

THE LOWCOUNTRY LIFESTYLE: COASTAL INFRASTRUCTURE, ECOTOURISM, AND
ENVIRONMENTAL JUSTICE IN SOUTH CAROLINA

by

JEFFREY PAUL BEAUVAIS

(Under the Direction of James E. Byers)

ABSTRACT

Access to marshes is a prerequisite for neighboring communities to benefit from the rich array of services provided by these ecosystems. Although marshes are ostensibly public property in South Carolina, USA, the reality of coastal access is much more complex and influenced by the distribution of coastal infrastructure and the forces that drive development. In this dissertation, I employ an integrative framework to critically investigate the environmental justice dimensions of public and private water access infrastructure (Chapters 2 and 3) and coastal armoring (Chapter 4). I found that both private docks and coastal armoring were concentrated in majority White areas, suggesting that White South Carolinians possess greater private access to marshes. Additionally, I present a detailed case study of a proposed ecotourism resort on Bay Point Island (Chapter 5) to analyze how knowledge claims are woven into contesting narratives on the socioecological impacts of the proposed resort and how these narratives are metabolized by the governance structure of Beaufort County, South Carolina. I found that the Beaufort County government favored knowledge claims that fit within the bureaucratic structure of the county's development code, which limited debate over meaningful questions related to access to Bay Point.

INDEX WORDS: Environmental justice, political ecology, coastal infrastructure, docks, armoring, water access, politics of knowledge, ecotourism, South Carolina

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DEDICATION

Cindy and Steve Beauvais, for raising me and moving to the house on Heron's Nest,
which launched my love of the marsh

Andrew Beauvais, for being my closest friend through all my past and future years

Elaine Matteo Treweek, for always being there to talk, all the wonderful nights
watching movies, and boundless encouragement

Bruce Treweek, for instilling in me an appreciation of history, limericks, and kindness

Jezzy and Cocoa, for being my marsh exploring buddies

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ABBREVIATIONS AND ACRONYMS

ACS – American Community Survey

BPILLC – Bay Point Island, LLC

CBG – Census Block Group

DHEC – Department of Health and Environmental Control

DNR – Department of Natural Resources

EJ – Environmental justice

MHI – Median household income

NHGIS – National Historical GIS

OCRM – Ocean and Coastal Resource Management [a division of DHEC]

SLR – Sea level rise

WAI – Water access infrastructure

ZBOA – Zoning Board of Appeals

CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

Ecologists open windows through which we can view nature, but these are not the only ones available to us...No matter how much nature now “shimmers” for ecologists, it had a more palpable and tangible reality before the twentieth century for those who struggled with it to create livelihoods or to build communities.

- *What Nature Suffers to Groe*

Mart A. Stewart (2002)

When an issue becomes live — when it becomes salient, as political scientists put it — people disagree. The question is how to handle and structure that disagreement within the political system. Will it fuel the process of government, or will it paralyze it?

- “Why Andrew Yang’s New Third Party Is Bound To Fail”

Jamelle Bouie (2022)

Perhaps when I’m finished I’ll remember what I’d hoped to say in the first place.

- *House of Leaves*, Footnote 65, p. 54

Mark Z. Danielewski (2000)

Positionality Statement

On September 20th, 2016, the Hilton Head Island town council met for its biweekly meeting. On the council's agenda that evening was a request from Bay Point Island LLC (BPILLC) for the town council to accept a petition for annexation of their property, Bay Point Island. BPILLC hoped to build an "ecoresort" on Bay Point, an idea they perceived to be aligned with both their priorities and the town's reputation as a pioneer of sustainable tourism. During public comment, a Hilton Head resident approached the podium and explained his opposition to any potential annexation. In introducing his point, he mentioned that he had "...been there [Bay Point] many, many times. I've been hunting and fishing over there in the waters and marshes around there..." After finishing his comments, a local lawyer and manager of the island for BPILLC cut to the microphone and initiated this exchange:

Lawyer: "...if he's been hunting on Bay Point Island, I'm calling DNR because that's not allowed."

Resident: "It's public waters isn't it?"

Lawyer: "In the waters right."

Although the threat was meant at least partially in jest and met with some laughter from the crowd, the resident was clearly displeased and shouted his response from a chair near the back of the room. Despite the lawyer's recognition that the waters were public, the sentiment of exclusivity and control lingered with concerns over what the future of Bay Point would hold.

This meeting happened one month after I began my PhD here at UGA and when I encountered this recording this exchange struck me deeply. As a student in the ICON program, I've read extensively on the importance of reflexivity throughout the research process – the critical act by which we reflect on our normative priors, our motivations, and our methodology to understand the role these factors play in our work. I've taken this deep gaze at myself routinely

through my graduate career, but encountering this exchange engendered a new round of reflection as a series of memories passed through my mind: My frustrated and frightened self in 7th grade speaking to police as they threatened to take my friends and me to juvie for playing paintball on a hammock island a neighbor (falsely) claimed to own; harassment from people not to get near their docks as we swam in our neighborhood's creek; passing by ceaseless luminous yellow private property signs explicitly banning hunting, fishing, or any trespassing as my uncle drove me throughout Beaufort County, describing with a resigned and lamentable tone all the places he used to hunt and fish before the development began; dirty looks from homeowners as I parked my car along Land's End searching for public "beach" access that barely existed, a "You're on camera" sign menacing on a light pole over my head. These first-hand experiences meshed with the concerns I had heard from many residents of Beaufort County about the "ecoresort"¹ and a general loss of public access to the waterways and islands that characterize the coastal Southeast.

The collection of experiences I describe above, in tandem with reading the writings of Black and Gullah-Geechee authors (particularly Queen Quet, Emory Campbell, and Melissa Cooper) early in my graduate career, brought me to this dissertation. I am as much a resident of the coast as I am an academic researcher. The results of my research matter to me beyond completing this degree or dispassionate academic interest; I have a personal, emotional, and moral stake in ensuring equitable access to the marshes throughout the region I call my home. I am a product of being raised in an affluent, White family that owned waterfront property. Although I experienced in many ways how privatization is operated and maintained in space, my

¹ What to call the proposed project on Bay Point underwent many permutations over the past six years but "ecoresort" or something comparable was the term most often used during this meeting.

interactions with this system are only a subset of human experiences with being able to reach and use coastal waters. Under the recognition that all research is situated and partial (Haraway 1988, Sullivan 2013) we can move towards a more expansive understanding of socioecological systems. This is not, as many critics have argued, a call for absolute epistemological relativism or the abandonment of science. It is a recognition of two key points: 1) the physical sciences have long dominated natural resource decision-making to the exclusion of other valid perspectives and 2) the inherent complexity and embeddedness of socioecological systems necessitates epistemological pluralism (Hirsch et al. 2013, Popa et al. 2015) to break this dogma. As David Demeritt (2006) puts it, "...once we acknowledge that 'the operative question is how to distinguish between good constructions and bad' (Latour 2004), it becomes possible to recognize that the commitment to reasonableness, honesty, and open deliberation is as important for our politics as for our science." In the spirit of being transparent in my motivations and creating a "good construction", I share this experience at the onset to reveal how and why this project came to be and what I hope my work will achieve throughout my career.

Theoretical Foundations

It seems that nearly every paper I read on applied coastal ecology opens with a passage emphasizing the proportion of the local, national, or international population that lives within proximity of the coast. Although a verifiable cliché at this point, it is an illuminating one. This rhetorical trope points to nature's "tangible reality" for humanity, the inseparable entanglement of human and non-human nature. This entanglement, however, does not imply uniformity. Environmental costs and benefits are spread unevenly among individuals in socioecological

systems, often shaped by iterative, interacting physical and social processes (Robbins 2004 pp. 4–5, Reyers et al. 2018).

Several fields have long recognized the unevenness of environmental benefits and burdens. Chief among these is the field of environmental justice (EJ). Protests beginning in the early 1980s against the disposal of PCB-contaminated soil in the predominantly Black community around Afton, North Carolina are often considered the events that began the EJ movement. The roots of EJ, however, reach back at least to the Civil Rights Era, where Black Americans organized to resist deadly industrial and agricultural working conditions (Spears 2014, Williams 2018), lack of access to outdoor recreation (Kahrl 2012b), and disparate levels of federal assistance to farmers (Daniel 2013). Nearly four decades of EJ research has routinely demonstrated that race and economic class are correlated with increased exposure to chemical hazards in the environment (Ringquist 2005, Bullard et al. 2008, Mohai et al. 2009). EJ scholarship has shown that Latino (Peña 2003, Bullard et al. 2008), Asian American (Tai 1999, Bullard et al. 2008) and American Indian (Ishiyama 2003, Schlosberg and Carruthers 2010) communities also experience environmental injustices and have organized to combat it.

Environmental justice concerns far more than toxic substances and pollution. Today, EJ researchers and movements have expanded their attention to climate change/sea level rise (Sze and London 2008, Schlosberg and Collins 2014), the impact of “natural” disasters (Lewis et al. 2017, Chakraborty et al. 2019), and natural resource distribution/management (Schneider et al. 2019, Riley and Gardiner 2020). Collectively, these diverse subjects of EJ inquiry highlight the movement’s general goal of addressing environmental racism - the unequal distribution of environmental benefits and burdens along racial lines (Bullard and Johnson 2000, Taylor 2014). Importantly, environmental racism is context dependent and universal patterns should not be

expected. For example, Riley and Gardiner (2020) employed a comparative regression analysis approach to examine the distribution of tree canopy cover and estimated value of ecosystem services provided by trees in nine cities across the United States. They found that the magnitude and direction of the correlation between race and canopy cover varied in different regions. California cities consistently showed negative relationships between canopy cover and areas with higher populations of racialized minorities, while some cities in the Midwest showed positive relationships. Although it may be tempting to suggest those Midwest cities are not experiencing environmental inequity in canopy cover, the authors recognize the limits of relying solely on large-scale, quantitative approaches (Riley and Gardiner 2020). They note that the history of economic and population declines in Midwest cities may be driving a deceptive positive association between communities of color and lower quality, unmanaged urban canopy.

While recognizing the social and academic importance of the EJ movement, many authors have offered valid critiques of the field. Typically drawing from more critical² disciplines like political ecology or realms of study like racial capitalism³, these critiques offer insight into the limitations of EJ and potential avenues for integration. Most prominently, Pulido's (2000) influential work compellingly demonstrated that EJ research was characterized by a narrow conception of environmental racism that was not aligned with more nuanced and contemporaneous understandings of racism. By watering racism down to an intentional, malicious act, EJ research was missing broader forms of racism manifested in cultural, political, and economic structures (Pulido 2000). Heynen *et al.* (2006, p. 9) offered a complementary

² By critical I refer to research that analyzes how power operates within social systems.

³ By realm of study, I am referring to multiple disciplinary perspectives like environmental history, political ecology, geography, and critical legal studies that address racial capitalism. Additionally, the concept of racial capitalism has seen a recent resurgence since being coined (Robinson 1983) and I argue many works do analyze racial capitalism even if they do not use the terminology.

critique, noting that many EJ studies address the symptoms of environmental racism and how to distribute them under a liberal framework, not the forces of capital that produce these symptoms.

Today many EJ studies have taken this critique to heart, and a robust EJ literature has emerged. For those unfamiliar with critical research these concepts might seem slippery, but a detailed example of what merging EJ and political ecology provides can be seen in work around Flint, Michigan. Histories of neighborhood redlining (Ranganathan 2016), the desertion of the city by once prominent auto industries (Pulido 2000, Ranganathan 2016), and white flight to the surrounding suburbs led to chronic disinvestment in the city core (Clark 2018). In Flint, this history of racially imbricated divestment manifested as a spatialized lack of investment in public water infrastructure, particularly in poor Black neighborhoods. Compounded with neoliberal austerity measures enacted by a series of emergency fiscal managers (Pulido 2016, Ranganathan 2016, Clark 2018), including halting corrosion control treatments (Pieper et al. 2017), these forces ultimately resulted in the lead water poisoning that continues to affect residents of Flint. Furthermore, organizing efforts by impacted Flint residents were paramount in bringing the poisoning to light in the face of repeat inaction by numerous state authorities (Clark 2018). Thus, the drivers and consequences of the lead crisis in Flint cannot be understood as a matter of intentional decisions by a handful of bad actors or unlucky consequences of water chemistry. Only a transdisciplinary approach – the merging of contributions from physical scientists, social scientists, citizen advocacy groups, and other non-academic entities – is needed to understand and respond to environmental injustices.

Overview of Chapters

This dissertation uses an integrative approach, primarily drawing from environmental justice and political ecology, to address the overarching research question: What forces structure *de facto* access to marshes and estuaries along the South Carolina coast? The coastal regions of South Carolina are dominated by salt marshes, which are estuarine ecosystems present across temperate zones worldwide. Along the Atlantic coast in the southeastern United States, salt marshes are characterized by a relatively small number of salt tolerant plant species, which typically show strong zonation along elevational gradients due to multiple drivers such as competition, inundation, and salinity (Pennings et al. 2005). Marshes provide numerous ecosystem services to coastal communities (Martínez et al. 2007) and the habitat provided by foundational salt marsh species is vital for a rich array of fishes, crabs, birds, mammals, and other organisms. Aside from their habitat provisioning services (Barbier et al. 2011), marsh vegetation stabilizes sediment (Deegan et al. 2012), attenuates wave strength (King and Lester 1995, Möller et al. 1999), and are exceptionally efficient carbon sinks despite their small global area (Chmura et al. 2003, Mcleod et al. 2011). Other species, such as the Eastern oyster (*Crassostrea virginica*) improve water quality by filtering suspended particles and nutrients from the water column (Coen et al. 2007). Lastly, many of the animal species present in salt marshes are of significant economic and cultural value to South Carolinians (Goodwine 2015, Willis and Straka 2016).

Prerequisite to benefiting from many of these services (particularly provisioning and cultural services) is the capacity to access them. The concept of “access” can be understood through many lenses. In their seminal work, Schlager and Ostrom (1992) defined access as “the right to enter a defined physical property,” emphasizing the role established rules, norms, and

systems of property rights play in determining who is allowed to collect and use natural resources within given spaces. Other definitions have shifted from a singular focus on property rights. For example, Ribot and Peluso (2003) define access as the “the ability to derive benefit from things.” By centering “ability” and “benefit” over “rights” and “entry”, this critical definition allows us to analyze how power between actors enables some individuals to make use of ecosystem services while others cannot.

Access also has an established legal meaning in coastal ecosystems. Most US states (Frank 2011) and many countries around the world (Blumm and Guthrie 2012, Alterman and Pellach 2022) legally recognize navigable waterways and areas below certain intertidal elevations as public land. In the US context, this legal protection is known as the “public trust doctrine” and dates to both English common law and Roman law (Scanlan 2013, Alterman and Pellach 2022). In South Carolina, all lands below mean high water are public domain, except in the rare cases of King’s Grants from the colonial period where private property can extend into the intertidal (Clineburg and Krahmer 1971, McMaster 2006). “Horizontal” access, or the extent of the intertidal range that is preserved as public property, is the most common form of legally protected access across US states and Europe (Alterman and Pellach 2022). Other types of coastal access are considerably less established in law. Most importantly for this dissertation, the land along the marsh-land interface (the “upland”) can be privately owned, creating a barrier of private property. Categorized as “vertical” access by Alterman and Pellach (2022), no US states have established standards designed to ensure public ability to reach the water from the upland. Vertical access is augmented by both privately and publicly owned infrastructure like docks, marinas, piers, boardwalks, and boat ramps. I collectively classify these structures as “water access infrastructure” (WAI), which I define as any structure that facilitates entry into the marine

environment. Not only do WAI enhance marsh access, but they also serve as an easily identifiable proxy for associated private and public upland parcels.

Chapters 2 and 3 synthesize these various concepts of access and utilize quantitative mapping approaches to address questions primarily centered on distributive justice of WAI. **In Chapter 2, I examine the contemporary distribution of private and public WAI along the South Carolina coast.** This chapter uses 2016 infrastructure data to assess the relative abundance of public v. private WAI and how they are located with respect to the racial and economic composition of their surroundings. This was the first chapter I completed and working through this chapter, in tandem with the improvisation forced onto me by the pandemic, provided a path to my third and fourth chapters. **In Chapter 3, I present a longitudinal analysis of private WAI distribution in coastal South Carolina.** This chapter builds on Chapter 2 by assessing how the distributional equity of private docks has changed from the early 1990s to 2016. This chapter also presents data of general ecological and planning interest, as I track how the abundance and length of private WAI have changed from the mid-20th century to 2016.

Chapters 2 and 3 provide a detailed look at WAI in South Carolina, however, many other structures are prevalent across US coastlines. **In Chapter 4, I provide an analysis of the racial and economic distribution of coastal armoring infrastructure along the South Carolina coast.** Armoring infrastructure itself can also affect coastal access but importantly also brings with it a unique set of EJ considerations in the face of sea level rise.

Although Chapters 2-4 largely utilize a traditional EJ framework focused on questions of distributive justice, to the best of my knowledge, these chapters present some of the few analyses of justice and coastal infrastructure in the literature. Thus, these chapters lay the foundation for future work on marsh access in the coastal Southeast. Furthermore, my discussions provide a

more critically attuned perspective to understand the historical and contemporary forces that generate the patterns I document. One of the primary drivers of coastal development and privatization is the tourism industry. Although coastal South Carolina has long hosted environmentally centered tourism (i.e. beach vacations), there is growing use of the concept of “ecotourism” in the region. Ecotourism operations frequently position themselves as a merging of a conservation ethos and community empowerment, providing a win-win approach to tourism (Donohoe and Needham 2006, Phelan et al. 2020). Substantial research into ecotourism, particularly in the global South, has demonstrated that ecotourism ventures frequently harm neighboring communities (Fletcher and Neves 2012, Büscher and Fletcher 2017), often through the acceleration of land dispossession (Benjaminsen and Bryceson 2012).

Typically, critical studies of ecotourism occur after tour companies and resorts are established, preventing robust analysis of the processes and social relations that generate these operations. A central function of environmental decision-making institutions is the valuation of knowledge claims (Taylor and de Loë 2012, van der Molen 2018). Therefore, when a regulatory authority is tasked with deciding whether to approve an ecotourism development, it must weigh the validity of the rationale, opportunities, and drawbacks given for that project. Critical political ecology highlights the importance of investigating socioecological knowledge claims, as debates over what constitutes valid knowledge and who possesses it are wrapped up in systems of social exclusion and power differences between actors (Walley 2002, Davis 2005, Goldman et al. 2011 p. 4). The governance structures that incorporate or silence the knowledge of multiple actors shapes socioecological conditions and may further marginalize groups who are deemed to possess less valuable knowledge (Walley 2002). **In Chapter 5, I examine the overlap of knowledge politics and technocratic governance in the controversy over a proposed**

“ecotourism” lodge on Bay Point Island, South Carolina. I employ narrative analysis of interviews, public meetings, and planning documents to investigate how different groups deploy knowledge claims to advocate for or against the lodge through Beaufort County’s bureaucratic planning structure.

CHAPTER 2

DIFFERENTIAL EQUITY IN ACCESS TO PUBLIC AND PRIVATE COASTAL
INFRASTRUCTURE IN THE SOUTHEASTERN UNITED STATES⁴

⁴ Beauvais, J., N. P. Nibbelink, and J. E. Byers. 2022. Differential equity in access to public and private coastal infrastructure in the Southeastern United States. *Ecological Applications*.
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Abstract

Despite the ubiquity of coastal infrastructure, it is unclear what factors drive its placement, particularly for water access infrastructure (WAI) that facilitates entry to coastal ecosystems such as docks, piers, and boat landings. The placement of WAI has both ecological and social dimensions, and certain segments of coastal populations may have differential access to water. In this study, we employed an environmental justice framework to assess how public and private WAI in South Carolina, United States is distributed with respect to race and income. Using publicly available data from state agencies and the US Census Bureau, we mapped the distribution of these structures across the 301 km of the South Carolina coast. Using spatially explicit analyses with high resolution, we found that census block groups with lower income are more likely to contain public WAI, but racial composition has no effect. Private docks showed the opposite trends, as the abundance of docks is significantly, positively correlated with census block groups that have a greater percentage of White residents, while income has no effect. We contend that the racially unequal distribution of docks is likely a consequence of the legacy of Black land loss, especially of waterfront property, throughout the coastal Southeast over the past half-century. Knowledge of racially uneven distribution of WAI can guide public policy to rectify this imbalance and support advocacy organizations working to promote public water access. Our work also points to the importance of considering race in ecological research, as the spatial distribution of coastal infrastructure directly affects ecosystems through the structures themselves and regulates which groups access water and what activities they can engage in at those sites.

Introduction

Societies have modified shorelines for centuries to utilize, augment, and control the ecosystem services provided by coastal environments (Dugan et al. 2011). Structures like docks, boat landings (ramps), marinas, and piers facilitate access to water, modulating where and how humans interact with coastal ecosystems. We collectively refer to these types of structures as “water access infrastructure” (WAI), which can be either publicly or privately owned. WAI fulfill multiple roles for coastal populations. They provide recreation, space to observe and enjoy coastal ecosystems, and influence how people interact with marine environments by providing spaces to harvest seafood resources.

The distribution of public and private WAI serves as a quantifiable index of *who* has access to coastal ecosystem services. In this article, we define access as the ability to physically enter the marine environment (Schlager and Ostrom 1992, Ribot and Peluso 2003). Most US states (Frank 2011) and many other countries (Blumm and Guthrie 2011) legally recognize all navigable waterbodies and areas below mean high water as public property; however, all waters are not functionally public. Long stretches of private property along the water/land interface (the “upland”) can prevent water access. Thus, for those who do not possess their own private WAI, the ability to enter coastal waters is primarily determined by the availability of public WAI. This potential disconnect between the legal and functional status of defined waterbodies emphasizes the importance of examining the socioeconomic distribution of public and private WAI.

Focusing on who has access to water through WAI can be investigated under the framework of environmental justice (EJ). EJ is an activist and scholarly movement that arose from grassroots organizing against environmental racism - the unequal distribution of environmental benefits and burdens along racial lines (Bullard and Johnson 2000, Taylor 2014).

Although environmental justice coalesced around the human health impacts of toxic industries and waste sites (Ringquist 2005, Bullard et al. 2008, Mohai et al. 2009), it has expanded in recent decades to encompass a wider range of human-environment interactions. Among these, the equitable distribution of ecosystem services is an emerging and important subfield. Dominant research topics in this area include access to greenspaces such as parks and trails for leisure (Wolch et al. 2014, Rigolon 2017, Suárez et al. 2020), availability of safe drinking water (Ranganathan and Balazs 2015, Schaider et al. 2019, Heck 2021) and the distribution of regulating services such as heat mitigation and carbon sequestration provided by urban tree canopy cover (Jenerette et al. 2011, Schwarz et al. 2015, Riley and Gardiner 2020). Racial (Pulido 2016, Rigolon 2017, Schaider et al. 2019, Riley and Gardiner 2020) and economic disparities (Jenerette et al. 2011, Schwarz et al. 2015, Kim et al. 2019) have been documented in the distribution of ecosystem services, though the relative strength of racial and economic disparities vary depending on context and is strongly influenced by local history (Riley and Gardiner 2020).

Although natural resource management is increasingly viewed through the lens of EJ, few studies examined the justice dimensions of access to coastal ecosystems and the availability of public WAI (Montgomery et al. 2015, Paloniemi et al. 2018, Kim et al. 2019, Pitt 2019). Availability can be measured through several metrics, including simple counts of public WAI in an area or the distance individuals must travel to reach public WAI (Haeffner et al. 2017, Kim et al. 2019). In Miami, Florida, Montgomery et al. (2015) found that race, ethnicity, and economic status affected public beach access, as non-Latinx White and higher income neighborhoods were significantly closer to public beaches than other neighborhoods. Working in Helsinki, Finland, Paloniemi et al. (2018) found physical, transportation, and legal barriers to accessing public

beaches across the city, though they did not directly evaluate the effects of race, income, or other socioeconomic factors. These studies highlight the importance of assessing the availability of public access to coastal environments and to contextualize this within the broader landscape of private water access.

Considering the scarcity of research into the factors that control the distribution of water access in both the ecological and EJ literature, we used mapping and regression to examine the following question: How are public WAI (boat landings and piers) and private WAI (docks) distributed across economic and racial groups along the coast of South Carolina? We hypothesize that private WAI abundance and the probability that a census block group (CBG) will contain any public WAI will be positively correlated with median household income and the proportion of the population that is White. Likewise, we predict that the average distance to the nearest public WAI will be negatively correlated with median household income and the percentage of the population that is White. We consider the likelihood of containing public WAI and the distance to the nearest public WAI as different metrics for assessing availability. In short, we predict wealthy areas with a higher proportion of White residents will contain a greater abundance of private WAI, be more likely to have any public WAI, and will be closer to public WAI than lower income areas with a higher proportion of non-White residents.

Our study contributes to the growing literature on EJ and natural resource access by providing one of the first large-scale spatial assessments of public and private WAI distribution. Investigating who can utilize WAI has important implications for ecology and coastal management, as different racial and ethnic groups consume self-caught seafood at different rates (Burger et al. 1999, Ellis et al. 2014), prioritize and collect different species (Hunt and Ditton 2002), and use different techniques and gear (Brown and Toth Jr 2001). Thus, understanding

where these structures are on the landscape and who can readily use them illuminates patterns of access to natural resources and can improve our understanding of impacts on resources.

Methods

Study System

We conducted our research in six coastal counties of the southeastern US state of South Carolina (Figure 2.1, inset map). Counties are geographic subdivisions of a state that have their own local governments. The coastal portions of these counties are characterized by salt marshes, which is typical of the southeast US, while interior portions of these counties contain freshwater and brackish tidal rivers. All areas below mean high water are legally defined as public property in South Carolina, but this does not guarantee functional water access. Without a boat, navigable saltwater/freshwater rivers are only accessible from public WAI or the upland, which can be privatized and block access to waters.

South Carolina is an advantageous study system because WAI data were readily available for all six counties and these counties are both racially and economically diverse, which allows a robust analysis of WAI distribution. Furthermore, part of our decision to locate our study in South Carolina was based on the writings and experiences of Gullah-Geechee authors and their colleagues (Campbell 2011, Hoke and Watson 2013, Ellis et al. 2014, Goodwine 2015). The Gullah-Geechee are descendants of formerly enslaved African peoples, largely from West-Central Africa who formed their own language, cultural practices, and livelihood systems along the coast from Jacksonville, Florida to Jacksonville, North Carolina (Ellis et al. 2014, Goodwine 2015, Zimmerman et al. 2021). Today, there are an estimated 200,000 people of Gullah-Geechee heritage living in the coastal counties of North Carolina, South Carolina, Georgia, and Florida

(NPS 2005), though the Gullah-Geechee diaspora throughout Northern America, Central America, and the Caribbean is undoubtedly much larger (Campbell 2011). Furthermore, social stigma and racism against the use of the Gullah-Geechee language throughout the 20th century (Jones-Jackson 1978, Campbell 2011) led to many communities not recognizing themselves as Gullah-Geechee (Campbell 2011, Cooper 2017), resulting in a likely underestimate of people of Gullah-Geechee descent in the coastal Southeast. The Gullah-Geechee are a federally recognized cultural group that has deep ties to and knowledge of the socioecological systems of South Carolina and other Southeastern states. Seafood gathering is particularly important to the Gullah-Geechee in this region, and many rely on the resources from marshes for subsistence, economic, and cultural uses (Beoku-Betts 1995, Gullah Geechee Cultural Heritage Corridor Commission 2012, Ellis et al. 2014, Goodwine 2015).

Defining the Study Area

We conducted our analysis at the census block group level. The US Census Bureau subdivides counties into smaller geographic units known as census tracts, which are themselves divided into census block groups, designed to encompass between 600-3,000 people. Census tracts and CBGs do not represent political jurisdictions but are used by the Census Bureau to summarize and report demographic data. CBGs represent the highest spatial resolution for demographic data in most situations and are routinely used in EJ research (Schwarz et al. 2015, Riley and Gardiner 2020).

We downloaded shapefiles for the 583 CBGs that made up our focal counties from the Census Bureau TIGER/Line Shapefile website (<https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html>). Because we are only interested in residential and public

areas, we removed six CBGs that encompassed military bases and three CBGs that made up the Port of Charleston. We also removed one CBG in Horry County because it consisted of small docks on manufactured canals that are not reflective of development patterns anywhere else on the South Carolina coast. After removing these block groups, our final, full study area consisted of 573 CBGs.

We divided our study area into “Beach,” “Freshwater,” “Interior,” and “Marsh” Zones (Figure 2.1) following the saltwater/freshwater dividing line from the South Carolina Department of Natural Resources (<https://www.dnr.sc.gov/marine/dividingline.html>) and official beachfront jurisdictional lines from the South Carolina Department of Health and Environmental Control (DHEC, <https://gis.dhec.sc.gov/shoreline/>). We classified CBGs with more than 1 km of marsh/saltwater shoreline as part of the Marsh Zone, CBGs with greater than 0.25 km of beach shoreline and less than 1 km of marsh shoreline as part of the Beach Zone, and CBGs with more than 1 km of freshwater river shoreline as part of the Freshwater Zone. We classified all other CBGs in the study area as part of the Interior Zone. We chose a 1 km minimum shoreline length to define the Freshwater and Marsh Zones to ensure we were only selecting CBGs with appreciable levels of shoreline, as we observed that many CBGs with low lengths of shoreline were comprised of small embayments that did not contain navigable water (Appendix A: Table A.1).

Objectives

We addressed our research question through four objectives: 1) Enumerate, visualize, and quantify the density of public and private WAI across the entire 573 CBG region; 2) analyze the likelihood a CBG will contain any public WAI with respect to the racial and economic

composition across the 283 CBGs of the Beach, Freshwater, and Marsh Zones; 3) analyze the distance to the nearest public WAI across the 283 CBGs of the Beach, Freshwater, and Marsh Zones; and 4) analyze the abundance of private WAI with respect to the racial and economic composition across the 187 CBGs of the Marsh Zone.

Data Collection – Response Variables

We collected data on public and private WAI abundance for Objectives 1, 2, and 4 from shapefiles of WAI from DHEC’s public GIS server (<https://sc-department-of-health-and-environmental-control-gis-sc-dhec.hub.arcgis.com/>). These shapefiles contained digitized outlines of boat landings, docks, and piers which we cross-referenced with city and county websites to verify and distinguish between public (piers and boat landings) and private (docks) infrastructure. We counted and recorded how many of each structure type was present within each CBG in ArcMap 10.6.1 (ESRI 2018) at a 1:1,500 scale. For Objective 3, we used the “Cost Distance” tool in ArcMap to measure the distance to the nearest public WAI along a shapefile of roads and highways from the South Carolina Department of Transportation’s public GIS website (<http://info2.scdot.org/GISMapping/Pages/GIS.aspx>). We then extracted distance values for 100 randomly placed points per CBG along that road network, with a minimum distance of 10 m separating each point. We averaged these extracted values to get a mean distance to nearest public WAI for each CBG.

Data Collection – Predictor Variables

Since WAI are necessarily built along bodies of water, we measured the length of shoreline of each block group in ArcMap. We measured shoreline using 30 m resolution land

cover rasters from NOAA's Digital Coast portal (<https://coast.noaa.gov/digitalcoast/data/>) and labeled each shoreline segment as either "Beach," "Marsh," or "Freshwater" following the same saltwater/freshwater and beachfront lines discussed above (Appendix A: Fig. A.1, A.2).

Freshwater ponds and wetlands are also important natural resource areas, particularly for the Gullah-Geechee (Halfacre et al. 2010, Hurley and Halfacre 2011), but they are beyond the scope of this study, and we did not include them in the measure of shore length.

We gathered data on demographic predictors from the American Community Survey (ACS) that the US Census Bureau administers in the years between decennial censuses and models demographic characteristics from a yearly sample of approximately 3.5 million households across the United States. We collected data from the 2012-2016 5-year average using the R package "tidycensus" (Walker and Herman 2021) in R Version 4.0.4 (R Core Team 2021) to correspond with the published date of the WAI data. We used median household income as a measure of CBG economic status and the percent of the CBG population classified as White by the Census Bureau as a measure of racial composition. We chose to represent racial composition through the percent White variable because White and Black residents were by far the most prevalent racial groups across the Zones used in the analysis (Figure 2.2A/B). Because the Census Bureau does not collect data that allows us to distinguish Gullah-Geechee from Black residents who are not of Gullah-Geechee heritage, we cannot directly analyze the distribution of WAI with respect to Gullah-Geechee communities. Despite this limitation, the Gullah-Geechee comprise a large share of the Black population in coastal South Carolina given their long history in the area (Goodwine 2015, Zimmerman et al. 2021).

We selected additional predictor variables, percent homeownership and total population, based on our system-level knowledge and prior EJ studies (Kim et al. 2019, Riley and Gardiner

2020). The state of South Carolina requires proof of title for dock permits (S.C. Code Ann. §54-13-10), thus a concentration of rental property in a CBG may be correlated with lower abundances of docks.

Objective 1 - Structure Density Mapping

To visualize differences in the distribution of public and private WAI across the landscape, we calculated and mapped the density of WAI for every 100 m grid cell across the 573 CBG study area using the “Point Density” tool in ArcMap. We calculated WAI density values for both a 10 km and 1.6 km radius area around each focal cell. Thus, for each cell in the mapped outputs, the density value represents the number of public or private structures within 10 km or 1.6 km. We chose these values to represent driving (10 km) and walking (1.6 km) distances. Although these exact distances are arbitrary, we believe they are reasonably representative of the availability of WAI for those with and without a vehicle. Additionally, we calculated the total and percent land area that contained public or private WAI within driving or walking distance.

Objective 2 – Public WAI Logistic Model

Because piers and public boat landings are commonly built along freshwater rivers and beaches, we used the 283 CBGs of the Beach, Freshwater, and Marsh Zones to model the distribution of public WAI. We fit a logistic regression using the “glmmTMB” package (Brooks et al. 2017) in R to model the probability a CBG would contain any public WAI. We chose to model public WAI presence/absence because the range of public WAI abundance was small (0-4), and we feel the results of the logistic regression are more readily interpretable. We ran a

supplemental analysis on public WAI abundance using a Poisson regression that yielded comparable results. We include this analysis in Appendix A: Table A.2, Fig. A.3.

We included a centered median household income variable (in thousands of USD) and percent White as the predictor variables of interest. Other fixed effects included percent homeowners in the CBG, centered population of the CBG (in hundreds of people), shore length (in km), and the number of docks in the CBG to account for the potential influence of private WAI abundance on public WAI. We used total population in lieu of population density because CBG land area (the denominator for population density) is highly collinear with shore length. We included county and census tract as random effects to account for the nesting of CBGs within census tracts within counties. We tested and found no support for an interaction between the variables for income and race, so we removed the interaction from the model. We did not find any evidence of multicollinearity of predictor variables ($VIF < 2$).

We ran similar model diagnostics for Objectives 2-4. We examined residuals for homoscedasticity using the “DHARMA” package (Hartig 2021) in R. Due to the implicit spatial nature of our data, we analyzed the residuals from our regression to determine if we needed to explicitly include space in the model. A Moran’s I test assuming an inverse-distance weighting relationship on the residuals revealed no significant autocorrelation ($z = -0.31, p = 0.75$); therefore, we did not include an explicit spatial covariance structure in this model. We used likelihood ratio tests to examine the significance of individual terms in the model. To assess the strength of significant terms, we calculated and plotted their conditional effects using the “ggeffects” package (Lüdtke 2018). “ggeffects” generates predicted values for the response variable across the range of a focal predictor variable while holding all other terms in the model

constant at their mean values. The y-axes of conditional effects plots are back-transformed to the original scale of the data.

Objective 3 – Distance to Public WAI Model

In addition to modeling the probability of public WAI presence, we used distance to the nearest public WAI as a response variable. This approach has been used in other EJ analyses of public water access points (Montgomery et al. 2015, Kim et al. 2019) and has the advantage of providing a more embodied measure of the accessibility of public WAI than simple presence/absence or counts. Because individuals must travel to reach public WAI, travel distances often influence people's willingness and ability to use these public spaces (Montgomery et al. 2015, Morelle et al. 2019). Distance to nearest public WAI was lognormally distributed and we fit this data using a linear mixed effects model. We included the same fixed and random effects as in Objective 2 but swapped the length of shoreline with the overall land area (in km²) as this analysis covers a larger portion of CBG geometry and not just coast-adjacent portions.

We assessed model residuals for normality and homogeneity of variance and a Moran's I test found no evidence of residual spatial autocorrelation ($z = 1.53$, $p = 0.12$). There was no evidence of multicollinearity ($VIF < 2$). As before, we used likelihood ratio tests to examine significance of model fixed effects and plotted conditional effects using the "ggeffects" package.

Objective 4 – Private WAI (Dock) Model

Unlike our models of public WAI, we only analyzed the 187 block groups in the Saltwater Zone (Figure 2.1) for our model of dock abundance. We restricted our geographic area

because docks cannot be built along beachfront and are uncommon on inland, freshwater rivers (the Saltwater Zone contained 90.8% of the docks across the entire study area). We fit a zero-inflated, negative binomial mixed model with dock count as the response variable using “glmmTMB”. We included the same random and fixed effects as in the public WAI abundance model with two exceptions: 1) we log transformed shore length to meet assumptions of homoscedasticity in model residuals and 2) we swapped out the fixed effect for total dock count with the abundance of public WAI in the CBG to account for the potential influence of public WAI abundance on private WAI. We again tested and found no support for an interaction between the variables for income and racial composition. We found no evidence of multicollinearity ($VIF < 2$).

As before, we examined the model residuals for homoscedasticity using the “DHARMA” package and spatial autocorrelation using ArcMap. A Moran’s I test revealed significant spatial autocorrelation of model residuals ($z = 2.16$, $p = 0.031$). Residual spatial autocorrelation violates the assumption of observational independence for inferential statistical tests (Ver Hoef et al. 2018) and must be corrected by using spatial regression approaches to obtain reliable estimates of significance. We refit the model with a spatial exponential covariance structure (Liu 2016), which eliminated spatial autocorrelation of the residuals ($z = 0.65$, $p = 0.51$). As with the public WAI models, we used likelihood ratio tests to determine the significance of individual model terms and the “ggeffects” package to calculate conditional effects of race and income. We chose to analyze private WAI abundance instead of density because our count model met regression assumptions better than a similar model that used private WAI density as a response variable.

