CLIMATE CHANGE, SEA—LEVEL RISE, AND COASTAL SYSTEM EVOLUTION:

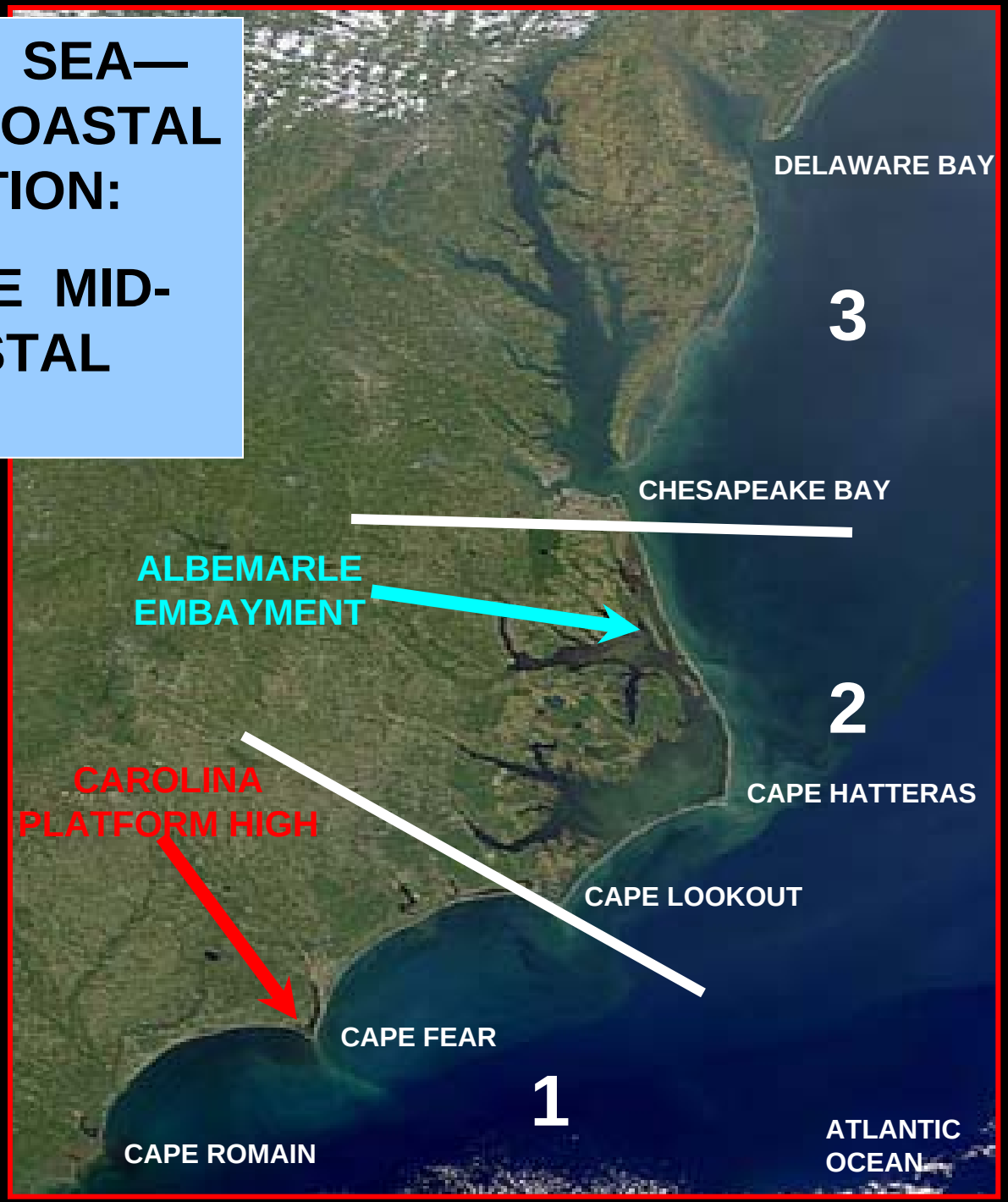
OVERVIEW OF THE MID-ATLANTIC COASTAL SYSTEM

STANLEY R. RIGGS

DEPT. OF GEOLOGICAL SCIENCES

EAST CAROLINA UNIVERSITY

GREENVILLE, N.C.



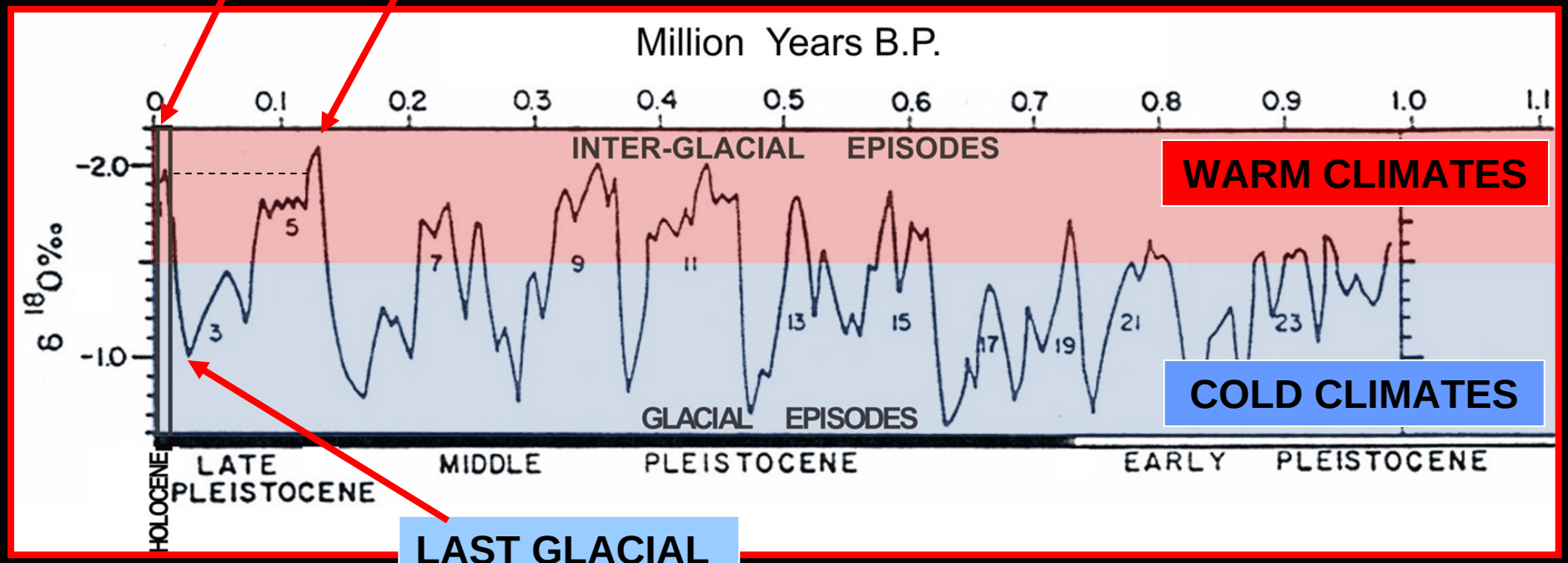
SOUTHERN PROVINCE (# 1)	NORTHERN PROVINCE (# 2)
Cretaceous-Miocene Framework	**Pliocene-Quaternary Framework**
Dominantly Rock Control	Dominantly Sediment Control
Steep Slopes (ave. = 10 ft/mile)	**Gentle Slopes (ave. = 0.5 ft/mile)**
Coastal Plain-Draining Rivers (Many)	**Piedmont-Draining Rivers (4)**
Black-Water Rivers	Brown-Water Rivers
Low Sediment Input	High Sediment Input
Low Fresh-Water Input	High Fresh-Water Input
Short Barrier Islands--Many Inlets (18)	**Long Barrier Islands--Few Inlets (4)**
Maximum Astronomical Tides/Currents	Minimal Astronomical Tides
Maximum Salt-Water Exchange	Minimal Salt-Water Exchange
Narrow Back-Barrier Estuaries	**Deeply Embayed Estuaries**
Regularly Flooded	Irregularly Flooded
Astronomical Tide Dominated	Wind Tide and Wave Dominated
High Brackish Salinities	Highly Variable Salinities

PROXY FOR THE ICE AGES:

GLACIATION—DEGLACIATION, CLIMATE CHANGE, AND SEA—LEVEL FLUCTUATION

TODAY'S INTERGLACIAL

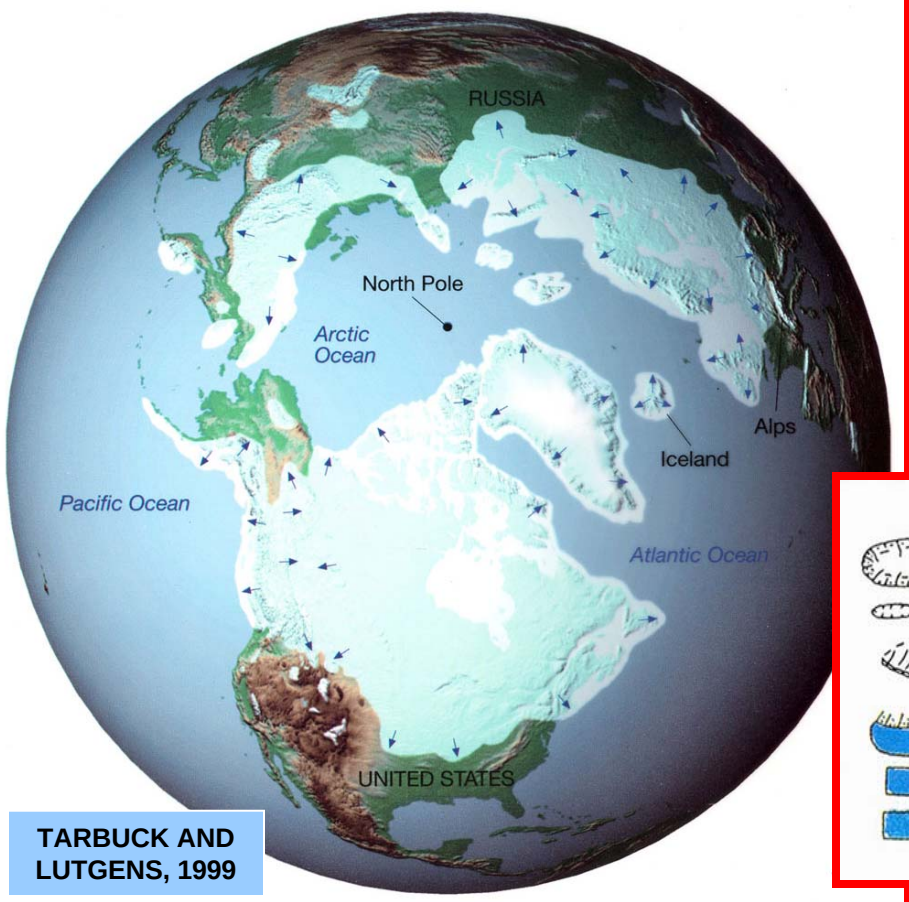
LAST INTERGLACIAL



LAST GLACIAL MAXIMUM

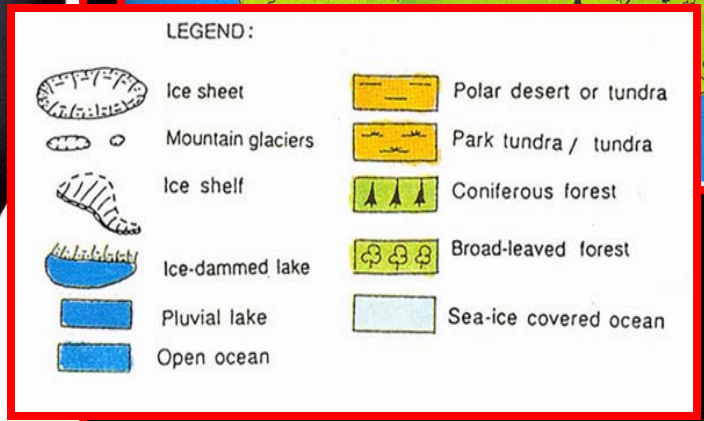
SHACKLETON & OPDYKE (1973)

