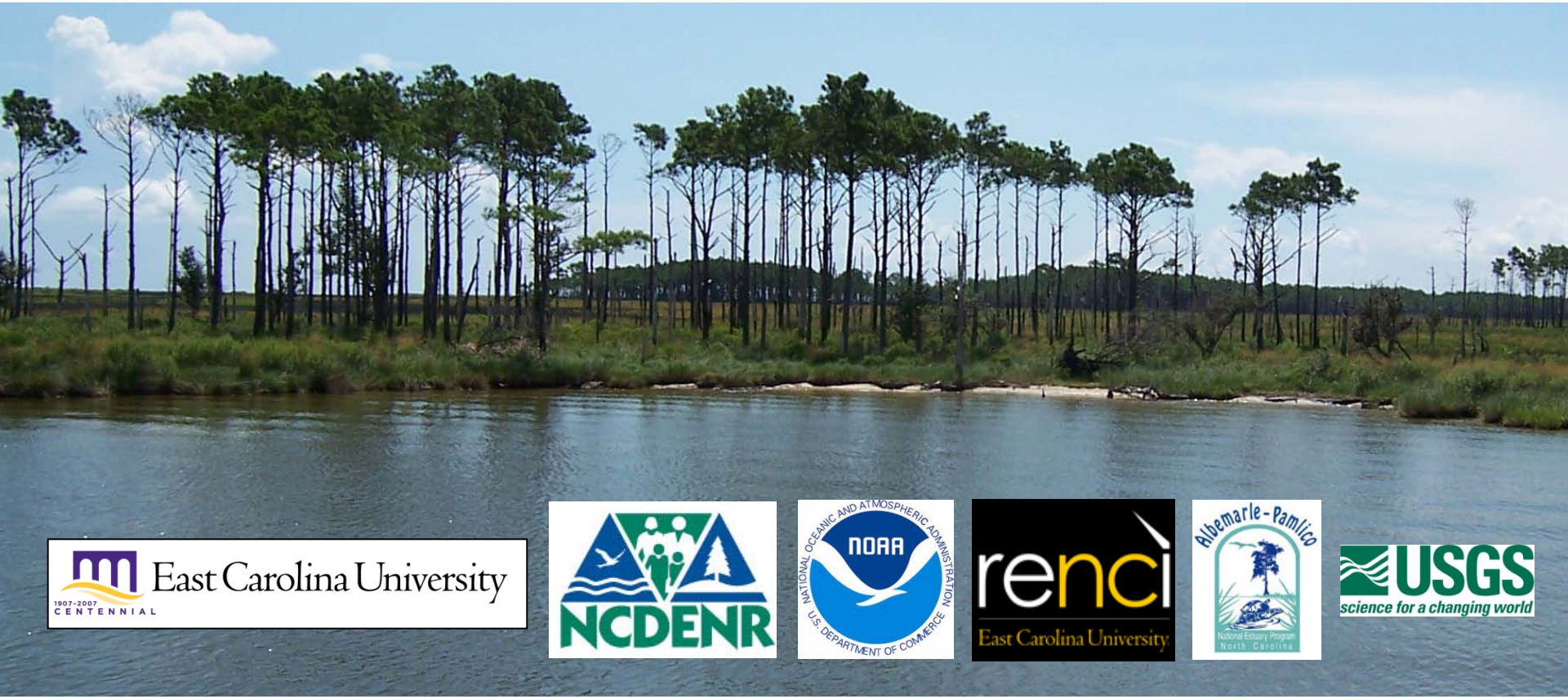
The Complex and Dynamic Nature of the North Carolina Estuarine Shoreline



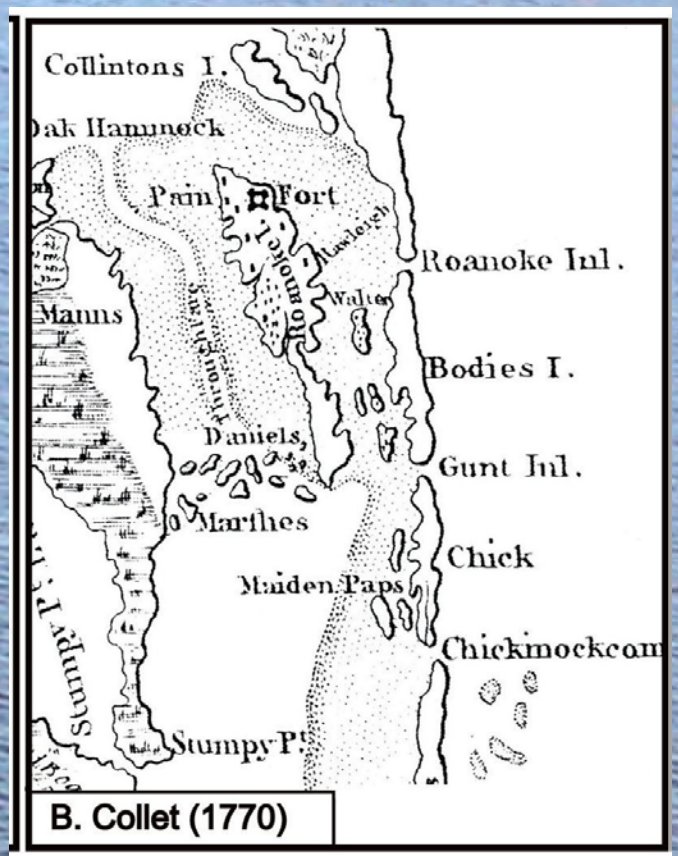
Walsh, J.P.[1], Corbett, D.R.[1], Eulie, D.[1], Geis, S[2], Mulligan, R., Burgess, B.[1], Elkins, S[1], Rouse, W.[1], Thornton, E. [1], Burns, R. [1], Balbuena, S.[1]

[1]Department of Geological Sciences and the Institute for Coastal Science & Policy, East Carolina University, Greenville, NC 27858

[2]NC Division of Coastal Management, Raleigh, NC 27699-1638

[3]Engineering, Queens University

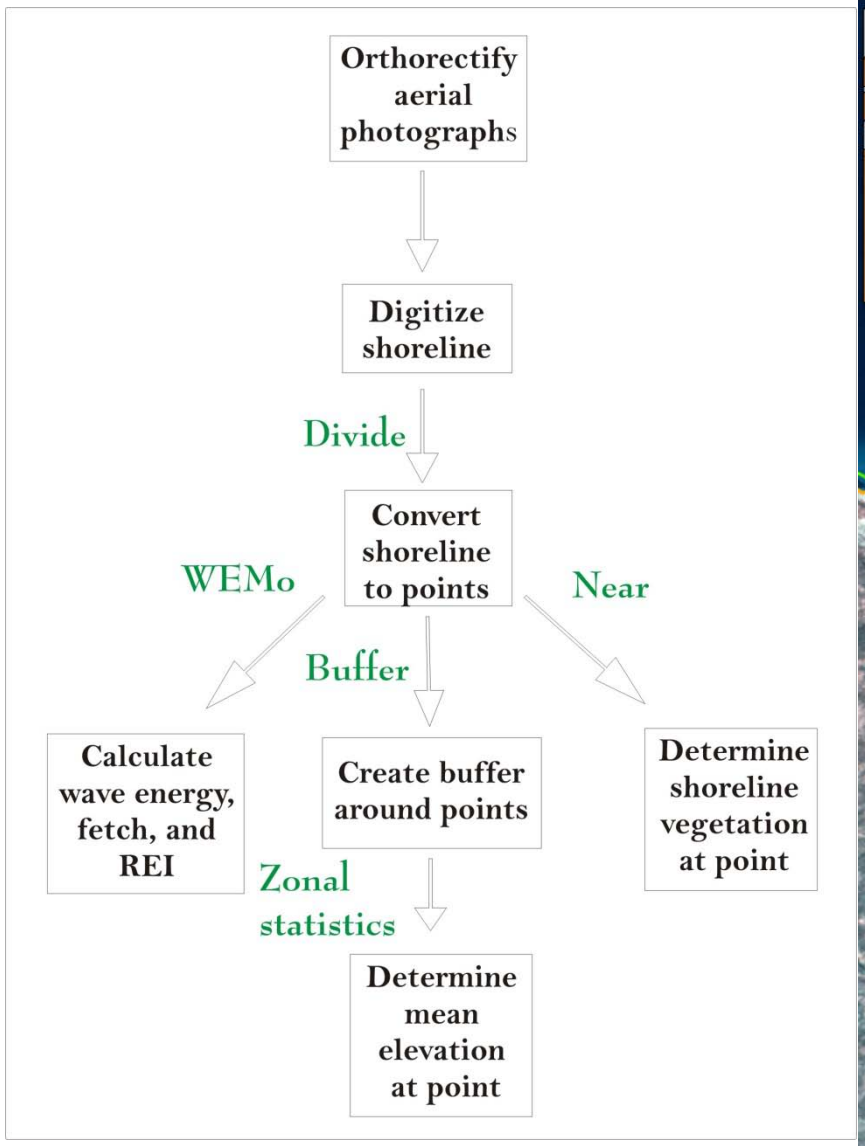
Estuaries

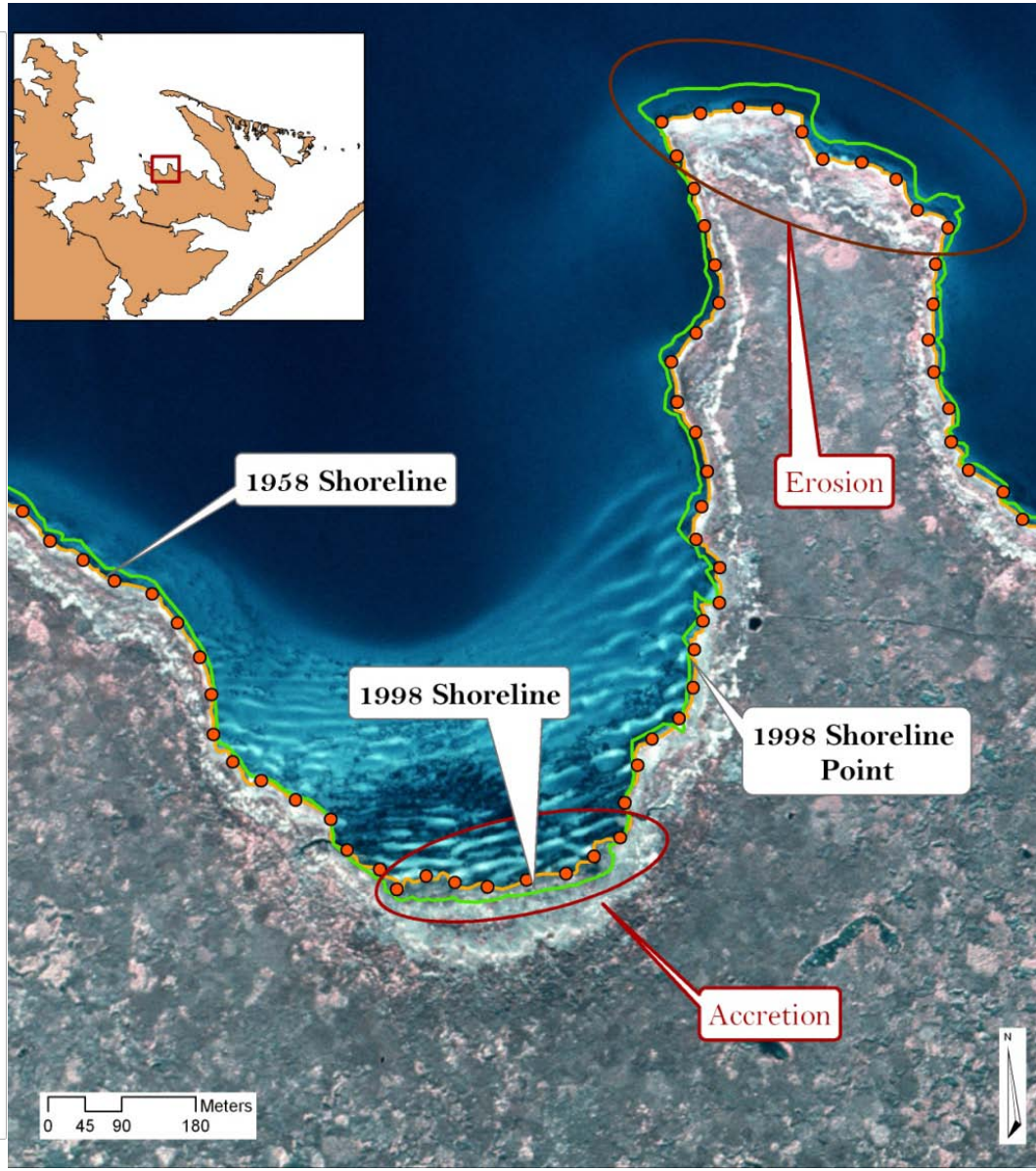


Critical habitats
Key resources
Experiencing change
(Riggs & Ames, 2003)

NOAA Project - Quantifying Shoreline Change

Cowart et al., 2009

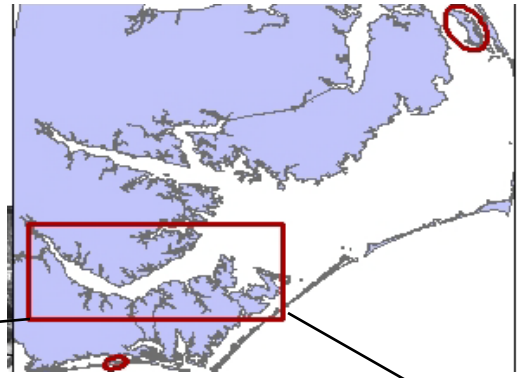


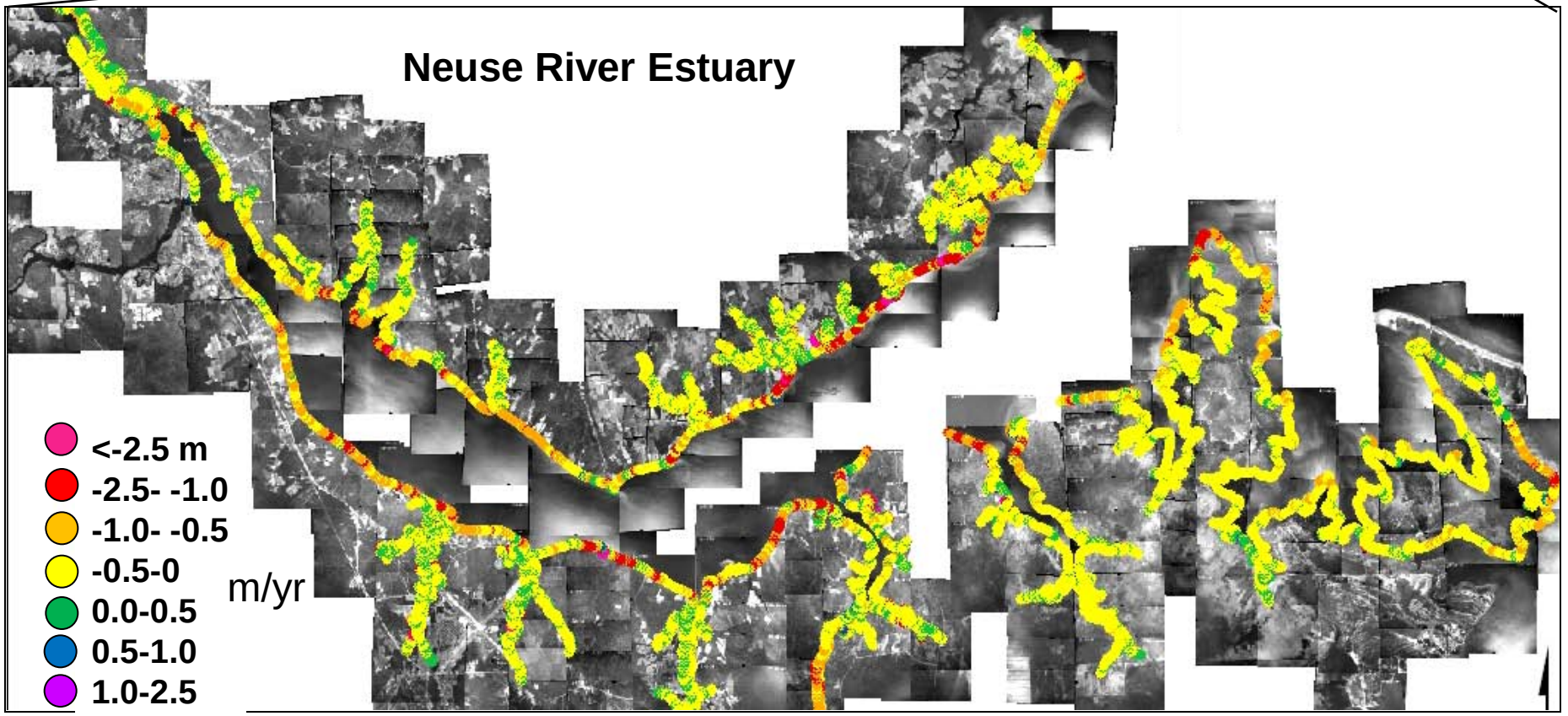


Estuarine Shoreline Erosion Rates

- **Great variability in rates, some large (>2 m/yr)**
- **Average ~0.25 m/y, ~0.6 m/yr along trunk**
- **Function of fetch (wave energy) and shore type**

