

Master's Project

Stakeholder Analysis Regarding Coastal Residents' Opinions, Perceptions and Knowledge of
Terminal Groins in North Carolina

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Executive Summary

Terminal groin usage in North Carolina is a contentious issue amongst coastal managers, homeowners, and policymakers. My research shows that this issue consists of a mixture of cultural, political, economic, and historical factors that all impact opinions on whether or not terminal groins should be implemented. As part of my project, coastal residents were surveyed on their knowledge of terminal groins including:

- 1) where and how terminal groins were used
- 2) their perceptions on terminal groin effectiveness
- 3) their view of what impacts might be seen if terminal groins were used
- 4) their stance on terminal groin usage

North Carolina's historical stance prevented the use of any shoreline hardening devices, such as terminal groins (Learn NC, March 2015). However, a policy shift in 2011 allowed for four pilot sites along the North Carolina coast (Senate Bill 110 and Division of Coastal Management, March, 2015). Amongst the four pilot sites, one site was permitted and is in the process of building their groin, while two others are in the beginning stages of permitting (Army Corp of Engineers-Wilmington Office, March, 2015). The fourth site has been embroiled in a continuous debate and has not progressed on the project (North Carolina Coastal Federation, 2015). None of the sites have been studied to measure their effectiveness or their impacts (positive or negative). In 2015, two new, additional terminal groin sites were announced, allowing for six sites to be permitted versus the originally agreed upon four (Dewitt, 2015).

With the potential for terminal groin usage expanding and a potential policy shift in coastal management on the horizon, it is important to find out what coastal residents think about terminal groins. The use of terminal groins has the potential to affect coastal residents in many ways including economically, socially, and environmentally. Therefore, coastal residents' understanding of and opinion of terminal groins in general, their opinion on their effectiveness, and how they feel about their usage needs to be analyzed. A stakeholder analysis was performed asking questions that focused on gauging coastal residents' knowledge of terminal groins' function and structure, their potential impacts, and they were asked toward what direction they

wanted to see North Carolina move, hardening methods or other methods. Using the information gained from my analysis, policymakers have a more detailed view of coastal resident's opinions' which they can use to derive their own opinions and policies. Non-governmental organizations have access to surveyed residents opinions and can identify knowledge gaps, which could influence how they discuss and approach the terminal groin issue.

Methods used in the stakeholder analysis included semi-structured interviews with policymakers at the state and town level as well as with coastal homeowners. Another method that was used was an online survey that was aimed at coastal residents in nine North Carolina counties. I conducted my analysis using NVivo and Qualtrics. This report gives an overview of the results from both the interviews and the survey.

The first section of my report provides an overview of the history of North Carolina coastal processes and barrier islands as well as an overview of the policy framework impacting North Carolina terminal groin usage. The second section provides a description of my project's objectives, reasons why stakeholder analyses are such a necessary component of policy decision making, the hypotheses being tested and a more complete description of the methodology. The final section describes, in detail, the results of both the interviews and the survey, as well as a discussion of what these results indicate.

A quick synopsis of my conclusions are included here: Coastal residents are more aware of the topic than expected but they are split on their effectiveness, split on whether or not they want to move towards using terminal groins, and have mixed opinions on their impacts. Policymakers are equally split and express frustration regarding how the topic is discussed and perceived. There is no consistent reason for terminal groin usage as that differs by region and the rationale for interviewee stances depends on whether or not they view the beach as natural. Areas of agreement amongst both homeowner and policymaker interviewees include the need for site specific usage if terminal groins are used, a need for comprehensive scientific study before they are considered, and the desire to not see them used willy-nilly.

While my initial project intended only looking at coastal residents' perceptions and knowledge of terminal groins, throughout the study, various policymakers made recommendations on how to make coastal management more effective in general and also included suggestions on what needs

to happen regarding future decisions regarding terminal groins. These recommendations are listed below:

- (1) Governmental and non-governmental agencies need to educate the public on coastal processes, especially potential future homeowners, so they understand erosion, hazard zones, and sand movement thus enabling informed decision making when investing
- (2) Policymakers and other interested parties need to change and/or clarify the terminal groin debate so the conversation is clearly and solely about terminal groins and their purposes versus groins in general
- (3) Real estate agents, insurance personal, and homeowners need to hold honest conversations about the risk involved in living on the coast
- (4) State lawmakers need to clarify what the state is willing to do regarding coastal management including funding for management efforts, their willingness to use various methods of beach stabilization, and clarify the goals of beach management so that coastal managers are working with defined goals
- (5) Scientists and policymakers need to ensure that updated modeling tools are used by the Army Corps of Engineers for more accurate results and/or make getting approval to use other modeling tools easier
- (6) The Army Core of Engineers and the Coastal Management Division needs to ensure that oceanographers are included in the design stage of terminal groins, working alongside the engineers
- (7) Amongst all parties involved it is important to be aware that the topic of terminal groins is not just a financial conversation, it also involves peoples' way of life and that is just as important.
- (8) The last recommendation was for North Carolina to really discuss and decide what to do regarding re-building if/when an area is destroyed. This discussion needs to be held at all levels (town, county, and state) but particularly by state lawmakers.

Table of Contents

Overview.....	6
Introduction to North Carolina Barrier Islands.....	6-8
Policy Background.....	8-11
Literature Review.....	12-13
Purpose of Study/Research Goals.....	13-16
Methodology.....	17-20
Results	
Demographics.....	20-21
Previous Knowledge of Terminal Groins.....	22
Knowledge of Terminal Groins.....	22-23
Yes Respondent Data.....	24-30
No Respondent Data.....	31-35
Interviews	35-56
Discussion.....	56-61
Conclusion.....	61-62
Reference.....	63-64
Appendices.....	65-79

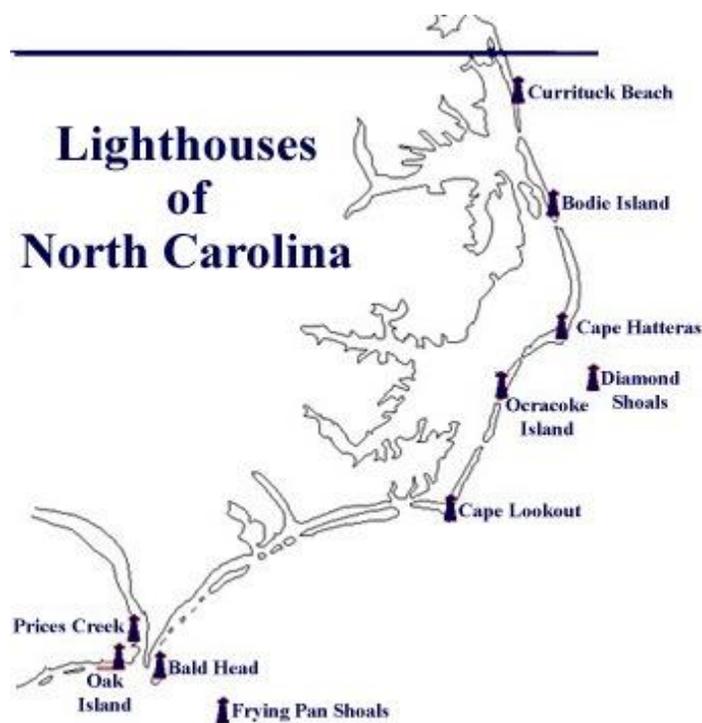
Overview

North Carolina is known worldwide for its beautiful beaches. The combination of sun, sand, wind, and waves brings residents and tourists back year after year (Learn NC, March 2015). One of the great attractions, North Carolina beaches, offer their natural and untamed feel.

Historically, North Carolina politicians have enacted policies to protect over 301 miles of islands and coastal areas (Learn NC, March 2015). However, a shift in policy, currently under consideration to allow the use of hard structures for shoreline stabilization, could lead to shoreline hardening and a shift in where and how sand moves along the North Carolina coast (Learn NC, March 2015).

Introduction to North Carolina Beaches

Located in the central portion of the United States Atlantic seaboard, North Carolina beaches are subdivided into two distinct zones due to their geometry and geologic processes.



Map from:
<http://www.columbus.k12.nc.us/carolina/light/>

A line drawn from Raleigh to Cape Lookout provides the dividing line between the southern coastal zone and the northern coastal zone (Riggs, et. al, 2011). The southern zone consists of

relatively steep sloping land surfaces when compared to the northern zone (Riggs, et. al, 2011). This steeper slope produces short barrier islands, hugging the mainland, which have produced narrow estuaries connected to the ocean by approximately 18 inlets (Riggs, et. al, 2011). The Northern Zone, due to its gentle slope, developed long barrier islands with broad and expansive estuaries located behind them (Riggs, et. al, 2011). Another condition of the Northern Zone is that there are only three major inlets and some inlets are ephemeral, opening and closing due to storm events (Riggs, et. al, 2011). These two coastal zones can be further divided into four coastal embayments (geological compartments) that are defined by the capes and the associated cape shoals. The geographic orientation of these embayments and their associated geometry determine the areas' waves and current dynamics, tidal characteristics, and their response to storm systems (Riggs, et. al., 2011). All of above conditions factor into sediment transport and erosion rates along the coast.

Barrier islands cover approximately 90% of North Carolina's coastline (Pilkey, et. al., 2004). Barrier islands are long bodies of unconsolidated sand that are separated from the mainland by an estuary, lagoon, or something similar (Pilkey, et. al., 2004). They are separated from the other barrier islands by inlets at both ends (Pilkey, et. al., 2004). Barrier islands can be either simple or complex barriers (Pilkey, et. al., 2004). Complex barrier islands have an abundant sand supply resulting in high and wide barrier segment, consisting of a series of beach ridges and swales with extensive dune fields (Pilkey, et. al., 2004). Simple barrier islands have a small supply of sand available resulting in low and narrow islands (Pilkey, et. al., 2004). They are dominated by inlets and overwash. About 70% of North Carolina's barrier islands are simple, 25% are complex, and the remaining, and 5% are headland beaches (Riggs, et. al., 2011). All barrier islands are responsive to the dynamic forces of wind, waves, sea level rise, and storm events, however, simple barrier islands tended to be more impacted by these processes (Pilkey, et. al., 2004).

Barrier islands, including North Carolina's, have a typical life cycle. Once a barrier island is formed it instantly begins eroding. Eroding is the natural way of island migration in response to environmental stimuli such as rising sea level. Island migration involves the retreat of the open ocean shoreline, the widening of the estuary/lagoon side of the island by overwash, and elevation of the central part of the island by overwash processes (Pilkey et. al, 2004). These three factors

eventually cause the island to move towards the mainland. If the rate of migration is fast enough the island can meet the mainland, which is what happened in Kure and Carolina Beach (Pilkey, et. al., 2004). Erosion of a barrier island is a natural process, however, this process becomes problematic when barrier islands are developed and the residents desire to stop or control island migration, in order to protect their way of life. The question becomes what measures are North Carolina citizens and policymakers willing to do to control this natural migration?

Previously, North Carolina towns and coastal residents facing beach erosion only had beach renourishment and/or sandbagging as an option to address the problem (North Carolina Coastal Resource Commission, 2015). Other states allowed for these methods but they also allowed for hard structures including terminal groins, groins, breakwaters, rickrack, and jetties (Knapp, 2012). The idea behind these structures are that they act to trap sand, preserving the beaches and towns/homes behind them (Hargrove, 2013).

Proponents of shoreline hardening argue that shoreline hardening is cheaper than beach renourishment (Knapp, 2012), less of an eyesore than sandbagging (Dean, 2009), that they offer protection for homes and town infrastructure (Hargrove, 2013), and that without this protection development will be negatively affected; resulting in a loss of revenue (Learn NC, May 2015). Opponents to shoreline hardening argue that hard structures increase erosion downstream, resulting in the need for further hardened structures (North Carolina Coastal Federation, May 2015). Also, they cite a NC Coastal Resource Commission report showing that hardened structures do not decrease the need for beach renourishment (NCCRC, 2010).

North Carolina Policy Background

Legal Framework

North Carolina's history of coastal management actually goes back the 1930-40's, when the Civilian Conservation Corps began a project aimed at controlling erosion in the Outer Banks (Pilkey, et. al., 2004). This effort involved creating a massive dune line that reached from the Virginia border to Ocracoke Island (Pilkey, et. al., 2004). These dunes were built with the intention of stopping erosion since the prevailing thought at the time was that the islands were eroding away. It was only later that scientists realized that they were migrating not disappearing (Pilkey, et. al., 2004).

In 1972, Congress authorized the Coastal Zone Management Act whose goal is to “preserve, protect, develop, and where possible, to restore or enhance the resources of the nation’s coastal zone.” (CZMA, retrieved January 2016).

In 1974, under the impetus of the CMZA, North Carolina developed their Coastal Area Management Act (CAMA, retrieved January 2016). The goals of CAMA include:

- “(1) To provide a management system capable of preserving and managing the natural ecological conditions of the estuarine system, the barrier dune system, and the beaches, so as to safeguard and perpetuate their natural productivity and their biological, economic and esthetic values
- (2) To insure that the development or preservation of the land and water resources of the coastal area proceeds in a manner consistent with the capability of the land and water for development, use, or preservation based on ecological considerations
- (3) To insure the orderly and balanced use and preservation of our coastal resources on behalf of the people of North Carolina and the nation” (CAMA, retrieved January 2016)

In order to achieve these goals, CAMA created the Coastal Resource Commission (CRC) and the Division of Coastal Management (DCM) (CRC, retrieved January 2016). The CRC is mandated to “establish policies for the N.C. Coastal Management Program and adopt implementing rules for both CAMA and the N.C. Dredge and Fill Act (CRC, retrieved January 2016). The commission designates areas of environmental concern, adopts rules and policies for coastal development within those areas, and certifies local land use plans.” (CRC, retrieved January 2016).

CAMA designated twenty counties as coastal, including counties with estuarine and ocean shore acreage, making them subject to CAMA regulations (Knapp, 2012). These coastal counties were then charged with developing their own coastal land use plans. These plans are subject to CAMA approval but once passed can be used to protect and preserve coastal resources (Knapp, 2012). It is within this legal framework that North Carolina’s coastal management has been implemented.

Policy Framework

Beginning in 1985, North Carolina banned hardened structures (jetties, groins, breakwaters, terminal groins and bulkheads) on the oceanfront, as they were not considered an appropriate way to stabilize the shoreline by the Coastal Resource Commission (Riggs, et. al., 2011). Instead, they opted to use beach renourishment, sandbagging, relocation, and other methods to maintain oceanfront areas (Riggs, et. al., 2011). The 1985 ban allowed for a few exceptions to shoreline hardening including protecting historic buildings that could not be moved and keeping navigational channels, such as Oregon Inlet, open (Learn NC, March 2015). This generally accepted practice became law in 2003, until then it was just understood that they would not be allowed (Riggs, et. al., 2011).

