Land-Sea Interactions in the Albemarle-Pamlico Estuarine System

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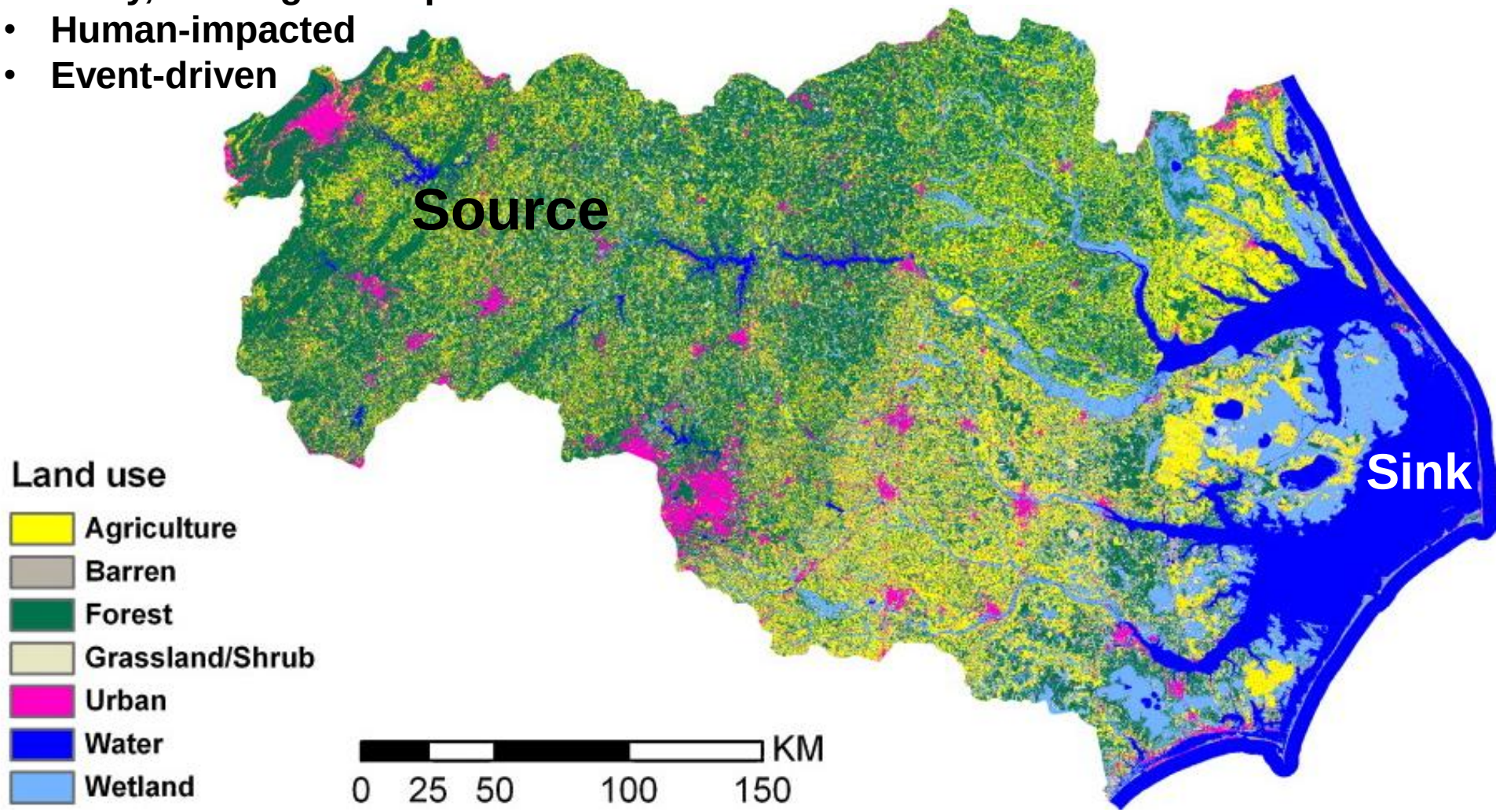
Motivation for the Research

- **Sediment and solute cycling is critical to ecosystem distribution and function.**
- **Need to determine the impact of humans on coast and its processes and vice versa.**
- **Desire to understand the past and help determine the future.**
- **Science should inform managers and the public**

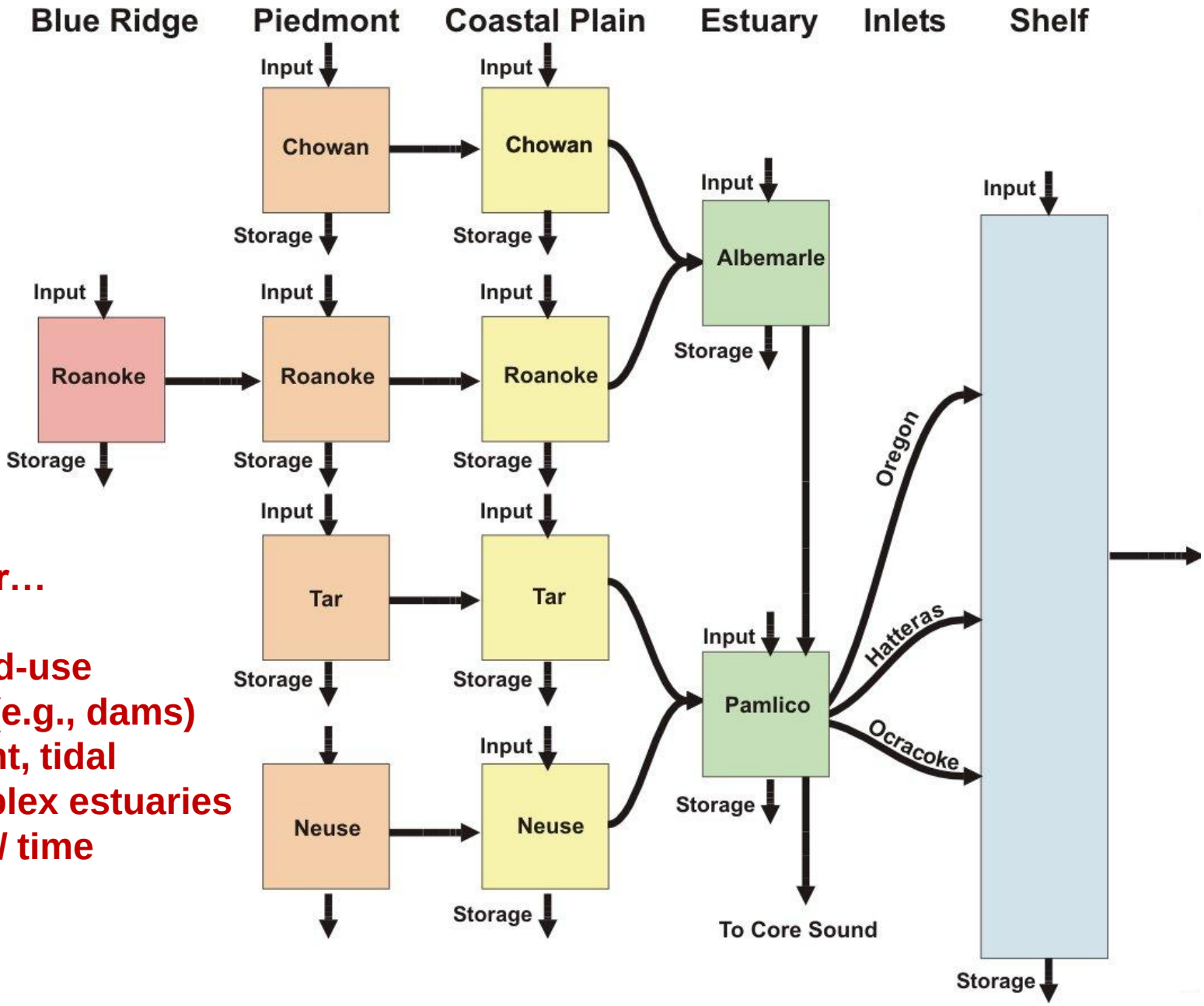
Understanding the S2S APES Sedimentary System

- **In theory simple, but:**
- **Many, heterogenous parts**
- **Human-impacted**
- **Event-driven**



Johnston et al., 2011, Ecological Modeling

A “Simple” APES Sediment Budget

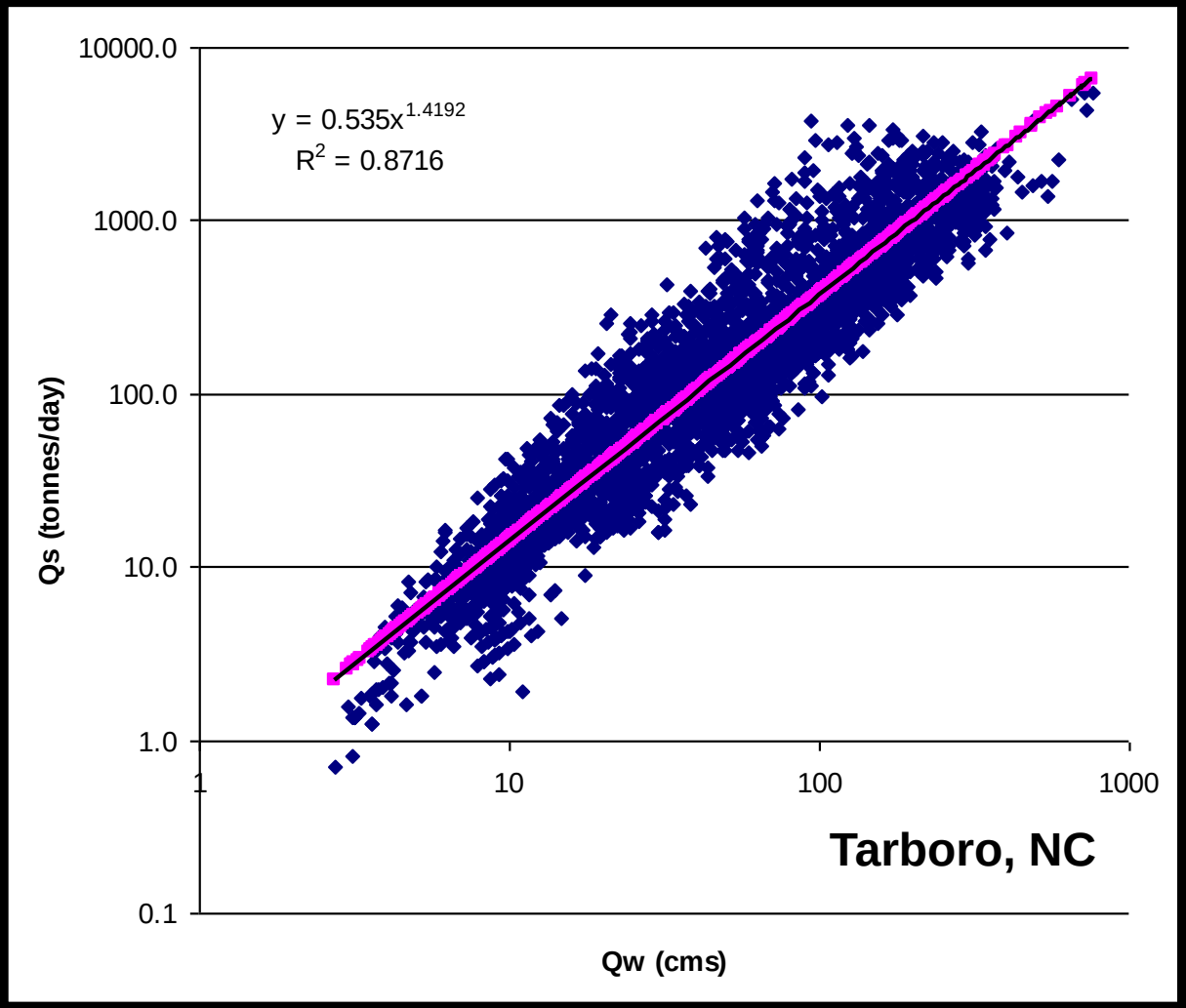


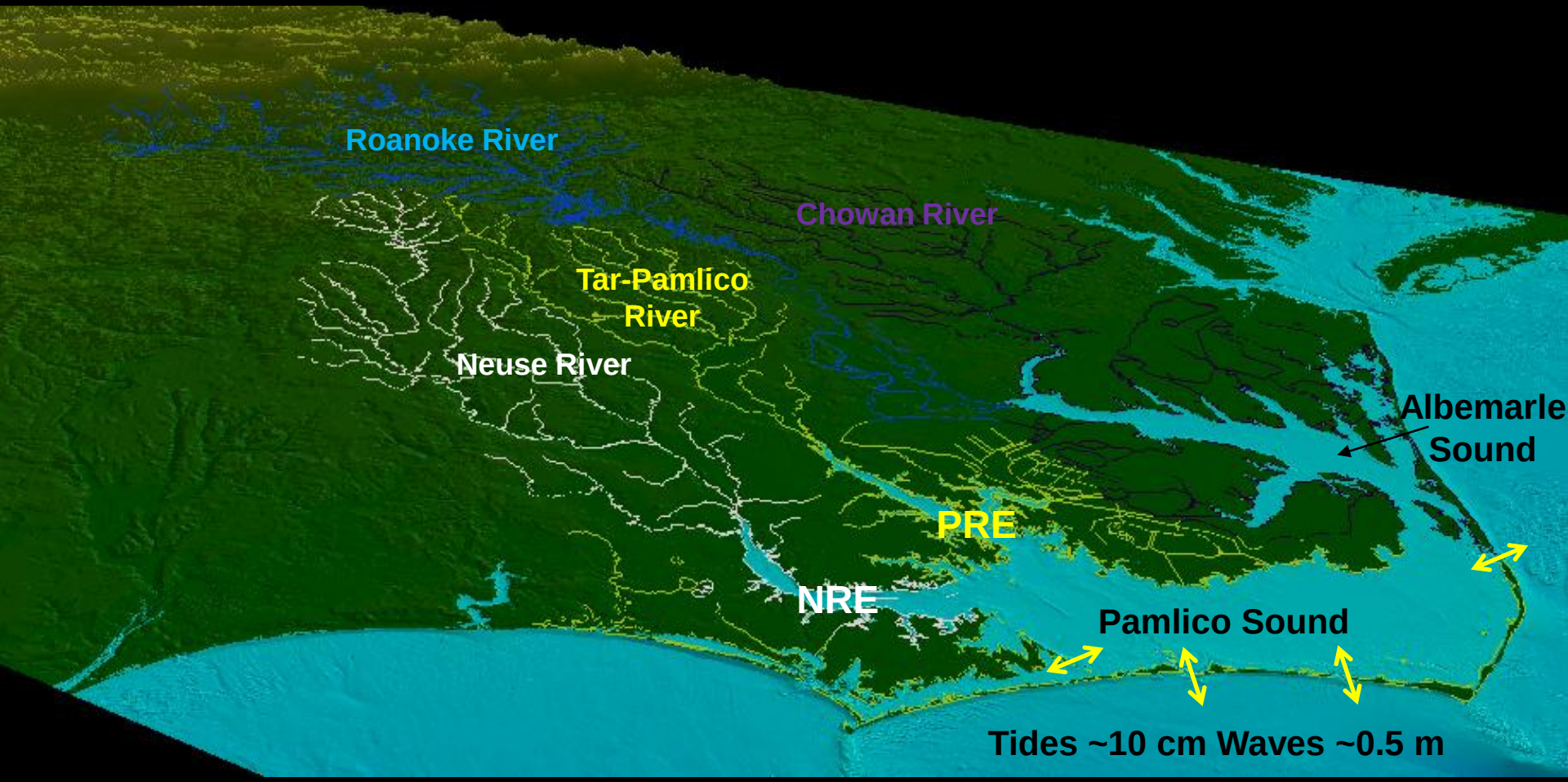
Also consider…

- Variable land-use
- Alterations (e.g., dams)
- Low-gradient, tidal
- Large, complex estuaries
- Changing w/ time

Sediment Rating Curves

- SSC available from limited systems, and many tidally affected
- Low gradient rivers have larger scatter and less dominance of peak events (Meade et al., 1990).
- Land-use has key control on yields (e.g., Simmons, 1993).





