Sandpiper Pond Restoration of Wetlands & Coastal Habitat: Water Quality Results

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Circa 1989

Post Hugo

Circa 2001

outlet closed

Sept. 2005

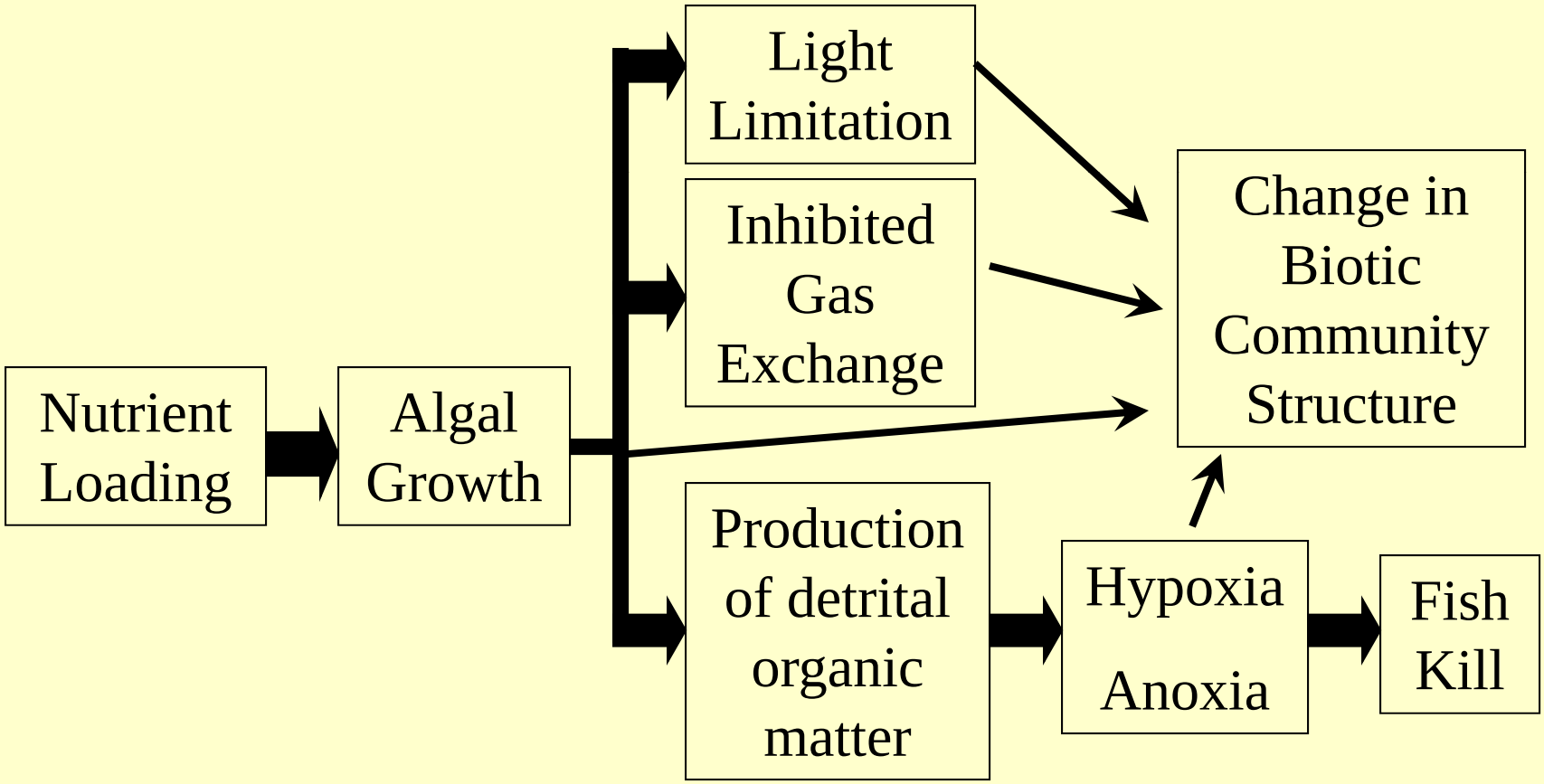
outlet cut

Education Efforts

Hypothesis

- **Cutting the outlet will convert the pond from a freshwater to a marine system.**
  - Increase in salinity
  - Decrease eutrophication
  - Decrease hypoxia

Eutrophication



Eutrophication Criteria

Analytes	Estuary	Streams	SC Ponds
Phosphorus (ppm P)	0.01	0.0525	0.06
Nitrogen (ppm N)	0.1	0.87	1.5
Chlorophyll a (ppb)	20	0.44	40
Turbidity (NTU)		3.89	50

Dissolved Oxygen Criteria for Estuaries:

Biological Stress: <5 ppm DO Hypoxia: <2 ppm DO

Citations

•Estuary: NOAA's National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries (Bricker et al. 1999)

•Rivers: US EPA Office of Water's Ambient Water Quality Criteria Recommendations (draft). Level III Ecoregion 63 streams.

•South Carolina Coastal Plain: R. 61-68 Water Classification and Standards

Experimental Design

- Bi-weekly sampling over a period of 14 months.
  - Pre-outlet construction: September 2004 to April 2005
  - Post-outlet construction: April 2005 to September 2005
  - Post-post outlet construction: September 2005 to present
- Sampling Sites
  - North Pond
  - South Pond
  - Outlet
- Funding insufficient for sampling a control site
- Rain Data from Brookgreen Gardens
  - NOAA National Climate Data Center
  - Cumulative rainfall for 7 days prior to sampling

SAMPLING SITES

North Pond:

Samples collected from center of pond by boat.

South Pond:

Samples collected from edge of pond.

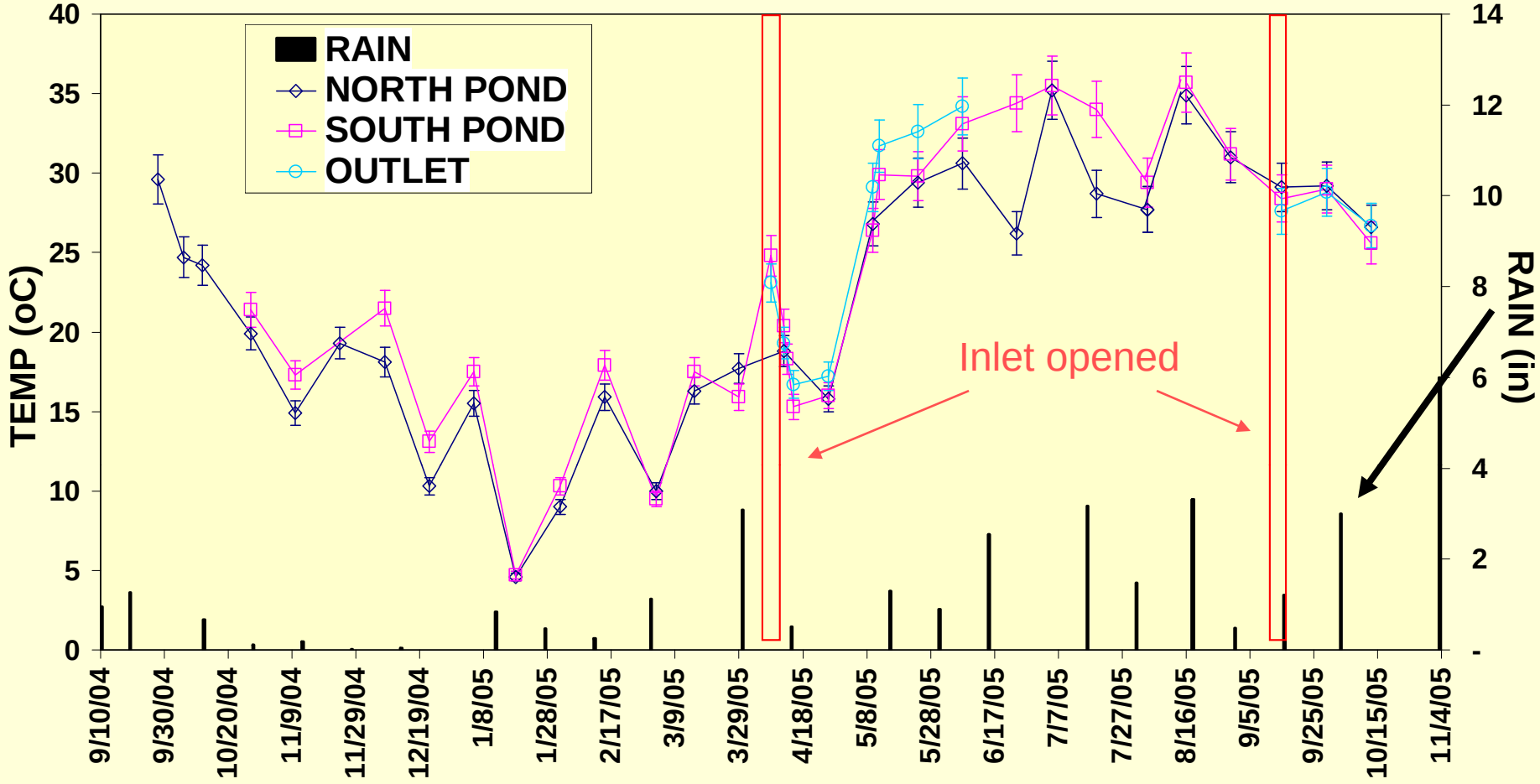
Outlet:

Samples collected by mid-outlet.

