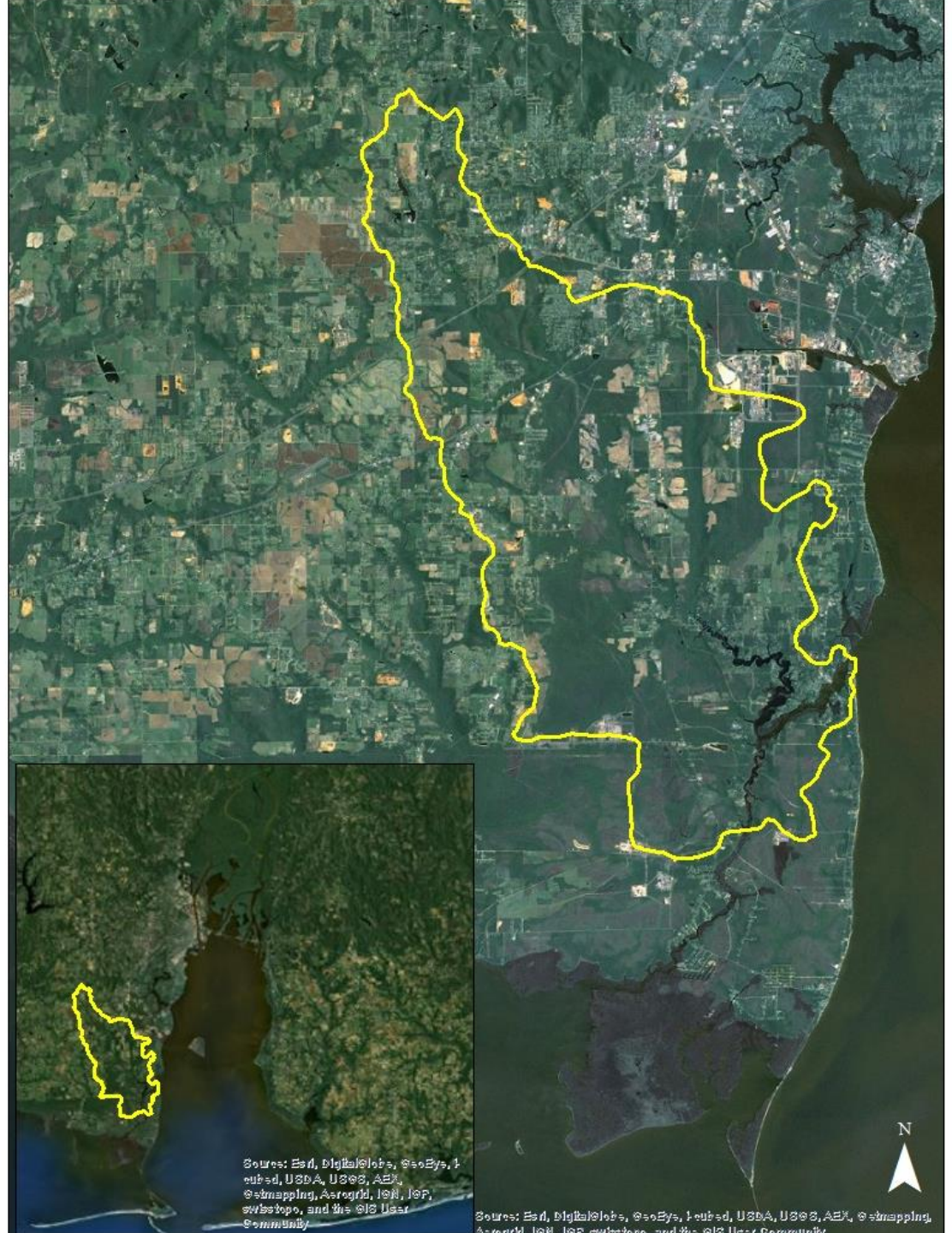
Fowl River Restoration

Science Advisory Committee

May 10, 2019



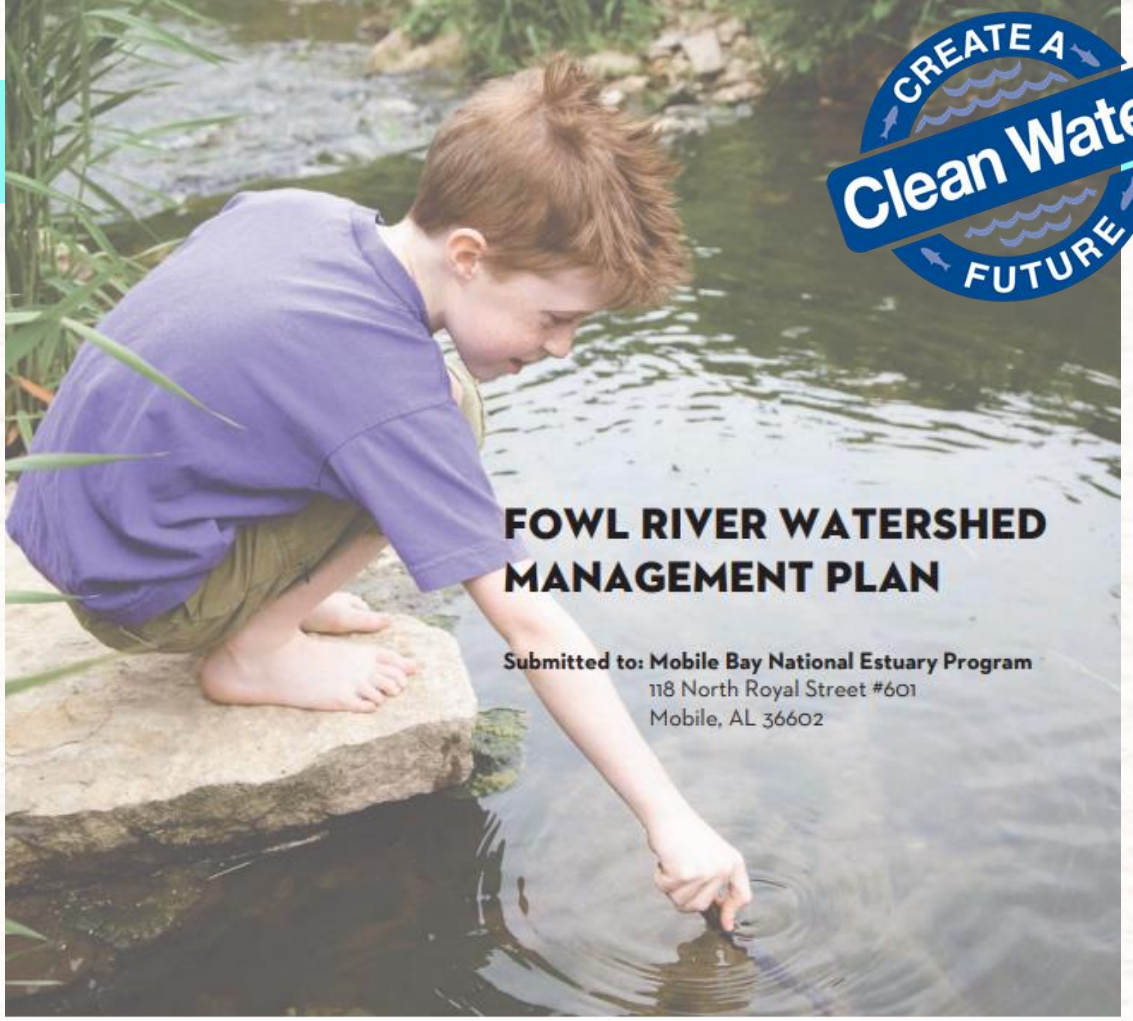
Fowl River Marsh Study

Overarching Purpose (in compliance with the MBNEP Comprehensive Conservation & Management Plan): To preserve what people value most about living on the Alabama coast (access, fisheries, heritage, environmental health and resilience, and water quality), while improving the quality of water in Mobile Bay.

Fowl River Marsh Study

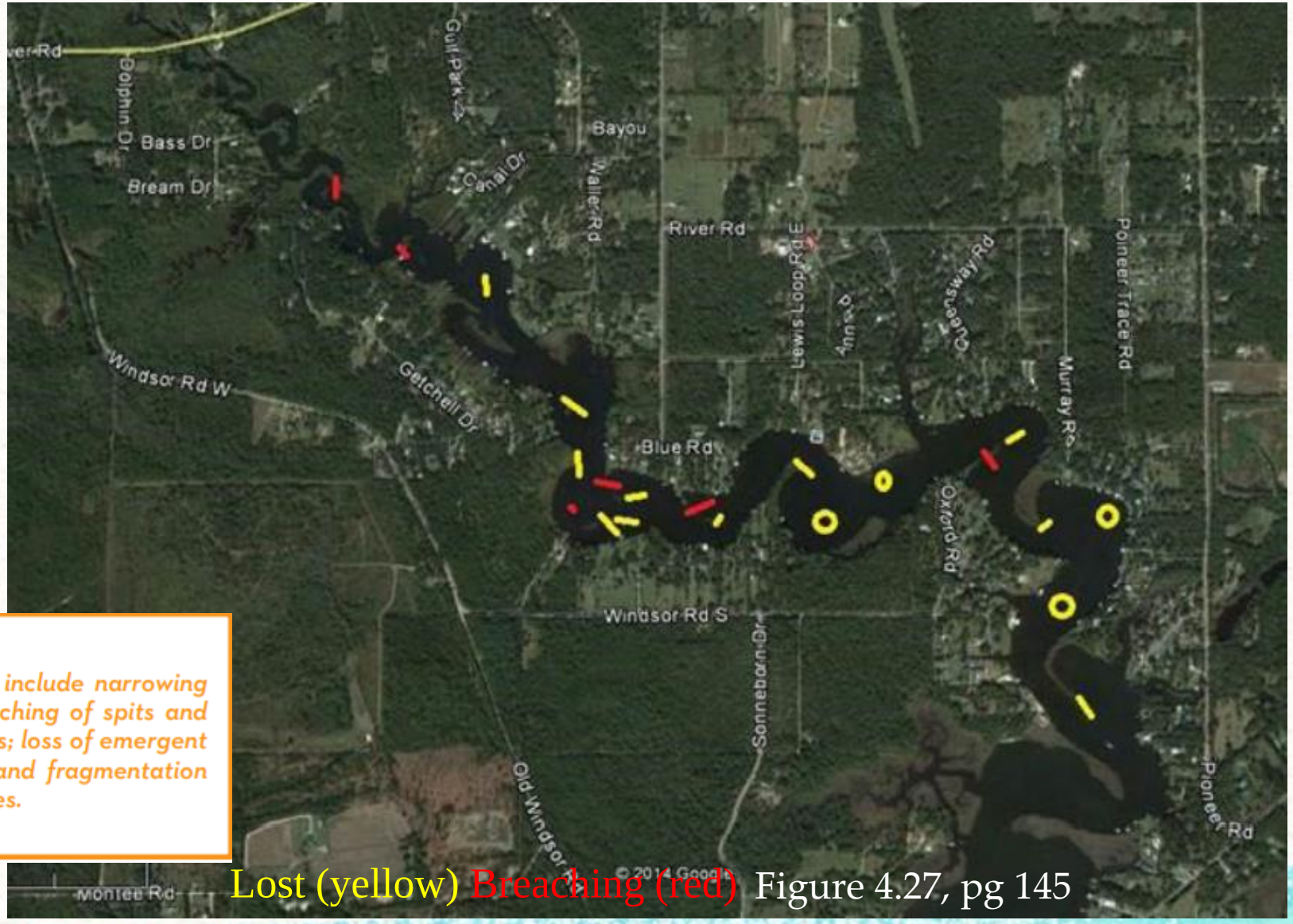
A Fowl River Watershed Management Plan was completed in 2016.

One of the priorities identified in the Plan is the preservation of spits and marshes along the river.



Submitted by: GOODWYN MILLS CAWOOD · Dauphin Island Sea Lab · Alabama · Alabama Cooperative Extension System · ESA · planning NEXT · SCE · Stantec

Fowl River Marsh Study



Changes include narrowing and breaching of spits and point bars; loss of emergent habitat; and fragmentation of marshes.

Lost (yellow) Breaching (red) Figure 4.27, pg 145

Photo by S. St. John

Photo by S. St. John

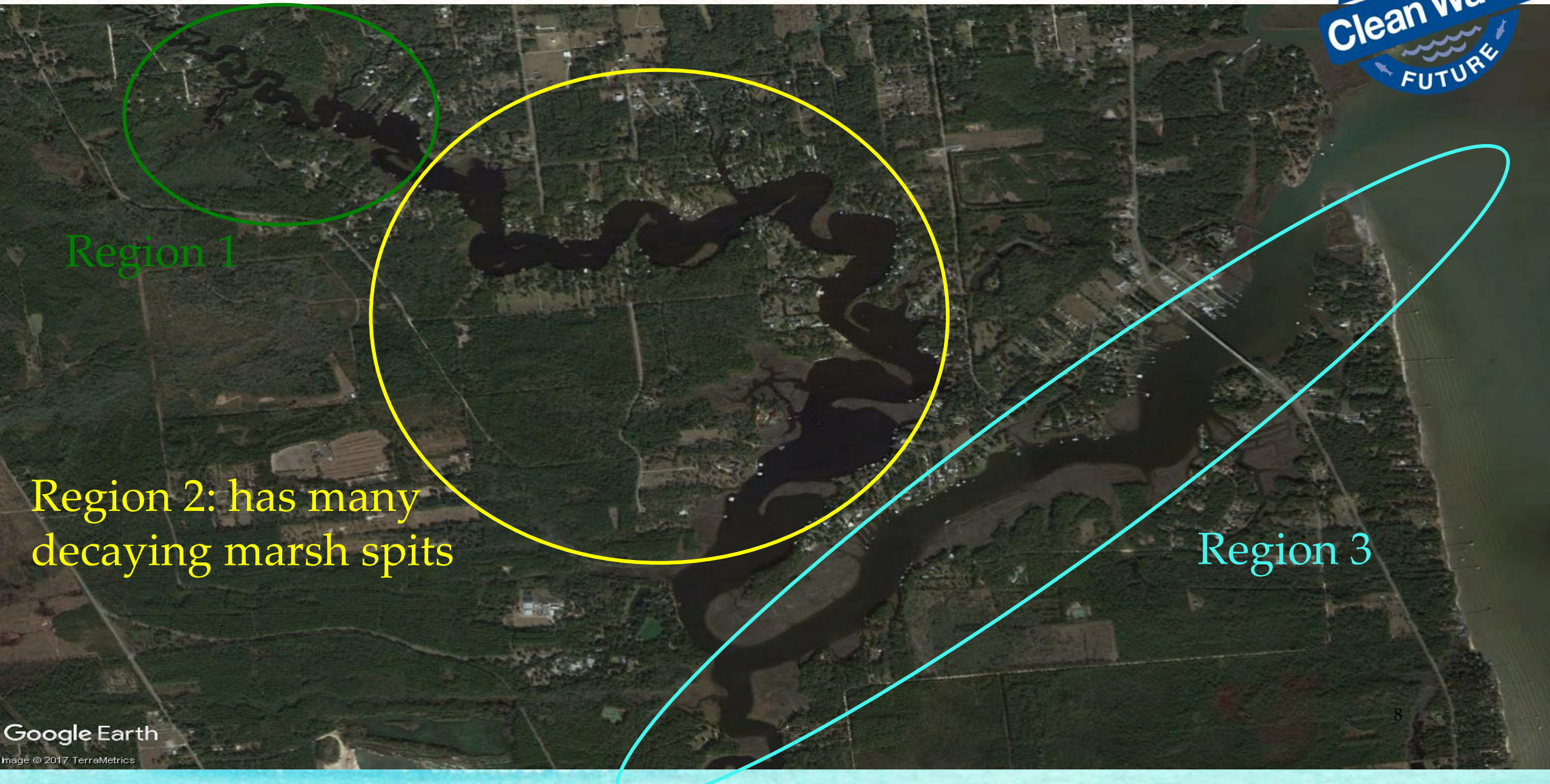
Fowl River Marsh Study

Specific goals for the study:

- Characterize the status and health of the wetlands in the brackish zone of Fowl River

- Understand the causes of wetland decline observed in many areas of the River

- Inform best-practice engineering designs for wetland restoration and protection


Region 1
Region 2: has many decaying marsh spits
Region 3
Google Earth
Image © 2017 TerraMetrics

Fowl River Marsh Study

- Study focused on Region 2

- Main goal: Elucidate marsh spit decay (but at the same time also documenting the status and health of marshes in the other Regions)

- Three hypothesized mechanisms (acting separately or in conjunction):
  - Sea level rise: Salt intrusion and higher flooding
  - Sediment starvation
  - Boat wakes and wave energy

Fowl River Marsh Study

- To look into these mechanisms, the study has three integrated components:
  - Vegetation: impacts of these processes on the wetlands
  - Sediments: sediment starvation
  - Hydrology: salt intrusion, flooding, nutrients, and wave energy

Vegetation, porewater salinity, and elevation characteristics of tidal marshes along Fowl River, Alabama

Just Cebrian, Joshua Goff, Tim Thibaut, Howard Horne

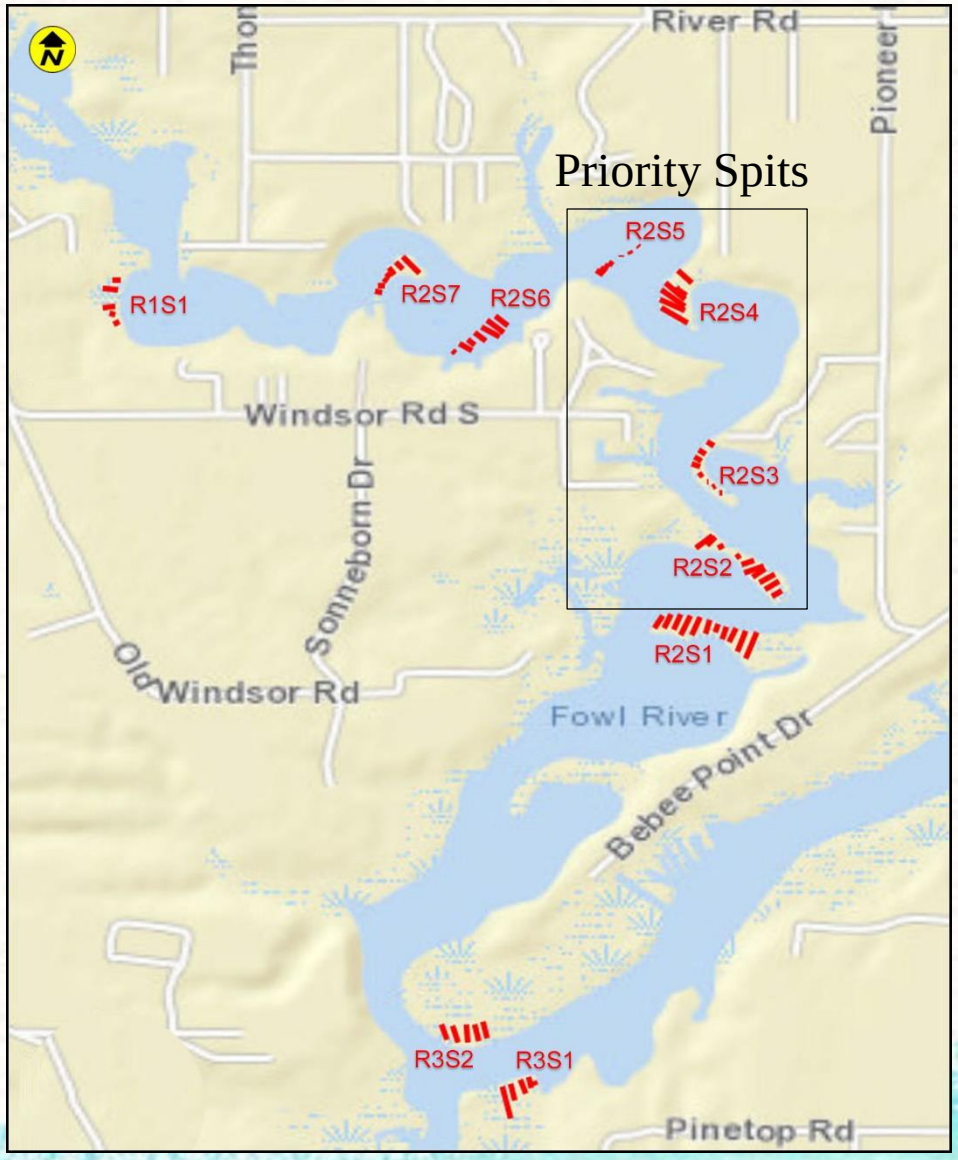
Fowl River Marsh Study - Vegetation

Questions

(1)What is the general marsh health status across the 3 Study Regions?

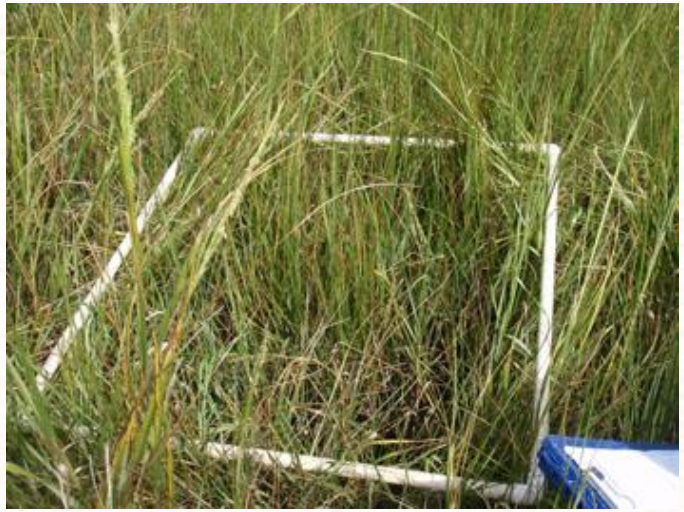
(2)What are the factors that influence the health of marshes in the brackish transitional zone where fresh and salt waters mix?

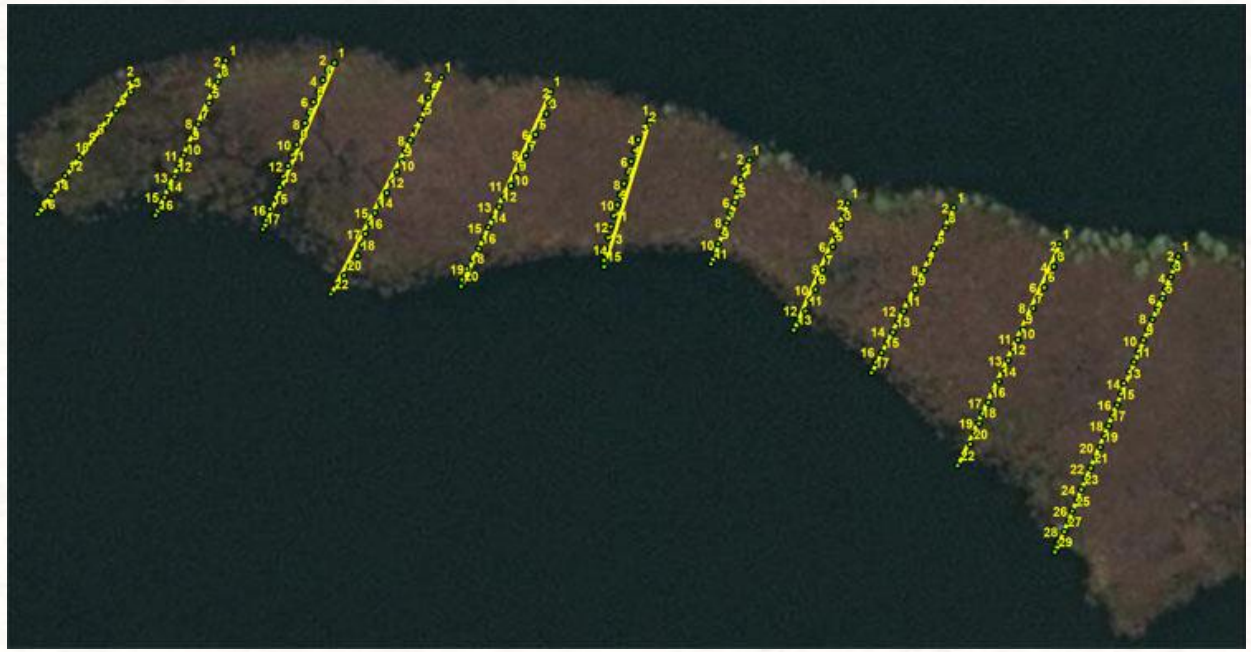
The Vegetation Component surveys were performed at 10 sites across the three Study regions, encompassing the priority spits and marshes upstream and downstream.



PLANT SPECIES DIVERSITY, DISTRIBUTION, and % COVER

Percent coverage and species composition were measured within 1-m^2 quadrats placed every 3 m (~ 10 ft) along survey transects.





895 quadrats were sampled along 74 survey transects in August and September, 2018.

MARSH ELEVATION

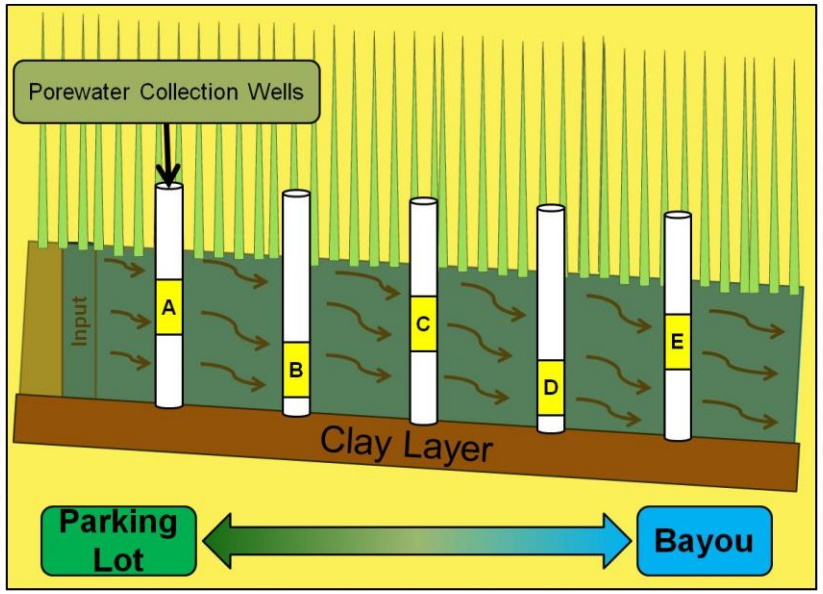
Trimble® Real Time Kinematic (RTK) GPS: horizontal and vertical accuracy < 5 cm (2 in)

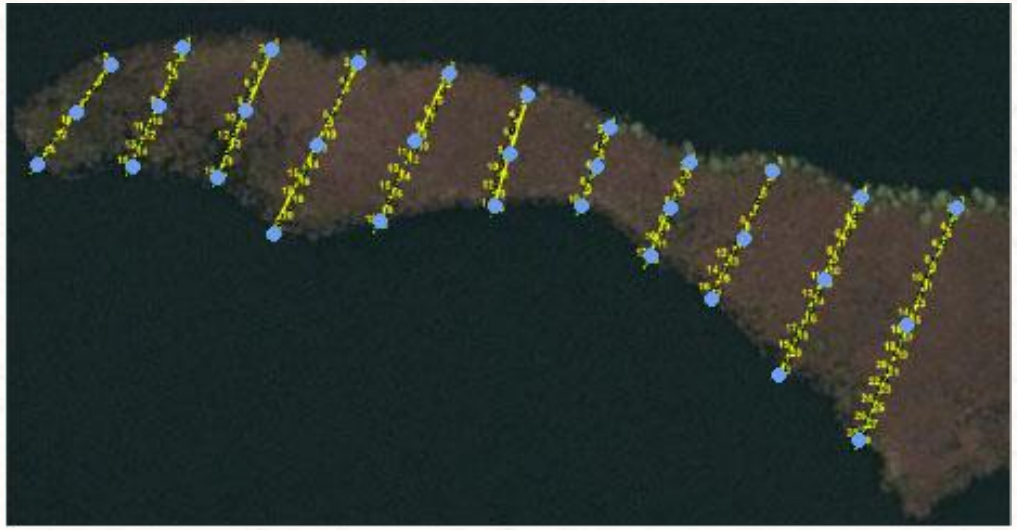
All stations

Spring and Fall 2018

MARSH POREWATER SALINITY

Marsh sediment wells: slotted PVC pipe





4 sampling rounds in 2018:

- May/June
- July
- August
- October

Plant Diversity

73 plant species were recorded in quadrats.