	Water Discharge (m^3/s)	Sediment Load (t/y)	Yield ($t/km^2/y$)
Chowan	130	1.6×10^5	14
Roanoke	251	3.1×10^5	14
Tar-Pamlico	153	1.9×10^5	19
Neuse	173	2.1×10^5	13
	707	8.7×10^5	

From Giese al., 1979; Simmons, 1993

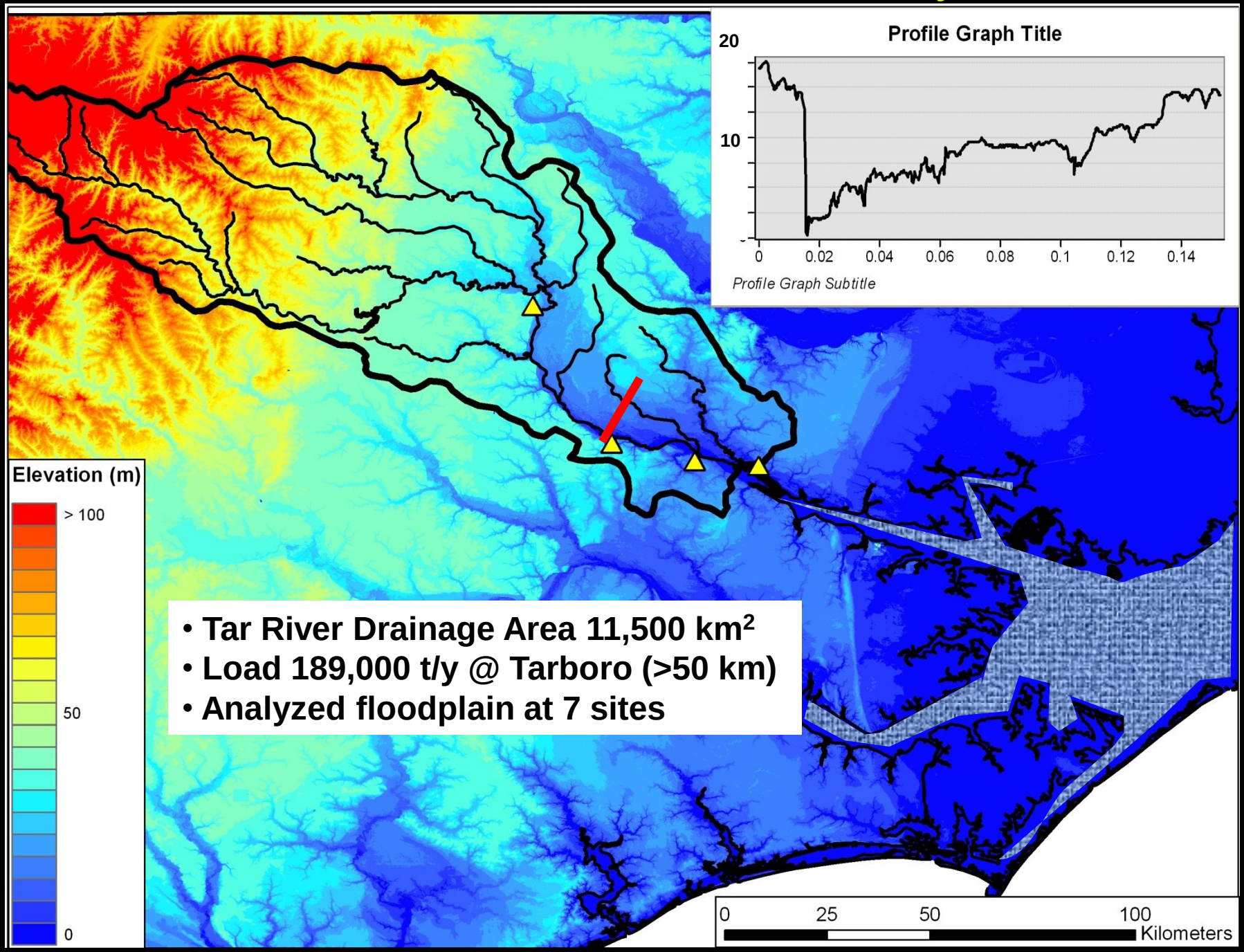
Sediment Inputs ≈ Outputs

- River inputs from gauges are ~10^6 tonnes/yr
- Sediment accumulation in the APES: 1- >10 mm/y

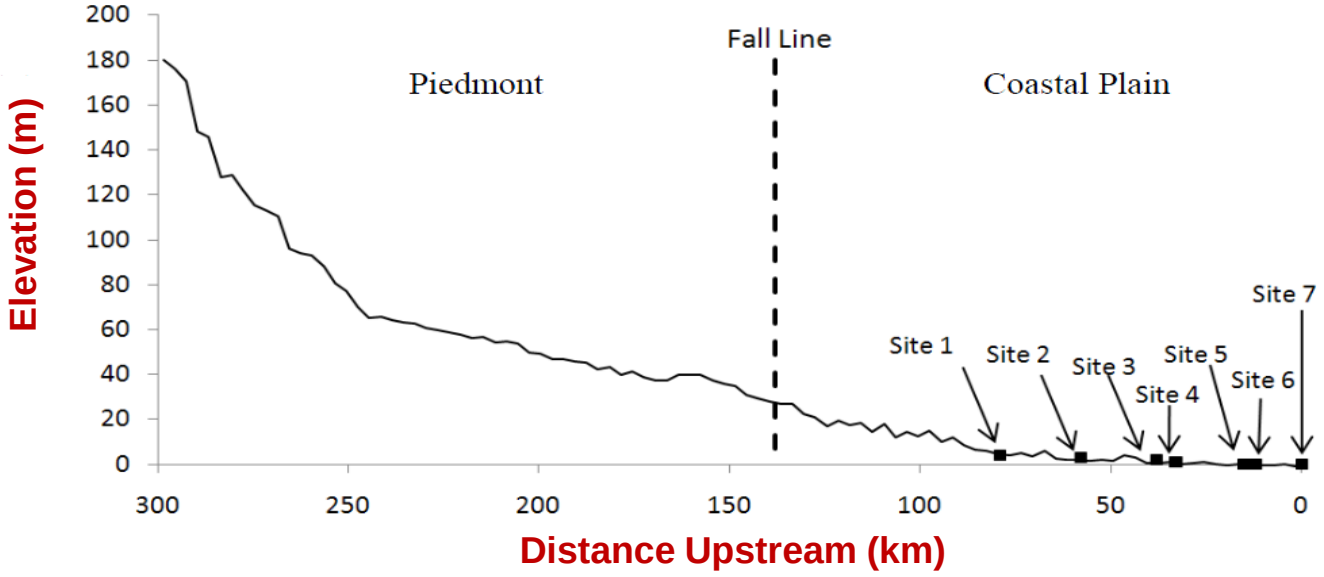
(Benninger and Wells, 1993, Cooper et al., 2004; Giffin and Corbett, 2003; Corbett et al., 2007)

- Using these data and assuming a bulk density and average accumulation rate, estuarine storage is potentially much higher.
- But the devil is in the details.

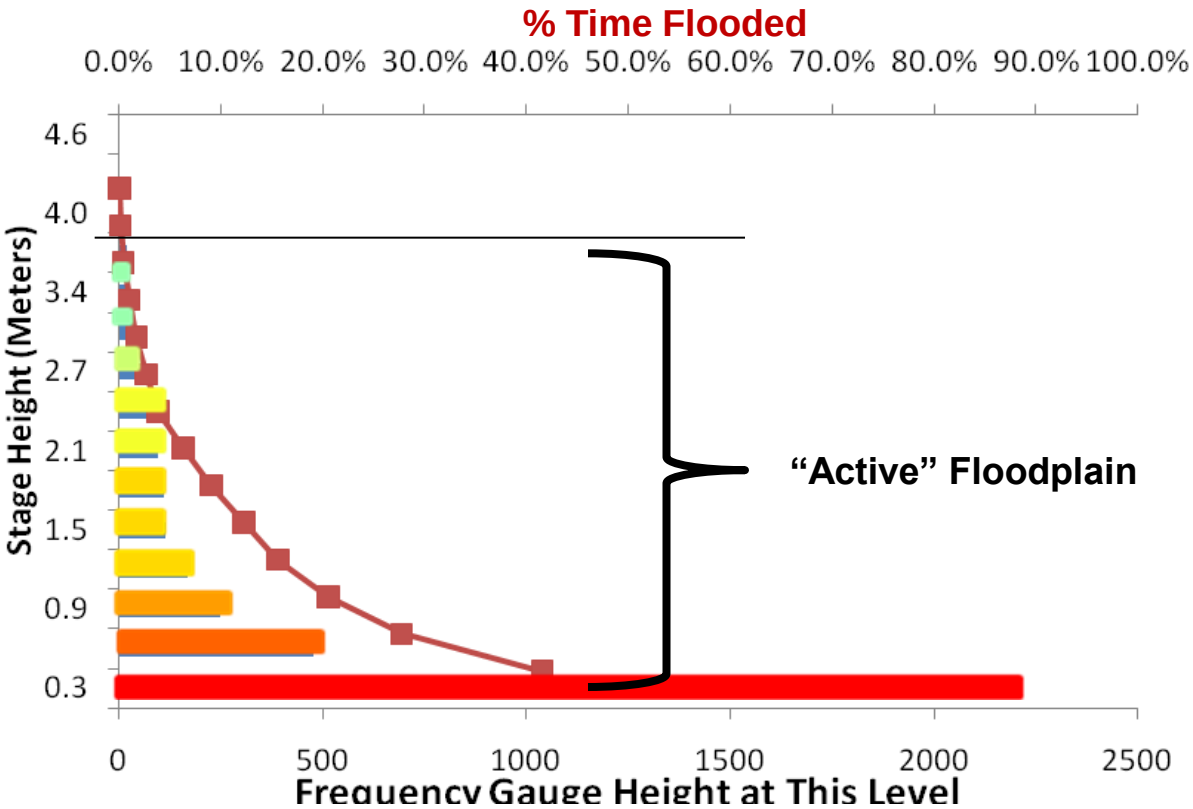
How much sediment makes it to the estuary?



