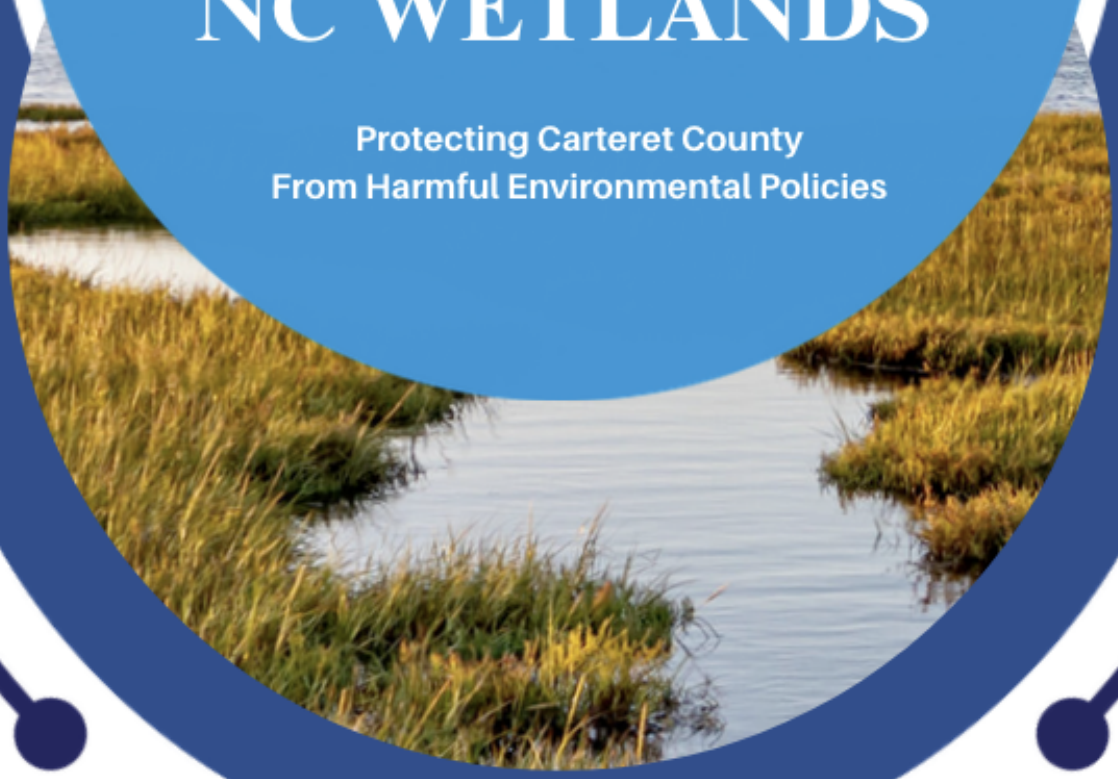
UNC | COLLEGE OF ARTS AND SCIENCES
Public Policy

COASTAL CAROLINA RIVERWATCH

FALL 2023

THE FUTURE OF COASTAL NC WETLANDS

Protecting Carteret County From Harmful Environmental Policies



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Senior Public Policy Capstone Final Portfolio

About Coastal Carolina Riverwatch

Coastal Carolina Riverwatch is a female-led clean water association working to protect the quality of water and life in coastal NC. They work in Eastern North Carolina and serve the White Oak River Basin. Their long-term projects in the past year have focused on protecting water quality in fisheries, evaluating the effects of concentrated animal feeding operations (CAFOS) on water quality, and working with community members to understand what the most pertinent issues are facing the coastal community.

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Executive Summary

Wetlands are extremely valuable ecosystems, however, they have historically been subjected to high levels of degradation due to urban development. Carteret County is one of 20 coastal counties in North Carolina, supporting a variety of ecosystems, including wetlands. North Carolina wetlands contribute significantly to the state's economy, biodiversity, public health, and flood protection. Due to changes in federal and state protections in 2023, increased development could put wetland health at risk.

Our client partner, Carolina Coastal Riverwatch (CCRW) aims to provide persuasive statistical indicators and policy solutions to strengthen community advocacy for the importance of wetlands amidst recent state policy changes that eliminate wetland protections in NC. For this project, they charged us with gaining an understanding of current wetland degradation and researching potential solutions for future regulation. We analyzed trends in Carteret's wetland degradation, making comparisons to key water quality indicators, hoping to find a link between the two. Following this, we researched both the current policy landscape of wetland protections and policy options for the future.

Through our research, we concluded that:

(1) there is a lack of evidence of substantial wetland degradation or urban development in Carteret County over the past 25 years;

(2) there is a lack of generalizable evidence for select water quality indicators, making it difficult to visualize any changes in water quality; and

(3) historical state-level wetland protections in North Carolina can be attributed to the little change seen in wetland prevalence and health.

These conclusions led us to make the following policy recommendations:

(1) better collection and organization practices of wetland data;

(2) the implementation of two comparative county-level policies from Maryland; and

(3) the expansion of Carteret County-level wetland protections beyond federal and NC mandates.

Protecting Carteret County's wetlands is crucial for ensuring long-term sustainability in a future marked by the effects of climate change and increasing coastal development. In light of recent policy shifts at the federal and state levels, this report stands as a resource for county-level officials to help inform them of the best practices moving forward regarding wetland protections.

Project Background

Due to recent changes in federal and state policies that place a large portion of NC's wetlands at risk of development, Coastal Carolina Riverwatch (CCRW) requested our assistance on conducting a project that analyzes how wetland degradation in Carteret County, NC, will impact local water quality. On May 25, 2023, the U.S. Supreme Court made its ruling on Sackett v. Environmental Protection Agency (EPA). This ruling has been a landmark case in environmental protection, reducing the scope of the Clean Water Act (CWA). Passed in 1972, the CWA is responsible for regulating the levels of pollutants in almost all bodies of water in the U.S., including wetlands (Clean Water Act, 1972, § 816). This new ruling focused on a part of the original bill that limits protections to "navigable waters." Isolated wetlands that do not border larger bodies of water no longer meet these requirements, and thus are no longer protected under the CWA(*Sackett v. Environmental Protection Agency*, 2023). Over 2.5 million acres in NC have been affected (Sorg, 2023). Previously, the state had its own legal protections for wetlands in addition to the CWA, but these too have been overturned.

On June 27, 2023, the NC Senate overruled Governor Cooper's veto on Senate Bill 582, which, among many other clauses, reclassified the definition of wetlands. This bill clarifies North Carolina's definition of wetlands to be consistent with the federal definition (Sorg, 2023). With the recent ruling in Sackett v. EPA, NC's isolated wetlands are no longer protected under the CWA. Without new legislation to protect at-risk wetlands, new developments could potentially pollute their waters or destroy them completely. Though isolated wetlands may not border primary drinking sources, their water quality can still impact groundwater sources (Sorg, 2023). To protect coastal drinking water sources and habitats, local governments must create new legislation to bolster the holes in the CWA. The next few months will be especially important in that process.

Importance of Wetlands

Economic

Biodiversity

Public Health

Shoreline Erosion

Wetlands are one of the "most productive and complex ecosystems on Earth," with the life of humans and nature being closely linked to the environmental functions and benefits that wetlands contribute to local communities (Finlayson et al., 2021; Kumar et al., 2021). Wetlands are generally divided into five major types: marine, estuarine, lacustrine, riverine, and palustrine. In Carteret County and other municipalities along NC's coast, much of the land cover is classified as or is adjacent to various types of wetlands. Due to the county's proximity to the Atlantic Ocean, its wetlands are subjected to natural degradation via storm surge, disintegration of barrier islands, increased salinization, and shifts in estuarine deltas. As one of the most vulnerable ecosystems to the effects of climate change, natural causes of wetland deterioration are increased by rising temperatures and sea levels that ultimately result in reduced biomass (Kumar et al., 2021). Furthermore, human activity is a leading factor in habitat destruction and fragmentation (McCauley et al., 2012). There are six primary anthropogenic causes of wetland degradation: infrastructure development, conservation of land, water withdrawal, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive species (Kumar et al., 2021). Human activity and natural hazards compound to undermine the immense benefits that wetlands provide, as discussed below.

Economic

Wetlands serve as vital hubs for recreational activities, encompassing pursuits such as fishing, hunting, photography, and boating. In coastal counties, recreational fishing stands out as a significant contributor to both county GDP and employment, with wetlands estimated to play a direct role in up to 90 percent of the fish caught recreationally (EPA, 2006). The appeal of wetlands extends to tourism revenue, driven by the diverse animal and plant species they support, prompting individuals to travel to witness their beauty and local populations. Geographically, some wetlands boast abundant plant life that can be sustainably harvested for a

variety of consumer products, ranging from medicines to specialty items. The degradation of wetlands is poised to have a detrimental impact on the tourism and recreation sector of a county's economy. This sector, a crucial component of overall economic activity and essential for attracting future population growth, is intricately linked to the well-being of wetlands. While quantifying the dollar value of wetland degradation is challenging, similar to other environmental impact evaluations, the benefits of land can be estimated using market and non-market valuation techniques. Among these techniques, cost-benefit analysis and cost-effectiveness analysis are two prominent methods (Feather, 1999).

Biodiversity

Nutrient-rich soils and an abundance of water resources generate an ecosystem that is suitable for a wide variety of species (Kumar et al., 2021). With two-thirds of all marine animals utilizing coastal wetlands for food and shelter at some point during their lifespan, wetlands are crucial sites of biodiversity and bioproductivity, particularly for fish, amphibians, and waterbirds (NC Division, n.d.b; Li et al., 2018). In fact, coastal NC marshes are considered to be some of the most productive systems on Earth for finfish and shellfish species (NC Division, n.d.-b).