Methods

- EPA Methods
- Field Measurements (Hach meters)
  - Temperature
  - Salinity/Conductivity
  - Dissolved Oxygen
  - pH
- Laboratory Measurements
  - Turbidity
  - Total Suspended Solids/Volatile Suspended Solids
  - Chlorophyll and Phaeopigment
  - Total Nitrogen and Total Phosphorus

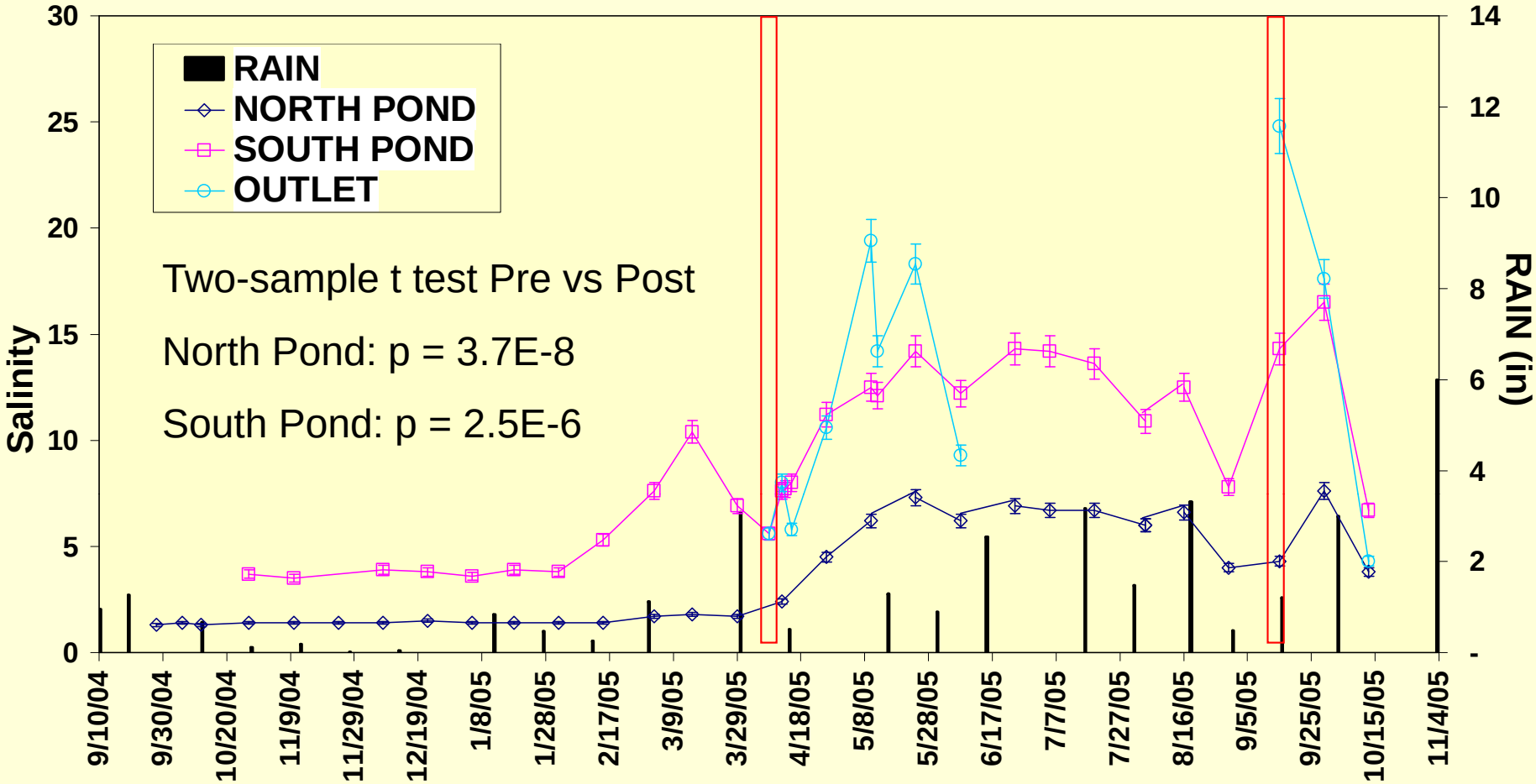
HACH
DR/890 Colorimeter
Dissolved Oxygen
pH
Colorimeter
Conductivity
Turbidity



Warming trend due to seasonal variability.

Error bars represent %RSD = sd/mean x 100 for sample replicates

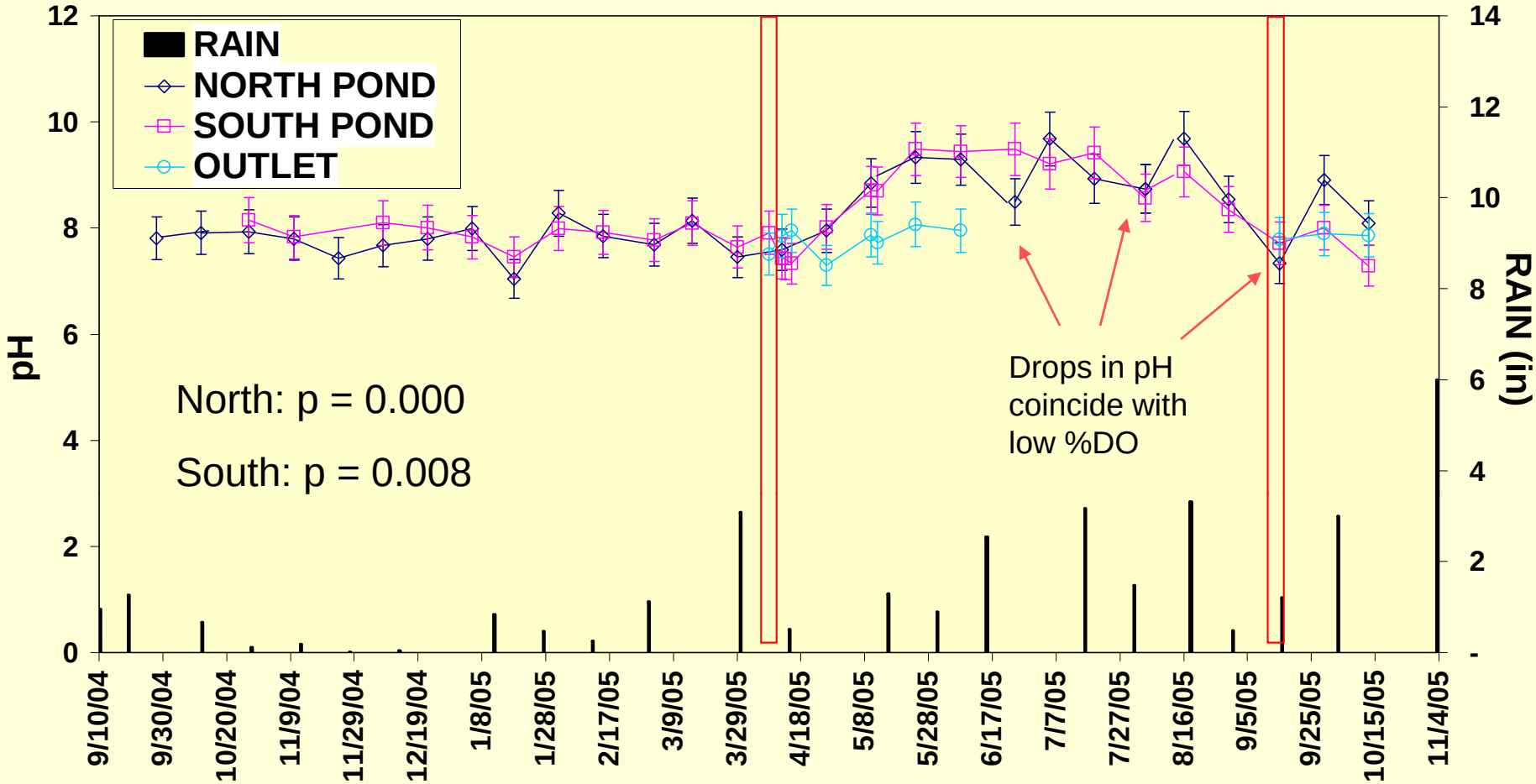
Outlet after the 2nd opening in September, 2005 and Creek Location.



