IMPACTS OF TERMINAL GROINS ON NORTH CAROLINA’S COASTS

By

Whitney Knapp

Dr. Dan Rittschof, Advisor
May 2012

Masters project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

2012
Abstract

In 1985, North Carolina banned the use of hard structures along its coastline for the purposes of protecting private property. The policy was heralded as the way to manage barrier islands in the light of sea level rise. In 2011, the General Assembly overturned this ban to allow the construction of up to four terminal groins at inlets where some of the most vulnerable beachfront properties are located.

This project examines the potential impacts of terminal groins to North Carolina’s coastline. Biological and physical impacts to the coastal environment were assessed, as well as human and economic impacts to the coastal region. Case studies were conducted to determine the long-term impacts of hard structures in New Jersey and Florida, two states that have traditionally relied on coastal armoring to protect private properties.

Results show that faced with rising sea levels, terminal groins are likely to cause more harm than good. Recommendations of the best course of action, including rolling easements, stricter building codes in inlet hazard areas, and a property buy-out program are made to North Carolina in order to help them better protect and manage the coastline.
Abstract .......................................................................................................................... i
List of Acronyms ........................................................................................................... iii
Introduction ..................................................................................................................... 1
1. Legal Framework ....................................................................................................... 2
  1.1 Coastal Zone Management Act of 1972 ............................................................... 2
  1.2 North Carolina Coastal Area Management Act .................................................... 3
    1.2.1 Areas of Environmental Concern ................................................................. 4
    1.2.2 Land Use Plans ............................................................................................. 5
  1.3 Institutional Ecology ............................................................................................... 6
    1.3.1 Coastal Resources Commission and Coastal Resources Advisory Council ...... 7
    1.3.2 Division of Coastal Management ................................................................. 7
    1.3.3 North Carolina General Assembly ............................................................... 7
  1.4 Hard Stabilization Ban ......................................................................................... 8
  1.5 North Carolina Senate Bill 110 (NC SL 2011-387) .............................................. 9
2. Impacts of Hard Stabilization .................................................................................. 10
  2.1 Environmental Impacts ..................................................................................... 12
    2.1.1 Physical Impacts ........................................................................................... 12
    2.2.2 Direct Biological Impacts ............................................................................. 14
    2.2.2 Indirect Biological Impacts ........................................................................... 15
  2.2 Human Impacts .................................................................................................. 16
  2.3 Summary of the Pros and Cons of Terminal Groins ......................................... 20
3. Lessons to be learned from other states ............................................................... 22
  3.1 New Jersey ........................................................................................................ 22
    3.1.1 New Jersey Coastal Management Laws ....................................................... 22
    3.1.2 Enforcement .............................................................................................. 23
    3.1.3 Impacts and Lessons ................................................................................... 24
  3.2 Florida ................................................................................................................ 26
    3.2.1 Florida Coastal Management Laws ............................................................ 26
    3.2.2 Enforcement .............................................................................................. 28
    3.2.3 Shoreline Structuring Policies .................................................................... 28
    3.2.3 Impacts .................................................................................................... 31
  3.3 Lessons ............................................................................................................... 32
4. Analysis of Policy Alternatives ............................................................................ 34
  4.1 No Action .......................................................................................................... 34
  4.2 Land Use Plan Revisions ................................................................................... 35
  4.3 Rolling Easements ............................................................................................. 35
  4.4 Incorporate Inlet Hazard Areas into AEC’s ......................................................... 36
  4.5 Community Buy-Out Programs ......................................................................... 39
4. Recommendation of Best Alternative .................................................................... 40
References .................................................................................................................. 42
## List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEC</td>
<td>Areas of Environmental Concern</td>
</tr>
<tr>
<td>CAFRA</td>
<td>Coastal Area Facility Review Act</td>
</tr>
<tr>
<td>CAMA</td>
<td>North Carolina Coastal Area Management Act</td>
</tr>
<tr>
<td>CCCL</td>
<td>Coastal Construction Control Line</td>
</tr>
<tr>
<td>CRAC</td>
<td>Coastal Resource Advisory Council</td>
</tr>
<tr>
<td>CRC</td>
<td>Coastal Resources Commission</td>
</tr>
<tr>
<td>CZMA</td>
<td>Coastal Zome Management Act of 1972</td>
</tr>
<tr>
<td>DCM</td>
<td>Division of Coastal Management</td>
</tr>
<tr>
<td>DENR</td>
<td>North Carolina Department of the Environment and Natural Resources</td>
</tr>
<tr>
<td>FLDEP</td>
<td>Florida Department of Environmental Protection</td>
</tr>
<tr>
<td>FWS</td>
<td>United States Fish and Wildlife Service</td>
</tr>
<tr>
<td>IRP</td>
<td>Imminent Risk Property</td>
</tr>
<tr>
<td>NCBIWA</td>
<td>North Carolina Beach, Inlet, and Waterway Association</td>
</tr>
<tr>
<td>NCGA</td>
<td>North Carolina General Assembly</td>
</tr>
<tr>
<td>NERRS</td>
<td>National Estuarine Research Reserve System</td>
</tr>
<tr>
<td>NJDEP</td>
<td>New Jersey Department of Environmental Protection</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>PSDS</td>
<td>Program for the Study of Developed Shorelines</td>
</tr>
<tr>
<td>USACE</td>
<td>United States Army Corps of Engineers</td>
</tr>
</tbody>
</table>
Introduction

Barrier islands are dynamic ecosystems that span the entire length of the east coast of the United States (Dean, 1999 and McAllister, 2007). As sea level rises, these islands move inland when storms wash over them, carrying sand to the backside of the beach, or winds blow sand into dunes. Barrier islands are a natural buffer between the mainland and ocean storms. Waves usually break at a slight angle to the coastline (Inman and Dolan, 1989). This causes longshore currents and sand to move up or down the coast throughout the year. Often, sand movement and direction are seasonal and depend upon prevailing winds.

Inlets are a vital component of the barrier island system. When strong storms hit, the water sometimes rushes back out to sea with enough force to break through the island forming an inlet (Dean, 1999). Left alone, inlets open and close over years to decades, with other inlets forming at other locations along the beach. In many cases, inlets close and open in the same place over a time span of many years.

Usually, over time, the mouth of the inlet migrates up or down the beach. As inlets migrate, stationary structures like homes and surveyed property near the inlet can become endangered. One option for protecting this property is to construct a terminal groin, often a rock barrier that extends perpendicular to the beach and parallel to the inlet, to prevent further inlet migration and allow sand transported alongshore to accumulate in front of the properties (Dean, 1999). In North Carolina, several coastal towns with beachfront properties would like to take advantage of this technology (McGrath, 2010).

Terminal groins are built perpendicular to the beach, and extend into the ocean adjacent to an inlet to stop the loss of sediment to an inlet. When properly designed and filled, sediment in the longshore transport system is supposed to travel over and around the groin, rather than being
lost from the system. While terminal groins are beneficial to property owners at the inlet, they disrupt the natural barrier island processes of overwash, inlet migration, and shoaling. Further, they can rob barrier islands down shore of vital sand used to maintain their beaches, leading to increased beach nourishment in those areas.

This paper examines the terminal groin debate in North Carolina. Section 1 looks at the legal framework in place in North Carolina to govern this issue. Section 2 examines the impacts of hard stabilization on beaches, including the biophysical, human, and institutional ecologies. Section 3 looks at how New Jersey and Florida have approached beach structuring and the lessons that can be learned from them. Section 4 discusses the alternatives to terminal groins, and Section 5 proposes the best course for North Carolina to take.

