

Well I wish we were on the beach talking or paddling in the marshes but we are stuck in front of these computers to talk about the coastal zone. So I am going to provide quite a few images and hopefully a few facts and questions to at least get you thinking about it remotely. The beach and inlets are some of the most dynamic, energetic, hazardous, and at the same time beautiful areas in the world, and yes I do include the salt marshes in that, too. Nothing like smelling the marsh and seeing the life there in what is one of the most productive natural ecosystems in the world.

In this week's discussion of the Coastal Zone we will look at the major controls on the coasts (waves, wind, tides, people) but we will also consider a few policy issues. This is one of my favorite topics (actually a collection of topics really as it is much more than just the beach) and we could go on and on but I will try to constrain myself a bit. This looks like a lot more than what is really required to answer the questions. Most of the info is in the slide set, honest. The exception is to listen to a video and to look up just a couple of things from the sites I mention.

We could call this discussion – Beauty and the Beast because that really is what the Coastal Zone is all about. Our questions will deal with a few current issues, too, like we did w/ the WOTUS rules last week. So this week I would like to start with a court decision.

**A. Court Decision on Nags Head on the Outer Banks.** Please read the pdf on Canvas: Lawsuit Against the CRC (Coastal Resources Commission). The suit was brought by a home owner wanting to rebuild their home on the beach after a fire destroyed it. The Town and the CRC would not grant a permit to rebuild so the owner sued; all of this is of course grounded in CAMA (Coastal Area Management Act) rules. The Court has now ruled in favor of the Town and the CRC. What do you think of this ruling? What would you do or want to do? The basis of the ruling is the setback rules that are part of a question later in the assignment. Erosion rates and setbacks are perhaps the most important guiding rules on the coast and there are updates every five years or so. Please give your opinion and give definitions and what the major function/purpose are of the CRC and CAMA. Use the following websites to help address that latter question of function/purpose.

<https://deq.nc.gov/about/divisions/coastal-management/coastal-management-rules/cama>

<https://deq.nc.gov/about/divisions/coastal-management/coastal-resources-commission>

Opinion: This scenario raises some interesting questions and highlights the relationship between freedom of choice and regulation. I suppose I don't feel too bad given the fact that they had purchased the home in 2008, and must have had some conception of the risk of buying coastal real estate. It is not like they lost property that had been in the family for years. That aside, their proposed site was 1/15<sup>th</sup> (!) of the standard setback line and given the erosion rates, it would be a poor long-term investment in my opinion. Although I would like to side with the individual when it comes to battles with the government, rebuilding a home here would be foolish. Even so, I still ask myself. Should they be allowed to build there if other houses are there? In some regards, they have been shut out from land they purchased, even though they will lose this land to the sea eventually. I suppose it is good we have these regulations though, because my taxes would go towards nourishing beaches that protect their foolish investment. All things considered, this a funny scenario to ponder.

CRC: The Coastal Resources Commission is the governing body for CAMA. It establishes policies and adopts rules for CAMA and the NC dredge and fill act. The commission designates areas of environmental concern and certifies local land use plans. The CRC consists of 13 members.

CAMA: The Coastal Area Management Act was enacted with the basic goal of protecting, preserving, managing and developing North Carolina's coastal resources in a responsible manner. It covers 20 coastal counties in the state. Areas of Environmental Concern are an important part of CAMA regulations. An AEC is an area of natural or societal importance and they are used to protect uncontrolled development that might damage property, public health or the environment.

**B. Time for some Fun Facts, Trivia, Bar Tidbits to Impress Your Friends.** We do need to know a few facts in order to appreciate as well as understand the coastal zone. So first, what is the Coastal Zone and What is the Beach? They are much more than just where you put your towel or build castles or swim in the breakers. Use the definitions I provide in the slides, not what is on Google.

Coastal Zone: CAMA defines the coastal zone as the counties that are adjacent to, adjoining, intersected or bounded by the Atlantic Ocean, extending offshore to the limits of State jurisdiction, or any coastal sound. This includes 20 counties here in North Carolina.

Beach: William Bascom defined the beach as the entire system of sand set in motion by waves, to a depth of 10 meters or more off ocean coasts.

### **1. A Few Factoids and Bar Tidbits (trivia night)**

a. What type of tides do we have here in Wilmington? What is the tidal range?

In Wilmington we have semi-diurnal tides. A semi-diurnal tidal cycle is characterized by two high tides and two low tides of approximately equal heights during each tidal day. The largest tidal range we experience is about 5.5 to 6 feet.

b. What area has the largest tides in the world?