An additional 41 species were identified in supplemental inventory surveys.

Notable S

– *Eleoc* IKERUSH

AL

– *Ludwi* DBOX

Ne

– *Ampe* BING ASTER

Nev

Laurel Wilt Disease

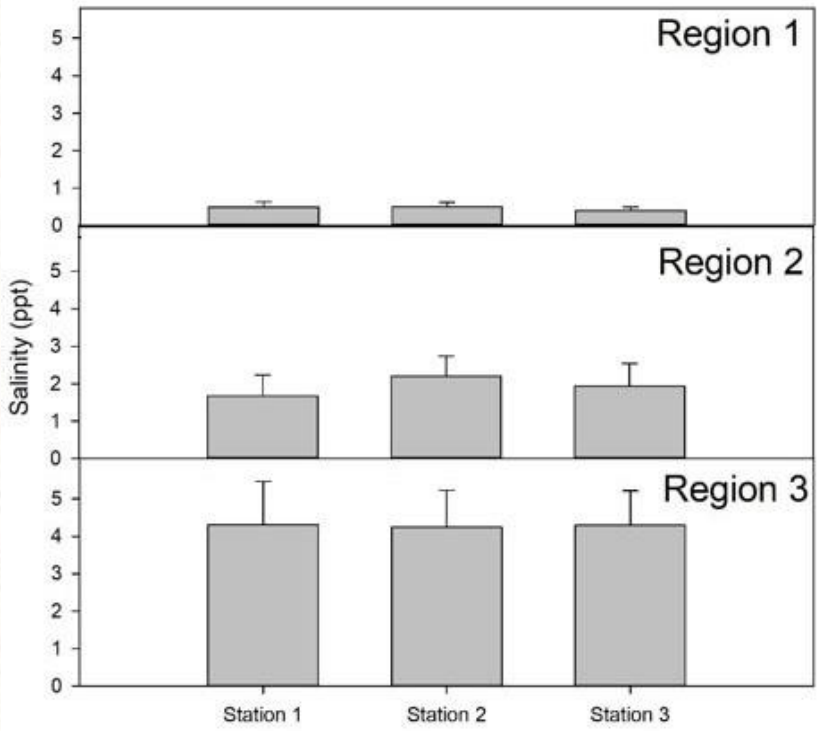
Species Diversity and % Cover

Site	Total No. Species	Average No. Species/quadrat	Average % Cover/quadrat
R1S1	29	2.6	61.4
R2S7	32	5.5	53.6
R2S6	35	7.5	65.9
R2S5 (Strout)	29	5.3	46.8
R2S4 (Closing Hole)	41	6.3	62.0
R2S3 (Lightcap)	30	5.0	56.1
R2S2 (Tapia)	38	5.0	59.0
R2S1	21	3.9	48.8
R3S2	13	2.3	33.9
R3S1	9	2.2	45.8

Porewater Wells

Total Salinity Range: 0.10 – 8.7 ppt

Average Salinity



Percent Cover

SITE	Sawgrass	Black Needlerush
R1S1	46.6	0.0
R2S7	9.8	0.0
R2S6	3.0	0.0
R2S5 (Strout)	9.5	0.9
R2S4 (Closing Hole)	30.1	6.1
R2S3 (Lightcap)	14.2	20.6
R2S2 (Tapia)	20.1	13.8
R2S1	1.0	34.7
R3S2	3.5	37.6
R3S1	0.0	24.4

HYDROGEOMORPHIC (HGM) MODEL

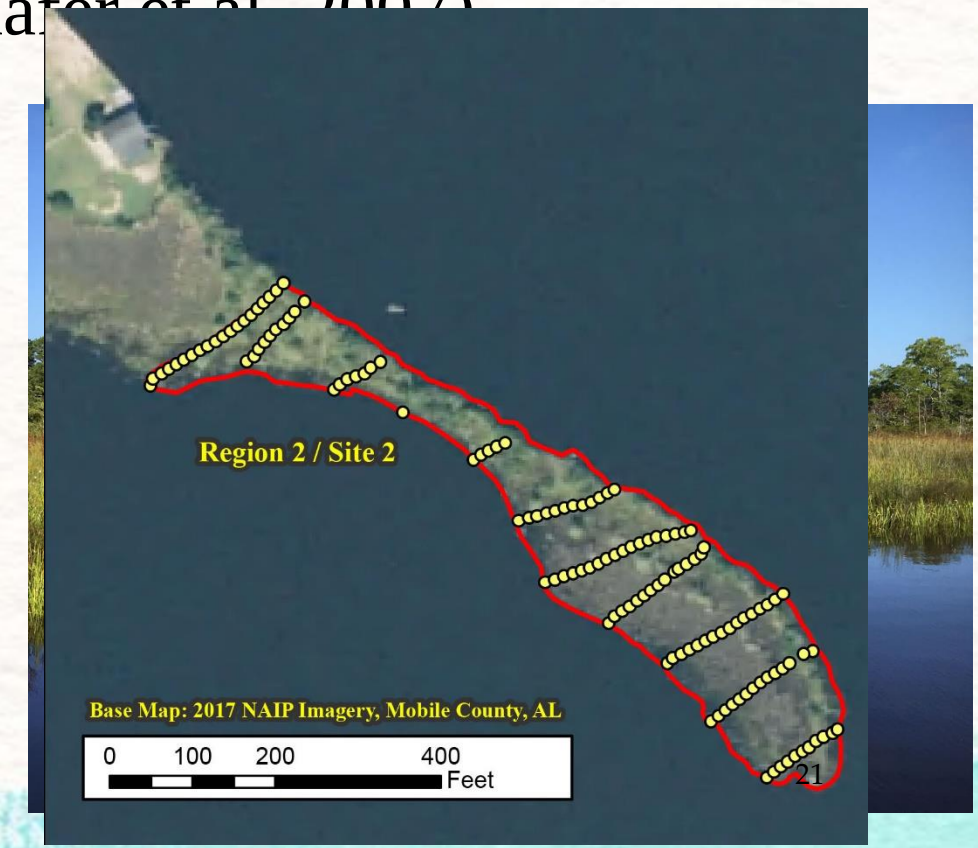
HGM assesses the capacity of Alabama fringing tidal marshes to perform specific ecosystem functions (Shafer et al. 2007)

Landscape-scale variables:

Field variables:

- Marsh Patch Size
- Mean Marsh Width
- Aquatic Edge
- Hydrologic Regime
- Vegetation Height
- Wave Energy Exposure
- Adjacent Land Use

- Mean % Cover of Marsh Vegetation
- % Cover of Invasive or Exotic Species
- % Cover by Woody Plant Species
- Nekton Habitat Diversity



HYDROGEOMORPHIC (HGM) MODEL

Variables are combined using mathematical expressions to estimate 5 major ecosystem functions.

Wave Energy Attenuation
Biogeochemical Cycling
Nekton Utilization Potential
Provide Habitat for Tidal Marsh Dependent Wildlife Species
Maintain Plant Community Composition and Structure

HGM Assessment Scores

SITE	FCI AVERAGE
R1S1	0.76
R2S7	0.69
R2S6	0.83
R2S5 (Strout)	0.42
R2S4 (Closing Hole)	0.73
R2S3 (Lightcap)	0.68
R2S2 (Tapia)	0.71
R2S1	0.67
R3S2	0.60
R3S1	0.68

FLORISTIC QUALITY INDEX (FQI)

FQI estimates wetland habitat quality based on plant species composition.

A coefficient of conservatism (C value) is scaled from 0 to 10 and applied to wetland plant species, based on:

1. Breadth of habitat preference(s)
2. Tolerance to disturbance

Example C values

Black needlerush = 8
Sawgrass = 7
Torpedo grass = 0

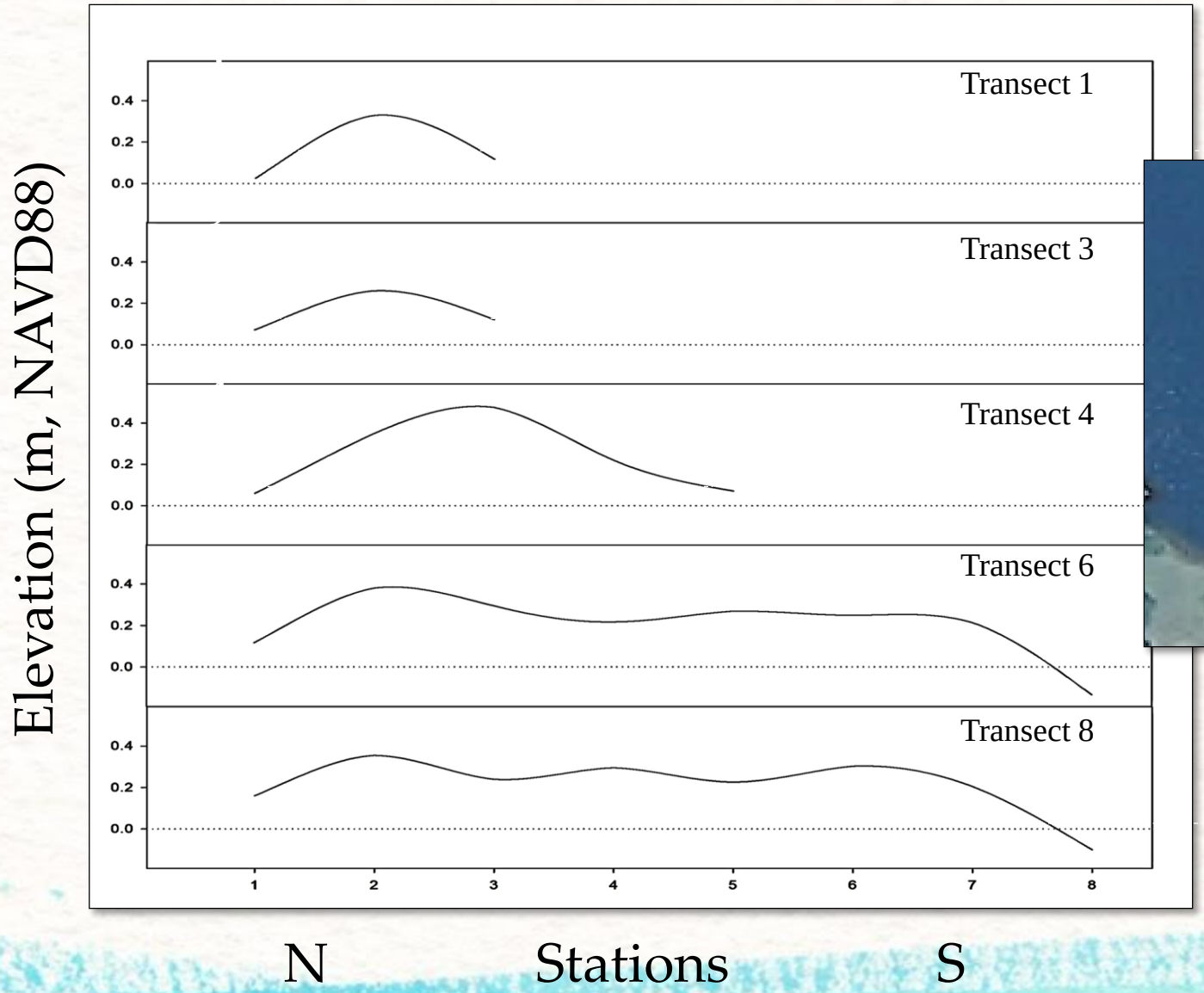
Floristic Quality Index Scores

SITE	FQI SCORE
R1S1	6.7
R2S7	5.2
R2S6	5.2
R2S5 (Strout)	4.7
R2S4 (Closing Hole)	6.2
R2S3 (Lightcap)	6.6
R2S2 (Tapia)	6.4
R2S1	7.1
R3S2	7.1
R3S1	7.5

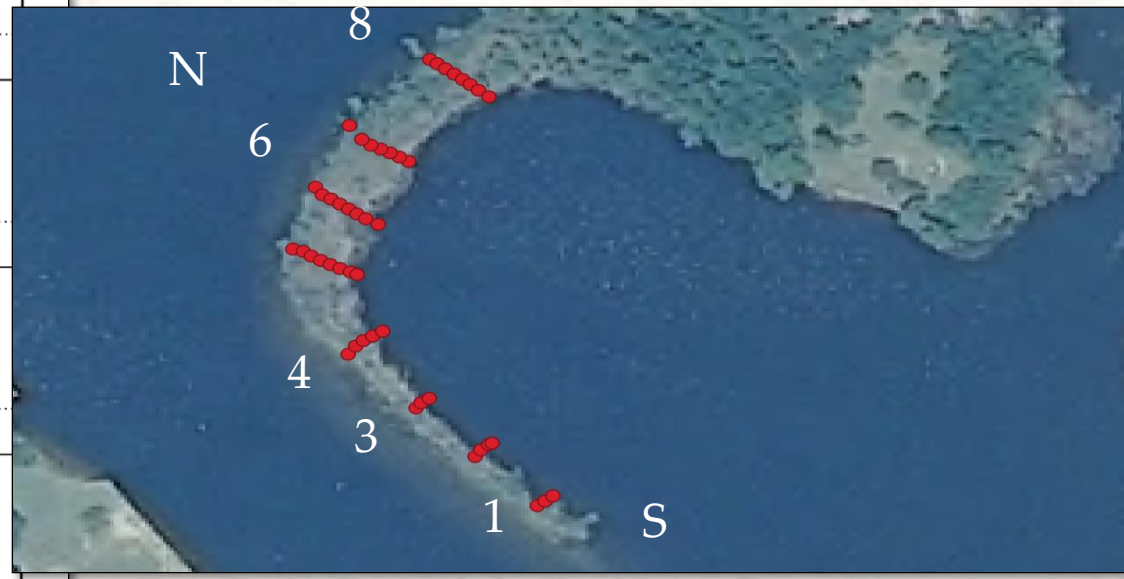
Elevation (m, NAVD88)

Site	Min.	Max.	$\overline{X}$
R1S1	-0.08	0.50	0.21
R2S7	-0.23	0.38	0.13
R2S6	-0.16	0.34	0.19
R2S5 (Strout)	-0.20	0.56	0.20
R2S4 (Closing Hole)	-0.01	0.65	0.29
R2S3 (Lightcap)	-0.13	0.48	0.20
R2S2 (Tapia)	-0.23	0.56	0.24
R2S1	-0.31	0.32	0.12
R3S2	-0.19	0.26	0.15
R3S1	-0.36	0.20	0.10

Fowl River Marsh Study - Vegetation



Lightcap (R2S3) Elevation



Strout, Closing Hole, and Tapia each have a similar ridge feature.

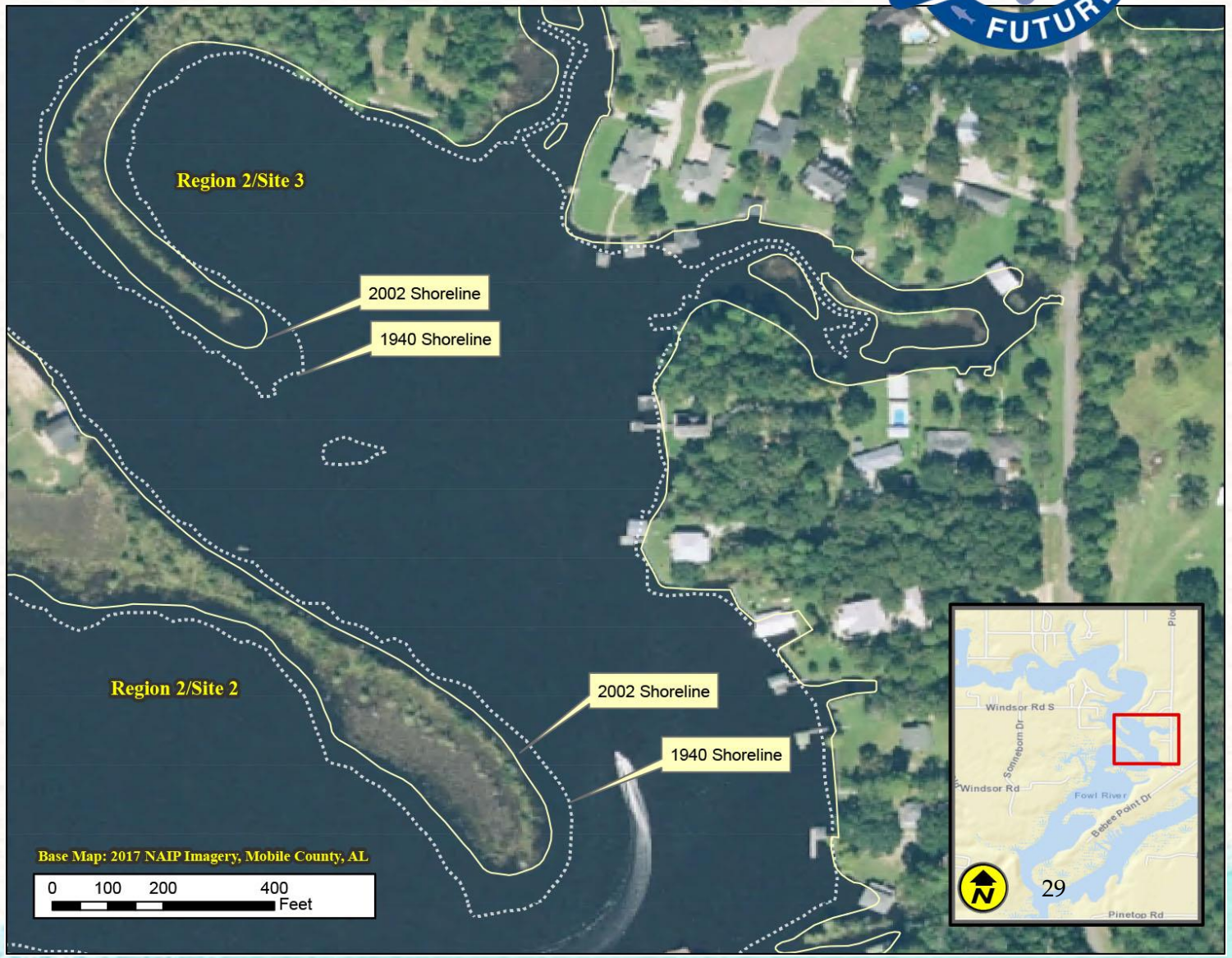
Elevation (m, NAVD88)

Site	Min.	Max.	$\overline{X}$
R1S1	-0.08	0.50	0.21
R2S7	-0.23	0.38	0.13
R2S6	-0.16	0.34	0.19
R2S5 (Strout)	-0.20	0.56	0.20
R2S4 (Closing Hole)	-0.01	0.65	0.29
R2S3 (Lightcap)	-0.13	0.48	0.20
R2S2 (Tapia)	-0.23	0.56	0.24
R2S1	-0.31	0.32	0.12
R3S2	-0.19	0.26	0.15
R3S1	-0.36	0.20	0.10

Elevation Change

Is the elevation of the marshes stable or shifting, and what impacts can be expected from future SLR?

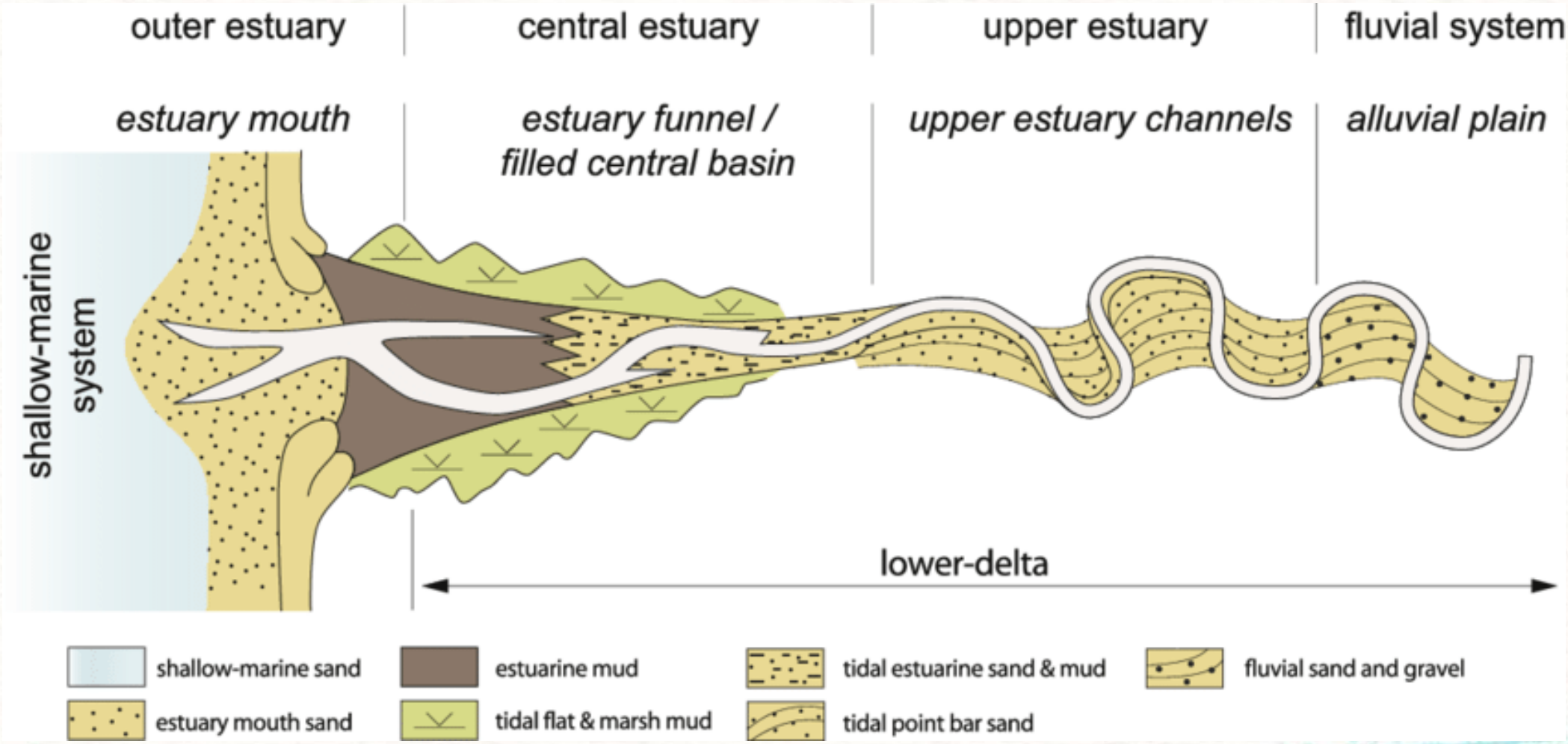
Is the diversity, distribution, and coverage of plant species changing?