Results

Descriptive Statistics of Coastal South Carolina Counties

A total of 43 public piers, 124 public boat landings, and 11,953 private docks were present across the entire 573 CBG study area in 2016. Dock abundance varied by county. Charleston County contained the most docks (5,888 docks, 49.25% of the total), while Jasper County only contained 204 docks (1.7% of the total). Likewise, Charleston County contained the most public WAI with 41, while Jasper County contained the fewest with 12. Charleston County had the highest density of private WAI (4.67 docks/km of shoreline) while Colleton County had the lowest density of private WAI (0.71 docks/km of shoreline). For public WAI, Horry County had the highest density of structures (0.062 public WAI/km of shoreline), while Beaufort and Charleston counties had the lowest (0.031 public WAI/km of shoreline).

The total population of our 573 CBG study area was 969,129 people, with 482,855 people in the Interior Zone, 329,607 in the Marsh Zone, 133,200 in the Freshwater Zone, and 23,467 in the Beach Zone (Figure 2.2A). Overall, an estimated 67.5% of the study area population was White, 22.9% was Black, 6.4% was Latinx, 1.1% was Asian, and less than 1% was either American Indian, Pacific Islanders, or another race. When aggregated by Zone, the Beach Zone showed the lowest racial diversity (82.8% White), while the Interior Zone showed the highest racial diversity (Figure 2.2B). CBGs in the Marsh Zone had a substantially higher median household income (\$64,602) than CBGs in the Freshwater (\$38,512), Interior (\$43,483), and Beach (\$51,740) Zones (Figure 2.2C). Lastly, CBGs in the Beach Zone had a higher median percent White (92.2%) than the Marsh (78.7%), Freshwater (72.6%), and Interior (64.8%) Zones (Figure 2.2D).

Objective 1 - Structure Density Mapping

WAI density was highly heterogeneous (Figure 2.3). Our 573 CBG study region covered a total area of 1,370,664 ha. Of the total area, 1,150,340 ha was within 10 km (driving distance) and 589,068 ha was within 1.6 km (walking distance) of a navigable fresh or saltwater river. For the region within 10 km of water (Figure 2.3 A/B), 953,721 ha (82.9% of land area) contained a private WAI within 10 km and 1,033,531 ha (89.8%) contained a public WAI within 10 km. Public WAI covered a greater land area than private WAI at the 10 km search radius due primarily to the presence of public boat landings along some freshwater rivers in Horry and Georgetown counties. Although the total land area within 10 km of a public WAI was greater than private WAI, the density of these structures was two orders of magnitude larger for private WAI. At walking distance, there was a pronounced difference in the land area within the 1.6 km search radius of a private and public WAI (Figure 2.3C/D). 356,187 ha (60.4%) contained a private WAI within 1.6 km, while 92,613 ha (15.7%) contained a public WAI.

Objective 2 – Public WAI Logistic Model

The probability of a CBG containing a public WAI decreased with income (Table 2.1, $\chi^2(1) = 9.76$, $p = 0.0018$), but was unaffected by percent White ($\chi^2(1) = 0.38$, $p = 0.53$). As expected, the term for shore length was highly significant and positively correlated with public access probability ($\chi^2(1) = 11.46$, $p < 0.001$) and the number of docks was borderline significant ($\chi^2(1) = 3.67$, $p = 0.054$). Examining the conditional effects, the predicted probability of a CBG containing a public access structure plummeted from 61.2% [95% confidence interval: 44.1–75.9%] to 2.3% [0.3–14.3%] from the lowest to highest income CBGs (Figure 2.4A). As

shoreline increased, the likelihood of a CBG containing a public WAI increased from 22.3% [15.7–30.8%] to 98.7% [69.7–100%].

Objective 3 – Distance to Public WAI Model

The distance to nearest public WAI model yielded distinct results from the logistic regression of public WAI. Neither income (Table 2.2, $\chi^2(1) = 2.33$, $p = 0.13$) or racial composition ($\chi^2(1) = 1.48$, $p = 0.22$) showed a significant relationship with public WAI distance. Only land area ($\chi^2(1) = 16.61$, $p < 0.001$) and total population ($\chi^2(1) = 4.82$, $p = 0.028$) showed positive correlations with public WAI distance (Figure 2.5A/B). Our model predicted distance to nearest public access to increase from 4.56 km [4.07–5.10 km] to 13.63 km [8.39–22.15 km] across the range of CBG area in the study. Likewise, as population size increased, the distance to nearest public WAI increased from 4.55 km [3.98–5.22 km] to 7.93 km [5.22–12.04 km].

Objective 4 – Private WAI (Dock) Model

The spatial exponential model of dock count showed a reverse of the trends seen in the public WAI logistic model. Our analysis revealed no effect of income on dock abundance (Table 2.3, $\chi^2(1) = 0.05$, $p = 0.82$), but did reveal a significant, positive effect of percent White (Table 2.3, $\chi^2(1) = 7.61$, $p = 0.0058$). Shore length showed a highly significant, positive correlation with dock count (Figure 2.6B, $\chi^2(1) = 42.78$, $p < 0.001$), but no other terms were statistically significant. Racial composition demonstrated a strong conditional effect, as the number of docks in a CBG increased from 24 [12–46] to 78 [48–126] docks between CBGs that are 0 and 100% White (Figure 2.6A). The two large dock outliers did not influence the statistical significance and

conditional effects of these variables, as a model rerun without these outliers showed negligible differences.

Discussion

General Interpretation of Results and Methodological Considerations

We found that public and private WAI differ in their distribution across the South Carolina coast. The relationship between public WAI, race, and income was contingent on the metric of public WAI availability used and ran counter to our hypotheses. We found that public infrastructure was more likely to occur in areas with lower household incomes, longer shorelines, and more private WAI. Public WAI presence had no correlation to the racial composition of a CBG. On the other hand, the distance to the nearest public WAI showed no relationship with income or racial composition but increased with the land area and population of CBGs. Private WAI partially conformed to our predictions, as abundance was greater in predominantly White CBGs, while income was not correlated.

The results of the public WAI models suggest that the contemporary distribution of public structures is broadly equal across racial groups and economic classes in these six counties, with an elevated likelihood of public WAI presence in lower income areas (Figure 2.4A). The divergent results we obtained from both public WAI analyses highlight the importance of evaluating multiple response variables when examining access and being deliberate and transparent in their application (Riley and Gardiner 2020). We see value in considering the probability of occurrence, the abundance of public WAI (Appendix A: Fig. A.3), and distance metrics for public WAI availability and suggest all approaches have utility depending on need and purpose. For example, a city planner may value building additional WAI in areas where they

are already present if a large population lives nearby and providing additional structures will alleviate issues like crowding. Alternatively, planners could rely on distance-based information if their goal is to provide a new place of access in an area that is currently far from public WAI.

Our analysis of docks revealed that private WAI are more abundant in areas with proportionately larger White populations. Holding all other variables constant, docks were 3.3 times more abundant in CBGs that were 100% White (Figure 2.6A). Although docks serve as a conservative proxy for private water access, this finding suggests that Black and Gullah-Geechee residents may have substantially less private access to marshes than White residents. The lack of an income effect on dock abundance is surprising, as docks are expensive structures. Short, modest docks cost a few thousand dollars at a minimum and long docks with amenities like boat lifts can cost tens of thousands of dollars. It is possible that wealthier CBGs had larger average property sizes, which would tend to drive down the number of docks in a CBG even if most individual properties had docks. Unfortunately, we do not have data on average lot size in CBGs. Our infrastructure data set does not have information on when docks were built so we cannot rule out the possibility that docks in lower income CBGs are older and temporally mismatched with the current economic status of CBGs. This possibility seems unlikely, however, as docks are a valuable property addition that would increase home cost for new buyers. Lastly, the lack of an income effect at the CBG level may be due to the scalar limitations of large-scale mapping (Mohai et al. 2009). Although CBGs are the smallest spatial scale at which we can collect demographic data on race and income, development patterns are non-random and occur at scales below what CBG data can capture. For example, waterfront property can be exceptionally more expensive than adjacent lots that are not on the water, potentially obscuring income effects at the CBG level that are occurring at the household level.

Environmental Justice Implications and Future Directions

This study represents one of the few large-scale analyses of the distribution of WAI in either the ecological or EJ literature. We define access as the ability to physically enter the marine environment, specifically focusing on the relative availability of public and private WAI. This is an intentionally narrow definition given the complexity of a topic like access. Other scholars have conceptualized access as “the ability to derive benefit from things” (Ribot and Peluso 2003), which encompasses a broader suite of activities than simply being able to enter an environment (Schlager and Ostrom 1992). While entry into an environment is typically a prerequisite to utilize ecosystem services, we are not considering other factors that influence the ability of coastal residents to benefit from those services (Palma et al. 2012, Ernstson 2013, Sikor et al. 2017). For example, physical barriers such as parking and lack of transportation (Paloniemi et al. 2018) and symbolic barriers such as signage (Palma et al. 2012, Appendix A: Figure A.4) or fear of interactions with law/game enforcement officials (Finney and Potter 2018) may also prevent individuals from accessing the marine system. Broader conceptualizations of racism rooted in critical social sciences can illuminate patterns of environmental injustice that are difficult to detect through purely quantitative and mapping approaches (Pulido 2000). We encourage future research into these aspects to better understand the suite of factors that affect marsh access within the coastal Southeast.

Given the relative lack of research into the distribution of WAI in this region and the additional dimensions of access our study did not address, we approach making any definitive statements about equity and justice with caution and encourage further research on this topic. However, we believe this research has illuminated important, meaningful patterns in the distribution of WAI that serve as a starting point for assessing equity in marsh access. Several

potential equity concepts could be applied to assess the impacts of WAI distribution and actions to ameliorate inequitable access. For example, one set of criteria for determining equity - "need-based" or "compensatory" models - posit that the distribution of access should be enhanced in historically underserved communities to achieve equality in outcomes and meet community needs (Smoyer-Tomic et al. 2004, Kim et al. 2019, Kim et al. 2021). Both metrics used to examine public WAI did not show any correlation to racial composition, but we found that public WAI are two orders of magnitude less abundant than private WAI which strongly skewed towards majority White CBGs. This finding raises the question of whether the 167 public WAI are enough to meet the needs of the nearly 1 million residents that live in these six coastal counties. Under a "need-based" model, future public WAI would need to be concentrated in majority non-White communities to compensate for the lower levels of private WAI. Furthermore, this overall low abundance of public WAI is accentuated by the small and patchy network of land within walking distance of public WAI (Figure 2.3D), which could limit public access further for those who do not own a car.

Private WAI abundance increased sharply in CBGs with a proportionately larger White population, suggesting that non-White residents do not own as many waterfront parcels as White residents. We suggest that the most likely explanation for the racial imbalance of private WAI is rooted in the history of property ownership along the Southeast coast. Following the Civil War, emancipated peoples and their descendants acquired a significant percentage of the private property in this region (Fisher 1978, Rivers 2007, Kahrl 2012b), delivering a measure of autonomy and opportunity within the broader racist structure of the post-War South. Black communities continued to grow and acquire property until the mid-20th century, when the increasing desirability of coastal land and influx of primarily White migrants from other parts of

the US displaced Black and Gullah-Geechee landowners (Rivers 2006, Kahrl 2012a, Kahrl 2012b, Goodwine 2015). Several exploitative mechanisms have driven the steep decline in Black and Gullah-Geechee landownership throughout the Southeast (Fisher 1978, Rivers 2007, Kahrl 2012a, Daniel 2013, Kahrl 2016). In our study area, mechanisms like the instability of ownership due to heirs property (Johnson and Floyd 2006, Rivers 2006) and rising property taxes (Thomas 1978, Gullah Geechee Cultural Heritage Corridor Commission 2012, Dean 2013) have contributed to land loss among Black and Gullah-Geechee residents. Thus, we contend that the current racially uneven distribution of docks is an environmental justice issue stemming from the racialized nature of historic and modern property ownership. Although we cannot speak directly to the historical aspects of this hypothesis because we only looked at a single point in time, our landscape scale analysis, coupled with the more localized work of Southern historians, strongly implicates property dynamics in the modern-day imbalance of private water access. We are currently evaluating this mechanism by examining distributions of WAI from 1950-2010 in relation to historic Census data.

Integrating Environmental Justice and Ecology

Questions centered on environmental justice are more than purely social issues. Further analyses of the factors that drive WAI placement can help address ecological questions centered on the dynamics of human-modified aquatic ecosystems. The physical structure of WAI themselves can directly affect ecosystem structure and function. Coastal infrastructure has been shown to alter the composition of benthic invertebrate communities (Connell 2000, Seitz et al. 2006, Bulleri and Chapman 2010, Iveša et al. 2010), limit the density and biomass of macrophytes (Shafer 1999, Alexander and Robinson 2006, Gladstone and Courtenay 2014),

obstruct the transfer of materials and energy between aquatic and terrestrial ecosystems (Heerhartz et al. 2014), and facilitate the spread of introduced species (Glasby et al. 2007, Tyrrell and Byers 2007, Bishop et al. 2017, Rodriguez-Rey et al. 2021). As the pace of development in the marine environment increases (Bugnot et al. 2021), ecologists need to incorporate a broader understanding of coastal infrastructure to predict its spread and mitigate undesired effects.

Moreover, who can access and utilize ecosystem services is relevant to ecologists because different groups interact with the environment in unique and meaningful ways (Burger et al. 1999, Brown and Toth Jr 2001, Hunt and Ditton 2002). In freshwater systems in both Mississippi (Brown and Toth Jr 2001) and Texas (Hunt and Ditton 2002), researchers found differences in the seasonality, frequency, gear used, quantity of catch, and species targeted by Black and White fishers. Differential proximity of WAI to high-quality habitat for seafood species or public harvesting areas could shape harvest strategies, altering impacts on resources. Aside from fishing, other human activities occur at WAI. High concentrations of boating around boat landings, marinas, and ports have been linked to chemical contamination (Schiff et al. 2007, Guerra-Garcia et al. 2021) and noise pollution (Haviland-Howell et al. 2007, Popper and Hawkins 2019, Bugnot et al. 2021) that can directly affect the physiology of marine species. The distribution and accessibility of WAI has direct and indirect effects on coastal ecosystems that bridge social justice and environmental concerns.

Conclusion

All areas below mean high water are legally codified as public land under South Carolina law, but our analysis of WAI suggests that equitable water access may not be realized in practice. The racial imbalance in the amount of private access to water has important implications for

contemporary non-White communities, particularly the Gullah Geechee. Many popular accounts of the Gullah Geechee portray them as an historic group; however, the Gullah Geechee are still prevalent along the coast and deeply connected to coastal ecosystems (Campbell 2011, Goodwine 2015). We have shared these findings with Gullah Geechee and open land preservation advocacy organizations along the South Carolina coast to support their efforts in maintaining and expanding public water access. We note, however, that our work is just a first step, and large-scale mapping analyses cannot be substituted for the lived experiences of Black and Gullah Geechee fishers. We see these limitations as evidence for the importance of interdisciplinarity in ecological and EJ research. Strategic partnerships with local communities, historians, geographers, and social scientists working at finer-grain spatial scales are needed to understand the social processes that generate environmental injustices and how communities experience and resist them. As ecologists face increasing calls to incorporate a critical analysis of race into our work (Pickett and Grove 2020, Schell et al. 2020), there are ways to employ familiar methodologies, cultivate relationships with other bodies of knowledge, and develop research programs that advance our understanding of ecology while contributing to the communities and ecosystems in which we work.

Acknowledgements

We would like to thank J. Warren for his assistance with the initial structure counting. We would also like to thank R. Richards, M. Evans, R. Smith, S. Markley, S. Holloway, and H. Cheol Chung for their sage statistical and R advice. J. Blaze, K. Capps, M. Pierce, E. Resetarits, R. Smith, M. Tomamichel, K. Zemaitis, and S. Ziegler provided constructive feedback on drafts. This project was supported by a grant from the Andrew W. Mellon Foundation.

Table 2.1. Summary of regression output for fixed and random effects for the logistic regression of public WAI.

Fixed Effects				
Variable	Untransformed Coefficient	SE	χ^2 Value	p-value
Intercept	-1.8	0.84	-	-
Income (thousands \$)	-0.026	0.0079	9.76	0.0018
% White	-0.0045	0.0071	0.38	0.53
% Homeowner	0.01	0.0092	1.21	0.27
Population (hundreds)	0.0034	0.012	0.07	0.78
Shore length (km)	0.031	0.011	11.46	<0.001
Dock abundance	0.0059	0.0032	3.67	0.054
Random Effects				
Level		Variance		
County		1.99*10 ⁻⁹		
Census tract		0.28		
Abbreviations				
SE		Standard error		
χ^2		Chi-squared value from likelihood ratio test		

Table 2.2. Summary of regression output for fixed and random effects for the model of distance to nearest public WAI.

Fixed Effects				
Variable	Untransformed Coefficient	SE	χ^2 Value	p-value
Intercept	1.10	0.20	-	-
Income (thousands \$)	0.0025	0.0016	2.33	0.13
% White	-0.0022	0.0019	1.48	0.22
% Homeowner	0.0045	0.0025	3.24	0.072
Population (hundreds)	0.0065	0.0029	4.82	0.028
Land area (km ²)	0.0033	0.00080	16.61	< 0.001
Dock abundance	-0.00060	0.00060	0.99	0.32
Random Effects				
Level		Variance		
County		2.64*10 ⁻¹⁰		
Census tract		0.28		
Abbreviations				
SE		Standard error		
χ^2		Chi-squared value from likelihood ratio test		

Table 2.3. Summary of regression output for fixed and random effects for the model of private WAI abundance.

Fixed Effects				
Variable	Untransformed Coefficient	SE	χ^2 Value	p-value
Intercept	0.79	0.53	-	-
Income (thousands \$)	0.00077	0.0034	0.05	0.82
% White	0.012	0.0042	7.61	0.0058
% Homeowner	0.0098	0.0052	3.49	0.062
Population (hundreds)	0.0045	0.0058	0.61	0.43
Shore length (km)	0.58	0.088	42.78	<0.001
Public access presence	0.27	0.17	2.69	0.10
Random Effects				
Level		Variance		
County		7.89*10 ⁻⁹		
Census tract		0.049		
Abbreviations				
SE		Standard error		
χ^2		Chi-squared value from likelihood ratio test		

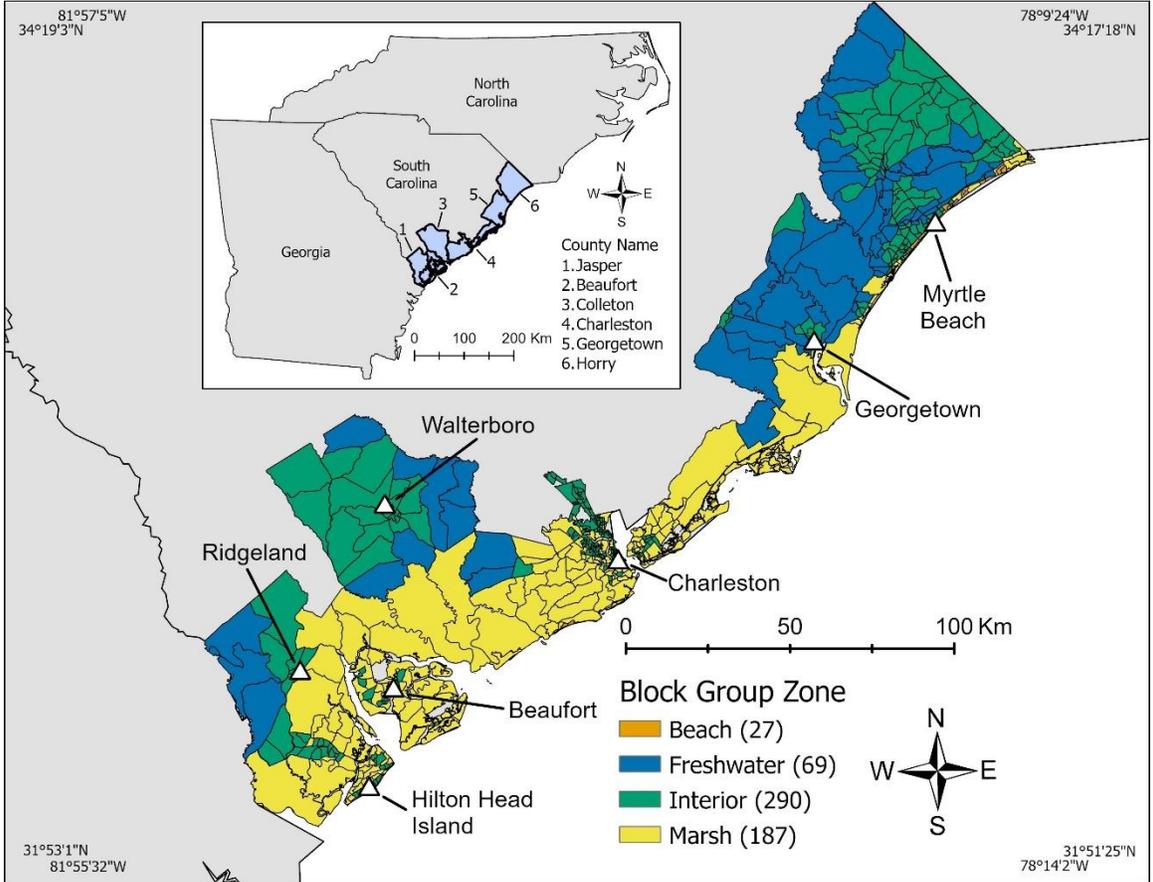


Figure 2.1. Main map shows census block groups (CBG) and Zone classification for the study area in coastal South Carolina in the southeastern United States. Numbers in the legend represent the number of CBGs in each Zone. Inset map (top left) shows South Carolina and neighboring states, along with a numbered legend for the six coastal counties. Major cities in South Carolina are marked by white triangles and associated text. Main map scale 1:1,250,000, county inset map scale 1:8,250,000. CBGs in the Beach Zone are small and may be difficult to discern at the scale of the full study area.

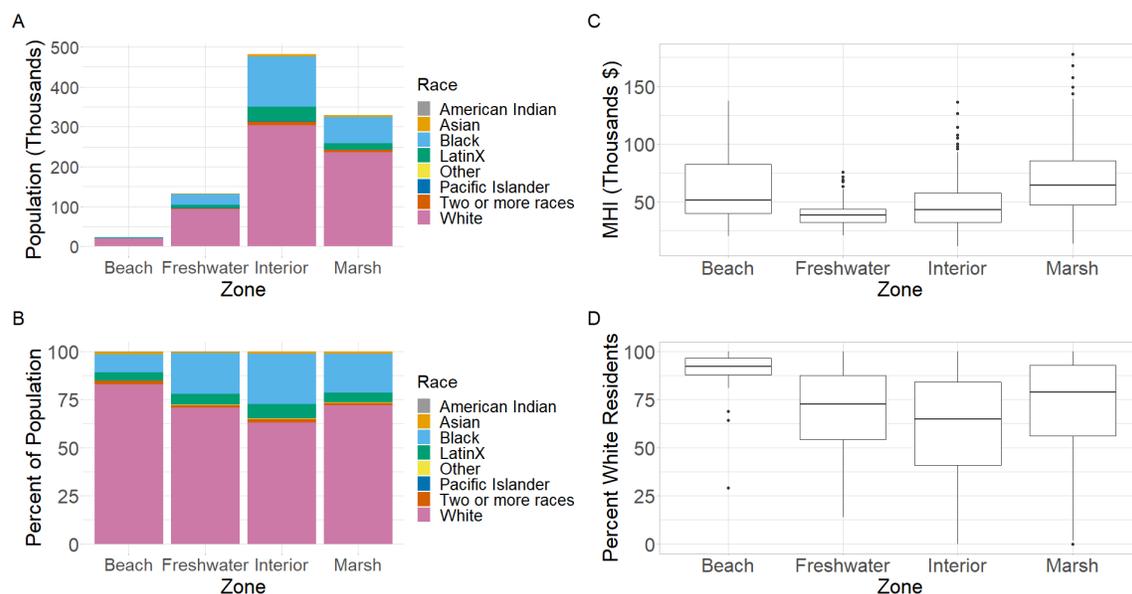


Figure 2.2. Zone-level descriptive statistics for total population in thousands of people (A) and percent population (B) of ACS-defined racial groups. Panels C and D represent boxplots of CBG median household income (MHI) in thousands of dollars and percent White residents across Zones, respectively. The black midline of the boxplot represents the median, box edges represent the 25th and 75th percentile (interquartile range, IQR), error bars represent 1.5 * IQR, and individual points represent outliers outside of the error bar range.

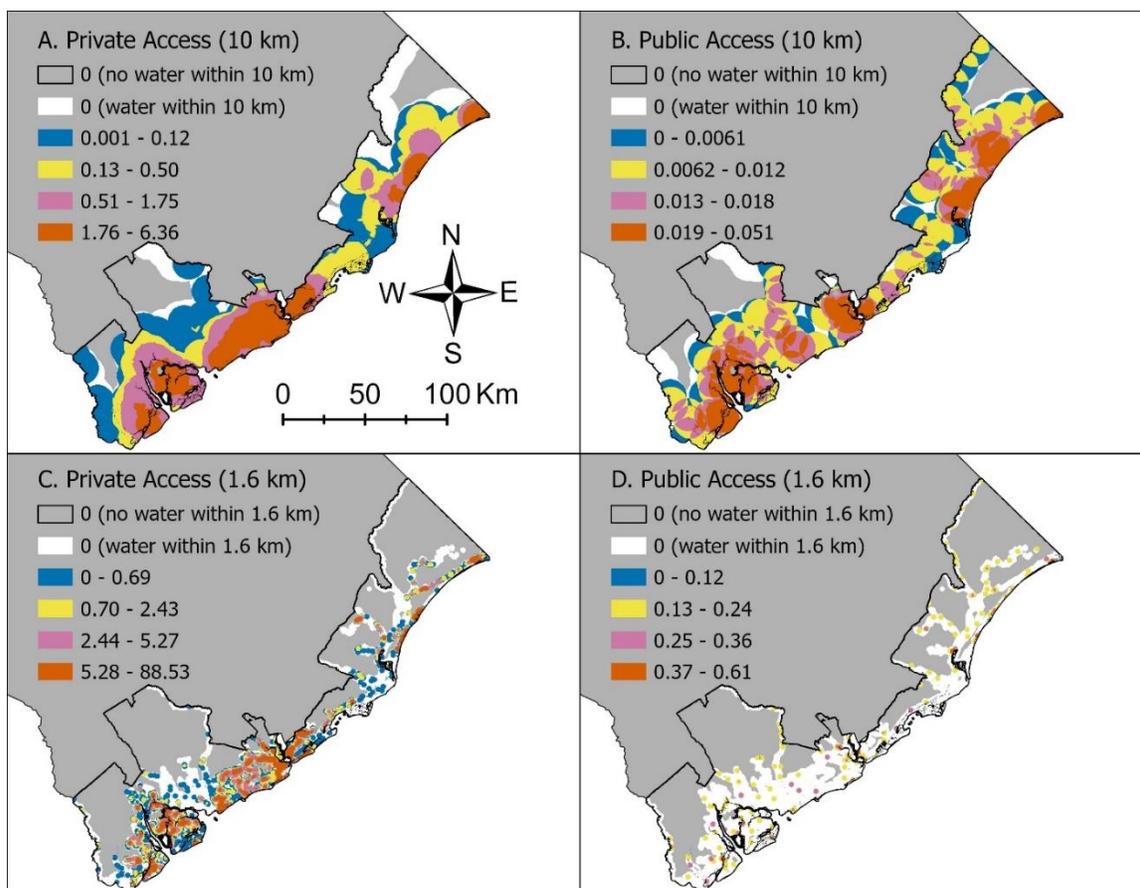


Figure 2.3. Water access infrastructure (WAI) density maps for private (Panels A and C) and public (Panels B and D) WAI across the entire six-county study area. Counties are outlined in black, gray space represents areas with no water or WAI within the search radius, white represents area with water, but no WAI within the search radius. The color ramp on the map represents 20% quantiles of density values for WAI and is used across all panels. Note the different scales of density values for private and public access with the same search radii (i.e. A v. B and C v. D). Scale 1:2,500,000 for all panels. Distance scale and compass orientation is the same for all panels.

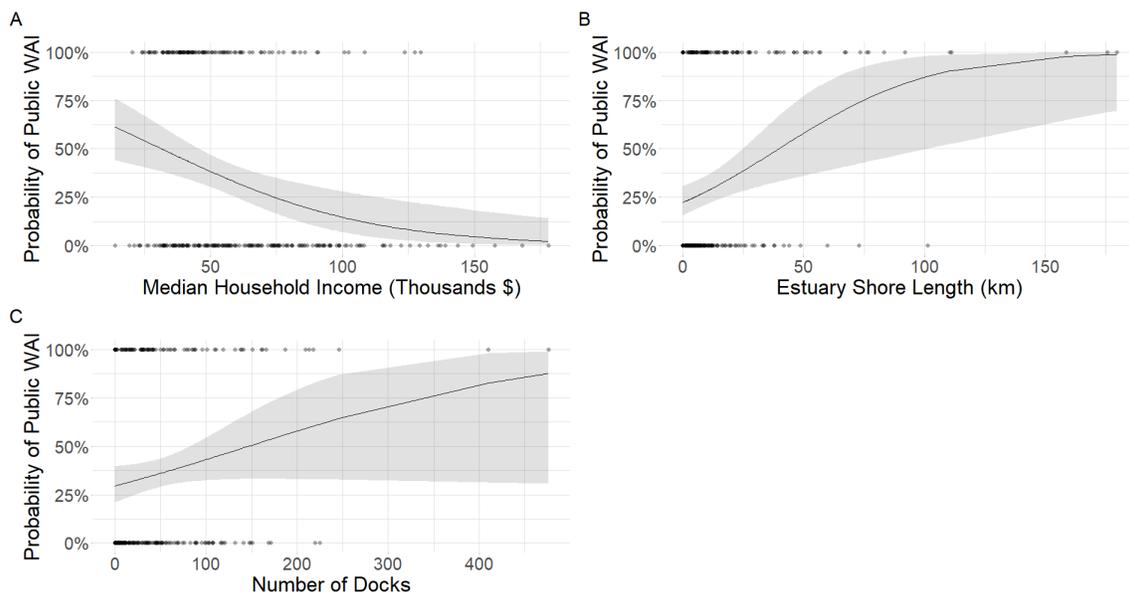


Figure 2.4. Conditional effect plots for income (A), shoreline length (B), and dock abundance (C) in the logistic regression of public WAI. Lines represent conditional effect predictions with 95% confidence intervals. Points plot the raw data and darker points indicate overlap of two or more points. Income: $\chi^2(1) = 9.76$, $p = 0.0018$, shoreline: $\chi^2(1) = 11.46$, $p < 0.001$, dock abundance: $\chi^2(1) = 3.67$, $p = 0.054$.

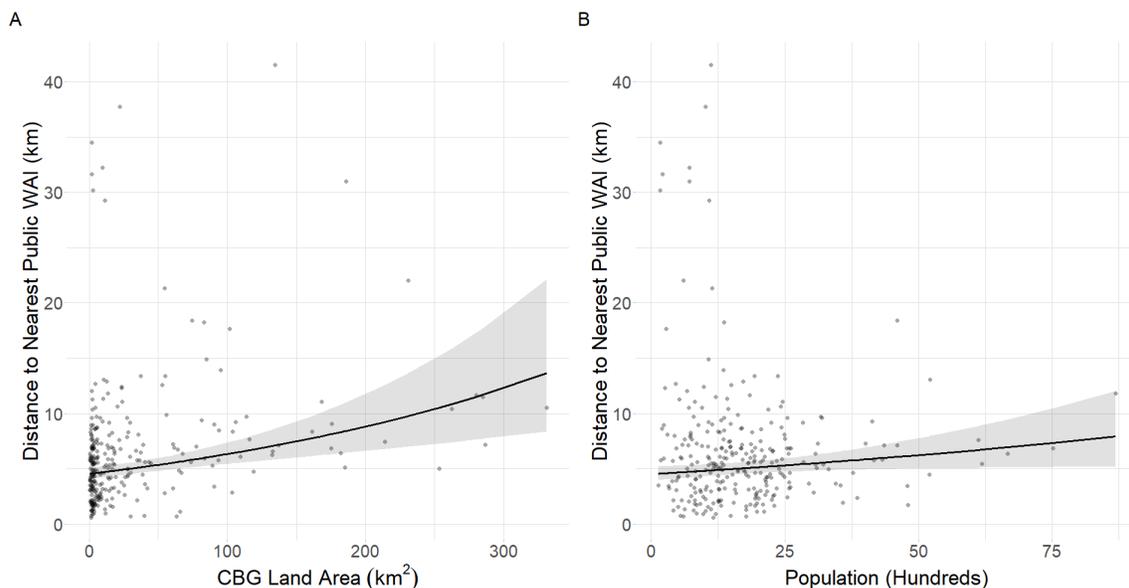


Figure 2.5. Conditional effect plots for census block group (CBG) land area (A) and population size (B) in the model of distance to nearest to public WAI. Lines represent conditional effect predictions with 95% confidence intervals. Points plot the raw data and darker points indicate overlap of two or more points. CBG land area: $\chi^2(1) = 16.61$, $p < 0.001$, total population: $\chi^2(1) = 4.82$, $p = 0.028$.

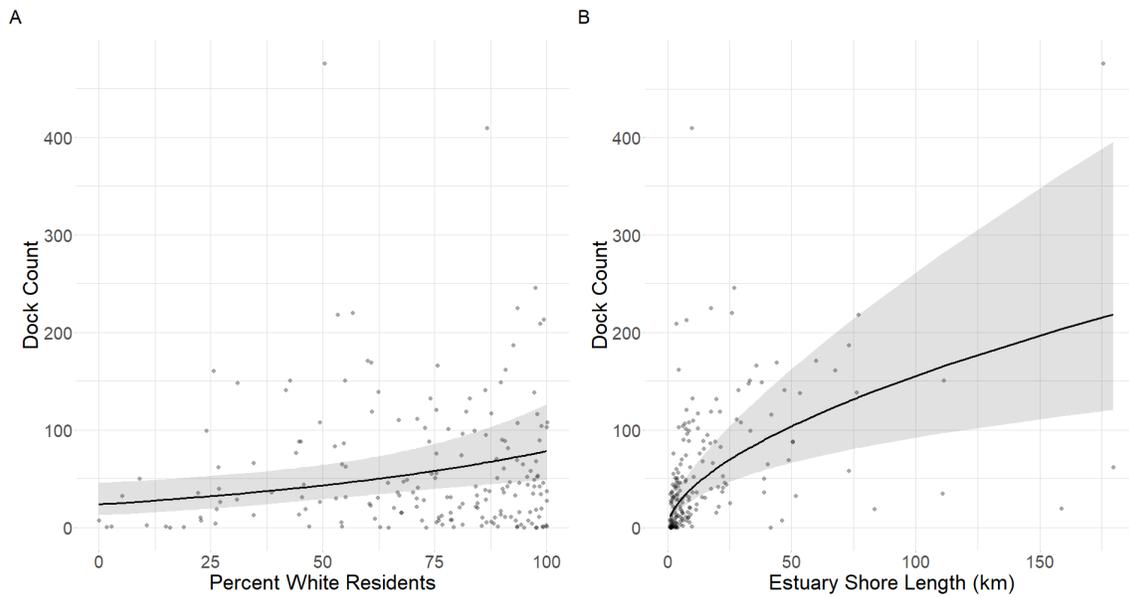


Figure 2.6. Conditional effect plots for percent White (A) and shore length (B) in the model of private dock count. Lines represent conditional effect predictions with 95% confidence interval. Points plot the raw data and darker points indicate overlap of two or more points. Percent White: $\chi^2(1) = 7.61$, $p = 0.0058$, shoreline: $\chi^2(1) = 42.78$, $p < 0.001$.

CHAPTER 3
EXPONENTIAL GROWTH OF PRIVATE COASTAL INFRASTRUCTURE INFLUENCED
BY GEOGRAPHY AND RACE IN SOUTH CAROLINA⁵

⁵ Beauvais, J., Markley, S., and Byers, J. To be submitted to *Estuaries and Coasts*.

Abstract

Homeowners in coastal environmental often augment their access to surrounding estuarine ecosystems by building private, personal docks on their property. Despite the commonality of docks, particularly in the southeastern United States, few scholarly works have investigated their historical development, their distribution across the landscape, or the environmental justice dimensions of this distribution. In this study, we utilized historic aerial photography from multiple sources to track the abundance and size of docks across six South Carolina counties from the 1950s to 2016. Across our roughly 60-year study period, dock abundance grew two orders of magnitude, mean length of newly constructed docks doubled, and the cumulative length of docks ballooned from 34 to 560 km. Additionally, we drew upon a novel Census data set that interpolates demographic characteristics in consistent 2010 Tract boundaries to analyze the racial and economic distribution of docks at the Tract level in 1994, 1999, 2011, and 2016. Median household income and dock abundance were only correlated in 2011. Racial composition, measured as the percent of a Tract's population that was White, positively correlated with dock abundance in each year. Taken together these metrics indicate the growing desire for direct estuary access, however that access does not appear to be equally spread across racial groups. Because docks enhance estuarine access and demarcate private property, our study provides longitudinal insights into environmental justice concerns related to disparate private property ownership. Our analysis found a persistent correlation between the racial characteristics of an area and dock abundance, strongly implicating that White South Carolinians have had disproportionately greater private water access for the past two decades.

Introduction

Coastal environments are dynamic, ecologically rich areas that provide numerous ecosystem services for human populations including provisioning of seafood for personal consumption and sale, spaces for recreation, and continuity of cultural practices. To utilize many of these services, individuals must first be able to access them. Access is a complex topic that has received extensive attention in the social sciences, but considerably less quantitative work has been done to document the landscape of access for coastal residents. For our purposes, we narrowly define access as the ability to physically enter the marine environment (Schlager and Ostrom 1992, Ribot and Peluso 2003). In most US states navigable waterways (in the case of freshwater rivers) and areas below mean high water (in the case of estuaries) are preserved as public property under the “public trust doctrine” (Frank 2011). While these *de jure* (legal) rights of access to water are longstanding and frequently upheld against challenge (McMaster 2006, Takacs 2008, Blumm and Guthrie 2012), they also obscure the *de facto* (actual), lived experience of access. Although estuarine waters generally cannot be privately held, the land along them can be privately owned creating a barrier to access for non-property owners.