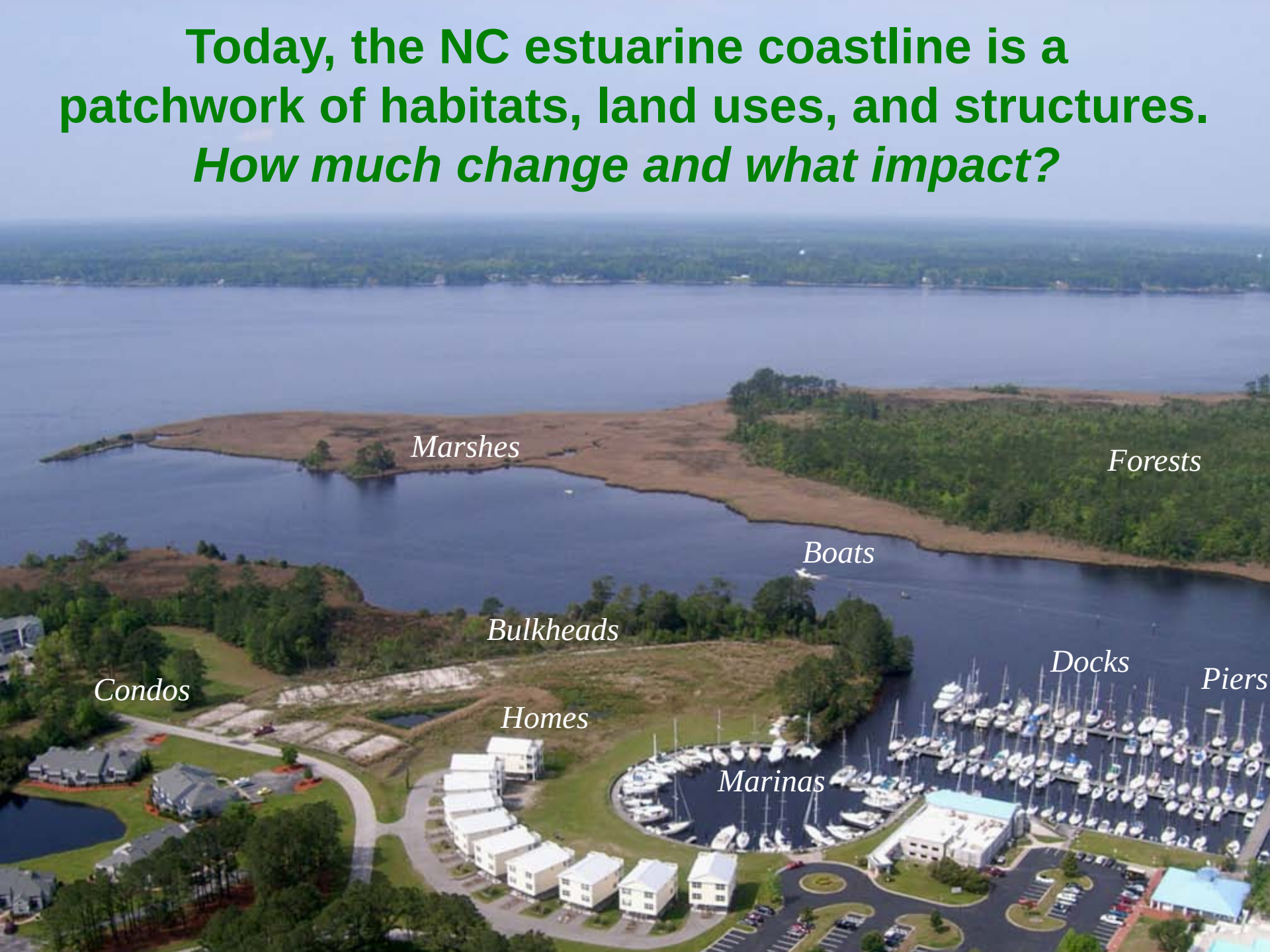
(Cowart, 2009; Cowart et al., 2009; Cowart et al., submitted)





Today, the NC estuarine coastline is a patchwork of habitats, land uses, and structures.

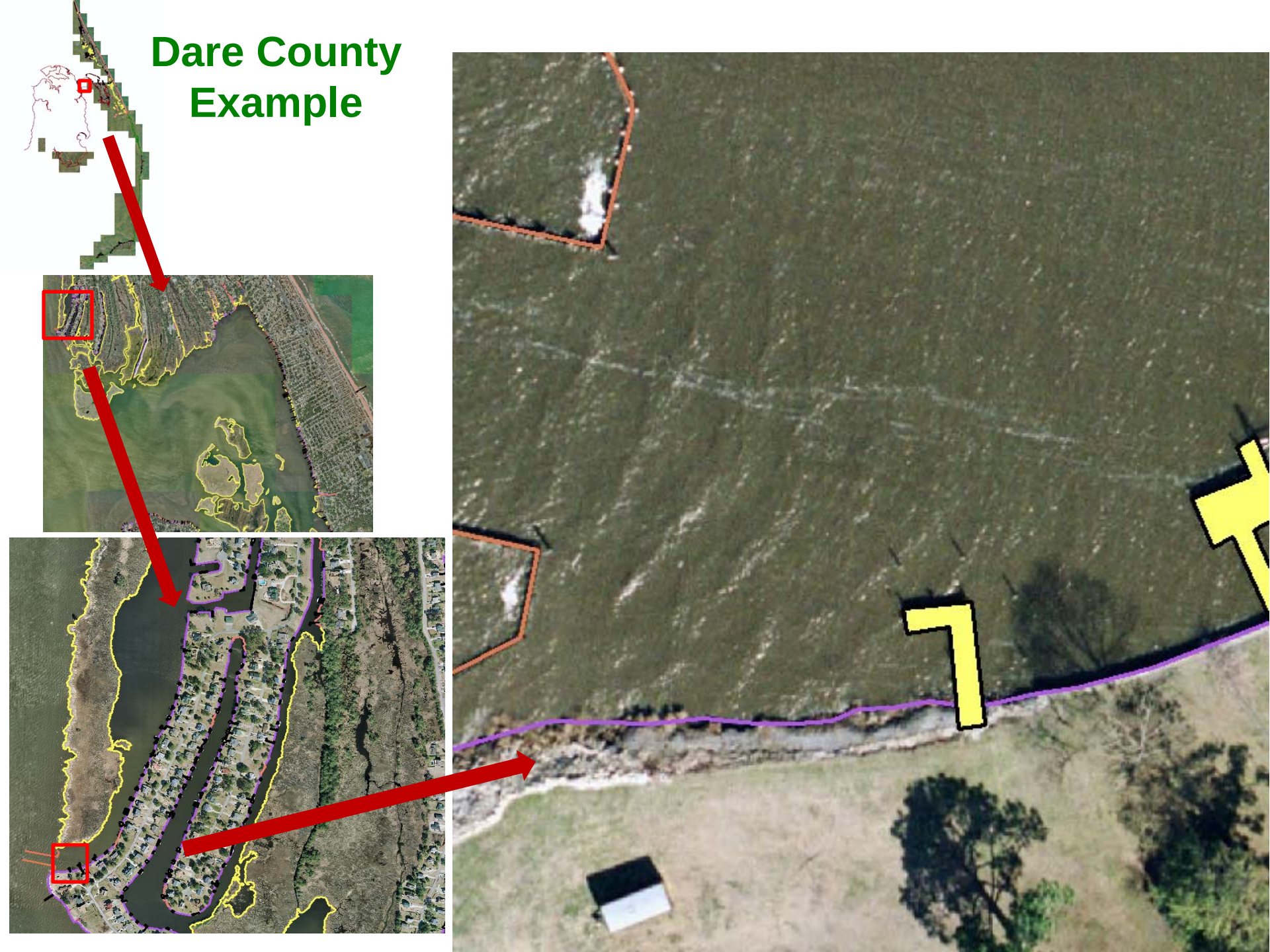
How much change and what impact?



NC DCM Project – Mapping the State

- **Baseline character of shoreline**
- **Heads-up Digitizing (Geis and Bendell, NCDCM, 2008)**
- **1:300-500 scale; Up to 20 ft stream width**

Dare County Example



GIS Data Obtained

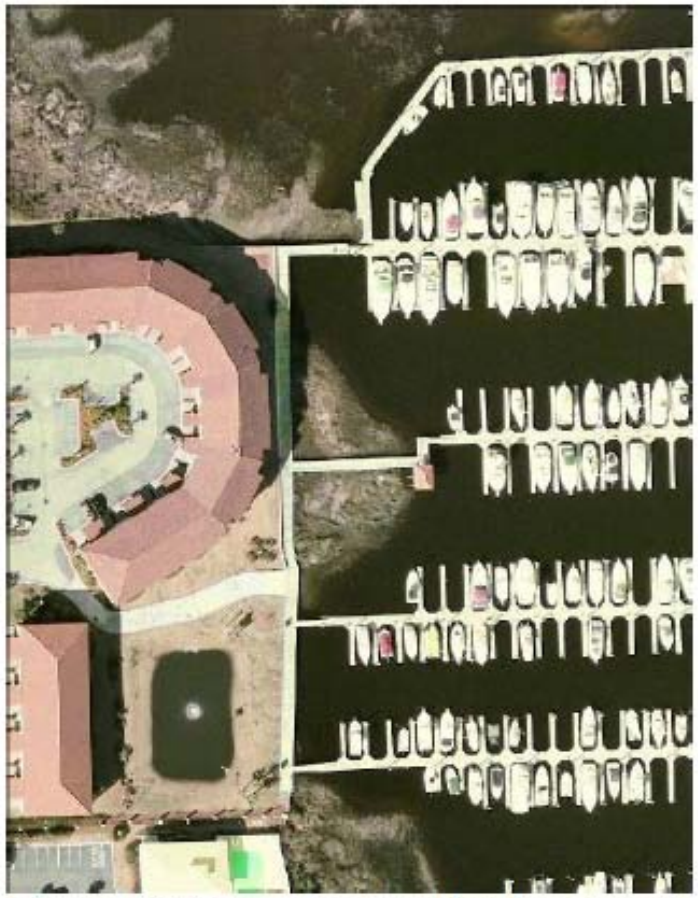
- **Shoreline position and type**
  - **Marsh**
  - **Swamp forest**
  - **Sediment bank**
  - **Modified with engineered structure**
  - **Miscellaneous**

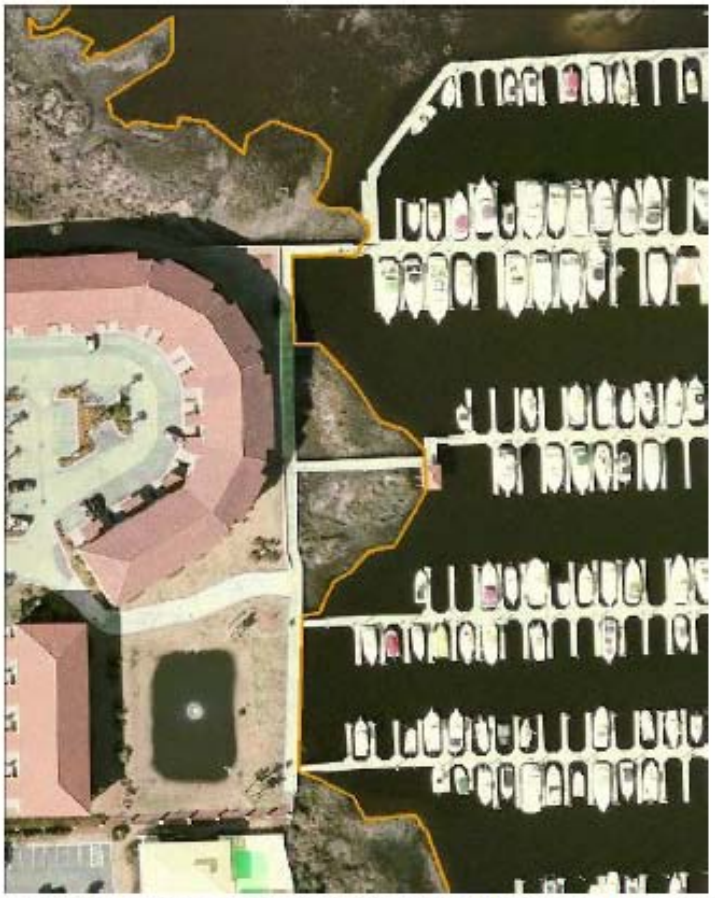
- **Line Structures**
  - **Vertical structures (bulkheads)**
  - **Breakwaters**
  - **Groins and jetties**
  - **Sloped structures**
  - **Sills**

- **Polygon Structures**
  - **Boat ramps**
  - **Bridges**
  - **Piers, floading docks and wharfs**

Rules and Training

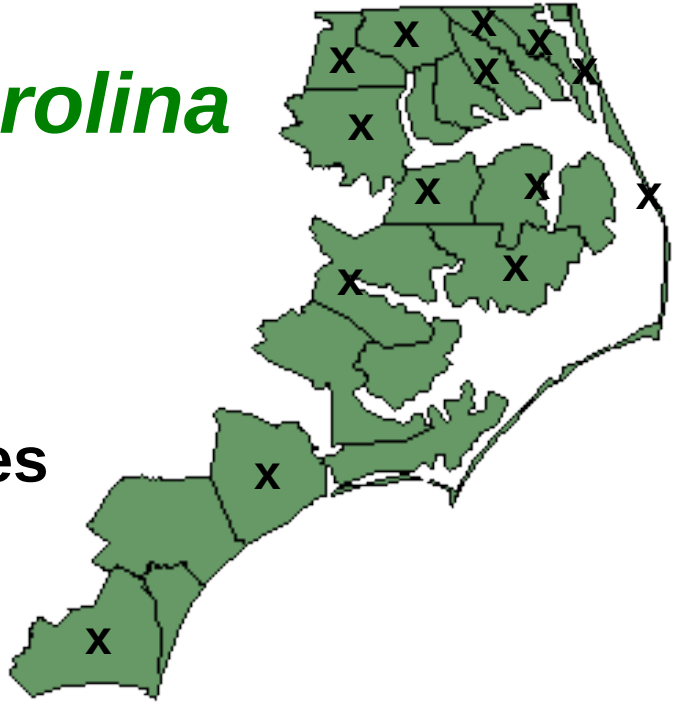
- **Detailed manual (Geis and Bendell, NCDCM, 2008)**
- **Specific rules for problem areas**
- **Training exercise**
- **Digitizer test**