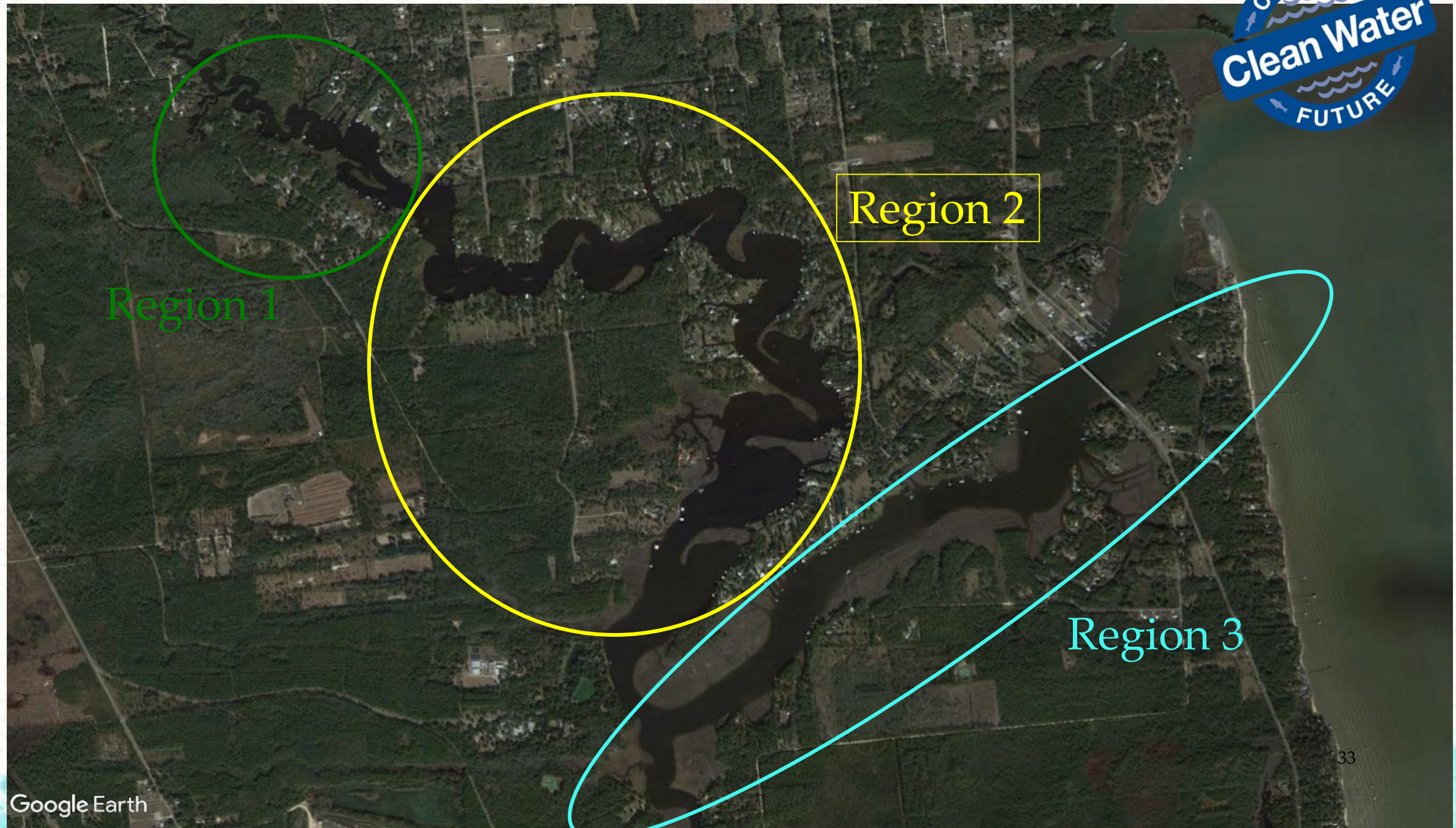


Fowl River and Marsh Sediment Dynamics

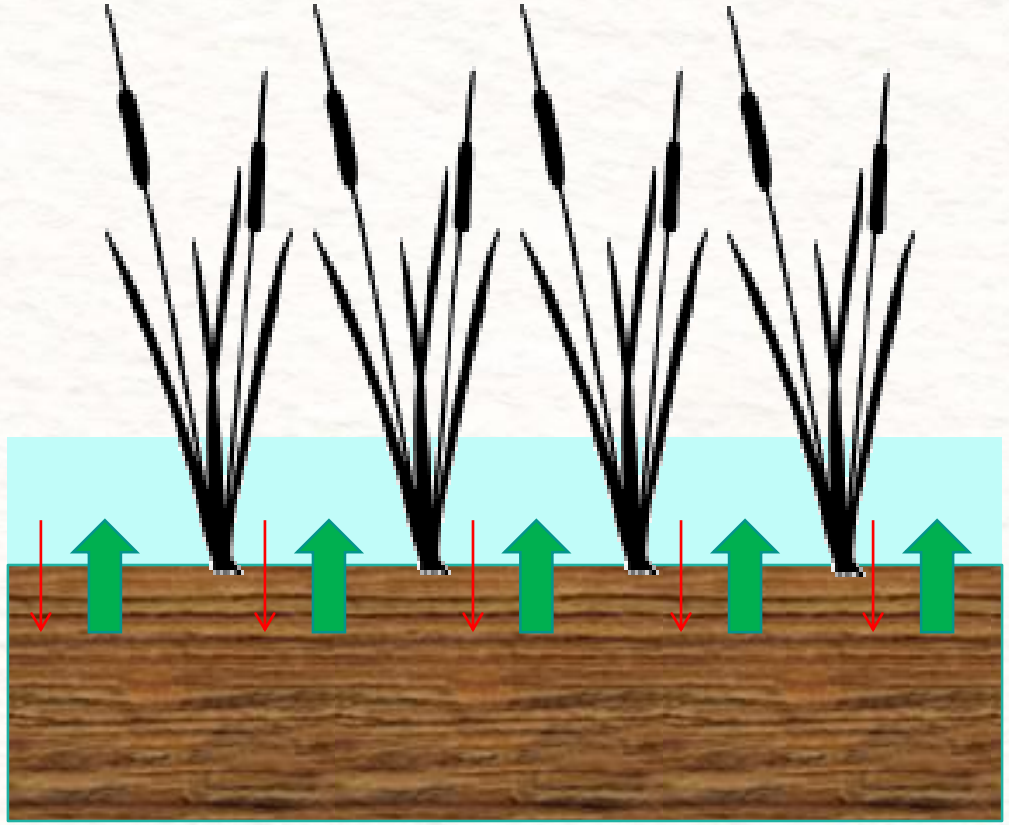
Alex Beebe, Marlon Cook, Ruth Carmichael

Fowl River Marsh Study - Sediment


outer estuary
central estuary
upper estuary
fluvial system
estuary mouth
estuary funnel / filled central basin
upper estuary channels
alluvial plain
shallow-marine system
lower-delta
shallow-marine sand
estuarine mud
tidal estuarine sand & mud
fluvial sand and gravel
estuary mouth sand
tidal flat & marsh mud
tidal point bar sand


Region 1
Region 2
Region 3
Google Earth

$$\Delta Marsh\ Elevation\ = Net\ Accretion - \Delta Sea\ Level$$



Fowl River Marsh Study - Sediment

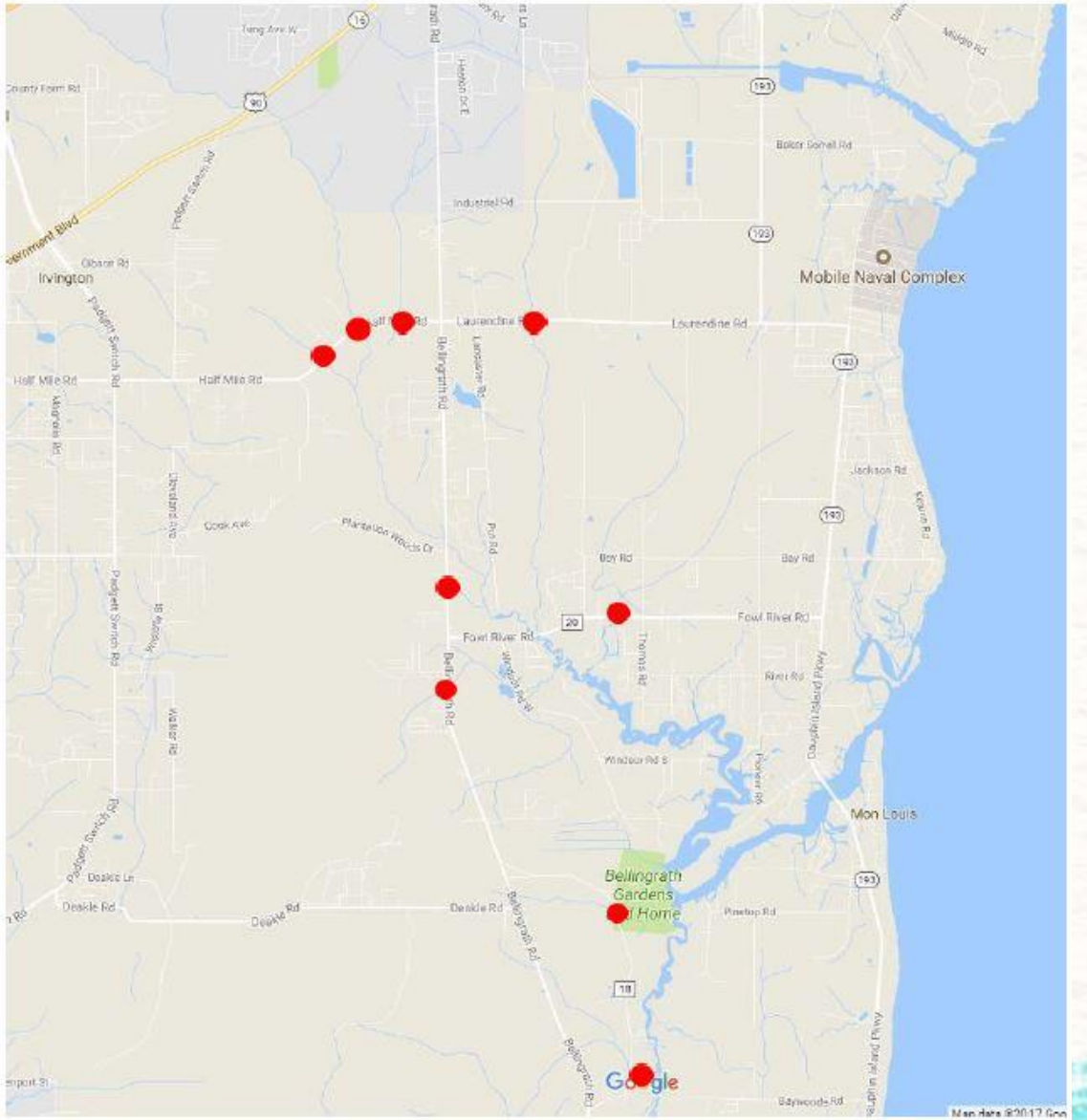
Questions:

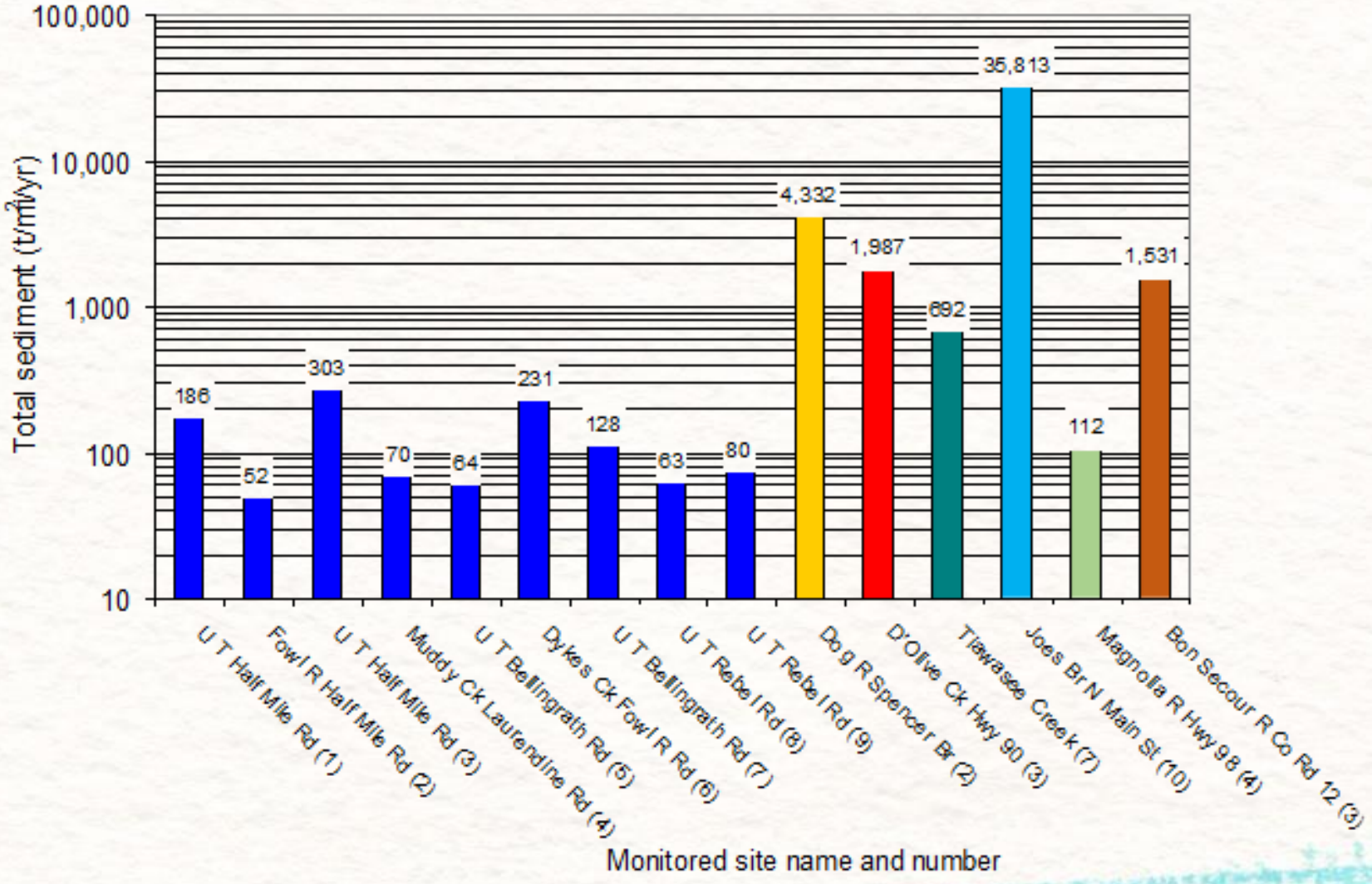
1. What is the current sediment supply, fate, and transport in Fowl river?

2. How do the current sediment conditions compare to the past?

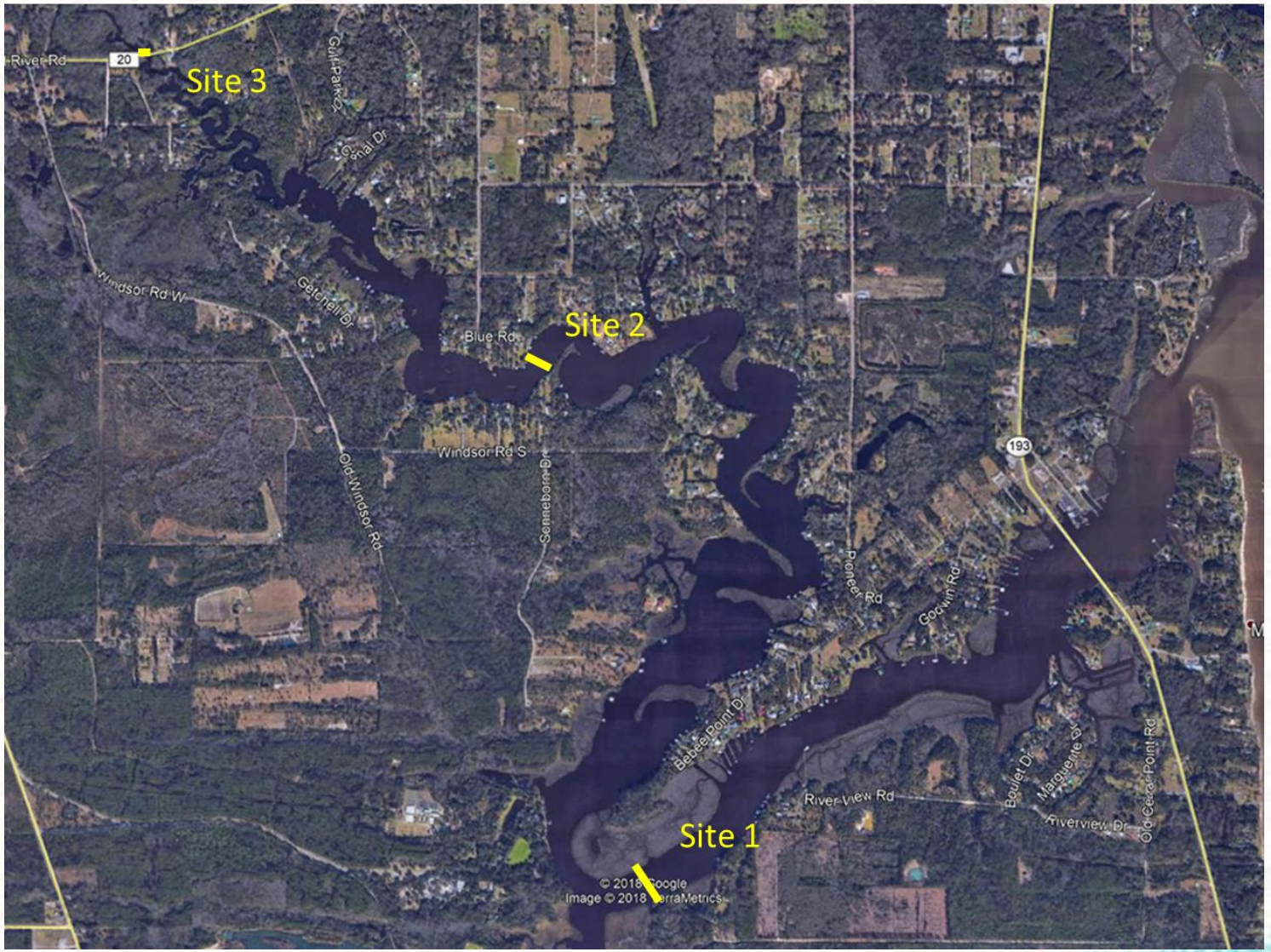
3. What are the accretion/erosion rates for the marsh?

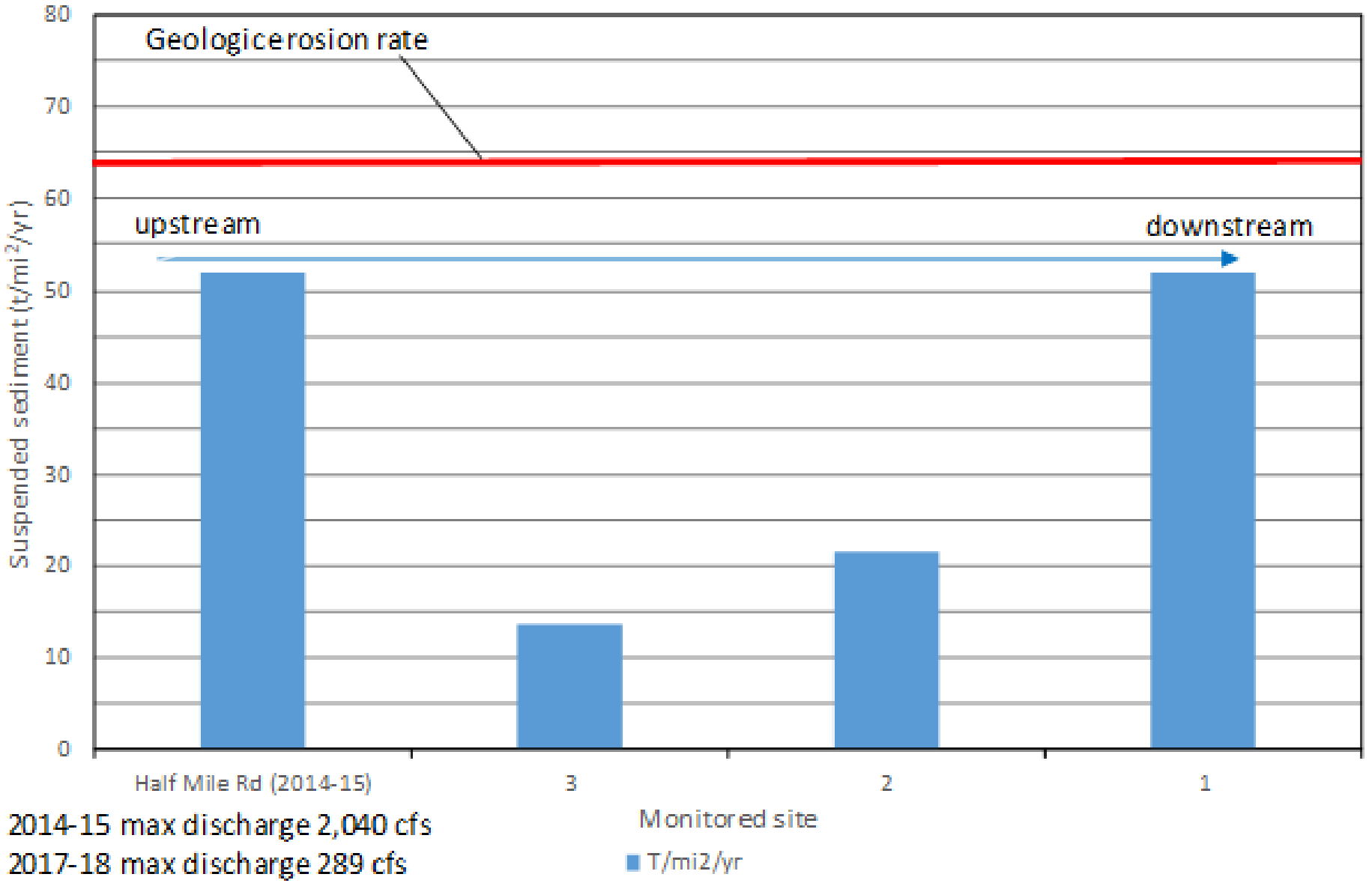
Previous
Fowl River
Water-Quality
and Sedimentation
Assessment
2015




100,000
10,000
1,000
100
10
Total sediment (t/mi²/yr)
186
52
303
70
64
231
128
63
80
4,332
1,987
692
35,813
112
1,531
U T Half Mile Rd (1)
Fowl R Half Mile Rd (2)
U T Half Mile Rd (3)
Muddy Ck Laurendine Rd (4)
U T Bellingrath Rd (5)
Dykes Ck Fowl R Rd (6)
U T Bellingrath Rd (7)
U T Rebel Rd (8)
U T Rebel Rd (9)
Dog R Spencer Br (2)
D'Olive Ck Hwy 90 (3)
Tiawasee Creek (7)
Joes Br N Main St (10)
Magnolia R Hwy 98 (4)
Bon Secour R Co Rd 12 (3)
Monitored site name and number

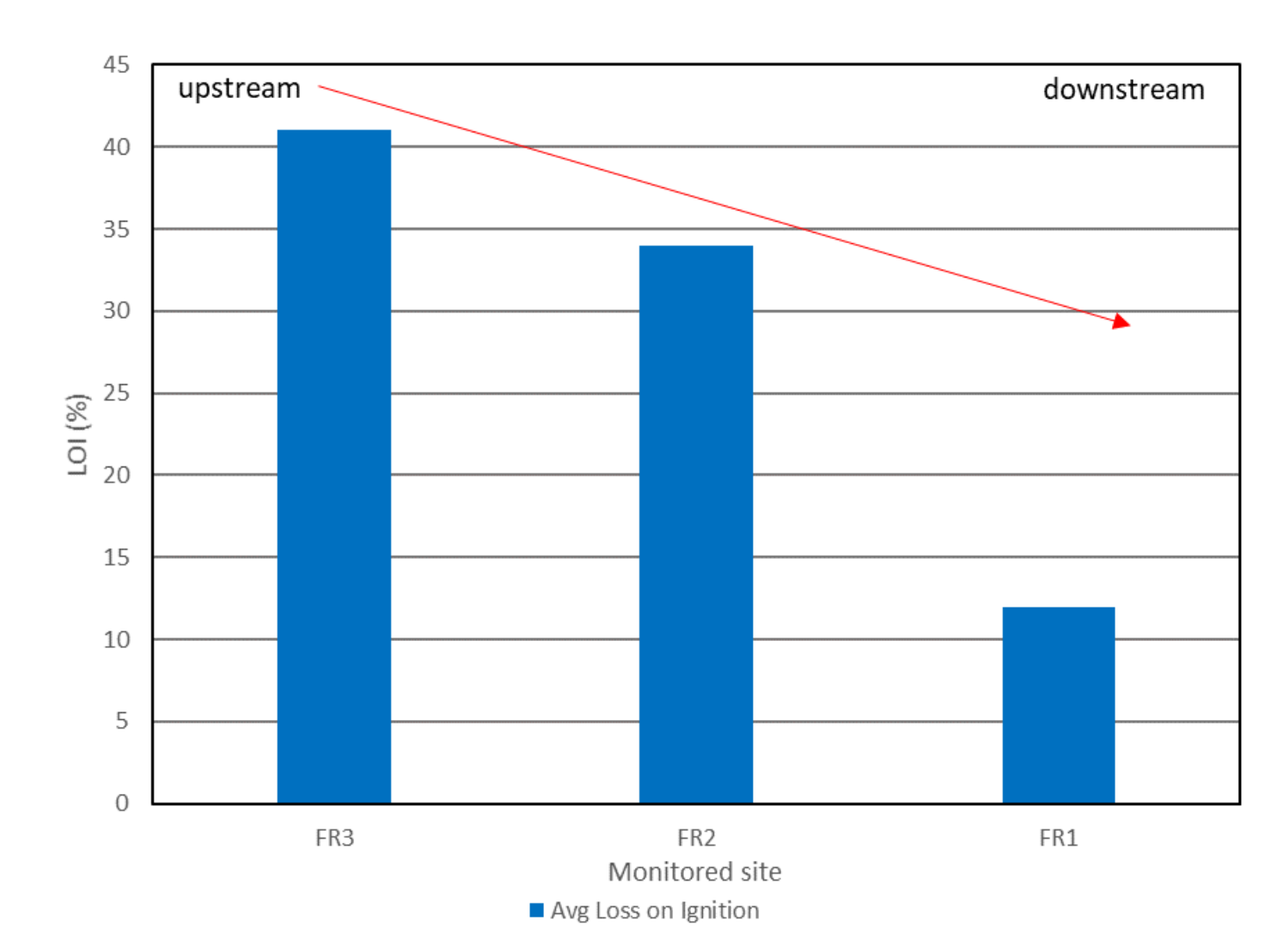
Fowl River Marsh Study - Sediment





2014-15 max discharge 2,040 cfs

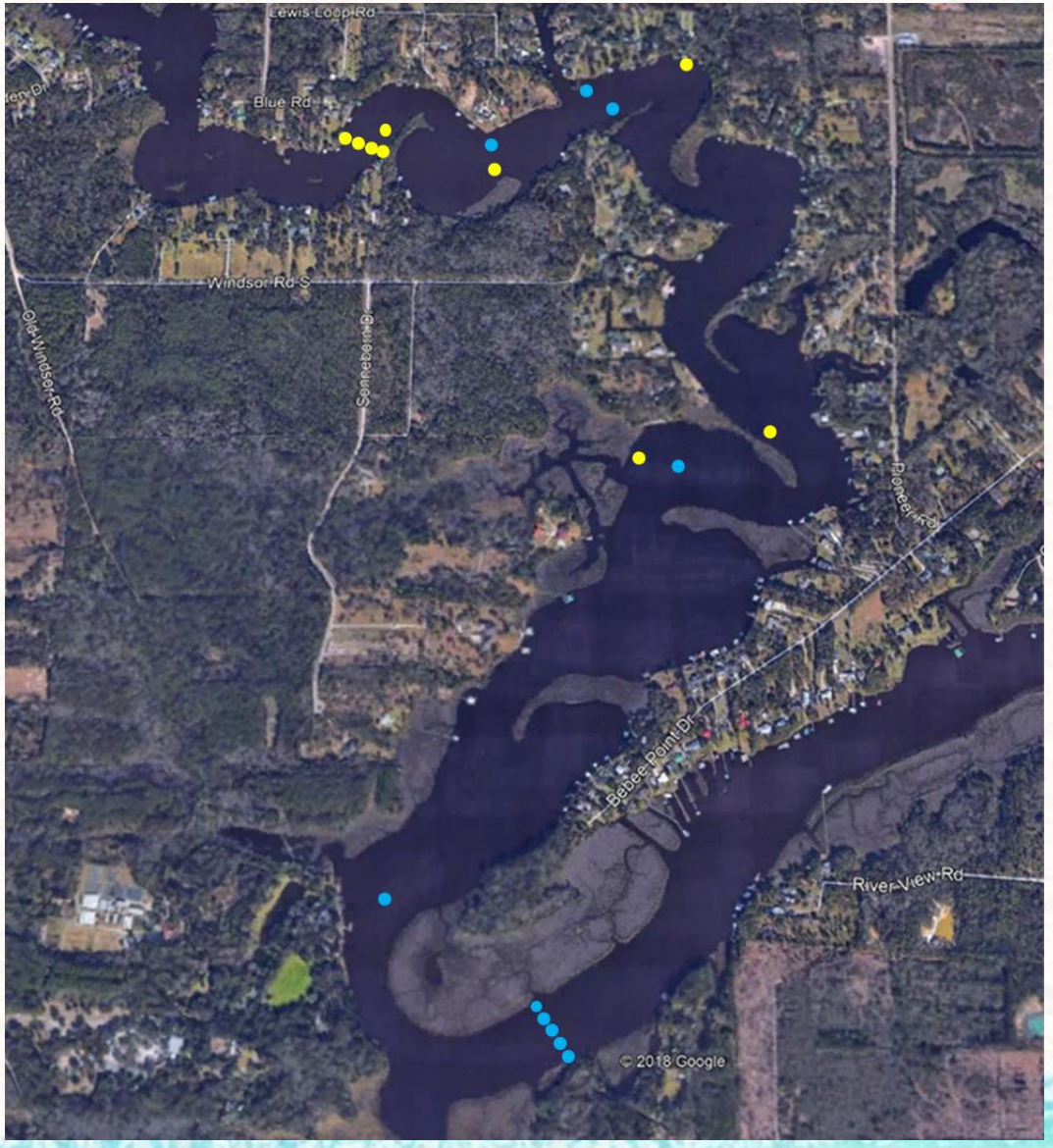
2017-18 max discharge 289 cfs



Decreasing Loss On Ignition (LOI) from upstream to downstream in the estuary shows that organic material is settling out in the mid and downstream areas resulting in sediment deposition dominated by organic-rich clay.