The Coastal Plains region - which encompasses nearly 45% of the state's total land area - contains approximately 95% of the state's wetlands (Davis, 2022; The State, n.d.). Almost three-quarters of NC's endangered, threatened, or rare species rely on wetlands for survival (NC Division, n.d.d). Carteret County's wetlands are home to over 40 of such species, including the American alligator, the piping plover, and the Alabama vertigo mollusks (Ratcliffe, 2020). When analyzing historical extinctions, 66% are aquatic species, thus "highlighting the exceptional sensitivity of the wetland and freshwater ecosystems to external pressures" (Denny, 1994).

Degradation is detrimental to the biodiversity of wetland ecosystems. The loss of even small populations of species can lead to significant loss in genetic diversity / loss of rare alleles. This is especially true in smaller wetlands, which oftentimes sustain populations not found in larger wetlands due to lacking common predatory species and containing a differing landscape. In contrast, large wetlands are vital for preserving regional biodiversity by maintaining both abundance and frequency of species (McCauley et al., 2012). Saltwater intrusion and increased salinity drastically alters the structure of biotic communities and the relationships between plant and animal species (Li et al., 2018). Water withdrawal or increased water consumption most heavily impacts waterbirds, a biologically rich taxon that relies on amphibians as a primary part of their diet in addition to wetland flora for shelter (Verones et al., 2013). Eutrophication, or harmful and excessive cyanobacteria blooms caused by excess nitrogen from agricultural run-off, have the ability to kill large amounts of fish in a short span of time (Lopez, 2019). Each of these natural and anthropogenic causes of degradation allow for the spread of invasive vegetation that have the potential of out-competing native plant-life (McCauley et al., 2012).

Public Health

Wetlands provide numerous benefits for the health of those who live around them. Firstly, the health of wetlands impacts the incidence and spread of both infectious and communicable diseases in humans (Horwitz & Finlayson, 2011). There have been many documented cases that changes in land-use and losses in biodiversity associated with wetlands can increase the spread of numerous infectious diseases. Examples of infectious diseases that are associated with wetlands include malaria, West Nile virus, and schistosomiasis. Wetlands improve water quality, so degradation of wetlands will result in low water quality and poor sanitation and hygiene. All of these effects increase the likelihood of contracting communicable diseases, such as diarrheal diseases (Horwitz & Finlayson, 2011).

Healthy wetlands are crucial to preserving human nutrition. Many major food sources either grow in wetland ecosystems, such as fish and shellfish, or are dependent on wetlands for irrigation, such as rice. Maintaining healthy wetlands promotes healthy and diverse diets (Horwitz & Finlayson, 2011). Additionally, wetlands benefit health because they contain nutrients and products that can be utilized for medicinal or pharmaceutical purposes. Such products can be extracted from sources such as animals, fungi, bacteria, algae, and other lower plants found by wetlands (Horwitz & Finlayson, 2011).

Finally, healthy wetlands are crucial to maintaining human health because they filter toxins out of the water (Horwitz & Finlayson, 2011). Changes to the composition of wetlands can lead to increased mobilization and human exposure to these toxic chemicals. Documented human exposure has occurred in areas where wetlands have been disturbed by human activities. The health effects from toxins vary but can develop due to acute to chronic exposure to toxins (Horwitz & Finlayson, 2011).

Shoreline Erosion

Wetlands serve as natural buffers that offer protection against shoreline erosion and flooding in various ways. Their unique ecosystem, consisting of various plant species and intricate root systems, plays a pivotal role in stabilizing coastlines and mitigating the impacts of erosion. Wetlands help protect against flood damage by storing either flood waters or water that collects in isolated depressions. Trees and other wetland plants can also help to slow the speed of flood waters. It has been found that property located behind wetlands along the seashore often fares much better during storms than those that are not located behind wetlands. Additionally, wetlands help to prevent flooding by protecting shorelines. Wetlands located between rivers and high ground can help to buffer shorelines against erosion. The vegetation found in wetlands strengthens the sediment by binding soil with their roots (Soil and Water Conservation, 2022).

This vegetation is dense both above and below ground, allowing it to absorb energy and reduce wave action during storms (NCDEQ, n.d.).

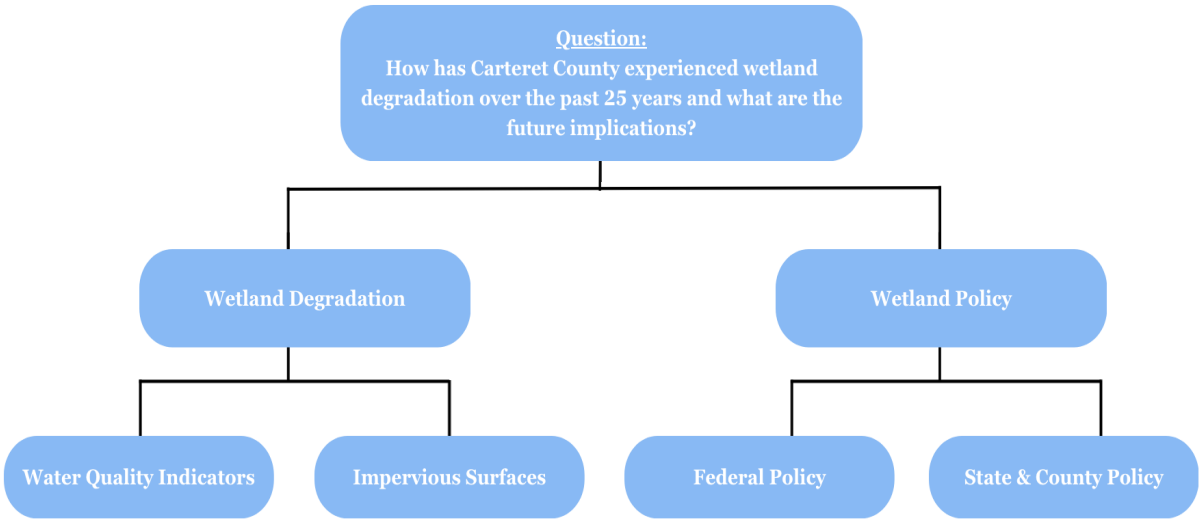
A 2019 Duke University-led study found that the death of marsh plants can double the rate of shoreline erosion in hard-hit marshes, such as those affected by the Deepwater Horizon oil spill. This study also found that the loss of wetland vegetation increases the rate of erosion on wave-stressed shorelines by 100%. To come to this conclusion, a three-year field experiment was conducted at salt marsh sites in Florida with similar soils, vegetation, and wave exposure as marshes that were hit by the Deepwater Horizon spill. The sites were divided into test plots subjected to three different treatments. In some plots, they repeatedly cut the plants' stems down to the ground but left the roots intact. In other plots, they used herbicide to kill the plants, including the roots. Other plots were left unaltered to serve as controls. The study found that in the plots where just the stems were cut off, no extra erosion occurred because the roots were still intact to hold things together. In plots where the roots were killed, the amount of land loss increased by 100%. This experiment confirmed what large-scale observational studies have found - if disturbances like heavy oiling kills the roots of wetland plants, there is more erosion, and because the eroded area is much lower in elevation and is flooded continuously, the plants cannot grow back (Duke University, 2019).

While wetlands are resilient ecosystems, this study demonstrates the threat that development poses and the implications for further wetland degradation. Wetlands serve a crucial role in protecting shorelines from erosion and mitigating flood damage. They are significant ecosystems and must be protected to in turn protect our population.

Problem Statement

Recent federal and state legislation have made North Carolina's wetlands vulnerable to degradation via urban development. Coastal Carolina Riverwatch (CCRW) has requested us to analyze wetland degradation and subsequent effects on water quality in Carteret County, NC within the past 25 years. To supplement this analysis, our team will conduct thorough research regarding wetland legislation on the federal, state, and county-level within our study period. This research will aid our team in making the most informed and feasible recommendations for CCRW on how they can urge local policymakers to protect Carteret County wetlands.

Methodology



Over the course of our project, we conducted research on the changes to wetland coverage and associated water quality in Carteret County, NC, as well as changes to wetland protection programs and policies at the federal, state, and county-level that have occurred within the past 25 years. Utilizing our findings, we developed the most feasible policy recommendations that can be implementable in Carteret County to prevent future wetland degradation that will likely occur as a result of recent federal and state changes in wetland protections.

PART 1

A Review of Historical Wetland Degradation Trends

Key Points

Main Findings:

1. We concluded that our analysis of dredge-and-fill data is not generalizable nor helpful in determining wetland degradation.
2. Utilizing C-CAP Land Cover Data, we observed minimal changes in both land development and wetland prevalence.
3. Based on these findings, we cannot conclude there has been notable wetland degradation in Carteret County in the past 25 years.

Our research began by conducting secondary research regarding wetland degradation in Carteret County within the past 25 years via collecting dredge-and-fill permits and various geographical maps. This was further supported through data analysis software, including R and ArcGIS. The lack of adequate organization of dredge-and-fill permits and longitudinal maps created from land cover data ultimately did not provide evidence of significant levels of wetland degradation over our period of study.

Statistical Conceptualization of Wetland Degradation

Dredge-and-Fill Permits

Beginning our data collection, we were first tasked with finding databases with dredge-and-fill (D&F) permits in Carteret County from the last 25 years. Dredge-and-fill permits are required for any project that excavates land or fills in land in any "estuarine waters, tidelands, marshlands, or State-owned lakes" (NC. Gen. Stat. § 113-229, 1975). Looking at D&F permits is important because anytime the seafloor is being moved, raised, or lowered, there is a potential for wetland degradation. CCRW presumed that by finding and organizing the D&F permits from the past 25 years, we could refine our search for wetland degradation and pinpoint where protections are most needed.

