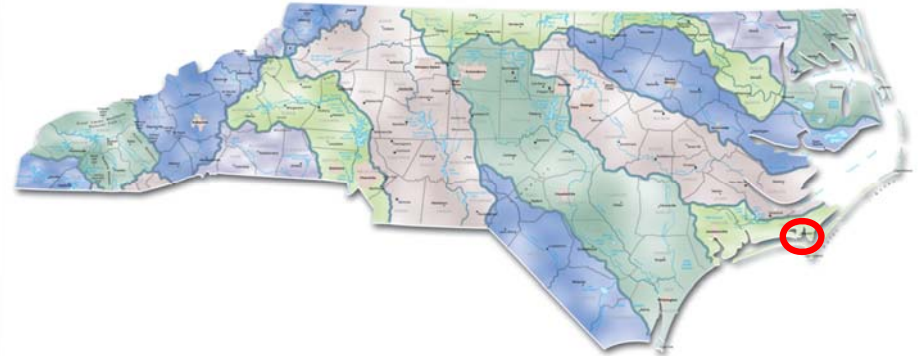


# Benefits and challenges of continuous flow and nitrogen monitoring in a restored salt marsh in North Carolina

J. Randall Etheridge, François Birgand, Michael R. Burchell II



## Site Location

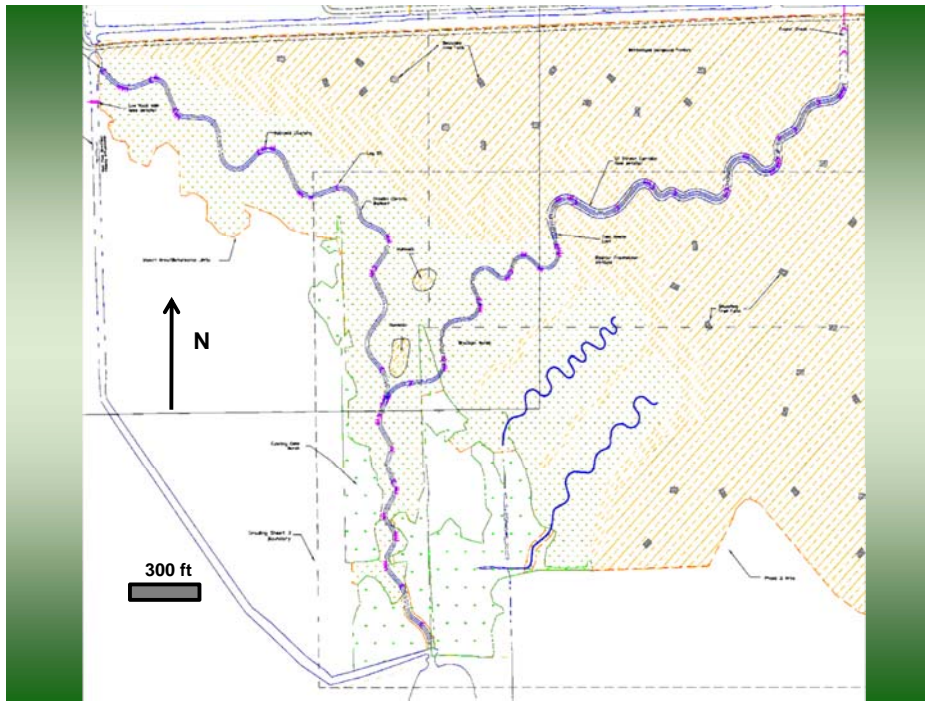


## Restoration Goals

- Improve water quality in the North River
- Restore habitat
- Provide design guidance for future salt marsh projects in coastal North Carolina







## Construction



## Restoration




## Research Questions

- Can continuous monitoring be used to quantify the ability of a restored salt marsh to retain excess nutrients?
- Are there seasonal, daily, or tidal trends in nutrient release or retention?
- Is there a relationship between nutrient retention or release and the type of organic matter present in the stream?