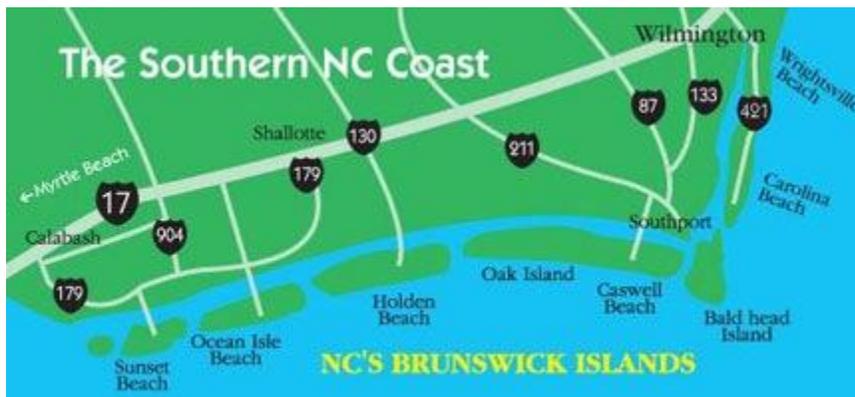
However, in 2010, the North Carolina General Assembly enacted session law 2009-479 (House Bill 709) directing the Coastal Resource Committee to study the feasibility and advisability of using terminal groins as an erosion control device (NCCRC Terminal Groin Study Recommendations, 2010). This opened the door to the idea of hardened structures being used for shoreline stabilization. In 2011, the North Carolina General Assembly overturned the regulatory ban on the use of hard structures for shoreline stabilization (Senate Bill 110 and Division of Coastal Management, 2015). The 2011 statute allowed for four terminal groins to be built in inlets for shoreline stabilization. In order to qualify for a permit, petitioners had to show:

- (1) “That structures or infrastructure are imminently threatened by erosion, and nonstructural approaches to erosion control, including relocation of threatened structures, are impractical. “ (North Carolina Division of Coastal Management, March 2015)
- (2) An environmental impact statement had been completed
- (3) A list of property owners and local governments to be impacted by the constructed groin must be compiled and such parties had to be notified of the proposed construction
- (4) A plan for the groins construction and maintenance as well as its accompanying fill project
- (5) A inlet management plan must be completed”

(Senate Bill 110 and Division of Coastal Management website, 2015)

In 2013, Senator Bill Rabon (R-Brunswick) introduced a terminal groin provision into the proposed Coastal Policies Act, which would have lifted the limit on the number of groins allowed in North Carolina (Brown, 2013). With his proposal, any beach that would benefit from erosional control could apply for a terminal groin permit. His proposal was modified in July 2013, keeping the cap on the number of groins allowed but easing the permitting process and defining what a terminal groin is more clearly (Brown, 2013).

During the budget session of 2015, Senator Henry Brown (R-Onslow) and Senator Bill Rabon (R-Brunswick) introduced provisions into the state budget lifting the cap on the number of terminal groins that could be built (Binker, September 2015). As of September 15, 2015 the final budget, while maintaining the cap on terminal groins, did increase the cap from four to six. The new terminal groins are intended for New River and Bogue inlet (DeWitt, September 2015). Currently, there are four sites that are interested in obtaining a terminal groin permit: Figure 8 Island, Bald Head Island, Ocean Isle Beach, and Holden Beach (Army Corps of Engineers Website and North Carolina Coastal Federation, 2015).



Map from:
<http://coastalnc.com/welcome-to-coastal-north-carolina/>

In March 2015, the Bald Head Island project started while Figure 8 Island is likely not to pursue a terminal groin at this time due to property right issues (personal communication with Sara Hallas, March 2015). As evidenced by the new provisions, the pressure to preserve beaches in North Carolina is increasing along with the desire for terminal groins and other shoreline hardening structures. Therefore, an understanding of what coastal residents know and think of terminal groins and their impacts along North Carolina's coast is necessary.

Literature Review

A literature review was conducted to examine if others had surveyed coastal residents' and policymakers' opinions and perceptions of terminal groins and, if so, to relate their findings to my own. Most terminal groin research has focused on the structural, natural, and economic benefits and/or disadvantages, or on the impacts of terminal groins. Because there has been little examination of stakeholder perceptions and knowledge of terminal groins, I broadened my review to include studies that looked at shoreline hardening in general, perceptions and opinions of coastal policies throughout the United States, as well as other research in which stakeholder opinions and/or perceptions of environmental issues (sea level rise and climate change) were considered. The research that looked at other environmental concerns such as sea level rise and climate change (Shipley, 2014 and DeMarco, 2007, respectively) showed that awareness of the environmental issue was higher than expected and that in both cases the public expected the state to be active in mitigating/addressing the relevant issue.

A review of the literature on stakeholder opinions and/or perceptions of coastal policies in other locales show a similar desire by the public regarding the expectation that the state will oversee and handle any coastal issues. According to the Monmouth University Polling Institute (2013), 56% of New Jersey coastal resident impacted by Superstorm Sandy say that government at the state level should handle most of the costs for projects to reduce damage from future storms and other coastal hazards such as erosion. The majority of residents in New Jersey (82%), a state with a history of using terminal groins and other shoreline hardening structures, support the use of bulkheads, jetties, seawalls and groins to prevent coastal erosion and the associated damage (Monmouth University Polling Institute, 2013). When respondents were asked whether they supported hard structures or natural barriers, researchers found “strong” levels of support from a majority of residents for both hard structures (53%) and natural buffers that restrict views (57%) (Monmouth University Polling Institute, 2013).

In contrast, a Climate Access study in California that looked at what mitigation strategies respondents were willing to implement to address sea level rise found a very different response. In general, they found that many respondents were less supportive of sand replenishment (33%),

sea walls (33%), and purchasing coastal property to induce retreat 37% (Krosnick, 2013). Instead respondents supported improved building codes for coastal development (62%), limiting the rebuilding of damaged structures (55%), limiting new development in flood and inundation zones (53%) and building sand dunes as a means of coastal protection (48%) (Krosnick, 2013).

One study in North Carolina focused on opinions regarding best means to handle shoreline change including: shoreline retreat, stopping insurance subsidies, limiting rebuilding and shoreline hardening (Kelly, 2010). This study interviewed six respondents representing several different aspects of coastal planning (Kelly, 2010). Based on her findings, the researcher recommended serious consideration of shoreline retreat instead of stopgap measures that “only serve to temporarily stabilize the unstable barrier island coastline” (Kelly, 2010). Knapp’s 2012 study entitled, “Impacts of terminal groins on North Carolina’s Coasts”, compares New Jersey’s and Florida’s usage of terminal groins and extrapolates to North Carolina’s coasts. The study also offers policy recommendations including no action, land use revisions, rolling easements, community buy out programs, and incorporating inlet hazard areas into CAMA’s AEC’s (Knapp, 2012). Her analysis indicates that a combination of all these policies would be most effective at addressing North Carolina’s shoreline change (Knapp, 2012).

The findings of the literature review show that views differ regarding the use of shoreline hardening tools and that even in supportive states, such as New Jersey, the preference is for natural buffers, but only by a slim margin. It also demonstrates that there is likely no one answer that will address all the concerns of North Carolina’s shifting shoreline. With these results in mind, my research aimed to examine the range of opinions, knowledge and perspectives that North Carolinians hold in regards to shoreline hardening, specifically terminal groins.

[Purpose of Study/Research Goals](#)

As mentioned above, a review of the literature on terminal groins in North Carolina literature reveals that research has been completed in the following areas:

- The potential impacts of terminal groins on coastal states, particularly North Carolina (NC Coastal Resource Commission, 2010; Miller, et. al., Coastal Engineering, 1996; Knapp, 2012; Riggs, 2009)
- The potential policy options available in North Carolina as well as the policies that impact terminal groin usage (Kelly, 2010; Hargrove, 2013)
- Other options for shoreline stabilization in North Carolina (sand bagging, living shorelines, relocation) (Dean, 2009; Currin, et. al., 2010)
- Economic observations on terminal groin usage and maintenance in North Carolina and other sites (Pietrafesa, 2012; Landry, et. al., 2003, Whitehead, J. 2011)
- The overall functionality of terminal groins is considered in these studies (ASBPA, 2008; Kraus, et. al., 1994)
- Other shoreline stabilization methods that might be considered other than terminal groins (Ray-Culp, 2007; Ranasinghe, et. al., 2006)
- Other studies that looked at public knowledge on an environmental issue or concern, specifically North Carolina concerns (Shiply, K., 2014; DeMarco, K. 2007; Carlozo, N. 2012)

Although many different aspects of terminal groins in North Carolina have been studied, topics crucial to developing a rational and responsive public policy on this topic remain unexplored. One such area is the knowledge level that coastal residents and policy makers have regarding terminal groins: how they work and how they impact the coastline. Another topical area that remains unexplored concerns coastal residents perceptions of terminal groins, their effectiveness, and their opinion of whether or not they should be used in future coastal management. Since terminal groins are likely to be increasingly considered as an option for shoreline stabilization, it is essential that stakeholder knowledge and perceptions be accessed. Knowing what coastal residents know or what they think regarding terminal groins will allow policymakers to consider their constituents desires. Therefore, governmental and non-governmental agencies can design

more effective campaigns for or against terminal groins using their understanding of the public's knowledge.

According to a World Wildlife Fund (WWF) study by Goulder & Gawler (2005), a stakeholder analysis provides policy makers, NGOs, and regulatory agencies with a more in-depth understanding of stakeholders' perception and understanding of a specific topic. Their research shows insights that could be gained by a stakeholder analysis include:

- 1) An understanding of the relationships that are in play within the field;
- 2) An understanding of any information gaps, perception gaps amongst different socio-economic groups of stakeholders;
- 3) An understanding of the stance various groups of stakeholders hold;
- 4) An understanding of areas where there is an overall lack of understanding/knowledge;
- 5) Major concerns and goals of the various stakeholders.

The goal of my research is to provide data that will help address items 2 and 4. These insights provide the aforementioned organizations with the data they need to design media, social marketing, and outreach campaigns aimed at advancing their agendas. The information can be used to design more comprehensive terminal groin policies that reflect coastal residents' desires, as policymakers have direct access to their beliefs and knowledge levels. Also, the use of a stakeholder analysis allows those involved the opportunity to voice their opinion about terminal groins and their impacts, as well as having those opinions be valued and recorded.

Objectives

Previous research has not investigated stakeholder knowledge and perception of terminal groins and their ecological and geological impacts. This Master's Project assesses stakeholder knowledge level, perceptions of terminal groins, and of the effectiveness and potential impacts. I also included questions that asked for their opinion of the future direction of North Carolina coastal policy and whether or not it should include terminal groins.

This stakeholder analysis focuses on the extent to which various stakeholder groups:

- Understand how sand moves along the coastline, the ecological and geological impacts of this movement, and also what happens if this sand movement is curtailed in any way?

- Understand what groins are, how they actually work, the strengths and weakness of groins?
- Understand the impacts on the coastline from hard barriers such as terminal groins
- Understand groins and sand movement and how these two forces impact the coastline, particularly in the context of North Carolina?
- What is their perception of terminal groin effectiveness and what do they think impacts this effectiveness?
- What is their opinion of the use of terminal groins, do they support overall coastal hardening, and what is their reaction to other options such as retreat and community buyouts?

The specific hypotheses that I tested for those who stated they do know what a terminal groin is includes:

- Hypothesis 1: the majority of North Carolina coastal residents do not know what a terminal groin is
- Hypothesis 3: of those that do know what a terminal groin is, the majority don't know how it works
- Hypothesis 4: in regards to impacts, most residents only think of one impact (ecological or geological) not both (ecological and geological)
- Hypothesis 7: most of the respondents are not aware of how sand moves along the North Carolina coastline

The specific hypotheses that I tested for those who state they do NOT know what a terminal groin is include:

- Hypothesis 1: Among those who don't know what a terminal groin is, most don't think they will have an impact
- Hypothesis 2: If they do think they have an impact, the majority of respondents only think of one impact (geologic or ecological, not both)
- Hypothesis 3: (a) the most compelling reason for terminal groins will be property protection while (b) the impact on animals will be most compelling for those against terminal groins

Methodology

In order to assess stakeholder knowledge and perceptions of terminal groins in North Carolina, two different methods were used. One method, the online survey, was intended to gauge the knowledge level of North Carolina coastal residents over the age of 18. In this case, coastal residents were defined as residents living in the following counties: Currituck, Carteret, Dare, Pender, New Hanover, Brunswick, Onslow, Hyde, and Pamlico. These counties were chosen because out of the twenty CAMA coastal communities in North Carolina, only these nine counties have direct access to the ocean, thus giving more relevant data. The second method, policymaker interviews, were conducted in-person and by phone over the course of two months (October-December 2015). Policymakers were chosen to represent different levels of governance and lasted 30-45 minutes. Further details are located below.

Online Survey

The survey was designed to gather data about the stakeholders' knowledge of sand movement, terminal groins, and their ideas of what ecological and geological impacts terminal groins will have on the North Carolina coastline (See Appendix A-Online Survey Questions).

To ensure the survey reached a large number of respondents, I distributed the online version through existing contacts among the coastal communities through Facebook, email, and professional connections and through a wide variety of individuals and organizations including rotary clubs, town and county social media pages, county and town chamber of commerce, churches, and personal contacts. I received positive responses from all of the above, however, church groups were the organization least likely to share the survey. I also sent surveys through NC-20 members, North Carolina Coastal Federation Members, Duke coastal networks, and personal professional connections. NC-20 members are coastal residents who focus on sustainable development economic plans. North Carolina Coastal Federation members focus on environmental and water quality issues. The Duke University coastal network includes students, professors, and other coastal connections. A strategy of plus two was implemented whereby connections were asked to send the survey onto two other relevant connections. All surveys required participants to provide consent before they could proceed.

The survey included questions on what a terminal groin is, how they are positioned, how sand moves along the coasts, how terminal groins might impact the coast, and several others. Surveys were conducted online and were composed so that the respondent could do the survey all at one time or come back to it as time allows. The survey was designed so that depending on their answer to screening questions (age and knowledge of terminal groins), they were directed to the correct survey for them. For example, if they were not over 18 years old they were taken to a thank you screen and an explanation that the researcher is looking for only respondents over 18 years old. If they did not know what a terminal groin is, they were taken to a screen that has a definition provided and then a set of simplified questions. If they answered that they know what a terminal groin is, they were directed to the full survey. The survey had a completion bar so that respondents knew how much longer they had until they finished the survey. The time needed to complete the survey depended on the respondent's knowledge and amount of writing they did for opinion questions.

Prior to its release, the survey was piloted with two different groups. One group involved giving the survey to Masters and PhD students at Duke's Statistical Consulting Center. They went through the online survey checking it for understandability and consistency, made suggestions on how to word things to get a better statistical result, and made suggestions on how to effectively analyze the data. The second group that piloted the survey were classmates in the Duke Environmental Leadership Masters of Environmental Management program as well as Don Wells, our consultant. Few if any of these individuals had any knowledge of terminal groins before taking the survey so their input was on ease of use, question clarity, and question flow. Analysis of surveys was done using Qualtrics software and included filtering the report for completed surveys versus total number of surveys, calculation of means, variances, standard deviation, and minimum/maximum values. From this data, confidence intervals were derived. Graphical representations were used for interpretation of results. The methodology and analysis of my project was influenced by the studies performed by DeMarco, K. (2007) and Shipley, K. (2014). Both studies looked at public opinion on an environmental issue such as climate change and sea level rise, respectively.

Policy interviews

Nine interviews were conducted with policymakers (6 interviews) and homeowners (3 interviews) during the months of October-December 2015. Each interview lasted approximately 45 minutes with a range of 20-60 minutes. The interviews were conducted one-on-one, either in person or by phone. In all cases, consent was secured, allowing a voice recorder to be used in each session.

Interview questions were selected to correspond to the interviewee's background (i.e. policy questions for a policymaker while homeowners had a different set of questions). Many of these questions overlapped, however, there were a few questions specific to the interviewee's background (See Appendix B-Policy Questions).

Subjects were selected by asking those active in the field for recommendations on who should be interviewed, i.e. who were the key actors. From these provided names, interviewees were selected by how involved in the discussion of terminal groins they seemed. A purposive sample selection method was used to make sure that a diverse group of opinions was represented. Subject selection also occurred through a literature and media review to see who was frequently quoted in articles and papers on this topic. Once a list of potential interviewees was compiled, direct solicitation of interviews occurred. Each candidate was contacted by phone or email to see if an interview could be arranged. The target number of completed interviews was nine to twelve individuals.

I was unable to obtain an interview with a proponent of terminal groins in the state legislature despite numerous requests. This lack of pro-terminal groin stance at the legislative level means that my results at that level are biased towards the opponent side. However, this bias was balanced out with other interviews at the town level as most of those were neutral or pro-terminal groin. As I did not do a level-by-level analysis but instead combined interviews into one pool, the bias may not be significant.