Despite this reasonable presumption, the actual pursuit of collecting extensive / detailed D&F permit data and drawing wetland conclusions was inhibited by challenges and limitations explored in *Data Collection* and *Statistical Analysis*.

Data Collection

- *Key Point.* Due to issues of collecting CAMA and D&F permit data from 1998 to 2022 and the high variability in permits (further explained in the *Statistical Analysis*) between years, ranging from 100 (2017) to 830 (2006), we concluded that our analysis is not generalizable nor helpful in achieving our first goal: determining wetland degradation.

Reaching out to the NC DEQ's Department of Coastal Management (DCM), our team was given access to a database of scanned permits. The D&F permits were part of a Laserfiche

database, cataloging all general permits submitted to the DCM, organized by year, going back to 1985. Our initial goal was to isolate the D&F from other general permits, pinpoint their location on a map of Carteret County, and create a map showing any changes in location or intensity over the last 25 years. Splitting the work among our five group members, we each agreed to pour over five years from 1998-2022. Though we were pleased initially with the volume of available data and the analysis we could seemingly perform, it quickly became clear that the organization of the data would be a problem.

Our main issue with the available permits was separating D&F permits and CAMA permits, within a slow, unorganized database. CAMA, The Coastal Area Management Act, protects 20 coastal counties in NC, requiring developers to submit an additional permit when they are developing near a CAMA-protected body of water. This permit requires developers to detail how their development may affect nearby protected waters. Almost every body of water in Carteret County requires a CAMA permit. Each file in the database consisted of a scanned original document, sorted by county. We expected to isolate the permits filed for Carteret County by searching, and then sort out the D&F permits from the CAMA permits. Unfortunately, from 1998-2002, the permitting form did not require a distinction between the two, known simply as “CAMA and Dredge and Fill General Permit". This meant we would have to read through each scanned document to understand the scope of the project, determine whether dredging was done, and note the address. The Laserfiche website provided no method of downloading an entire year of permits all at once, forcing us to click back and forward and scroll often. Coupled with extremely slow loading times, our data entry process was severely stalled.

Similar problems persisted in the later years of our analysis. After 2003, the permit form had a line to check whether it was a D&F or CAMA permit, which did make things easier to enter. However, the loading times to access the scans persisted, and the volume of permits increased, as well. Totaling all the CAMA and D&F permits from 1998-2022, our group would have had to look over 10,500 total permits. The lack of speed and organization in the database made this an inefficient use of our time.

We elected, as a group, to instead analyze the raw number of both types of permits, and observe the trend on a county level, rather than plotting individual addresses. It was disappointing to move this goalpost, but we needed to move on in the interest of time. Regardless of the change, CAMA permits still apply to any development in Carteret County that affects bodies of water. While these may not be related to direct wetland degradation through dredging, we agree that the volume of CAMA permits, along with D&F, could be useful in predicting water quality changes.

Statistical Analysis

After analyzing the data for CAMA and D&F permits which we summarized in Figure 1 and Table 1, we noticed some interesting trends. The total number of permits fluctuated greatly over time, but there were periods with noticeable trends. The database notes years with

hurricanes, but these had little effect on the overall trend. From 1998 until 2006, permits generally increased, peaking in 2006 with 830 permits (Figure 1). After 2006, the permits generally decreased until 2017, with only 100 permits filed in Carteret that year. After 2017, the total number sharply increased, peaking again at 660 in 2021. In total, we observed a negative trend in permits over time. Our regression predicts a decrease of 4.6 permits each year. We don't think that this trend is generalizable over the last 25 years because of the high variability in permits. We concluded that the GIS data would be more helpful in analyzing longitudinal wetland degradation.

Figure 1 & Table 1: Dredge & Fill Permits Trend

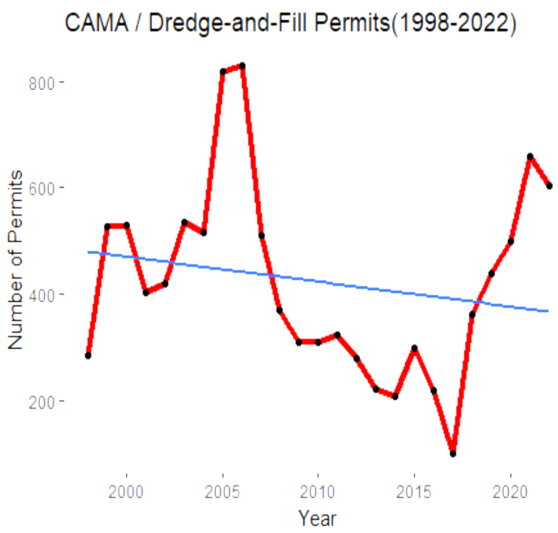


Table 1: Regression Results

Dependent variable: *Number of Permits*	
Years	-4.689
	(5.075)
Constant	479.591***
	(71.055)
Observations	25
R^2	0.036
Adjusted R^2	-0.006
Residual Std. Error	182.994 (df = 23)
F Statistic	0.854 (df = 1; 23)

Note: *p<0.1; **p<0.05; ***p<0.01

Notes. Figure and table created using data collected from NCDEQ Division of Coastal Management.

The Coastal Change Analysis Program (C-CAP)

Due to our initial plan of just utilizing dredge-and-fill permits to evaluate wetland degradation not meeting our expectations, we decided to alter our approach and look at raw indicators of land cover measured at the county-level. Impervious surfaces - or the land cover equivalent of urban development - can be used to evaluate wetland degradation and is highly correlated with water quality impairments (see Appendix A).

We discovered an overwhelming amount of data from the NOAA, but most were contained in reports that aggregated findings that were nationally representative. Ultimately, we discovered that our best tool to analyze data at the smallest scale was by using NOAAs C-CAP Regional Land Cover and Change Tool, so that we could filter by state and choose to customize reporting at the county level and watershed. County-level reports are uniform and available for all 100 NC counties, but we decided to look solely at Carteret County for clarity of analysis.

Although C-CAP provided substantive data regarding relevant land cover classifications, we explain within *Utilization and Analysis* how the data did not indicate the occurrence of significant levels of wetland degradation within Carteret County over the past 25 years.

Database Information

The National Oceanic and Atmospheric Administration (NOAA) is the primary agency responsible for the Coastal Change Analysis Program (C-CAP). The C-CAP focuses specifically on developing and utilizing regional land cover data of coastal zones in order to analyze change over time through 22 standardized classifications of ecosystems (NC, n.d.-b). These classifications include 6 relevant to wetlands: palustrine forested wetland, palustrine scrub / shrub wetland, palustrine emergent wetland, estuarine forested wetland, estuarine scrub / shrub wetland, and estuarine emergent wetland (NOAA, n.d.-b).

It is important to also make note of the differences between the C-CAP and the National Wetlands Inventory (NWI), the leading resource that provides information about the nation's wetlands, riparian, and deepwater habitats (US Fish, n.d.), and our rationale for selecting NOAA's program. Despite not having as extensive wetland classifications as the NWI, the C-CAP provides data that can be used longitudinally in ways that the NWI does not. Instead, data from the NWI provides accurate information on current wetlands but does not provide accessible historic data.

Furthermore, the C-CAP utilizes the same definitions of Developed Land and produces datasets for the same years as the National Land Cover Database (NCLD). The NCLD will be further explained in *GIS Conceptualization of Wetland Degradation.* The datasets from C-CAP can be used in tandem with the NCLD to analyze changes in both impervious surfaces and wetland prevalence / boundaries. Ultimately, NOAA and the C-CAP was determined to be a more applicable resource than the NWI for the parameters of our research.

Utilization and Analysis

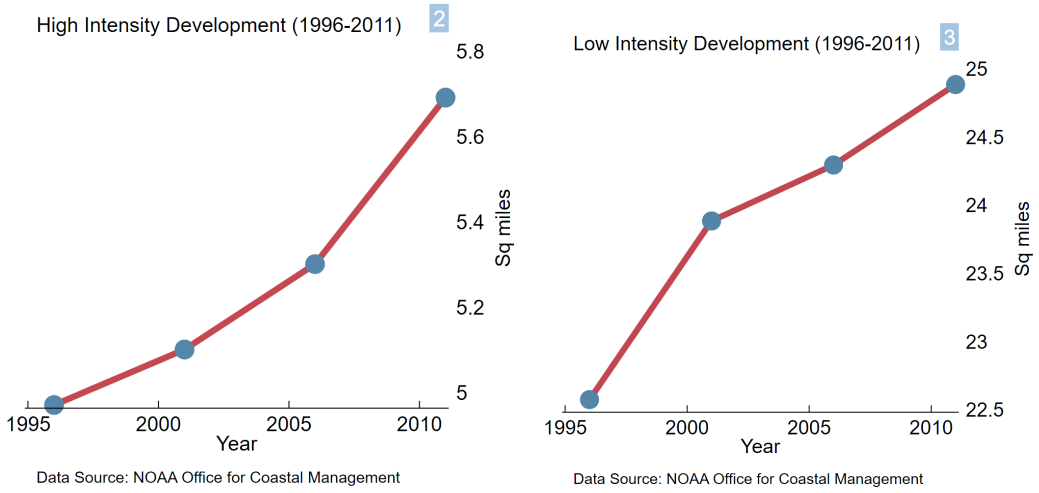
- *Key point.* Through the creation of scatter plots and following analyses of C-CAP data, we observed minimal changes in both land development and wetland prevalence. We were unable to draw viable conclusions from these observations due to limitations of C-CAP data, including the scarcity of data and various recategorization of wetlands from one type to another. This contributes to the narrative that wetlands in Carteret County have not experienced substantial degradation over the past 25 years.