In many areas “water access infrastructure” (WAI) such as docks, piers, boat landings, and marinas mediate where individuals can access coastal ecosystems and what activities they can engage in at those sites. Private, personal docks augment individual access to estuaries by providing entry through their fixed structure (particularly in soft-sediment ecosystems) and a place to store and launch vessels. Moreover, docks are a conservative proxy for the number of private property parcels in an area, providing a useful, easily identifiable feature to quantify the extent of shoreline privatization. Thus, analyzing how private docks are distributed across a

landscape can help address the potential disconnect between legal and functional access to coastal waters.

By centering the distinction between *de jure* and *de facto* experiences of water access, we shift our focus towards questions of who enjoys these benefits through private ownership of waterfront land. The field of environmental justice (EJ) has long noted that environmental benefits and burdens are frequently distributed along lines of social hierarchy, such as those entrenched in race and class. EJ scholars and activists have compellingly shown that a variety of environmental burdens including toxic substance storage sites (Mohai and Saha 2007, Spears 2014, Kramar et al. 2018) and poorer air quality (Miranda et al. 2011, Bell and Ebisu 2012, Clark et al. 2014) are generally concentrated in lower income, non-White communities. Research on beneficial ecosystem services such as those provided by urban tree canopy have shown greater cover in more affluent, White neighborhoods (Jenerette et al. 2011, Locke et al. 2021); however, local context has been shown to be important in driving the strength and direction of those effects (Riley and Gardiner 2020). Comparatively few works have directly quantified access in coastal systems through an EJ framework, but studies that have found mixed results with respect to the influence of race and income on public access points (Montgomery et al. 2015, Haeffner et al. 2017, Kim et al. 2019). To our knowledge, only one other study has focused on the socioeconomic distribution of private water access (Beauvais et al. 2022).

Apart from the spatiality of environmental benefits and burdens, temporal changes in these aspects are another critical, yet underrepresented aspect of EJ research. Most EJ studies are conducted at a single point in time, limiting their explanatory power (Mohai and Saha 2015). This issue peaked early in the development of EJ research, with skeptical researchers questioning whether documented disparities in exposure to toxic-waste facilities were the result of deliberate,

racist actions (Pulido 2000, Taylor 2014) or low-income and non-White communities moving into these areas after the sites were established (e.g. Been and Gupta 1997). Temporal comparisons in such a situation could help parse whether an observed racial pattern is cause or consequence of a toxic facility. Regrettably, the paucity of long-term EJ studies limits our understanding of the formation and longevity of environmental injustices and the processes that shape them. Although uncommon, the longitudinal EJ studies we do have generally demonstrate that facilities were sited in majority non-White communities at the time of their founding and that the establishment of toxic facilities caused negligible changes to the racial composition of surrounding communities through time (Mohai et al. 2009, Taylor 2014, Mohai and Saha 2015). Thus, while notably more difficult to conduct, longitudinal EJ research provides greater context for how different communities experience environmental injustices and how injustices progress through time.

This study builds on previous research we conducted on public and private WAI distribution in coastal South Carolina in 2016 (Beauvais et al. 2022). We quantified a total of 11,953 private docks in the six coastal counties of South Carolina, and the pervasive presence of docks along the coast inspired us to examine the historical development of these structures. While some studies have examined the current extent of built structures in marine systems at the local (Peterson et al. 2019), national (Gittman et al. 2015), and international (Bugnot et al. 2021) scale, few focus on the historical progression of coastal infrastructure. Additionally, most investigations are focused on large industrial infrastructure or armoring and do not quantify the extent of private, personal WAI. This is a curious omission, as docks have been shown to have numerous ecological effects, including shifting community composition (Connell 2000, Sanger

et al. 2015), enhancing invasive species (Lagos et al. 2017), and shading macrophytes (Alexander and Robinson 2006, Gladstone and Courtenay 2014).

More importantly, our prior work explicitly focused on environmental justice implications of public and private WAI. We found that racial composition strongly influenced dock abundance in Census block groups while household income had no effect. As noted, however, this research only considered a single year of data (2016) and the historical condition of private water access remained unclear. In this study, we address two primary questions. First, how has dock abundance and length changed along the South Carolina coast from 1950-2016? We predict that dock abundance and lengths will increase through time, with abundances demonstrating punctuated growth spurts (“start and stop”) across time. Second, has the distribution of docks with respect to the economic and racial composition of Census Tracts changed from 1994-2016? We expect a positive relationship between both the percentage of a Census Tract’s White population and median household income with dock abundance. To our knowledge, this study represents the first longitudinal analysis of private WAI.

Methods

Study System and Extent

We conducted our research in the six counties along the South Carolina coast (Figure 3.1, inset map). The waterways of coastal South Carolina are composed of estuaries that form the transition to interior brackish and freshwater rivers, typical of other southeast US states. In South Carolina all areas below mean high water are public property, however, as discussed above, this legal status does not ensure functional access to coastal waters. Our study builds on prior

research we conducted on dock distribution in this same area and further system description can be found therein (Beauvais et al. 2022).

We collected and analyzed data at the Census Tract level. Census Tracts are a sub-county geographic unit used by the Census Bureau to summarize Census data. The protocol used by the Census Bureau to designate Tracts has changed over time but stabilized following the establishment of Tracts across the entire United States for the 1990 Census (Census Bureau 1994, 2022). Since the 1990s, Tracts have been designed to encompass 1,200-8,000 people and generally follow visually identifiable, permanent features of the landscape such as roads, bodies of water, and above-ground utility lines (Census Bureau 1994). Our six counties initially consisted of 223 Tracts (Figure 3.1, main map). Since we are primarily interested in personal docks in residential areas, we removed four Tracts that were composed entirely of military bases/housing, one Tract that made up the Myrtle Beach airport, and five Tracts that made up the Port of Charleston (Figure 3.1, orange Tracts). We also removed one Tract in Horry County that was an extremely high outlier in dock abundance and demonstrated a unique development pattern not replicated anywhere else in South Carolina.

Objectives

We assessed our research questions through three objectives: 1) enumerate new, removed, and existing docks in the 212 Tracts across our study area (green and blue Tracts, Figure 3.1) across all years (1950s-2016); 2) analyze how the length of new docks has changed over time in the 212 Tracts across our study area (1960s-2011); and 3) analyze how existing dock abundance is distributed with respect to the racial and economic composition across the 111 Tracts with more than 1 km of saltwater shoreline (1994-2016). The date ranges of our objectives

differ because we were constrained by years where necessary data was available. We define “new” as docks we could verify were constructed between two years of imagery, “removed” as docks that were missing between two years of imagery, and “existing” as the number of extant docks in each year of imagery (calculated as existing docks from the prior year of imagery + new docks - removed docks).

Data Collection – Response Variables

We gathered all data on docks from three sources of historical aerial photographs of the South Carolina coast. We obtained imagery for years prior to 1990 from the University of South Carolina Thomas Cooper Library courtesy of Bill Sudduth (“pre-1990 imagery”). Pre-1990 image quality varied from 1.25-4.5 m resolution, with greater resolutions typically found in later years. The South Carolina Department of Natural Resources (DNR) provided statewide, 1-meter resolution color infrared imagery from 1994 and 1999. We downloaded 1-m resolution 2011 imagery from the US Department of Agriculture National Agriculture Imagery Program’s Geospatial Data Gateway (<https://nrcs.app.box.com/v/gateway/folder/19350726983>). We present the years of imagery for each county in Table 3.1. Lastly, we also utilized 2016 data from our prior study of South Carolina docks (Beauvais et al. 2022). These data were not imagery, but pre-digitized dock polygons acquired from the Ocean & Coastal Resource Management division of the South Carolina Department of Health and Environmental Control (<https://sc-department-of-health-and-environmental-control-gis-sc-dhec.hub.arcgis.com/>).

For all imagery, we systematically searched for docks in every county/year combination in ArcGIS Pro Version 2.9 (ESRI 2021). For every dock we encountered we placed one point at the base of the dock where it connected to the upland and one point at the waterward end of the

dock at 1:2,500 scale (Appendix B: Figure B.1). We extracted Census Tract information to the base point of every dock to obtain Tract-level dock counts. Because we worked with a longitudinal data set and most docks are preserved from year to year, we opted to sequentially analyze each county and build upon the dock data from the prior year of imagery (e.g. the completed dock point layer for Beaufort 1955 served as the starting point for 1959, 1959 served as the starting point for 1972, etc.). This approach 1) greatly reduced the labor of manually identifying and labeling the same docks, 2) aided in identification of new and removed docks, and 3) allowed us to determine the longevity of dock occupation at a given location (“dock presence”).

Because of our continuous approach to counting docks, we had to determine whether points from prior years of imagery mapped to docks in current imagery. Small variations in georeferencing historic imagery caused some points placed on docks to shift slightly across years (Appendix B: Figure B.1, Figure B.2). When this occurred, we referenced imagery from prior years and relied on the overall number of docks in the scene, dock shape, angle of points, placement relative to consistent objects across images, and maximum displacement of points between imagery years to determine which docks were maintained, new, and removed. Full details on these assignment rules, as well as quality control and assessment protocols to ensure consistency across researchers are described in Appendix B. Because the 2016 data came as pre-drawn polygons instead of imagery, it proved enormously difficult to match this with our point data set and we only report the existing number of docks for 2016.

We calculated dock lengths using the “geosphere” package (Hijmans 2021) in R Version 4.2.1 (R Core Team 2022). We noted 167 times where a dock in the same location underwent obvious expansions, replacement, or experienced damage that altered the length of the dock by

more than 10 meters. This is an underestimate of these occurrences, as we did not quantify these situations before 1994. If a dock changed in length, we marked the dock from the prior decade as removed and treated the modified dock as new to account for this length change. In our analysis of counts, however, we ignored these instances, because these changes were made to the same structure on the same private lot. Our length data do not include the 2016 data because the complex polygon format prevented us from calculating dock lengths.

Data Collection – Census and Landscape Variables

We selected our predictor variables for the socioeconomic analysis based on our system-level knowledge and prior EJ studies. We obtained our historical Census Tract variables from the National Historical GIS (NHGIS, Manson et al. 2021) and Historical Housing Unit and Urbanization Database (HHUUD10, Markley et al. 2022). These variables include the housing unit and population counts, median household income (MHI), white population share, and homeownership rate for the 1990, 2000, and 2010 decennial Censuses and the 2019 five-year ACS sample. Since Census Tracts are redrawn every ten years, these variables need to be harmonized into a single consistent Tract geometry to allow historical comparison. Data from the 2010 decennial Census and 2019 five-year ACS sample are already in the same Census Tract vintage, so no data interpolation is necessary for those years. However, the 1990 and 2000 data are not compatible. Fortunately, the makers of HHUUD10 and the NHGIS time series dataset have already conducted the requisite areal interpolation. Specifically, HHUUD10 provides ready-made housing unit count data in consistent 2010 Census Tracts back to 1940, while the NHGIS provides a series of crosswalk weights to convert the other variables to the same vintage.

We thus combine the HHUUD10 housing unit data with NHGIS crosswalk-produced data with the Census and ACS data to get our 1990 and 2000 Tract variables into the 2010 Tract vintage.

In addition to our demographic variables, we also collected data on shore length because prior work showed it was strongly correlated with dock abundance (Beauvais et al. 2022). We relied on this previous work to calculate the length of beach, freshwater, and deep-water saltwater/brackish shore length for Tracts (excluding isolated ponds and golf course lagoons). These measurements are derived from 2016 30-m resolution land cover rasters from NOAA's Digital Coast portal (<https://coast.noaa.gov/digitalcoast/data/>) and South Carolina's freshwater/saltwater dividing line (<https://www.dnr.sc.gov/marine/dividingline.html>). We used a single estimate of shore length for all years and therefore assumed that shore length within Tracts does not appreciably change over the course of our study. We are comfortable with this assumption given the relatively short time scale (22 years) of our socioeconomic analysis.

Objective 1 – New, Removed, and Existing Dock Abundance

We summed the number of new, removed, and existing docks in each Tract to obtain counts for the entire 212 Tract study area. We grouped dock counts into 10-year bins to align with the decadal nature of Census data and attempt to ensure each county contained a count in each decade (Table 3.1). Although this does increase our temporal resolution of dock counts in some bins relative to others, we believe this is a minor issue and our rationale is explained in Appendix B. For removed docks, we noted the decade they were first constructed to determine the longevity of dock presence. We frame dock longevity in terms of presence because docks might have undergone repairs or replacement, but still occupy the same space. Furthermore, our EJ framing focuses on docks as a conservative proxy for private property parcels, therefore the

presence of a dock at a given location through time is a more relevant measure than whether it is the same dock. Because dock abundance displayed characteristics of exponential growth, we fit a simple exponential curve to existing dock abundance, population, and housing units to compare their rates of growth. To visualize where docks are placed on the landscape, we provide a GIF of dock locations (Appendix B: Figure B.3) and county level counts for each decade in Appendix B (Appendix B: Figure B.4).

Objective 2 – Dock Lengths

As with the counts, we summarized dock lengths at the level of the entire 212 Tract study area, taking the mean length of each dock type for every decade. We opted to statistically analyze only new dock length because only a small proportion of docks are removed each decade (Table 3.2), thus any changes in existing dock length are likely driven by the construction of new docks. We conducted an ANOVA with post-hoc Tukey tests on new dock lengths and decade to determine whether new docks have gotten longer over time. We provide county level lengths for each decade in Appendix B (Appendix B: Figure B.5).

Objective 3 – Socioeconomic Analysis of Dock Distribution

Unlike our descriptive analysis of dock counts and lengths across the entire study area, we only included 111 Tracts with greater than 1 km of saltwater shoreline in our statistical analysis of dock distribution (Figure 3.1, blue Tracts). We used this reduced data set because docks cannot be built along the beach and are uncommon in freshwater rivers due to navigability concerns. This 1 km cutoff was chosen to ensure that Tracts had an appreciable amount of developable shoreline, as we noted that many Tracts with little shoreline were comprised of

small embayments that did not contain navigable water. We also removed any Tracts with less than 100 housing units from the analysis. We include two tables in Appendix B that quantify how the choice of cutoff affects the number of Tracts and docks included in the model (Appendix B: Table B.1, Table B.2). Lastly, we only analyzed Census data from 1990, 2000, 2010, and 2019 in this analysis because all counties in South Carolina had Tract level Census data by 1990.

For each decade we fit a separate zero-inflated, negative binomial mixed models with existing dock count as the response variable using the R package “glmmTMB” (Brooks et al. 2017). We included median household income (MHI) and percent White as our predictor variables of interest. We corrected MHI for inflation using the “priceR” package (Condylis 2022), converting all MHI values to 2010 US dollars (USD). We also included the percent homeownership, population, and shore length in the model as fixed effects. The state of South Carolina requires proof of title for dock permits (S.C. Code Ann. §54-13-10), thus a higher proportion of rental property in a Tract may be correlated with lower numbers of docks. We used total population in place of population density (total population/land area) because there was a high correlation between Tract land area and shore length, which was already included in the model. We centered and scaled all fixed effects in the model by their standard deviations to allow for direct comparison of coefficient values. To account for unexplained variance at the Tract level and the nesting of Tracts within counties, we included both Tract ID and county as random effects. We tested and found no support for an interaction between the variables for income and race in all decades, so we removed the interaction from all models. We did not find any evidence of multicollinearity of predictor variables in any decade ($VIF < 3$).

We used likelihood ratio tests to test for the significance of fixed effects. To examine the magnitude of fixed effects, we plotted their conditional effects using the “ggeffects” package (Lüdtke 2018). “ggeffects” generates predicted values of the response variable (dock count) for a focal predictor variable while holding all other fixed effects constant at their mean value. We qualitatively assessed these conditional effects to see if the influence of economic and racial composition changed over time. We ran similar diagnostics for all models. We examined residuals for homoscedasticity using the “DHARMA” package version 0.4.6. (Hartig 2022). We used a Moran’s I test assuming an inverse-distance weighting relationship in ArcGIS Pro to assess whether there was any spatial autocorrelation in model residuals for each decade. For all decades we found no evidence of spatial autocorrelation (1990: $z = 1.59$, $p = 0.11$; 2000: $z = 1.81$, $p = 0.07$; 2010: $z = 1.29$, $p = 0.20$; 2019: $z = 1.66$, $p = 0.10$).

Results

Objective 1 – New, Removed, and Existing Dock Abundance

Existing dock abundance showed continuous growth throughout the entire study period. Trends in existing dock abundance were largely driven by new dock construction, as a small number of docks were removed each decade relative to new construction (Table 3.2). The largest relative increase in docks occurred in the 1990 decade (i.e. between 1985-1994) where the number of docks in our focal counties increased by a factor of 2.38 (from 2,034 to 4,841), resulting in two-thirds of all docks in these six counties being new construction (Table 3.2). The 1990 decade also contained the greatest number (425) and percent of docks (20.89%) that were removed (when accounting for all counties, Table 3.2). The number of housing units, total population, and number of docks per 1000 housing units/people also steadily increased through

time, with only a slight deviation in docks per housing units in the 1980 decade (Table 3.2). We found that the growth rate of docks (Figure 3.2, $r = 0.057$) was roughly double the growth rates of population ($r = 0.021$) and housing units ($r = 0.029$).

Although we cannot directly measure the durability of a given dock, our analysis demonstrated the longevity of dock presence at a site (Table 3.3). Slightly more than half of the sites where a dock was first noted in the 1960 decade were still occupied by a dock in 2011 (2010 Census decade, Table 3.3). Given the distribution of our imagery years (Table 3.1), this suggests that these sites have continually contained a dock for a minimum of 46-56 years, depending on the county. Because our imagery data began in the 1950s (Charleston or Colleton counties) or 1960s (Beaufort, Georgetown, Horry, and Jasper counties) sites that contained a dock then might have been occupied for even longer. Because we used the 2010 decade as our baseline year for comparison of dock longevity, the percent of dock sites that remain occupied in 2010 naturally increases through time because less time has elapsed between when the dock was first built and our baseline year of 2010. Looking at a cohort of docks built within the same decade, there appears to be a decreasing or possibly hump-shaped distribution of when a dock is removed (Table 3.3). For example, at the sites first occupied by a dock in 1970, the peak number of removed docks occurs in 1990, with a sharp decline in the number of removed docks in that cohort after.

Objective 2 – Dock Lengths

Existing dock length demonstrated sizeable heterogeneity (Appendix B: Figure B.6) within all study years, though mean existing dock length increased by 19.46 m from 1960 to 2011 (Table 3.4). As with dock counts, existing dock lengths are primarily driven by new dock

construction. Mean new dock length approximately doubled from 34.13 m to 70.38 m from 1960 to 2011. Our ANOVA showed a significant change in mean dock length across the study duration ($F_{5,10063} = 104.7, p < 0.001$). A post-hoc Tukey test showed significant differences in new dock length in the 2000 and 2010 decades (Figure 3.3). As noted earlier, the polygon format of the 2016 data prevented a simple straight-line measurement of dock length and is not included in the analysis.

Objective 3 – Socioeconomic Analysis of Dock Distribution

We conducted our generalized linear mixed models on the 111 Tracts with greater than 1 km of saltwater shoreline. At the Tract-level, median MHI (all values corrected to 2010 USD) fluctuated slightly across years but stayed relatively constant, varying from \$49,105 in 1990 to \$56,488 in 2019 (Figure 3.4). The highest and lowest income Tracts, however, varied more substantially. The lowest income Tracts fluctuated through time, with a minimum MHI of \$17,505 in 1990 and a maximum of \$24,352 in 2000. The MHI of the wealthiest Tracts increased consistently across the 4 decades, with a minimum MHI of \$124,039 in 1990 to a maximum of \$165,533 in 2019. Percent homeownership was steady through time, with the median varying between 73.9%-78.4% from 1990-2019 (Figure 3.4). The racial composition of Tracts varied through time (Figure 3.4). The median, minimum, and maximum percent White residents remained consistent through time, hovering between 78.4%-82.9%, 12.1%-16.1%, and 98.9-100%, respectively. The median percent Black population fell considerably through time, from 17.7% in 1990 to 9.9% in 2019. The maximum percent Black population was steadier, ranging from 79.2%-85.8% over time.

Our analysis revealed a consistently strong, positive relationship between percent White and the abundance of private docks in each decade of data (Table 3.5, $p < 0.05$ for all likelihood ratio tests). On the other hand, MHI demonstrated a significant, negative relationship, but only in 2010 (Table 3.5, $\chi^2(1) = 4.61$, $p = 0.03$). There was a marginally significant, positive correlation between MHI and dock abundance in 2000 (Table 3.5, $\chi^2(1) = 3.54$, $p = 0.06$). As expected, percent homeownership (except for the 2000 decade), population, and length of shoreline also showed significant, positive correlations with the number of docks in a Tract (Table 3.5). The standardization of coefficients allows us to directly compare their magnitudes and therefore their relative strength on the abundance of docks. Length of shoreline is consistently the strongest effect, while percent White, percent homeowner, and total population had generally similar coefficient estimates (Table 3.5). The conditional effects plots generated from “ggeffects” (Figure 3.5) contextualizes these coefficients in more relatable numbers. For example, in 2000 the predicted number of docks was expected to increase from 17 to 65 in Tracts with 0 to 100% White residents. Overall, these conditional effect estimates show a 6.4x, 3.8x, 7.8x, and 3.9x increase in dock abundance across the percent White continuum in 1994, 1999, 2011, and 2016, respectively. Complete model results, including random effects for Tract and county can be found in Appendix B (Appendix B: Table B.3).

Discussion

Dock Abundance and Lengths

Our analysis of dock abundance and length conformed to our predictions with both increasing over time. Considering the longstanding growth of the southern US in general (Watkins 1978, Glaeser and Tobio 2008, Hoffman and Hogan 2008) and the coastal Southeast in

particular (Allen and Lu 2003, Terando et al. 2014, Sanger et al. 2015), the rising number of docks is unsurprising. Although dock abundance always increased (Table 3.2), there was a general oscillation between high (greater than 50% change) and modest (17-38% change) growth throughout our study years. Furthermore, in the periods of intense growth, docks increased at a much greater rate than either the number of housing units or population (Figure 3.2). This is particularly apparent between 1985-1994, when the number of existing docks in the coastal counties more than doubled. Dock abundance might be showing signs of saturation following the 2010 decade (Figure 3.2), but it is unclear if this is due to fewer available parcels on waterfront land or a general slowdown in development, as the last decade in our study saw the lowest percent change in the number of housing units of any decade (9.49%). Regardless, docks have clearly demonstrated a sharp rate of increase that has outpaced both population and housing growth throughout the past 60-70 years (Figure 3.2).

Once placed, docks occupy a site for decades. Our analysis found that 52% of sites that contained a dock built in the 1960 decade still contained a dock by 2011 (Table 3.3), strongly implying continuous dock presence for a minimum of 46-56 years. The relatively low number of docks that were removed each decade was punctuated by a spike of 425 docks between 1985-1994. This spike in removals occurred regardless of when the dock had been first constructed. We suggest this spike is most likely a result of Hurricane Hugo, a destructive category four storm that made direct landfall on Sullivan's Island (~7 km southeast of downtown Charleston, SC) in September 1989.

Existing dock lengths also increased through time, largely driven by the doubling of mean new dock length from 34.13 m in the 1960 decade to 70.38 m in 2011. Our ANOVA revealed that despite the wide variability in dock lengths, docks built in the 2000 and 2010

decade were significantly longer than docks built in prior decades (Figure 3.3). Extremely long docks also became more prevalent in later decades, as evidenced by the increasing density of upper outliers in Appendix B: Figure B.6. We believe this increase in length is likely a result of new construction occurring on parcels located further from deep water, as lots immediately adjacent to deep water are highly desirable and likely to be bought up first. Thus, newer parcels built along marsh front would necessitate longer docks to reach deep water.

Economic Distribution of Docks

Our analysis of the historic demographic distribution of docks partially aligned with our hypotheses. Contrary to our expectations, median household income showed an inconsistent correlation with dock abundance, both in terms of direction and statistical significance. We found a significant, negative correlation in the 2010 decade and a borderline significant, positive correlation in the 2000 decade. Racial composition (% White) showed a strong positive correlation with dock abundance in all decades. There is, however, little evidence that racial composition and time interacted over our study period, as the coefficient estimates for the % White term in our models remain positive and stable.

The variability of the relationship of median household income is peculiar and difficult to parse with this data. Why household income shows weak and insignificant effects in 1994 and 2016 but shows significant (or nearly so) effects that switch signs between 1999 and 2011 could have several interacting explanations. First, we may be incorrectly conceptualizing the relationship between docks and personal income by ignoring important decisions made by homeowners. We predicted an increasing abundance of docks with higher income because docks are expensive structures to build and maintain. Docks, however, are more than an economic sink,

they increase home value and are perceived as desirable additions by homeowners (Kelty and Bliven 2003, Wyman and Worzala 2016). Thus, modest income homeowners may tolerate the high initial costs of building a dock to increase the value of their home, leading to a dampened effect of income on dock abundance. Second, we might be missing important predictor variables that covary with MHI, such as the size of private property lots. It is feasible that the increasing disparity between the lowest and highest income Tracts through time (Figure 3.4) move alongside a contemporaneous disparity in mean lot sizes. All else being equal, larger average lot sizes in a Tract would likely result in fewer docks because individuals may not build more than one dock per lot under current South Carolina regulations (S.C. Code of State Regulations §30-12-A-1a), potentially explaining the negative relationship between MHI and dock count in 2011. Unfortunately, we had difficulty acquiring data on lot sizes because many municipalities that possess this information did not respond to our requests. Third, median household income is only one measurement of economic status and other variables, such as the availability of liquid assets or home value, might be more reflective of an individual's ability to pay for a dock. Lastly, as we discussed in our earlier work, this may be a consequence of the limitations imposed by aggregated spatial data that cannot capture the effect of income at the household level (Mohai et al. 2009). Ultimately, we believe a combination of housing development drivers occurring at a spatial scale below the Tract level are the likely root of these fluctuating income relationships.

Racial Distribution of Docks

We found a persistent racial imbalance in the distribution of private docks from 1994-2016, with Tracts that contained a larger proportion of White residents possessing substantially more docks. The results from 2016 concur with our prior study (Beauvais et al. 2022), which was

conducted at the finer-grain Census block group level, suggesting robustness of these results to differing levels of spatial aggregation (Tuson et al. 2019). Our imagery sets allowed us to assess general development patterns as far back as the late 1940s-1950s for most counties, but we were unable to use this full data set for our analysis of the socioeconomic distribution of docks. This is an unfortunate consequence of working with historical Census data in rural areas, as they generally did not contain spatial units at the sub-county level until the entire United States was divided into Tracts for the 1990 Census (Census Bureau 1994). Future data releases, such as the recent publishing of complete 1950 Census records, might alleviate these limitations, though working through these handwritten records require significant time and labor.

Although observational studies cannot directly assign causality, we offer three possible mechanisms that could explain the positive correlation between race and dock abundance:

Mechanism 1) History of property ownership

Mechanism 2) Aggregation obscures an interaction of race and income

Mechanism 3) Bias in dock permitting

The first mechanism is rooted in historical analyses of property ownership along the Southeast coast. Following the end of the Civil War and the collapse of the plantation economy, the perceived marginal value of coastal land enabled emancipated Black and Gullah-Geechee communities to acquire tremendous amount of property throughout the coastal Southeast (Kahrl 2012a, 2012b, Grabbatin 2016). The tenuous nature of Black landownership in this region (Faulkenberry et al. 2000, Rivers 2007, Kahrl 2016), coupled with rapidly appreciating values of waterfront land during fueled the well documented, precipitous decline of Black landownership throughout the mid-20th century (Fisher 1978, Copeland 1984, Kahrl 2012b). As Black landowners lost (and continue to lose) their land, these properties are characteristically bought up

and converted into sprawling planned communities that cater to predominantly White migrants from other parts of the US (Dean 2013, Hargrove 2020). This dual process of Black displacement and ensuing subdivision of properties into multiple parcels could produce the positive correlation we observed between dock abundance and the proportion of a Tract's population that is White. We noted some support for this proposed mechanism. The median percent Black population of our coastline Tracts halved from 1990-2019, while the median percent White population remains stable. This pattern suggests that Black residents are leaving coastal Tracts, while White residents maintain. Furthermore, even after controlling for length of shoreline, predominantly White Tracts consistently possessed more docks across all decades, suggesting that the way the shoreline is divided among racial groups could be an important factor. Concrete evidence in support of this mechanism could come from a deep analysis of property records, with a focus on how parcel size has changed over time. Some historians have undertaken this work in other Southern states (Fisher 1978, Kahrl 2016), but we know of no robust analysis of property transfers and parcelization in our counties.

Our second mechanism draws from our discussion above about potential mismatches between income aggregated at the Tract level and income at the household level. If White homeowners have more disposable financial resources and aggregation of household income obscures this, then that could explain the observed positive correlation between % White and dock abundance. Ample evidence of a national disparity in household wealth between Black and White Americans lends credence to this proposed mechanism (Bhutta et al. 2020). Like Mechanism 1, there is some evidence in our data to support this mechanism as we noted a modest correlation between % White and MHI (Appendix B: Figure B.7) at the Tract level in all years of the study. We note, however, that we tested for and found no interaction of race and

median household income and that the correlation between these two variables did not produce any collinearity issues. Additionally, our previous analysis at the finer-grain Census block group level similarly found no interaction between race and income. Testing this mechanism would require further disaggregation of our response variables to as close to the household level as possible (e.g. the Census block).

Our third mechanism posits that bias in dock permitting drives the racial imbalance in dock abundance. If systematic differences in the approval of docks from White and non-White applicants occurs, then White areas may contain more docks. There is little literature examining the permitting of docks in South Carolina, thus we are unable to assess whether Mechanism 3 is occurring. The vast number of docks in this region, the low number of dock permit requests that appear to be denied each year (Kelty and Bliven 2003), and the lack of racial identification on forms or direct interaction permitters have with applicants suggests that this is less likely than Mechanism 1 or 2.

Regardless of the underlying mechanisms, we argue that the preponderance of docks in predominantly White Tracts is an environmental justice issue that has persisted for at least two decades. While we are intentionally working under a narrow definition of access (Ribot and Peluso 2003) that prioritizes the capacity for physical entry into estuaries and salt marshes, the strength and consistency of the racial imbalance in dock abundance is clear from our data. Because docks both facilitate entry into waterbodies and are a conservative proxy for waterfront private property, our analyses suggest that White South Carolinians have possessed greater access to estuaries than other groups in South Carolina. Public WAI such as fishing piers and boat ramps might ameliorate the racial imbalance in private access, however, we were unable to analyze their distribution over time due to incomplete record keeping of when these structures

were built and the difficulty in distinguishing between public and private WAI from imagery alone. We did find that public WAI in SC in 2016 were disproportionately placed in low-income areas, however, they were orders of magnitude less abundant than private docks (Beauvais et al. 2022). Future quantitative work should be done to distinguish between the alternative mechanisms we propose, as these point to potential avenues for reconciling the disparity in private access.

Conclusion

Docks are long-lived structures that have grown at twice the rate of the population or housing units along the South Carolina coast since the 1960s. As of 2011, 10,092 docks, totaling 560 linear kilometers dotted the marshes and major coastal rivers of six South Carolina counties, which is more than 75% greater than the nominal length of the state's coastline (301 km). Although there is a wealth of research on the effects of anthropogenic structures on productivity (Alexander and Robinson 2006, Gladstone and Courtenay 2014), community composition (Tyrell and Byers 2007, Scyphers et al. 2015, Gittman et al. 2016), and a range of other ecological processes (Heerhartz et al. 2014, Bishop et al. 2017, Dugan et al. 2018), recent attempts to quantify the extent of marine infrastructure have largely focused on large-scale, commercial (Bugnot et al. 2021) or armoring infrastructure (Gittman et al. 2015). Our work suggests that small, personal docks can be the most abundant form of marine infrastructure in some regions and should be considered in subsequent analyses.

Apart from their ecological effects, docks both facilitate human activity in marshes and mark the location and extent of privatized waterfront. We found that the distribution of docks, and therefore access to coastal waters, has skewed in favor of White South Carolinians since at

least the early 1990s. Given the central importance of estuaries to communities throughout the Southeast USA (Goodwine 2015) this racial imbalance in access constitutes an entrenched EJ issue. Our work, when placed in context with the insights of communities, historians, and geographers suggests that while the waterways of South Carolina are held as a public resource, a predominant means of access to them remains inequitably distributed.

Acknowledgements

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Table 3.2. Summarized dock counts across the study area (excluding the 11 military/industrial Tracts). New refers to docks we could verify were built in that decade, removed refers to docks that disappeared in that decade, existing refers to all docks during that decade. Because 2019 data were downloaded in the form of pre-defined polygons, we could not track which docks were new or removed relative to 2010.

Decade	New docks	Removed docks	Existing docks	% New docks	% Previous decade's docks removed	Housing units	Docks/1000 housing units	Population	Docks/1000 people
1950	—	—	197*	—	—	81,479	2.42	214,839	0.92
1960	413 [†]	44 [†]	945	43.7 [†]	22.34 [†]	107,717	8.77	267,770	3.53
1970	676	148	1,473	45.89	15.66	133,734	11.01	527,540	2.79
1980	736	175	2,034	36.18	11.88	197,463	10.3	539,305	3.77
1990	3232	425	4,841	66.76	20.89	288,767	16.76	582,769	8.31
2000	1691	69	6,463	26.16	1.42	364,121	17.75	711,007	9.09
2010	3780	151	10,092	37.46	2.33	498,566	20.24	879,758	11.47
2019	—	—	11,886	—	—	545,866	21.77	1,021,157	11.64

*Only Charleston and Colleton had imagery in the 1950s and Colleton contained no docks. [†]Because 1960 is the first decade of imagery for Beaufort, Georgetown, Horry, and Jasper, these four columns in 1960 only represent Charleston and Colleton. The existing docks column for 1960 represents all counties. After 1960 all columns report for all counties.

Table 3.3. Table summarizing the longevity of dock presence across all six coastal counties (excluding the 11 military/industrial Tracts). Table should be read horizontally (e.g. of the 676 docks first identified in 1970, 46 were removed by the 1980 decade, 123 by the 1990 decade, etc.).

Decade	Number of new docks	Removed by 1960	Removed by 1970	Removed by 1980	Removed by 1990	Removed by 2000	Removed by 2010	Number remaining (2010)	Percent remaining (2010)
1950	197*	44	23	27	39	0	5	59	29.95
1960	792 [†]	—	125	102	121	12	19	413	52.15
1970	676	—	—	46	123	12	10	485	71.75
1980	736	—	—	—	142	7	28	559	75.95
1990	3232	—	—	—	—	38	62	3132	96.91
2000	1691	—	—	—	—	—	27	1664	98.40
2010	3780	—	—	—	—	—	—	3780	100

*As in Table 3.2, only Charleston and Colleton are represented in 1950. [†]Unlike in Table 3.2, we report all docks first identified in 1960 for all counties. Since it is possible docks in Beaufort, Georgetown, Horry, and Jasper existed prior to 1960, these might not truly be “new” docks under our definition and should be understood as a minimum longevity in those counties.

Table 3.4. Summarized dock lengths across the study area (excluding the 11 military/industrial Tracts). New refers to docks we could verify were built in that decade, removed refers to docks that disappeared in that decade, existing refers to all docks during that decade.

Decade	New docks mean length (m)	Removed docks mean length (m)	Existing docks mean \pm SD length (m)	Total linear km of existing docks
1950	—	—	49.07* \pm 50.44*	9.67
1960	34.13 [†]	47.08 [†]	36.00 \pm 35.54	34.02
1970	33.64	34.43	35.08 \pm 32.61	51.67
1980	40.84	42.44	36.53 \pm 35.74	74.3
1990	46.04	40.2	42.61 \pm 46.51	206.28
2000	56.17	47.21	46.18 \pm 50.11	298.48
2010	70.38	44.03	55.46 \pm 58.76	559.88

*Only Charleston and Colleton had imagery in the 1950s and Colleton contained no docks.

[†]Because 1960 is the first decade of imagery for Beaufort, Georgetown, Horry, and Jasper, these two columns in 1960 only represent Charleston and Colleton. The existing columns for 1960 represents all counties. After 1960 all columns report for all counties.

Table 3.5. Regression output for fixed effects from each decade. Values represent standardized beta? coefficients from each decade and significant terms are bolded for identification. Full model results can be found in Appendix B: Table B.3.

