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.
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.
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
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 2: has many decaying marsh spits
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
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.
Percent coverage and species composition were measured within 1-m² 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 Species

– *Eleocharis olivacea* — OLIVE SPIKERUSH

– *Ludwigia alata* — WINGED SEEDBOX

– *Ampelaster carolinianus* — CLIMBING ASTER

New Mobile County Record

New to Alabama

Plant Diversity

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An additional 41 species were identified in supplemental inventory surveys.

Notable Species

– *Eleocharis olivacea* — OLIVE SPIKERUSH

– *Ludwigia alata* — WINGED SEEDBOX

– *Ampelaster carolinianus* — CLIMBING ASTER

New Mobile County Record

New to Alabama
Laurel Wilt Disease
<table>
<thead>
<tr>
<th>Site</th>
<th>Total No. Species</th>
<th>Average No. Species/quadrat</th>
<th>Average % Cover/quadrat</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1S1</td>
<td>29</td>
<td>2.6</td>
<td>61.4</td>
</tr>
<tr>
<td>R2S7</td>
<td>32</td>
<td>5.5</td>
<td>53.6</td>
</tr>
<tr>
<td>R2S6</td>
<td>35</td>
<td>7.5</td>
<td>65.9</td>
</tr>
<tr>
<td>R2S5 (Strout)</td>
<td>29</td>
<td>5.3</td>
<td>46.8</td>
</tr>
<tr>
<td>R2S4 (Closing Hole)</td>
<td>41</td>
<td>6.3</td>
<td>62.0</td>
</tr>
<tr>
<td>R2S3 (Lightcap)</td>
<td>30</td>
<td>5.0</td>
<td>56.1</td>
</tr>
<tr>
<td>R2S2 (Tapia)</td>
<td>38</td>
<td>5.0</td>
<td>59.0</td>
</tr>
<tr>
<td>R2S1</td>
<td>21</td>
<td>3.9</td>
<td>48.8</td>
</tr>
<tr>
<td>R3S2</td>
<td>13</td>
<td>2.3</td>
<td>33.9</td>
</tr>
<tr>
<td>R3S1</td>
<td>9</td>
<td>2.2</td>
<td>45.8</td>
</tr>
</tbody>
</table>
Porewater Wells
Total Salinity Range: 0.10 – 8.7 ppt

### Average Salinity

![Average Salinity Chart]

### Percent Cover

<table>
<thead>
<tr>
<th>SITE</th>
<th>Sawgrass</th>
<th>Black Needlerush</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1S1</td>
<td>46.6</td>
<td>0.0</td>
</tr>
<tr>
<td>R2S7</td>
<td>9.8</td>
<td>0.0</td>
</tr>
<tr>
<td>R2S6</td>
<td>3.0</td>
<td>0.0</td>
</tr>
<tr>
<td>R2S5 (Strout)</td>
<td>9.5</td>
<td>0.9</td>
</tr>
<tr>
<td>R2S4 (Closing Hole)</td>
<td>30.1</td>
<td>6.1</td>
</tr>
<tr>
<td>R2S3 (Lightcap)</td>
<td>14.2</td>
<td>20.6</td>
</tr>
<tr>
<td>R2S2 (Tapia)</td>
<td>20.1</td>
<td>13.8</td>
</tr>
<tr>
<td>R2S1</td>
<td>1.0</td>
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</tr>
<tr>
<td>R3S2</td>
<td>3.5</td>
<td>37.6</td>
</tr>
<tr>
<td>R3S1</td>
<td>0.0</td>
<td>24.4</td>
</tr>
</tbody>
</table>
HYDROGEOMORPHIC (HGM) MODEL

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

Landscape-scale variables:
- Marsh Patch Size
- Mean Marsh Width
- Aquatic Edge
- Hydrologic Regime
- Wave Energy Exposure
- Adjacent Land Use

Field variables:
- Mean % Cover of Marsh Vegetation
- % Cover of Invasive or Exotic Species
- % Cover by Woody Plant Species
- Vegetation Height
- Nekton Habitat Diversity
HYDROGEOOMORPHIC (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

<table>
<thead>
<tr>
<th>SITE</th>
<th>FCI AVERAGE</th>
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</thead>
<tbody>
<tr>
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<td>0.76</td>
</tr>
<tr>
<td>R2S7</td>
<td>0.69</td>
</tr>
<tr>
<td>R2S6</td>
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<tr>
<td>R2S5 (Strout)</td>
<td>0.42</td>
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<tr>
<td>R2S4 (Closing Hole)</td>
<td>0.73</td>
</tr>
<tr>
<td>R2S3 (Lightcap)</td>
<td>0.68</td>
</tr>
<tr>
<td>R2S2 (Tapia)</td>
<td>0.71</td>
</tr>
<tr>
<td>R2S1</td>
<td>0.67</td>
</tr>
<tr>
<td>R3S2</td>
<td>0.60</td>
</tr>
<tr>
<td>R3S1</td>
<td>0.68</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>SITE</th>
<th>FQI Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1S1</td>
<td>6.7</td>
</tr>
<tr>
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<td>R2S6</td>
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<tr>
<td>R2S5 (Strout)</td>
<td>4.7</td>
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<td>R2S4 (Closing Hole)</td>
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</tr>
<tr>
<td>R2S3 (Lightcap)</td>
<td>6.6</td>
</tr>
<tr>
<td>R2S2 (Tapia)</td>
<td>6.4</td>
</tr>
<tr>
<td>R2S1</td>
<td>7.1</td>
</tr>
<tr>
<td>R3S2</td>
<td>7.1</td>
</tr>
<tr>
<td>R3S1</td>
<td>7.5</td>
</tr>
</tbody>
</table>
## Elevation (m, NAVD88)