THE ICE AGE WORLD



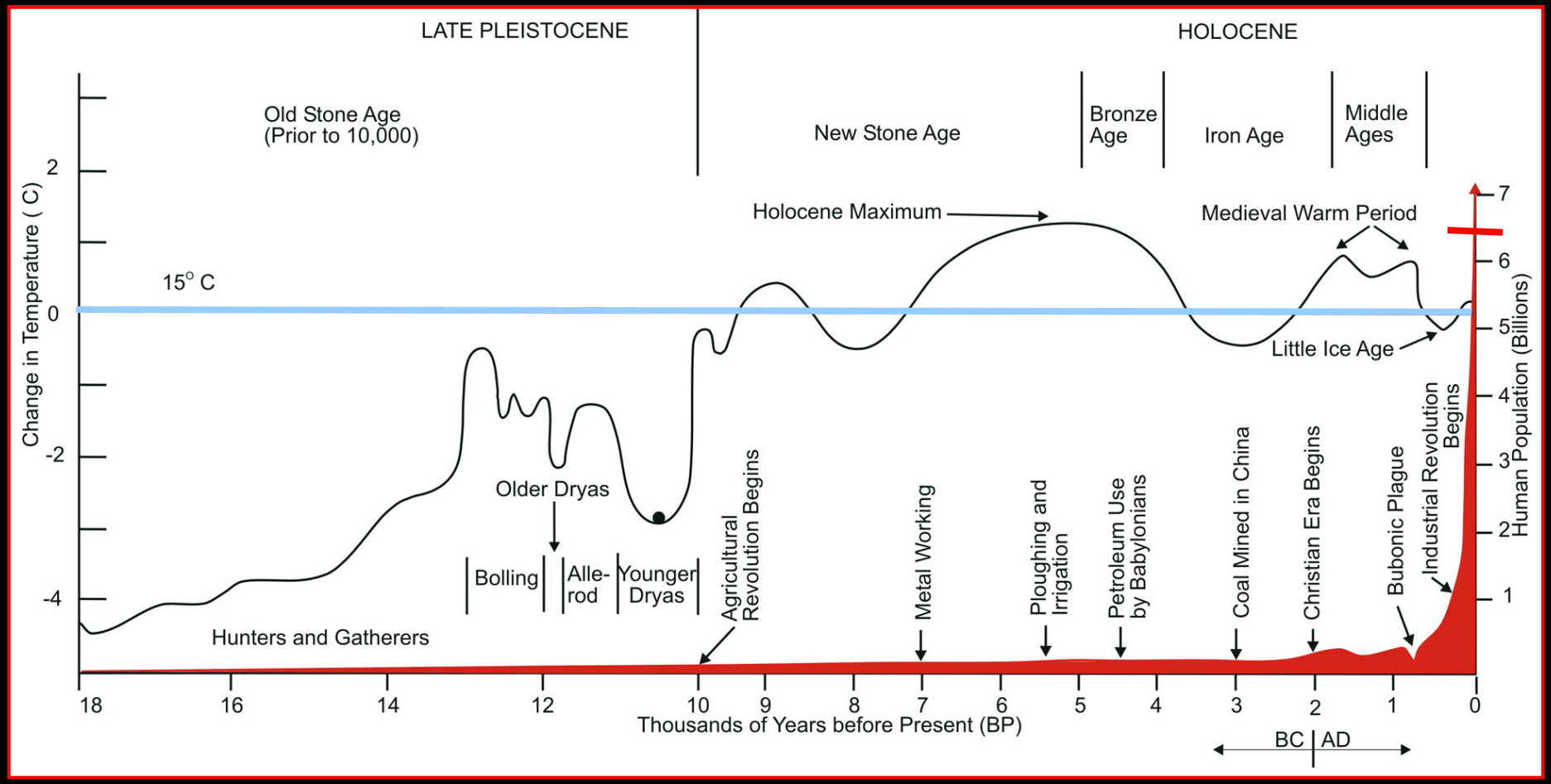
TARBUCK AND LUTGENS, 1999

NORTH AMERICA 18,000 YEARS AGO: LAST GLACIAL MAXIMUM



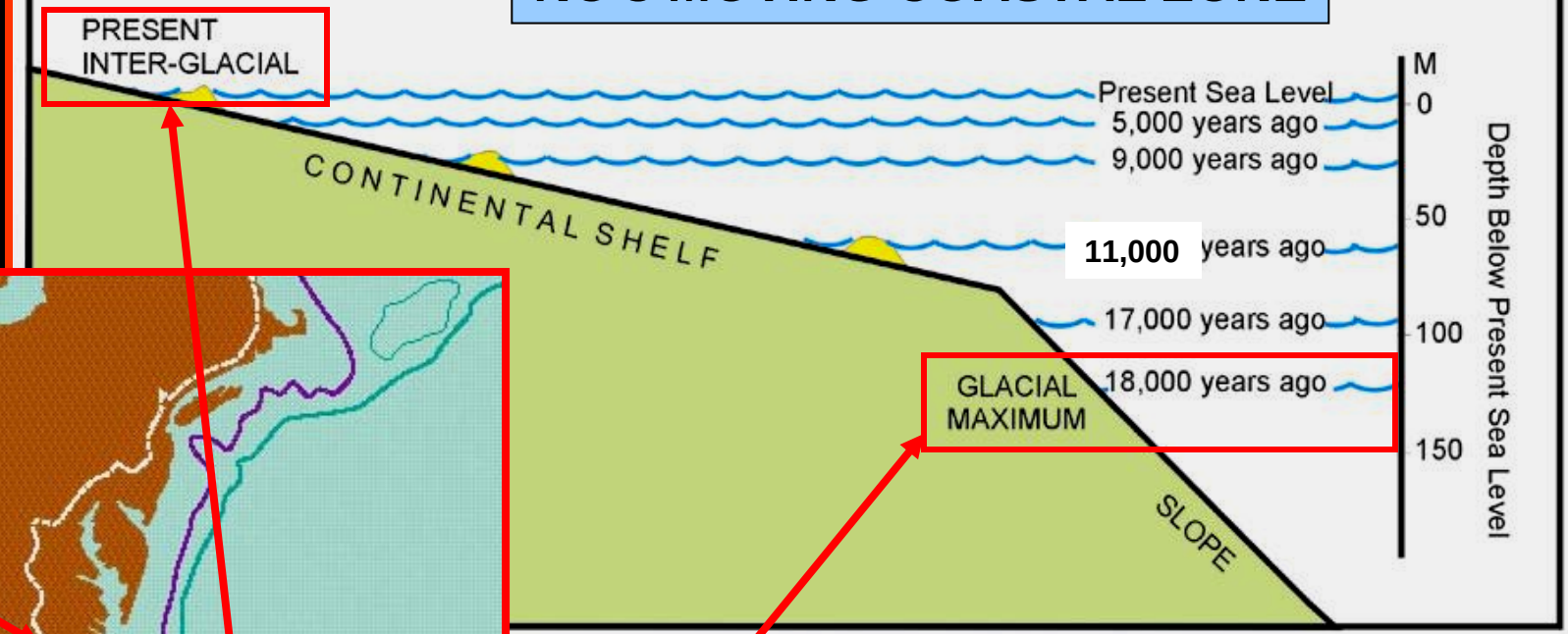
ANDERSEN & BORNS, 1994

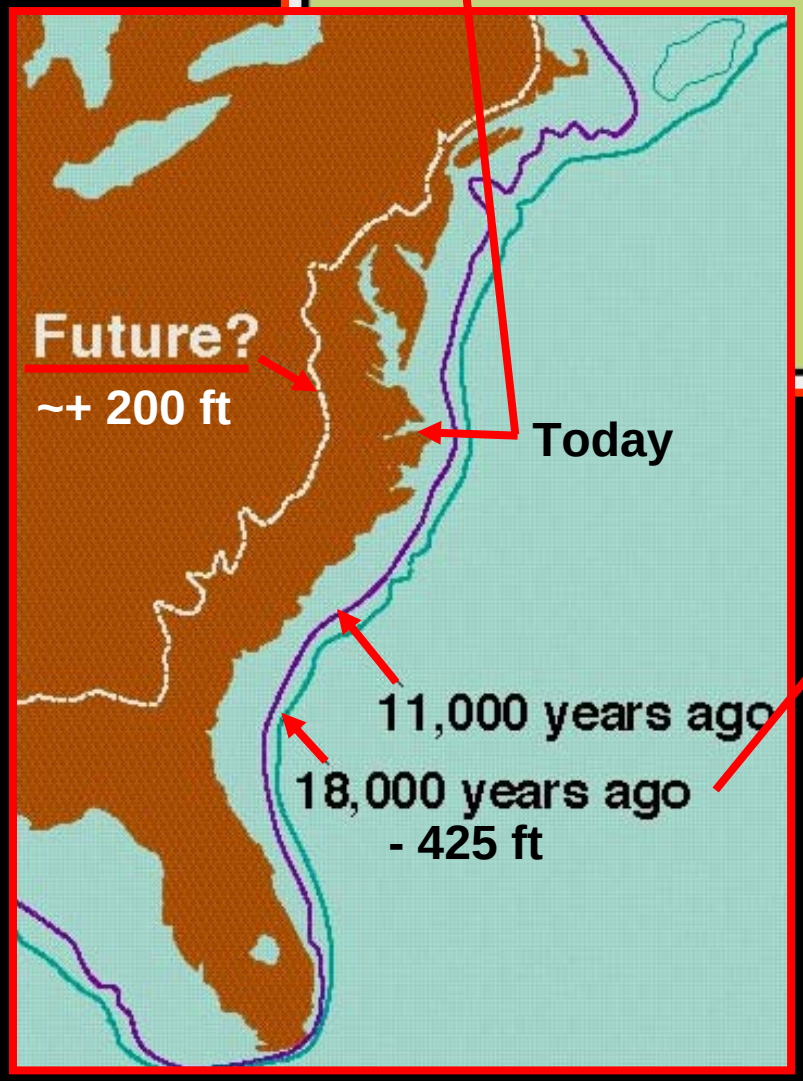
POST-GLACIAL GLOBAL CLIMATE CURVE AND HUMAN POPULATION: HISTORY OF WARMING & COOLING!



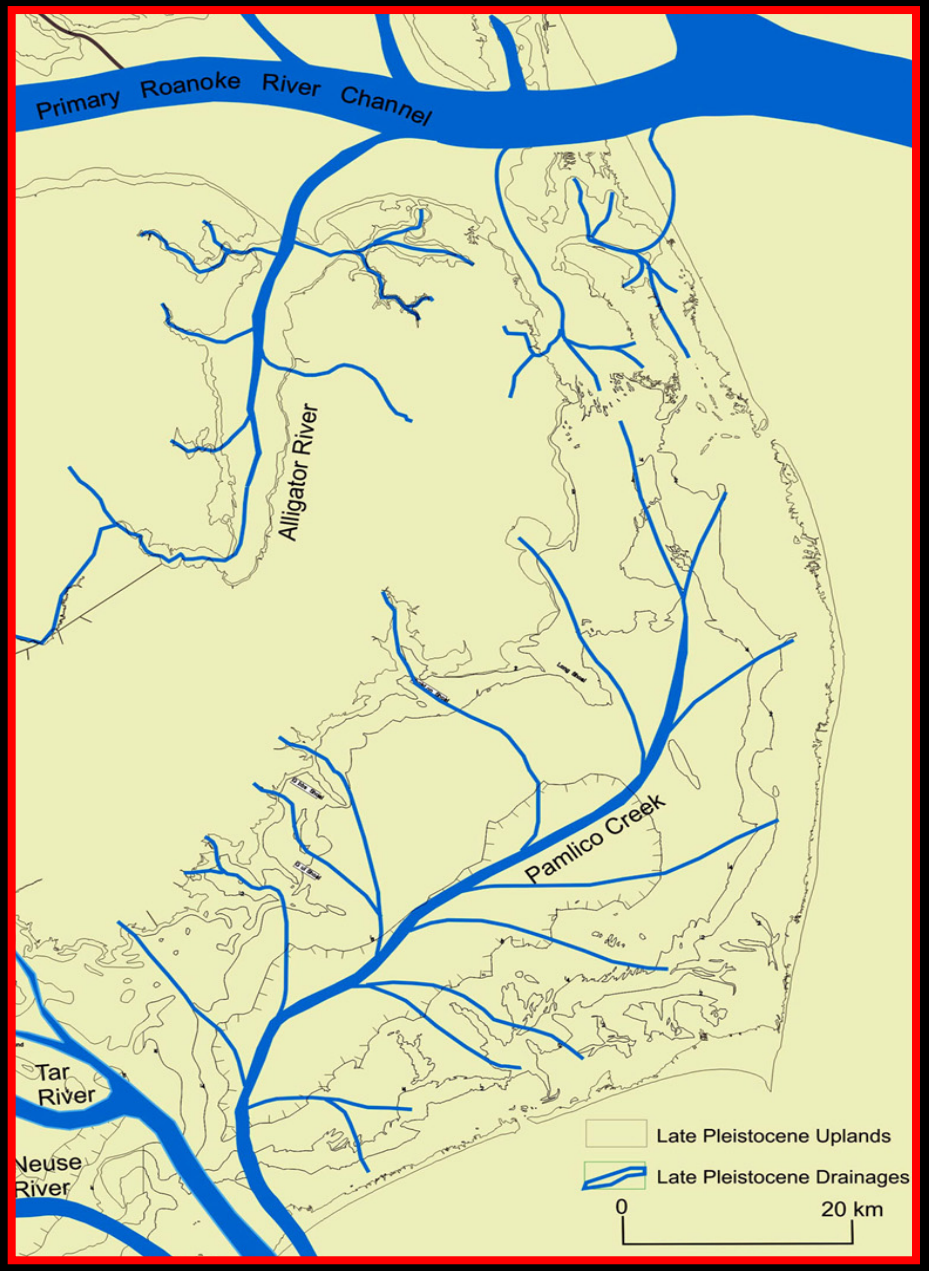
MODIFIED FROM UCAR/OIES, 1991 AND HOUGHTON ET AL., 1990

NC's MOVING COASTAL ZONE





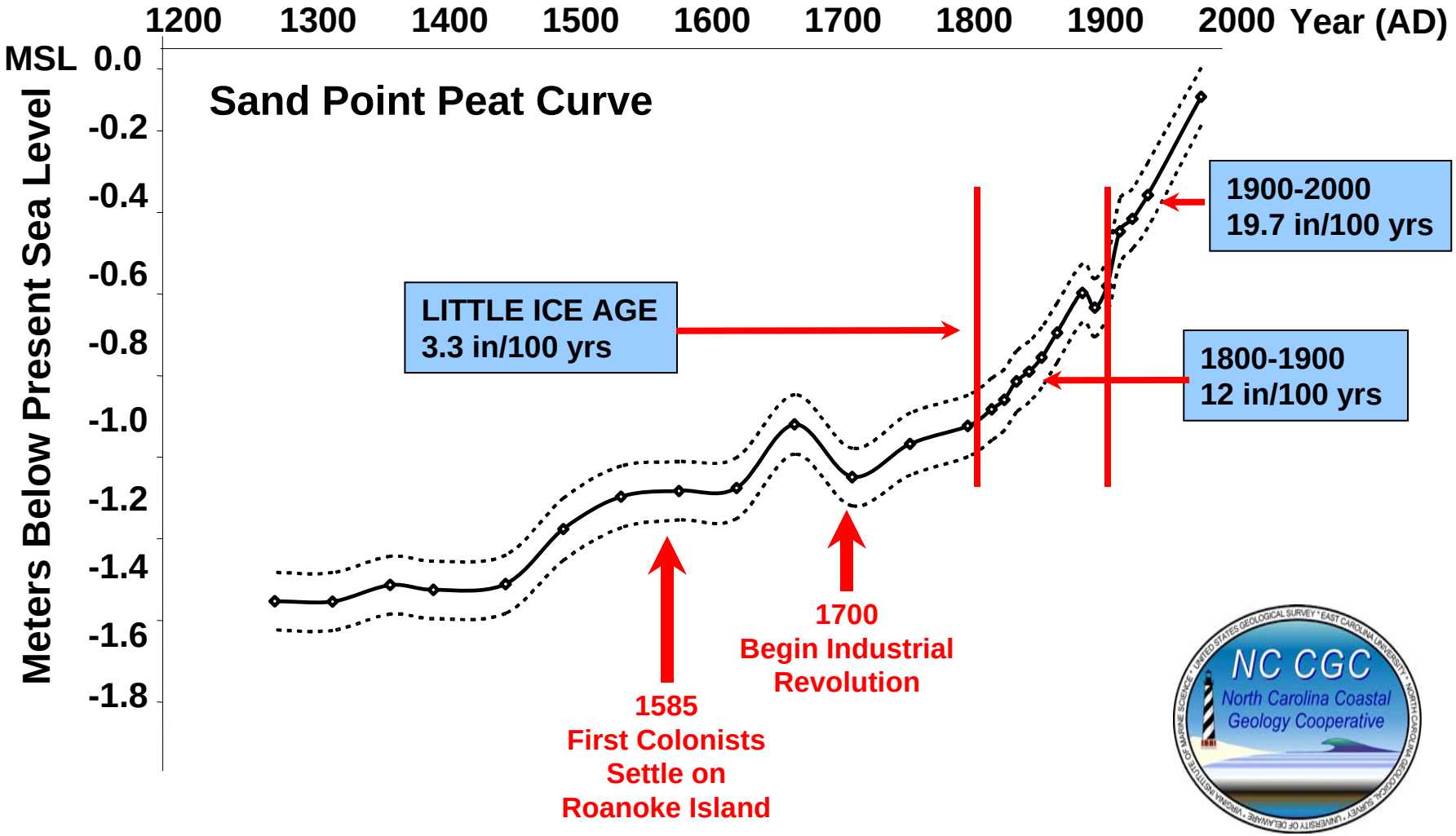
POST-GLACIAL SEA--LEVEL RISE FLOODS UP AND ACROSS THE CONTINENTAL SLOPE & SHELF PRODUCING OUR MODERN COASTAL SYSTEM

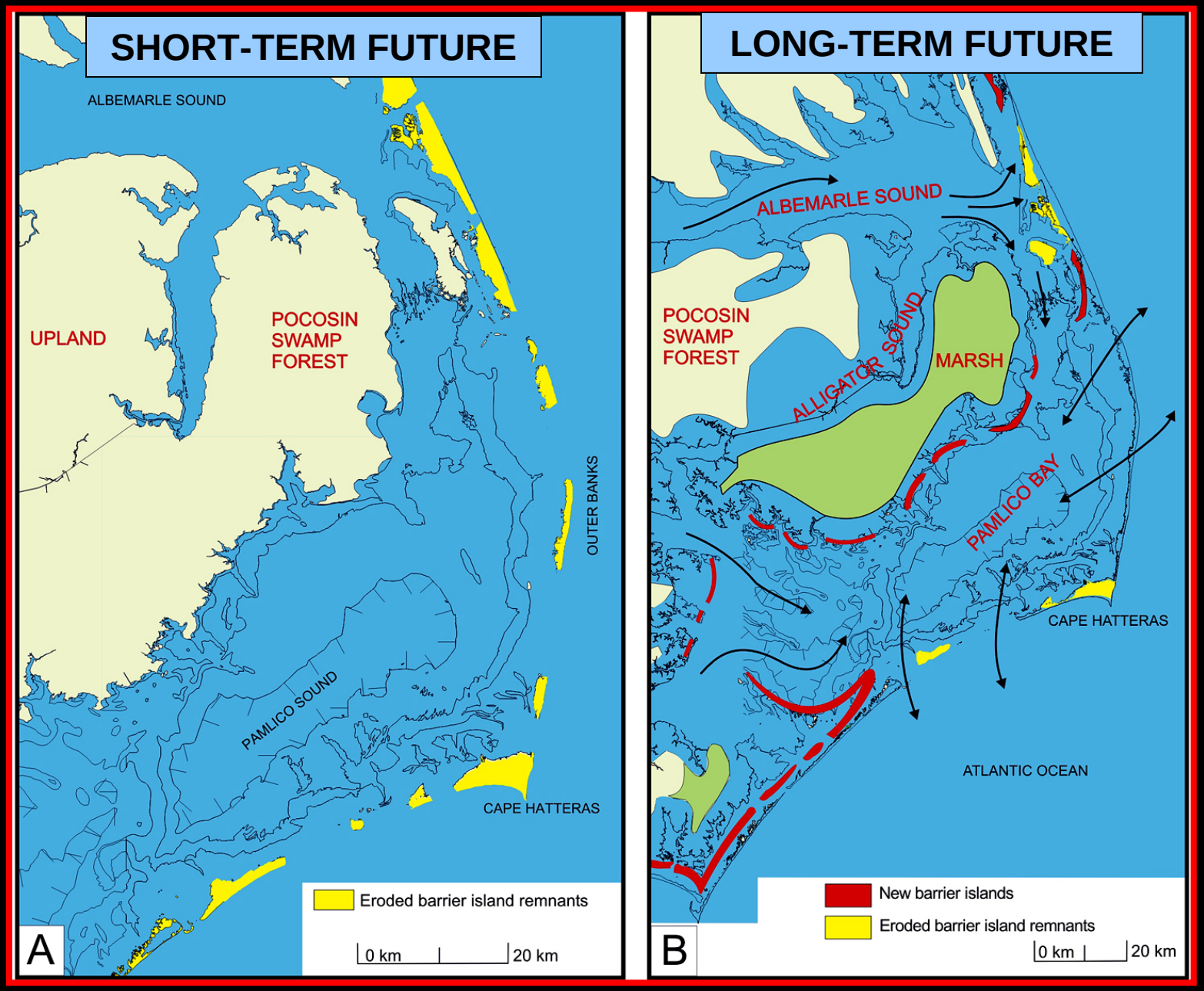


LAST GLACIAL MAXIMUM

1999 AD

NORTH CAROLINA SEA LEVEL CURVE





COLLAPSE MAPS OF THE NORTHERN OUTER BANKS, NC

OCEAN SHORELINE IN NE NC DURING THE LAST INTERGLACIAL PERIOD (~125,000 YEARS AGO)

