Quantifying the Water Quality Benefits of a Restored Tidal Stream Using Intensive Nitrate and Flow Monitoring

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

Introduction

- In a joint effort between NCSU, the NC Ecosystem Enhancement Program, and the NC Coastal Federation 14 ha of salt marsh and 1000 m of tidal stream were restored (Figure 1) at North River Farms (Figure 2) in 2005 and 2006
- Goals for the salt marsh and tidal stream restoration:
  - o Restore habitat
  - o Reduce nutrient loads reaching the North River
  - o Provide design guidance for future salt marsh restoration projects in coastal North Carolina

Figure 1. The restored salt marsh and stream three years after construction and planting were completed.

- Upstream row crop agriculture is a large source of nutrients to the North River
- Reduction of nutrient loads by salt marshes is used to promote restoration
- Quantifying the reduction in nutrient loads is difficult due to complex patterns of flow and nutrient dynamics
- Recently developed technology allows for intensive monitoring of nutrient concentrations

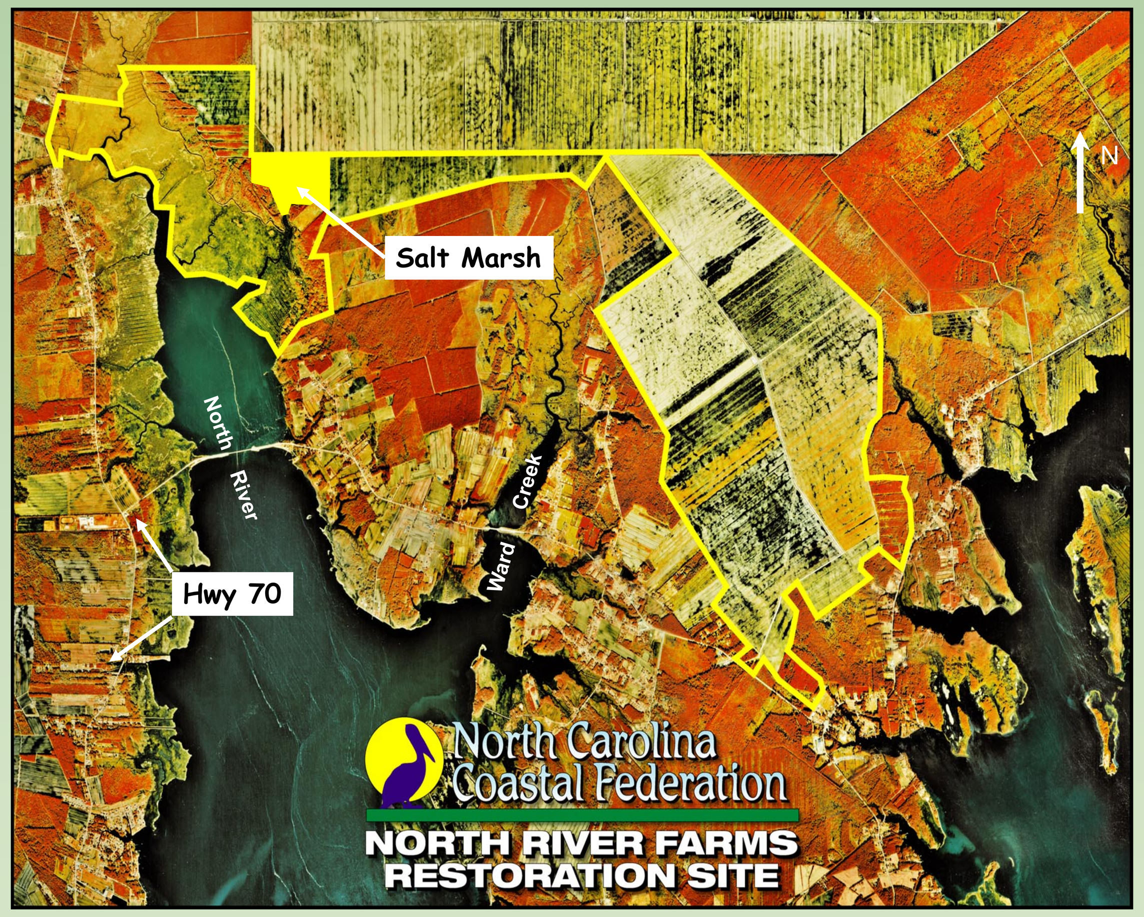

Figure 2. Location of the salt marsh restoration at North River Farms

Research Questions

- Can in-situ UV-Visual spectrophotometers be used to continuously monitor the nitrate (NO_3-N) concentrations in a tidal stream?
- Does the restored system serve as a source or sink of nitrogen?
- How much nitrogen is removed or released by the system?

Continuous Monitoring Methods

- Monitoring goal: Use continuous flow and NO_3-N monitoring to determine the mass of NO_3-N entering and leaving the system
- Upstream/downstream monitoring design (Figure 3)

- Equipment used to monitor flow at each station:
  - o Doppler velocity meter
  - o Wooden trapezoidal flume
  - o Pressure transducer water level recorder

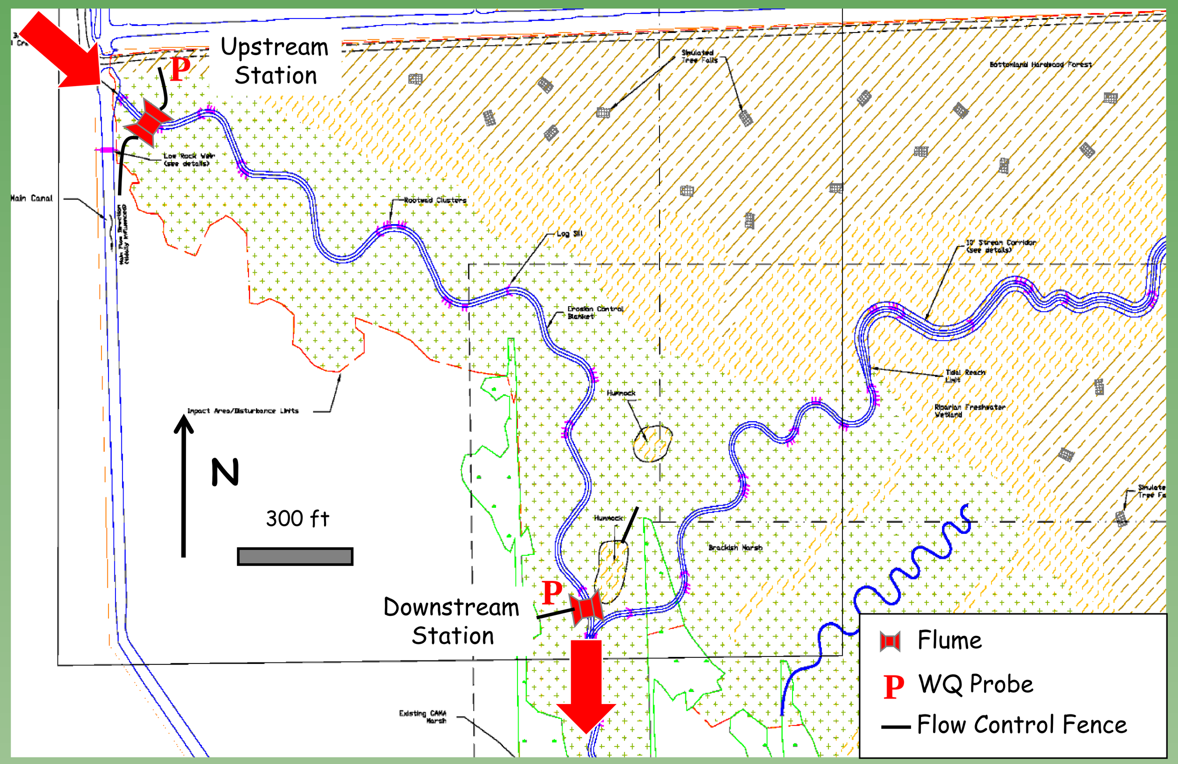

Figure 3. Design plan for the restored salt marsh and the upstream/downstream monitoring.