Salinity increased after outlet opening – South Pond's connection with marsh is important.

Increase just before 1st opening is thought to be due to high water (storm) event.

Outlet closes soon after each opening - salinity drops below that of South Pond.

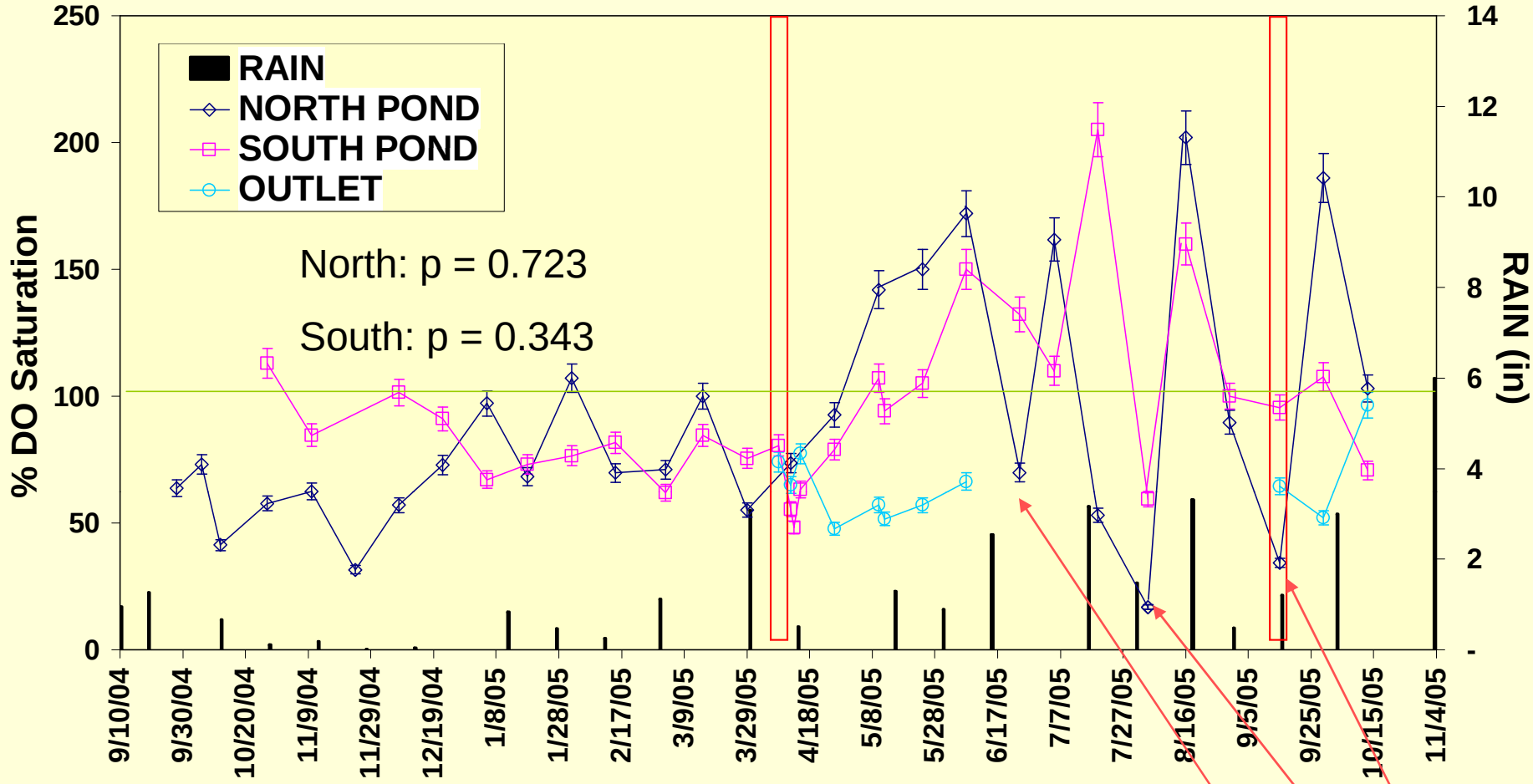


Significant increase in both ponds after first opening. Mean pH after opening was 8.5. Maximum values of 9.6!

This is thought to reflect an increase in photosynthesis.

The pH in both ponds are higher than in the outlet

Low pH at outlet is coincident with lowest DO and highest Volatile Suspended Solids (VSS). Suggests this site is net heterotrophic due to VSS loading and also water stagnancy as outlet closed rapidly.



Drops in pH coincide with low %DO

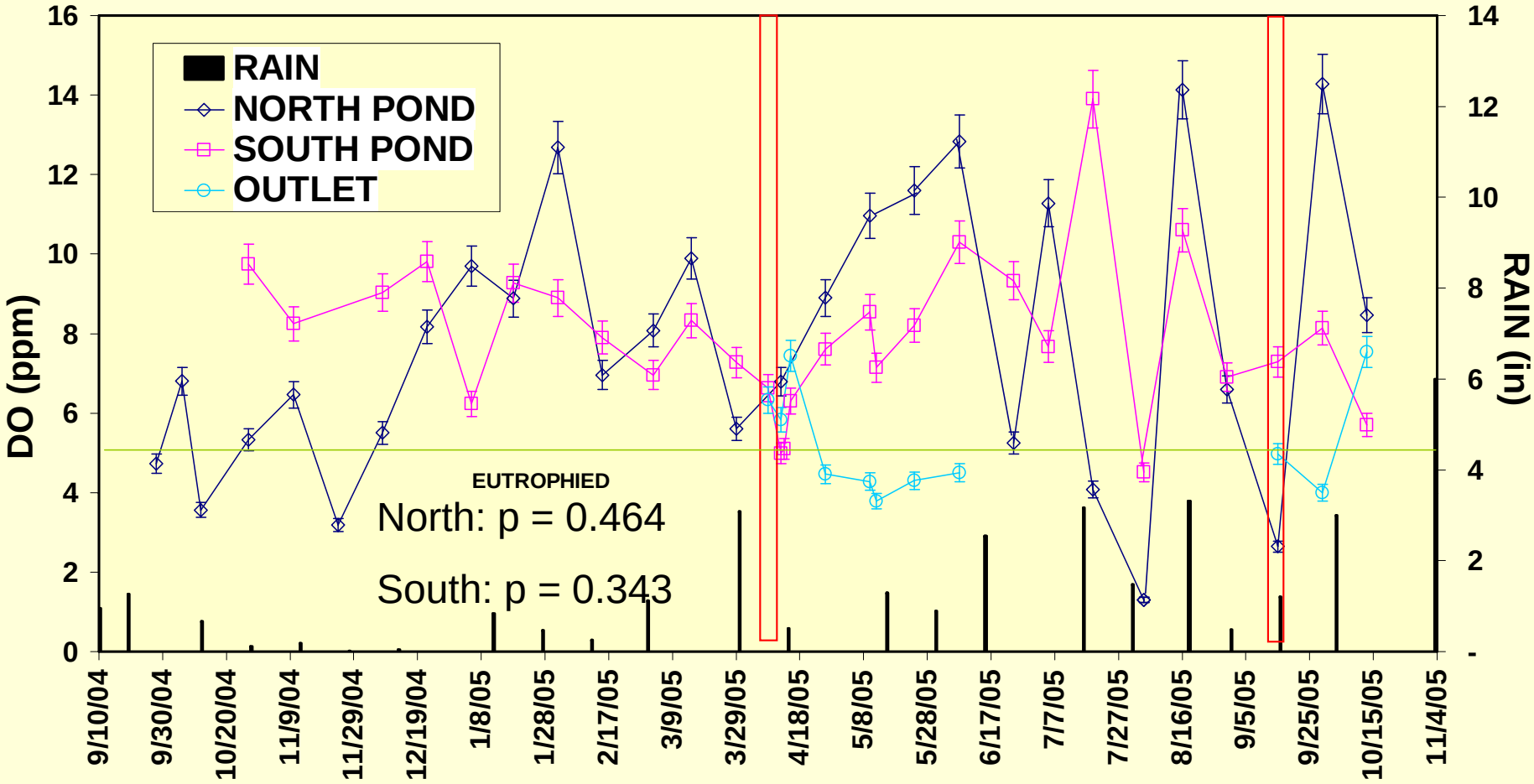
% Saturation = [Observed DO]/[Saturated DO]

100% = Saturated >100% Supersaturated <100% Undersaturated

Both ponds are saturated or undersaturated until first opening.