The C-CAP Land Cover Atlas created by the NOAA Office for Coastal Management provides county level land cover statistics and data summary sheets for various land cover categories (NOAA, n.d. -c). Land cover categories for the available years of 1996, 2001, 2006, and 2011 are expressed in square miles and properly labeled according to their geographical

characteristics. One limitation of this tool is that corresponding reports are limited to displaying land cover category fluctuations between only two selected years of interest, for instance 1996 to 2001. In order to conduct a longitudinal analysis on all 4 available reported years, land category data for each reported year was coded in a newly created Stata dataset and labeled appropriately. Two-way scatter plot visualizations were created for land cover categories of interest, in particular with distinct focuses on the two areas of development changes and wetland land cover changes.

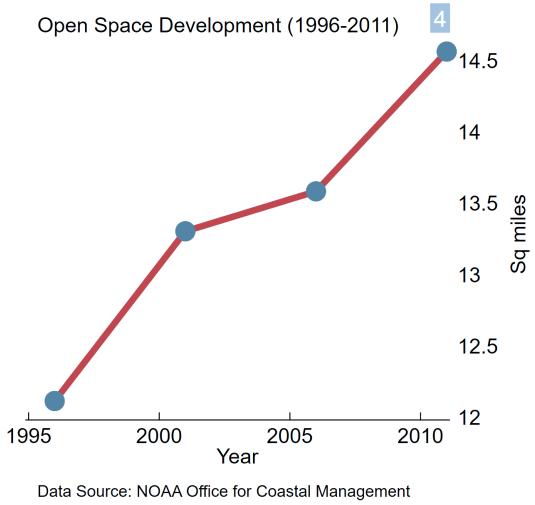
We observe minimal changes in high intensity development, with high intensity development plotted in Figure 2 increasing by less than a square mile during our period of interest and low intensity development plotted in Figure 3 increasing by roughly 2.5 square miles during the same period. This difference is most likely explained by the type of development done during this period. Since Carteret County is not a highly industrialized county given its maritime local economy and spread out population, low intensity development is expected to outpace high intensity development. Plausible explanations for more low intensity development are related to single family household development in the county in contrast to highly industrialized and commercial buildings. Increases in high and low intensity development have increased from the last recorded data point, but the slopes differ, indicating that gaps between recorded gaps observe faster rates of development than others. Open space development plotted in Figure 4 has increased by roughly 2.5 square miles, following a similar increase along low intensity development, despite making up a lower proportion of total development. Open development could include parks, recreational areas, and areas where constructed materials are minimal to the landscape. Overall, low intensity development is the most common type of development in the area, likely indicative of single family housing construction to meet county population growth over the timeframe.

Figures 2 & 3: Trends of High & Low Intensity Development in Carteret County



Notes. Created from C-CAP Regional Land Cover and Change (2023). Y-axis represent different scales, but both are measured in square mileage. Years between those listed on the graph have no reported data.

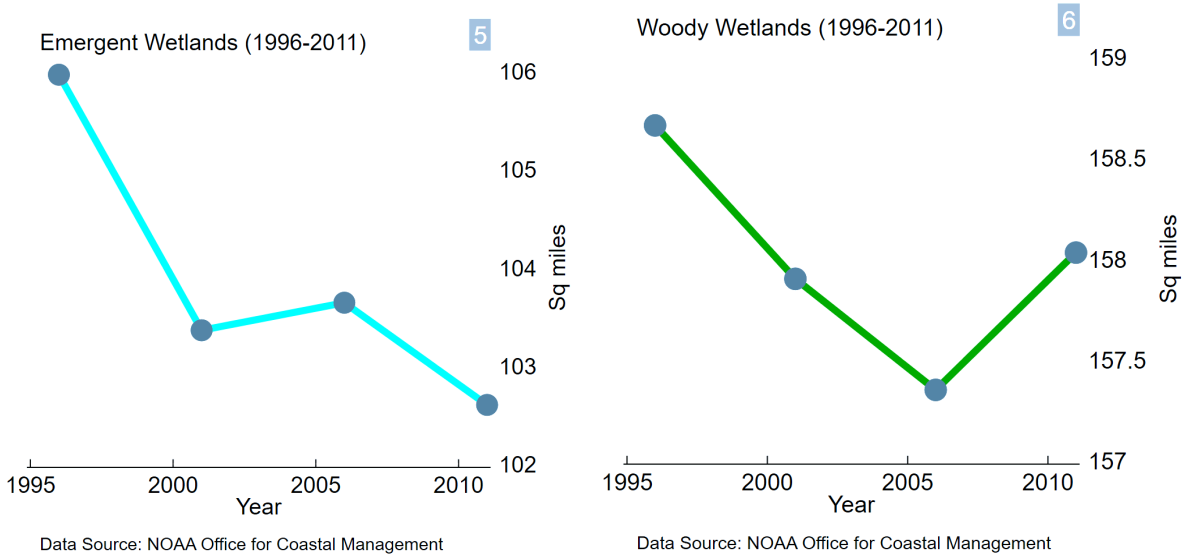
Figure 4: Trend of Open Space Development in Carteret County



Notes. Created from C-CAP Regional Land Cover and Change (2023). Y-axis represent different scales, but both are measured in square mileage. Years between those listed on the graph have no reported data.

In addition to minimal increases in development trends we observe minimal decreases in wetland prevalence in Carteret County in Figures 5 and 6. Emergent Wetlands have decreased by roughly 3 square miles and Woody Wetlands initially decreasing by roughly 1.5 square miles from 1996 to 2006, but regained 0.5 square miles between 2006 and 2011. Overall, Woody Wetlands are the most common type of wetlands in Carteret County, as visible by the y-axis.

Figures 5 & 6: Trends of Wetland Classification Degradation in Carteret County



Notes. Created from C-CAP Regional Land Cover and Change (2023). Y-axis represent different scales, but both are measured in square mileage. Years between those listed on the graph have no reported data.

There are several important considerations worth mentioning when interpreting the trend analysis on the development and wetland land cover categories. First, there are limitations in the trend analysis due to the scarcity of data points we have, as we only have 4 reported years. If more years were available, additional data points could be plotted and a more accurate year-by-year analysis could be done for a 20+ year period. Secondly, there are several assumptions one has to be careful about when interpreting the data, including the consideration that one type of wetland category loses prevalence due to recategorization into another type of wetland. For example, Emergent Wetland prevalence could be decreasing because some of them now fall under the criteria of a Woody Wetland. Although this analysis is insightful in demonstrating the general stability of these geographical features in Carteret County, it is only one component of our analysis needed to build a bigger picture.

GIS Conceptualization of Wetland Degradation

Our third strategy for determining wetland degradation in Carteret County over the last 25 years was to collect and utilize different GIS maps that visualize wetland boundaries/classifications, impervious surfaces, and urban development. We initially hoped to collect these maps primarily from local sources in order to gain data with the most specificity and accuracy. However, after communicating with many contacts across county- and state-level municipalities, it became clear that GIS data most relevant to changes in wetland degradation would come exclusively from federal databases. After analyzing federal databases in great detail, we selected the NCLD to utilize for our geospatial analyses.

As we elaborate within *Utilization and Analysis*, our results from using the NCLD corroborate our findings from our regressions of C-CAP data: there has been minimal change in wetland and impervious surface prevalence in Carteret County over the past 25 years.

The NCLD was the exclusive contender for land cover data related to impervious surface and urban development due to its potential for longitudinal comparisons and specificity of differing levels of development. Furthermore, the MRLC ensures that this dataset takes information from various federal agencies that measure different aspects of land data and classifications (Multi-Resolution, n.d.-a). The North Carolina State University (NSCU) Libraries website maintains an extracted version of the national data that is re-projected to the NC state plane (NC State, n.d.-a). In order to reduce file size and streamline the geospatial analysis process we utilized the NCSU University Libraries repository version. Since each shapefile includes detailed raster level data that uses different symbologies to represent various land category layers for all 100 NC counties, we reduced the scope to Carteret County.

Table 2: Definitions of the Modified Anderson Land Cover Classification System

Land Classification	NCLD Description
Grouped by Impervious Surfaces	
Developed, High Intensity (HI)	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial / industrial. Impervious surfaces account for 80% to 100% of total cover.
Developed, Medium Intensity (MI)	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
Developed, Low Intensity (LI)	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
Developed Open Space (OS)	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Grouped by Wetlands	
Woody Wetlands (WW)	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands (EHW)	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Notes. Adapted from *Multi-Resolution Land Characteristics Consortium Class Legend and Description (n.d.-b)*. The National Land Cover Database (NCLD), managed directly by the U.S. Geological Service (USGS) but contributed to by a multitude of agencies within the Multi-Resolution Land Characteristics Consortium (US Department, n.d.). The NCLD utilizes a modified version of the Anderson Land Cover Classification System to classify different types of land cover..