Homeowner interviewees were selected using the above method, however, there were some additional factors that impacted who was selected. Both Figure 8 Island homeowners were opposed to terminal groins while the Bald Head resident supported the use of terminal groins. Every effort was made to find a supporter of terminal groins on Figure 8 Island as well as an opponent on Bald Head Island. However, Bald Head Island's project had a 90% approval rating

by residents (personal communication with shoreline protection manager). Privacy restrictions on Figure 8 Island made connecting with residents difficult.

Coding of interview data was performed using NVivo qualitative analysis software. The themes for analysis included: terminal groin ecological/geological impacts, attitudes toward terminal groins, justification used for/against terminal groins, understanding of terminal groin function, and direction of coastal management policy.

Results

A total of 597 surveys were started during the period from November 3, 2015 until January 1, 2016. Out of these surveys, 436 surveys were completed resulting in a completion rate of 73%. There was a dropout rate of 26%. The mean length of time for completion was eighteen minutes. In the future, a larger sample size would be advisable to increase the representative quality of the results, however, for a preliminary investigation this is acceptable.

Demographics

The demographics of survey respondents are shown below. Figure 1 shows the respondents county of residency. Out of the 436 respondents, 348 lived within 0-5 miles from the coast, 51 lived between 5-10 miles, and 16 lived between 10-15 miles. 10 individuals lived further than 15 miles from the coast while 2 individuals did not know. 93% of the respondents were Caucasian, 5% preferred not to say, 2% were Latino/African American/ Pacific Islander or other. 336 out of 429 respondents owned their property versus renting. A few respondents chose not to answer this question.

In which county do you live?

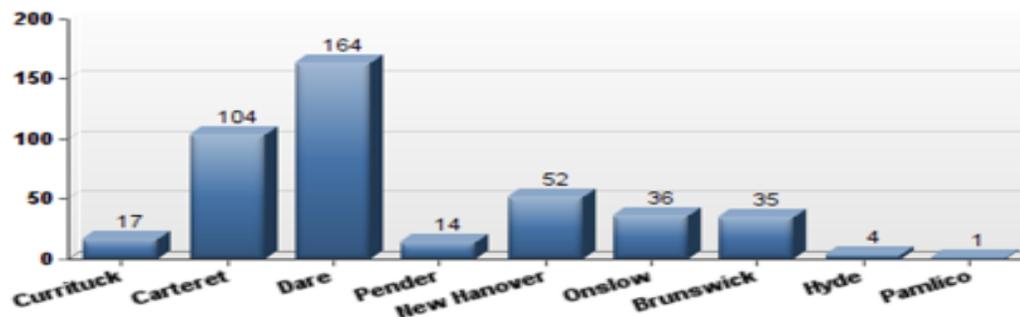


Fig. 1 County of Residence

The following graphs show the education level (Fig. 3) and the income level (Fig. 2) for respondents.

What is your annual income?

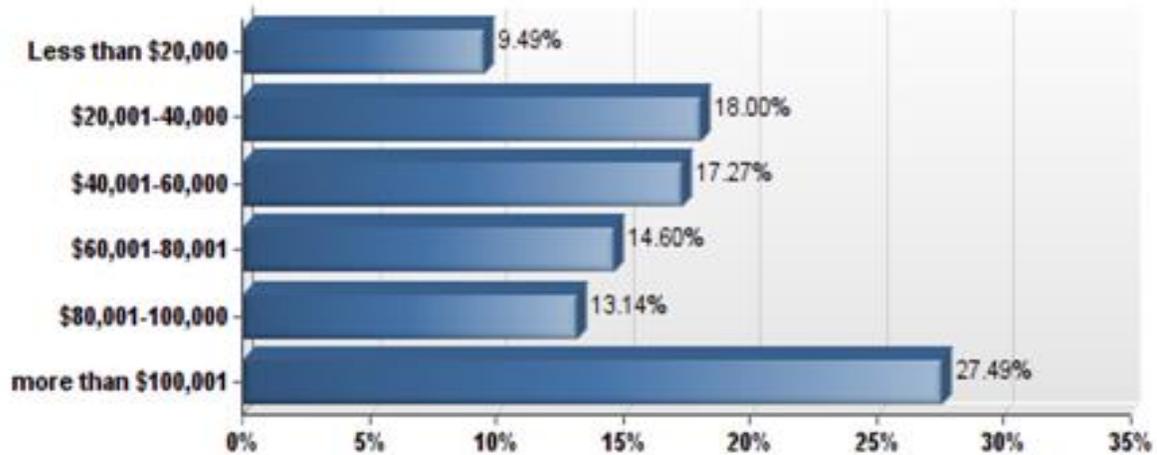


Fig. 2 Annual Income of Respondents

What is the highest level of education you have completed?

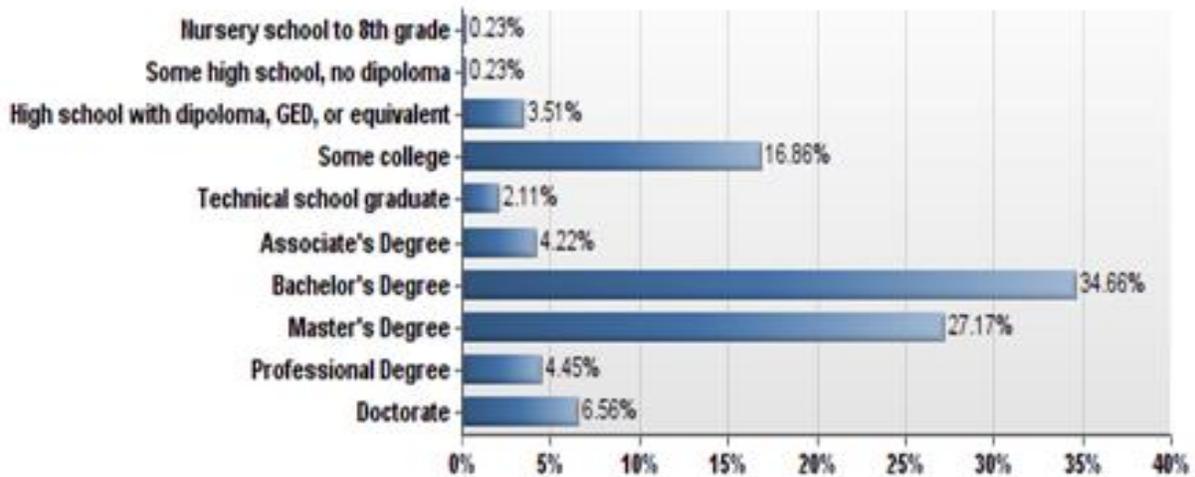


Fig. 3 Education Level of Respondents

Previous Knowledge of Terminal Groins

The next two questions asked respondents how they had heard about the survey as well as finding out whether they had been exposed to this topic previously through advocacy efforts, personal or professional exposure.

How did you hear about this survey?

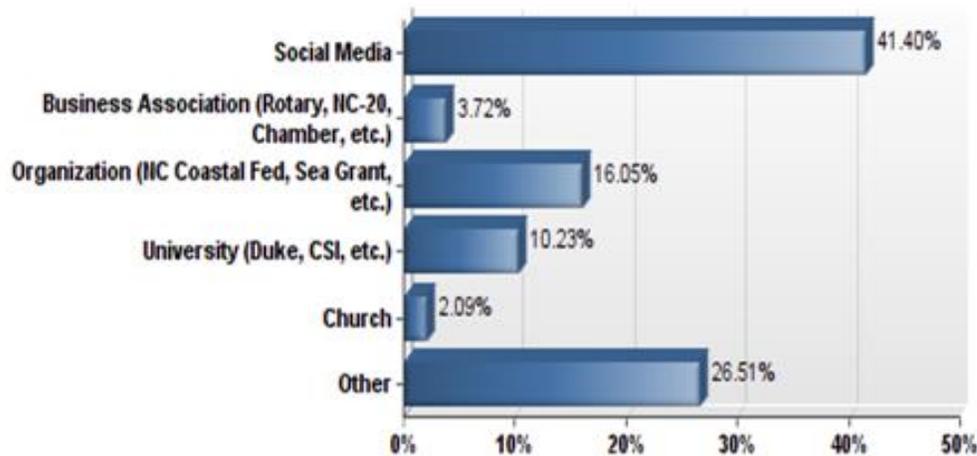


Fig. 4 How Respondents Heard about Survey

78% of respondents had not been exposed to any advocacy efforts on this topic. 64% had no personal or professional exposure to this topic before the survey.

With this demographic data in mind, the following results for both those individuals who indicated they knew what a terminal groin was, hereafter referred to as the Yes Survey, and those who reported they did not know what a terminal groins was, hereafter referred to as the No Survey, will be shown.

Knowledge of What a Terminal Groin Is or Not

In order to determine which group the respondent belonged to a screening question was asked. This screening question also addressed Hypothesis 1 which stated that “the majority of North Carolina coastal residents do not know what a terminal groin is”. The results are shown below in Fig. 5. All results in both surveys will be reported as percentages of the total number of

respondents in that category (Yes Survey or No Survey). All confidence intervals were calculated for a 95% confidence level.

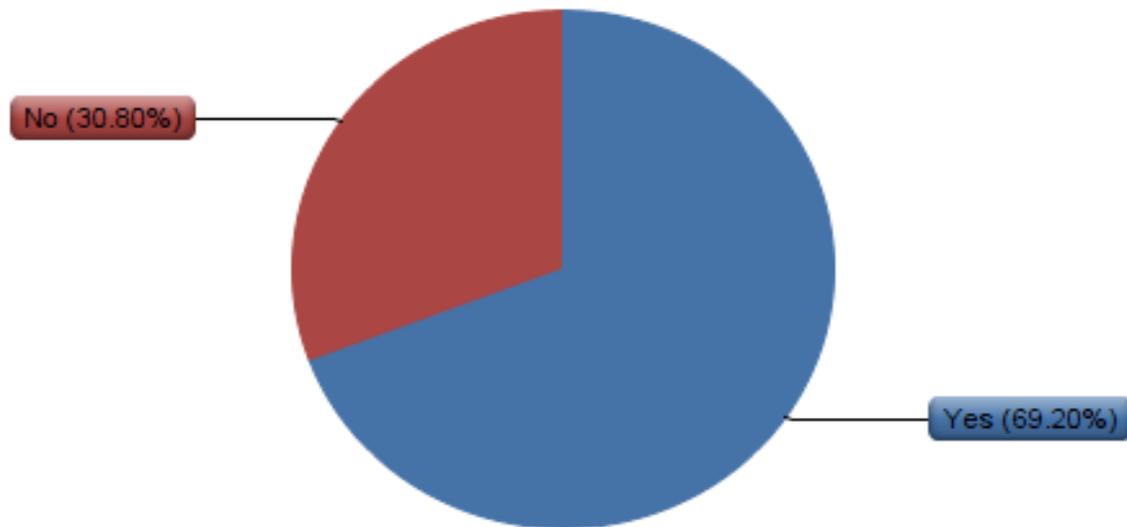


Fig. 5 % of Respondents Who Knew What a Terminal Groin Is

The results (Figure 5) shows that 69.2% of respondents did indicate that they knew what a terminal groin was while 30.8% did not know. The confidence interval for this question was CI: ± 0.4 . This rejects hypothesis 1 above indicating that most people in this sample were aware of what a terminal groin was.

At this time survey data will be broken into the yes respondents (301 individuals) and the no respondents (134 individuals). Respondents were not required to answer all questions and so the number of respondents does differ on each question, which is why percentages are used.

Yes Respondent Survey Data

Question: In what ways and for what purposes do you think terminal groins are designed?

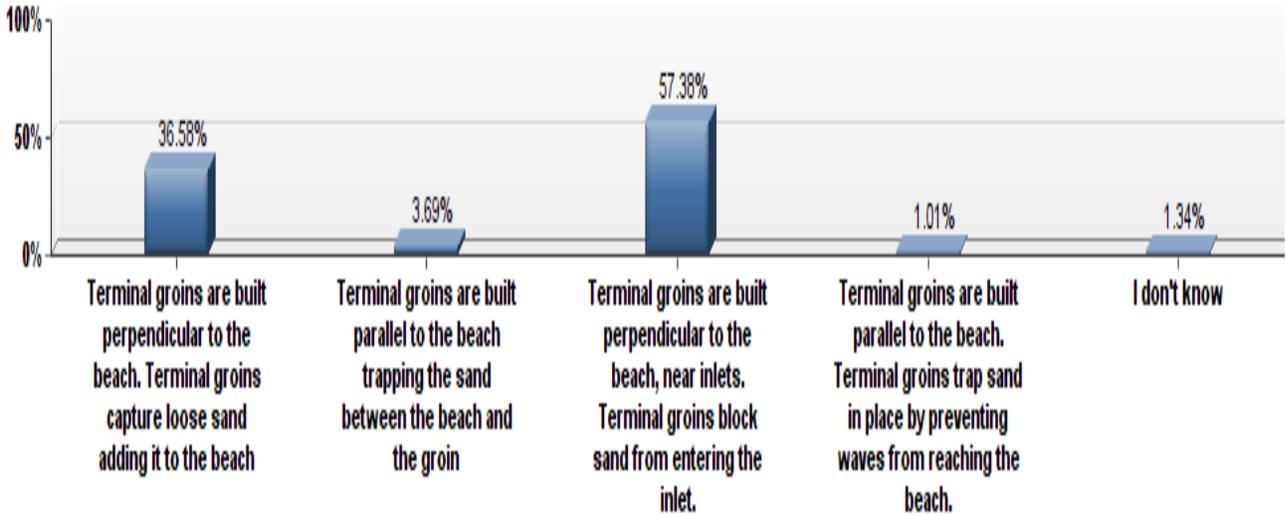


Fig. 6 Percentage of Respondents indicating how a groin is built and what it does

Figure 6 shows that most respondents are aware that terminal groins are built perpendicular to the beach. 57.36% think that they keep sand from entering an inlet while 36.56% think it is intended to capture loose sand, adding it to the beach. The confidence interval for this question was CI: +/-0.12.

Question: For what purpose do you think terminal groins are built? (choose all that apply)

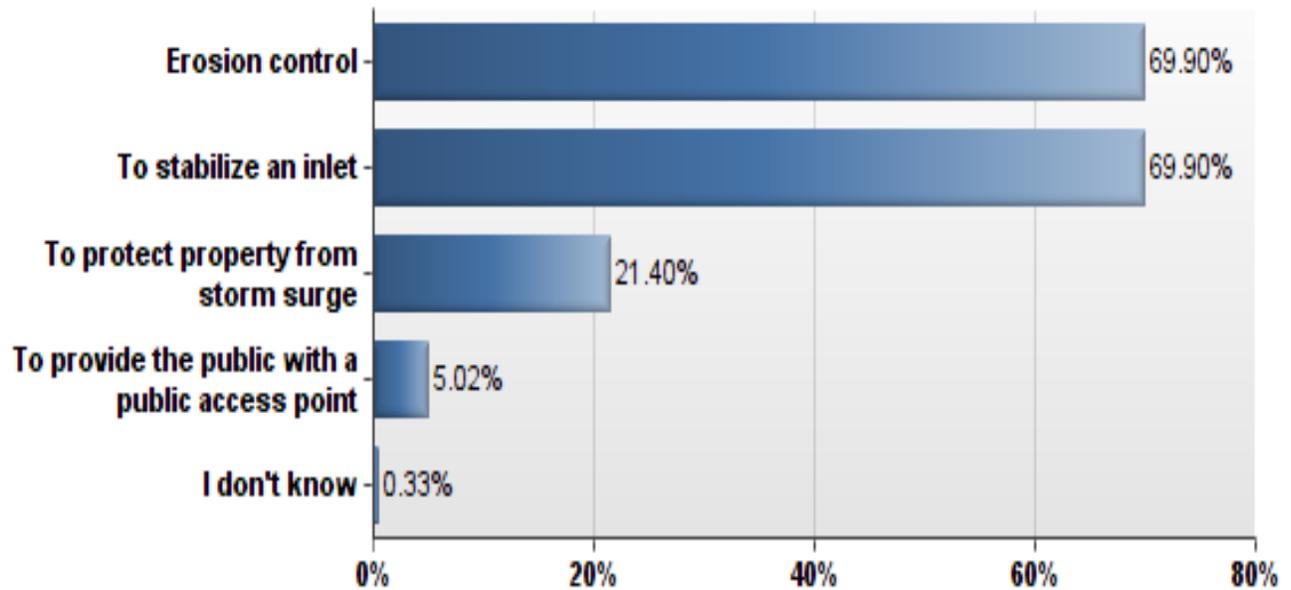


Fig. 7 % of Respondents indicating the purpose of terminal groins

In Figure 7, respondents were allowed to choose as many applications for terminal groins as they thought applicable. The results show that respondents thought erosion control and stabilizing inlets were the purpose of terminal groins. Many respondents see terminal groins as being used for both purposes. These two questions were testing Hypothesis 3: of those that do know what a terminal groin is, the majority don't know how it works. These results suggest that the majority are aware of how they work and what their purpose is.