Variability was greatly increased after opening suggesting lack of stability in balance between respiration and photosynthesis.

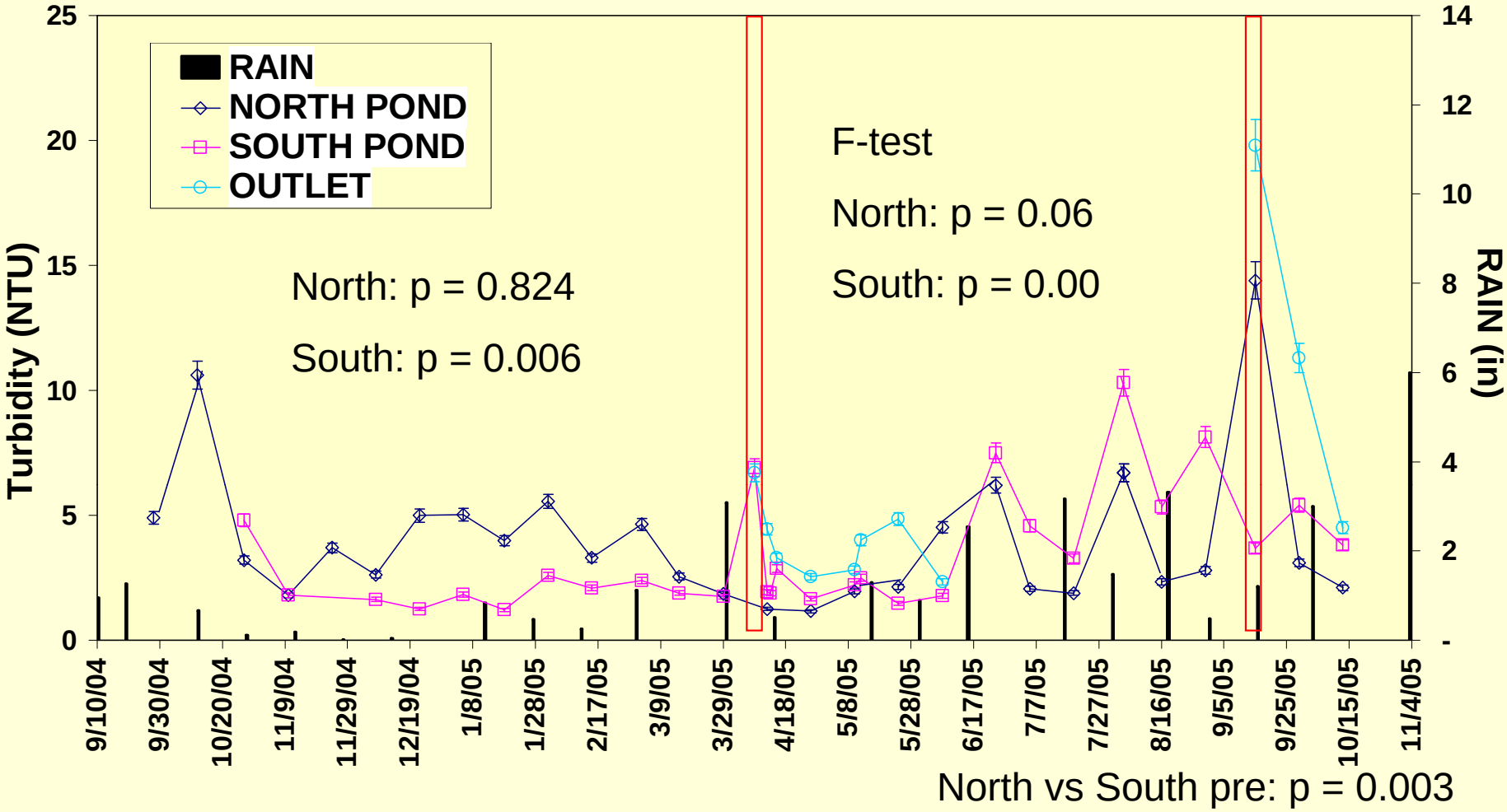
No consistent correlation with temp., rain or chlorophyll suggesting importance of rooted plants in contributing to % DO.



