Shoreline Data Analysis and Change Mapping

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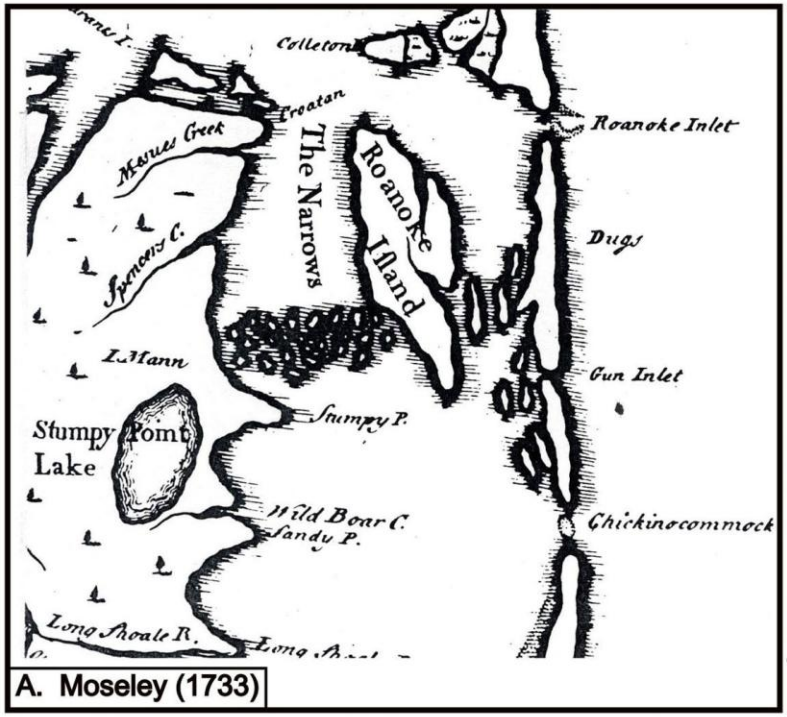
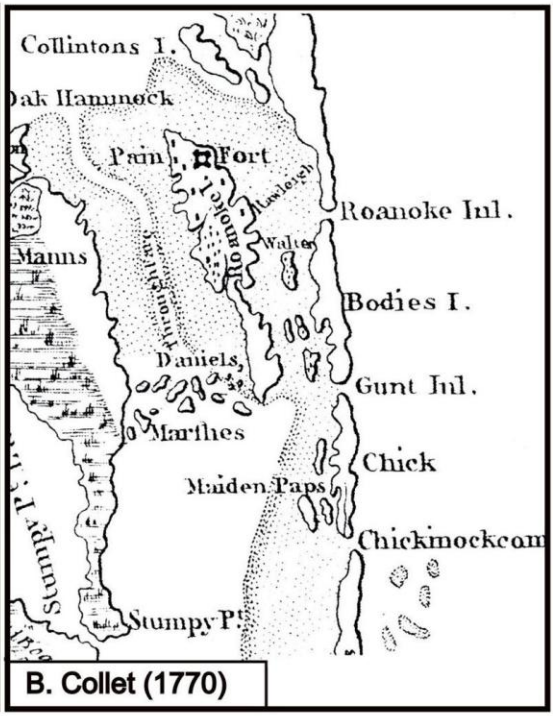
UNC Coastal Studies Institute

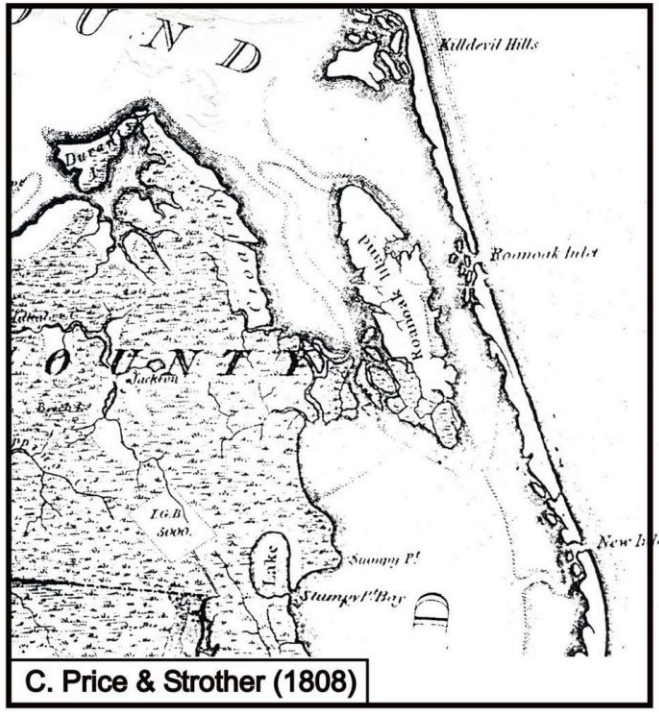
Change of the NC Estuarine Coast



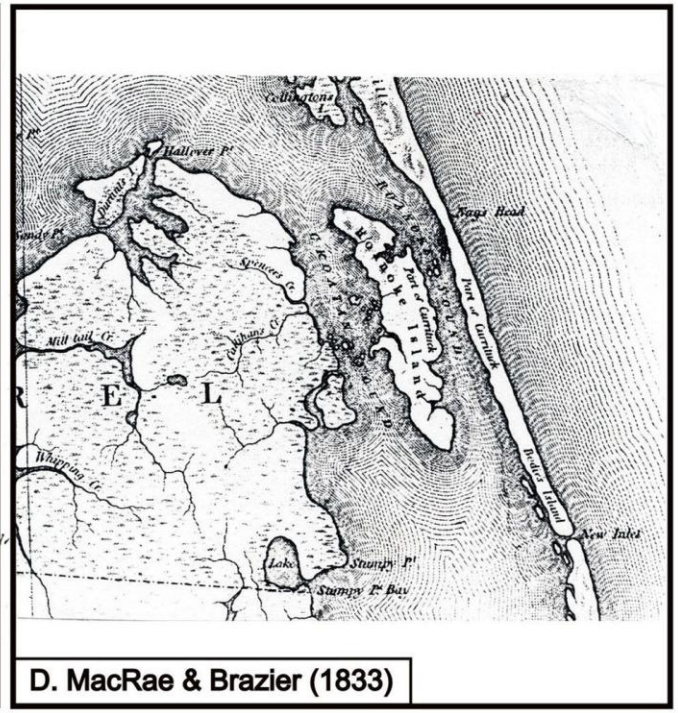
A. Moseley (1733)



B. Collet (1770)

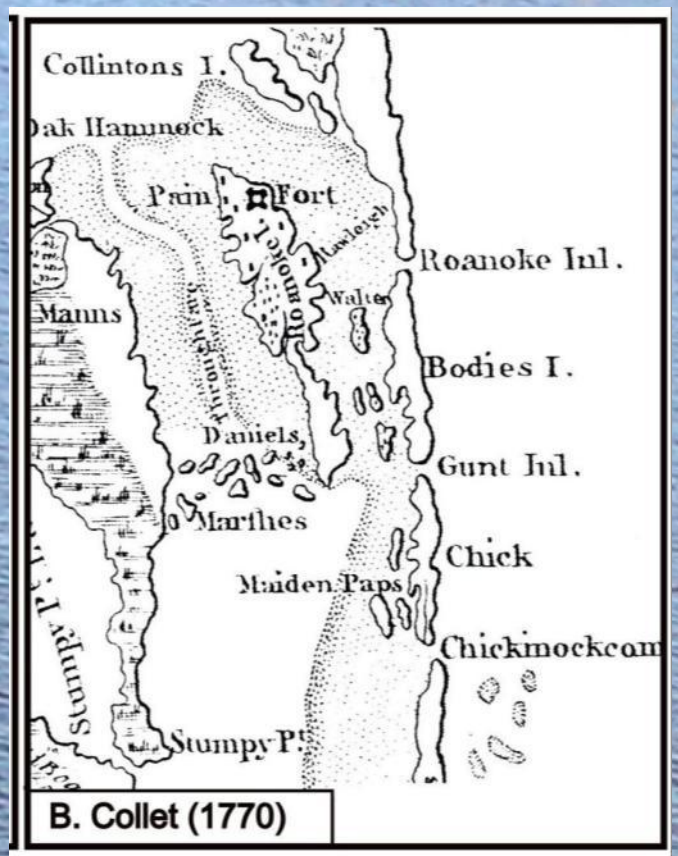


C. Price & Strother (1808)



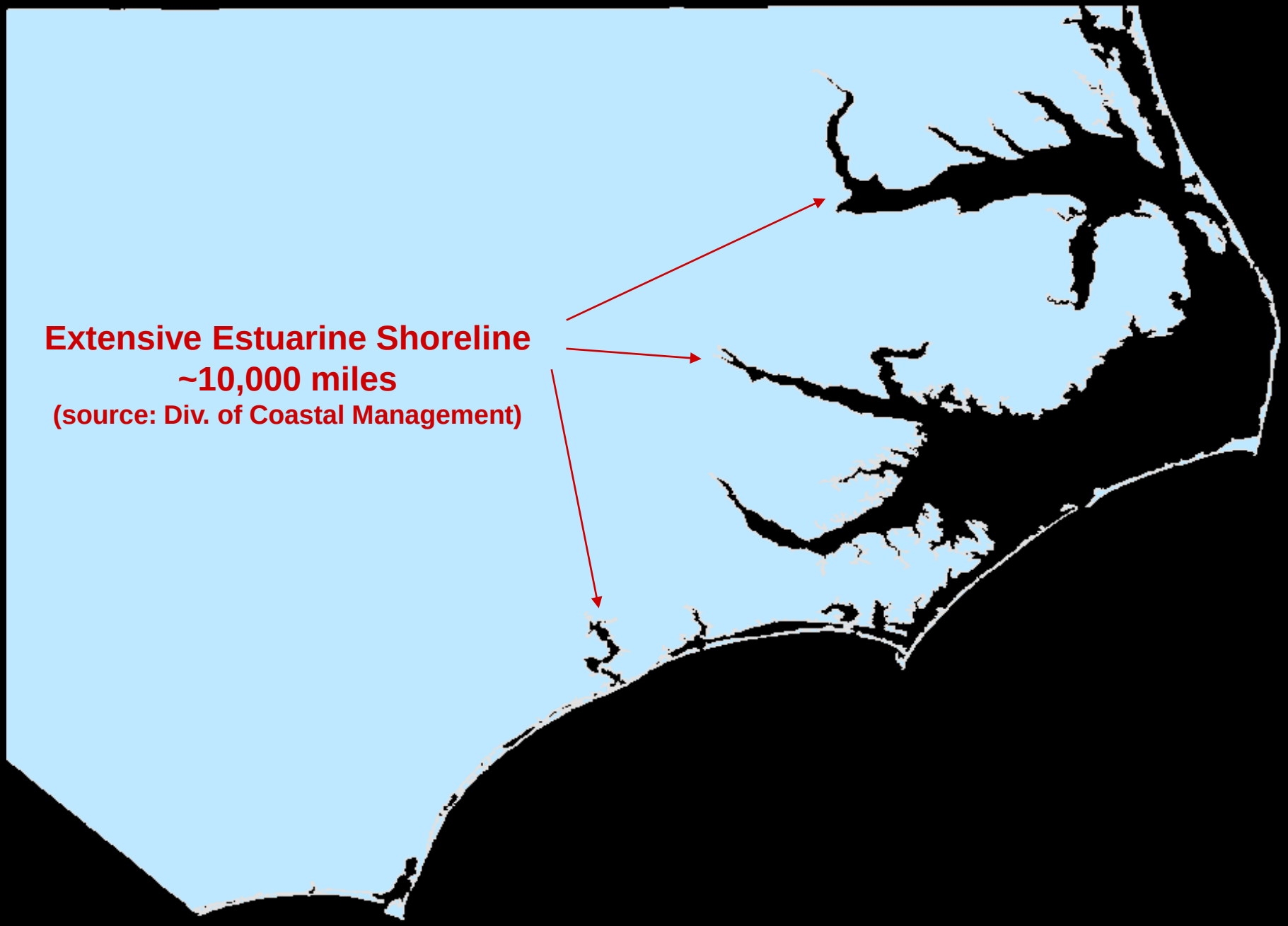
D. MacRae & Brazier (1833)

Estuaries



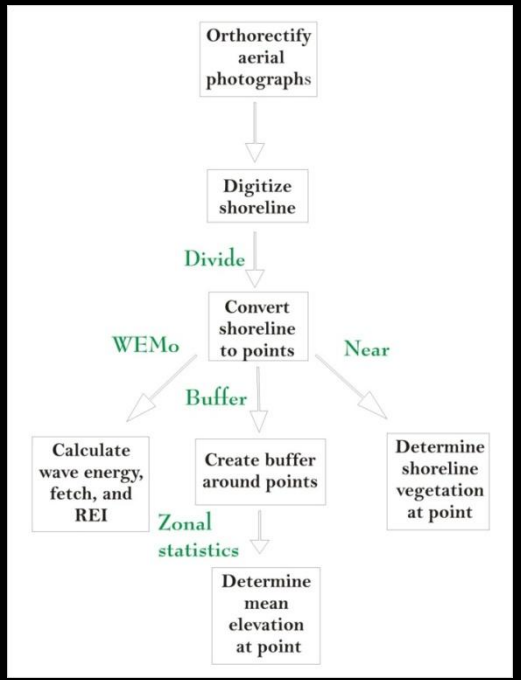
Critical habitats
Key resources
Experiencing change
(Riggs & Ames, 2003)

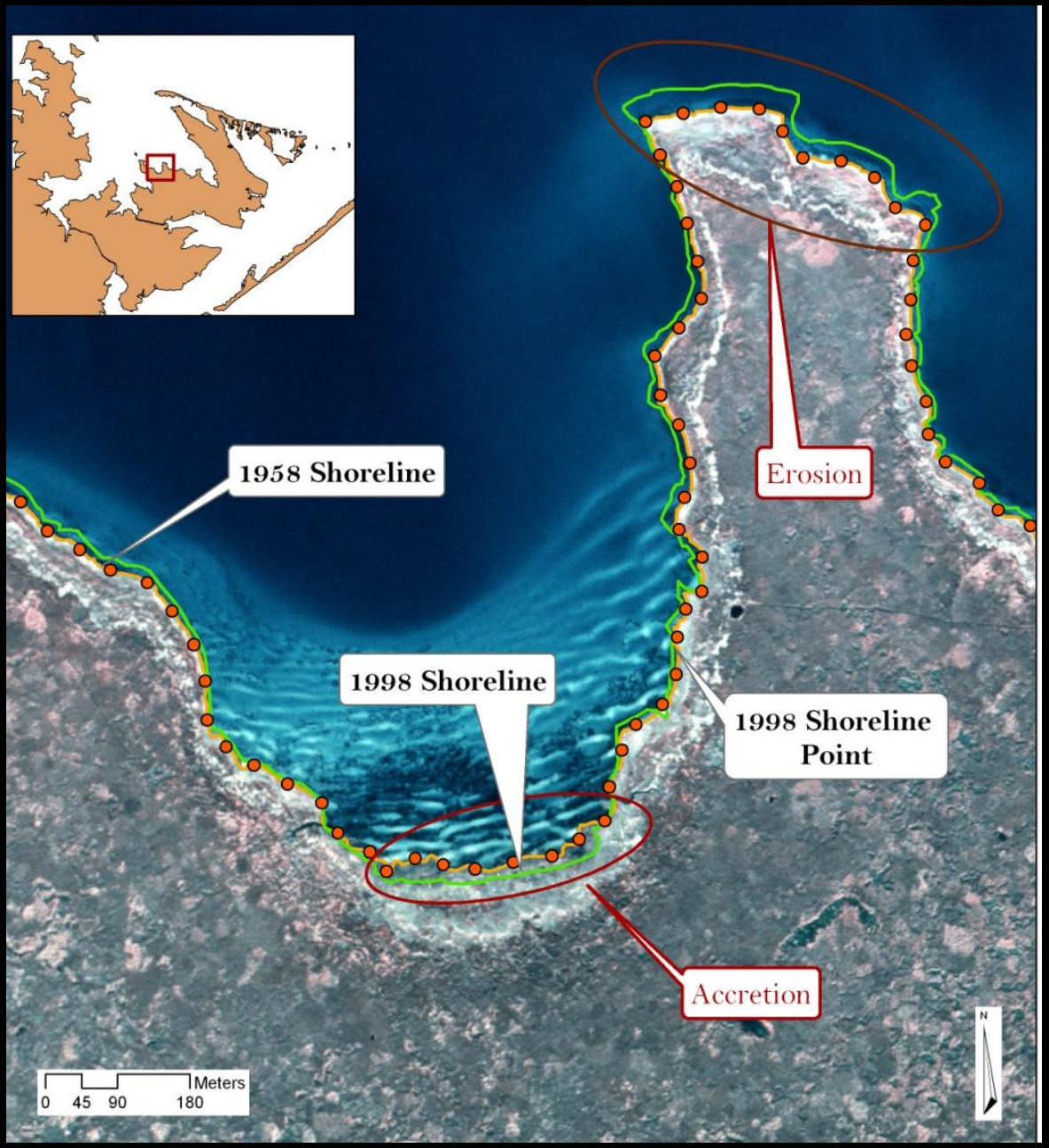
Most of the NC coastline borders protected coastal water bodies.