# Research Questions

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# Research Objectives

- Quantify the ability of a restored salt marsh to dissipate excess nutrients
- Quantify the timing and kinetics of nutrient dissipation and/or release
- Correlate the dissipation and/or release of nutrients to the type of organic matter



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# Methods

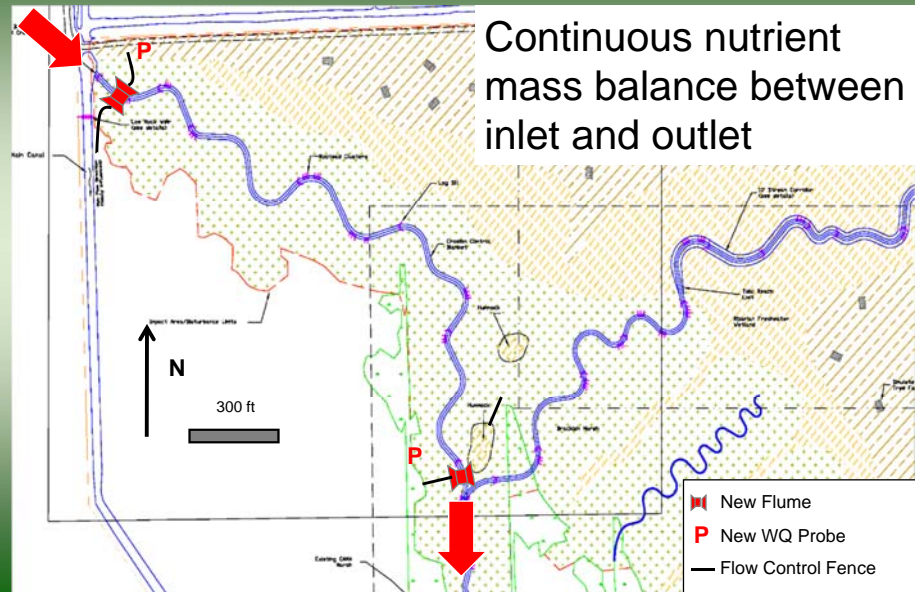
Continuous nutrient mass balance between inlet and outlet

The map illustrates the Klamath River estuary, showing the river's course from the inlet on the left to the outlet on the right. The river is depicted with a blue line, and the surrounding land is shown with various patterns (yellow, green, and white). Key features include the Klamath Canal, the Klamath River, and the Klamath River Estuary. The map includes a north arrow and a scale bar indicating 300 ft. Two red arrows point to the locations of the new flume and the new WQ probe, both marked with a red 'P'. The legend identifies the symbols: a red arrow for 'New Flume', a red 'P' for 'New WQ Probe', and a black line for 'Flow Control Fence'.

Legend:


- New Flume
- New WQ Probe
- Flow Control Fence

Continuous nutrient mass balance between inlet and outlet




# Flow Monitoring in a Tidal Stream

- Cannot use normal rating curve due to bi-directional flow
- Flumes serve as a constant cross section – cross section area measurement creates the most error in flow monitoring



Downstream flume at high tide



Downstream flume between tides

- Cannot use normal rating curve due to bi-directional flow
- Flumes serve as a constant cross section – cross section area measurement creates the most error in flow monitoring

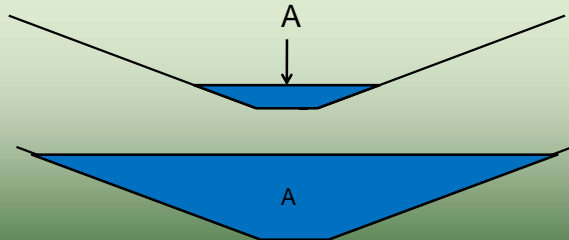




## Flow Calculations

$$Q = V \times A$$

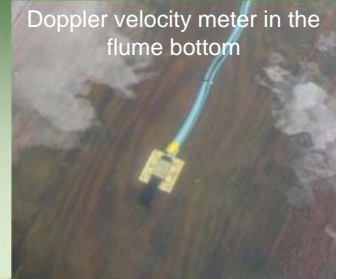
- Q: flow
- V: velocity
- A: cross-section area