1. Legal Framework

1.1 Coastal Zone Management Act of 1972

In order to better manage coastal land use in the United States, the Coastal Zone Management Act (CZMA) (Public Law 92-583, 16 U.S.C. 1451-1456) was adopted in 1972. The main goal of the CZMA was to recognize growth in the coastal region, including development of salt marshes, and work to balance economic uses with the environmental importance of these areas (NOAA, 2011a).

The CZMA is administered by the National Oceanic and Atmospheric Administration (NOAA), and includes two programs: the National Coastal Zone Management Program and the National Estuarine Research Reserve System (NOAA, 2011a). There are no federal requirements for managing coastal lands in the CZMA (FWS, 2011). Instead, both programs are voluntary (NOAA, 2011a).
Under the National Coastal Zone Management Program coastal states were encouraged to develop their own coastal zone management plans (FWS, 2011). NOAA would help states develop their plans and, upon federal approval, provide grant money for states to use to implement their program. In addition, all federal coastal activities in a state with a coastal management plan are required to be consistent with that state’s management plan.

The second part of the CZMA established the National Estuarine Research Reserve program (NERRS, 2011). This program is also a partnership between NOAA and coastal states that protects important coastal resources for long-term research, monitoring, and education. Today there are twenty-eight different reserves.

1.2 North Carolina Coastal Area Management Act

North Carolina passed their Coastal Area Management Act (CAMA) (1973, c. 1284, s. 1; 1975, c. 452, s. 5; 1981, c.932, s. 2.1.) in 1974, and it was approved under the CZMA in 1978 (DCM, 2011b). The main goal of CAMA was to recognize the various needs to the state’s coastal areas, including natural value, industry, and recreation, and provide a mechanism to ensure a balanced development of these needs.

CAMA established both the Coastal Resources Commission (CRC) and the Division of Coastal Management (DCM) to implement and enforce these regulations (Coppola, 2011). Twenty counties containing estuarine and ocean shore were designated as North Carolina’s coastal zone, and subject to CAMA regulations. Under CAMA, the designated coastal counties are responsible for creating their own coastal land use plans, which must comply with CAMA regulations. Local governments can also create and implement their own land use plan, subject to approval by the CRC. The state is responsible for providing and enforcing standards, reviewing
local land use plans to ensure compliance, and establishing areas of environmental concern (DCM, 2011a).

1.2.1 Areas of Environmental Concern

One of the largest ways that CAMA has impacted coastal land use is by allowing the CRC to create Areas of Environmental Concern (AEC) in designated coastal regions (DCM, 2011a). AEC’s are considered areas valuable to the state or at risk of being destroyed by erosion or flooding (CAMA §113A-113). There are four categories these areas can be placed under: estuarine and ocean system, the ocean hazard system, public water supplies, and natural and cultural resource areas. In total, AEC’s encompass almost all water and approximately 3% of land in designated coastal areas (Coppola, 2011).

Estuarine and ocean system areas include the marshes, brackish waters, and shores of North Carolina’s coasts, which make up one of the largest estuary systems in the United States (DCM, 2007). In this area, special permits are required to develop public trust areas including the Atlantic Ocean, navigable water bodies, areas of significant fish resources, all estuaries including oceans, sounds, tidal areas and tributaries, lands within seventy-five feet of the normal high water level of estuarine waters, and coastal wetlands in the twenty counties, defined as areas that occasionally flood during lunar or wind tides.

The ocean hazard system considers the lands making up the state’s barrier islands and inlets connecting to the sounds (DCM, 2007). Within this region, special permits are required to develop lands between the mean low water line to the first stable line of vegetation plus sixty times the long-term, average annual erosion rate added to the distance of erosion expected from a major storm. This area can be anywhere between 145 and 700 feet wide. Areas identified as coastal flood with velocity hazard (“V zones”) by the Federal Insurance Administration and inlet
hazard areas, determined by the DCM based on inlet migration patterns for a particular inlet, are also subject to permitting restrictions.

AEC’s designated to protect the public water supply in coastal areas include areas designated A-II by the NC Environmental Management Commission, meaning the waters are best used for public drinking water and areas of rapidly draining sands that extend to a shallow groundwater table of drinking water (DCM, 2007). Currently these areas only include the Fresh Pond between Nags Head and Kill Devil Hills, Toomer’s Creek near Wilmington, and Buxton (Hatteras Island).

Natural and Cultural AEC’s are site specific and designated to protect areas of environmental or cultural resources significant to the entire state (DCM, 2007). These areas can include coastal habitats that are essentially unchanged by human activity, areas essential to threatened, rare, or endangered species as determined by the state or federal government, unique geological formations, and significant archaeological resources.

1.2.2 Land Use Plans

In addition to designating areas of environmental concern, CAMA also requires all coastal counties to create comprehensive land use plans to examine their economic and development goals, as well as resource protection and reduction of storm hazards (DCM, 2008). In addition, local municipalities within designated coastal counties have the option of creating their own land use plan. These plans provide guidance for both individual developments and regulatory ordinances. In order for the DCM to grant a permit for a project the project must be consistent with the land use plan for that area.

While the flexibility of CAMA has allowed coastal areas to create land use plans best suited to their needs, it has also allowed for over 90 different land use plans to be adopted
This has resulted in a patchwork of different land use plans that lack consistency with neighboring and overlapping plans. The lack of consistency has created a lack of coordination and communication that is especially apparent when examining the management of the environment and natural resources in the state. Typically, land use plans do not include environmental provisions, except when required, and instead rely on the state to manage the environment.

By allowing the plans to suit the needs of the community, typically land use plans have favored economic development over conserving the natural ecosystem (McPherson, 2009). In order to acknowledge this shortfall, 2002 revisions to CAMA Land-Use planning guidelines required a land suitability analysis to examine natural system constraints as well as stressing the importance of maintaining water quality. Unfortunately, this revision has resulted in few impacts since land use plans do not include enforceable policies and are only used as a guide to aid decision-making. Further, land use plans are generally fitted to existing town ordinances, rather than fitting town ordinances to land use plans.

1.3 Institutional Ecology

In order to successfully implement, regulate, and monitor CAMA, several governing bodies were established. They include the CRC, the Coastal Resource Advisory Council (CRAC), North Carolina Department of the Environment and Natural Resources (DENR), and DCM. In addition, the North Carolina legislature plays a large role in shaping coastal policy through the passage of new legislation. All of these bodies can influence whether hard structures will be built along North Carolina’s beaches.
1.3.1 Coastal Resources Commission and Coastal Resources Advisory Council

In order to implement CAMA, the CRC was formed. The CRC is a fifteen-member body appointed by the governor to a term of four years. The CRC establishes policies for the North Carolina Coastal Management Program and adopts implementing rules for both CAMA and the N.C. Dredge and Fill Act (DCM, 2011b). The commission designates AECs, and develops rule and policies governing coastal development in those areas, as well as certifying local land-use plans. To provide technical expertise to the CRC, the 45-member CRAC was formed. This body is made up of representatives from coastal counties and cities, regional government, and state agencies.

1.3.2 Division of Coastal Management

Under CAMA, the DCM, a division of DENR, was designated as the governing body in charge of carrying out and enforcing all rules passed by the CRC, including issuing CAMA permits, and providing support to local coastal land use planning efforts (McPherson, 2009). DCM works to maintain public beach and waterfront access, and administers the North Carolina Coastal Reserve system. In addition to the above responsibilities, DCM monitors coastal erosion rates to determine impacts of coastal development.

1.3.3 North Carolina General Assembly

The North Carolina General Assembly is in charge of creating and passing laws (statutes) in North Carolina (NCGA, 2011a). The General Assembly is a bicameral legislature consisting of a 50 member Senate, and a 120 member House of Representatives. Representatives of both chambers serve two-year terms, with no term limits.

