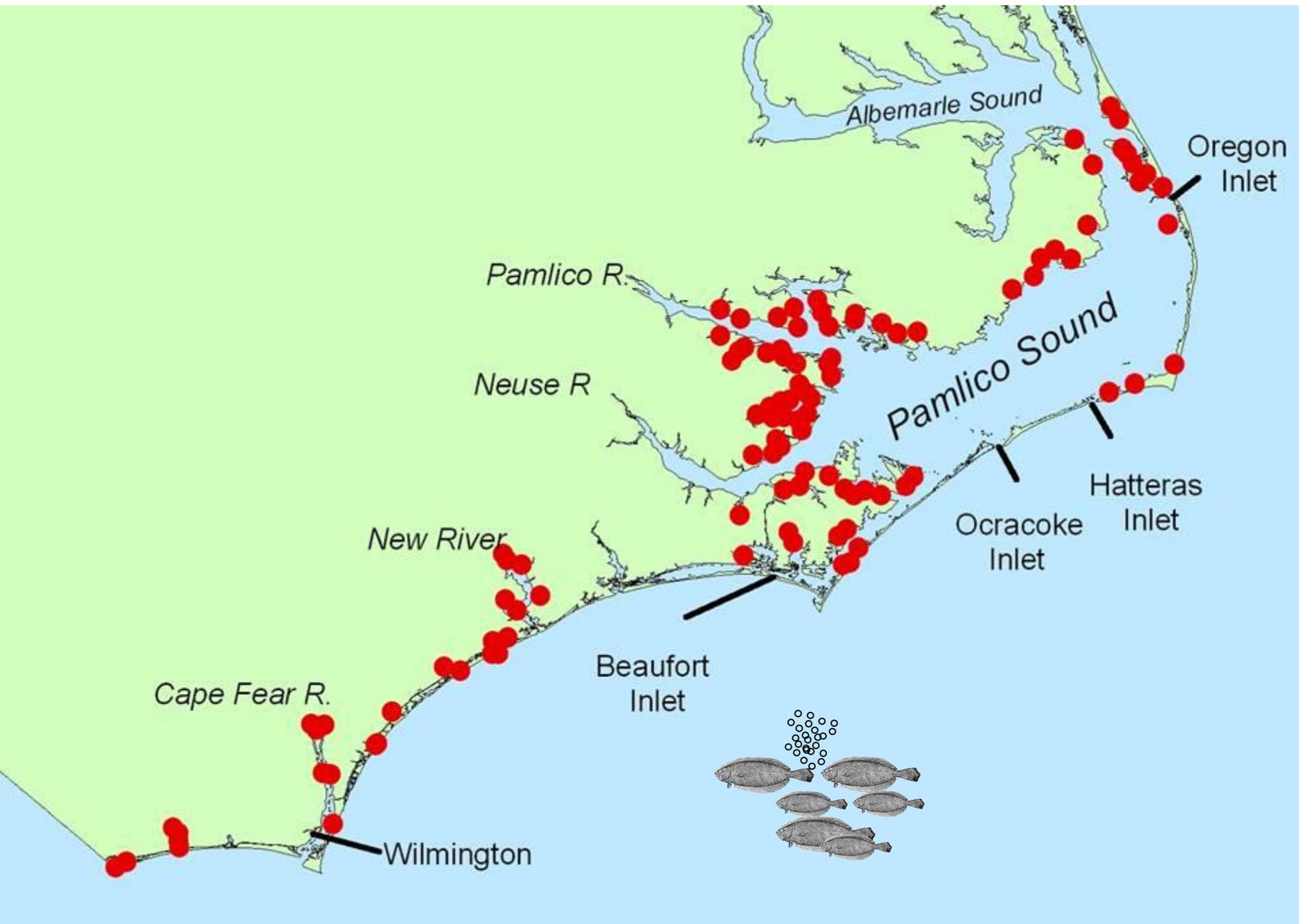


**Len Pietrafesa**  
**Professor Emeritus - NC State Univ.**  
**PhD – Physics**  
**CCU Burroughs & Chapin Scholar**  
**Former Head of the Department of Marine,**  
**Earth, Atmospheric Sciences - NCSU**  
**Former Dean for Research of PAMS-NCSU**

- **Chair Emeritus of the NOAA Science Advisory Board**
- **Chair Emeritus APLU Board of Weather, Climate, Hydrology**
- **Commissioner Emeritus AMS Enterprise on Weather, Water, Climate**
- **Fellow, American Meteorological Society**
- **I am a bench scientist, and alike Sergeant Joe Friday of Dragnet....**  
**“I only report the Facts.... Just the Facts” .....**

## **I was asked about: Estuaries, Salt Water Marshes, Barrier Islands and Inlets**

- Estuaries and Salt-Water Marshes are coastal water bodies, with plants, that form when fresh water from land and rivers, flows into and mixes with salt water from the ocean**
- The mixing of fresh & salt water creates a unique environment brimming with coastal life**
- And hold life-giving nutrients from the land and from the ocean, forming an ecosystem that contains more life per square inch than the richest Midwest farmlands**
- Estuaries and Marshes provide essential habitat for over 75 percent of our nation's Commercial and Recreational Fish catch, wildlife habitats, and more than 28 million jobs**
- These Fish alone, generate ~ \$120 billion yearly (in 2017 \$), so, are national treasures**
- Sunset Beach (SSB) is a Bar-Built, Barrier Island Estuary with a Salt-Water Marsh and contains Primary Nursery Areas (PNAs)**
- Estuaries and Salt Water Marshes are “Storm Energy Absorbing”; so protect the Mainland**