- UV-visual spectrophotometer (Figure 4) measures absorbance of water from the UV to visual range
- NO_3-N concentrations are calculated from the absorbance
- NO_3-N concentrations from probes are calibrated to laboratory values

Figure 4. UV-Visual spectrophotometer in the restored tidal stream in March 2011.

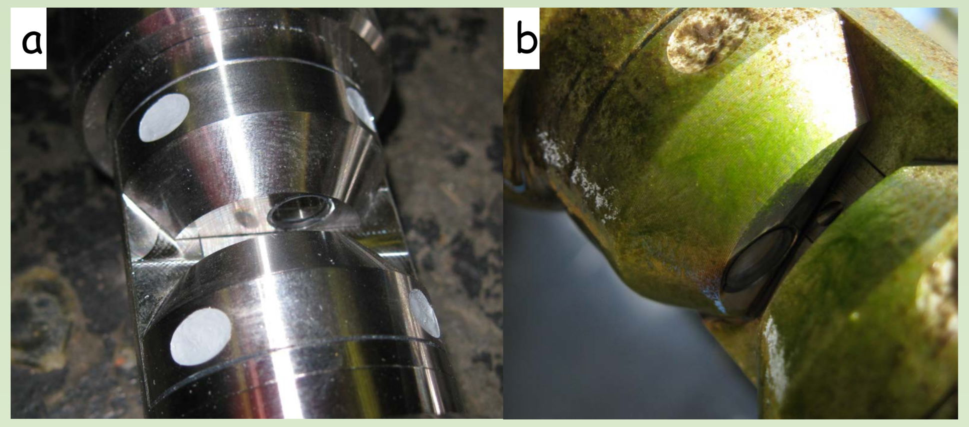

Figure 5. **a)** Clean spectrophotometer in the lab. **b)** Spectrophotometer after being submerged in the stream for one week. The slight brown area just to the left of the measurement window is visual evidence of fouling.

Results

UV-Visual Spectrophotometer Evaluation

- Probes initially installed in the tidal stream (Figure 4)
- Fouling greater than expected
- Visually obvious (Figure 5) and seen in sudden concentration drops after cleaning (Figure 6)
- Thought to be caused by Fe and Mn oxide precipitation on measurement windows