Decade	Median household income	% White	% Homeowner	Population	Shoreline
1990	-0.047	0.54	0.52	0.27	0.66
2000	0.32	0.35	0.19	0.39	0.76
2010	-0.25	0.49	0.52	0.29	0.6
2019	-0.15	0.35	0.4	0.33	0.61

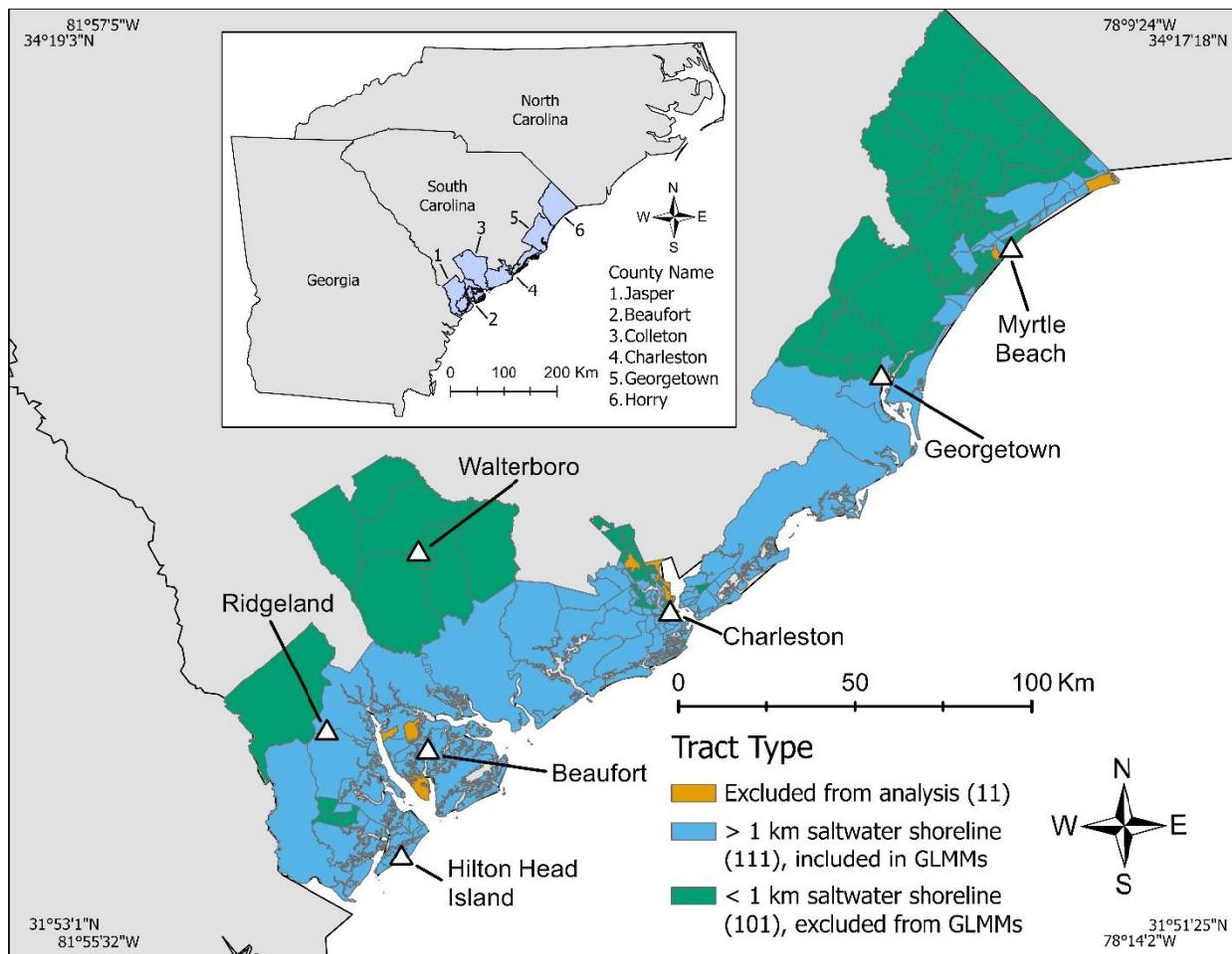


Figure 3.1. The main map shows Census Tracts in the study area. Orange Tracts are primarily military and industrial installations and excluded from all analyses. Blue and green Tracts are both used in the analysis of general development trends, but only blue Tracts are used in the socioeconomic analysis (GLMMs). Numbers in parentheses in the legend represent the number of Tracts in each category. Inset map (top left) shows South Carolina and neighboring states. Major cities in South Carolina are marked by white triangles and associated text. Main map scale 1:1,250,000, county inset map scale 1:8,250,000.

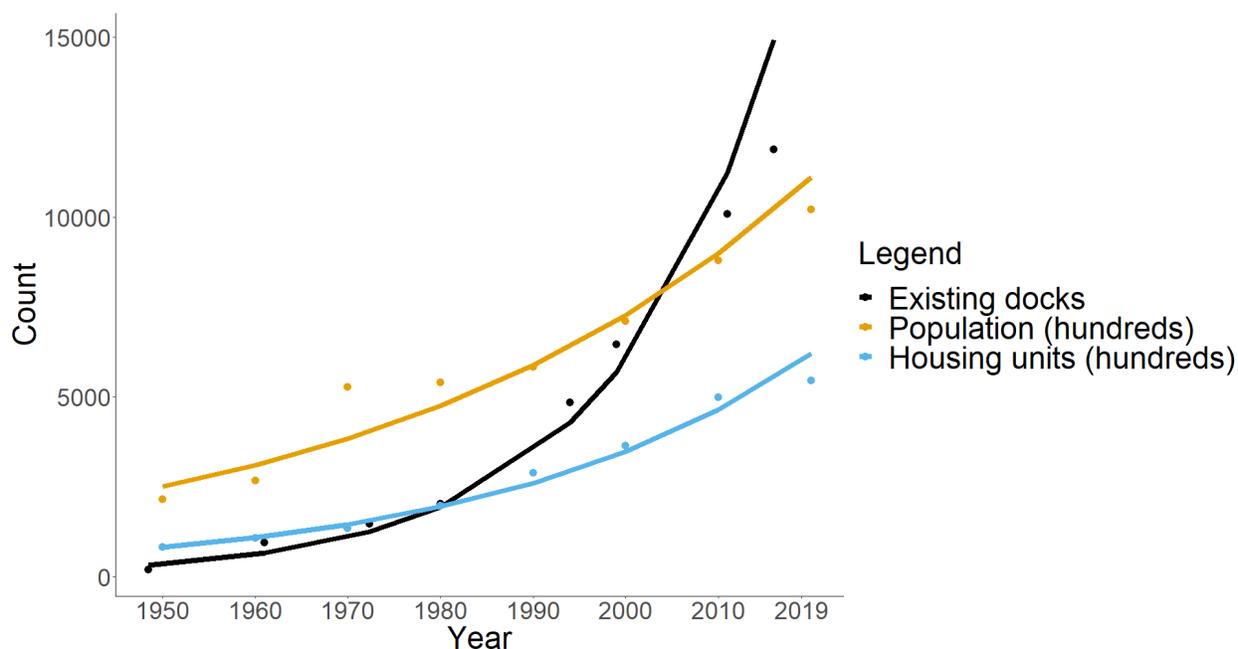


Figure 3.2. Growth rate of existing docks, human population (in hundreds), and housing units (in hundreds) across all six coastal counties (excluding the 11 military/industrial Tracts). Dock counts are fit to mean imagery years (Table 3.1) for each Census decade. Lines represent simple exponential growth curves fit to each variable. Estimated growth rates: r (existing docks) = 0.057, r (population) = 0.021, r (housing units) = 0.029.

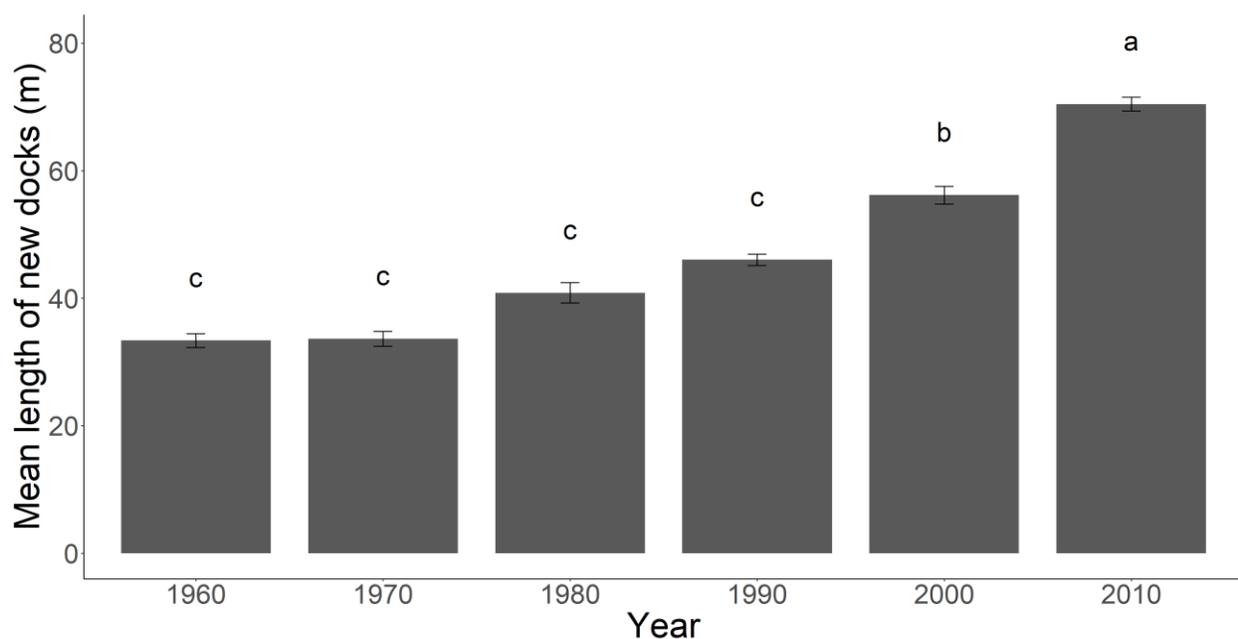


Figure 3.3. Results from the ANOVA of mean length of new docks over time ($F_{5,10063} = 104.7$, $p < 0.001$). Error bars represent standard errors. Different letters represent significant differences between groups from post-hoc Tukey test (with p -values adjusted for multiple comparisons).

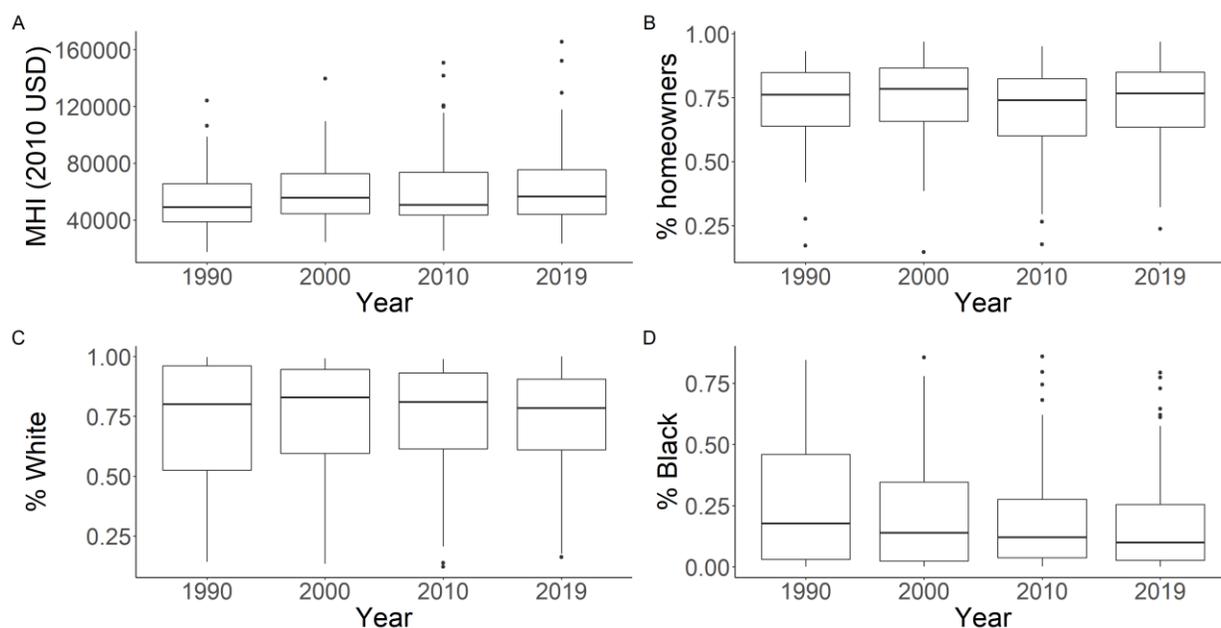


Figure 3.4. Boxplots of median household income (MHI, 2010 USD) (A), % homeownership (B), % White (C), and % Black (D) across the 111 Tracts used in the socioeconomic analysis. The black midline of the boxplot represents the median, box edges represent the 25th and 75th percentile (interquartile range, IQR), error bars represent 1.5 * IQR, and individual points represent outliers outside of the error bar range.

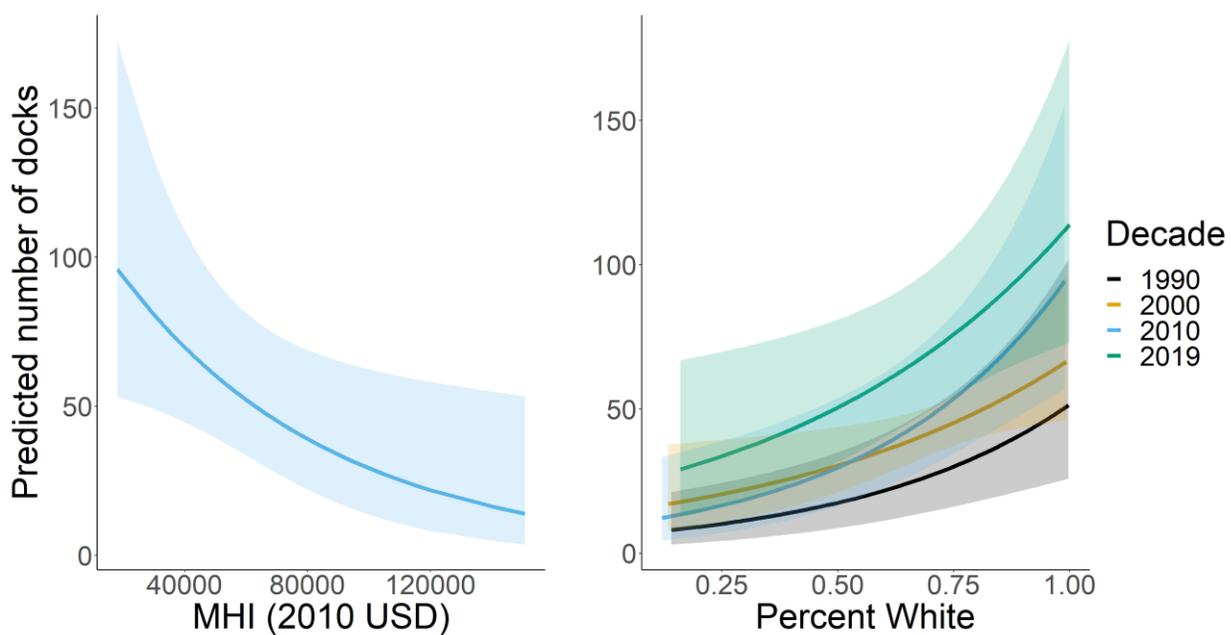


Figure 3.5. Conditional effects plots for all years of significant effects for median household income (MHI) (A) and % White (B) on the predicted number of docks. Lines represent conditional effect predictions with corresponding bands representing 95% confidence interval

CHAPTER 4
INFLUENCE OF RACIAL COMPOSITION ON THE DISTRIBUTION OF COASTAL
ARMORING IN SOUTH CAROLINA⁶

⁶ Beauvais, J., and Byers, J. To be submitted to *Marine Ecology Progress Series*.

Abstract

The desire to stabilize coastlines has led to widespread use of hard armoring infrastructure across the globe, however, ecologists and coastal managers have increasingly documented the deleterious effects of armoring on ecological communities. Although many studies have assessed economic and landscape correlates of armoring, few studies incorporate race as a predictor of armoring. Race may be an important force structuring the placement of armoring due to the long history of Black land loss in the US South. Here, we assessed the racial and economic distribution of armoring in the US state of South Carolina using a high spatial resolution data set and a combination of spatial statistics and generalized linear mixed models. We found that armoring was spatially patchy and different patterns of clustering emerged depending on whether we analyzed armoring abundance or lengths. We found a higher abundance of armoring in areas with a larger percentage of White residents and homeowners, however, no predictors we analyzed were significantly correlated with armoring length. These results highlight that racial composition is a strong predictor of armoring abundance on private, personal property, which may provide further insight into the social drivers of armoring. Furthermore, the relationship between race and armoring has implications for the equitable implementation of SLR adaptation strategies, as armoring is one approach communities might adopt to fend off rising waters. We conclude by suggesting future directions for research from an environmental justice perspective.

Introduction

Over the past three decades, coastal researchers have increasingly recognized the ecological challenges presented by pervasive efforts to stabilize intrinsically dynamic coastlines. Infrastructure built parallel to the shore is often referred to as “armoring” and can take on a variety of forms. Hard, artificial objects such as seawalls, bulkheads, riprap, and other related infrastructure have been a default approach to armoring for decades, if not centuries (Dugan et al. 2011, Rangel-Buitrago et al. 2018). Although built to protect and preserve the current shape of coasts, hard armoring frequently produces adverse effects on coastal environments. Hard armoring structures like seawalls have been tied to increased localized erosion along beachfronts (Miles et al. 2001, Defeo et al. 2009) and these structures sever connectivity between the beach and land ecotone (Hsu et al. 2007, Heerhartz et al. 2014). In the context of sea level rise (SLR), coastal ecosystems like salt marshes have the capacity to migrate landward depending on complex interactions of the magnitude of SLR, tidal amplitude, and sediment supply (Kirwan et al. 2010). Hard armoring, however, interrupts this landward migration by presenting an impermeable barrier, producing the well-documented phenomenon of “coastal squeeze” (Doody 2004, Torio and Chmura 2013, Pontee 2013).

Hard armoring not only affects the geomorphology of coastlines, but also affects biotic communities. Studies across a variety of taxa have found that the physical complexity and composition of armoring influences community composition of benthic invertebrates and vegetation (Chapman 2003, Seitz et al. 2006, Gittman et al. 2016, Gehman et al. 2018, Strain et al. 2020). Hard infrastructure can also alter species interactions such as competition and predation (Moreira et al. 2006, Bulleri and Chapman 2010), which can in turn facilitate the establishment of introduced species (Glasby et al. 2007, Tyrrell and Byers 2007, Airoidi et al.

2015). These effects might be particularly pronounced in soft-sediment environments, where armoring provides hard surfaces that are naturally scarce but conducive to the settlement of sessile invertebrates or epiphytic algae (Bulleri 2005, Byers and Grabowski 2014). In these soft-sediment ecosystems, Dugan *et al.* (2018) proposed a broad typology of anticipated armoring effects based on the interaction of the energy of the environment and the purpose of the infrastructure. Under this model, the ecological impacts of armoring would be most pronounced in areas of high energy and with structures designed to completely halt the movement of water (Dugan *et al.* 2018). They found that studies generally conformed to these predictions for the availability of natural habitat and community composition but noted a scarcity of research for other ecologically relevant variables such as productivity (Dugan *et al.* 2018).

Given these genuine concerns over the cumulative impact of coastal armoring, numerous studies have mapped these structures in regions across the world. Research in Japan (Walker and Mossa 1986, Masucci and Reimer 2019), Taiwan (Hsu *et al.* 2007), Colombia (Rangel-Buitrago *et al.* 2018), the United States (Gittman *et al.* 2015, Peterson *et al.* 2019), and global analyses (Bugnot *et al.* 2021) have documented extensive coastal armoring. In the US, most armoring along the Atlantic and Pacific coasts occurred in areas not exposed to the open ocean and armoring prevalence was higher in counties with larger GDPs and housing density (Gittman *et al.* 2015). In the US state of Georgia, the probability of armoring on an individual parcel increased with parcel slope, hydrological energy, erosion rates, and presence of armoring on a neighboring parcel (Peterson *et al.* 2019). Additionally, county identity also influenced armoring presence, but not in ways that directly tracked population or urban/rural characteristics of those counties (Peterson *et al.* 2019). Other studies in the US have examined how homeowner decision making influences armoring presence through both modeling (Beasley and Dundas 2021,

Gardner and Johnston 2021) and survey approaches (Scyphers et al. 2015, Stafford and Guthrie 2020). Many of these studies concur that the presence of armoring in neighboring parcels is a strong, positive predictor of armoring (Scyphers et al. 2015, Stafford and Guthrie 2020, Beasley and Dundas 2021). Other work has emphasized the importance of parcel-level landscape characteristics on armoring presence, suggesting that parcels at lower risk of water damage, such as those in areas with low wave energy or situated at higher elevations, are less likely to be armored (Gardner and Johnston 2021).

Notably, although many of the studies in the USA incorporate economic variables in their work, few have examined or theorized the relationship between race and coastal armoring. This omission may be partly due to the choice of spatial scale and methodology, as quantitative racial characteristics of households are not available and researchers using a survey instrument may be reticent to ask detailed demographic questions out of fear of reducing survey response rates (Stafford and Guthrie 2020). Nonetheless, race may be an important but overlooked predictor of armoring on private property, particularly in the geographic context of the US South. Research by Southern historians has documented the extensive loss of Black-owned land in the coastal Southeast from the mid-20th century to today (Fisher 1978, Kahrl 2012b). The mechanisms fueling this racially skewed land loss, including forced partition sales of property (Copeland 1984, Rivers 2006, Dyer and Bailey 2008) and property tax hikes (Thomas 1978, Dean 2013, Kahrl 2016), have contributed to the transformation of the coastal Southeast from a mostly rural region of sparse development into the booming real estate market of today (Kahrl 2012a, 2014). As many of the studies discussed above demonstrate, private property owners are an important component of the armoring landscape, implicating the racial dynamics of property in the distribution of armoring.

A few studies have found race to be an important variable in the distribution of coastal infrastructure. In North Carolina, there was a negative correlation between the percent armored coastline and the percent of a Census Block Group's population that identified as non-White (Siders and Keenan 2020). Prior work on private docks found racial composition was a significant predictor of dock abundance in South Carolina (Beauvais et al. 2022). Although not armoring, that work demonstrates that another common form of infrastructure on private property is correlated with the racial characteristics at the scale of Census Block Groups. Thus, preliminary work suggests that race should be accounted for in studies of armoring. Furthermore, the distribution of armoring has substantial implications for how communities will experience SLR (Siders and Keenan 2020, Taylor et al. 2022), as armoring is one possible adaptation mechanism coastal municipalities might employ. Thus, our study strives to improve our understanding of the social forces that influence armoring while also providing insights into the EJ dimensions of shoreline hardening.

In this study, we address two questions: 1) Does shore parallel armoring show spatial clustering across the South Carolina coast? and 2) How is the abundance and extent (length) of artificial shore parallel armoring structures distributed with respect to the racial and economic composition of Census Block Groups? For question one, we hypothesized that shore parallel armoring would be patchily distributed and show significant spatial clustering in more populated, urban areas. For question two, we hypothesized that wealthier CBGs with a larger share of White residents would possess both a greater abundance and total length of armoring structures. Together, these approaches support a detailed analysis of the socioeconomic distribution of shore parallel armoring.

Methods

Study System and Area

We analyzed the distribution of armoring infrastructure across six counties on the South Carolina coast (Figure 4.1). The coastlines of these counties consist primarily of intertidal salt marshes that form the transition between the land and water. We conducted all analyses at the Census Block Group (CBG) level, which is the smallest spatial scale for which the Census Bureau publishes data for years between decennial censuses. The six study counties were composed of 583 CBGs, which we reduced to 572 CBGs after removing six CBGs that were entirely military bases/housing and five CBGs that comprised the Port of Charleston. We further reduced the data to only CBGs with greater than one kilometer of saltwater or beach shoreline to match the area covered by the armoring data set (described below). We chose a one-kilometer minimum shoreline requirement to reduce the likelihood of including CBGs with incorrectly assigned shoreline due to the relatively coarse, 30 m resolution land cover data we used to calculate shoreline length (Beauvais et al. 2022). This minimum shoreline requirement only excluded 25 structures totaling 2.9 km from the study. After applying this shoreline filter, our final full study area consisted of 246 CBGs.

Shore Parallel Armor Abundance and Length

We obtained data on armoring infrastructure (originally collected by Jackson 2017) from the Ocean and Coastal Resource Management division (OCRM) of the South Carolina Department of Health and Environmental Control. Armoring infrastructure was originally digitized from various aerial photography sources from 2003-2013 (Jackson 2017). Armoring data was represented as polylines, which we analyzed in ArcGIS Pro version 2.9 (ESRI 2021).

Sixteen of these armoring structures crossed CBG boundaries. In these cases, we split the structure into new polylines to correctly assign them to individual CBGs. We extracted CBG information to each polyline and summarized the total number and length of each type of armor in R version 4.2.1 (R Core Team 2022). We then grouped all shore parallel armoring structures into a single category for analysis.

Question 1 – General Distribution and Clustering of Armoring

We categorized armoring location into two classes – beach and marsh. Because relatively little armoring was placed along the beachfront, we manually recorded each of these structures. We also analyzed the co-occurrence of armoring and private docks. We collected 2011 private dock data in an earlier study from the USDA’s National Agriculture Imagery Program (Beauvais et al. in preparation). To analyze the co-occurrence of docks and armoring, we converted dock and armoring polylines to a single point placed at the start of the dock and at the midpoint of an armoring structure. We then used the ‘Generate Near Table’ tool in ArcGIS Pro to identify whether at least one dock was located within a 50 m radius of the center of each armoring structure. We chose a 50 m radius to ensure a large enough search area to identify association with docks on the same private property parcel while minimizing spurious associations with docks on other lots.

We employed two approaches to assess spatial patterns in armoring. First, we used the ‘Line Density’ tool in ArcGIS Pro to quantify the density of armoring across at a 100 m scale with a one km search radius across the 246 CBG study area. The ‘Line Density’ tool works by first dividing the study area into a grid of cells with a user specified area (0.01 km², 100 m x 100 m). The tool then searches a user defined circular area around the center of each cell, sums the

length of all armoring polylines found within the search area, and divides this total length by the area of the search circle. We chose a 1 km search radius ($\approx\pi$ km² search circle) to allow for easily interpretable density values.

Our second approach used the ‘Hot Spot Analysis’ tool to identify statistically significant clusters of armoring. The ‘Hot Spot’ tool calculates a Getis-Ord G_i^* value (Ord and Getis 1995) for every CBG, allowing us to analyze clustering at a Census defined level of aggregation. We modeled spatial relationships between CBGs using a queen contiguity spatial weights matrix. We calculated hot spots for both armoring counts and lengths to determine whether different patterns existed for these two variables.

Question 2 – Racial and Economic Distribution of Armoring

We used a generalized linear mixed model framework to test whether the abundance and length of armoring were correlated to CBG characteristics. We collected all demographic predictor variables from the 2013 American Community Survey (ACS) 5-year average using the R package “tidycensus” version 1.2.3 (Walker and Herman 2022). The ACS is an annual survey of 3.5 million US households that the Census Bureau conducts in years between decennial censuses. Even though most of the armoring data came between 2006-2011, we chose the 2013 ACS 5-year average due to limited API availability of pre-2013 ACS data at the time of analysis. We selected six demographic variables to include as fixed effects based on our prior work in the system (Beauvais et al. 2022) and prior environmental justice studies (Kim et al. 2019, Riley and Gardiner 2020). We included median household income (MHI) and the percent of the CBG population that identified as White as fixed effects for the economic and racial composition, respectively. We also included total population and the mean age of the CBG population (Kim et

al. 2019) as fixed effects to account for discrepancies in CBG population size and control for the potential influence of coastal South Carolina's sizeable population of retirement communities (Faulkenberry et al. 2000). We selected the percent of the CBG population that owned their home to account for potentially greater investment in protecting owned versus rented assets. Lastly, we also included the percent of the CBGs homes built after 1989 as a fixed effect because the state of South Carolina banned the construction of new seawalls along the beach in 1988 (S.C. Code Ann. §48-39-250). Thus, CBGs with a larger share of homes built from 1990 onward might have less armoring due to prohibitions and stricter review of armoring permit applications.

In addition to the six demographic variables, we also incorporated the length of saltwater or beach shoreline as a fixed effect, drawing on prior work (Beauvais et al. 2022) that measured shore length using 30-m resolution land cover data from NOAA's Digital Coast (<https://coast.noaa.gov/digitalcoast/data/>). We included all beach shoreline and saltwater shoreline, regardless of proximity to standing deep water, because shore parallel armoring structure could feasibly be built anywhere along the land/marsh interface.

Preliminary analysis showed a strong concentration of shore parallel armoring in Beaufort and Charleston counties, suggesting that county identity might play a significant role in armoring abundance and length. We included county as a fixed effect in the analyses and Census Tract and CBG as random intercepts to account for the spatial nestedness of Census data.

For armoring counts, we fit a negative binomial mixed effects model using the "glmmTMB" package version 1.1.4 (Brooks et al. 2017) for all 246 CBGs. Armoring lengths were lognormally distributed, and we fit a log-transformed armoring lengths response variable (measured in meters) using a linear mixed effects model in "glmmTMB". We excluded any CBGs that did not contain armoring from the length model, reducing the 246 CBGs used in the

count model down to 155 CBGs. We filtered out CBGs without armoring because we were interested in what factors correlate with the total length of armoring, not what influences the presence of armoring. We included all fixed and random effects described above for both models. We also centered and scaled all fixed effects in both models by their standard deviations to allow for comparison of fixed effects. Because the county fixed effect was a categorical variable with six levels, we were unable to scale this term. We found no evidence of multicollinearity for either model after assessing the Pearson correlation values and VIF for all model fixed effects (all VIF < 3). We conducted further diagnostic tests on models using the “DHARMA” package version 0.4.6 (Hartig 2022). All model residuals conformed to assumptions of homoscedasticity, however, the armoring count model showed evidence of modest underdispersion. Additionally, given the inherent spatial nature of Census data, we examined residuals from both models for spatial autocorrelation using a Moran’s I test assuming inverse-distance spatial weights. We found no evidence of residual spatial autocorrelation in either the count ($z = 1.56$, $p = 0.11$) or length ($z = 0.59$, $p = 0.55$) model.

We tested for the significance of fixed effects using likelihood ratio tests. For the categorical county fixed effects, we conducted a post-hoc Tukey HSD with a Bonferroni correction using the “emmeans” package version 1.8.1-1 (Lenth 2022). For the continuous fixed predictors, we plotted marginal effects for significant terms using the “ggeffects” package version 1.1.3 (Lüdtke 2018).

Results

Question 1 – General Distribution and Clustering of Armoring

Overall, 1,611 shore parallel armoring structures covered 159.31 km in our study area (Jackson 2017; Table 4.1). Only 26 pieces of armoring totaling 8.38 km occurred along South Carolina's officially defined beachfront, with the remaining armoring occurring in marsh areas (Table 4.1). We found that 865 of the 1,611 (53.7%) armoring structures in the data set occurred within 50 m of a private dock. In terms of length, these structures correspond to 59.58 km of the 159.31 km (37.4%) of armoring along the South Carolina coast.

The 'Line Density' analysis showed a patchy distribution of armoring (Figure 4.2). Large patches of high armoring densities occurred around James Island, Sullivan's Island, and the Isle of Palms in Charleston County (Fig. 4.2). High armoring densities also occurred along Broad Creek and the Sea Pines Resort on Hilton Head Island, Fripp Island, Land's End, and Dataw Island in Beaufort County, and along the northeastern most section of the Intercoastal Waterway in Horry County (Fig. 4.2).

The results of the hot spot analysis differed slightly depending on whether counts or lengths of armoring were analyzed (Figure 4.3). For counts, statistically significant hot spots were identified in Beaufort County in CBGs encompassing downtown Beaufort, Bluffton, Lady's Island, St. Helena Island, and Fripp Island. In Charleston County, hot spots were identified around the James Island region. When analyzing lengths, hotspots were identified in Beaufort County in southern St. Helena Island, Fripp Island, southeast Hilton Head Island, and Bluffton. Other hot spots were identified in Jasper County along the Savannah River and in the northeast most portion of Horry County.

Question 2 – Racial and Economic Distribution of Armoring

The negative binomial model of armoring counts demonstrated a significant, positive effect of percent White (Table 4.2, $\chi^2(1) = 7.63$, $p = 0.0058$) and percent homeowner ($\chi^2(1) = 7.10$, $p = 0.0078$). Shoreline length showed a marginally significant, positive correlation ($\chi^2(1) = 3.40$, $p = 0.065$). Comparison of the standardized coefficients for continuous predictors and marginal effect plots (Figure 4.4) suggests that the racial composition and percent homeowners in a CBG have a similar magnitude of effect on armoring abundance. Analysis of the marginal effects contextualizes these coefficients – the number of armoring structures in a CBG is predicted to increase from 1.6 to 7.8 between CBGs that are 0 to 100% White and 1.1 to 8.9 between CBGs that are 0 to 100% homeowners. County also showed a significant effect ($\chi^2(5) = 44.68$, $p < 0.001$) and a Tukey HSD post-hoc test on county revealed significantly higher armoring counts between Beaufort, Charleston, Georgetown, and Jasper counties relative to Horry County (Figure 4.5). Given the small number of CBGs in Jasper and Colleton, inferences about county-level effects for these counties should be made with caution. The model of armoring lengths showed very different patterns than the count model. No terms in the model were significantly correlated but income showed a marginally significant, positive correlation ($\chi^2(1) = 3.40$, $p = 0.065$, Table 4.3).

Discussion

As predicted, rural areas of counties tended to have a lower density of armoring structures, however, armoring was not uniformly dense in urban areas. Some urban areas contained relatively little armor despite being adjacent to water (Fig. 4.2). The patchy distribution we observed is driven in part by the presence of vacation resorts and wealthier

suburbs. For example, downtown Charleston had relatively little armoring outside of a few large marinas, but the nearby vacation resort of Wild Dunes on the Isle of Palms had a large expanse of high armor density. Likewise, in Beaufort County, the vacation resort of Fripp Island and the wealthy community of Dataw Island had high armoring densities. Although many areas of high armoring density appeared in beachfront communities, only 26 shore parallel armoring structures were located along the beach in South Carolina. As discussed earlier, this result is undoubtedly a consequence of South Carolina's prohibition on most shore parallel armoring structures along the beach after amendments to the South Carolina state code in 1988. In many of these instances, the high armoring densities occurred on the interior marsh side of these communities.

Statistical analyses of clustering at the CBG level revealed different patterns depending on the variable being considered. When analyzing armoring abundance, significant clustering hot spots occurred in parts of southern and northern Beaufort County, and south of downtown Charleston. Analyses of total armoring length, however, preserved some hot spots in southern and northern Beaufort County, did not identify hot spots in Charleston County, and detected new hot spots in Jasper and Horry County.

Our analysis of demographic correlates of armoring partially conformed to our predictions for the count model, but not for the length model. In the count model, percent White and percent homeowners were both positively correlated with armoring abundance, while median household income was not a significant covariate. Furthermore, significant county level differences existed for the count model, with Horry County CBGs possessing less armoring. The length model, on the other hand, revealed no significant effects of any of our predictor variables. Curiously, our results differ slightly from a comparable study conducted in the neighboring state of North Carolina (Siders and Keenan 2020). Although both studies found a significant, positive

correlation between percent White and armoring, we found this effect only for armoring counts, while Siders and Keenen (2020) found a significant effect for the percent of shoreline armored, which is derived from a length-based measurement. Importantly, both studies drew on different data sets. Our work used a high-spatial resolution data set that contained digitized polygons for individual pieces of armoring. Siders and Kennan used Environmental Sensitivity Index (ESI) maps provided by the National Oceanic and Atmospheric Administration (NOAA), which classifies segments of shoreline into 15 categories and is a slightly coarser-grain source of armoring data. Thus, the choice of data set and their differences in spatial resolution may contribute to different findings between armoring studies. Nonetheless, these studies are in broad agreement about the influence of racial composition on armoring prevalence and the weight of the evidence demonstrates that race is an important variable to consider in future studies.

Different forces appear to drive the abundance and total length of armoring in our study area and although we obtained different results for abundance and length, both response variables might be insightful depending on research objectives. The divergent results between armoring abundance and length in both the clustering analyses and mixed effect models in our study emphasizes the importance in being deliberate in the choice of response variables. Analyses of counts might have more utility in studies investigating the armoring trends and priorities of individual homeowners, while analyses of length might be more suitable for understanding net ecological effects of armoring at larger spatial scales.

Our work suggests that a large proportion of the total armoring in South Carolina is located on private, personal property. The co-occurrence analysis indicates that a minimum of 53.7% of the armoring abundance and 37.4% of the total armoring length occurred within 50 m of a dock. These are conservative estimates, as not all private property parcels with armoring will

also contain a dock. Docks also show a significant, positive correlation with the percent of a CBG population that identifies as White (Beauvais et al. in preparation). Thus, the distribution of private property clearly influences armoring and other coastal infrastructure in South Carolina. Given the deeply racialized history of land acquisition and loss in the southeast US (Rivers 2007, Kahrl 2012), understanding the placement of armoring will require greater attention to the interplay between race and property.

Future Directions - Environmental Justice Dimensions of Armoring

Apart from being a potential driver of armoring, the implications of SLR reveal another important dimension of the relationship between race and armoring in South Carolina. Current and future projected SLR is forcing coastal populations and managers to make difficult decisions on how to respond. The range of possible options for SLR adaptation are typically categorized as “protection”, “accommodation”, and “retreat” (Gibbs 2016, Dodman et al. 2022). As the names suggests, the “protection” option entails advancing armoring to guard coastal regions from SLR, “accommodation” typically involves retrofitting existing buildings or requiring new buildings to be made more resilient to inundation, and “retreat” involves planned divestment from coastal areas and incentivizing or requiring coastal populations to move inland (Gibbs 2016, Dodman et al. 2022). Research across a multitude of disciplines has investigated how to employ these strategies without harming the substantial economic investment many coastal property owners have put into their homes (Titus 1998, Cooper and McKenna 2008). More critically, the climate justice movement has raised concerns over where and how each of these strategies will be deployed and whether adaptations to SLR will entrench or exacerbate existing environmental justice issues in coastal areas, particularly in the case of planned retreat (Ajibade 2019, Tubridy

et al. 2022). Returning to North Carolina, the implementation of SLR adaptation strategies markedly differs across racial groups (Siders and Keenan 2020). Buyouts of property, a component of the “retreat” strategy, were significantly more likely in CBGs with a higher non-White population and lower population density, while armoring was more abundant in CBGs with a larger White population and high population density (Siders and Keenan 2020). Other research across the US has highlighted the concentration of buyout programs in low income and non-White communities (Martinich et al. 2013, Siders 2019).

Although part of the portfolio of SLR response options, the detrimental impacts of hard, artificial armoring has led many coastal researchers, managers, and communities to analyze and implement alternative forms of armoring such as living shorelines. These “green” armoring approaches make use of natural materials to provide coastal protection and erosion control (Smith et al. 2018, Polk and Eulie 2018), and are often coupled with restoration efforts of macrophytes, terrestrial dune vegetation, and oyster reefs (Bilkovic et al. 2016, Safak et al. 2020, Suedel et al. 2022). Interest in these “nature-based solutions” has exploded in the past few years, with extensive academic, governmental, and public initiatives gaining steam across the US. Due to its relative novelty, few studies have examined the justice implications of living shoreline projects (Grabowski et al. 2022). We argue, however, that without proactively engaging with a diverse range of communities in the research and implementation of living shorelines (Taylor et al. 2022), these projects might help to alleviate the ecological consequences of hard armoring while leaving climate injustices around SLR intact.