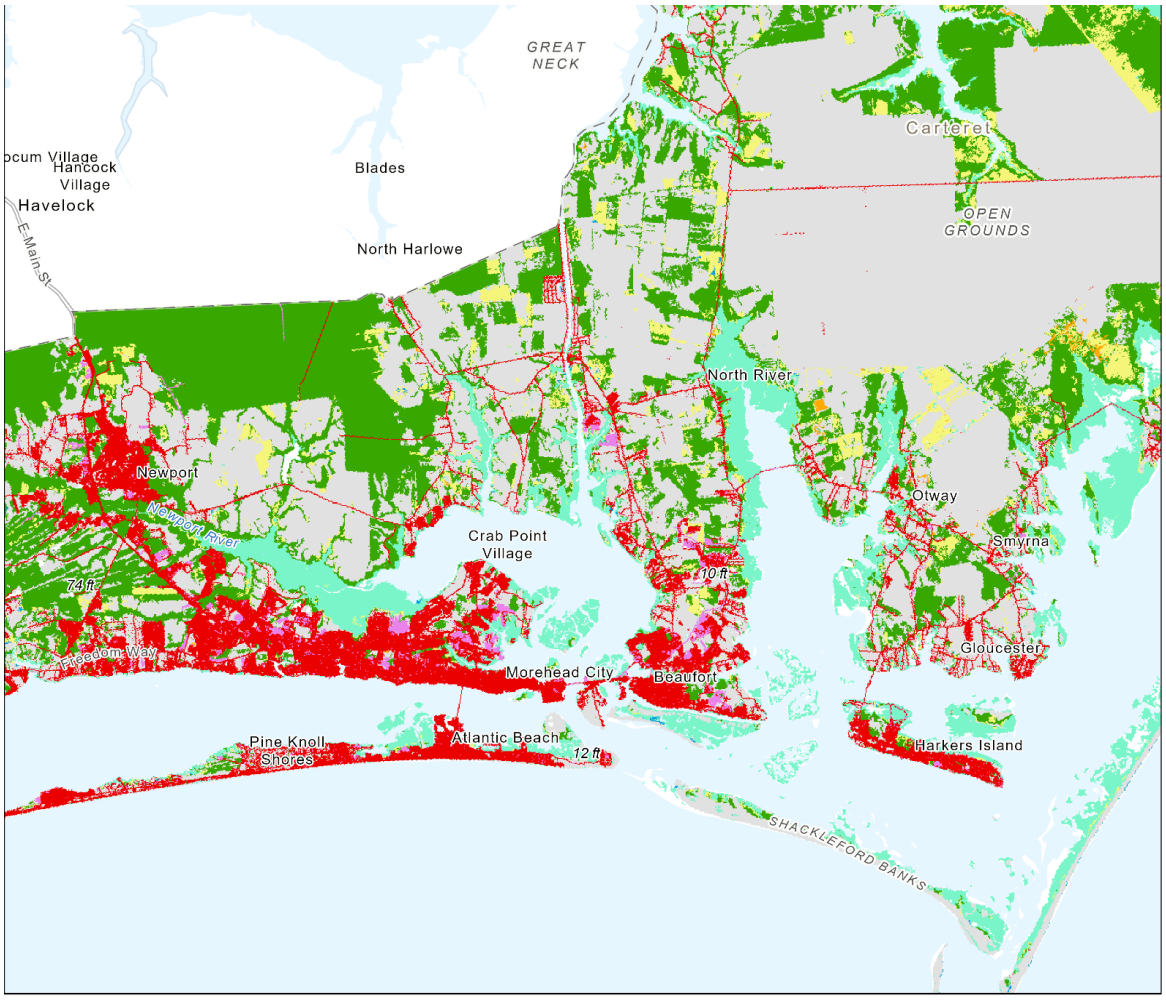
Utilization and Analysis

- *Key point.* By utilizing NCLD data within ArcGIS analysis, we were able to visualize differences in impervious surfaces and wetland classification between years 2001 and 2019. As seen in the change index, we observed urban change indicative of development into areas originally recorded as wetlands or non-impervious surfaces, although these changes were minimal. This further supports our previous findings that wetlands in Carteret County have not experienced substantial degradation over the past 25 years.

In order to clip NCLD data to Carteret County on ArcGIS, we utilized TIGER/Line datasets from the U.S. Census Bureau as our primary source for county-level boundaries (US Census, 2022). Despite county boundaries changing over time, we used the 2022 dataset for each analysis. After extracting the statewide data using the Census county-level boundary for Carteret County, we were able to create layers that visualized land cover categories within the Carteret County Census boundary to visualize and compare changes in impervious surfaces and wetlands per selected NCLD survey year. Given the crowded symbology for all available land categories, non-wetland land categories were grouped together and open water pixelation was made transparent. After creating side-by-side map visualizations, it became clear that identifying land category changes between years was difficult to analyze by viewing minimal changes in the raster data pixelations. In order to observe change over time from 2001 to 2019, we utilized a change index to observe changes in impervious surface coverage and wetlands prevalence. The following change index was used as a raster dataset, extracted for Carteret County using the 2022 Census boundary and altered from its default symbology for easier interpretation.

Figure 7 uses the most recent NLCD shapefile for 2019 as the baseline year. Additionally, the change index is layered simultaneously with the 2019 base year to show impervious surfaces and wetland prevalence across a majority of the Carteret County landscape. A high volume of impervious surfaces are concentrated in the area surrounding Morehead City, Beaufort, Newport, and Atlantic Beach, which are all municipalities where a high percentage of the county population resides. Woody wetlands and Emergent Herbaceous Wetlands are located in close and distant proximities to areas of development, where a noticeable patch of Emergent Herbaceous Wetlands borders the northwest portion of Morehead City and east of North River. Although most of these wetlands have remained from the 2001-2019 period, the urban change represented by pink shading is indicative of development into these areas originally recorded as wetlands or non-impervious surfaces. Most urban change extends from originally impervious surface pixelated areas, which can be interpreted as expansion of municipal/town development and economic growth during this 18-year period. Wetland within class change represented by yellow pixelation is indicative that wetland categorization has altered during the time frame, meaning that herbaceous wetlands are not considered woody wetlands or vice versa. Woody Wetland change and Herbaceous Wetland change is less prominent across our scope, indicating that there has been minimal increases in new wetlands during this period.

Figure 7 : Land Cover Change Index in Carteret County (2001-2019)



Notes. Adapted from *NC State University Libraries (n.d.-b)*. This ArcGIS map's symbology is described by the associated legend. Light gray shading includes all non-wetland and non-impervious surfaces geographical features. This map does not represent the full extent of Carteret County, but rather scaled to see more detailed symbology.

Summary of Part 1 Findings

Our research indicates that Carteret County has not experienced notable levels of wetland degradation in the past 25 years. Through visual interpretation of impervious surface/development maps, there has not been a substantial decrease in wetland prevalence since 1998. Additionally, there have been no significant increases in development over the past 25 years, explaining why little to no wetland degradation has been seen. The lack of wetland degradation and development over the past 25 years can potentially be attributed to the protections that have existed for wetlands since 1972 under the Clean Water Act (CWA) and additional protections put in place under North Carolina state law, as we will explore in *Part 3*. However, as previously mentioned, recent legislative changes have put NC wetlands at risk. Since these decisions are so recent, there have not been any noticeable changes in North Carolina thus far, as affirmed through our research. The implications of these policy decisions could put over 2.5 million acres of wetlands in NC at risk (Sorg, 2023).

PART 2

A Review of Potential Water Quality Indicators

Key Points

Main Findings:

1. 5 key indicators were analyzed for trends, but much of the data was fragmented or incomplete.
2. Regressions of indicators failed to produce a generalizable depiction of Carteret County's water quality.
3. The reality of wetland health is difficult to see without more organized and comprehensive data sources.

Our research began by conducting secondary research regarding water quality in Carteret County within the past 25 years utilizing 5 water quality indicators: harmful algae blooms, swim advisories, shellfish closures, 303(d) listings, and economic impacts of recreation. The fragmentation of sources providing water quality data contributed to our inability to determine a clear trend in water quality over our period of study.

Harmful Algae Blooms

The first indicator utilized in our analysis of water quality was the presence of harmful algae blooms in Carteret County over the past 25 years. Through data collection via secondary research and contacting sources at the North Carolina Department of Environmental Quality (NCDEQ), we were able to compile a dataset on reports of harmful algae blooms since 1999. From the results of our statistical analysis, we concluded that there is no noticeable trend in the data. It appears that there has been a decrease in the number of reports in the past 5 years, however, this can be attributed to our data limitations. Therefore, we cannot conclude whether wetland degradation has influenced the presence of harmful algae blooms in Carteret County due to harmful blooms being an unreliable proxy for water quality.

Methods and Data Collection

We assumed that there would be scientific documentation of harmful algae blooms that could be accessed through secondary research. Through this internet search, we found an ArcGIS dashboard on the NCDEQ's website, which showed citizen reports of fish kills and algal blooms in North Carolina. However, it only showed reports from 2019 until present day. Since our analysis focused on changes in the past 25 years, we extended our search to other sources to obtain data outside of the dashboard's date range. We reached out via email to two contacts who work in the NCDEQ's Division of Water Resources (DWR): Elizabeth Fensin, who is an Algal Ecologist, and Dan Wiltsie, who is an Algal Bloom Response Coordinator. They were able to provide a dataset of documented algae blooms from 1999-2016 which included where in Carteret County the bloom was located, what date it was recorded, the density of the bloom, and the

dominant type of algae in the bloom. We took this dataset and combined it with the reports from the Fish Kill & Algal Bloom Report Dashboard to create our own dataset we utilized for our statistical analysis and overview of water quality using harmful algae blooms as a proxy.

One limitation we encountered with the data we collected was the change in the methods of recording and reporting of algae blooms. Prior to the creation of the Fish Kill & Algal Bloom Report dashboard, Fensin was responsible for compiling the data of reported algae blooms. She explained that most of the algae blooms reported from 1999-2016 were in areas that were regularly monitored by the DWR. After the dashboard was created in 2019, the blooms recorded were solely citizen reports. An additional limitation is the two-year gap between when the dashboard was created and when the provided algae bloom dataset ends, meaning there is no data recorded for the years 2017 and 2018.

