Nitrogen and Salinity Distributions in a River Dominated Estuary

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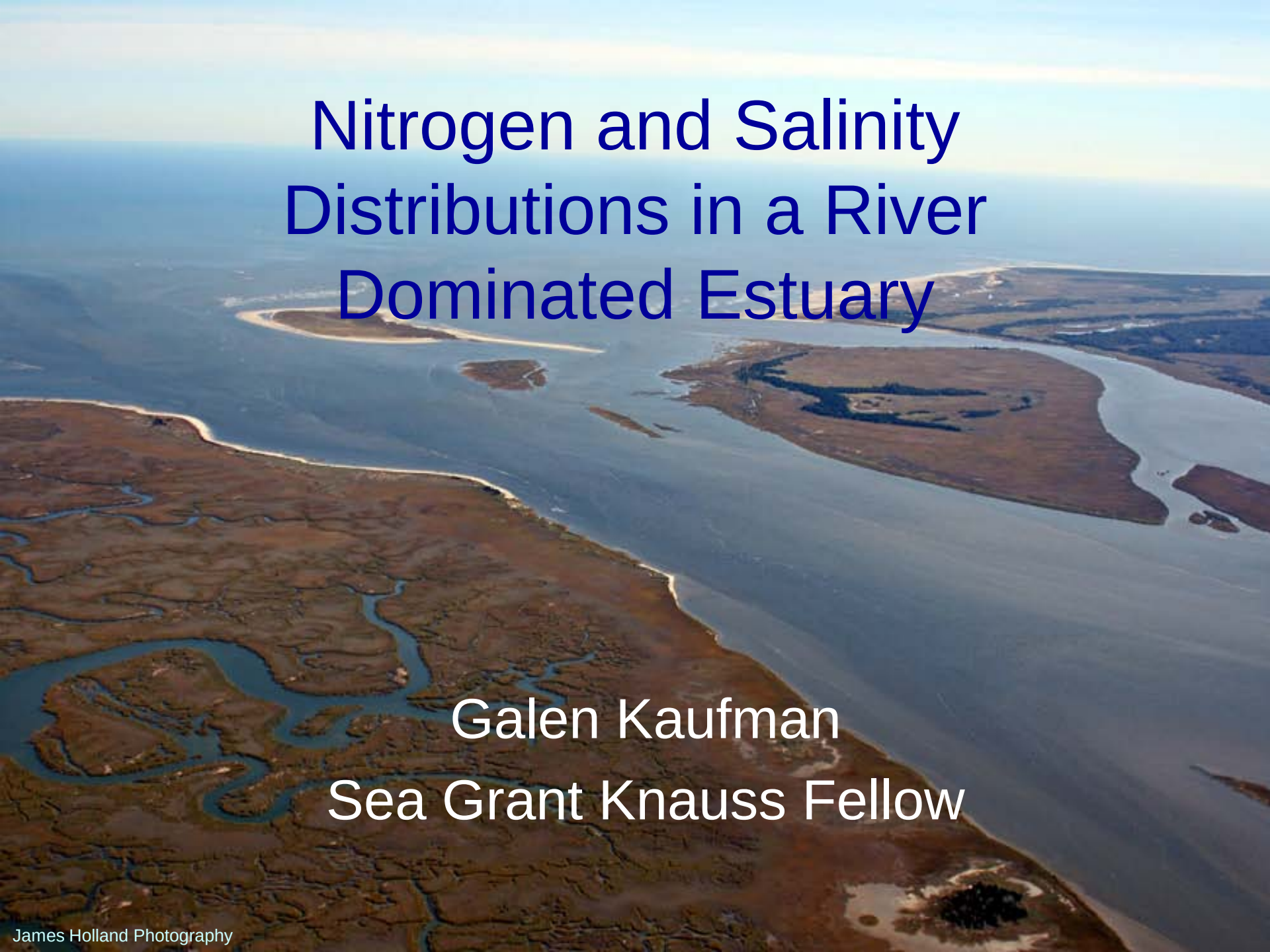
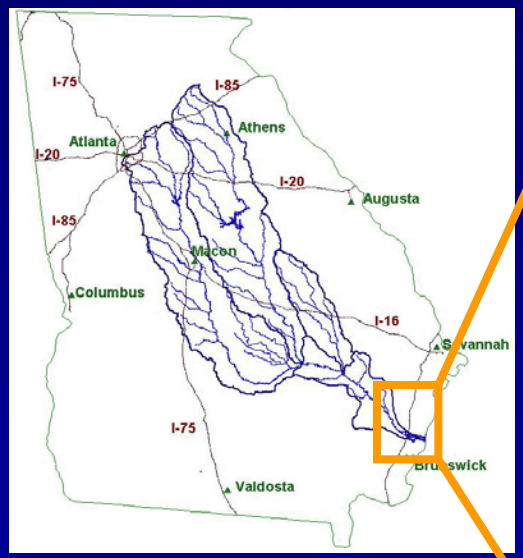
Sea Grant Knauss Fellow