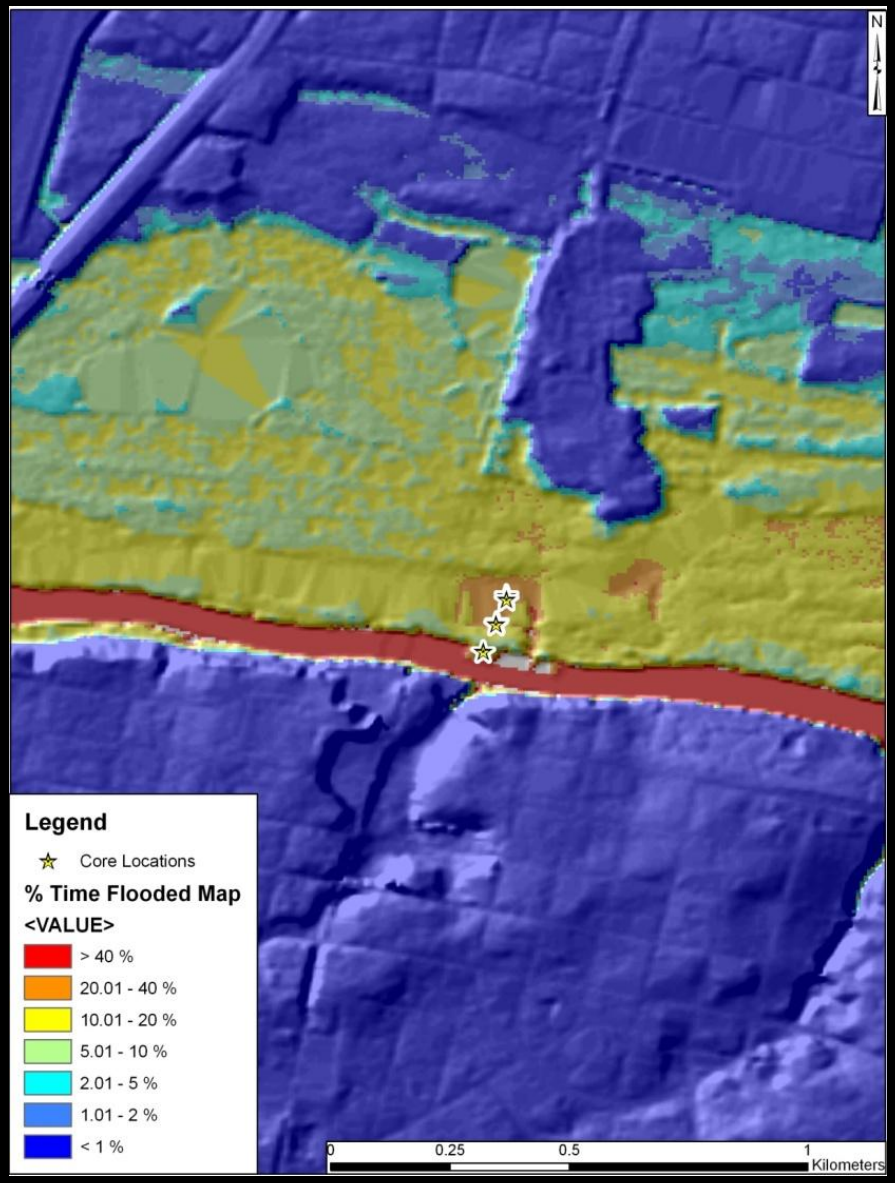
Tar River long profile

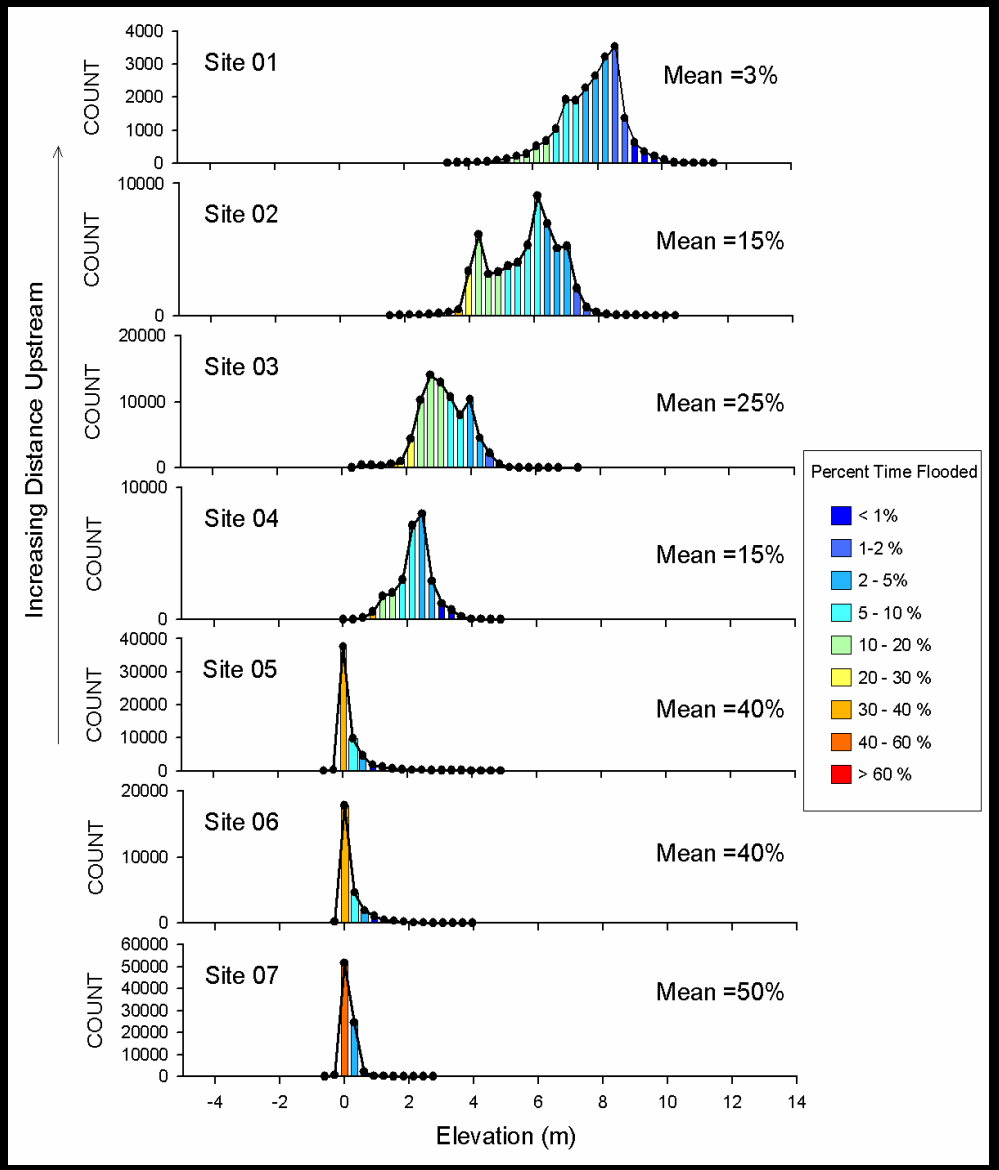


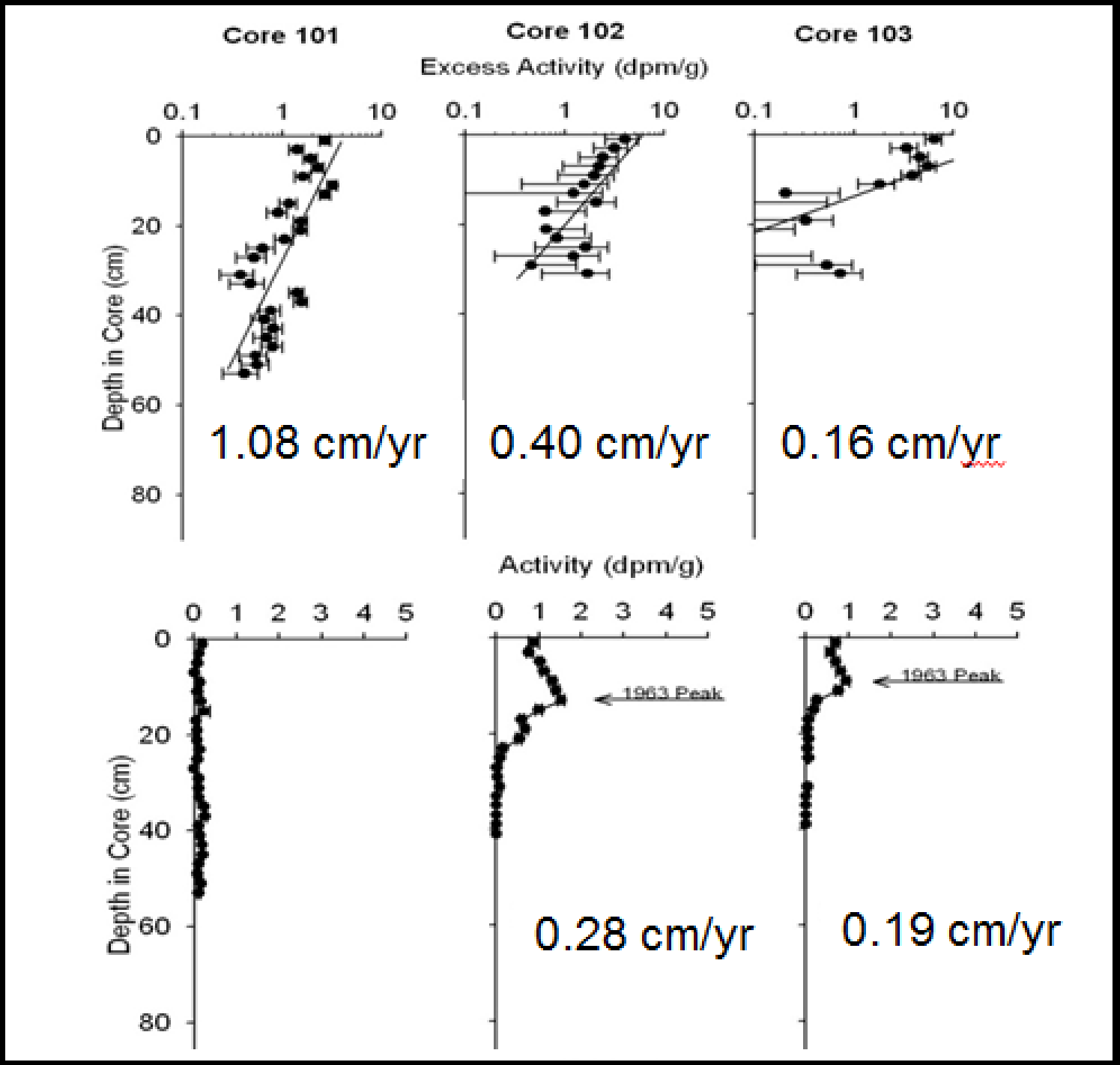
Data from Site 4 Greenville River Gauge



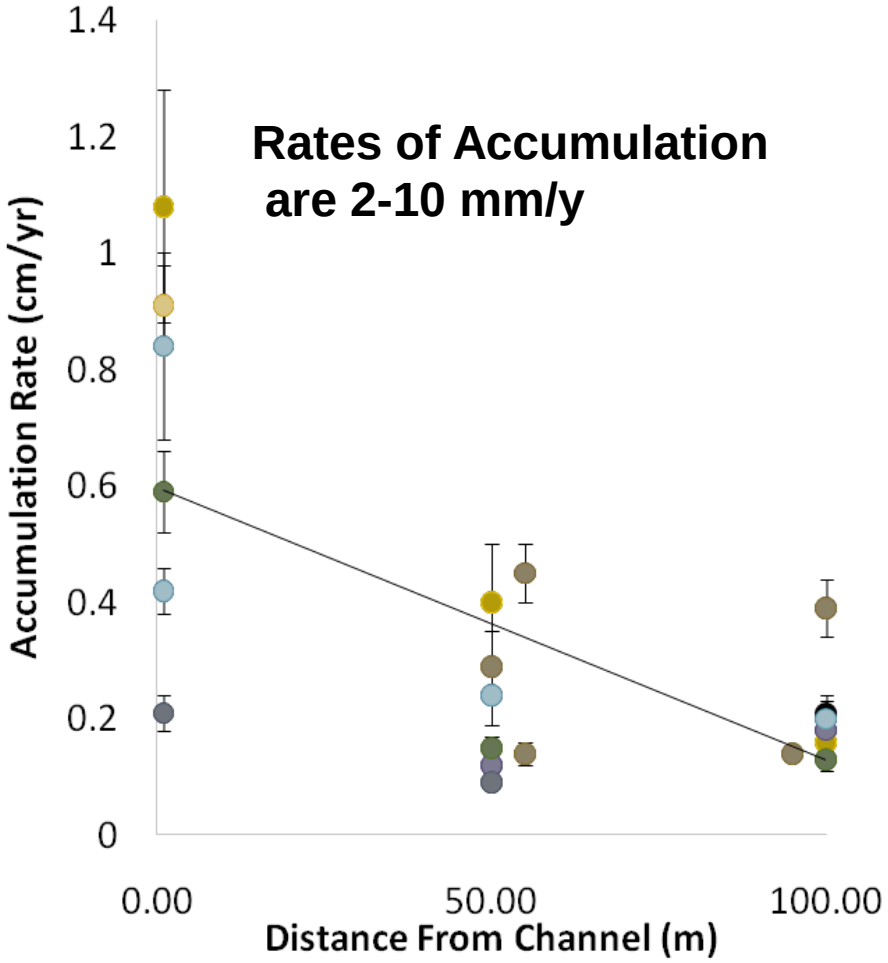
Characterized the Active Floodplain

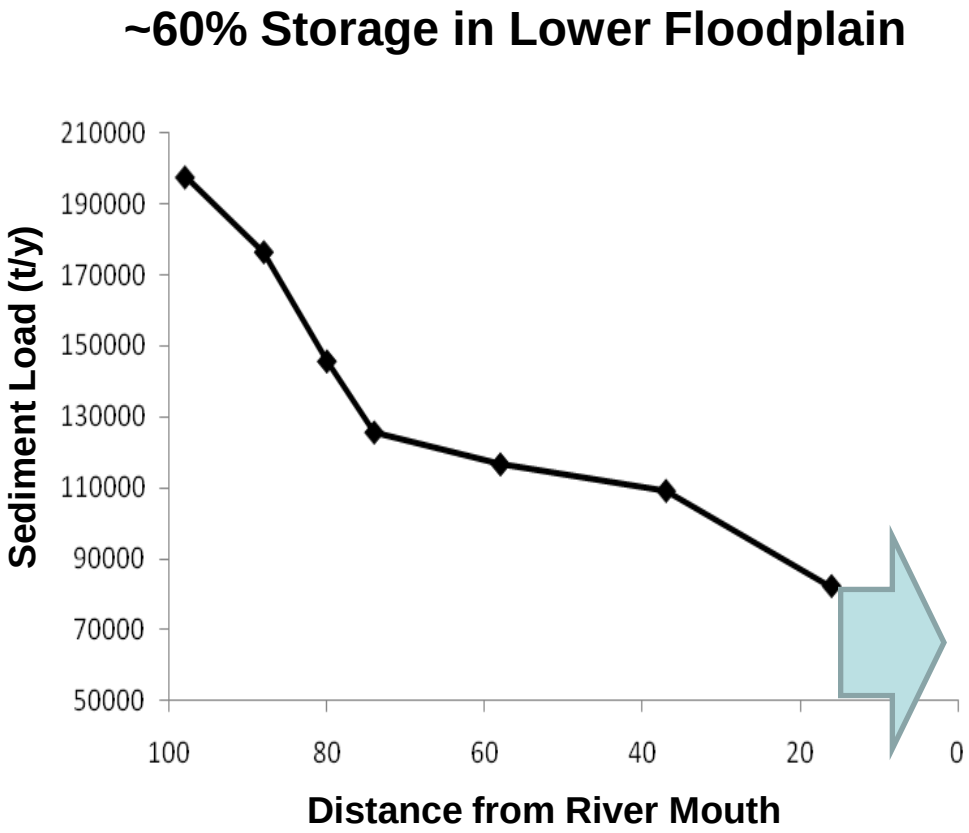




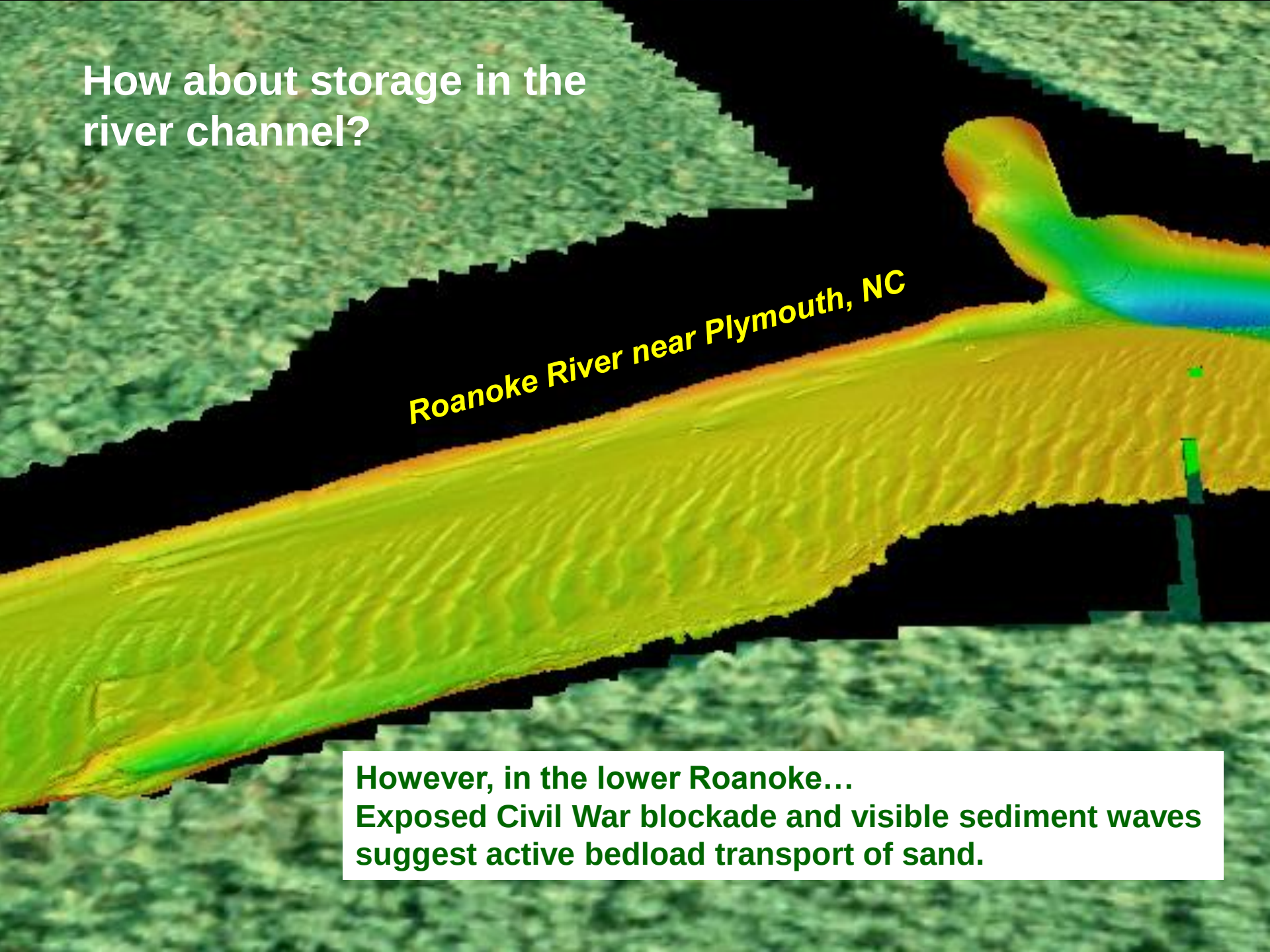

Core 101
Core 102
Core 103
Excess Activity (dpm/g)
0.1
1
10
0
20
40
60
80
Depth in Core (cm)
1.08 cm/yr
0.40 cm/yr
0.16 cm/yr
Activity (dpm/g)
0
1
2
3
4
5
1963 Peak
0.28 cm/yr
0.19 cm/yr

Floodplain Sedimentation and Storage

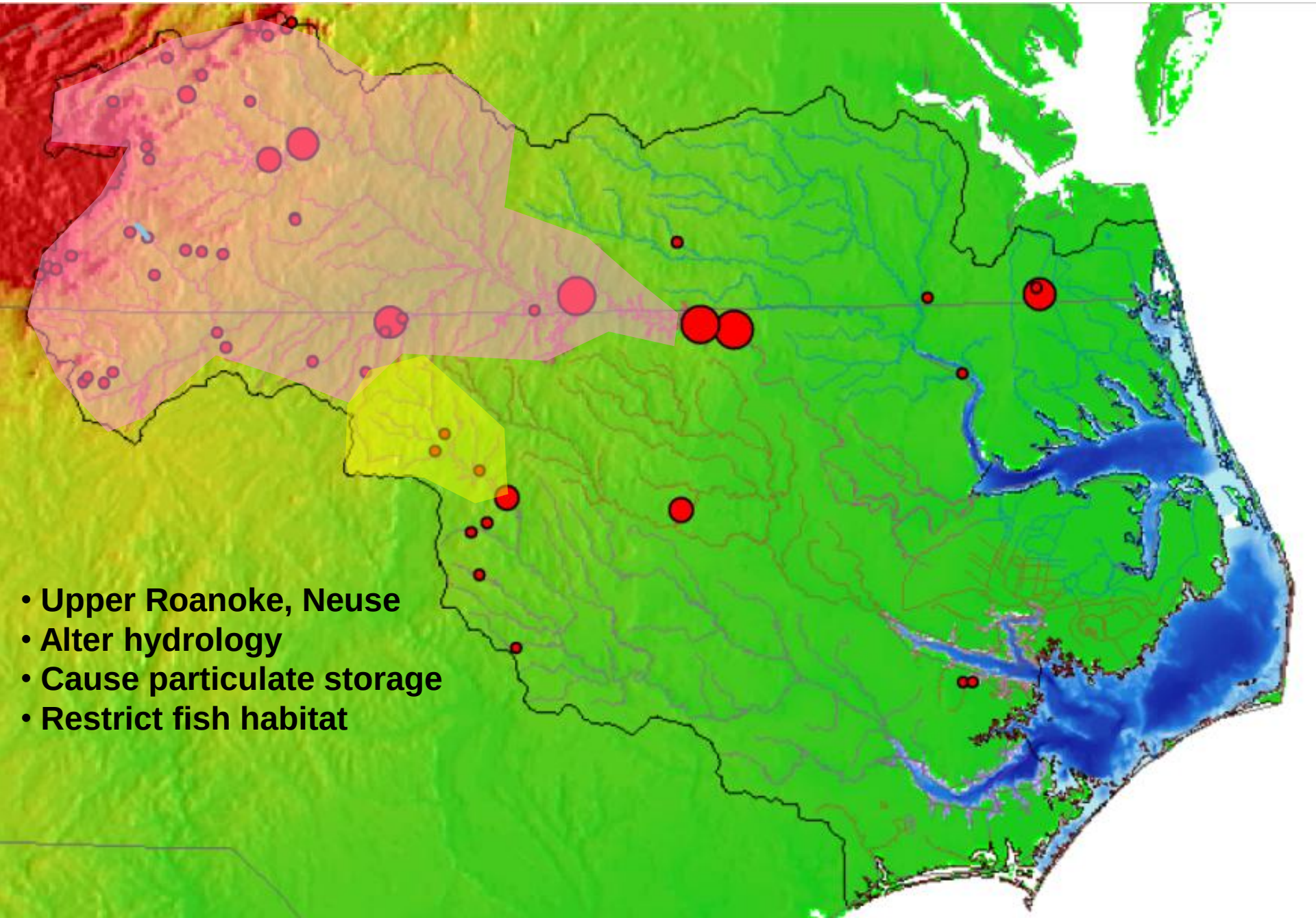




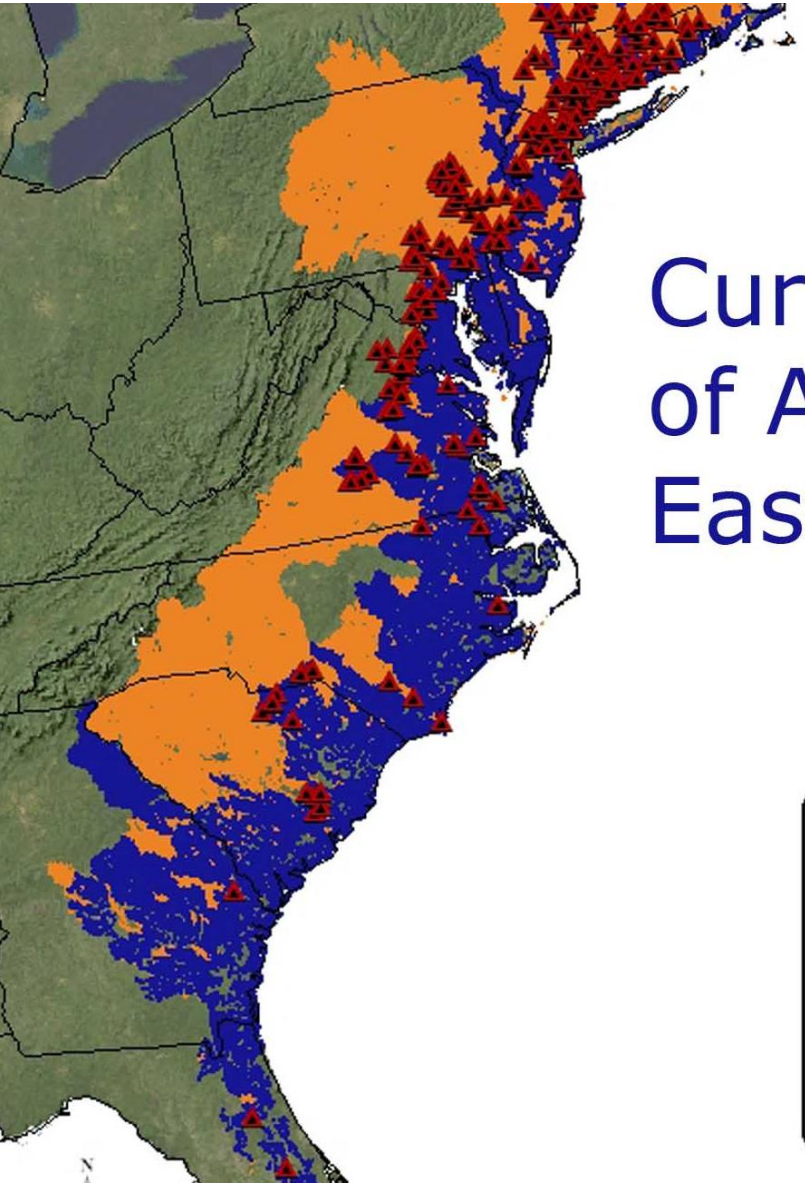
- Lower river storage is substantial.
- Consistent other work (Simmons, 1993; Phillips, 2006).
- This has important implication for biogeochemical processes.


How about storage in the river channel?
Roanoke River near Plymouth, NC
However, in the lower Roanoke…
Exposed Civil War blockade and visible sediment waves suggest active bedload transport of sand.