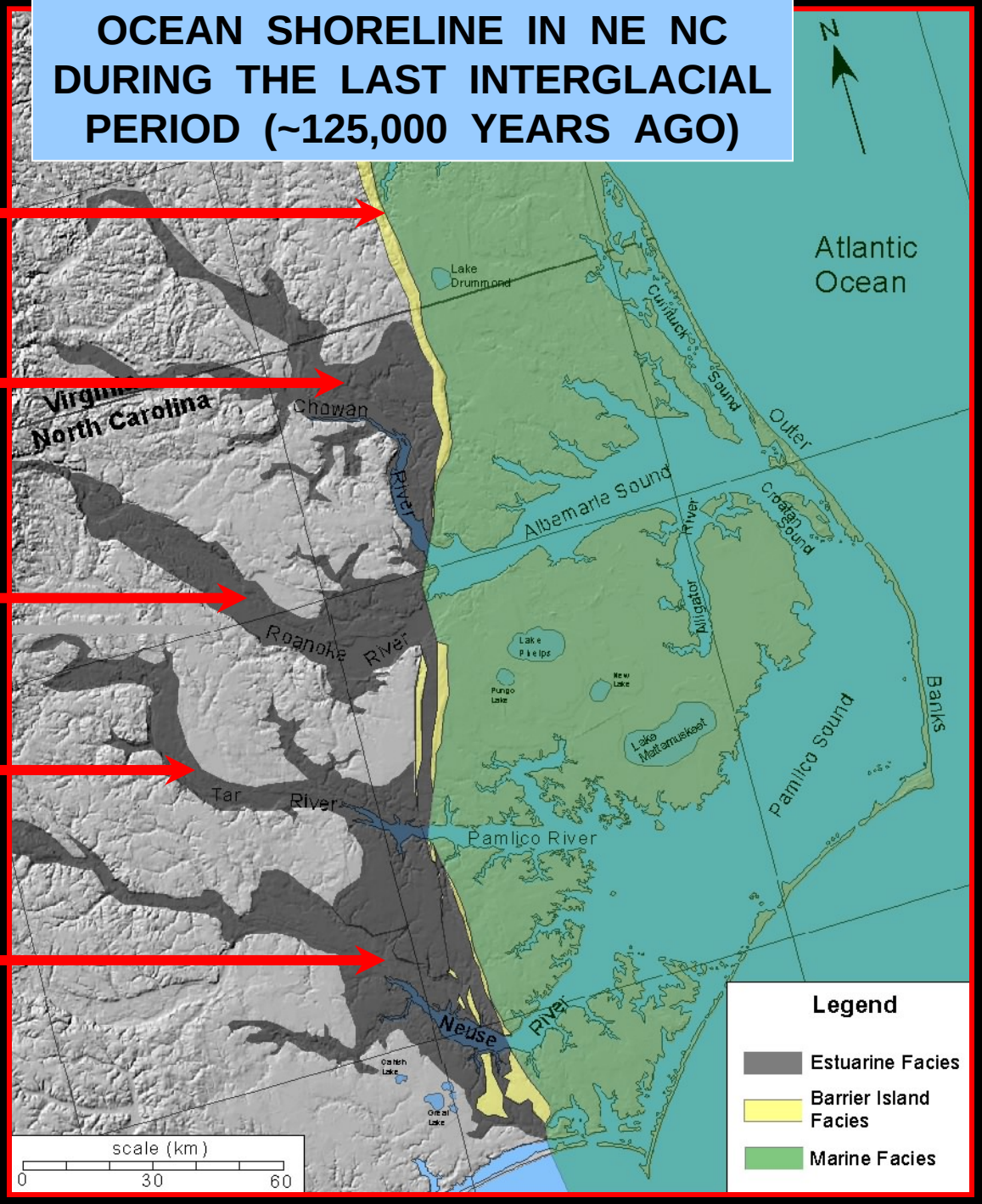
SUFFOLK SHORELINE

CHOWAN RIVER ESTUARY

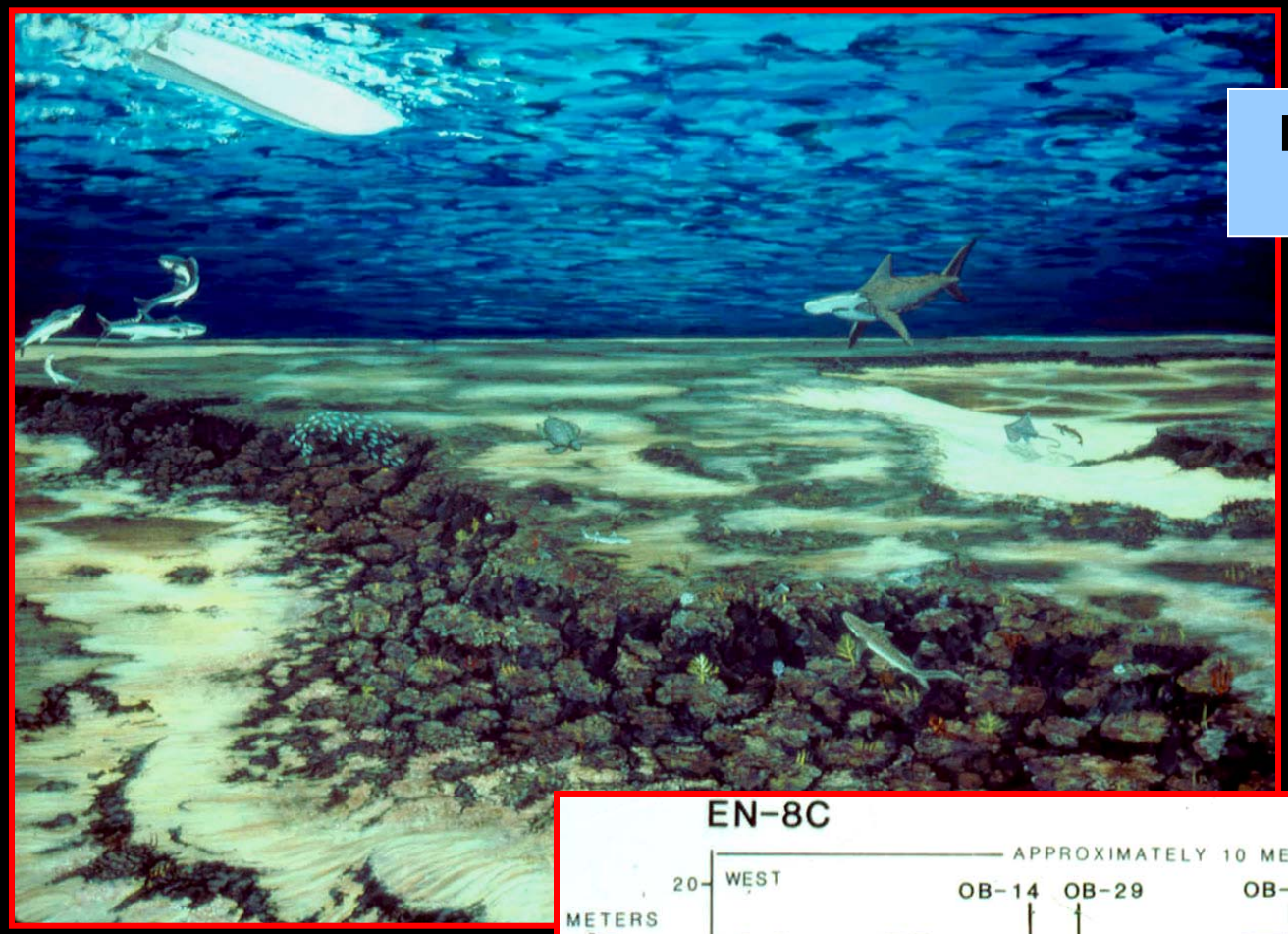
ALBEMARLE SOUND

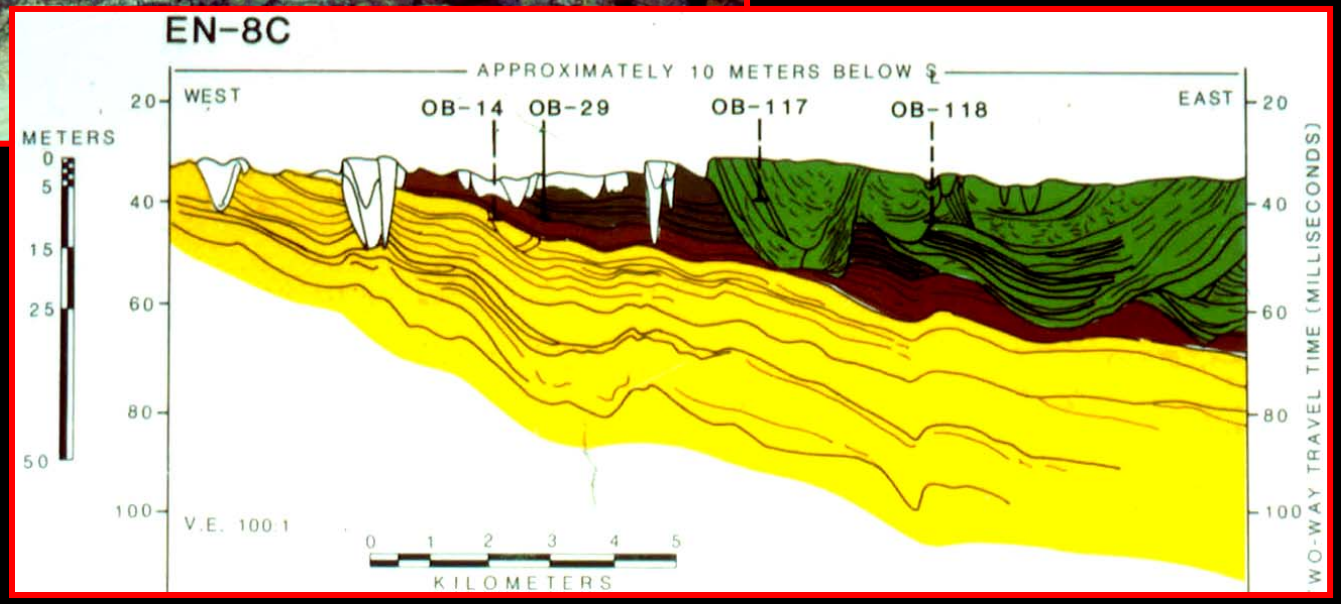
PAMLICO RIVER

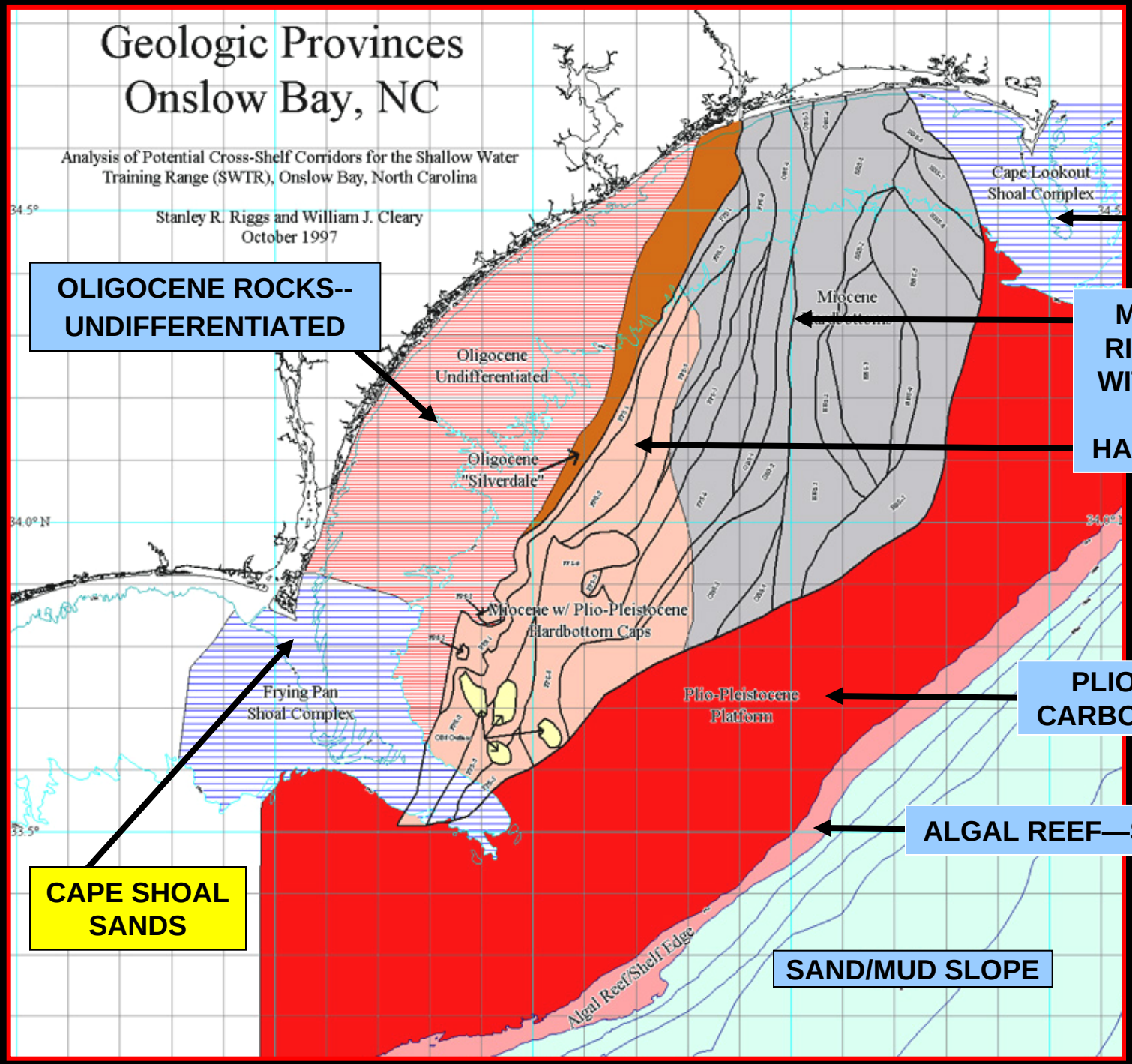
NEUSE RIVER ESTUARY



ROCK-FLOORED ONSLOW BAY






Geologic Provinces
Onslow Bay, NC
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Cape Lookout Shoal Complex
Miocene
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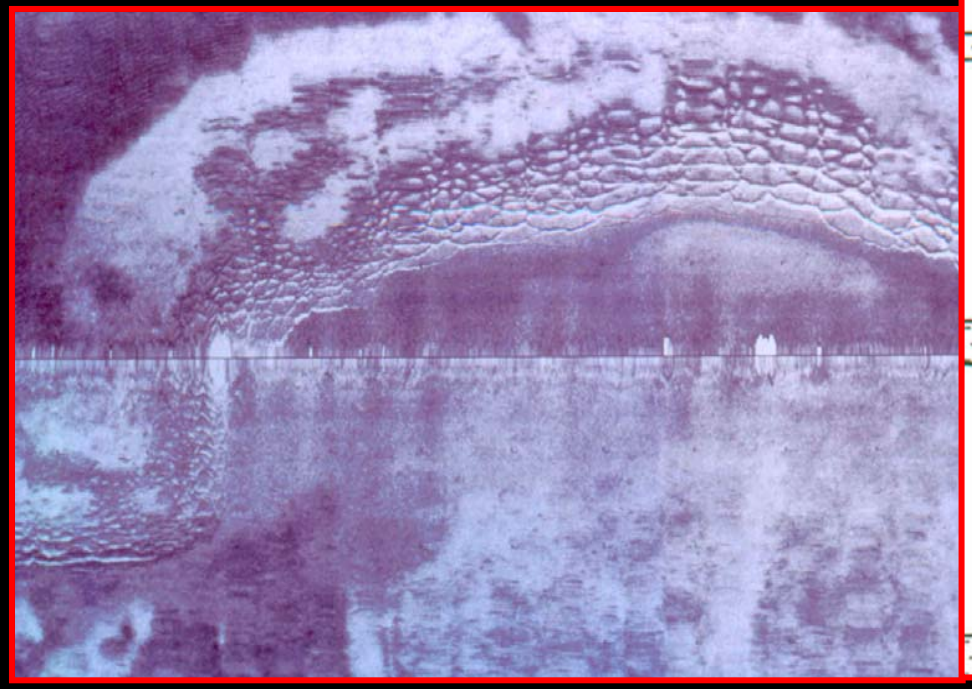
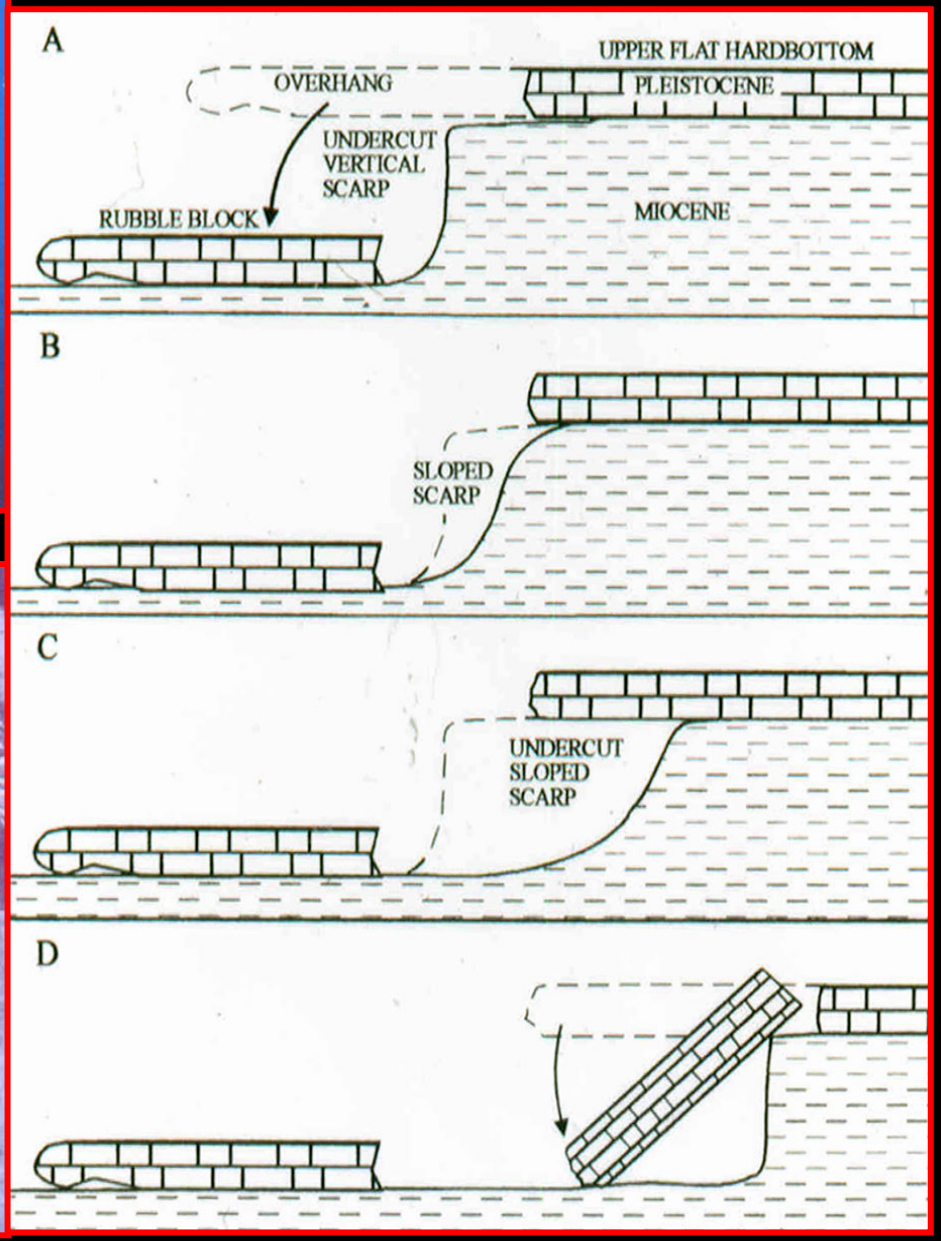
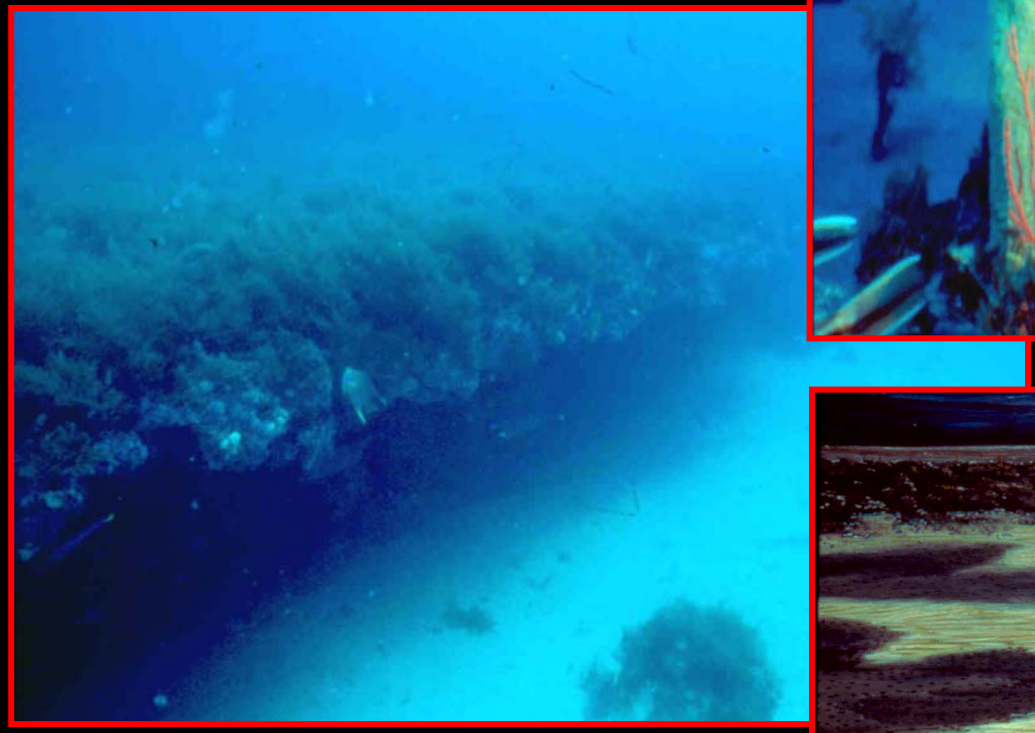
Oligocene "Silverdale"
Miocene w/ Plio-Pleistocene Hardbottom Caps
Frying Pan Shoal Complex
Plio-Pleistocene Platform
Algal Reef/Shelf Edge
CAPE SHOAL SANDS
OLIGOCENE ROCKS--UNDIFFERENTIATED
MIOCENE PUNGO RIVER FORMATION WITH PLEISTOCENE CARBONATE HARDBOTTOM CAPS
PLIO-PLEISTOCENE CARBONATE PLATFORM
ALGAL REEF—SHELF EDGE
SAND/MUD SLOPE
CAPE SHOAL SANDS