Quantifying Shoreline Change

- NOAA project
- Obtain aerial photographs or other suitable data.
- Map and compare shorelines using GIS software.
- Relate shoreline to measureable parameters.

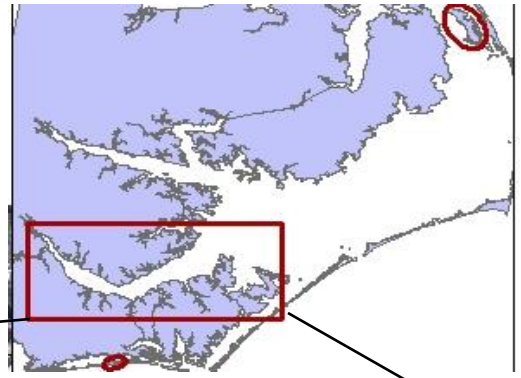


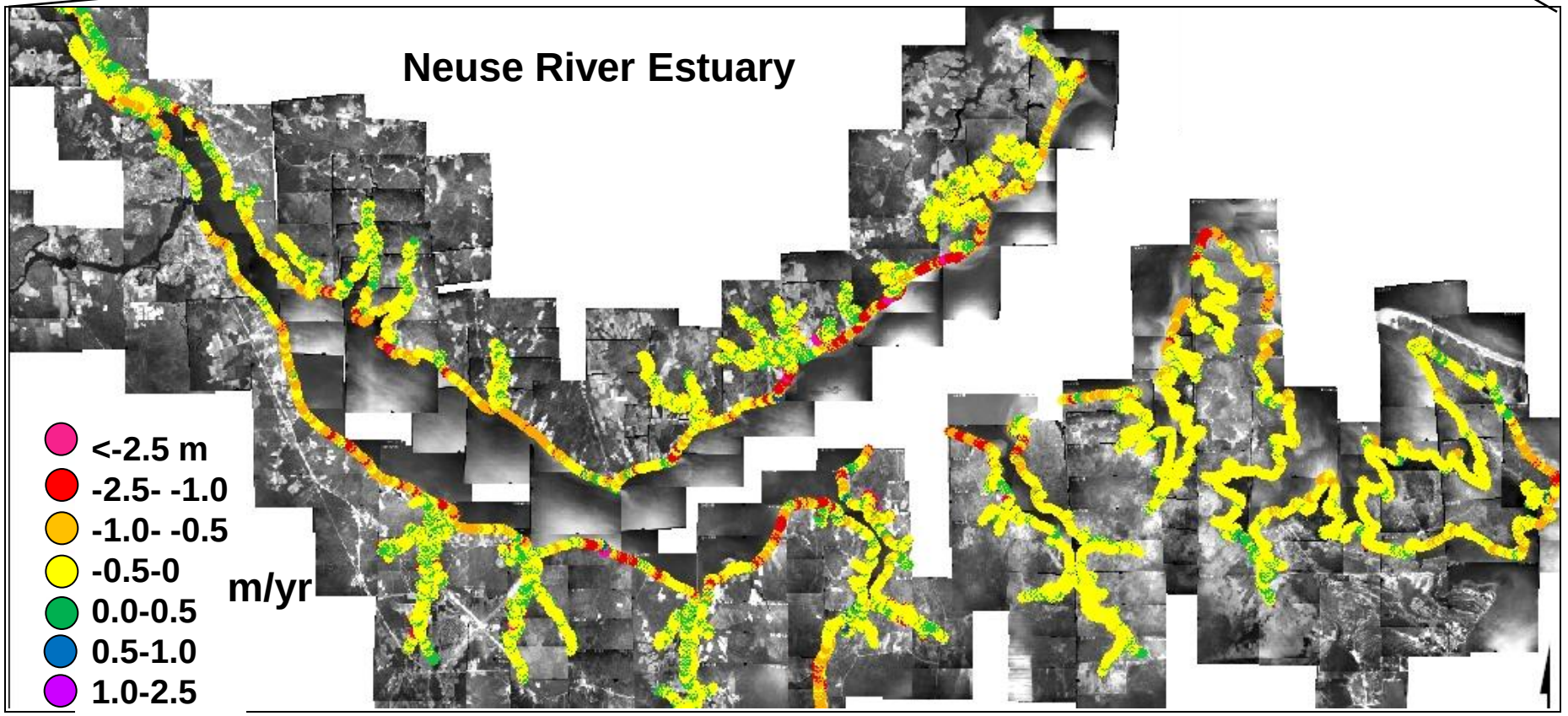


Estuarine Shoreline Erosion Rates

- **Great variability in rates**
- **Average ~0.25 m/y, ~0.6 m/yr along trunk**
- **Large (>2 m/yr) locally**

(Cowart, 2009; Cowart et al., 2009; Cowart et al., 2011)





Key Insights

- **Shoreline type and character affects rate of change.**

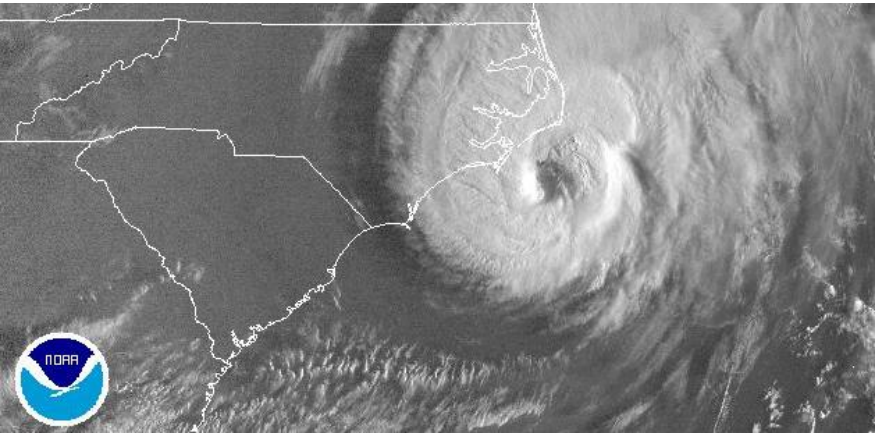
Parameter	Wetland	Forest	Sediment Bank	Other
Shoreline Change Rate (m/yr)	-0.53	-0.57	-0.70	-0.56
Elevation (m)	0.85	1.40	1.09	1.09
Fetch (km)	4.9	3.5	4.6	3.7

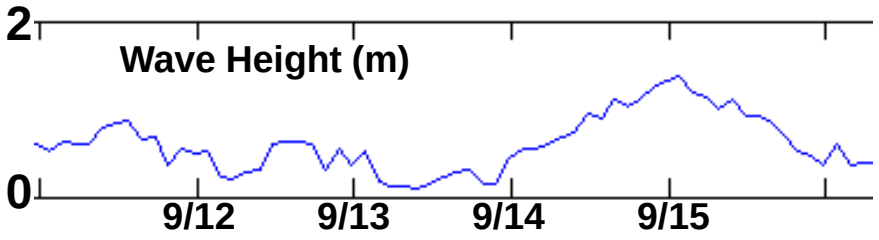
- **Fetch has influence on erosion rates.**

Innermost		Inner		Outer		Outermost	
SCR (m/yr)	-0.41	*SCR (m/yr)*	-0.53	*SCR (m/yr)*	-0.58	*SCR (m/yr)*	-0.72
Elevation (m)	1.07	*Elevation (m)*	1.44	*Elevation (m)*	0.94	*Elevation (m)*	0.62
Fetch (km)	1.91	*Fetch (km)*	3.55	*Fetch (km)*	4.04	*Fetch (km)*	7.36

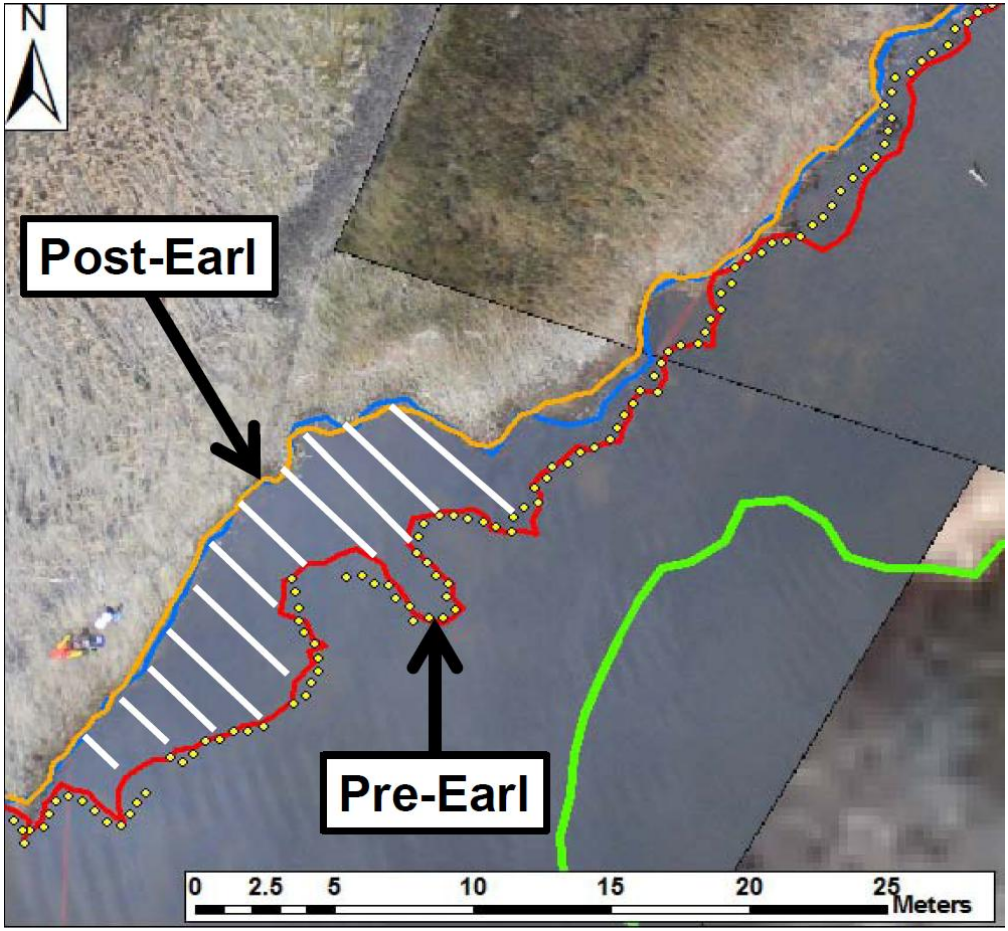
Storms are Key Drivers of Change

Neuse River Estuary, H. Ophelia





Hyde County, Hurricane Earl
>5 m Erosion



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

How much change and what impact?


The State needs a baseline…

DCM Goals for Mapping Project

1. **To delineate an accurate estuarine shoreline, and quantify the mileage of various shoreline types and the quantity of various shoreline associated structures**

2. **To begin to understand the cumulative effects of development along the estuarine shoreline (shading, ecosystem function loss, public trust coverage, etc.)**

3. **To aid our understanding of how permitting activities affect coastal residents and the environment**

Estuarine Shoreline Mapping Summit December, 2008

The overall goals of this workshop were to:

- Identify methodologies to ensure ESM project is used as a baseline for DENR agencies
- Increase understanding about other estuarine shoreline mapping efforts in NC
- Identify priority regions for mapping estuarine shoreline
- Investigate and work towards opportunities to collaborate
- Identify resources to support mapping efforts

ESM Summit Survey Results (December 2007)

- Survey Monkey
- 30 survey participants
- 60% managers, 40% technicians
- 54% of respondents agencies map estuarine shorelines
- Participants include: USGS, NOAA, East Carolina University, NC State University, NC Department of Transportation, Albemarle-Pamlico National Estuary Program, Division of Marine Fisheries, Division of Environmental Health, Division of Coastal Management, Division of Water Quality, Division of Water Resources, Sea Grant, Center for Geographic Information and Analysis, DENR Information Technology Services, and Geodynamics LLC.

Methodology used to map the shoreline?

- 86% Aerial Orthophotography interpretation (digitizing)
- Other (combinations with above)
  - 36% GPS-based field data collection
  - 36% LIDAR-based interpretation
  - 29% Imagery-based spectral analysis

Do you use estuarine shoreline data as part of your job?

- 77% Yes

How do you use estuarine shoreline data?

- Defining shellfish closing areas
- Report mileage to the EPA
- Planning compliance, use support assessment
- Academic research
- Shoreline change rates
- NC Strategic Conservation Plan
- Mapping location of pollution sources

Charting the Estuarine Environment:

A methodology spatially delineating a contiguous, estuarine shoreline of North Carolina

Prepared by:

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Ocean and Coastal Policy Analyst
NC Division of Coastal Management

&

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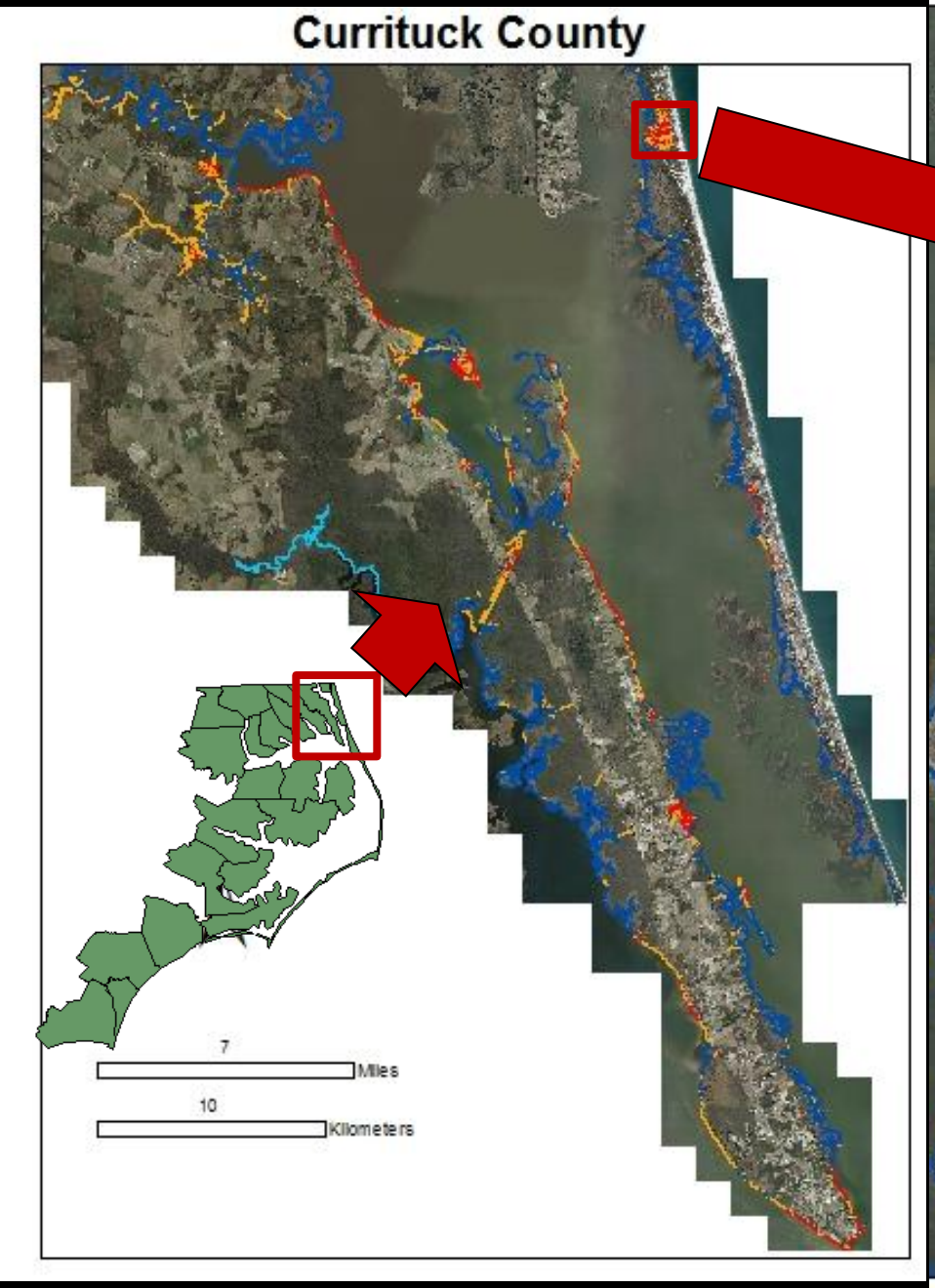
NC Division of Coastal Management

Updated: March 22, 2010

Methods

- **Heads-up Digitizing (Geis and Bendell, NCDCM, 2008)**
- **ArcGIS, PC with dual-monitor and digitizing pen**
- **20 Coastal (CAMA) Counties**
- **1:300-500 scale; Up to 20 ft stream width**

High-Resolution Mapping of the NC Shoreline



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

Swamp Forest

Marsh

Sediment Bank

Modified

Shoreline Type: Marsh

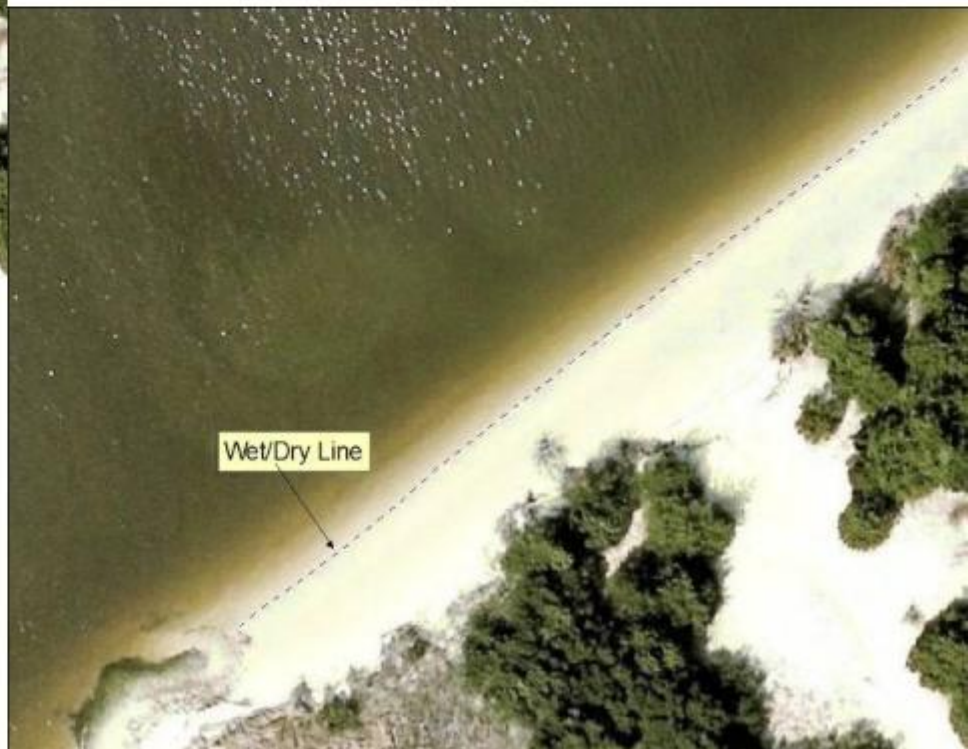
(vegetation/water interface or waterward edge of vegetation)

Shoreline Type: Swamp Forest

(mainland tree canopy to represent shoreline)

Shoreline Type: Sediment Bank

(wet/dry line represented by boundary b/t wet & dry sand)



Shoreline Type: Modified with Engineered Structure

- Types of structures (9 groups)
- Structure Delineation Methodology
  - Polyline (breakwaters, groins, jetties)
  - Polygon (boat ramps, piers, docks)
  - Unknown (may need ground truthing?)

Structure Groups	Structure Type Category	Shapefile Type
Boat Ramp	boat_ramp	Polygon
Breakwater	Breakwater	Polyline
Bridges	Bridge	Polygon
Groins and Jetties	groin_jet	Polyline
Piers, floating docks (including ramps) and wharfs	pier_fd_wharf	Polygon
Sill	Sill	Polyline
Sloped structures	Sloped	Polyline
Unknown	Unknown	Polyline or Polygon
Vertical structures	Vertical	Polyline

Shoreline Type: Modified with Engineered Structure

Shoreline Type: Miscellaneous

- Inland county boundaries

  (coastal county shoreline crosses into inland county)

- Boundary between two coastal county shorelines

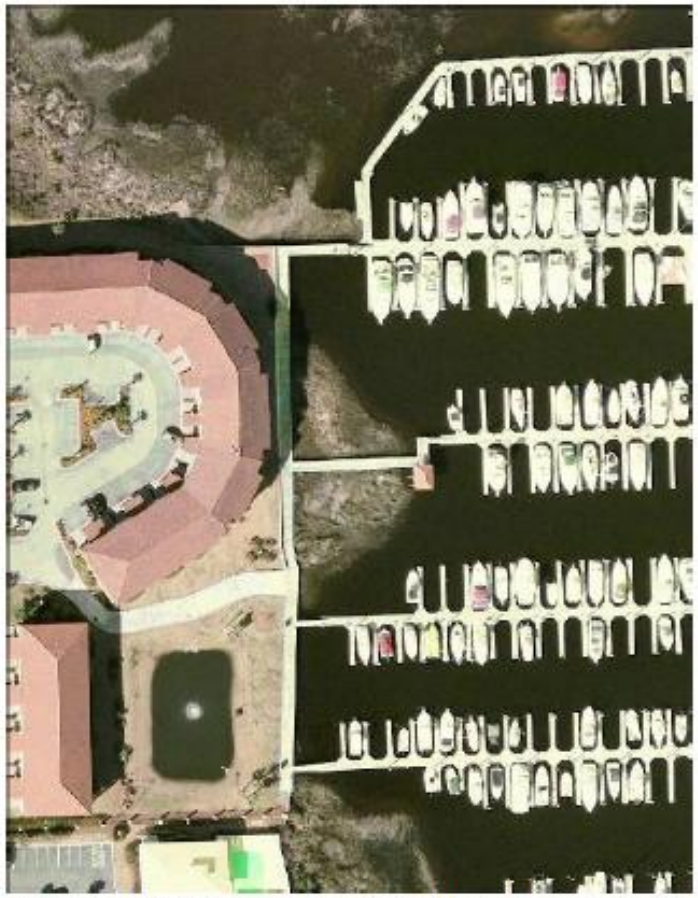
- Upstream extent of rivers

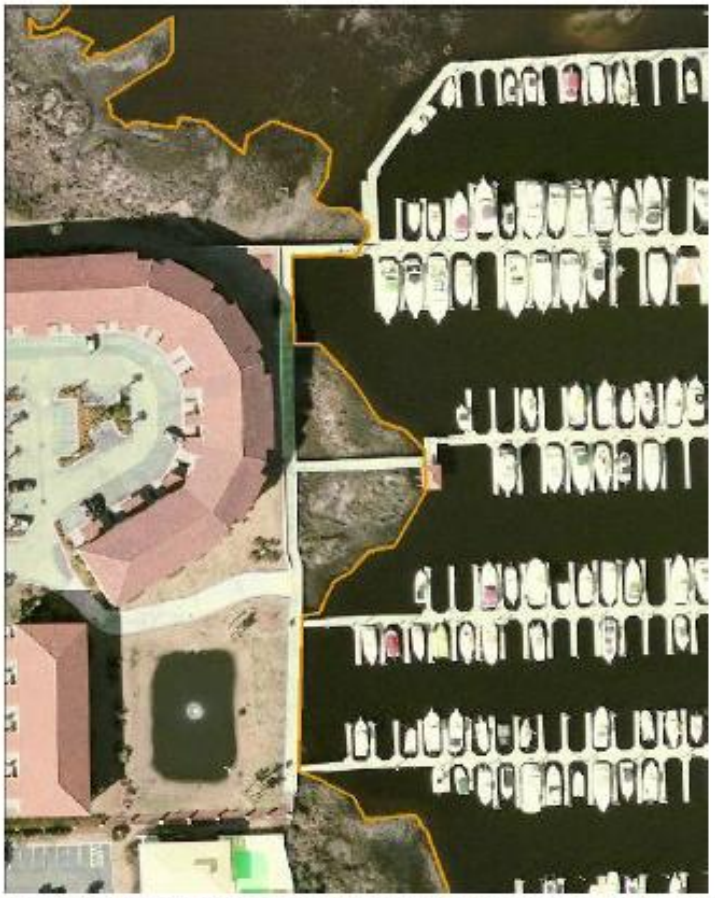
  (20 foot rule)

Dare County Example

Rules and Training

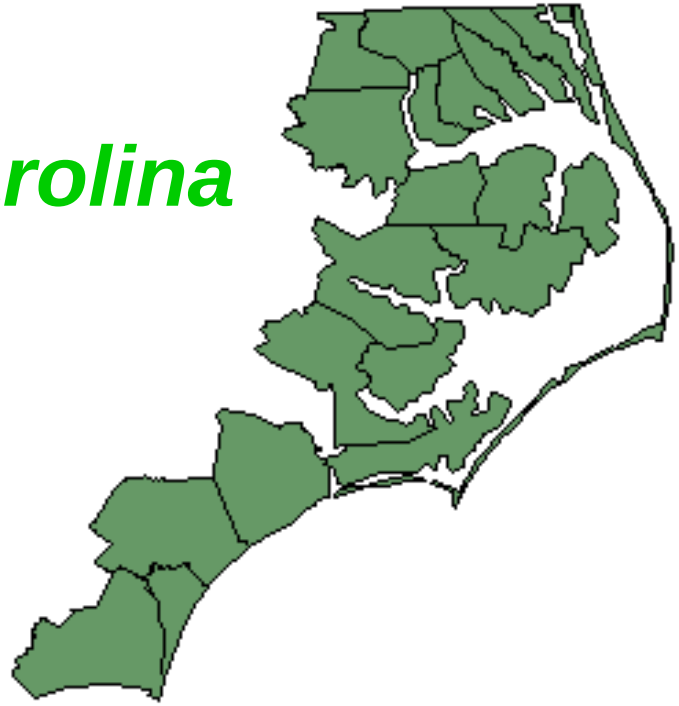
- **Detailed manual (Geis and Bendell, NCDCM, 2008)**
- **Specific rules for problem areas**
- **Training exercise**
- **Digitizer test**





Mapping Coastal North Carolina

- 20 Coastal Counties
- ~20,000 km of shoreline
- Completed in 2011



	Swamp Forest	Marsh	Sediment Bank	Modified***	Total	Structures****
Totals (km)	4009	12936	1914	967	19826	28,341
Totals (%)	20	65	10	5	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

Accuracy Assessment

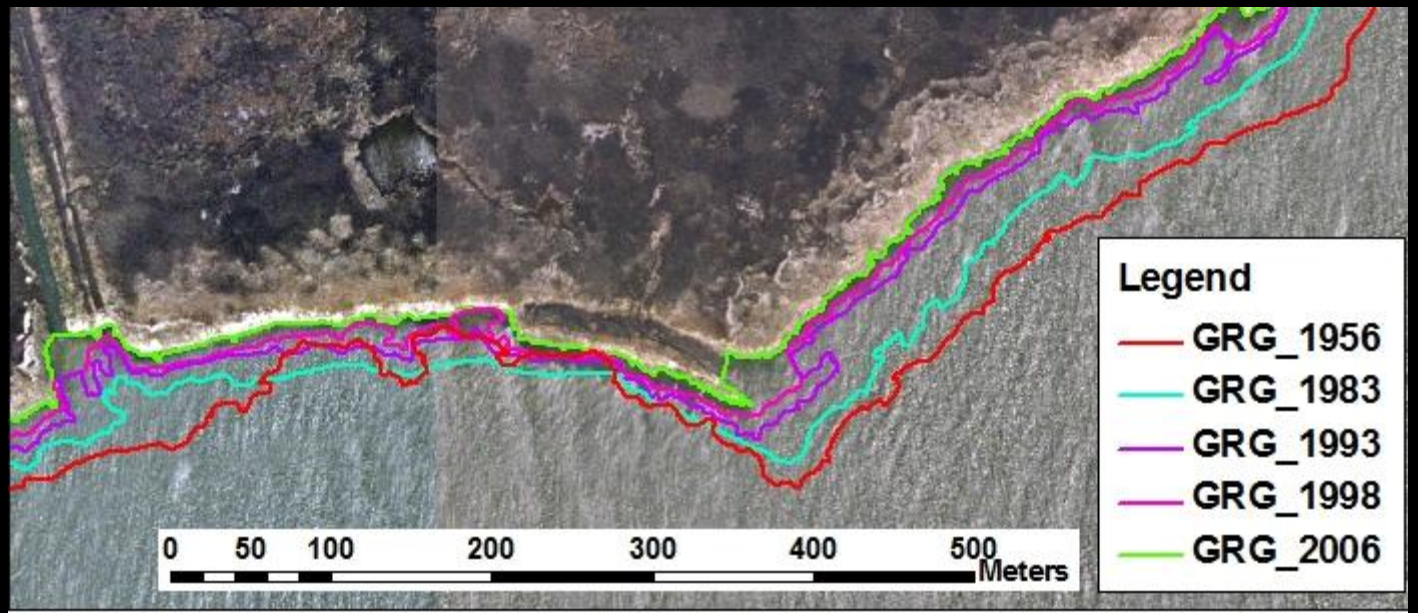
- **Informal, undergrad project**
- **Shoreline: RTK GPS vs GIS**
- **Structures: Boat survey vs. GIS**
- **Not concurrent**
- **Fixed structures ~2.5 ft error**

Table 1 Number of Structures Observed	
Heads-Up Digitizing	Boat Survey
146	155

Burgess et al., 2010

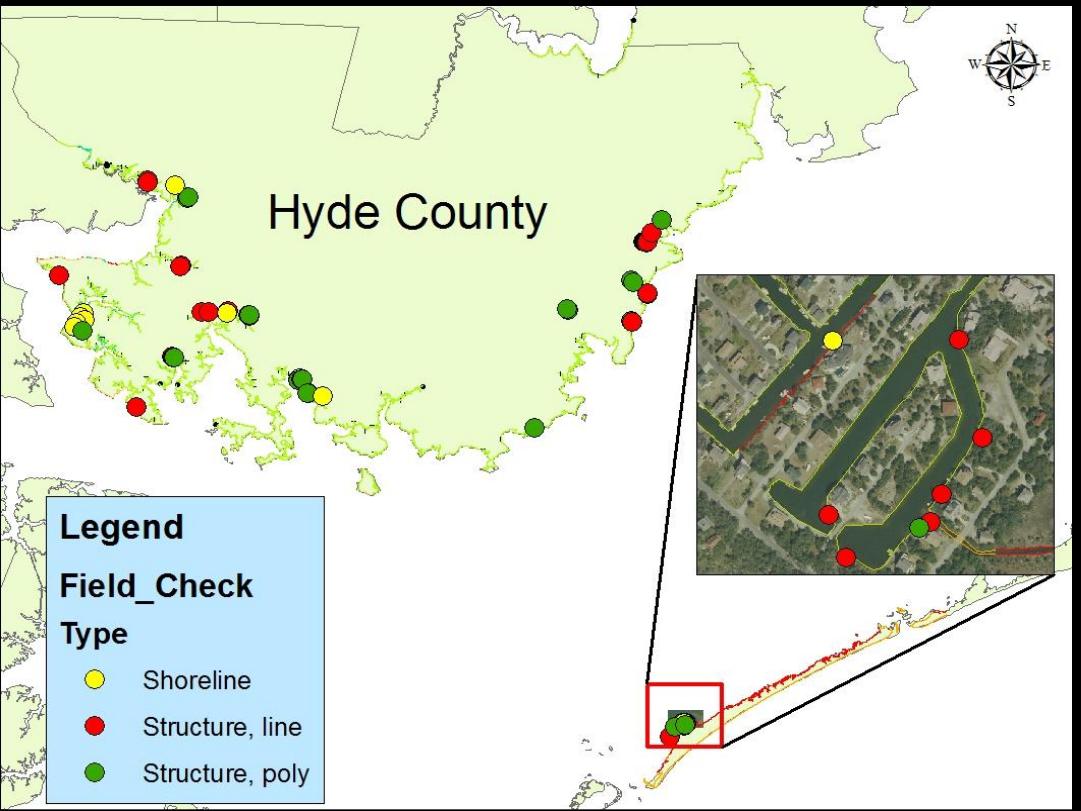
Possible Research and Management Uses

- **Map shoreline erosion**
- **Evaluate storm losses or hazards**
- **Determine coastal development rates and patterns**
- **Evaluate permitting trends**
- **Assess habitat impacts**
  - **Use CDAITS and historic and recent SAV mapping Count for structures permitted in various habitats**



Example DCM Application

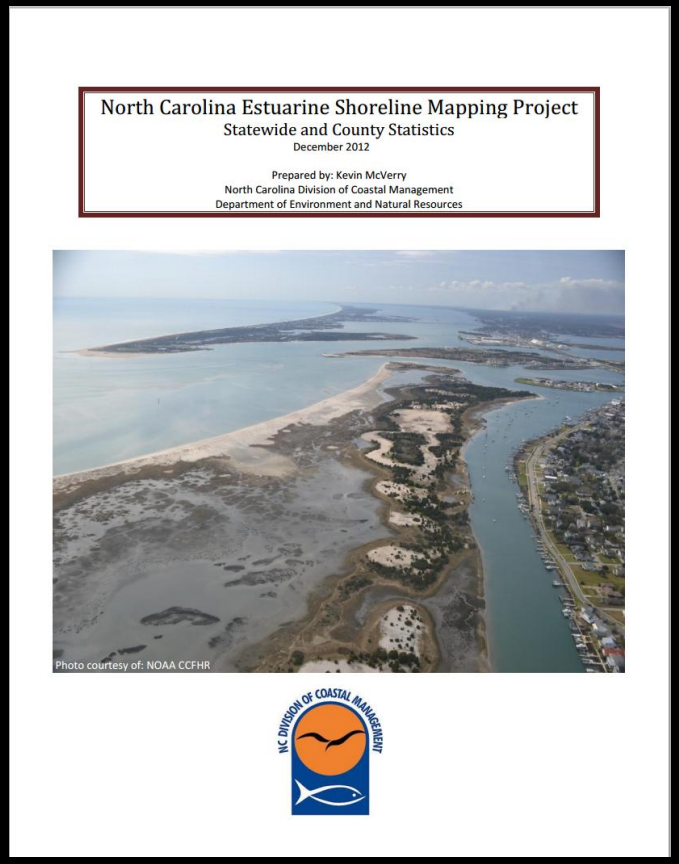
- **C-DAITS**
  - **Coastal Development Activity and Impact Tracking System**
  - **Permitting database**
  - **Tie x, y coordinate points generated by field staff to the shoreline as an update**

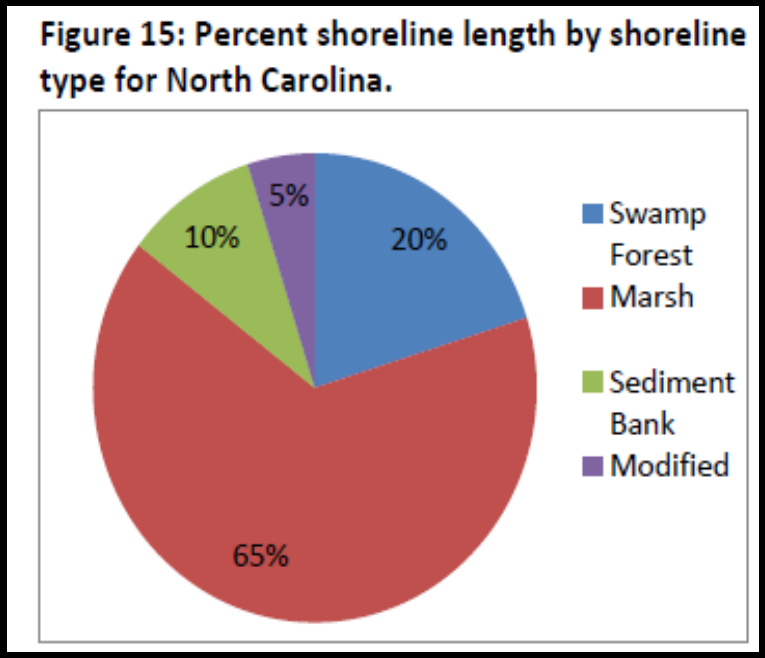


Hyde County			
ACTIVITY	**COUNT**		
Bridge	2		
Bulkhead(wood)	15		
Finger pier	7		
Groin(rock/vinyl)	1		
Pier "L" head	2		
Pier "T" head	3		
Pier or dock	12		
Riprap	10		
Total Structures Permited after Feb 1, 2007			
52			

Analysis of the NC Estuarine Shoreline

- **DCM Shoreline Summary**





- http://dcm2.enr.state.nc.us/estuarineshoreline/ESMP%20Analysis%20Report%20Final%2020130117.pdf

Analysis of the NC Estuarine Shoreline

- **Valuable summary data.**

Table 2: Shoreline length for North Carolina by shoreline type.

Shoreline Type	Miles	Percent
Swamp Forest	2,490.4	20.2
Marsh	8,038.5	65.3
Sediment Bank	1,189.3	9.7
Modified	601.0	4.9
Total	**12,319.1**	

Figure 15: Percent shoreline length by shoreline type for North Carolina.

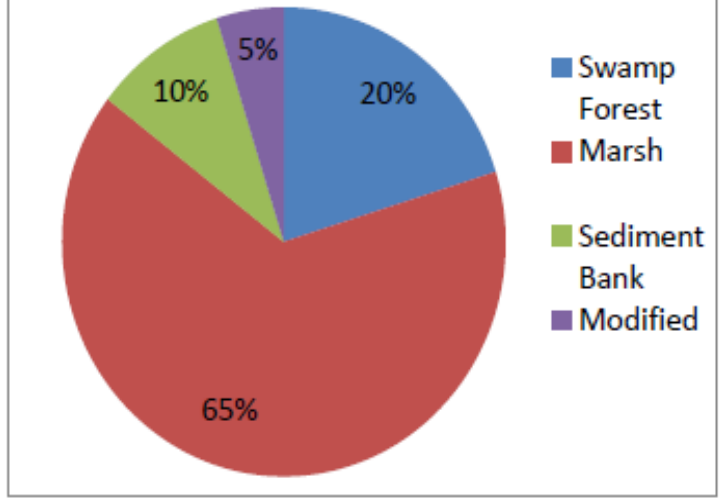


Table 16: Area of shoreline access structures within North Carolina.

Structure Type	Total Number of Structures	Average Area in Feet^2	Total Area in Feet^2	Average Area in Acres	Total Area in Acres
Bridge	546	25,426	13,957,045	0.58	320.4
Pier/Floating Dock/Wharf	27,795	879	24,465,451	0.02	561.6
Total	**28,341**		**38,422,497**		**882.1**

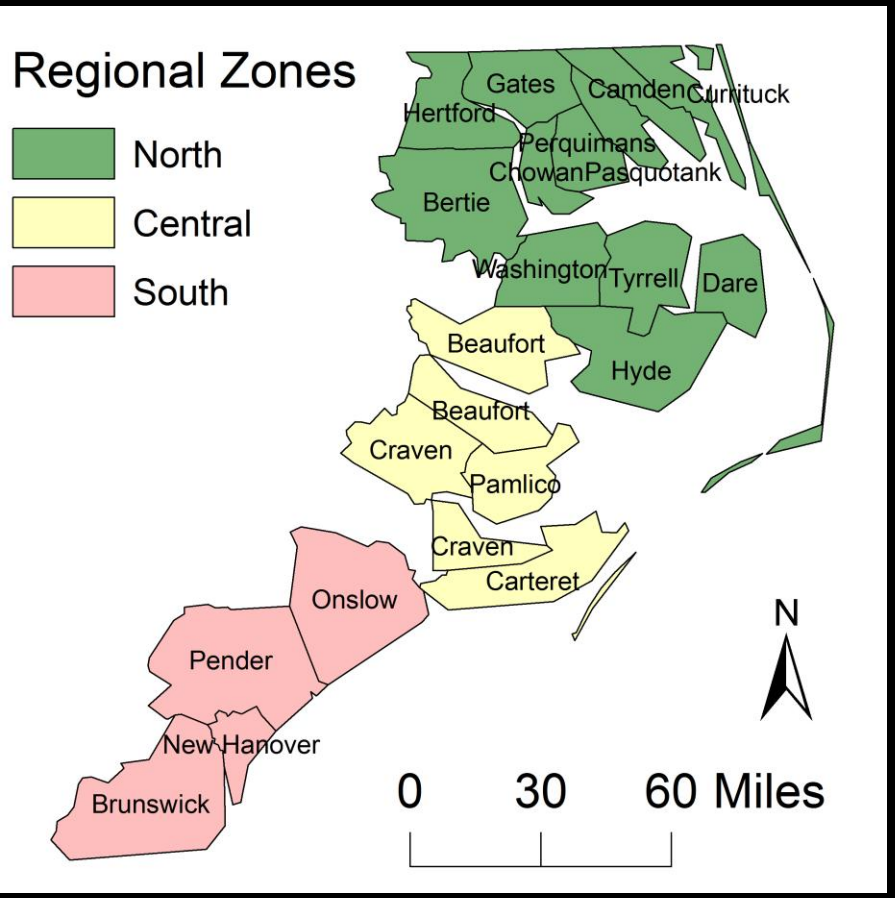
Additional Analysis of Data

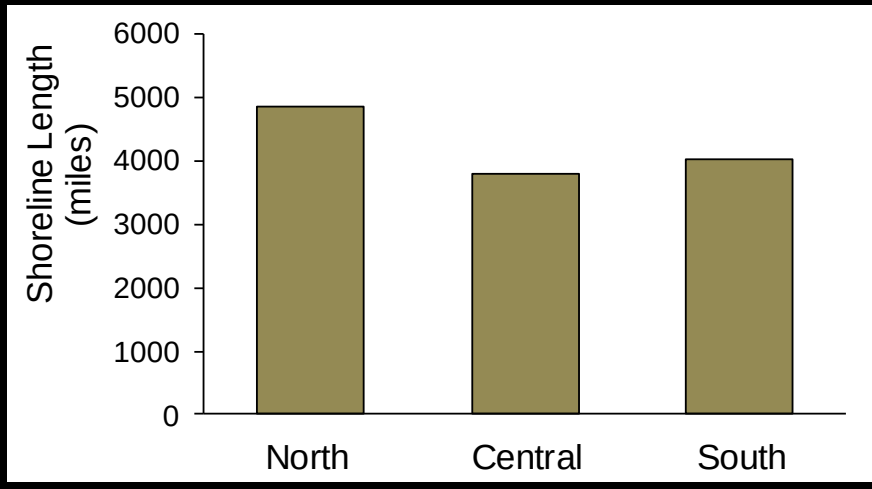
- Analysis of specific regions
- Hot-spot analysis
- Relationship with SAV, LiDAR

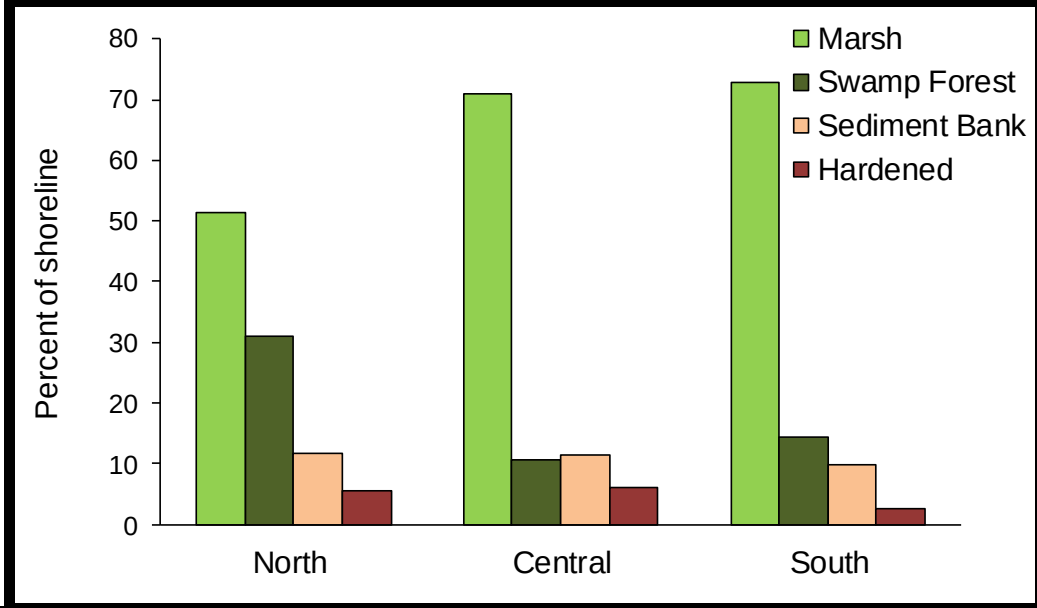
Wrightsville Beach

North vs Central vs South

- **Similar shoreline lengths**
- **North – less marsh, more hardened**

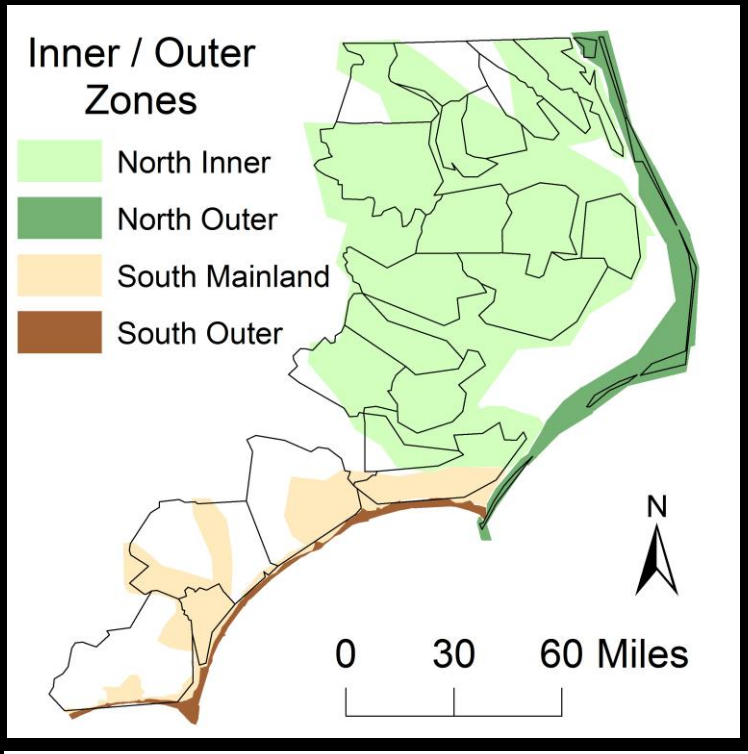


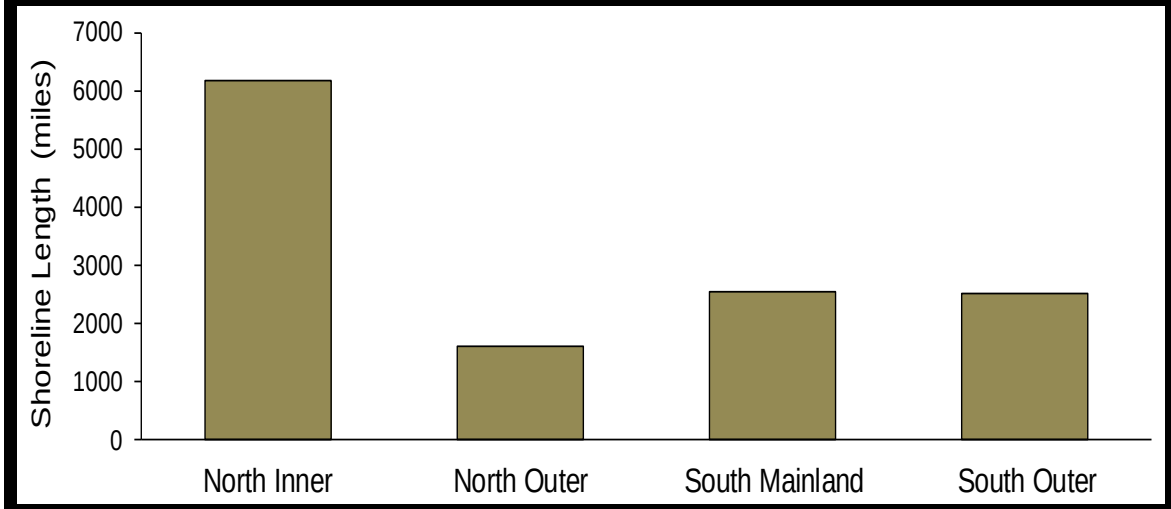


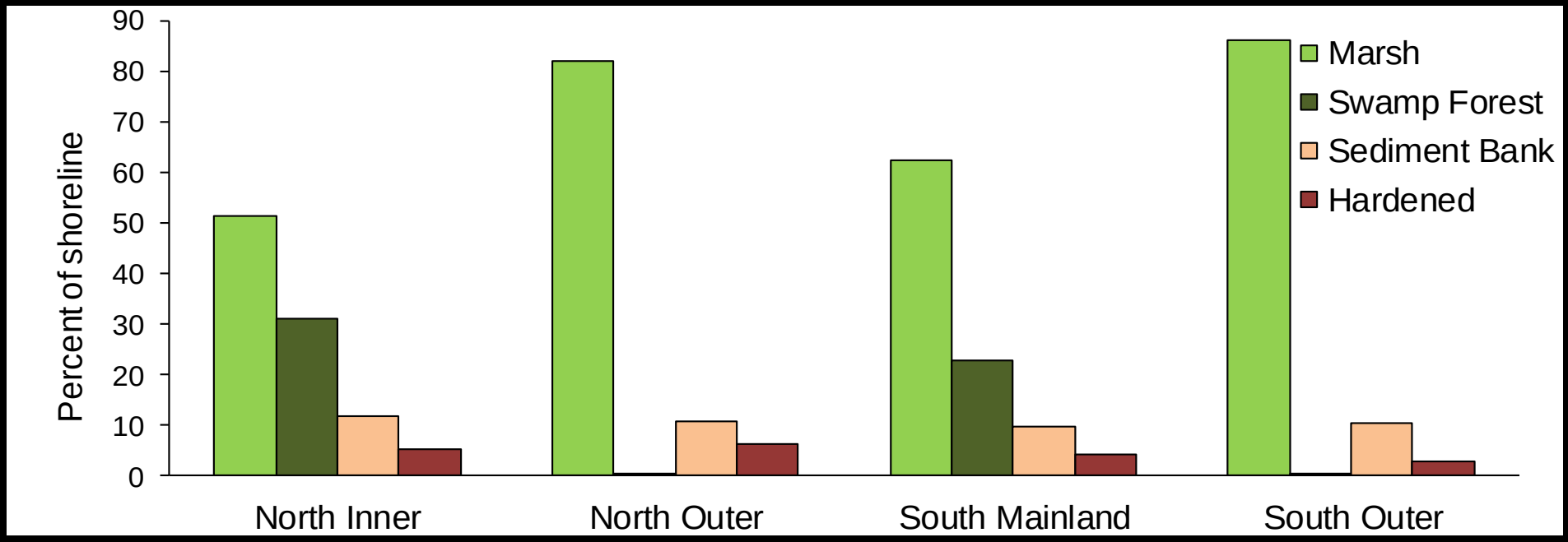


Inner vs Outer Coast Areas

- Northern IBX > double shoreline
- Not much difference in hardening

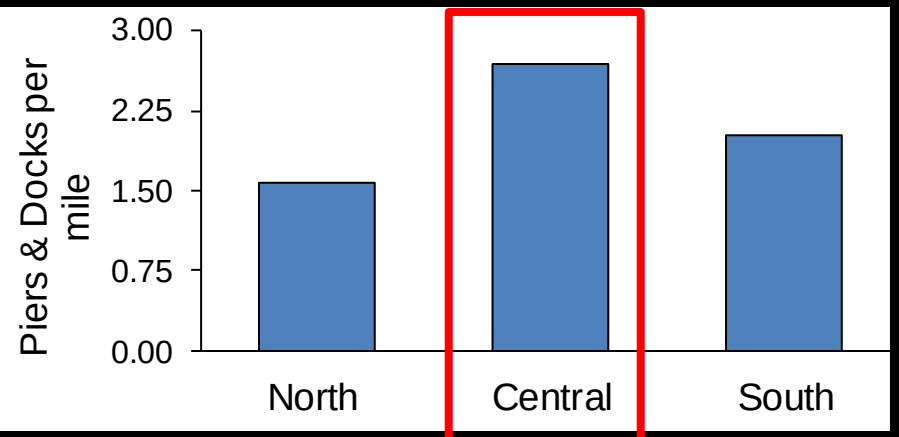


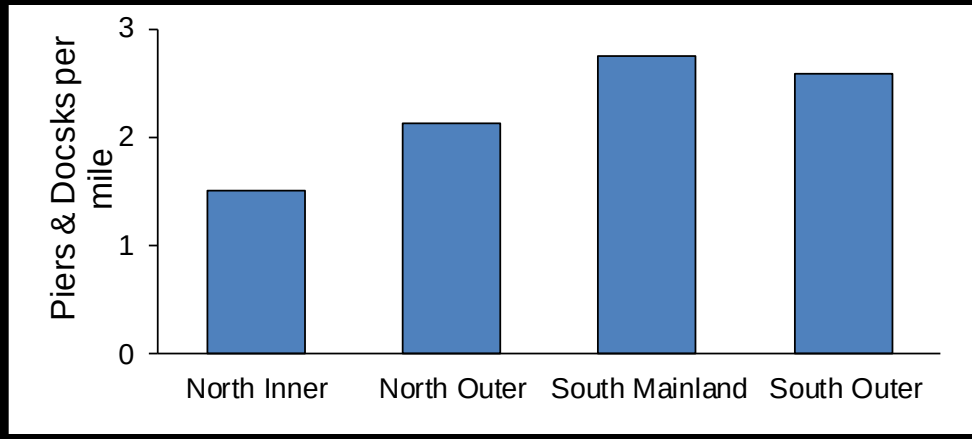


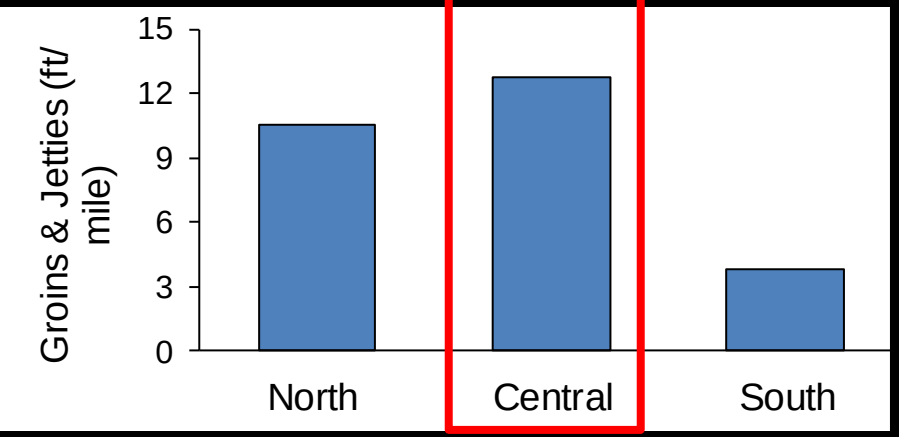


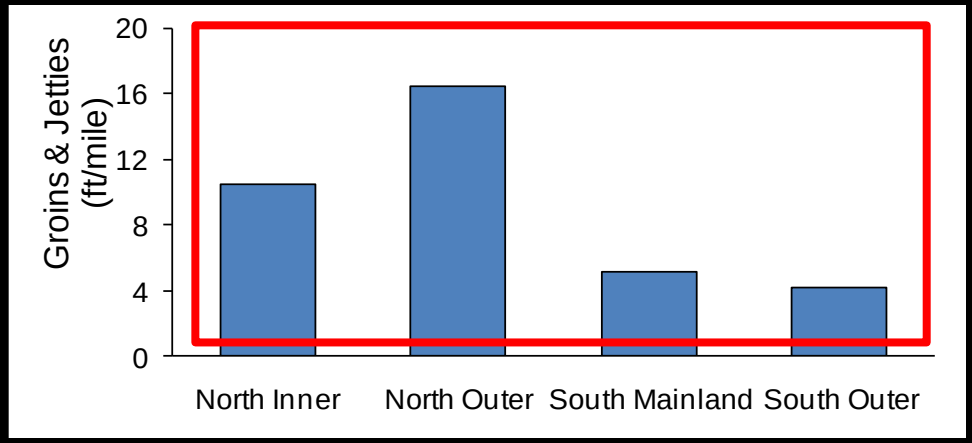
Data Normalized by Distance

- **Shows greater density of development in Central region**
- **Different modification in North vs South**

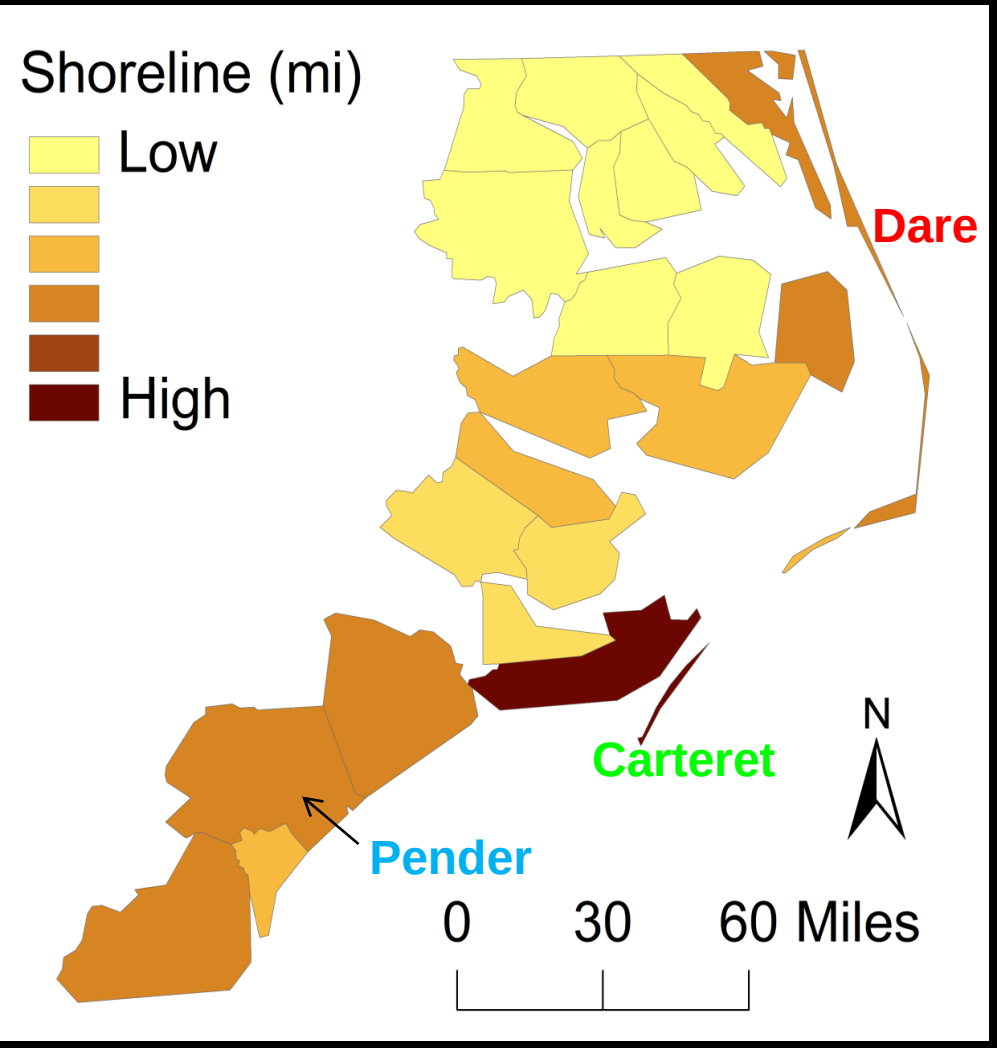








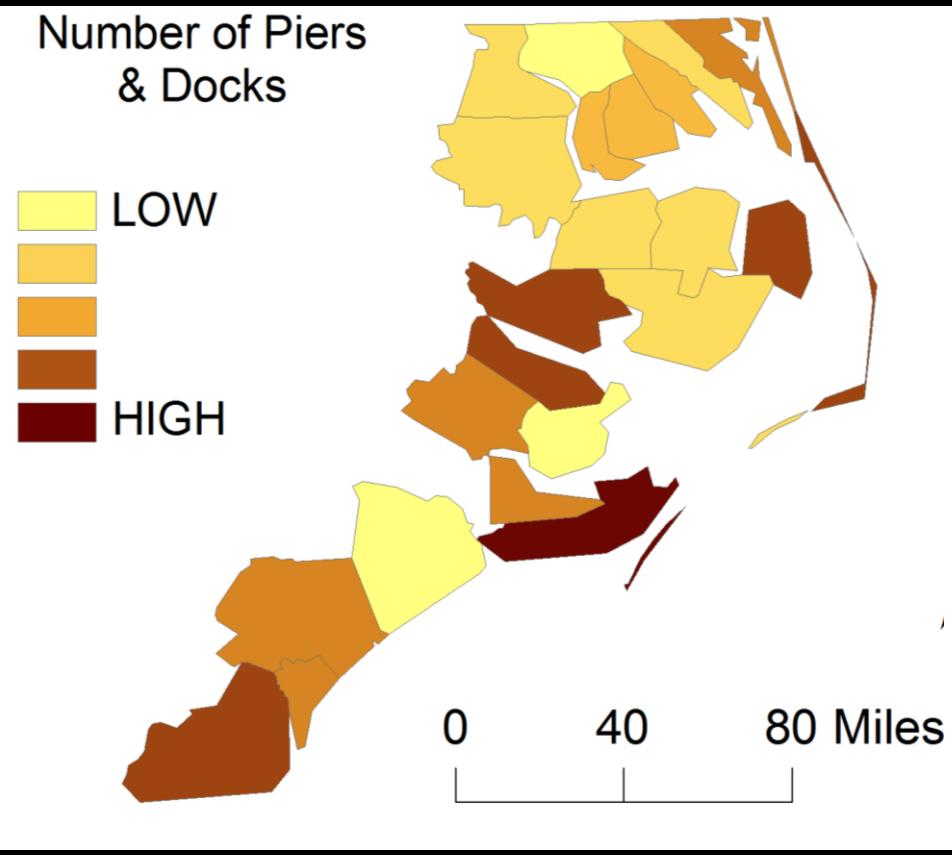
Data by County

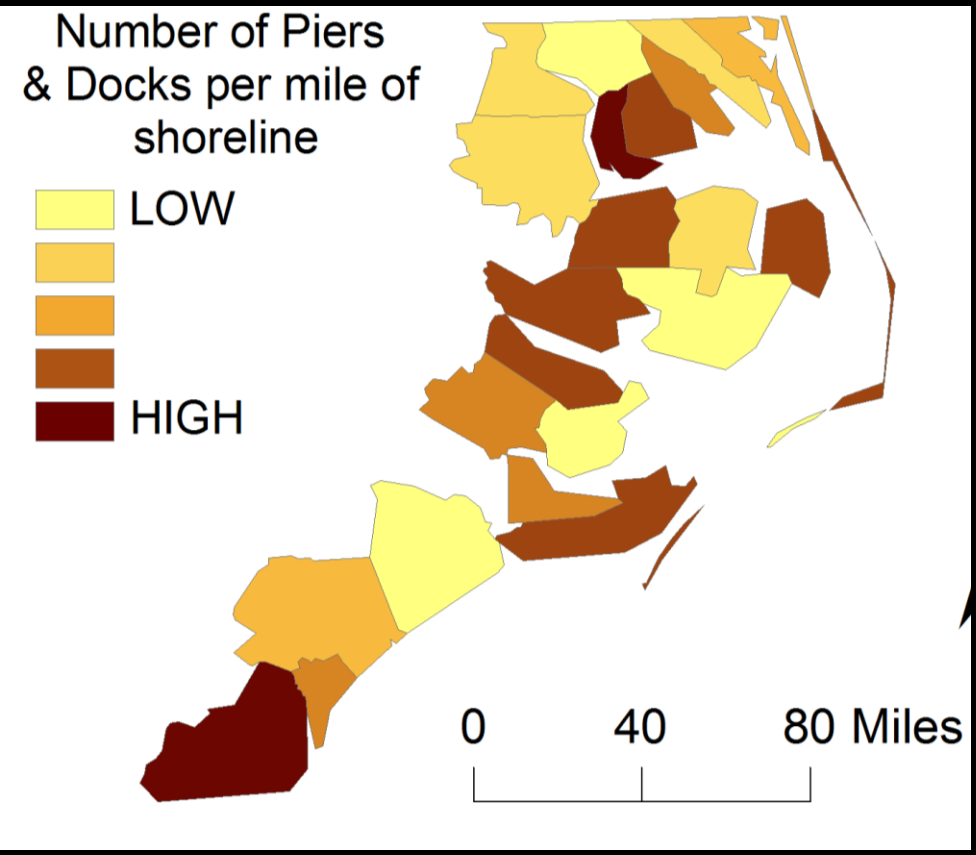


County	Shoreline (mi)	Shoreline Hardened (mi)	Marsh (mi)
Beaufort	863.3	81.7	552.2
Bertie	322.5	2.1	5.1
Brunwsick	1007.8	38.1	749.6
Camden	258.6	12.9	93.0
Carteret	1746.7	89.1	1440.6
Chowan	139.3	17.2	0.9
Craven	548.5	27.9	193.1
Currituck	1106.3	61.8	895.2
Dare	969.3	85.6	703.2
Gates	145.7	0.2	6.5
Hertford	207.2	2.9	3.4
Hyde	859.7	10.4	711.2
New Hanover	814.7	20.8	665.9
Onslow	1145.5	30.0	882.5
Pamlico	633.4	32.0	508.0
Pasquotank	217.5	29.3	12.8
Pender	1068.5	10.8	643.0
Perquimans	240.0	32.8	5.7
Tyrrell	304.9	8.9	63.2
Washington	85.4	9.0	0.3