Impact of Dams



Ongoing NMFS-funded Research

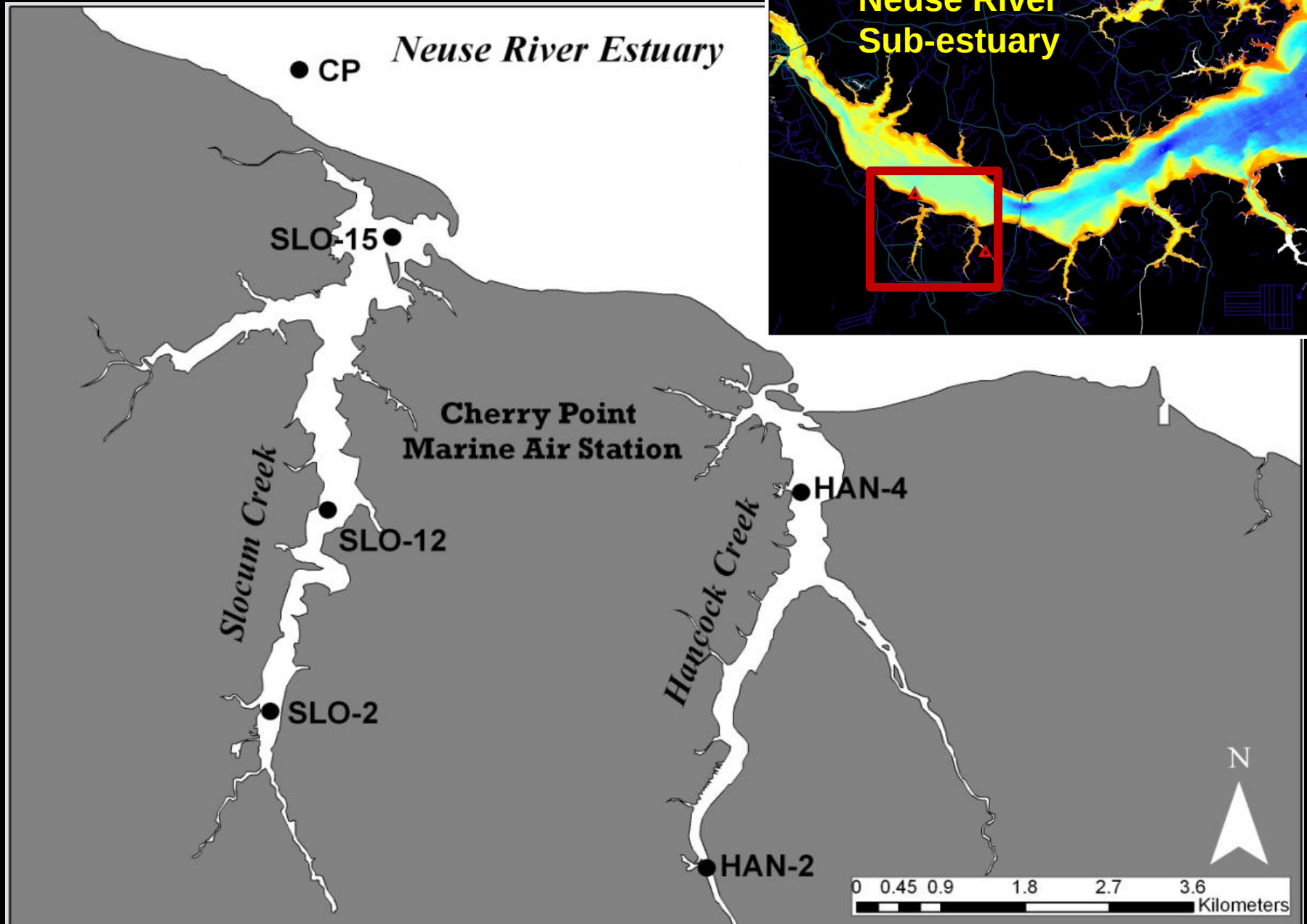


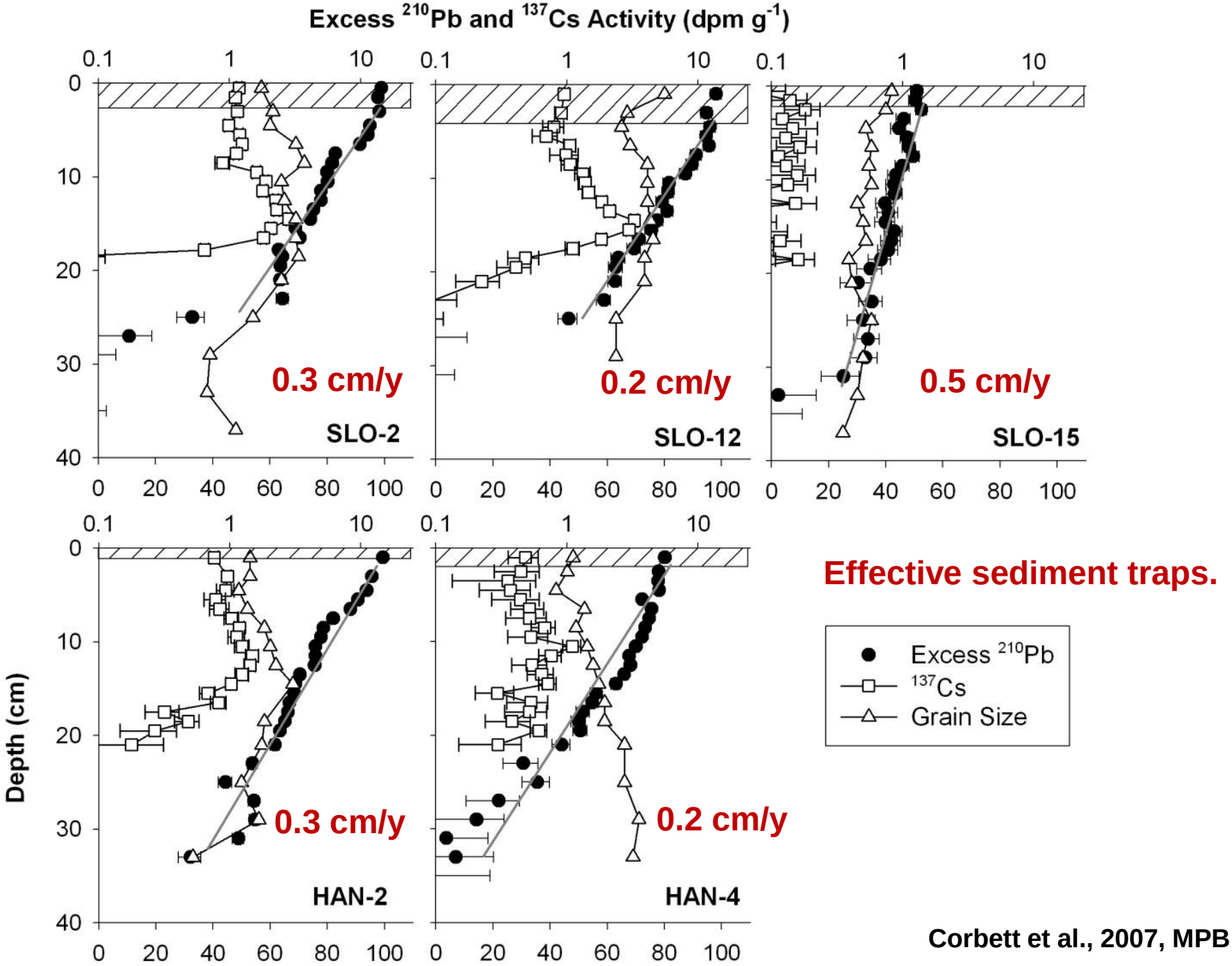
Current and Historic Range of American Shad on the East Coast of the U.S.

Legend

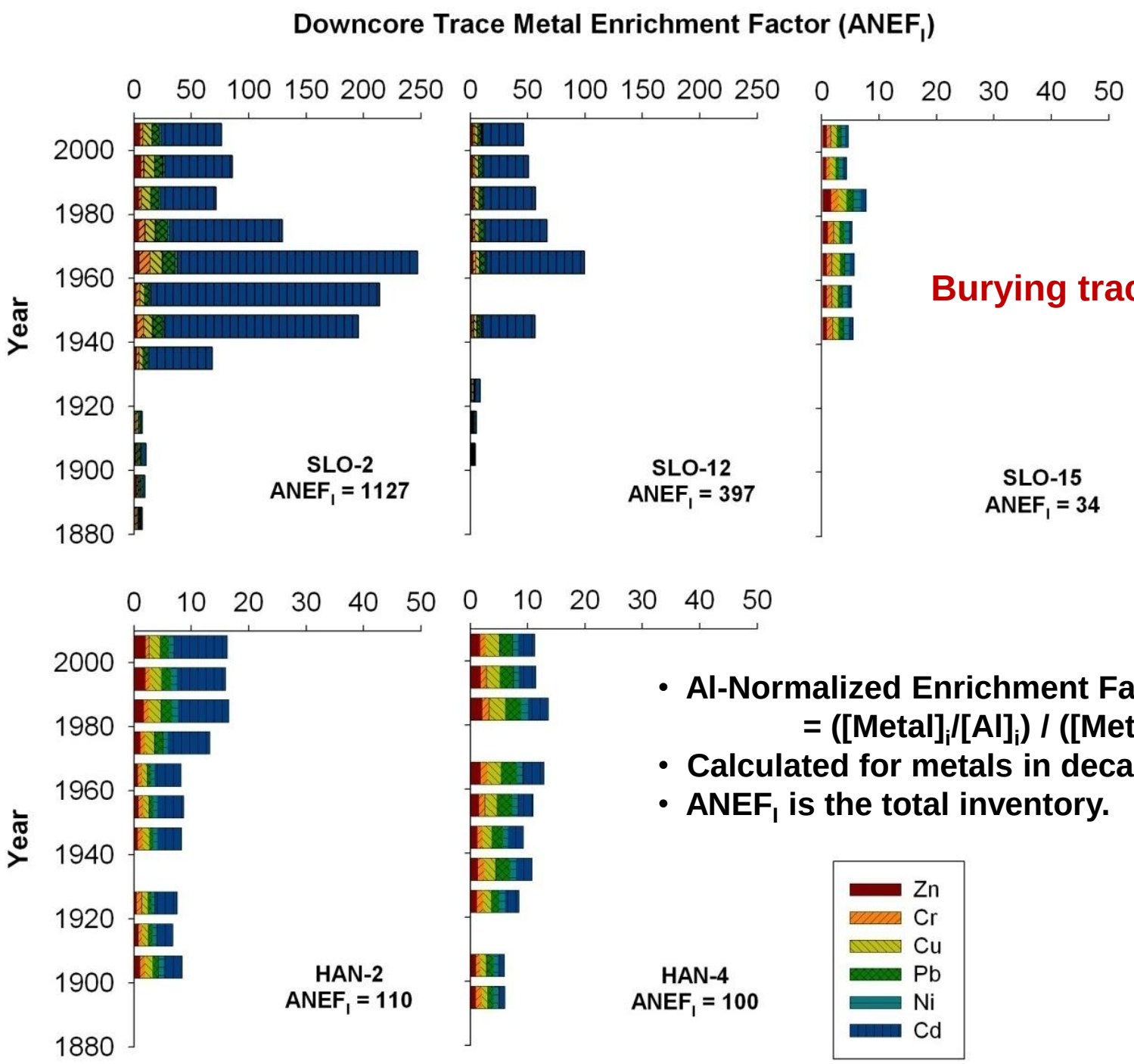
- Barrier to Fish Passage
- Historic Spawning Ranges
- Current Spawning Ranges

How do estuarine tributaries and sub-estuaries function?





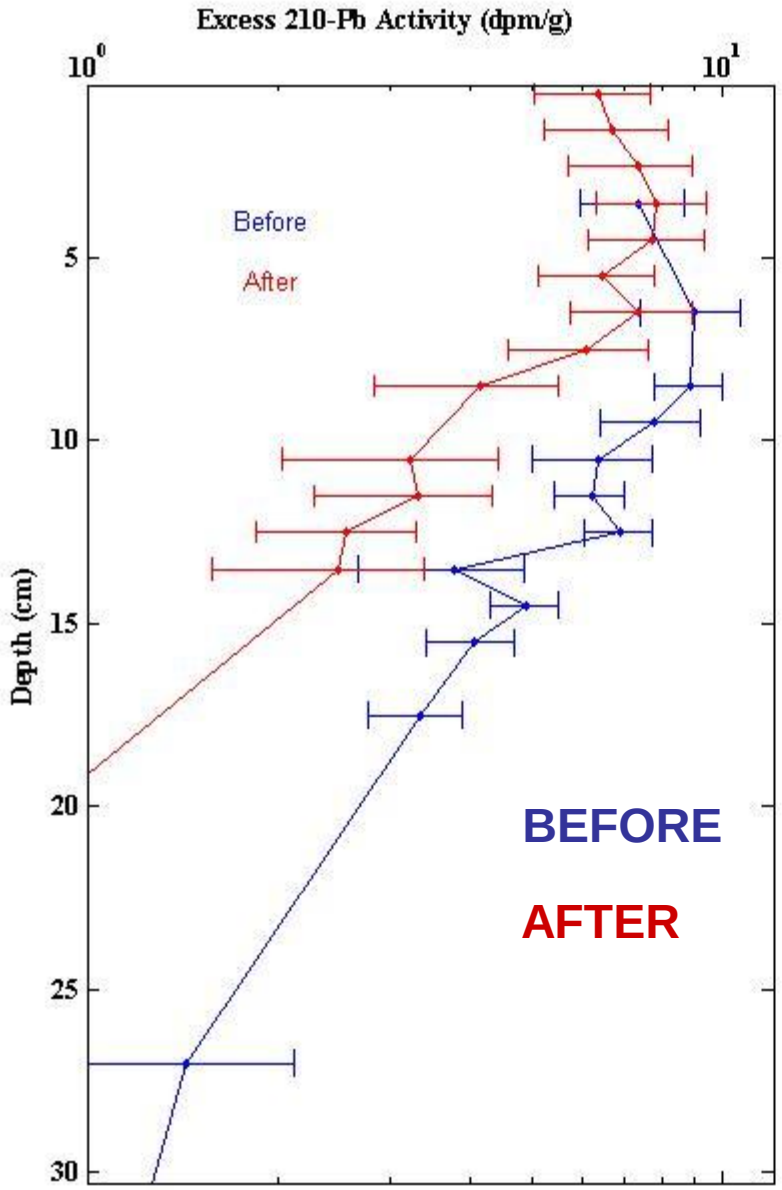
Corbett et al., 2007, MPB

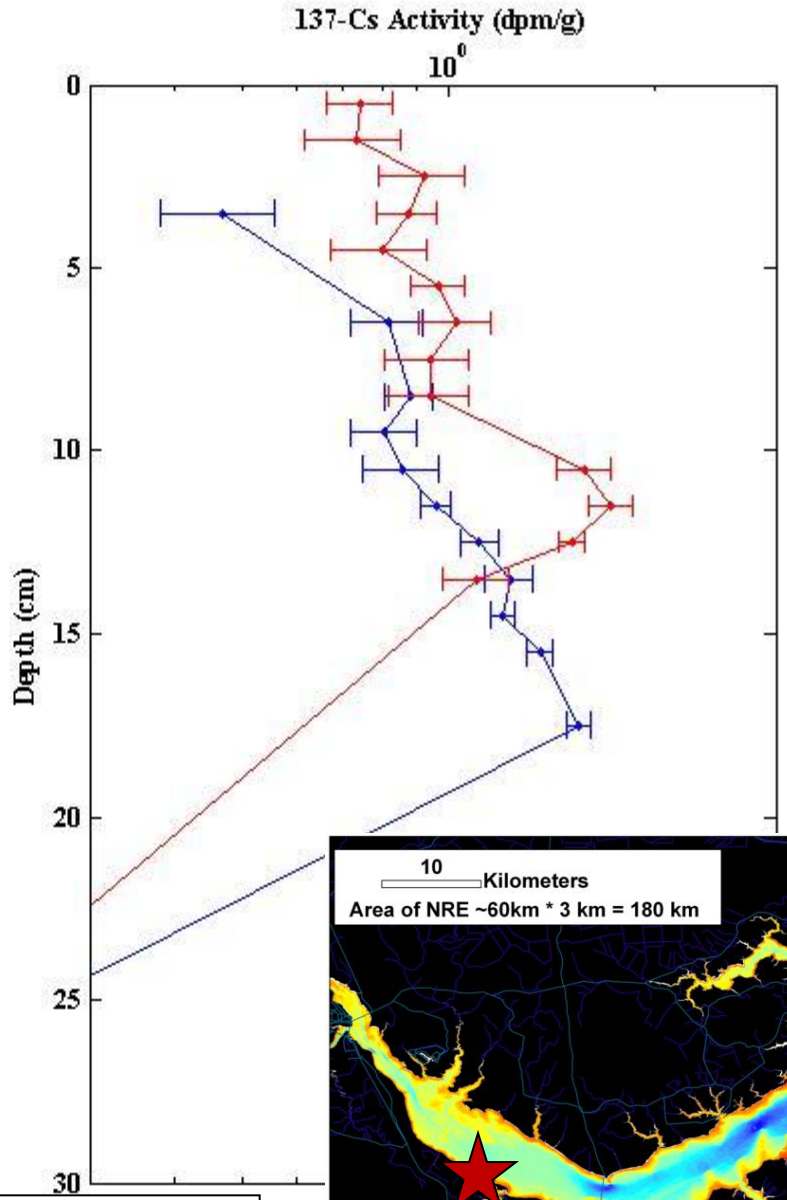


Burying trace metals.

- **Al-Normalized Enrichment Factor (ANEF)**
  $= ([Metal]_i/[Al]_i) / ([Metal]_b/[Al]_b)$
- **Calculated for metals in decades intervals.**
- **ANEF$_I$ is the total inventory.**