Question: How much impact do you think terminal groins will have on following features of the North Carolina Coast?

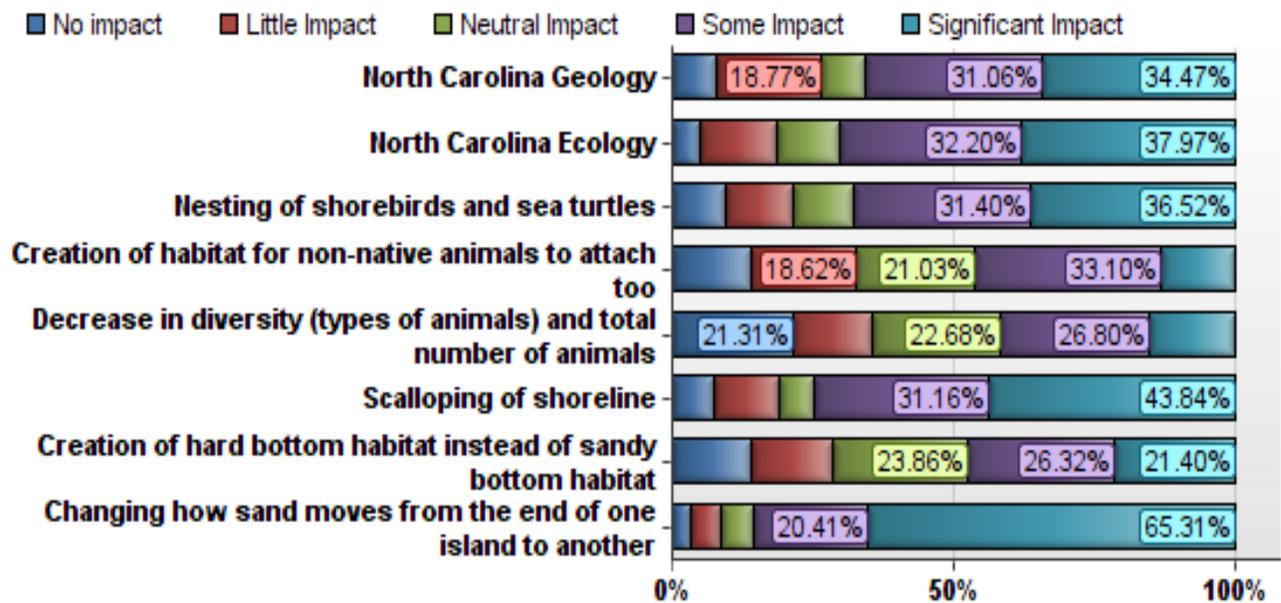


Fig. 8 Impacts of Terminal Groins as stated by Respondents

Figure 8 shows that 65.31% of respondents expect a significant impact on sand movement along the coast including scalloping and changes in how sand moves from one island to another. 37.97% of respondents also expect a significant impact on North Carolina ecology with 36.52% indicating an impact on nesting shorebirds and sea turtles. 21.31% expect no impact on animal diversity or numbers. This data shows that the main impact is expected to be geological in nature.

This question was intended to answer Hypothesis 4: in regards to impacts, most residents only think of one impact (ecological or geological) not both (ecological and geological). This data shows that while respondents did consider both impacts they prioritized geological impacts.

The next two questions were intended to test Hypothesis 7: most of the respondents are not aware of how sand moves along the North Carolina coastline.

Question: In your opinion, along the North Carolina coastline, in what overall direction does sand move?

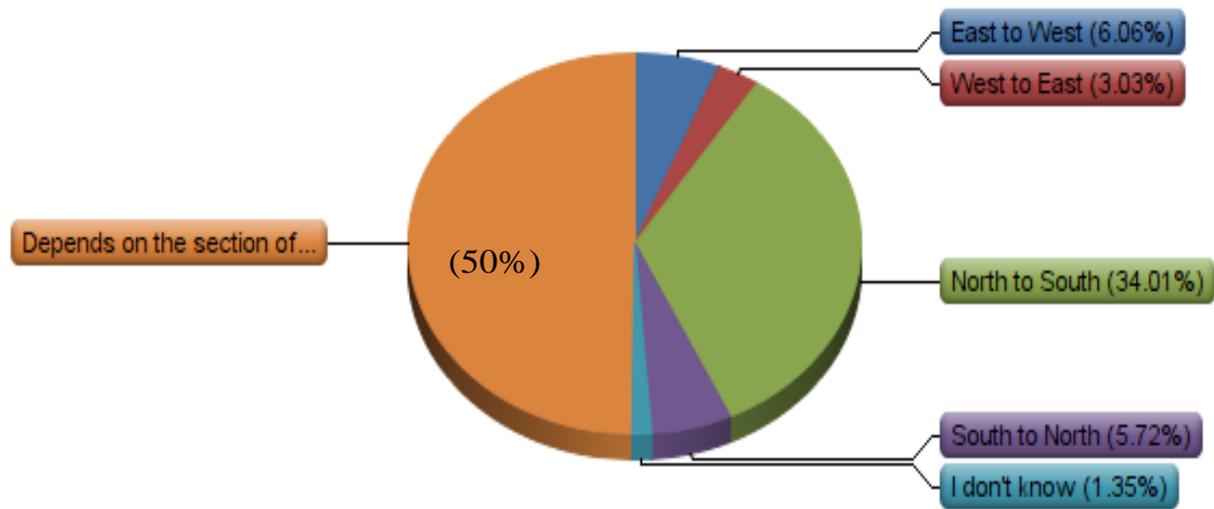


Fig. 9 % of Respondents Indicating how sand moves along NC coast

The data in Figure 9 shows that 50% of respondents selected “it depends on what section of the coast you are considering”, which is the most accurate answer. The confidence interval for this question was $CI = \pm 0.19$. This means that 50% of respondents did not select the correct answer, indicating support for the hypothesis.

Question: In your opinion, which end of a North Carolina barrier island generally loses more sand to the erosion?

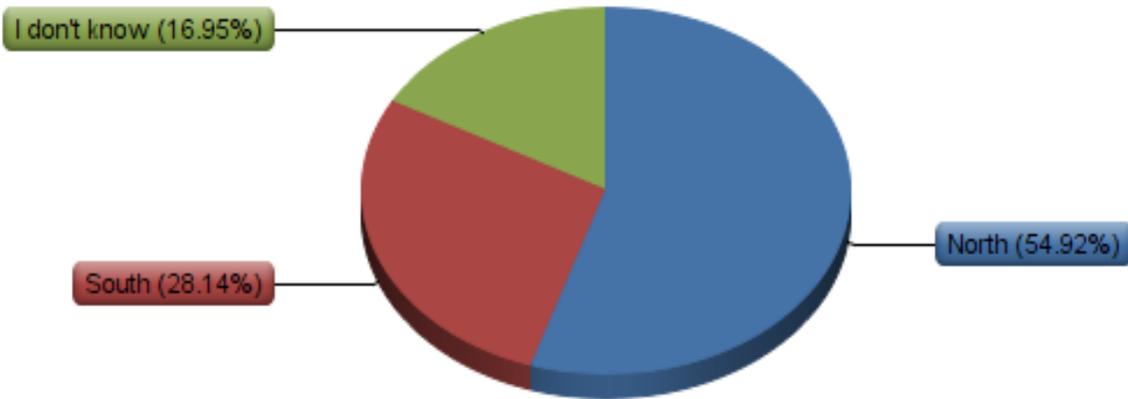


Fig. 10 % of Respondents Who Knew Where Sand Loss Occurred

Figure 10 reveals that almost 17% of the respondents who knew what terminal groins were are not sure which end of the island loses the most sand. The confidence interval for this question was $CI = \pm 0.09$.

Question: Would you consider terminal groins effective at preventing beach erosion?

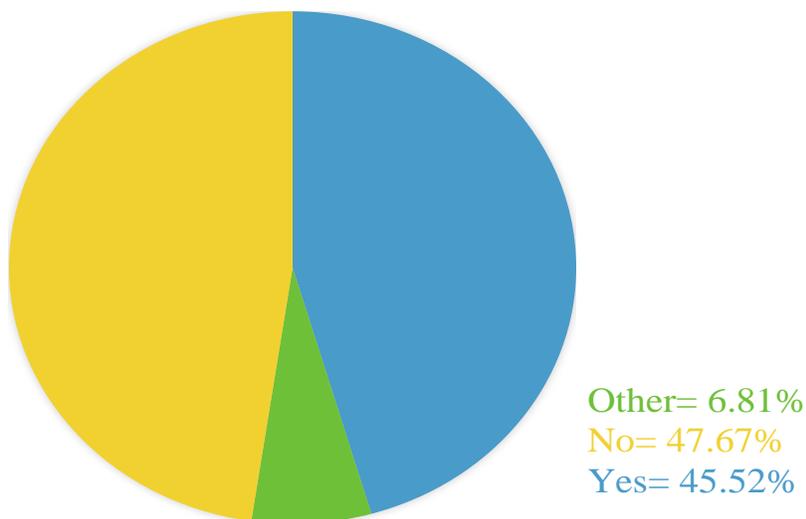


Fig. 11 % of Respondents Response to Effectiveness Question

Figure 11 shows that respondents in the Yes Survey are almost evenly split on whether or not they thought that terminal groins are effective in erosion control, which they listed as one of the main purposes of terminal groins. 47.67% indicate they do not think they are effective while 45.52% said they were. However, this question also allowed for comments and amongst those respondents who indicated they were effective there were a lot of qualifiers such as dependent on location, likely to cause problems in other areas, and only for a short distance. Amongst those who said they are not effective the comments included can't beat Mother Nature and they are never effective. The other category represented here is due to the fact that a few respondents did not indicate either way instead they made a general comment or a comment that was unrelated to the question.

Question: Do you think that the area where a terminal groin is positioned (i.e. Nags Head vs. Bald Head Island), makes a difference to its effectiveness?

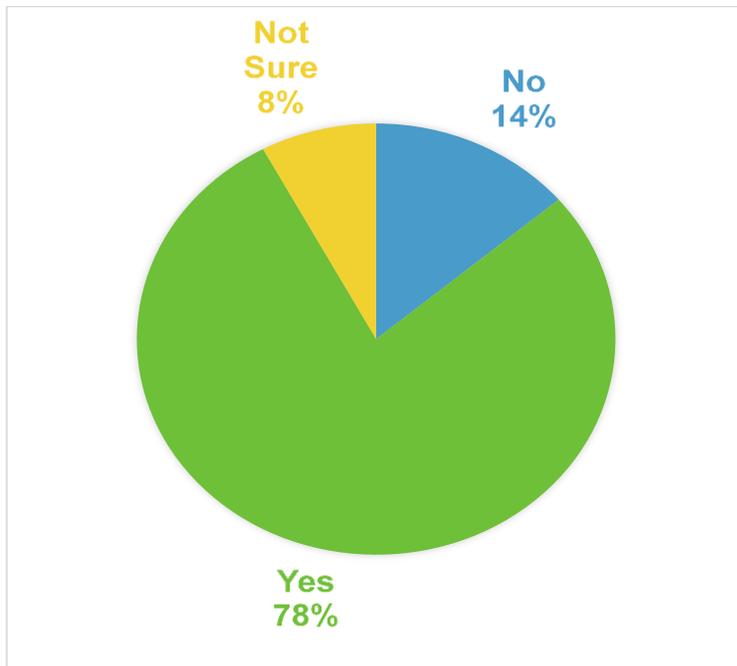


Fig. 12 % of Respondents who think terminal groin location impacts effectiveness

Figure 12 shows that the majority of respondents believe that location matters in terminal groin effectiveness. Comments from the majority indicate that ocean and sand dynamics in that area are critical to whether or not terminal groins are effective. Those respondents who indicated they

No Respondent Survey Data

Data for the No Survey was obtained from those respondents who self-identified themselves as not knowing what a terminal groin was. There were 134 respondents in the No Survey. These respondents were given a brief definition of what a terminal groin is and then asked questions based on that definition. The provided definition was technical in nature with the intention of reducing any potential bias that might be introduced. The definition that was used was “Terminal groins are hard structures built perpendicular to the coast at the end of an island or near an inlet.” While efforts were made to reduce any introduced bias, it is impossible to guarantee that none existed.

Question: The purpose of terminal groins is to trap sand at the end of an island, preventing the sand from entering inlets. In your opinion, do you think they impact other areas outside of the inlet area?

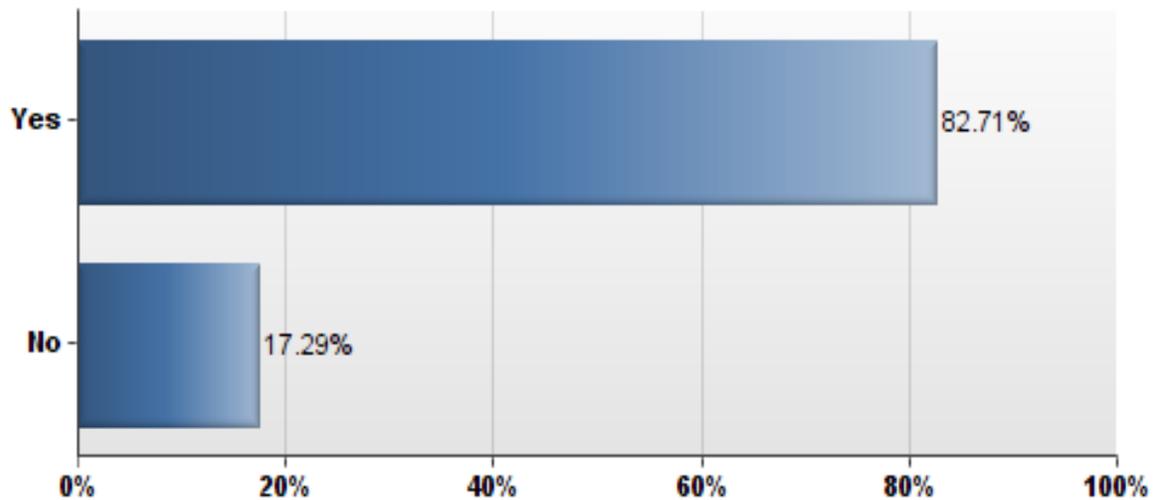


Fig. 14 % of Respondents who expects impacts out of the terminal groin area

Figure 14 clearly shows that amongst those respondents that did not know what terminal groin is they expected it to impact areas outside of its original area. The confidence interval is CI: +/-

0.06. This question was asked to test Hypothesis 1: Among those who don't know what a terminal groin is, most don't think they will have an impact. The data clearly contradicts the hypothesis.

Question: How much impact do you think terminal groins will have on following features of the North Carolina's Coast?