North Pond had some DO's below estuarine eutrophication criteria

Biological Stress < 5 ppm DO

Hypoxia < 2 ppm DO

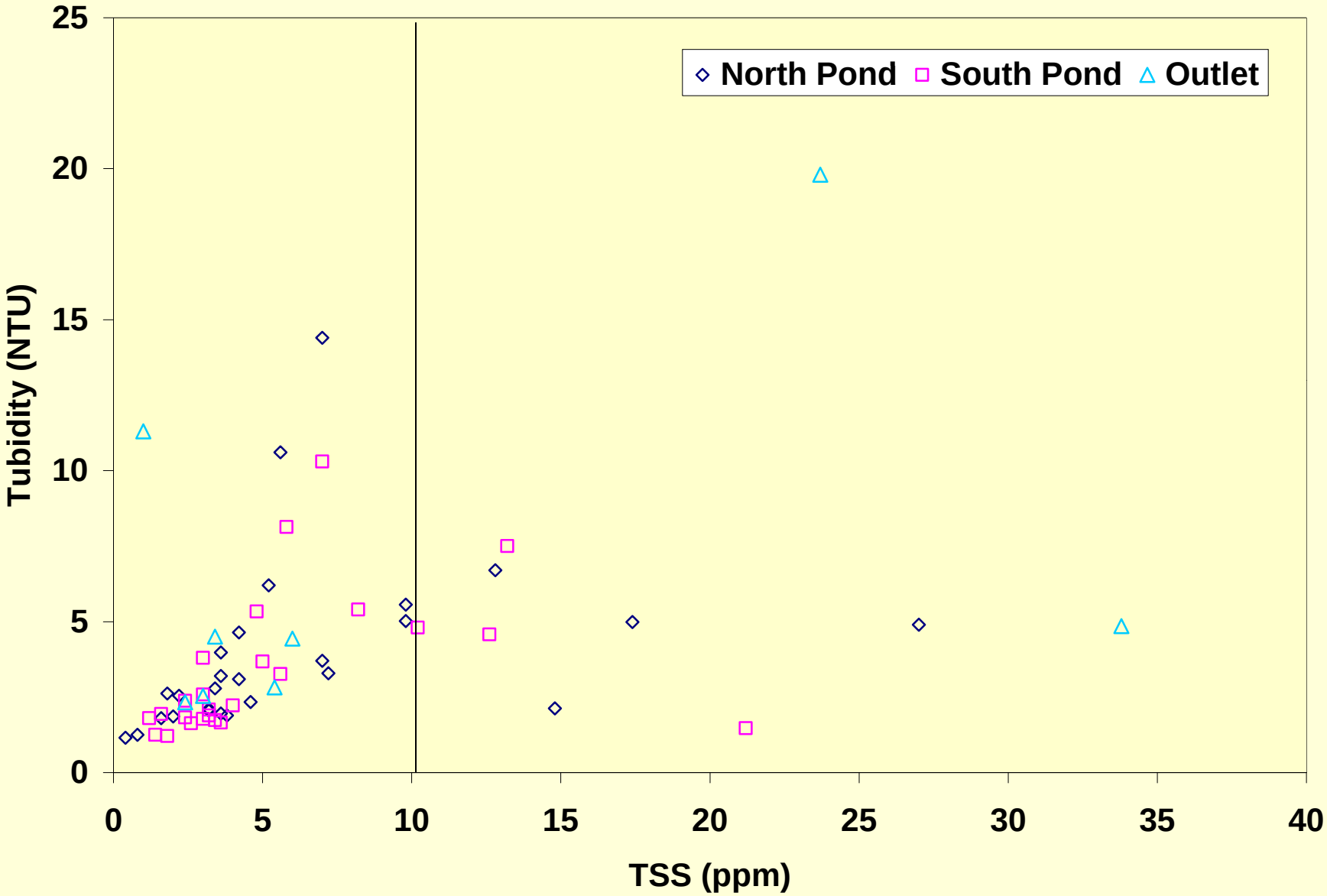


North vs South pre: p = 0.003

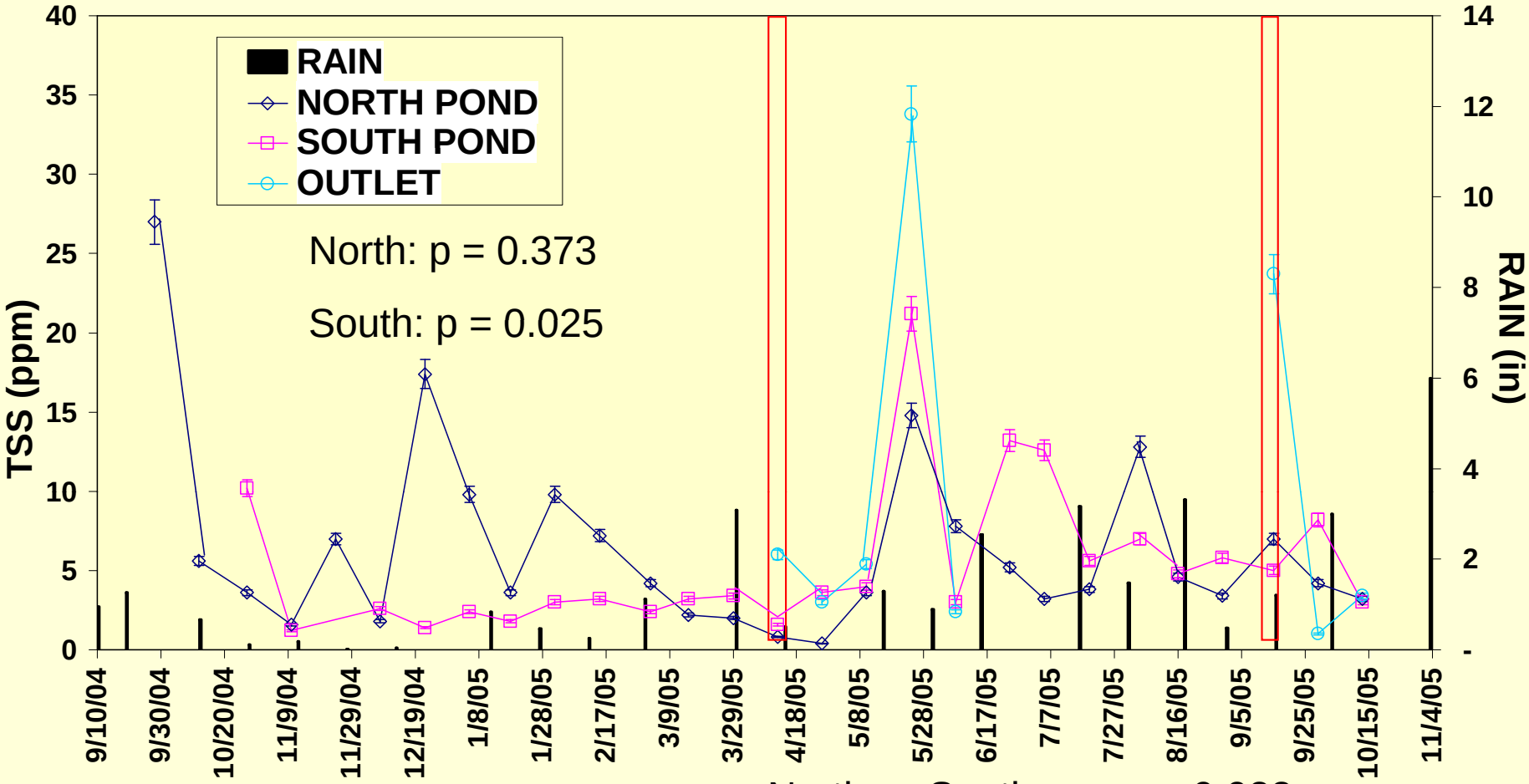
North Pond is initially greater than South Pond. North vs South post: p = 0.418

South Pond increases significantly after outlet is cut. Chlorophyll was also significantly higher in South Pond after outlet was cut.

Variability in South pond increases.



Correlation holds for TSS < 10 ppm



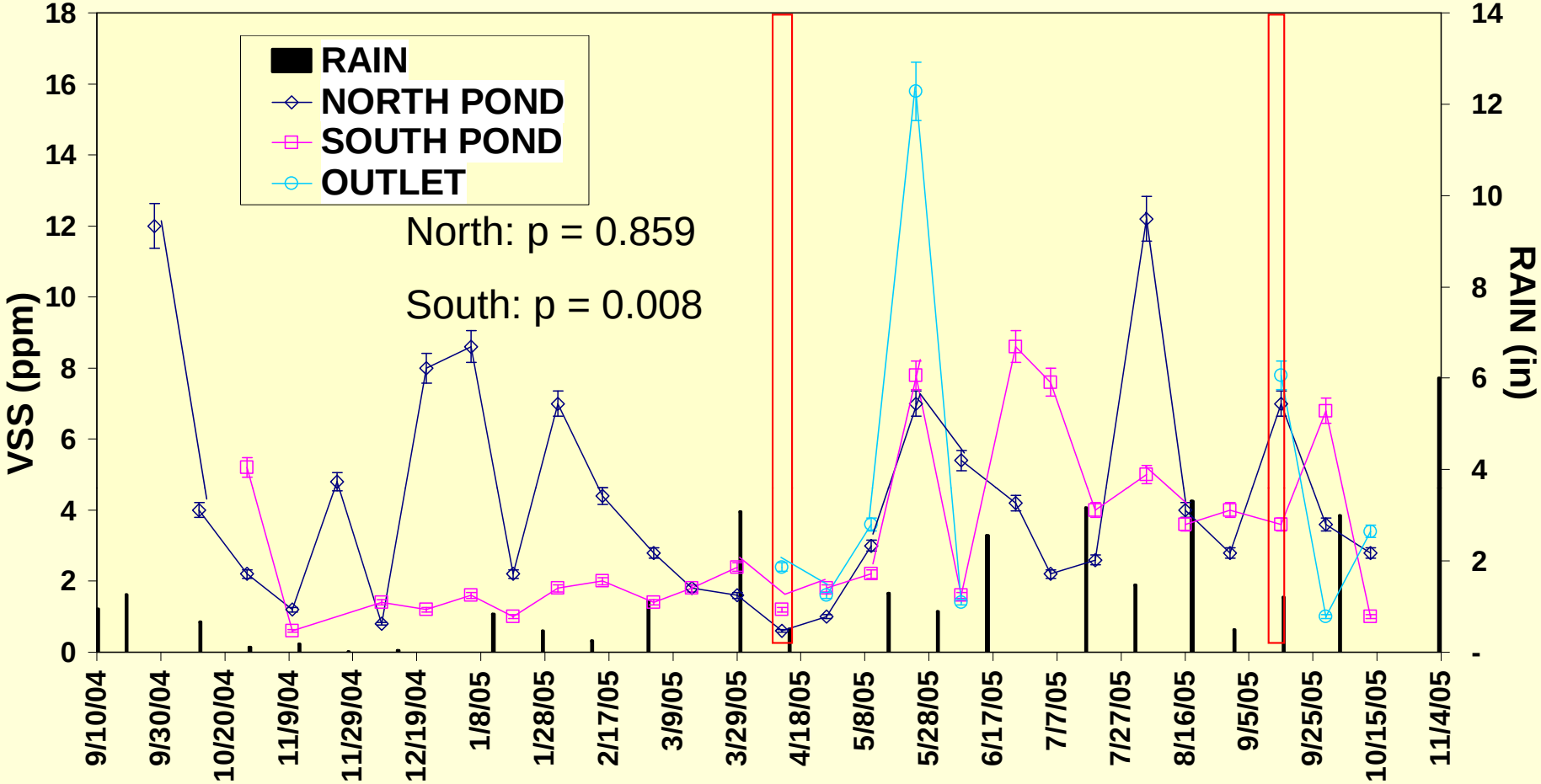
North vs South pre: p = 0.028

North vs South post: p = 0.176

North Pond is usually greater than South Pond before outlet is cut.

After opening, South Pond increases significantly. Chlorophyll was also significantly higher in South Pond after outlet was cut.

Variability increases in the South while it decreases in the North.