Hurricane Ophelia

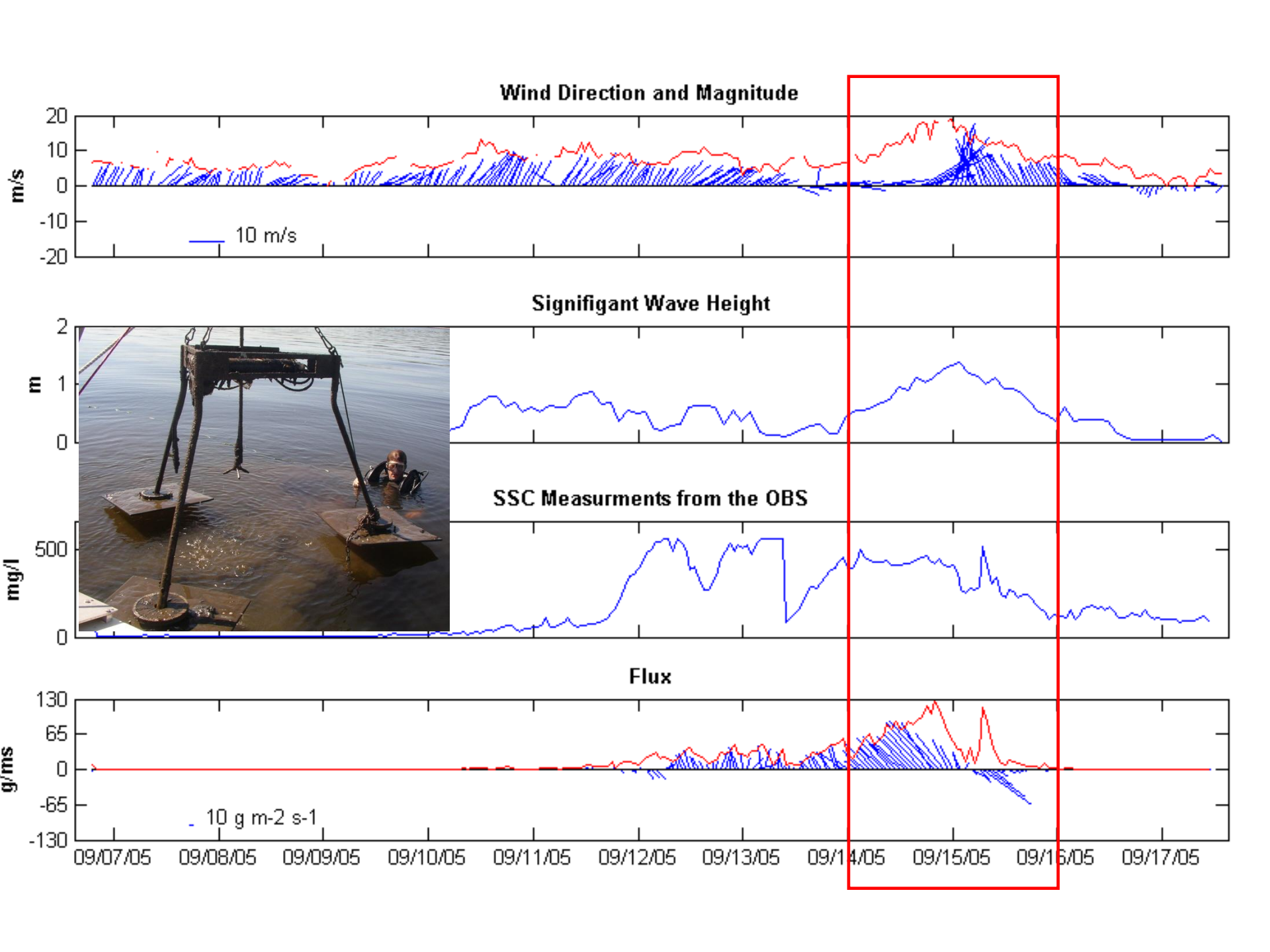




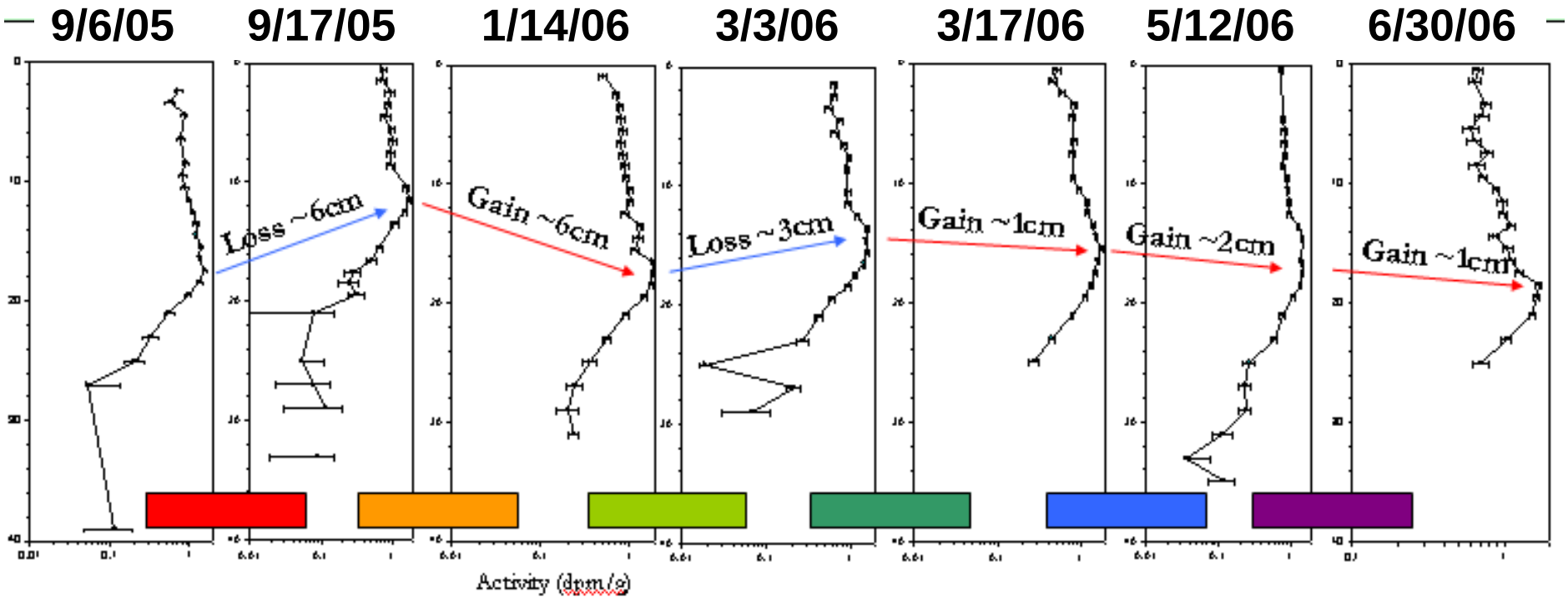
BEFORE

AFTER

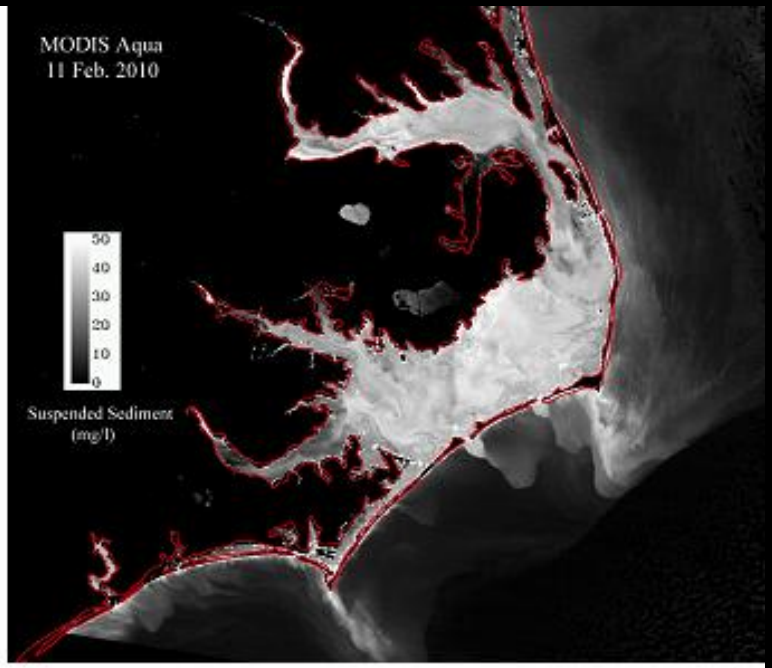
- **Truncated profile suggest ~ 6 cm loss**
- **Substantial reworking despite modest accumulation**

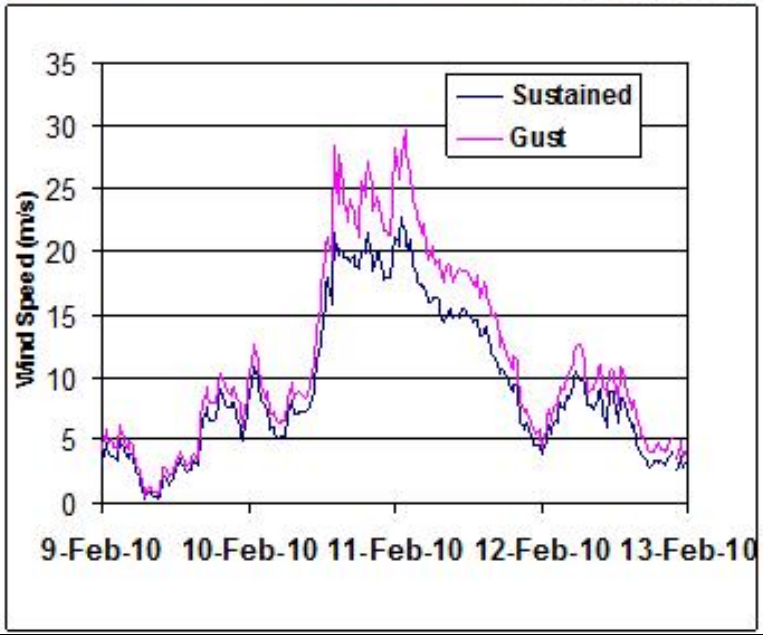

Wind Direction and Magnitude
m/s
20
10
0
-10
-20
10 m/s
Signifigant Wave Height
m
2
1
0
SSC Measurments from the OBS
mg/l
500
0
Flux
g/ms
130
65
0
-65
-130
10 g m-2 s-1
09/07/05
09/08/05
09/09/05
09/10/05
09/11/05
09/12/05
09/13/05
09/14/05
09/15/05
09/16/05
09/17/05

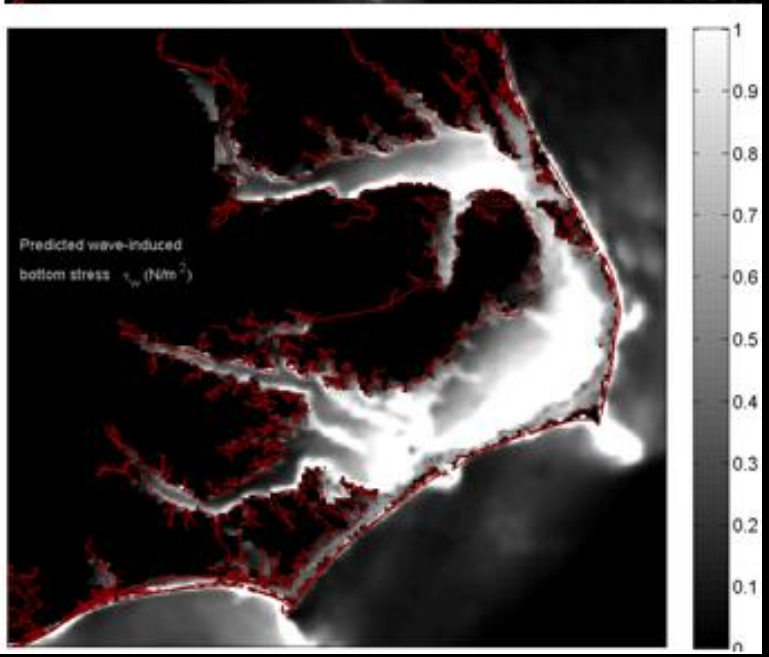
Neuse Estuary Seabed Dynamics



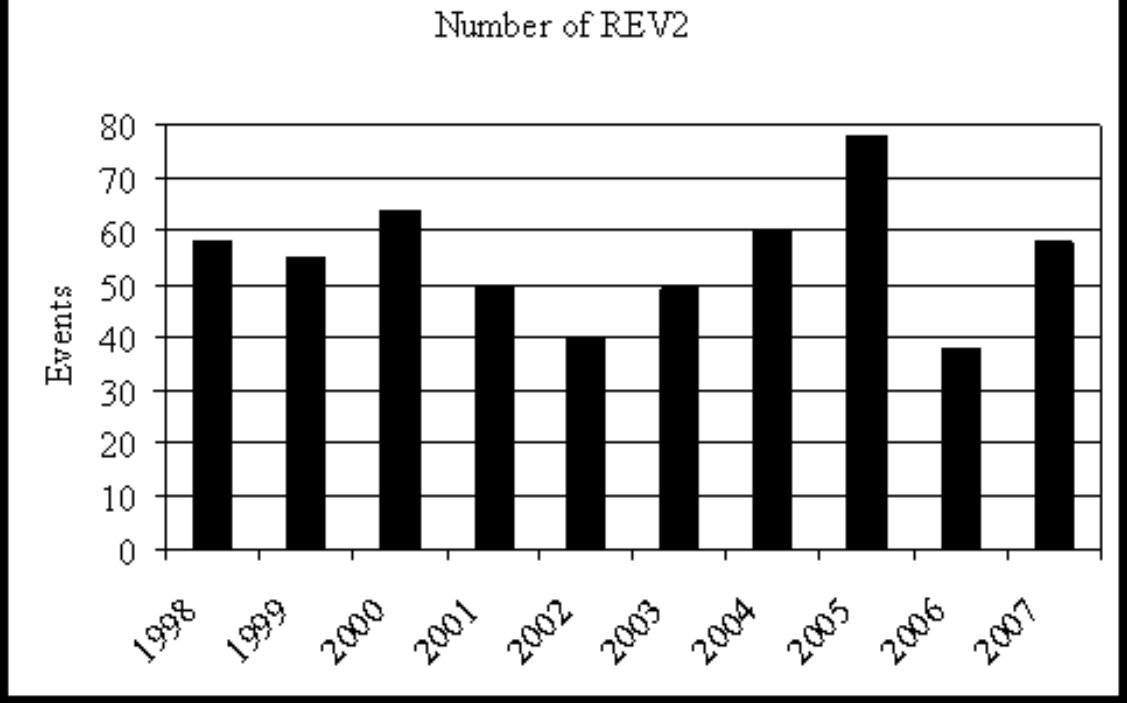
- **Significant reworking**
- **Net increase ~ 1cm/y and ^{210}Pb rate ~1cm/y**
- **Important for sediments and nutrients cycling and likely ecosystem functioning**

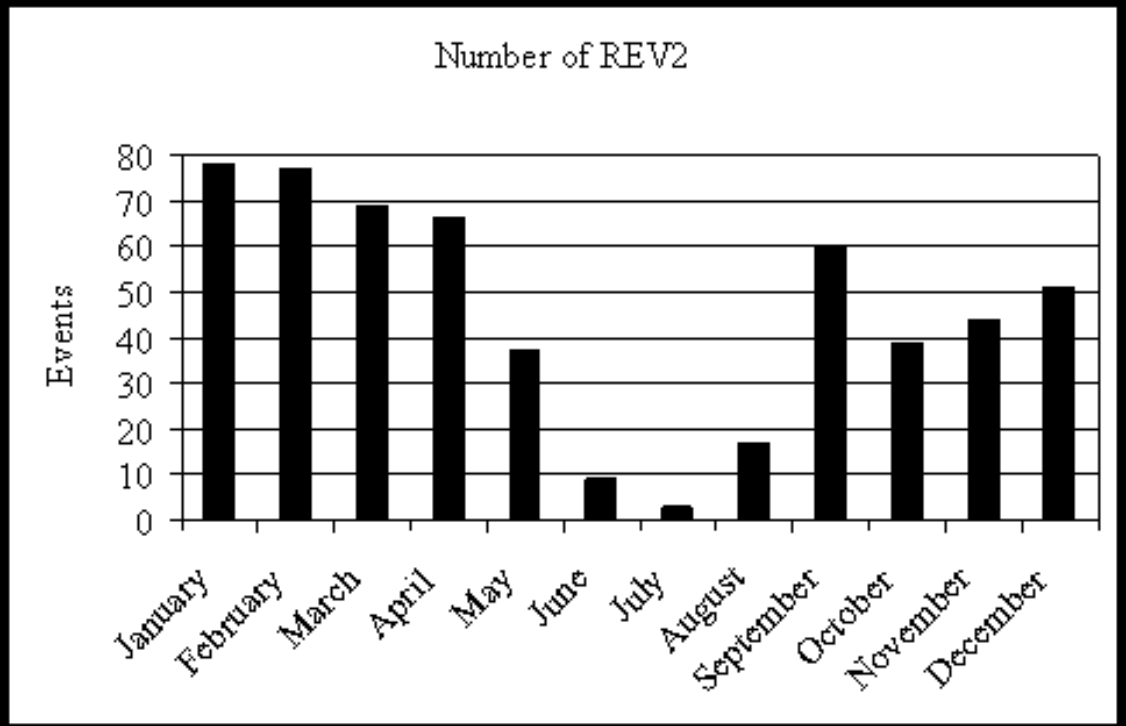






MODIS imagery from Rick Miller; Model results form Ryan Mulligan

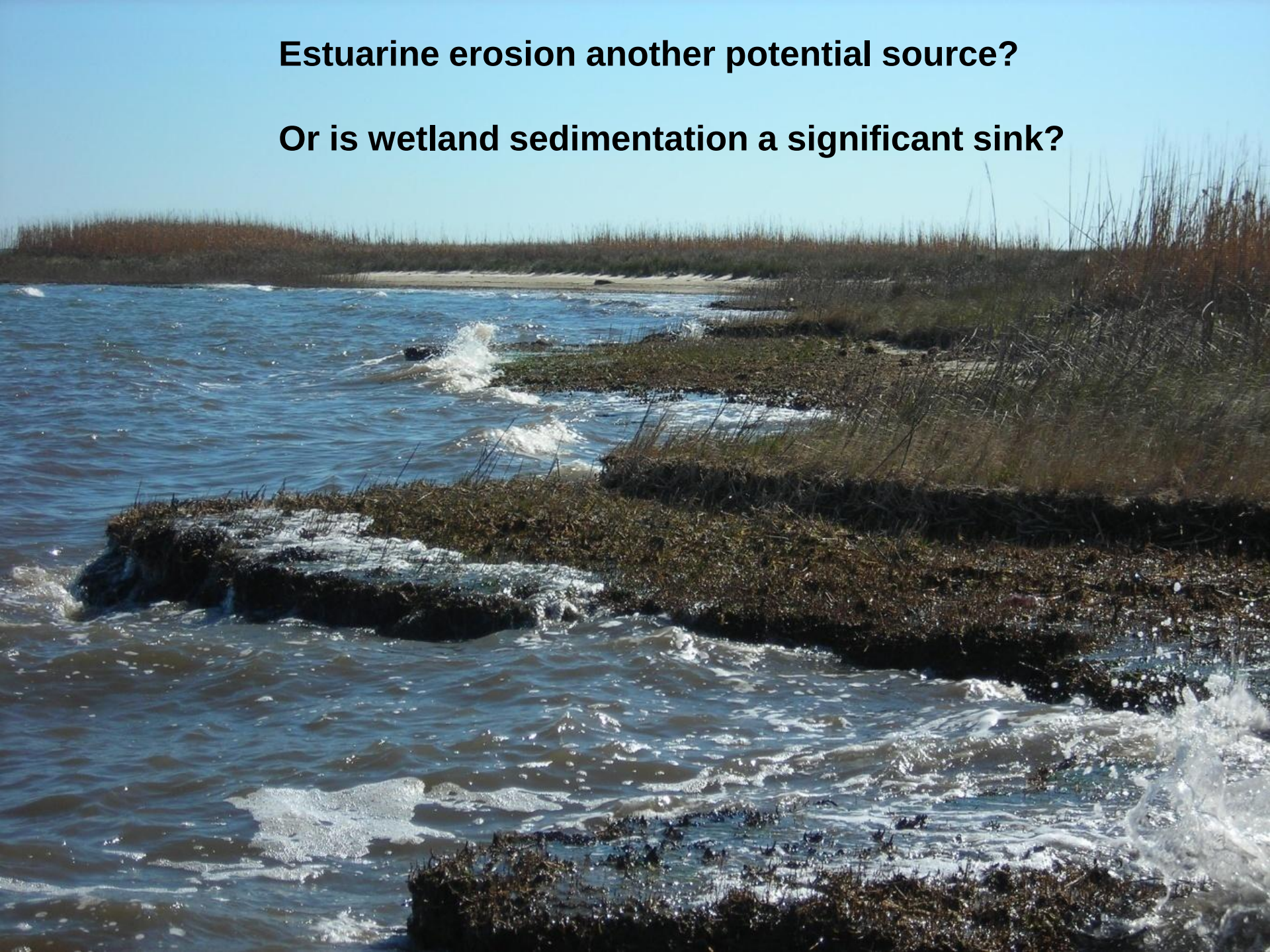




- **Resuspension ~4 % of time**
- **~50 events per year**

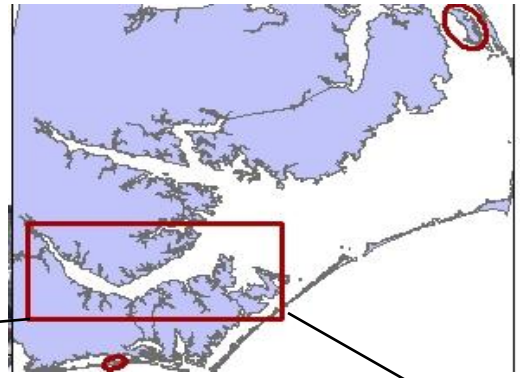
Estuarine erosion another potential source?