Mapping Coastal North Carolina

- **20 Coastal Counties, ~16,000 km**
- **Already digitized about 14**
- **Interesting, invaluable dataset**
- **Many management & research uses**



APES Data without southernmost counties…

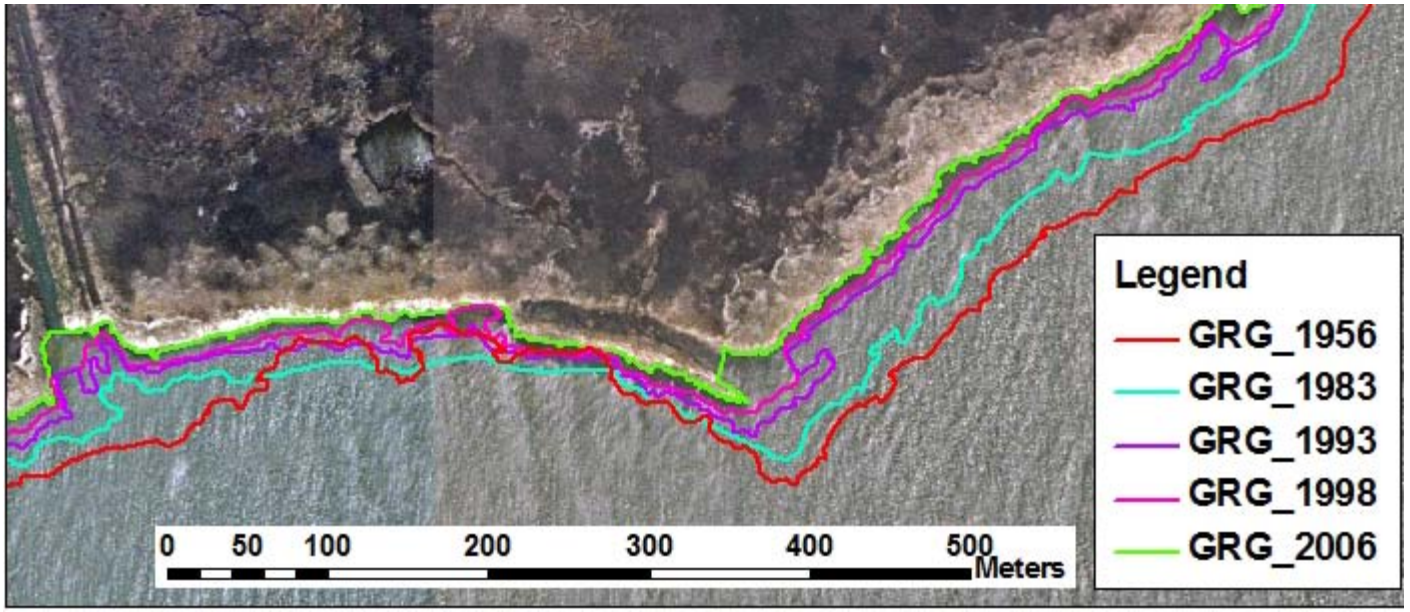
	Swamp Forest	Marsh	Sediment Bank	Modified***	Total	Structures****
Totals (km)	1746	4281	1318	538	7883	9852
Totals (%)	22	54	17	7	100	

***This includes any engineered shorelines such as bulkheads, rip-rap, and seawall

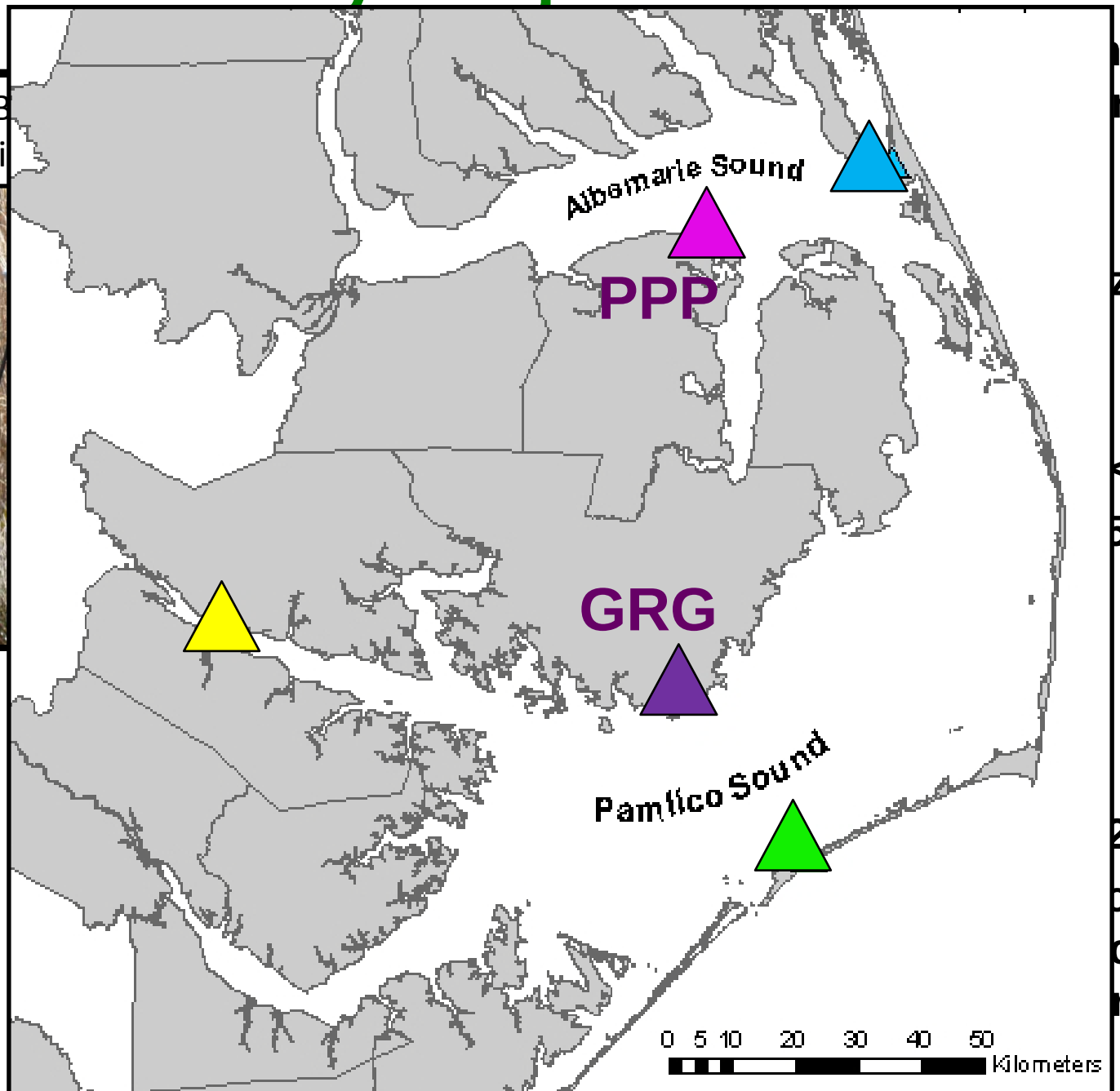
****Structures may include bridges, piers, docks, floating docks, wharves, duck blinds, and boat houses

Possible Research and Management Uses

- Map shoreline erosion
- Evaluate storm losses or hazards
- Determine coastal development rates and patterns
- Evaluate permitting trends
- Assess habitat impacts
  - Compare CDAITS with time-series SAV mapping



APNEP Study - Objectives and Methods



poral
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< 0.1 m
5 m

2 months:
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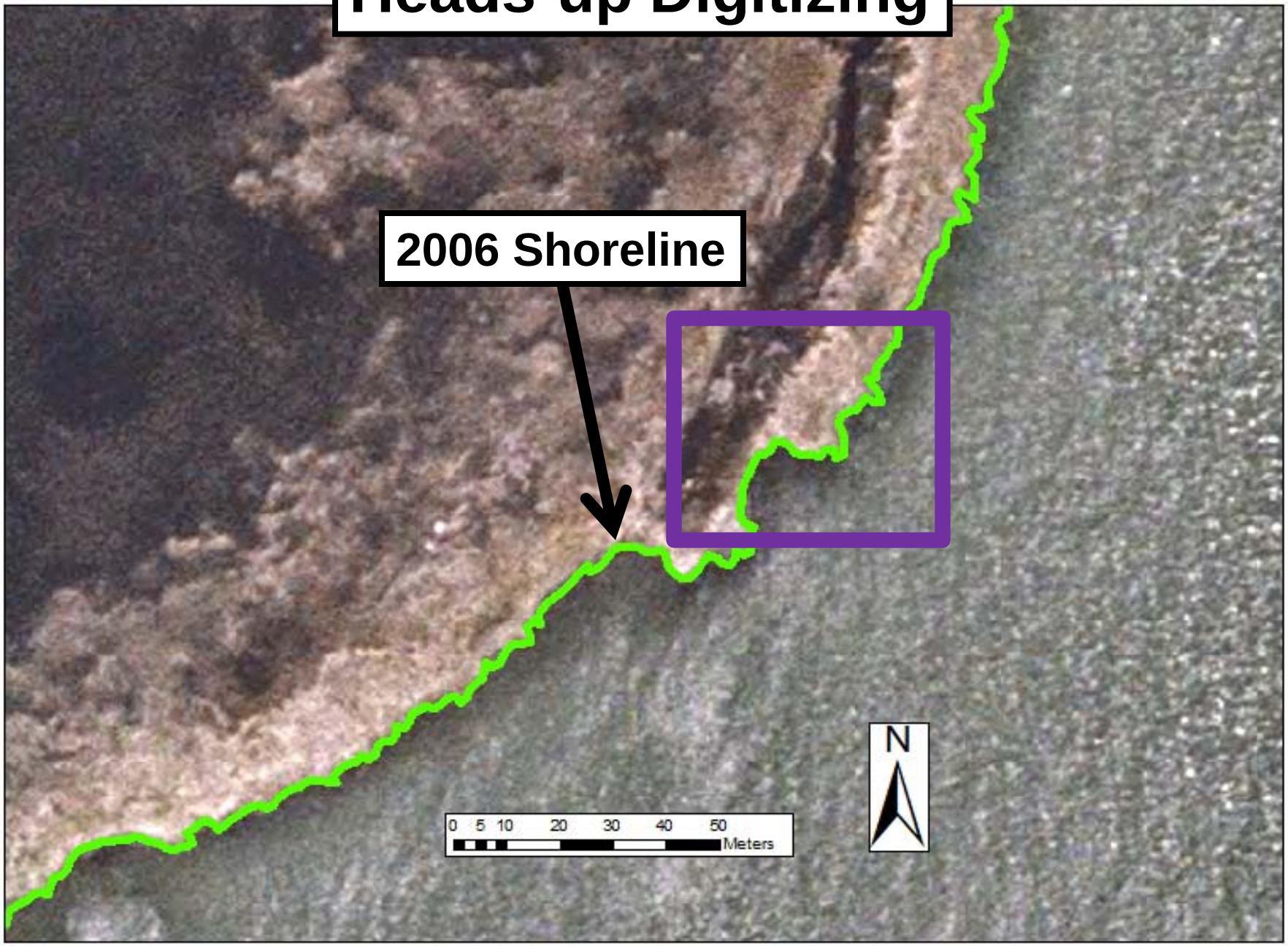
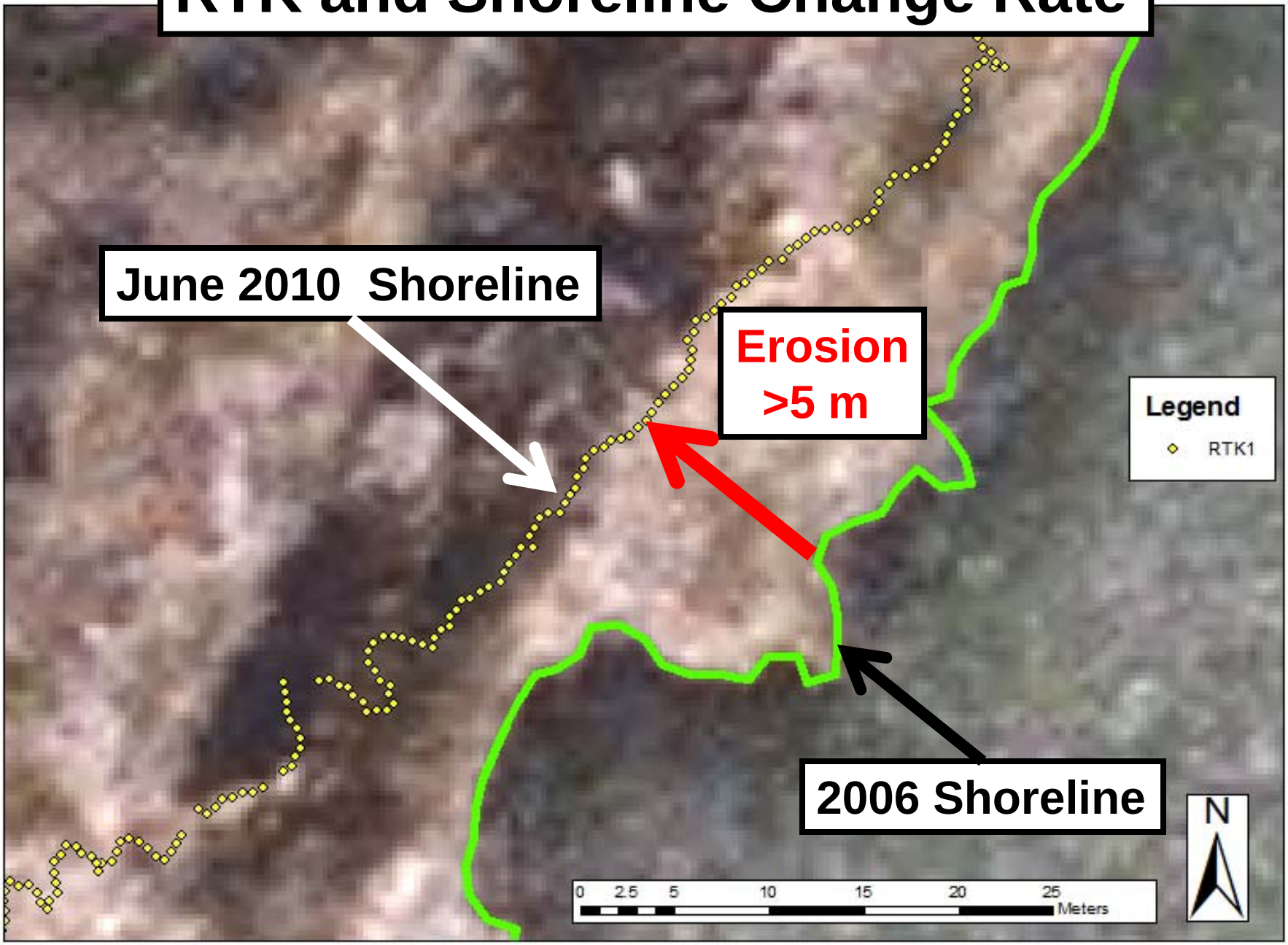
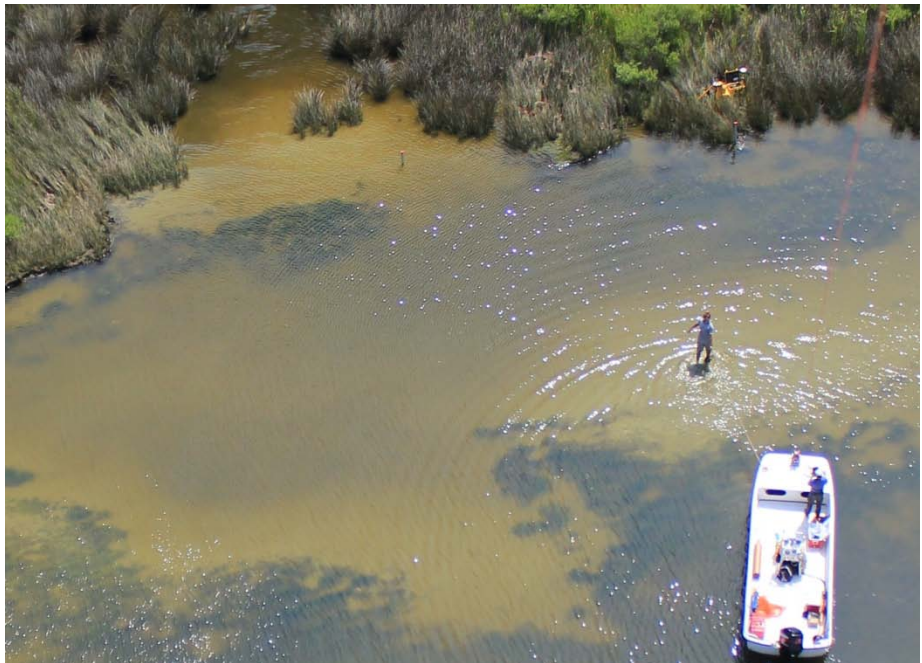
Heads-up Digitizing