James Holland Photography

Altamaha River

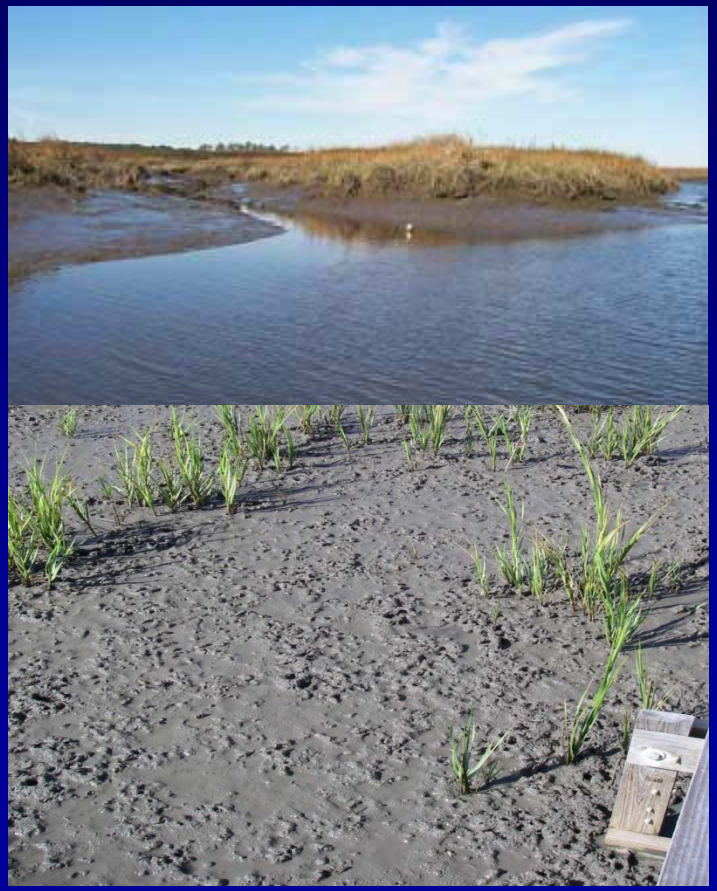
- One of the larger rivers on the East Coast
  - Drainage area= 36,300km^2 (Potomac=38,000km^2, Hudson=34,700km^2)
- Extensive estuarine system



Lessons Learned

Rhodamine dye and mud are not friends

+



=BAD

Nitrogen

- Excess in many estuaries
- Role in eutrophication
- Many sources
  - Natural
    - Decomposition
    - Fixation
  - Anthropogenic
    - Agriculture
    - Wastewater

Nitrogen

- Many factors affect its distribution
  - Biological
    - Nitrogen cycle
  - Chemical
    - Salinity
    - pH
  - Physical
    - Transport from rivers and marshes
    - Sediment/water fluxes

Salinity

- Important determinant of estuarine ecology
- Dynamic behavior in estuaries
- Can be used as a proxy for transport

Goal

Describe salinity and nitrogen distributions and explore their dynamics in the Altamaha River estuary

Methods

- Meta-analysis of benthic flux data
- Nitrogen budget
- Hydrodynamic and water quality modeling

Meta-analysis

- Combined results of a variety of studies related to estuarine sediment N flux
- Criteria for inclusion considered
  - Similar study areas
  - Similar measurement techniques
- Final count: 39 papers