## Continuous Flow Monitoring

- Doppler velocity meter records velocity and water depth in flume
- Average velocity and water depth recorded every 15 minutes
- Use manual stream gaging to relate Doppler velocity to actual flow in the flume

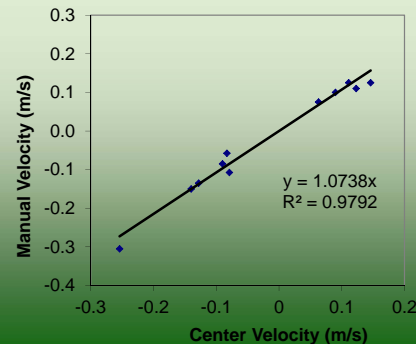
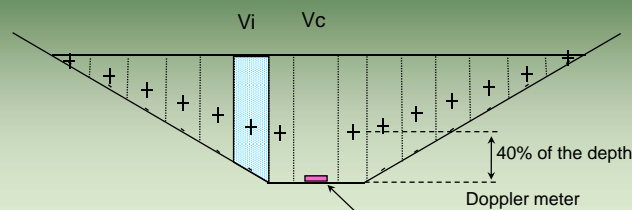
Doppler velocity meter in the flume bottom



Manual Stream Gaging

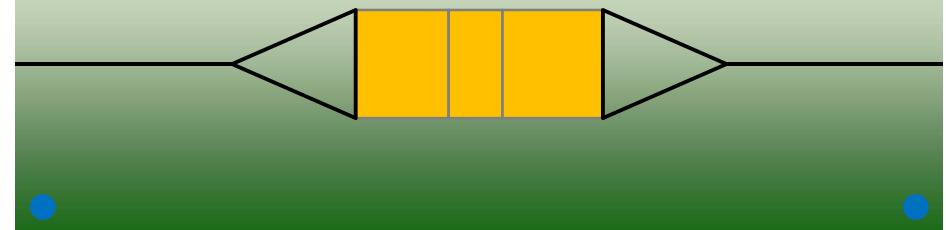


## Flow Calibration



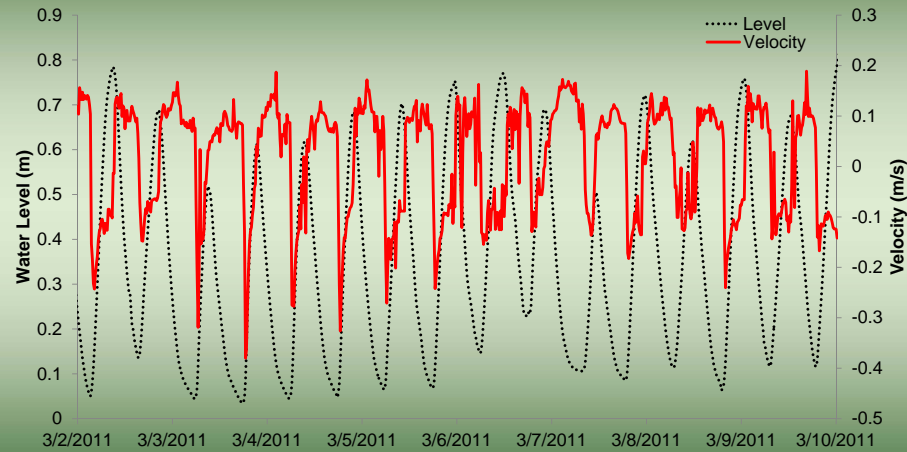
## Flow Monitoring in a Tidal Stream

- One challenge presented in the marsh: high tide or water level above the flumes
- Solution: direct flow through the flume using impermeable fence