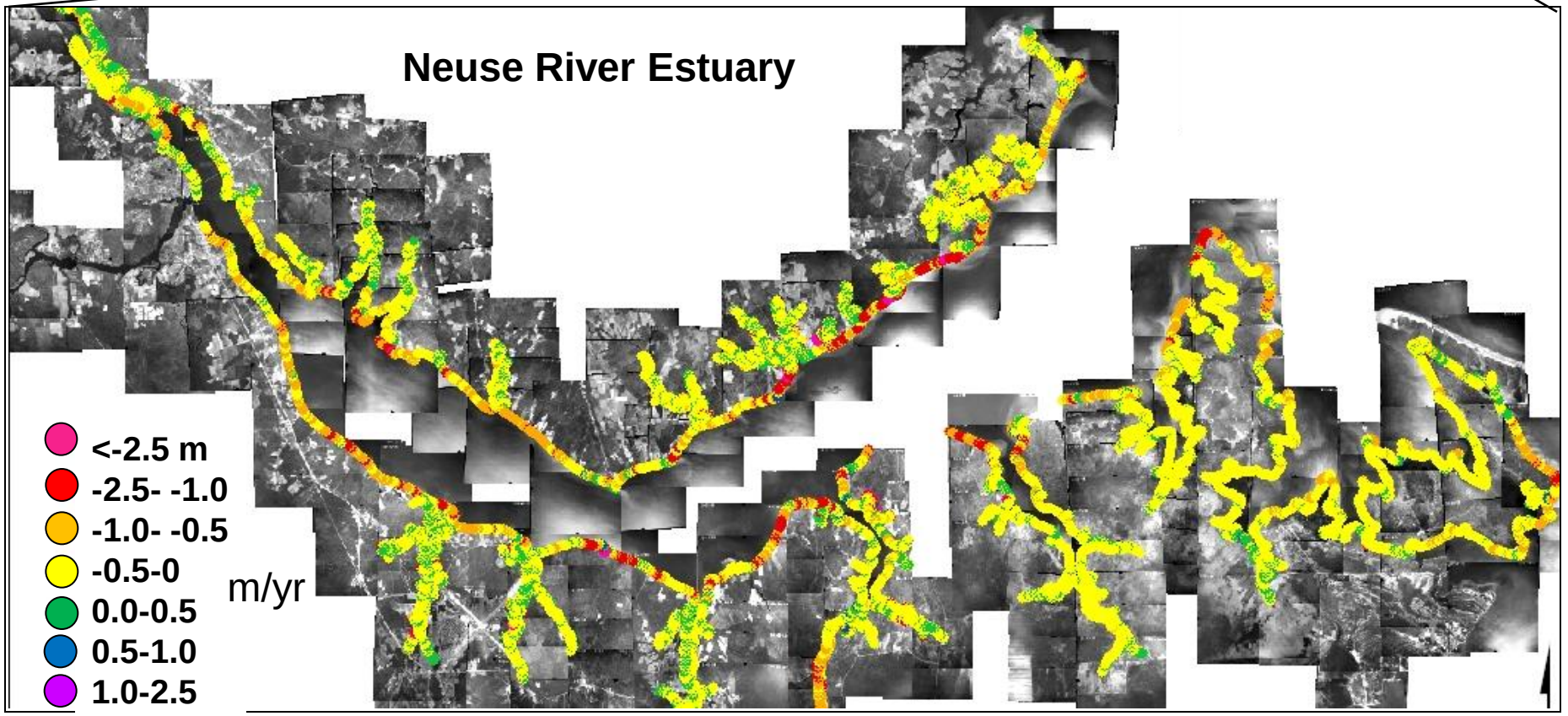
Or is wetland sedimentation a significant sink?



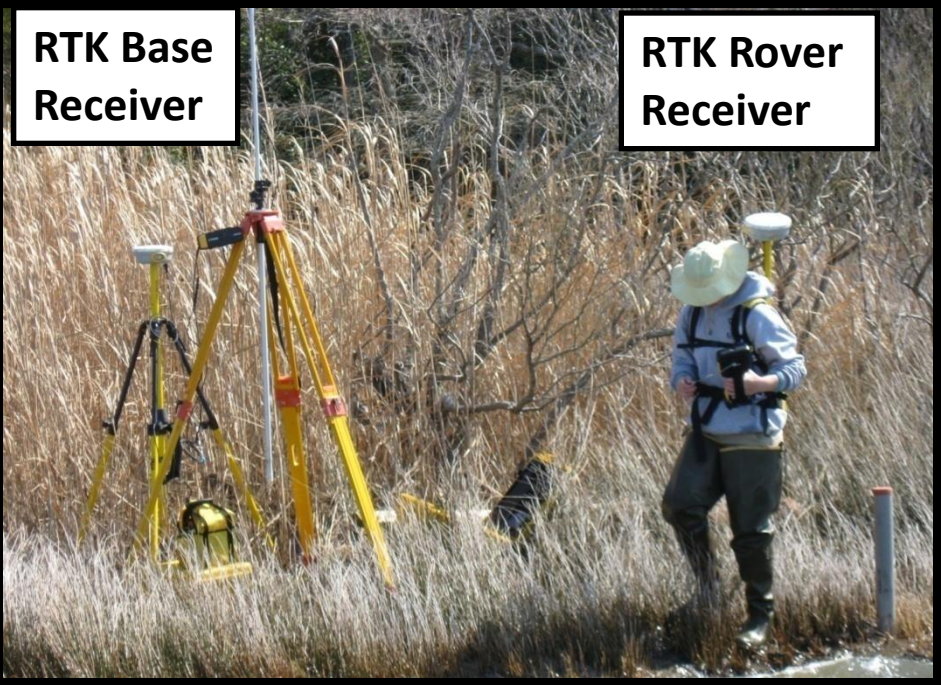
Estuarine Shoreline Erosion Rates

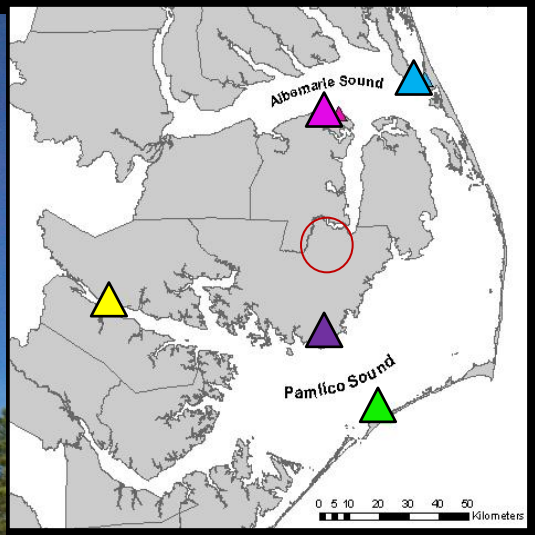
- Great variability in rates; average ~0.25 m/y
- They are large (>2 m/yr) in some locations.
- Along trunk averages about 0.6 m/yr.
- Both fetch and shoreline type appear important.





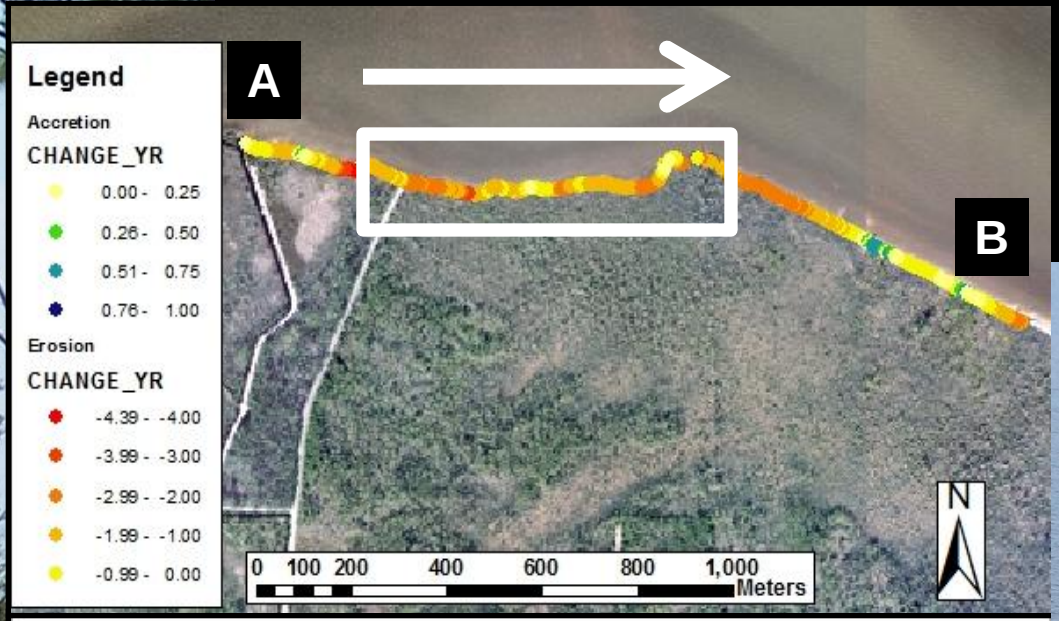
Estuarine Shoreline Change

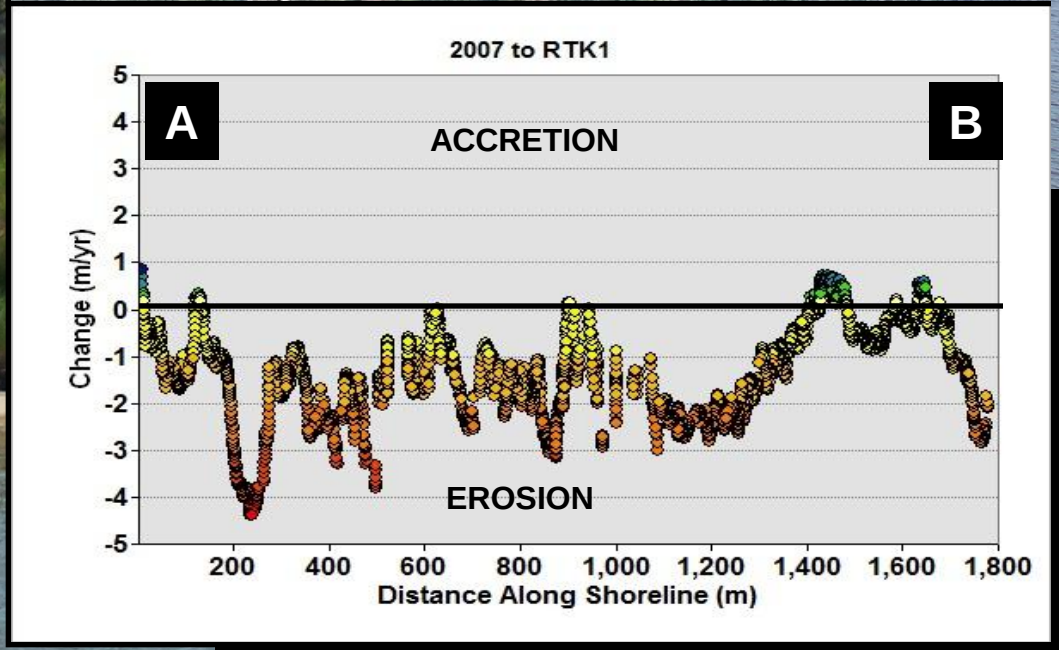




(Eulie et al., In press, L&O Methods

- Understand temporal (e.g., storms) and spatial variability
- Heads-up Digitizing
- RTK-GPS
  - Instrument: < 0.1 m
  - Survey: < 0.5 m
- Balloon Aerial Photography
- 5 sites, Every ~2 months

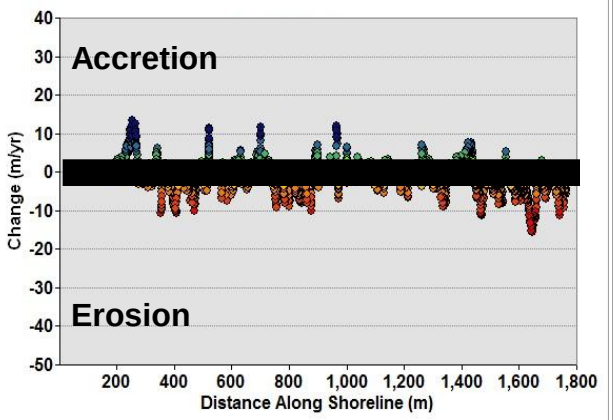

Legend
Accretion
CHANGE_YR
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 1.00
Erosion
CHANGE_YR
-4.39 - -4.00
-3.99 - -3.00
-2.99 - -2.00
-1.99 - -1.00
-0.99 - 0.00
A
B
0 100 200 400 600 800 1,000
Meters
N


2007 to RTK1
A
B
ACCRETION
EROSION
Change (m/yr)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Distance Along Shoreline (m)