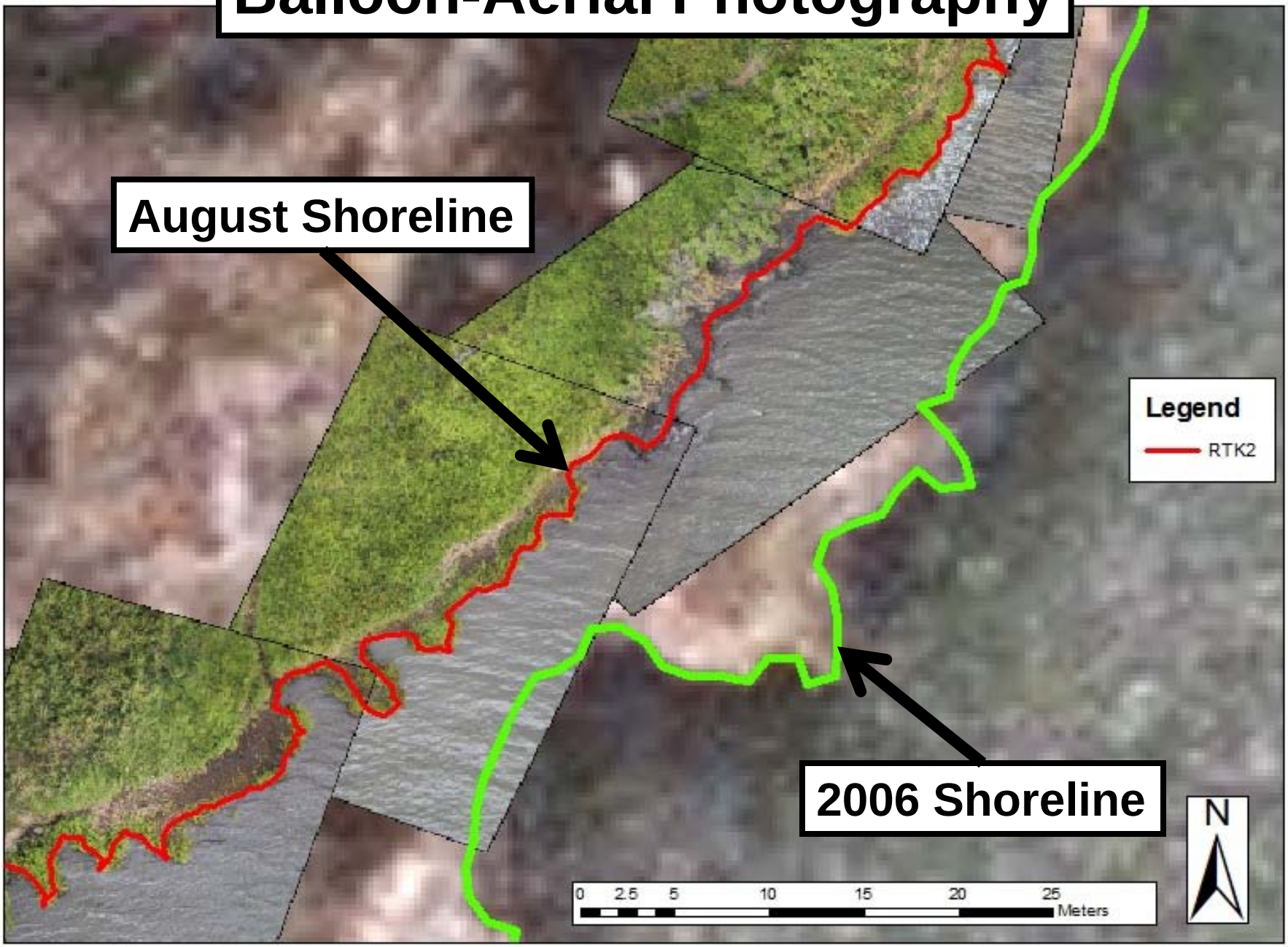
RTK and Shoreline Change Rate

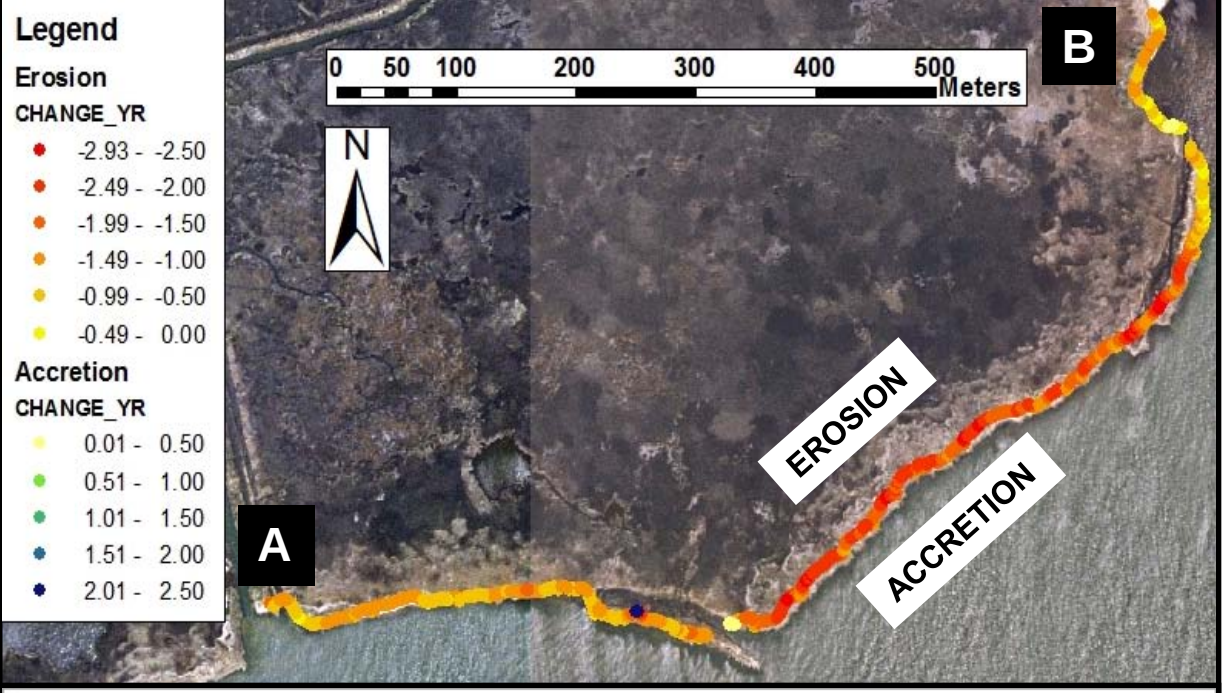


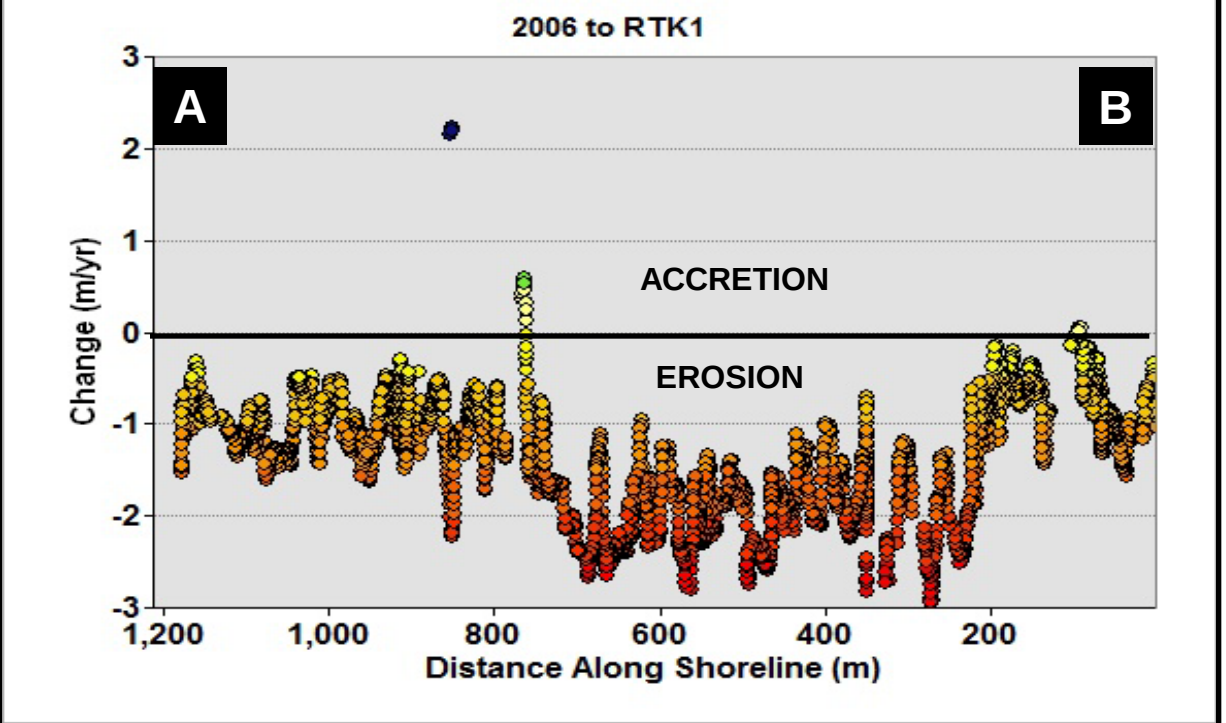
Balloon-Aerial Photography



Balloon-Aerial Photography







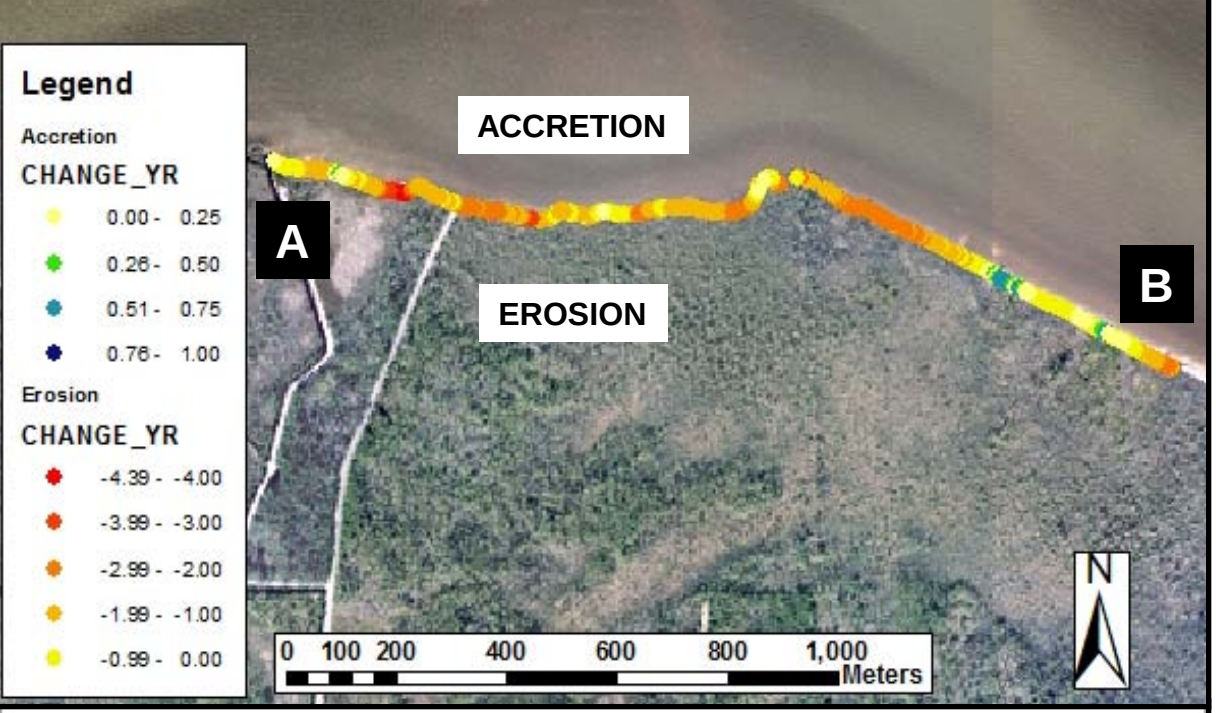
Gull Rock Game Land (GRG) 2006 to June 2010