The Bay of Fundy has the largest tidal range in the world. It experiences a tidal range of about 43 feet.

c. What is longshore drift? And what is the dominant direction of longshore drift along our coast?

Longshore Drift is the result of wave run-up on the foreshore, when waves approach the shore at an oblique angle. The run-up or swash occurs at the angle of wave approach, and a gravity-driven return flow follows, as the water moves back down the swash slope into the ocean. Sediment is entrained by waves and transported in the direction of wave advance in a series of saw tooth motions up and down the beach. Longshore drift makes up a substantial overall portion of sediment transport in the surf zone and often times is the dominant process. Along our coastline the dominant direction is south to north, as the majority of our swells approach with a southerly angle.

d. When do rip currents usually occur and when are they worst? Need to be able give a public service announcement

Rip currents occur when waves approach roughly perpendicular to the shoreline. As waves break, water piles up on/near the shore. The water is carried in the alongshore direction by feeder currents, and back offshore by rip currents. The rip currents flow through channels cut through the bar or along structures like jetties and piers. Several studies have shown that rip current speeds increase as tidal height decreases. They are worst when the waves are up, and the tide is low. At low tide, more waves are breaking on the sandbar and the large volume of water must return seaward via rip currents.

e. What controls wave size and type? All you surfers better know this. After all, you don't want to tell anyone to go surfing in Corpus Christi, Texas, right?

Wind direction, speed, fetch length and duration dictate offshore wave size.

As waves begin to enter intermediate and shallow water, they begin to feel the bottom. Incident wave angle, the orientation of the coastline, beach slope, and beach composition (beach, rock, reef) affect how incoming waves interact

with the surf zone and beach. The way in which waves break is important because it has an effect on surf zone dynamics, such as the rate of energy dissipation and sediment entrainment. There are three types of breaking waves that exist on a continuum: spilling waves, plunging waves and surging waves.

Spilling waves are characterized by instability at the wave crest, and the development of foam that slides part way down the wave face as the wave approaches shore. The waveform remains intact, and wave height decreases slowly as breaking occurs; think of a small day at Wrightsville Beach or Malibu, where the wave gently peels along at a steady clip. These types of waves are good for relaxed fun in the sun, and a hotdoggin' approach to wave riding.

Plunging breakers are characterized by the rapid transformation of the waveform. The lip of the wave pitches outward and downward, plunging into the water and creating a hollow pocket of air, which surfers call the barrel. In the world of surfing, a deep and lengthy barrel ride is the ultimate act and the Pipeline and reefs of the South Pacific offer some of the best warm water barrels in the world.

Surging breakers occur when low, long waves reach a steep beach and create a back and forth motion of water across the foreshore. These types of waves are usually not so good for surfing. Here in Wilmington, I have seen them occur on long period ground swells that coincide with high tides.

The type of breaking wave is dictated by the Iribarren number,  $\xi$ :

$$\xi = \frac{\tan\beta}{\sqrt{\frac{H}{L}}}$$

where  $\beta$  is the beach slope, H is the wave height, and L is the wave period. The higher the Iribarren number, the more the breaking wave trends towards the surging end of the spectrum, while the lower the Iribarren number, the more the breaking wave trends towards the spilling end of the spectrum.

Technical information taken from "Introduction to Coastal Processes and Geomorphology" by Robin Davidson-Arnott



Just for Fun. Isla Blanca Jetty, South Padre Island, TX. Hurricane Katrina. <https://www.gulfster.com/Daily/2014PictureGallery/texas/index.html>

f. Although Wrightsville Beach is recognized as a good surf town, the Outer Banks at times is recognized as being in the top 10 for surfing. Why is the Outer Banks likely a better place for surfing than Wilmington?