In order for a bill to become law in North Carolina several steps must occur (NCGA, 2011b). First, it must pass both houses, and be signed by the presiding officer of both houses.
At that point, the bill is presented to the governor for approval. The bill will become law if the governor signs it, or allows ten days to pass without her signature. If the governor vetoes a bill, it is returned to the General Assembly, where 3/5 of the members must vote to override the veto.

1.4 Hard Stabilization Ban

In 1985 the NC CRC banned the use of all hard structures (Saxton, 2011). This rule was amended in 1992 to allow for protection of significant historic sites and navigation channels. In 2003 CAMA was amended to include the hard structure ban. Under this law

(b) No person shall construct a permanent erosion control structure in an ocean shoreline. The Commission shall not permit the construction of a temporary erosion control structure that consists of anything other than sandbags in an ocean shoreline. (NC G.S. §113A-115.1).

All prior designated exceptions were still allowed under this law, as well as structures constructed prior to 1974.

Since this amendment was added to CAMA several bills have been introduced in the state legislature to allow for the construction of terminal groins. They include SB 599 (2007), which would allow a one terminal groin to be built as a “pilot” project to assess the feasibility of using terminal groins as an erosion control method (NCGA, 2007). Beaches under consideration included Bald Head Island, Figure Eight Island, North Topsail Beach, and Ocean Isle Beach. While this bill passed the senate, it never passed the house.

In 2009 SB 832 was introduced (NCGA, 2009) to allow for the construction of terminal groins in North Carolina. While this bill ultimately didn’t pass the senate, House Bill 709 was signed into law (NC SL 2009-479). This bill directed the CRC to conduct a feasibility study to
determine if the use of terminal groins would be an effective measure to control erosion around inlets.

The CRC completed their study in the spring of 2010 at a cost of $280,000 (Coburn, 2011). The report examined five existing terminal groins in both North Carolina and Florida to determine their effectiveness at controlling erosion, their environmental impact, the impacts of nourishment and dredging on the system, and the impacts of different designs and construction materials (CRC, 2010). An economic assessment was conducted to determine the value of the inlet area to local municipalities and counties as well as costs associated with the terminal groin. In their final report, the study found no conclusive evidence to support or prohibit development of terminal groins.

In addition, the report provided recommendations to the General Assembly outlining requirements that should be met before a terminal groin is built. They include showing that other remediation methods (including relocating structures) are impractical, the groin must not interrupt the natural down shore movement of sand, an environmental impact statement must be conducted, a third party review of all environmental studies and construction plans, financial insurance for maintenance and removal costs, third party monitoring of impacts, and make the project part of a beach nourishment project.

1.5 North Carolina Senate Bill 110 (NC SL 2011-387)

In 2011 the North Carolina legislature approved SB 110, allowing for the construction of up to four terminal groins along North Carolina’s coast. This bill was allowed to become law in June 2011 without the governor’s signature (NC SL 2011-387).

In order for the CRC to grant a permit for the construction of a terminal groin, the applicant must prove that: 1) the area is imminently threatened by erosion and all other
approaches would be impractical, 2) an environmental impact statement meets the requirements of NC G.S. 113A-4, 3) Property owners and governments that would potentially be affected by the groin have been notified, 4) A plan for construction and maintenance, as well as management of the inlet, estuarine, and ocean shorelines affected by the inlet has been prepared. This plan should address steps that will be taken to monitor impacts, develop a baseline to assess adverse impacts, provide mitigation measures if the adverse impact threshold is exceeded, and for removal of the groin if impacts are unable to be mitigated, and 5) Proof of financial assurance to cover the cost of maintenance and monitoring, implementation of mitigation, removal, and restoration of the property (NC SL 2011-387).

2. Impacts of Hard Stabilization

As sea level rises and sediments move naturally barrier islands erode and would otherwise change location, and homes and businesses become closer to the surf (Dean, 1999). In an effort to protect their investments, beach communities attempt to stabilize or restore their beaches with structures such as groins that trap sand moving down the beaches. Trapping sand leads to other beaches needing to be restored because the sand stops moving down the beach. Dredged and groined inlets exacerbate impacts by further disrupting natural movements of sand.

Over the last 100 years, 86% of beaches along the East Coast (USA) have experienced erosion causing sand loss ranging from centimeters to hundreds of meters in width (Zhang et al., 2004). In North Carolina, sea levels are currently rising at a rate of 18 inches per century, and sea levels are expected to rise between 39 and 55 inches by 2100 (Riggs et al., 2011). As sea levels rise, rates of island erosion will increase, and coastal communities will see greater impacts from hurricanes and other coastal storms leading to permanent or long-term loss of sand.
(FitzGerald et al., 2008; Michner et al., 1997; Riggs et al., 2011). Storm surges will be higher, breaking over seawalls, levees, and barrier islands, and beach erosion from these storms will increase.

In order to reduce erosion near structures, many areas choose to harden the beach. Hard structures include seawalls, rickrack, breakwaters, groins, terminal groins, and jetties. Seawalls stand parallel to the coast providing a barrier between the town and the ocean (Dean, 1999). Many times, these walls are placed in front of the dune line, becoming the beaches first line of defense against waves. This prevents the beach from accessing its natural reserves of sand, causing the beach face to erode even faster. The ends of seawalls pose another problem. During storms, the ocean moves around the seawall causing severe erosion at these points. Because of this, the cost to maintain a seawall can be extreme.

Breakwaters are made of rocks or concrete placed offshore and parallel to the coast to reduce wave intensity on the beach, thereby reducing sediment loss (Dean, 1999). They can either be attached to the bottom or floating. While breakwaters reduce sand loss on the beach behind them, beaches not protected by the breakwater tend to erode due to disruption of the long shore current.

Groins extend perpendicular to the beach into the sea (Dean, 1999). They are used to stop the longshore movement of sand by trapping it at these points. Terminal groins are built perpendicular to the beach, and extend into the ocean adjacent to an inlet to stop the loss of sediment to an inlet. Jetties are hard structures on the sides of inlets that keep inlets open for navigational purposes. Jetties trap the sand moving north to south, keeping it on the beach and out of the inlet. All three kinds of structures prevent the natural movement of sand and cause erosion problems for down-drift beaches.
In the past, beach nourishment was the only legal long-term alternative for maintaining and restoring beaches in North Carolina. This process involves sand being dredged from offshore or from local inlets (Dean, 1999). The sand is mixed with water and pumped onto the beach. Initially, currents carry some of this sand underwater to compensate for the change in beach slope. These projects can cost millions of dollars for the initial nourishment, and millions more to maintain them. And as sea level rises, supplementation intervals shorten from over ten years to about 3, and people begin to turn to hard structures to reduce the costs of erosion control.

2.1 Environmental Impacts

2.1.1 Physical Impacts

Barrier islands form as sea level rises and river deltas become inundated and shaped by physical forces into islands. As sea level rises, islands migrate inland. Barrier Islands form a buffer between the ocean and the land behind it, playing a critical role in protecting the mainland by absorbing the energy from the ocean before it can reach the mainland (Riggs et al., 2011). Storm frequency from year-to-year causes the rates of erosion on barrier islands to vary over time.