**This is from a study of  
105 NC Fish Nurseries  
(PNAs)**

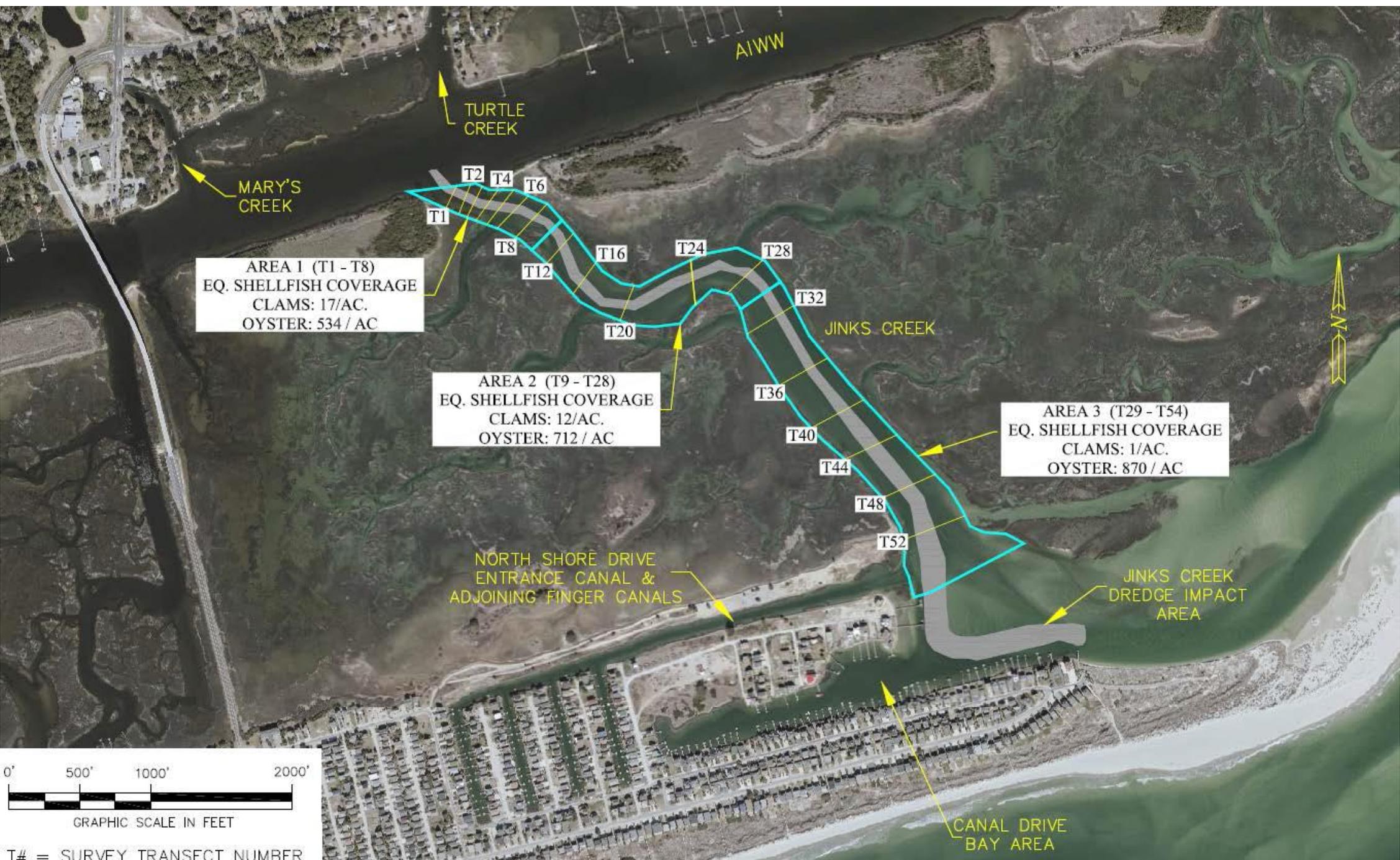
**77 PNAs had 23 years of data**

**Note Two PNAs are  
at OIB and at SSB**

**These are designated PNAs  
by the NOAA - NMFS  
And the NCDMF**

**These are discussed in  
JSR, Vol. 64, 1-2, 2010.  
Publication in the  
Journal of Sea Research:  
Chis Taylor (NOAA Beaufort),  
John Miller (NCSU\*),  
Len Pietrafesa (NCSU),  
Dave Dickey (NCSU) and  
Steve Ross (NOAA-Wlmngtn)**

**\* deceased**



Some PNA  
Samples  
Collected  
By Moffet  
&Nichols?

I guess.....



**If SSB is a PNA  
And there are some  
Species of Fish  
That are spawned  
Offshore and have  
to get to the  
SSB PNA, and the  
Pathway is via Tubbs  
and Jinks Creek,  
then, why isn't  
Jinks Creek,  
de facto, a PNA?**

**Contact S. Ross  
and/or C. Taylor**

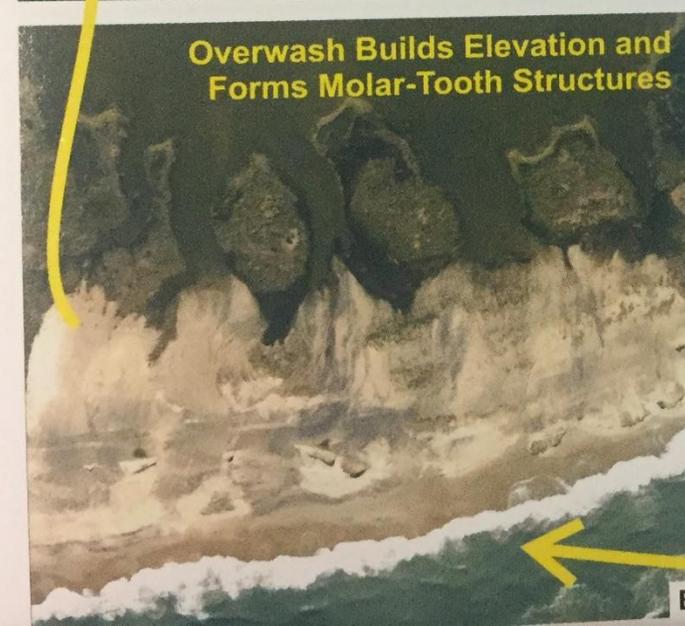
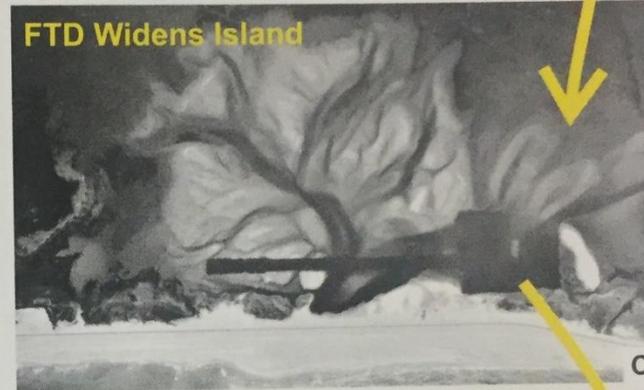
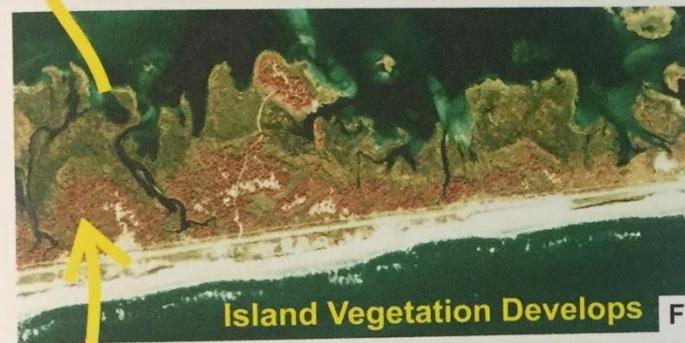
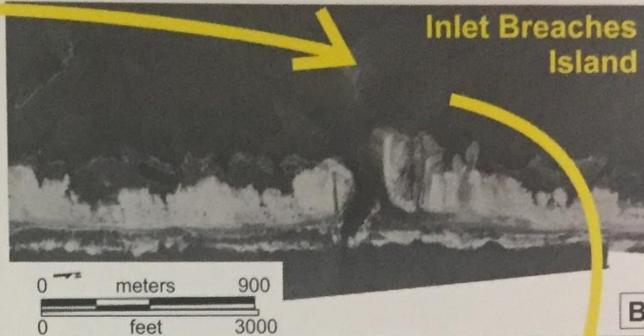
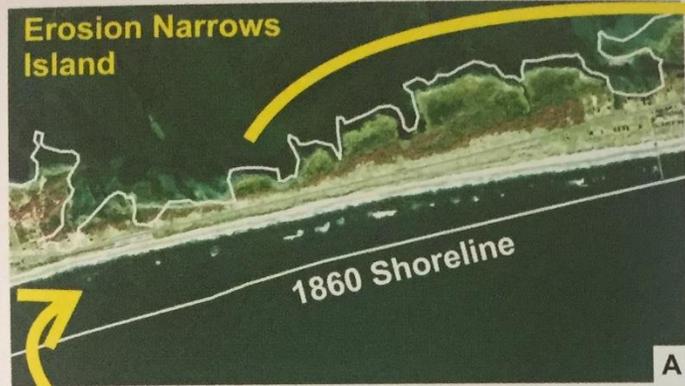
# What is a Barrier Island, generally speaking?

- **Barrier Islands form on Coasts of very wide & stable Continental Margins, which started forming**
- **~ 20,000 to 18,000 years ago, after the last Ice Age**
- **Eastern Atlantic Coast Barrier Islands were formed when SLR slowed, some ~ 7000 to ~ 3000 years ago**
- **They consist of Over-Wash Fans, a Shore Face, a Surf Zone, a Beach, Sand Dunes and a Tidal Inlet....plus,**
- **Longshore Drift, Flood & Ebb Tide Deltas, a Tidal Marsh, Tidal Creeks, and a Tidal Flat .....**

**For Inlets, in General, Sediments come from: 1) Along Beach Flow; 2) Offshore Waves;  
3) Rivers; 4) Over-Wash Fans**

- At Tubbs Inlet, flood tides, waves and alongshore flows bring sediments into the SSB system**
- At the Tubbs Flood Tide Delta, waves are refracted and go into the Inlet, then go in landward**
- The SSB/OIB Inter-Tidal Marsh is dominated by Spartina vegetation**
- Tubbs drains ~ 2.5 square miles of the Marsh and the AICWW**
- There are no rivers introducing freshwater into the SSB system**
- The sedimentary deposits of SSB derive from the Pleistocene Epoch (~ 2.5 MYA to 11.7 TYA years ago) and the Holocene Epoch (11.7 TYA to the Present)**
- Presently, Beach Sands came from Eastward and Westward Littoral Drift, Offshore SGW Breaking and Refraction... and also during Storms from Alongshore Currents and Waves**
- Mean Tidal Range at Tubbs is ~ 4.5 feet**
- Mean Winds at Tubbs are ~ 10 to 15 mph in speed**
- Mean Waves at Tubbs are ~ 2-3 feet in amplitude**
- The history of movement of Tubbs was basically westward prior to its relocation in 1969-70 via M. Gore's dredge and fill program**

- **Barrier Islands are altered by STORM-DOMINATED PROCESSES**
- **Barrier Islands act as a “Dam” or “Buffer” to the Mainland**
- **Because of SLR, there is generally a continued receding of beachfront shoreline**
- **Because Storm Over-Wash is inhibited in the developed areas of SSB, some north to south narrowing of the island.....can be expected**
- **Normally, offshore storm waters flow across the NC Southern Barrier Islands to create Over-Wash Fans and build island elevation and width; like a tank tread**
- **But buildings, as on all NC southern Barrier Islands, impede that process**