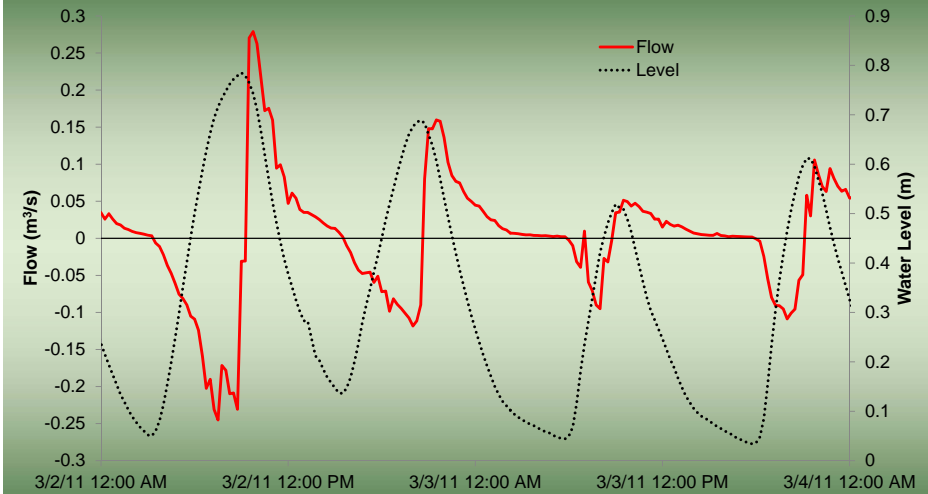


## Downstream Flume

Stage and Velocity



## Downstream Flume Flow



## Continuous Water Quality Monitoring

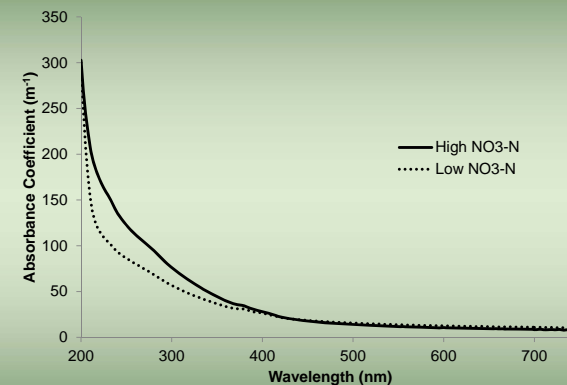
- Monitored using UV-visual spectrophotometer placed in the stream
- Absorption spectrum and parameters measured every 15 minutes

Parameter	Maximum	Resolution
NO <sub>3</sub> -N	70 mg/L	0.1 ±mg/L
TOC	150 mg/L	0.2 ±mg/L
DOC	90 mg/L	0.2 ±mg/L
Turbidity	1400 FTU	1.3 FTU