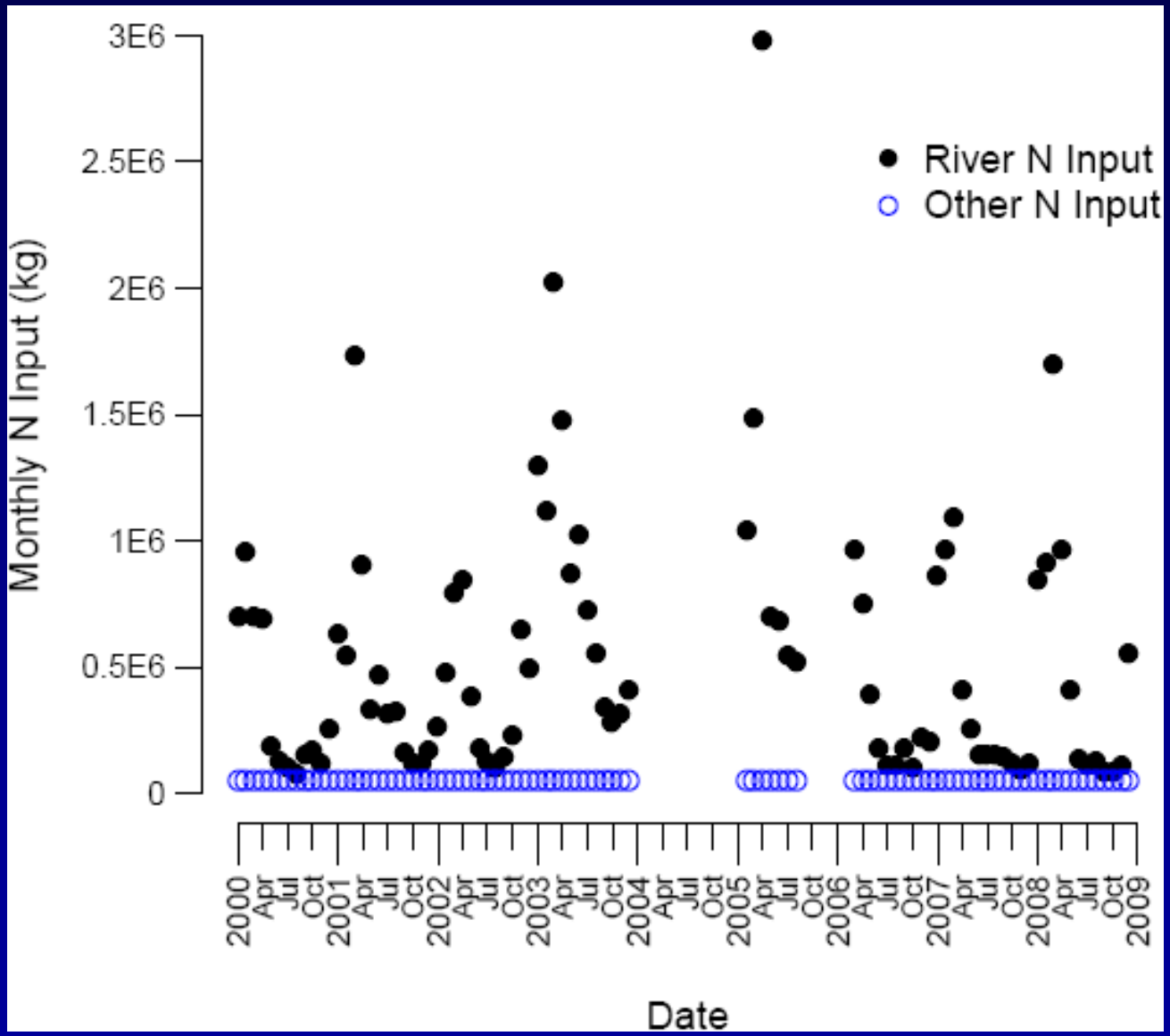
Meta-analysis Results

- No relationship between benthic ammonium (NH_4^+) flux and salinity
- Possible relationship between NH_4^+ flux and other variables (Temp, water column NH_4^+ concentration, sediment oxygen demand)
- Flux of NO_x small, little relationship to other variables

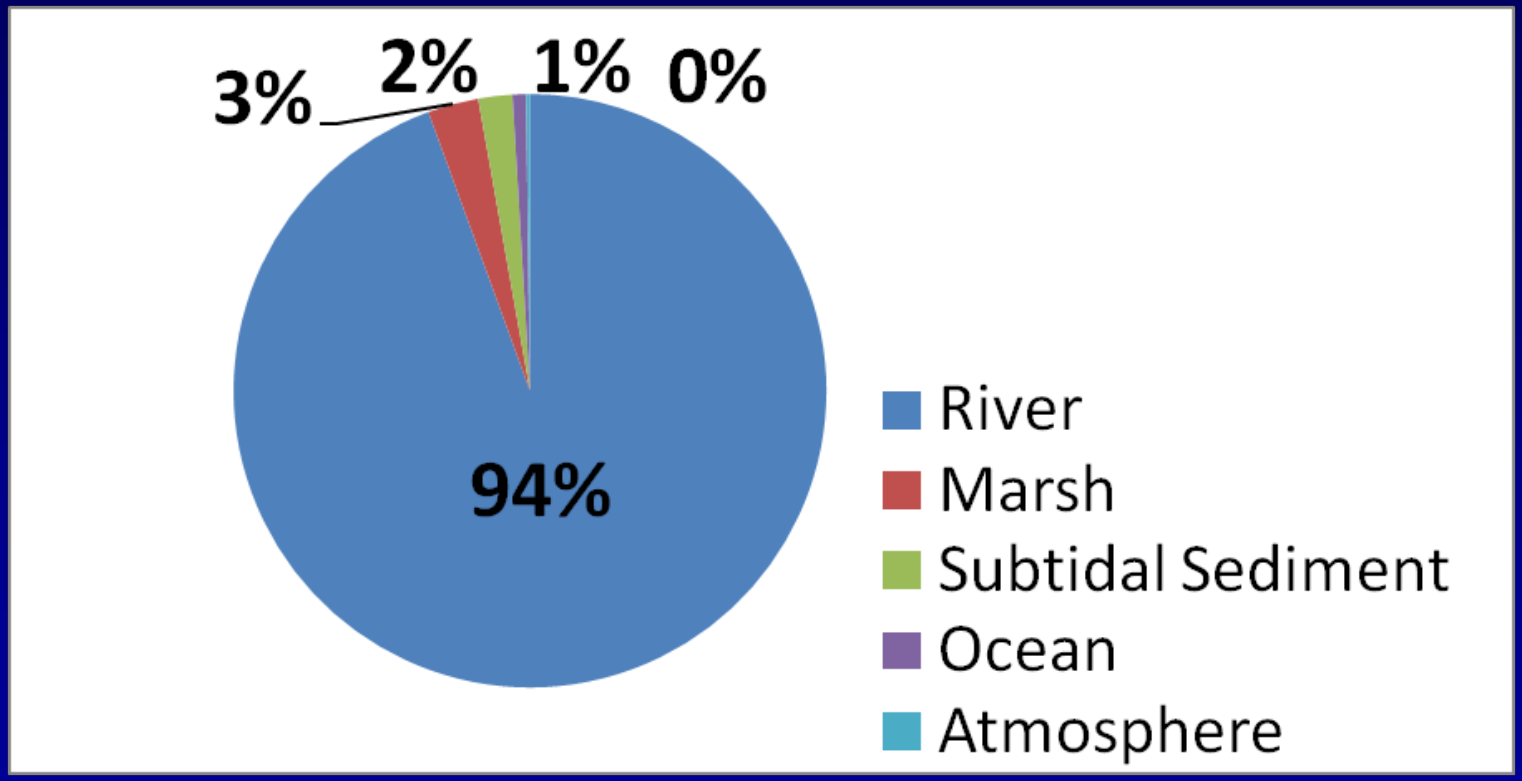
Nitrogen Budget

- Sources considered
  - River
  - Atmosphere
  - Marshes
  - Sediment
  - Mixing with ocean