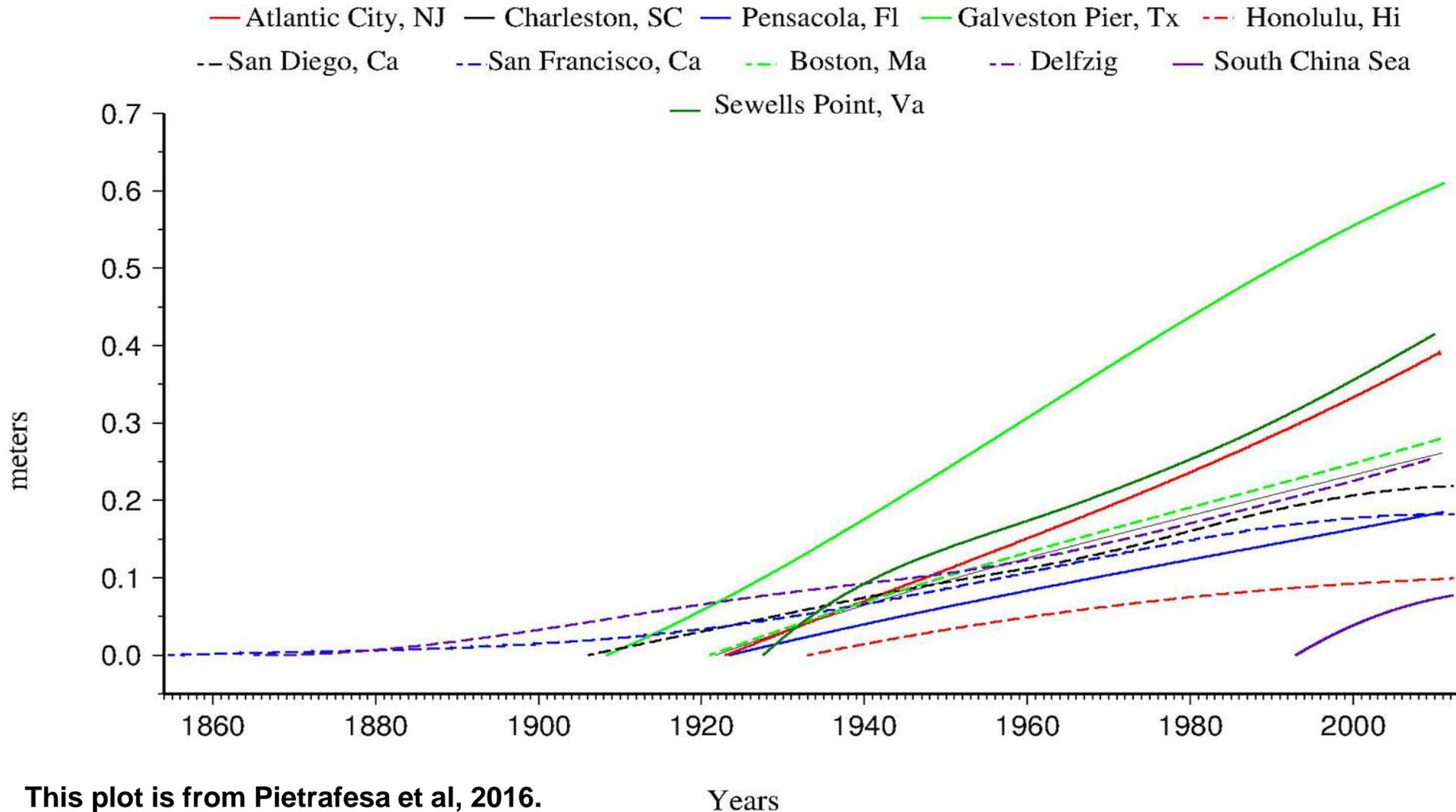
**On the "Life Cycle of Barrier islands"**

**SLR brings water Onto Island from Offshore**

**Then a Storm Brings water onto the back side Over-wash Creates a Flood Tidal Delta (FTD)**

**The Purge creates an "Outlet" => An Inlet and ETDs**

# Normalized Trends for Mean Sea Level Data : January 1854 - June 2012



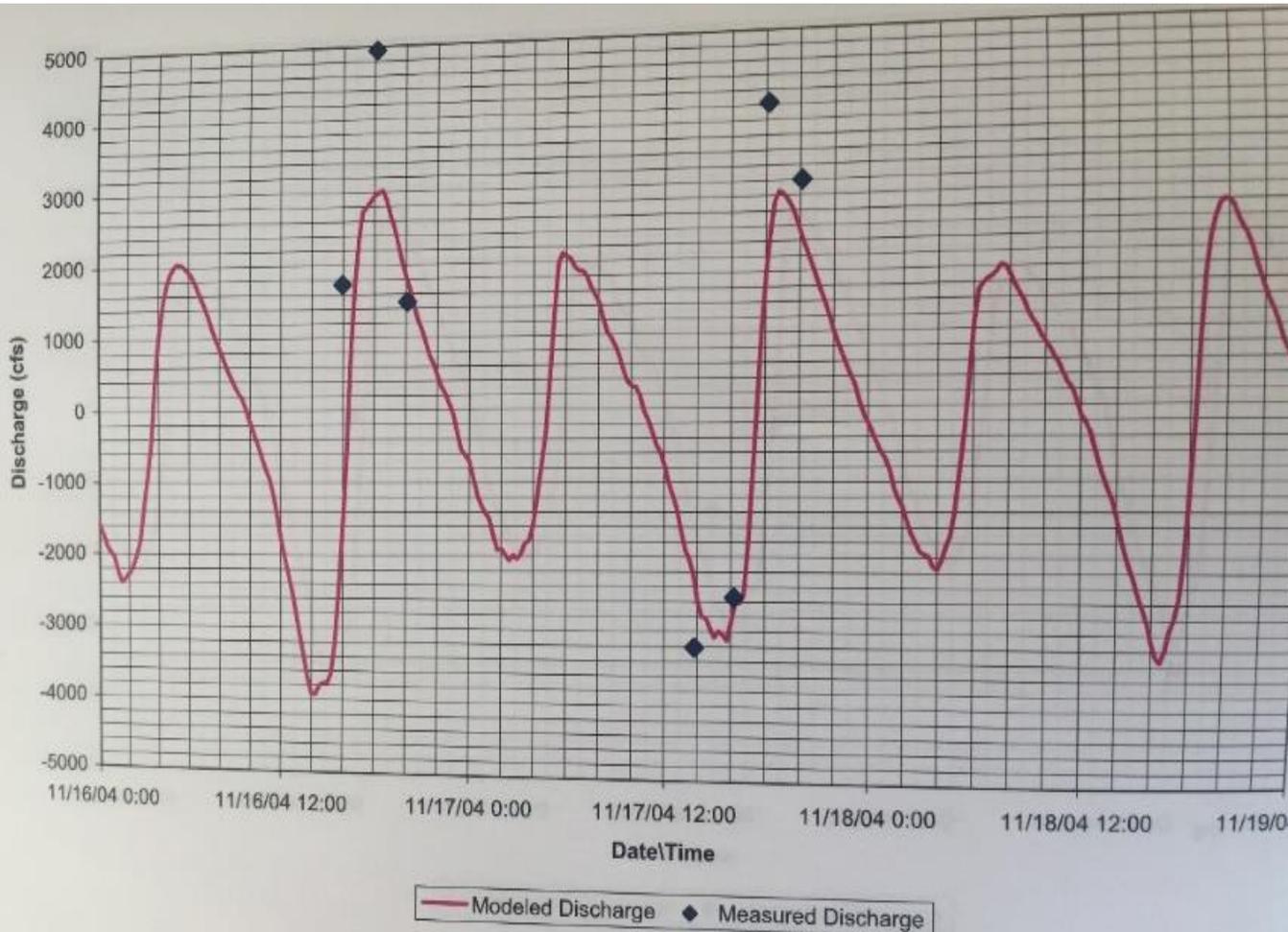
This plot is from Pietrafesa et al, 2016.

Here we see very different trends in SLR from locale to locale; for eg. Galv. TX ~ 6.5mm/yr, Chas.~3.0mm/yr, Sewell's Pt VA and Atlantic City NJ ~ 0.8 to 10.0 mm/yr, etc.

BTW, From NOAA-NOS: A vertical datum (VD) is an established surface that serves as a reference. All water level observations, are referenced as height above referenced VD.