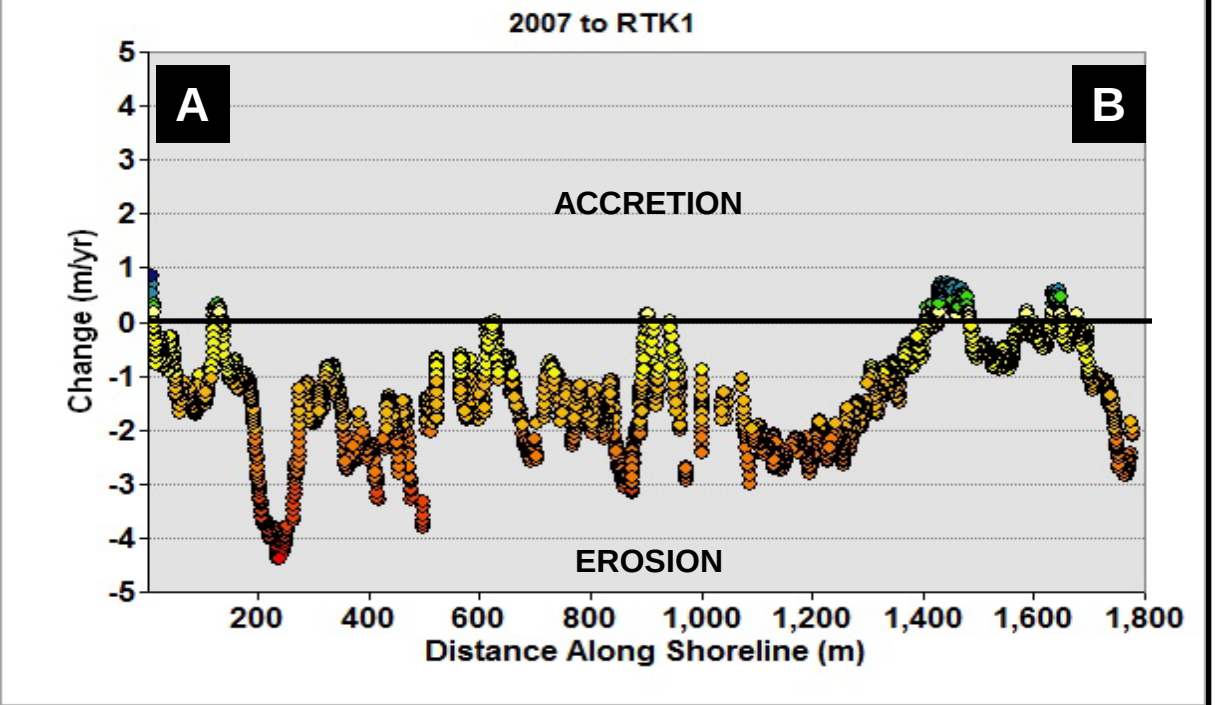
-1.3 ± 0.6 m/yr

Water

Land

Palmetto-Peartree Preserve (PPP) 2007 to June 2010

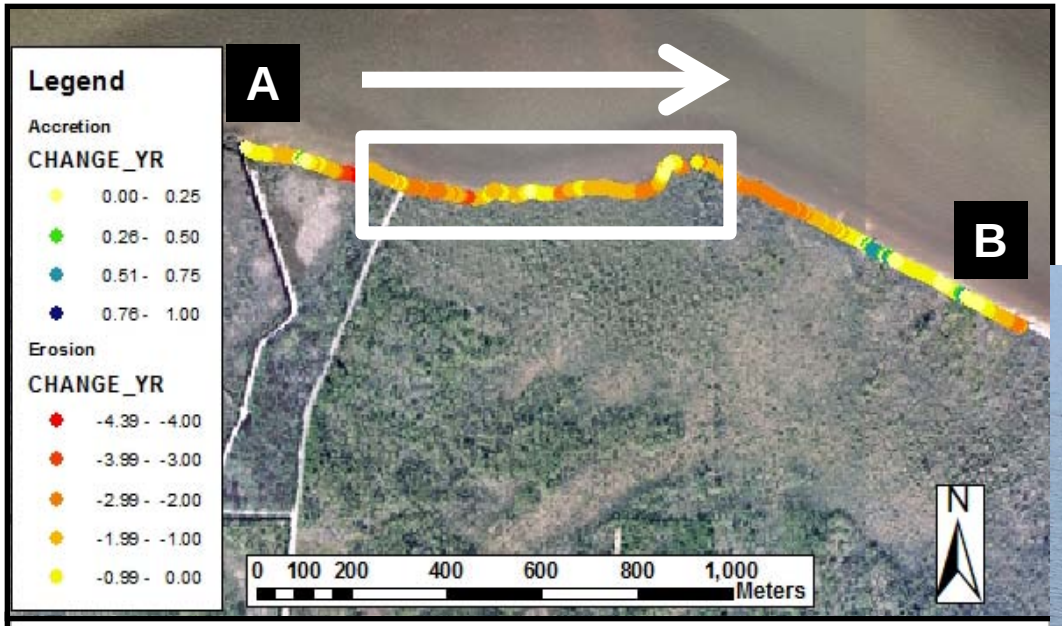


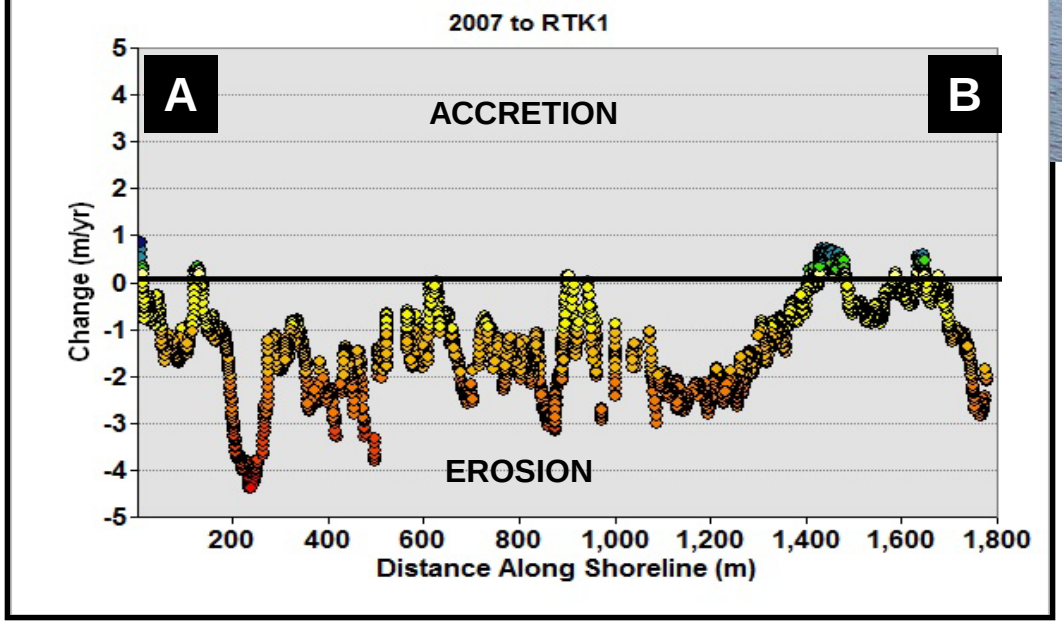


-1.4 ± 1.0 m/yr

Water

Land


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
N
0 100 200 400 600 800 1,000
Meters

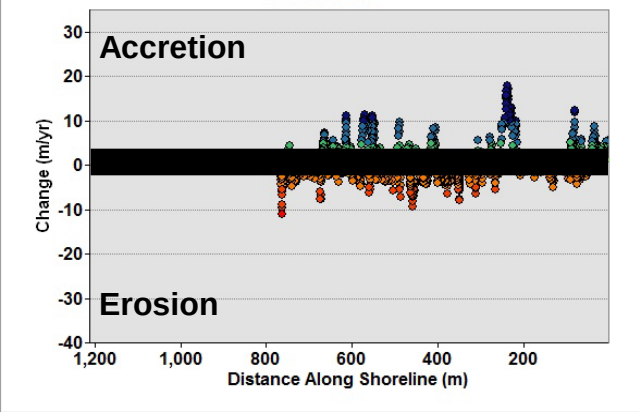

2007 to RTK1
A
B
ACCRETION
EROSION
Change (m/yr)
5
4
3
2
1
0
-1
-2
-3
-4
-5
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Distance Along Shoreline (m)

-1.4 ± 1.0 m/yr

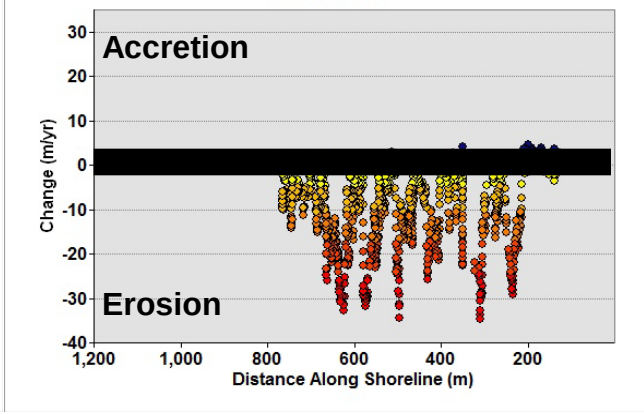
Gull Rock Game Land (GRG)

June 2010 – December 2010

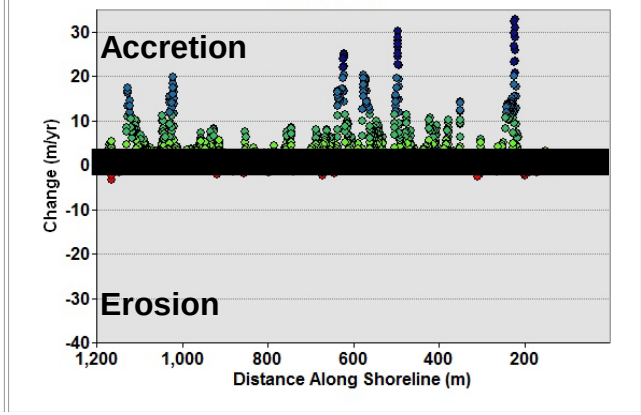
June – Aug



Aug – Oct



Oct – Dec

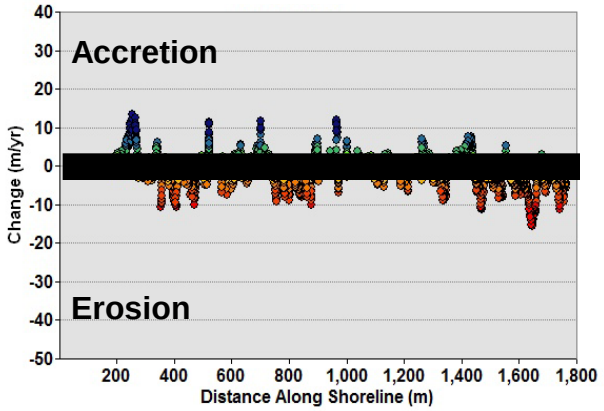


0.4 ± 3.7 m/yr	**-8.6** ± 8.9 m/yr	**3.2** ± 4.7 m/yr
0.2 yr (2.0 mo)	0.15 yr (1.8 mo)	0.19 yr (2.3 mo)

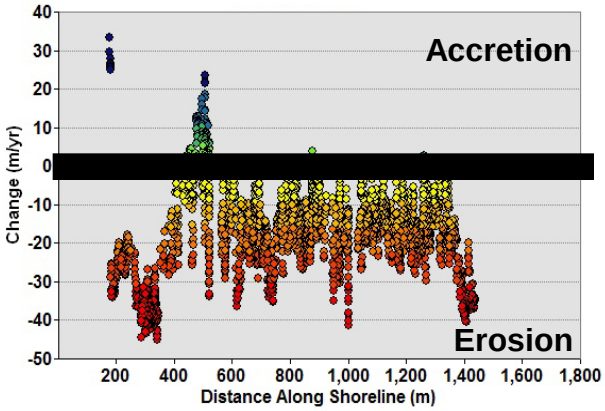
Palmetto-Peartree Preserve (PPP)