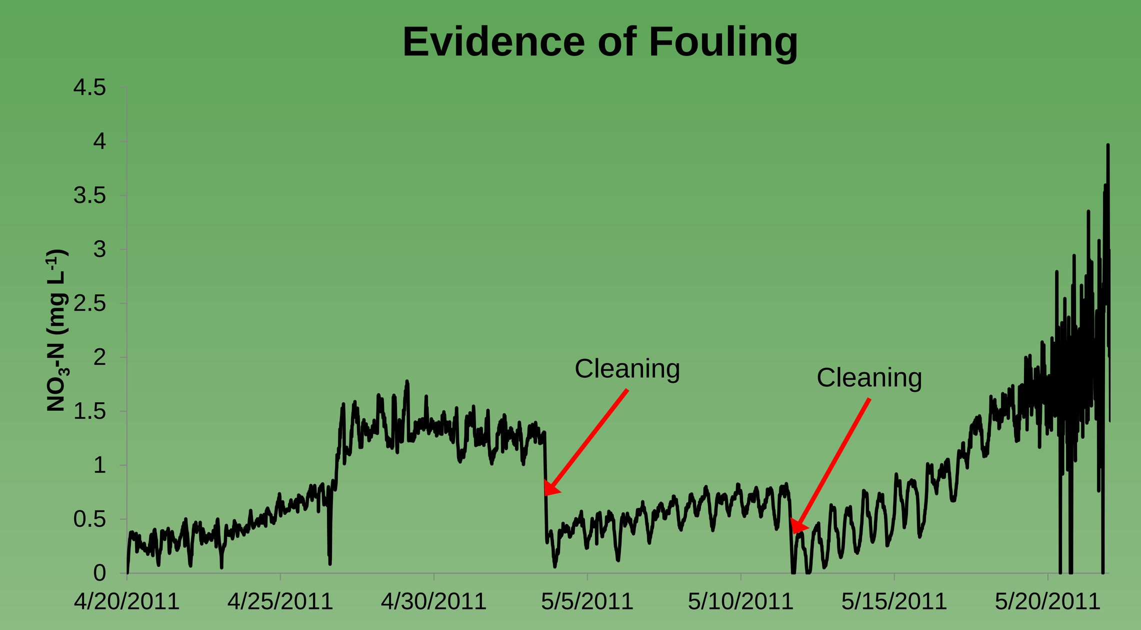

Figure 6. The steady increase in NO_3-N concentrations following cleaning is evidence of the severe fouling that occurred with the probes installed in the stream.

- Solution: Remove probe from the stream and pump water to the probe (Figure 7)
- Pumping system sequence:
  1. Pump water from the stream to the spectrophotometer
  2. Take measurement
  3. Drain stream water and purge the system
  4. Rinse the measurement windows with pressurized tap water
- Result: Fouling greatly reduced

Figure 7. The downstream monitoring station in July 2011 after the spectrophotometer was removed from the stream.

Short-term Mass Balance

- The mass of NO_3-N entering or leaving the salt marsh was calculated every 15 minutes for one week in March 2011
- Normal tidal flux (Figure 8) and storm flow (Figure 9) were observed during this week
- Mass balance result: 2 kg of NO_3-N removed in one week

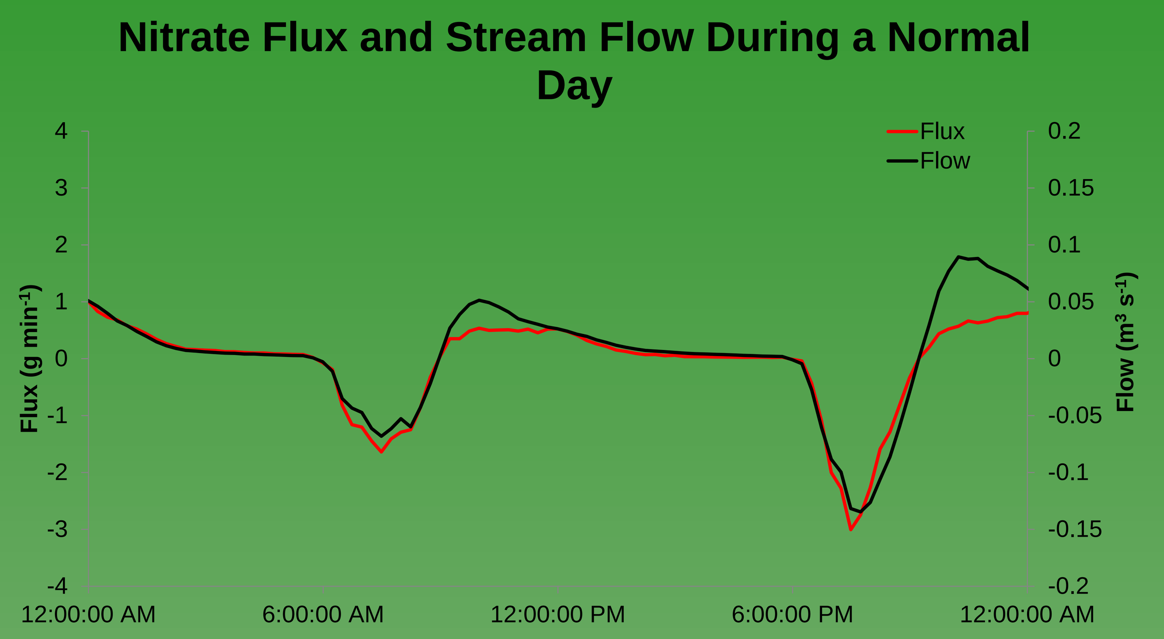

Figure 8. The stream flow and flux of NO_3-N for March 3, 2011 at the downstream station. Note: positive flow/flux is going out to the estuary and negative flow/flux is coming into the marsh.