Simple barrier islands make up over 70% of North Carolina’s shoreline, including all beaches south of Cape Lookout and Cape Fear (Riggs et al., 2011). These beaches are classified as those with a relatively limited supply of sediment that are dominated by inlet and overwash dynamics. Storm surges play a critical role in increasing elevation and forming these islands by opening inlets and depositing sediment on top of and behind the island through overwash. Sediment is also moved between islands in the system through the longshore current, which transports sediment parallel to the beach (Inman and Dolan, 1989).
Inlets are a dynamic component of the barrier island system that can open and close, widen and narrow, or migrate based around an equilibrium point (Riggs et al., 2011). Studies have shown that inlet dynamics are vital to the functioning of simple barrier islands, and that 70% of the North Carolina coast has had at least one inlet over the past hundred years. Over time, tidal flow in and out of the inlet builds sand shoals that serve as both a major sediment source for the island and the foundation for islands to migrate landward in response to sea level rise.

When unmoving structures are placed on barrier islands and inlet dynamics are altered, barrier islands experience a narrowing of the island and an increased rate of erosion (Riggs et al., 2011). By using structures such as terminal groins to prevent the loss of sand in front of properties built in the dynamic inlet system, this process is further interrupted. Proponents of terminal groins argue that if they are constructed properly and filled in, terminal groins would not trap sand, but instead allow it to flow around the structure (ASBPA, 2008). Either way, sand for the nourishment project must be pumped from limited offshore supplies or from the tidal deltas to fill in the terminal groin, further trapping and limiting the already limited sediment supplies.

While terminal groins may protect the properties located in inlet hazard areas, they also cause a need for continued nourishment of the beaches. In all cases studied, beach nourishment was necessary after the construction of the terminal groin to maintain the beach (CRC, 2010). Many times the rate of nourishment increases after the placement of a terminal groin. On Pea Island NC, the erosion rate after construction of the terminal groin was greater than the rate before construction, resulting in over 7.7 million cubic yards of sand being placed back on the
beach (Pilkey et al., 2008). In addition, the terminal groin on Bogue Banks, NC has needed small-scale nourishment projects to maintain the beach for over 40 years.

The CRC has found that terminal groins can reduce erosion along the beaches directly adjacent to them, but they can also change currents and wave patterns causing beaches further downshore to experience moderate erosion (CRC, 2010). Terminal groins have been found to disrupt natural barrier island processes such as preventing barrier island overwash. This allows sediment in front of the dune system to be transported offshore during a storm event rather than being moved to the sound side of the island, leading to further narrowing of the barrier island and a lack of sediment on the sound side of the island. In addition, terminal groins tend to cause inlet stabilization and prevent inlet migration.

### 2.2.2 Direct Biological Impacts

Few studies have examined direct biological impacts of terminal groins. It is known that placement of the terminal groin would result in a direct loss of soft bottom nearshore and subtidal habitat at the groin site (CRC, 2010). While some may argue that introduction of hard bottom habitat would add diversity, this type of hard bottom habitat is not native to North Carolina. Additionally, the introduction of this non-native structure can impact species that rely on the sandy beaches for feeding and nesting, and allow for the introduction of invasive species to the system.

A 2008 study by Dugan et al found that armored shorelines supported significantly less habitat area, as well as fewer invertebrates and birds than unarmored segments of the same beach. Hard structures, such as terminal groins, can lead to changes in sediment composition, causing coarser sediment with more shell hash to accumulate (USACE, 1984). Terminal groins can also change the relative abundances of invertebrates found on the beach. One study found that *Donax*
were absent from the area around the terminal groin, but the bivalve, *Crassinella martinicensis*, and the polychaete, *Podarke obscura*, were more abundant (USACE, 1984).

The use of hard structures to stabilize inlets has been found to lead to the loss of habitat for both piping plovers (FWS, 1996) and nesting sea turtles (FWS, 2008). For sea turtles, hard structures can lead to loss of access to suitable nesting area, abandonment of nests, and interfere with proper nest cavity construction and covering.

### 2.2.2 Indirect Biological Impacts

Areas that construct terminal groins in North Carolina will also have to undergo a subsequent beach fill project. There will be biophysical impacts that must be assessed (NC SL 2011-387). Beach nourishment can lead to increased water turbidity, burial of invertebrates, changes in nutrient cycling, and sorting out of shell fragments (Peterson & Manning, 2001; Smith et al., 2002; USACE, 2001). Typically, sediment on nourished beaches is more compact, and nourished beaches are wetter and warmer than un-nourished beaches. This can cause changes in composition of organisms, a decrease in organism abundance and nesting capability, and increase the occurrence of false crawls in sea turtles (Avissar, 2006; Hackney *et al.*, 1996; Hayden and Dolan, 1974; Peterson *et al.*, 2006; Reilly and Bellis, 1983; Rumbold *et al.*, 2001; Smith *et al.*, 2002)

Few studies have reported the impacts repeated beach nourishment over a period of decades has on marine organisms. In Delaware Bay, beach nourishment created a habitat unsuitable for horseshoe crab nesting due to differences in sand color and grain sizes from the original beach (Avissar, 2006; Smith *et al.*, 2002). In Florida, studies indicate that beach nourishment increases the number of false crawls and decreases the number of sea turtle nests in the season following the nourishment project (Rumbold *et al.*, 2001). Brock *et al.*, (2009)
reported a 600% increase in hatchling disorientation of loggerhead sea turtles from beachfront lighting in the season following a beach nourishment project. This is of particular importance since loggerhead sea turtles are native to North Carolina beaches.

While no long-term effects of beach nourishment have been found for surf zone fishes, studies have found impacts on both mole crabs (*Emerita talpoida*) (Hackney *et al*., 1996; Hayden and Dolan, 1974; Peterson *et al*., 2006; Reilly and Bellis, 1983) and coquina clams (*Donax* sp.), (Hackney *et al*., 1996; Peterson *et al*., 2006; Reilly and Bellis, 1983) which are common food sources for surf zone fishes. The greatest impacts to *Emerita* and *Donax* occur during the nourishment project itself (Hackney *et al*., 1996; Peterson *et al*., 2006). Population recovery can vary from one month to over a year, with re-population mostly coming from new larval recruits (Reilly and Bellis, 1983). This causes a decrease in biomass, which could have long-term impacts that propagate up through the food chain.

### 2.2 Human Impacts

In 2003 it was estimated that 153 million people lived in coastal counties of the United States (Crossett *et al*., 2004). Population density of coastal counties averages over 300 people per square mile, and 50% of the US population lives within a half hour of the coast. In addition, fourteen of the twenty largest cities in the US are located within the coastal zone.

The North Carolina coastline includes over 300 miles of barrier beaches, and over 3,000 miles of estuarine shoreline (Figure 1). The twenty coastal counties are home to almost 1 million people, or 10% of North Carolina’s resident population (US Census, 2010). The cumulative property value of homes in these coastal areas totals several billions of dollars.

** Insert Figure**
While coastal towns and counties generate a large portion of their revenue from property tax, not all properties are at risk or would benefit from the construction of a terminal groin (Coburn, 2011). The loss of all 1,983 properties in the 30-year risk areas of North Carolina would result in a loss of ad valorem tax revenue of about $7 million per year. This impact is even less when only properties imminently at risk from erosion at inlets are considered. Imminent Risk Properties (IRPs) properties are defined as those with sandbag protection or those located between two sandbag locations. Currently in North Carolina, there are 204 IRPs which, combined, generate less than half a million dollars per year in ad valorem tax revenue.

Another factor that must be considered is tourism, which is a major industry for North Carolina. In 2009, North Carolina had over 170,000 homes used primarily for second homes, which generated $1.9 billion in economic activity for the state (Dept. of Commerce, 2009). Tourism was ranked as the 7th largest industry in the state, providing 212,291 jobs in 2008. In coastal counties, over 11 million tourists visit each year, creating over 30,000 jobs, and over $100 million in local tax revenues (Dept. of Commerce, 2010).