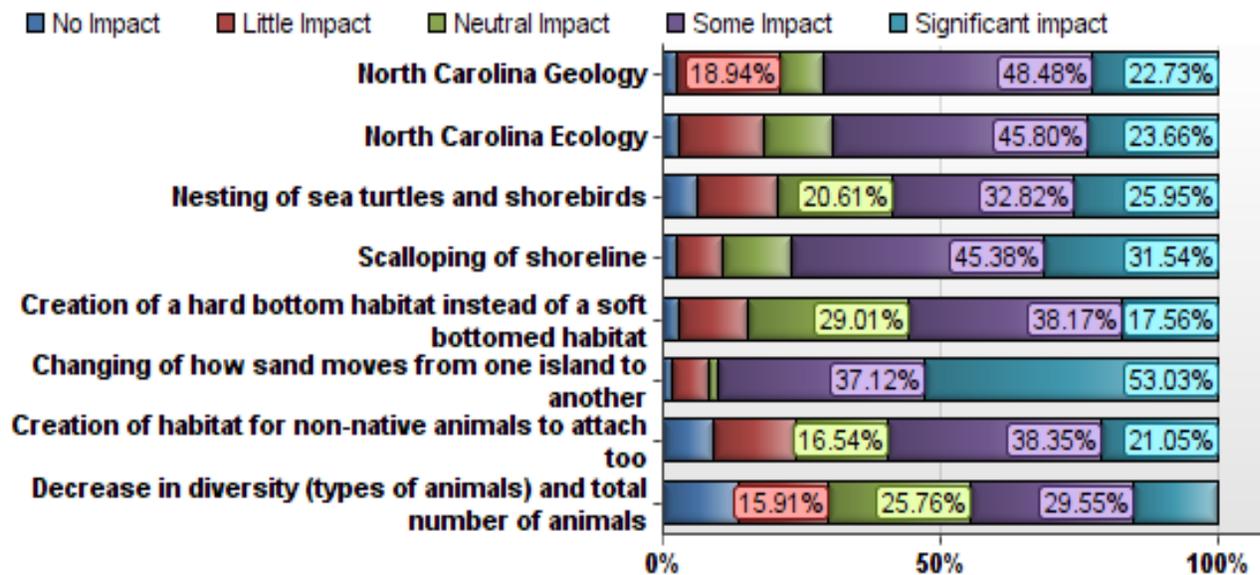


Fig. 15 Impacts of Terminal Groins Expected by Respondents

Figure 15 indicates that respondents expect significant impacts in how sand moves from one island to another island with scalloping of the shoreline being the next significant impact. Most indicated that some impact was expected in the majority of the categories. This question addressed Hypothesis 2: If they do think they have an impact, the majority of respondents only think of one impact (geologic or ecological) not both. Since together scalloping of shoreline (31.54%) and sand movement from island to island (53.03%) were the two main categories marked as significant, both of which relate to the geology of the coast, the hypothesis is supported.

Question: Proponents of terminal groins state that terminal groins are better than current methods of shoreline protection. Below are a list of their reasons. Indicate how you feel about each argument.

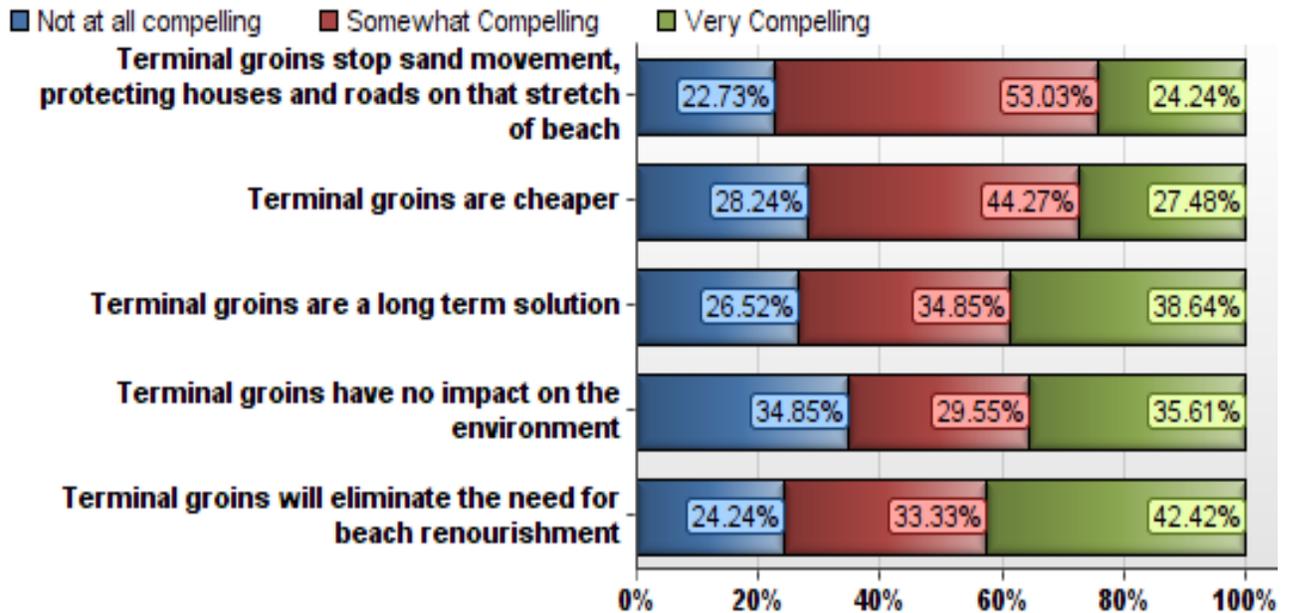


Fig. 16 Respondents Indicate Proponents most Compelling Argument

Figure 16 shows that 42.42% of No Survey respondents find the argument that having terminal groins will reduce/eliminate the need for beach renourishment most compelling. The next most compelling reason for having terminal groins is that they are a long term solution. In the somewhat compelling category, the most selected option was that terminal groins protect houses and roads. However when you consider the very compelling category, protecting houses and roads is the lowest ranking “most compelling” argument for having terminal groins. This rejects Hypothesis 3a which states that the most compelling reason for terminal groins will be property protection.

Question: Opponents of terminal groins state that terminal groins are destructive to North Carolina's shoreline. Below is a list of their reasons. Indicate how you feel about each argument.

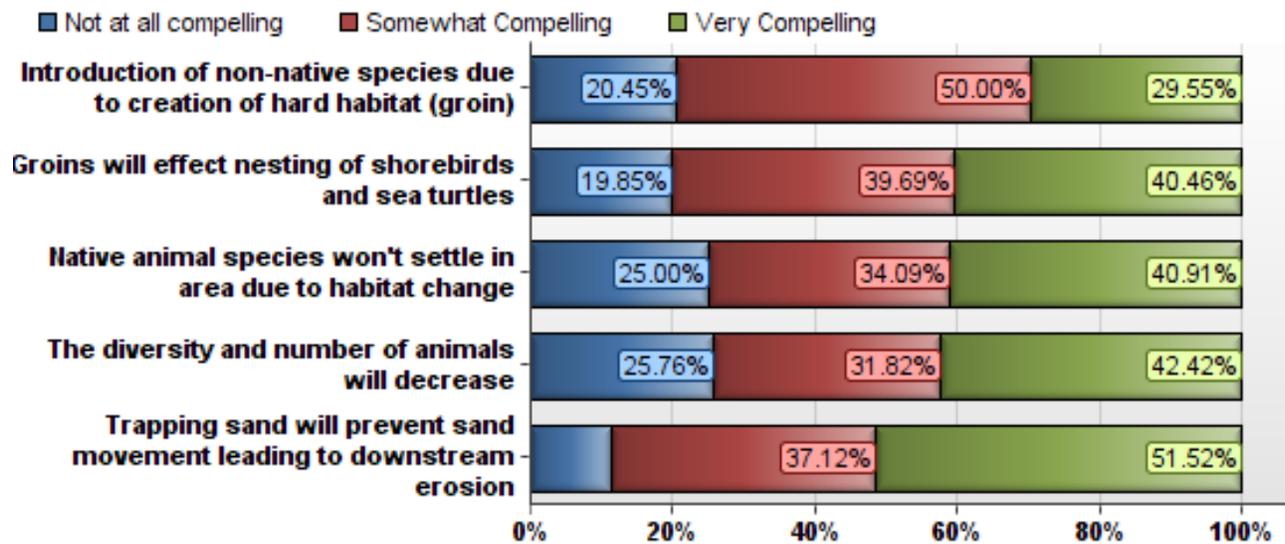


Fig. 17 Respondents Indicate Opponents Most Compelling Argument

Figure 17 shows that 51.52% of No Survey respondents find downstream erosion is the most compelling argument against terminal groins; followed by decrease in animal diversity and richness. Impacts on animals ranked as the two top least compelling argument against terminal groins. This rejects Hypothesis 3b: the impact on animals will be most compelling for those against terminal groins.

Question: In which direction would you like to see North Carolina move?

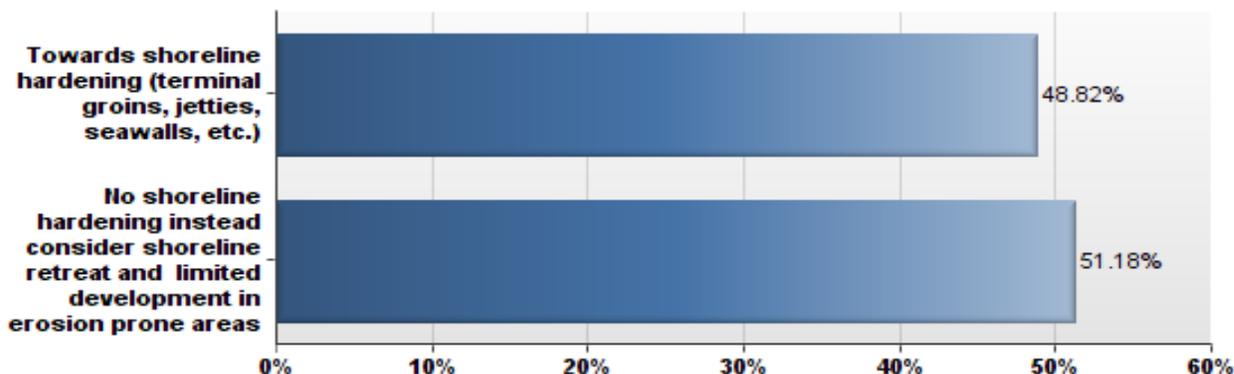


Fig. 18 Respondents Indicate the Direction they would like to see NC coastal management go

Figure 18 shows a split amongst No Survey respondents. The confidence interval for this question is $CI = \pm 0.09$. While 51.18% did not want to see shoreline hardening and were willing to consider limited development and shoreline retreat, 48.82% wanted to move towards shoreline hardening.

These responses and the ones above indicated that coastal residents are mixed in their understanding of the issue and their stance on the future of North Carolina's beaches. Following are the results of the interviews conducted with homeowners and policymakers.

Policy Interviews-Homeowners

Three interviews were conducted with North Carolina Coastal homeowners in areas that have already begun terminal groin construction or are considering building terminal groins. Two interviews were conducted with Figure 8 Island homeowners while one interview was conducted with a Bald Head resident. Below are the results from the interviews. Full transcripts were not included as there was the possibility of individuals being identified by their comments. However, transcripts are available upon request with the understanding that identifiers would be removed.

Question: How long have you lived here? What attracted you to this site?

Respondents in both locations said that they had chosen where they lived because it was recommended to them by friends and/or family. Upon visiting the area, the beauty and location of the island finalized the decision. The longest resident had been there for over

30 years while the shortest term resident had been there since 2000, with one resident having been there for sixteen years. However, this resident had owned property on that island since 1973.

Question: Do you have or have you had beach erosion? If so, how much beach have you lost? Are there any areas of being lost due to erosion?

None of the homeowners I interviewed had had any erosion near their homes, although they had seen beach erosion occur on the island. As one homeowner put it, "Sometimes the dunes erode a little bit then they build back up." Another homeowner stated,

"No, we are on the interior of the island in the maritime forest area, and that was by choice when I bought the property out here because, as I said, I was involved in the maritime business and I have a great respect of what the ocean can do, especially to barrier islands."

The next two interviewees were from Figure 8 Island where erosional control is the main justification for a terminal groin usage. When asked about houses in danger due to erosion, this is their response.

First homeowner, "Well, I don't think that, at the present time there's not any property that is endanger of being lost. There were some threatened houses about five years ago at the North end but since then the beach has accreted significantly and now they have a fairly wide, couple of hundred yards or more of beach in front of those houses, and they're not threatened at all." Another homeowner stated,

"Well, right now, on the storm that came through a couple of weeks ago - made some severe erosion on the South end of the Island and the Northern part was relatively untouched. But a few years ago there were maybe 8 to 10 houses that at that time were threatened but since then there's been a natural buildup of sand and they are not threatened at all now because there is a 1/4 mile long spit of sand and the sand bags that were put in are now almost covered up with naturally accreted sand."

Question: Until recently North Carolina banned structures such as groins and jetties, however, they are now allowing four to six test sites of terminal groins. How do you feel about these structures in general?

These homeowners represented two sites (Bald Head and Figure 8 Island) and as you can see they had differing views on terminal groins.

”Well, I’m not in favor of arbitrarily just sticking out groins or jetties but if there’s a specific area or problem that should be addressed, such as a shipping channel being cut too deep and too close to the corner of an island, then we need to do something to try to stabilize the beaches.”

First homeowner on second site: “In general, I think that they’re a mistake. You know, we had a lot of foresight several years ago to ban such structures because of the unintended consequences, the adverse effects that they caused. That ban stayed in place for a while and served well, I think. But then a few years ago there was a move on to allow them again, I think it’s primarily instigated by developers and they were able to, after a lot of effort, they were able to get the legislature to agree to allow a couple, some of these on a trial basis.” Second homeowner at that site,

“I’m opposed to them in general because of books I have read and a number of them and the scientists I have talked with in person are almost all, all but one, are opposed to hardened structures and a few years ago there was a letter signed by 42 coastal geologists from around the world opposing terminal groins.”

Question: Both sides of this topic have strong opinions about terminal groins and other structures. What do you think are the strength and weakness of terminal groins?

Supporting homeowner: “The strengths, you can solve a specific problem if you design a groin structure properly, it depends on what you’re trying to solve as to whether a groin is a solution, but they have been a solution in quite a number of cases. The downside on it, the problem with it, is you’re not entirely sure how the structure will affect sand

movement and beach erosion on the downstream side of a groin location. So you're never really sure how that does work."

This homeowner was opposed to his specific site but neutral otherwise on this question.

"Yeah, I think that there some strengths and I'll tell you when - not, not in this case, there's not any strengths in this case. But you take Topsail Island where the inlet is actually migrating at a rapid rate and, you know, this is the problem, when you have a migrating inlet and it is really threatening a lot of structures and threatening the island itself, then I think that a terminal groin might be considered in order to try to stabilize the inlet. But Rich Inlet is the most stable inlet in North Carolina. It's incredibly stable. And why anybody would want to alter a stable inlet, not just a stable inlet, but the most beautiful inlet in the state, is just beyond me."

This homeowner opposed terminal groins and groins in general, "I think the weakness is that it puts sand in one place and automatically is robbing sand from somewhere else. It doesn't produce any sand, it just determines more where it is located. It's been tried in many, many other places and the effects are mostly bad."

Question: Do you think that terminal groins have any ecological impacts on the coast? What impacts do you think they have? Do you think that terminal groins have any geological impacts on the coast? What impacts do you think they have?

All three homeowners thought there would be impacts in both ecological and geological ways. However, how they viewed this impacts differed on their backgrounds and initial opinion of terminal groins. The homeowner who supported terminal groin usage stated, "Well, ecological, one of the things it will do is like any marine structure it provides a habitat for marine life and I can tell you from the jetties that were up in Manasquan, NJ, that some of the best fishing from the shore you can actually have and they actually set up the jetties up there where there's a concrete cap out

at the end, at the ocean end, and it's just a wonderful fishing area and I would expect that you'd have a similar situation out here. But, they're not going to set it up for fishing from shore, but I would imagine that the boats that come primarily out of the Southport area are going to love fishing alongside that thing after it's constructed. The only geological impact that I could think of is a sand drift, it affects the movement of sand and that may change but it remains to be seen just how it does, as far as any real geological effect, these structures themselves are not large enough to cause any, what I would call, geological effects, we're certainly not going to get any land subsided through earthquakes or anything like that related to a groin structure."