Two major factors make the Outer Banks better for surfing than Wilmington: the considerably smaller continental shelf and wide-open swell window. The narrow continental shelf allows waves to enter the surf zone, having lost less energy than here in Wilmington, and most of the East Coast for that matter. The Outer Banks, especially the zones south of Oregon Inlet, are known for their powerful barreling surf. This area is home to iconic East Coast surf breaks like S-Turns, the beach just north of Rodanthe, where there always seems to be water and sand on the highway, and the Hatteras Lighthouse, which some consider the mecca of East Coast surfing. The Outer Banks, Hatteras Island in particular, has a wide-open swell window. It sticks out far into the Atlantic and is able to pick up swell from nearly all directions. It also has more beaches that have favorable wind options, with beaches that face S, SE, E and NE. Wilmington faces south and east. We are firmly planted in the Onslow Bay, an indentation in the North Carolina coast between Cape Fear to the south and Cape Lookout to the North. Due to this fact, we are sheltered from many of the larger, long period, North swells the East Coast sees in the winter and spring months. Taking all of this into account, Wilmington is still a great place to be a surfer and Masonboro Island is truly a gem, thanks to its long jetty and south facing beach that protect the surf from northerly winds. Mid-period south swells accompanied by offshore winds, light up the south end of Wrightsville and Masonboro Island. Now if only the town of Wrightsville Beach would lower their hourly parking rates...



**Figure 1. Early March Swell. The Lighthouse.**



**Figure 2: Early March Swell. South of Avon.**

g. What is the rule on terminal groins in NC? How many are now allowed and by what legislative law? Two different legislative sessions approved the # of terminal groins.

A terminal groin is a permanent erosion control structure that is constructed on the side of an inlet at the terminus of an island to limit or control sediment passage into the inlet channel. They are used to reduce beach erosion, reduce the frequency of beach nourishment projects and slow the migration of inlets. But they cannot adversely impact the value or enjoyment of adjacent properties, damage the public beach, obstruct public access or result in increased damage. Senate Bill 110 in 2011 allowed 4 terminal groins on the NC coast and in 2015 2 more were allowed.

h. Tropical storm names are reused every 6 years, unless they are retired. What 3 things may lead to their retirement? Hazel, Fran, Floyd, Matthew, Florence and more have been retired. By the way, how do these 5 storms rank in NC as far as their severity/costs/deaths? I give my assessment but there may be others

Storm names are retired because of the number of lives lost, incredibly high amounts of destruction, or extremely high intensity.

Severity – Florence (Most costly NC disaster) & Hazel, followed by Floyd, Fran and Matthew

Cost – Florence, Floyd, Fran, Matthew, Isabel

Death - Floyd, Florence, Matthew, Fran, Hazel

i. What quadrant (NW, NE, SE, SW) is associated with the most damage in a hurricane, usually? At what wind speed are tropical storms named? What about hurricanes?

The North East quadrant is the most dangerous, due to the stronger onshore winds and storm surge. Tropical storms are named when their wind speeds reach 39mph, and hurricanes are named when their wind speeds reach 74mph.

**2. And speaking of hurricanes.** They are the most costly of the billion dollar natural disasters described in the slide set and in these websites:

<https://www.ncdc.noaa.gov/billions/>

<https://www.climate.gov/news-features/blogs/beyond-data/2018s-billion-dollar-disasters-context>

**So in this regard, let's consider billion dollar disasters over the last 40 years.** What percent and total \$\$ value of the total billion dollar disasters is associated with tropical storms and are there any trends over time? keep in mind that these are inflation adjusted values to try to normalize the data. However, there are issues with comparing the data; one is that we have lots more infrastructure and buildings (more expensive ones) in harms way today. But this is still a barometer of the severity of storms on our coast.

Trends: The number and cost of disasters are increasing. This is due to a combination of increased exposure, vulnerability and climate change. Tropical cyclones represent the second most frequent event type when it comes to billion dollar disaster events, and they are also responsible for the highest number of deaths. From 1980 – 2018, the average number of billion dollar events was 6.2, but from 2014 – 2018 the annual average rose to 12.6 events, with 2018, 2017, and 2018 ringing in as historic years. Climate change has played a role in the increasing frequency of extreme weather events, in particular extremely heavy rainfall in the Eastern United States.

% of total damages \_\_\_\_\_ 55.1% (!) \_\_\_\_\_ \$\$ Value of Total Tropical Storm Disasters \_ 919.7 billion dollars \_\_\_\_\_

**3. We could ask hurricane questions all day but we will have a presentation by someone later, let me just pose one more set of questions.** What factors control the formation of hurricanes and “encourage” intensification? You may want to look up a little stuff on your own but there is a lot in the slides. By the way the preliminary forecast for 2020 is that it will be slightly above normal (warm ocean waters and no El Nino event (shearing winds are often associated these to reduce Atlantic storms).

Water of at least 26.5 degrees Celsius over a depth of 50 meters, thunderstorm activity and low wind shear promote hurricane intensification.