Nitrogen Budget



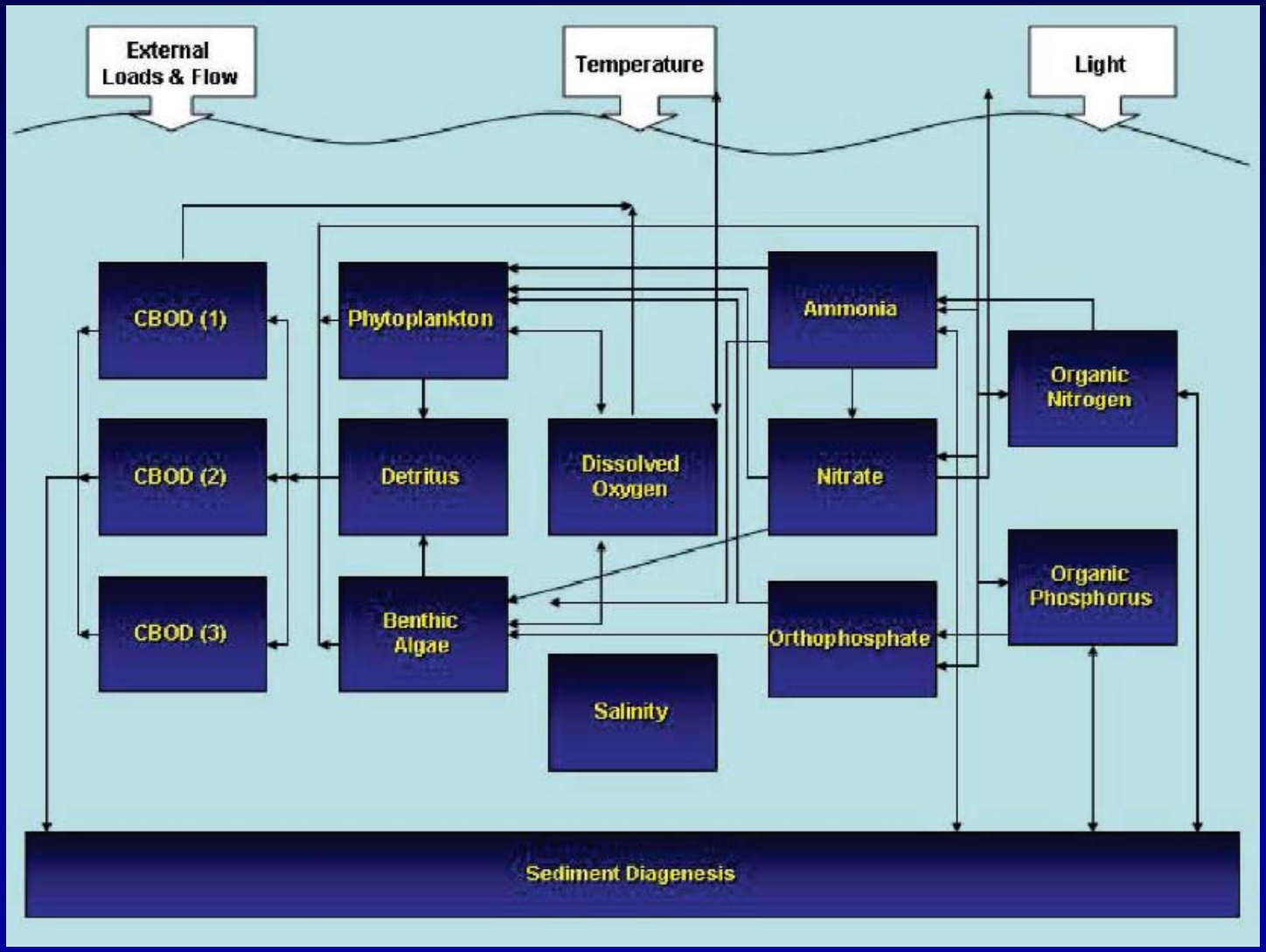
Nitrogen Budget



WASP - Water Quality Model

- EPA's Water Quality Analysis Simulation Program (WASP)
- 2 stand-alone models
  - Physical Transport
  - Water Quality (EUTRO)
- Models sediment and water column processes

WASP


External Loads & Flow
Temperature
Light
CBOD (1)
CBOD (2)
CBOD (3)
Phytoplankton
Detritus
Benthic Algae
Dissolved Oxygen
Salinity
Ammonia
Nitrate
Orthophosphate
Organic Nitrogen
Organic Phosphorus
Sediment Diagenesis

Using WASP in the Altamaha River Estuary

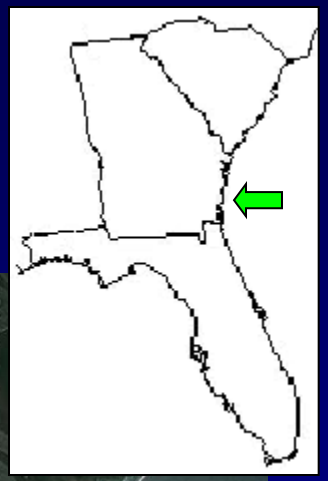
A few of the important components needed to run WASP :