- **The Oak, Holden, OIB and SSB islands had a sand source from Frying Pan Shoals when the major flow of the Cape Fear River was East of the Present-Day Cape Fear River**
- **But the USACE built a Dam at Zeke's Island in the 1800s, which forced the dominant flow to the West side of Bald Head Island**
- **This sand source was further cut off by digging and continuing to deepen the shipping channel in the 20th century for the Wilmington Port**
- **Since then, these islands get sand from alongshore and offshore**
- **All of the sand portion of these islands is sitting on top of older sedimentary rock units; called the Eocene Castle Hayne (56 to 34 MYA) and the Cretaceous Pee Dee formations (145-56 MYA): S. Riggs (ECU)**
- **For e.g., Oak Island is actually a rock headland with almost no sand and the AIWW channel was dynamited and dug through the rocks: S. Riggs (ECU)**

- **Jinks Creek is embedded in the SSB estuary/salt-water marsh system and connects the AIWW to the Atlantic Ocean via Tubbs Inlet**
- **Aerial Photos show that it has been functioning in place at least since 1938**
- **&N observations show that the flow via Jinks creek is ~ 5000 Cubic Ft<sup>3</sup>/sec**



**Moffat & Nichols RMA-2  
Model Output (red line)  
Is based on Tidal forcing**

**Versus Actual Observations  
(black diamonds)**

- **The differences in M&N model output and Actual Observations, show the importance of Wind Forcing**
- **For example, at the time of the observations shown, the local winds were from the NW and W at ~ 7 to 12 mph; as observed by the NOAA - NWS**
- **These are typical winds for this area (Weisberg and Pietrafesa, 1983)**
- **While the Astronomical Tides are persistent and regular, a little bit of coastal wind can go a long way in creating stronger Floods and stronger Ebbs through Jinks Creek**
- **3000 cubic feet/sec is tidal and 2000 cubic feet/sec is wind driven @ 10mph**
- **So, nominally 2000 cubic feet/sec/10mph of wind can come into a system**

**From the prior discussion, You can clearly see that the M&N RMA-2 Model output needs to be increased by at least 40%- 60% in terms of the true Volumetric Flux through Jinks Creek**

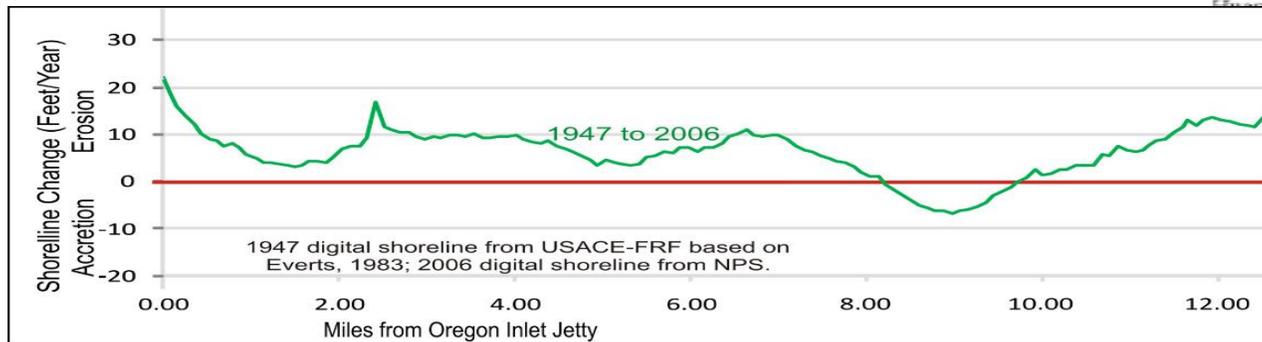
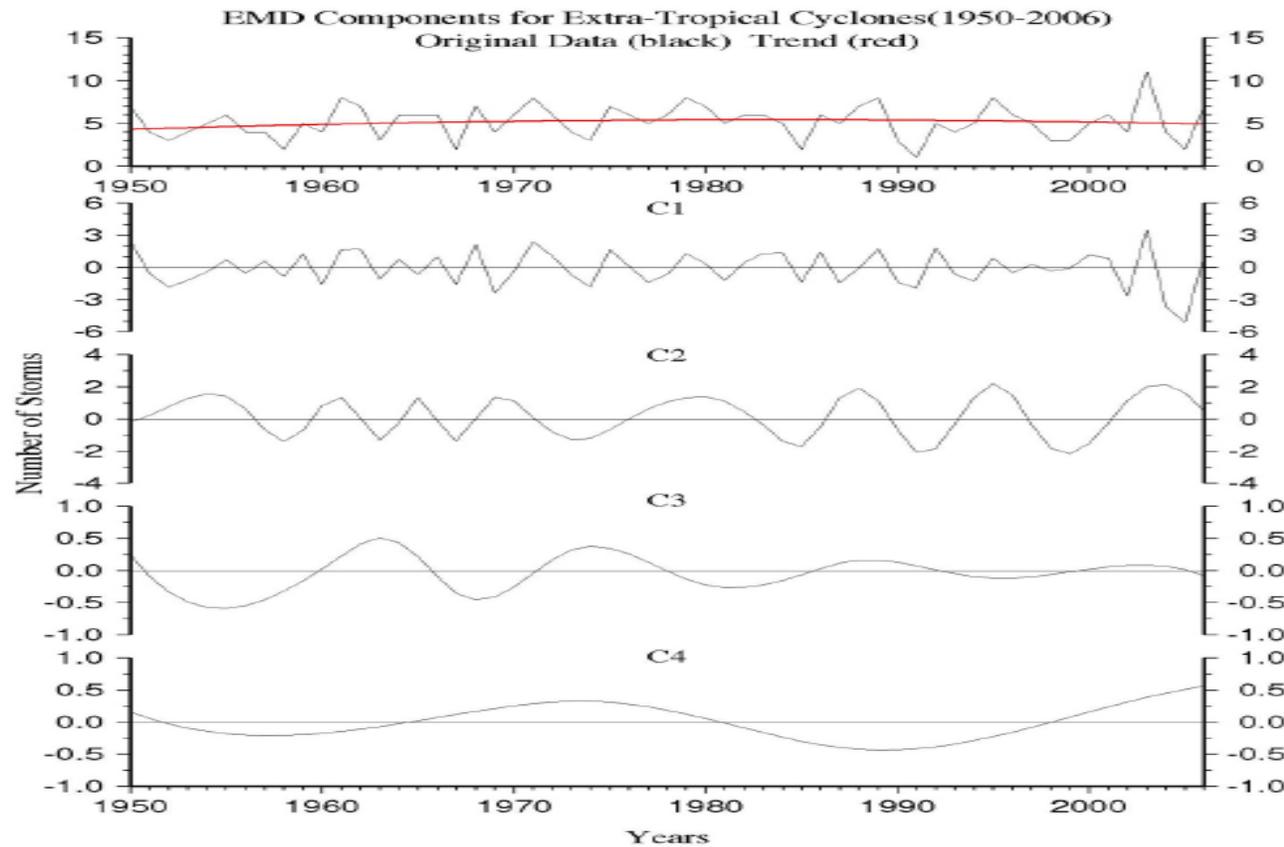
**This is a significant Flux of water and explains why Jinks Creek has remained open and functional from, at least, 1938 to the Present; as documented**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
•Here are the NOAA NWS documented average winds in the region of Tubbs Inlet:													
<b>NWS</b>	10.4 mph	10.5 mph	11.6 mph	11.5 mph	11.5 mph	10.4 mph	10.4 mph	10.4 mph	9.3 mph	10.4 mph	10.4 mph	10.4 mph	10.6 mph
<b>W&amp;P</b>	12.5	12.6	13.9	13.8	13.8	12.5	12.5	12.5	11.2	12.5	12.5	12.5	12.7

**But we also have Winter to Spring and Summer to Fall Atmospheric Storms here**

**A plot of the number of ETC winter storms along the SC coast over the period 1950 – 2006 Versus the movement of the NC Coast (done by Riggs et, al., ECU)**