Channel bed sediment characterization

- Organic-rich clay
- Relatively coarse-grained sand



Fowl River Marsh Study - Sediment

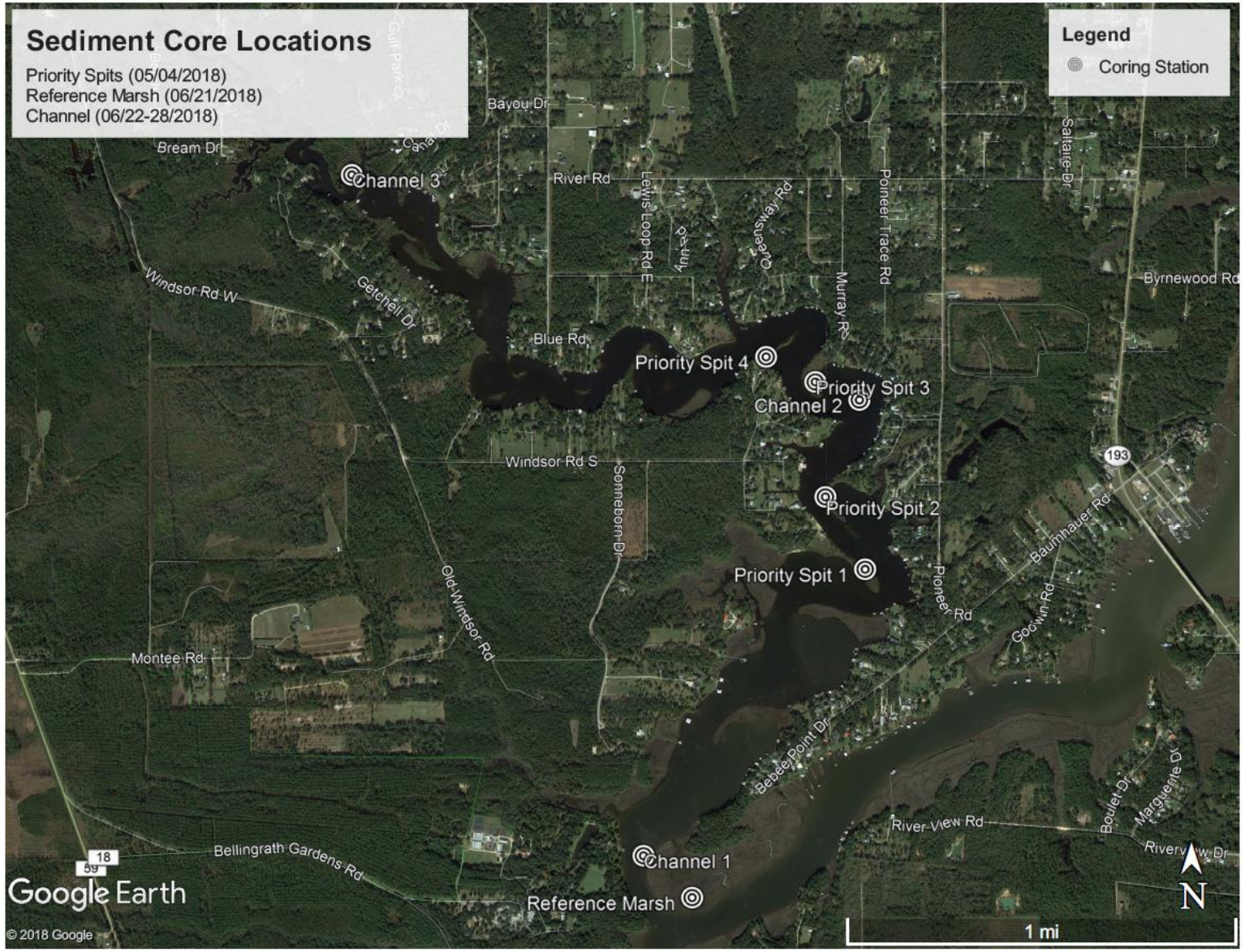
Questions:

1. What is the current sediment supply, fate, and transport in Fowl river?

   Very little river sediment reaches the spits (Region 2)

2. How do the current sediment conditions compare to the past?

3. What are the accretion/erosion rates for the marsh?


Sediment Core Locations
Priority Spits (05/04/2018)
Reference Marsh (06/21/2018)
Channel (06/22-28/2018)
Legend
Coring Station
Bayou Dr
Bream Dr
Channel 3
River Rd
Lewis Loop Rd E
Queensway Rd
Murray Rd
Pioneer Trace Rd
Saltaire Dr
Byrnewood Rd
Windsor Rd W
Getchell Dr
Blue Rd
Priority Spit 4
Priority Spit 3
Channel 2
Windsor Rd S
Sonneborn Dr
Priority Spit 2
Priority Spit 1
Baumhauer Rd
Pioneer Rd
Goodwin Rd
Old Windsor Rd
Montee Rd
Bebee Point Dr
River View Rd
Boulet Dr
Marguerite Dr
Bellingrath Gardens Rd
Channel 1
Reference Marsh
Google Earth
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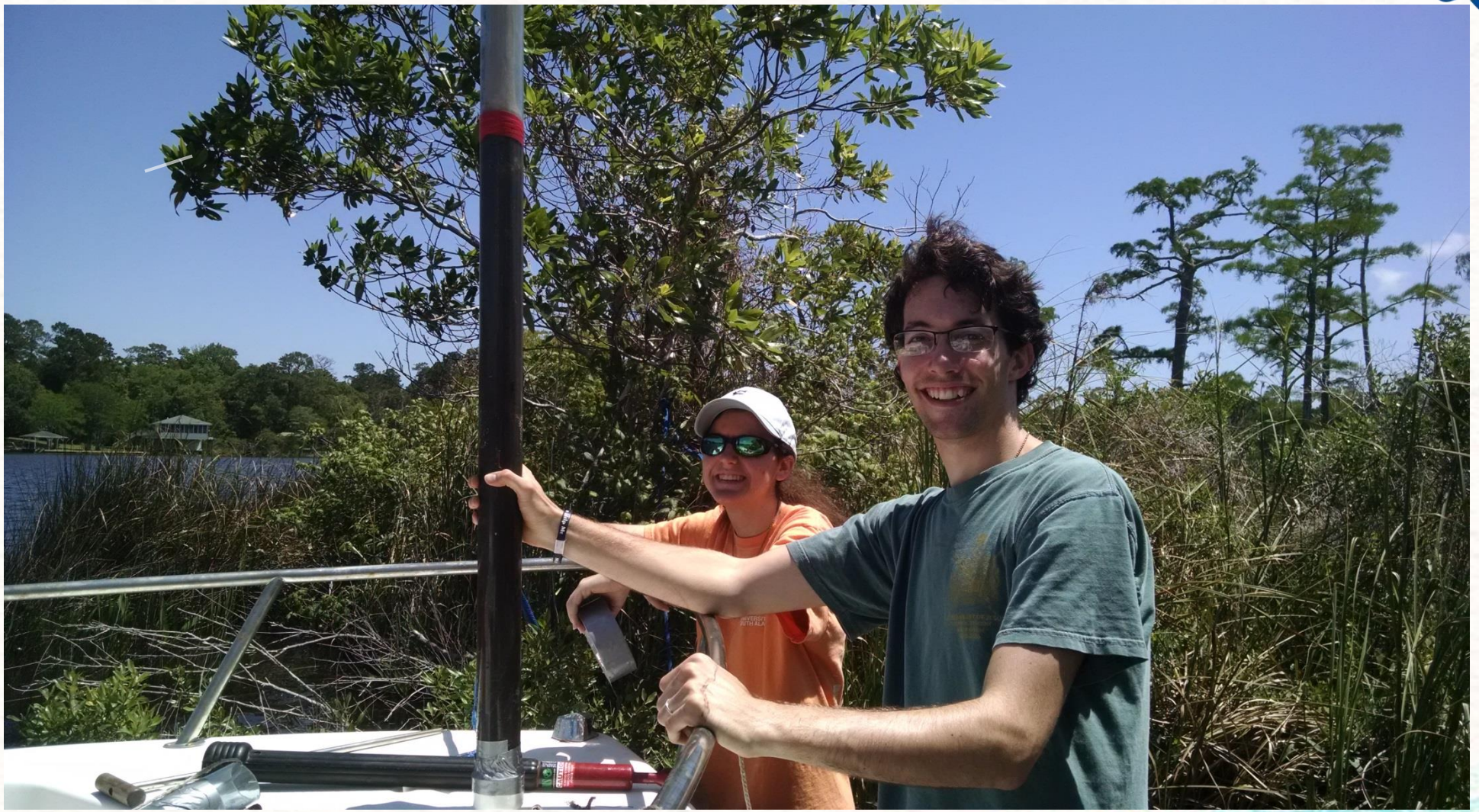
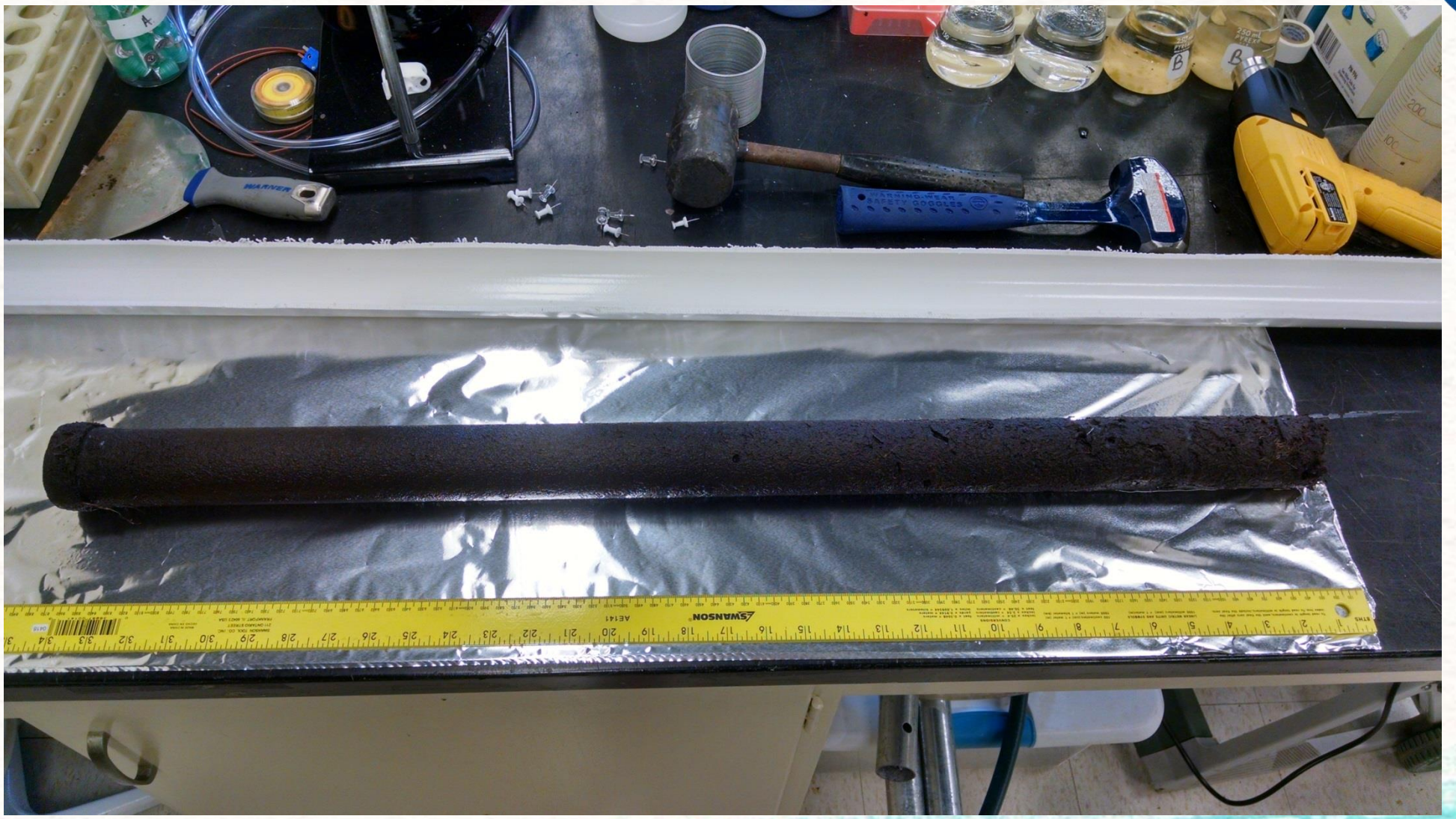
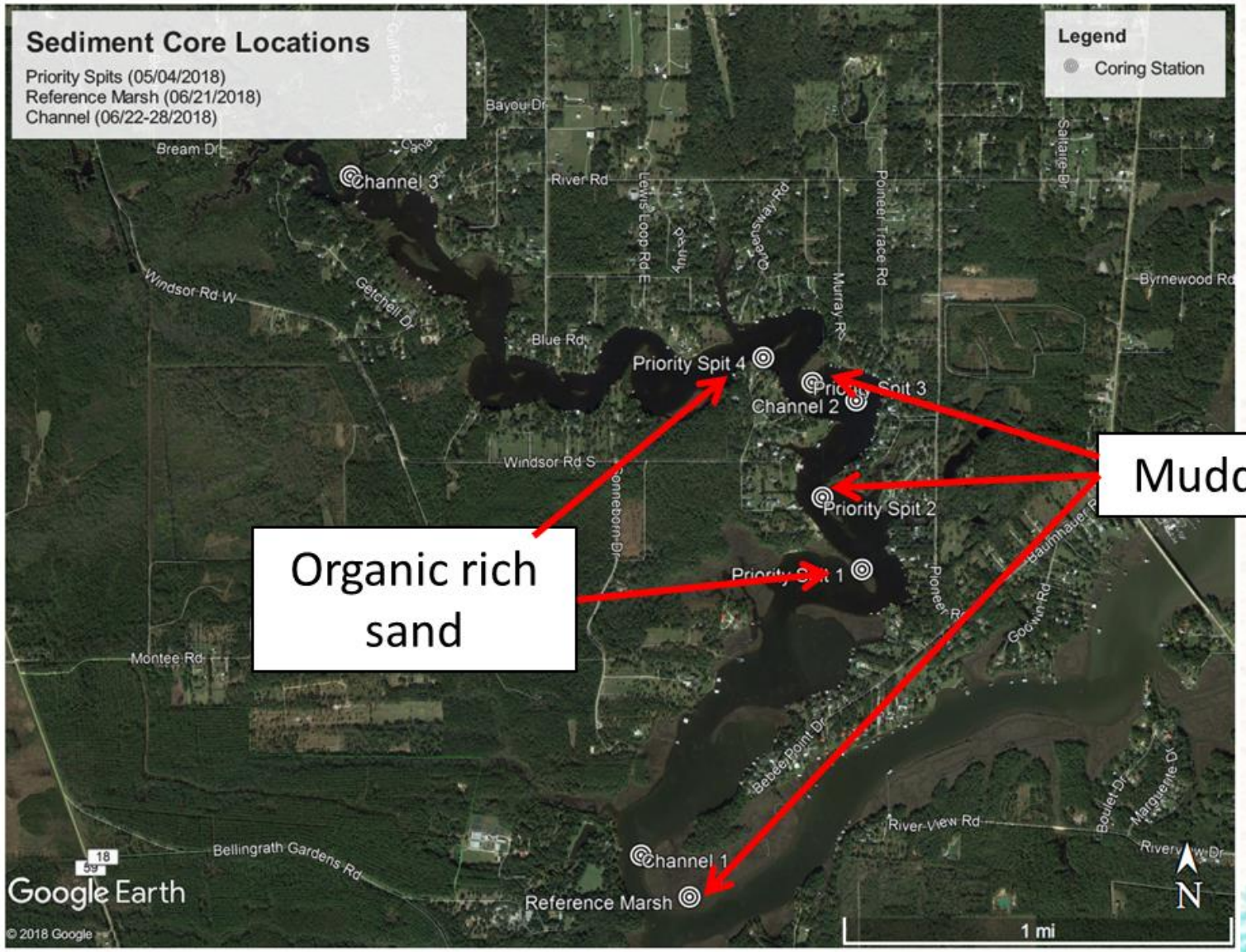
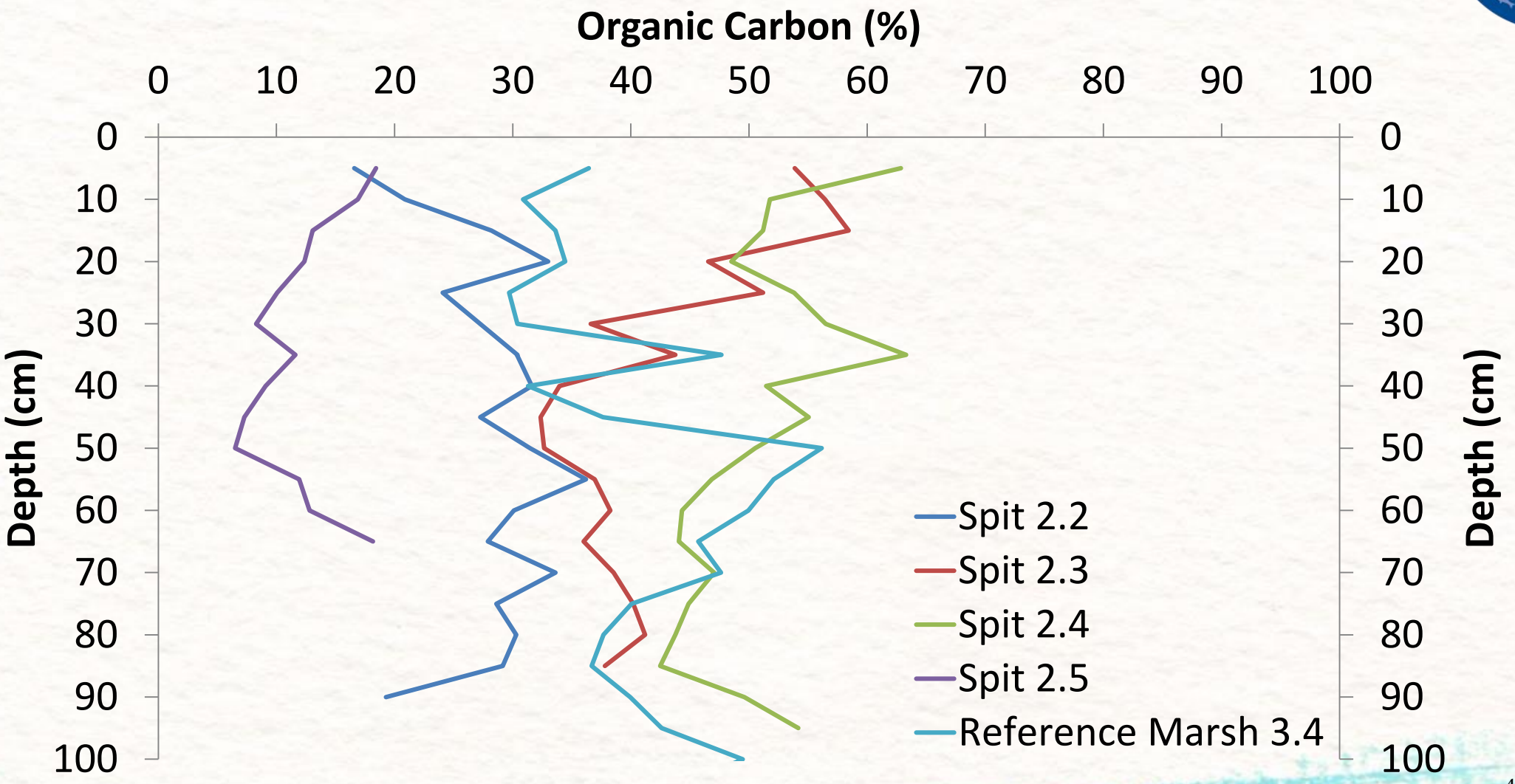
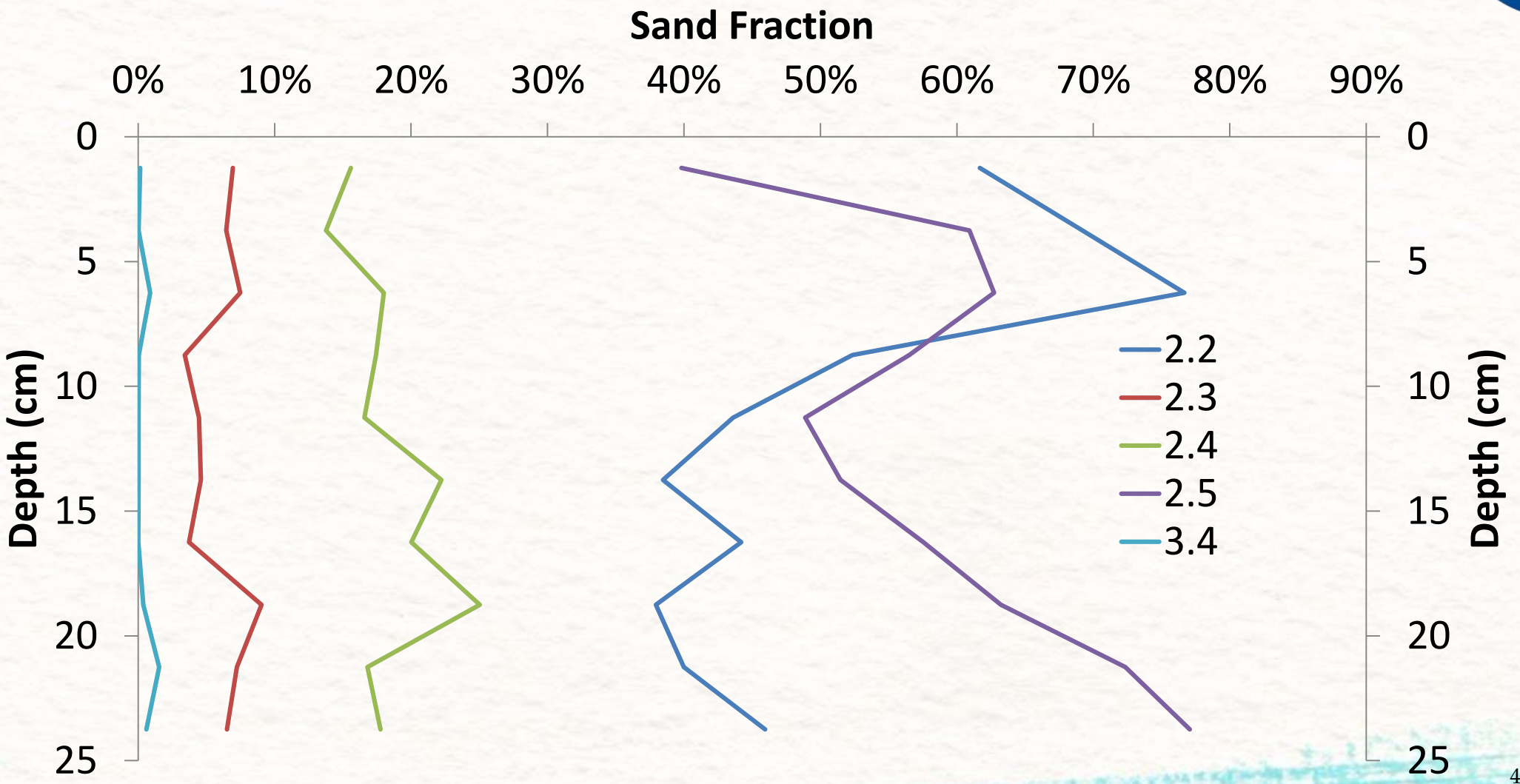
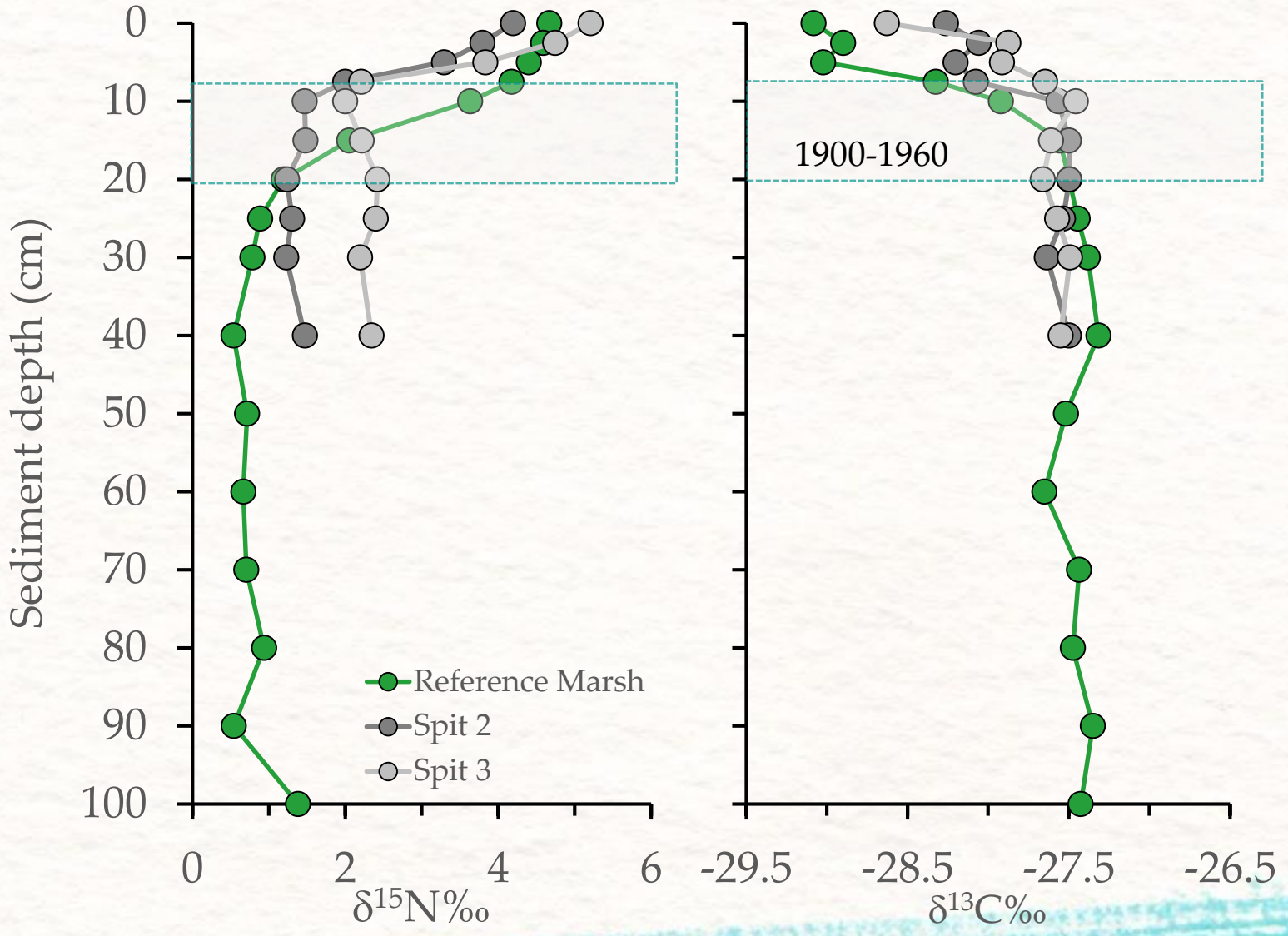