Because of the value the coastal area and tourism provide to both state and local governments, when homes and businesses along the coast are threatened, it is only natural to want to protect them. This is the case on Bald Head Island, North Topsail Beach, Ocean Isle Beach, Holden Beach, and Figure Eight Island, where several homes are in danger of falling into the ocean due to inlet erosion (McGrath, 2010) (Figure 2). Currently, Holden Beach, Beach, Ocean Isle Beach, Bald Head Island, and Figure Eight Island are actively involved in the application process to build a terminal groin to protect these properties (Queram, 2012).
Figure 2: Beaches currently considering terminal groins. All images taken from Google Maps on December 9, 2011.
2.3 Summary of the Pros and Cons of Terminal Groins

Terminal groins offer a permanent solution to erosion problems many beachfront property owners along inlets in North Carolina are facing. Terminal groins could decrease the nourishment interval, reducing the costs of beach management for beach towns (NCBIWA), as well as decreasing the dredging interval of the inlet by stabilizing it and preventing shoaling of sand in the inlet (NCBIWA; CRC, 2011).

On the other hand, terminal groins prevent natural barrier island processes such as sand migration, overwash, and inlet migration, which are necessary for the successful development and movement of a barrier island, and lead to an overall narrowing of the barrier island (CRC,
Terminal groins are not a solution to beach nourishment projects, and coastal towns will have to continue to fund beach nourishment projects in addition to the expense of constructing a terminal groin (ASPBA, 2008). While terminal groins can allow for sand accretion at an inlet, they can also cause erosion problems further down the beach, alter currents, and change wave patterns along the beach (CRC, 2011).

Placement of the terminal groin results in the alteration of the bottom habitat from a soft, sandy bottom to a hard bottom habitat (CRC, 2011). While this can allow new species to colonize the area, this type of habitat is not native to North Carolina and can allow for invasive species to populate the nearshore system. Terminal groins can also cause a change in composition of invertebrates (USACE, 1984), leads to a loss of habitat for seabirds, and prevent access to suitable nesting areas for sea turtles (FWS, 2008).

Experts such as Orrin Pilkey (Duke University), Stan Riggs (East Carolina University), and Andy Coburn (Western Carolina University – Program for the Study of Developed Shorelines) have spoken against the use of terminal groins along the coast of North Carolina. In a 2011 paper, Coburn conducted a fiscal analysis of terminal groins and found that the long-term costs outweigh the potential long-term benefits of a terminal groin at all inlets in North Carolina. A 2011 news article by Young and Pilkey states that while terminal groins may benefit a few property owners, they can also adversely impact property owners further down the beach (Young and Pilkey, 2011). Finally, over 40 scientists from around the world signed a position paper published by the Program for the Study of Developed Shorelines against the use of terminal groins (PSDS, 2011).
3. Lessons from other states

3.1 New Jersey

The state of New Jersey consists of over 1,700 miles of coastline, including 125 miles of open-ocean, and 90% of New Jersey’s residents live in coastal counties (Bernd-Cohen and Gordon, 1999). Because of this, New Jersey was already involved in coastal management before the passage of the CZMA in 1972. They passed the Wetlands Act in 1970 and the Coastal Area Facility Review Act in 1973. After the passage of the CZMA, New Jersey created a state based approach to coastal management by creating their Coastal Management Program, which was officially approved by the Federal government in 1978 (NJ DEP, 2007).

3.1.1 New Jersey Coastal Management Laws

The goal of the Coastal Management Program is to better monitor the coastal ecosystems of New Jersey as a whole (NJ DEP, 2007). It integrates all coastal laws in the state, including the main three: the Wetlands Act of 1970, the Coastal Area Facility Review Act (CAFRA), and the Waterfront Development Law. The Wetlands Act of 1970 regulates development, dredging, altering, and polluting of the estuarine zone in order to prevent deterioration and preserve its ecological balance (NJSA 13:9A), while the Waterfront Development Law regulates development of all waterfront and navigable waters in the state (NJSA 12:5-3).

Compared with the previous two laws, CAFRA is a much more comprehensive regulatory act. It designates the bays, harbors, sounds, wetlands, inlets, tidal areas, and barrier beaches as the coastal area, and creates guidelines to regulate development in these areas in order to both preserve fragile ecosystems and encourage economic development (NJSA 13:19). CAFRA requires permits to develop new structures that are at least 150 feet landward of the mean high water line, but does not require permits to reconstruct a dwelling that is destroyed by
a storm or fire, or to construct patios, decks, or additions that do not increase the footprint of the
development. In order to be granted a permit, the proposed construction must conform with air
and water quality standards, provide for disposal of solid waste, result in a minimal impact to
existing water supplies, result in minimal interference with the natural inhabitants of the region,
must not impair public health or safety, and must result in minimal degradation of unique or
irreplaceable lands, historical or archeological areas, and existing public scenic attributes at the
site and within the surrounding region.

In addition to permitting requirements for construction, CAFRA creates several programs
to maintain the beaches in the state. The first program is the Shore Protection Fund, which
designates money to complete stabilization, restoration, and maintenance projects. A second
program is the “Adopt a Beach” program, which encourages citizens and groups to sponsor a
beach for cleanup efforts. In order to ensure successful beach management for future
generations, CAFRA also creates provisions to promote educational programs related to barrier
beaches.

3.1.2 Enforcement

In order to implement and enforce state laws regarding coastal management, New Jersey
has created several enforceable policies. They include the Coastal Zone Management rules
(NJAC 7:7E), which create standards for the use and development of resources in the coastal
zone, and the Coastal Permit Program rules (NJAC 7:7), which established review procedures for
permit applications and appeals from permit decisions.

3.1.2 Shoreline Structuring Policies

While New Jersey prefers to utilize non-hardened solutions to mitigate shoreline erosion,
hard structures are allowed, provided that a permit is granted (NJSA 13:19). Structures in place
prior to 1981 are exempt from the permitting requirement when conducting repairs, replacements, or renovations (NJSA 12:5-3). In order to construct a hard structure along the beach five conditions must be met: The structure is necessary to protect public beach areas or infrastructure along the developed shoreline from erosion, the structure will not adversely impact the local shoreline sand supply, the structure will not impact downshore sand movement, the structure will cause a minimum impact to living marine and estuarine resources, and the structure is consistent with the state’s Shore Protection Master Plan (NJAC 7:7E-7.11). In addition, the state authorizes the use of rip-rap or sandbags for up to 90 days following a storm (NJAC 7:7E-3A.3).

3.1.3 Impacts and Lessons

While Cape May, NJ may have been the location that started the American tradition of the yearly summer trip to the beach (Cape May, 2011), today it is the location for innovative beach engineering methods such as “back-passing” during nourishment to create a gentler beach slope (Degener, 2011), a new breakwater called a Beachsaver Reef, and a Double-T sill across the ends of the groins to decrease erosion (Giovannozzi et al., 2003).

The entire coastline of New Jersey, with the exception of the Gateway National Recreation Area, Sandy Hook spit, and Island Beach State Park, is considered highly developed (Hall and Pilkey, 1991). In order to protect these properties, New Jersey has a history of shoreline stabilization dating back to 1870, which is the longest history of shoreline stabilization in the US (Pilkey and Wright, 1988). It is estimated that 50% of New Jersey’s coast uses some form of armoring, including over five miles of seawalls and revetments and over 350 groins (Hall and Pilkey, 1991). In addition, six of the eleven inlets in the state are held in place by rock jetties.
Many of the groins in place along New Jersey’s coast were constructed between the early 1900’s and the 1960’s (Donohue et al., 2004). These groins range in length from under 100 feet to some that are over 500 feet in length. New Jersey has recognized the detrimental effects that groins have had on their coast and, in 1989, began a Beach Erosion Control Project between Sandy Hook and Manasquan Inlet. It was determined that groins over 400 feet in length would prevent the longshore movement of sand, severely limiting the lifetime of the planned beach nourishment project. Since the cost was too high to completely remove the groins, notches were cut in them instead to allow for the longshore transport of sediment along these beaches. This project has been successful in prolonging the interval between beach nourishment projects.