- Approximately 21 mm (0.8") of rain fell on March 6, 2011
- Storm flow (Figure 9):
  - o Shown as a reduction in magnitude of negative flow as the tide is rising instead of a large peak in the hydrograph
  - o The peak in NO_3-N flux is caused by a spike in the NO_3-N concentration.
  - o The source of NO_3-N is likely the upstream agricultural production.

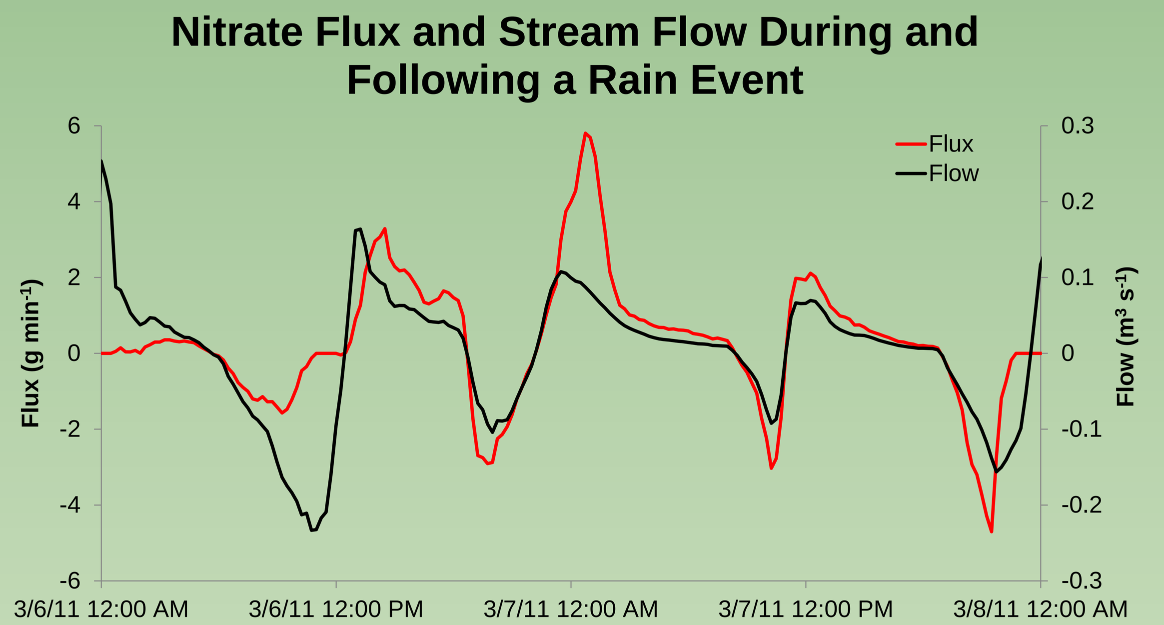

Figure 9. The stream flow and NO_3-N flux for March 6-7, 2011.

Summary

- The primary difficulty of using UV-Visual spectrophotometers in a tidal stream is instrument fouling.
- Fouling can be reduced by minimizing the time the probe is exposed to the stream water.
- The probes provide a method of capturing important NO_3-N flux events, such as storms, that are often missed in other sampling schemes.
- During one week of data collection 2 kg of NO_3-N were retained in the restored marsh and tidal stream.
- Long-term mass balances will be developed now that the fouling has been reduced.

Research Funded by: