North Carolina's Coasts in Crisis: A Vision for the Future

October 2008

Riggs, Culver, Ames, Mallinson, Corbett, & Walsh

Department of Geological Sciences and Institute for Coastal Science and Policy, East Carolina University

- Collaborative effort of many researchers

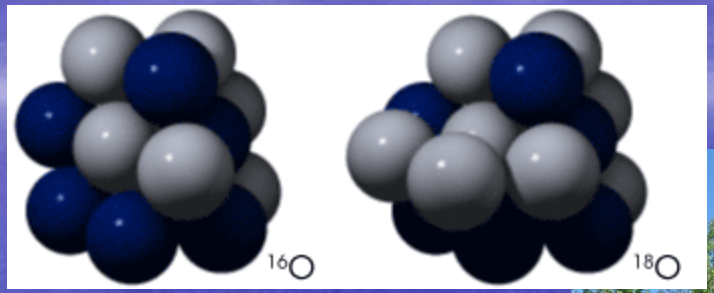
- Led by East Carolina University, the United States Geological Survey, and the North Carolina Geological Survey

- Contributions from scientists at the University of Delaware, the University of Pennsylvania, and the Virginia Institute of Marine Sciences.

Purpose

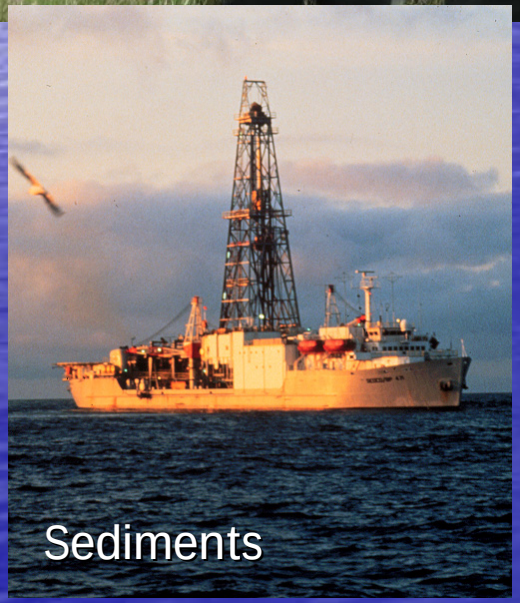
- To lay the framework for this report, that is, the foundation for understanding that climate and sea level HAVE changed and will continue to change
- To present the record we see in North Carolina

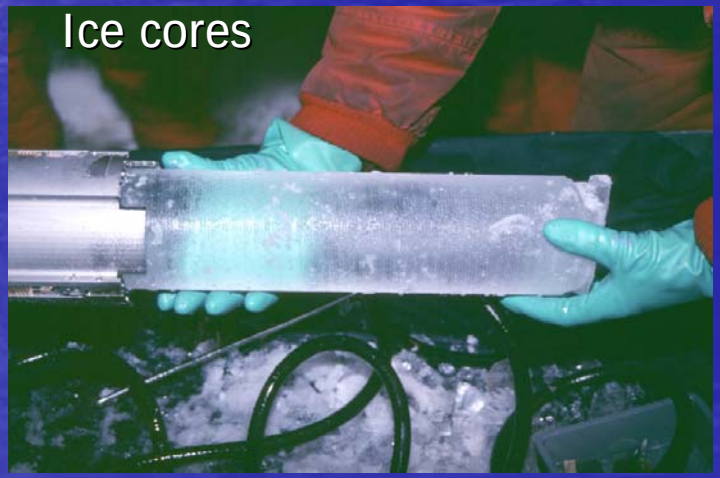
First: How do we understand the record of sea-level change?

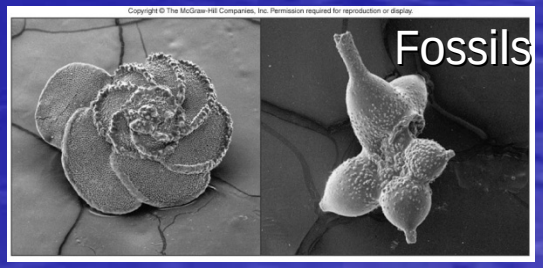


Geochemistry

DATA!







Numerous Ice Ages During the Pleistocene

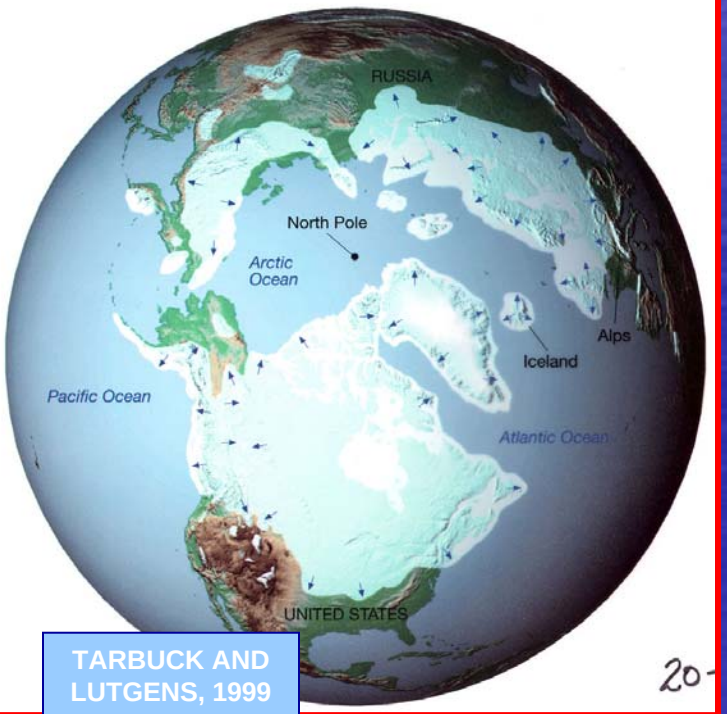
Mechanism for SL Change

ICE SHEETS GROW

→ **SEA LEVEL FALLS**

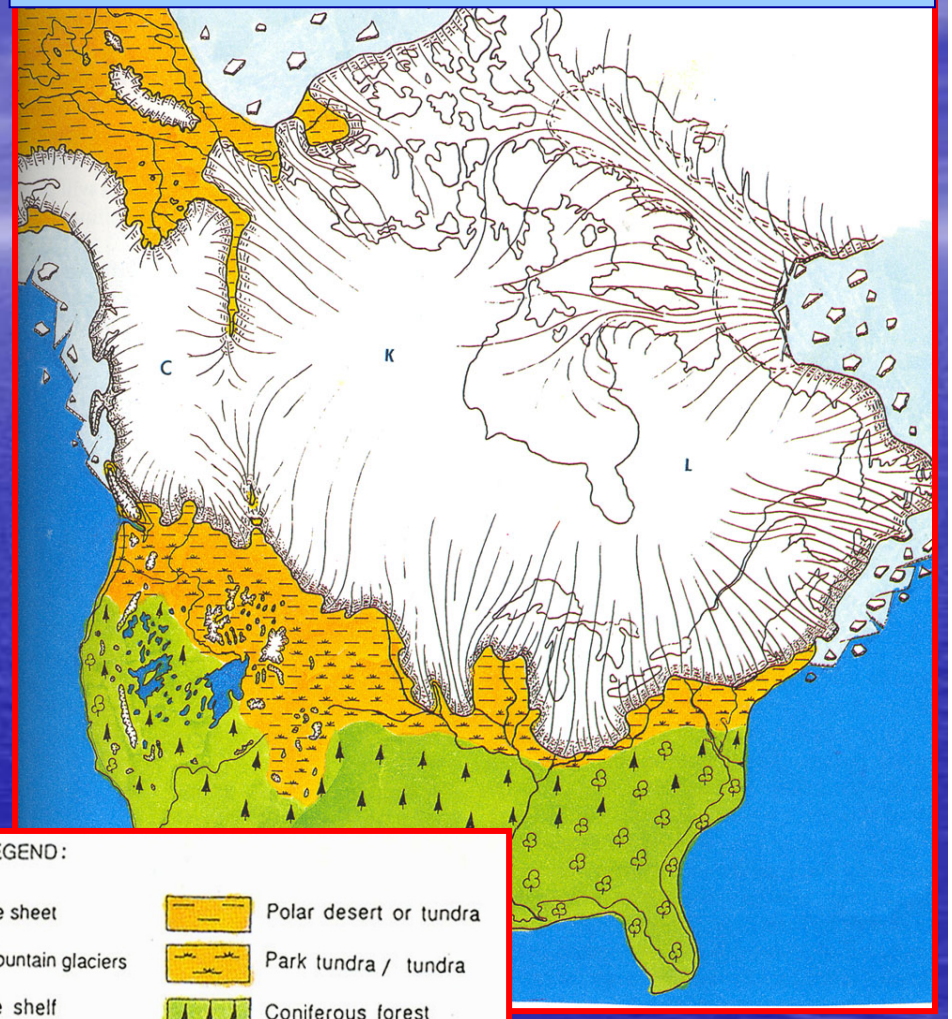
ICE SHEETS MELT

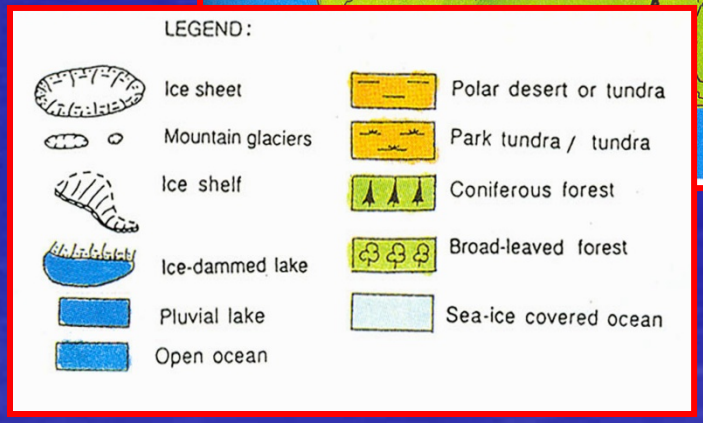
→ **SEA LEVEL RISES**



TARBUCK AND LUTGENS, 1999

NORTH AMERICA: 18,000—20,000 YEARS AGO





ANDERSEN & BORNS, 1994

The Pleistocene Record

SEA-LEVEL CURVE – LAST 1 MILLION YRS

YOU ARE HERE

Ice sheets melt
Sea-level rises
INTERGLACIALS

WARM

Present sea level

HIGH SEA LEVEL

400 feet

LOW SEA LEVEL

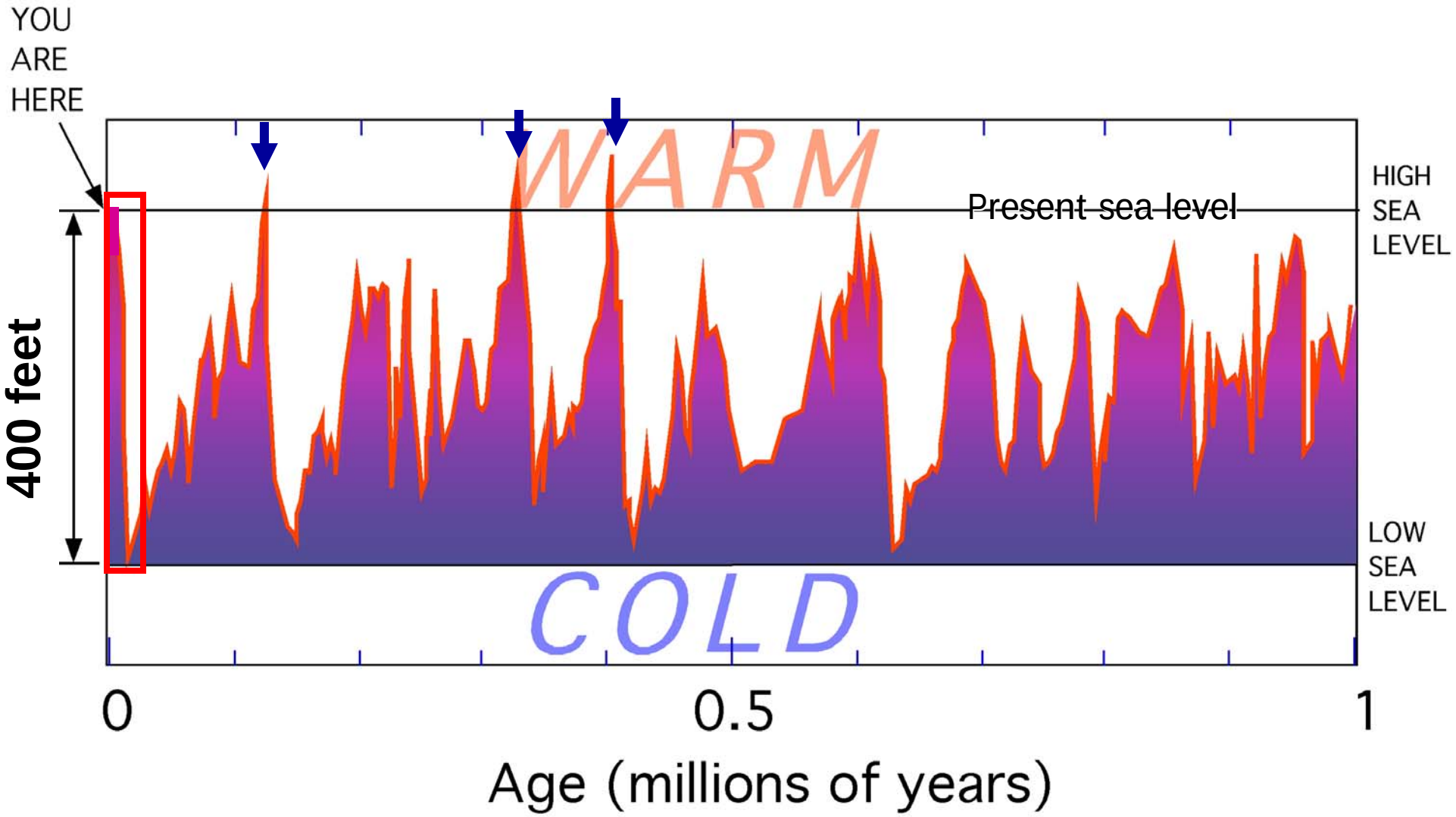
COLD

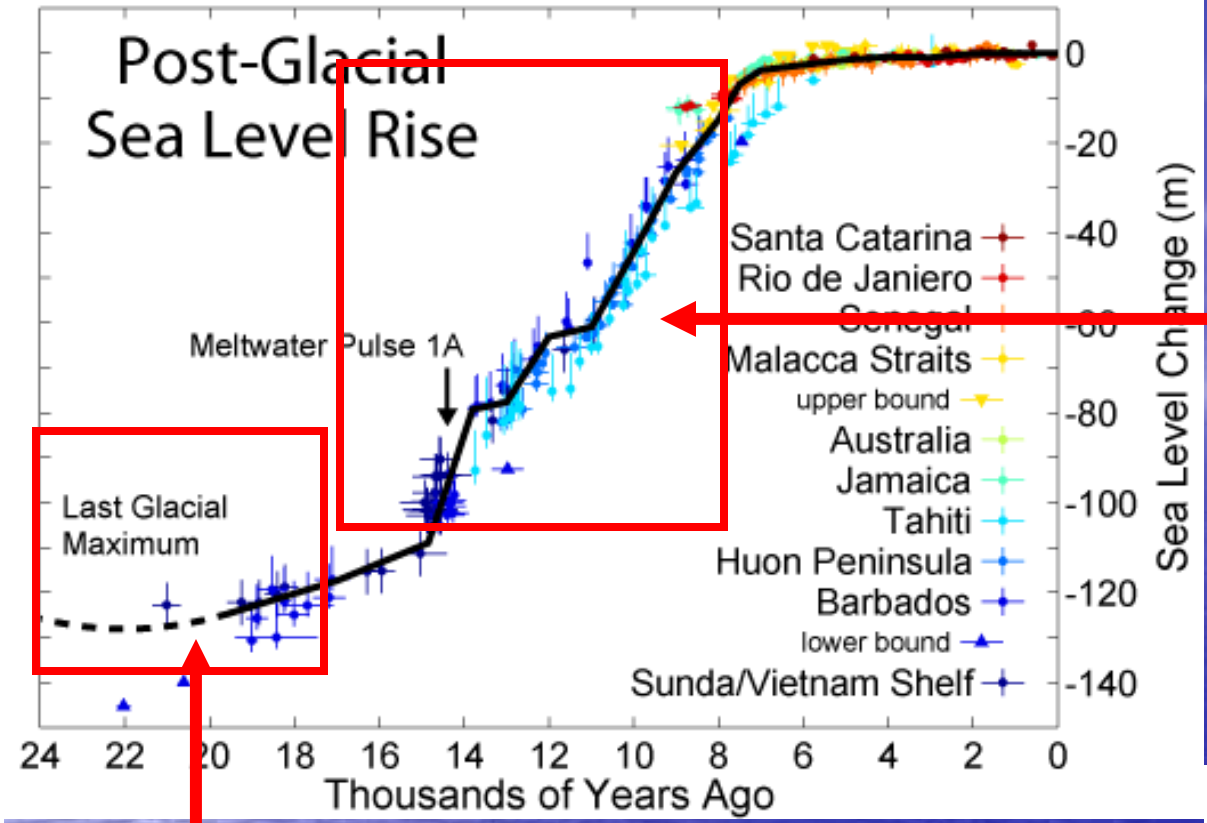
Ice sheets grow
Sea-level falls
GLACIALS

0 0.5 1

Age (millions of years)

3 OF THE LAST 4 INTERGLACIALS EXPERIENCED HIGHER SEA LEVEL THAN TODAY (BY 25 to 50 FEET) DUE TO MELTING OF THE WEST ANTARCTIC ICE SHEET AND/OR THE GREENLAND ICE SHEET





Holocene (<10,000 y)

Slow rise of ~ 4 inches/century

Termination 1
SL rose at an ave. rate of ~5 ft/century

The Last Glacial Maximum (LGM)
Sea level was ~400 feet lower

CONSENSUS

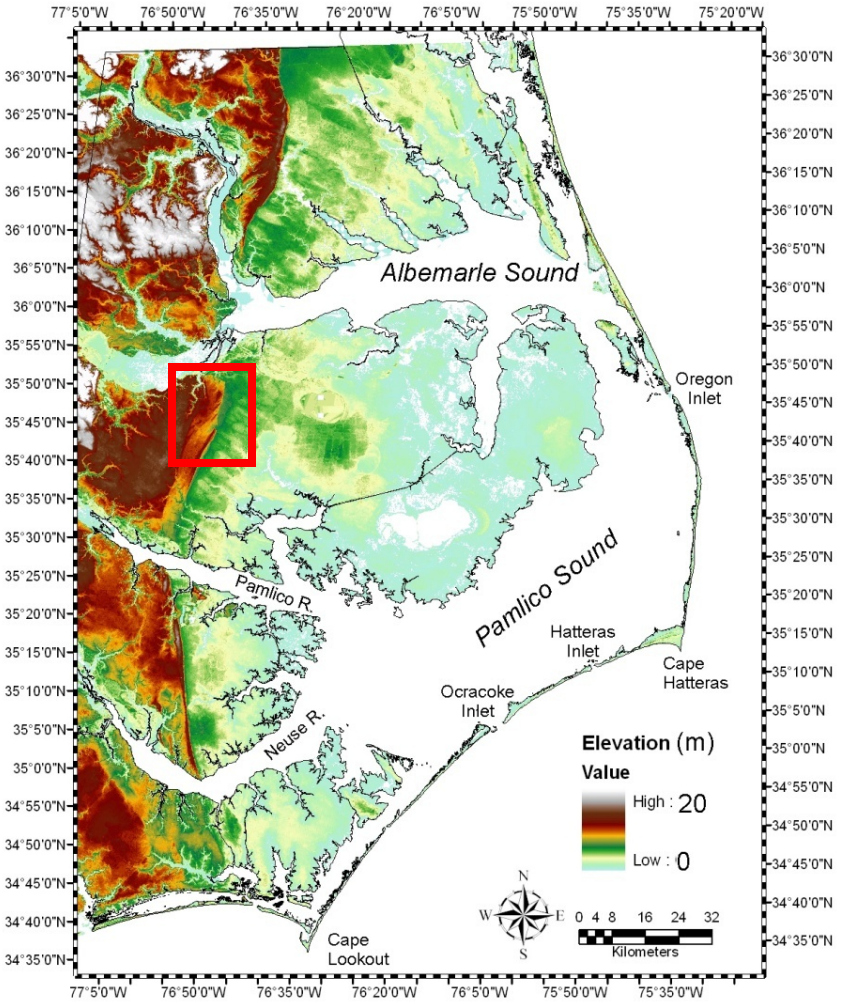
- There is no debate within the scientific community that climate and sea level have changed in the past and will continue to change in the future.
- For our purposes (i.e. living with and adapting to the change), the mechanism of change is academic.

- Throughout NC we have abundant evidence of past climate and sea-level change, which gives us some idea of what to expect in the near future.

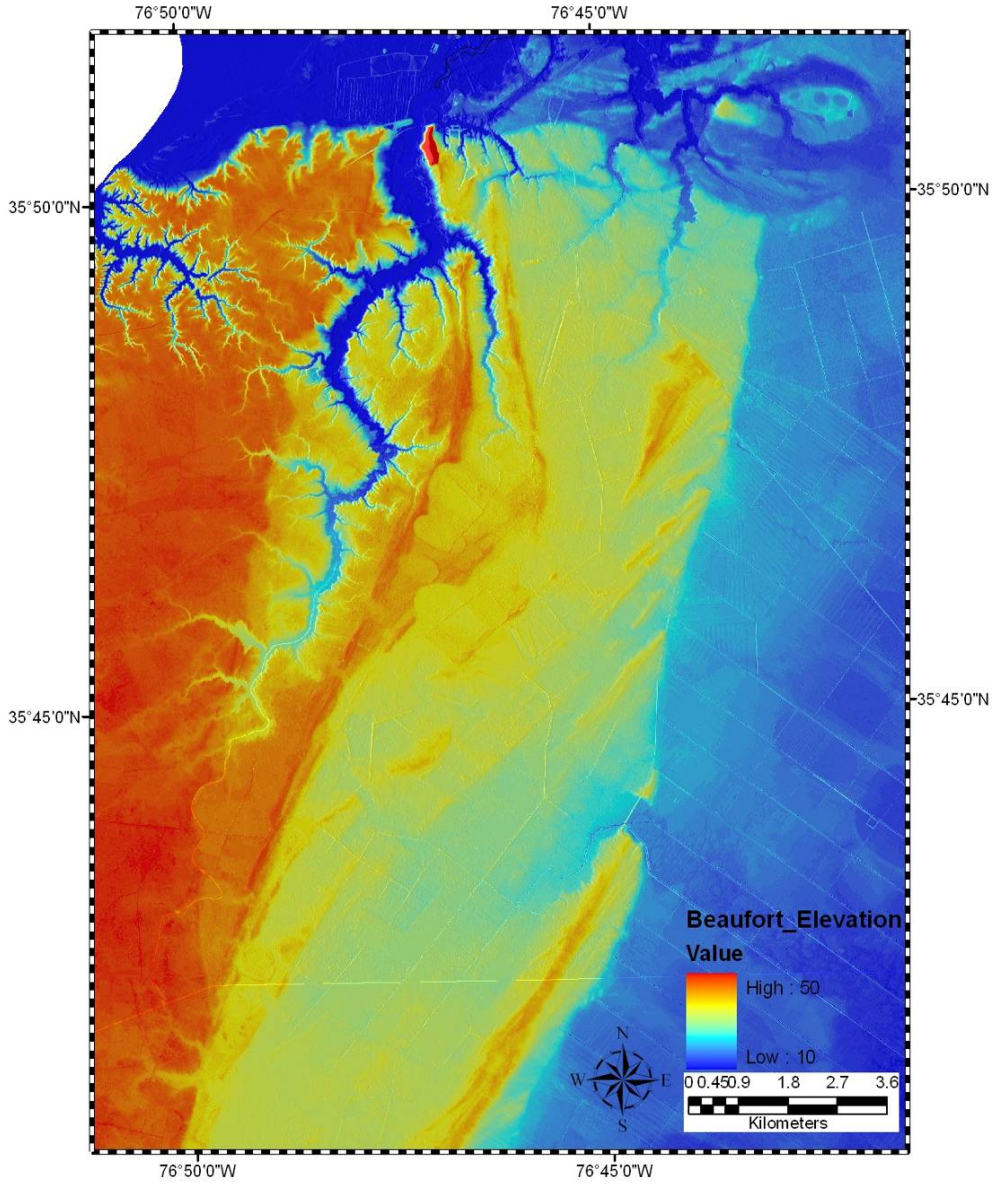
Tools for understanding SL change in North Carolina

- Mapping geomorphic features using LiDAR and GIS
- Coring
- Geophysics
- Paleoenvironmental reconstructions using fossils and sediments
- Dating
- Tide gauge records

Coastal plain geomorphic features include ancient, stranded shorelines indicating higher sea levels than today



Suffolk Shoreline



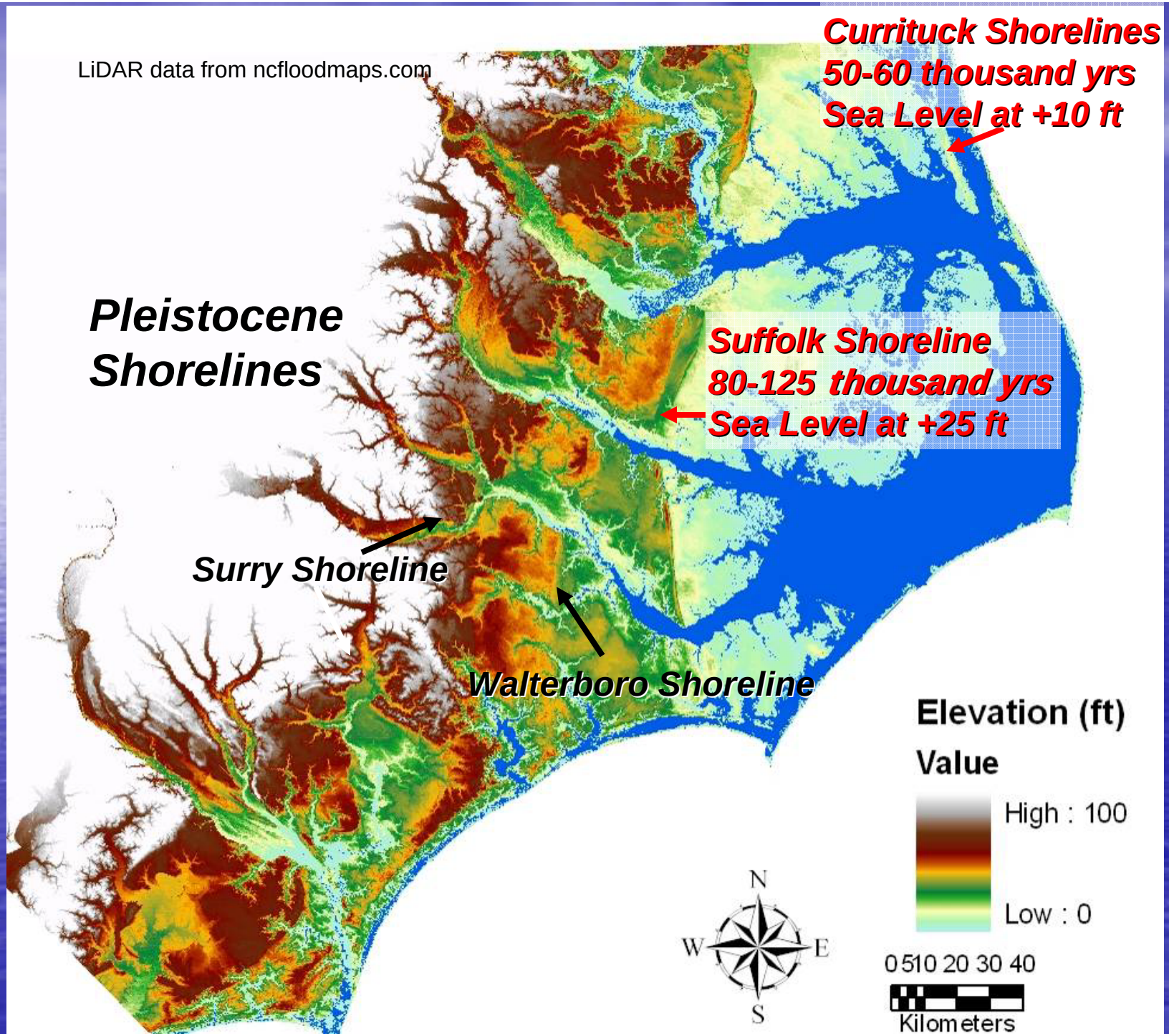
LiDAR data from ncfloodmaps.com

Coastal deposits occur far inland and above sea level

dated using:

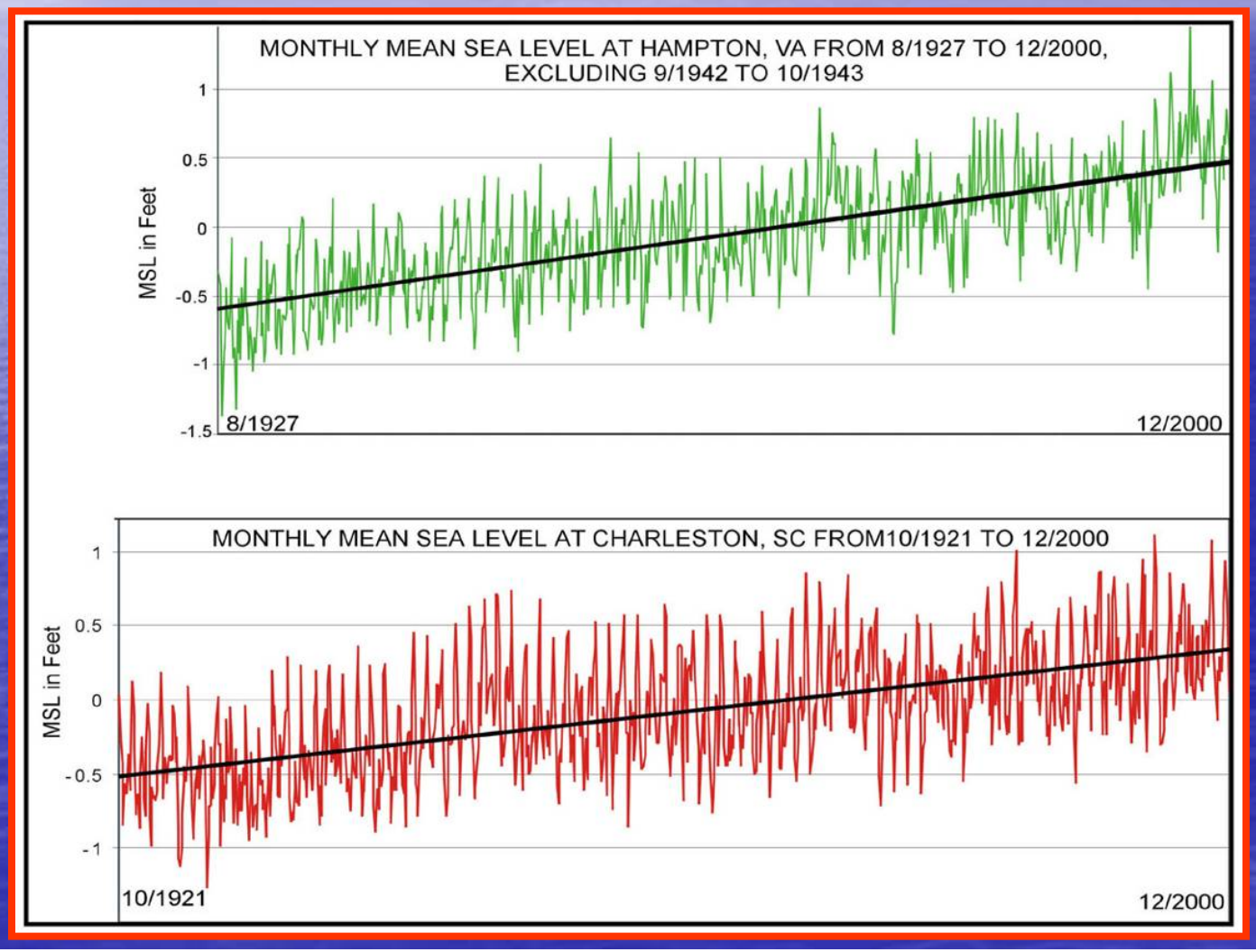
Pleistocene deposits
U-series
Amino Acid Racemization
Optically Stimulate Luminescence

Holocene deposits
Radiocarbon
Lead-210
Optically Stimulate Luminescence

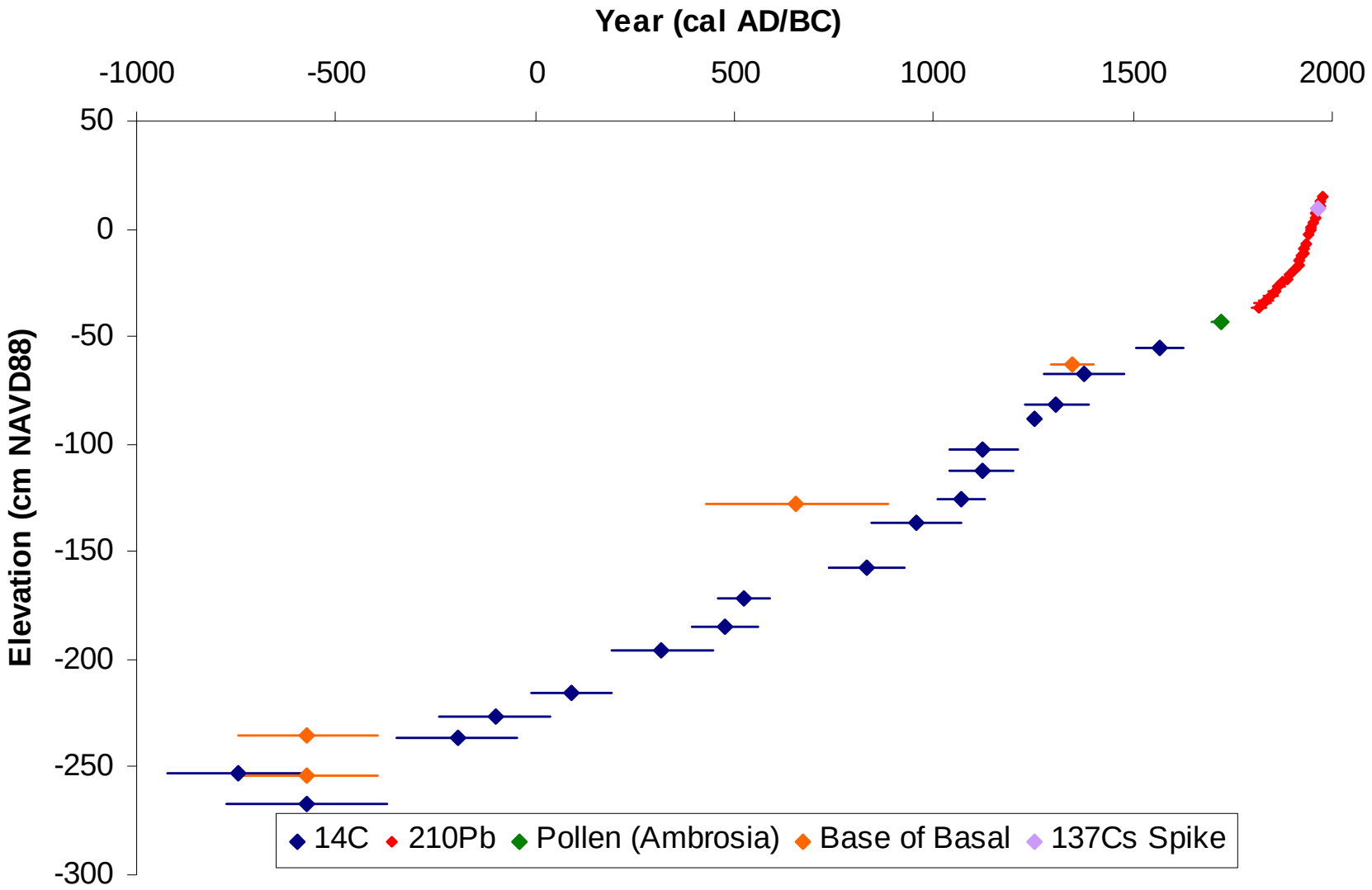

LiDAR data from ncfloodmaps.com
Currituck Shorelines
50-60 thousand yrs
Sea Level at +10 ft
Pleistocene Shorelines
Suffolk Shoreline
80-125 thousand yrs
Sea Level at +25 ft
Surry Shoreline
Walterboro Shoreline
Elevation (ft)
Value
High : 100
Low : 0
N
W
E
S
0 5 10 20 30 40
Kilometers

Holocene Sea-Level Rise in NC

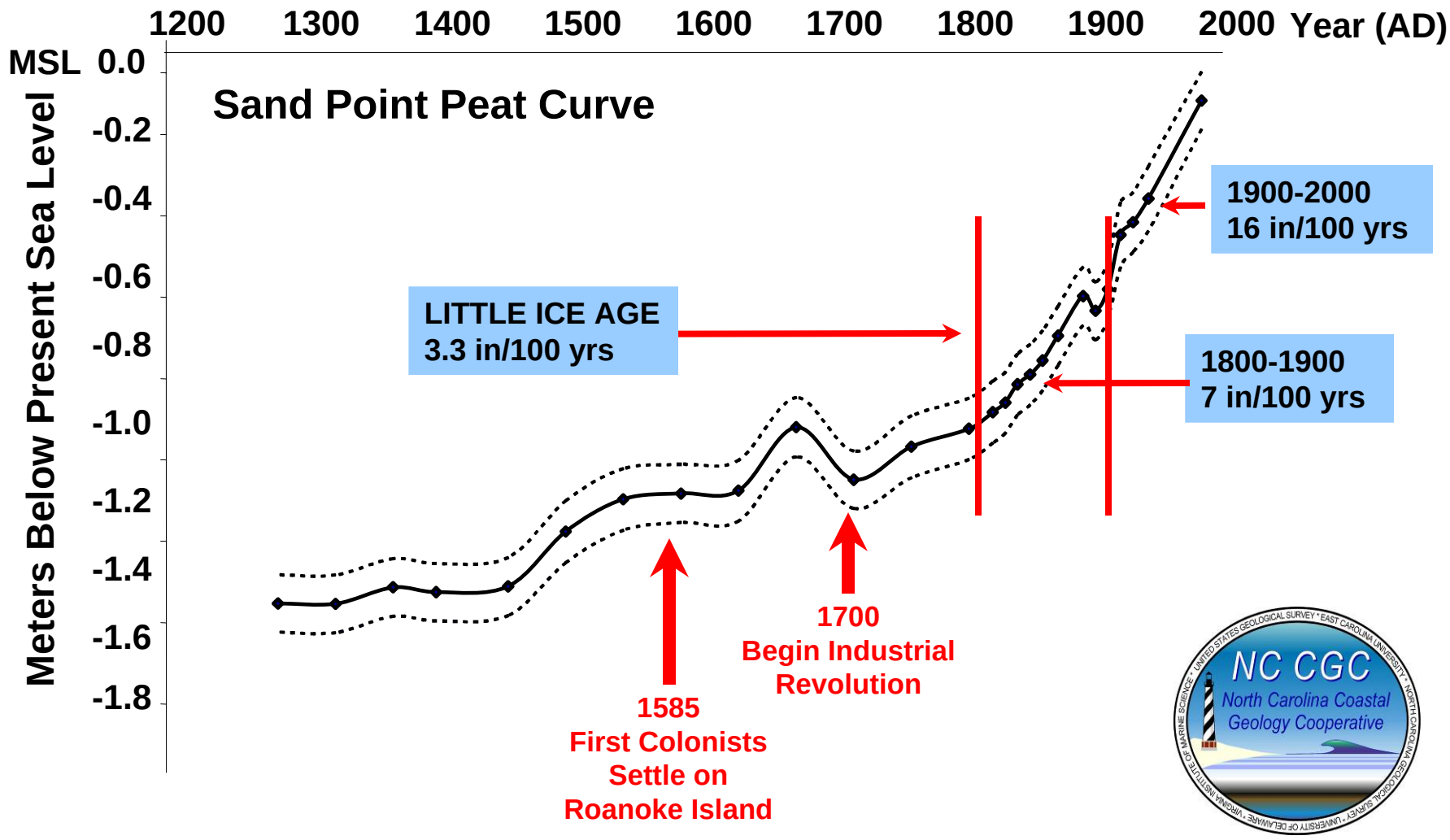
- What we know and how we know it.



Marsh peats and micro-fossils provide sea-level information

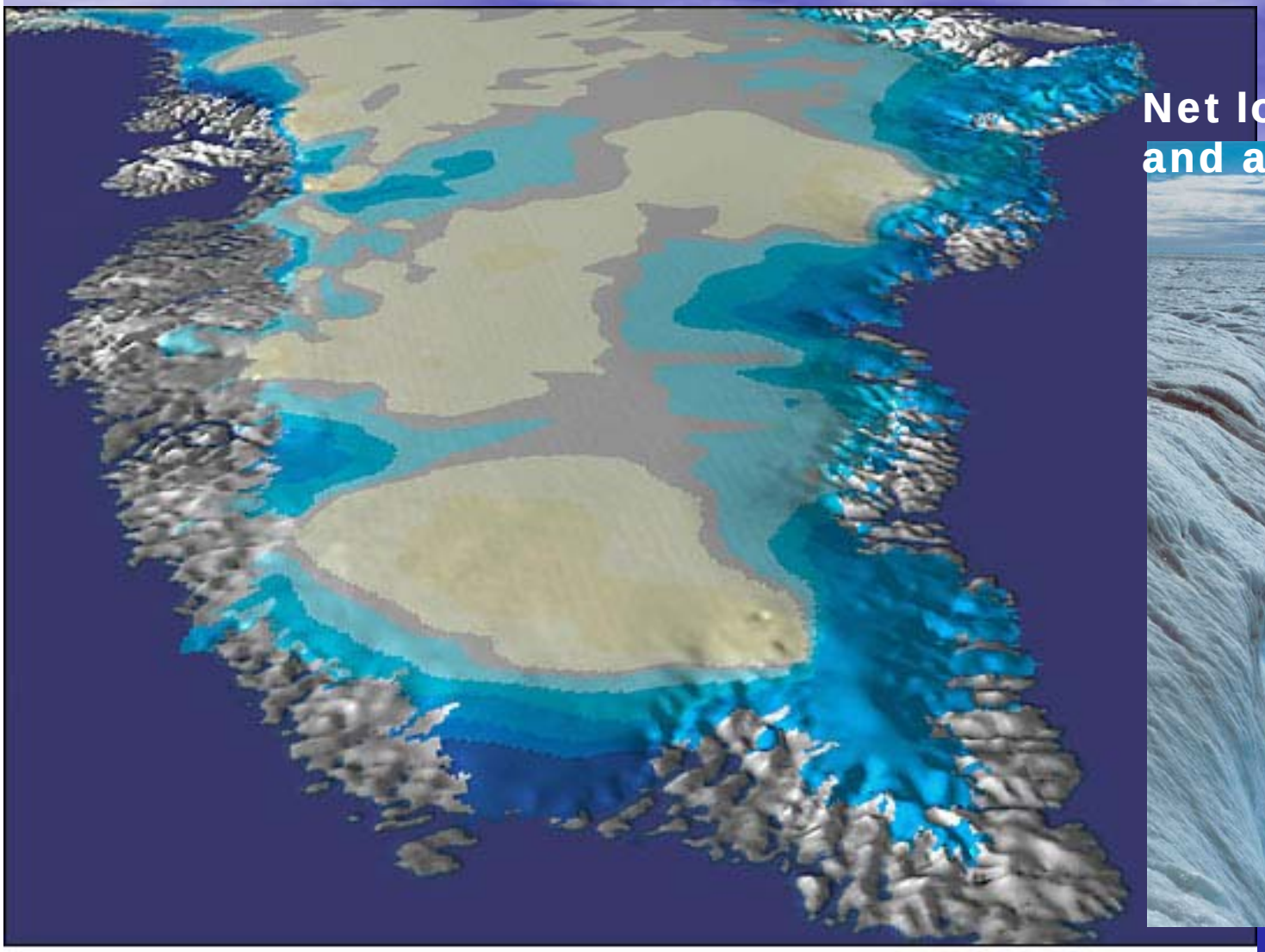

Year (cal AD/BC)
-1000
-500
0
500
1000
1500
2000
Elevation (cm NAVD88)
50
0
-50
-100
-150
-200
-250
-300
14C
210Pb
Pollen (Ambrosia)
Base of Basal
137Cs Spike

NORTH CAROLINA SEA LEVEL CURVE



The Greenland Ice Sheet Wild Card!

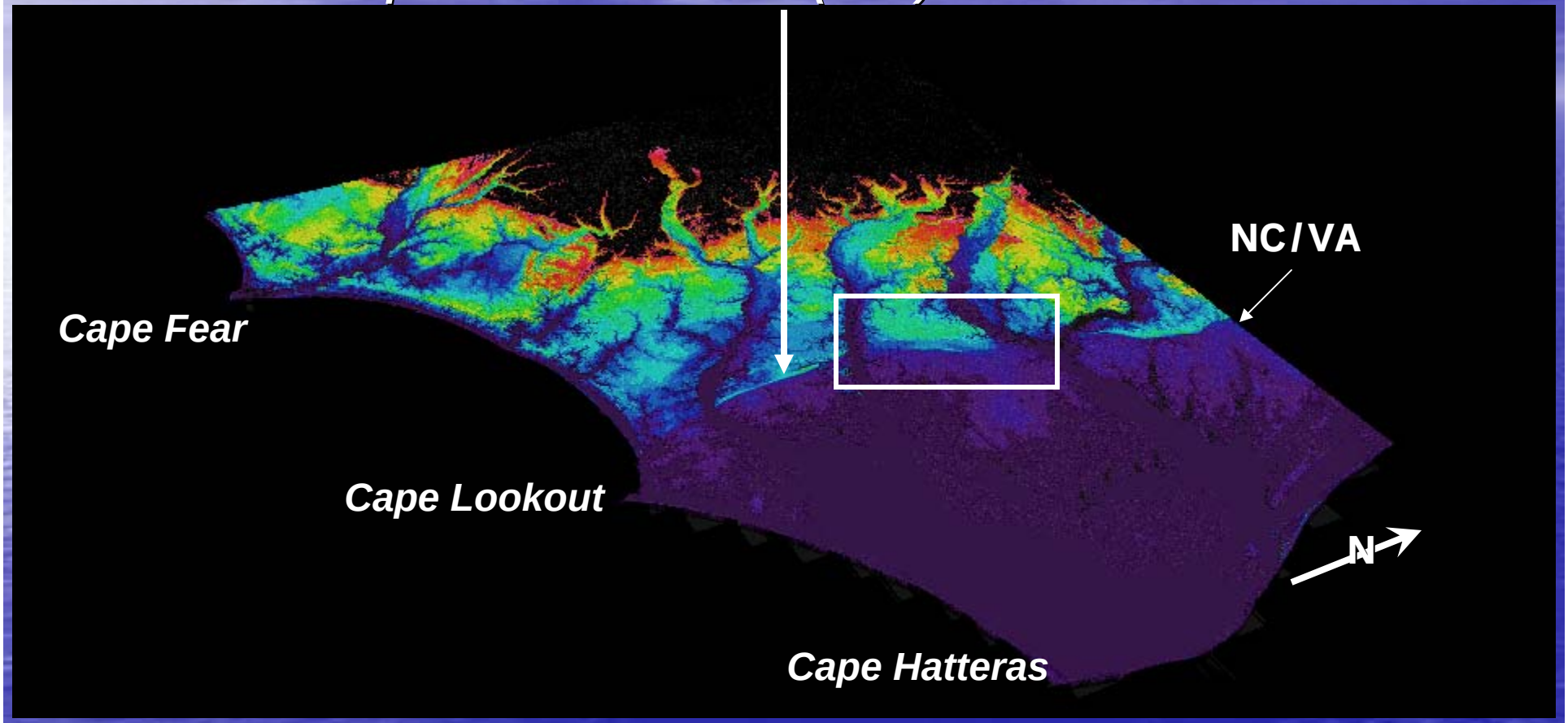
3 million cubic km of ice – can raise sea level by 20 feet



Net loss of 59 km³/yr and accelerating

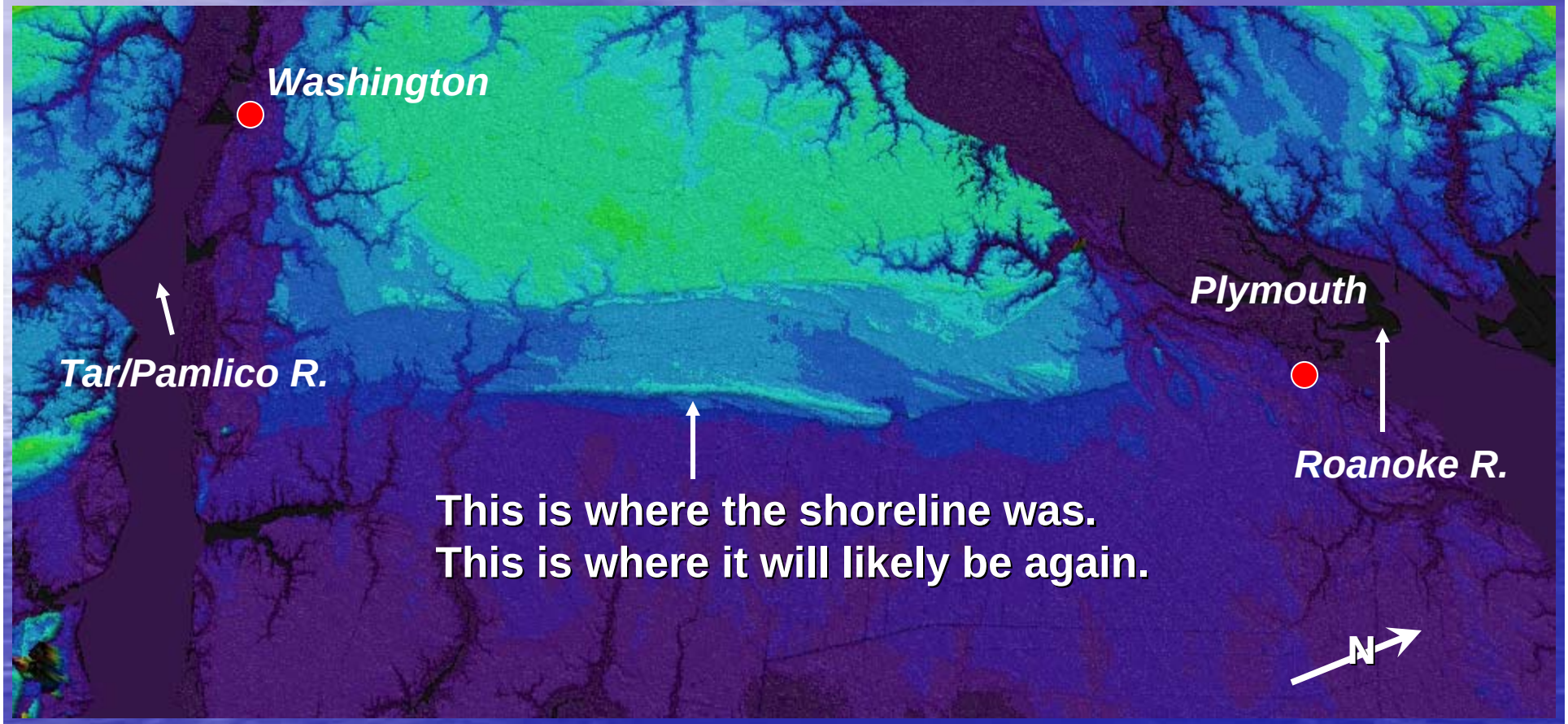
Oblique view of North Carolina elevation

Suffolk Shoreline - ca. 125,000 to 80,000 yBP
Represents RAPID 6 m (20 ft) sea-level rise

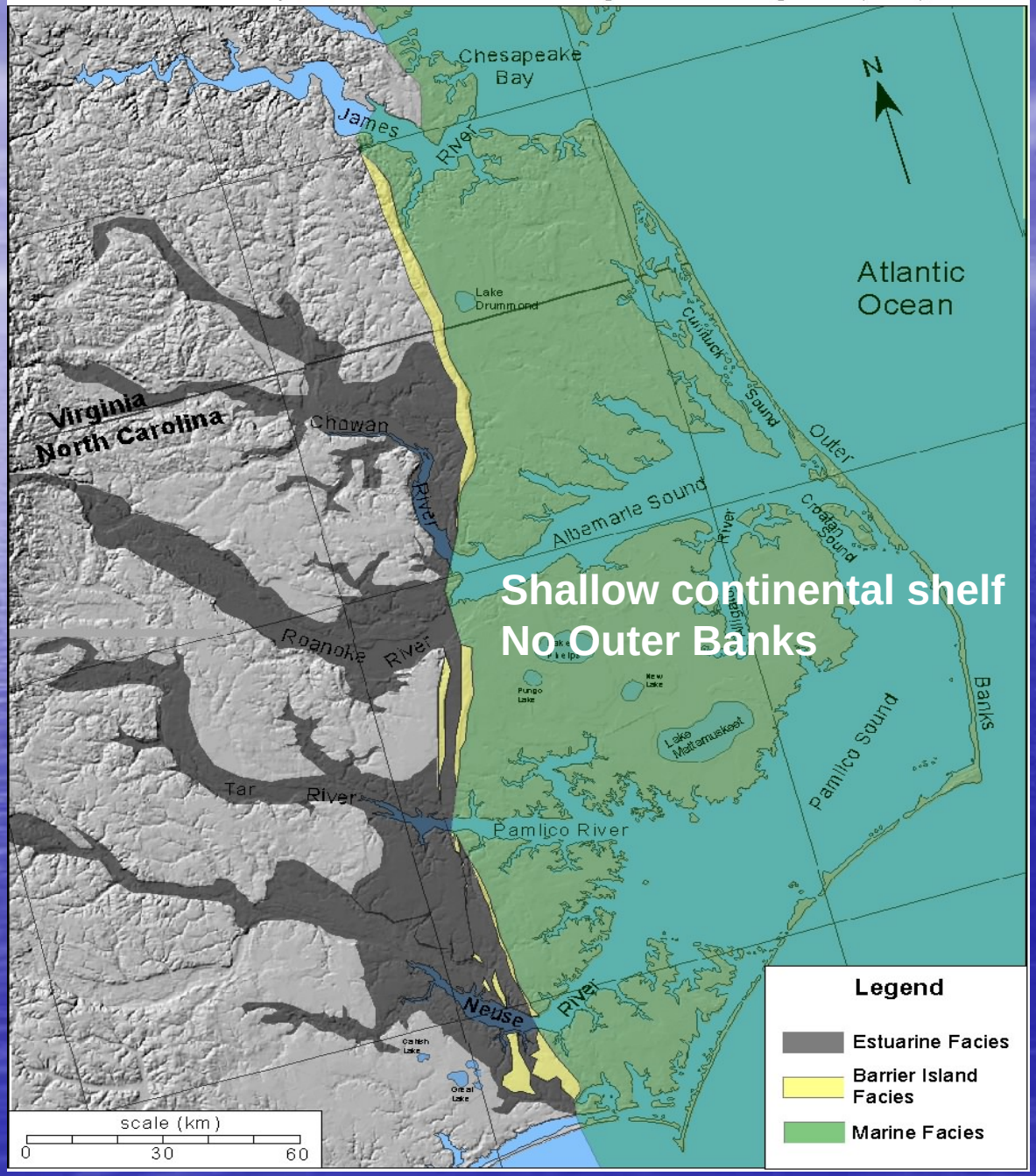


Color-coded to illustrate land (light blue and bright colors) and sea (dark blue)

Suffolk Shoreline - ca. 125,000 to 80,000 yBP
AND PERHAPS 100 to 500 YEARS IN THE FUTURE?



Idealized facies model of deposits associated with the last interglacial sea-level highstand (MIS-5).

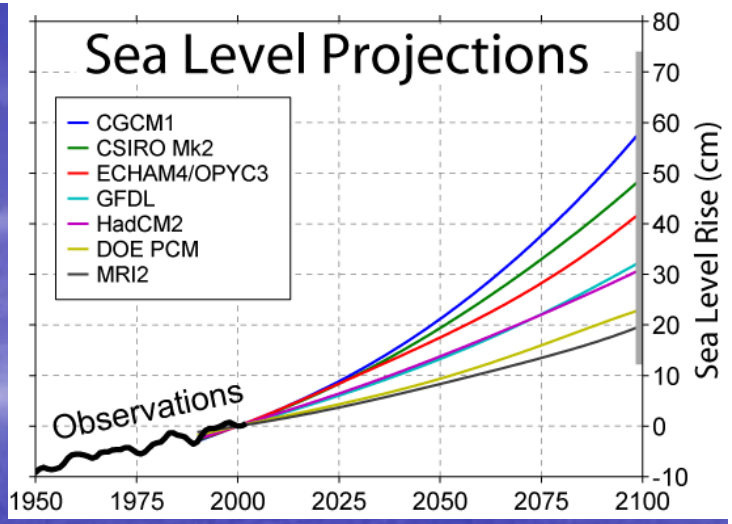


125,000 – 80,000 years ago

AND

100 to 500 years in the future

Conclusion



- We know sea level and climate have changed dramatically in the past.
- We know rates of sea-level rise are increasing.
- We appear to be repeating the scenario of GIS collapse that occurred the last time climate was this warm.
- We can expect sea-level rise in NC of at least 1.8 to 3 feet by 2100.
- As SL rises, and climate changes, we're faced with increasing rates of erosion and possibly greater hurricane intensity that can cause catastrophic collapse of the barrier islands and dramatic coastal changes.

Caught in the inevitable wake of a rising sea-level and changing climate.

Bolivar Peninsula
Following Hurricane Ike

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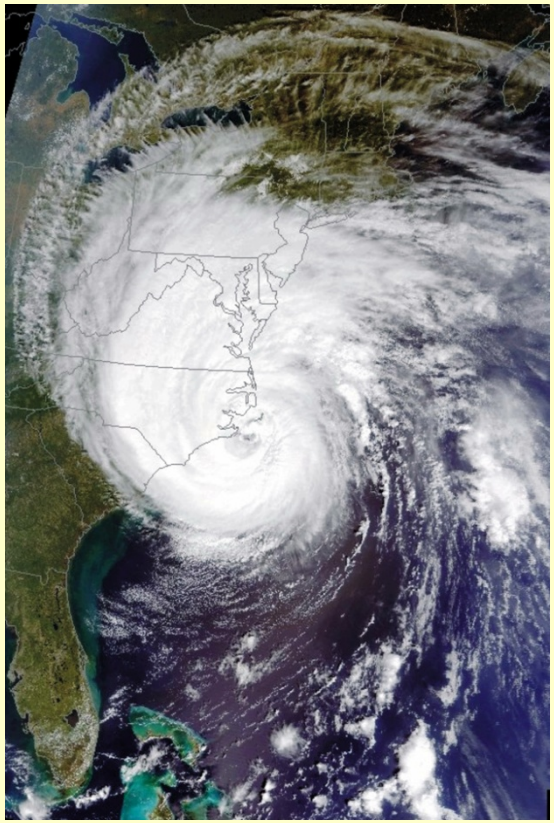
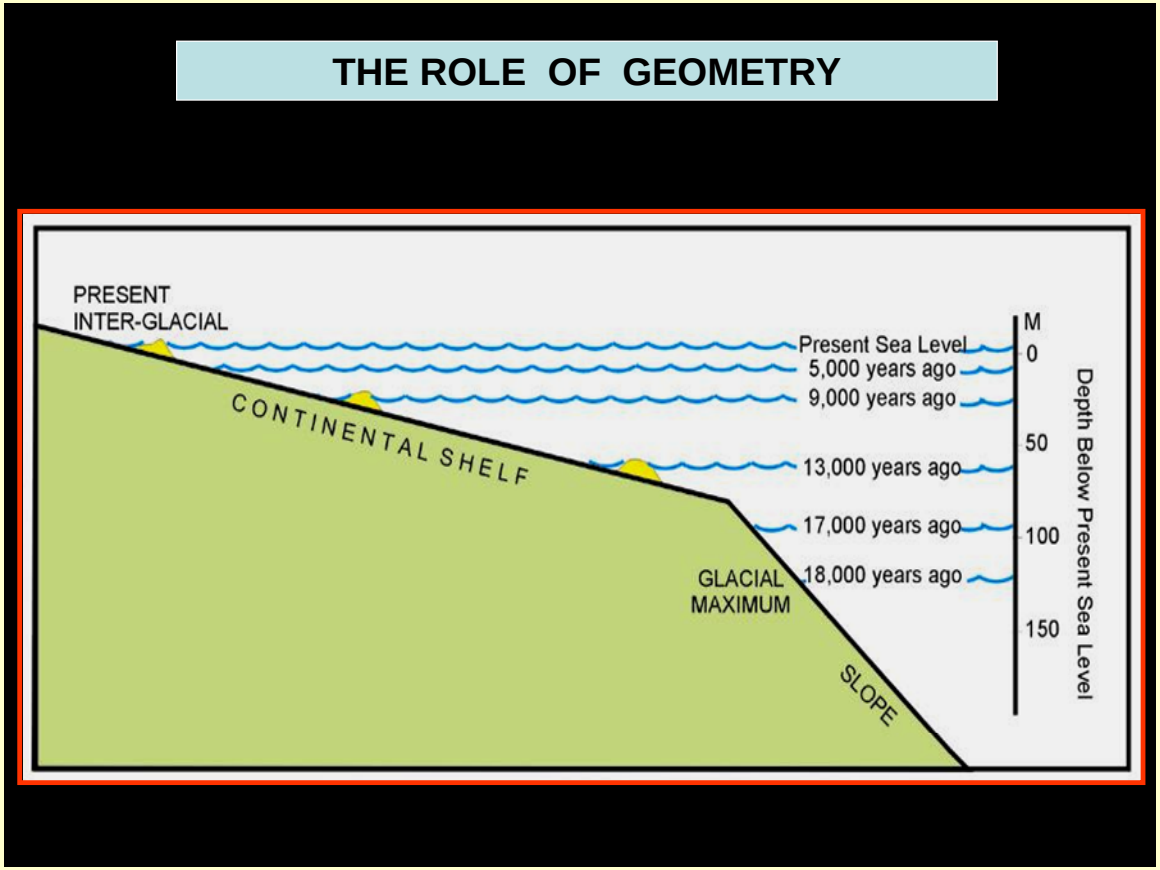
North Carolina's Coasts in Crisis:

A Vision for the Future

AGENTS OF COASTAL CHANGE

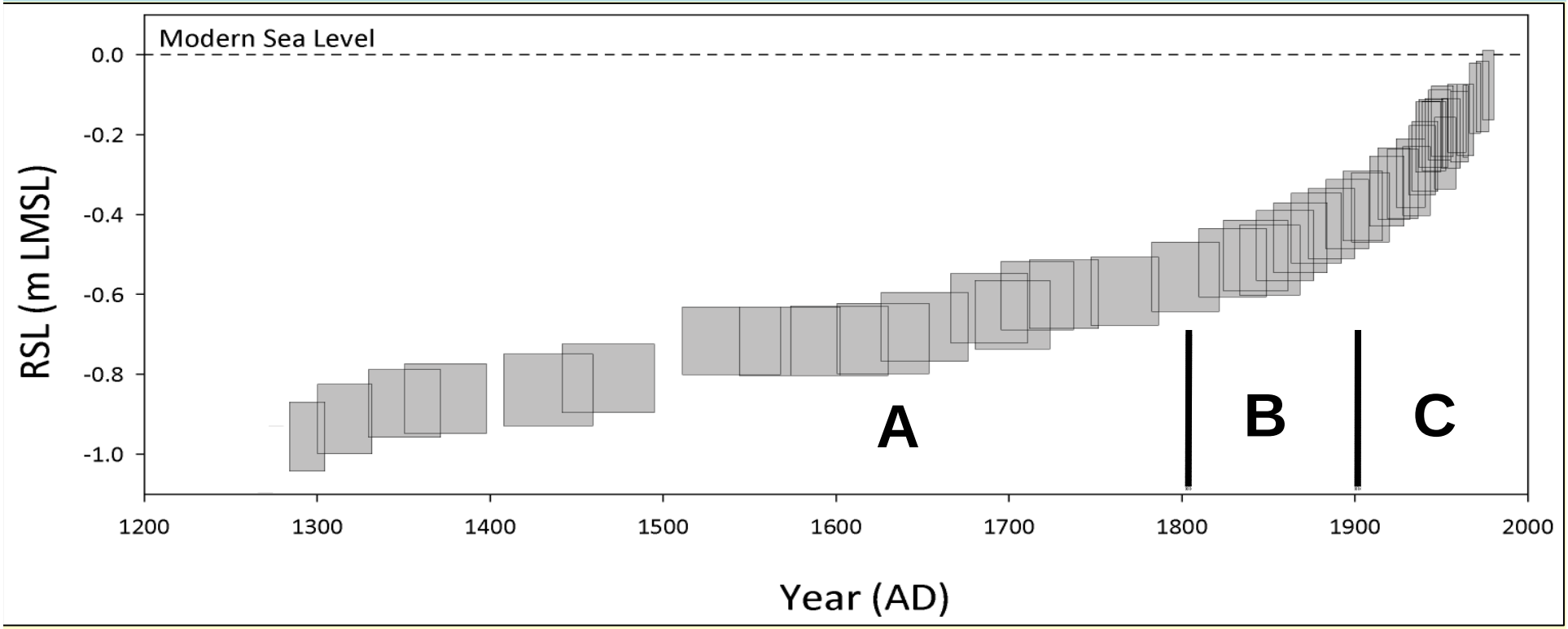
Sea-level rise





Storms

Rate of relative sea-level rise since 1300 AD, Roanoke Island



A. Pre 1800 AD: 3 inches per century

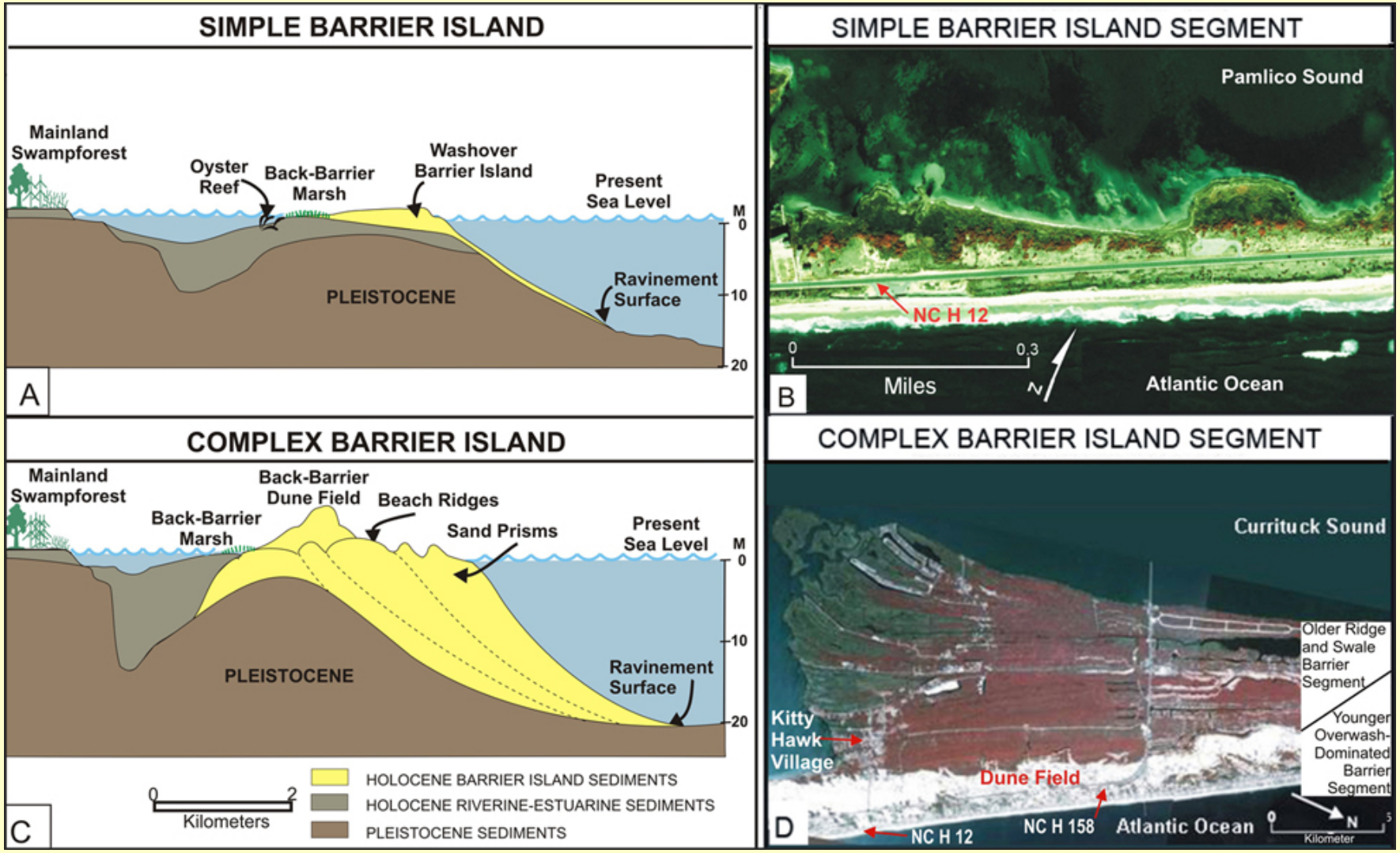
B. 19th Century: 7 inches per century

C. 20th Century: 16 inches per century

Kemp, Horton, Culver, Corbett (ECU and U. Penn, unpublished)

A barrier island coast: fundamental to our coastal economy

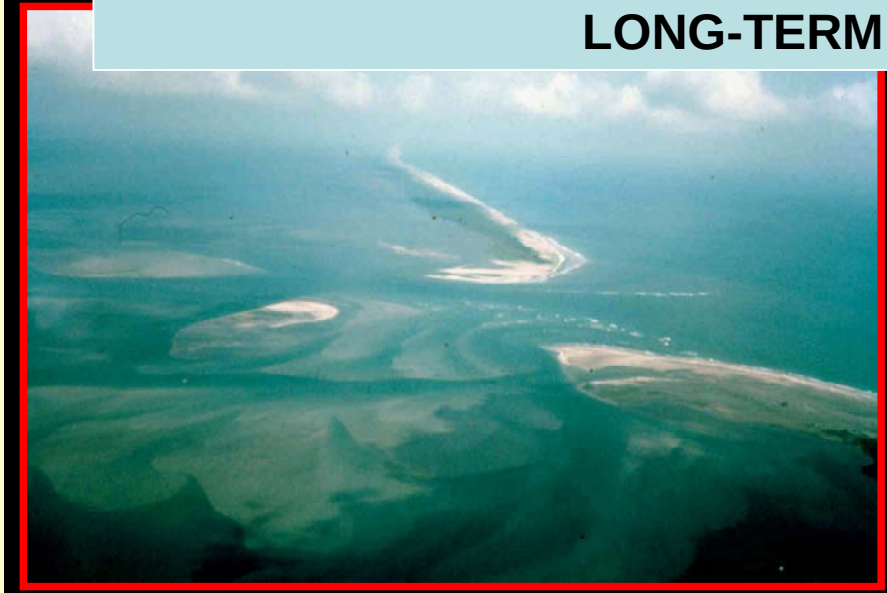
Barrier islands are not created equal



Oregon Inlet

Isabel Inlet

INLETS AND OVERWASH FANS ARE ISLAND BUILDING PROCESSES CRUCIAL FOR THEIR SHORT-TERM HEALTH AND LONG-TERM EVOLUTION!



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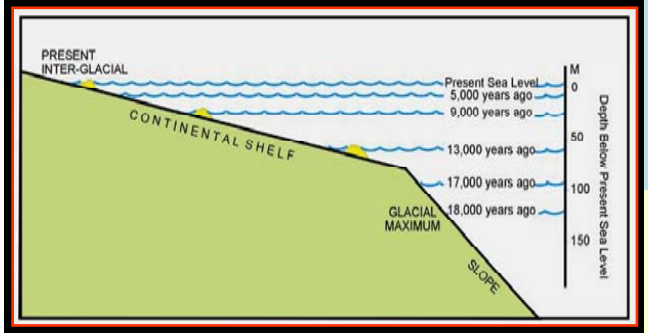
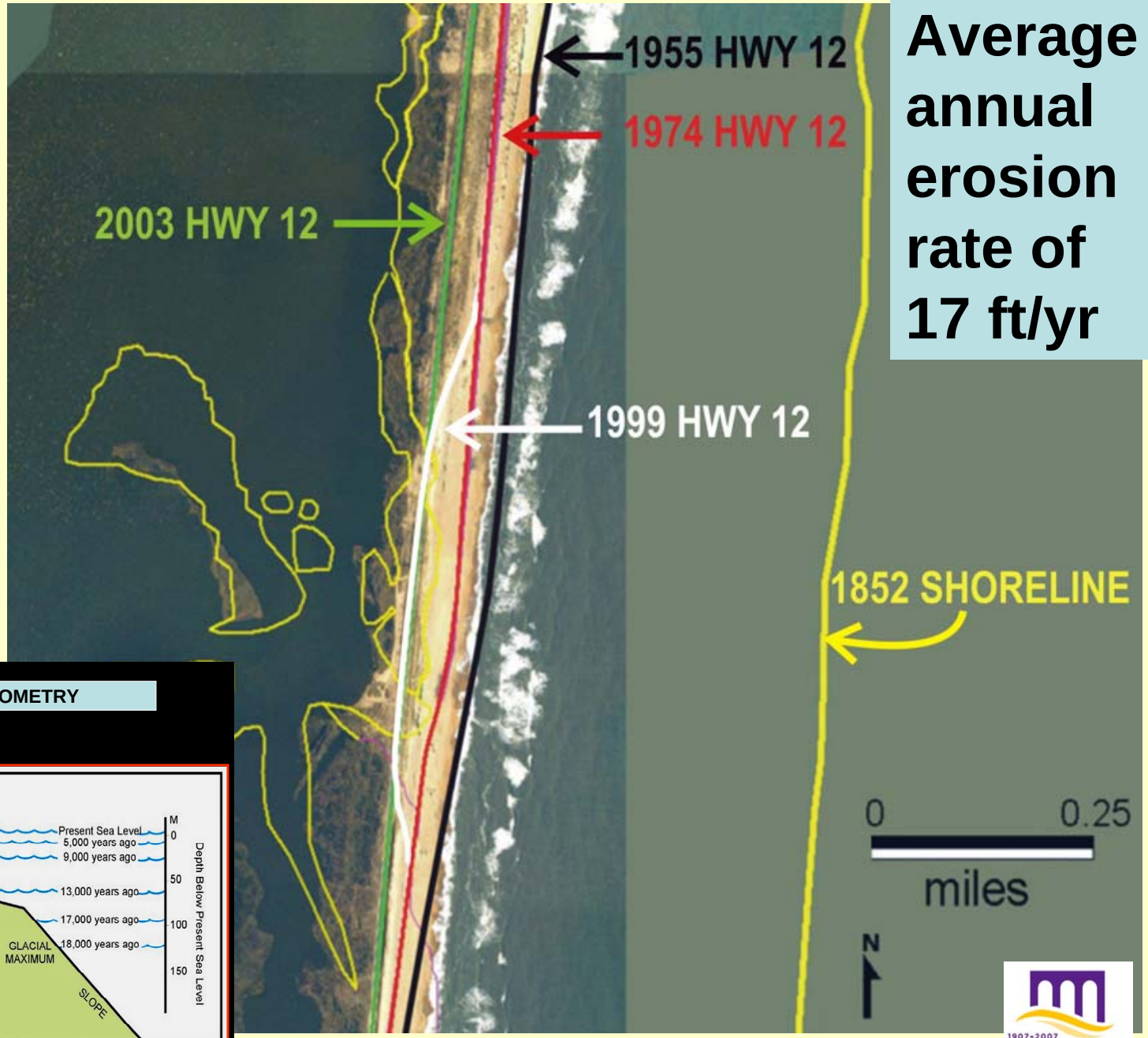
THE ROLE OF GEOMETRY

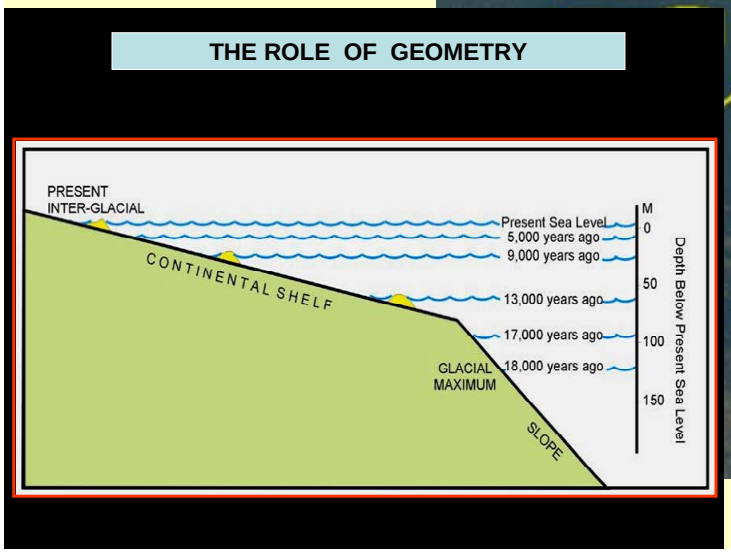


Constructed Barrier Dunes

Avon-Buxton: 75% of island width lost since 1852



Average annual erosion rate of 17 ft/yr



WHERE'S THE BEACH?

HARDENING IS NOT THE ANSWER

South Nags Head (A,C,D) and Bogue Inlet (B)

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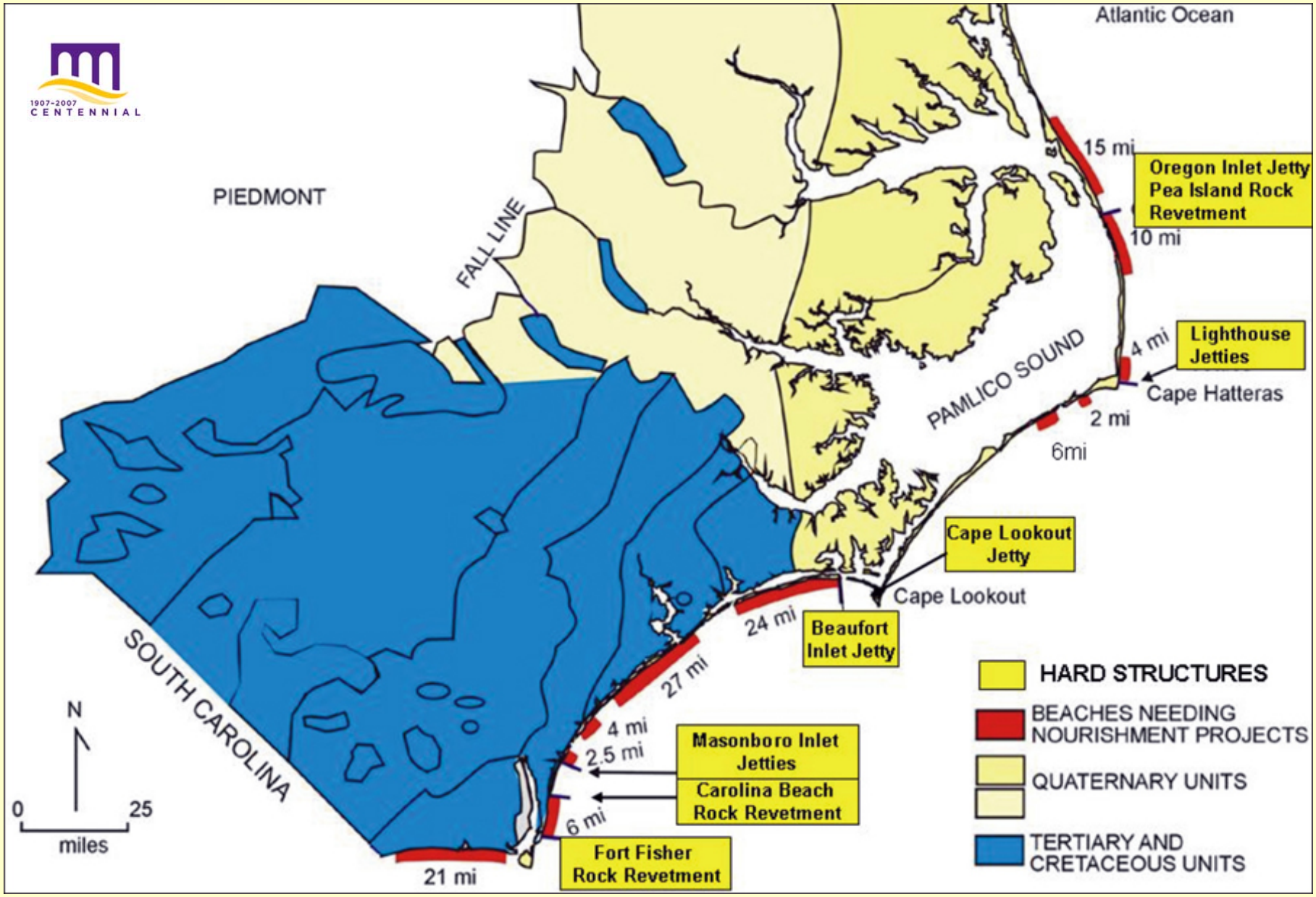
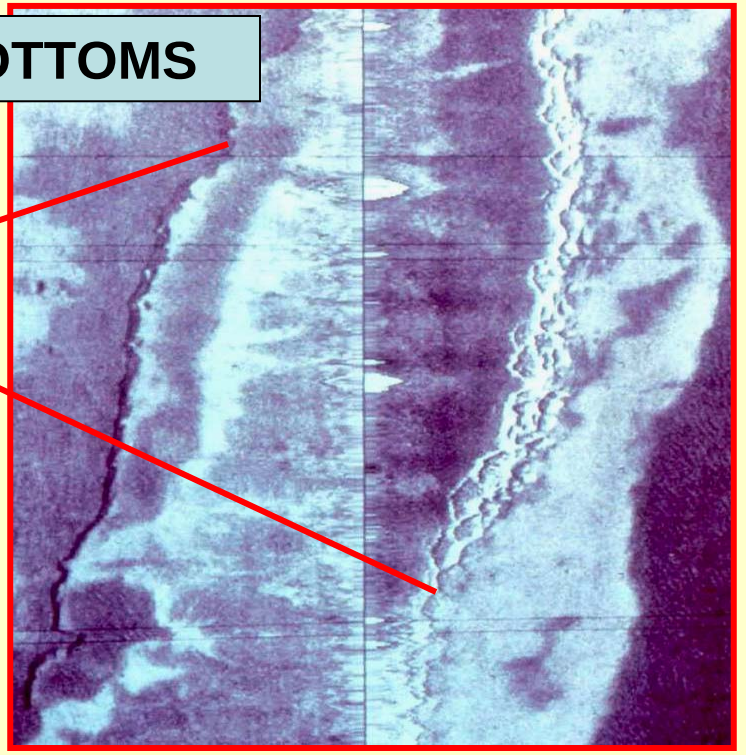
Coastal communities desire beach nourishment for 122 miles of coast



ONSLOW BAY HARDBOTTOMS



Beach nourishment: expensive, must be repeated, there is not always a source of sand

CAROLINA BEACH, NC
*1985 = 792,000 Yds^3
*1988 = 951,000 Yds^3
1991 = 1,009,000 Yds^3
1995 = 1,158,000 Yds^3
1998 = 3,300,000 Yds^3
2001 = 1,000,000 Yds^3
2004 = 680,000 Yds^3
TOTAL = 8,890,000 Yds^3
(18 yrs & 7 operations)

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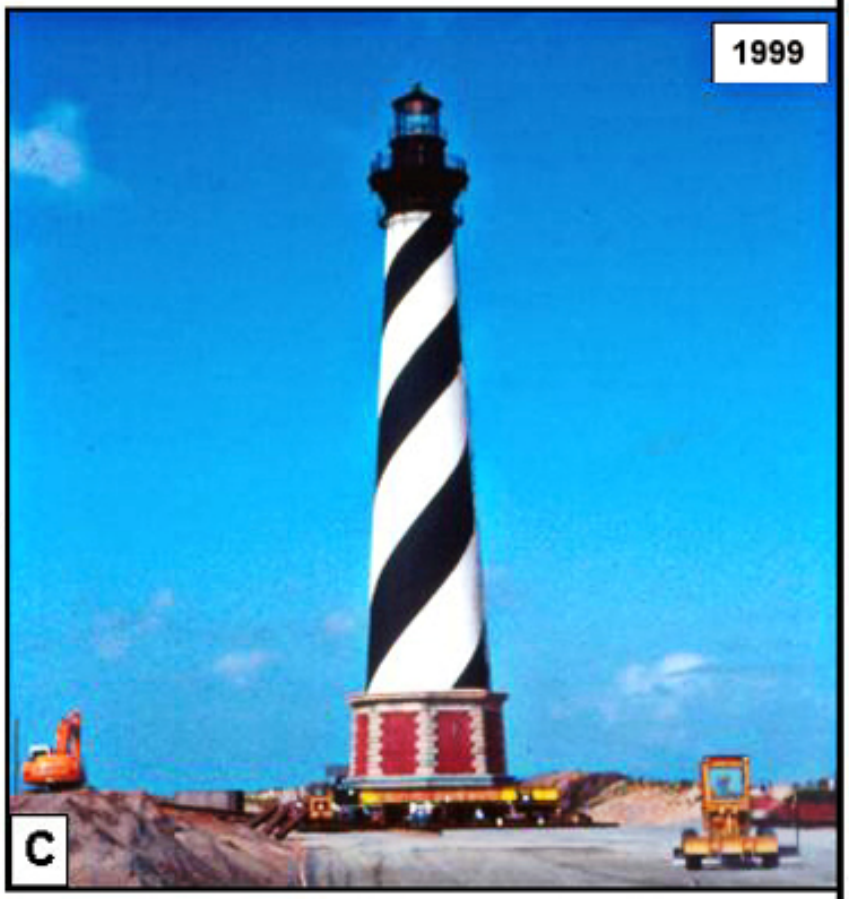
GROINS/JETTIES PREVENT LONG-SHORE SEDIMENT TRANSPORT RESULTING IN SEVERE DOWNSTREAM EROSION

Cape Hatteras Lighthouse



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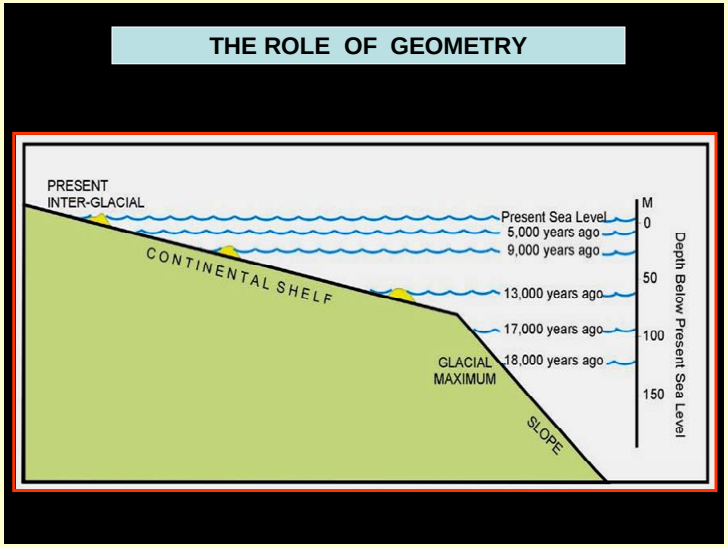
- **It doesn't matter if a person does not accept the implication of human activities in climate change.**

- **It doesn't matter if a person does not accept that global warming or climate change is occurring.**

- **Because many people do and are changing the way they do business; this makes climate change relevant to everyone.**

- **The fact is that sea level is rising and we have storms.**

- **Our basic problem is that we have built static infrastructure on moving land: adaptation is the only solution.**



Significance of Climate Change to Coastal North Carolina: examples

- Sea level will likely rise >3ft by 2100 (a large portion of Currituck, Carteret, Dare, Hyde, Tyrell, Pamlico counties are only 1 to 2 ft above current sea level).

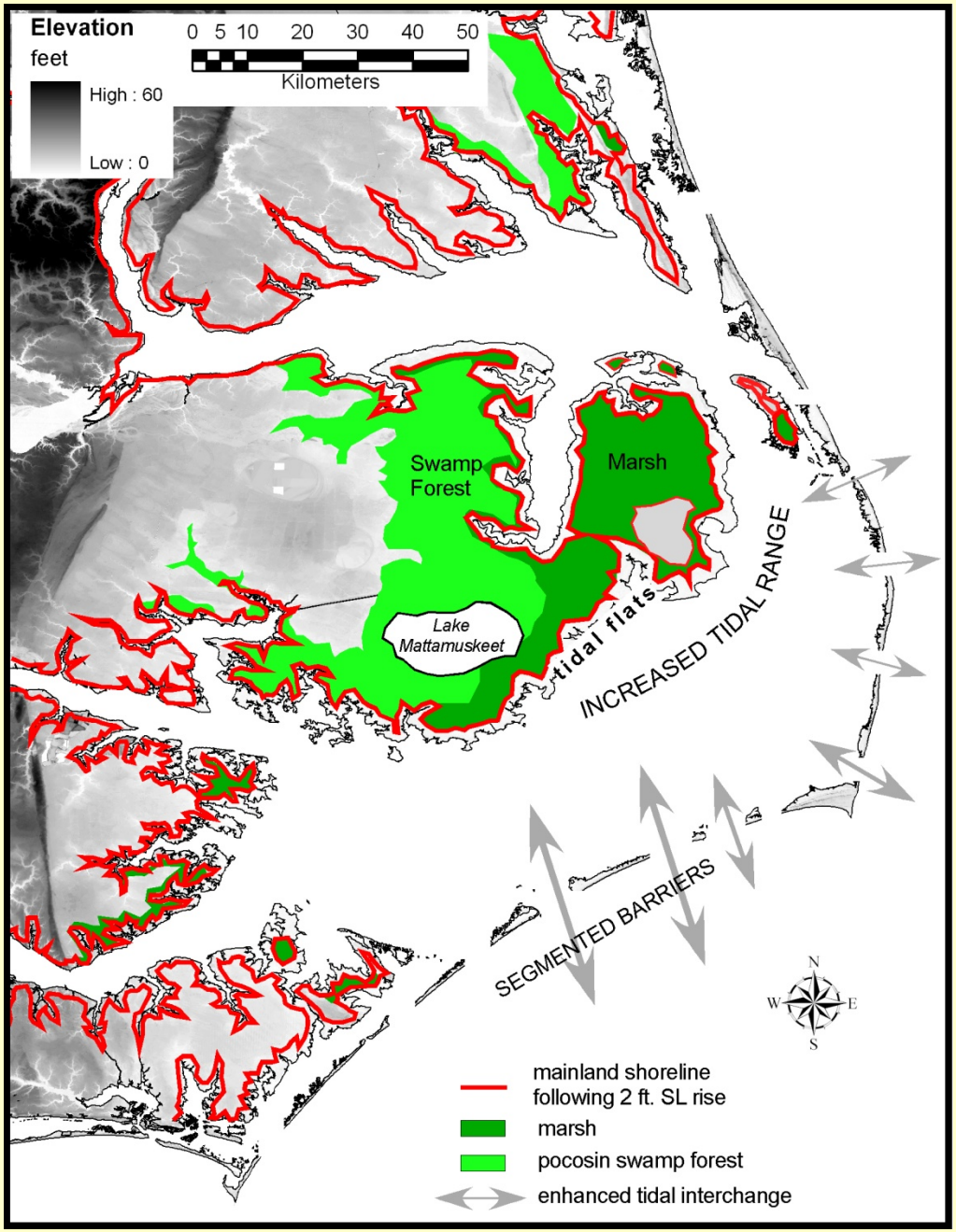
- One third of economic activity in NC is sensitive to weather & climate ($100 billion/yr) (eg. tourism, forestry, agriculture)

- Climate change is the greatest challenge to sustainable tourism in the 21st century.

- If we don't begin to adapt now, it will cost us more in the future.

Relocation: an example of adaptation

The Future



2 ft of sea-level rise (by ~2050)

But if a "Katrina" hits next summer..

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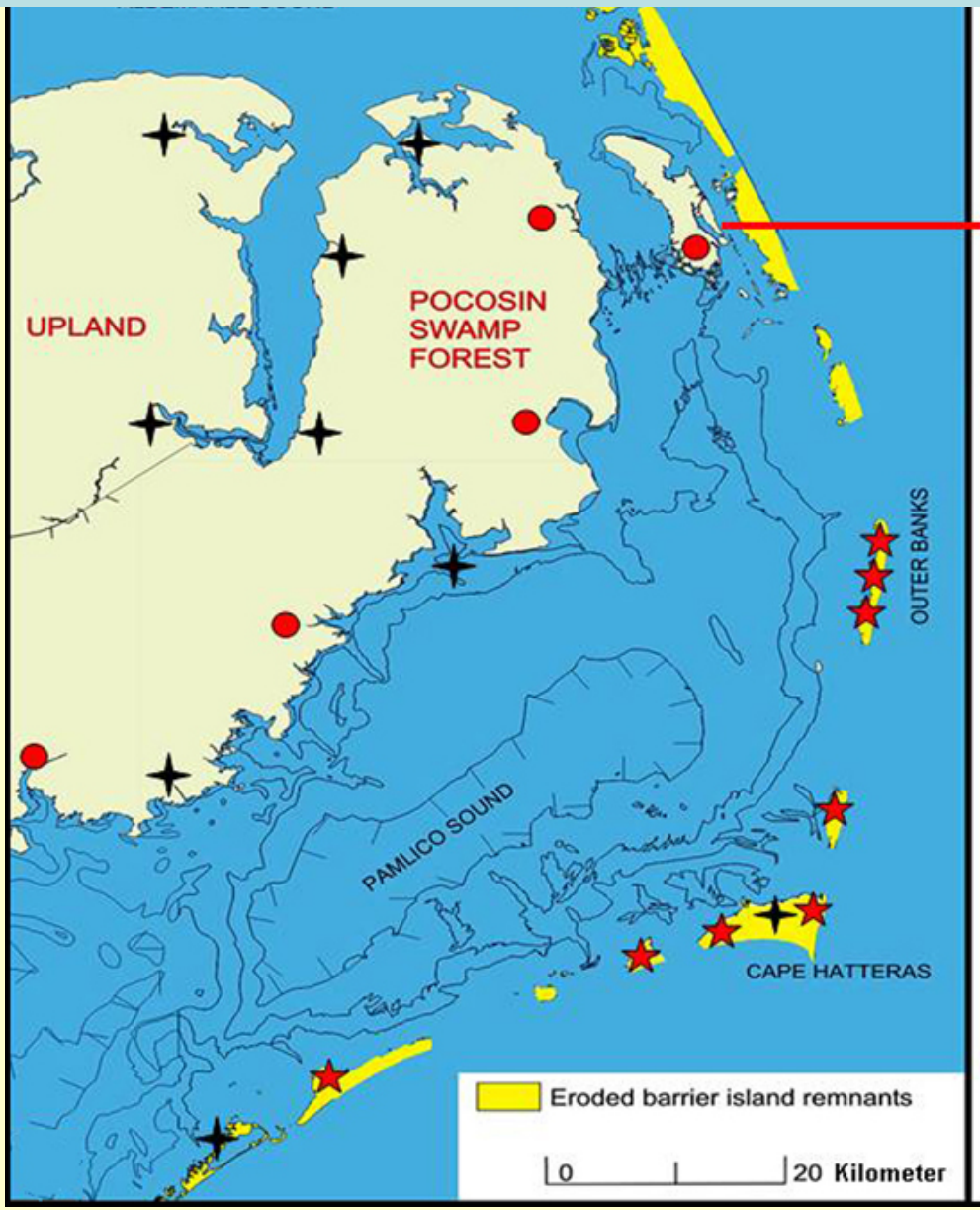
The Future: “A String of Pearls”



URBANIZED BARRIER ISLANDS

EIGHT OCRACOKE-STYLE DESTINATION VILLAGES, EACH WITH VAST OVERWASH FLATS AND INLETS

MAINLAND FERRY HUBS

POTENTIAL ECO-TOURS

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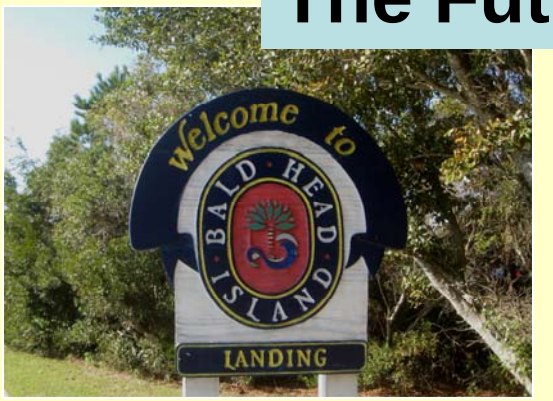
12 knots

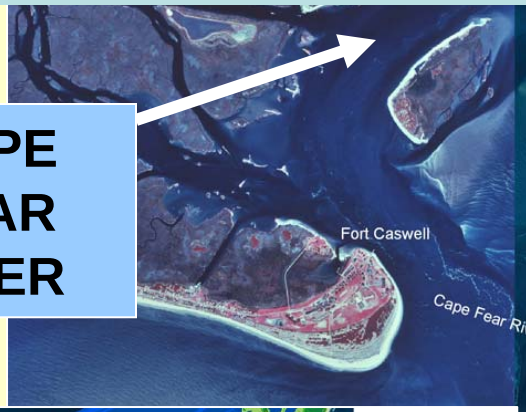
The Future: Rapid Transit

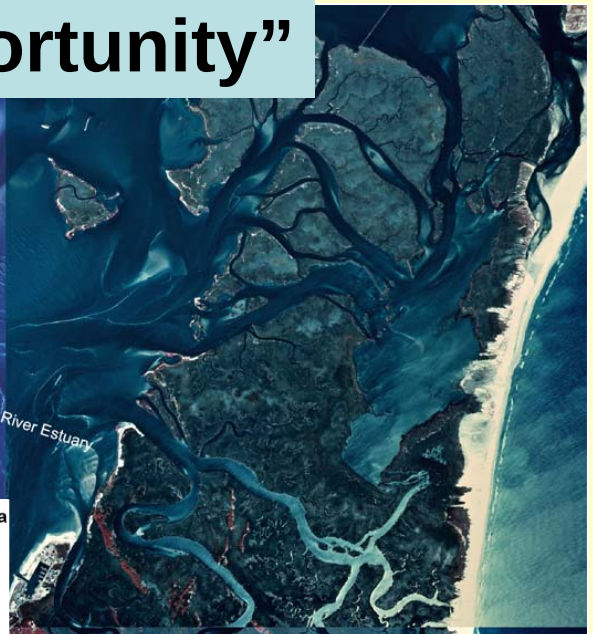
35 knots

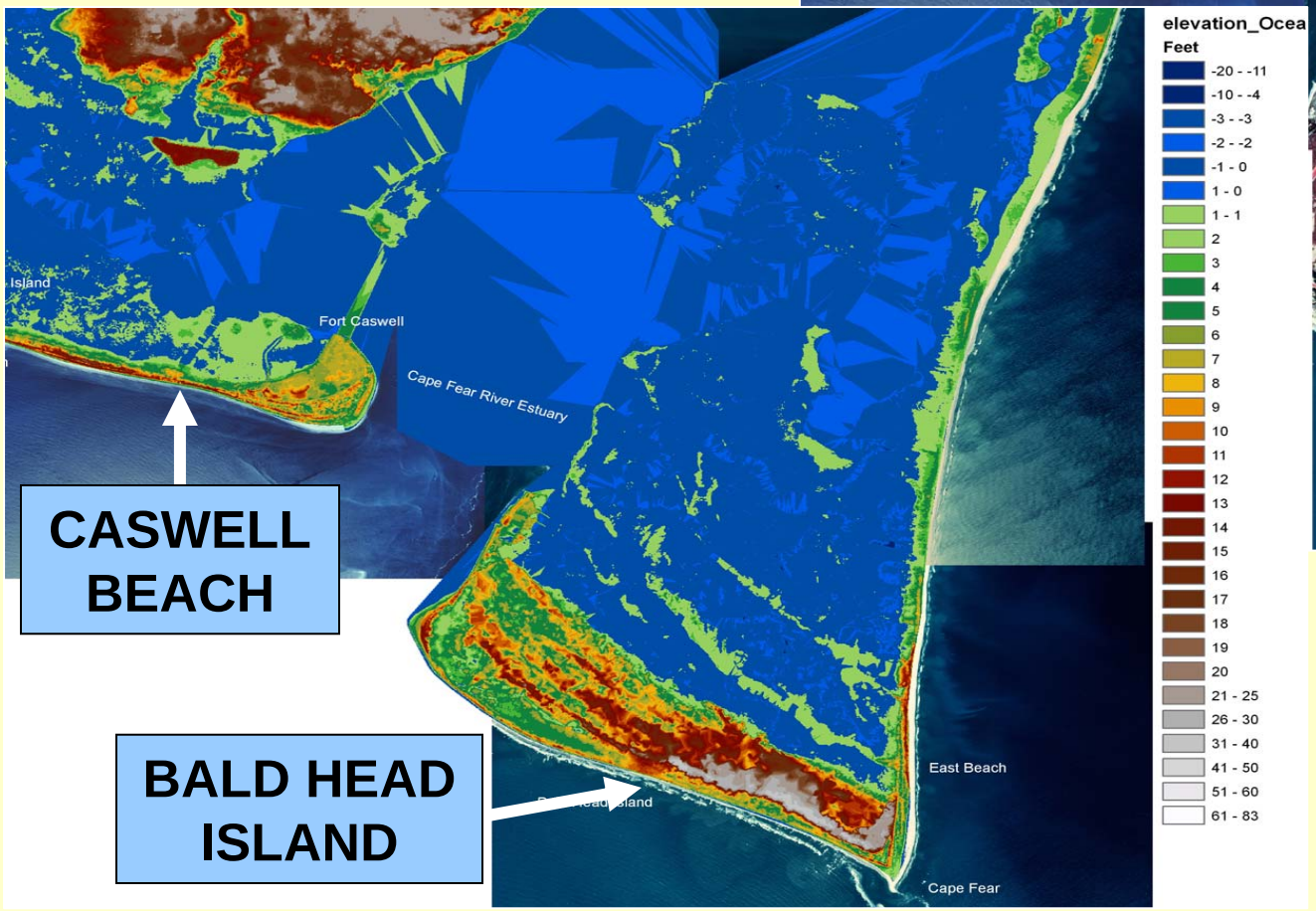
The Future: “Islands of Opportunity”



CAPE FEAR RIVER

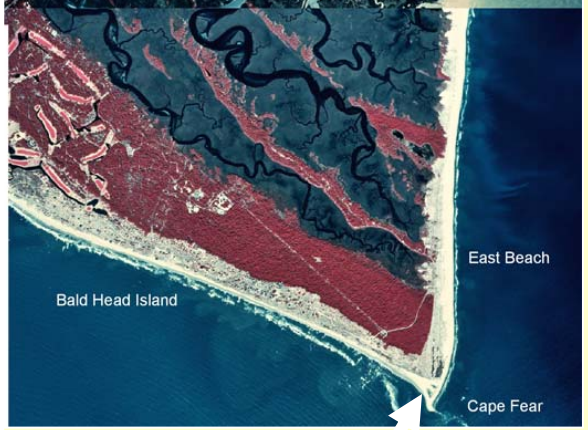






CASWELL BEACH

BALD HEAD ISLAND



CAPE FEAR

The Future: “Islands of Opportunity”

BALD HEAD ISLAND
TRAMS & BIKES

BALD HEAD ISLAND
ELECTRIC CARTS

PUBLIC BEACH ACCESS

Climate Change and Coastal North Carolina: Possible Actions

- **Create a Commission on Adaptation to Climate Change** to review other states' initiatives, to assess the costs and benefits of various responses, to prepare a science-based strategic plan.

- **Initiate a science-based study** to assess the socio-economic impact of barrier island breaks.

- **Create a Coastal Adaptation Fund** to provide sustained research support, to purchase at-risk land or conservation easements, to encourage ecologically beneficial erosion control structures, to inventory coastal resources, to identify particularly vulnerable coastal areas.

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- **Commission a panel of experts** to assess the capacity of state government to respond, adapt and mitigate the impacts of climate change.

- **Increase support to Sea Grant** and other outreach/extension programs to provide practical climate change information.

- **Fund university research centers** to address climate change and adaptation issues.

- **Plan for the adaptive economic development of a "string of pearls"** in northeastern NC.

- **Plan for the adaptive economic development of "islands of opportunity"** in southeastern NC.

Climate change is affecting North Carolina now

We must plan for it and adapt to it or pay a greater price if we manage our coastal resources disaster by disaster

1907-2007
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