June 2010 – January 2011

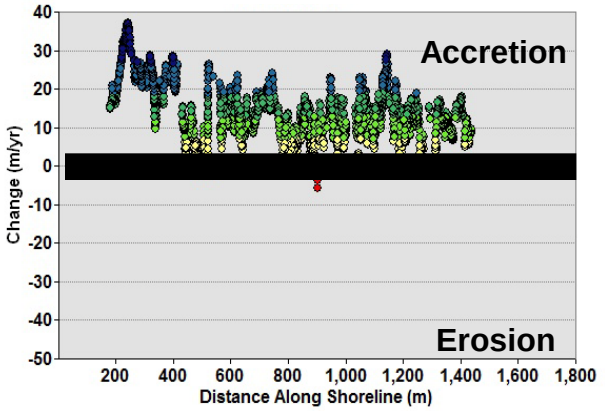
June – Aug



Aug – Oct

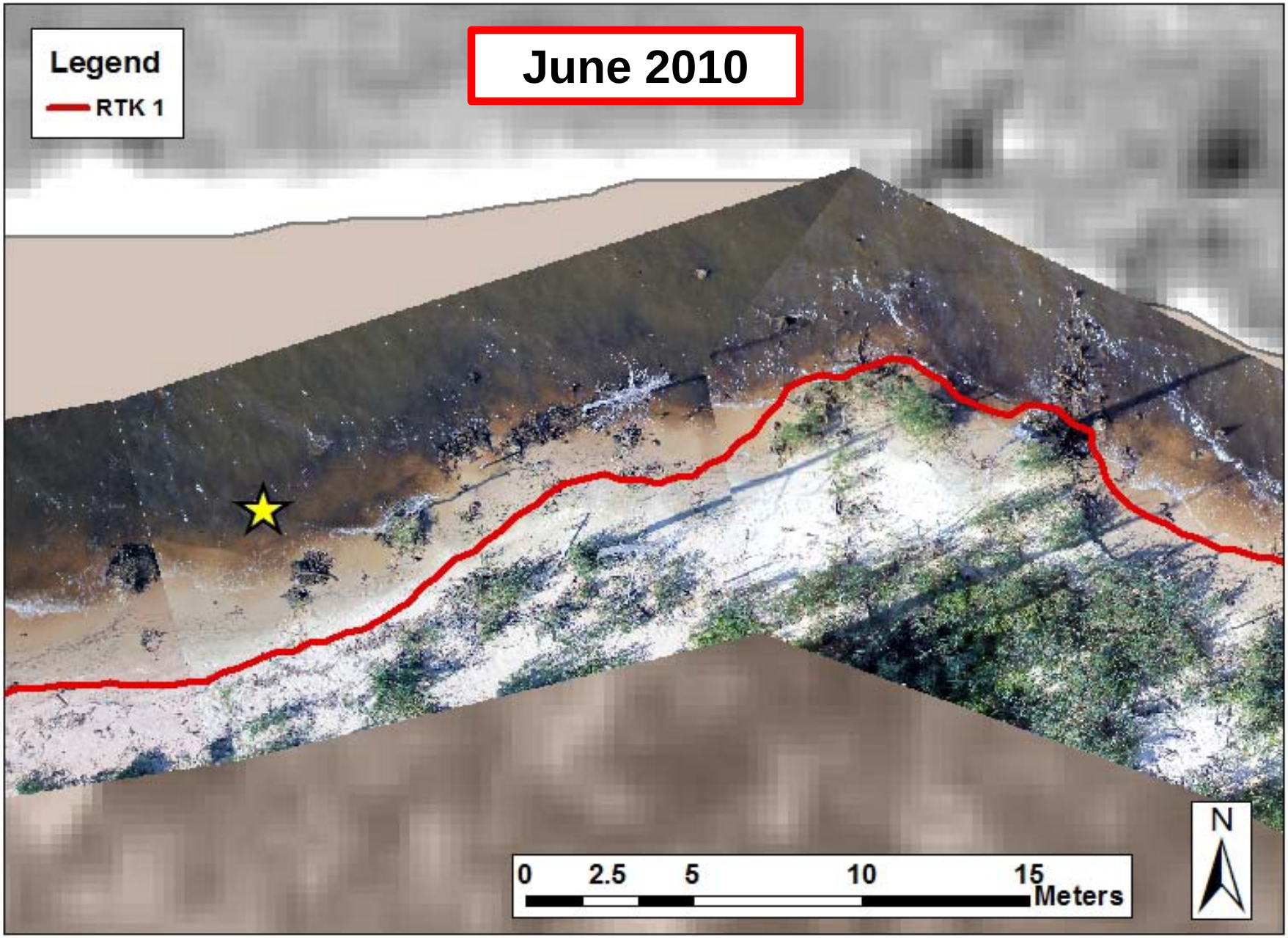


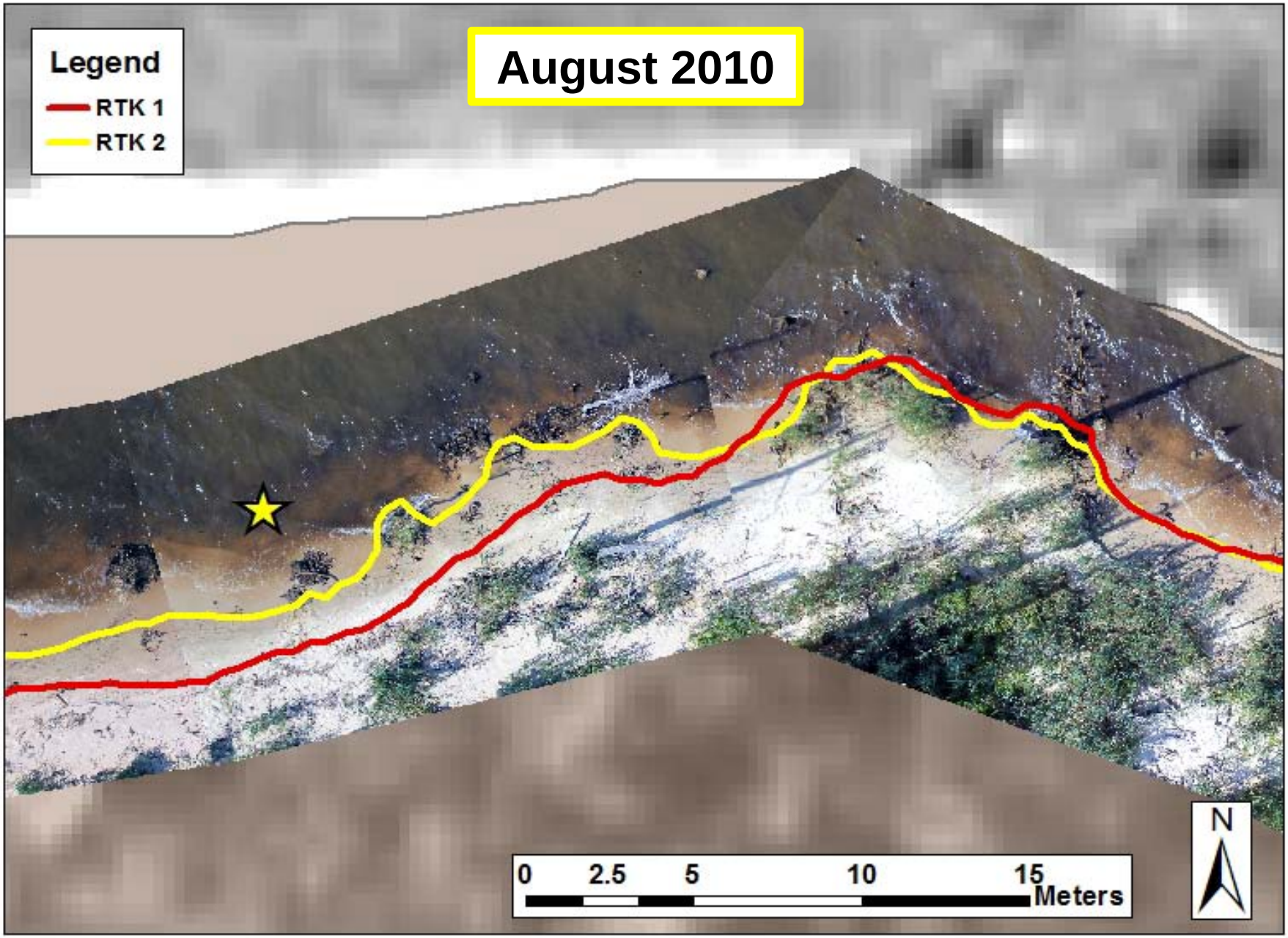
Oct – Jan

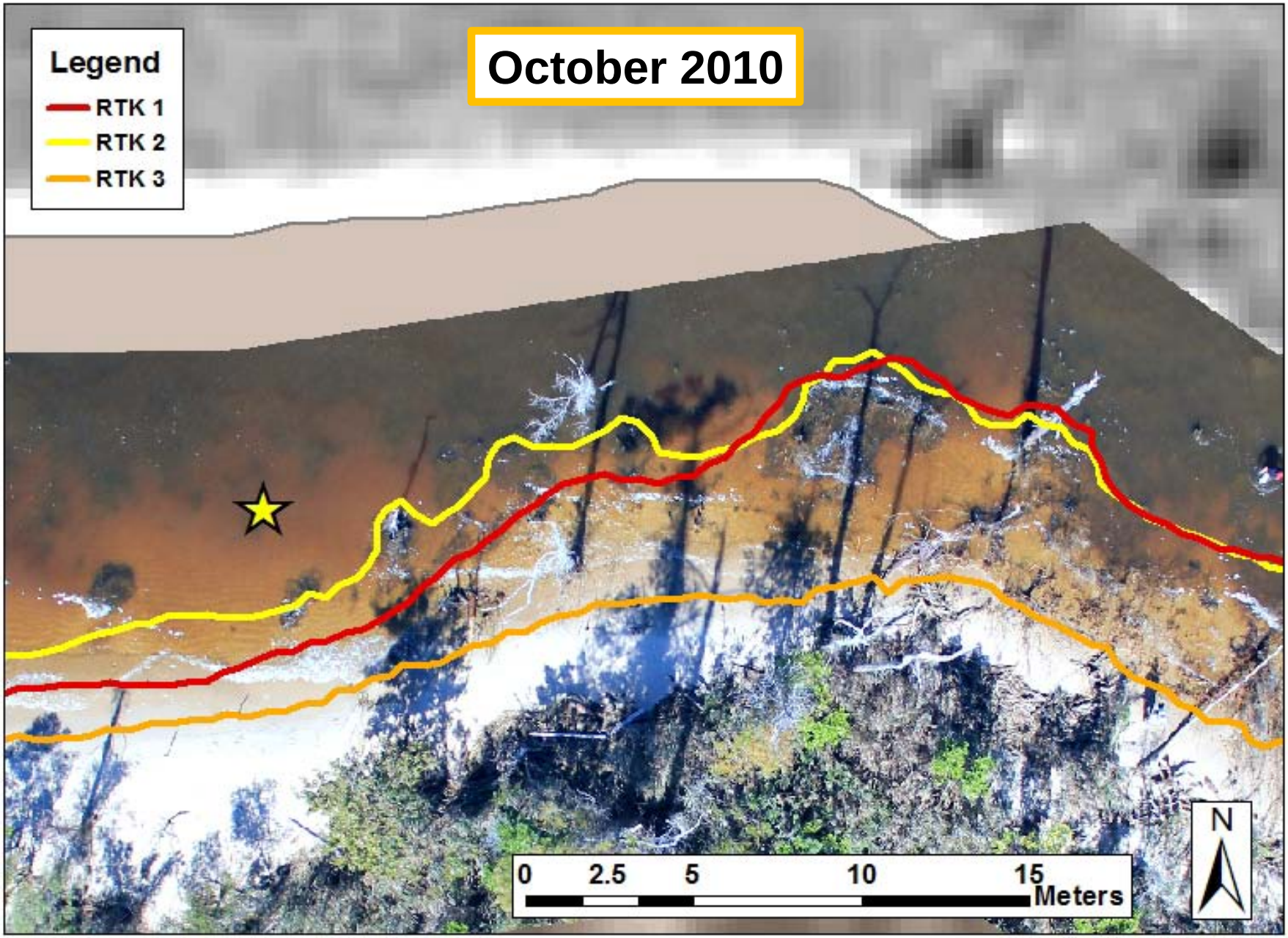


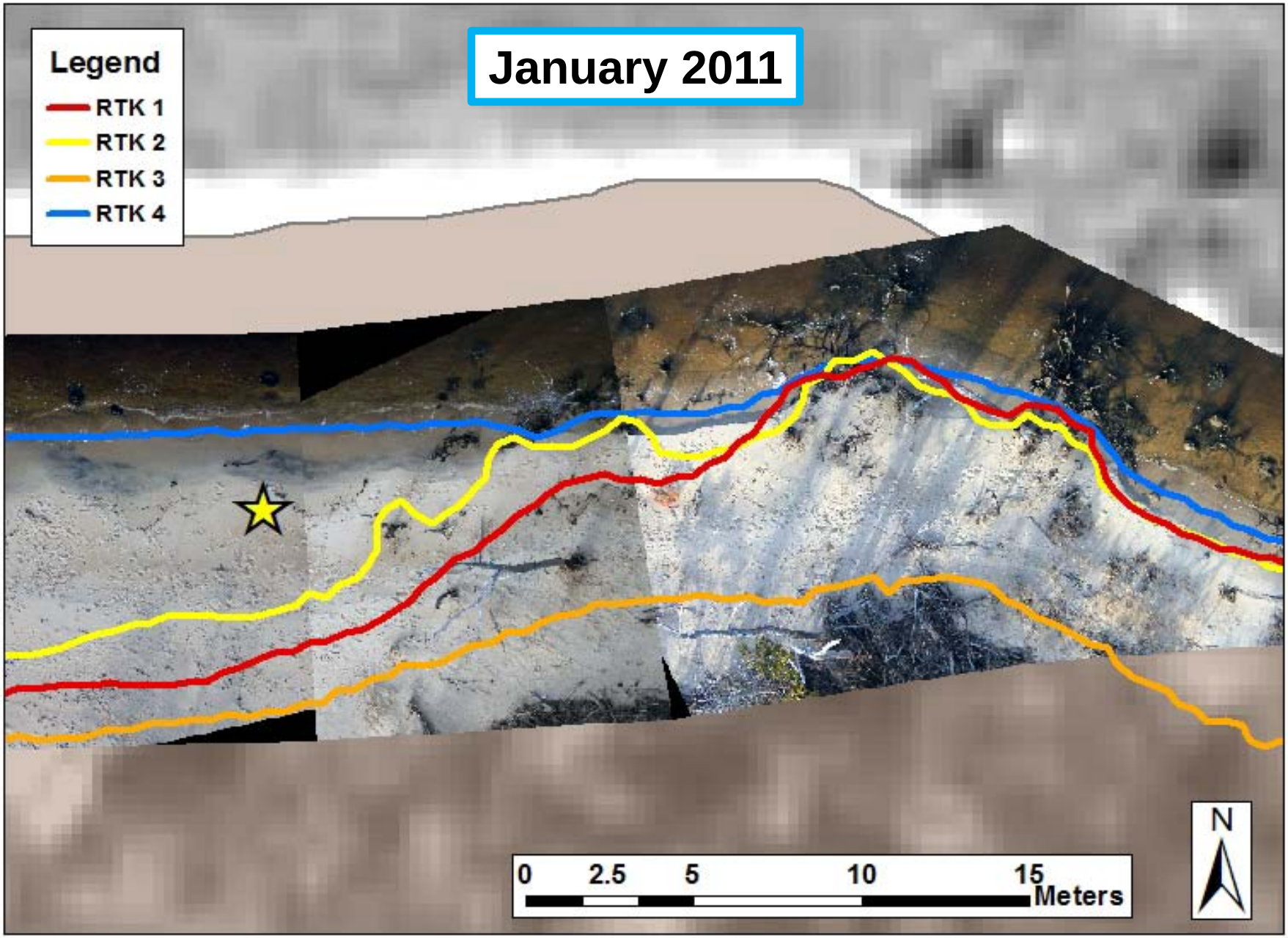
-1.4 ± 3.8 m/yr	**-17.1** ± 11.2 m/yr	**13.7** ± 7.3 m/yr
0.19 yr (2.3 mo)	0.13 yr (1.6 mo)	0.25 yr (3.0 mo)

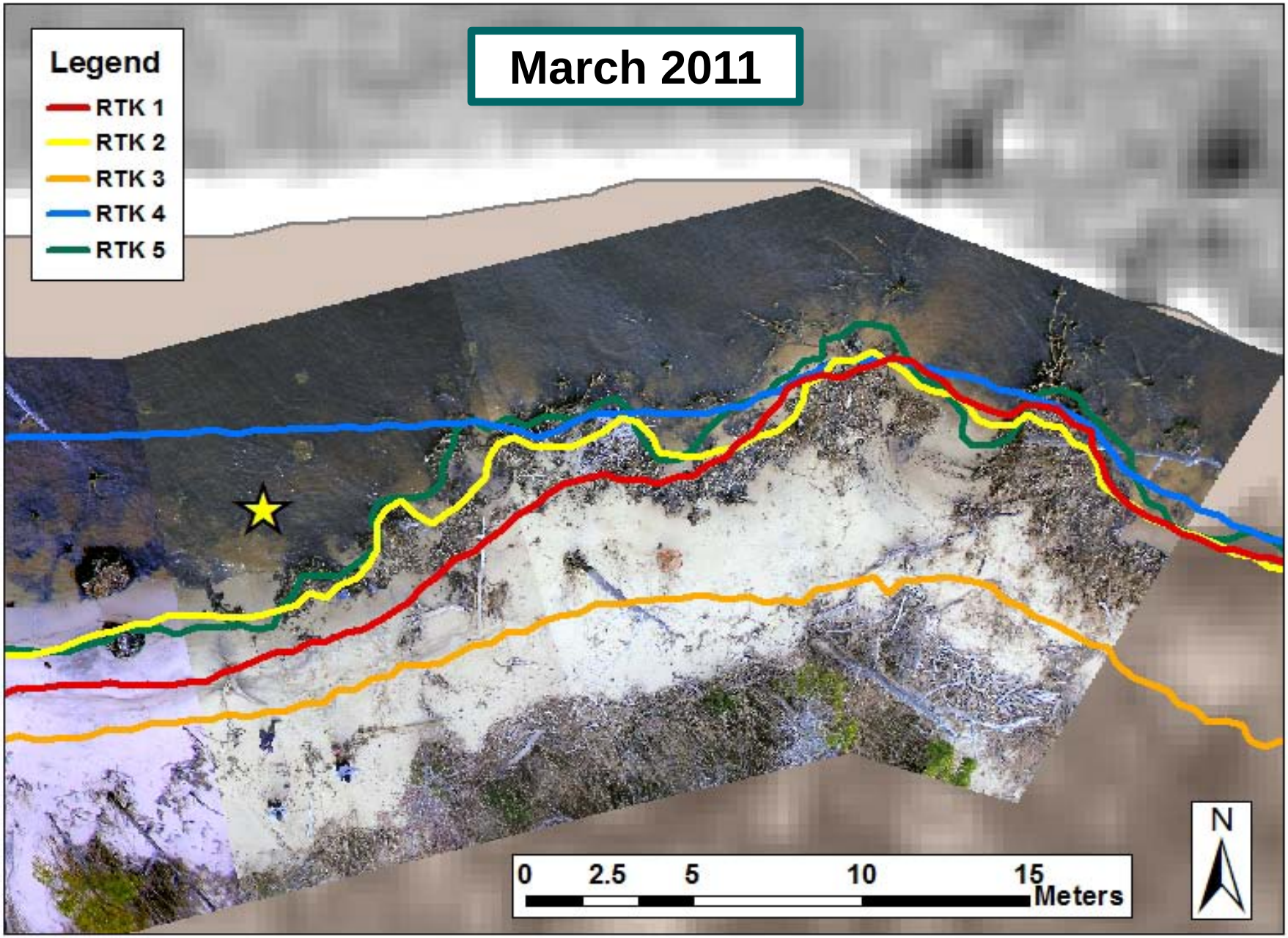
Site	RTK1 – RTK2 June - Aug	RTK2 – RTK3 Aug - Oct	RTK3 – RTK4 Oct – Dec/Jan
GRG	**0.43** 3.7 m/yr	**-8.6** 8.9 m/yr	**3.2** 4.7 m/yr
PPP	**-1.4** 3.8 m/yr	**-17.1** 11.2 m/yr	**13.7** 7.3 m/yr
GCP	**2.7** 2.9 m/yr	**0.9** 4.6 m/yr	**9.7** 11.8 m/yr
KHW	**-0.1** 5.7 m/yr	**-1.6** 2.9 m/yr	**0.4** 2.1 m/yr
OCR	----------	**-3.5** 27.2 m/yr (Aug – Sept)	**0.3** 2.2 m/yr (Sept – Dec)