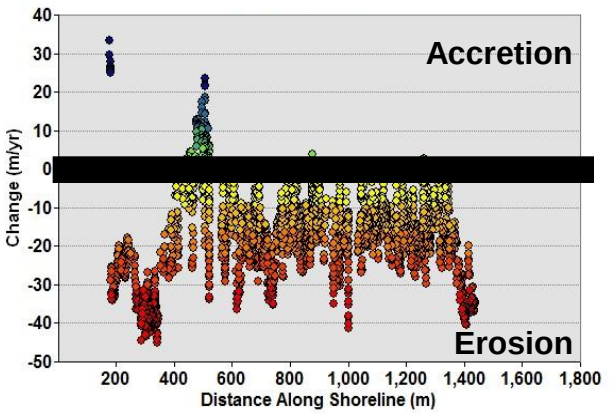
-1.4 ± 1.0 m/yr

Palmetto-Peartree Preserve (PPP)
June 2010 – January 2011

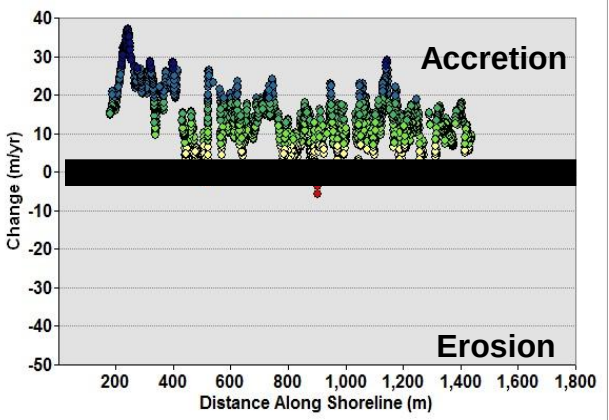
June – Aug



Aug – Oct

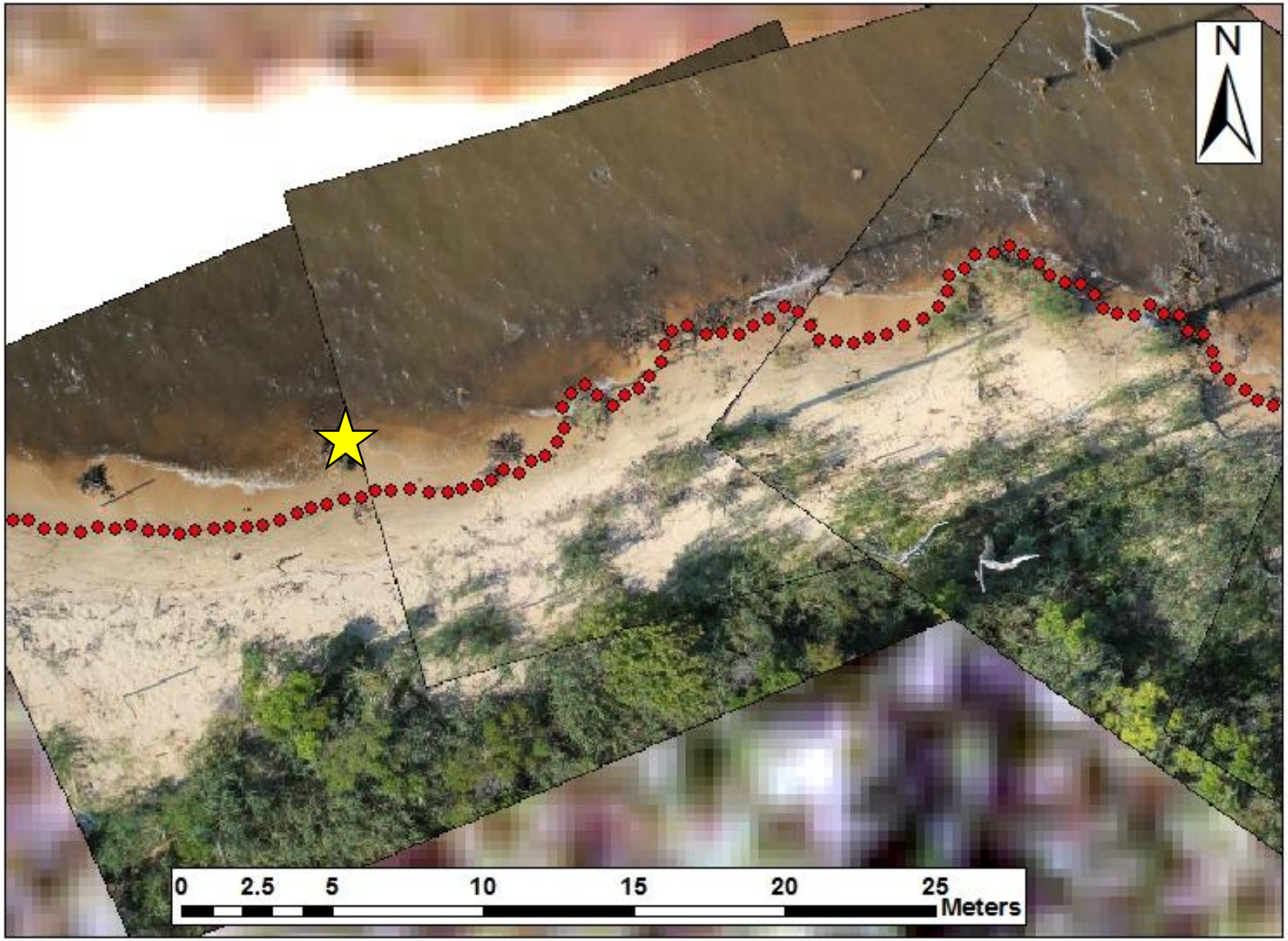


Oct – Jan

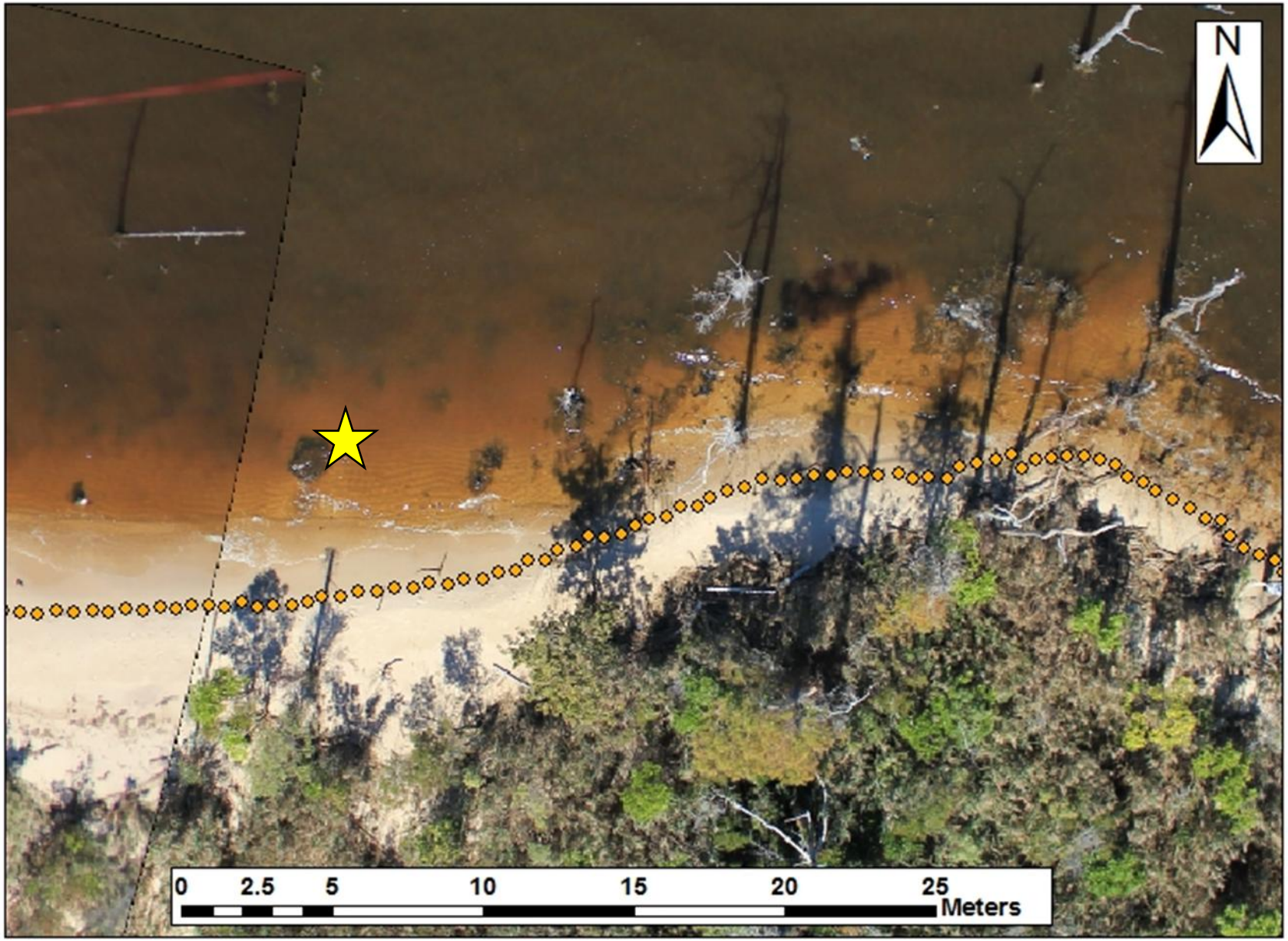


-1.4 ± 3.8 m/yr	**-17.1** ± 11.2 m/yr	**13.7** ± 7.3 m/yr
0.19 yr (2.3 mo)	0.13 yr (1.6 mo)	0.25 yr (3.0 mo)