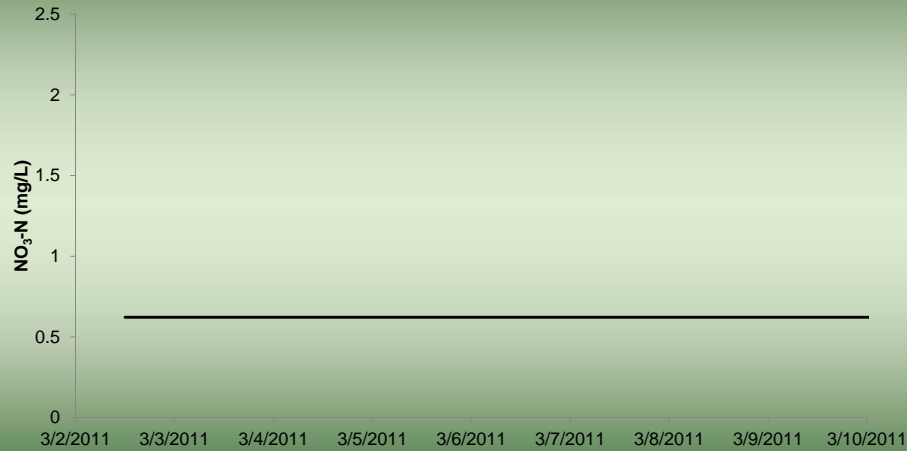
## Continuous Water Quality Monitoring

Absorption Spectra



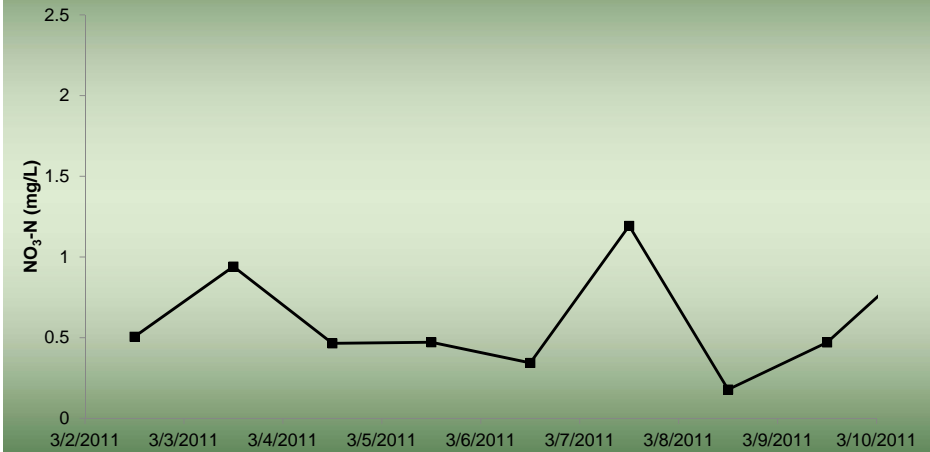
## Downstream Flume – Weekly Sample

Nitrate Concentration



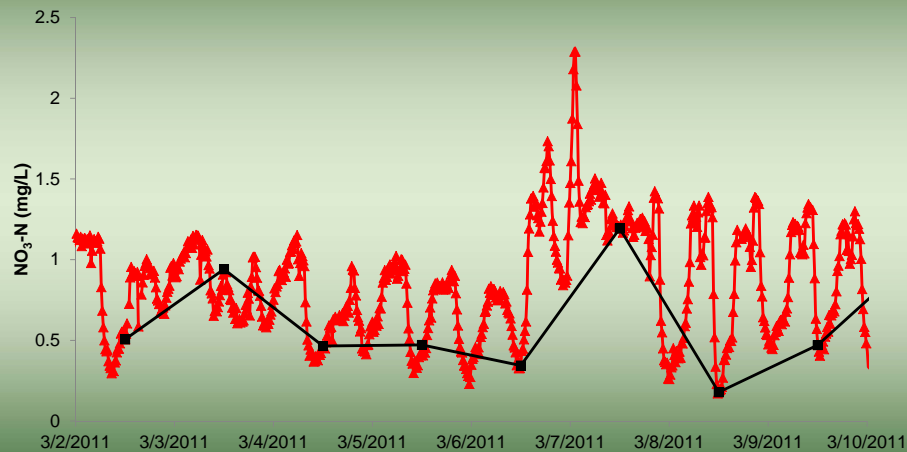
## Downstream Flume – Daily Sample

Nitrate Concentration



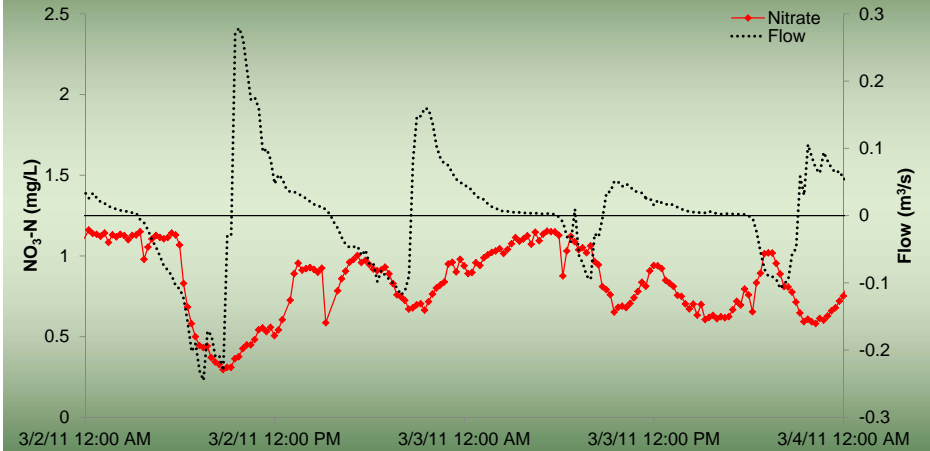
## Downstream Flume – 15 minute sample interval