The homeowners at the other site who opposed terminal groin usage on their island also expected impacts. Their responses are shown below,

"Oh, yeah, they have tremendous ecological impact. And that's what the Environmental Impact Statements are supposed to do. Environmental Impact Statement that were done for the terminal groin at Rich Inlet were grossly inadequate, I mean, they are just awful but anyhow that needs to investigate. We know that, and they did and they even have pictures of what the North end will look like after the terminal groin is in place. And all of this really, I don't know how big but it must be 100 acres or more, of this sandy spit at the end of the island where there are now, multi, hundreds of nesting shore birds, that will all be gone and they admit that. That will be gone, so it has huge ecological impact, and some of these birds there are threatened species, like the piping plover, and I just, I cannot see any justification for that." The second homeowner stated,

"Yes, there is, down-drift erosion, any time you put these terminal groins, it does cause a buildup of sand on one side of the groin and erosion on the other side. So you have down-drift erosion that just comes along with terminal groins, I mean that's just a well-known phenomenon and, you know, if you look at places like NJ or FL coast, they'll put in one of these groins and it works for about a, well maybe quarter of a mile or less of accretion and then on the other side you get erosion, then they put in

another one to take care of that erosion, then they put in another one and if you look at an aerial photo of the coast in those states, it just looks like a ladder with one after another of these terminal groins, or these jetties, groins or jetties, that are put there for stabilization purposes. And, I mean, that just ruins a natural beach. The scientist have said that if this Figure 8 terminal groin is built the whole north end beyond the groin will be washed away and there will be nothing but a deep channel of water there instead of a beach.”

Question: Which direction would you like to see North Carolina move towards: continued business as usual coastal management using engineered solutions such as groins to stabilize shorelines or coastal management that is based more on environment-based planning? Why?

The response of the terminal groin support to the above question,

“Terminal groins and other structures should be used primarily to keep navigation access open, I wouldn’t really consider using them for much else. One of the reasons I built on the interior of Bald Head was to stay away from actual beachfront because it’s a dynamic system, it’s an ocean that’s sand, there’s nothing hardened there and things do move and they do change. And if people want to build right up next to the ocean, that’s their choice, but they should not have the right to totally try to modify the environment to suit their wants rather than their needs. They should use the property to, you know, for something that it’s suited for rather than try to modify it strictly to accommodate what they want it to be.”

The two non-supporters view on other options for coastal management,

“Well, I really haven’t thought that one through so that would take some thinking to come up with one. I wouldn’t just want to see groins or jetties just arbitrarily put in, there may be a need to install some of these systems in areas that have been developed many years ago and now are suffering from the effects of a dynamic marine system and maybe you could protect them. But at some point

you also have to realize that there may be a time where you just have to say, that's enough, let it go back to a natural state and be done with it. But, I mean there's economic considerations to deal with here with recreational revenue for states and localities. It's a very complex consideration to come up with a, you know, one way or another way, a decision and at this point I really, I haven't looked into that much"

Second homeowner response, "Certainly one that is based more on environment sound plan."

Even if that plan said maybe shoreline retreat is an option?

"Yeah, I think so. We know, this island has been there and we have pictures for 100 years that show that that inlet is really, has been stable over the last 100 years. Now as I said before if you have an unstable inlet and then you might have one that is migrating and really causing a lot of problems because of that migration, then you might, that might be a reasonable consideration is to do some engineering to try to stop that. But if you have a stable inlet and you don't have any threat to properties right now, you ought to leave it alone."

Question: If you could tell policymakers one thing regarding terminal groins, what would you say?

Even though these homeowners had differing views dependent on their sites and backgrounds, the response to this question was similar in a lot of ways. The support of terminal groins stated,

"Take the time to study what is trying to be accomplished by a terminal groin. Don't just arbitrarily set yourself in stone to where you are for or against them. Keep an open mind to look at what is being proposed and base your decision on facts, not on emotions."

The two opponents to terminal groins differed in their basic stance on terminal groins but agreed on their site specific views about terminal groin usage. The first homeowner stated, "I would say don't even consider hardened structures unless it is obvious that they're absolutely necessary. You know like for navigation sometimes, you have to put

in a jetty in order to make a passageway that the boats can, big boats can go through. Or in the other case that I told you about was an inlet that's migrating at a very rapid rate, Topsail Island was migrating at like 50 feet a year at one point. Then I think it's work considering but those only extreme cases where it should be considered, otherwise should not even be considered, we should go back to our prior good legislative sense that said no." The second homeowner stated,

"Unless there was scientific evidence that it was a good thing and not a bad one, I think that is extremely unlikely that terminal groins should be used because all the coastal geologists who have studied this, except the one who is on the payroll, have said it's a bad idea."

As you can see from the above comments, terminal groins cause a lot of strong emotion amongst coastal homeowners. One of the interviewees was profoundly against the whole idea of terminal groins, while the other opponent was mainly against the one proposed for his specific island. The supporter was very clear that even well designed terminal groins could have unintended consequences, which could only be minimized by taking the time to study the purpose of the specific terminal groin.

Policy Interviews: Policymakers

Interviews with policymakers included representatives from North Carolina legislature, town mayors, heads of homeowner associations, and scientists. The North Carolina representatives included a democrat, republican, and an independent. Interviews ranged from 20-60 minutes with an average of 45 minutes. Efforts were made to interview county representatives and senators as well, however, requests never received a response.

Questions: How have you been involved with terminal groin policy in the past? Currently?

Four out of the six interviewees are currently involved with terminal groin projects. Two of them are lobbying for terminal groin permits and working with the Army Corps of Engineers to acquire permits. Another interviewee is in the process of building a terminal groin while the

fourth is actively involved in discussions regarding a terminal groin at an inlet. Two of the representatives have previously and still are lobbying against the use of terminal groins preferring to maintain the ban. Below are a few of their responses to this question.

State level response, “I was on the Coastal Resources Commission for seven years and fought very hard to maintain our policy on no hardened structures on our beaches and, then when the legislature passed the Pilot Project for I guess four I fought that, that was a couple of years ago, I guess, four years ago, and then when it expanded in the budget so there wasn’t any way to fight it because it happened here in the conference report which was against our rules”. Second state level response,

“So, mainly it has been in regards to legislation that has come up over the last two sessions. Last session, I believe, was the first time that we opened up the possibility of, I believe it was 4, terminal groins to be utilized in North Carolina. The idea at that time was sort of a pilot group, or pilot study, authorizing study of how well it would work, etc. This last legislature, there were negotiations during the budget process which I am co-chair of transportation appropriations and it got tied to the dredging as a, you know a program, the argument was, that if we were going to put more money into the dredging as an infrastructure, they wanted to be able to authorize more permanent solutions. So they, the original proposal from the Senate was uncapped and, I believe, we bumped it up by 2 to 6. So that’s where my involvement has been.”

Scientist response, “We have been struggling with trying to find a resolution to a deep draft channel adjacent to our island. Accelerated erosion due to the actions of the Army Corps of Engineers has been an ongoing problem with, resulting in non-natural beach erosion. So, the question about what’s the solution to this engineered problem and the engineered problem is the dredged channel. Over the years I have contacted various academic and environmentalists, as many people as I could to try to find a more or less invasive, more natural solution to the engineered problem with no good results, no answers.”

Town level response, “How have I been involved in it in the past . . . , I worked with other towns and the mayors across the North Carolina coast and North Carolina Sea Grant and other experts in the early days to determine that consideration of a terminal groin option might be a good idea for North Carolina. Knowing that terminal groins were presently, at that point in time, allowed to be used by the US Army Corps of Engineers or the state to protect areas of interest whether they be navigation or whether they be historic or whatever, and that I felt that people’s rights and the rights of the public were equally as important, so I was part of the coalition of towns that decided that terminal groin legislation should be considered in the state of North Carolina to allow for them to be used in a pilot program. I’m really not involved currently other than I am one of the legislation pass to allow for 4 terminal groins a couple of years ago, since then from a legislative endeavor, none of us have, of the original coalition we’ll call it, have been involved since and nor were involved with the addition of the, and actually I don’t even think we were made aware of the addition of the additional two terminal groins.” Another town level response,

“I was one of the communities in North Carolina instrumental in passing a legislation introduced in our legislature to change state policy that allows for the construction of terminal groins in the state of North Carolina. And I’m still involved because the community that I lead is trying to get one permitted, hopefully we’ll have it permitted in the spring and construction will begin next quarter.”

Question: How much of your constituency is coastal (i.e. live at the beach)? How many would you estimate are impacted by coastal erosion?

This question turned out to be a very interesting question as this is where the split in definitions of terminal groins and what they were used for was observed. In the southern region of North Carolina, erosional control was the main justification for terminal groins but as you can see this norther state level leader did not agree.

Northern state level leader, “All of it . . . well actually, well I mean depending on how you define coastal.”

How many properties would you estimate are in imminent danger of being lost to erosion?

“(Sigh - long silence) So, I don’t have . . . see now, that’s an interesting question because it doesn’t necessarily relate to terminal groins. Terminal groins are just at the edges of, you know, either a peninsula or an island. And, you know, as far as properties that will be protected by terminal groins in that management strategy, you’re talking about bridge placements, you know, landing areas and ferry infrastructure, so and boating infrastructure. As far as homeowners that will be affected by this, there really aren’t any in my area, as far as ones that will be protected by beach re-nourishment that are in trouble, I don’t have the exact figure, I would guess . . . We have a few hundred, well, yeah, a few hundred depending on the size of the event it could be much higher.”

Here is a response from a southern town leader and you can see how her response differs from the northern leader, “100% of our population is located on the beach, and I feel that all of them are impacted whether directly or certainly indirectly impacted by any erosion whether at the end of the island or the middle of an island or wherever. There are probably 15 structures, 15 to 20 structures imminently in danger.”

Second southern leader response to the original questions, “Oh, probably nearly half of our population is ocean front.

Ok, and how many properties would you estimate are in imminent danger of being lost to erosion?

“Well, under proper management and doing the right things to manage the coast of North Carolina, I would say zero. If we are unable to do management of our coastal resources, then I would say ultimately all of them would be. We must keep in mind that we are *not* talking about anything natural here. This is not a natural process that is occurring, there is nothing natural about the shoreline or the coast of southeastern North Carolina. In 1938 and 1942 the US Army Corps of

Engineers came through southeastern North Carolina and created the largest inter-basin transfer of water that's ever occurred, called the Atlantic Intercostal Waterway."

This question also started to bring out the difference in how supporters of terminal groins used history to back up their stance while it was rarely, if ever, mentioned by opponents. Below are the rest of the responses to how much of their area was coastal:

"Not much. Actually, if we're talking actual coastal, none. However, I have Swansboro and that area that is affected by the tides and everything else and the White Oak River and all and storms affect them just the way coastal folks get affected."

Question: You have previously stated that you support/oppose hardened structures such as terminal groins. Why?

State level response, "First of all I do not agree with terminal groins. I think our policy of nothing sticking out in the ocean over the years has benefited the state of North Carolina. I can understand because of what has happened in development on the coast why people are looking for these terminal groins to protect their investments. If you put a groin in, it's going to cause problems down below. I mean the sand has been moving up and down the coast for a millennium and for us just to play with it, and they've done it in other states and they've made problems, resolved problems, made problems, resolved problems, you know it's a continuing process. But I have not been in agreement with the program since its ideas have cropped up." Second state level response,

"Well, I'm fairly convinced that and the other geologist's research that it causes additional damage, it doesn't really help what, I mean, it may help the particular spot where it traps the sand but it doesn't have a big impact on property and so I feel very strongly about that and also argued during this debate in the legislature that we're facing sea level rise, we're in a hot spot, sea level rise is much more significant sea level rise than thought at first and that we are likely to see more impact than previously thought so/ and this is not a solution. I feel very strongly

about coastal management issues and this does not seem to be a good way to deal with the emergence of sea level rise.”

The third state level response from a supporter but watch how history is used again as a justification, “Now, do I support terminal groins or not? I do support them but I think they should be utilized sparingly and where they are there to protect infrastructure. One of the things that people really don’t understand about the Outer Banks is we are nowhere near what the original state of the Outer Banks was. If you go back in history and you can look at the, if you’ve ever been to the history center down there, they’ve got a treasure trove of information, and when you go back and you look, we were a maritime forest which is a very stable system. It’s not moving the way that some of the folks, like Pilkey and others, would want you to believe that return to a migrating island system, we weren’t, we were maritime forest. The problem is in the 16 and 17 hundreds, we cut down all of the wood and then we allowed grazing on the dunes that existed there and so we overgrazed to the point that we became very flat then we’re moving a lot. Back in the 30’s, President Roosevelt brought in the CCA and the WPA to build the dunes system that goes from VA all the way down to Ocracoke and they did that with grass thrush that helped catch all that sand that was blowing around. Then we actually re-nourished in the 50’s and in the 70’s. So we can’t return to what we had before, so stabilization, some man-made stabilization is appropriate at this point.”

The next few statements are from a scientist and from town level leaders. The scientist response, “Finally the community here reluctantly has been looking at an engineered solution to an engineered problem. It’s not something they chose but they felt like it is something that was imposed on them. We are the only sustainably developed barrier island in America. So, we’re not talking about houses that were abutting the coastline, we’re not talking about homes that had lawns, for instance, or a grid-like pattern, we’re talking about people who built back 300, 400 yards from the wet sand and in a matter of days the shore line was at their doorstep. So, we’re not talking about irresponsible development, we’re

not taking about irresponsible homeowners but when they did the backup-the-envelope calculation, the impact to the community and, frankly, the county retreating, of letting those homes go into the channel, the impact was significant in terms of a tax impact, maybe more significant to the county and the school system than Brunswick Co. So this isn't just about rich people protecting their homes, this is about a community protecting its right to be here, in light of a deep water channel that's engineered by a federal agency."

The striking thing to notice throughout the scientist's response is her level of frustration with the process, how it is very obvious that the terminal groin was not what they wanted to do but felt that they had been forced to do. In contrast, the town level response shows a very different mindset,

First town leader: "That's a pretty safe assumption. Yes, I think that we need to find the best options for long term management of all of our coastline, our marshes, our ecosystems, our fisheries, ah, and then oysters and shellfish and habitat, while at the same time balancing recreational and navigational uses of our for boating, and recreation purposes for the residents and the tourists that come to visit." Second town leader,

"Because they are often the only solution at the end of an island to trap the sand from falling back into the inlet, and that's what they are . . . they are sand traps. It's quite different tidal influences at an inlet than there are at the middle of an island."

Question: Many supporters state that terminal groins will reduce beach erosion, reduce the need for beach renourishment, and not have much of an impact on the coastline. Do you agree? Why or why not?

Again with this question, look at the response difference between the northern and southern responses,

Northern state leader, "They do an excellent job of inlet protection but they don't do it fully, we still have to have other maintenance items, like dredging or what have you, to

support it. As far as beach protection, again that's not what they are designed to do, so, you know, I'm sure they have some benefits to them in that regard but that's not the primary focus of it. But I do believe they create stable endpoints of islands."

Southern town leader, "I agree with that". Second southern town leader,

"I certainly agree and I have the scientific basis, we have hired the best of the experts to work with us, to make sure that our beaches, our oceans and in our specific area are properly managed. We've utilized the best of the experienced people from across the country, Florida who has used them in numerous applications, we've consulted with the University of Florida to gain their knowledge and experience. We've used engineers that have built and constructed these things, we've used Dr. Bill Cleary who's an expert on inlets and inlet migrations and management, so yes, I would say that I support finding the best option regardless of what it may be to create long-term management for our shoreline for not only this generation but future generations."