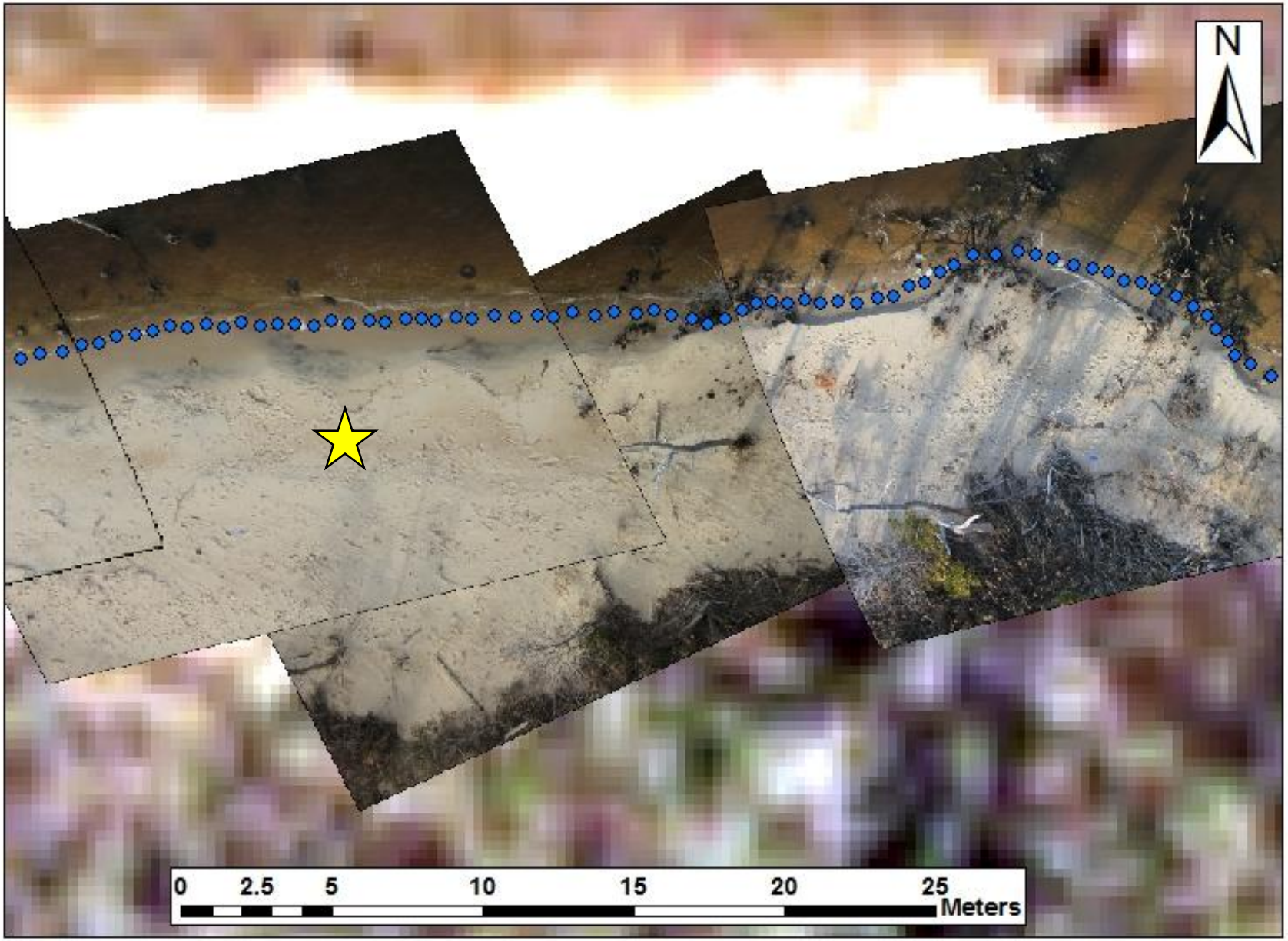
August 2010



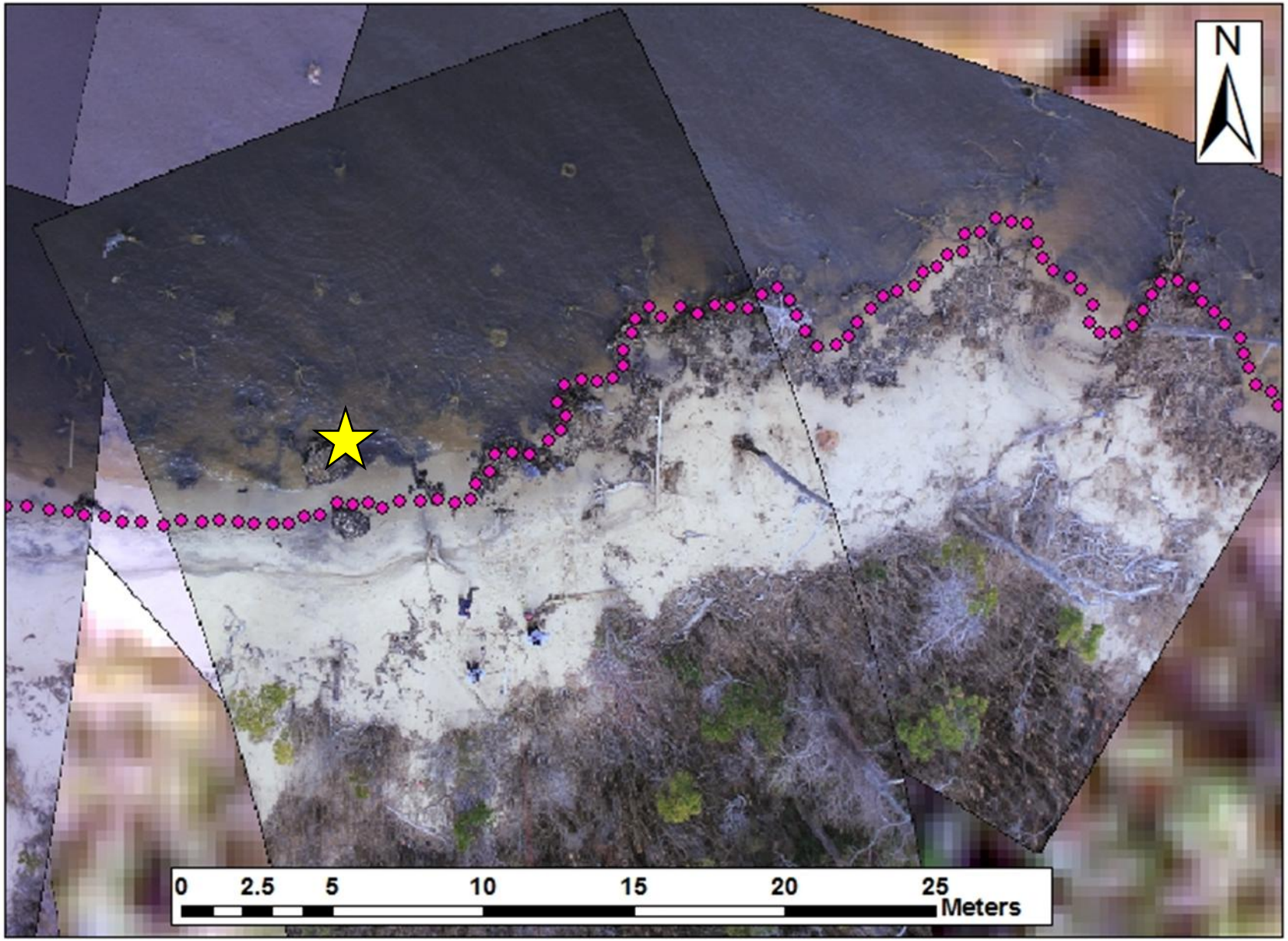
October 2010

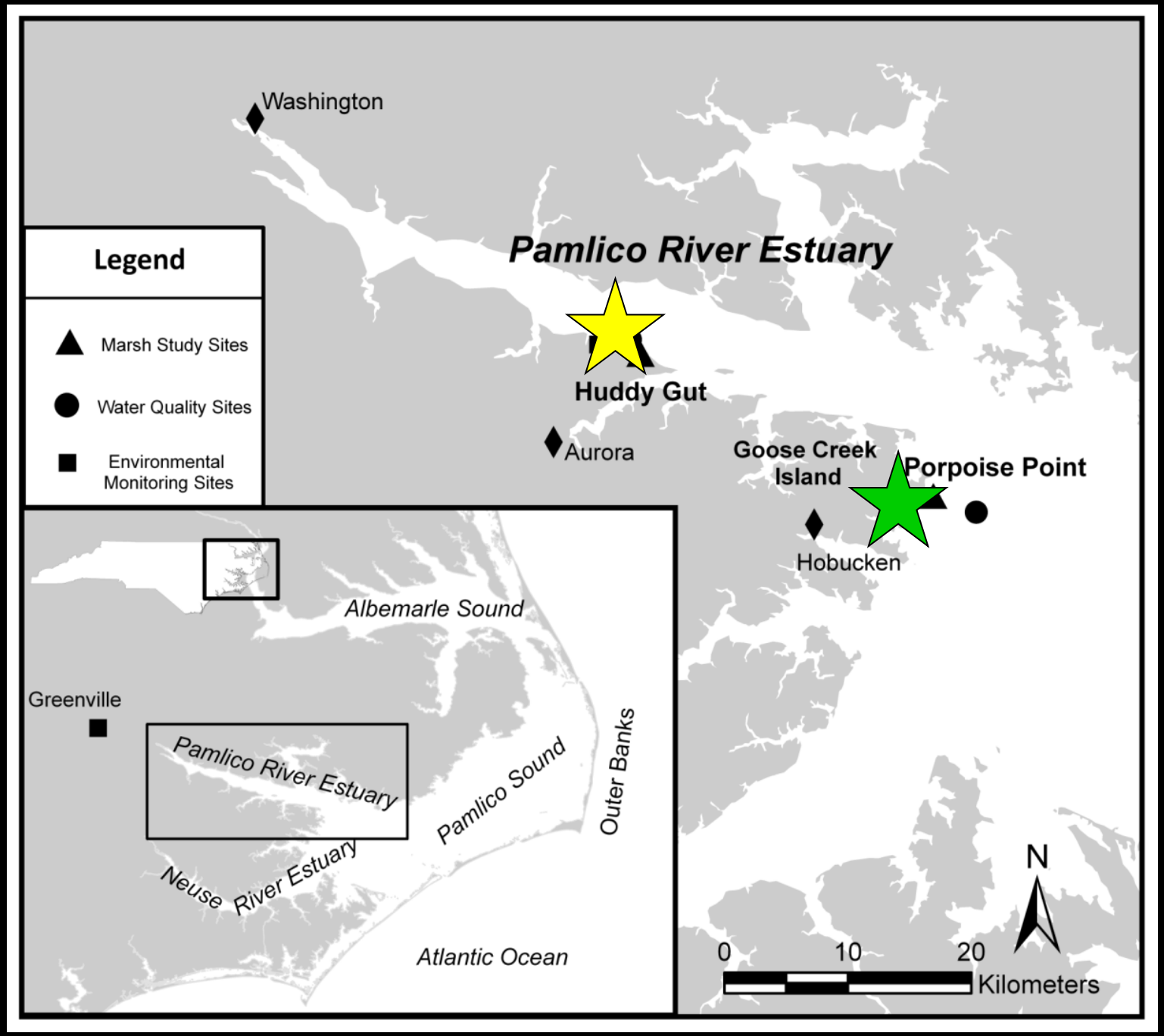


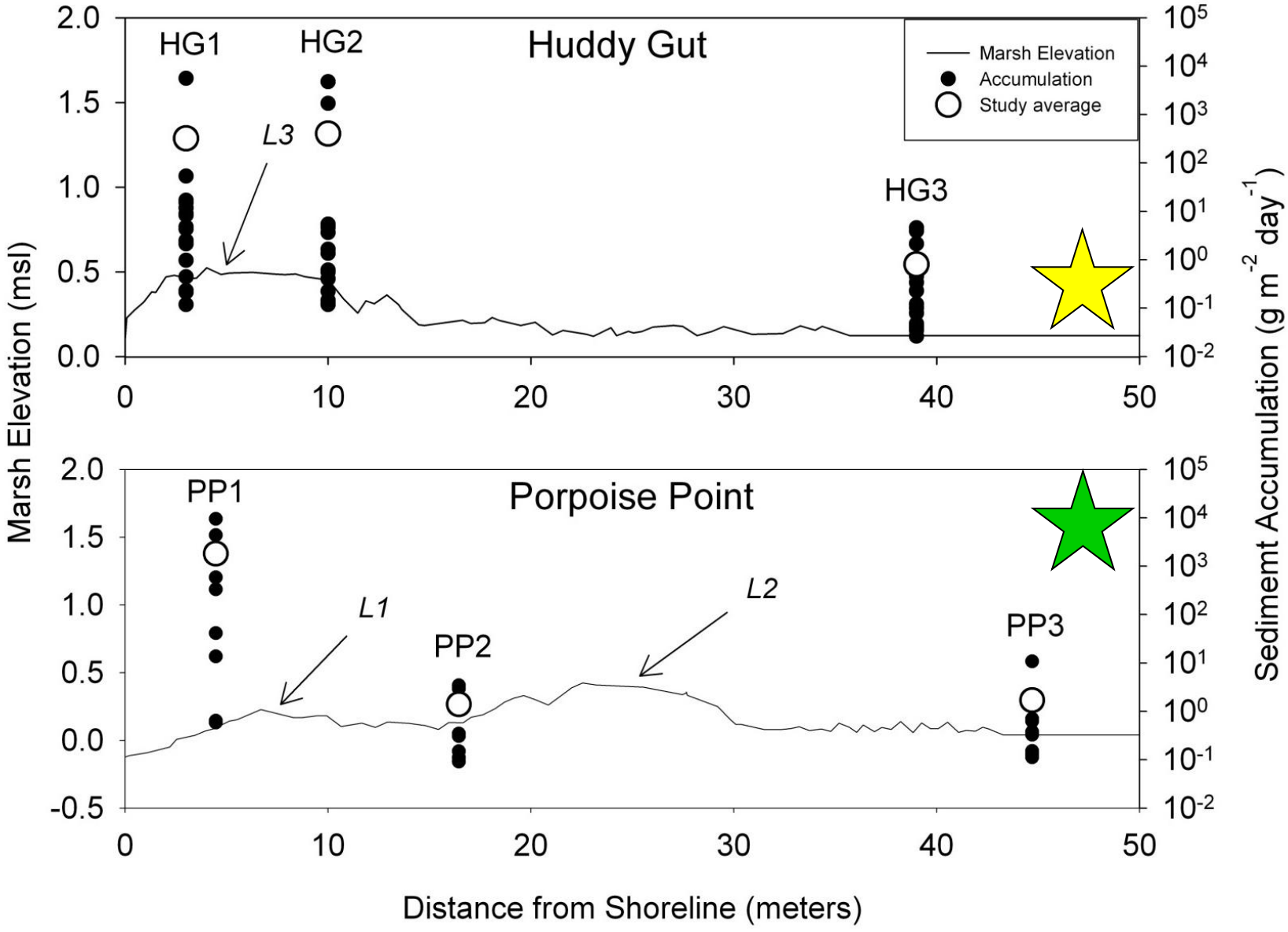
January 2011



March 2011



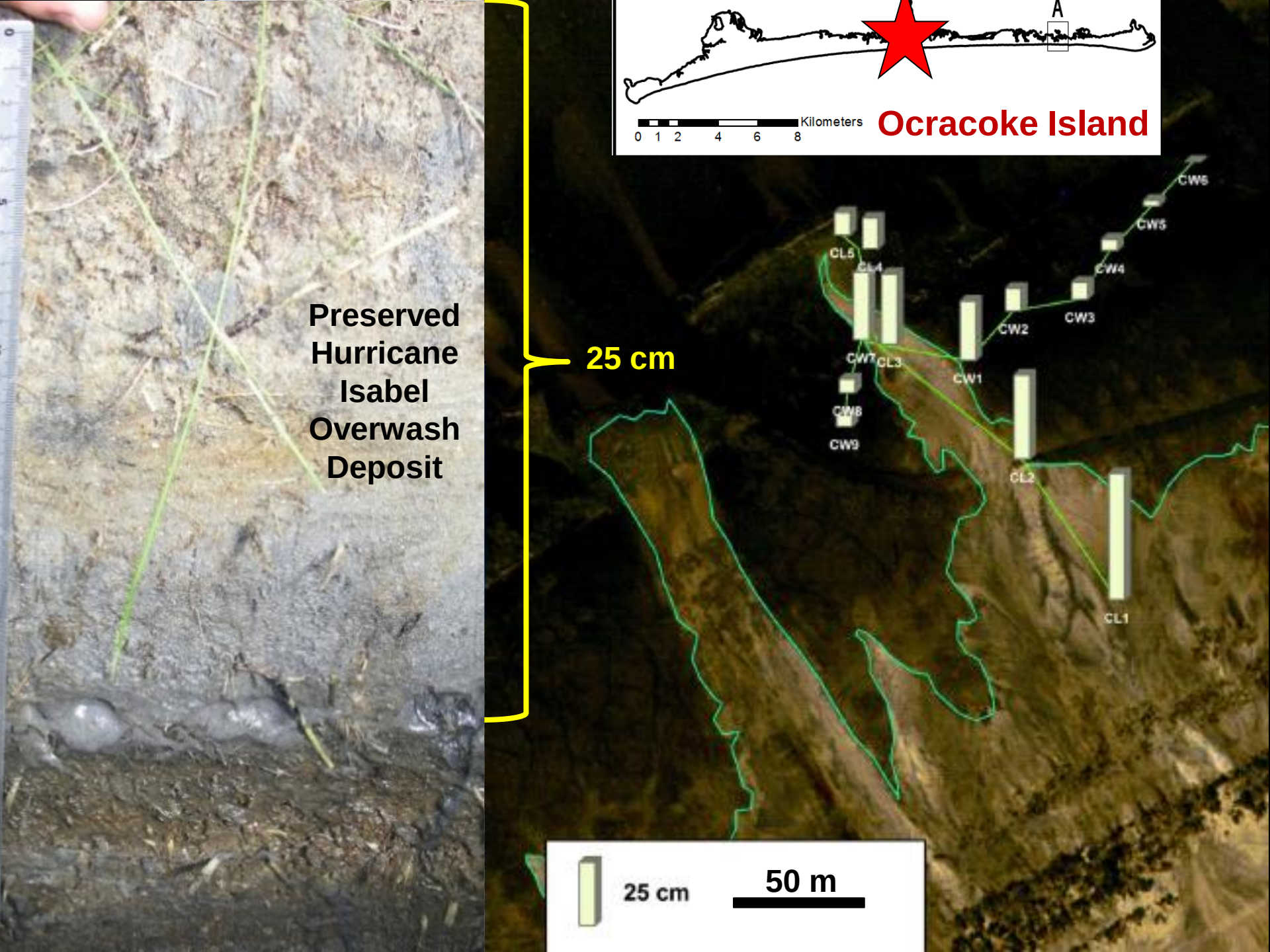

Washington
Pamlico River Estuary
Legend
Marsh Study Sites
Water Quality Sites
Environmental Monitoring Sites
Huddy Gut
Aurora
Goose Creek Island
Porpoise Point
Hobucken
Albemarle Sound
Greenville
Pamlico River Estuary
Pamlico Sound
Outer Banks
Neuse River Estuary
Atlantic Ocean
N
0
10
20
Kilometers



- **Accretionary at all sites; Higher seaward.**
- **Berm morphology had key influence sedimentation.**

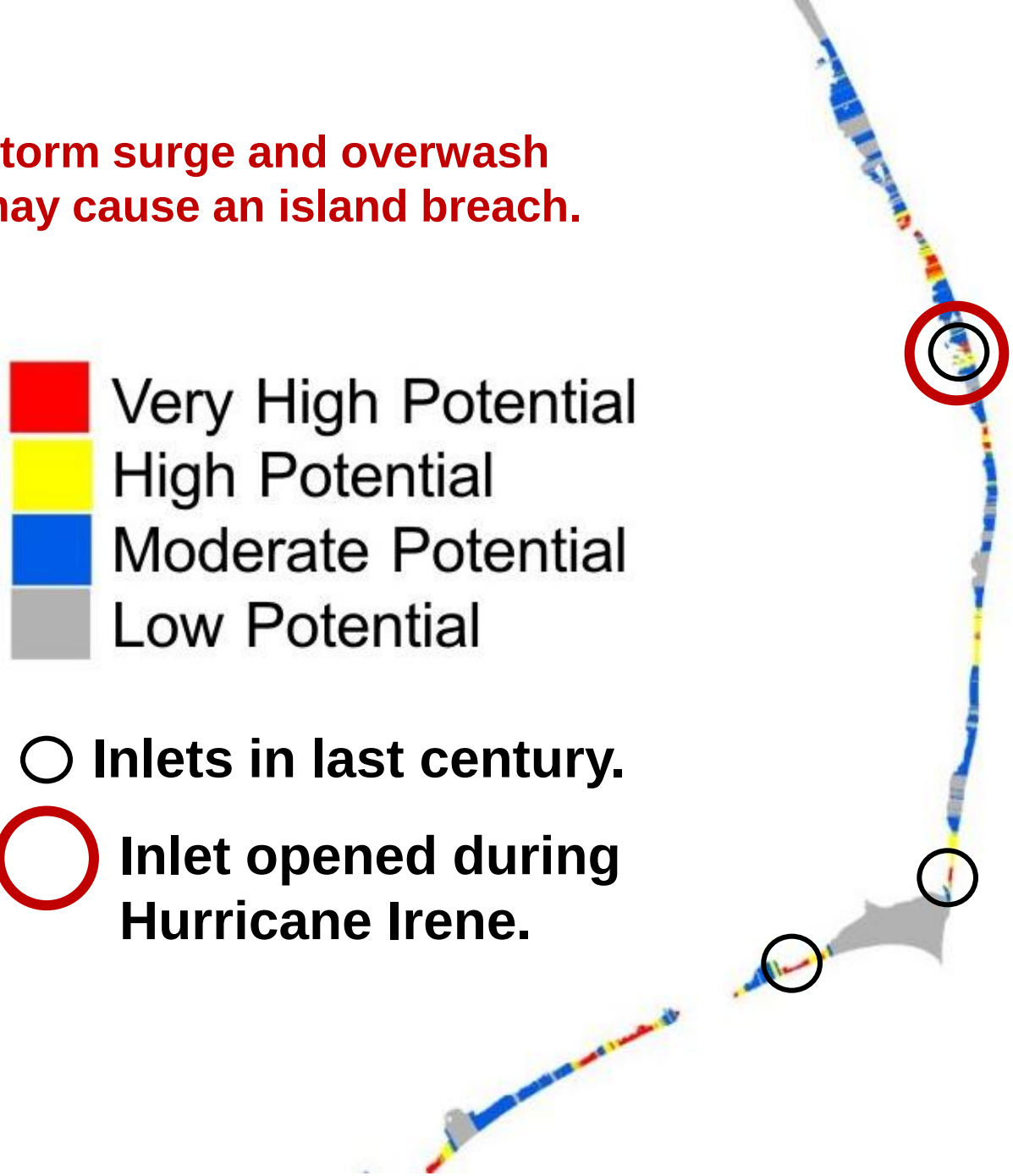
Storm Surge, Overwash and Inlet Opening

- **Influences salinity**
- **Sediment exchange**
- **Island evolution**


A
Kilometers
0 1 2 4 6 8
Ocracoke Island
CW6
CW5
CW4
CW3
CW2
CW1
CW7
CW8
CW9
CL5
CL4
CL3
CL2
CL1
Preserved
Hurricane
Isabel
Overwash
Deposit
25 cm
25 cm
50 m

- **Many historical inlet sites.**
- **Much of OBX was an inlet in the ancient past.**
- **500 years ago, OBX was far more permeable.**

Storm surge and overwash may cause an island breach.



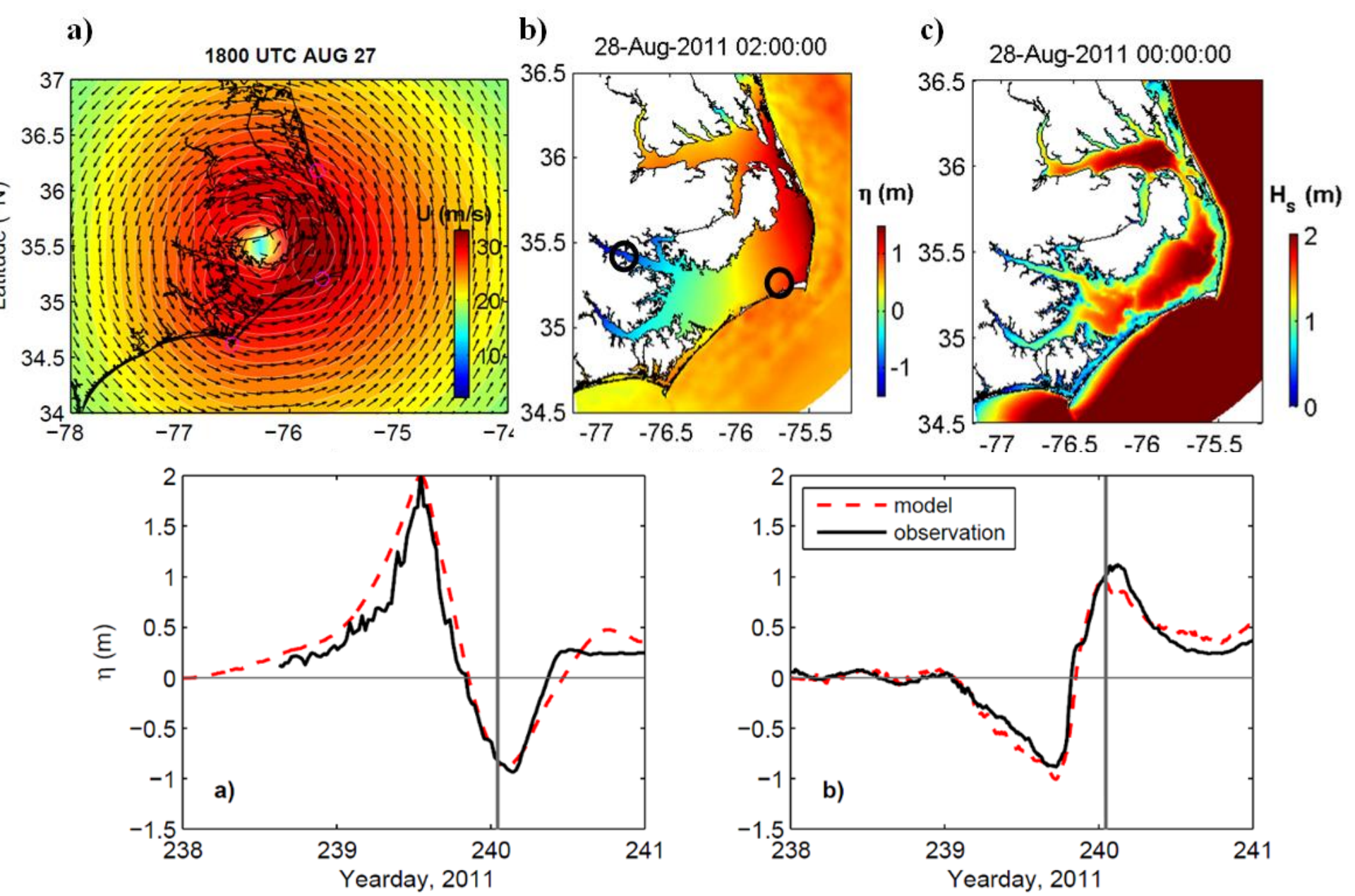
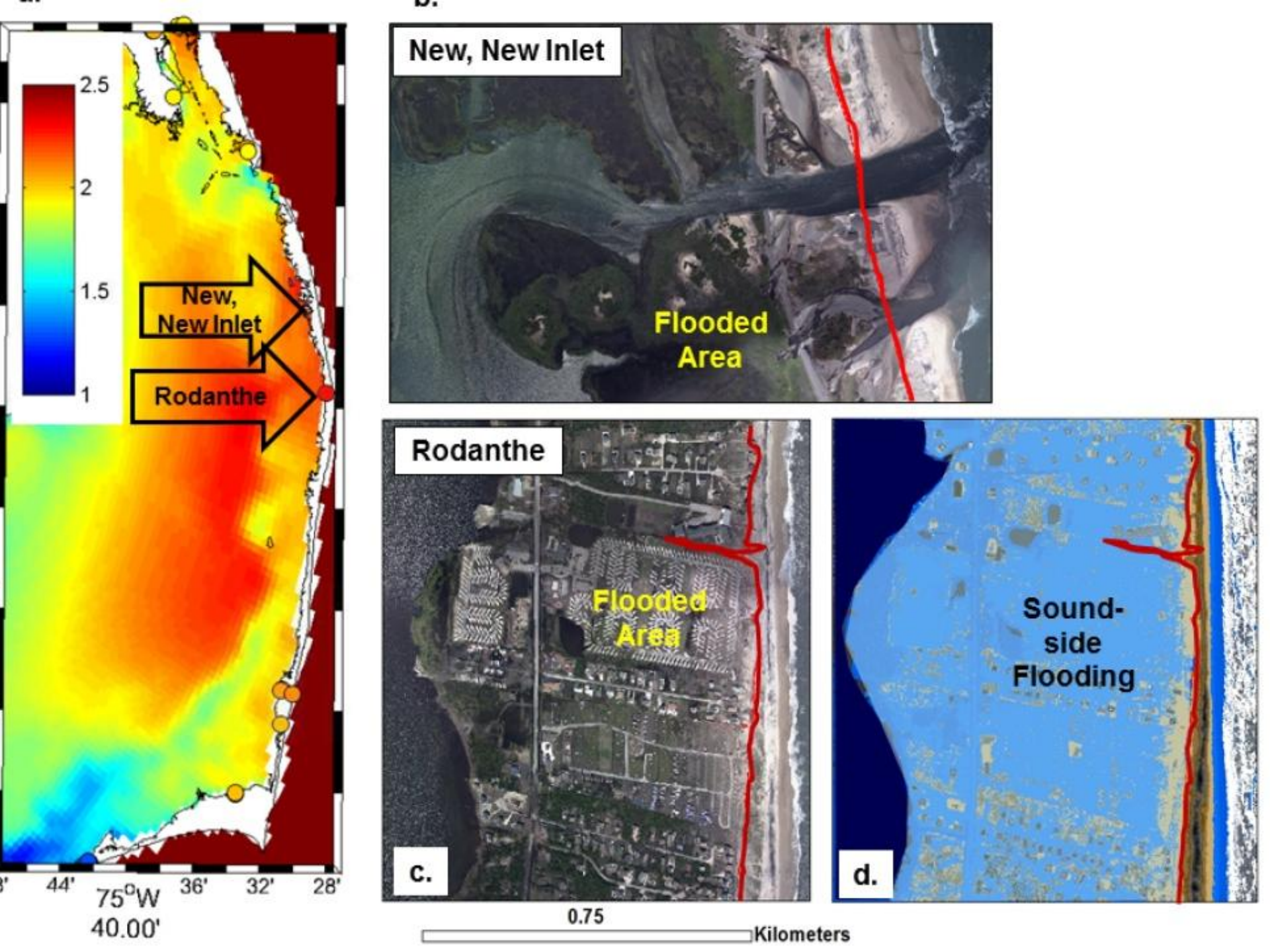


Figure 2: Time-series comparison of observed and predicted water-level displacement: a) in a tributary estuary on the western side of Pamlico Sound, and b) the eastern side of Pamlico Sound near Cape Hatteras (Stn. HCGN7, courtesy of NOAA). Vertical line indicates time of Fig. 1b. **Mulligan et al., submitted**


a.
2.5
2
1.5
1
New,
New Inlet
Rodanthe
44'
75°W
36'
32'
28'
40.00'
b.
New, New Inlet
Flooded
Area
Rodanthe
Flooded
Area
c.
Sound-
side
Flooding
d.
0.75
Kilometers

Conclusion: A Not-So-Simple Sedimentary System

- It's a complex system … just for sediment.

- Human impacts can be large, especially locally.

- land-sea interactions are diverse and will change