WARNER
SWANSON


Sediment Core Locations
Priority Spits (05/04/2018)
Reference Marsh (06/21/2018)
Channel (06/22-28/2018)
Legend
Coring Station
Channel 3
Priority Spit 4
Channel 2
Priority Spit 3
Priority Spit 2
Priority Spit 1
Channel 1
Reference Marsh
Muddy peat
Organic rich sand
Bream Dr
Bayou Dr
River Rd
Windsor Rd W
Getchell Dr
Blue Rd
Windsor Rd S
Lewis Loop Rd E
Pioneer Trace Rd
Murray Rd
Byrnewood Rd
Saltaire Dr
Montee Rd
Bellingrath Gardens Rd
River View Rd
Google Earth
© 2018 Google
1 mi
N


Organic Carbon (%)
0
10
20
30
40
50
60
70
80
90
100
Depth (cm)
Spit 2.2
Spit 2.3
Spit 2.4
Spit 2.5
Reference Marsh 3.4


Sand Fraction
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
0
5
10
15
20
25
Depth (cm)
2.2
2.3
2.4
2.5
3.4


Sediment depth (cm)
0
10
20
30
40
50
60
70
80
90
100
1900-1960
Reference Marsh
Spit 2
Spit 3
0
2
4
6
δ15N‰
-29.5
-28.5
-27.5
-26.5
δ13C‰

Fowl River Marsh Study - Sediment

Questions:

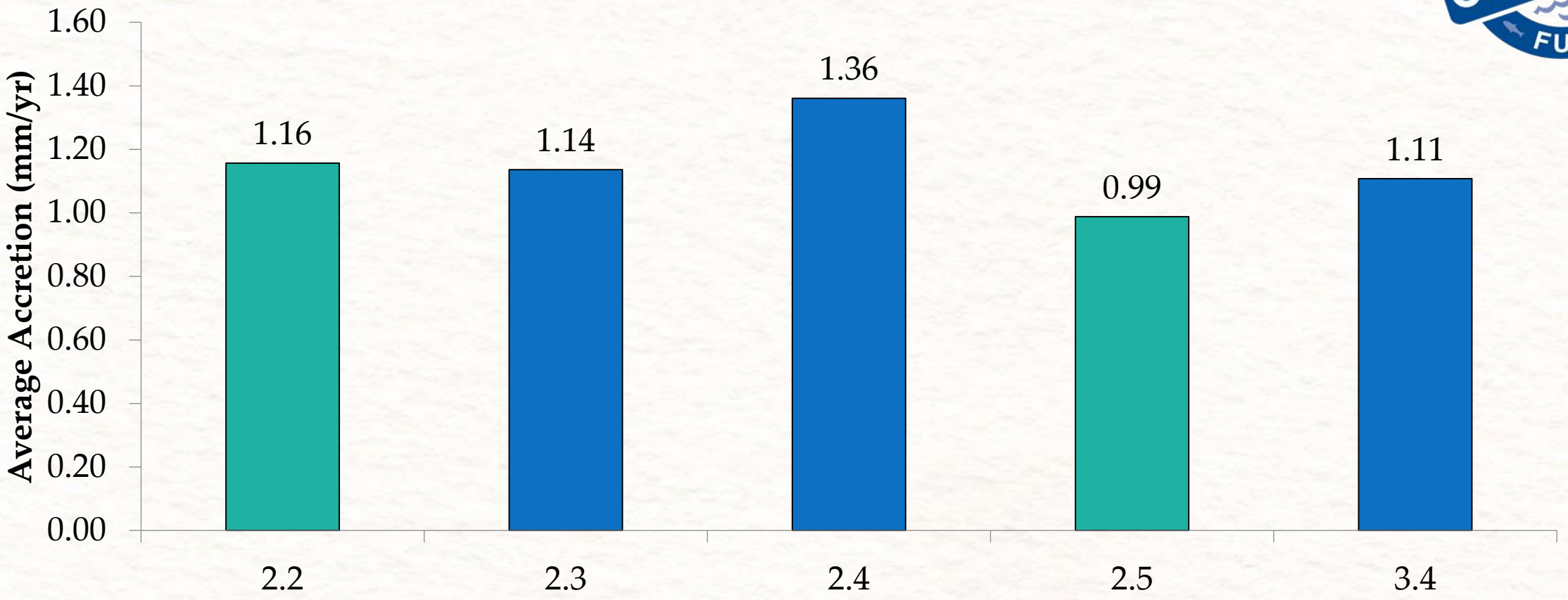
1. What is the current sediment supply, fate, and transport in Fowl river?

   Very little sediment reaches the downstream areas (Regions 2 & 3)

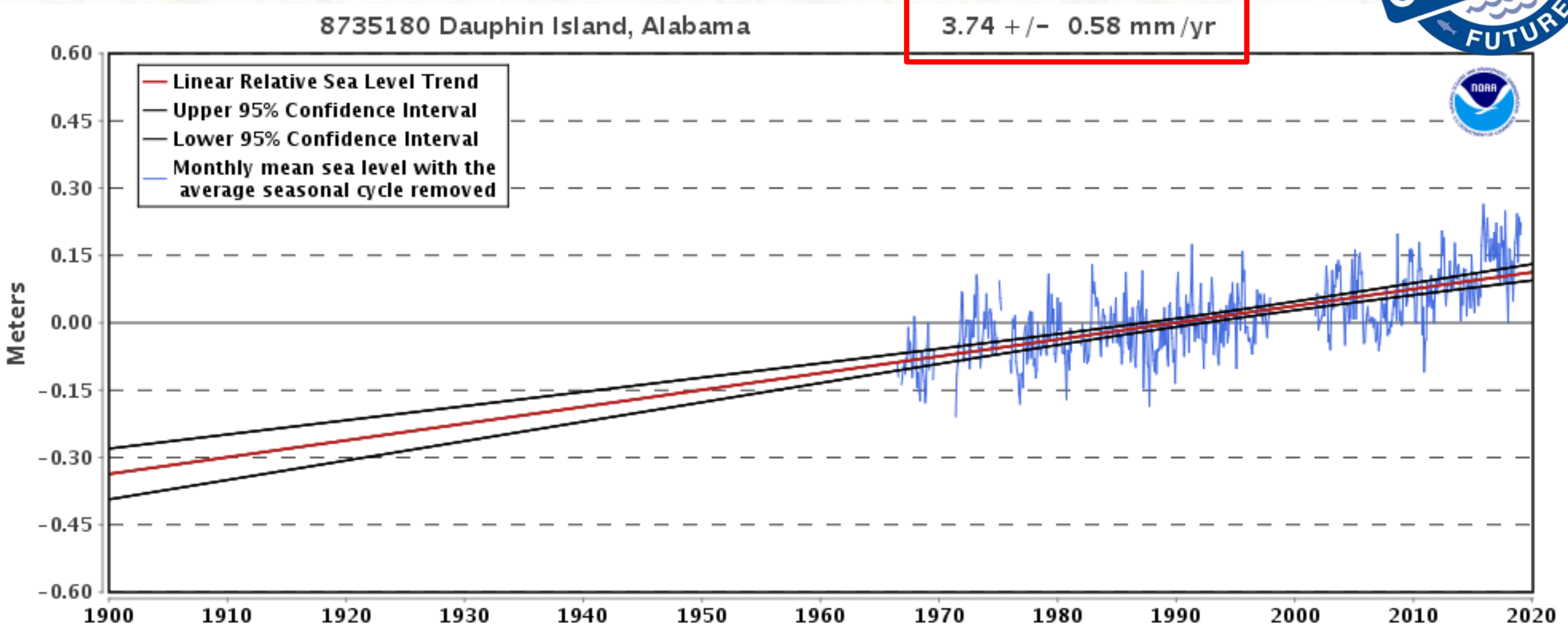
2. How do the current sediment conditions compare to the past?

   Same lithology (sediment type) but composition is changing

3. What are the accretion/erosion rates for the marsh?



Mean (mm/yr)	Sigma	Variance	Std. Error	Rel. Std. Error
1.15	0.13	0.02	0.06	5 %



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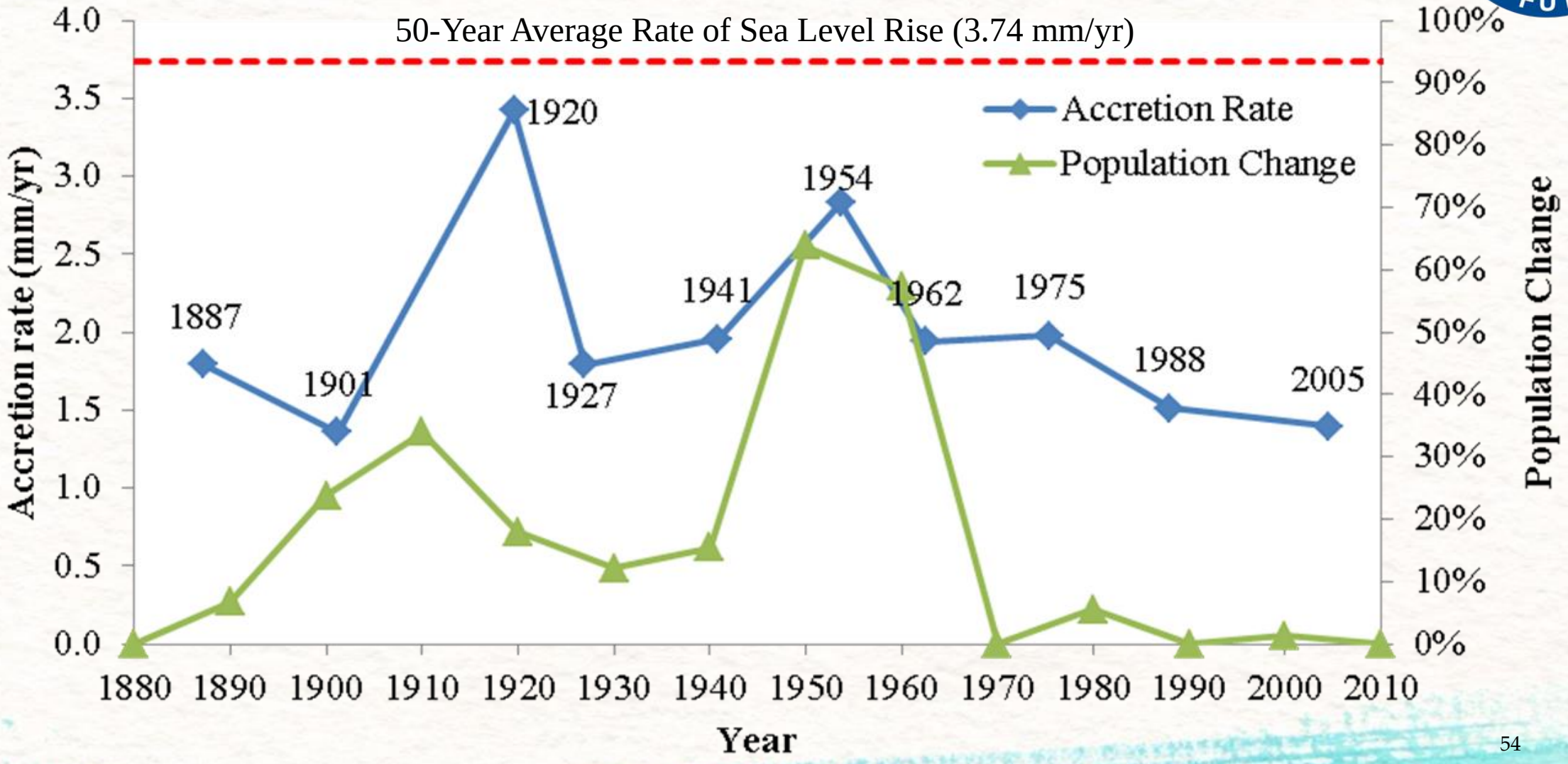
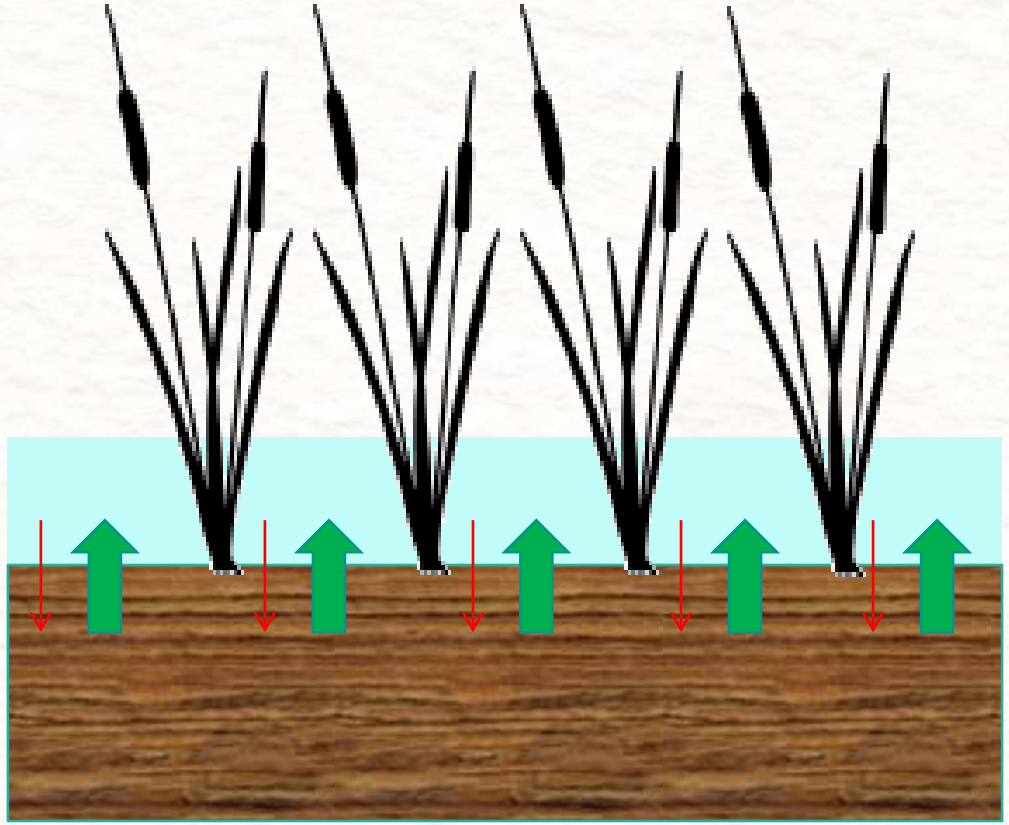

50-Year Average Rate of Sea Level Rise (3.74 mm/yr)
Accretion Rate
Population Change
Accretion rate (mm/yr)
Population Change
Year
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
1887
1901
1920
1927
1941
1954
1962
1975
1988
2005

$$\Delta Marsh\ Elevation\ = Net\ Accretion - \Delta Sea\ Level$$



Fowl River Marsh Study - Sediment

Questions:

1. What is the current sediment supply, fate, and transport in Fowl river?

   Very little sediment reaches the downstream areas (Regions 2 & 3)

2. How do the current sediment conditions compare to the past?

   Same lithology (sediment type) but composition is changing

3. What are the accretion/erosion rates for the marsh?

   Accretion is not keeping pace with sea level rise (need sediment)

Boat Wakes in Fowl River

Stephanie M. Smallegan, PhD, PE, Bret M. Webb PhD, PE, DCE, Evan Mazur, Luke Lamonte

UNIVERSITY OF SOUTH ALABAMA

I. Objectives

01 Measure Tides and Waves

02 Evaluate Wave Conditions

03 Describe Wave Frequency

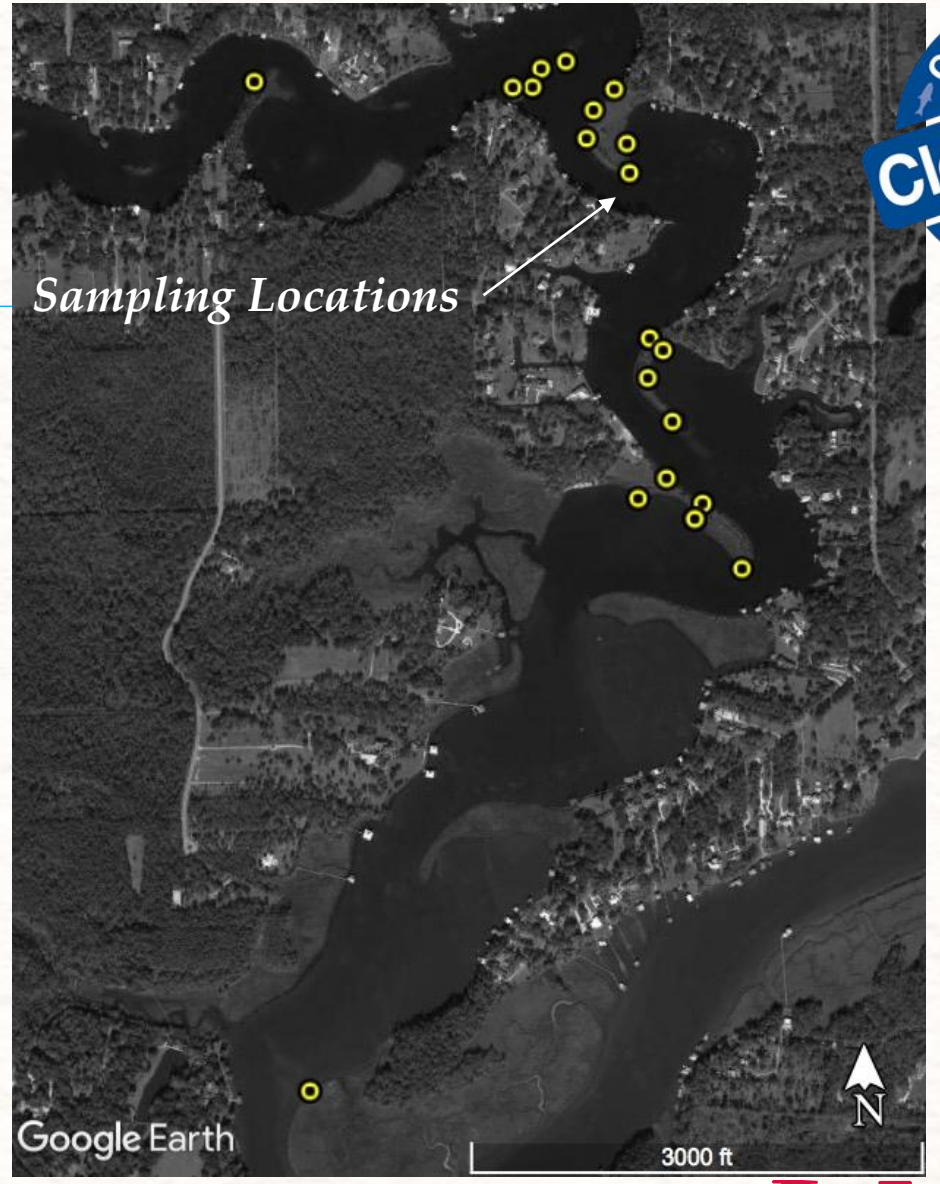
04 Inform Restoration Design

Photo Courtesy: Sam St. John

II. Study Information

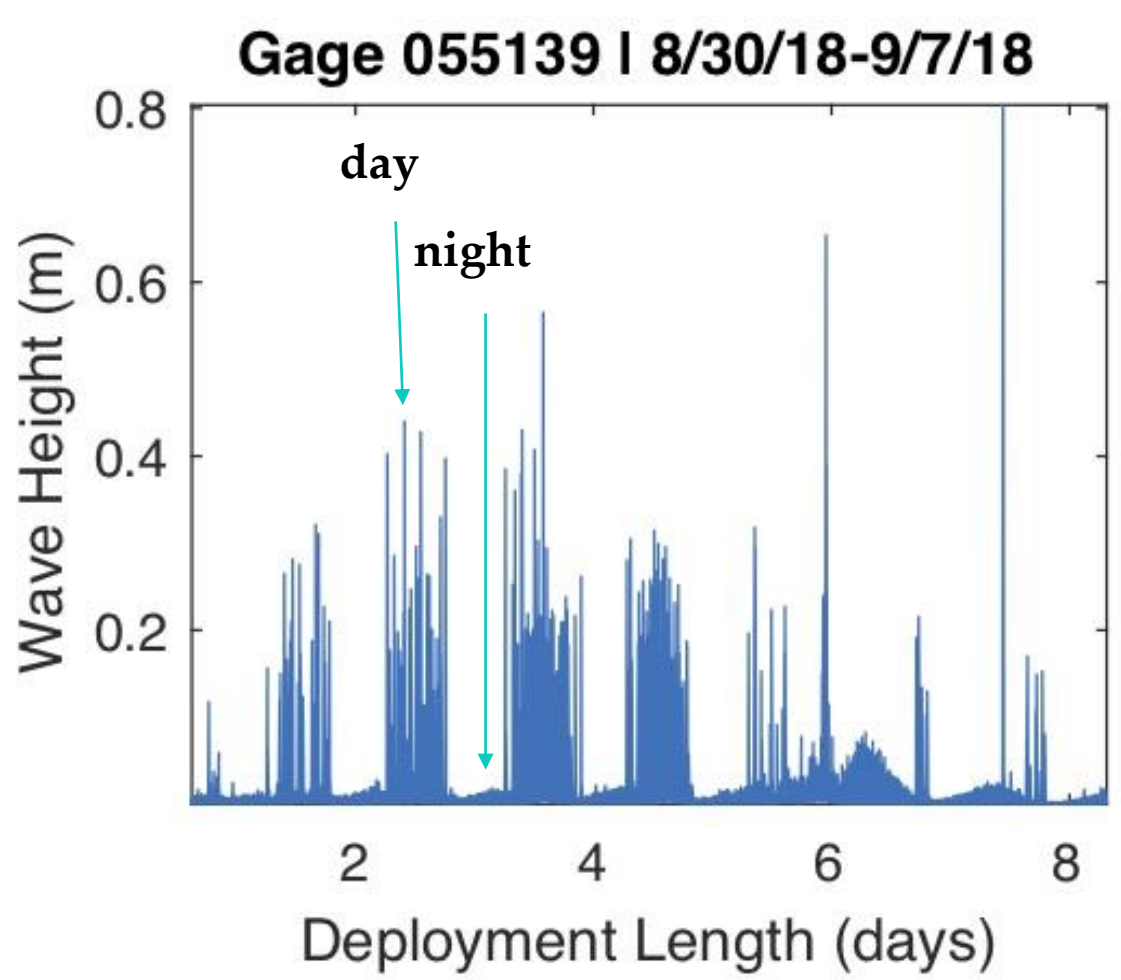
Fowl River – North of Bellingrath

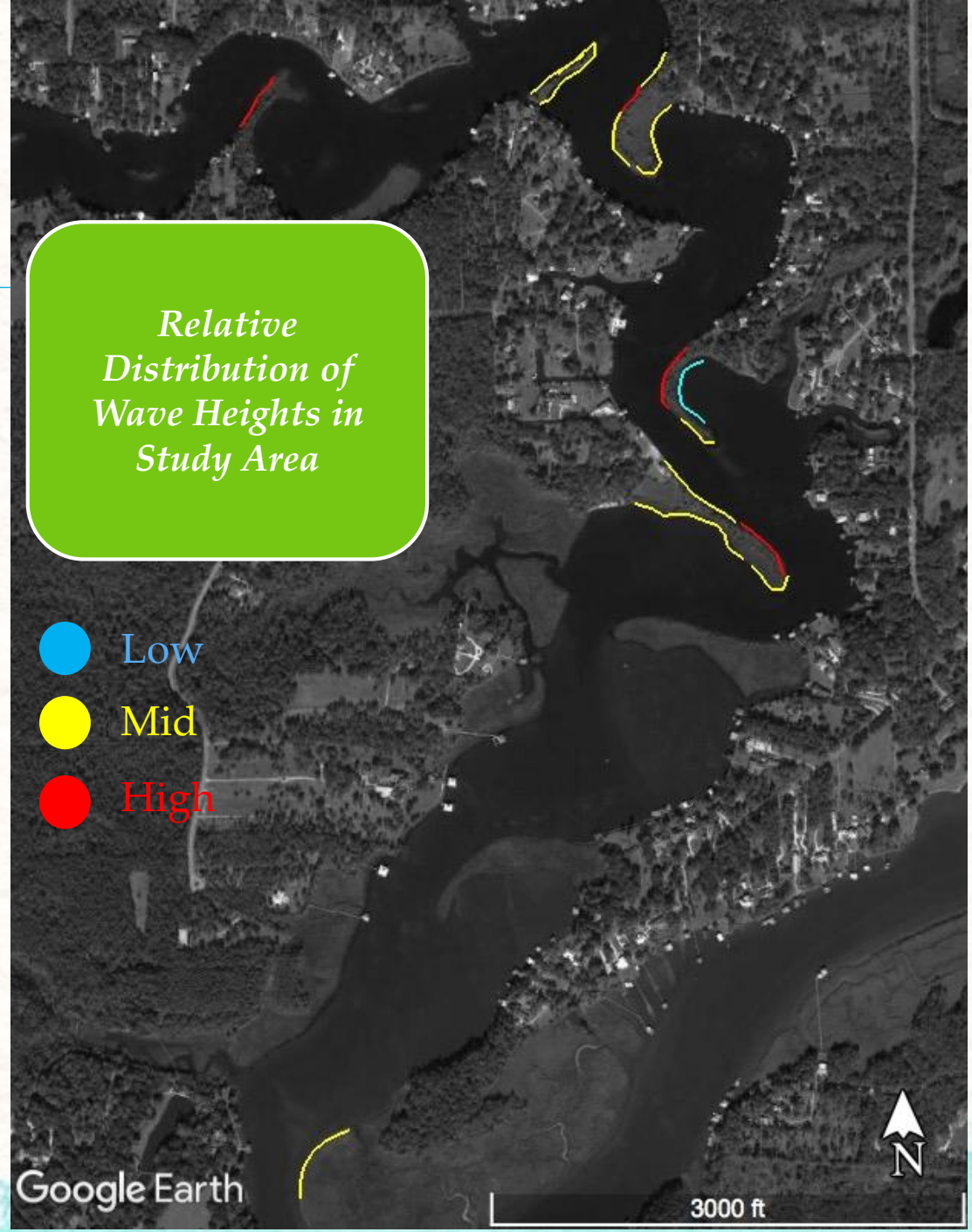
- May 24 – October 3, 2018
- Few data gaps
- Ten wave gages
- Some gage locations permanent
- Other gage locations rotated



III. Wave Heights

It's All Boat Wake!!!