Types of Algae Blooms

Algae blooms occur when there is an overgrowth of bacteria in a body of water and the type of algae present determines whether the bloom is harmful or not (US Environmental, 2023a). There are three main types of algae that, when present, can cause harm to humans, animals, and the environment: cyanobacteria (more commonly known as blue-green algae), dinoflagellates, and diatoms (CDC, n.d.). The dataset provided by the NCDEQ indicated the dominant algae type in each reported bloom. The list included algae blooms regardless of whether they contained harmful algae, so we cleaned the data to only include harmful blooms. In total, there have been 83 recorded algae blooms from 1999 until present day. Among the algae blooms reported, 75 of them predominantly contained harmful algae. The most common type of harmful algae present in blooms were diatoms, occurring in 72 of the blooms. Dinoflagellates were present in 5 blooms and blue-green algae in 4 blooms. There were some blooms that contained multiple types of dominant algae, such as diatoms and blue-green algae, diatoms and dinoflagellates, or diatoms and another type of algae that is not harmful.

Location of Blooms

Table 3 shows the location and frequency of recorded harmful algae blooms in Carteret County since 1999. Out of the harmful algae blooms recorded, approximately 70.7% were located in Calico Creek. Fensin originally pointed this out to our team and suggested that the high concentration of algae blooms in this location was due to Calico Creek's proximity to a wastewater treatment plant. Upon further investigation, our team found that Calico Creek has been listed as a Category 5 impaired waterbody on North Carolina's 303(d) list since 2008 (North Carolina, 2021). Based on the 2022 Integrated Report, Calico Creek is still listed as a Category 5 impaired body of water (NCDEQ, n.d.-a). This can be attributed to the Morehead City Wastewater Treatment Plant (WWTP) which has been recognized as a single-point source of pollution and majorly responsible for Calico Creek's water quality issues (North Carolina,

2021). Between 2008 and 2010, the Morehead City WWTP underwent upgrades with the goal of limiting the flow of nutrients and waste being discharged into Calico Creek (North Carolina, 2021). After the upgrade, there were decreases in some nutrients being discharged, however, monitoring data reported no significant differences of algae density in Calico Creek (North Carolina, 2021). Therefore, we are unable to conclude whether the presence of algae blooms in Carteret County (particularly Calico Creek) can be attributed to wetland degradation or if it's due to sources of pollution, such as the Morehead City WWTP.

Table 3: Locations of Total Harmful Algae Blooms in Carteret County since 1999

Location	Number of Harmful Blooms
North River	4
Ward Creek	3
Broad Creek	3
W. Thorofare Bay	1
Calico Creek	53
Neuse River	2
Jonaquin Creek	1
Back Creek	7
South River	1

Notes. Created using data provided from NCDEQ Division of Water Resources' recorded algae bloom dataset (recorded data 1999-2016) and Fish Kill & Algae Bloom Dashboard (recorded data 2019-2023).

Statistical Analysis

- *Key point.* The results of our statistical analysis show that the number of harmful algae blooms fluctuates considerably each year and there is no noticeable trend. Despite the apparent decrease in harmful algae blooms in recent years, we cannot conclude this to be an accurate representation due to the changes in recording algae bloom presence.

Figure 8 and Table 4 summarize the results of the statistical analysis of harmful algae blooms. As seen in Figure 8, the number of algae blooms fluctuates considerably each year. The line of best fit shows there has been an overall decreasing trend in algae blooms per year. However, the R^2 value of 0.054 tells us that the line of best fit does not accurately reflect the data. This is supported by the peak of 12 algae blooms in 2007 and then 0 algae blooms from 2017-2023. Additionally, we can use the p-value of the regression to see whether there is a trend

or not in the dataset. Given that there is no "*" by the *Constant* value in Table 4, we can conclude that there is no trend between the distribution of variables. Therefore, based on the results of our regression, there is no trend of how many harmful algae blooms have occurred since 1999. While there have been no reports of algae blooms since 2016, the decreasing line of best fit is not reflective of the variables in the dataset, which is supported by the R^2 value.

As seen in Figure 8, there have been no reports of any algae blooms since 2017. However, this could be attributed to the lack of data for 2017-2018 and the changes in recording bloom activity, which was previously discussed in *Methods and Data Collection*. Therefore, it is unclear whether the decrease in bloom activity is reflective of actual bloom activity and water quality, or if it is a consequence of the limitations in our data.

Figure 8 & Table 4: Algae Bloom Analysis

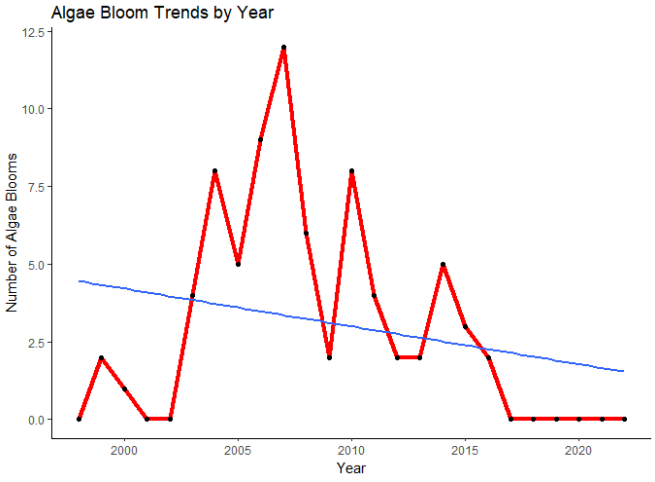


Table 4: Harmful Algae Blooms Regression Results

	Dependent variable: *Number of Harmful Blooms*
Years	0.169
	(0.148)
Constant	2.489
	(2.066)
Observations	25
R2	0.054
Adjusted R2	0.013
Residual Std. Error	5.320 (df = 23)
F Statistic	1.315 (df = 1; 23)
Note:	*p<0.1; **p<0.05; ***p<0.01

Notes. Created using data provided from NCDEQ Division of Water Resources' recorded algae bloom dataset (recorded data 1999-2016) and Fish Kill & Algae Bloom Dashboard (recorded data 2019-2023).

Swim Advisories

The second bureaucratic indicator we utilized as a proxy for water quality was official swimming advisories. We initially believed that these warnings would be issued and maintained at the county-level through the Carteret County Environmental Health Department, but we were quickly informed by the department director that the North Carolina Department of Environmental Quality (NCDEQ) was the only agency responsible for issuing swimming advisories and notifications for all coastal counties in the state. More specifically, water monitoring and health warnings fall under the jurisdiction of the NCDEQ's Recreational Water Quality Program.

Even though we quickly received detailed swim advisory reports for our desired years of study, the utilization of these advisories as an indicator of water quality was inhibited by

limitations related to narrow state-level collection of data, as described in the following two sections. The inability for us to use swim advisories as a reliable proxy is further corroborated by the regression results discussed in *Data Collection & Statistical Analyses.*

The Recreational Water Quality Program

The Recreational Water Quality Program, following the guidance of the EPA's BEACH Act (2000), closely surveys ocean beaches, sounds, bays, and estuarine rivers for the presence of enterococcus bacteria (North Carolina, n.d.-b). This bacteria, although not directly harmful to humans, is used to represent the contamination of water sources by fecal material, most commonly by wastewater treatment plants, sewage and septic discharge, domestic animal and wildlife waste, agricultural application of manure, and run-off from various agrarian lands (US Environmental, 2023b). The presence of fecal matter in recreational waters can also be representative of the presence of disease-causing bacteria, viruses, and protozoa that are not only transmitted through direct contact, but also by eating fish or shellfish harvested from the contaminated source (US Environmental, 2023b).

Swimming advisories are issued by the Recreational Water Quality Program when levels of enterococcus bacteria have "exceeded EPA standards for two consecutive tests or… for five samples collected within thirty days" (North Carolina, n.d.-b). From April to September, the program analyzes data from swimming locations weekly to twice a month. Testing for all sites decreases to twice a month in October and to once a month for the duration of non-swimming season (November to March) (North Carolina, n.d.-b).

Although only adjacently related to swimming advisories, we were disappointed to learn that the program does not collect data beyond enterococcus bacterial levels. To ensure robust protections, wetlands require different water quality standards (WQS) than other surface water resources (US Environmental, 2023c). As discussed in the EPA's 2008 *Nutrient Criteria Technical Guidance Manual for Wetlands*, data pertaining to wetlands' hydrology, soil, and vegetation are all important measures for wetland health and safety (Office, 2008, p. 22-24). However, NC does not have a formal, ongoing wetland monitoring program (National Association, 2015, p. 7). This lack of broad state-level monitoring and documentation represents a significant limitation in our research / ability to evaluate a wide variety of water quality indicators.

Data Collection & Statistical Analyses

- *Key point.* Through analysis of two separate regressions by years 1998 to 2022 - one of total swim advisories issued and the other of total number of days with active swim advisories - we concluded that this data is not generalizable for the purposes of analyzing water quality due to limitations of the data source and repeatedly high variability.

Despite the program's website maintaining an archival list of advisories issued since 2005, we were concerned about the accuracy of the data provided and desired information dating back to 1998. We contacted Erin Bryan-Millush, the manager of the Recreational Water Quality Program, in order to gain access to current and historical data directly from NCDEQ databases. The official records for the years included online varied slightly from the website archive. In order to ensure uniform data collection and hopefully garner the most clear-cut examination of swimming advisory trends, we opted to utilize only the 113 advisories recorded in the government resource for Carteret County between 1998 and 2022.