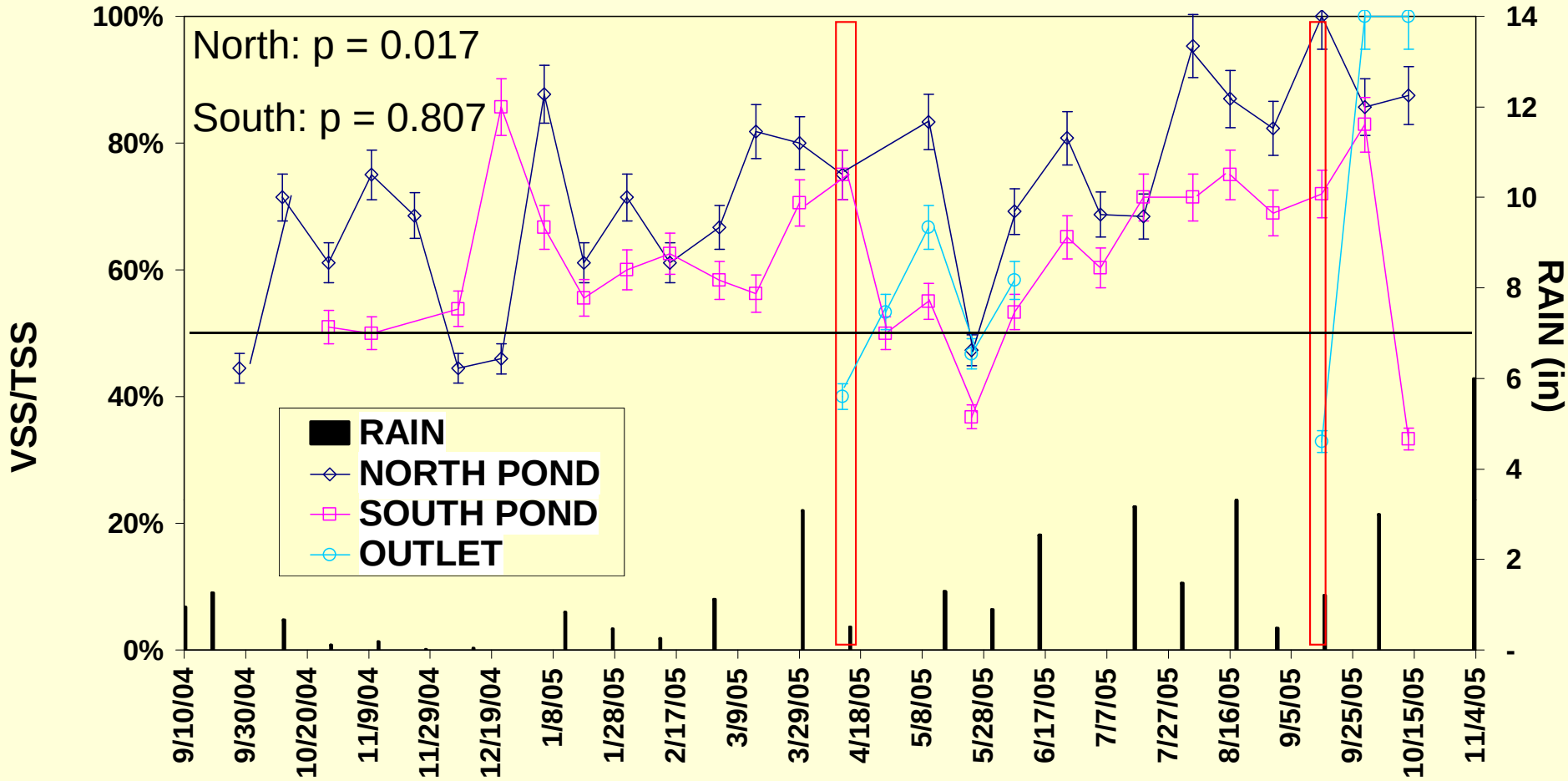
North Pond is generally greater than South Pond for pre samples; this is not the case for the post samples.

North vs South pre: p = 0.009

North vs South post: p = 0.498

Variability decreases in the North Pond after the opening, it increases in the South Pond.

South Pond shows a significant increase after opening the outlet.

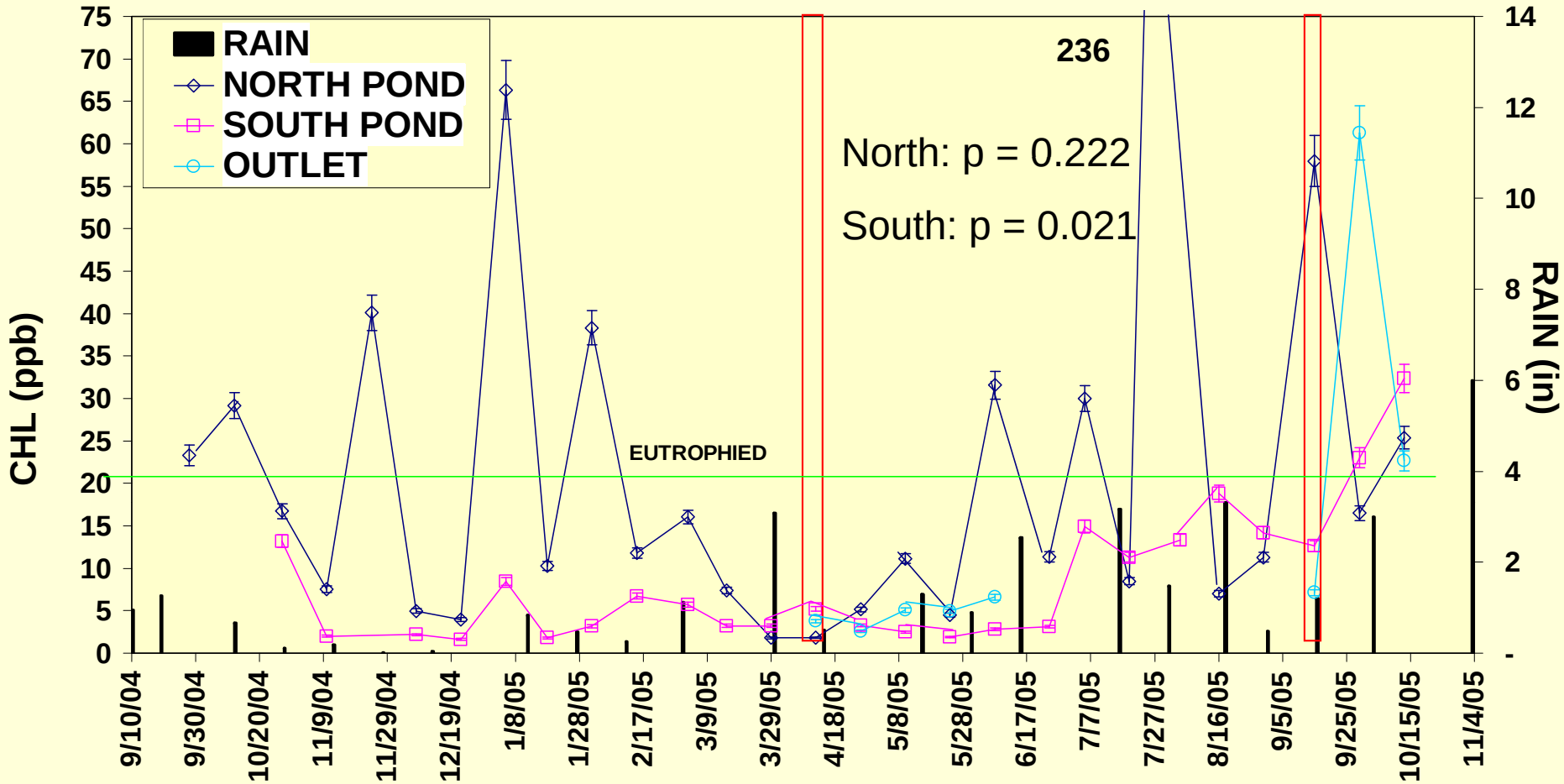


North Pond > South Pond. Chlorophyll also higher in North than South Pond

North vs South: p = 0.004

Increase in ratio for both ponds through the summer.

North Pond increases significant after opening.