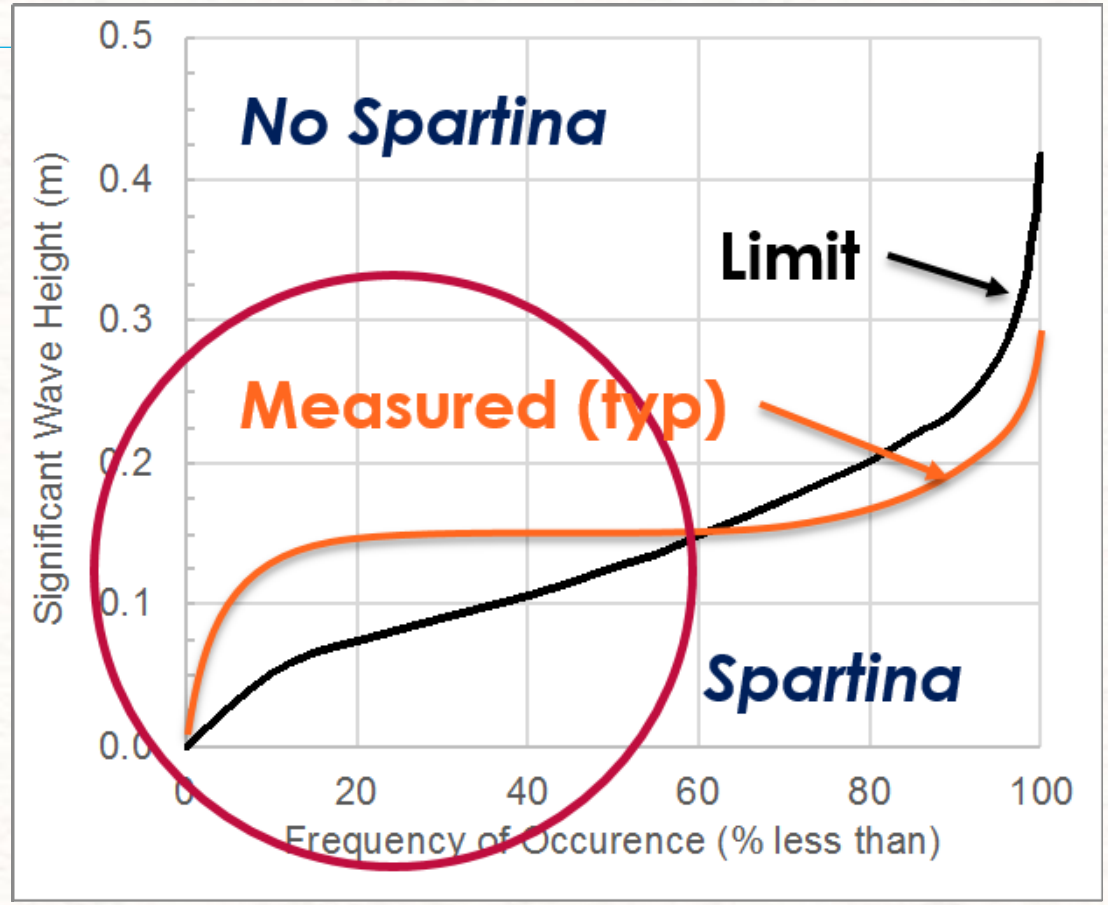




IV. Wave Frequency

Focus on the Frequent Events

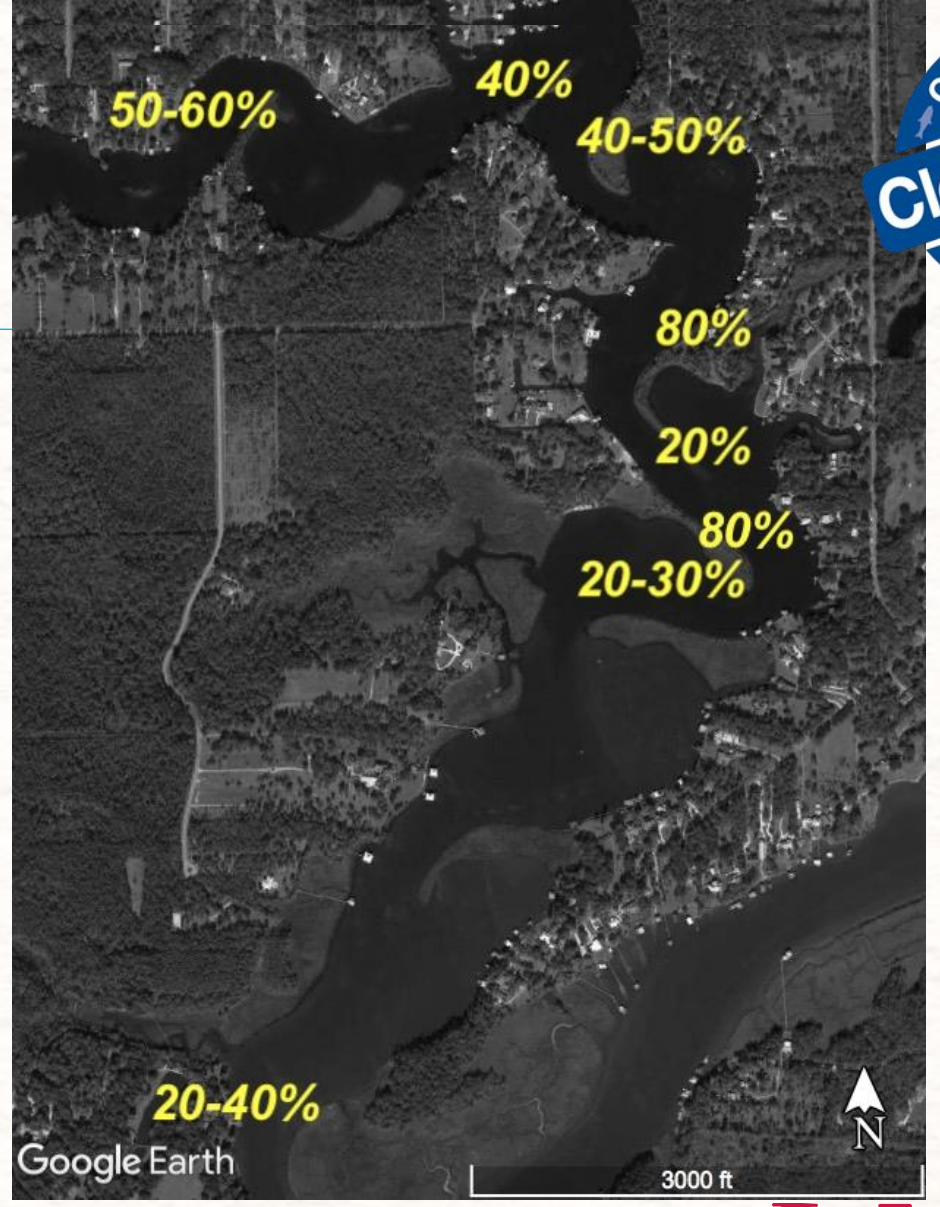
- Persistent wave action
- Exceeding limit most of the time
- Could this be contributing to erosion and loss of marsh?



IV. Wave Frequency

Exceedance Percentage Values

- All sites exceed limit for some amount of time
- Some sites exceed limit 80% of the time
- No site experiences extremely large waves



Key Points

Wave Statistics

All Boat Wake!
Wave Heights Small

Wave Frequency

All Sites Exceed 20%
Some Sites Exceed 80%

Restoration Implications

Small Structures
Supplement Sediment

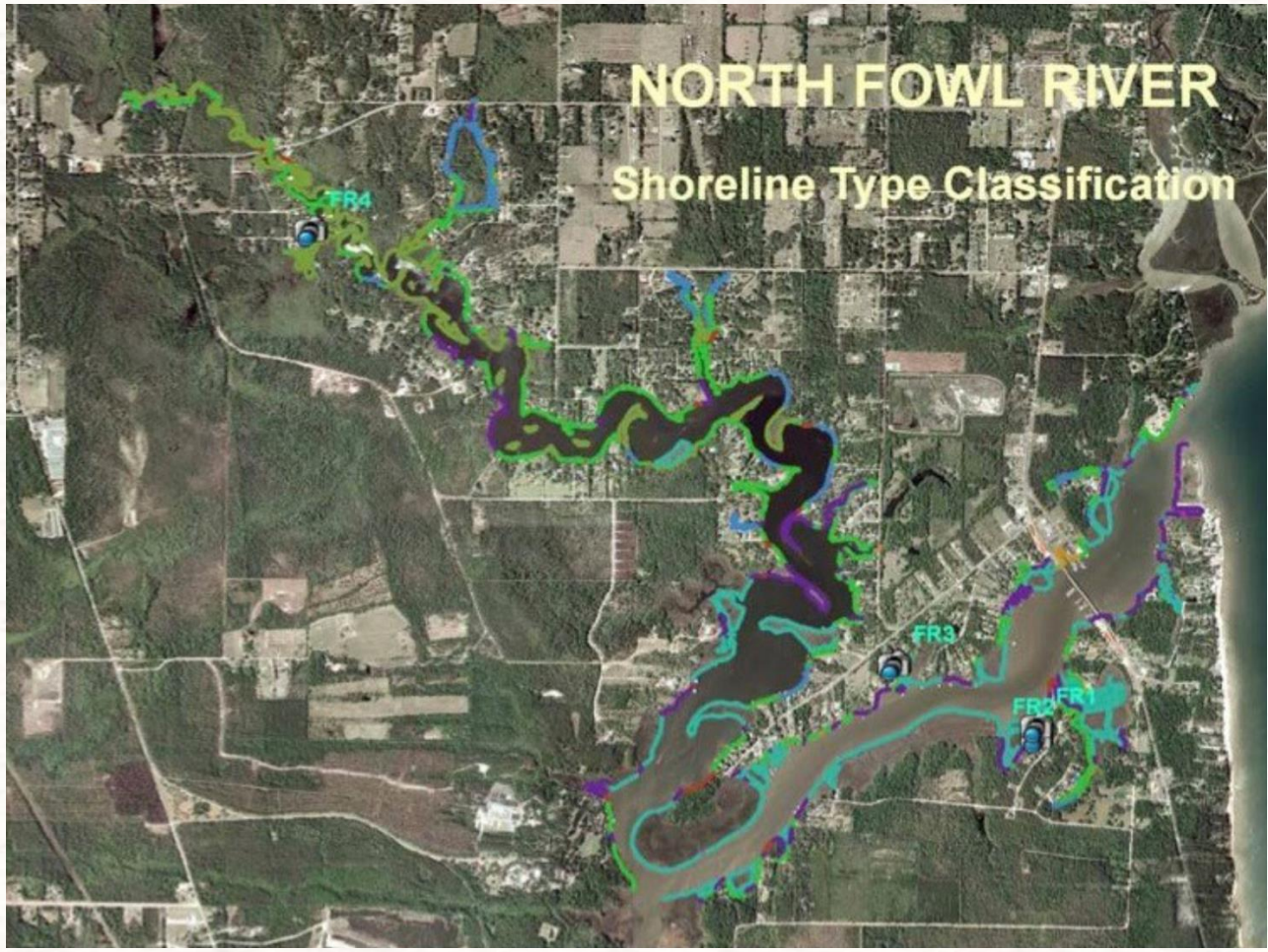
Photo Courtesy: Sam St. John

Sea Level, Salinity, Suspended Sediments and Nutrients

John Lehrter, Brian Dzwonkowski, Alexis Hagemeyer, and Jeff Coogan

Questions and Hypothesis

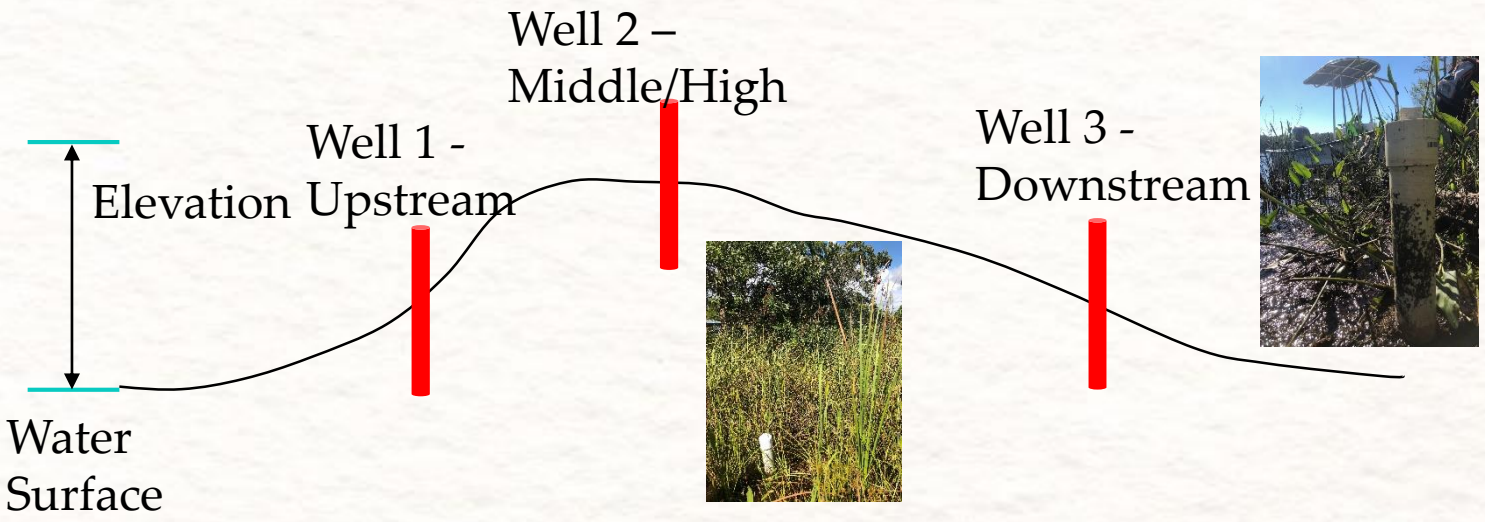
- **How are changing marsh spits related to sea level rise, salinity, and nutrients?**
  - Flooding due to sea level rise (Reed 2002)
  - Porewater salinity drives the growth and distribution of *Juncus roemarianus* (Eleuterius 1984) and other estuarine vegetation (Howard and Mendelssohn 1999)
  - Sedimentation rates (Stumpf 1983)
  - Shoreline change and loss caused by nutrient over-enrichment (Deegan et al. 2012)
- Can we diagnose causes for loss of spit shoreline by process of elimination? How may we restore Fowl River spits in consideration of environmental change?

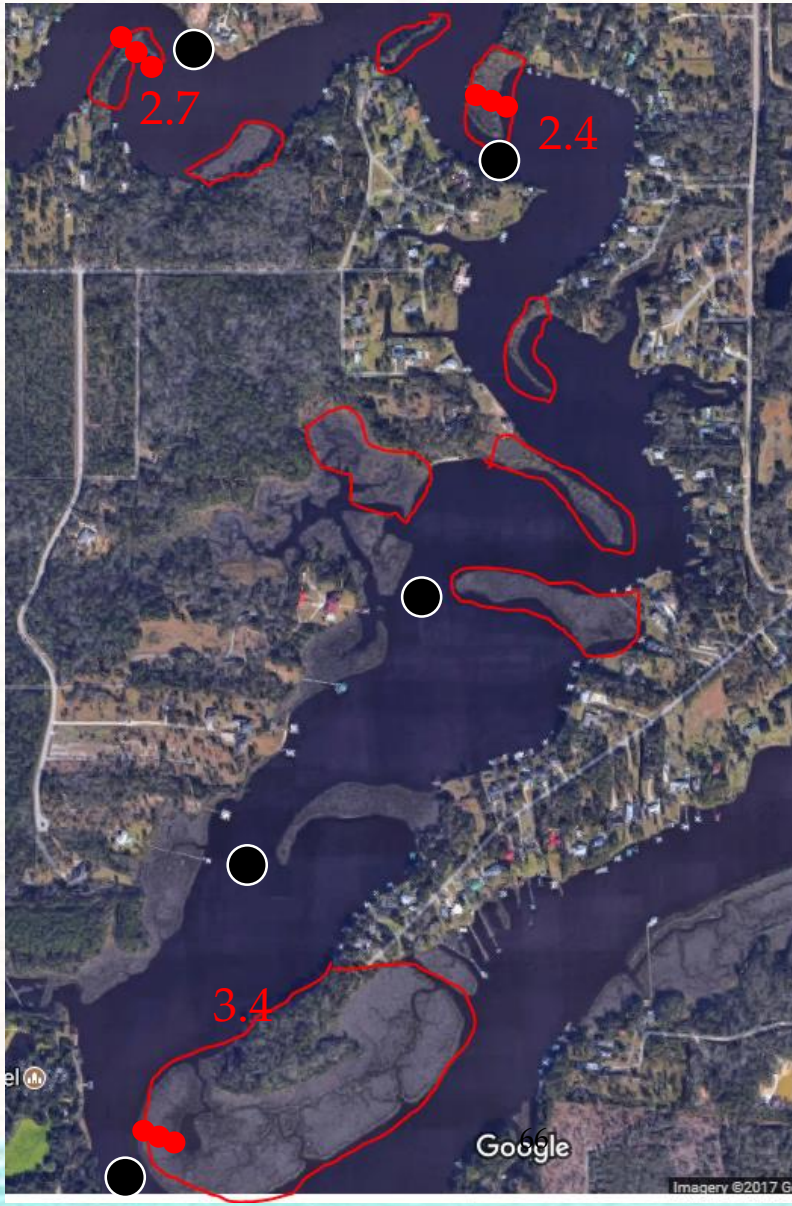


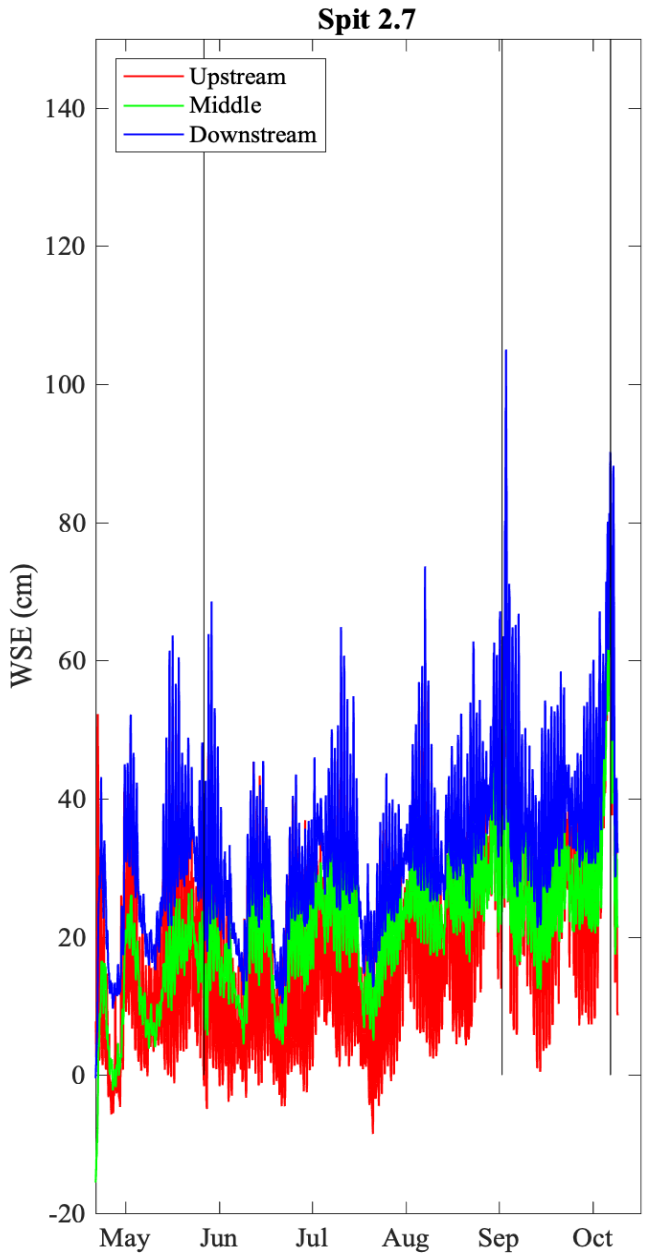
Jones and Tidwell (2012); Fowl River Watershed Management Plan (2016)

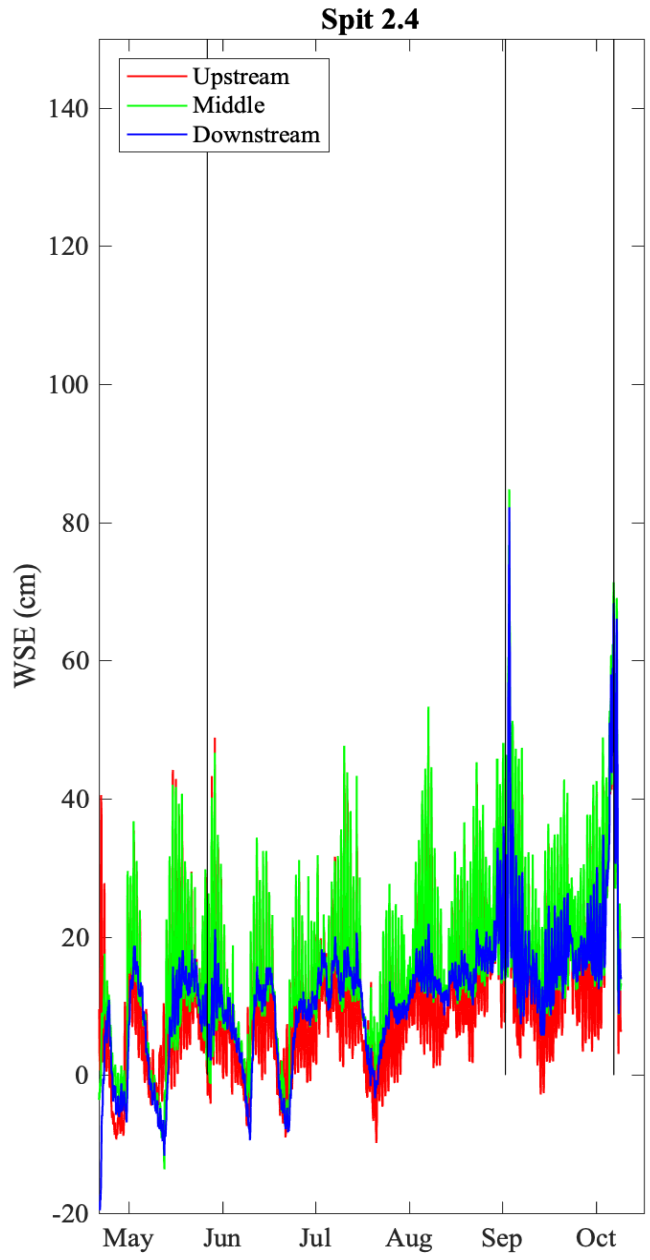
Methods – Fowl River Marsh Hydrography

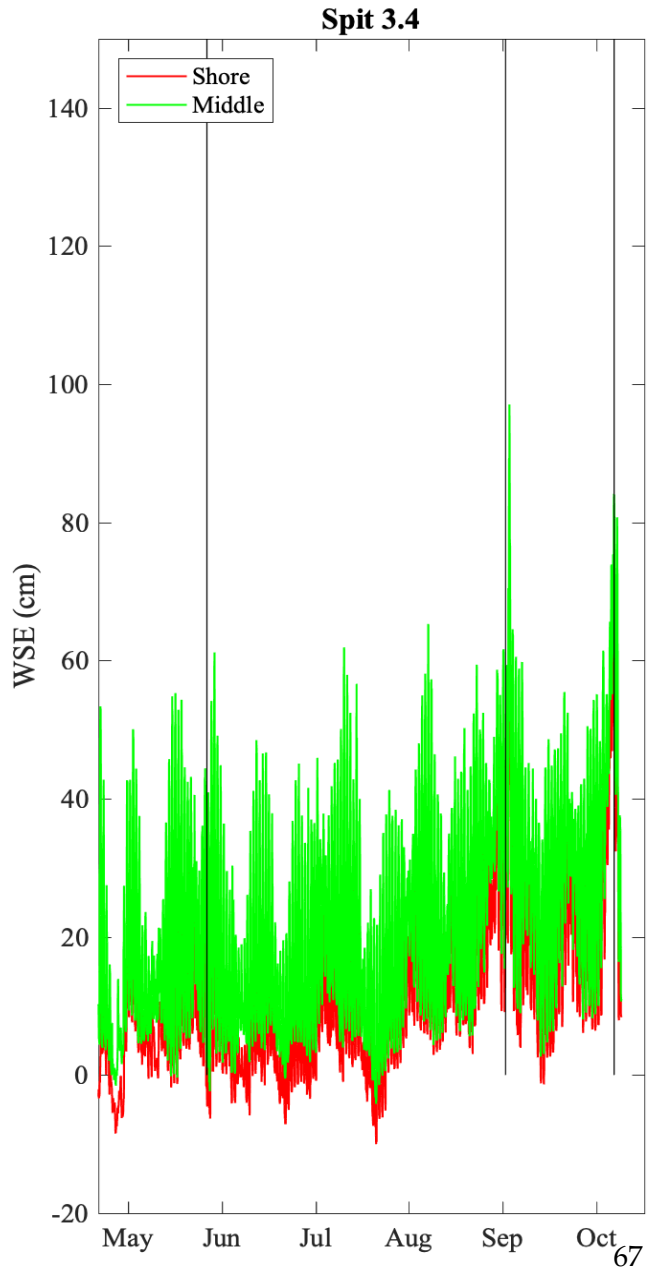
- Continuous measurements from Apr to Oct 2018
- 3 marsh spits with porewater wells
  - Three wells per spit across elevation gradient
  - Surveyed points with real-time kinematic (RTK) GPS
  - Instrumented with data loggers for depth and salinity