Conclusion

Coastal armoring is an extensive form of coastal infrastructure that is distributed unevenly along the South Carolina coast. Race was a significant predictor of armoring abundance, with CBGs containing a larger proportion of White residents possessing more armoring. Overall, the evidence provided by this study compellingly demonstrates that research into the distribution of armoring, particularly for studies occurring in the US South, need to examine race more directly in their analyses. Racial composition not only provides critical social context into how armoring on private property is distributed, but also has direct implications for how coastal communities respond to climate change and SLR. Armoring will continue to be one of the most politically palatable options as more land is threatened by SLR (Dodman et al. 2022), creating conditions for the inequitable implementation of climate adaptations across racial groups. Coastal governments and researchers need to meaningfully engage with communities during the planning and implementation of SLR adaptation, or risk reifying existing climate injustices along the coast.

Acknowledgements

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Table 4.1. Abundance and lengths of individual types of shore parallel armoring across the 246 CBG study area.

Category	Structure Identity	Count	Length (km)
Sloped armoring	Revetment	187	24.16
	Riprap	237	24.08
	Concrete slope	5	0.17
Vertical armoring	Unclassified vertical armoring	99	18.75
	Bulkhead	914	78.41
	Seawall	116	7.00
Hybrid armoring	Combined sloped and vertical structure	52	6.69
	T-Groin	1	0.053
Total Shore Parallel	—	1,611	159.31

Table 4.2 Summary of output for fixed and random effects for the negative binomial GLMM of armoring count. Significant terms are italicized for emphasis.

Fixed Effects				
Variable	Standardized Beta Coefficient	SE	χ^2 Value	p-value
Intercept	2.33	0.22	—	—
Income (thousands \$)	-0.21	0.17	1.37	0.24
% <i>White</i>	<i>0.42</i>	<i>0.15</i>	<i>7.63</i>	<i>0.0058</i>
Mean age	0.014	0.15	0.008	0.93
% <i>Homeowner</i>	<i>0.42</i>	<i>0.15</i>	<i>7.1</i>	<i>0.0078</i>
% homes built after 1989	-0.19	0.16	1.47	0.22
Population (hundreds)	0.14	0.14	1.01	0.31
Shore length (km)	0.27	0.16	3.4	0.065
<i>County</i>	—	—	<i>44.68</i>	<i>< 0.001</i>
Random Effects				
Level	Variance			
Census Tract	0.41			
CBG	1.76*10 ⁻⁸			
Abbreviations				
SE	Standard error			
χ^2	Chi-squared value from likelihood ratio test			

Table 4.3. Summary of output for fixed and random effects for the linear mixed model of armoring lengths. Length values modeled in meters.

Fixed Effects				
Variable	Standardized Beta Coefficient	SE	χ^2 Value	p-value
Intercept	6.47	0.17	—	—
Income (thousands \$)	0.27	0.14	3.4	0.065
% White	0.11	0.13	0.83	0.36
Mean age	0.086	0.13	0.44	0.51
% Homeowner	0.023	0.13	0.033	0.86
% homes built after 1989	-0.18	0.13	2.04	0.15
Population (hundreds)	-0.074	0.12	0.41	0.52
Shore length (km)	0.18	0.11	2.53	0.11
County	—	—	3.46	0.63
Random Effects				
Level		Variance		
Census Tract		9.32*10 ⁻⁹		
CBG		0.053		
Abbreviations				
SE		Standard error		
χ^2		Chi-squared value from likelihood ratio test		

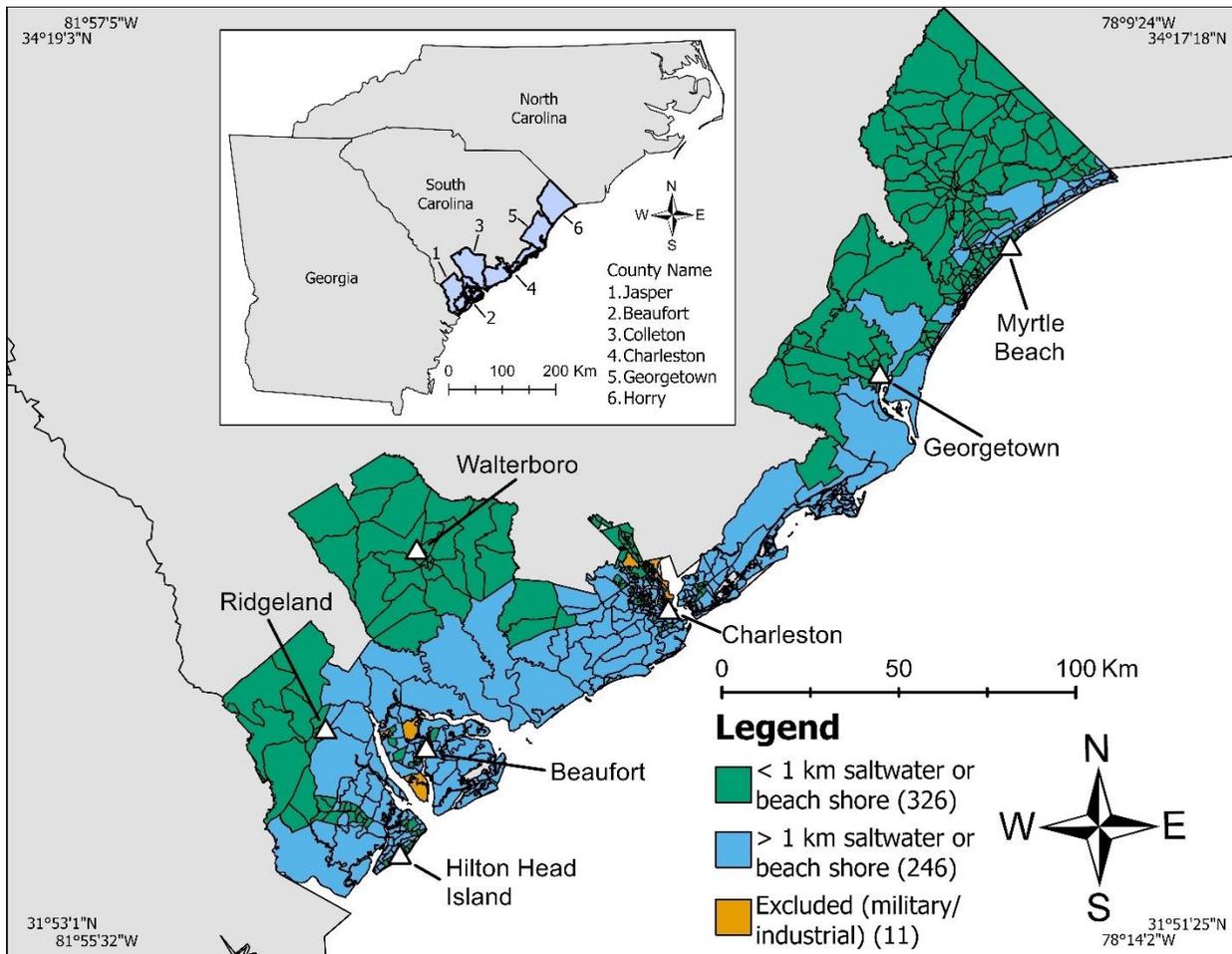


Figure 4.1. The main map shows Census Block Groups (CBGs) in the six coastal counties of study. Orange CBGs are entirely military or industrial areas that were excluded from all analyses. Green CBGs contain less than 1 km of saltwater shoreline and are excluded from the study. Blue CBGs contain more than 1 km of saltwater shoreline and are included in the study. Numbers in parentheses in the legend represent the number of CBGs in each category. Inset map (top left) shows South Carolina, neighboring states, and counties for which armoring data was available. Major cities in the study counties are marked by white triangles and associated text. Main map scale 1:1,250,000, county inset map scale 1:8,250,000.

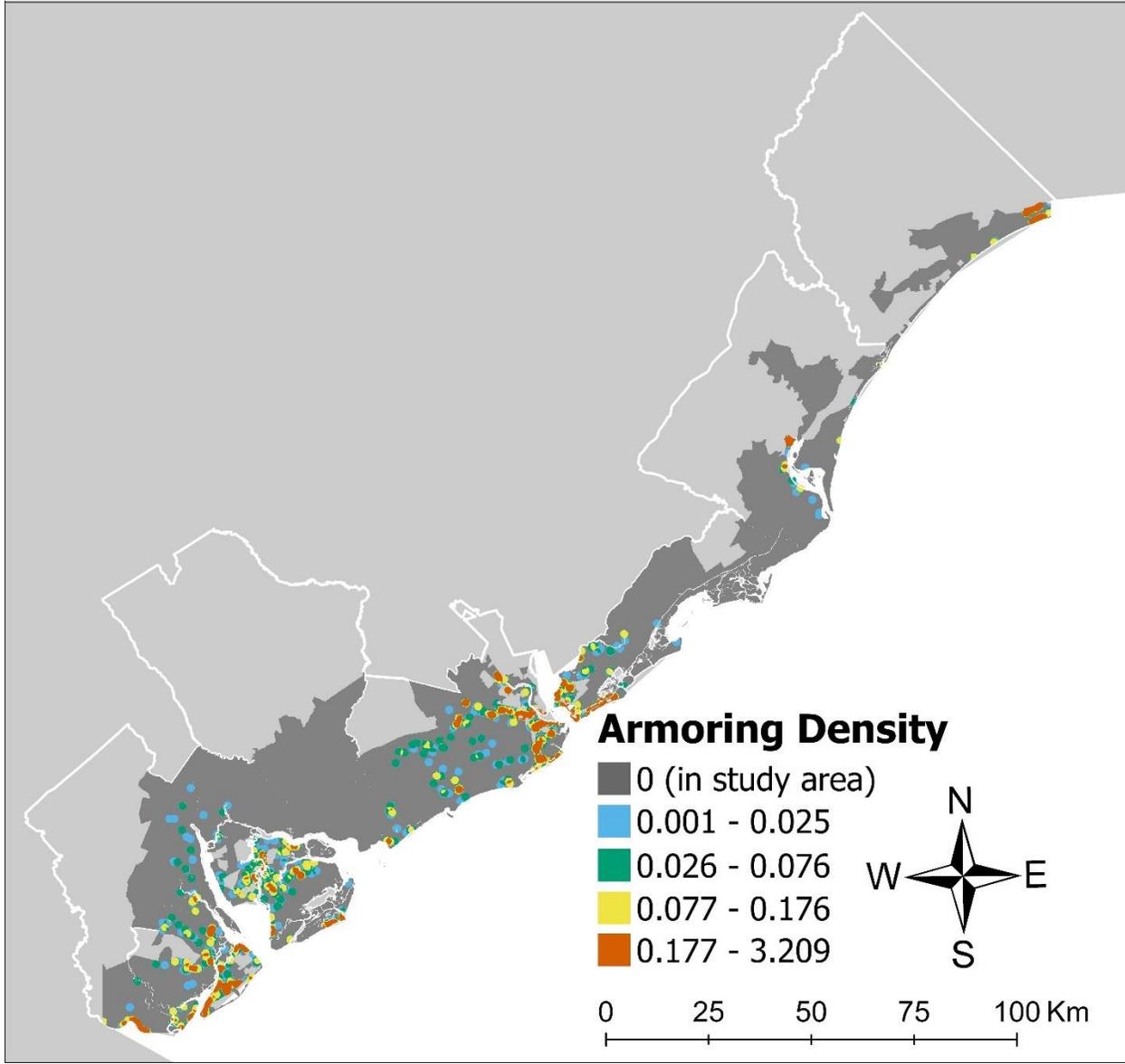


Figure 4.2. Line density map of all shore parallel armoring. White lines represent boundaries for the six coastal counties, dark gray areas represent areas in the 246 CBG study area without any armoring in search area, color ramp shows densities calculated as the total length of armoring per $\pi \text{ km}^2$ (circular search area with a radius of 1 km) for each $.01 \text{ km}^2$ grid cell. Color ramp groups represent quantiles containing an equal number of observations in each group. Map scale 1:1,250,000.

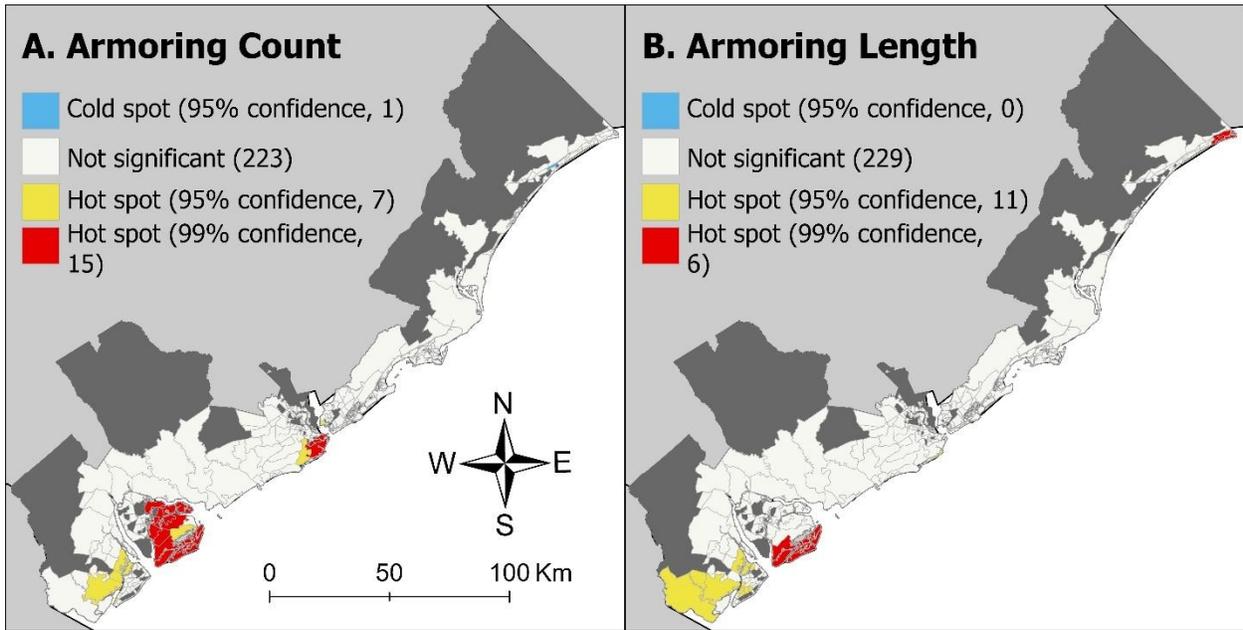


Figure 4.3. Hot spot analysis for armoring counts (A) and armoring length (B). Dark gray areas represent count boundaries, color ramp represents statistical significance of cold spots and hot spots as calculated from the Getis-Ord G_i^* statistic. Number in parentheses in legend represent the confidence level and number of CBGs in at that confidence level, in that order. Map scale: 1:1,850,000.

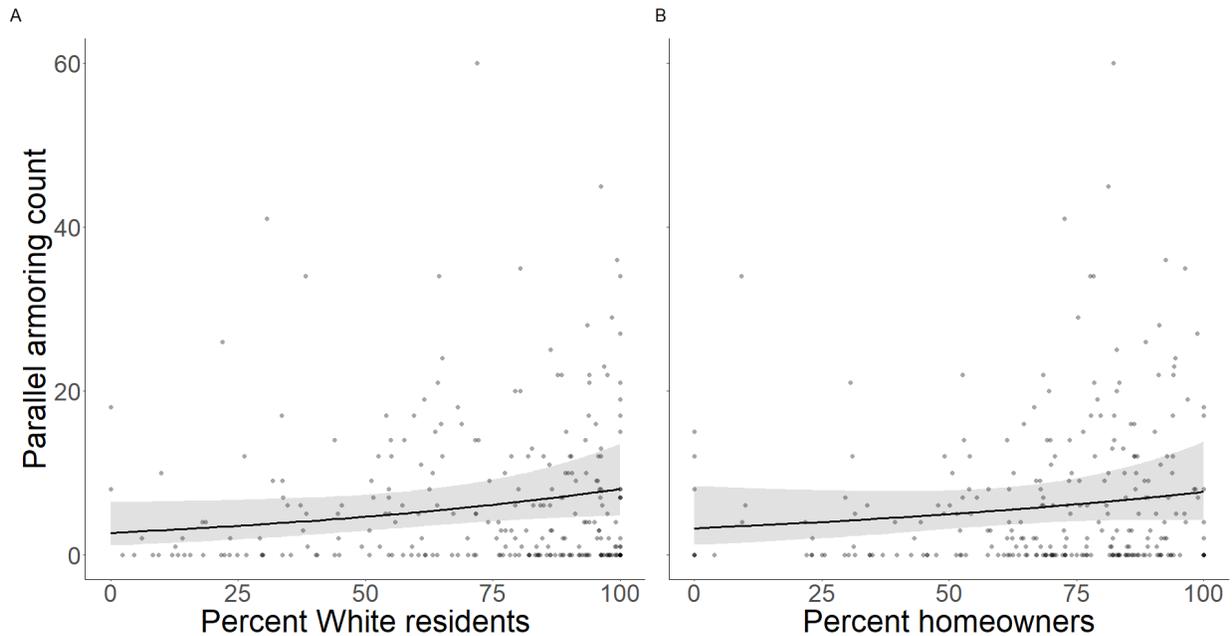


Figure 4.4. Marginal effects plots for percent White (A) and percent homeowners (B) in the negative binomial model of shore parallel armoring count. Both terms showed a significant, positive correlation with armoring abundance (percent White: 4.2, $\chi^2(1) = 7.63$, $p = 0.0058$), percent homeowner: $\chi^2(1) = 7.10$, $p = 0.0078$). Solid line represents the marginal effect estimate and bands show 95% confidence intervals around the estimate. Points plot the raw data and darker points indicate the overlap of two or more points.

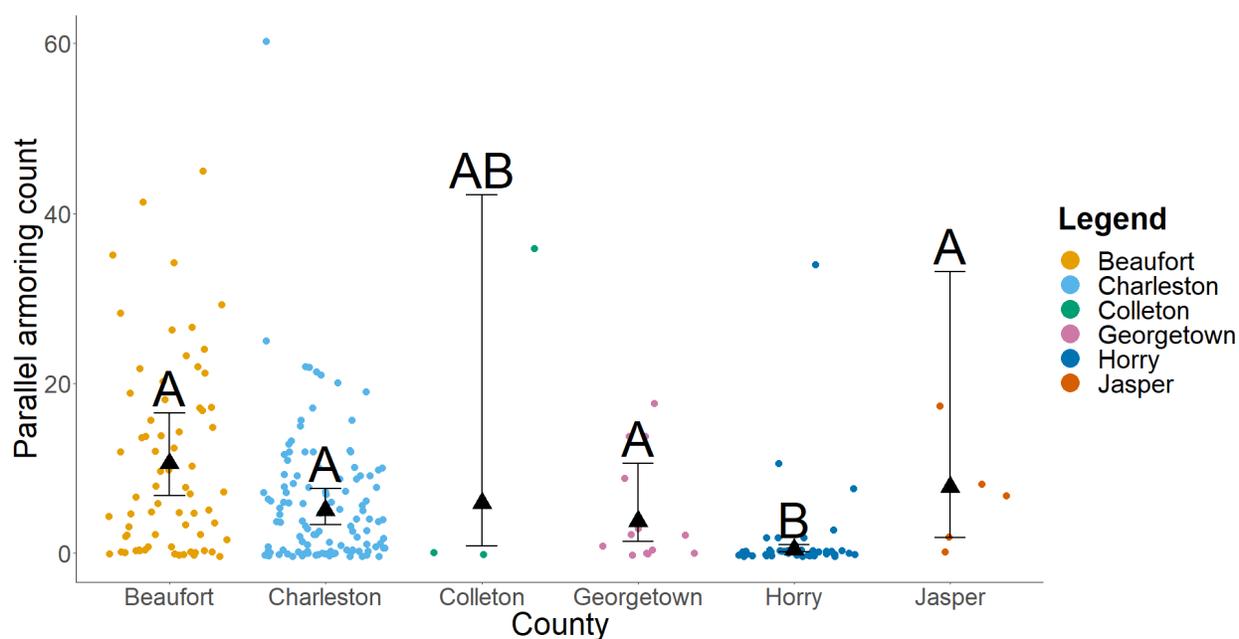


Figure 4.5. Tukey HSD post-hoc analysis of county fixed effect in the negative binomial model of shore parallel armoring count ($\chi^2(5) = 44.68, p < 0.001$). Letters represent significantly different pairwise contrasts with alpha levels adjusted for multiple comparisons using a Bonferroni correction. Black triangles represent individual county estimates with associated 95% confidence interval error bars. Circular points plot the raw data colored by county. Raw data points are jittered to avoid overlap and provide a better visualization of observations per county.

CHAPTER 5

SHIFTING SANDS, SHIFTING NARRATIVES: ECOTOURISM, KNOWLEDGE, AND
GOVERNANCE IN SOUTH CAROLINA⁷

⁷ Beauvais, J. To be submitted to *Environment and Planning E: Nature and Space*

Abstract

Ecotourism is a popular and growing form of environmental tourism that promises a win-win approach to conservation by simultaneously providing economic growth, environmental protection, and empowerment of local communities. Critical geographers and political ecologists, however, have called both the underlying logic and real-world results of ecotourism development into question. Notably though, many of these studies occur after ecotourism businesses are already running, limiting our understanding of how different groups contest the formation of these businesses and the governance processes the underlie ecotourism establishment. In this paper, I present a case study of a proposed ecotourism resort on Bay Point Island, South Carolina, USA. I conducted a narrative analysis of semi-structured interviews to understand how different groups that supported or opposed the resort constructed narratives from knowledge claims about ecotourism, ecological conditions of Bay Point, and social impacts of the resort. Groups frequently used the rhetoric of science to bolster the strengths of these narratives, but in truth drew from a more eclectic collection of knowledge sources to support their positions. When tasked with presenting these narratives to formal decision-making authorities in the local government, groups transformed their narratives to better align to the county's development code. Important narratives around social justice concerns were functionally absent from these meetings, greatly diminishing the concerns raised by some groups in decision-making moments. As ecotourism continues to grow across the globe, understanding how the structure of local governments influences the content and process of debate is crucial in ensuring robust democratic deliberations, as opposed to narrow adherence to technocratic standards.

Introduction

Since its emergence in the late 20th century, ecotourism has grown into a major sector of the global tourism market (Donohoe and Needham 2006, Holden and Fennell 2012 p. 323). A large part of this growth has been driven by shifting interests of travelers towards vacation destinations that offer environmental amenities while maintaining environmental integrity (Wight 1996, Scheyvens 1999, Carrier and Macleod 2005). A consensus on the definition of ecotourism is elusive (Donohoe and Needham 2006), however, many formulations of ecotourism contain similar themes, including ecological sustainability/conservation, visitor education, integration of local culture, and sharing the benefits of tourism with local communities, all occurring in an outdoor, “nature-based” setting (Donohoe and Needham 2006, Holden and Fennell 2012 pp. 323–325, Phelan et al. 2020).

Because of the admirable tenets promising both environmental protection and economic growth, ecotourism is often pitched as an ideal model for sustainable development and a win-win approach to “community-based conservation” (Scheyvens 1999, Mbaiwa and Stronza 2009, Stronza et al. 2019). As tourism providers and global development funders (Duffy 2008) have lauded the benefits of ecotourism, a wide body of research has questioned this pervasive win-win rhetoric. Some authors have noted mixed practices and commitments across tour operators acting in the same region (Self et al. 2010) suggesting that a general lack of accreditation requirements for ecotourism can lead to misappropriation of the term. Given the centrality of environmental conservation in many ecotourism operations, conservation biologists and ecologists have attempted to assess the impact of ecotourism on conservation goals. These efforts have had limited success due to sparse data from ecotourism operations, a lack of longitudinal data, and a narrow range of response variables in existing research (Bateman and Fleming 2017, Brandt and

Buckley 2018, Stronza et al. 2019). Studies that managed to collect these types of data have shown mixed results, with evidence of positive effects of ecotourism revenue on populations of some charismatic endangered species (Buckley et al. 2016), a range of effects on animal behavior and physiology depending on the species and response variable (Bateman and Fleming 2017), and context-dependent effects on forest cover (Brandt and Buckley 2018).

Detailed analyses of ecotourism also come from more critical social science perspectives. These critiques are particularly prominent in the global South, where most ecotourism research has been conducted due to the geographic origins and density of ecotourism operations (Ceballos-Lascuráin 1987, Duffy 2006). Ecotourism has been implicated in the racially skewed loss of land and natural resource access to large tourism operators (Benjaminsen and Bryceson 2012, Bluwstein 2017), reinforcement of gender and racial stereotypes in destination communities (Johnson 2018), and spatially localized exacerbation of environmental injustices for communities (Zebich-Knos 2008, Meletis and Campbell 2009). In this view, ecotourism often serves simply as a rebranding of the same forces of capital accumulation that undergird tourism (Büscher and Fletcher 2017), recapitulating the enclosure of common spaces (Corson and MacDonald 2012, Fairhead et al. 2012) well known to areas of historic conservation interest (Brockington and Igoe 2006). Others have sought to understand the prolific growth of ecotourism as a reflection of neoliberalism, citing the propensity of major economic development funds, environmental NGOs, and governments to support ecotourism as a market fix to environmental degradation (Duffy 2008, Fletcher and Neves 2012).

While a concentration of research in the global South has provided these valuable insights, ecotourism has spread globally (Higham and Carr 2003, Jenkins and Wearing 2003, Nepal 2004) and few studies have investigated ecotourism in the southeast United States.

Furthermore, most studies occur after ecotourism companies are already operating, and few track the process by which resorts are established. This post-establishment entry point might contribute to the tendency of critical geographical research to focus on processes such as land grabbing and capital accumulation. Other forces besides the working of capital shape the fate of ecotourism. As I will discuss here, ecotourism can ignite contentious debates within a community. While various actors debate whether and how an ecotourism company should be allowed to operate, local governments must evaluate these claims as part of the decision-making authority (Bäckstrand 2003, van der Molen 2018). How decision-making bodies assimilate, prioritize, or omit knowledge claims from various actors is both constitutive of and shapes the power relations between groups, providing opportunities for the democratization of knowledge or reinforcing existing social hierarchies (Walley 2002, Sjölander-Lindqvist et al. 2020). From this pre-establishment vantage point, the role competing knowledge claims play in local environmental governance can be more robustly explored.

In this study, I present a case study of the proposed development of an ecotourism resort⁸ on Bay Point Island in Beaufort County, South Carolina, USA using a critical political ecology framework to address four primary questions:

- 1) How do different groups in Beaufort County define and interact with ecotourism as a concept in general and in relation to Bay Point Island?
- 2) What knowledge claims are incorporated into narratives about the ecological, economic, and cultural effects of the proposed Bay Point Island resort?
- 3) How do these narratives differ when groups discuss them in informal (e.g. public outreach, interviews) and formal (e.g. decision-making meetings) settings?

⁸ The meaning of the term resort was a minor point of contention throughout my interviews and the terms used to describe the project shifted through time. I use resort simply to denote a tourism operation that provides lodging to its guests.

- 4) How does the governance structure of Beaufort County process knowledge claims/narratives about the proposed resort and incorporate them into their decisions?

Study Area

Bay Point Island (hereafter Bay Point) is a small, outer barrier island located in Beaufort County, South Carolina (Figure 5.1A). Although privately owned for decades and a site of intermittent human use at least since the colonial period, Bay Point is functionally undeveloped and only accessible by boat. The nearest population centers are the heavily developed, tourism-centered Hilton Head Island to the south and the sparsely developed, rural St. Helena Island⁹ to the north (Figure 5.1B). As of the 2020 Census, Hilton Head was home to a little over 38,000 people and had a racial composition of approximately 5.6% Black, 13.2% Latinx, and 77.7% White. St. Helena had a total population of around 8,000 people and a racial composition of approximately 48.9% Black, 4.7% Latinx, and 43.3% White. St. Helena is home to one of the largest Gullah-Geechee populations in the Southeast and several Gullah-Geechee civic societies are based on the island. The Gullah-Geechee are a federally recognized cultural group in the United States who have a language and cultural practices distinct from other Black communities in the United States (Goodwine 2015, Cooper 2017). People of Gullah-Geechee heritage make up a prominent proportion of the Black population of the coastal Southeast, with a conservative estimate of 200,000 Gullah-Geechee in the coastal counties of North Carolina, South Carolina, Georgia, and Florida (NPS 2005). Fishing¹⁰ is an important component of the livelihood systems of Gullah-Geechee communities, and nearshore waters in general play a major role in Gullah-Geechee culture (Beoku-Betts 1995, Ellis et al. 2014, Goodwine 2015). This centrality of

⁹ As with Bay Point, I will omit “Island” when naming Hilton Head and St. Helena throughout this article.

¹⁰ I use fishing generally to incorporate any type of seafood harvesting, including the collection of oysters, blue crabs, shrimp, etc.

intertidal ecosystems, particularly salt marshes, highlights the importance of maintaining access to marshes for contemporary Gullah-Geechee communities throughout the southeast US.

Bay Point is surrounded by salt marshes and tidal creeks that flood twice daily at high tide (Figure 5.1C). As part of the last string of barrier islands before reaching the Atlantic Ocean, Bay Point is largely subject to the same forces that shape the morphology of other outer barrier islands, such as a predominant current that drives a general north-south migration of the islands (Hoyt and Henry Jr. 1967), the dependence of island vegetation on shallow groundwater (Masterson et al. 2014), and the relationship between sediment supply and sea level rise (Gerald et al. 2006, Timmons et al. 2010). According to the Beaufort County government, the upland¹¹ area of Bay Point is 294 acres (1.19 km²). In comparison, Hilton Head and St. Helena contain roughly 26,801 acres (108.46 km²) and 40,189 acres (162.64 km²) of upland area, respectively.

Chronology of Bay Point resort

The first public knowledge of the proposed “ecoresort”¹² on Bay Point came during a meeting of the Hilton Head town council in September 2016 (Figure 5.2). In this meeting, representatives of Bay Point Island LLC (BPILLC) put forward a resolution for the council to accept a petition for annexation of Bay Point into the town of Hilton Head¹³. Although the council unanimously passed BPILLC’s motion, the annexation process was denounced by local environmental groups, inveighed against in a slew of public opinion pieces, and scrutinized by local reporters. The *Island Packet*, a local Hilton Head newspaper, provided several negative

¹¹ Upland refers to areas of stable land that are not flooded during the normal high tide cycle.

¹² This was the phrase used to describe the resort at the time. See footnote 8 (p. 105).

¹³ Importantly, this resolution was not a vote on whether Hilton Head should annex Bay Point. Rather it was a request to file the petition for annexation which would begin the process of the town doing due diligence on the proposal for annexation.

opinion and investigatory pieces on the annexation, including one article that reported that the mayor and another town council member had failed to disclose their financial ties to the spokesperson for BPILLC. By April 2017, a few members of the Hilton Head council began to voice concerns over the project and due diligence on the annexation stalled.

From this point things remained quiet until late summer 2019, when BPILLC introduced new plans for their resort. In this iteration, BPILLC sought to build under a special use permit for ecotourism¹⁴. Following initial meetings with members of the county government, a council member representing neighboring St. Helena convened a public meeting on October 15th, 2019, at the St. Helena library to discuss the proposed ecotourism resort with the developers. The meeting was attended by roughly 150 people including residents and representatives from several local environmental and community groups. Following a presentation from the developer Luckett & Farley and the resort operator Six Senses, a lengthy period of public comment exclusively criticized¹⁵ the proposed ecotourism resort. Shortly after, in December 2019, county staff denied the special use permit request from BPILLC, citing that it did not meet the standards of ecotourism defined in the county code.

At some point around or shortly after the initial denial, county staff told BPILLC they would consider a revised proposal. Following revisions to the plan, county staff concluded in

¹⁴ Special use permits are a component of the Beaufort County development code that allow for potential development in certain zones, pending an established series of reviews by county staff, public comment, and vote by the county's Zoning Board of Appeals. The ecotourism special use permit has existed in the current county code since its drafting in 2014 and adoption in 2016. Numerous individuals interviewed, however, noted that this was the first time that any major project had sought this ecotourism special use permit. Furthermore, a few individuals strongly implied that the inclusion of the ecotourism special use was a late addition to the development code advocated for by an attorney later associated with BPILLC.

¹⁵ Only one audience member offered brief remarks that could be construed as tepid support. Their remarks were grounded in a desire to see Bay Point remain undeveloped but believing that development was a foregone conclusion was pleased that a more "eco-minded" developer was doing it.

May 2020 that the new proposal met the requirements for the special use permit¹⁶ and a hearing before the Zoning Board of Appeals (ZBOA) was held in September 2020. Given its significance, I will discuss the ZBOA meeting in greater detail throughout the piece, but after three hours of presentation, public comment, and questioning, the ZBOA voted unanimously¹⁷ to deny the ecotourism special use permit. BPILLC then appealed the decision in the Beaufort County Circuit Court, with a decision denying their appeal handed down in July 2022.

Throughout this piece, I reference three broad position groups regarding the proposed ecotourism resort on Bay Point: supporters, opponents, and undeclared. I define supporters as those who advocated for the proposed resort, opponents as those who advocated against it, and undeclared as individuals/organizations that did not state a position. Importantly, groups within each of these categories were not monolithic and stated diverse rationale for their positions. There was no substantial support for the resort outside of those who were directly associated with BPILLC, while the opposition consisted of residents of Beaufort County and environmental NGOs. Undeclared parties fell into two distinct camps - government organizations that did not publicly declare an ideological stance on Bay Point and a few private citizens unfamiliar with the plans for a resort.

Methods

This project draws from a collection of interviews, recorded public meetings, planning documents, and local newspaper articles related to Bay Point. I conducted a series of semi-structured interviews with one group of supporters, six groups of opponents, and seven groups of

¹⁶ Beaufort County planning staff provided this approval with the recommendation that the county require a development agreement to ensure that these provisions of ecotourism would be met by the resort.

¹⁷ One ZBOA member recused themselves from voting due to a conflict of interest.

undeclared individuals from October 2020 to November 2021. Although I was only able to conduct one interview with supporters of the resort, there was ample written and public meeting material from supporters for analysis. During these interviews, I asked individuals about their understanding and use of ecotourism as a concept and their views on the proposed ecotourism resort on Bay Point. I also analyzed video recordings of three public meetings and two webinars hosted by a local environmental NGO concerning Bay Point (I attended two of the meetings and one of the webinars in real time). Lastly, I collected a bevy of documents from public records and local newspaper searches. All public records I analyzed can be found by searching for case 2020CP0702160 on the Beaufort County public index (<https://publicindex.sccourts.org/beaufort/publicindex/>). All newspapers articles will be shared on request.

I transcribed all interviews in two stages. First, I imported raw recordings into Otter AI software for automated transcription. I then listened to all recordings and edited the automated transcripts to correct errors, introduce punctuation to improve readability, and remove unnecessary repeat words and sounds. Given their length and video format, I did not transcribe the recordings of public meetings and opted instead to code them *in vivo*. I have anonymized the identities of all individuals I interviewed. To be consistent with my anonymized interviews and avoid overloading the reader with additional acronyms and actors, I also generally refrain from directly naming individuals or organizations when discussing public comments.

I coded all research material in Atlas TI Version 22.1.4 and I grouped codes under two levels of hierarchy. The first level related to which of the four research questions a passage best related. A second level of hierarchy further refined the passages. For example, a passage coded as general definition of ecotourism might contain a second code highlighting the key components

of that definition such as “giving back to the community.” I analyzed all research materials using a narrative analysis approach. Narrative analysis is a method of analyzing text or interview materials in which the researcher interrogates how the statements an individual makes are reflective of the process by which they construct stories to understand and explain their position (Wiles et al. 2005). Under a political ecology framework, narrative analysis allows me to investigate how socioecological knowledge claims are more than uncomplicated statements of “Truth”, they are instead wrapped up in the ideology and priorities of the speaker (Forsyth 2003).

Ecotourism Narratives

General Definitions

Understandings of ecotourism across all groups drew from a relatively consistent set of concepts, overlapping heavily with those identified in other published literature (Donohoe and Needham 2006). All descriptions of ecotourism noted the centrality of the non-human environment and environmental protection was one of the most stated aspects of ecotourism by all groups. An emphasis on general environmental education also dominated definitions but there was a slight deviation within the education theme between groups. Both opponents and undeclared parties noted that the education tourists receive from a provider should develop an appreciation or love for the environment, ideally engendering positive associations and behavioral changes towards conservation. For example, an existing tour provider in the Beaufort region stated that, “We often get clients from different parts of South Carolina or the country...and it falls on our shoulders not just to do that [provide education] but to make them fall in love with it [the environment]...and when you love something you tend to want to protect it. And that’s the goal...” In contrast, supporters of the resort tended to discuss how the resort

would educate guests on sustainability practices put in place by the resort and the ecology of the area, but the experiential and “transformative” dimensions of this education were less salient.

The relationship of ecotourism to local culture was also a common theme among all groups. Members of all groups routinely highlighted the inseparability of “Lowcountry”¹⁸ culture from the non-human environment and therefore a necessary component of ecotourism. While incorporating local culture was a common theme, community empowerment was a notably less frequent general aspect of ecotourism. Opponents and supporters diverged on what meaningful community empowerment meant in ecotourism. Supporters of Bay Point generally cited concepts such as “giving back” to neighboring communities, typically through revenue sharing approaches. In contrast, opponents or undeclared parties focused on local ownership and control of tourism operations to provide community benefits and authenticity. This focus on local control in all forms of tourism often appeared during interviews, with numerous other participants highlighting the importance of local control in promoting accurate representations of Gullah-Geechee culture and promoting synergy across small businesses in the area. Thus, although human communities were frequently invoked in conceptions of ecotourism, the economic and social empowerment of these communities was a less common element with substantially different conceptions of how it should operate (Cobbinah 2015).

Ecotourism as Narrative

Regarding Bay Point itself, the exact use of ecotourism was not present in the initial formulation of the resort. Although frequently called an “ecoresort” in early presentations to the

¹⁸ The “Lowcountry” is a term used to describe the coastal region of southern South Carolina.

Hilton Head council in 2016, I found no instances where the developing parties used the term ecotourism to describe their project. Additionally, across 19 newspaper articles, 13 public opinion pieces, and four interviews published in *The Island Packet* or *Beaufort Gazette* from 2016-2017, the proposed resort was never described as ecotourism. The first use of ecotourism appears to have occurred around late summer 2019 when the resort reemerged seeking a special use permit from Beaufort County. I do not raise this point to suggest that BPILLC radically changed the foundational aspects of their messaging. Many of the fundamental principles that BPILLC and Six Senses promoted in public meetings, such as sustainability and working with the local community, remained consistent through time. This does, however, highlight that “ecotourism” in this instance relates as much to an underlying ideology of how to practice tourism as it does to technical language present in bureaucratic development codes.