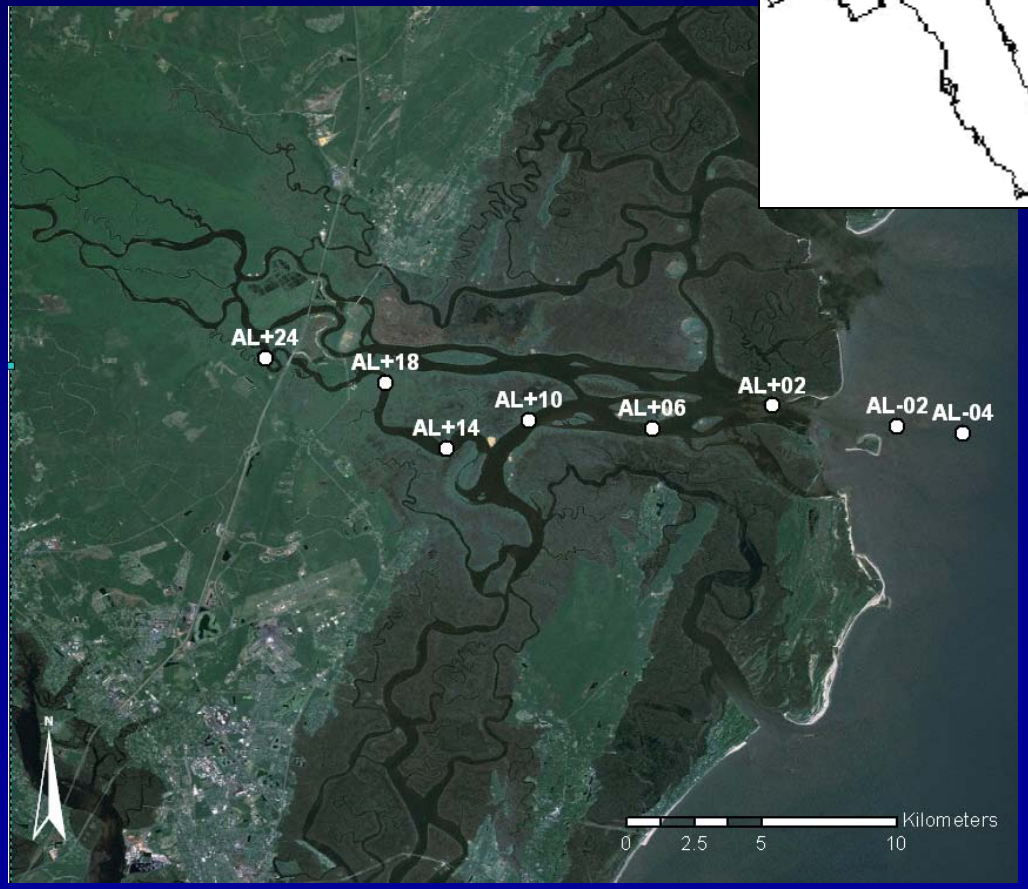
a) Water Quality Observations
b) Hydrodynamics
c) Constants/Kinetic Rates
d) Sensitivity Analysis
e) Calibration

Using WASP in the Altamaha River Estuary

a) Water Quality Observations

- Monitoring data collected by the lab of Dr. Samantha Joye as part of the Georgia Coastal Ecosystems Long Term Ecological Research (GCE-LTER) project