State level response: "That is exactly wrong on all fronts, every single front. It exacerbates erosion, increases the need for re-nourishment and does not protect property." Second state level response,

"They'll probably reduce some erosion and the thing I would take issue with is impact on the coast line. The sand moves up and down the coast because Mother Nature wanted it to. And the sand continually moves, it replenishes and takes away, it replenishes and takes away, its part of our ecological system and when you put something in the water that stops it you change something down the road. Somewhere down the road there's going to be a result, probably detrimental, caused by that groin."

Question: Many opponents state that terminal groins will cause increased erosion downstream of the groin, will change the habitat from soft sand to a hard bottom, change the animals found there due to habitat shift, and that they are not as resilient to storms. What do you think of these geological/ecological concerns? Why?

This questions brought out the fact that each side wanted to see unbiased, scientific evidence but the main component was that none agreed on the science or on the sources.

State level response, “I honestly don’t know. Intuitively I would tend to agree with them because once you stop the movement of the sand, it’s gonna, things are going to happen on the other side. The natural movement of the animals’ stops and so there is probably some truth in what they say, but how much is true, I honestly don’t know. But it will cause a problem down the road. Somebody is going to be affected by any groin that goes in the water.” Second state level response,

“I share them all which is why I am opposed to terminal groins . . . and other groins and jetties and sea walls. I liked a policy for 30 years with no hardened structures.” The third state level response was very different then the two above,

“As far as them not working to protect infrastructure, again it’s anecdotal, but it’s certainly has worked well for Bonner Bridge, um for a long, I forget when Martin came in but it was the 80’s wasn’t it, so that’s 20, 35, 40 years with absolutely no maintenance on it. So, that’s done a very good job. As far as the animal, you know, changing it to a hard bottom, that’s not how they’re designed, they’re just at the terminal of an island and it’s not down, it doesn’t continue on throughout the bed. So I would be very skeptical without some sort of environmental impact study to say that that definitely is a problem. As far as sediment control, creating beach erosion further down, we’re going to have beach erosion no matter what, and we need to have beach nourishment in certain areas to protect property and the infrastructure of tourism, because people don’t come here to sit on pilings from old houses or septic tanks or anything else like that. So beach nourishment is something we need to continue to do. I think it has shown

that it will protect inlets and again if we change the tone of the conversation from beach protection to inlet protection which is what it is really about, then I think it shows that it does what it is supposed to do.”

First town level response, “Well, I have asked them for any evidence or supporting facts to any of those statements and to date they have been unable to produce such or unwilling to provide such so let’s go back to your first one, down drift erosion was the first one I think you mentioned . . .If you look at the study done by Spencer Rogers, Rob Walker and Rudy Rudolf, Ft. Macon was built by one of our past presidents and Thomas, many, many, many years ago, I don’t remember who it was . . . And they have done monitoring of that, there is no evidence or indication of down drift erosion sand being robbed from the beaches there. The same thing holds true with Pea Island as I told you in, I think I told you, you know the National Park Service and DOT when the Oregon Inlet terminal groin went in. They wanted to be sure there was not any problems and so they hired North Carolina State because they wanted a non-bias approach to it to do it and from my understanding Marjorie Overton monitored it every two months for 25 years. And that has not been the case, the opponents to terminal groins have never advocated for, pursued or been willing to fund the removal of the terminal groin at Ft. Macon, the terminal groin at Pea Island, the rock embedment at Ft. Fisher nor pursued the removal of the jetties at Wrightsville Beach which do, in fact, stop sand bypassing and would, in fact, be construed as very detrimental to Masonboro Island, which is a nature preserve. And so, you know, there’s no indication or fact that it would have any effect down drift. There’s no evidence of that in North Carolina, there’s no evidence of that in other places. Sure they can cite examples of New Jersey where groin fields exist, again groin fields and not and sure you can cite examples of down drift erosion issues.”

The second town level stated, “Um, I think that they are not substantiated by facts. There are two existing terminal groins in the state of North Carolina at present and they have been there for a long time. I don’t think any of those arguments have been proven to be true in these locations.”

Question: Since most of the beaches under consideration for terminal groins are barrier islands and they are meant to move, how much state effort should be involved in preventing this movement? Would you be willing to use state funds for terminal groins?

State level response: “Yeah, again, you can’t . . . we’ve already opened the box. They didn’t use to shift like they shift now because of man-made intervention so I feel that it’s appropriate that we maintain the economy that has been established, which people often overlook the fact the reason that people come see us is because of the beautiful environment. We know that, we live here and we know it. It’s not to spite it, we want to preserve it and maximize it at the same time. So, I think its two things of state lands, you know from the high water mark, the public beaches, we have tourism is our number two industry in the state, I believe . . .it’s a major investment and/or we get a major return from that investment so I think it’s important that the state has a hand in making sure we maintain it.” The response from another state level leader was dramatically different,

“Well, not at all. Not one dime of taxpayer money. I mean state taxpayer money, if the local taxpayers agree to pay for it, yeah, but not state money . . . and not federal money.”

The final state level response was extremely practical. In summary it states we are already there so we need to maintain it but if its destroyed don’t ask to put it back. See the following comments,

“The towns can’t afford it, the cost is too great for the towns. Most towns on the ocean side and the cost is tremendous. I mean look what we’re doing with NC 12, every time we have a storm we’re repairing it. We’re building a new bridge because Mother Nature decided we ought to, she wanted a new inlet. Again to me it doesn’t make a lot of sense. We spend millions of millions of dollars but again we built, allowed building out there where it should not have done, should not have been done. Can you tell a person he can’t build something on his property? I really, I have a problem with that. But I can tell a person that you built it, it’s your problem and that’s where we lost the boat. We permitted it, we allowed it to happen, we built the roads and we’re stuck with the problem.”

For two of my sites, the beaches are private so this question only really applied to one town level leader.

Town level response, “Well, I can tell you the island I’m on is not going to move too far windward, unless the intercostal waterway is closed down because it’s got no place to go. And yes, I think that our beaches are state parks in North Carolina and they should be, the state should be involved in the protection of recreation areas.”

Question: What would it take for you to change your stance on terminal groins?

Again this question brought out each speakers desire for proof one way or the other but both sides have reservations about the research that has already been done.

State level response, “I don’t want to say yes, if there is any chance, I mean, my instinct is to say no, there’s no chance. But I am a legislator and I don’t like to be close minded. So, I don’t know what you would say because I haven’t seen anything out there to convince me otherwise. I just don’t want to ever close my mind to an option, I just am not convinced that there is anything out there that could convince me. I don’t think I would be an effective governing official if I said, “Absolutely not, never.” Cause that is just too close minded. I am just not aware of anything out there that could convince me otherwise.”

Town level response, “Proof. Scientific evidence and proof. And I’ve not been given that, I’ve received exactly the opposite. Evidence says it will work and it has worked in every state along our coast except for Oregon.” Second town level response,

“Um, facts that would prove that it would, facts and experiences that would prove that they did not work as intended or designed.

Additional Question: What do you think the perception of terminal groins is? Is the conversation that is occurring accurate do you think?

This question was added after an interview by the suggestion of the interviewee who expressed concern over my inclusion of erosion control with terminal groin usage. As mentioned above, the difference in conversation on this aspect of the topic is substantial. Therefore, the addition made sense.

Northern state leader, “You know, [sigh] my concern would be that the way that you’re asking the questions is based on people’s perceptions of what the discussion is about as opposed to what the reality is. So I forget which one it was that you asked me in the early on . . . we’re talking about beach protection, I mean the discussion about protection, really discussion, policy wise, isn’t anything about beach protection. It’s about stabilization of inlets, it’s about stabilization of the ends of islands so that you know, you can build the infrastructure, so most people think of it as the jetty system.”

Second state level response, “You know, it is my experience working on the CRC and working with the community of town commissioners up and down the coast that there is a huge, huge lack of basic information about coastal dynamics and there is a strong desire to control and respond.”

Scientist response, “I think there is a challenge in the perception, you know, it comes down to private property/community rights versus states’ rights. So, I, as a private citizen, have the right to take whatever risk I want, and you the state can’t tell me whether or not I can do it. And then, oh, but by the way, if my house gets blown away I want you to pay me, with Federal Government through FEMA, so again I think the biggest challenge is the lack of clarity between the roles and responsibility of the state, the Federal Government and local communities and private properties and having clarity about ‘yes, if you own property, beachfront property on North Topsail or Topsail, the second most vulnerable barrier island, in the US, let me give you, property owner, clarity from the state that in the event, or when that big hurricane comes this is the maximum that the state will give you if you lose everything’ or ‘the state will give you nothing’.

Whatever it is, let's have clarity before so that property owners can make wise decisions about the risks that they're taking. Right now there is a push to minimize, to, you know, I think we're becoming more sophisticated as a nation and responding, you know, we've got nourishment, it's not called nourishment any more, it's called storm mitigation, that's fine it does do that, but are you giving homeowners a sense false hope? Yes, absolutely.

Town level response, "I think that the special interest groups have tried to categorize them into something they're not, a terminal groin is a single structure at the terminus of a barrier island, it is not a groin field, it is not a jetty, it is not an obstruction for public use, it is not an obstruction for robbing sand from other areas down drift and I think the special interest groups that have, we'll say, gone after this have tried to call them jetties, have tried to call them groins and continue to do so today. They are a terminal groin by definition, no one has supported groin fields that I'm aware of or multiple groins, nor have any of the people that I have associated with at this time been involved in proposing jetties at the locations." Second town level response,

"Well that probably depends on who you talk to. I think there is some misinformation out there to the general public, they are also portrayed as jetties which are large structures and they are not that, they have an entirely different function and are built for entirely different needs. So, it does take some education to get the right information out there."

Discussion

Major Findings

Survey results show that the North Carolina residents surveyed are more aware of terminal groins, their uses and their impacts than hypothesized. Homeowner interview results show that both sides agree that if terminal groins are used they should be site specific, extensive scientific study must be performed before a site is approved, and that the only reason that any of them can see terminal groins being used is for navigational reasons. Areas of disagreement include a fundamental disagreement over their usage at all. Amongst policymakers, results show that there

was a mix of frustration and concern over the topic and how it's being handled both policy wise and with the public.

The results also showed that stakeholder perspectives on this topic derives from a mixture of culture, history, economics and politics and is not just a decision on coastal management. Many times during the policy interviews, interviewees made the point that our beaches have a history of being managed and that they are not natural and the perception that they are gives people the wrong basis on which to make decisions regarding terminal groins. When discussing the idea of other management options up to and including retreat, many policymakers responded that that would never happen, since the people who live on these islands entire culture revolves around the islands themselves. In fact, this negative response to the idea of retreat was also seen in the survey when a similar question was asked and one respondent said (paraphrase) “stop wasting time on ideas that we will never accept and come up with ones that are realistic and practical.” They addressed it to Duke and other scientists. I also received some very strongly worded personal messages from survey respondents on this question. The last two components, political and economic, seem to garner the most attention when terminal groins are discussed, but for many respondents both in the survey and in the interviews this was not the reason to consider terminal groins. The reason was to protect way of life.

Survey results from those who indicated that they knew of terminal groins show that these respondents think terminal groins are used equally for erosion control and to prevent sand from entering an inlet, that they impact sand movement from one island to another and impact sand movement along the coast. The survey results also indicate that awareness of how sand moves is mixed, meaning that a large segment of respondents are not sure which direction sand moves or if there is a difference depending on the location under consideration. Respondents did indicate that location of terminal groins are important in their effectiveness, but they were split in their decision of whether or not they thought they were effective at erosional control. Survey respondents who indicated that they had no previous knowledge of terminal groins shared the concern showed those who indicated that they did over geological impacts to the coast. They also indicated a concern that the impacts would range over a larger area then just the location of the terminal groin. These geological concerns are the main argument against terminal groins

made by survey respondents while the idea of lessening the need for beach renourishment was the main reason cited for support for them.

The striking component of policy interviews I completed was the degree of separation and clarity that occurred between those who oppose terminal groins and those who support their usage. When talking to supporters of terminal groins, they were very clear in their use of definition of what a terminal groin is and is not and they stressed the fact that our beaches are not natural and have been managed and engineered since the 1930's. They also used the North Carolina terminal groins already in existence as proof to back-up their stance. On the other side, those who oppose terminal groins were less definitive about the difference between terminal groins and groins, constantly referred to our natural beaches, and used New Jersey and other similar states as examples of the potential impacts of terminal groins (again mixing the usage of groins with terminal groins) to back-up their stances. It was also striking that supporters had almost an identical response to questions while opponents' responses and perspectives were more diverse. Another thing that stood out was the fact that amongst supporters there was a clear difference in what they said the purpose of terminal groins was—in the interviewees from the southern section of the state the purpose was definitely erosional control while in the northern Outer Banks interviewees said that they were for navigational purposes only (i.e. to stabilize inlets).

Recommendations that emerged from policymaker interviews included: educating the public on coastal processes especially potential future homeowners; changing the debate so the conversation is clearly and solely about terminal groins; honest conversation with homeowners about the risk involved in living on the coast; a need for clarification on what the state is and is not willing to do; a need to update the models used by the Army Corps of Engineers for more accurate modeling results; including oceanographers in the design of terminal groins to work alongside engineers; and increasing the awareness that while finance is a component of the discussion, way of life is just as important. The last recommendation was for North Carolina to really discuss and decide what to do regarding re-building if/when an area is destroyed.

These recommendations were relatively consistent across spectrum of perspectives on terminal groins. Both supporters and opponents wanted to see more education on coastal processes,

clarification on the debate of terminal groins which would help with perception issues, clarification on the state's role in management decisions and processes, and an inclusion of way of life and not just economics in the conversation. A few recommendations came specifically from the scientist that was interviewed, including updating the modeling software used by the Army Corps of Engineers and the inclusion of oceanographers in terminal groin development plans to ensure that oceanic processes were considered in the placement of terminal groins (if they are used). The recommendation to have a more thorough conversation on risk was also only mentioned by a few interviewees, but they included the scientist and two of the state level leaders. These three interviewees either opposed terminal groins or reluctantly supported them for cases where there were no other options.

Similar Studies

As mentioned in the literature review, the studies by Knapp and Kelly also looked at shoreline change and terminal groins. In both studies, they looked at policy alternatives that address some of the recommendations made above. While my study did not include an in-depth review of these policies, several were mentioned either by interviewees or as part of a question, including retreat, limited rebuilding and changing inlet hazard zones. When mentioned or discussed in my project, many participants felt that retreat was not a viable option and suggested strongly that other solutions be considered. Further study of these options would be beneficial in order to narrow down feasible solutions.

Other studies that focused on environmental awareness of or knowledge of an issue, such as Shipley, showed that North Carolina residents were familiar with the issues. These results line up with my own in that awareness of the topic is high but opinions on what to do or what direction to take is mixed. Even though our topics differed this results shows the public knows about the issues they may just not know what to do with that knowledge.

Limitations and Suggestions for Future Research

This study was conducted on a relatively small sample size and therefore only offers a snapshot of the public's understanding of terminal groins. Methods to increase the strength of the survey results include increasing sample size to at least 1,500 individuals in order to adequately

represent the population of interest. This number is based on the recommendation from Duke's Statistical Consulting Center students and is calculated based on the fact that North Carolina's coastal resident population is ~700,000 individuals. It would also be beneficial to increase the socio-economic diversity of the respondents to determine if this variable impacts knowledge level. One hypothesis, the one that would have looked at socio-economic variables on knowledge level, was unable to be tested due to the lack of diversity in the sample obtained. It would also have been beneficial to have included more interviewees (both homeowner and policymakers) with differing viewpoints to see if the trends noted in my research held true with more participants.

Future research projects could include a repeat of this project with a larger sample size and an increase in the number of sectors that would be included in interviews (i.e. scientists and insurance representatives). The conversation of terminal groin usage in North Carolina impacts more than just homeowners and policymakers: it also includes scientists and the insurance sector, however, due to time constraints I was unable to include stakeholders from these areas. For a more complete view of both the conversation and the links between sectors interviews for these sectors should be considered. This expansion of who should be interviewed was a policymaker's suggestion.