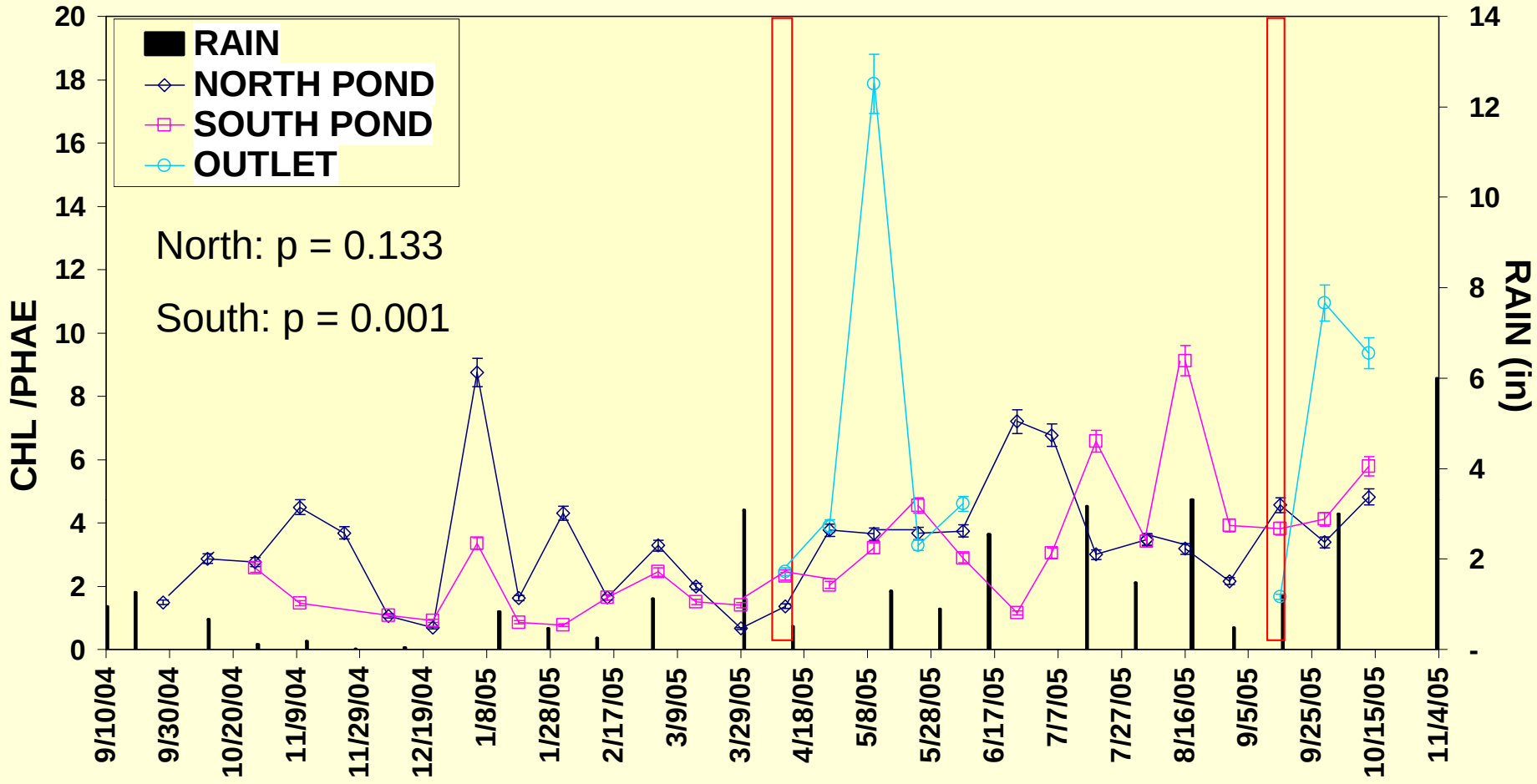


North Pond > South Pond North vs South: p = 0.015

Levels in the North Pond are above eutrophication levels for many dates pre and post.

Increase in South Pond after opening.

High values after 2nd opening don't seem to be caused by rain or seasonal variation. (Keep increasing through Fall)