Docks and Piers

Big counties = more

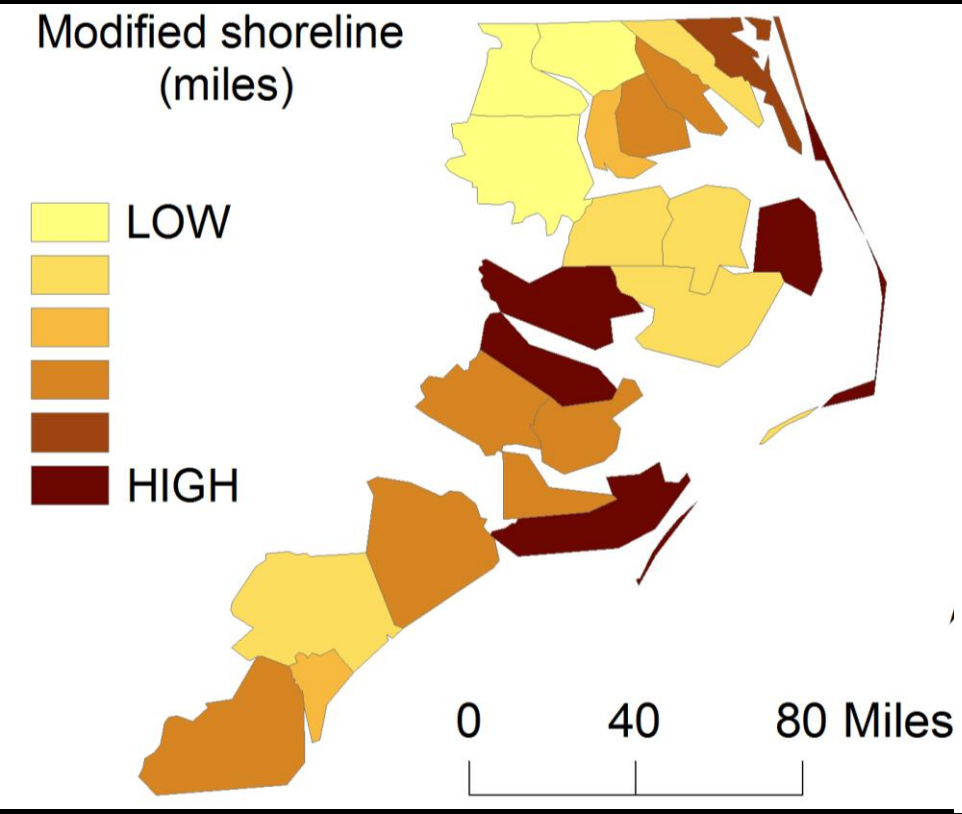


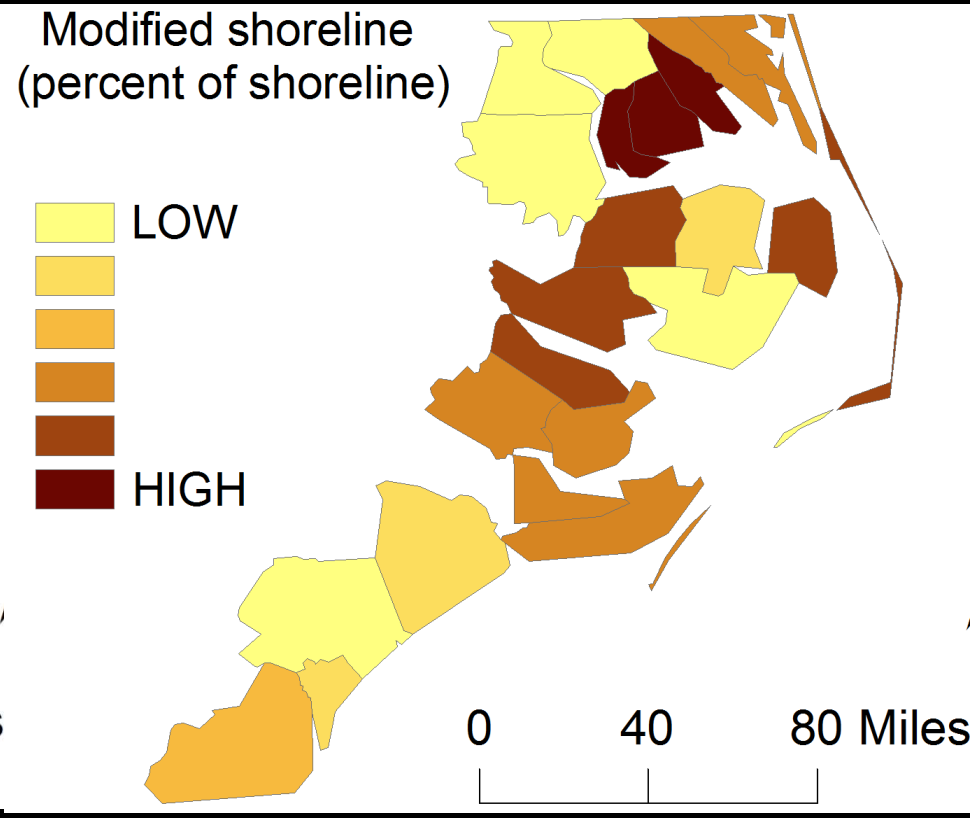


Inland counties w/ high density

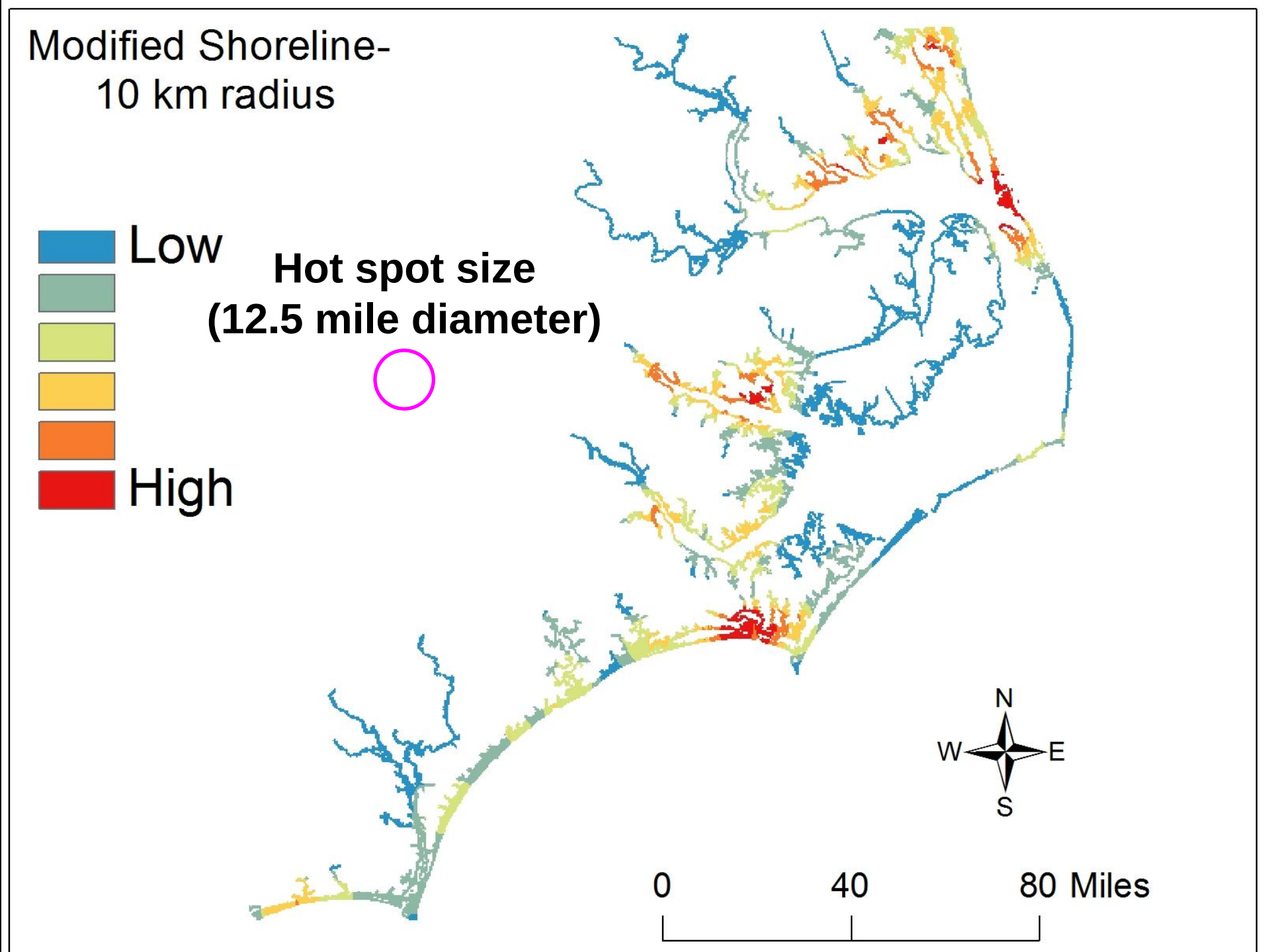
Modified Shorelines

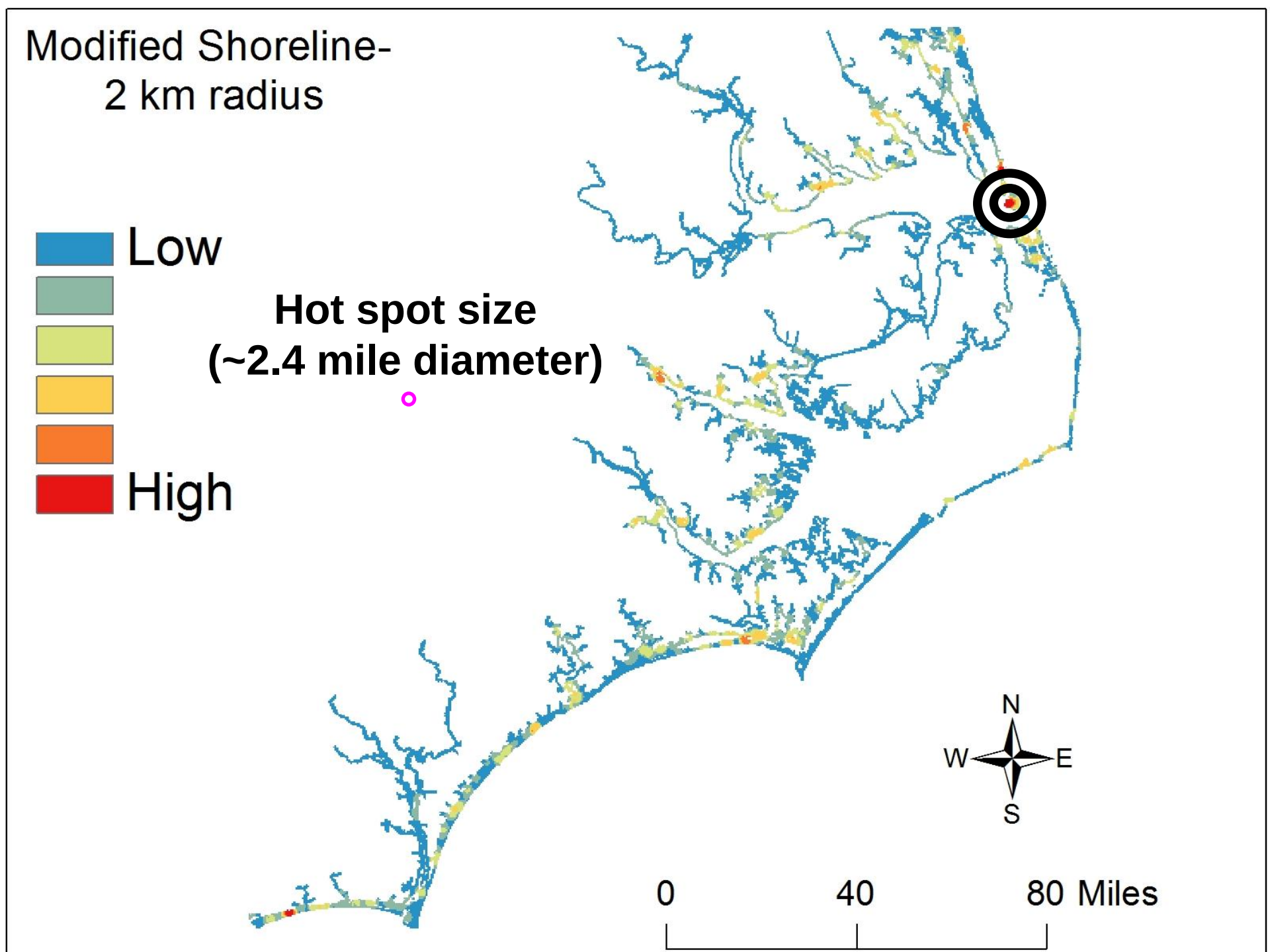
Similar size dependence



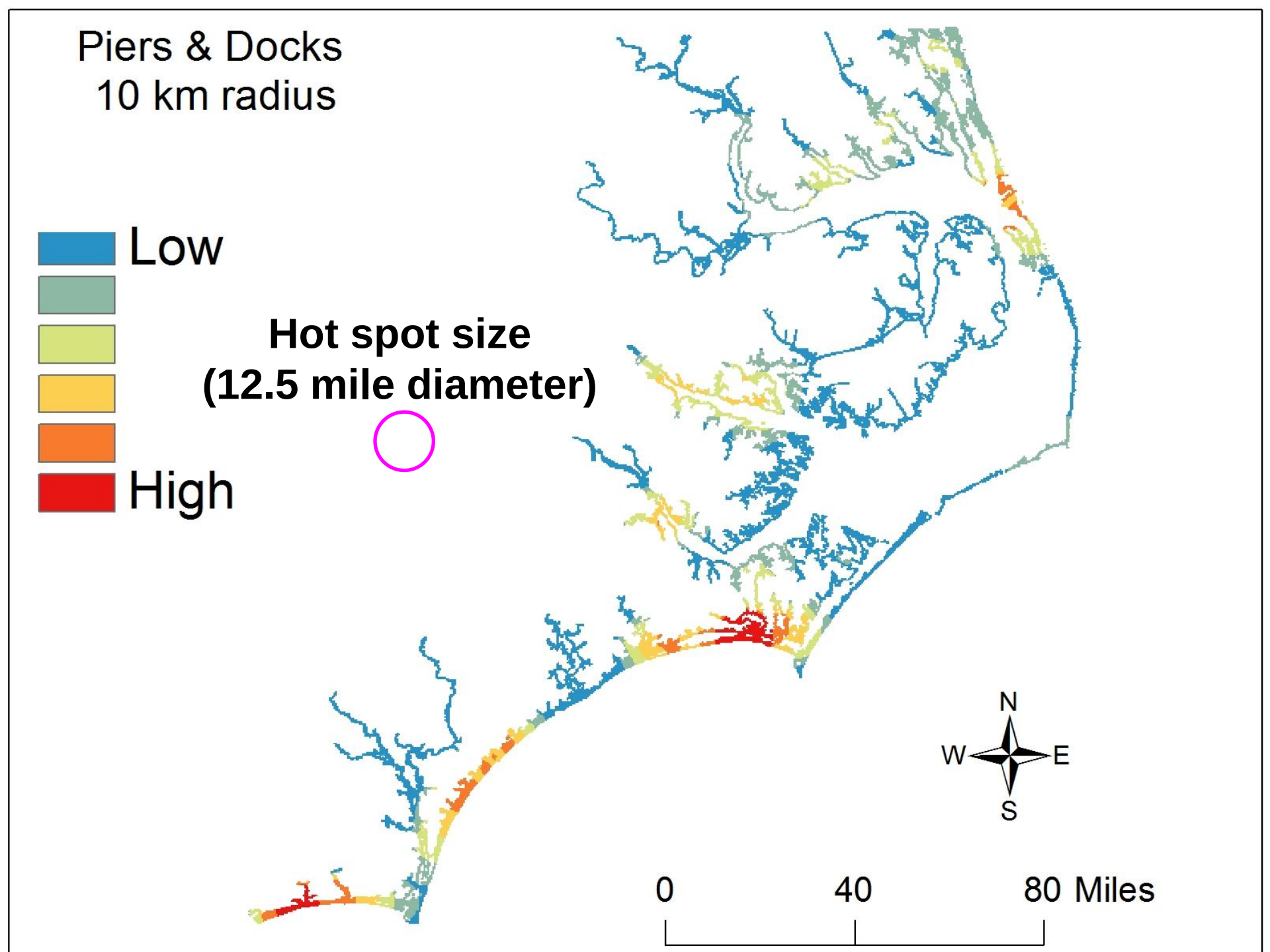


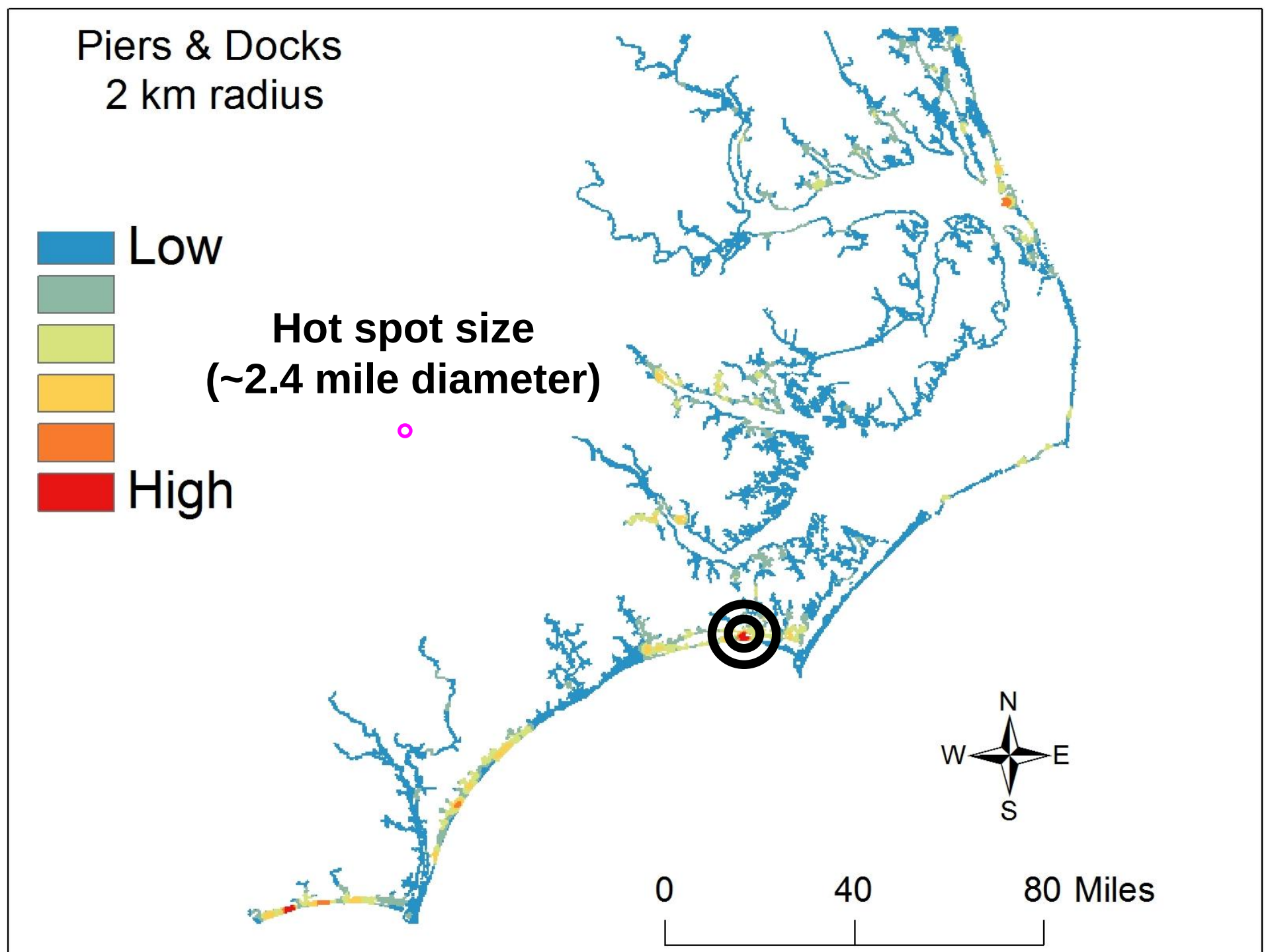
Note, the IBX counties


Modified Shoreline-
10 km radius
Low
High
Hot spot size
(12.5 mile diameter)
N
W
E
S
0
40
80 Miles