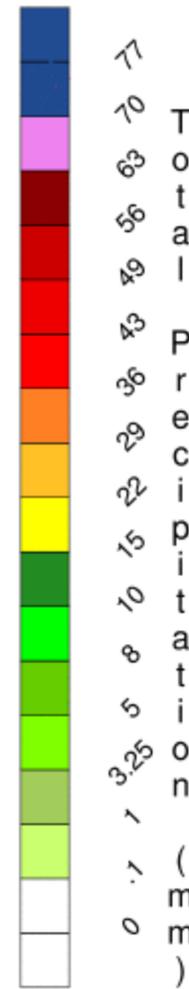
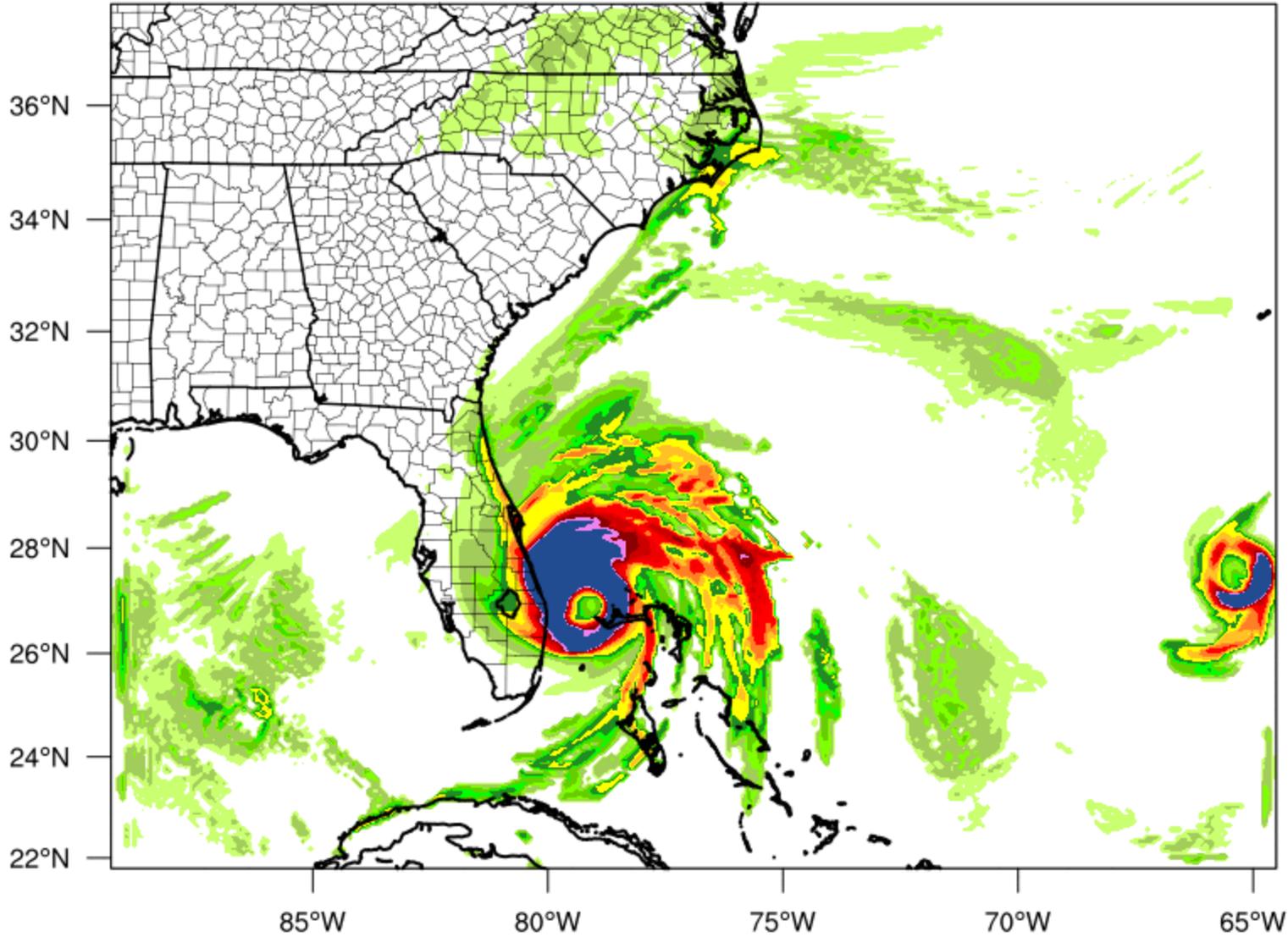
**Annual ETC variability  
In #'s of Storms is large;  
Ranging from 3 to 13  
There is ETC variability of:  
2 -3 years, 5-7 years,  
14-15 years and 30- 35 years  
(done by Pietrafesa)**



# REAL-TIME WRF

Init: 2016-10-07\_00:00:00  
Valid: 2016-10-07\_06:00:00

Total Precipitation (mm)