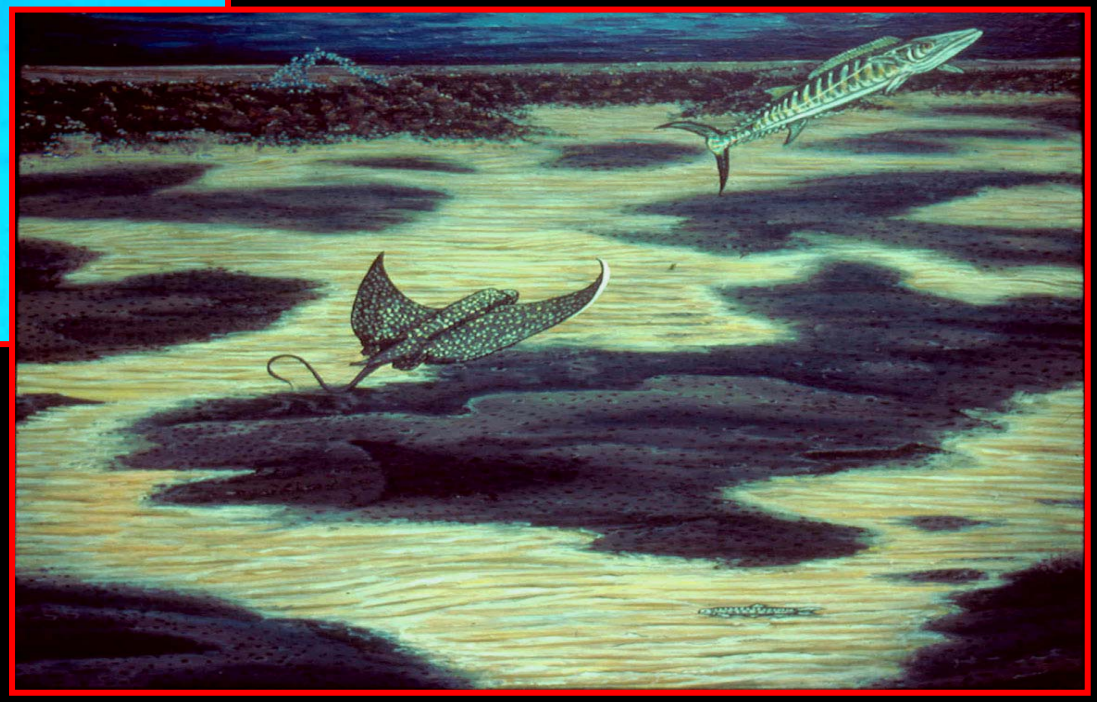
EVOLUTION OF HARDBOTTOM RUBBLE RAMP

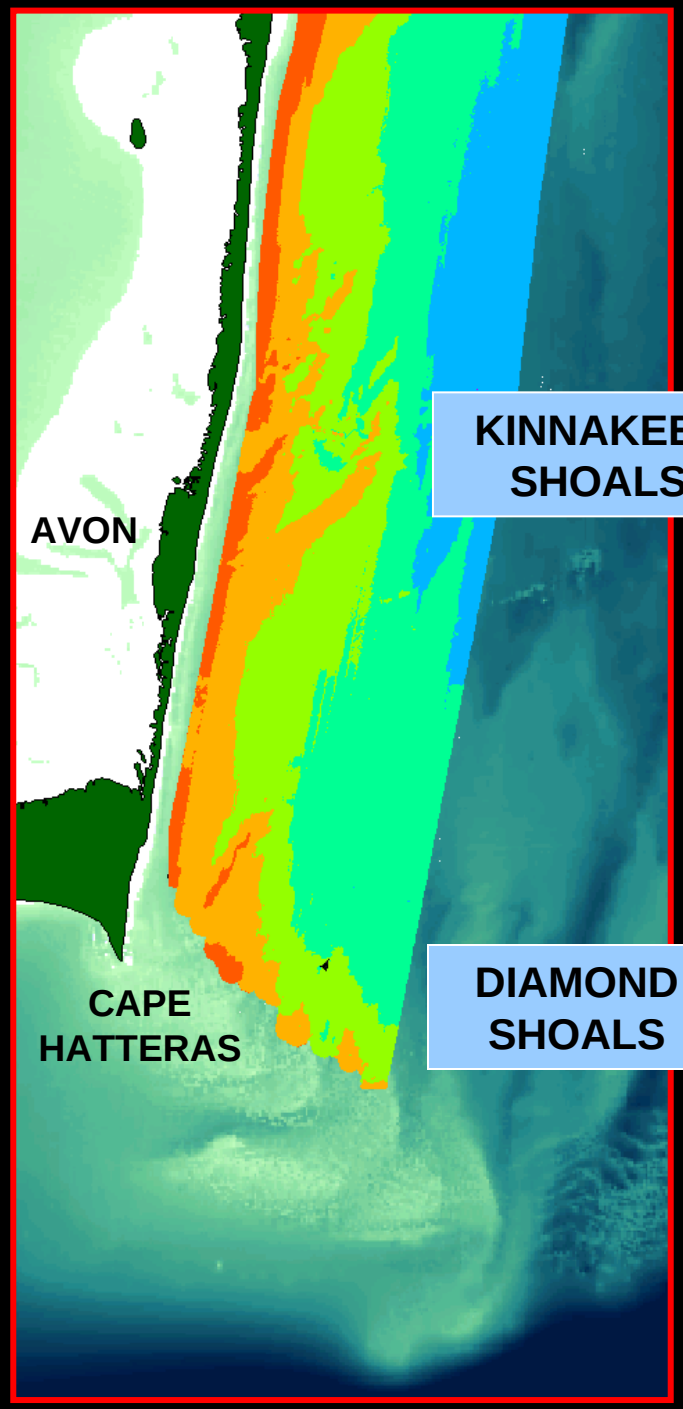


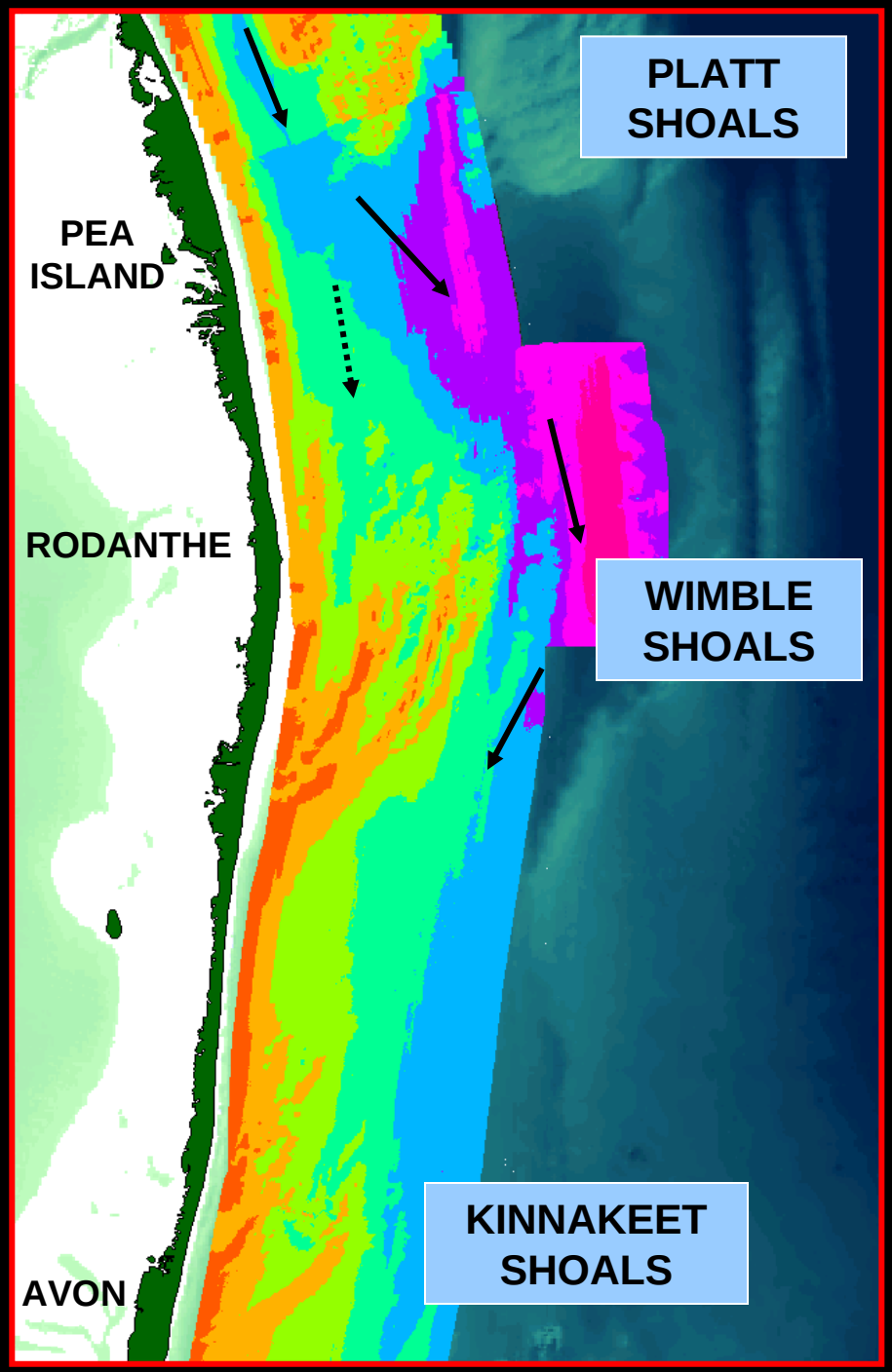


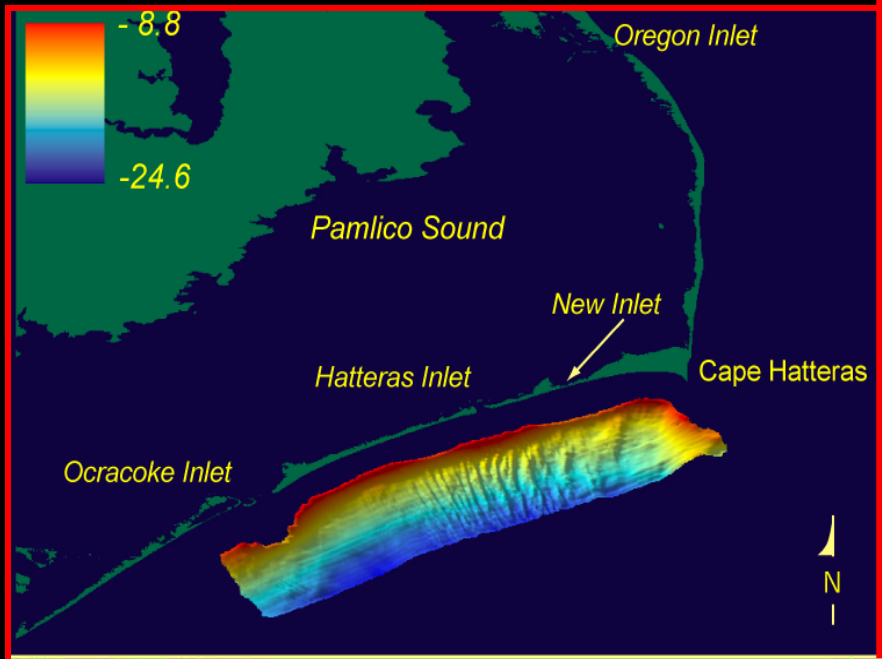
ONSLOW BAY HARDBOTTOMS

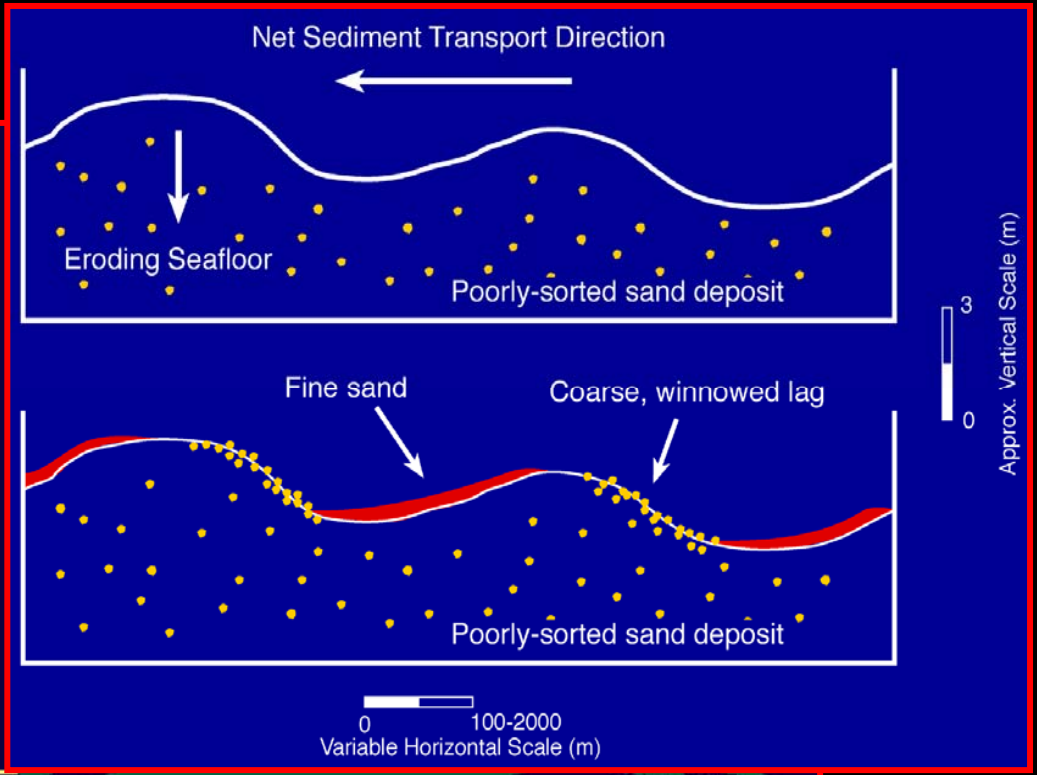


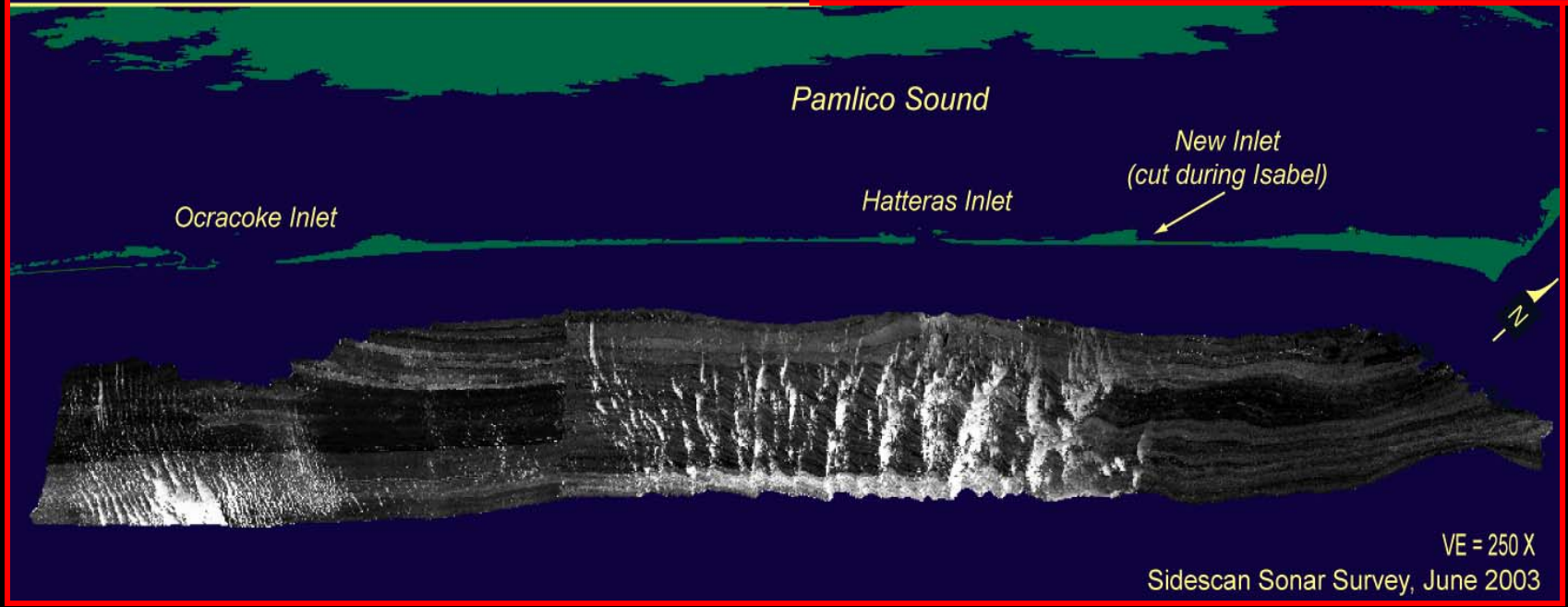


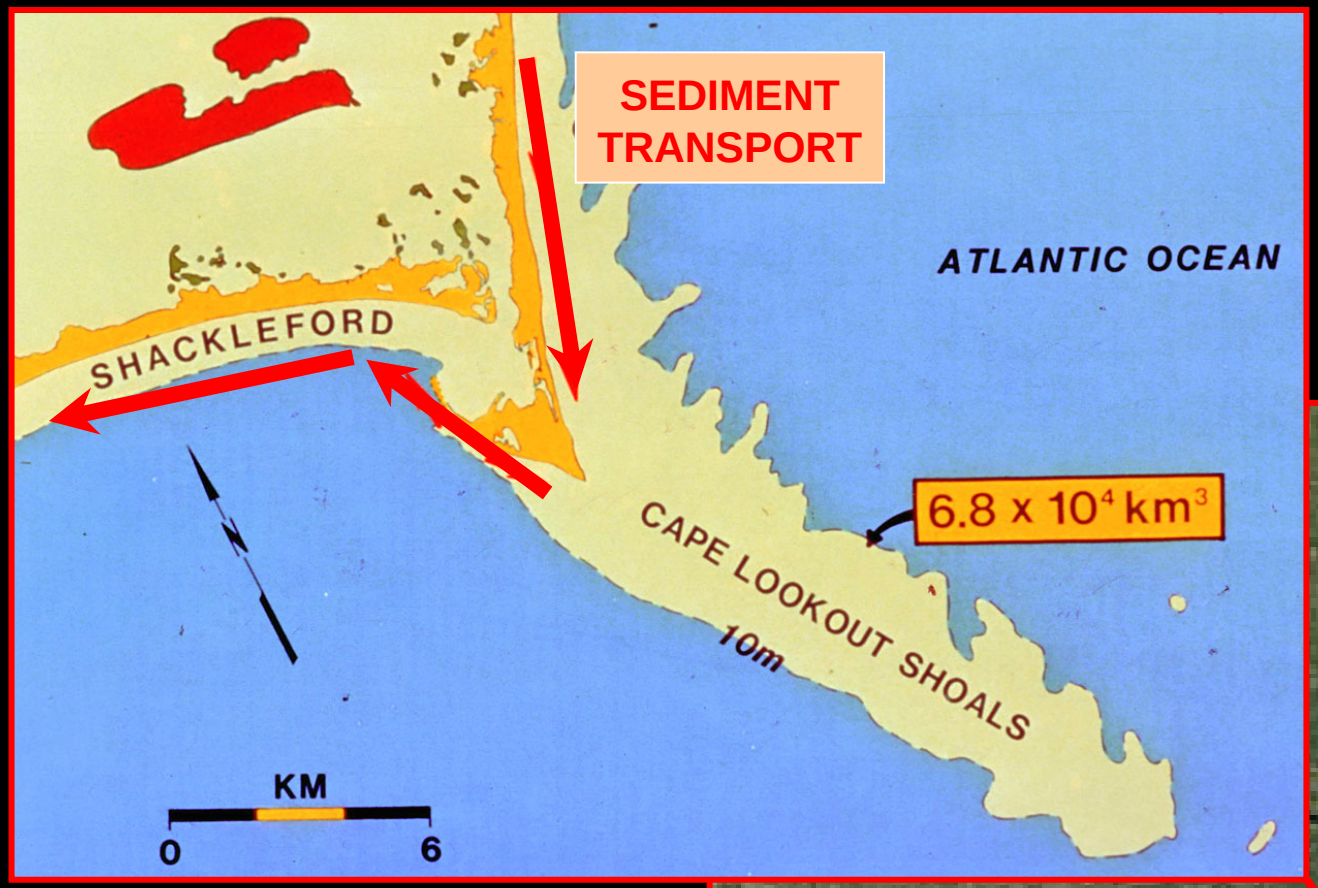

KINNAKEET
SHOALS
AVON
CAPE
HATTERAS
DIAMOND
SHOALS

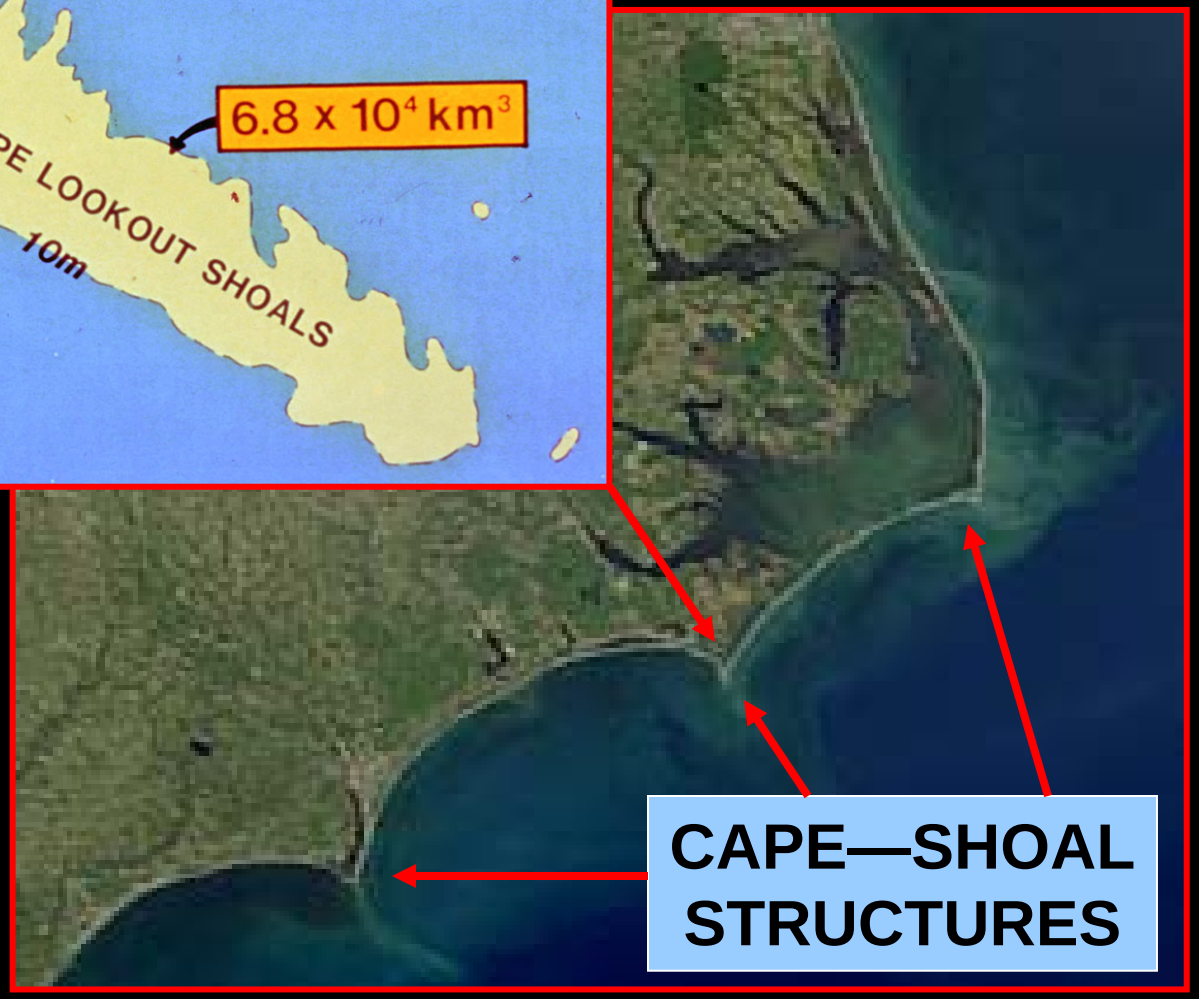

PLATT
SHOALS
PEA
ISLAND
RODANTHE
WIMBLE
SHOALS