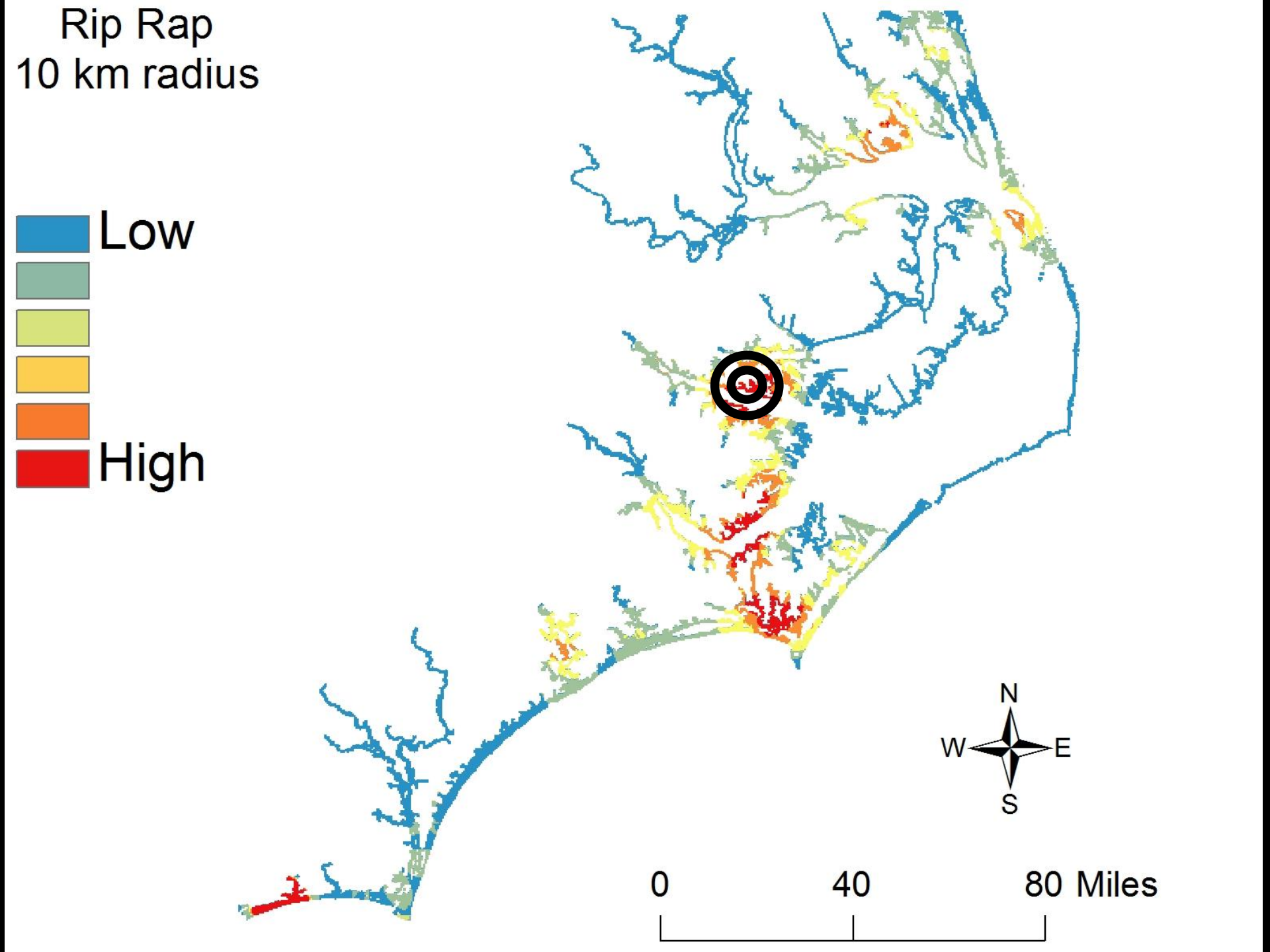

Modified Shoreline-
2 km radius
Low
High
Hot spot size
(~2.4 mile diameter)
N
W
E
S
0
40
80 Miles

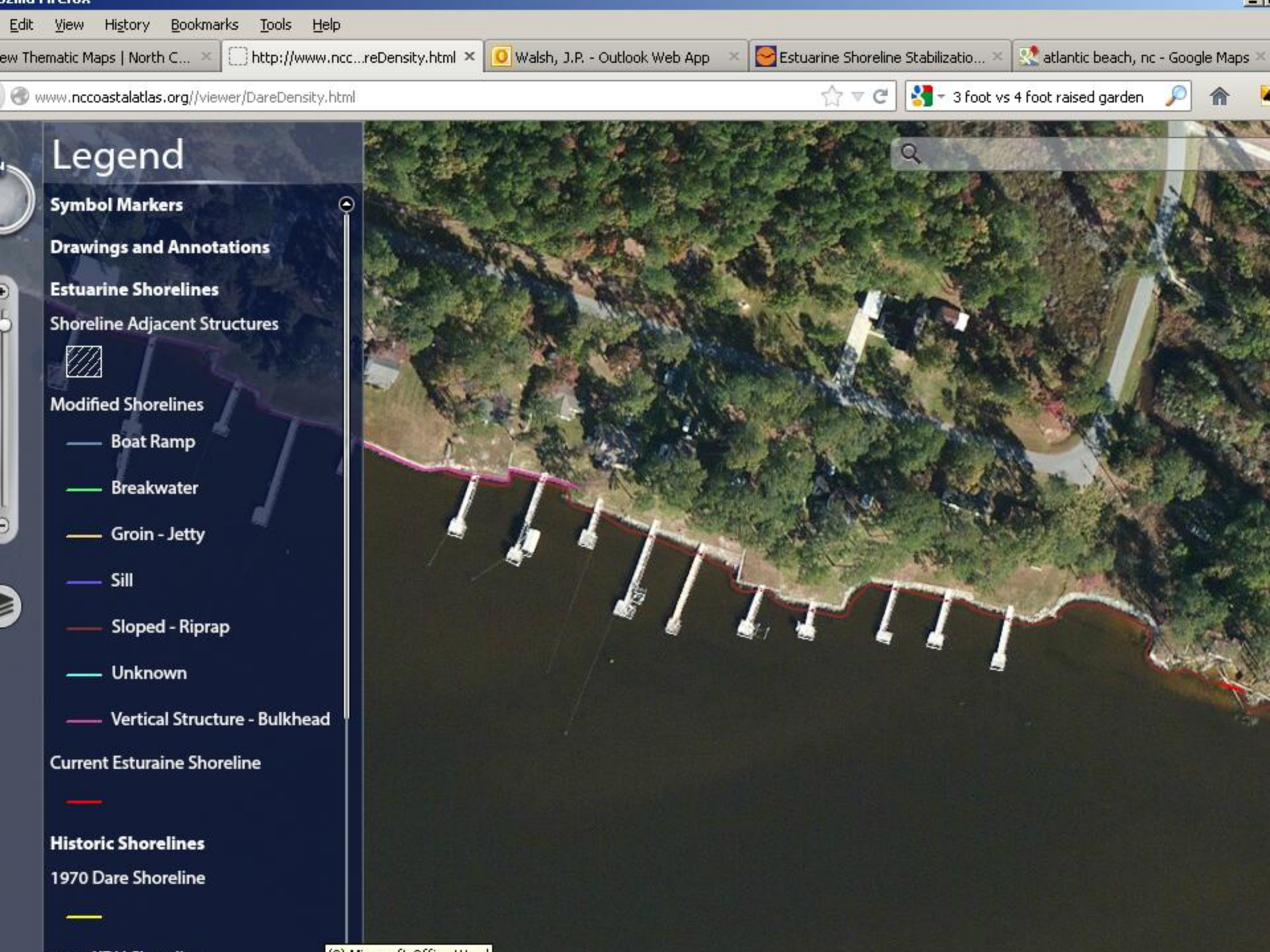
Collington Island

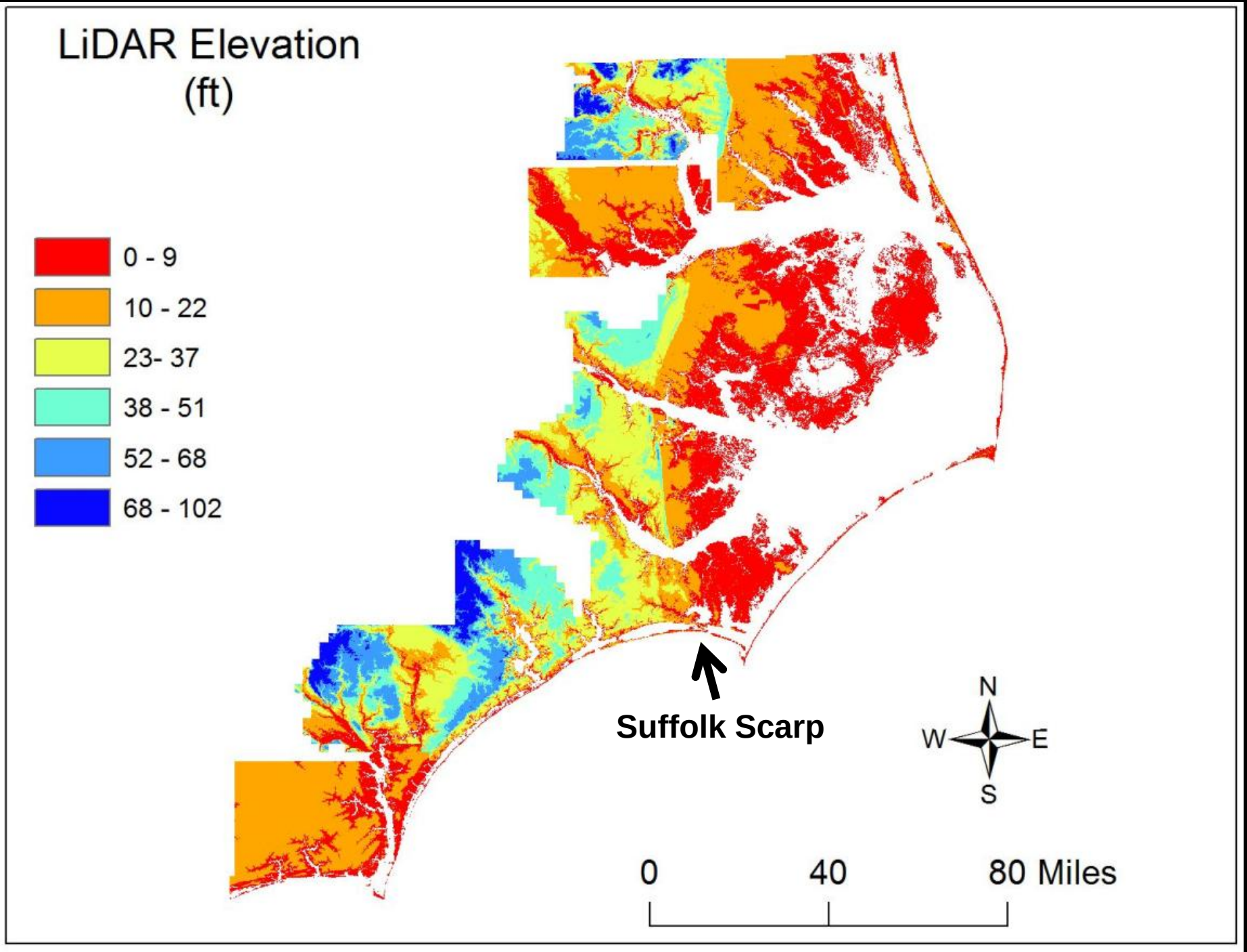

Piers & Docks
10 km radius
Low
High
Hot spot size
(12.5 mile diameter)
N
W
E
S
0
40
80 Miles

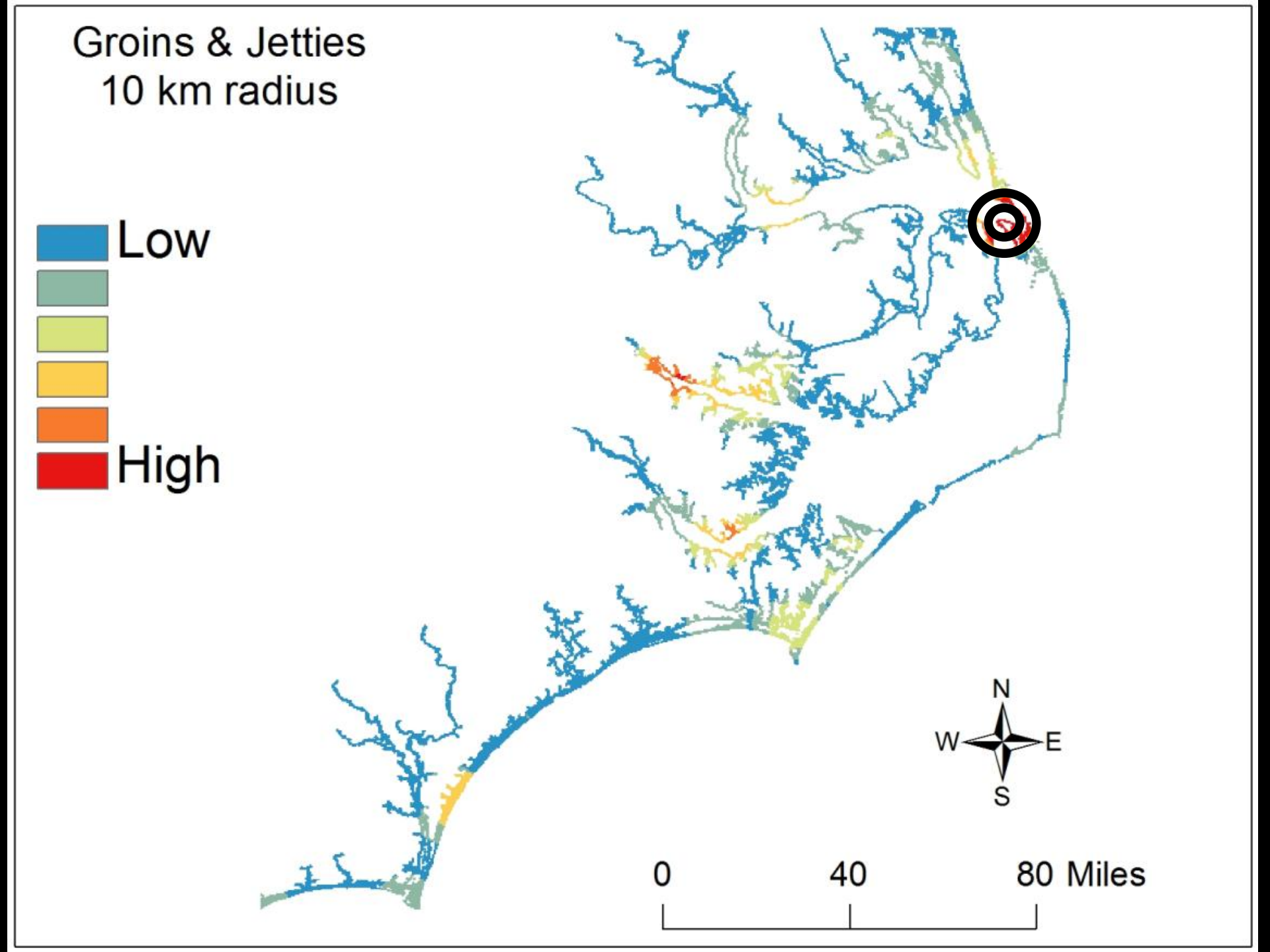

Piers & Docks
2 km radius
Low
High
Hot spot size
(~2.4 mile diameter)
N
W
E
S
0
40
80 Miles


Atlantic Beach


Rip Rap
10 km radius
Low
High
N
W
E
S
0
40
80 Miles


Edit View History Bookmarks Tools Help
ew Thematic Maps | North C...
http://www.ncc...reDensity.html
Walsh, J.P. - Outlook Web App
Estuarine Shoreline Stabilizatio...
atlantic beach, nc - Google Maps
www.nccoastalatlas.org//viewer/DareDensity.html
3 foot vs 4 foot raised garden
Legend
Symbol Markers
Drawings and Annotations
Estuarine Shorelines
Shoreline Adjacent Structures
Modified Shorelines
Boat Ramp
Breakwater
Groin - Jetty
Sill
Sloped - Riprap
Unknown
Vertical Structure - Bulkhead
Current Esturaine Shoreline
Historic Shorelines
1970 Dare Shoreline


LiDAR Elevation
(ft)
0 - 9
10 - 22
23- 37
38 - 51
52 - 68
68 - 102
Suffolk Scarp
N
W
E
S
0
40
80 Miles


Groins & Jetties
10 km radius
Low
High
N
W
E
S
0
40
80 Miles

Northern Tip of Roanoke Island

Conclusions

- **NC has come a long way in the last 5 years…**
- **Collecting an extensive dataset**
- **Data highlights areas of impact and change**
- **Need to analyze more areas and make data available**
- **Open to feedback and questions…**