As seen in Figure 9 and Table 5, the number of swim advisories issued per year does not correlate to a particular trend despite a positive line of best fit. This is greatly reflected in the table through analyzing the R^2 and p-values. The p-value determines whether a trend exists within a dataset by calculating how probable the null hypothesis is for our data. In this case, the null hypothesis is simply that there is no trend at all. This value is high, as indicated by the lack of any "*" by the *Constant*, and therefore confirms the null hypothesis and signals that there is not a viable mathematical trend that can explain the dispersion of data points seen in Figure 9. Furthermore the R^2, which indicates how accurately the line of best fit represents the data, is measured between 0 and 1. This value is 0.03 - extremely close to 0 - which signifies that the trend is not an adequate representation of the relationship between the variables. This can be visualized in the wide variation of swim advisories issued in Carteret County per year, with the minimum being 0 in multiple years and the peak being 25 in 2014.

Figure 9 & Table 5: Swim Advisory Analysis

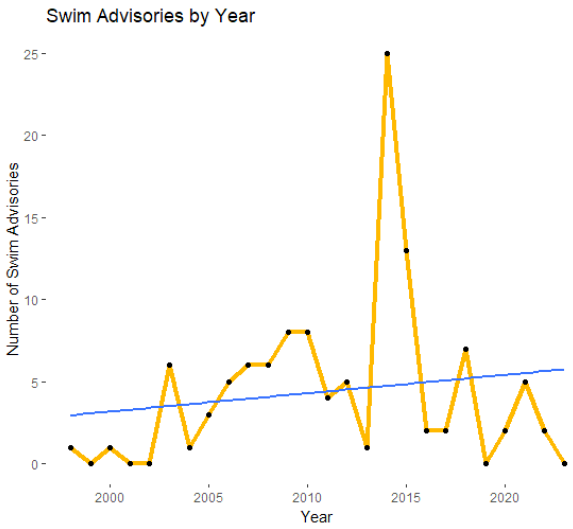


Table 3: Total Swim Advisories Regression Results

	Dependent variable:
	num_advisories
years	0.112
	(0.140)
Constant	2.949
	(2.043)
Observations	26
R2	0.026
Adjusted R2	-0.015
Residual Std. Error	5.360 (df = 24)
F Statistic	0.636 (df = 1; 24)
Note:	*p<0.1; **p<0.05; ***p<0.01

Notes. Created using data from Recreational Water Quality Program, NCDEQ.

The year 2014 is a clear outlier in our collected data, with 12 more advisories being issued than the next highest year (2013). This can potentially be explained by the arrival of

Hurricane Arthur on the shores of coastal NC in July, 2014. According to an annual hurricane season summary report issued by the National Oceanic and Atmospheric Administration (NOAA), Arthur first made contact with Cape Lookout - a popular recreation area within Carteret County - after accelerating across the Atlantic Ocean (National Oceanic, 2015, p. 3). Arthur was the "earliest hurricane to make landfall in North Carolina since records began in 1851," and caused significant damage to the Outer Banks and nearby Dare County. These damages were predominantly the result of storm surge flooding (National Oceanic, 2015, p. 4).

As previously described, one of the primary ways in which enterococcus bacteria enters water sources is through run-off from various agricultural sites. With Arthur making initial landfall in Carteret County, the combination of rainfall and storm surge flooding could be a likely culprit for the significant increase in swim advisories issued that year. Per the 2014 report provided by the Recreational Water Quality Program, 15 of these advisories were issued within the four weeks immediately following the arrival of this hurricane.

It is also important to note that while these records differentiate between counties, they do not indicate the exact location of the testing site beyond a brief description. Therefore, we were unable to determine which reports correlate to wetland-specific or wetland-adjacent waters. The advisory reports did, however, indicate the total number of days in which a given report was active in Carteret County. In order to exhaust all possible avenues of utilizing the swim advisories, we conducted a second regression that examined the potential relationship between the total number of days in which a swim advisory was active by year. This is summarized in Figure 10 and Table 6.

Figure 10 & Table 6: Swim Advisories Analysis

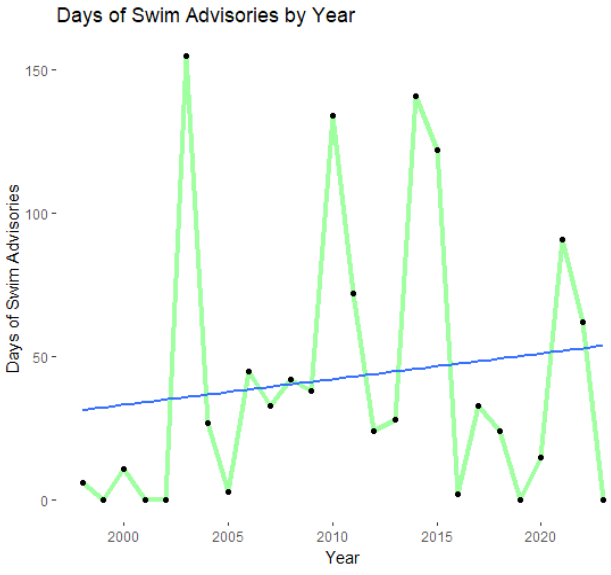


Table 4: Total Swim Advisories (Days) Regression Results

	Dependent variable:
	days_advisories
years	0.895
	(1.265)
Constant	31.427
	(18.435)
Observations	26
R2	0.020
Adjusted R2	-0.020
Residual Std. Error	48.363 (df = 24)
F Statistic	0.501 (df = 1; 24)
Note:	*p<0.1; **p<0.05; ***p<0.01

Notes: Created using data from Recreational Water Quality Program, NCDEQ.

Similar to what was discovered from the regression for Figure 9 and Table 5, we were unable to draw any conclusions from the line of best fit. This can yet again be seen when interpreting the R^2 and p-values present in Table 6. The p-value is high, indicating that there is not a mathematical trend that can accurately explain the pattern of data points visualized in Figure 10. Additionally, the R^2 value is extremely close to 0 at 0.02. Just as previously emphasized, this low R^2 value indicates the way in which this trend line does not fit our data. This is supported by how the variability in total days is much more extreme than that of total swim advisories.

In summary, based on limitations pertaining to the swim advisories themselves and our two regression results, we concluded that the predicted trends are not generalizable and do not provide an adequate means of determining water quality within Carteret County.

Shellfish Closures

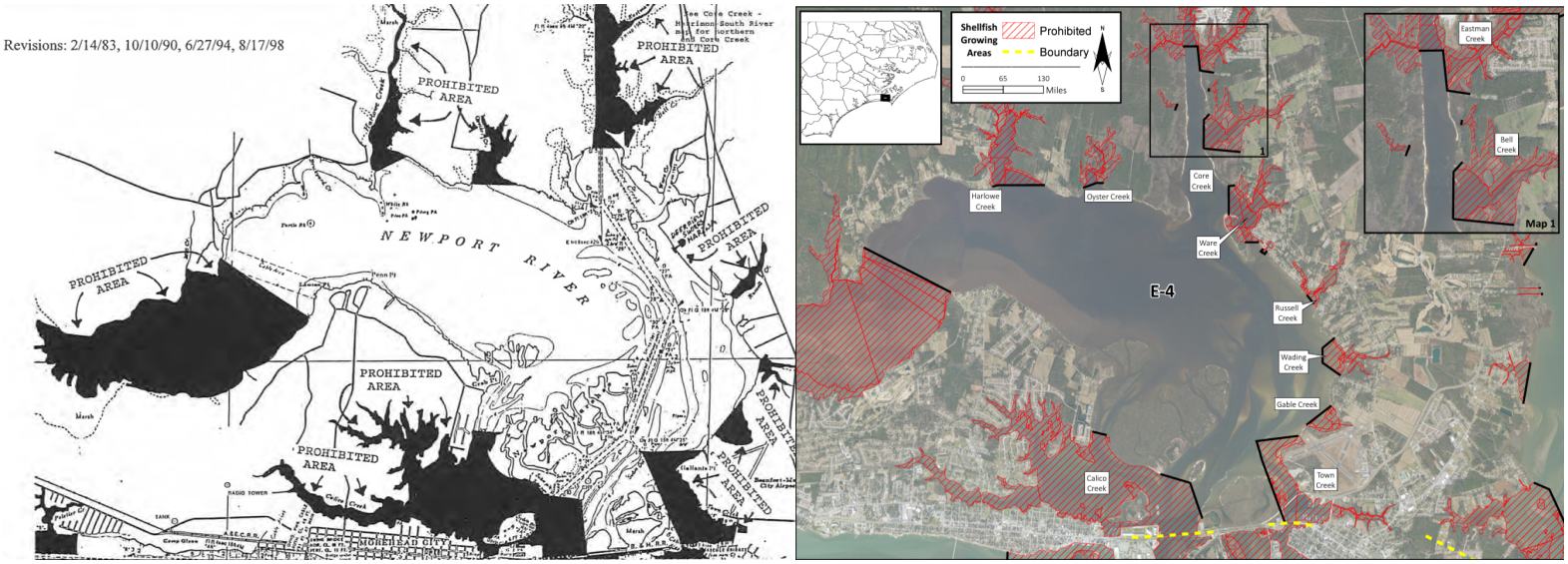
Growing Area Map Analyses

As keystone species, shellfish can be one of the best indicators of the water quality in its ecosystem. Shellfish growth areas are where oyster and other shellfish harvesting is done. The NCDEQ Division of Marine Fisheries routinely tests the water in these areas for bacteria, closing the site if there is too much contamination, particularly of fecal coliform bacteria. Harvesting shellfish when bacteria levels are too high presents the risk of contaminating surrounding waters further. If an area becomes too contaminated over a long period of time, it will become permanently closed. By looking at key growing areas and how their permanent closures have changed over time, we can compare closures to trends in wetland degradation. We selected the Newport, North, and White Oak River growing areas, because of their prominence within Carteret County.