KINNAKEET
SHOALS
AVON


- 8.8
-24.6
Oregon Inlet
Pamlico Sound
New Inlet
Hatteras Inlet
Cape Hatteras
Ocracoke Inlet
N


Net Sediment Transport Direction
Eroding Seafloor
Poorly-sorted sand deposit
Fine sand
Coarse, winnowed lag
Poorly-sorted sand deposit
3
0
Approx. Vertical Scale (m)
0
100-2000
Variable Horizontal Scale (m)

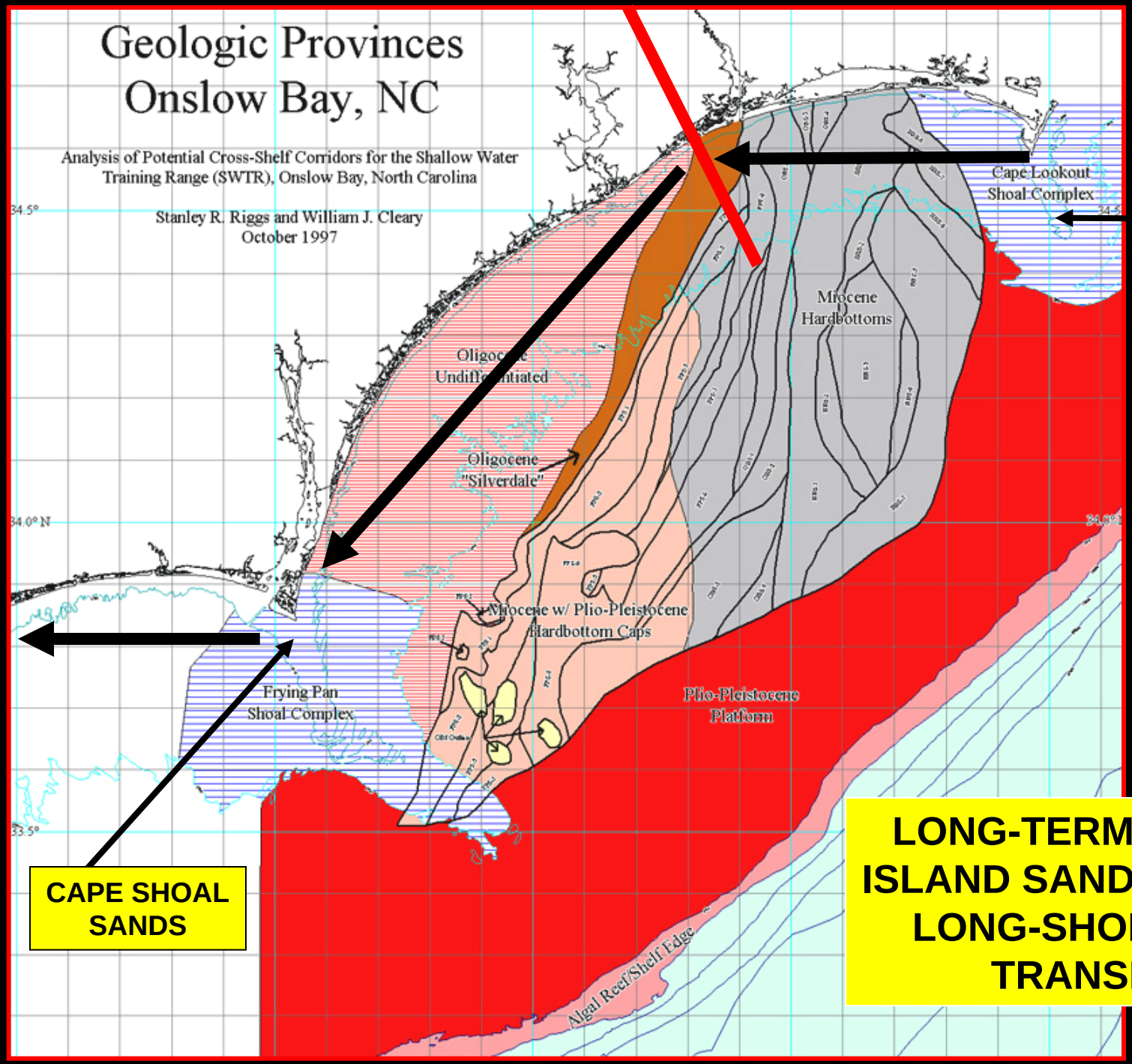

Pamlico Sound
New Inlet
(cut during Isabel)
Hatteras Inlet
Ocracoke Inlet
N
VE = 250 X
Sidescan Sonar Survey, June 2003