This shift in language was noted by a handful of opponents I interviewed, coloring their understanding of ecotourism with some describing the term as “fluid” and a “...hard thing to pin down.” To these opponents of Bay Point, ecotourism functioned as an opportunistic phrase adopted by developers after their initial plans in Hilton Head failed to materialize. Others were more direct, calling the use of ecotourism in this instance “greenwashing”:

Individual 1: “Are we talking about the real meaning of the word or the greenwashing of the word for marketing purposes? ...you can be a conservationist and you can be a conservationist of convenience. And if you are coopting the term ecotourism to fit into a marketing plan, that may be a position of convenience...It’s not like saying we’re a four-star resort, we’re an ecotourism resort. It’s not a moniker like that. I mean, I think the term like we’ve talked about can be coopted.”

Individual 2: “I really hate that word.”

JB: “Coopted or?”

Individual 1&2: “No, ecotourism!” [Simultaneously]

Groups also questioned why the plan included extensive lodging and supporting infrastructure on the island. As one organization wrote in a letter to the ZBOA, “Given the unique ecosystem and

important habitat on Bay Point Island, true ecotourism would be significantly less impactful than the current plan. The inclusion of so many structures waylays the natural migration and fluctuation of the island and its features.” In interviews, opponents often pointed to specific examples of what they considered true ecotourism already occurring in Beaufort County, none of which included lodging:

“...this ecotourism special use had never really been pursued before by any entity in Beaufort County, and we have what you would probably label as ecotourism, it’s already here and it already exists. You can find it in places, like on St. Philip’s Island where they’re doing their tours out there...there are old structures from the previous owner on the island, but there’s not really a plan to increase the footprint of those structures, they’re going to use what they have.”

“And it’s so different from an existing hotel deciding, ‘Hey, what makes this place really special is the water. Let’s start a kayaking program to get people on the water.’ That’s a totally different question than let’s build a resort on an untouched, pristine barrier island that ebbs and flows and changes with the tide and that’s home to multiple endangered species and thousands of shorebirds and provides value in its own right.”

The concept of genuine ecotourism versus a greenwashed use of the term was frequently brought up by environmental NGOs and served to critique the legitimacy of BPILLC’s plans. By focusing on the proposed 50 cottages for the island and contrasting it to extant Beaufort County tour operators who do not provide lodging; opponents painted the Bay Point development as just another resort by a luxury hotelier that was inconsistent with the requisite environmental protection in ecotourism. In contrast, supporters steadfastly held that their proposal was an exemplar of ecotourism by highlighting their conservation plans, sustainable construction practices, and commitment to the community. For example, in two public meetings representatives of Six Senses held up their “sustainability funds” that returned “...0.5% of our revenues from that property and it goes to local social and environmental projects...we look to

partner collaboratively with local groups using the sustainability funds to the benefit of them and the local environment.”¹⁹

Ecotourism Narratives in Formal²⁰ Settings

Although many supporters and opponents of the resort shared a broad understanding of ecotourism as being centered on preservation of the environment, education, and cultural engagement, how each of those elements should operate differed substantially in interviews. The juxtaposition of overlapping and divergent components of ecotourism pointedly demonstrates that the meaning of ecotourism was not a settled term from which to start the debate over Bay Point, and all groups, particularly those opposed to the resort, made these points forcefully. This line of argument, however, took a different shape in formal meetings and written materials. In these venues, both opponents and supporters of the resort structured their arguments around whether BPILLC’s proposal satisfied the definition of ecotourism provided by the development code. As one opponent put it when describing a letter they provided to the ZBOA:

“And one of the things that's important is that, because I knew it was going to the Zoning Board of Appeals, that you can't simply just make a an emotional appeal about the fact that, ‘Oh it'd be so terrible if it's [Bay Point] lost.’ You need to find very concrete evidence that it is contrary to ordinances that have been passed before. And if you don't have those ordinances in place, then it makes it very difficult to do that, because you know what's going to happen is that the developer, who has usually more resources than a county does, can turn around and sue the county government for not being compliant with their own ordinances.”

¹⁹ Six Senses also noted that 50% of water sales were directed to local water projects and all revenue from stuffed animal sales were given to “local children related initiatives and projects.”

²⁰ Throughout the remainder of this piece, I use formal to designate official decision-making events in the special use permit process. This includes any submissions to or arguments during the ZBOA meeting and to the court case following ZBOA denial.

This need to prioritize the development code was evident throughout the ZBOA meeting.

Opponents called on the ZBOA to use their discretionary power when deciding whether the resort proposal met the criteria laid out in the code:

“The applicant is here asking special permission for something – to build a resort on Bay Point Island. And because of that it requires heightened scrutiny and exercise of your discretion. But the most compelling and instructive reason for denial tonight is the application’s failure to meet any of the four criteria for a special use permit under the code.”

“You’re [the ZBOA] a necessary part of working through the nuances and challenges of our imperfect code and our imperfect world. And I believe that this gives you discretion in how you consider requests presented to this body for approval or denial. In the case of the Bay Point request, I know that lawyers have told you the code is clear and their client’s desire to build a multi-million-dollar luxury resort on the low-lying, erosion prone, infrastructure deficient, wildlife filled barrier island is perfectly appropriate under the ecotourism definition.”

Supporters of the resort also concentrated on the development code, frequently referencing their compliance to development standards. Additionally, supporters sought to convince the ZBOA that they had limited discretionary power and that the decision before them was about “the rule of law”:

“You all’s [the ZBOA] responsibility is to implement the position you were put in by Beaufort County. Our local government has a structure whereby the county council sets the ordinances, they adopt the laws, they adopt the zoning and then the people live by it. And when a problem comes up with it, they come to the Zoning Board of Appeals. You all are basically in fact acting as a judicial or quasi-judicial body. And it’s your job to take the truth as you find it and then to...apply the code.”

Although noting that the ZBOA acts as quasi-judicial body, supporters sought to curtail the scope of this judicial discretion by emphasizing the ZBOA’s overlying mandate to “apply the code” as dictated by the county’s legislative bodies. Moreover, by perseverating on how the proposal conformed to technical stipulations around lot sizes, percent impervious surface, and

similar aspects, supporters tried to circumscribe the arena of debate to the narrow definition of ecotourism in the county code.

Divergent narratives around what ecotourism consisted of and should look like were clearly present in my interviews. This suggests that the application of integral components of ecotourism are fluid, context-dependent, and that generalized academic definitions might be of little practical utility to lay individuals and organizations (Donohoe and Needham 2006, Reimer and Walter 2013, Cobbinah 2015). Many authors have remarked that the breadth of definitions presents a conceptual problem for even application of ecotourism (Donohoe and Needham 2006, Higham 2007 pp. 1–19, Cobbinah et al. 2017). I argue instead that this variety acted as a fundamental component of the advocacy surrounding the Bay Point resort. The inconsistency of personally held definitions formed a foundation around which groups framed the resort as a legitimate or illegitimate expression of ecotourism. While present during debate in the permitting process, these narratives were clothed in more technical language that centered the legal definition of ecotourism under Beaufort County’s code. By appealing to the established ecotourism definition, both supporters and opponents attempted to root their arguments in the purported objectivity of county ordinances that they felt would sway the ZBOA.

Conservation Narratives

Island Health

As quotes from the prior section hinted, another major nexus of knowledge claims gravitated around the ecological status of Bay Point and what conservation actions were needed on it. Supporters of the resort frequently pointed to a deep history of human use of Bay Point in both official narratives presented to local authorities and interviews:

“Well, I would say to you first, that one premise that you should be aware of and has been put out there that's false is the idea that this island is a pristine island that was untouched by man and suddenly, it's now being assaulted...The reality of it is that island has been farms, it has been luxury homes for people that lived here, it's been hunting ground, it's been illegal campsites, it's been essentially, as anything that's proximal to a very large human population, it's been subjected to all of those things for a very long time, centuries.”

As illustrated by the mention of illegal campsites, supporters often painted contemporary human use of the island as damaging. Supporters frequently brought up littering and other issues they perceived as the result of fish camps²¹ and the accumulation of trash washing up from the ocean. As a result of this damage, supporters highlighted their efforts to improve the island to “...a more natural state,” lauding BPILLC’s efforts to prevent a lightning strike fire in 2017 from “ravaging the entire island and possibly St. Philip’s or more” and their collaboration with the Department of Natural Resources’ Sea turtle program. Supporters positioned their efforts as reflective of their stewardship for the island:

“I’m out on the island regularly. I go out maybe once a week or so and what we’re doing when we’re out there is we’re picking up trash... And I would like to see for the benefit of the island those efforts be allowed to be increased and us be allowed to truly take care of the island in the way it needs to be taken care of. And from what I’ve seen that’s what the developers are trying to do as well. It seems we all agree that Bay Point needs to be preserved and I think that the plan of the developers is the proper way to do that.”

By portraying Bay Point as a place substantially impacted by humans where employees of the BPILLC remove “bucketsful” of trash every week and control fires that the Beaufort County government will not, supporters strengthened their claim that approval of the ecotourism resort was the most viable path to protecting the island. The emphasis supporters placed on local damage to the environment, often known as degradation narratives, is congruous with other

²¹ In local terms, a fish camp is typically a small, overnight camp in a relatively remote area meant to facilitate access to prime fishing spots during weekend trips. Lodging at camps can vary from temporary (i.e. tents) to simple, permanent structures.

ecotourism providers in the global South (Laudati 2010, Benjaminsen and Bryceson 2012).

Although important distinctions exist between the contexts of Bay Point and the global South²², the shared use of degradation narratives to position privately held ecotourism as the solution to local mistakes and misuse is revealing of common tactics used by ecotourism companies.

Opponents of the resort told a starkly different story about the ecological condition of Bay Point. Almost every organization and individual resisting the resort described the island as “pristine”, “untouched”, “undisturbed”, and “virgin ground”. Although this language implies a complete lack of human use, these same individuals did recognize that Bay Point was visited by and important to Beaufort County locals. Thus, these descriptions were meant in relation to what many saw as rampant development along some portions of the South Carolina coast:

“...the majority of the coast is developed...there are very few coastal areas that are still untouched and undisturbed. And so whenever there's a place like Bay Point, that is still undeveloped, and has a healthy marsh, a healthy beach, we are really trying to do everything that we can to make sure that it doesn't get developed.”

This perceived minimal human use of Bay Point led others to voice similar sentiments that Bay Point was generally healthy, and that local use had not caused meaningful ecological damage to the island.

“...the camps they're talking about there might have been six guys that stay there one weekend a month or something, so the impact would be negative [intended to mean negligible]...And they [local fishers] are generally pretty good stewards, they cleaned up stuff, so they didn't trash it.”

Opponents were strongly skeptical or outright dismissive about BPILLC’s claims that the resort would protect the island and shared the general sentiment that BPILLC “...are not any

²² In the global South degradation narratives are often used to justify land grabbing and consolidation of decision-making authority outside of communities (Davis 2005, Benjaminsen and Bryceson 2012). In this instance, Bay Point had been privately owned for decades and these degradation narratives were instead used to sway the ZBOA to permit private development.

environmental saviors to Bay Point, that's kind of ludicrous.” Others were more exasperated by what they saw as a predictable pattern of coastal development, with a representative of one local environmental NGO stating, “There's just not that many places left like Bay Point. I mean, we just can't keep doing this...It is so ludicrous. And it's not going to be successful! It's not gonna work! So why? I mean, it doesn't make economic sense. Much less environmental sense.” Both members of the public and individuals I interviewed also remarked on their doubts that the business model for the resort would work due to the size and environmental conditions of Bay Point. For some opponents, this incredulity meshed with a belief that the conservation ethos held by BPILLC was superficial and lacked an awareness of normal dynamics of Southeast barrier islands, particularly concerning BPILLC’s narrative around protecting Bay Point from “ravaging” by fire. As put by a former state environmental official familiar with the island:

“So what if Bay Point burns? It's probably a natural process and what harm will it do? I mean, so what?...all they're gonna do is make sure none of the houses burn down they put up. Cause if the pine straw burns out there it's not gonna hurt anything.”

A similar feeling was voiced by another locally respected environmental authority²³, who remarked that BPILLC’s plans were both not reflective of the island’s state or what conservation was needed for Bay Point:

“You know, one of the things that happens there is that the density of use was so low and the fish camps would get washed out and replaced later. And so because of its location, there's just wasn't, there was very little use there...the system was too dynamic and changing too rapidly for you to have the type of habitat that needs the kind of description [conservation actions] that they were trying to create. If it had been an isolated island out there that had high elevations, long leaf pine where you'd do prescribed burns, and, you know, management intensive type landscaping, you could have made that case, but this was just the opposite.”

²³ I use the term authority here loosely and primarily to designate this as an individual as someone who many I spoke with held in high regard for their depth of environmental knowledge. This feeling was not shared by some supporters of the resort.

For opponents, Bay Point was already in its “natural state” and needed little active management to keep it that way. Thus, a narrative of maintaining the status quo for Bay Point emerged, rooted in what opponents saw as its uniqueness as a functionally undeveloped island amidst an increasingly urbanized coast.

Island Stability

Bay Point’s future also became a site of narrative construction by supporters and opponents. Opponents of the resort consistently highlighted how sea level rise (SLR) imperiled the already dynamic and erosional nature of the island. These arguments were made in both interviews and decision-making meetings, with some opponents linking it directly to the special use ecotourism provisions of the county code in formal settings:

“...And that [Bay Point resort] is just not smart development. I mean, you’re trying to build on a shifting piece of sand that ultimately will end up in the Port Royal Sound as just a bunch of debris.”

“Beaufort is the most vulnerable to the effects of carbon-caused climate change including increased storm intensity and sea level rise...This scientific fact must further drive your decision to deny the permit, as the impending sea level rise violates the basic goals, objectives, and first principles of land use, those that are set forth in your special use statute. Because climate science directly affects the issue today, Bay Point will soon be subject to the same fate as Harbor Island [a nearby island dealing with major SLR flooding and erosion issues]. The sea levels are rising and as the good book says, ‘It is foolish to build upon shifting sands,’ let alone with flood waters rising.”

To some local opposition, the idea of building on Bay Point in the face of SLR was treated as comically naïve and further reinforced their belief that developers lacked substantial ecological knowledge of the area. As one opponent put it, “...I’ve watched it [Bay Point] come and go and it’s just ludicrous to me that they [BPILLC] could convince anybody to buy anything on Bay Point...I just kind of have a laugh at it.”

For opponents, the narrative of an unstable, shifting island soon to be besieged by SLR underlie what they felt was the “common sense” absurdity of the resort. Supporters of the resort balked at this description. No supporters denied the reality of SLR, instead constructing a narrative that Bay Point was no more at risk to SLR than any other coastal area:

“First of all, sea level rise is a threat to all of us. So to single out Bay Point Island as a particular increased, you know, exposure...is a, bit of a stretched premise with regard to being particularly troublesome to Bay Point Island. That being said, we looked at the facts. So we're, we're concerned about it, as everyone should be concerned about. So when when we looked at this, the first thing we did is we asked the question, what is [sic] the experts say...And so if you look at the elevations of the island, if you look at the historical satellite data, and you look at the projections, according to NOMA [I believe they mean NOAA] with regard to sea level rise, and even in the most extreme, the areas of the island that we're talking about are not subject to even those models.”

This supporter continued, noting that even if the island were eliminated due to SLR, this shouldn't prevent the active conservation management that resort would provide:

“...we do not live on a theory of 100 years in the future with regard to our interaction and obligation to nature. If we took that view, which was the island is going to be sunk in 100 years anyway, what does it matter? Or why are you doing anything on it? Then we lose the protection of the turtles, we lose the protection of the ecosystem, because 100 years, it's not going to exist, why do we care about it at all?...and right now, there's actually no evidence that that island would even be gone in 100 years, let alone what the opposition has stated, which is the island will disappear in 10 or other other claims, inflammatory claims that aren't based in science of any kind, other than an individual who has a science degree, expressing his personal opinion that is not rooted in any accepted science, which he's entitled to but it's not something that we're going to make our decisions based on. Because that's, that's an emotional argument, not a, not a scientific argument. And that doesn't help the island to make that argument.

Supporters also presented this narrative in the ZBOA meeting. During this meeting, an employee of BPILLC provided this same narrative while demonstrating how the island core would remain intact even after three to four feet (0.9-1.2 m) of SLR using NOAA's Sea Level Rise Viewer tool (<https://coast.noaa.gov/slr/#>).

As both quotes demonstrate, supporters articulated that even under the most extreme scenarios, the central part of Bay Point where the resort would be built would remain intact. Supporters further bolstered this stability claim by referencing the seaward movement of the state's beachfront jurisdictional lines in 2017, remarking that, "If you looked at tree growth, including some parts of the island, it generally has accreted, it has grown by the OCRM [Ocean and Coastal Resource Management] line change is proof of that, direct proof."²⁴ Opponents countered these claims in strong terms. Some opponents remarked that the purported accretion of the island based on the official state lines was a myopic source of information for the actual risk to the island: "Trying to say what the past five years meant. I mean, it's so transitional. It's so ephemeral. I mean, one storm it's gone. They're just trying to tweak some science to make it look good in that little narrow time window." Opponents also brought in external academics to provide credence to their claims of island instability. In a public webinar one of these academics highlighted that other facets of SLR would have severe impacts on Bay Point long before the island "sunk":

"The entire island is very rapidly changing in response to rising sea level and storms... looking at 2019 [satellite imagery], that vegetation is just not coming back. And it's not gonna come back and we're only gonna lose more. Because as I said earlier, this is a very low elevation island, there are not large interior dunes, there's not a lot of sand volume, the water table is coming up in the interior of the island, and we're losing all of this stuff [interior forest of the island] in here. I would say that within the next 10 years there will not be any trees viable on this island...because the rate at which the island is shrinking and the water is coming up is not gonna provide for the ability to maintain that maritime forest."

Throughout this individual's presentation they presented a long series of satellite imagery across Bay Point to make their case that the majority of the beaches along the island were rapidly

²⁴ OCRM conducts periodic revisions of the beachfront lines as part of its regulatory authority to permit development in these areas. It is important to note that the rules for how the beachfront jurisdictional lines were revised in 2017 changed from prior years, which may have contributed to the accretion claimed by supporters.

eroding. By highlighting other effects of SLR that were not addressed by supporters, opponents built upon their established narrative that Bay Point would not remain a viable place for the resort due to its intrinsic instability. Furthermore, this narrative also implicitly contested that the narrative held by supporters conceived of the impacts of SLR too narrowly. Other forces of SLR, opponents argued, would render the Bay Point resort defunct even if the ocean did not literally overwash the island's core.

Sources of Knowledge for Conservation Narratives

Although both supporters and opponents stated a desire to conserve Bay Point, the rationale for why conservation was needed and the appropriateness of an ecotourism resort to achieve that goal formed a topic of conflict. Supporters relied on a degradation narrative portraying Bay Point as an island in poor condition due to local misuse, forcing a need for private development that could provide a revenue stream for conservation. Opponents, on the other hand, used hyperbole about the pristine nature of Bay Point to accentuate the almost sacrilegious damage they felt the resort would cause. Additionally, opponents constructed narratives around the instability of Bay Point and the threats posed by SLR to position the resort as a foolish endeavor that demonstrated BPILLC's unfamiliarity with local ecology. Supporters countered with their own narrative that conceded the realities of SLR but assured that the location of the resort would remain intact even in the most extensive cases of SLR.

In contrast to the transformation that ecotourism narratives underwent in formal settings, the conservation narratives remained largely unchanged. Instead, in both informal and formal settings, groups paid much attention to bolstering the legitimacy of their knowledge claims by adopting the rhetoric of science. To justify narratives around island degradation and stability

despite SLR, supporters routinely drew on what they emphasized was “established science.” This “established science” was directly contrasted to opposition narratives, which one supporter characterized as “not rooted in any accepted science.” In some instances, this “established science” was discussed in general terms, while in other cases supporters mentioned specific data from government agencies as support. Many opposition parties also centered scientific sources as the basis of their narratives. Opposition groups drew on their experience as former state environmental officials and identity as (or collaborations with) university researchers to establish legitimacy in assessing the island’s current and future ecological state. In many cases, the opposition and support relied on similar sources of scientific information to build diametrically opposed narratives, such as the use of satellite imagery to infer erosion/accretion dynamics or the use of popular sea level rise modeling tools to demonstrate that Bay Point would or would not be a viable spot for the resort in the near future.

Science as a way of knowing held considerable power among both supporters and opponents of Bay Point, however, both groups drew on other knowledge bases to form their narratives. Despite discrediting “emotional arguments” and “personal opinion” made by opponents, supporters cited many personal observations of their own when making knowledge claims. For example, one supporter judged that the health of Bay Point had been improved under private ownership because a clutch of alligators had recently been born on the island and that the island was generally accreting because they had observed tree growth in new areas. Opponents also routinely made claims about Bay Point that were rooted in personal experience with the island, conversations with residents, or “common sense” about coastal ecosystems. This hybridization of knowledge sources follows other studies that show that knowledge formation is complex and dynamic, resisting simple classification into static categories like “scientific” and

“local” (Agrawal 1995, Walley 2002). Instead, all groups drew on a myriad of sources to form their narratives about Bay Point. Despite the eclectic knowledge claims deployed by both supporters and opponents, knowledge deemed as scientific still held primacy among both groups, demonstrating the significant social clout and political power attributed to a depoliticized “science” (Walley 2002, Forsyth 2003, Demeritt 2006). These findings emphasize a central tenet of critical political ecology, namely that environmental knowledge represents more than a set of objective “facts” (Robbins 2006, Goldman et al. 2011, Bixler 2013). Instead, environmental knowledge is an arena of contestation, a site in which differentially powerful actors work to generate explanations of and solutions to environmental issues that are enmeshed in their ideological, political, and economic positionality (Forsyth 2003).

Justice Narratives

Employment and Education

The economic effects of the Bay Point resort were another major area of narrative formation. Most prominently, supporters made repeated claims about the economic benefits the resort would bring. Stable jobs were a point of emphasis for supporters, who touted that the resort would employ anywhere from 100-130 or 329²⁵ people in full-time and part-time positions “ranging from minimum wage to six figures.” Most of these employees would be “hosts” and “guest experience makers” responsible for catering to individual patrons of the resort.

Throughout several public presentations, supporters routinely emphasized that they would be “sourcing their local talent” from St. Helena and Port Royal, as well as buying produce

²⁵ Different employment figures were projected throughout the lifetime of the proposal. The 100-130 estimate came during the first meeting on Hilton Head in 2016, while the 329 estimate came during the St. Helena library meeting in 2019.

and seafood from Gullah-Geechee farmers and fishers. Targeted employment of Gullah-Geechee served a dual purpose. First, the promise of jobs and local resource use was undoubtedly meant to engender support for the resort among the Gullah-Geechee community. Second, supporters routinely emphasized the interweaving of Lowcountry and Gullah-Geechee culture as part of ecotourism, so hiring or buying products from local Gullah-Geechee served to provide an authentic experience for guests:

“We all want to make sure that partnering with the local farmers is a key component of this operation and we are more than glad to not only include the cultural experience for the guests trying to get to know the community and the cultural experiences they will have, but also making sure that the education that we can bring to the people from St. Helena and the community of the ways of doing sustainability is very well understood.”

The emphasis on educating the local community and employees about sustainability was constantly portrayed as part and parcel with employment at the resort:

“...it’s not just going in and throwing in some boards and nails and making a quick buck, they’re gonna learn about the methodologies necessary for sustainable development and construction. And those things permeate the community, they start to adopt those practices which they haven’t seen before.”

The focus on the educational aspects of ecotourism also resolves a contradiction between the island health and employment narratives offered by supporters. By providing extensive training to employees and the community at large, supporters could reconcile the tension between the value of local knowledge provided by employees with the damage local communities caused to Bay Point. This example demonstrates ecotourism not only serves as a narrative device in and of itself, but aspects of ecotourism’s amorphous definition also can also work dialectically to resolve internal conflicts that arise.

Opponents of the resort flatly rejected the economic promises offered by the resort. Many opponents were frustrated with the rhetoric of community engagement and felt that the

developers had done nothing to gather community input into resort plans. Members of two oppositional organizations remarked that even after providing suggestions for revising the resort plan numerous times, representatives for the resort developers gave the same presentation at multiple venues. Likewise, a representative of another group opposed to the resort stated in a public meeting attended by the developers that:

“I keep hearing the repetitive statements of using local farmers...the fishermen are gonna work with us. Well, I represent them and they told me to come here tonight and raise cane...So to come in, and people have already notified me that this presentation was done elsewhere, saying definitely the Gullah-Geechee community was going to work with you because of economic empowerment...but they all told me the opposite.”

Moreover, many opponents were angered by what they saw as a paternalistic focus on education, countering that “...there’s a lot of things that you [developers] don’t know about here that we definitely do know.”

Opponents also raised concerns about racism at the resort surrounding compensation and hiring Gullah-Geechee workers to serve as “hosts” for visitors. At the St. Helena library meeting, one resident commented that, “...what I noticed was minimum wage, that is \$7.25 an hour and these people [Gullah-Geechee] have been liberated from slavery 165 years ago.” A video produced by one opposition group of that meeting contained a chyron reading “‘Cultural experiences for guests’ means having ‘natives’ perform on site or take guests on tours.” Other opponents voiced similar points, noting that the plan for different boat departure points to the island for staff and guests revealed a racist attitude towards employees that “...you see that in resorts all over the place. And always the first thing you want to look at when you're at a hotel is the kitchen entrance. I mean, that's just a reality.”

Collectively, these comments reveal a conviction that employment at the resort would reinforce racial stereotypes for wealthy visitors (Johnson 2018). This narrative is grounded in

long-standing concerns that tourism generates a “culture of servitude” (Faulkenberry et al. 2000) and a recrudescence of the aesthetics and racial hierarchy of the South’s plantation era (Finewood 2012, Goodwine 2015 pp. 9, 315, Hargrove 2020). Thus, as developers portrayed the resort as a source of substantial economic benefit to the region, particularly to the Gullah-Geechee living on neighboring St. Helena, local opposition drew on existing narratives that tourism offered only menial, low-paying jobs and exported profits to parent companies located far away.

Access to Bay Point

Lastly, access to Bay Point was another focus of the opposition. Opponents frequently described Bay Point as a treasured place for Beaufort County residents that was used like public land despite private ownership:

“One of the almost intangibles for Bay Point from the local’s perspective is due to its isolation and it’s instability in terms of storms and things like that, it was sort of assumed that that’s public land. And the locals have used it that way...with Hilton Head having so many tourists, hordes and hordes coming in, if you’re a local, where can you get away from it all? Just right across the entrance to Port Royal Sound you get to Bay Point.”

Concerns over access were especially prevalent in relation to the Gullah-Geechee. Opponents stated specific concerns that resort development would negatively impact Gullah-Geechee access to Bay Point, which was positioned as a place of vital importance to fishers in the area. In turn, this loss of access would further imperil Gullah-Geechee livelihoods that required expansive access to healthy marshes:

“And a lot of that comes down to just the foundation of the Gullah-Geechee culture is very, very connected to the bounty of the land and the water and respecting those places. And so it is an environmental justice issue...there’s also major concerns about generally just racism...How are these guests going to react to the Gullah-Geechee community in the salt marshes around Bay Point? And those conversations about, you know, privatizing

a public asset were discussed and the developers constantly denied that that would happen. But it's just really hard for us to believe that, especially when you look at how other areas of the county have been developed.”

For opponents, the proposed resort represented another public area privatized by rampant tourism and real estate development. Despite the long private ownership of Bay Point, the largely absentee owners allowed locals to make extensive use of the island for subsistence, economic, and recreation activities. Even an individual who was unfamiliar with and stated no position on the Bay Point resort linked the loss of natural resource access due to tourism and real estate development to racialized employment patterns (Büscher and Fletcher 2017):

Interviewee: “...a lot of people coming down and wanting to buy vacation homes and they want it on the beach and they're willing to destroy the land to get that. Whether that is taking out the trees or the places where people could get in [into the marsh]...now you are not only affecting the environment, but you're affecting people's livelihoods as well. Something that should have been and usually is a free thing to go and do. But now they're pushing it [waterfront property] to be more private...”

JB: “Do you see other kind of livelihood systems being affected with the privatization that's going on with all this real estate development?”

Interviewee: “Yeah, I see more people work. Like so if you go to Fripp Island [a neighboring vacation resort], you rarely see Black vacationers. But you will see completely all Black workers, which I think is crazy.”

In this light, the opposition narrative around access frames the proposed resort as a type of racialized enclosure of the commons that would stifle local use of the island (Stoll 2017, Koot et al. 2022). This exclusion would be particularly damaging to nearby Gullah-Geechee who continue to derive a substantial component of their livelihoods from the waters around Bay Point. By enforcing private property boundaries that had long been unheeded or unknown, the Bay Point resort would be able to provide an imagined “remote,” “far flung,” and “exotic”²⁶ landscape to wealthy tourists who could afford the high fees of Six Senses Resorts²⁷.

²⁶ Each of these terms was frequently used by developers to describe Bay Point.

²⁷ Nightly rates at Six Senses resorts vary, but as of November 2022 prices ranged from 500-1,300 USD per night for a January 2023 stay.

Supporters of the resort only obliquely engaged with the issue of access. During the St. Helena library meeting, one supporter attempted to dispel fears that they would claim King's grant rights of ownership over the waters around Bay Point, even though they claimed they could do so if desired²⁸. King's grants refer to certain titles issued during the colonial era that extended private property ownership over tidal waters and beaches (McMaster 2006). Additionally, supporters made a few vague references about how locals would still be able to visit the island through the resort's educational programs:

“The island is gonna be open for [local] people to have the opportunity to enjoy what these people are going to be presenting to them in the form of education, in the form of understanding what's in the environment. The whole ecotourism thing is about the community and the environment.”

Thus, supporters generally dismissed claims that the resort would eliminate access by falling back on the *de jure* public status provided to intertidal waters in South Carolina and mentioning that the island would be open to the public via educational programs. Ultimately, however, supporters did not develop an expansive narrative about how the resort would influence local access to Bay Point.

Justice Narratives in Formal Settings

Both the economic and access narratives showed little rhetorical modifications in formal settings for supporters. Supporters continued to tout employment opportunities the resort would bring, as well as their commitment to purchasing local farmers and fishers:

“The economic effect of Bay Point Island will provide hundreds of direct jobs within the community, and hundreds more indirect jobs, all in a sustainable manner, with a fair wage and opportunities for education and growth. Bay Point Island has and will continue

²⁸ Two individuals from the opposition I interviewed noted that prior owners of Bay Point had also attempted to claim King's Grant and even “run people off the beach.”

to cultivate relationships with locals to source local food, services, and ecotourism tours, providing jobs and revenue outside of guest spending which will benefit Beaufort as well.”

Supporters also tied the broader economic benefits of the resort to the goals of Beaufort County’s comprehensive development plan:

“...the proposal meets the economic development component of the comp plan to create a more diversified business tax base. We will be creating about 160 full-time jobs during construction and about 150 full-time jobs once the eco-wellness retreat is up and running. It will be an actual, absolute benefit to Beaufort County without any draw on any taxpayer dollars whatsoever.”

Supporters continued to not engage with access in formal settings. Instead, supporters opted to center the private property rights of BPILLC:

“...the bottom line for many people has been they simply don’t want anything to happen to Bay Point. And I have to stand here...and remind you that this is private property. That the owners of private property in the United States of America are entitled to develop within the standards of the zoning guidelines of any particular county.”

Supporters also attempted to block involvement of two oppositional parties in the appeal of the ZBOA denial by claiming that the access narratives of the opposition were “...illusory at best” and that “while residents of the state have limited rights to use beaches through the public trust doctrine, those rights do not exist beyond the median high tide mark.” By pivoting away from discussions of access, supporters attempted to elevate private property rights over other concerns. Furthermore, the focus on private property also acted to discipline the ZBOA and raise the specter of a potential lawsuit should the resort be denied.

In contrast to the minimal changes in rhetoric for supporters, the opposition narratives around economic justice and reinforcement of racial hierarchies through the resort’s hiring practices was largely absent in formal venues. When the opposition did address economic aspects of the resort, it also invoked the language of Beaufort’s development plan. In response to

a goal of the development plan to provide affordable housing, one environmental NGO wrote that “the developers have made no commitment to hire locally²⁹ or at a certain wage point and hospitality workers are not likely to make enough money to afford the existing Beaufort County housing stock.”

For some opposition groups, the access narrative also underwent substantial transformation in formal settings. Although opponents continued to highlight the importance of Bay Point to the Gullah-Geechee and Beaufort residents at large, the narrative shifted away from the ability to physically enter Bay Point to how components of the resort, such as the proposed septic systems, would damage the island and surrounding marshes:

“Marine fish, crustacean, and bivalve populations will suffer as a result of increased and introduced chemical runoff, nutrient loads from human waste, and stormwater runoff. While the developer touts the benefits of the project to Gullah Geechee citizens, the reality of the project is that it will take advantage of the rich cultural tapestry of Beaufort County without significant benefit to the community.”

Although the viability of seafood populations can be interpreted as a dimension of access (Ribot and Peluso 2003), informal narratives did not package access in this way and were much more direct about how the resort would police its boundaries to appease wealthy guests. Given the force with which the opposition voiced concerns over racism in employment and access in informal settings, the outright omission of these narratives from some groups and the colorblind approach deployed in the statement about affordable housing is telling. Clearly some opposition groups again moved away from more critical dimensions of their informal narratives when addressing the ZBOA. This tactic was voiced by one opponent who felt that a focus on public access to Bay Point was not a powerful strategy in formal venues:

²⁹ At the time this letter was filed, the developers had made numerous public commitments to hire locally.

"Well, I focused on what I thought would have the most effective outlet. And I had seen through my years of experience, that simply having a play that this is a public area, is not sufficient to get what you want."

Some individuals and groups within the opposition, however, continued to forcefully voice the racial justice aspects of the access narrative. In the ZBOA meeting one individual claimed that the resort was "...perhaps the worst violation of the cannon of environmental justice this side of Flint, Michigan. It would destroy a mainstay of the Gullah community's cultural heritage." A representative of another group also declared that development of Bay Point threatened to further the "...destruction of our [Gullah-Geechee] land rights and our water rights," deepening existing environmental and economic injustices in Beaufort County.

Narratives and Governance

Interaction between Narratives and Beaufort County Government

The governing bodies of Beaufort County displayed distinct interactions with the subset of the narratives presented to them. One individual who worked for the Beaufort County government agreed with opponents about the breadth of the county's ecotourism definition:

"So the definition of ecotourism, as written in our code...basically included every use that we have here where accommodations are allowed. Because you have to have like two of four things and it's very easy to do two of those four things. If you're a hotel, and you offer kayak rental as something that someone staying in your hotel can do, and offered a nature hike, then technically that hotel could be classified as ecotourism underneath that definition [in the current code]."

Regardless of this critique, they noted that deliberations over what the ecotourism code should be was beyond the scope of their duty:

"...we're hired by the government or the county council to maintain the integrity of the

Community Development Code...And a lot of people wanted us to make a political recommendation...Meaning a recommendation based on their political desires and all of that. And that's not our role. We don't get to do that. We have to make a recommendation based on what we feel is the appropriate thing to do based on the code and how we can make that use appropriate. And that's exactly what we did.”

During the ZBOA meeting, county staff made one direct reference to the highly vague definition of ecotourism in the county code, however, most of their time was spent detailing how the plans for the resort met technical stipulations of Beaufort’s ecotourism special use permit, such as minimum open space and impervious surface requirements. Furthermore, county staff chastised the opposition narrative that BPILLC’s plan did not comply with the ecotourism special use permit and the county’s comprehensive plan:

“I’ve got a lot of folks who have come in here and have read certain parts of the comp plan thinking they know how to interpret the comp plan. And they’re taking parts of the comp plan that don’t apply to this area.”

The emphasis that county staff placed on applying the code was evident in their general lack of engagement with other group narratives. County staff made little or no direct reference to the ecological health, stability, or economic narratives, as these were outside the scope of the criteria listed for the special use permit. Likewise, county staff did not address the access narrative outside of one interview I conducted. When asked what they made of concerns over loss of access to Bay Point they dismissed the premise:

Individual 1: “...we didn't feel it was infringing on their fishing access. I don't know how it could infringe on their fishing access, because water is a public entity, it's not like anybody has a right to own it...that claim was not legitimate in my mind, that it was going to have any negative impact on anybody's fishing rights...”

Individual 2: “...So if people are going out fishing in the river or the creeks in and around the salt marsh, then because of our water laws in the United States, you're still allowed to do that, regardless of who owns the upland. So that there was no plan to restrict anybody from fishing any of the waters in and around the island.”

This response mirrors the stance taken by supporters of the resort that concerns over loss of access were unfounded due to the *de jure* protections afforded to public waterways. Thus, apart from a few comments on the breadth of the ecotourism definition in the development code, county staff did little to engage with narratives that were not wrapped up in the language of the county code, deferring instead to their technocratic role of interpreting and applying bureaucratic language around land use standards.

The ZBOA demonstrated a much more complex engagement with different group narratives, particularly the island health and stability narratives. ZBOA members peppered supporters with questions about the details of the resort's solar panel layout, waste management systems, drinking water use, wildlife management, and erosion control plans in the face of SLR. Their questioning revealed a skepticism about the conservation potential of the resort that overlapped with elements present in the opposition narrative. Importantly, however, the ZBOA positioned their questions about specific technical aspects, not broad normative reflections of whether the island required conservation via private development or whether the island would remain viable due to SLR. Discussion about economic justice or access narratives from the opposition were mostly absent given their omission or rhetorical transformation during the ZBOA meeting. The few times these narratives were raised, ZBOA members were conflicted in how to weigh them in their decisions:

“I am very serious to what the people in the community have to say about what's coming into their area...to hear that there hasn't been a conversation with any of the locals, whether the local farmers or local fishermen...makes me feel that it's just a smokescreen that's been blown up. But that's my own opinion. But I was just looking at some of the criteria that involves a special use for this and does it actually meet the criteria?”

Despite voicing a concern over the legitimacy of supporter claims to be committed to involving and supporting Gullah-Geechee food producers, this individual quickly returned to compliance

with the code as the focus of their judgement. The pattern of grounding concerns over the resort in the development code was exemplified in the ZBOA's final letter to BPILLC outlining their rationale for denying the special use permit. In their letter, the ZBOA cited the incompatibility of the resort with county code in all six of its stated reasons for denial with no mention made to aspects of the economic or access narratives.