**4. Perhaps the other largest issue facing the Coastal Zone today is sea level rise and nuisance flooding** and their impact on infrastructure and developments, so we should know something about these issues, too. However, one person has a different take on it. The comment below is in the Comments section below the video I want you to watch (<https://www.youtube.com/watch?v=wIKYgOQbQhA>)

**“The Seas have risen and fallen a thousand times since God created the earth the Heavens and all life. “ Global warming and Sea level rise” are myths created by the liberal left. They will claim they can protect you to gain power over you! It’s all garbage! These people know nothing of what the earth is truly doing!**

He is right in the first sentence but I might have to quibble a bit with the last couple of lines. I want you to look at this video, which gives a little context on several things:

- The variability of Sea Level Rise (SLR) along the coast of NC and the 2015 report that describes this
- Mention of erosion rates and setbacks as factors considered by the Division of Coastal Management (see ??s below)
- Consideration of infrastructure in cities like Wilmington and the planning that should be done

**Questions:**

**a. What does the 2015 Sea Level Report by the CRC Science Panel say about SLR on the Coast of NC. Sum up the variability and the reasons for that variability.** The 2015 Report is on Canvas and you may find additional information here (<https://www.coastalreview.org/2019/10/ncs-next-sea-level-rise-study-to-eye-2100/>) that mentions the current work to update SLR data in a 2020 report (supposed to be ready this summer). For information I have it on some authority that the report will look out hopefully to 2100 for scenarios, too.

**b. In the slides there is some basic information.**

- i. What is the current global rate of SLR? I can tell you it is increasing – it is not a linear rise.

From 1870 to 2000, the rise rate was 1.70 mm per year, and from 1993 to 2015 the rate was 3.17 mm per year.

- ii. Assuming we had a 1 m rise of sea level, what 3 states would lose the most land? Why?

With 1 meter of sea level rise, North Carolina, Florida, and Louisiana would lose the most land due to low lying topography, underlying geology and subsidence.

**c. What is Perigean Flooding?** (Sometimes called nuisance flooding, high tide flooding, sunny day flooding,, king tides, etc.). I actually prefer perigean flooding as those will be the largest tidal fluctuations. Explain why and when these occur and tell me when the next coastal flooding will occur here in Wilmington (use the slide set).

Perigean flooding is the temporary inundation of low-lying areas, during large high tide events. Around 6 to 8 times a year, a new or full moon coincides with the perigee of the moon, the point when the moon is closest to the Earth. When this occurs the Earth, Sun and moon are in alignment, and this combination creates tides that are significantly higher than other times of the year. In Wilmington, perigean flooding occurred on April 7<sup>th</sup> under the Full Pink Moon.

**5. Take your pick. Choose ONE OF THE THREE topics** below and provide a background, description, and then a specific example for it and how it has worked at that location. Of course you should know some information on all of these as good NC Earth Scientists, Natural History Buffs, and Concerned Citizens. Best references other than my slides are USACE, NCCF, and NOAA. Just a few sentences of facts and opinions, etc.

**a. Terminal Groins.** There is one now at Bald Head Island while others have been declined or are in litigation or consideration. The USACE , which controls permitting for them, has abundant information on the projects such as an EIS for each location. See this site for the plans as well as for other major porjects.

<https://www.saw.usace.army.mil/Missions/Regulatory-Permit-Program/Major-Projects/> . And this site from the Village of Bald Head has a summary, too.

[http://www.villagebhi.org/government/development\\_services/terminal%20groin/pdf/2013-02-14%20Workshop%20201%20Presentation.pdf](http://www.villagebhi.org/government/development_services/terminal%20groin/pdf/2013-02-14%20Workshop%20201%20Presentation.pdf)

**b. Living Shoreline** (multiple along NC Coast). Good source is <https://www.habitatblueprint.noaa.gov/living-shorelines/> and [http://www.nccoast.org/uploads/documents/factsheets/FS\\_LivShorlines.pdf](http://www.nccoast.org/uploads/documents/factsheets/FS_LivShorlines.pdf) particularly at Morris Landing.

