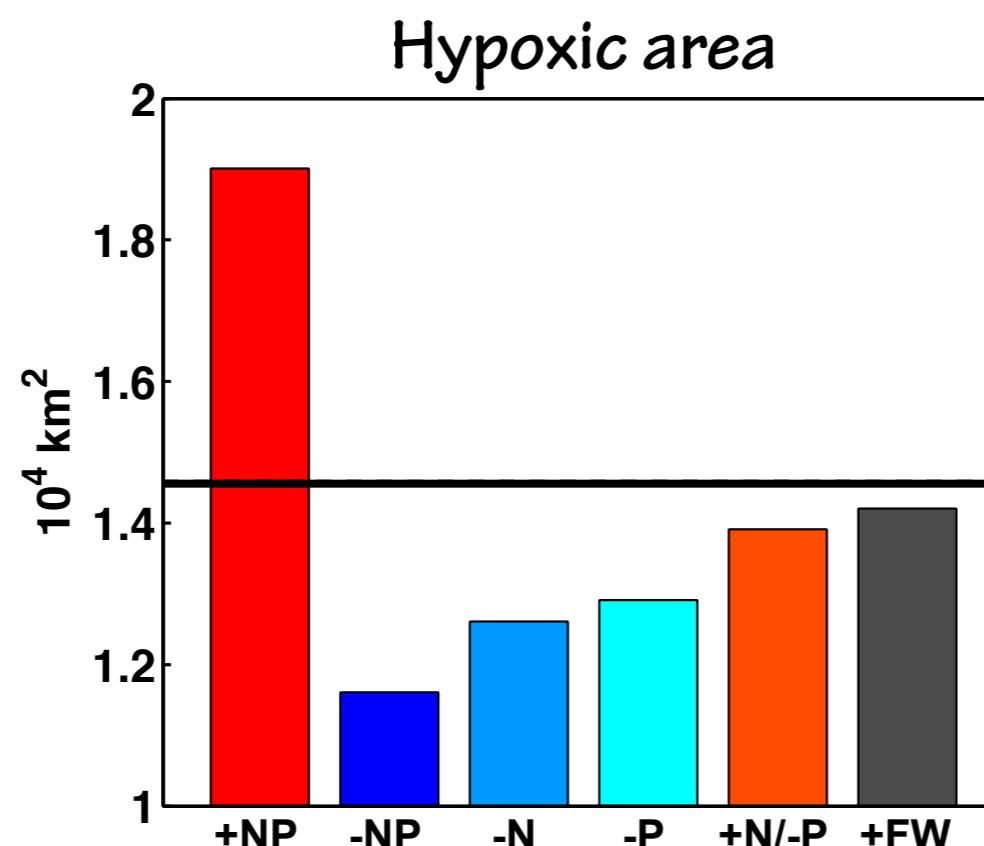
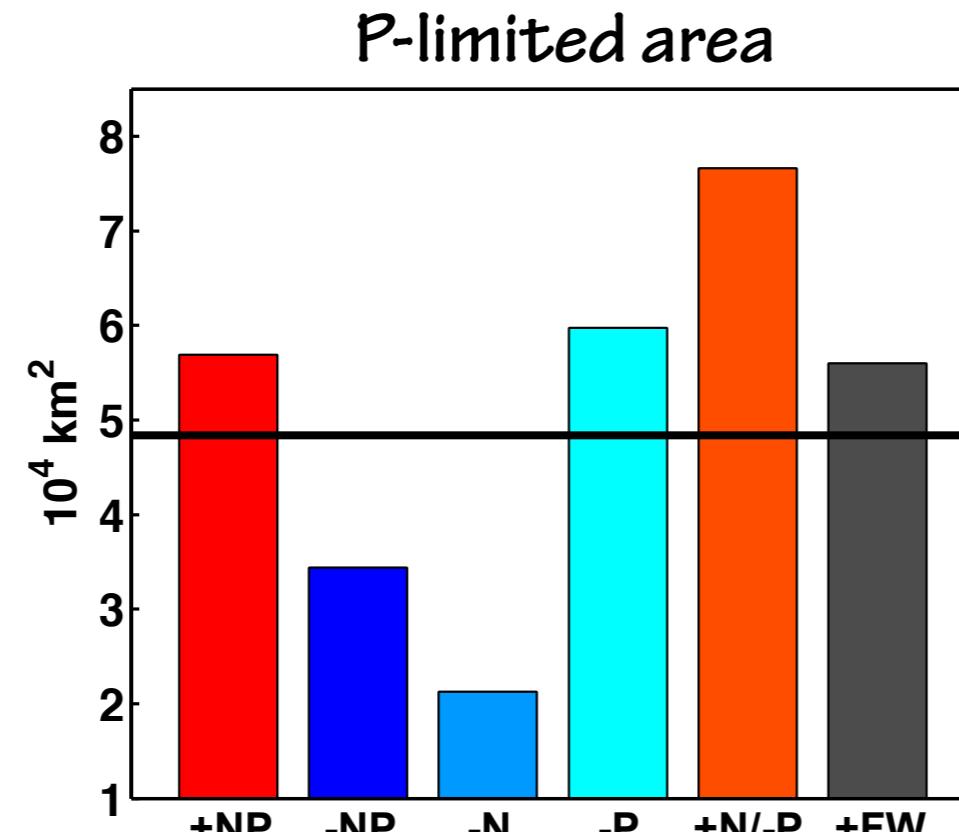
### Western shelf

- Small decrease in bottom  $O_2$
- During August
- Limited change in hypoxia

- ⇒ Contrasting effects of P-limitation on hypoxia
- ⇒ Overall reduction in the size of the hypoxic area
- ⇒ “Dilution effect” on the consequences of eutrophication

## 7. Sensitivity to river inputs

- +50% nutrients
- 50% nutrients
- 50% DIN
- 50% DIP
- +50% DIN, -50% DIP
- +50% freshwater



- DIN or DIP reduction limits the size of the hypoxic area
- Enhanced freshwater inputs promote hypoxia on the western shelf due to stronger stratification
- Hypoxic area well above the 5000 km<sup>2</sup> target

⇒ Largest reduction of hypoxia with DIN+DIP reduction

## 8. Conclusions

- ✓ Seasonal P-limitation develops in May-July on the mid-shelf
- ✓ P-limitation results in:
  - ⇒ a downstream shift of primary production and depositional fluxes
  - ⇒ less hypoxic conditions near the Mississippi delta
  - ⇒ an overall reduction in the size of the hypoxic area

P-limitation dilutes the effects of eutrophication over the Louisiana shelf

- ✓ Varying N and P loads or freshwater discharge has a significant impact on hypoxia
- ✓ Best strategy to mitigate hypoxia is a co-reduction of N and P load.