On the other hand, in 2004 New Jersey began the construction of two sea walls, totaling 2.2 miles in length, in the towns of Avalon and North Wildwood, in addition to a beach nourishment project, and habitat restoration (USACE, 2011). While the initial project proposal included nourishment at three-year intervals, the second nourishment cycle has not been completed due to a lack of funding. Both seawalls have been constructed.

Currently, New Jersey still tends to rely on hard structures or a combination of hard structures and beach nourishment to maintain their beaches. They have recently completed thirty-one coastal engineering projects, including both oceanfront and estuarine shorelines (NJDEP, 2011). Sixteen of these projects consisted of the construction or repair of hard structures and five were beach nourishment projects. New Jersey is in the process of reviewing or constructing sixteen new coastal engineering projects, four of which include the use of hard structures, and two of which are beach nourishment projects (NJDEP, 2012).
3.2 Florida

Florida has over 1,000 miles of open ocean coastline (Bernd-Cohen and Gordon, 1999), including 780 miles of sandy beaches along both the Atlantic Ocean and the Gulf of Mexico (Florida State of the Coast Report, 1998). Of the nineteen million residents, 57% live within ten miles of the coast. After the passage of the CZMA, Florida created the Coastal Management Program to coordinate state and federal activities, and protect their coastal resources (NOAA, 2011b). This program was approved by NOAA in 1981, and is managed by Florida’s Department of Environmental Protection.

3.2.1 Florida Coastal Management Laws

Florida’s Coastal Management Act (FS 380 Part II) establishes the Coastal Management Program and defines the role the Department of Environmental Protection will play in implementing and enforcing the Coastal Management Program. Under this law, local governments adjacent to the Gulf of Mexico or the Atlantic Ocean, or places where the waters contain marine plants or animals can receive assistance from the state to prepare coastal zone protection elements. Today, Florida’s Coastal Management Program works to implement twenty-four separate statutes that regulate coastal resources in the state (FL DEP, 2012).

Of these twenty-four statutes, there are four main statutes that regulate activities on the beaches and coasts. They are the Water Resources Plan (FS 373) which regulates water use and management, FS 258 which provides a framework to establish, regulate, and manage state parks, including aquatic preserves, FS 253 which designates uses and regulations for public submerged lands, including mineral rights, and FS 161 which consists of the Beach and Shore Preservation Act, the Coastal Zone Protection Act of 1985, and the Oceans and Coastal Resources Act.
The Beach and Shore Preservation Act created guidelines to reduce erosion and restore critically eroded beaches in the state. It established permitting standards for coastal stabilization construction activities require a permit (§161.041), authorized the collection of fees and fines for permits and permit violations (§161.0535-.054), and created a project approval process (§161.161). It also provided an inlet management strategy (§161.142-.143) and gives the DEP authorization to require dredging spoil to be placed on the beaches as beach nourishment sand (§161.042).

Under this Act, a setback line of 50 feet behind the mean high water line is established, with exceptions for existing structures and those along a vegetated coast (§161.052). In order to ensure the preservation of the beach/dune system, a coastal construction control line (CCCL) equal to a 100-year storm event was established on coastal barrier beaches in the state, except in locations were armoring is used (§161.053). Guidelines for both coastal armoring projects (§161.085) as well as beach nourishment projects are designated, including a state developed maintenance strategy and funding from local governments to carry out beach nourishment projects (§161.088, §161.091, §161.101).

Part II of the Beach and Shore Preservation Act established beach and shore preservation districts within each county (§161.25). Authority was given to the county board of commissioners to initiate projects, carry out projects, and use county funds to carry out projects (§161.26). Counties are also authorized to create comprehensive beach and shoreline preservation plans (§161.28), including an economic analysis of the proposed plan to determine overall feasibility (§161.29). Efforts must be made to ensure consistency and coordination between districts in the county (§161.34).
The Coastal Zone Protection Act of 1985 was created to control development in coastal areas in order to minimize damage to the environment and impacts from storm events. This Act designates the coastal building zone as the area between the seasonal high water line and 5,000 feet landward, requires that all construction maintain public beach access in these areas, and regulates the use of vehicles on the beach (§161.58).

The Ocean and Coastal Resources Act outlines the selection and responsibilities of the Oceans and Coastal Council, which was created to assist the state with management of ocean and coastal resources and to help the state maximize receipt of federal funds for ocean and coastal resource projects.

3.2.2 Enforcement

In order to implement and enforce state laws regarding coastal management, Florida has created several enforceable policies. They include the Rules and Procedures for Coastal Construction and Excavation (FAC 62B-33), which established the rules and permitting procedures for coastal construction activities in front of the CCCL and the fifty-foot setback, FAC 62B-34, which establishes general permitting procedures and requirements for any construction in front of the CCCL, the general rules for coastal construction permits (FAC 62B-41), and the rules and procedures for using geo-textile dune cores in dune restoration projects (FAC 62B-56).

3.2.3 Shoreline Structuring Policies

Florida outlines their coastal armoring policy under the Florida Beach and Shore Preservation Act (FS 161). Permits for hard structures may be granted under §161.085 to protect public or private structures at risk from storm damage, for future construction of hard structures where coastal changes could leave upland properties vulnerable to damage, and to connect
current hard structures, provided the overall length does not exceed 250 feet. Temporary use of hard structures is allowed for a period of 60 days, up to a maximum of 90 days, to mitigate impacts from a storm. Provisions are also included to remove hard structures determined to be unnecessary or those interfering with beach nourishment projects.

In order to protect coastal beaches and barrier dunes, which are subject to frequent and severe fluctuations, FS §161.053 established CCCLs. These lines are set equal to the predicted erosion from a 100-year storm surge and control the type and location of structures in the coastal zone (Dean, 2012). Structures in front of the CCCL that are protected by armoring capable of withstanding a 100-year storm may be permitted, but new structures not protected by armor or new hard structures are prohibited under this section (FS §161.053). Exceptions are made if there is an existing line of properties in front of the CCCL and there is no evidence of significant erosion on that portion of the beach, which allows many single-family dwellings to be constructed (Clark, 2012)

FAC 62B-33.0051 lays out sitting, construction and design criteria for any hard structure. Under this code, eligible structures must prove vulnerability using the dune erosion model in the University of Florida Report, “Erosion due to High Frequency Storm Events.” If the structure is not considered vulnerable under this model, the applicant can use erosion rates, natural physical features, and existing man-made structures to prove vulnerability under the following circumstances: the eligible structure will become eligible in the future, some of the eligible structures are vulnerable, and armoring of them would cause adjacent structures to become vulnerable, the structure would be at risk of collapse from erosion from a 15-year storm, or there is adjacent armoring that does not exceed 250 feet in length (FAC 62B-33.0051).
Hard structures must be placed as far landward as possible without resulting in destabilization of the beach or dune system, interfering with beach or dune stabilization of adjacent properties, or interfering with public beach access (FAC 62B-33.0051). Design of hard structures must minimize adverse impacts to the beach, adjacent properties, public assess to the beach, and marine turtle habitats and remain stable for a 50-year storm event. Construction is prohibited during turtle nesting season.