**c. Storm Damage Mitigation/Renourishment** (Topsail, Oak Island, Bogue, Carolina/Kure Beaches, etc.) One example recently that was approved and that is worth \$281 million is <https://www.coastalreview.org/2020/01/corps-funds-bogue-topsail-sand-projects/> and one for a project at Bogue Island is [https://saw-reg.usace.army.mil/PN2017/TOC\\_Signature\\_and\\_Exec\\_Summary.pdf](https://saw-reg.usace.army.mil/PN2017/TOC_Signature_and_Exec_Summary.pdf)

Beach nourishment is the practice of adding sand to beaches to mitigate erosion and increase beach width. This practice is seen as a “softer” alternative to hard armoring because it avoids many of the pitfalls associated with structures like

seawalls. Often dune renourishment is carried out during beach nourishment projects. A wide, nourished beach system allows the beach system to absorb wave energy and protects upland areas from flooding. Before carrying out a nourishment project, a sediment budget is developed, and sediment of the appropriate grain size, texture and color is sourced. Wrightsville Beach has been nourished 26 times since 1939. One of the most interesting projects that took place on Wrightsville Beach was the movement of Mason's Inlet 2900 feet to the North, which took place in 2001 and 2002. This project is considered an Engineering success. It improved the flushing of nearby tidal creeks and protected properties worth 237 million dollars.

**6. One of the biggest issues on the coast is erosion, whether it is from sea level rise, storms, or just during seasonal fluctuations.** Using the listed website below, investigate erosion rates and setbacks that have been established by the Division of Coastal Management as well as inlet hazard areas. Remember, inlets are the most dynamic site on the coast. This is why the CRC is currently revising these hazard areas to account for even larger areas of concern. This site is full of information, spend a little time investigating it.

<https://deq.nc.gov/about/divisions/coastal-management/coastal-management-oceanfront-shorelines/oceanfront-construction-setback-erosion-rate>

Answer the following questions using the website and/or slides.

**a. What is the default erosion rate for the coast of NC?** There are certainly areas greater than this but there are also areas of accretion, adding land.

The default erosion rate is 2 feet, but rates along the coast vary between 2 and 10 feet per year.

**b. What would be the setback (read what that is) for a house of less than 5,000 ft<sup>2</sup> with this default erosion rate.** (in the slide set, too)

60 feet = 2ft erosion rate x 30

**c. Let's compare. Provide the erosion rate and a comment on what you think is controlling that erosion rate:**

i. Wrightsville Beach

2 feet per year. The erosion rate at Wrightsville is governed by longshore sediment transport and periodic nourishment.

ii. Area fronting Fort Fisher State Historic Site and NC Aquarium

2.3 to 5.6. Hard structure and loss of sediment on the leeward side govern the erosion rate here.

iii. Lockwoods Folly Inlet; give value on west end of Oak Island (east side of inlet) and east end of Holden Beach (west side of the inlet)

The East side of the inlet is accreting at over 6 feet per year, but the west side is eroding at over ten feet per year. This disparity is due to the movement of the primary ebb channel.

iv. Rodanthe on the Outer Banks. Repeated breaching of the highway 12 and overwash. It is so bad they are constructing a new road/bridge in the marsh and water behind the island called the Jug Handle. I have a slide on this. What do you think about putting a bridge in the marsh, etc. (<https://www.ncdot.gov/projects/nc-12-rodanthe/Pages/default.aspx>)

2.4 to 4 feet per year. Overwash seems to be the dominant process here. For some reason this specific spot seems to amplify incoming swell, producing powerful surf.



**Figure 3. Early March Swell. The infamous S-Turns before the tide dropped and the waves turned on.**

I just heard a talk about the Jug Handle on the radio. The speaker seemed to be in favor of returning to a ferry system, although I don't think that would be feasible in peak season, and if a storm rolled through, it would create the ultimate bottleneck for residents of the lower Outer Banks. I know that a lot of money is lost, maintaining this section of road. Getting rid of this issue is a plus in my mind. Another plus is maintaining the ecological integrity of Pea Island, which I have heard the birders have pushed for. As a surfer, I am wondering how this project will affect access to Pea Island. There is a spot in the middle of the island, where the dunes are particularly tall, called "Long Walk". This spot offers up spectacular "shore pound barrels", hollow powerful waves that break close to shore, with little to know crowds. Maybe this change in the road system will make the experience of scoring good waves on Pea Island all the more rewarding. I have heard they want to make it so you have to bike or boat in. I am also concerned with how the new bridge will affect the water quality and ecosystem on the backside of the island. I hope they figure out a way to reduce chemicals and waste from cars/people from entering the water underneath the bridge. Either way, I think this is a fascinating project with a variety of pros and cons. I am interested to see how it all goes.



Figure 4. Early March Swell. Surfer tucked into a hollow wave at Longwalk.

Whew, I think that is enough – I know you do. As I said there is a lot going on with our Coastal Zone.