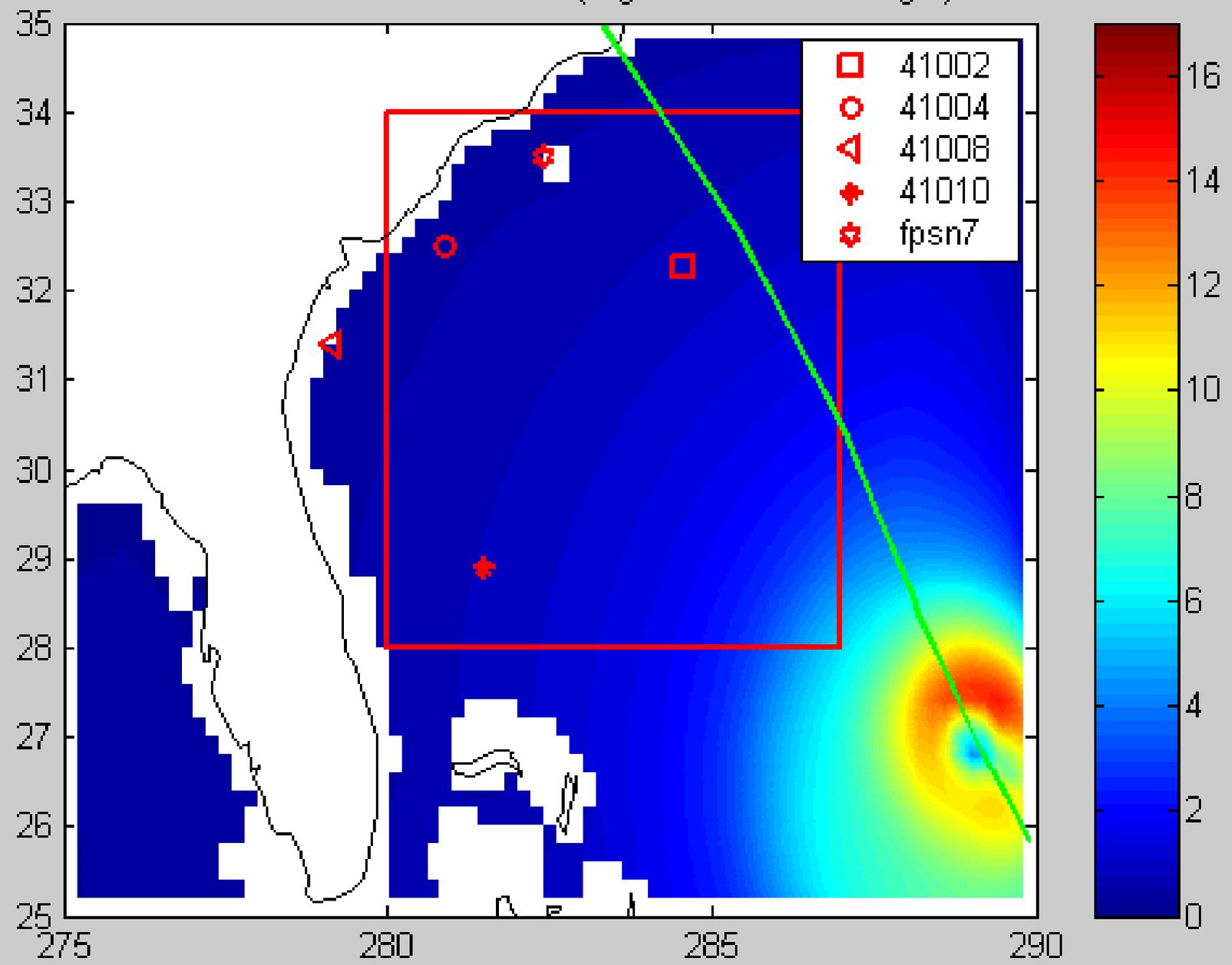


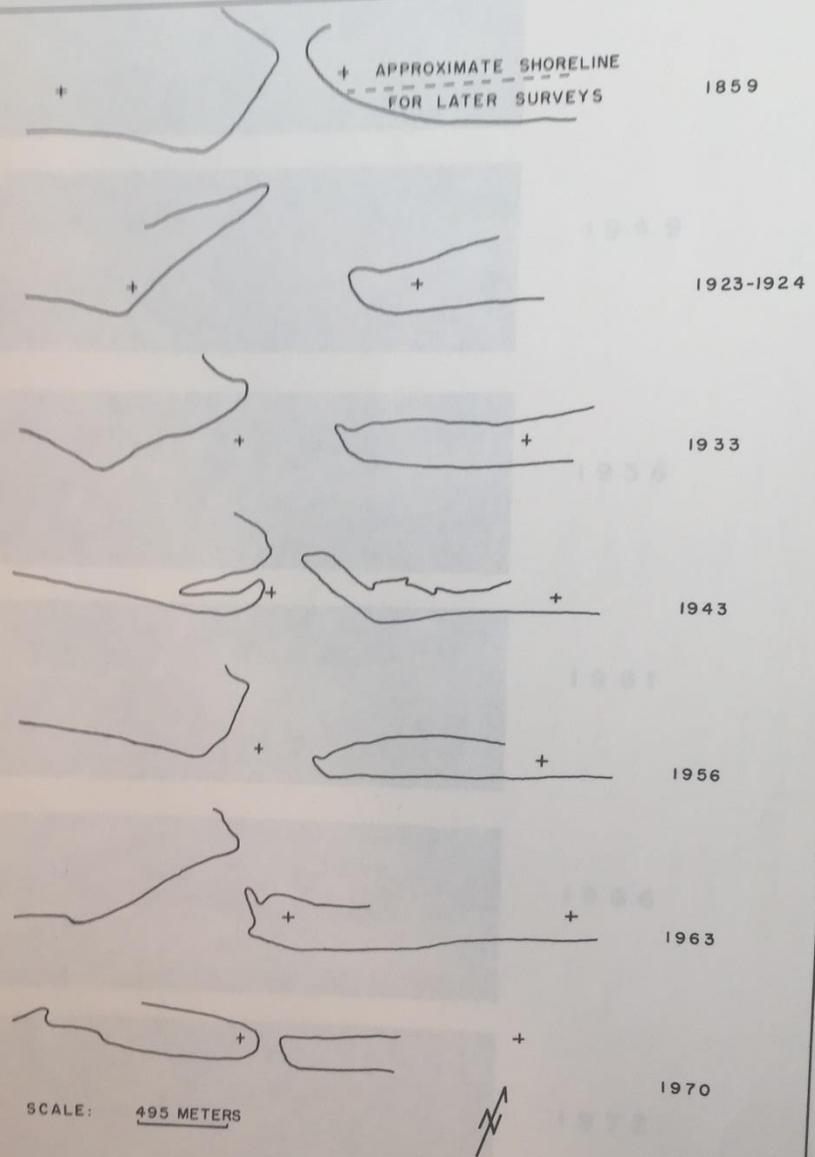
**TC's, especially  
Hurricanes,  
Which rotate  
Counter-  
Clockwise**





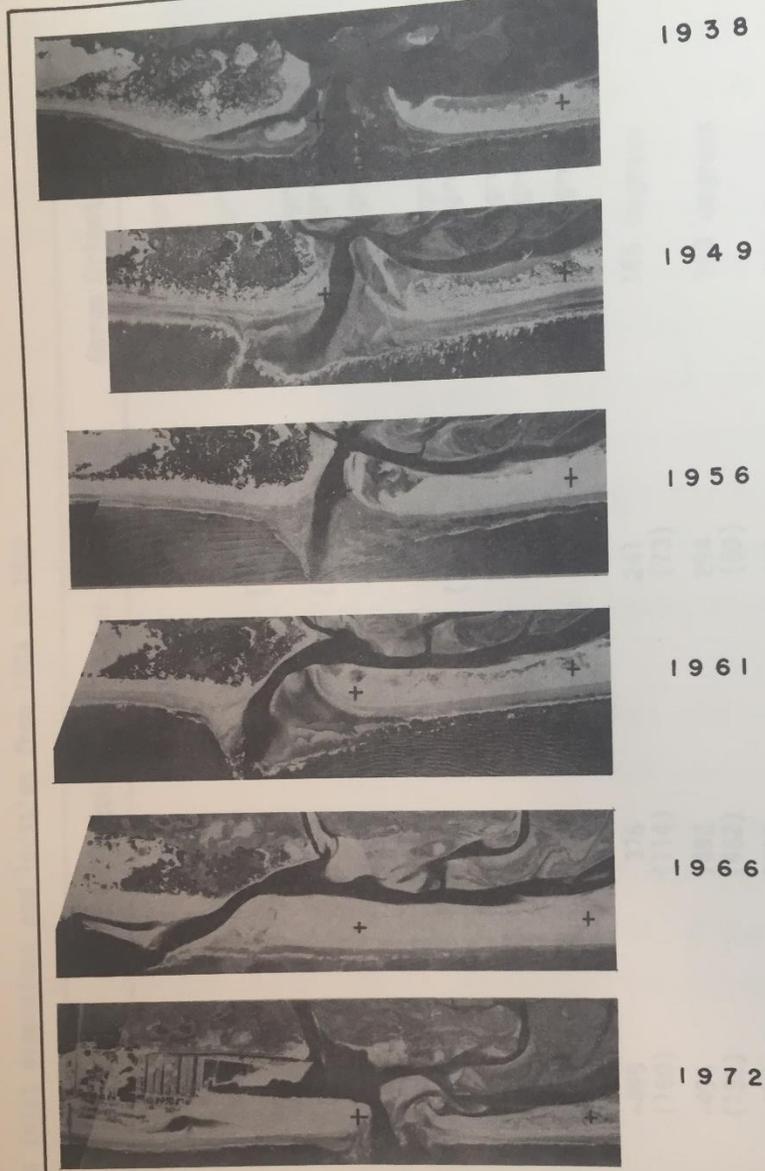
03/9/16--12 Hurricane Isabel (Significant Wave Height)





NOTE: SHORELINE IN 1859 SURVEY WAS INCONSISTENT WITH RECENT SURVEYS. THE X MARKS ARE IN THE SAME POSITIONS ON ALL DRAWINGS. (ADAPTED FROM DATA COMPILED BY USARMY CORPS OF ENGINEERS)

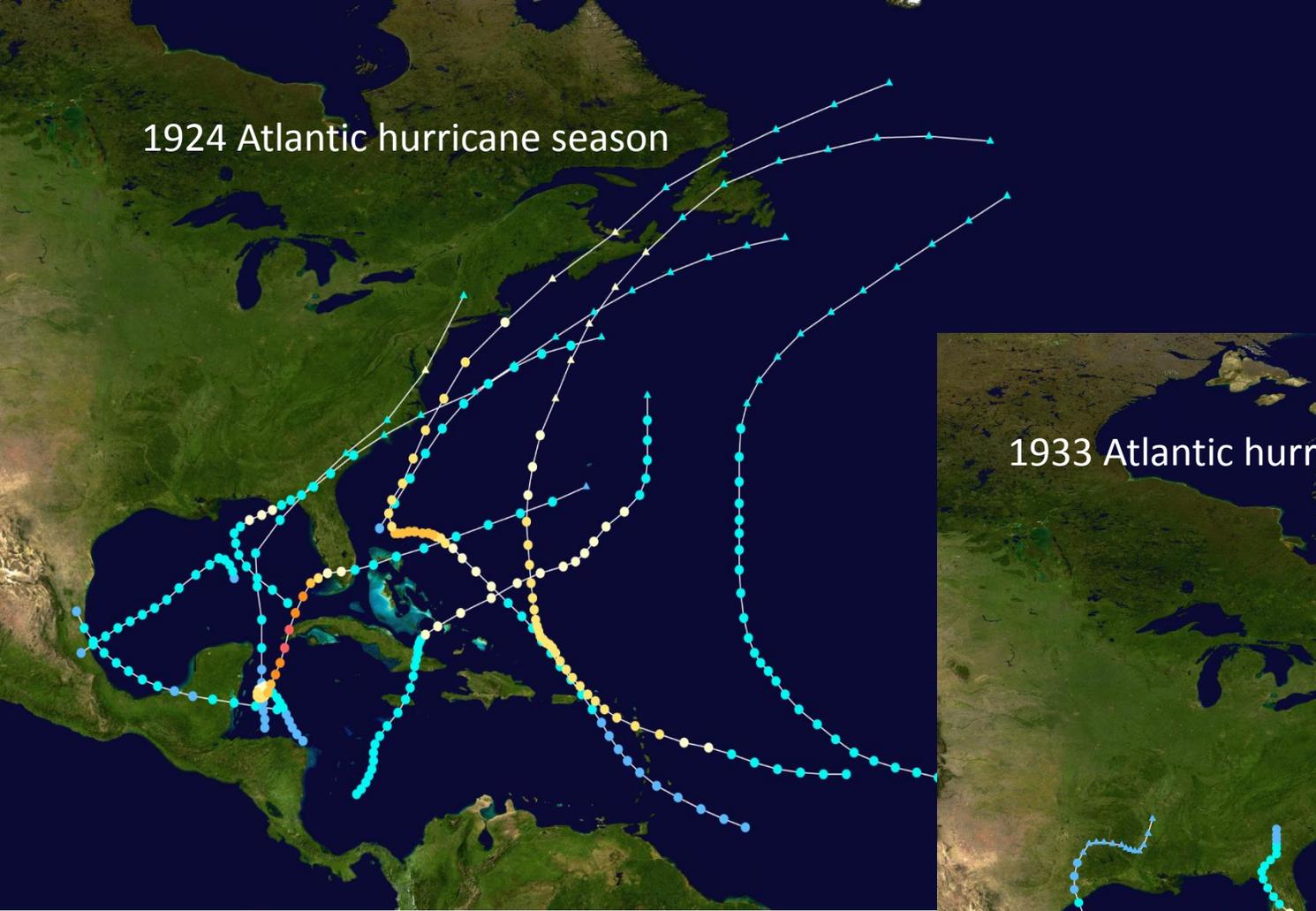
FIG. 2. SURVEYED SHORELINE OF TUBBS INLET, N.C.