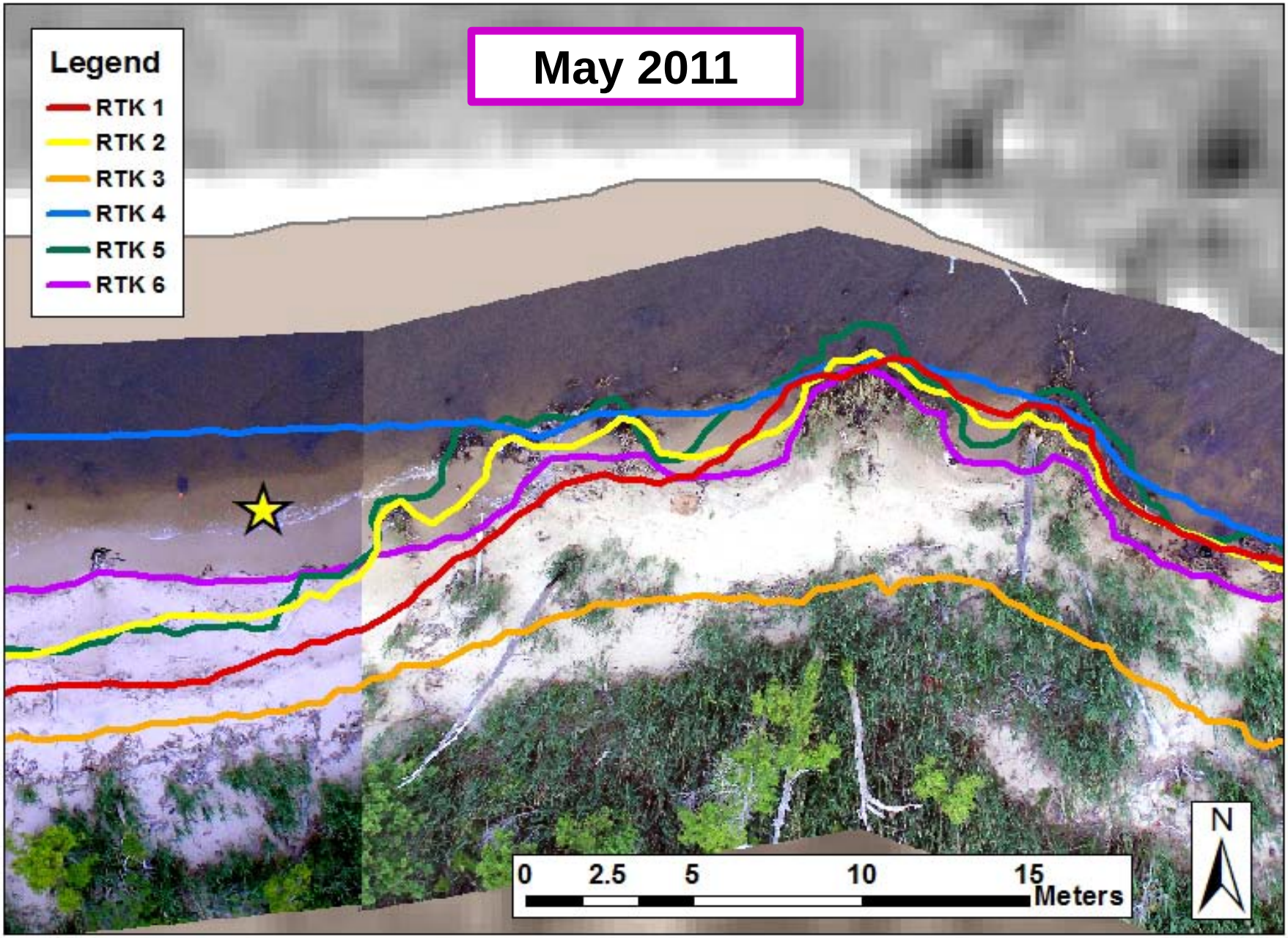

Legend
RTK 1
June 2010
0
2.5
5
10
15
Meters
N


Legend
RTK 1
RTK 2
August 2010
0
2.5
5
10
15
Meters
N


Legend
RTK 1
RTK 2
RTK 3
October 2010
0
2.5
5
10
15
Meters
N


Legend
RTK 1
RTK 2
RTK 3
RTK 4
January 2011
0
2.5
5
10
15
Meters
N


March 2011
Legend
RTK 1
RTK 2
RTK 3
RTK 4
RTK 5
0
2.5
5
10
15
Meters
N


May 2011
Legend
RTK 1
RTK 2
RTK 3
RTK 4
RTK 5
RTK 6
0
2.5
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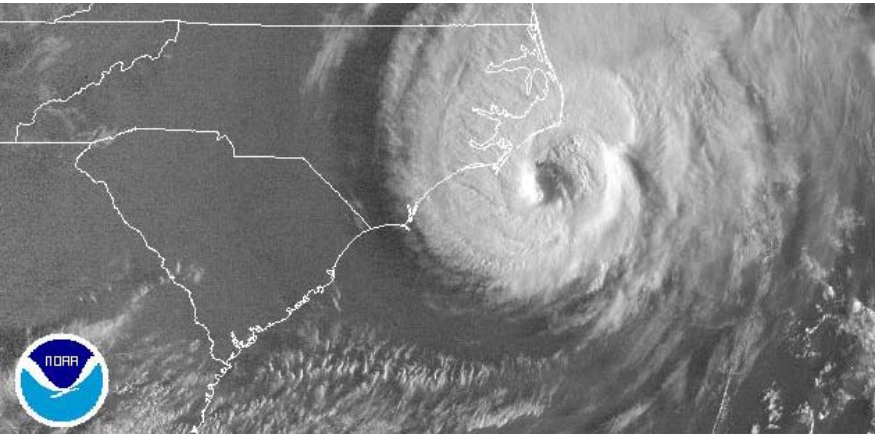
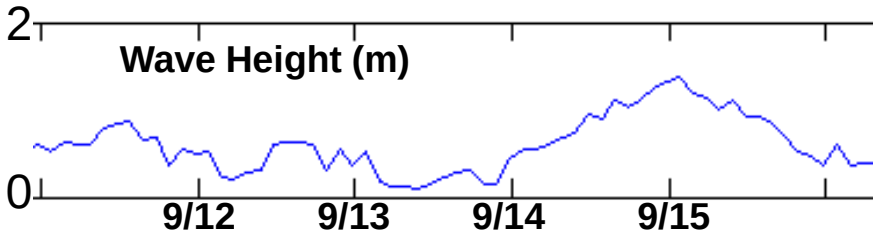
N

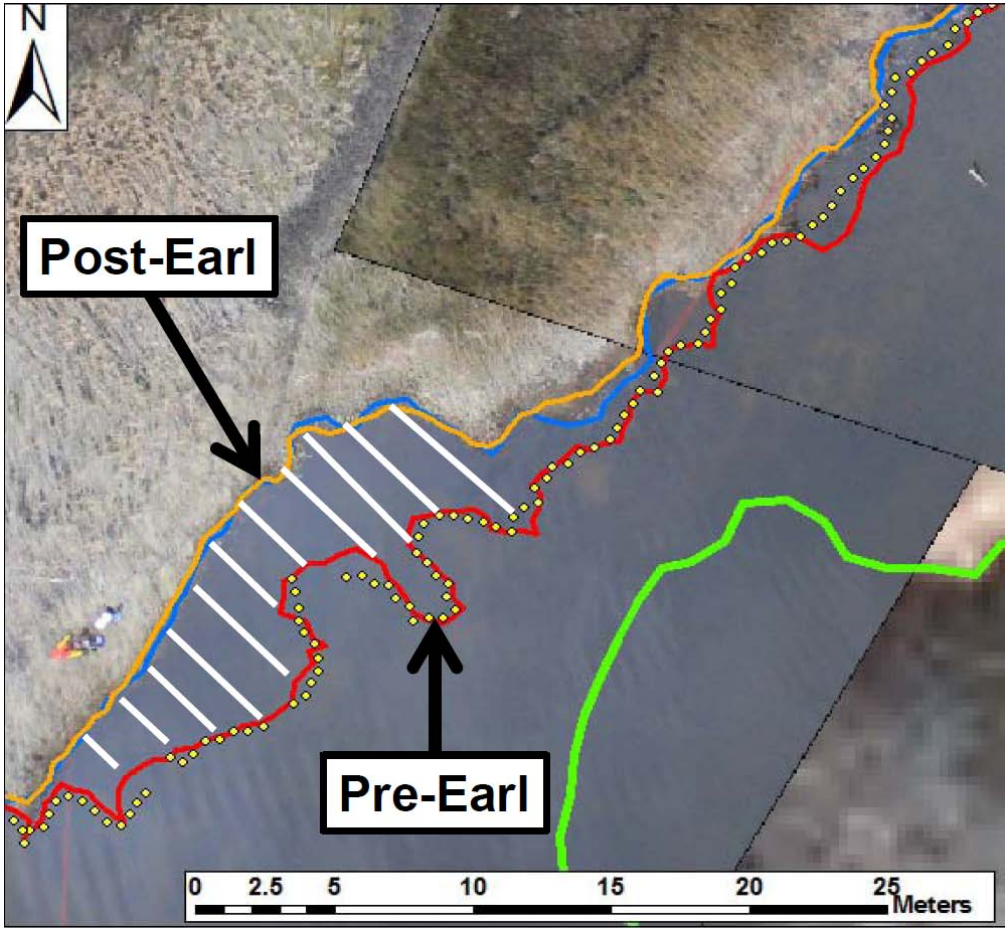
Storms are Key Drivers of Change

Neuse River Estuary, H. Ophelia





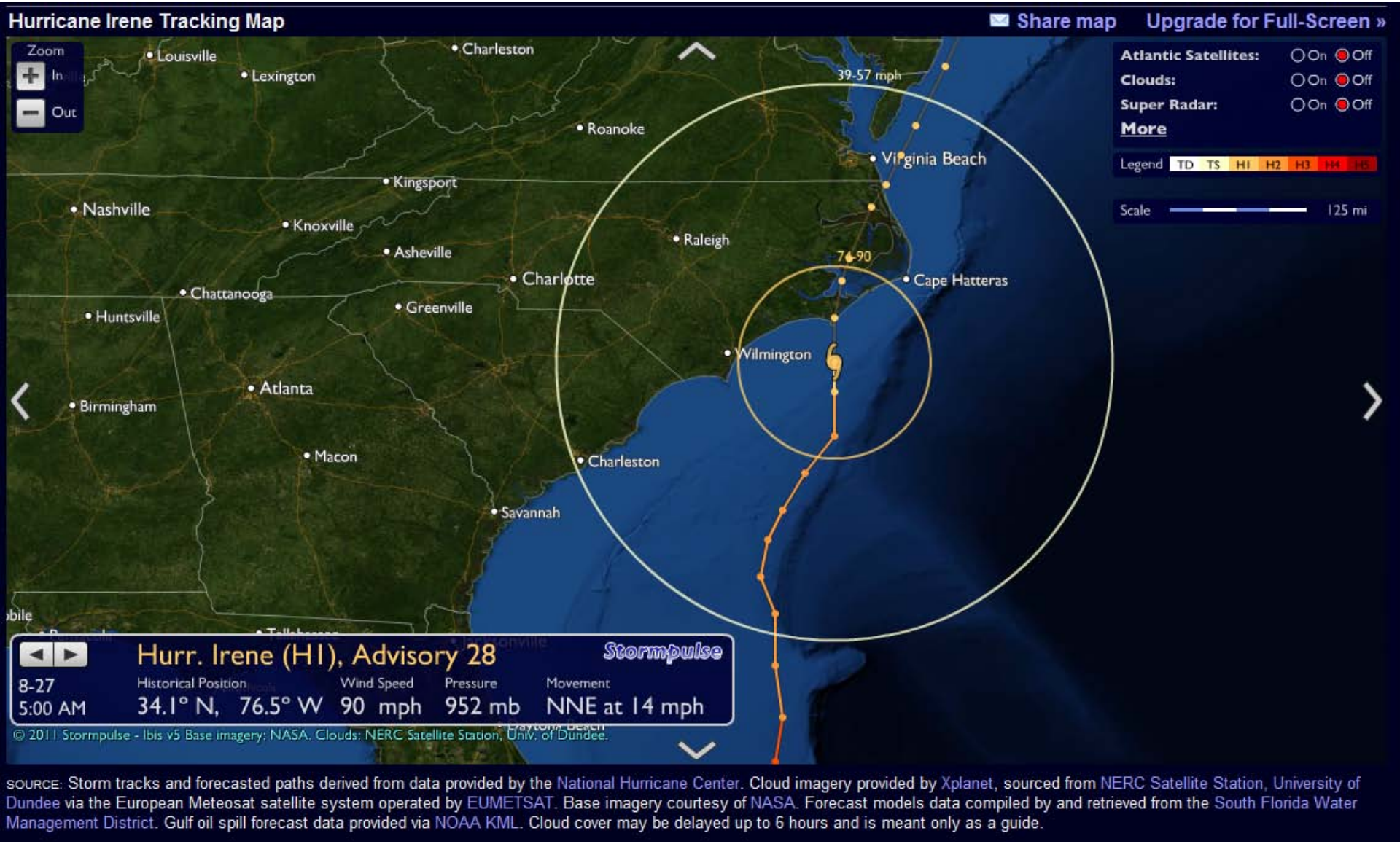
Hyde County, Hurricane Earl
>5 m Erosion