Another idea for future research would be a stakeholder analysis of the various policy options (terminal groins versus buyback programs vs. retreat vs. limited development vs. limited rebuilding) to see how stakeholders feel about these various options. Analyzing these options from the stakeholders' point of view will give policymakers a more detailed view of what is likely to have stakeholder buy-in, which options would never pass, and would narrow down the option pool to more actionable plans.

A third research option is a thorough review of the modeling methods used by the Army Corps of Engineers and other modeling options to see which modeling tool is most effective in case terminal groin use is decided upon in the future. A number of the policy maker interviewees mentioned that there are concerns about the accuracy and reliability of the modeling currently used. Another model was suggested that the policymaker thought was a better option, but since

it was not a United States model, its use required several hurdles to be overcome. Current policies make it difficult for towns to use non-US modeling tools even if there are better modeling options that would give more accurate results. Since the Army Corps of Engineers is the United States premiere organization in this field, it should be using the best tools. A thorough review will ensure that these tools are being used and will offer the Corps evidence it might need to justify updating its modeling tools.

Conclusion

This project has shown that terminal groin usage in North Carolina is a contentious issue with residents, homeowners, and policymakers split on the topic. Coastal residents are more aware of the topic than expected, but they are split on their effectiveness, divided over whether or not they want to move towards using terminal groins or not, and have mixed opinions on their impacts. My results reject several of the hypotheses that were postulated at the start of this project. The results that were rejected included the hypothesis that coastal residents were unaware of what terminal groins are, how they work, and the potential impacts they might have. However, the hypotheses regarding awareness of sand movement and terminal groin impacts were supported. This means that many respondents were not aware of how sand moved along North Carolina's coast. However, even though they were not sure of how sand moves they were most concerned on the geological impact of terminal groins versus the biological impacts. This could be due to additional emphasis being placed on this topic by opponents of terminal groins or it could be simply due to intuition.

Policymakers expressed frustration regarding how the topic of terminal groins is discussed and perceived. Striking features that came from my interviews with policy makers include the fact that there is no consistent reason for terminal groin usage as that differs by region and the rationale for policymaker stances' depends on whether or not they view the beach as natural. Areas of agreement amongst policymakers include the need for site-specific usage if they are used, a need for comprehensive scientific study before they are considered, and the desire to only use them sparingly.

These results indicate that any future policy decisions regarding terminal groins need to be decided carefully and should not be decided quickly or at the last moment. Consensus amongst all respondents and interviewees indicated that wholesale use of terminal groins is not desired, if they are used, it should be strategically. My results did not show a clear cut stance on where North Carolina stakeholders wanted beach management to go in the future. Instead my research demonstrated a split amongst respondents and interviewees, which for policymakers, is unfortunate as they have no clear signal on how to move forward. However, my results do indicate that a public awareness campaign is needed that focuses on educating the public on ocean processes, erosion, and hazardous zones. It also seems as if it is time to have a frank conversation regarding the risk of living and developing the North Carolina coast amongst North Carolina decision makers.

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Appendix A-Online Survey Questions

Introduction screen is the consent form (Appendix C)

Screening Question 1: Are you over 18 years old?

Yes (send to survey)

No (if not direct to a thank you but you can't message)

Screening Question 2: Do you know what a terminal groin is?

Yes (send to more in-depth survey) No (send to survey with definition)

Questions for the Yes Survey

In what ways and for what purposes do you think terminal groins are designed?

- Terminal groins are built perpendicular to the beach. Terminal groins capture loose sand adding it to the beach
- Terminal groins are built parallel to the beach trapping the sand between the beach and the groin
- Terminal groins are built perpendicular to the beach, near inlets. Terminal groins block sand from entering the inlet.
- Terminal groins are built parallel to the beach. Terminal groins trap sand in place by preventing waves from reaching the beach.
- I don't know

For what purpose do you think terminal groins are built? (Chose all that apply)

- Erosion control
- To stabilize an inlet
- To protect property from storm surge
- To provide the public with a public access point
- I don't know

How much impact do you think terminal groins will have on following features of the North Carolina coast?

	No impact	Little Impact	Neutral Impact	Some Impact	Significant Impact
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North Carolina Geology					
North Carolina Ecology					
Nesting of shorebirds and sea turtles					
Creation of habitat for non-native animals to attach too					
Decrease in diversity (types of animals) and total number of animals					
Scalloping of shoreline					
Creation of hard bottom habitat instead of sandy bottom habitat					
Changing how sand moves from the end of one island to another					

In your opinion, along the NC coastline, in what overall direction does sand move?

- East to West
- West to East
- North to South
- South to North
- I don't know
- Depends on the section of North Carolina's coastline you are considering

Which end of a NC barrier island generally loses more sand to the erosion?

- North
- South
- I don't know

Would you consider terminal groins effective at preventing beach erosion? Why or why not?

Do you think that the area where a terminal groin is positioned (i.e. Nags Head vs. Bald Head Island), makes a difference to its effectiveness? Why or why not?

In your opinion, should NC continue to stabilize beaches continually or should the state manage development so that natural processes are considered (i.e. environmental management/planning and/or shoreline retreat)? Why or why not?

Questions for the No Survey

Terminal groins are hard structures built perpendicular to the coast at the end of an island or near an inlet. Based on this definition, please answer the following questions to the best of your ability.

The purpose of terminal groins is to trap sand at the end of an island, preventing the sand from entering inlets. In your opinion, do you think they impact other areas outside of the inlet area?

- Yes
- No

How much impact do you think terminal groins will have on following features of the North Carolina coast?

	No Impact	Little Impact	Neutral Impact	Some Impact	Significant
North Carolina Geology					
North Carolina Ecology					
Nesting of sea turtles and shorebirds					
Scalloping of shoreline					
Creation of a hard bottom habitat instead of a soft bottomed habitat					
Changing of how sand moves from one island to another					
Creation of habitat for non-native animals to attach too					
Decrease in diversity (types of animals) and total number of animals					

Proponents of terminal groins state that terminal groins are better than current methods of shoreline protection. Below are a list of their reasons. Indicate how you feel about each argument.

	Not at all compelling	Somewhat Compelling	Very Compelling
Terminal groins stop sand movement, protecting houses and roads on that stretch of beach			
Terminal groins are cheaper			
Terminal groins are a long term solution			
Terminal groins have no impact on the environment			
Terminal groins will eliminate the need for beach renourishment			

Opponents of terminal groins state that terminal groins are destructive to North Carolina's shoreline. Below are a list of their reasons. Indicate how you feel about each argument.

	Not at all compelling	Somewhat Compelling	Very Compelling
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<p>Introduction of non-native species due to creation of hard habitat (groin)</p> <p>Groins will effect nesting of shorebirds and sea turtles</p> <p>Native animal species won't settle in area due to habitat change</p> <p>The diversity and number of animals will decrease</p> <p>Trapping sand will prevent sand movement leading to downstream erosion</p>			
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In which direction would you like to see North Carolina move?

- Towards shoreline hardening (terminal groins, jetties, seawalls, etc.)
- No shoreline hardening instead consider shoreline retreat and limited development in erosion prone areas

Demographic Information

In which county do you live?

- Currituck
- Carteret
- Dare
- Pender
- New Hanover
- Onslow
- Brunswick
- Hyde
- Pamlico

What is your zip code?

Approximately, how far from the nearest coast do you live?

- 0-5 miles
- 5-10 miles
- 10-15 miles
- 15 or more miles
- I don't know

Do you own or rent the property you are currently living in?

- own
- rent

What is your annual income?

- Less than \$20,000
- \$20,001-40,000
- \$40,001-60,000
- \$60,001-80,001
- \$80,001-100,000
- more than \$100,001

With what ethnicity do you identify?

- Caucasian or white
- Hispanic or Latino
- African American or black
- Asian/Pacific Islander
- Prefer not to say
- Other

What is the highest level of education you have completed?

- Nursery school to 8th grade
- Some high school, no diploma
- High school with diploma, GED, or equivalent
- Some college
- Technical school graduate
- Associate's Degree
- Bachelor's Degree
- Master's Degree
- Professional Degree
- Doctorate

How did you hear about this survey?

- Social Media
- Business Association (Rotary, NC-20, Chamber, etc.)
- Organization (NC Coastal Fed, Sea Grant, etc.)
- University (Duke, CSI, etc.)
- Church
- Other

Have you been involved in or been exposed to any advocacy efforts on this topic? If you answer yes, please explain.

- Yes _____
- No

Do you have any professional or personal background in coastal related issues exposing you to the topic of terminal groins prior to this survey? If you answer yes, please explain.

- Yes _____
- No

Appendix B-Policy Interview Questions (Homeowners and Policymakers)

Introduction: Thank you for agreeing to be interviewed as part of the research project called “Stakeholder Analysis Regarding Knowledge of Terminal Groins’ Function and Impacts in North Carolina”. This study is being done by Dia Hitt from Duke University. You were selected to participate in this study because of your expert knowledge of the topic and active participation in the debate about terminal groins in North Carolina.

The purpose of this research study is examine the range of opinion and knowledge that exists on this topic amongst those who have the greatest ability to influence its outcome.

Having agreed to the interview, you will be asked a set of questions that focus on your area of expertise. All participants in this field of expertise will be asked the same set of questions to allow for comparison across the respondents. This question will ask about terminal groins, how they work, their ecological and geological impacts if any, and your opinions on them. The interview will take approximately 1 hours to complete, depending on how in-depth your answers are.

To the best of my ability your answers in this study will remain confidential. Your participation in this study is completely voluntary and you can withdraw at any time. You are free to skip any question that you choose.

Homeowner Questions

- 1) How long have you lived here? What attracted you to this site?
- 2) Do you have or have you had beach erosion? If so, how much beach have you lost?
- 3) Until recently North Carolina banned structures such as groins and jetties, however, they are now allowing four test sites of terminal groins. How do you feel about these structures in general?
- 4) Both sides of this topic have strong opinions about terminal groins and other structures. What do you think are the strength and weakness of terminal groins?
- 5) Do you think that terminal groins have any ecological impacts on the coast? What impacts do you think they have?
- 6) Do you think that terminal groins have any geological impacts on the coast? What impacts do you think they have?
- 7) Which direction would you like to see North Carolina move towards: continued business as usual coastal management using engineered solutions such as terminal groins to stabilize shorelines or coastal management that is based more on

environment-based planning? Why? (may need to give examples of environment-based planning as a prompt-given if needed)

- 8) It has been shown that the installation of terminal groins in one area leads to sand buildup in that area but increased erosion further downstream. Do you think protecting one site is worth impacting a downstream site? Under what circumstances would this be true? Should the downstream site be compensated? Why or why not?
- 9) If you could tell policymakers one thing regarding terminal groins, what would you say?

Policymaker questions

- 1) How have you been involved with terminal groin policy in the past? Currently?
- 2) How much of your constituency is coastal (i.e. live at the beach)? How many would you estimate are impacted by coastal erosion? How many properties would you estimate are in imminent danger of being lost due to erosion?
- 3) What is your position regarding terminal groins—do you support or oppose them? Why?
- 4) Many supporters state that terminal groins will reduce beach erosion, reduce the need for beach renourishment, and not have much of an impact on the coastline. Do you agree? Why or why not?
- 5) Many opponents state that terminal groins will cause increased erosion downstream of the groin, will change the habitat from soft sand to a hard bottom, change the animals found there due to habitat shift, and that they are not as resilient to storms. What do you think of these geological/ecological concerns? Why?
- 6) Since most of the beaches under consideration for terminal groins are barrier islands and they are meant to move, how much state effort should be involved in preventing this movement? Would you be willing to use state funds for terminal groins?
- 7) Other options exist for rebuilding beaches, such as channel realignment, beach renourishment and sandbagging. What is your opinion on each of these alternatives? If one of these options is feasible for a site, would you prefer them over a terminal groin? Why?
- 8) If a terminal groin is built and it caused additional erosion downstream, as they have been shown to do, what do you think should be done at the downstream site to stabilize the beach? Would you support another terminal groin, some type of compensation for the lost beach, or another option?
- 9) There have been recommendations on how to address erosion and property damage. These recommendations include: rolling easements, community buyout program, coastal communities developing a 100 year plan that uses the best science available (including

sea level rise data) and make development decisions based on that, and the use of updated inlet hazard areas to limit new development in coastal regions. What is your opinion each of these recommendations?

10) What would it take for you to change your stance on terminal groins?

Appendix C-Online Survey Consent Form

Thank you for your willingness to help with this project. It is very much appreciated.

This 15 minute, anonymous survey is part of a research project called “Stakeholder Analysis Regarding Knowledge of Terminal Groins’ Function and Impacts in North Carolina”. This study is being done by Dia Hitt from Duke University. You were selected to participate in this study because you are a coastal resident of North Carolina who lives in Currituck, Carteret, Dare, Pender, New Hanover, Brunswick, Onslow, Hyde and Pamlico. We wanted to ask residents who might be impacted by terminal groins their opinions and knowledge of terminal groins and their impact.

North Carolina has recently allowed four test sites for terminal groins, opening the door to their use. The purpose of this research project is to understand the range of perspectives and opinions the residents of coastal counties in North Carolina hold about terminal groins and their impacts.

If you agree to take part in this study, you will be asked to complete an online survey. This survey will ask about terminal groins, how they work, their ecological and geological impacts if any, and your opinions on them. We will also ask some basic demographic data such as what county you live in, income information, etc.

We believe there are no known risks associated with this research study. We will make your survey responses anonymous and remove the IP address. Your participation in this study is completely voluntary and you can stop at any time for any reason. Again all of your responses are anonymous. You are free to skip any question that you choose but we encourage you to answer as many as you can.

If you have any questions regarding this survey or research project, please contact me at andrea.hitt@duke.edu. The advisor for this project is Dr. Elizabeth Shapiro, Duke Nicholas School of the Environment. Her contact information is elizabeth.shapiro@duke.edu and her phone number is 919-681-7781. To contact Duke’s IRB office, call (919) 684-3030.

By clicking “yes” below you are indicating that you are at least 18 years old, have read this consent form and agree to participate in this research study. Please print a copy of this page for your records.

Yes

No

Appendix D-Policy Interview Consent Form

Informed Consent Form for Policy Interviews

Thank you for agreeing to be interviewed as part of the research project called “Stakeholder Analysis Regarding Knowledge of Terminal Groins’ Function and Impacts in North Carolina”. This study is being done by Dia Hitt from Duke University. You were selected to participate in this study because of your expert knowledge of the topic and active participation in the debate about terminal groins in North Carolina.

The purpose of this research study is examine the range of opinion and knowledge that exists on this topic amongst those who have the greatest ability to influence its outcome.

You will be asked a set of questions that focus on your area of expertise. All participants in this field of expertise will be asked the same set of questions to allow for comparison across the respondents. The questions will ask about terminal groins, how they work, their ecological and geological impacts if any, and your opinions on them. The interview will take approximately 1 hour to complete, depending on how in-depth your answers are.

I believe there are no known risks associated with this research study. Your answers in this study will remain confidential. I will label participants as “Interviewer 1” and “Interviewer 2” and so on.

With your permission, interviews will be audio recorded and any notes that are taken will be kept confidential with only the researcher having access. Upon completion of the Master’s project, all audio tapes will be destroyed as will associated notes.

Your participation in this study is completely voluntary and you can withdraw at any time for any reason. You are free to skip any question that you choose.

If you have any questions regarding this survey or research project, please contact me at andrea.hitt@duke.edu. The advisor for this project is Dr. Elizabeth Shapiro, Duke Nicholas School of the Environment. Her contact information is elizabeth.shapiro@duke.edu and her phone number is 919-681-7781. To contact Duke’s IRB office, call (919) 684-3030.

If you agree to participate in this research study, please indicate below:

- YES, I agree that my interview can be recorded.
 NO, I do not agree to allow my interview to be recorded.



Name, position, and date
Appendix E-Survey Data