In the case of a coastal storm that causes structures to become endangered or vulnerable due to erosion, the government may take measure to protect the structures, or issue permits allowing for the protection of private structures (FAC 62B-33.0051). Emergency protection actions must be taken within 30 days of the event, and can be extended for an additional 30 days. Protection in this case must be minimum, to only prevent the collapse of a structure, and must facilitate removal. All structures must be removed within 60 days of installation. Temporary structures or emergency repair to existing structures have been allowed during sea turtle nesting season, so long as adequate protection measures were taken (Clark, 2012)

Under FAC 62B-41, coastal construction must not interfere with the public’s access to the beach, unless it is unavoidable to protect the beach or upland structure. Structures cannot interfere with the natural longshore and onshore/offshore movement of sediment, unless the applicant can prove that the construction will result in a net benefit to the beach and not result in a taking of marine turtles. Coastal armoring is only allowed under this code as a last resort to protect a structure at risk from a 5-year storm event and all other alternatives are not economically or physical practical. If the proposed structure will interfere with public beach access, an alternative means of access must be provided. Provisions are also included to modify, move landward, or remove existing structures if they are found to interfere with the natural
movement of sand. Coastal armoring is prohibited in federally designated critical habitat for marine turtles and in the Archie Carr National Wildlife Refuge.

3.2.3 Impacts

Where New Jersey has embraced coastal armoring to protect private properties, Florida has moved away from coastal armoring in favor of beach nourishment. There is no clear estimate of the amount of armoring along Florida’s coasts, but estimates place it anywhere between 70% (Dean, 2012) and 95% (Bush et al., 2004). Most of the armoring in place was constructed prior to the 1970’s when the beach nourishment program began (Dean, 2012).

With the establishment of a setback equal to the 30-year erosion projection in areas with an established CCCL in 1985, Florida began to move even further away from a policy of shoreline armoring towards a policy of beach nourishment (Ruppert, 2008). Since the 1980’s, Florida has carried out over 140 beach nourishment projects, which is the most along the Atlantic and Gulf Coasts in the US (Ruppert, 2008). Over the past decade 70 beach nourishment projects were permitted, and there are currently about 25 beach nourishment projects in the permitting phase (FL DEP, 2011). These projects are a combination of large-scale, community projects and small-scale projects funded by a development or property owner.

This trend has been coupled with an overall decline in the number of coastal armoring permits throughout the state. In the past decade, about 20 armoring projects were permitted, most of which were to repair or modify existing structures (FL DEP, 2011). The majority of the armoring projects were part of a larger project that included beach nourishment. While coastal armoring permit applications have declined, there has been an increase in the overall length of the hard structure applied for due to multiple property owners applying for one structure and permits to fill in gaps of already established structures (Ruppert, 2008).
A few permits have also been granted to remove projects considered damaging to the coastline or contributing to the erosion process (Dean, 2012). Over the past decade there was only one permit issued for the removal of a hard structure (FL DEP, 2011). With that being said, many of the structures in place have deteriorated with time or are required to be kept covered with sand (Dean, 2012). There are also a few pending permits to convert a temporary erosion control structure into a permanent one (FL DEP, 2011).

Not all permits for beach structuring are granted. Some of the pending permits have been in the permitting phase for over five years. A recent project to construct eleven breakwaters in Palm Beach County was eventually withdrawn due to concern about impacts to sea turtle nesting (Sorentrue, 2012). This plan was later modified to construct a series of groins off the coast, but was rejected in February of 2012 (Sorentrue and Valdes, 2012).

While the state of Florida does not have specific policies in place to ban the use of coastal armoring, several counties have stricter guidelines than the state. A law passed in 2008 in Sarasota County, Florida creates a virtual ban on the construction of seawalls by requiring property owners to prove that the seawall would not cause erosion damage to adjacent property owners (Sword, 2008).

### 3.3 Lessons

The key take-away message from New Jersey’s beaches for North Carolina is that it is much harder to undo beach hardening than it is to allow it in the first place. Even though the state has tried to shift its policy towards beach nourishment, New Jersey is still known for, and continues to repair and construct hardened shorelines. A similar take-away message comes from Florida, where they have tried to stop the use of hard structures in favor of beach nourishment. Even though few new hard structures are permitted, the amount of nourishment necessary to curb
the extensive erosion along their beaches to combat decades of damage caused by armoring is testimony that the impacts from coastal armoring never end. North Carolina needs to take these lessons to heart and take the time to create a long-term plan for its beaches before moving forward with terminal groins. As seen here, once the door is opened for hard structures, it is much harder to close it again.

Compared to New Jersey and Florida, North Carolina is faced with a much less difficult challenge of planning for sea level rise impacts on the coastal population. Only 10% of North Carolina’s population lives in coastal counties, compared to 90% in New Jersey and 57% in Florida. This difference will allow North Carolina to be much more flexible with their coastal management plans.

Every year Dr. Stephen Leatherman releases his annual report of the top ten beaches in America. In order to make the top ten list, beaches are ranked on a scale of one to five for 50 different criteria. Some of the criteria include factors such as water temperature and safety, but others include sand texture, development, beach width, and presence of wildlife, vegetation, and coastal armoring. One of the main benefits for a beach to make the top ten list is the increase in tourism that beach will experience the following year.

North Carolina’s beaches regularly make the top ten list. Last year, Cape Hatteras was ranked number five (Lowman, 2011), and in 2007 Ocracoke Island was ranked as number one (Dosier, 2007). North Carolina needs to remember why their beaches are ranked among the best in the country, and focus on modeling the rest of their coast after these beaches.
4. Analysis of Policy Alternatives

In the current situation, North Carolina has several options to deal with terminal groins, which would either result in continuation of current policy to allow terminal groins, or to prohibit construction. The first would be the option of no action: to allow the permitting process to take its course for beaches desiring to construct terminal groins to protect property. A second option would be for the CRC to require coastal communities wishing to utilize terminal groins to revise their land use plan to incorporate long term plans for sea level rise. The third option would be to amend CAMA to utilize rolling easements. A fourth option would be to incorporate the revised inlet hazard areas into AEC’s. A fifth option would be for coastal towns to divert funding from terminal groin construction and beach nourishment at inlets into a property buy-out program. A sixth, and final option would be to relocate properties in danger. Given the level of development on North Carolina beaches, this option is most likely not viable.

4.1 No Action

The first option North Carolina can take when dealing with terminal groins is the option of allowing the permitting process for terminal groins to take its course, and those who can meet the requirements may construct a terminal groin. While many people who are against terminal groins would argue against this action, there is also the view that terminal groins still may not become a reality due to the high cost, complex permitting process, and likely lawsuits (Pippin, 2011a; Pleti, 2012).

Since its passage in late June, beaches including North Topsail Beach, Holden Beach, Figure Eight Island, and Bald Head Island have already begun to move forward in the process (Holden Beach, 2011; Matson, 2011; Pippin, 2011b). They have notified the DCM of their interest in building a terminal groin, and have begun to consult with costal engineers to
determine cost and possible design. Recently, North Topsail Beach has decided to suspend their process in securing a terminal groin, and instead pursue inlet re-alignment and beach nourishment due since it could be completed within the year (Pleti, 2012).

4.2 Land Use Plan Revisions

It seems that the coastal communities interested in utilizing terminal groins as a method of preserving coastal properties are looking for the quick fix to their current problems, and not taking into consideration long-term implications of sea level rise. This could cause terminal groins to only be the first step in coastal armoring. As sea levels continue to rise, communities living in the present, and not planning for the future would be forced to rely on further stabilization measures such as groin fields, seawalls, and breakwaters to preserve properties.