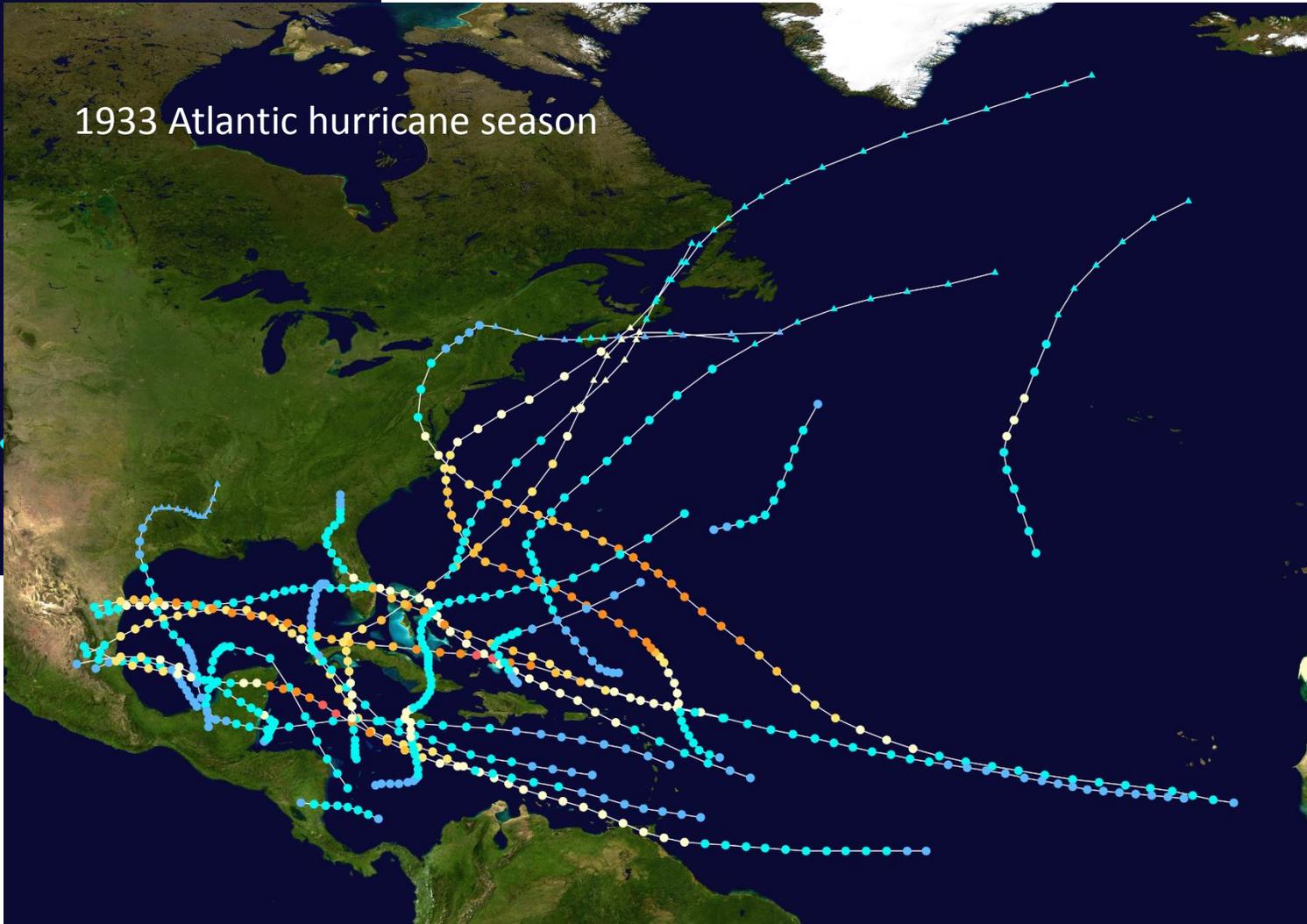
NOTE: THE X MARKS ARE IN THE SAME POSITIONS ON ALL PHOTOGRAPHS.

FIG. 3. SHORELINE IN VICINITY OF TUBBS INLET, N.C.