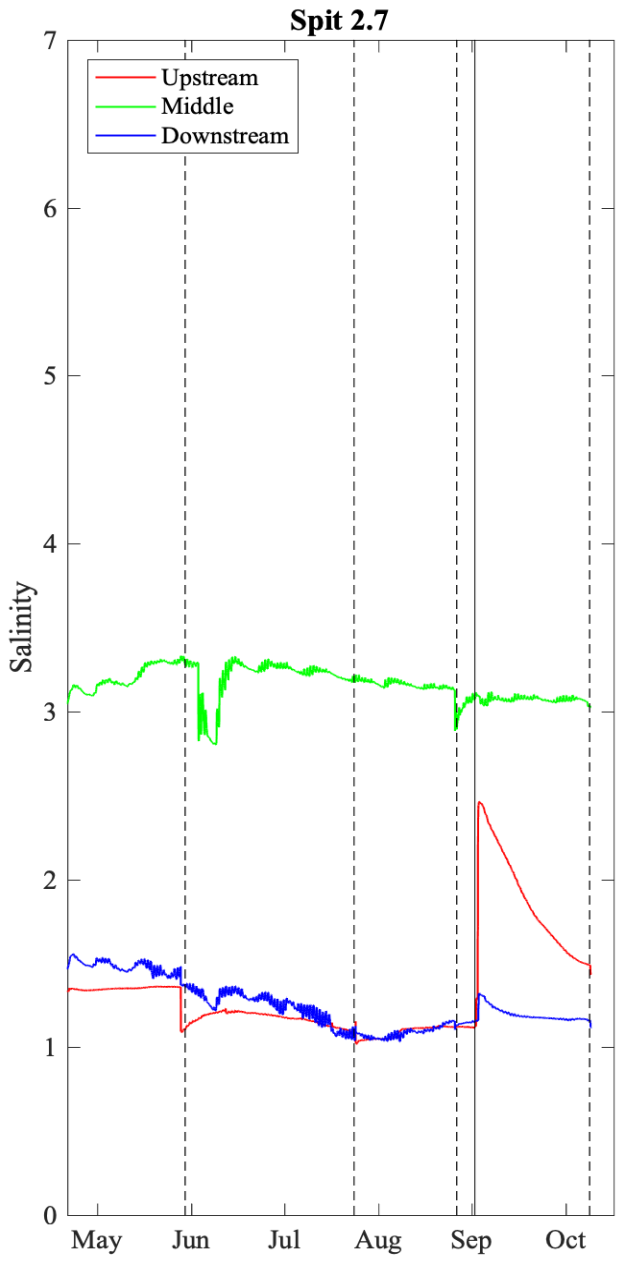


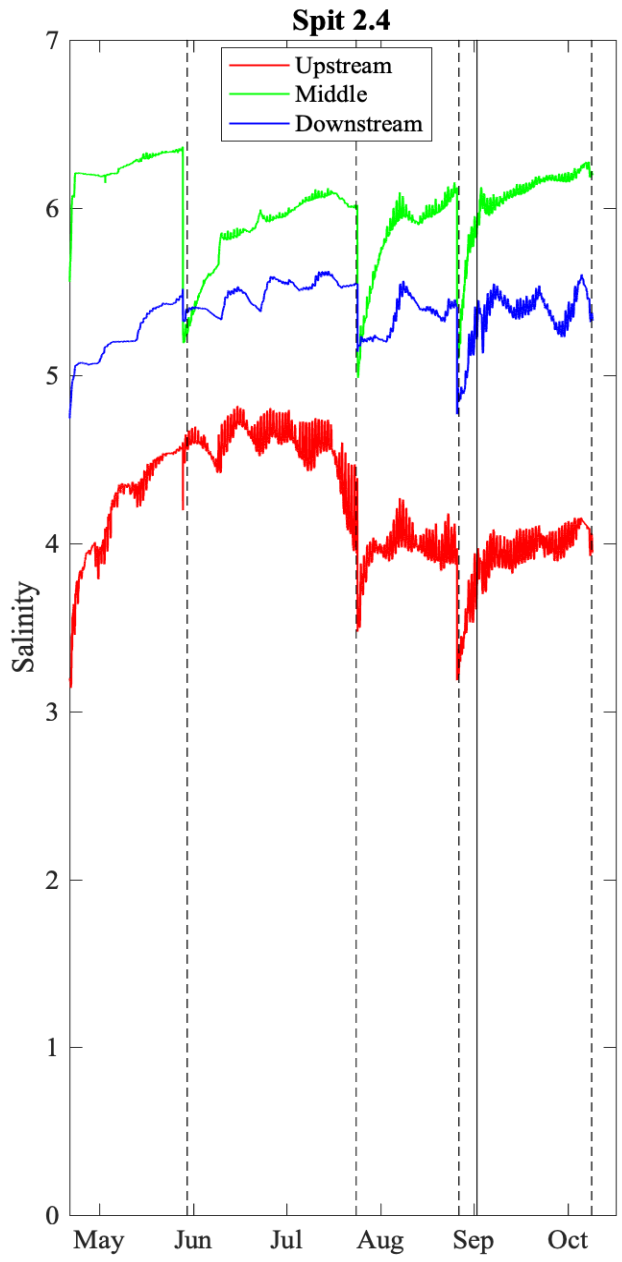


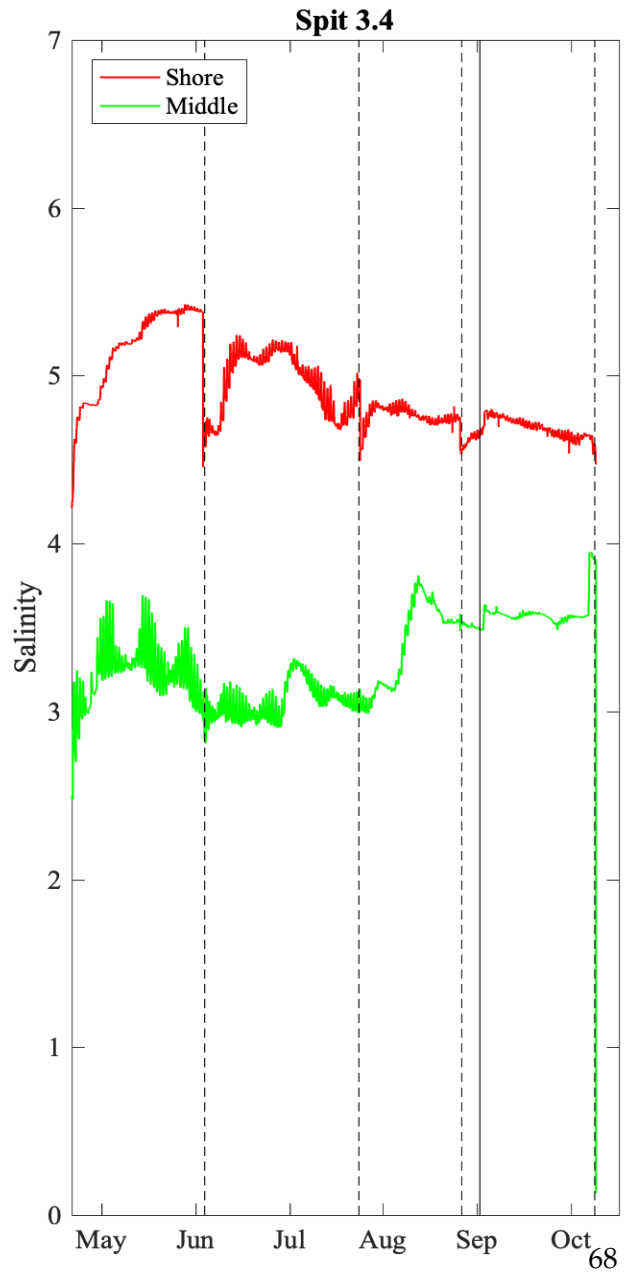

Spit 2.7
Upstream
Middle
Downstream
WSE (cm)
140
120
100
80
60
40
20
0
-20
May
Jun
Jul
Aug
Sep
Oct


Spit 2.4
Upstream
Middle
Downstream
WSE (cm)
140
120
100
80
60
40
20
0
-20
May
Jun
Jul
Aug
Sep
Oct


Spit 3.4
Shore
Middle
WSE (cm)
140
120
100
80
60
40
20
0
-20
May
Jun
Jul
Aug
Sep
Oct

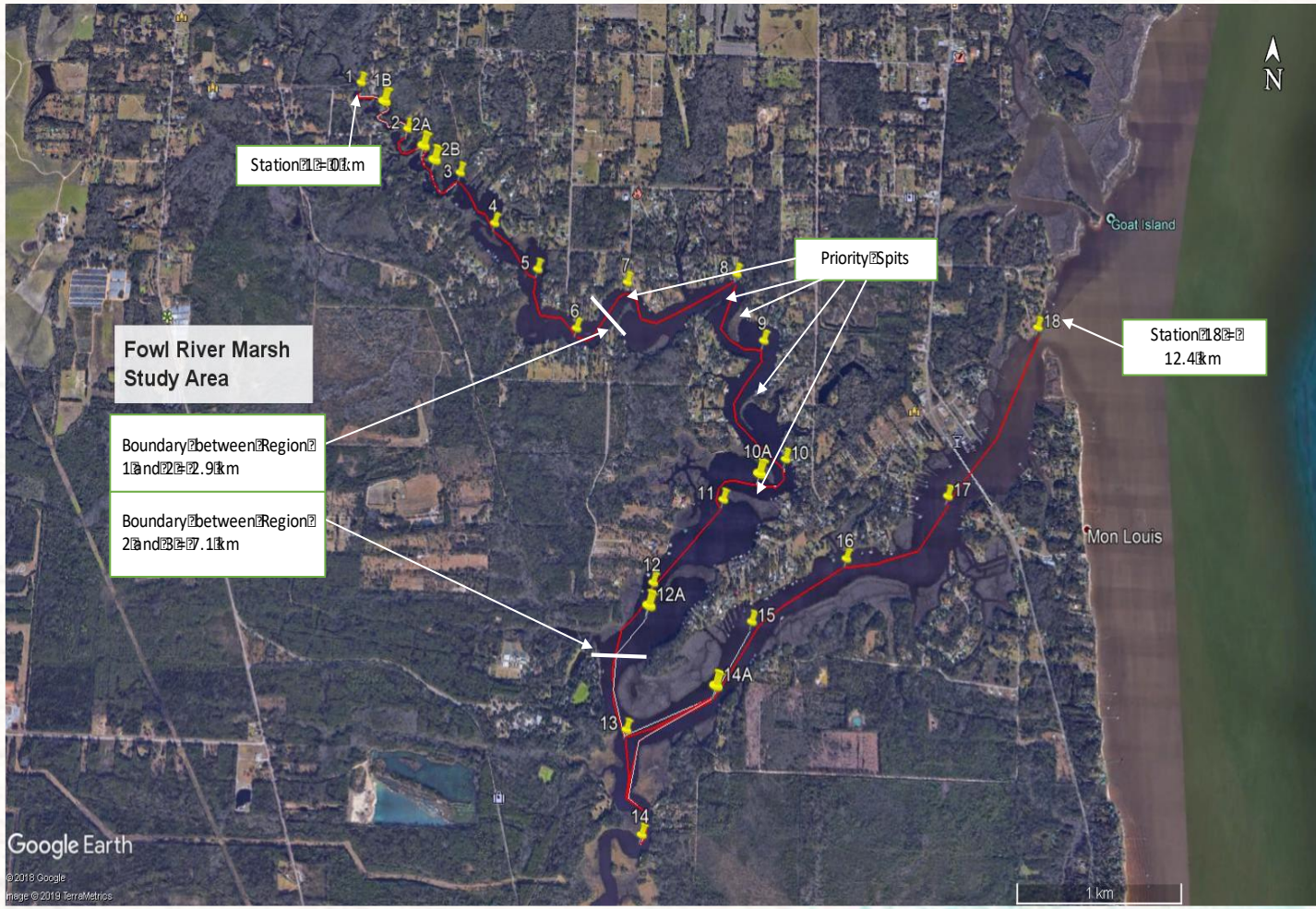

Spit 2.7
Upstream
Middle
Downstream
Salinity
0
1
2
3
4
5
6
7
May
Jun
Jul
Aug
Sep
Oct

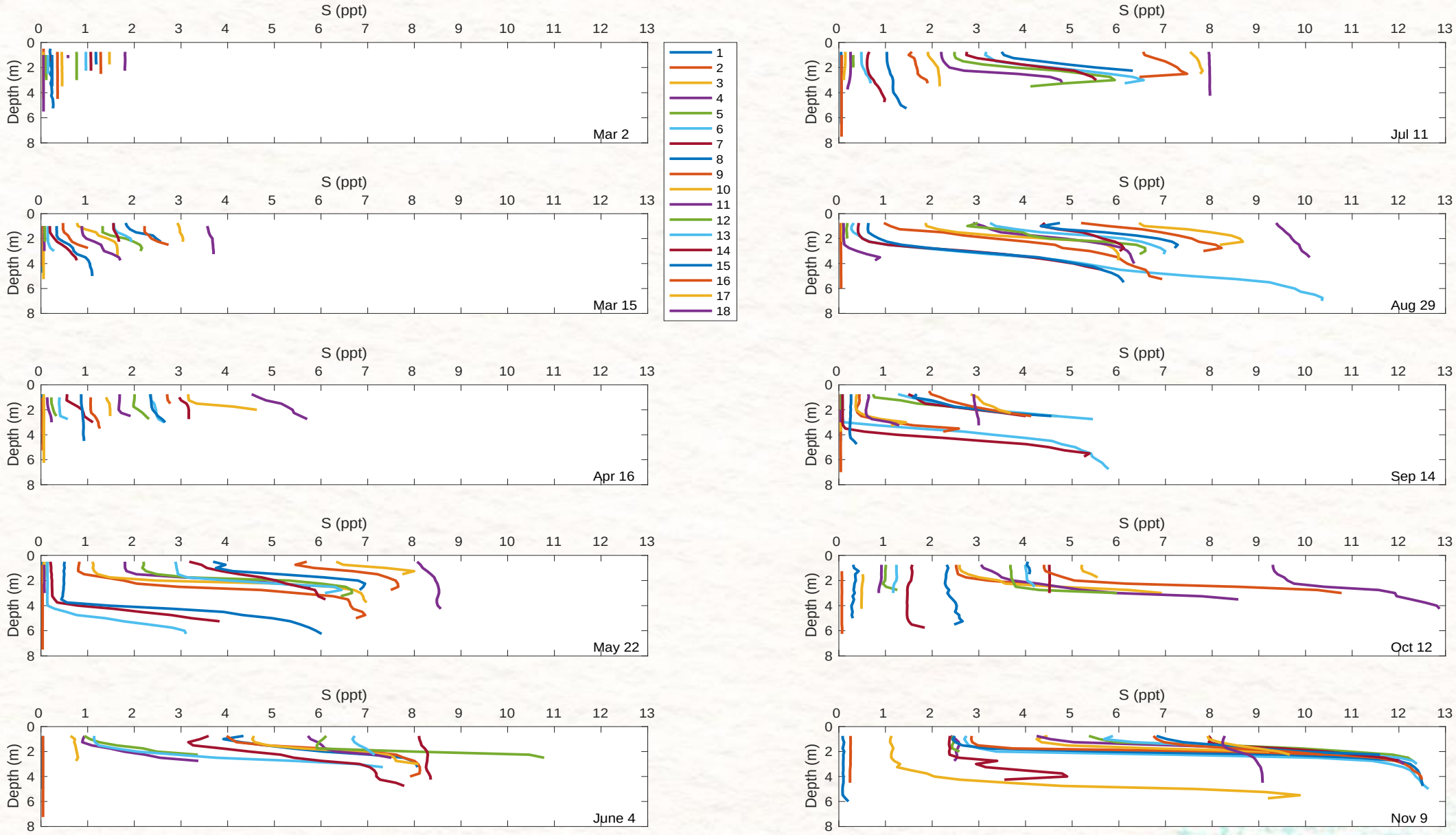

Spit 2.4
Upstream
Middle
Downstream
Salinity
0
1
2
3
4
5
6
7
May
Jun
Jul
Aug
Sep
Oct

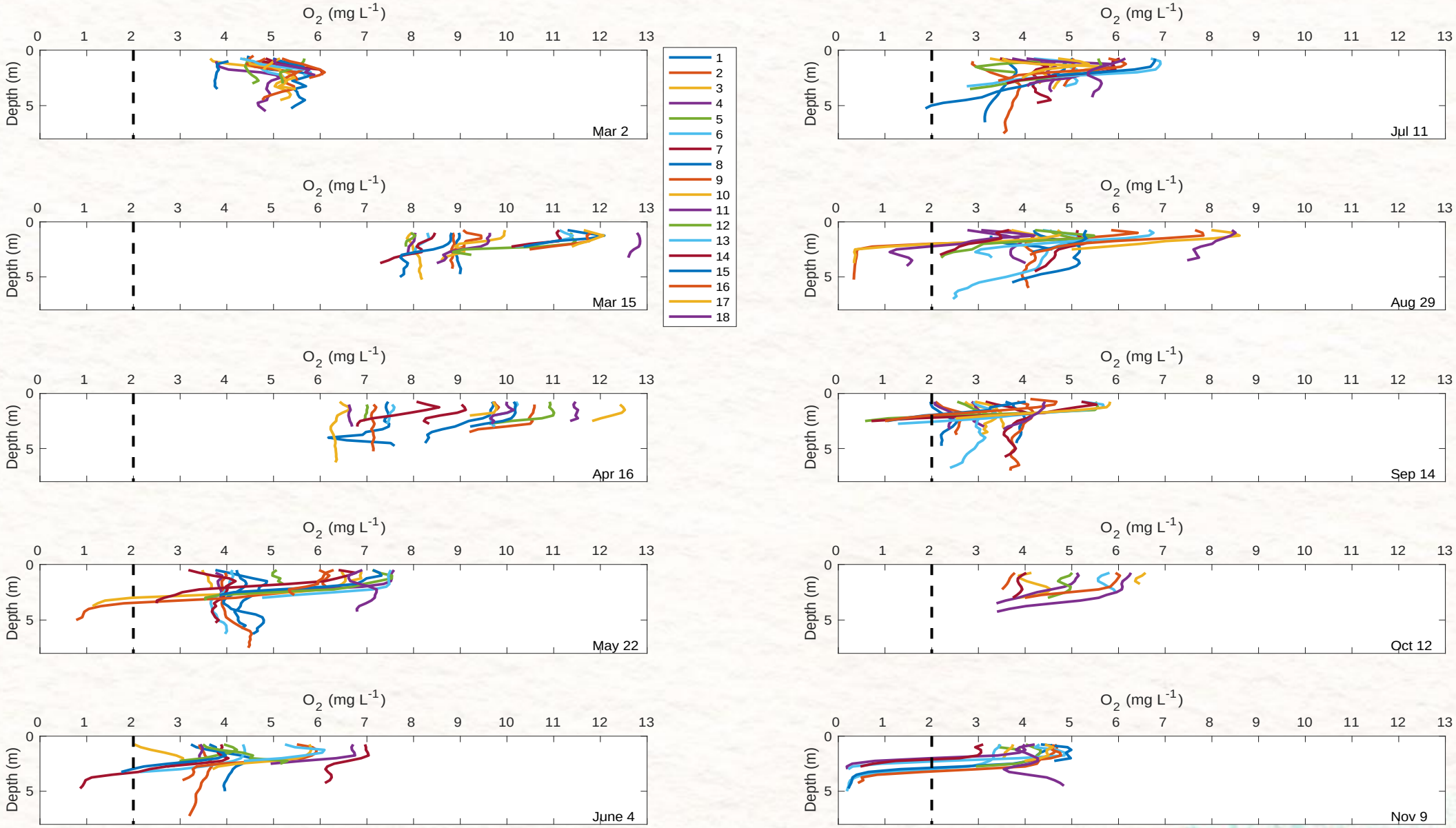

Spit 3.4
Shore
Middle
Salinity
0
1
2
3
4
5
6
7
May
Jun
Jul
Aug
Sep
Oct

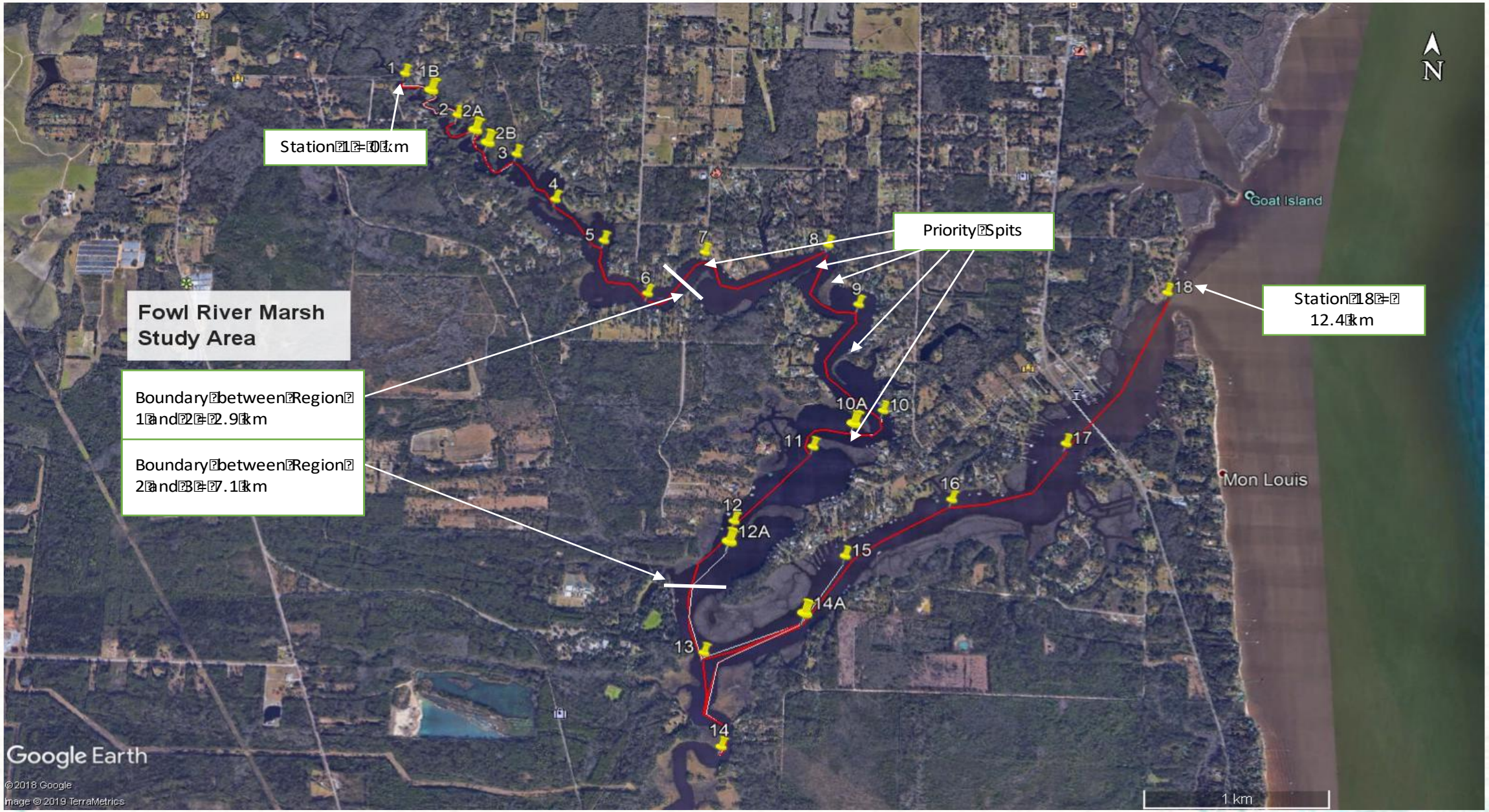
Methods – Fowl River Estuary Hydrography

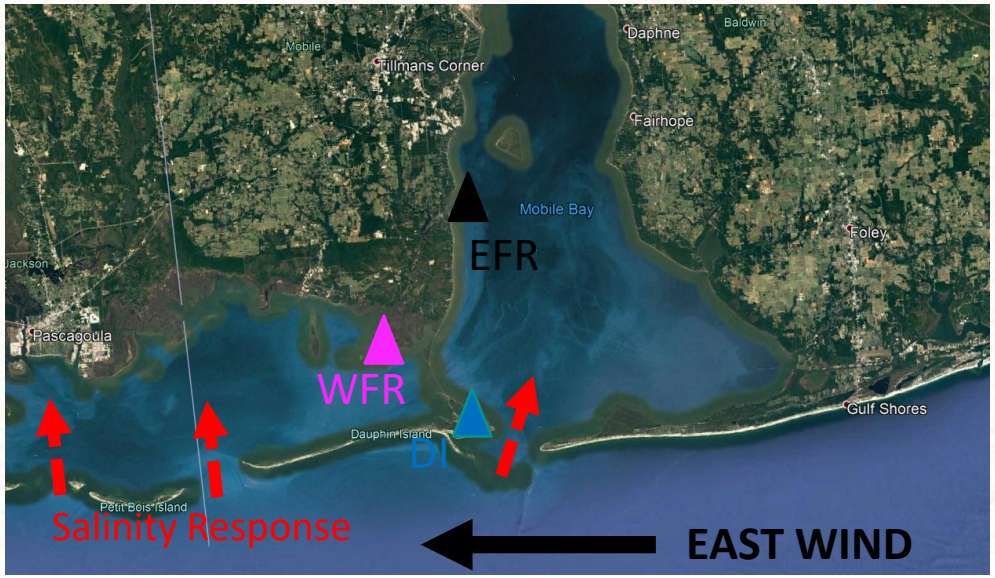
- Monthly surveys from Jan to Oct 2018
- 18 stations
  - CTD vertical profiles: S, T, depth, O_2
  - 8 discrete water sampling stations
    - Suspended sediments, nutrients, organic matter, Chl*a*
    - Surface and bottom samples

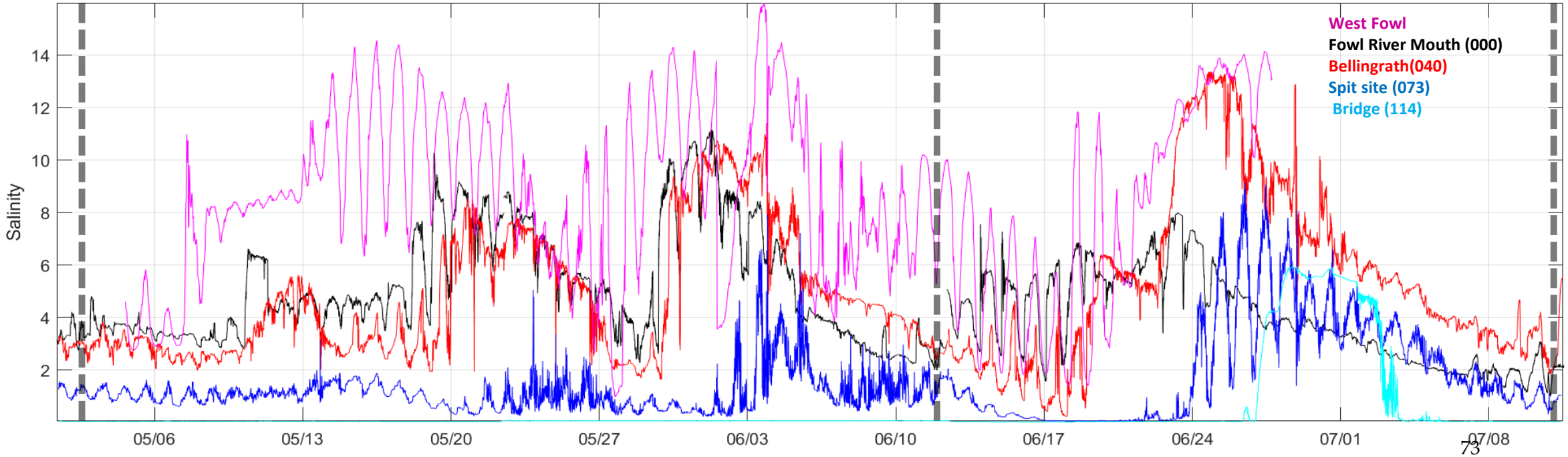



S (ppt)
Depth (m)
Mar 2
Mar 15
Apr 16
May 22
June 4
Jul 11
Aug 29
Sep 14
Oct 12
Nov 9
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

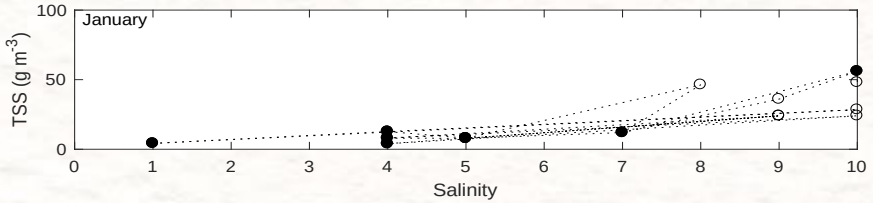

O2 (mg L-1)
Depth (m)
Mar 2
Mar 15
Apr 16
May 22
June 4
Jul 11
Aug 29
Sep 14
Oct 12
Nov 9
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

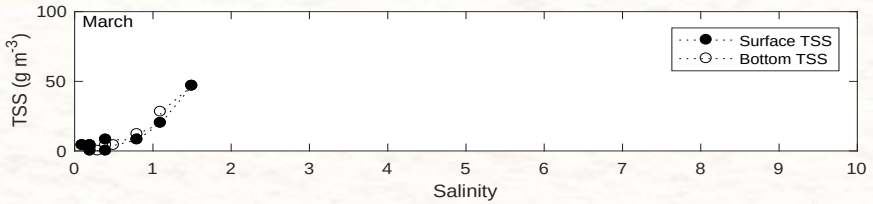

Fowl River Marsh Study Area
Station 1 – 0.1 km
Priority Spits
Station 18 – 12.4 km
Boundary between Region 1 and 2 – 2.9 km
Boundary between Region 2 and 3 – 7.1 km
Goat Island
Mon Louis
N
1 km
Google Earth
© 2018 Google
Image © 2019 TerraMetrics