MAJOR SEDIMENT SOURCES FOR DOWN-DRIFT BARRIER ISLANDS

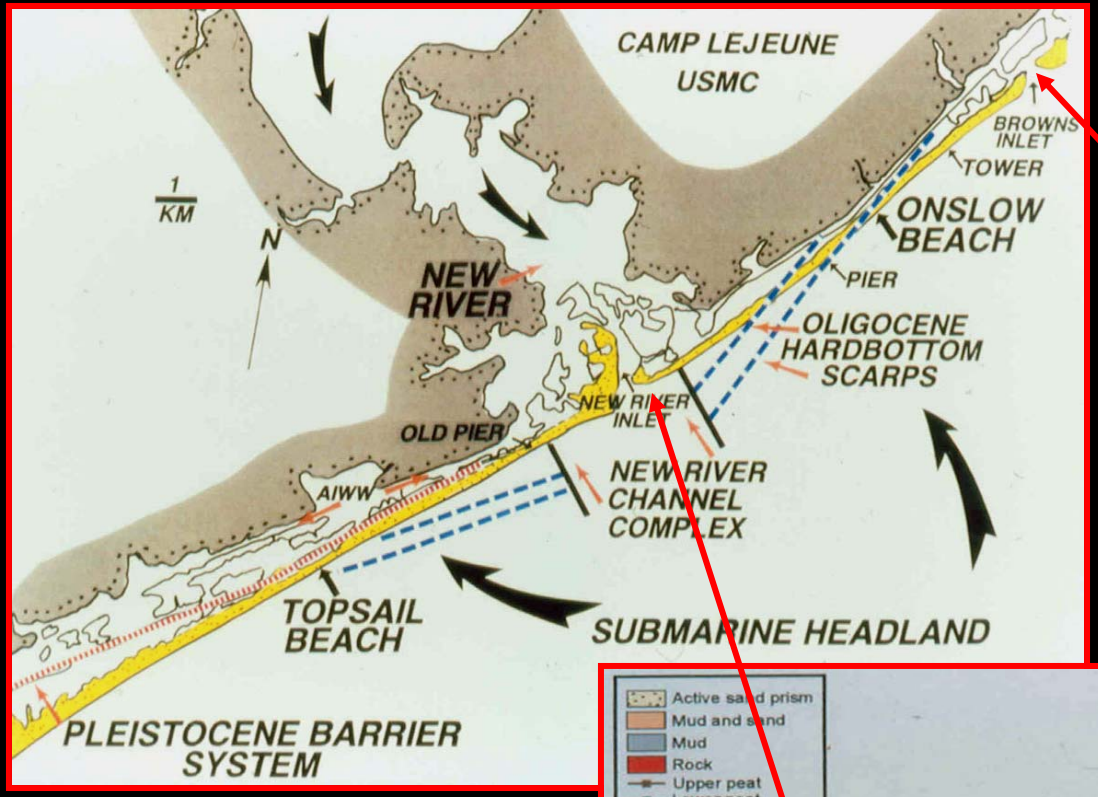
CAPE—SHOAL STRUCTURES

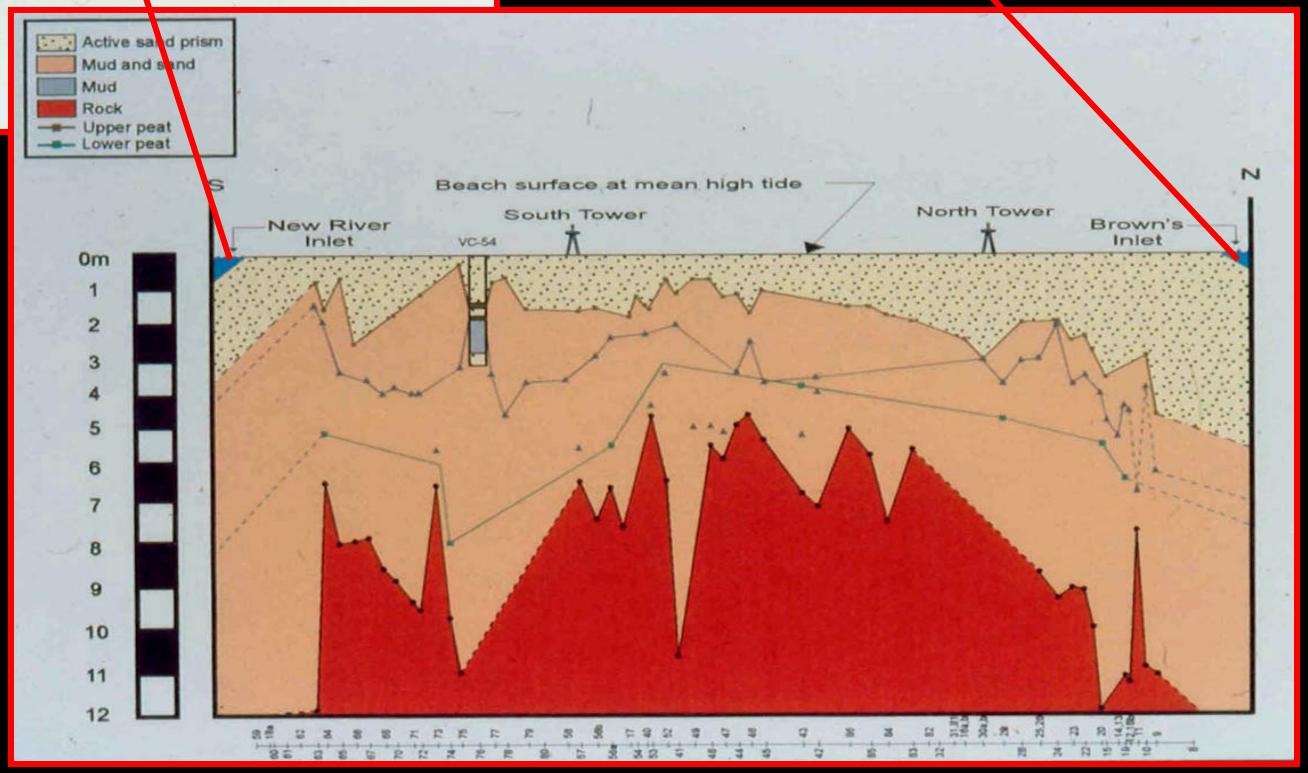


CAPE SHOAL SANDS

CAPE SHOAL SANDS

LONG-TERM, BARRIER ISLAND SAND SUPPLY & LONG-SHORE SAND TRANSPORT

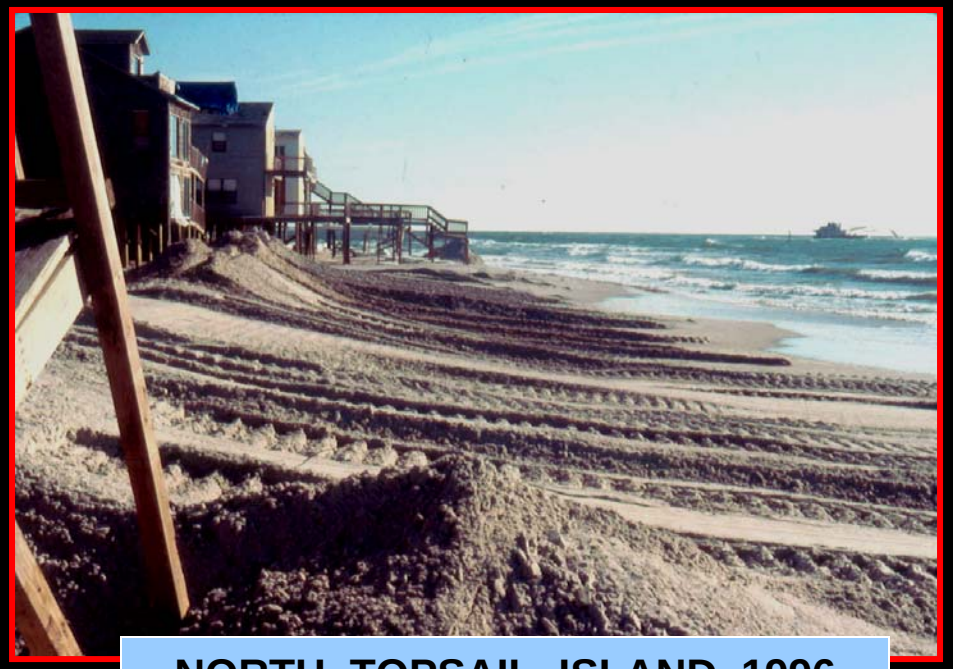




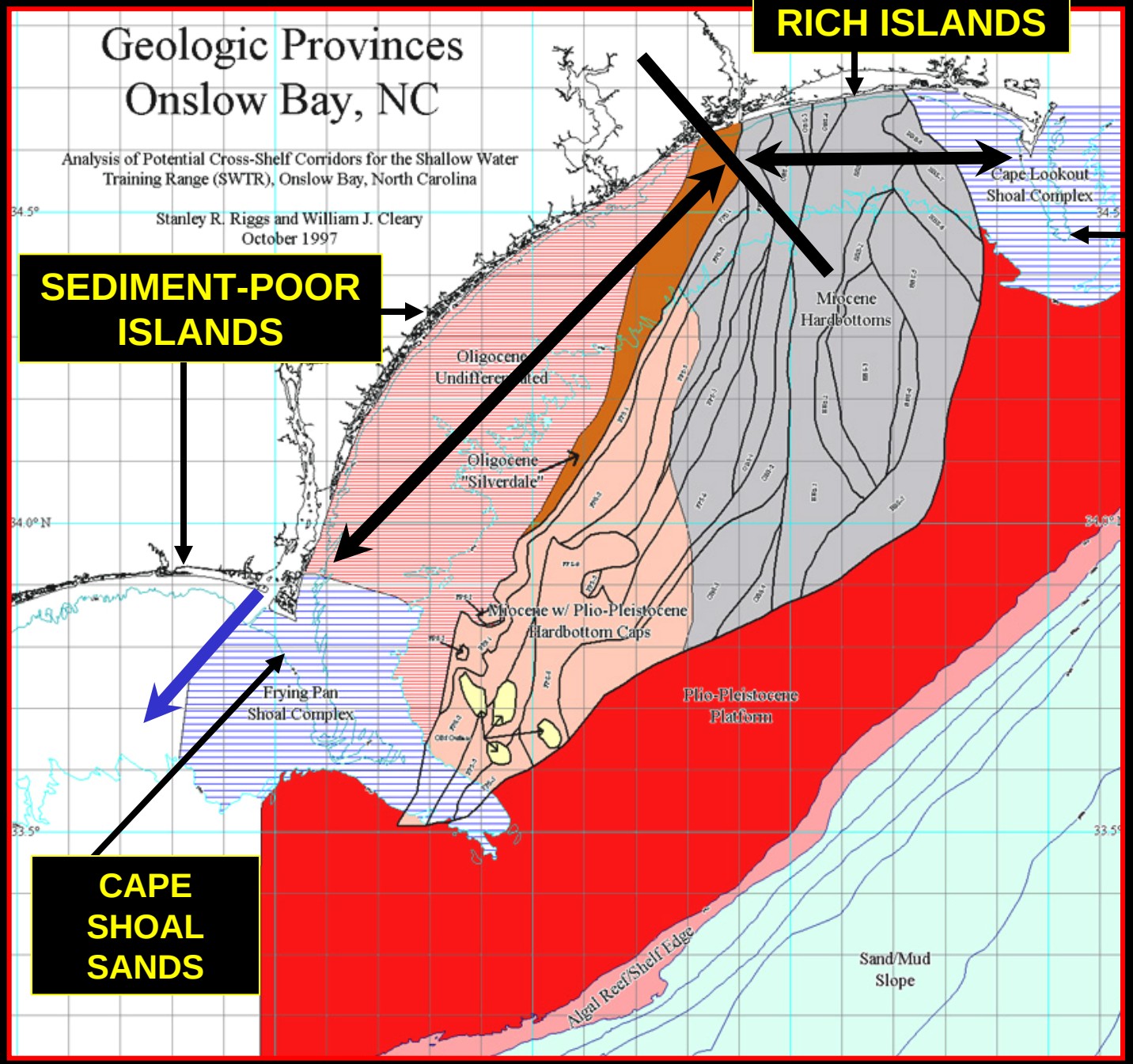
NORTH TOPSAIL ISLAND TO BROWN'S INLET

ONSLOW BEACH ROCK SUBMARINE HEADLAND

SOUTH ONSLOW BEACH 1996



NORTH TOPSAIL ISLAND 1996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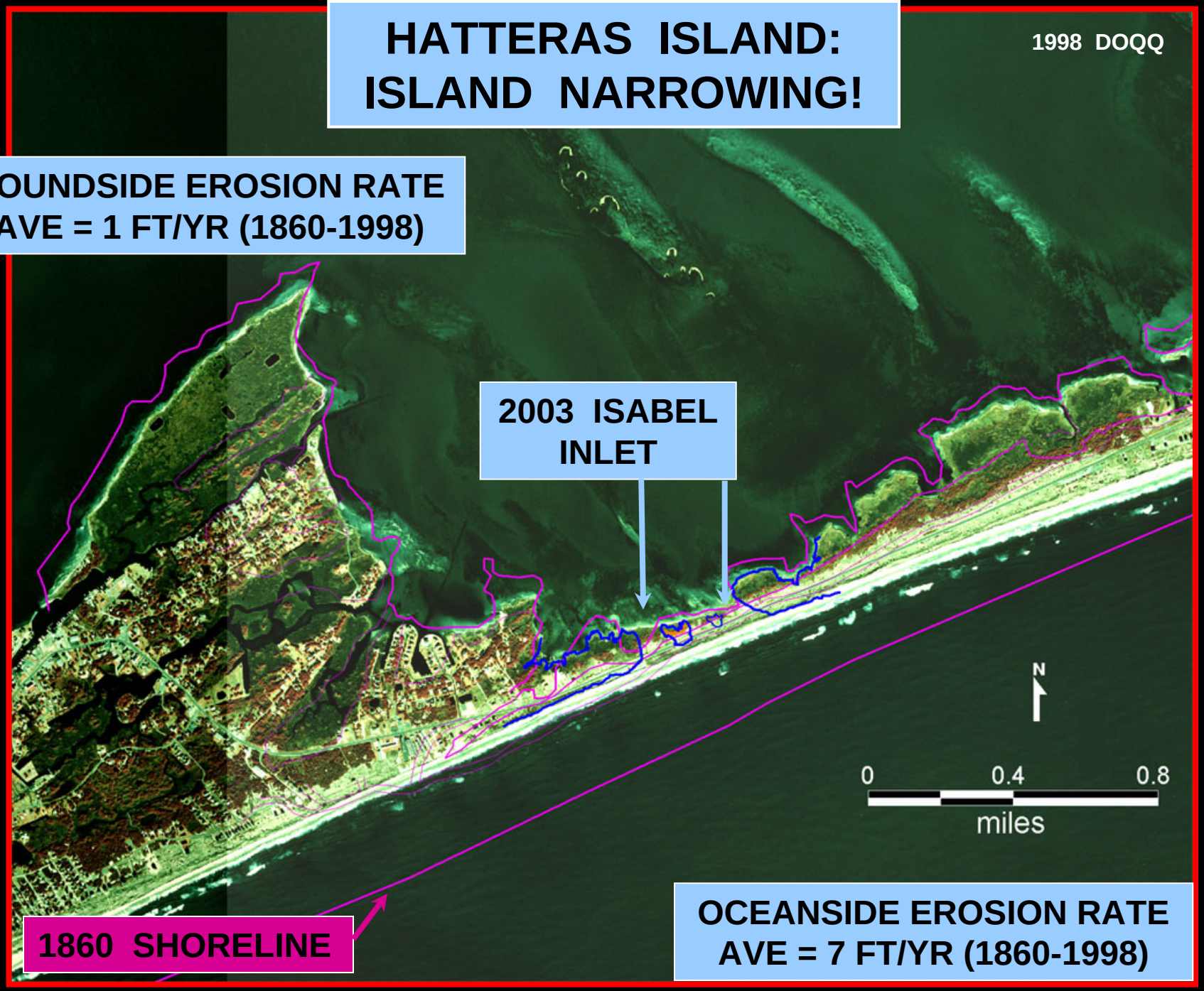
Frying Pan Shoal Complex
Plio-Pleistocene Platform
Algal Reef/Shelf Edge
Sand/Mud Slope
34.5°
34.0° N
33.5°

COQUINA ROCK AT FORT FISHER HEADLAND

INLETS AND OVERWASH: CRITICAL PROCESSES THAT BUILD ISLAND WIDTH & ELEVATION

HATTERAS ISLAND: ISLAND NARROWING!



HATTERAS VILLAGE AND ISABEL INLET 9-03

FRF PHOTO

USGS PHOTO

ISABEL INLET AND "GOING—TO—SEA" HIWAY 12

MARSH PEAT CROPING OUT ON BEACH

INLET CLOSURE

A NEWLY CONSTRUCTED DUNE RIDGE & HIWAY 12

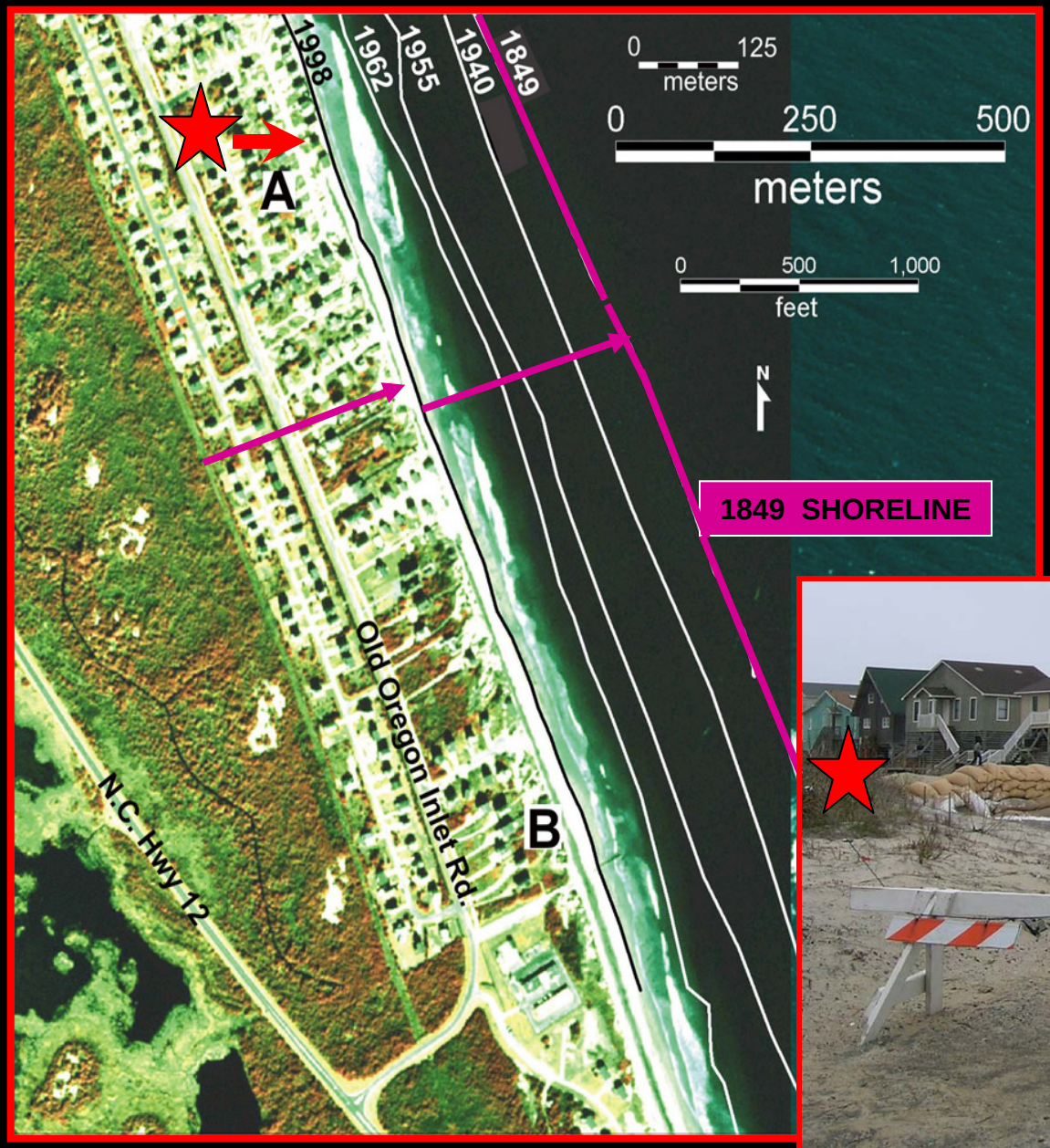
A SMALL BAND-AID FOR A CONTINUING PROBLEM AREA!