1924 Atlantic hurricane season

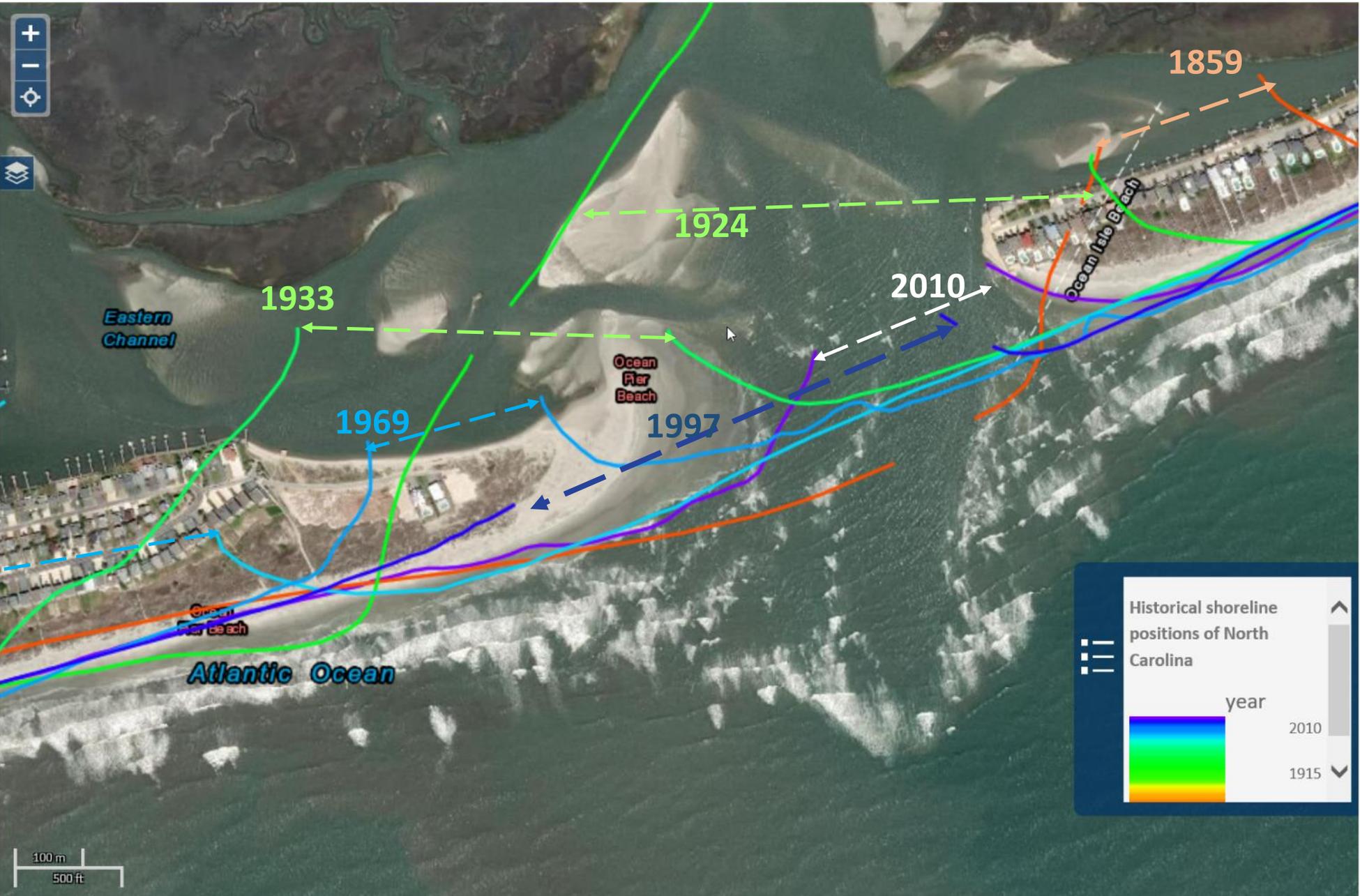


1933 Atlantic hurricane season



## How About the 1954-1956 widening?

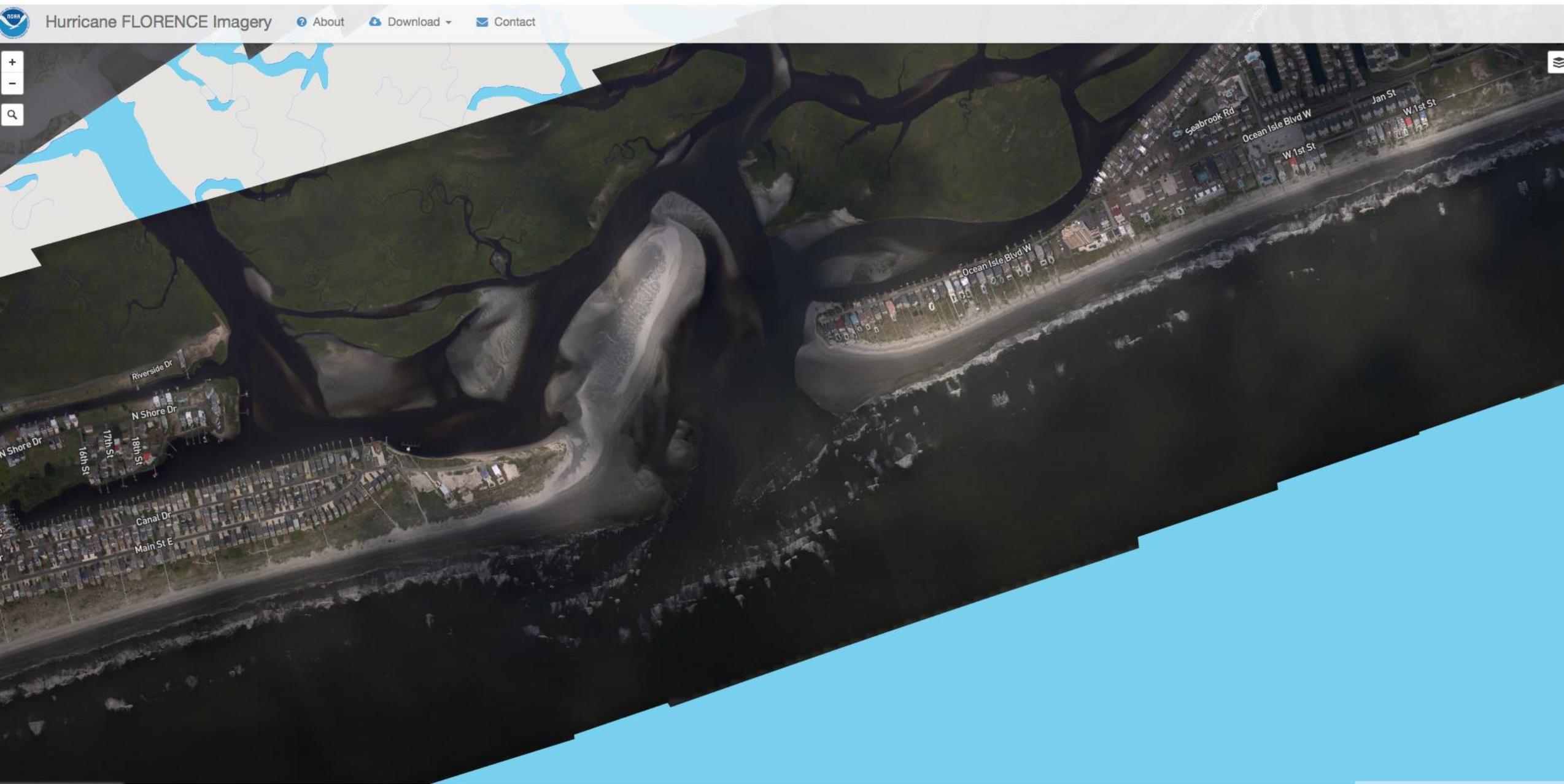
- August 30, 1954 – [Hurricane Carol](#) with 100mph winds
- September 10, 1954 – Strong waves from [Hurricane Edna](#)
- October 15, 1954 – [Hurricane Hazel](#) moves ashore near the SC/NC border as a [Category 4](#) hurricane, destroying 15,000 buildings and damaging 39,000 more  
Damage is greatest in [Brunswick County](#), where great coastal damage occurs due to the storm tide
- August 12, 1955 – [Hurricane Connie](#) produced severe beach erosion.
- August 17, 1955 – [Hurricane Diane](#) makes landfall near Wilmington
- September 19, 1955 – [Hurricane Ione](#) drops heavy rainfall
- August 16, 1956 – [Hurricane Betsy](#) brushes the coastline



2017 - Nov



1993 - Feb



- **Now, Lets assume that Jinks Creek is increased in Width and Depth**
- **Presently the Flood Tide Delta and the Creeks that Feed It,**
- **And limits offshore waters as a Primary Regulator on the Amount of Water that can get into the System**
- **And the Inlet Throat Configuration is supposed to be in Equilibrium with the Flow**
- **But, increasing the “efficiency” of the capacity of the system will pose a threat to the internal distribution of water within the System**
- **So that when a storm or storms do put more water into the System it is more likely that the integrity of the Flood Tide Delta will be modified and could be compromised**

- **This is not dissimilar to what happened to Folly Beach SC in 1993**
- **There the Folly River was dredged near the Stono Inlet**
- **The response to that increase in efficiency in the Inlet System  
Led to a loss of Folly Park on the south side**
- **The channels within the System adjusted**
- **Same kind of configuration as SSB and Tubbs**

## **So the Conclusions are:**

- Inlets move with 1-2, 3-5, 5-7, 15 and 30 year cycles, Related to:**
- Storms, aka Hurricanes and ETC's, SGW Refraction-Breaking & Rossby Waves**
- Jinks Creek will have to adjust to All of the Above**
- From the Aerial Photos it appears, that if Jinks is expanded, there will be**
- Continued Erosion at the West End of OIB, but then**
- There would be a flip to Erosion at the East End of SSB**
- There would likely be a Cut-Through at the East end of SSB during the next**
- Hurricane passage(s) or ETC passage(s)**
- Putting more water and energy in the Channels is dicey**
  
- That is how "Inlets" , without Rivers, are formed.....as "Outlets"**
- You mess with the Plumbing and the Storms and Waves will get You**

## **The Lessons Learned:**

- 1. Inlets are basically Unstable Creatures; (especially those not at the mouth of a River, such as Tubbs)**
- 2. Over the period(s) of One Storm (or Two Storms)**
- 3. Or a Storm Season (and we have two, TCs and ETC's)**
- 4. The Water that comes in during a Storm MUST GO OUT**
- 5. And will take the most CONVENIENT PATH TO GET OUT**

- Andy Coburn of WCU said:**

**“What I can say with confidence is that the ‘Property Values Argument’ does nothing to support dredging. It does, however, provide a lot of evidence regarding who should pay if dredging does happen. The owners who want the dredging Should pay the cost and the ‘repeated’ costs”**

## **Facts and Forecasts:**

- **During and Following Matthew massive amounts of Sand came into Tubbs and had settled in a Delta due to Matthew**
- **However, the Matthew Delta was breaching already**
- **The along came Florence**
- **The next properly positioned Storm or Storms, either of the TC or ETC varieties, could well cut thru the East End of SSB**
- **The Annual Costs to keep a Dredged Channel in place will be very \$\$\$\$ .....And Who will Pay those Costs?.....**



## Thank You

- For Q's regarding Geomorphology contact Dr. Paul Gayes at: [ptgayes@coastal.edu](mailto:ptgayes@coastal.edu)
- For Q's regarding Fish, Turtles, etc., contact Dr. Steve Ross at: [ross@uncw.edu](mailto:ross@uncw.edu)
- For Q's regarding economics of these kinds of expenditures, contact Dr. Andy Coburn: <http://www.ncpolicywatch.com/wp-content/uploads/2018/09/News-and-Views-for-9-23-2018-SEGMENT-TWO.mp3>: [acoburn@wcu.edu](mailto:acoburn@wcu.edu)
- Breaking News: <https://www.coastalreview.org/2018/10/deal-reached-on-sunset-beach-dredging/>