Using WASP in the Altamaha River Estuary

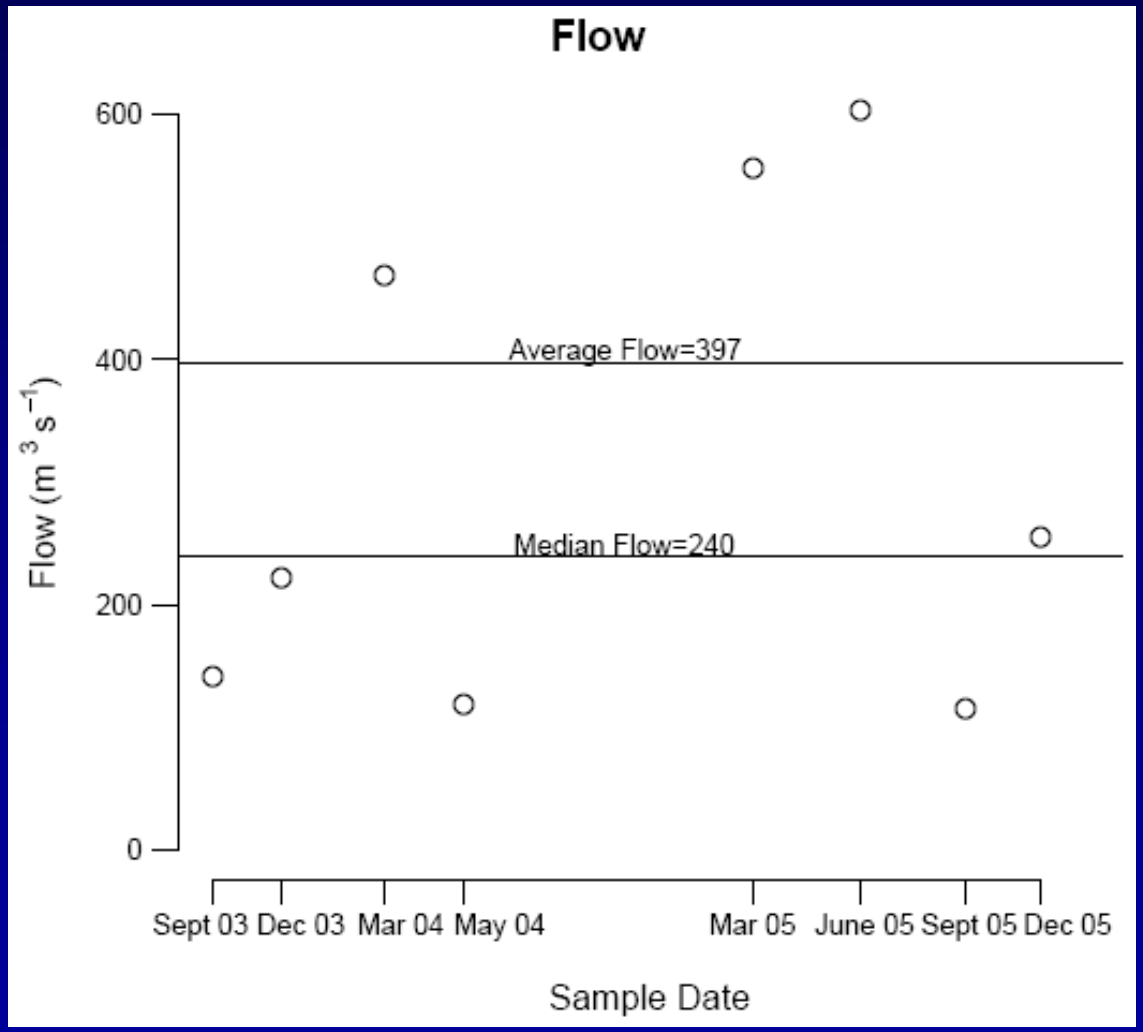
a) Water Quality Observations

- Sampling 2001-present
  - Samples are currently collected monthly
- Samples taken at surface and bottom during high and low tides
- LTER water quality data used in WASP

- Dissolved Oxygen
- Ammonium Nitrogen(NH_4^+)
- Nitrate Nitrogen(NO_3^-)
- Dissolved Organic Nitrogen
- Particulate Organic Nitrogen
- Organic Phosphorus
- Orthophosphate
- Phytoplankton
- Detritus
- Salinity

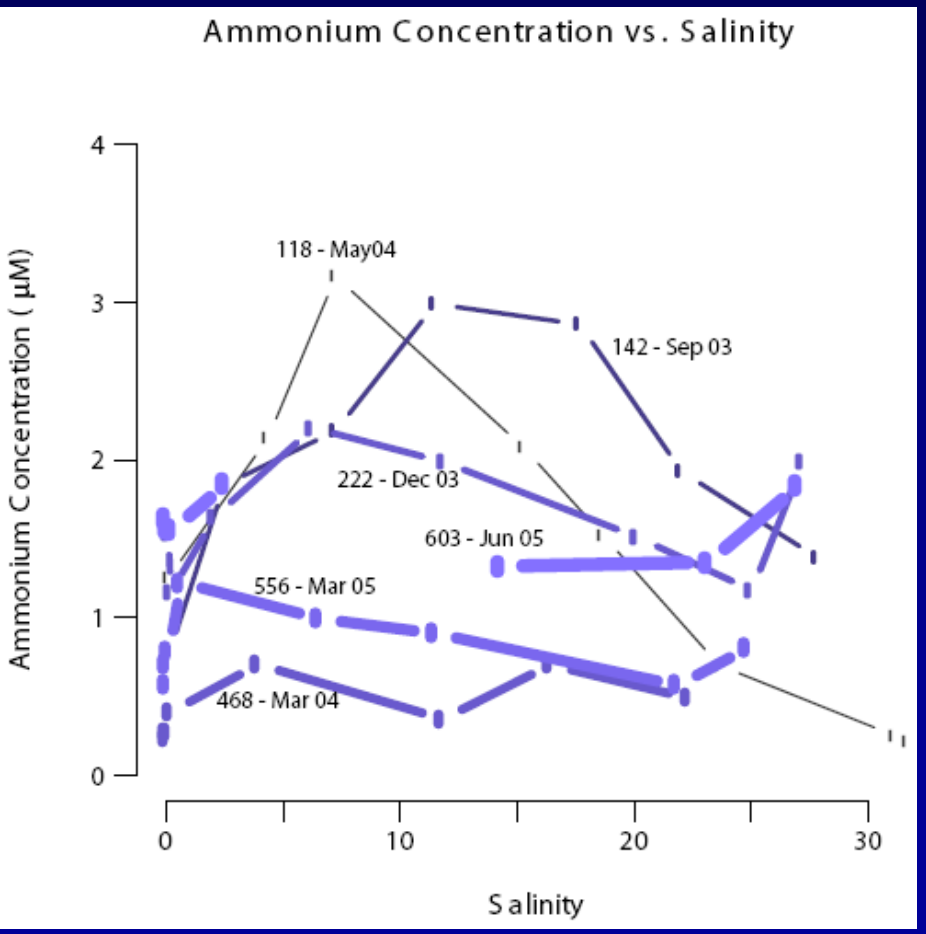
Using WASP in the Altamaha River Estuary