In North Carolina sea levels are expected to rise by 0.38 to 1.4m (1.25-4.6ft) over the next century (NCDENR, 2010). In order to ensure that coastal communities are planning for future sea level rise impacts, communities interested in using terminal groins should be required under CAMA to create a 100-year land use plan, taking into consideration the greatest predicted sea level rise of 1.4m. While many coastal communities don’t want to acknowledge the threat of sea level rise, by creating a long-term plan to address possible impacts will allow for coastal communities to have a vision of how to shape their town over the next century, and what tools they want to use to adapt to changes.

4.3 Rolling Easements

The second option North Carolina has is to amend CAMA to require coastal counties to incorporate a policy of rolling easements into their land use plans. Rolling easements are a policy that allow for natural barrier island movement inland through inland migration of public trust lands (Peloso, 2010). This policy does not allow for coastal armoring to occur, but instead
requires property owners whose homes fall on public trust land to move elsewhere. This policy is currently used by Texas.

While this policy sounds great on paper, it is easier said than done. Under this option, as sea levels rise, more and more homes are lost along the beach, which could eventually lead to a significant undermining of the local tax base. Furthermore, beachfront property owners, some of whom have paid millions of dollars for their oceanfront home, are reluctant to relocate, and feel that the government has the burden to protect their property from loss to the sea.

4.4 Incorporate Inlet Hazard Areas into AEC’s

A third option for North Carolina would be to incorporate the revised inlet hazard areas into CAMA’s AEC’s. In 2010 the DCM finished updating their inlet hazard area maps, which redefined the current inlet hazard areas (DCM, 2010). This data has not been incorporated into CAMA’s rules and policies, which currently regulate inlet development based on data from 30 years ago. Under the new inlet hazard area maps, homes currently in danger would fall into an inlet hazard area (Figure 2).

While this would designate these areas as AEC’s, CAMA currently still allows limited development in these areas. Structures must follow setback rules and locate structures behind the first line of stable vegetation, and density is limited to one unit per 15,000 square feet (15A NCAC 07H .0310). In order to prevent the need for terminal groins, new building should be prohibited in these areas. Current structures could be grandfathered in, but prohibited from rebuilding if a major storm destroys the property.
Figure 2: New Inlet Hazard Area Maps
4.5 Community Buy-Out Programs

A fifth option of North Carolina towns would be to take some of the funding set aside for beach nourishment projects at inlets and for a potential terminal groin and create a buy-out program where interested property owners could sell their property back to the town before it is destroyed. Construction and maintenance costs of a terminal groin over its lifetime would be far greater than the revenue coastal municipalities and counties would generate from these at-risk properties (Coburn, 2011).

If a buy-out program were created, communities would be under no obligation to protect these properties in imminent danger, and would only have to pay the value of the homes that are interested in selling. This would save the town both time and money by eliminating the need to
undergo the lengthy terminal groin permitting and construction process, and the subsequent beach nourishment and maintenance.

4. Recommendation of Best Alternative

In a perfect world, North Carolina would never have allowed the extent of coastal development that has occurred along their beaches, and, short of prohibiting all coastal development, would have restricted development to the sound side of the island, far from inlets. But this didn’t happen, and now homes are threatened by beach erosion and inlet migration and North Carolina is faced with a decision of what action to take. The people of these communities do not want to abandon their homes and see their communities begin the process of retreat. By examining the physical, biological, and human impacts the construction of terminal groins will have, there isn’t one clear best option for North Carolina to take - their best option would be a combination of the above solutions.

Since any alternative to allowing the terminal groin permitting process to move forward would require either the action of the legislature or the CRC, neither of which seems imminently likely, the evaluation and permitting process will most likely continue to move forward. Whether or not these communities will successfully secure financing to build a terminal groin and gain a permit allowing for its construction remains to be seen.

In the meantime, the CRC has the evidence it needs to begin to prepare for future sea level rise, and needs to ensure coastal towns are not just looking for a short-term fix to a long-term problem. Of the aforementioned policy alternatives, options two, four, and five seem most likely to be implemented, and implementation of all three would be the most appropriate course of action for North Carolina to take.
By implementing option two, the 100-year land use plan, coastal communities would be able to create a vision for their community. They would be required to decide if they believe sea level rise will occur, and what steps they want to take should it occur. Long-term solutions to coastal erosion would have to be found, but each community would be allowed to decide for itself what that solution should be.

While option four, restrict building in Inlet Hazard Areas, does not have the long-term impacts that option two would, it would successfully curb building at the most dynamic part of the beach, and provide a means to remove current properties from these vulnerable locations. This option alone most likely wouldn’t stop current residents from wanting a terminal groin to protect their properties, but might cause towns to be unwilling to fund a terminal groin since the next storm event could remove the need for the terminal groin entirely.

By implementing option five (community buy-out of imminent risk properties), in conjunction with options two and four, coastal governments would essentially be able to reduce their financial obligation to protect coastal properties, and justify not pursuing a terminal groin. While many property owners would most likely initially oppose this movement, it would give them the opportunity to recoup at least some of their financial investment, and would prevent them from losing their property outright to a storm or sea-level rise.

Unfortunately, the world is not perfect, and North Carolina is no exception. Because of past decisions to allow development on unstable land, tough decisions must be made, and when people’s homes and the economy are involved, those decisions only get harder. By taking steps to plan for future land use, North Carolina has a chance to positively impact both the economy and the environment.
References

American Beach and Shore Preservation Association (ABSPA). 2008. Terminal groins at coastal

Avissar, N. 2006. Modeling potential impacts of beach replenishment on Horseshoe crab
nesting habitat sustainability. Coastal Management 34:427-441.

beaches, dunes, bluffs, and rock shores. Coastal Management 27:187-217

Brock, K., J. Reece, and L. Ehrhart. 2009. The effects of artificial beach nourishment on marine
turtles: differences between Loggerhead and Green turtles. Restoration Ecology 17: 297
to 307.

Florida’s Atlantic Beaches: Coastal Hazards from Amelia Island to Key West. Duke
University Press, Durham, North Carolina, USA.

Cape May. 2011. History of Cape May, New Jersey. Available online at

Clark, R. 2012. Senior Coastal Engineer for Florida Department of the Environment. Personal

Available online at http://coastalcare.org/2011/01/a-fiscal-analysis-of-shifting-inlets-and-

Coppola, H. 2011. Environmental land use planning and integrated management at the river

Oceanic and Atmospheric Administration.

Dean, C. 1999. Against the tide: the battle for America’s beaches. Columbia University
Press, New York, New York, USA.

Dean, R. and S. Malakar. 1995. Erosion due to high frequency storm events (18 selected coastal
counties of Florida: user’s manual),” UFL/COEL-95/028, Coastal and Oceanographic
Engineering Department, University of Florida, Gainesville, FL.

Dean, R. 2012. Professor Emeritus at University of Florida. Personal Communication on March
20, 2012.


Florida Administrative Code. 62B-33, 34, 41, and 56.


Florida Statutes. 2011. Chapter 161, Chapter 253, Chapter 238, Chapter 373, and Chapter 380, Part II.


New Jersey Coastal Permit Program Rules. New Jersey Administrative Code Title 7 Chapter 7

New Jersey Coastal Zone Management Rules. New Jersey Administrative Code Title 7. Chapter 7E


New Jersey Waterfront Development Act. New Jersey Statutes Annotated 12:5-3

New Jersey Wetlands Act. New Jersey Statutes Annotated 13:9A


North Carolina Coastal Area Management Act (CAMA). North Carolina General Statutes Article Seven §113A-100 to §113A-134.4


North Carolina General Assembly. 2007. Senate Bill 599.


U.S. Army Corps of Engineers (M. Burlas et al.). 2001. The New York District’s Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Waterways Experiment Station Final Report.

United States Census. 2010. Factfinder2.census.gov