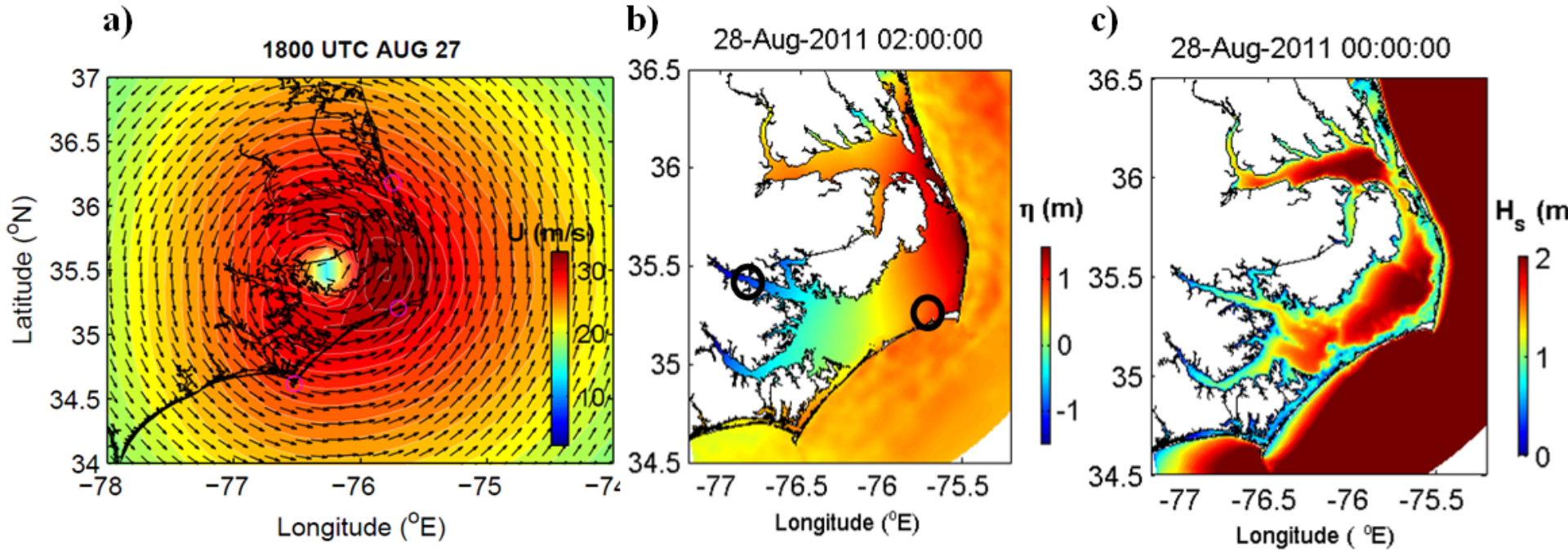
Conclusions

- **The coast of NC is extensive and complex.**
- **Infrastructure is widespread and abundant locally, yet much of the estuarine shore remains undeveloped**
- **A invaluable dataset is being collected for quantifying coastal change and useful for management applications and future research.**
- **Great spatial and temporal variability. Storms are key drivers. As data from Hurricane Irene show…**

Hurricane Irene – August 27th



SOURCE: Storm tracks and forecasted paths derived from data provided by the National Hurricane Center. Cloud imagery provided by Xplanet, sourced from NERC Satellite Station, University of Dundee via the European Meteosat satellite system operated by EUMETSAT. Base imagery courtesy of NASA. Forecast models data compiled by and retrieved from the South Florida Water Management District. Gulf oil spill forecast data provided via NOAA KML. Cloud cover may be delayed up to 6 hours and is meant only as a guide.


a)
1800 UTC AUG 27
U (m/s)
30
20
10
Latitude (°N)
Longitude (°E)
b)
28-Aug-2011 02:00:00
η (m)
Longitude (°E)
c)
28-Aug-2011 00:00:00
Hs (m
Longitude (°E)

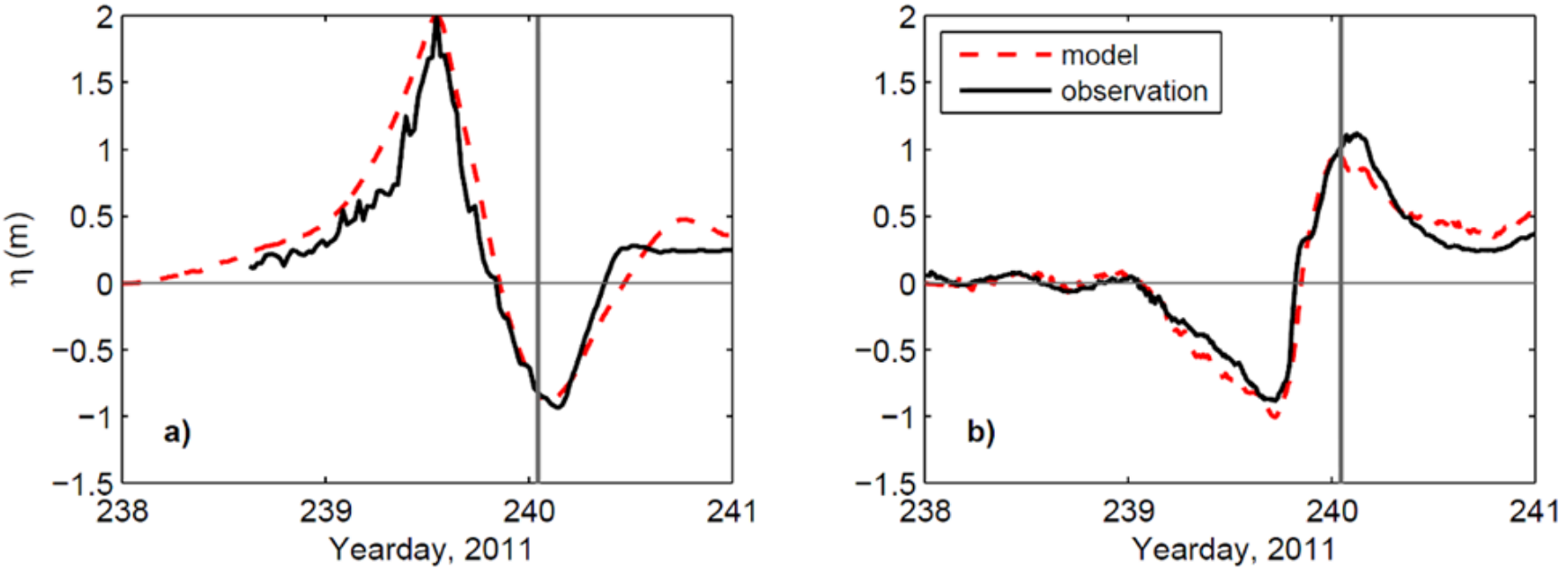
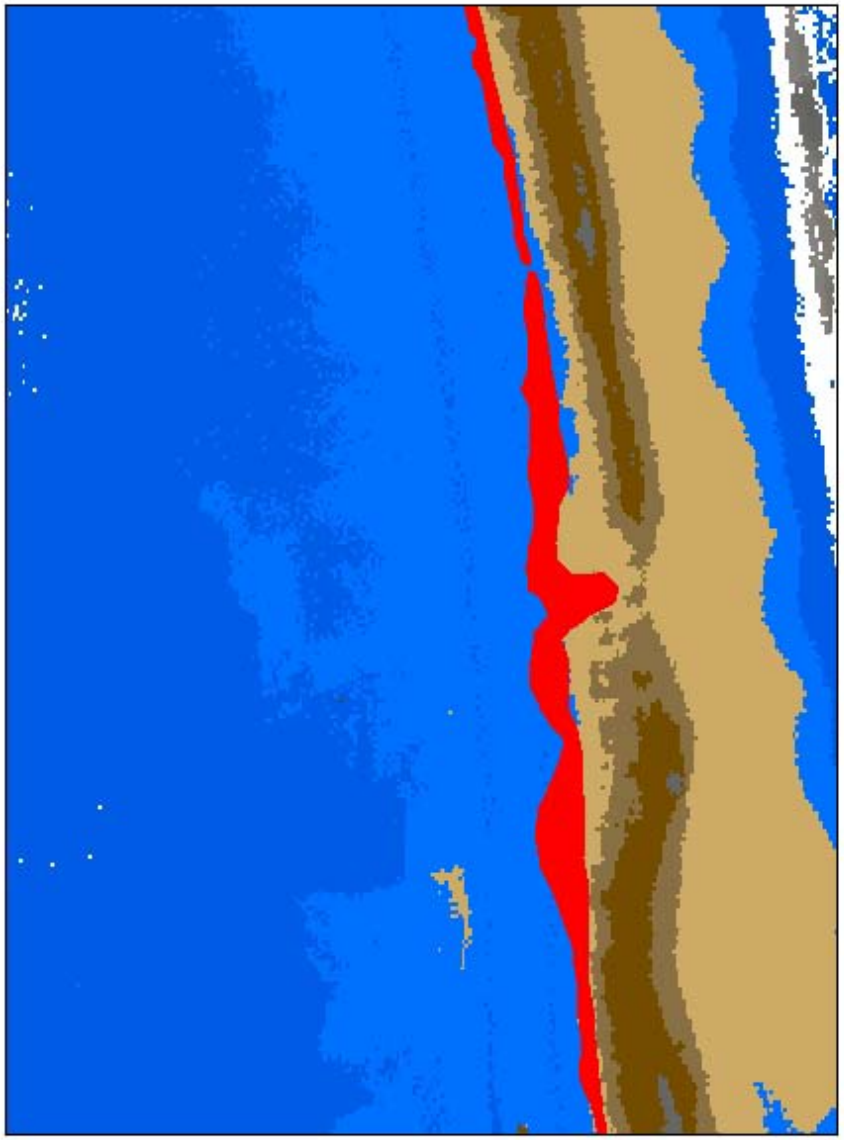


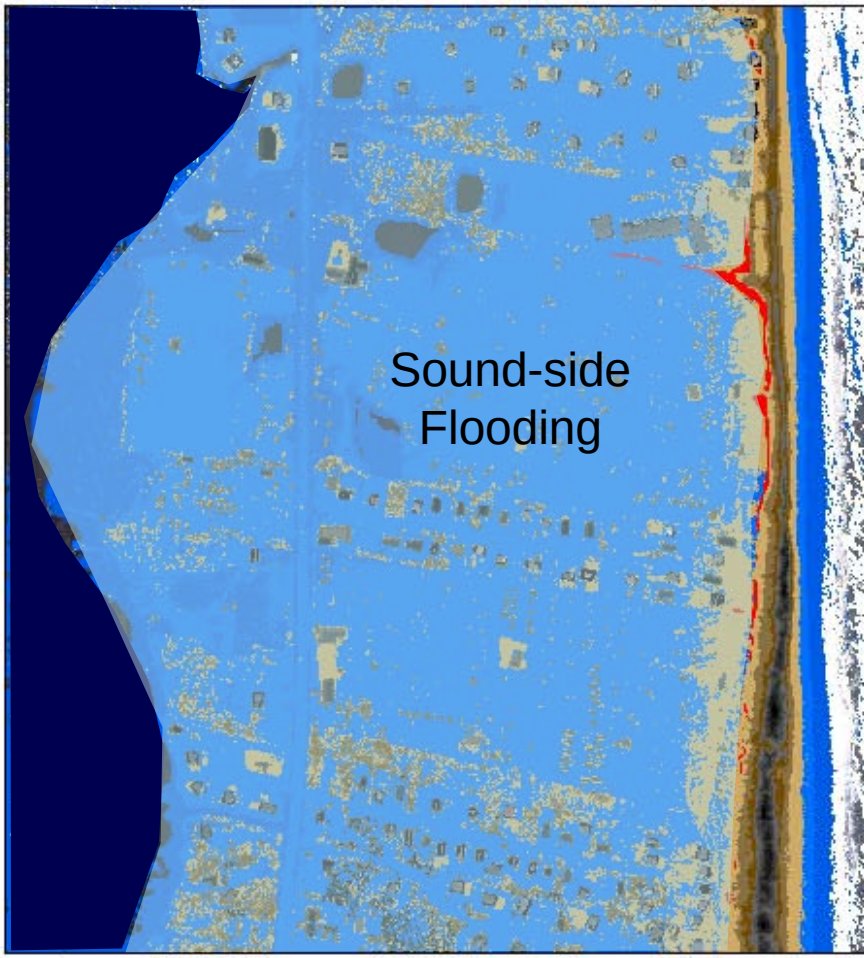
Figure 2: Time-series comparison of observed and predicted water-level displacement: a) in a tributary estuary on the western side of Pamlico Sound, and b) the eastern side of Pamlico Sound near Cape Hatteras (Stn. HCGN7, courtesy of NOAA). Vertical line indicates time of Fig. 1b.



125

Meters

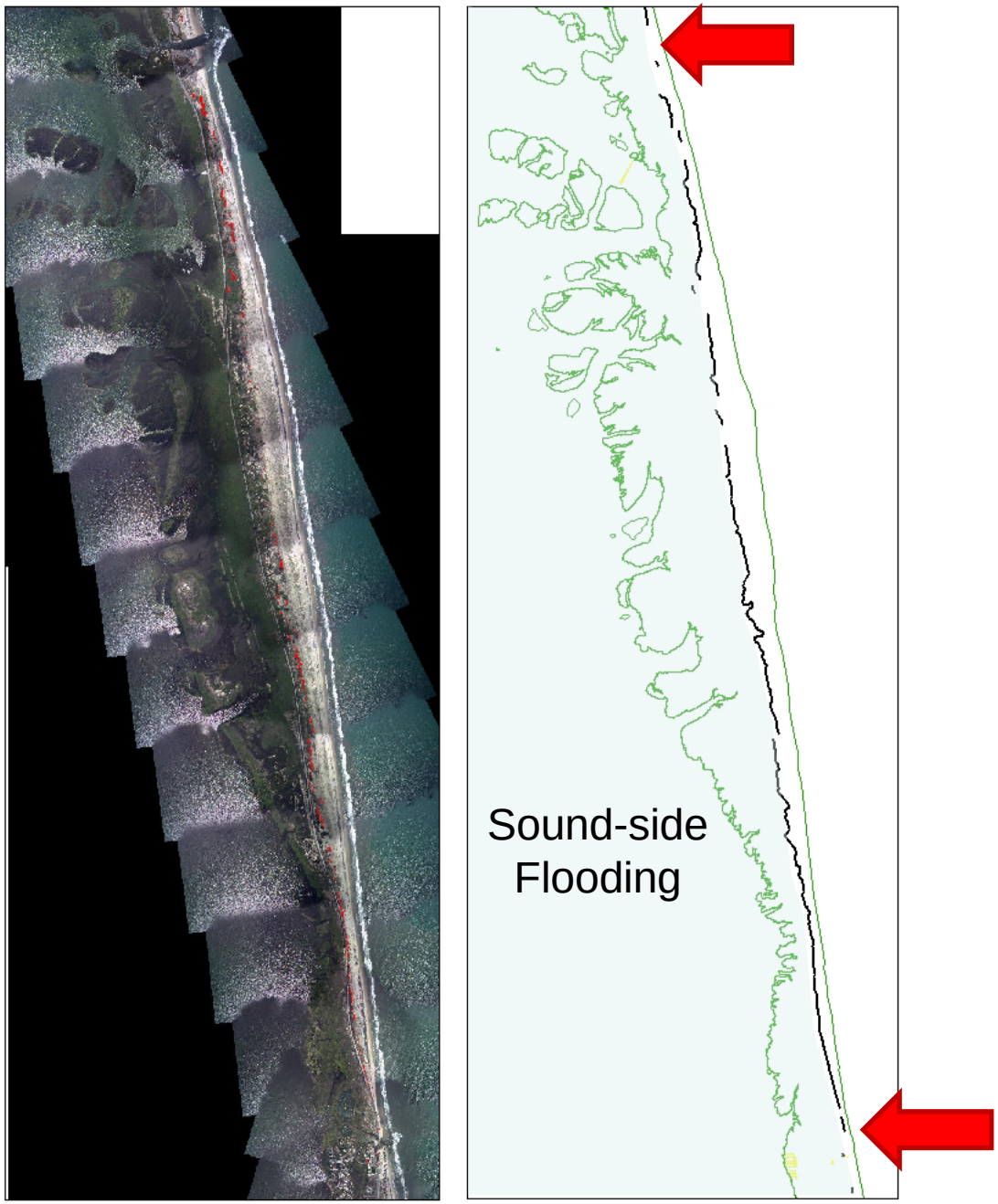
Prowler
Regal
FRIGIDAIRE



0.75

Kilometers

N


Sound-side
Flooding
N
1
Kilometers

Dune Ridge