Technocracy and the Language of Debate

The technocratic structure of Beaufort County's ecotourism code influenced the debate for all parties involved with the Bay Point resort. Staff of Beaufort County largely deferred to their role as objective agents of established laws and regulations, avoiding substantive, normative deliberation over whether the Bay Point resort should be allowed. For the ZBOA, however, a palpable tension could be seen among members of the board as they searched for a technical reason to deny the permit despite the approval of county staff.

As for supporters and opponents, the technocratic application of the development code by county staff and the ZBOA had noticeable impacts on how they presented narratives in formal settings. Supporters and opponents readily discussed what constituted valid ecotourism in informal conversations, however, in formal presentations these narratives were restructured to conform to the definition of ecotourism provided in the development code. Other narratives nearly dropped out from formal settings entirely. Opposition narratives around economic justice were functionally omitted while some members of the opposition forthrightly admitted that they felt narratives built around loss of access would not be convincing to the ZBOA. Other work on environmental governance has found that individuals not perceived to possess legitimate knowledge find their claims unheeded in decision-making processes (Walley 2002, Sjölander-

Lindqvist et al. 2020). Although there is certainly evidence of that in the terse dismissal of the access narrative by county staff, some members of the opposition to Bay Point opted to avoid this issue altogether by drawing the bulk of their objections to the resort from the island health and stability narratives. These narratives underwent far less significant rhetorical changes, as the stipulations of the development code were more amenable to debates over ecological damage to the island than they were to the economic or access justice implications of the resort. The efforts of both supporters and opponents to position their narratives as emblematic of “accepted” science provides further evidence that the direction of debate was dictated by group perception that county staff and the ZBOA would be more attentive to “objective” standards present in the development code.

Conclusion

Through this paper I have presented a detailed analysis of a proposed ecotourism in Beaufort County, SC to address the four questions below:

- 1) How do different groups in Beaufort County define and interact with ecotourism as a concept both in general and in relation to Bay Point Island?
- 2) What knowledge claims about Bay Point Island are incorporated into narratives about the ecological, economic, and cultural effects of the proposed resort?
- 3) How do these narratives differ when groups discuss them in informal (e.g. public outreach, interviews) and formal (e.g. decision-making meetings) settings?
- 4) How does the governance structure of decision-making bodies in Beaufort County process knowledge claims/narratives about the proposed resort and incorporate them into their decisions?

I found that both supporters and opponents of the resort drew on a similar set of concepts such as conservation, education, and community involvement to describe ecotourism in the

abstract. Groups differed, however, in the ways they believed these concepts should be operationalized (Question 1). These differences were accentuated in the specific context of Bay Point, as supporters and opponents crafted narratives that attempted to paint the resort as a legitimate form of ecotourism. Other knowledge claims themselves become stabilized, oft-repeated narratives around the island's current ecological health, its stability in the face of SLR, economic impacts of the resort, and how the resort would affect local ability to access the waters around Bay Point (Question 2). For example, supporters of the resort used degradation narratives to position Bay Point as an island damaged by local misuse, a trope deployed in other contexts to justify the need for ecotourism (Laudati 2010, Benjaminsen and Bryceson 2012). Opponents contested this explanation, arguing that Bay Point was in pristine condition and did not require extensive conservation management under an ecotourism model. Ultimately, the narratives built by supporters and opponents did not represent unblemished "facts" about Bay Point or the effects of the proposed resort. Instead, these narratives simplified the complexity of the socioecological system around Bay Point into stories complete with actors, conflict, and resolutions. In short, the biophysical reality of Bay Point served as raw material from which a medley of ideological, political, and economic priorities were constructed into cohesive narratives (Forsyth 2003, Goldman et al. 2011, Bixler 2013).

Both supporters and opponents substantially altered the rhetoric of some narratives in the context of formal decision-making moments. Despite county employees feeling that "...the outside organizations and the public had a greater influence on the Bay Point process than the staff..." the technocratic paradigm of the special permit requirements and process led both sides to reformulate their narratives in language that revolved around the content of the county code (Question 3). Other narratives, particularly those concerned with issues of access and economic

justice, were largely absent from formal settings. For the ZBOA, their final decisions were also rooted in the county code and showed a greater sympathy to ecological narratives than others (Question 4).

Most residents of Beaufort County I interviewed or who participated in public comment did not view ecotourism as a win-win scenario for Bay Point. Despite the presence of nuanced and diverse arguments about the resort in informal contexts, the structure of Beaufort County's special use permit code acted as a sieve through which narratives that could be easily related to the code were retained, while those that could not were filtered out. The legalistic vantage point of the county staff and ZBOA clearly shaped the direction of debate for both supporters and opponents of the Bay Point ecotourism resort, devolving environmental governance to squabbles about technocratic standards and development codes (Bäckstrand 2004, Rice 2016). This filtering effectively rendered concerns around justice and the resort null, stifling democratic debate over what the future of Bay Point should hold. As the popularity of ecotourism continues to grow, it is imperative that local environmental governance be reimaged so that space can be made for robust, democratic deliberation over these projects.

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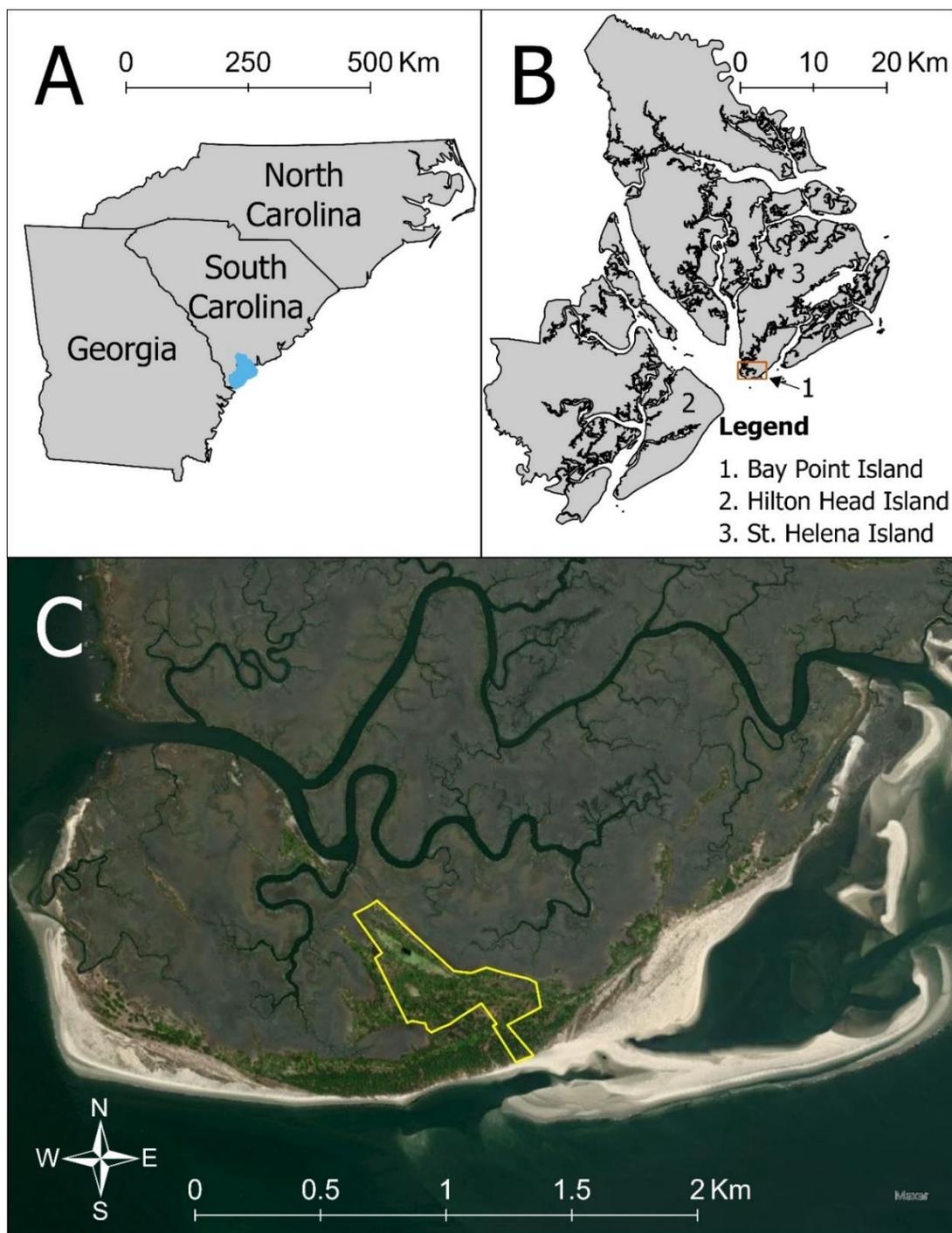


Figure 5.1. Maps detailing South Carolina and neighboring states (A), Beaufort County (B), and Bay Point Island (C). The blue area in map A represents Beaufort County, which is represented in greater detail in map B. Likewise, the orange box in map B encloses Bay Point Island, which is shown in greater detail in map C. The yellow outline in map C approximates the boundary submitted by Bay Point Island LLC for their proposed ecotourism resort. Map scales: A – 1:9,000,000; B – 1:600,000; C – 1:17,500. Compass rose is shared for all figures.

Bay Point Island Timeline

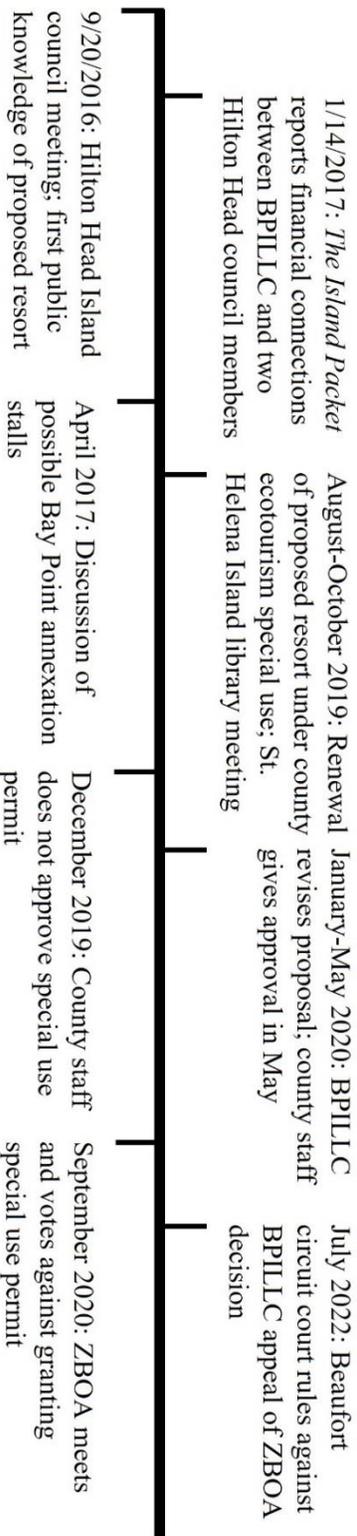


Figure 5.2. Timeline of events surrounding the proposed ecotourism resort on Bay Point Island. Abbreviations: BPILLC – Bay Point Island LLC, ZBOA: Zoning Board of Appeals.

CHAPTER 6

CONCLUSIONS

My research throughout this dissertation has sought to understand environmental justice issues around marsh access through mixed methodology and an integration of environmental justice and political ecology perspectives. In this conclusion I reflect on the process of conducting this research as an ICON student, summarize the main findings of each chapter, how they relate to one another, and provide final concluding thoughts.

Reflection on the Dissertation Process

As a fresh-faced PhD student who had spent three summers conducting community ecology work in the field and a year working as a lab technician, my only previous contact with critical social science came in a class I took in my final semester at Georgia Tech – PHIL 3127 Science, Technology, and Human Values. I don't remember why I took it and the only part of the content that stuck with me at the time was a discussion breaking down the historical origins of the basic/applied research dichotomy and a paper on biocultural ethics and language (Rozzi 2013). I recognize now that the class was essentially a light introduction to science and technology studies, a course undoubtedly needed in great supply at any STEM heavy academic institution. Sadly, the significance of what I was reading and listening to in lecture was lost on me and I entered ICON wholly unprepared for transdisciplinary research.

Entering ICON 8001 I struggled to grasp the materials I was reading, but my first sense that I might have a breakthrough came from reading Michael Dove's "Uncertainty, Humility, and Adaptation in the Tropical Forest: The Agricultural Augury of the Kantu." I'm not quite sure why this paper stuck with me. I don't think it's all that important in the history of ethnographic research and rereading it today I have some critiques of its conclusions, but it stuck with me all the same. This was the first paper to break me out of my epistemological shell and see that others – other people, other disciplines, other ways of knowing the natural world – were valuable and valid. Although Dove's discussion of humility and hubris largely concern the practices of "Westernized" agriculture, I realized its connection to how I needed to conduct my research. It would take considerably more internal struggle and coursework outside of Ecology to define the contours of an integrative project, but eventually I came to it. Today I still identify humility, both intellectual and personal, as the defining thing the ICON program taught me.

I began my research in earnest with a more explicit focus on documenting loss of water access for Gullah-Geechee fishers through a co-constructed research process. To do this, I moved down to Beaufort in the summer of 2019 in the hopes of establishing connections with Gullah-Geechee organizations in the area. I had extensively read works by Gullah-Geechee authors (e.g. Goodwine 2015, Cooper 2017) and others about academic misconduct within Gullah-Geechee communities. In GEOG 6810 and 8910 I had learned about ethically co-constructing research to avoid these pitfalls and generate a research process that meaningfully incorporated and contributed to the community you were working with. But the year I spent in Beaufort reminded me very directly that learning about and doing co-constructed research are very different things. I attempted to contact several Gullah-Geechee community groups in Beaufort, volunteered for events, and showed up to community meetings to build a rapport with

these organizations. While I endeavored to generate relationships, my efforts went nowhere, and I began to seriously doubt whether I had a place conducting EJ research in the South.

I returned to Athens in fall 2020 with little to show for my time spent in Beaufort. My inability to forge strong connections, coupled with the COVID pandemic, forced me to change my research goals and approach. The doubt I felt turned into resolve to reflect on why I was interested in this research, how I had approached creating connections, why my approach was not working, and how I could live up to the “agile scientist” mission of the ICON program. Part of this meant I had to come to terms with the reality that I would not be able to conduct the in-depth participatory mapping I had hoped to do. COVID and the level of trust needed to map sensitive information like former fishing spots, conflicts with landowners, etc. would not be possible in my dissertation. I pivoted instead to conduct additional mapping projects rooted in quantitative EJ research, forming my current Chapters 3 and 4.

The other part of this deep reflection in late summer/fall 2020 was a reinvigorated effort to make connections with the Gullah/Geechee Nation. I emphasized how my skills could contribute to existing projects they were undertaking and specific research products I could produce to aid with their efforts. By elevating and centering their ongoing work and continuing to participate in their events I was able to engender a more substantial relationship. While I was not able to co-construct a few chapters of my dissertation as I had hoped, I have been able to maintain an amicable, working relationship with Gullah/Geechee Nation. I have contributed to several projects, including collating their prior research into a private ArcGIS online server and a large-scale mapping analysis of how Gullah-Geechee land ownership has changed from Reconstruction to today.

My experiences crafting my dissertation reinforced the importance of humility and taught me additional lessons. I learned that while deep dives into theory help me conceptually organize my understanding of the interconnections between EJ and political ecology, this was seldom useful for community organizations. I believe this passage excellently summarizes this point:

I might be wrong, but it seems to me that most activists on the front lines do not need university researchers to help them understand the social theory that informs their struggle. On these matters, the activist is almost always the expert and must patiently explain things to the professor. Many activists do, however, need help marshaling the kind of evidence that meets the standards of proof established by the state, corporations, or general public discourse... (Wyly 2009)

This is not to denigrate the importance of critical theory. Certainly, a critical social science perspective is useful in interrogating why these “standards of proof” are embraced by “the state, corporations, or general public discourse.” It is simply to highlight that my relationship with Gullah/Geechee Nation got off the ground when I set the more abstract aspects of my work on the back burner and centered how my skills could help them with tangible projects they wanted to achieve. Lastly, these experiences taught me that forming new partnerships is a laborious process for organizations. Managing volunteers, writing grants, organizing people to come to a public meeting at a gym on a Thursday night - all these foundational features of community advocacy groups are comprised of difficult and time-consuming labor; managing a new relationship must be work that academics shoulder themselves. As I enter a policy fellowship with NOAA, I will carry these lessons with me, seeking to work towards a more just coastal environment that lives up in practice to the lofty language of public domain and access we have in our laws.

Summary of Findings

In Chapter 1, I introduced my overarching research question for this dissertation: **What forces structure *de facto* access to marshes and estuaries along the South Carolina coast?** This question is deliberately broad, as access is influenced by a confluence of socioecological factors. In this dissertation, I have primarily addressed this question by focusing on the role of coastal infrastructure (Chapters 2-4) and tourism (Chapter 5). I have provided insight into the current (Chapter 2) and historical (Chapter 3) state of WAI distribution in South Carolina, a detailed analysis of armoring distributions in South Carolina (Chapter 4), and how divergent narratives around ecotourism, ecological health, and cultural significance of a coastal island interact with the technocratic governance of Beaufort County (Chapter 5). In the spirit of humility and changes I made to my research discussed above, I approach making definitive statements about justice and equity with caution. The adaptations I had to make during my PhD mean that this work is primarily quantitative. While quantitative approaches are powerful and provide insights at spatial scales that are often prohibitively large for qualitative research, quantitative research can only speak so far to the embodied effects of environmental injustices as experienced by real people. Nonetheless, I have engaged in intellectually honest research, and I position my main conclusions in the section below as incomplete, but useful findings.

Chapter 2

In this chapter, I examined whether there was quantifiable evidence of racially or economically disparate access to estuaries through public and private WAI. Using public data from South Carolina state agencies and the Census Bureau, I quantified the abundance of private (docks) and public (piers and boat landings) WAI throughout Beaufort, Charleston, Colleton,

Georgetown, Horry, and Jasper counties. I then ran generalized linear mixed models to assess correlations between race and income and 1) dock abundance, 2) public WAI presence, and 3) distance to the nearest public WAI. Additionally, I also mapped the density of public and private WAI using a 1.6 km (1 mile) and 10 km search radius to mimic the availability of WAI within walking and driving distance, respectively.

Overall, I found differing patterns between private and public WAI. Racial composition was strongly correlated with dock abundance, as Census Block Groups with a higher proportion of White residents contained considerably more docks. Conversely, both public WAI presence and distance to nearest public WAI showed no correlation with race, and public WAI presence showed a negative correlation with income. These results compellingly demonstrate that White South Carolinians possess more docks and therefore likely greater private water access than Black and Gullah-Geechee South Carolinians. The results of the public WAI are slightly more promising – insofar as quantitative techniques can demonstrate, there appears to be no racially disparate distribution of public WAI. Importantly, however, this analysis can only assess distribution, and other physical and symbolic barriers to accessing public WAI might exist (Appendix A: Figure A.4). Moreover, private docks are two orders of magnitude more abundant than public WAI, resulting in a patchy distribution of public access within walking distance. This raises other concerns, such as whether there is enough public WAI to provide meaningful water access to South Carolinians and whether public WAI function equitably for those without a personal vehicle or people with mobility issues (Alterman and Pellach 2022).

In this chapter, I presented a longitudinal analysis of dock distribution at four time points across 22 years. I designed this chapter to examine whether the racial and economic distribution of docks observed in Chapter 2 was consistent through time, because longitudinal studies are uncommon in the EJ literature. Additionally, this chapter also provided general descriptive characteristics of dock development from the mid-20th century to today.

I used historical aerial imagery from multiple sources to collect data on dock abundance and historic Census data to analyze the correlation between racial composition and income in consistent geographic boundaries.

I found patterns that largely aligned with my findings in Chapter 2, suggesting that the racial imbalance in dock abundance towards White South Carolinians has been a persistent feature of the landscape for at least two decades. Along with the distributive justice trends I documented, I also found that docks had increased exponentially from the 1960s-2016, growing at double the pace of the population and housing units. Likewise, the mean length of newly constructed docks doubled from the 1960s to 2016. Lastly, I found that once placed at a site, docks persist there for decades, as half of the locations that first possessed a dock in the 1960s still had one in 2016.

Chapter 4

In this chapter, I analyzed the distribution of coastal armoring along the South Carolina coast. I employed similar methods to Chapters 2 and 3 but added additional spatial statistical approaches to assess the general distribution of armoring and identify armoring hot spots. I found that armoring density was generally lower in rural areas, however, armor density was patchily distributed across urban and suburban areas of the coast. Clustering analyses found divergent

results depending on whether counts or lengths were analyzed, emphasizing the importance of investigating and interpreting multiple response variables. My analysis of armoring abundance found that more armoring structures occurred in CBGs with a larger proportion of White residents and homeowners. Armoring length, however, was not significantly correlated with any predictor variables I analyzed, again emphasizing the importance of assessing multiple predictor variables. Furthermore, I found that a little over half of the armoring along the South Carolina coast co-occurred with docks. Given that armoring abundance is likely a more appropriate way to conceptualize the extent of armoring on residential private property, these results largely conform to and expand upon the findings of Chapters 2 and 3.

Chapter 5

A fundamental tenant of social science research is that communities are not monolithic. While this is undoubtedly true in Beaufort County, the overwhelming consensus from various local entities and residents stood in opposition to the proposed ecotourism lodge on Bay Point. Coastal residents and NGOs utilized public hearings/comments, webinars, newspaper opinion sections, and social media to voice their opposition to the proposed ecotourism lodge. Overall, opposition to the resort drew on a mixture of knowledge bases to generate public resistance to the lodge. Developers attempted to push back with their claims about Bay Point and what their project could achieve for the island and Beaufort County broadly. Dominant conflicting knowledge narratives emerged around the meaning of ecotourism, the ecological state and stability of Bay Point, and effects that resort development on economic justice and access in Beaufort County, particularly for Gullah-Geechee communities living on St. Helena. In formal meetings both supporters and opponents of the proposed resort crafted their arguments around

these narratives but reformulated the rhetoric of their arguments around the presence of a legally binding definition of ecotourism in the county development code. This was undoubtedly a strategic decision on their part, as individuals I interviewed noted they had to pick the arguments that would most appeal to the ZBOA. Likewise, the developing parties pushing for the resort also routinely sought to discipline the ZBOA into narrowing their focus solely on whether BPILLC's proposal fit under the ecotourism exemption of the development code.

Although bubbling underneath the surface and acknowledged by many parties, the fundamental tension between private property rights and community interests remained mostly untouched and unresolved by the ZBOA. Instead of a robust discussion of concerns over environmental justice and ensuring access to an island that was widely viewed as a public resource, formal decisions about the special use permit were largely circumscribed to analyses of whether BPPILLC's proposal met the criteria for ecotourism under the county development codes. Concerns over communal loss of access to Bay Point and associated justice issues for Gullah-Geechee took an ancillary role in deliberations and the ZBOA's stated rationale for denying the resort. Likewise, the legal ruling upholding the ZBOA's decision was grounded in judicial deference to local zoning authority under South Carolina law. Despite the current victory for opponents of the Bay Point ecotourism lodge, the rigid, incremental structure of the planning and zoning process in Beaufort County blocked vigorous, democratic debate over many important questions.

Tying Chapters Together

In the introduction, I discussed different notions of access from a variety of theoretical and legal positions (Schlager and Ostrom 1992, Ribot and Peluso 2003, Alterman and Pellach

2022). While South Carolina state law preserves areas below mean high water as public domain (“horizontal access”), it has no components preserving the ability of individuals to reach public waters from the upland (“vertical access”, Alterman and Pellach 2022). As a result, private development along the upland can functionally block large stretches of public marsh. From more critical perspectives, this can result in a reduction of access by preventing individuals from “entering” (Schlager and Ostrom 1992) or “deriving benefit” (Ribot and Peluso 2003) from marshes. If this reduction to access differentially impacts social groups, this could produce environmental injustices.

My analyses contest that in South Carolina the *de jure* and *de facto* status of marshes do not align and that access to marshes and estuarine habitats is an environmental justice issue. When analyzing the distribution of docks and armoring, both conservative proxies of coastal private property, I found consistently higher abundances of both types of infrastructure in predominantly White CBGs. For docks this pattern has been consistent for at least two decades and held even when analyzed at a more aggregated spatial scale, demonstrating robustness of these patterns to the choice of spatial scale. These results suggests that White South Carolinians possess more waterfront private property in South Carolina, concentrating vertical access to the marsh in their hands.

While Chapters 2, 3, and 4 are observational studies that cannot conclusively demonstrate causality, the racial distribution of docks and armoring align with well documented historical trends in Black property ownership. From the Civil War until the mid-20th century, the coastal Southeast had the largest proportion of Black-owned land in the United States (Fisher 1978, Rivers 2007). Around the mid-20th century skyrocketing coastal land values and a swath of racist local government practices (Mitchell 2000, Rivers 2007, Kahrl 2012a, 2016) chipped away

at Black landownership. Other authors have noted that many of these practices continue today (Rivers 2006, Copeland 2015), sustaining the loss of Black-owned land. Indeed, in Chapter 3 I documented a near halving of the median percent Black composition at the Tract level from the 1990 Census to 2019 ACS. **Thus, I argue that the history of property ownership along the Southeast coast may be one of the forces producing the observed racial disparity in private access.** The proliferation of docks over the past 70 years, along with the skewed distribution towards White South Carolinians for at least 20 of those years, constitutes an entrenched environmental injustice in private marsh access.

Outside of the focus on personal real estate, Chapter 5 examined a prominent driver of coastal Black land loss – the tourism economy. As Bay Point faced becoming home to a high-end ecotourism resort, supporters and opponents mobilized a series of knowledge claims to construct narratives about the rationale for or against and the impacts of the proposed resort. Groups opposed to the resort routinely situated Bay Point as a place of deep importance to locals and a public resource for Gullah-Geechee fishers due to decades of absentee ownership. As a result, many oppositional groups constructed a detailed narrative of how the development of an ecotourism resort on Bay Point would negatively impact all forms of access to the island. Despite this cohesive narrative around loss of access in interviews and public statements, it was not a major dimension of the arguments made to decision-making bodies in the Beaufort County government. Instead, groups prioritized other narratives centered on the ecological impacts of the resort, which were more readily relatable to the technical stipulations of the ecotourism special use provisions laid out in the county code. When I raised access issues in an interview with county staff, they were outright dismissed because of what staff perceived as immutable guarantees for public access under the public trust doctrine. Notably, however, this dismissal

does not engage with the valid concerns that the public trust doctrine does not carry the weight to prevent harassment of fishers by resort staff seeking to preserve a sense of isolation and exclusivity for resort patrons. **Thus, I argue that the technocratic structure of land use decisions in Beaufort County, coupled with limited understandings of access confined to *de jure* protections, prevented meaningful democratic debate over how to best preserve access on and around Bay Point.**

Future Directions

Other works have shown that the built environment is instrumental in cementing racial hierarchies by inscribing spatial segregation onto the landscape (Kahrl 2012a, Connolly 2014). I contend docks and armoring act not only as methodologically useful proxies for private property but restrict access through both their physical and symbolic characteristics. Unfortunately, the restrictions of the pandemic led me to adopt a less comprehensive approach that focused more directly on mapping, rather than also allowing me to include interviews and surveys on access to coastal infrastructure. There is, however, some support I found for this argument. Interviews I conducted with the managers of several large planned and gated communities in the area highlighted the symbolic control their mostly White residents felt over the intertidal. Each of these managers noted instances where they fielded calls from residents about individuals fishing near their properties, to which they had to inform these homeowners that was entirely legal. Thus, docks may represent an extension of private property into the estuarine environment that some White homeowners feel must be policed. Other communities are less open about the public status of waterways, placing both physical (e.g. fencing) and symbolic (e.g. Appendix A: Figure A.4) barriers along the marsh.

Armoring infrastructure can also directly influence access. Vertical hard armoring structures such as seawalls and bulkheads steepen the transition from upland to marsh, which can make entry into marshes more difficult at those locations. Likewise, even sloped structures can make access impractical or unsafe depending on their construction material (e.g. crossing craggy and loose riprap). Research in Moorea, French Polynesia found that residents felt the extensive use of armoring by typically wealthier waterfront property owners has limited their access to the island's coast (Calandra et al. 2022). Moreover, the established detrimental effects of armoring on marine biodiversity and morphological stability may further limit people's ability to "derive benefit" from the marsh (Ribot and Peluso 2003). Similar concerns about a transition from functionally boundless to highly constricted access were voiced in numerous informal conversations I've had in Beaufort County and in the works of Gullah-Geechee authors (Bailey 2001, Goodwine 2015, Cooper 2017).

Collectively, docks, armoring, and other built components of coastal private property deserve greater attention in understanding estuarine access. Future work should analyze the material and symbolic effects of coastal infrastructure on marsh access. Furthermore, research into the physical effects of these structures, particularly armoring, are increasingly needed as SLR will only continue to become a more omnipresent issue for coastal communities. We already see the beginnings of a racially distinct approach to adapting to SLR in the South (Martinich et al. 2013, Siders 2019, Siders and Keenan 2020) and further research on adaptation strategies, including the implementation of living shorelines, need to critically engage with the climate justice literature.

Concluding Thoughts

In this dissertation, I have contributed to our understanding of environmental justice issues around marsh access along the South Carolina coast. As argued by Pulido (2000), understanding environmental racism requires more than the documentation of inequitable distributions of environmental burdens here and there. It requires understanding the broad social forces that iteratively construct race and racism. In my three quantitative chapters I pointed to property dynamics, particularly the transfer of land from Black to White property owners, as an avenue by which unequal private access is produced and maintained. In my final chapter, I examined how the ubiquitous tourism economy of the coastal Southeast is also implicated in racially distinct loss of access, which was largely ignored by decision-making authorities in Beaufort County. As more and more waterfront land is subdivided into individual parcels for predominantly White migrants or converted into major tourism developments, the South Carolina coast becomes an increasingly White space. **Without substantial action to reconfigure vertical access through private property and a commitment to elevating concerns around equitable access of all forms in land use decisions, the spatial construction of a racialized coast will continue apace, transforming an environment that is enshrined as a public asset in law into a private playground in fact.**

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APPENDIX A: CHAPTER 2 SUPPLEMENTARY INFORMATION

Assigning Structures to CBGs

We overlaid the infrastructure shapefile with boundaries of CBGs (census block groups) and satellite imagery to confirm which CBGs they belonged to. Some docks are positioned such that they cross CBG boundaries. When this occurred, we counted the dock as belonging to whatever CBG the associated house was in.

We only considered structures that were present and digitized in the infrastructure shapefiles from OCRM (Ocean and Coastal Resource Management) to ensure we were best matching the date of the infrastructure layer and the 2012-2016 ACS 5-year estimate demographic data. Thus, if a structure was present in the satellite imagery basemap (imagery date range 2018-2020), but was not digitized in the OCRM shapefile, we did not include it. Likewise, some of the structures in the OCRM dataset were digitized and marked with the status of “Applied For”. Upon further examination, it appeared that structures with the “Applied For” status had not been built at the time that the infrastructure data was published, and the digitized outlines of those structures were based on permit applications. Except for three public piers that were clearly mislabeled, we excluded all structures with the “Applied For” status because they were not present when these data were collected (684 docks).

Calculating Shore Length

The highly serpentine nature of estuarine coasts makes estimates of shore length difficult to obtain. For our purposes, we wanted a high-resolution measure that accounted for the mosaic

of small navigable tidal creeks and twisting nature of the shoreline. To achieve this, we used 30-m resolution land cover data from NOAA's Digital Coast portal (<https://coast.noaa.gov/digitalcoast/data/>) by selecting the "2016 C-CAP Regional Land Cover" data set and searching for county names individually ("Beaufort", "Charleston", "Colleton", "Georgetown", "Horry", and "Jasper"). We reclassified this land cover into four classes: open water, saltwater marsh ("Estuarine Marsh"), freshwater marsh/wetlands ("Palustrine Marsh"), and land (all other land cover classes were collapsed into this category). When we examined this reclassified land cover layer, it was clear that the 30-m resolution was greatly underestimating the amount of shoreline in the area because it was counting many small, navigable tidal creeks as saltmarsh and not open water. We used the 'Expand' and 'Shrink' tools in ArcMap to expand and then shrink the open water raster cells by 2 cells. Although this will likely result in an overestimate of shore length, we felt that this step resulted in a better reflection of the shape of small tidal creeks upon examination at multiple sites across all counties.

After expanding/shrinking the reclassified land cover layer, we converted these rasters to separate polygons for each raster class and excluded all freshwater wetlands, marshes, and ponds from the data using a combination of the 'Cost Distance' tool and manual deletion of individual polygons. We then added a point every 10 m along the edge of the land polygon and inspected these points to remove any that were placed on small, uninhabitable islands. An image of what these points look like can be found in Figure A.1 and A.2. A full explanation of the steps used to create and edit this point layer can be found in the step-by-step guide in the public repository.

Lastly, we measured how far each point was to navigable deep water using the 'Cost Distance' tool and extracted information about the CBG and distance to water to each point.

Further steps were completed in ArcMap and descriptions can be found in the R scripts included in the public data repository.

Filtering out CBGs Based on Shoreline Length

We assigned CBGs to different environmental zones (“Beach”, “Freshwater”, “Interior”, and “Marsh”) based on the type and amount of shoreline present. We decided to have a minimum shoreline requirement for the Beach, Freshwater, and Marsh Zones because we wanted to make sure CBGs had an appreciable amount of shoreline that would feasibly allow WAI development. Due to the arbitrary nature of how CBG boundaries are determined, CBGs may have small stretches of Beach, Freshwater, or Marsh shoreline that are not functional due to their small size. Because of this we instituted a 0.25 km cutoff for the Beach Zone and a 1 km cutoff for the Freshwater and Marsh Zones. We chose a 0.25 km cutoff for the Beach Zone because of the high resolution of the beachfront jurisdictional lines used to determine these areas (see <https://gis.dhec.sc.gov/shoreline/>) and because the largely linear shape of beaches.

We chose a larger, 1 km cutoff for the Freshwater and Marsh for two primary reasons. First, the 2016 C-CAP NOAA land cover data used to classify land, marsh, and open water was much lower resolution (30 m) than the beachfront lines. We wanted to be more conservative with our measurements because this lower resolution can cause areas of marsh to be incorrectly classified as developable land, artificially inflating shore length. Second, the twisting nature of freshwater and saltwater rivers, combined with the expand/shrink function described above, led to many small embayments that are functionally undevelopable. This is particularly pronounced in marshes. After examining our CBGs, we felt a 1 km shoreline cutoff would be appropriate to avoid spurious inclusion due to the lower resolution land cover data and the more contorted

nature of these rivers. Ultimately, we recognize that these cutoff values are arbitrary, so we have included a table below showing the number of CBGs in each Zone for a range of cutoff values (Table A.1).

Public WAI Abundance (Poisson Regression)

We fit a mixed effects Poisson regression using the “glmmTMB” package in R to model public WAI abundance. This model used identical fixed and random effects as the logistic regression (Objective 2) discussed in the main article. The abundance of public WAI in a CBG of a CBG containing a public WAI decreased with income (Table A.1, $\chi^2(1) = 3.7$, $p = 0.054$), but was unaffected by percent White ($\chi^2(1) = 1.26$, $p = 0.26$). As expected, the term for shore length was significant and positively correlated with public WAI ($\chi^2(1) = 9.53$, $p = 0.0020$) and the number of private WAI was also significant ($\chi^2(1) = 5.25$, $p = 0.022$). The number of public WAI in a CBG was expected to decrease from 0.73 [95% confidence interval: 0.44–1.21] to 0.15 [0.04–0.56] across the range of income observed in our study area. Shoreline length and the abundance of private WAI showed stronger effects, with the number of public WAI expected to increase from 0.41 [0.29–0.58] to 1.90 [0.77–4.66] and 0.44 [0.31–0.63] to 1.74 [0.58–5.22] across the range of those variables, respectively.

Table A.1. Table showing the number of CBGs included in each Zone for four different combinations of minimum shoreline length requirements. Note that because some CBGs had both beach and saltwater (i.e. marsh) shoreline, we prioritized the marsh shoreline in the filter. For example, a CBG with 5 km of saltwater shoreline and 1 km of beach shoreline is classified in the “Marsh” Zone.

	Cutoff Values			
Zone	In paper - 0.25 km Beach, 1 km Fresh/Salt)	0.25 km Beach, 0.5 km Fresh/Salt	0.25 km Beach/Fresh/Salt	Minimum cutoff (> 0 km Beach/Fresh/Salt)
Beach	27	26	25	26
Freshwater	69	73	76	77
Interior	290	267	261	251
Marsh	187	207	211	219
Total	573	573	573	573

Table A.2. Summary of regression output for fixed and random effects for the model of public WAI abundance. The “SE” column refers to standard error, and the “ χ^2 ” and “p-value” columns contain the outputs from likelihood ratio tests.