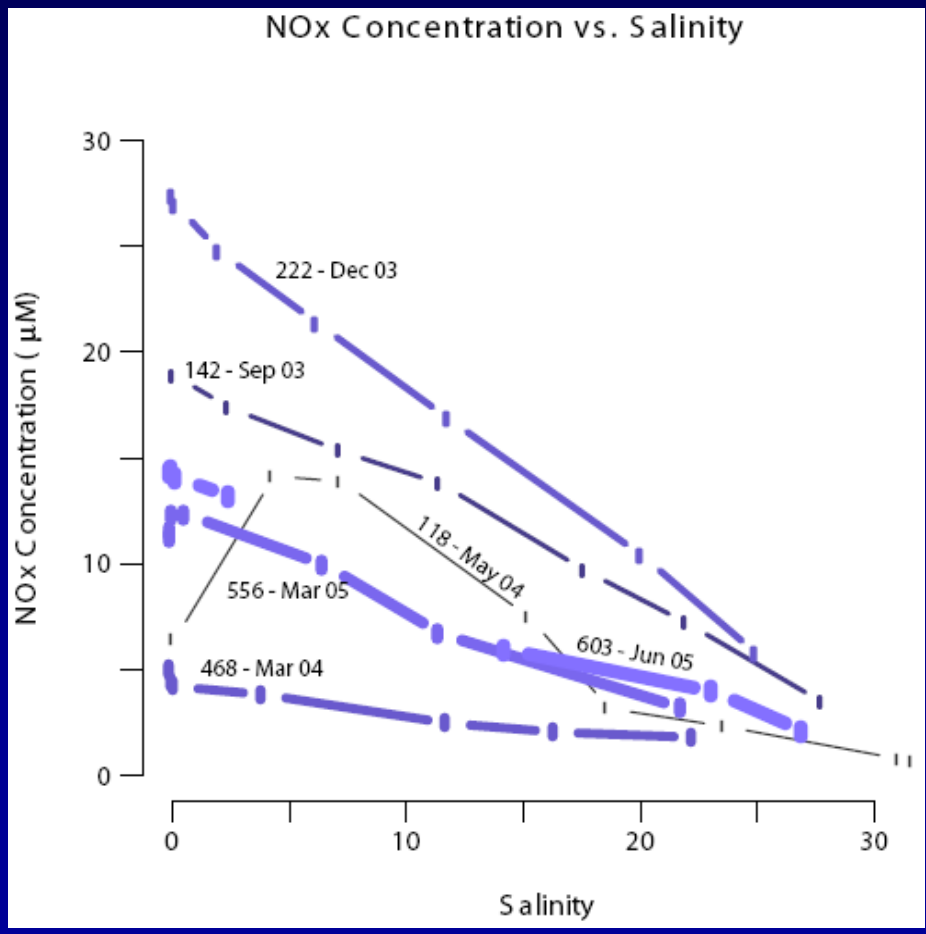
a) Water Quality Observations



Using WASP in the Altamaha River Estuary

a) Water Quality Observations





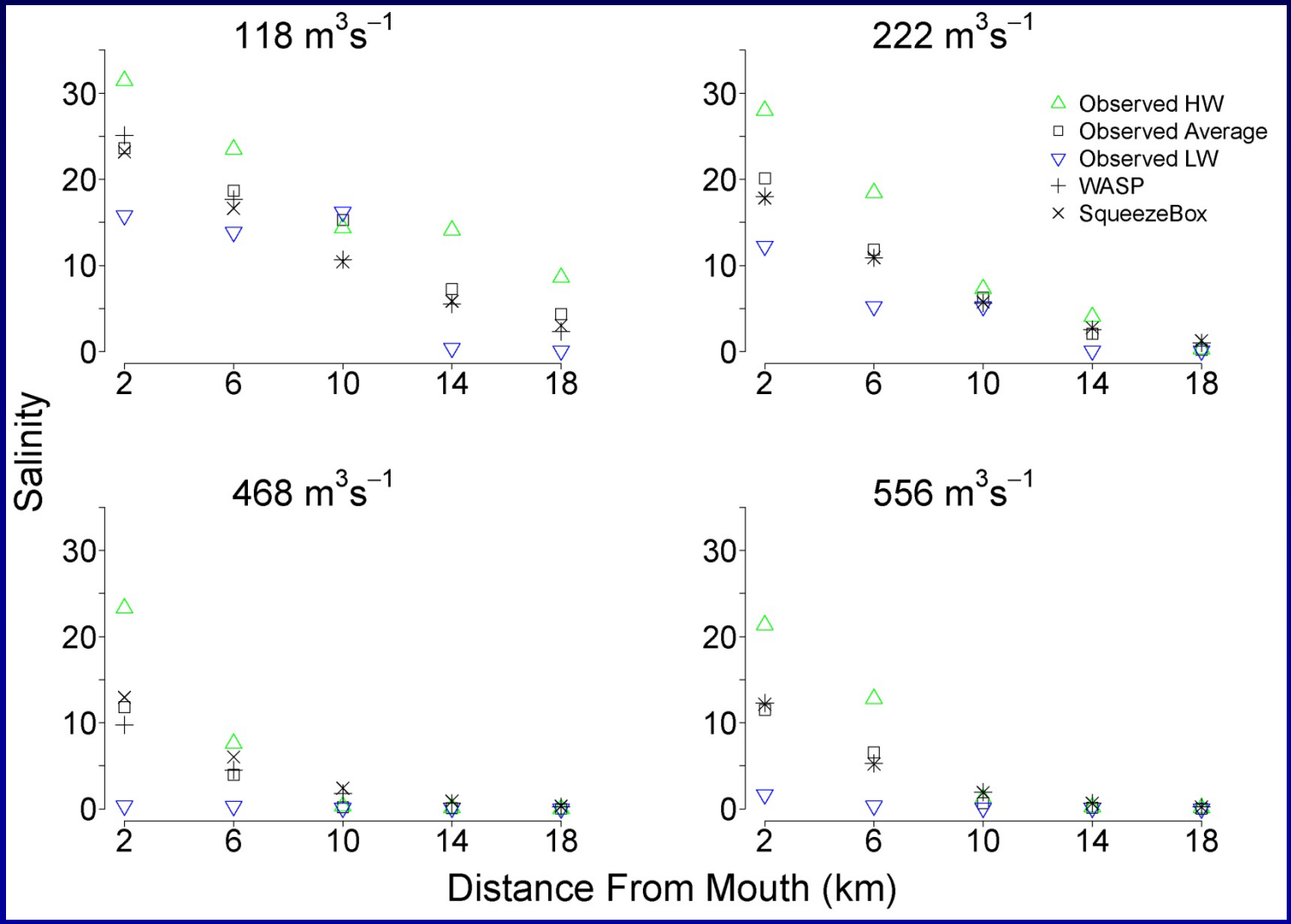
Using WASP in the Altamaha River Estuary

b) Hydrodynamics

- **SqueezeBox (Sheldon and Alber, 2002 & 2005)**
  - Simple box model
  - Calibrated for Altamaha River
  - Used to produce hydrodynamics need for WASP