“GOING—TO—SEA”
NC HWY 12

WHAT IS THE FUTURE OF PEA ISLAND NWR & NC HWY 12?

CONSTRUCTED BARRIER DUNE RIDGES ARE LIKE "FORT WALLS TO PROTECT AGAINST THE INVADING ENEMY"

SAND BAG THREAT TO NC'S BARRIER ISLAND BEACHES!

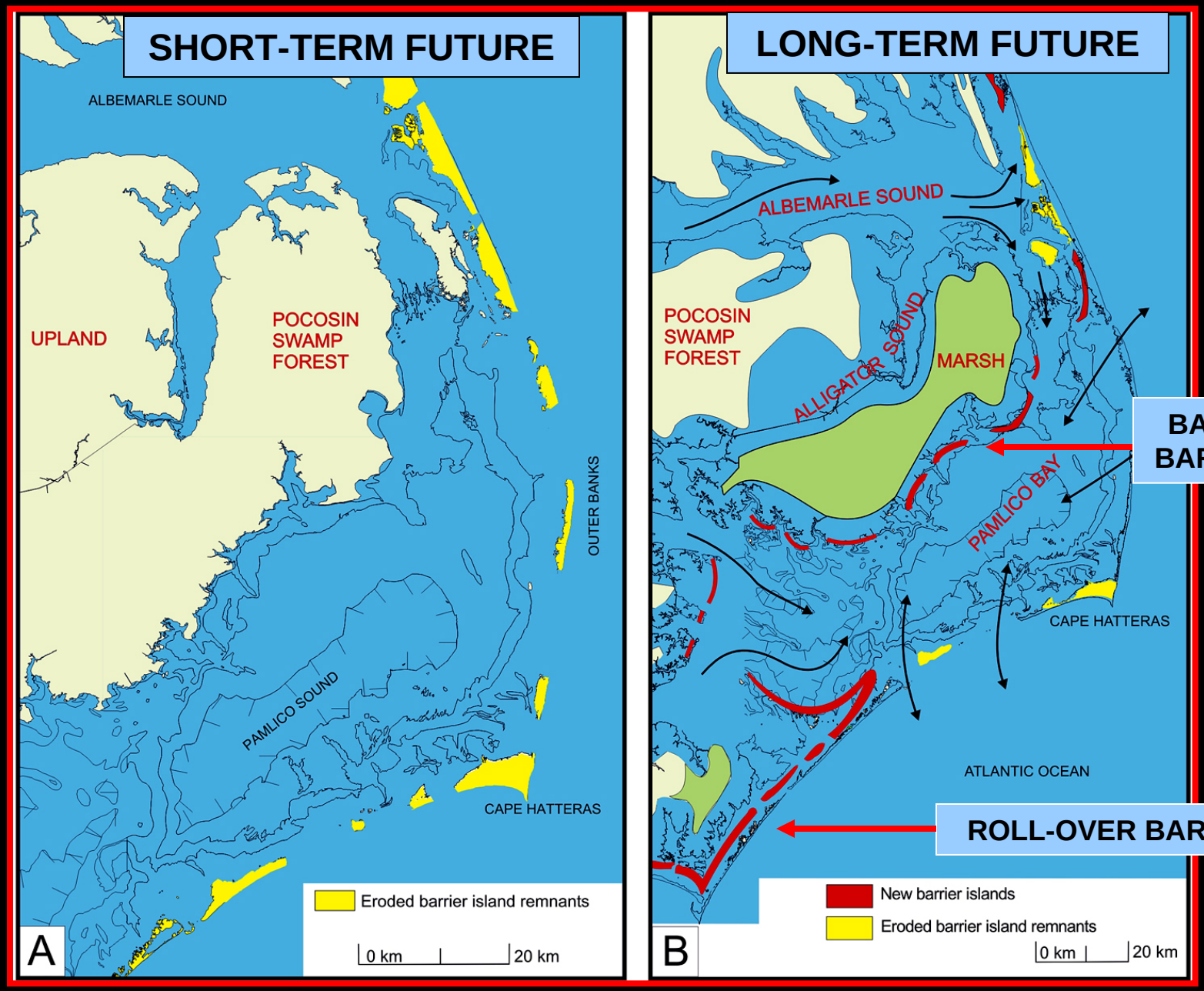


ALL NC BEACHES ARE ERODING AT LONG-TERM AVE. RATES UP TO -15 FT/YR!

NET SHORELINE RECESSION 1849-1998 ~1000 FT (S) TO ~750 FT (N)

NO WORRIES--WE'LL INCREASE THE "ARMY" AND HARDEN THE "FORT WALL"!

BUT THE OCEAN KEEPS COMING!

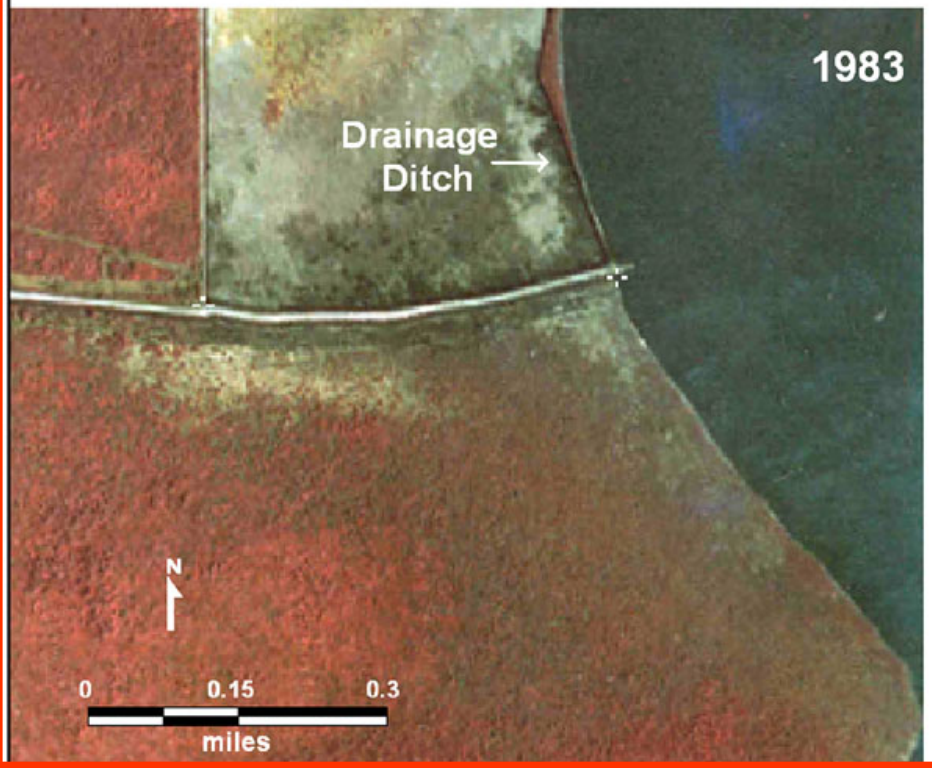


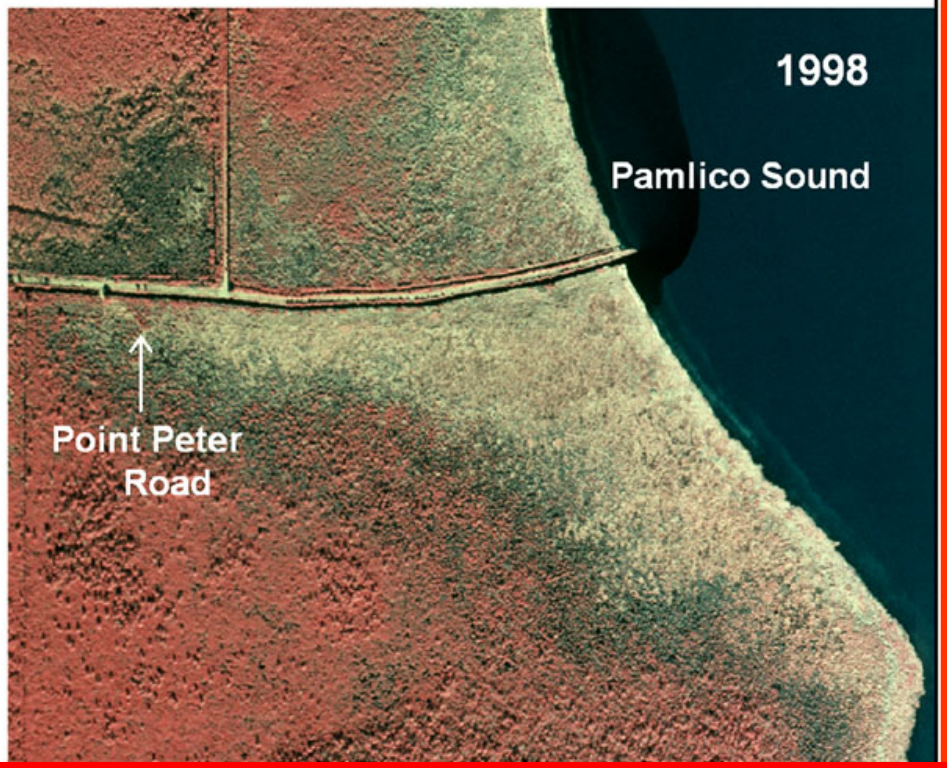
COLLAPSE MAPS OF THE NORTHERN OUTER BANKS, NC

EROSION RATES FOR DIFFERENT SHORELINE TYPES: NORTHEASTERN NORTH CAROLINA ESTUARINE SYSTEM

SHORELINE TYPE (% OF SHORELINES)	MAXIMUM RATE FT/YR	AVERAGE RATE FT/YR
SEDIMENT BANK (38%)		
LOW BANK (30%)	- 8.9	- 3.2
BLUFF/HIGH BANK (8%)	- 26.3	- 2.4
STRANDPLAIN BEACH	- 2.4	+0.2
ORGANIC SHORELINE (62%)		
MARSH (55%)	- 18.3	- 3.5
SWAMP FOREST (7%)	- 5.8	- 2.2
OVERALL WEIGHTED AVERAGE		- 3.2
HUMAN MODIFIED (?)	- 6.6	- 0.3

POINT PETER ROAD - ALLIGATOR RIVER NATIONAL WILDLIFE REFUGE



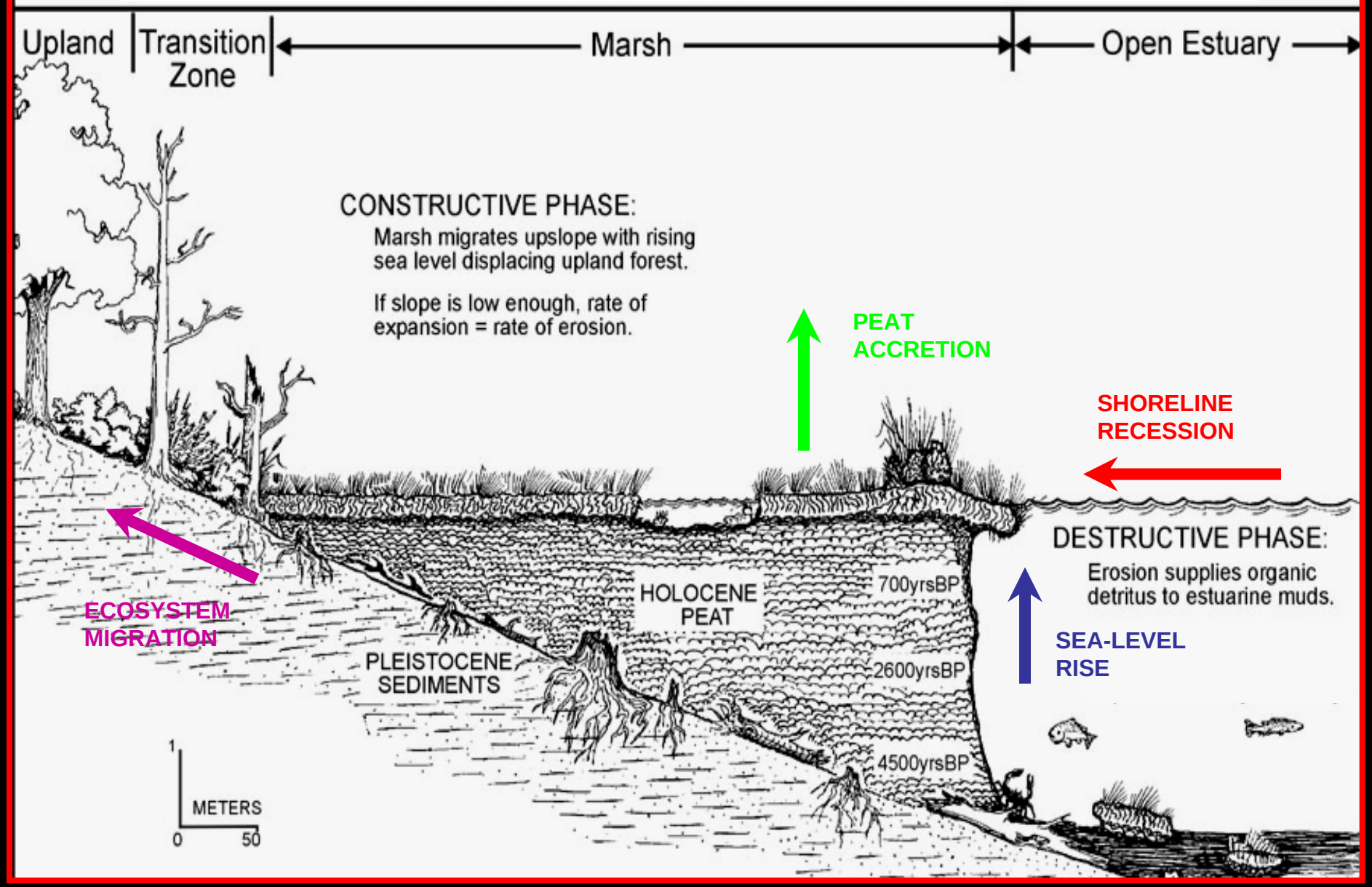


MARSH SHORELINE EROSION:

STORM = - 85 ft

LONG-TERM AVE. = - 3 ft/yr

EVOLUTION OF IRREGULARLY-FLOODED, WAVE-DOMINATED PLATFORM MARSH SHORELINES



ERODING PLATFORM MARSH SHORELINE

STABILIZED PLATFORM MARSH SHORELINE

FILLING & HARDENING WETLAND SHORELINES → **NO WETLANDS— NO SEAFOOD!!!!!**

ERODING LOW-SEDIMENT BANK SHORELINE

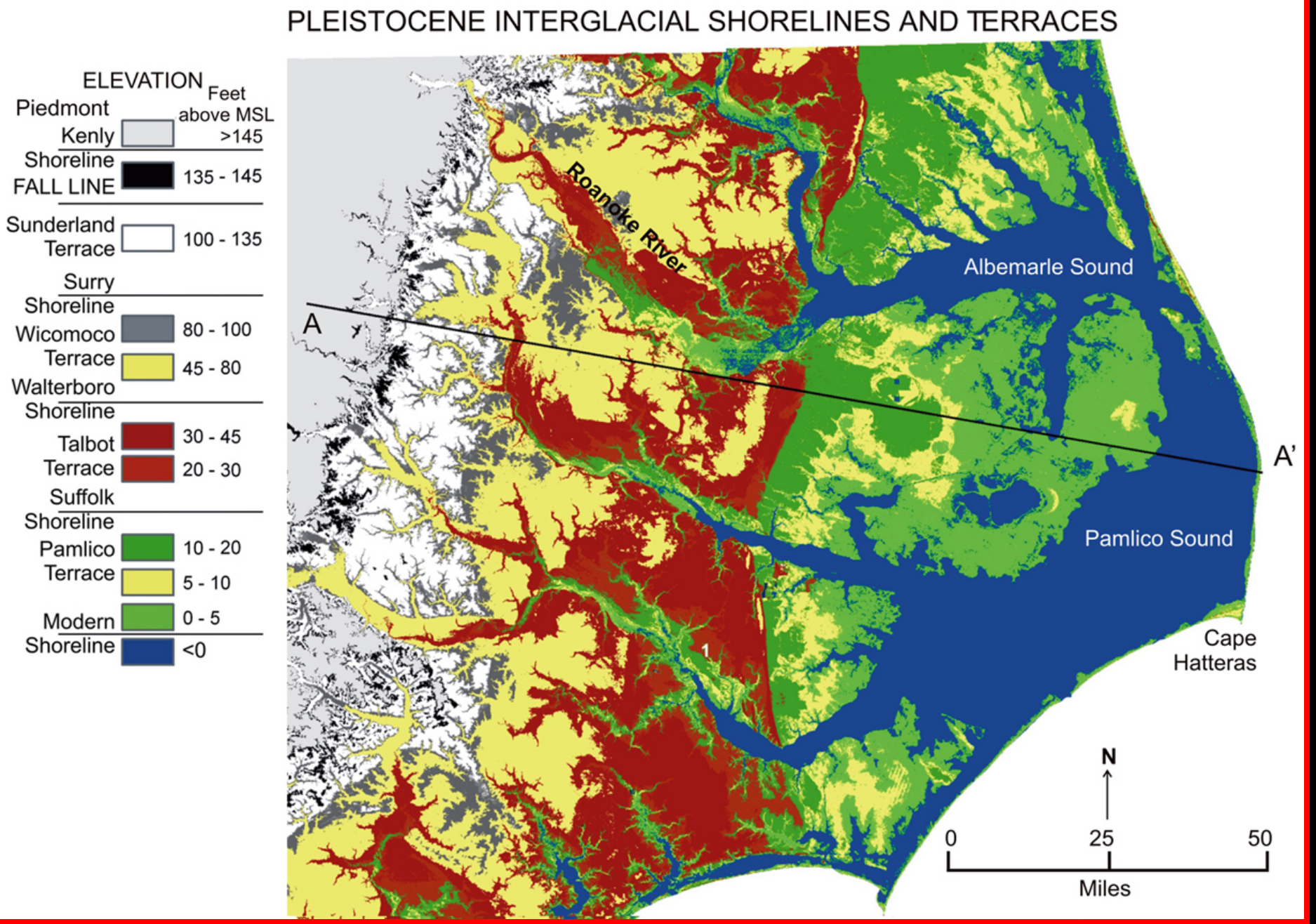
STABILIZED LOW-SEDIMENT BANK SHORELINES

CHOWAN RIVER ESTUARY: HIGH SEDIMENT BANK

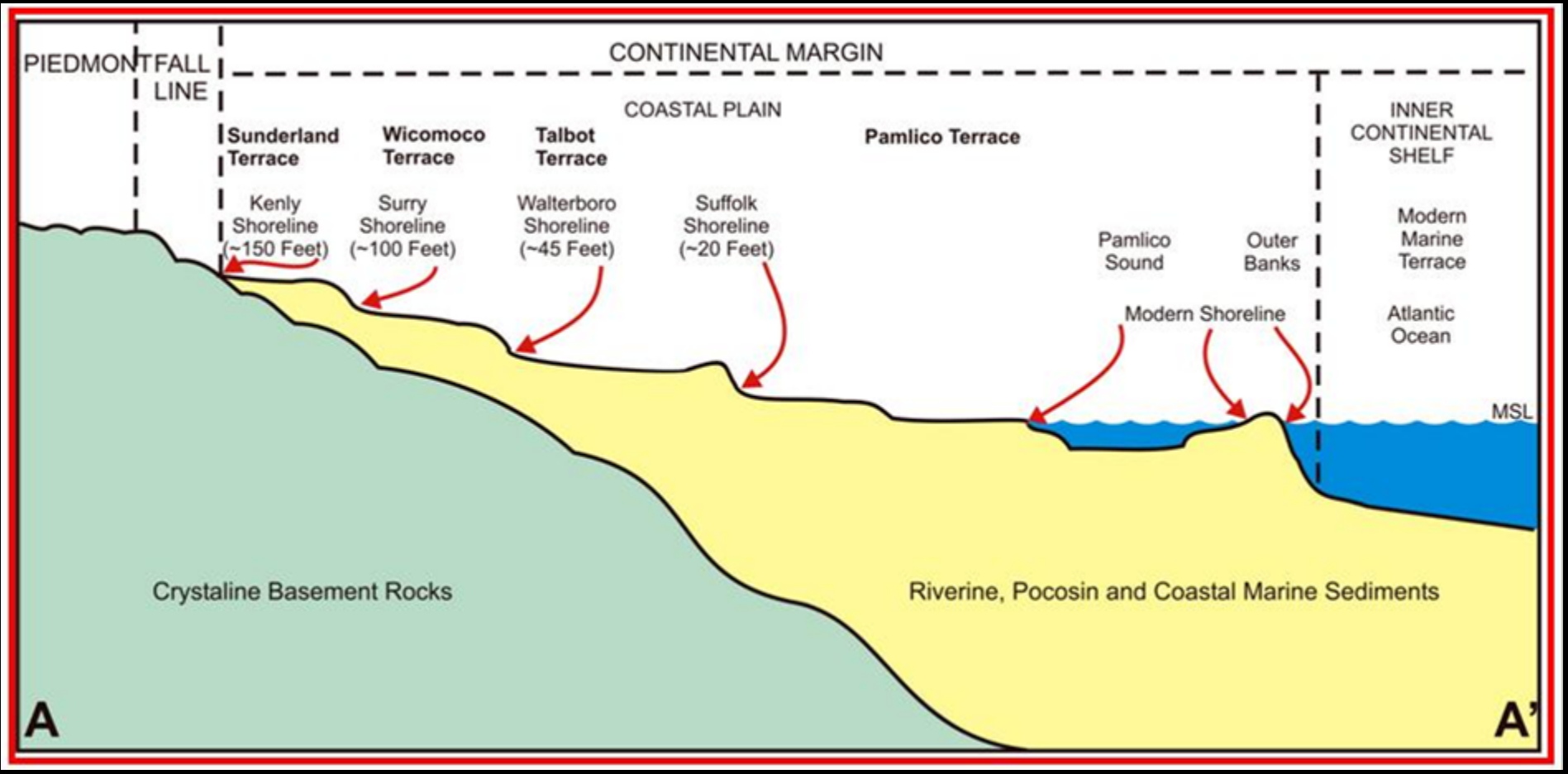
SHORELINE EROSION:

STORM = - 80 ft
LONG-TERM AVE.
= - 3 ft/yr

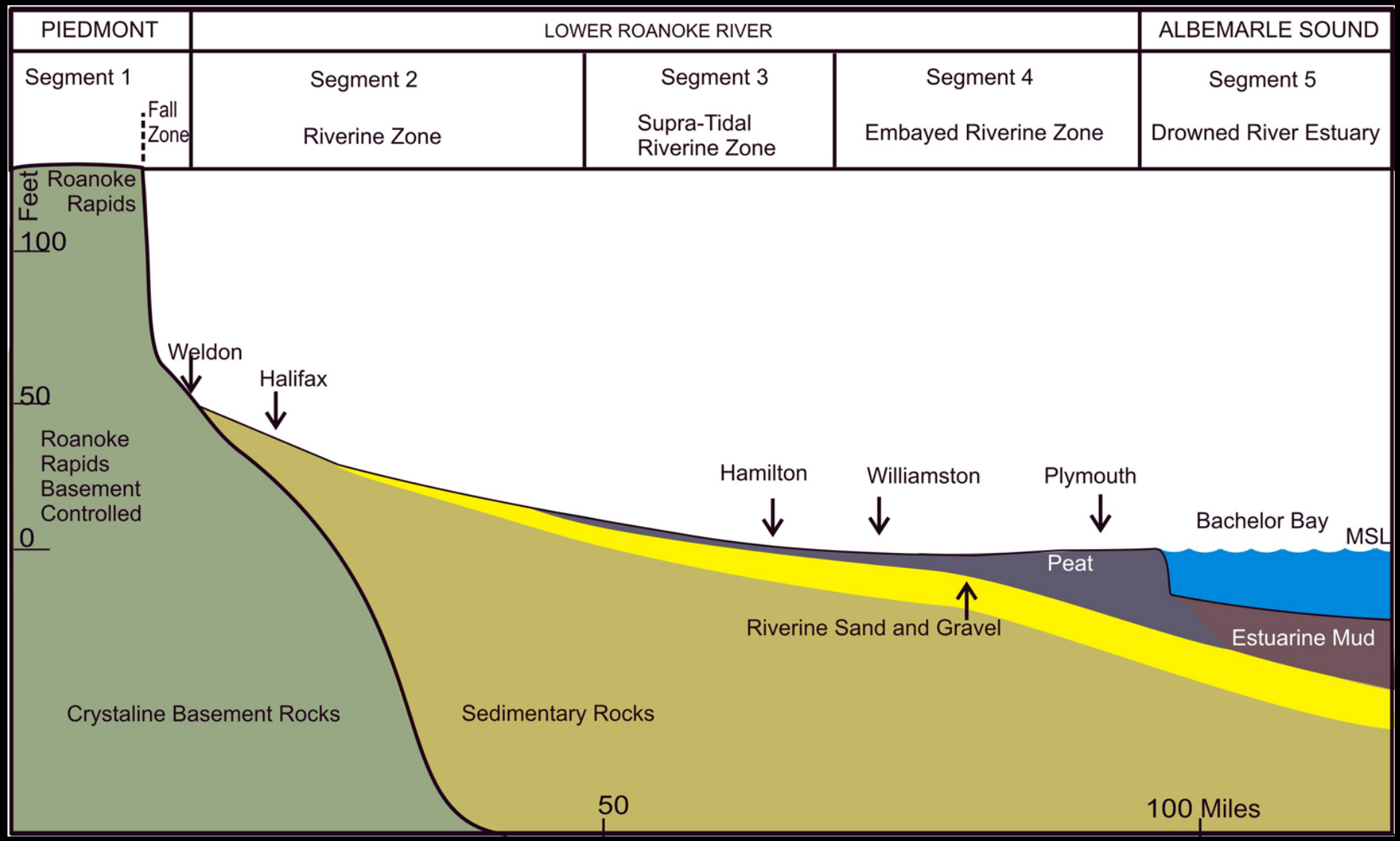
TOPOGRAPHIC MAP OF NE NORTH CAROLINA COASTAL PLAIN



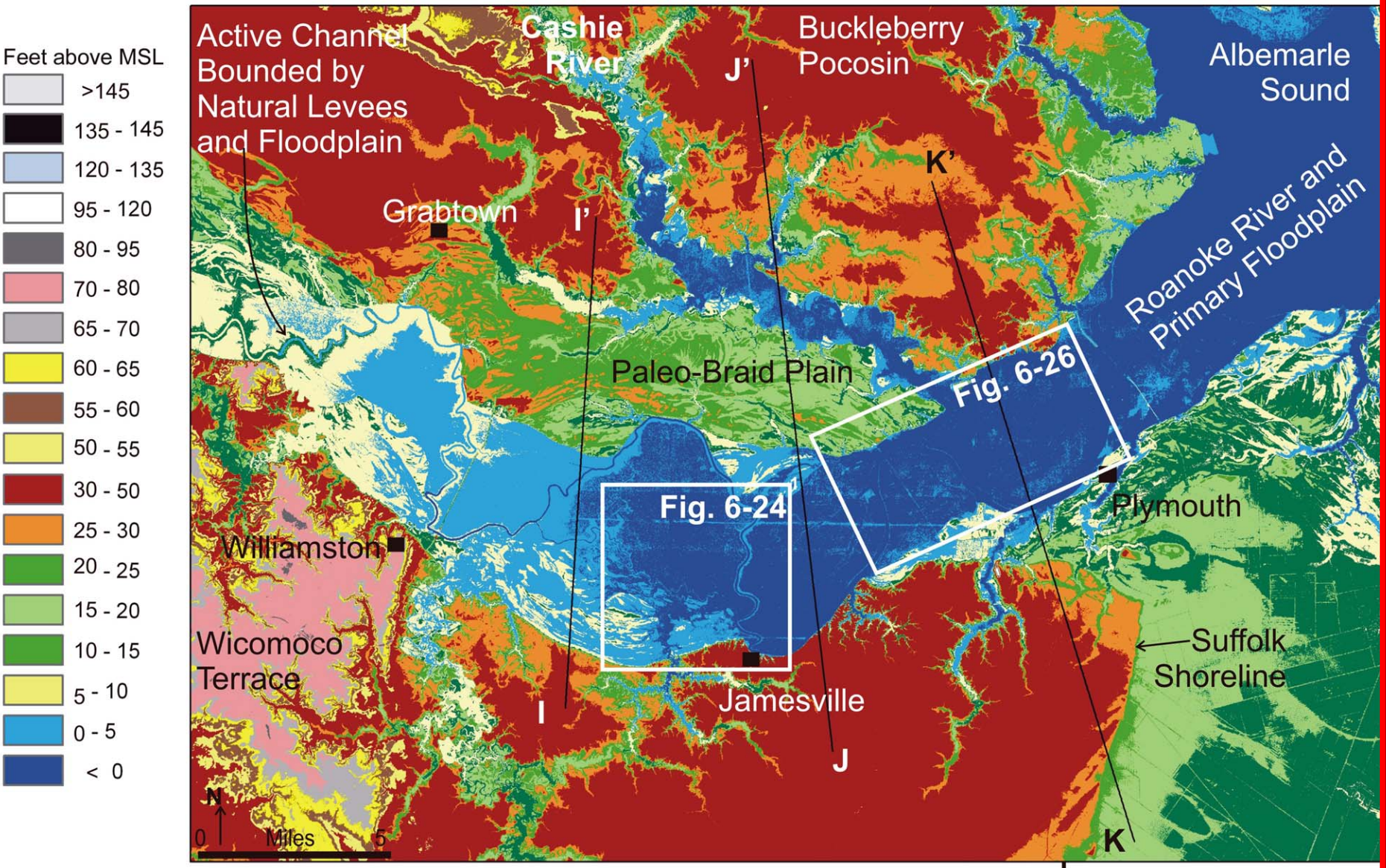
SCHEMATIC TOPOGRAPHIC PROFILE OF NE NORTH CAROLINA COASTAL PLAIN

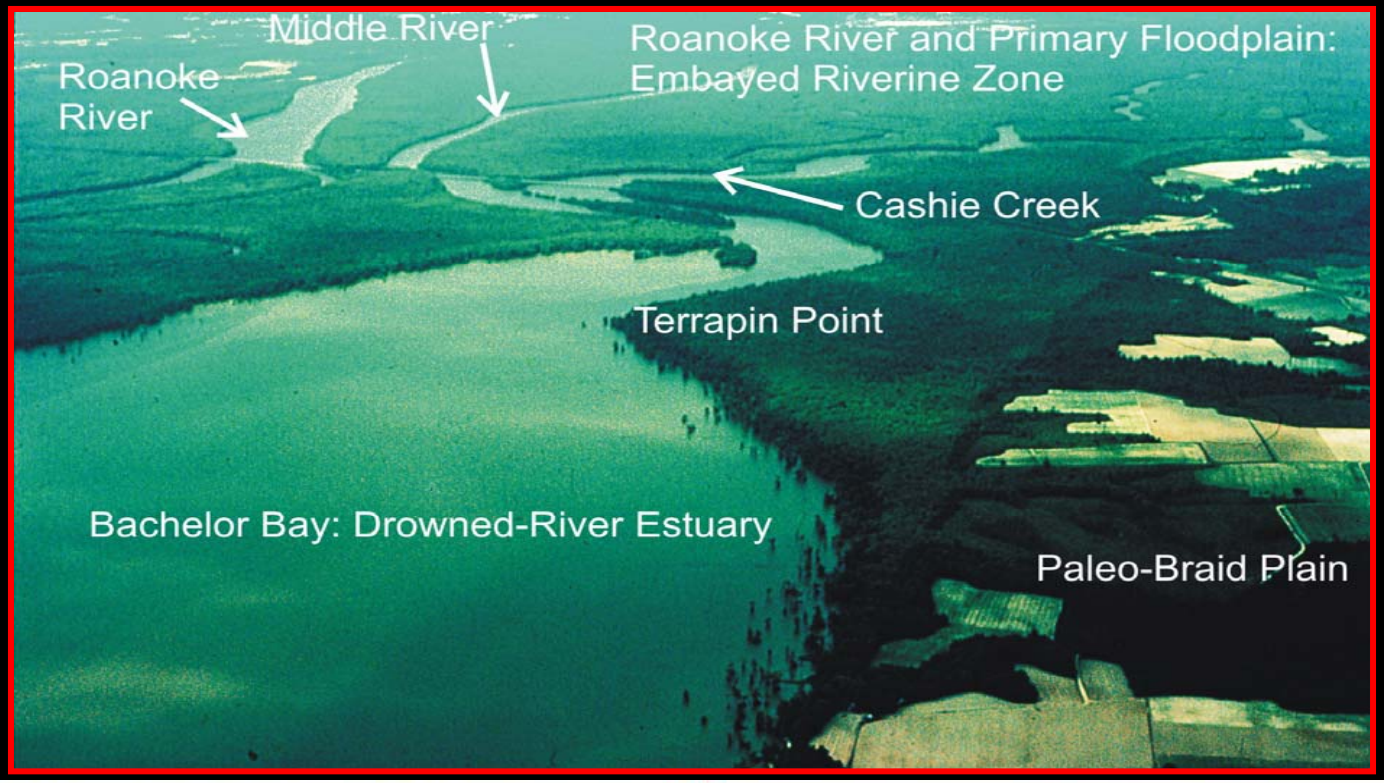


SCHEMATIC TOPOGRAPHIC PROFILE OF THE LOWER ROANOKE RIVER VALLEY



RIVER SEGMENT 4: EMBAYED RIVERINE ZONE




Middle River
Roanoke River and Primary Floodplain:
Embayed Riverine Zone
Roanoke
River
Cashie Creek
Terrapin Point
Bachelor Bay: Drowned-River Estuary
Paleo-Braid Plain

A

B

TO PRESERVE THE SHORT-TERM HEALTH & ALLOW THE LONG-TERM EVOLUTION OF OUR COASTAL SYSTEM, WE MUST ALLOW IT TO RESPOND TO THE NATURAL DYNAMICS!

THE CLIMATE IS CHANGING!

SEA LEVEL IS RISING!

STORMS ARE INCREASING IN FREQUENCY & INTENSITY!

WE BETTER GET SERIOUS ABOUT THE FUTURE OF OUR VITAL COASTAL ECONOMY AND CRUCIAL COASTAL RESOURCES NOW!