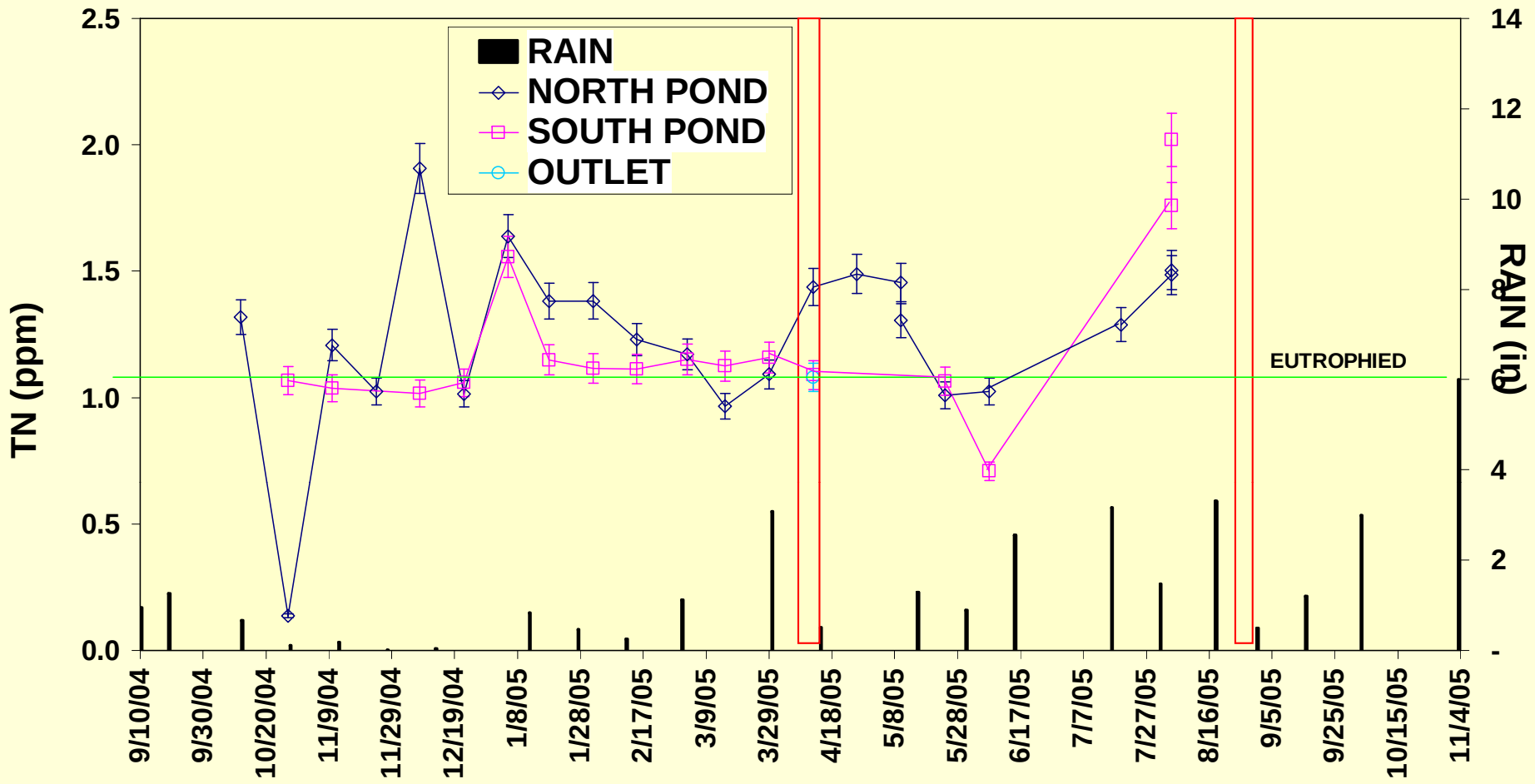


CHL/PHAE >1 for actively growing plankton community

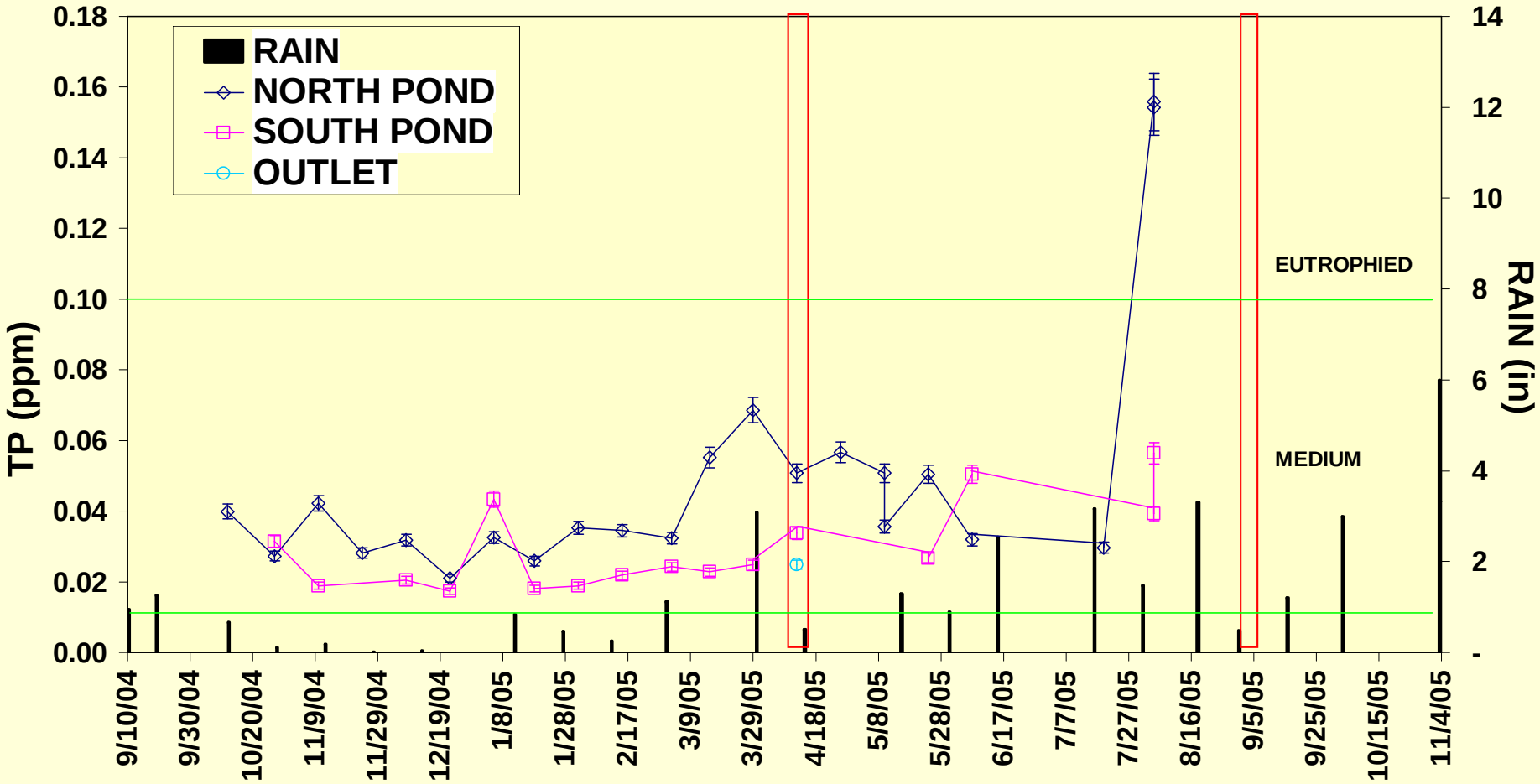
North Pond is generally greater than South Pond until midway through the post sampling period

North vs South* : p = 0.013

South pond increases after the inlet was cut



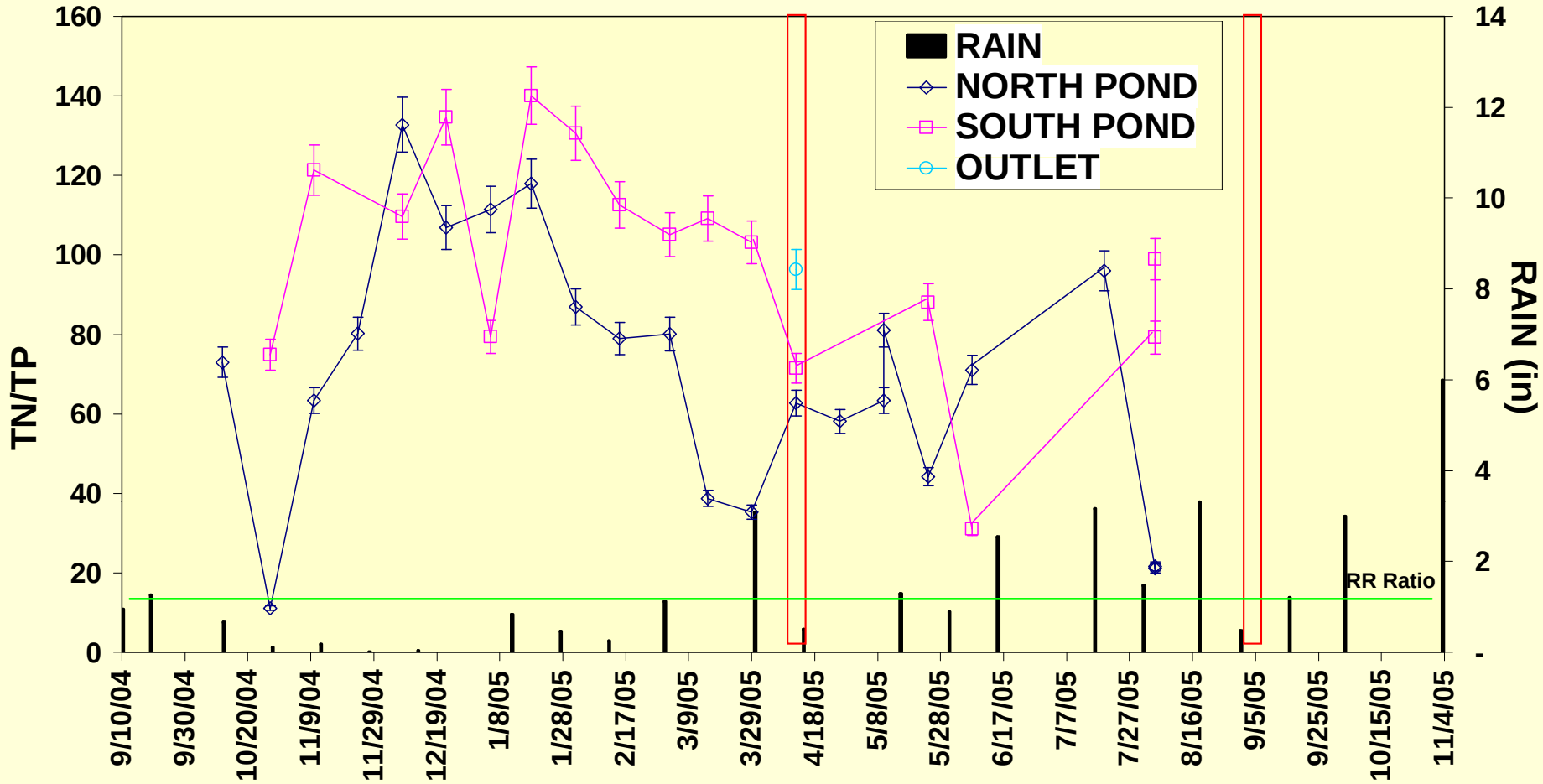
All but one sample lie above the estuarine eutrophication criteria.



All but one sample lie in the medium range for estuarine waters.

North Pond > South Pond

North vs South: $p = 0.011$



- Except for one sample, TN/TP > 16 suggesting terrestrial nutrient sources.
- Ratio declined after first opening giving TN/TP a more marine character probably from increase in plankton (South Pond chlorophyll increased.
- North Pond < South Pond pre and post. ??Suggests a more marine character to North Pond.

Conclusions

- Salinity (Somewhat more saline)
  - Increases in both ponds after each opening
  - Importance of connection to marsh through creek
- Eutrophication (Increased, especially in South Pond. Seasonal?)
  - Nutrients
    - Nitrogen loading pre and post
    - Phosphorus in medium range pre and post
    - Nutrient ratio reflective of terrestrial inputs
  - North Pond has more plankton activity pre and post
    - North Pond > South Pond for nutrients, %VSS and chlorophyll
    - Chlorophyll over eutrophication limit in North Pond
  - Opening enhances plankton activity in South Pond
    - Increases in pH in both ponds
    - Increases in chlorophyll, TSS, VSS and turbidity in South Pond
    - Increase in % DO (but not statistically significant in either pond)
      - Low %DO at outlet due to VSS loading
  - Rooted plants contribute more DO than phytoplankton
- Hypoxia (No significant change)
  - Observed once in North Pond post
  - DO less than 5 ppm observed frequently in North Pond and Outlet

Suggestions for Future Efforts

- Flaws in experimental design
  - Needed a control site. Could add now.
  - Needed more pre-opening data to characterize seasonal variability
  - Need much longer term data set for characterizing interannual variability (weather)
- Consider volunteer monitoring

VOLUNTEER MONITORING

Acknowledgments

Burroughs & Chapin Center for Marine & Wetland Studies, Coastal Carolina University

Waccamaw Watershed Academy, Coastal Carolina University

South Carolina State Parks

U.S. Fish & Wildlife Service

National Fish and Wildlife Foundation

United States Environmental Protection Agency

NACo Counties Care for America

NOAA Restoration Center — Restoring Our Nation's Estuarine and Marine Habitats

RESPIRATION

$$CH_2O + O_2 \Rightarrow CO_2 + H_2O$$

$$CO_2 + H_2O \Rightarrow H_2CO_3 \Rightarrow HCO_3^- + H^+$$

PHOTOSYNTHESIS

$$HCO_3^- + H^+ \Rightarrow H_2CO_3 \Rightarrow CO_2 + H_2O$$

$$CO_2 + H_2O \Rightarrow CH_2O + O_2$$