<table>
<thead>
<tr>
<th>Site</th>
<th>Min.</th>
<th>Max.</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1S1</td>
<td>-0.08</td>
<td>0.50</td>
<td>0.21</td>
</tr>
<tr>
<td>R2S7</td>
<td>-0.23</td>
<td>0.38</td>
<td>0.13</td>
</tr>
<tr>
<td>R2S6</td>
<td>-0.16</td>
<td>0.34</td>
<td>0.19</td>
</tr>
<tr>
<td>R2S5 (Strout)</td>
<td>-0.20</td>
<td>0.56</td>
<td>0.20</td>
</tr>
<tr>
<td>R2S4 (Closing Hole)</td>
<td>-0.01</td>
<td>0.65</td>
<td>0.29</td>
</tr>
<tr>
<td>R2S3 (Lightcap)</td>
<td>-0.13</td>
<td>0.48</td>
<td>0.20</td>
</tr>
<tr>
<td>R2S2 (Tapia)</td>
<td>-0.23</td>
<td>0.56</td>
<td>0.24</td>
</tr>
<tr>
<td>R2S1</td>
<td>-0.31</td>
<td>0.32</td>
<td>0.12</td>
</tr>
<tr>
<td>R3S2</td>
<td>-0.19</td>
<td>0.26</td>
<td>0.15</td>
</tr>
<tr>
<td>R3S1</td>
<td>-0.36</td>
<td>0.20</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Lightcap (R2S3) Elevation

Strout, Closing Hole, and Tapia each have a similar ridge feature.
### Elevation (m, NAVD88)

<table>
<thead>
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<th>X</th>
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</tr>
<tr>
<td>R3S1</td>
<td>-0.36</td>
<td>0.20</td>
<td>0.10</td>
</tr>
</tbody>
</table>
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
\[ \Delta \text{Marsh Elevation} = \text{Net Accretion} - \Delta \text{Sea Level} \]
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
Fowl River Marsh Study - Sediment

Site 1

Site 2

Site 3
Geologic erosion rate

Suspended sediment (t/m²/yr)

Half Mile Rd (2014-15)

2014-15 max discharge 2,040 cfs
2017-18 max discharge 289 cfs

Monitored site

T/m²/yr

upstream

downstream
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 depth (cm) vs. δ¹⁵N‰ and δ¹³C‰

- Reference Marsh
- Spit 2
- Spit 3

1900-1960
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?
Average Accretion (mm/yr)

<table>
<thead>
<tr>
<th>Mean (mm/yr)</th>
<th>Sigma</th>
<th>Variance</th>
<th>Std. Error</th>
<th>Rel. Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.15</td>
<td>0.13</td>
<td>0.02</td>
<td>0.06</td>
<td>5 %</td>
</tr>
</tbody>
</table>
8735180 Dauphin Island, Alabama

3.74 +/- 0.58 mm/yr

Mean (mm/yr) | Sigma | Variance | Std. Error | Rel. Std. Error |
--- | --- | --- | --- | --- |
1.15 | 0.13 | 0.02 | 0.06 | 5%
50-Year Average Rate of Sea Level Rise (3.74 mm/yr)
$\Delta Marsh Elevation = Net Accretion - \Delta Sea Level$
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
I. Objectives

01 Measure Tides and Waves
02 Evaluate Wave Conditions
03 Describe Wave Frequency
04 Inform Restoration Design
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!!!

Relative Distribution of Wave Heights in Study Area

Low
Mid
High

Gage 055139 | 8/30/18-9/7/18

Wave Height (m)

day

night

Deployment Length (days)

0.8

0.6

0.4

0.2

0

2

4

6

8

Google Earth

3000 ft
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
Methods – Fowl River Estuary Hydrography

- Monthly surveys from Jan to Oct 2018
- 18 stations
  - CTD vertical profiles: S, T, depth, O₂
  - 8 discrete water sampling stations
    - Suspended sediments, nutrients, organic matter, Chlα
    - Surface and bottom samples
Station 1 = 0 km
Station 18 = 12.4 km
Boundary between Region 1 and 2 = 2.9 km
Boundary between Region 2 and 3 = 7.1 km
Priority Spits
Suspended Sediment

- January
- March
- April
- May
- June
- July
- August
- September
- October

Surface TSS vs. Salinity

Bottom TSS vs. Salinity

TSS (g m⁻³) vs. Salinity
Nitrate

[Graphs showing nitrate concentration over salinity for each month from January to October]
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
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

Mean Sea Level (m) vs Year

Dauphin Island, trend = 3.30 mm y^{-1}
Salinity change = 0.055 y\(^{-1}\), \(p = 0.11\)
Avg Salinity 1985 = 6.52
Avg Salinity 2017 = 8.24
Monthly Mean Discharge (m$^3$/s$^1$)

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