Fixed Effects				
Variable	Untransformed Coefficient	SE	χ^2 Value	p-value
Intercept	-0.98	0.56	-	-
Income (thousands \$)	-0.0095	0.0051	3.71	0.054
% White	-0.0049	0.0044	1.26	0.26
% Homeowner	0.0053	0.0057	0.87	0.35
Population (hundreds)	0.0060	0.0077	0.59	0.44
Shore length (km)	0.0085	0.0027	9.53	0.0020
Dock abundance	0.0029	0.0012	5.25	0.022
Random Effects				
Level	Variance			
County	0.049			
Census tract	0.072			

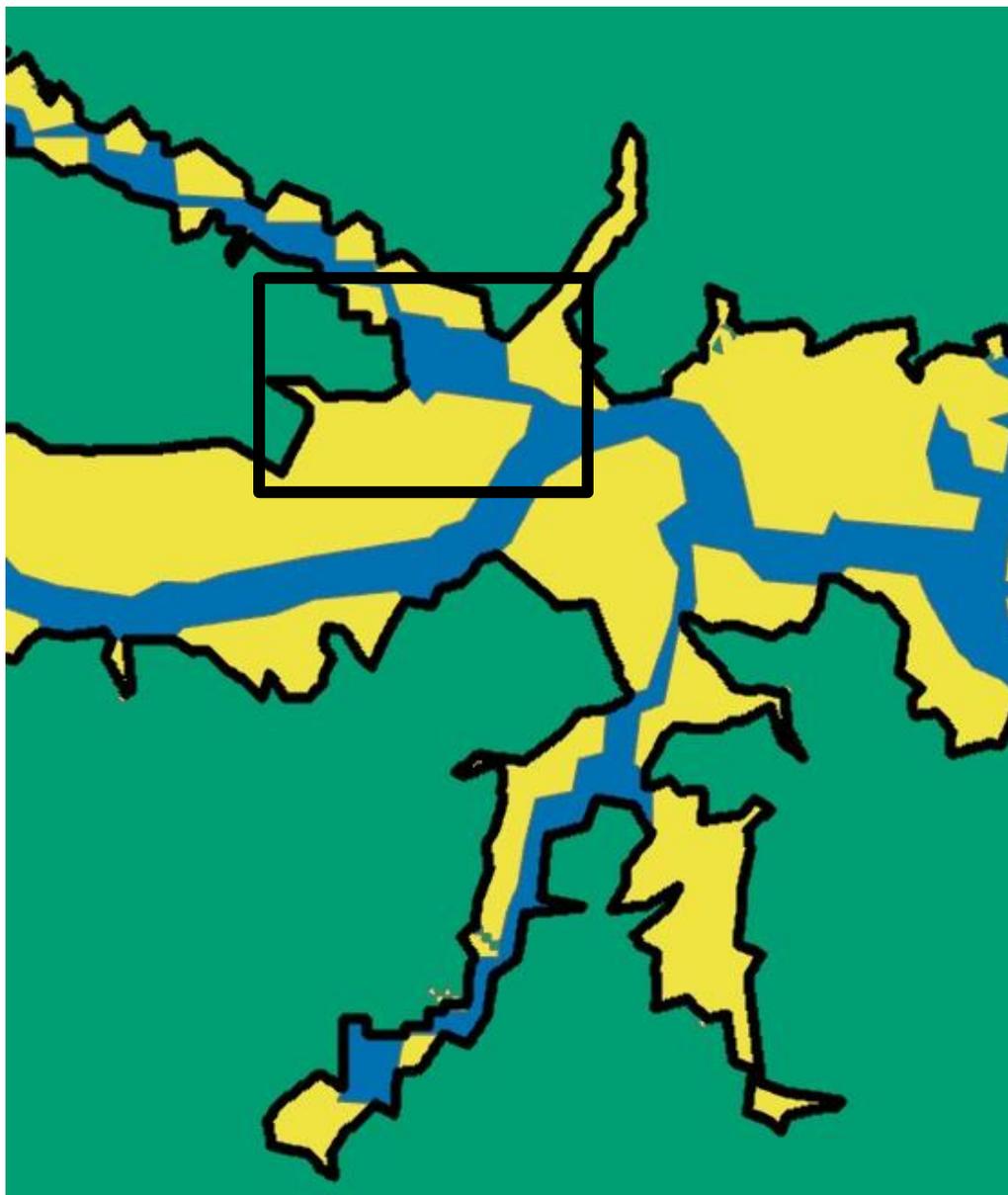


Figure A.1. Illustrative example of points used to measure shore length in Georgetown County, SC. Land areas are shown in green, yellow areas represent saltmarsh, and blue areas represent water. The black line is comprised of individual circles placed every 10 m along the land area border. The block box represents a zoomed in area shown in Figure A.2 where these individual points can be discerned. Map scale 1:19,000

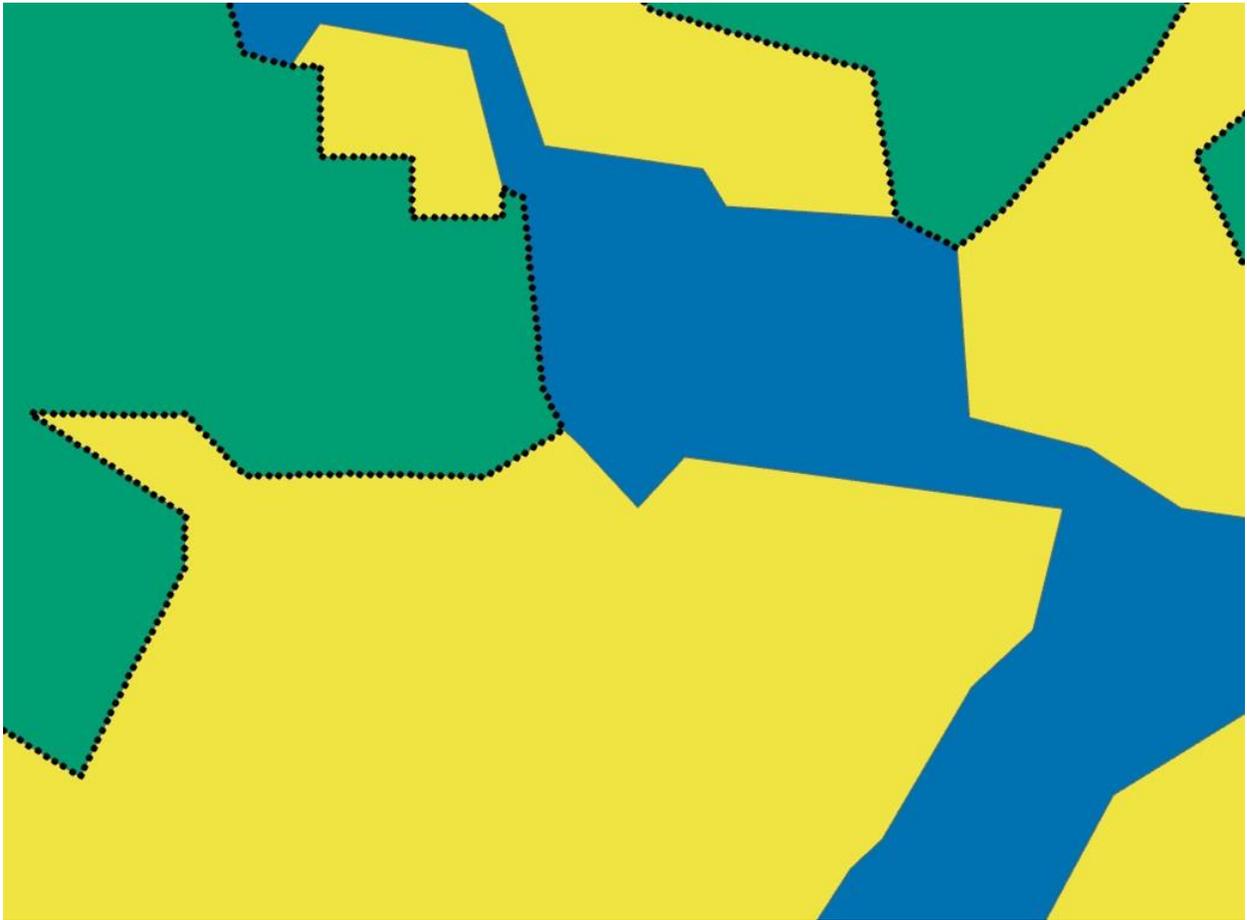


Figure A.2. Are represented by the black box in Figure A.1. Land areas are shown in green, yellow areas represent saltmarsh, and blue areas represent water. The black circles represent the points placed every 10 m along the land area border. Map scale 1:4,456.

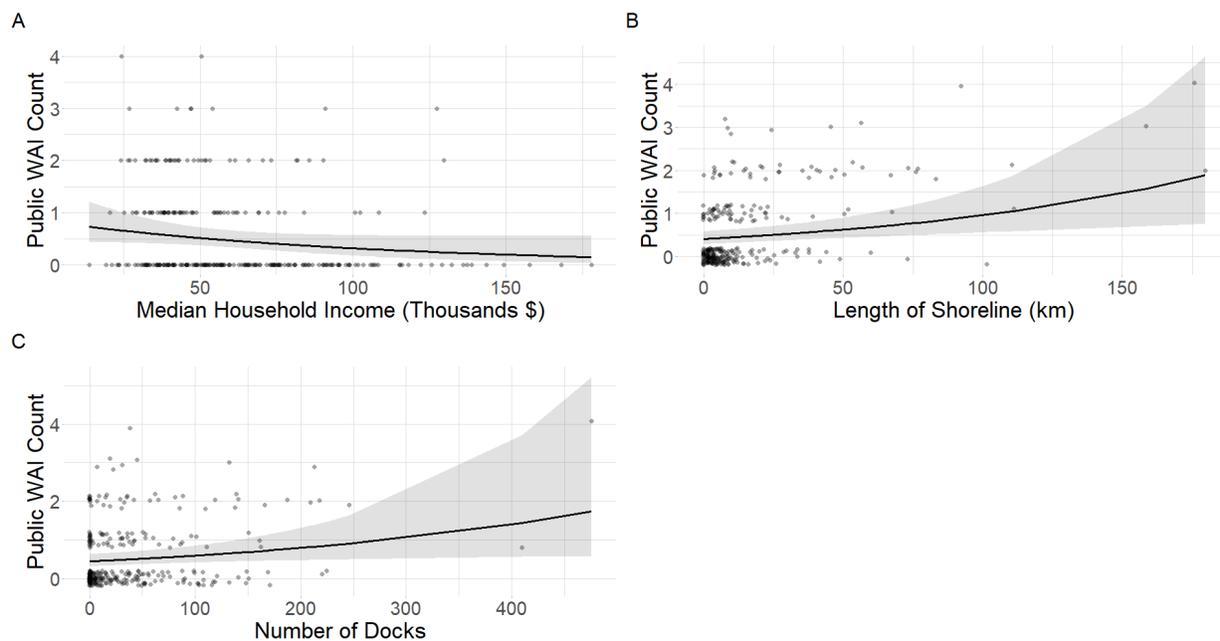


Figure A.3. Conditional effect plots for income (A), shoreline length (B), and number of docks (C) in the Poisson regression of public WAI abundance. Lines represent conditional effect predictions with 95% confidence intervals. Points plot the raw data with the “jitter” function applied to minimize overlap of points. Darker points indicate overlap of two or more points. Income: $\chi^2(1) = 3.7$, $p = 0.054$, Shoreline: $\chi^2(1) = 9.53$, $p = 0.0020$, number of private WAI: $\chi^2(1) = 5.25$, $p = 0.022$.



Figure A.4. Demonstration of signage on Hilton Head Island that may serve as symbolic barrier to accessing marshes. The entire creek this neighborhood is built on is public property by law, and within the neighborhood is a public fishing pier built and maintained by the county, but the message of “Private Property Members Only” is prominently displayed. The public pier access caveat at the bottom is in much smaller print and difficult to see from the road.

APPENDIX B: CHAPTER 3 SUPPLEMENTARY INFORMATION

Structure Assignment Rules and Quality Control

Pre-1990 image quality varied between 1.25-4.5 m resolution. A team of four undergraduate assistants and J. Beauvais checked the pre-1990 imagery. While in many instances the presence of docks was clear in the pre-1990 imagery, in some instances the image quality could impede object identification. To ensure consistency in deciding whether objects were a dock across varying image resolution and across five different researchers, we established a set of four criteria that had to be met for an object to be counted as a dock:

- 1) The object must have a base that is clearly attached to solid land
- 2) The object must terminate at or beyond the water's edge
- 3) Must have physical qualities of human-built infrastructure (i.e. clean edges, no undulation along the length of the object)
- 4) Occur in a logical place and have a logical shape for a dock (i.e. it must be linear and approach water directly with at most one bend)

We trained all undergraduate assistants over at least two sessions and encouraged them to mark any structures of which they were unsure. Following completion of a county/year imagery set, J. Beauvais checked all structures marked for additional review and made final decisions. J. Beauvais also conducted random spot checks to ensure that the listed criteria were being applied evenly. In instances where different images from the same year overlapped in space or multiple images of the same with area with varying resolution occurred, we always relied on the higher quality resolution to make final decisions on whether an object was a dock or not.

Imagery from 1994, 1999, and 2011 were of sufficient resolution to allow for easy identification of docks in almost all instances and while the criteria listed above still applied, we did not have to deliberate whether individual objects in question met them because of the high quality. Additionally, only J. Beauvais collected data on the 1994, 1999, and 2011 imagery.

Our approach of sequentially building on prior GIS layers (e.g. the completed dock point layer for Beaufort 1955 served as the starting point for 1959, 1959 served as the starting point for 1972, etc.) necessitated some criteria for determining which structures were new (Figure B.1), removed (Figure B.2), or maintained (Figure B.1) due to variations in georeferencing. An example of these situations can be found in Figure B.1. As noted in the main text, we relied on the attributes of the points, number of docks in the image, comparison between different years of imagery, and other context to make these decisions. For example, in the top image of Figure B.1 we see the original scene in 1955, where we have placed four sets of green points on the four docks (the points slightly obscure the docks in the original image). In the bottom image of Figure B.1 we see the same area in 1959. In this scene the points we placed in 1955 have generally shifted slightly backwards and to the right of the actual docks in the image. We needed to determine if these are the same docks in the 1955 and 1959 images. First, the shifts are relatively minor (a few meters at most) and well within expectations for georeferencing accuracy of historic imagery. Second, the angle and distance between each set of points relative to the docks in the scene are consistent. Third, in for the top-right dock we see it is in the same position on the shore relative to the adjacent clump of trees, which are clearly the same in the 1955 and 1959 images. Thus, we considered these four docks as being maintained from 1955 to 1959 and we mark two new docks (the blue circles).

Imagery Bins

Binning our imagery was necessary to pair our dock counts with data from the Census, which occurs every 10 years. Given the temporal distribution of our imagery some imagery bins contained multiple corresponding years of imagery for a single Census (Table 3.1). We argue this is a minor issue. First, due to the limitations of extrapolating data in areas that did not historically contain Tracts, we do not conduct any Tract-level statistical analyses prior to 1990 at which point there are no duplicate years of imagery in a bin (Table 3.1, “All counties”). Second, the major potential issue of increased resolution within imagery bins is if a dock was first identified and were removed within the same Census decade (e.g. a dock first identified in Beaufort 1955 that is removed in 1959, Table 3.1). This situation only occurred to 14 structures in the 1960 Census decade, and we have removed them from the analysis.

Temporal County Level Data

We present a GIF detailing dock locations over the study period in Figure B.3. We also present counts and lengths of new, removed, and existing docks at the county-level for those interested in an even more fine-grain look at dock development in Figures B.4 and B.5. Lastly, we provide a boxplot of existing dock lengths in Figure B.6 to demonstrate the heterogeneity in dock lengths. Charleston dominated in dock abundance throughout the entire study period, followed by Beaufort. Although we did not conduct any statistical analyses, a qualitative look suggests that dock lengths vary by county, with Beaufort, Charleston, and Jasper counties having longer docks on average than the other counties. Horry County consistently contains the shortest average dock length. We believe differences in dock sizes that differ by county might be rooted in differing landscape characteristics such as channel morphology and marsh depth across the

counties. For example, Horry County contains very little open marsh and most docks are built along a narrow, channelized portion of the Intercoastal Waterway, allowing docks to reach the water in a shorter distance.

Table B.1. Table showing the number of Tracts and docks included for four different levels of minimum shoreline length requirements. The “% of docks” column documents what percentage of docks remain relative to no cutoff.

		Cutoff (km of shoreline)														
		0			0.25			0.5			0.75			1		
Year	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	
1990	212	4841	—	120	4712	97.3	119	4712	97.3	116	4711	97.3	112	4685	96.8	
2000	212	6463	—	120	6243	96.6	119	6243	96.6	116	6242	96.5	112	6208	96.1	
2011	212	10092	—	120	9701	96.1	119	9701	96.1	116	9694	96.1	112	9645	95.6	
2019	212	4841	—	120	4712	97.3	119	4712	97.3	116	4711	97.3	112	4685	96.8	

Table B.2. Table showing the number of Tracts and docks included for four different levels of minimum number of housing units. This table builds from Table B.1, using the 1 km shoreline filter we decided upon as the starting point (i.e. the value for when the cutoff for housing units is 0). The “% of docks” column documents what percentage of docks remain relative to no cutoff.

		Cutoff (number of housing units)											
		0			50			75			100		
Year	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	# of Tracts	# of docks	% of docks	
1990	112	4685	—	109	4650	99.3	109	4650	99.3	108	4650	99.3	
2000	112	6208	—	111	6208	100	111	6208	100	110	6208	100	
2011	112	9645	—	112	9645	100	112	9645	100	112	9645	100	
2019	112	11342	—	112	11342	100	112	11342	100	112	11342	100	

Table B.3. Regression output for fixed and random effects from each decade. Significant p-values are bolded for identification. *The likelihood ratio test could not converge for the reduced model – this represents the Wald estimate.

Variable	Decade	Coefficient Estimate	SE (fixed)/Variance (random)	LRT Result
MHI (income)	1990	-0.047	0.14	$\chi^2(1) = 0.10, p = 0.74$
	2000	0.32	0.15	$\chi^2(1) = 3.54, p = 0.06$
	2010	-0.25	0.16	$\chi^2(1) = 4.61, \mathbf{p = 0.03}$
	2019	-0.15	0.16	$\chi^2(1) = 0.70, p = 0.40$
% White	1990	0.54	0.16	$\chi^2(1) = 11.89, \mathbf{p < 0.001}$
	2000	0.35	0.14	$\chi^2(1) = 5.78, \mathbf{p = 0.02}$
	2010	0.49	0.14	$\chi^2(1) = 10.77, \mathbf{p = 0.001}$
	2019	0.35	0.14	$\chi^2(1) = 5.43, \mathbf{p = 0.02}$
% Homeowners	1990	0.52	0.15	$\chi^2(1) = 11.23, \mathbf{p < 0.001}$
	2000	0.19	0.15	$\chi^2(1) = 1.48, p = 0.22$
	2010	0.52	0.14	$\chi^2(1) = 11.69, \mathbf{p < 0.001}$
	2019	0.4	0.13	$\chi^2(1) = 7.78, \mathbf{p = 0.005}$
Population	1990	0.27	0.11	$\chi^2(1) = 5.36, \mathbf{p = 0.02}$
	2000	0.39	0.11	$\chi^2(1) = 11.80, \mathbf{p < 0.001}$
	2010	0.29	0.1	$\chi^2(1) = 10.99, \mathbf{p < 0.001}$
	2019	0.33	0.11	$\chi^2(1) = 11.16, \mathbf{p < 0.001}$
Shoreline	1990	0.66	0.16	$\mathbf{p < 0.001}^*$
	2000	0.76	0.16	$\chi^2(1) = 25.52, \mathbf{p < 0.001}$
	2010	0.6	0.14	$\chi^2(1) = 21.13, \mathbf{p < 0.001}$
	2019	0.61	0.14	$\chi^2(1) = 22.05, \mathbf{p < 0.001}$
County (random)	1990	—	0.24	—
	2000	—	< 0.001	—
	2010	—	0.16	—
	2019	—	0.068	—
Tract (random)	1990	—	0.11	—
	2000	—	< 0.001	—
	2010	—	< 0.001	—
	2019	—	< 0.001	—



Figure B.1. Top – 1955 photo with four sets of green points placed at the upland base and waterward end of the docks, Bottom – 1959 photo with retained structures (green points) plus three new structures (blue circles). Note the rightmost new dock appears faint in the screenshot but is more obvious in the original imagery.

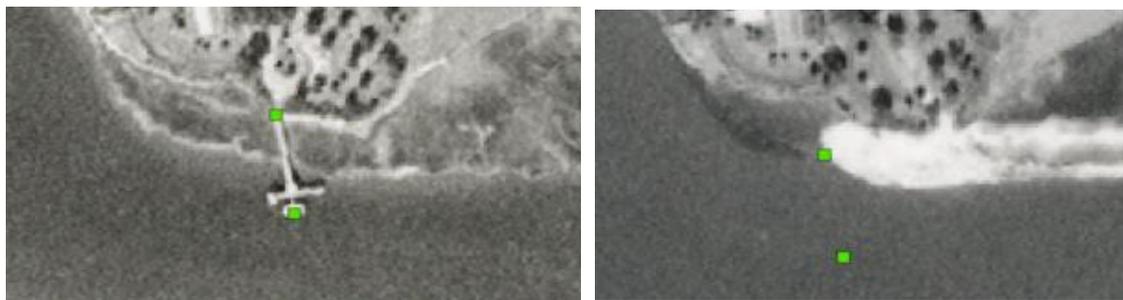


Figure B.2. Left – a dock in 1955, Right – same area in 1959 showing the 1955 points (green) and no dock. It is clear the dock was removed in the intervening years.

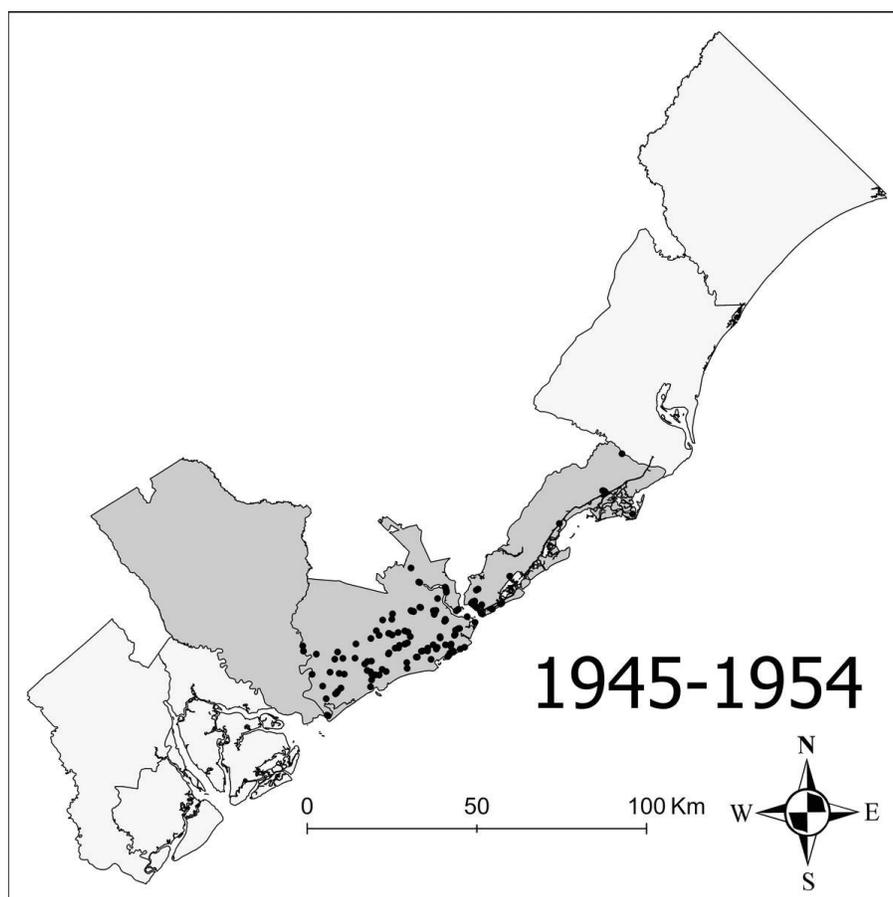


Figure B.3. Existing docks across the study area over all decades in the study. File is a GIF which cycles through all decades sequentially. Areas without imagery in the 1945-1954 period are a slightly lighter shade of gray. Circular points represent existing docks, while red triangles represent docks that were removed in that period. Removed docks are subsequently removed from future periods. Circular points are colored based on the decade they first appeared. Black circles – docks added from 1945-1954, orange circles – docks added from 1955-1964, light blue circles - docks added from 1965-1974, green circles – docks added from 1975-1984, yellow circles - docks added from 1985-1994, dark blue circles - docks added from 1995-1999, white circles - docks added from 2000-2011.

Figure B.4. County level dock counts from 1950-2019. Note that only Charleston and Colleton counties contained imagery from the 1950 decade and Colleton County contained no discernible docks at this time. Also, all counties contained docks in 1960, but Colleton (2), Horry (21), and Jasper (7) counties are difficult to see given the scale of the y-axis

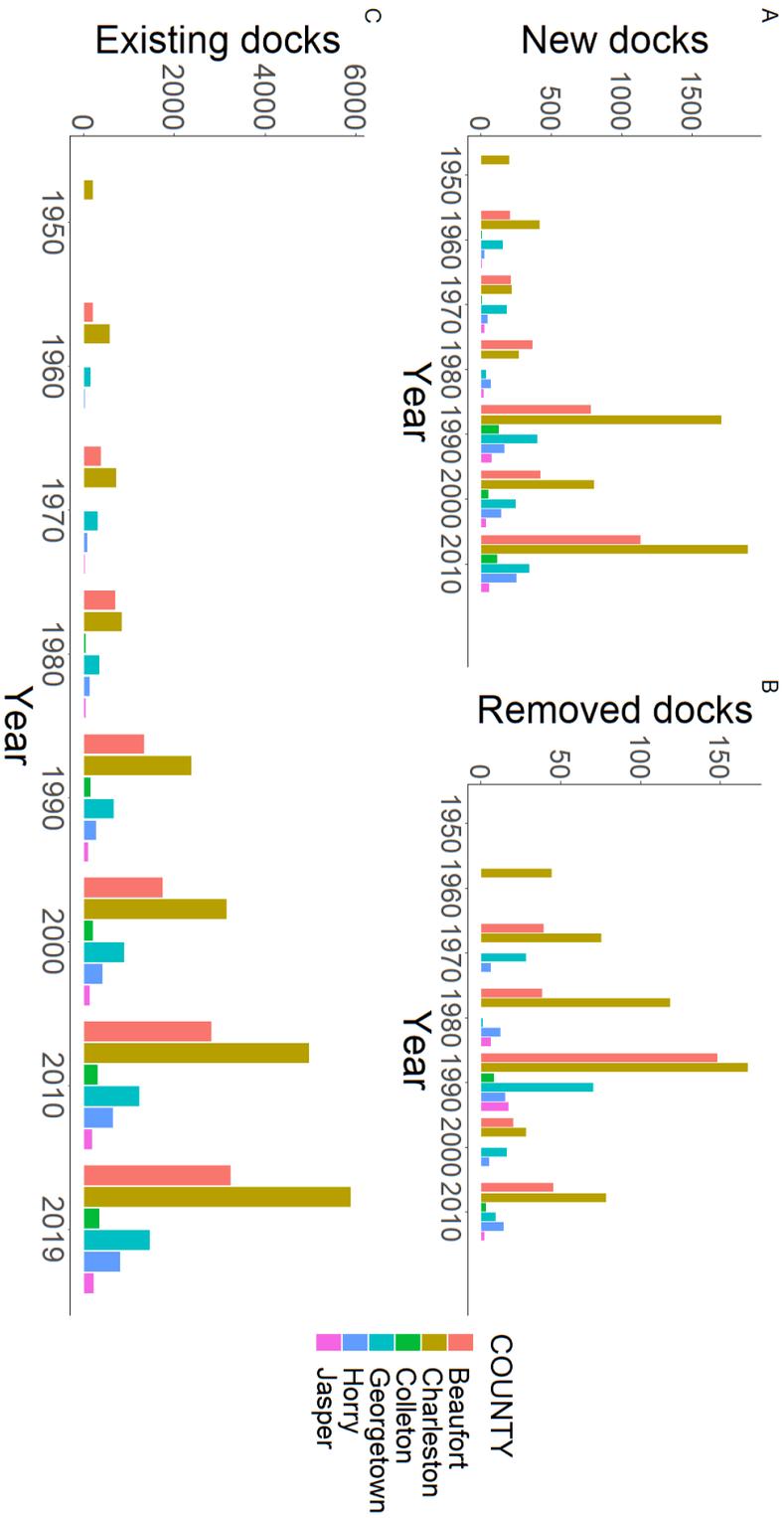
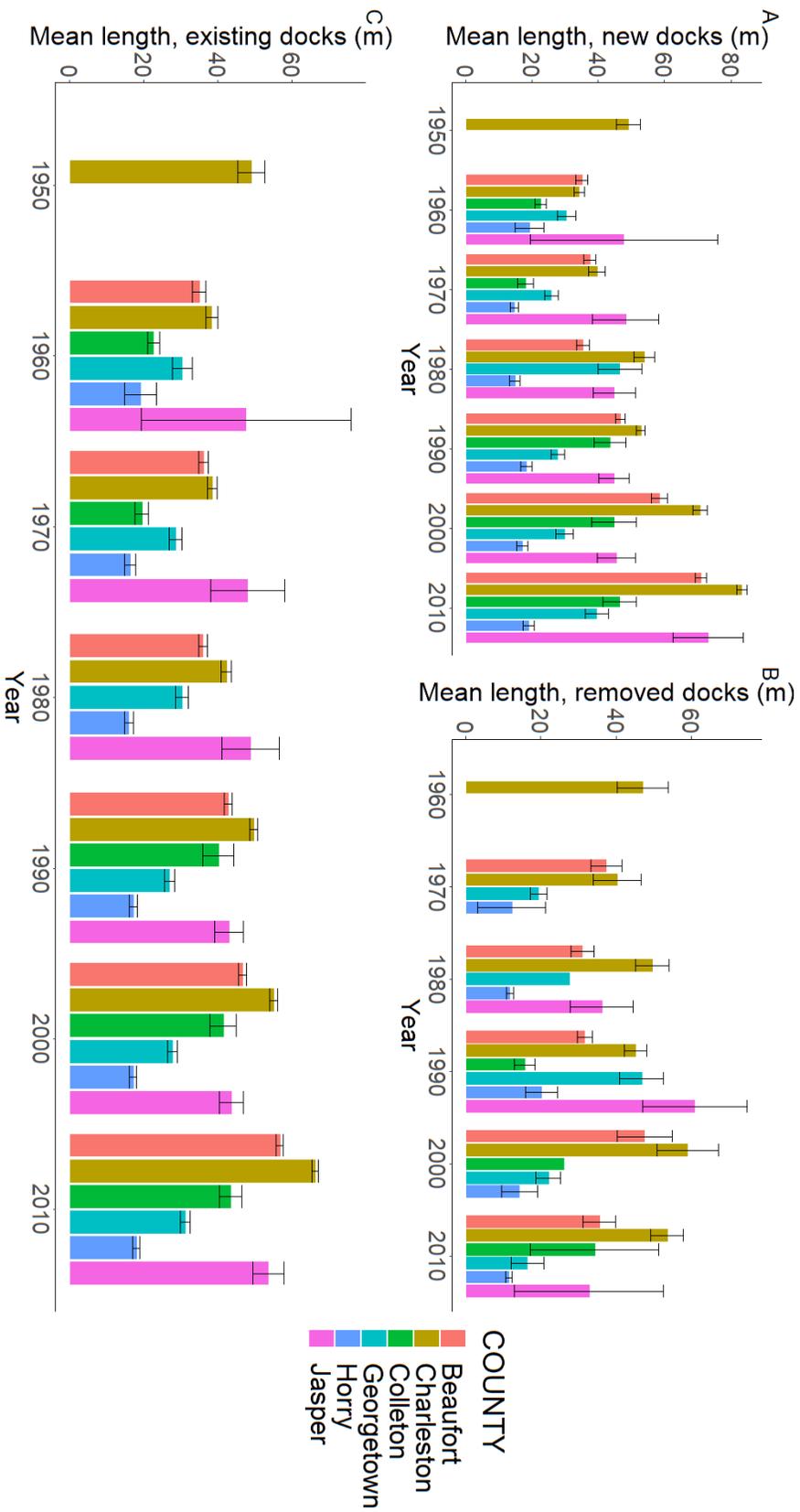


Figure B.5. County level mean dock lengths for new, removed, and existing docks. Note that only Charleston and Colleton counties contained imagery from the decade and Colleton County contained no discernible docks at this time. Error bars represent standard error.



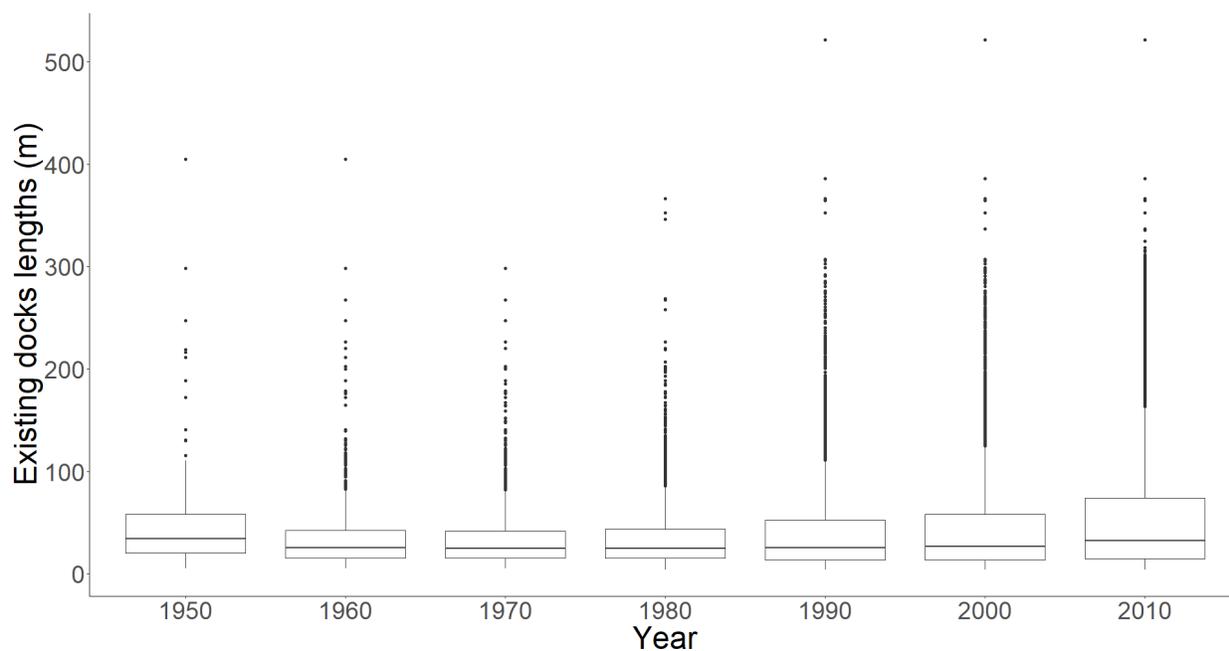


Figure B.6. Boxplot of existing dock lengths across the 212 Tracts of the study area. The black midline of the boxplot represents the median, box edges represent the 25th and 75th percentile (interquartile range, IQR), error bars represent $1.5 * IQR$, and individual points represent outliers outside of the error bar range

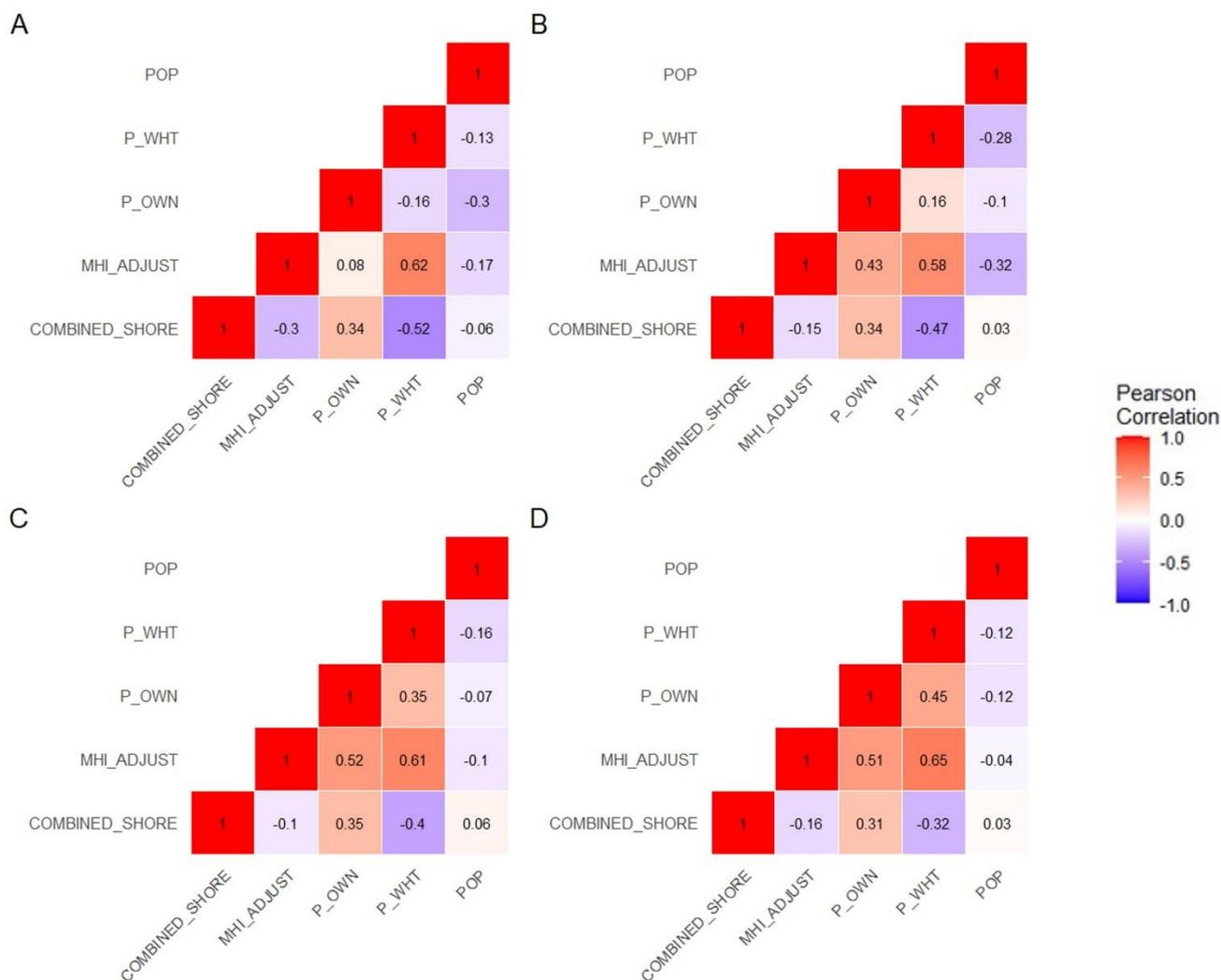


Figure B.7. Correlation heatmaps of predictor variables in 1990 (A), 2000 (B), 2010 (C), and 2019 (D). Numbers in cells represent values of Pearson correlation coefficients. Abbreviations: COMBINED_SHORE = shoreline length, MHI_ADJUST = median household income (adjusted to 2010 USD), P_OWN = % homeowners, P_WHT = % White, POP = population.