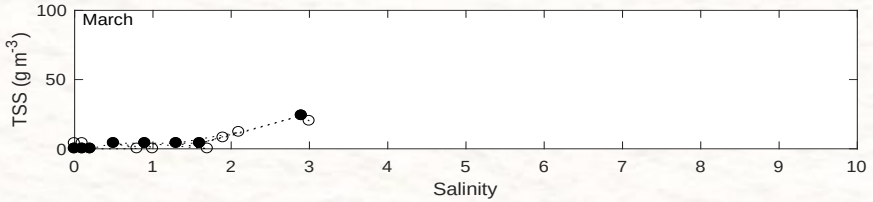

Mobile
Tillmans Corner
Daphne
Baldwin
Fairhope
Mobile Bay
EFR
Foley
Jackson
Pascagoula
WFR
Gulf Shores
Dauphin Island
DI
Petit Bois Island
Salinity Response
EAST WIND

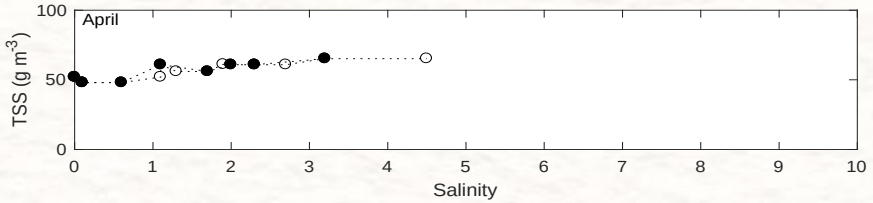

West Fowl
Fowl River Mouth (000)
Bellingrath(040)
Spit site (073)
Bridge (114)
Salinity
14
12
10
8
6
4
2
05/06
05/13
05/20
05/27
06/03
06/10
06/17
06/24
07/01
07/08

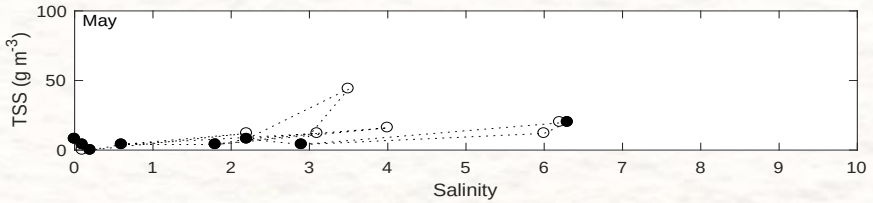
Suspended Sediment

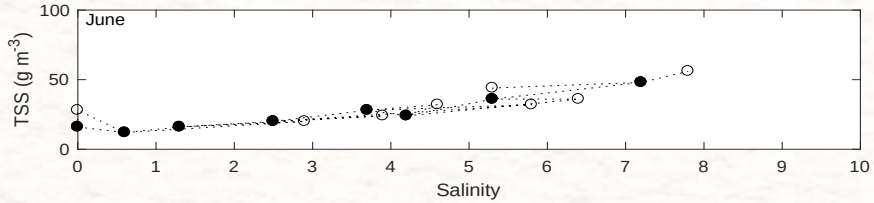


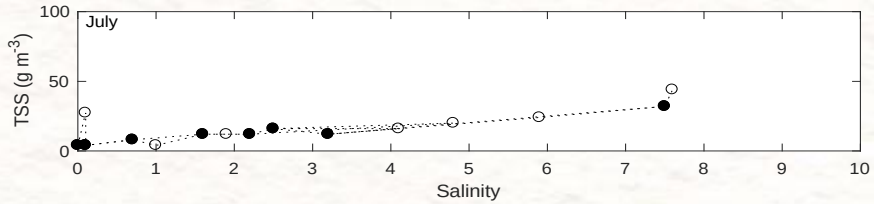


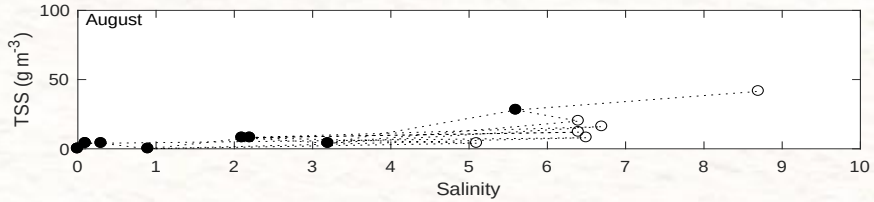


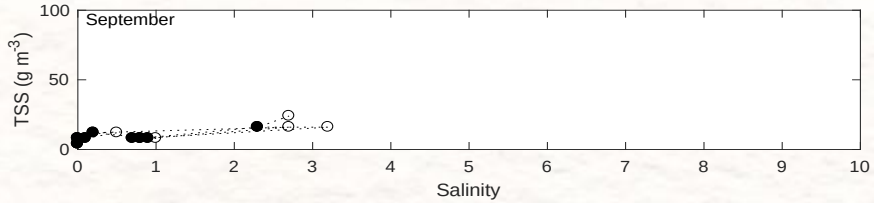


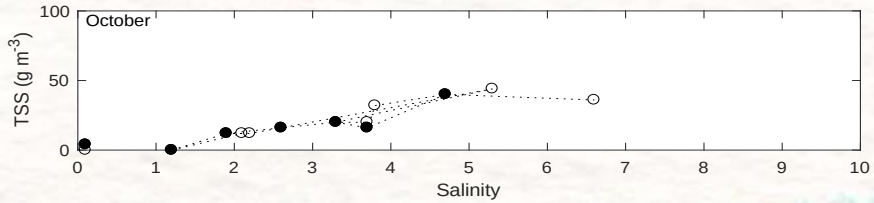




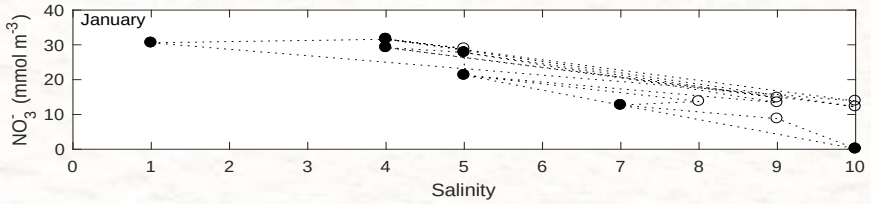


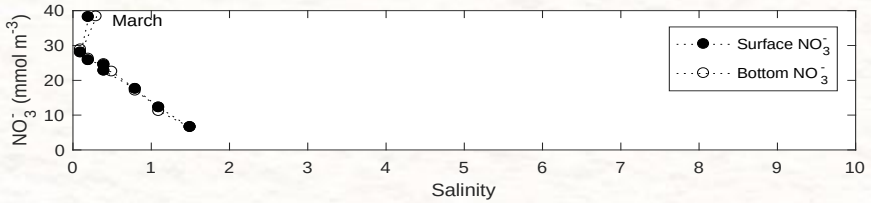


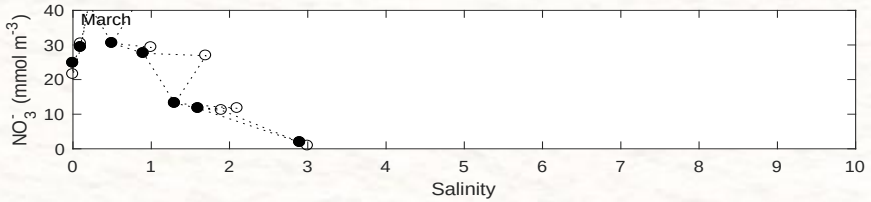


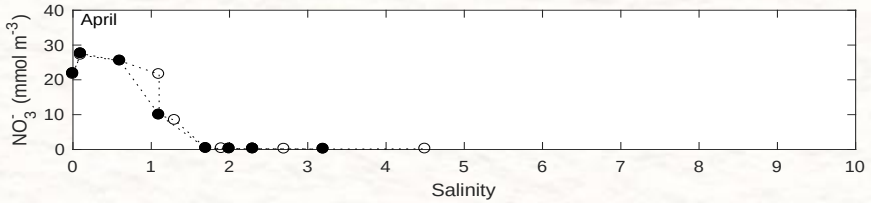


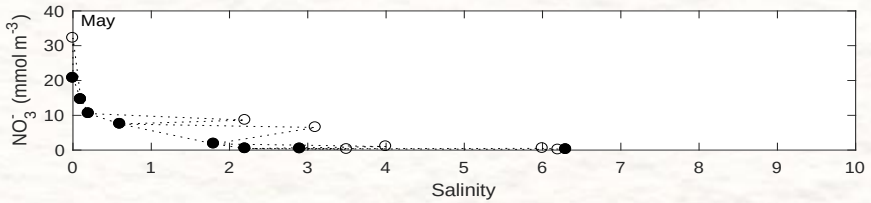
Nitrate

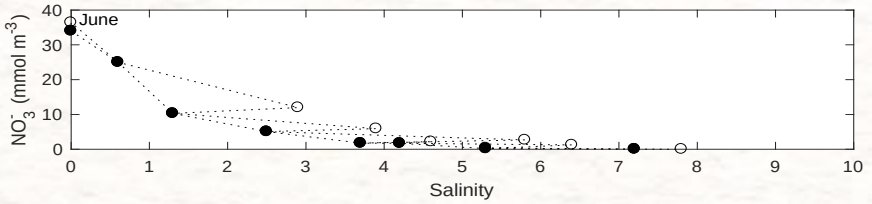

January
NO_3^- (mmol m^{-3})
Salinity

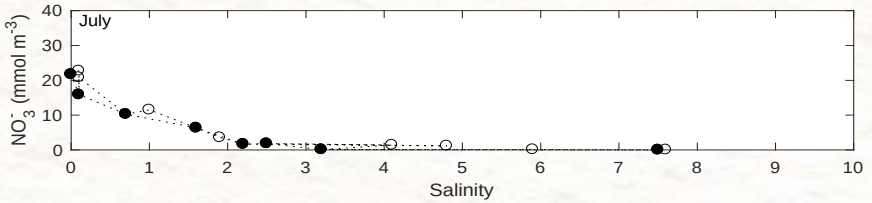

March
Surface NO_3^-
Bottom NO_3^-
NO_3^- (mmol m^{-3})
Salinity

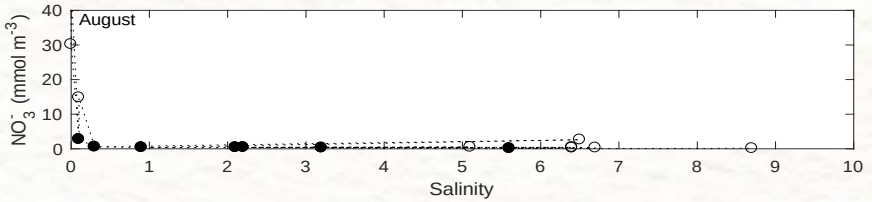

March
NO_3^- (mmol m^{-3})
Salinity

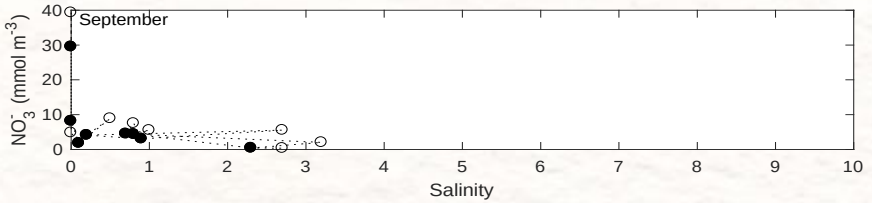

April
NO_3^- (mmol m^{-3})
Salinity

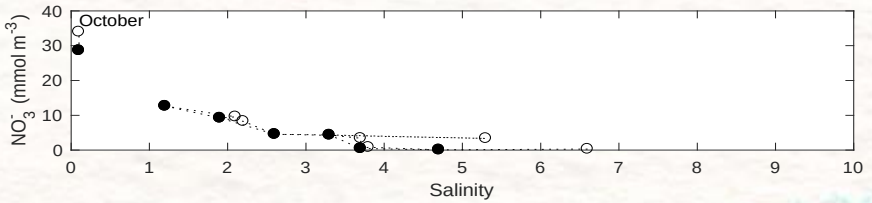

May
NO_3^- (mmol m^{-3})
Salinity


June
NO_3^- (mmol m^{-3})
Salinity


July
NO_3^- (mmol m^{-3})
Salinity


August
NO_3^- (mmol m^{-3})
Salinity


September
NO_3^- (mmol m^{-3})
Salinity


October
NO_3^- (mmol m^{-3})
Salinity

Conclusions

- **Unable to rule out any of our smoking guns**
- *Flooding:* marshes submerged during study, increasing trend
- *Salinity:* variability in porewater and riverine salinity; increasing trend
- *Suspended sediment:* low inputs from watershed, mainly from Bay
- *Nutrients*: Elevated

General Recommendations

- Restoration and adaptive management will need to consider trends and interactions among drivers
- Enhance sediment deposition on marsh spit surface, e.g. thin-layer disposal, to help spits maintain elevation vs sea level
- Protect spit edges from boat wakes
- Hydrologic engineering to reduce salinity intrusion
- Reduce nutrient loads

Fowl River Marsh Study

QUESTIONS, DISCUSSION AND FEEDBACK

Vegetation Characteristics of Spits

Spit 2.7:

- Average Herbaceous Cover: 54.1%
- Average Woody Cover: 2.8%
- Total Vegetative Cover: 56.9%
- **Total Number of Species: 26**

Sagittaria lancifolia Linnaeus — BULLTONGUE ARROWHEAD — **10.2%**

Magnolia virginiana Linnaeus var. australis Sargent —SILVER BAY — **1.2%**

Spit 2.4:

- Average Herbaceous Cover: 56.6%
- Average Woody Cover: 5.4%
- Total Vegetative Cover: 62.0%
- **Total Number of Species: 41**

Cladium jamaicense Crantz — SAWGRASS — **30.1%**

Juncus roemerianus Scheele —BLACK NEEDLERUSH — **6.1%**

Morella cerifera (Linnaeus) Small — WAX MYRTLE — **1.8%**

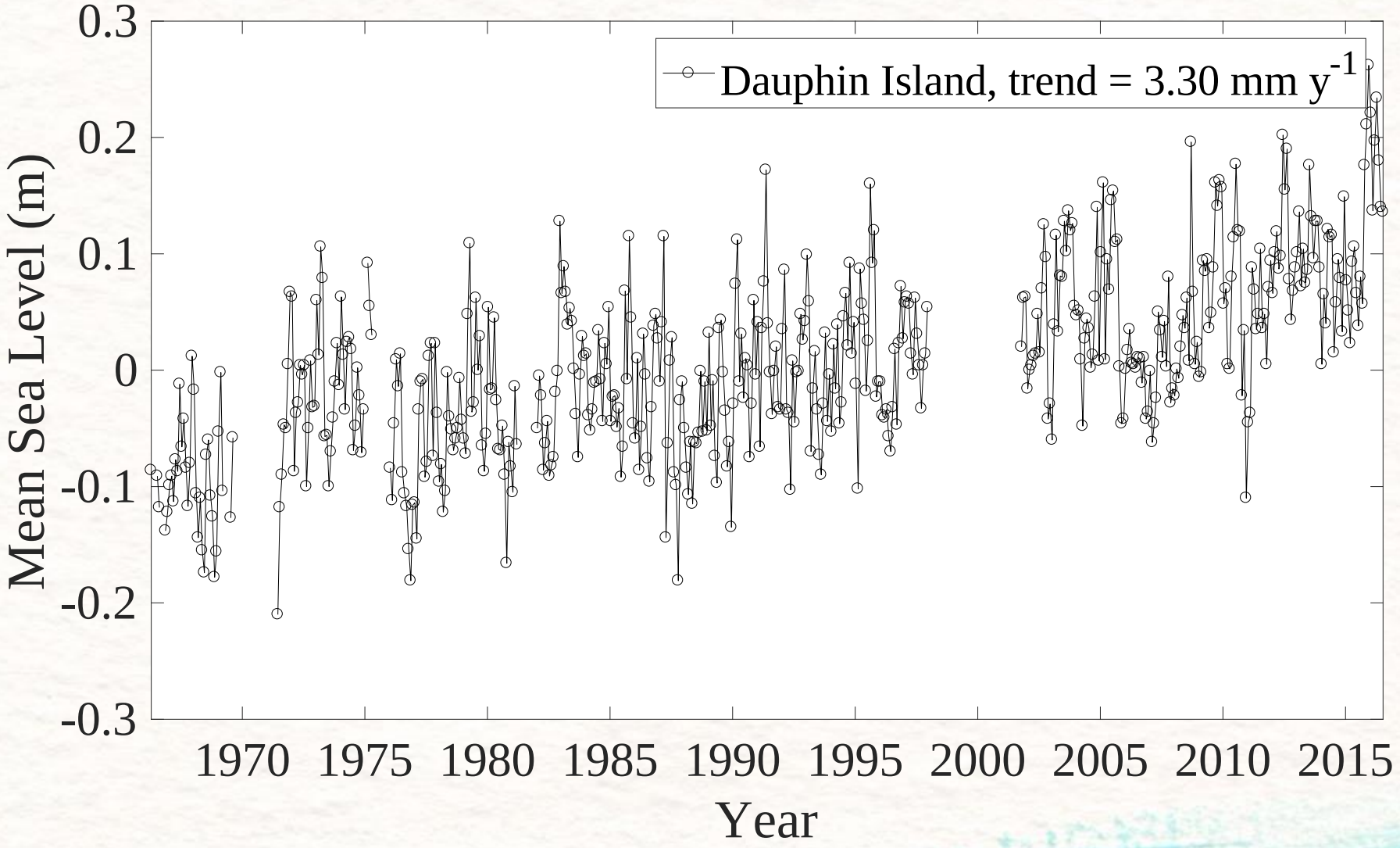
Spit 3.4:

- Average Herbaceous Cover: 33.9%
- Average Woody Cover: 0.0%
- Total Vegetative Cover: 33.9%
- **Total Number of Species: 13**

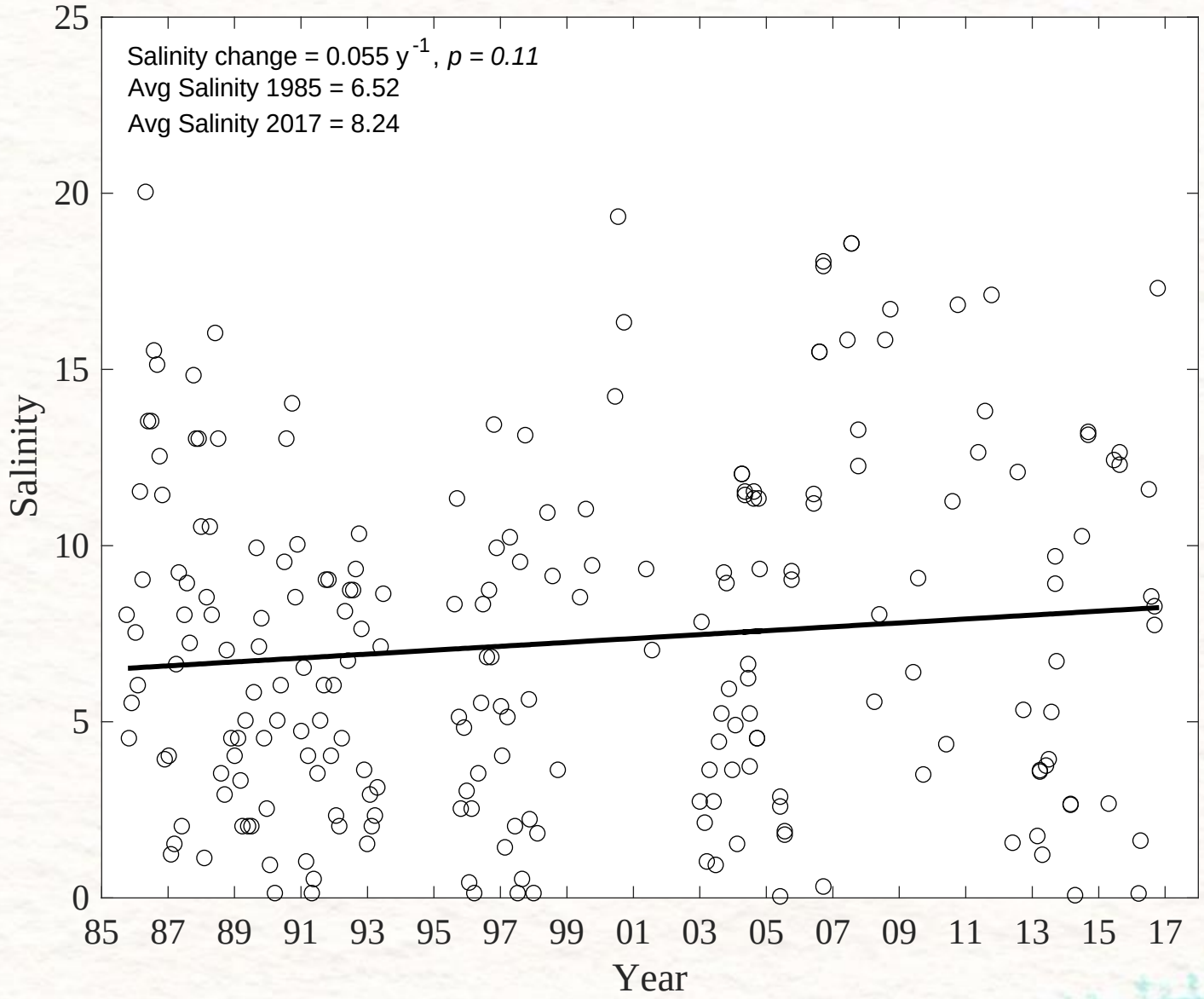
Juncus roemerianus Scheele —BLACK NEEDLERUSH — **24.4%**

Sagittaria lancifolia Linnaeus — BULLTONGUE ARROWHEAD — **4.4%**

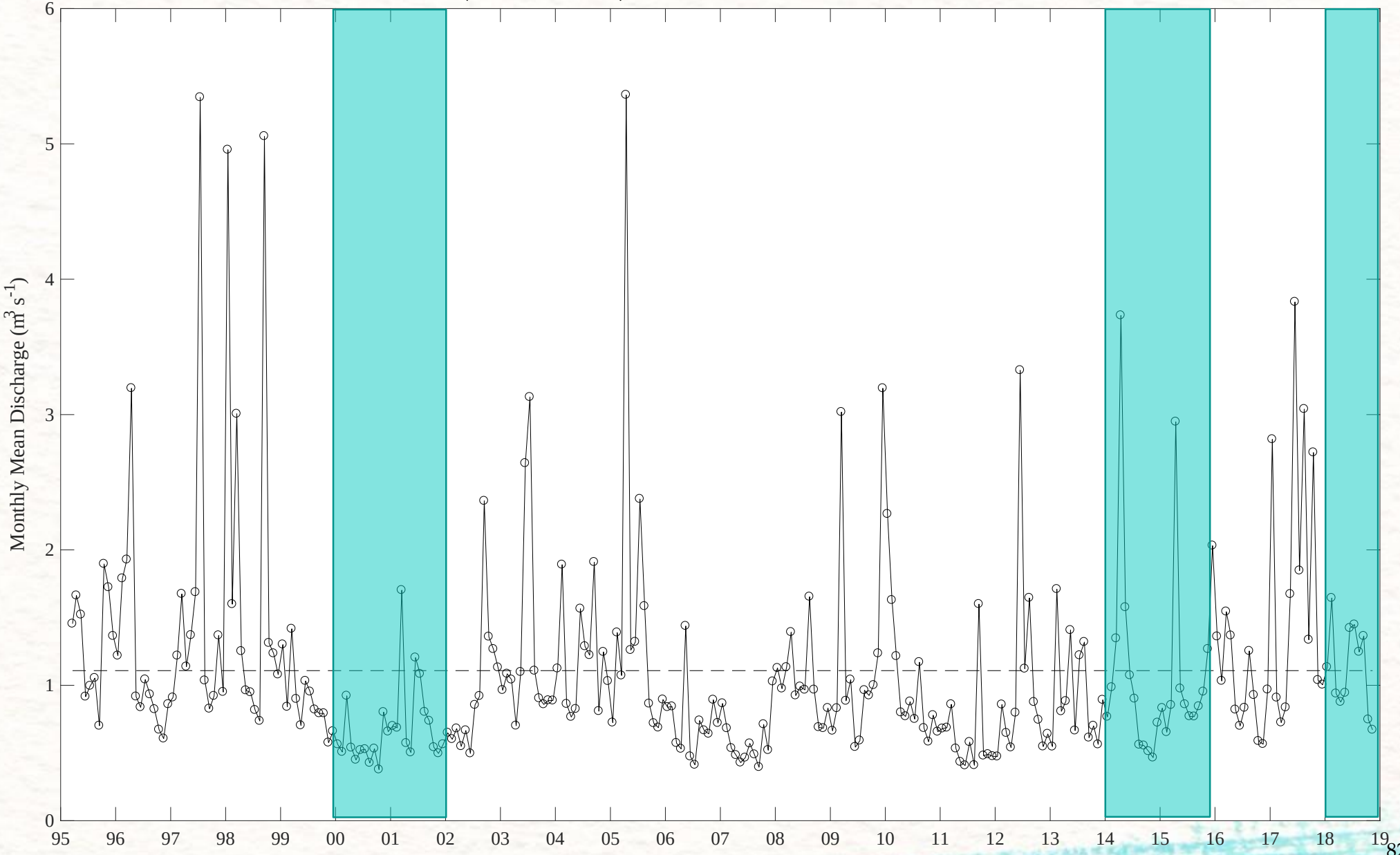
Trends


Dauphin Island, trend = 3.30 mm y-1
Mean Sea Level (m)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year

Trends


Salinity change = 0.055 y-1, p = 0.11
Avg Salinity 1985 = 6.52
Avg Salinity 2017 = 8.24
Salinity
Year
0
5
10
15
20
25
85
87
89
91
93
95
97
99
01
03
05
07
09
11
13
15
17

Lehrter (2005; 2008) DISL, EPA This Study



Conclusions

- **Unable to rule out any of our smoking guns**
  - *Flooding:* Marshes submerged during study, increasing sea level trend
  - *Salinity:* Porewater and riverine salinity; increasing trend
  - *Suspended sediment:* Low inputs from watershed, sediments mainly from Bay; accretion not keeping up with sea-level rise
  - *Boat wakes:* High frequency of boat wakes
  - *Nutrients/Eutrophication:* Highly eutrophic

General Management Options

- Restoration and adaptive management will need to consider trends and interactions among drivers
- Protect spit edges from boat wakes
- Avoid hardened shorelines that will increase erosion in adjacent areas, exacerbating land loss along the river
- Hydrologic engineering to reduce salinity intrusion
- Reduce nutrient loads
- Enhance sediment deposition on marsh spit surface, e.g. thin-layer disposal, to help spits maintain elevation vs sea level
- Purchase or dedication of land for conservation