Nitrate Concentration



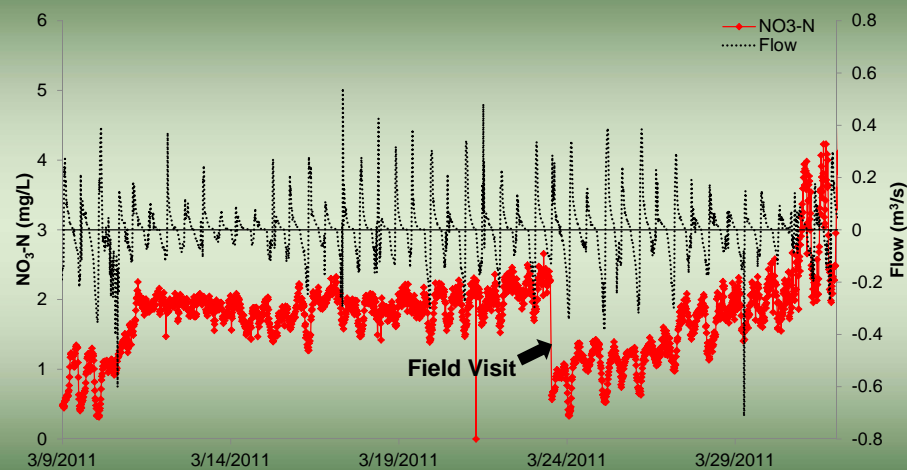
## Downstream Flume

Nitrate Concentration and Flow



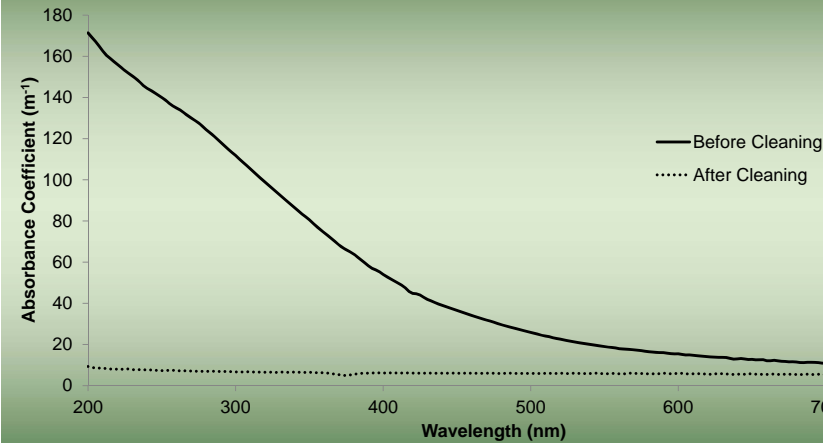
# The Problem

Nitrate Concentration and Flow



# The Problem

Absorption Spectra



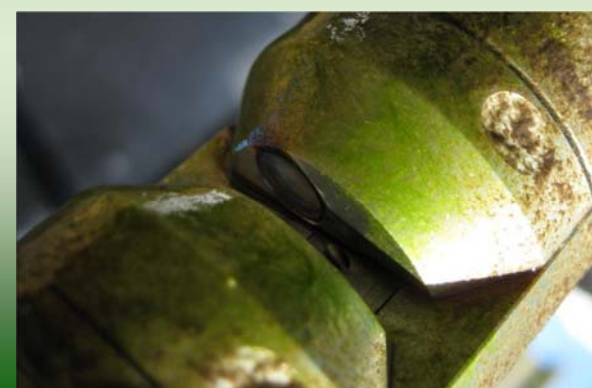
After Installation



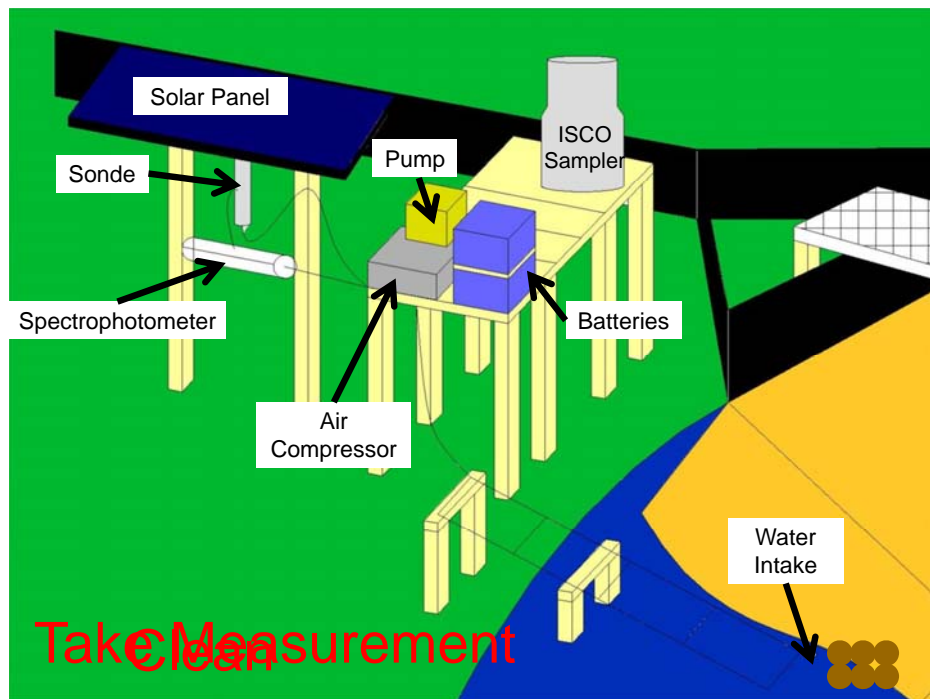
Two Weeks Later



Fouling







## Challenges of Continuous Water Quality Monitoring

- Preventing/reducing window fouling
- Calibration
- Solar power



## What We Hope to Accomplish

- Calculate the amount of nitrate entering or leaving the marsh every 15 minutes
- Minimize sources of error
- Use a long-term mass balance to determine the mass of nitrate being retained or released by the marsh

## Acknowledgements

- North Carolina Coastal Federation
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  - Evan Corbin
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  - Molly Mikan
  - Dr. Ken Krauss
  - Nicole Cormier
  - Rebecca Moss



## Other Research

- Continuously monitor:
  - DOC
  - pH
  - Conductivity/Salinity
  - Dissolved Oxygen
  - DOM Fluorescence
- Gas fluxes
- Stream stage using machine vision and web cams