Using WASP in the Altamaha River Estuary

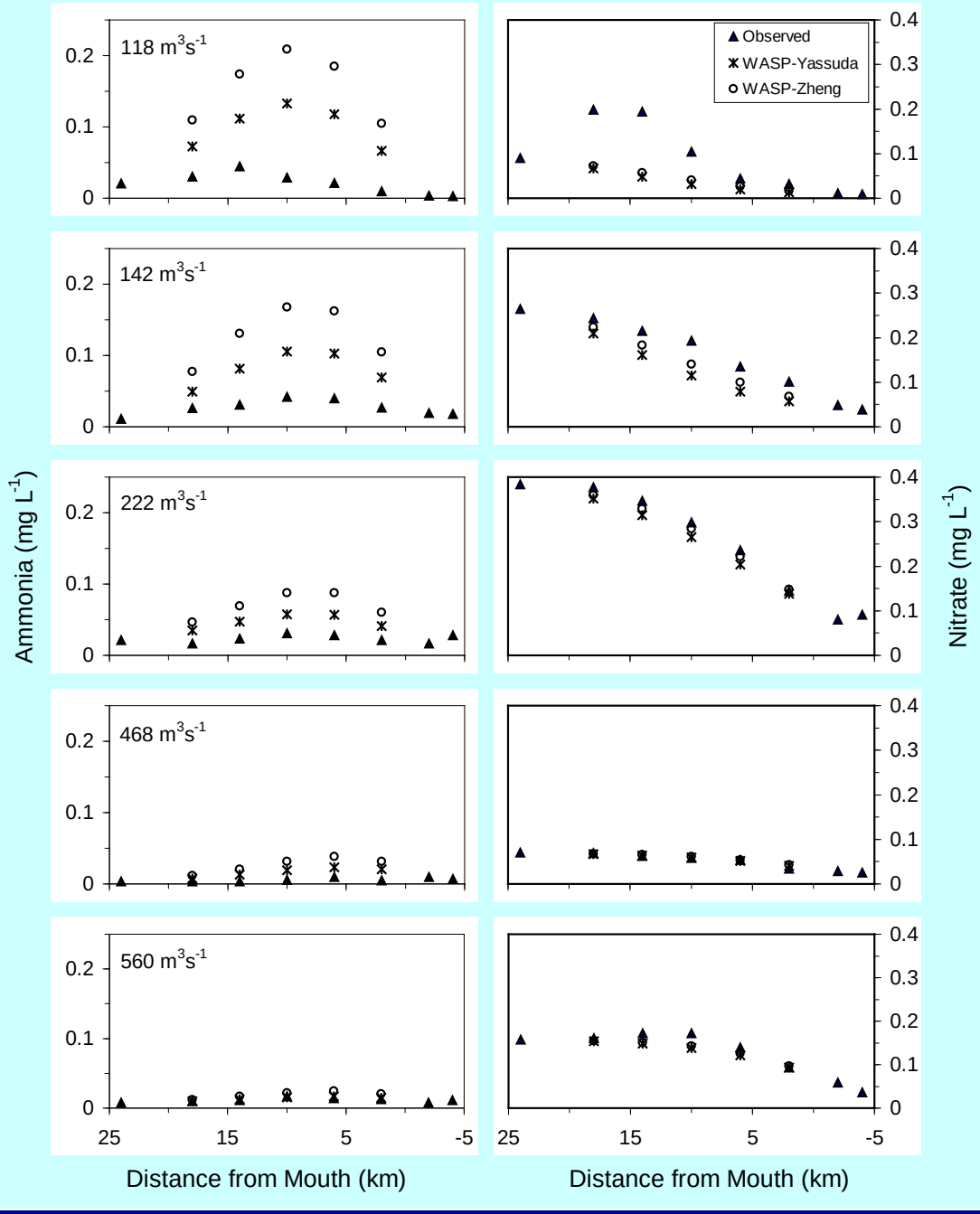
b) Hydrodynamics



Using WASP in the Altamaha River Estuary

c) Constants/Kinetic Rates

- Previous studies in similar systems
- Model documentation
- Literature


118 m3s-1
142 m3s-1
222 m3s-1
468 m3s-1
560 m3s-1
Observed
WASP-Yassuda
WASP-Zheng
Ammonia (mg L-1)
Nitrate (mg L-1)
Distance from Mouth (km)
Distance from Mouth (km)
0
0.1
0.2
0.3
0.4
25
15
5
-5

Using WASP in the Altamaha River Estuary

d) Sensitivity Analysis

- Analyzed model sensitivity to ~160 parameters and variables
- Done at high winter flow and low summer flows
- Tested local and global sensitivity

Using WASP in the Altamaha River Estuary

d) Sensitivity Analysis

- Results
  - During higher flows model elements associated with river inputs dominate
  - During lower flows factors associated with phytoplankton processing become more influential

Using WASP in the Altamaha River Estuary

e) Calibration

- Based on sensitivity analysis considering calibration with 8-13 parameters
- Using differential evolution optimization routine
- Currently using 4 dates with a wide range of nutrient and environmental conditions

Next Steps

- Complete calibration/verification
- Explore relationship between GCE-LTER collected data and more frequently collected data at an upstream USGS sampling station

Thank You

- My Committee
  - Dr. Merryl Alber, University of Georgia
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- The 5 mile long list of the people that have helped me through my grad school trek