- *Key point.* After comparing and contrasting three different historical growing area maps in Carteret County with those of 2022, we have concluded that each area experienced slight increases in permanent shellfish closures over the past 25 years, though no dramatic shifts have occurred.

Figure 11: Newport River Growing Area (Area E-4)

1998 Closure Map **vs** **2022 Closure Ma**

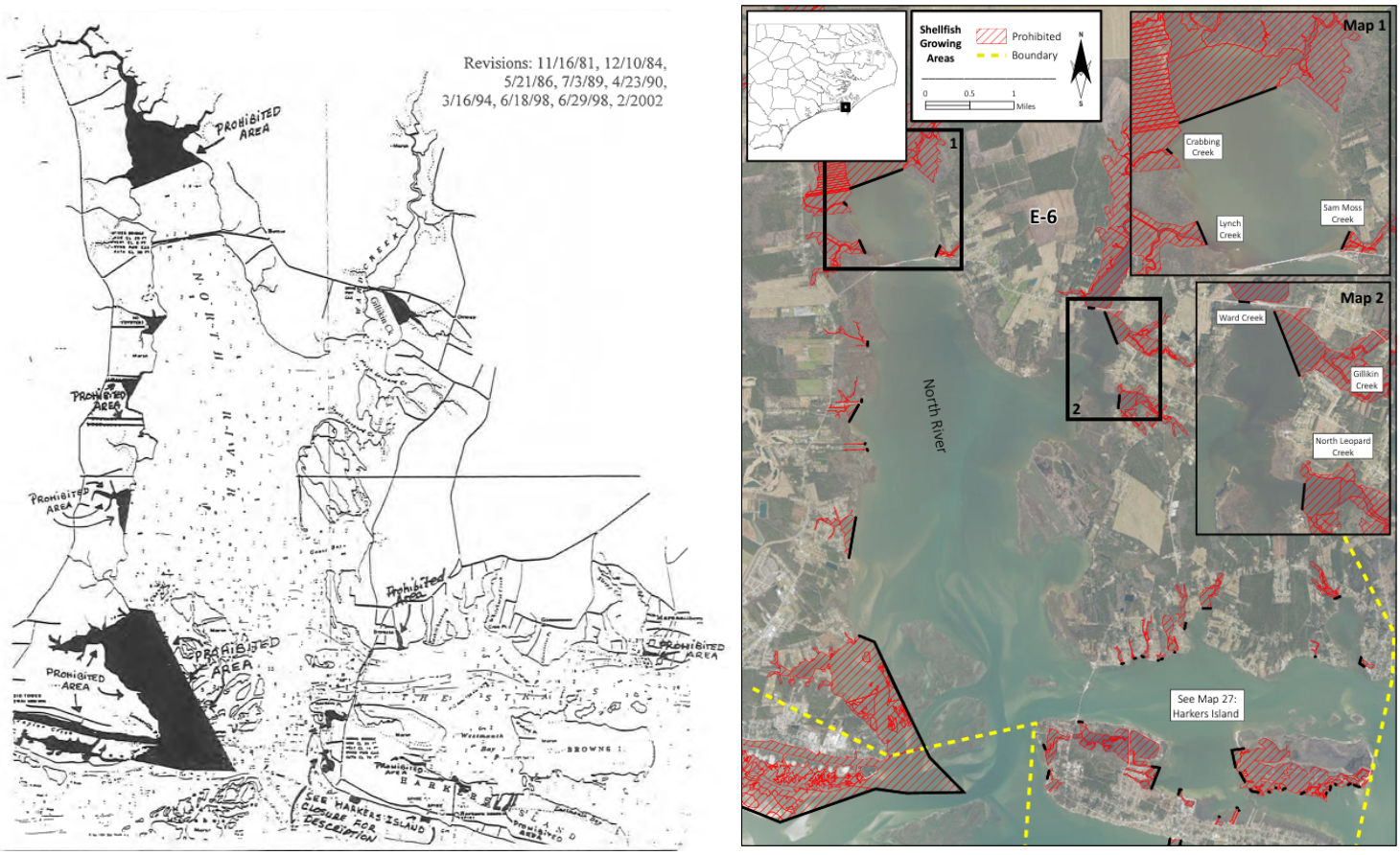


Notes. From the NCDEQ, E-4 HISTORY Division of Marine Fisheries – Shellfish Sanitation and Recreational Water Quality Section.

According to the NCDEQ Division of Marine Fisheries, "no other shellfish growing area has been as extensively studied as the Newport River (E-4 HISTORY, 2022)." Maps and surveys of the shellfish growing areas in the Newport River date back to 1969. Looking at the past 25 years specifically, the permanent closures have remained mostly consistent. The large prohibited areas have remained permanently closed, and there has been little change in the growing areas in smaller creeks. One notable change is the permanent closure of the Ware Creek growing area, occurring in the early 2000s. This small decline in the growing area is somewhat offset by the redrawing of the Core Creek prohibited growing areas. This change can be seen in the Northwest of each map, as well as in the magnified area in the 2022 map. This small gain in the growing area occurred in 2020. Overall, the permanent closures in the Newport River have experienced little changes in the total area which is consistent with previously discovered trends in wetland degradation.

Figure 12: North River Growing Area (Area E-6)

2002 Closure Map **vs** **2022 Closure Map**

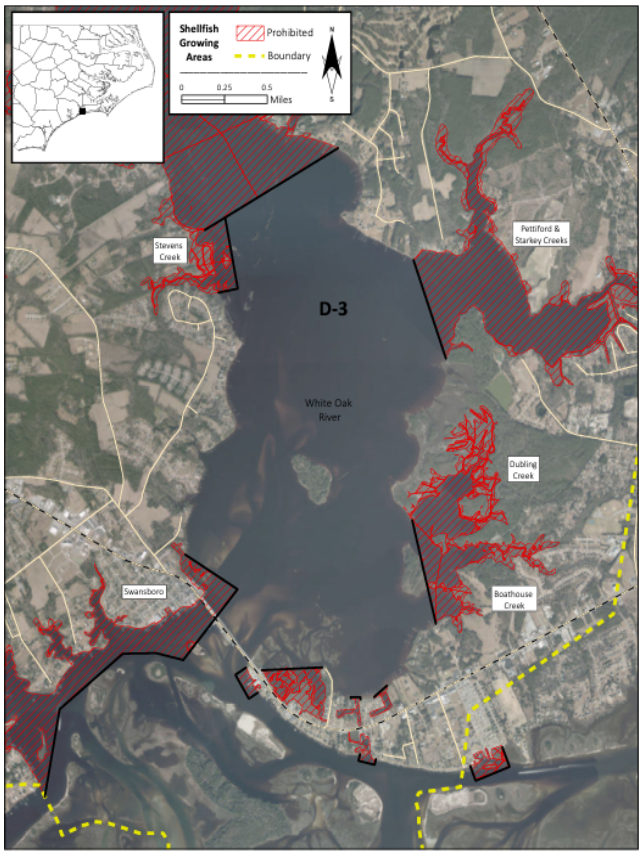


Notes. From the NCDEQ, E-6 HISTORY, Division of Marine Fisheries – Shellfish Sanitation and Recreational Water Quality Section.

Looking at the North River shellfish closure maps, we see a similar trend over the last 25 years to the Newport River, though with more dramatic increases in closures. Like the Newport River, the large prohibited areas - in the North and South West of the maps - remain largely unchanged. Two small creeks (Lynch Creek and Sam Moss Creek) have been permanently closed, seen just south of the river delta, in the Northwest. In the Southeast, large portions of growing areas in Harkers Island have been permanently closed, as well as numerous small creeks just north of this. The largest permanent closure, though, was at Ward Creek, seen in the Northeast of the map. However, what the maps alone do not display is that this largest change happened in 2004. Although the prohibited growing areas have considerably increased, little has changed in the past 19 years, again lining up with our discovered trends of wetland degradation.

Figure 13: White Oak River Growing Area (Area D-3)

1998 Closure Map **vs** **2022 Closure Map**



Notes. From the NCDEQ. D-3 HISTORY, Division of Marine Fisheries – Shellfish Sanitation and Recreational Water Quality Section.

Finally looking at permanent closures in the White Oak Growing Area, there is little difference to discuss outside of one main change. Though these two maps are somewhat difficult to compare due to the difference in hand-drawn versus satellite imaging, the new closure is found in the Southeast of the maps. Two creeks, Dublin Creek and Boathouse Creek have been permanently closed. Yet again, this change and the other small closures nearby all happened in 2006, meaning little change has happened over the past 15 years.

Analysis

Looking at the three largest shellfish growing areas in Carteret County, we expected to see a slight increase in permanent closures over the past 25 years, remaining consistent with low levels of wetland degradation. This seems to be the case, though each growing area increased in varying amounts. The North River experienced the most dramatic level of permanent closures,

while the Newport and White Oak Rivers had a milder increase. Overall, it is consistent with our expectations.

A potential weakness in this analysis is the lack of contextualizing data on temporary shellfish closures. While a database exists of all temporary closures conducted in Carteret County for these growing areas, the data is unavailable in a format that can be measured and analyzed in a timely manner. The spatial data is listed in nautical coordinates, and different closures often require extensive explanations. Ultimately, the temporary closure data was difficult to analyze in a longitudinal manner over the time period we wished due to the constantly changing nature of these smaller closures.

Clean Water Act: Section 303(d)

The Impaired Waters and Total Maximum Daily Load Program

Our team used the North Carolina Department of Environmental Quality (NCDEQ) 303(d) list to evaluate water quality over the past 25 years. Under section 303(d) of the Clean Water Act (CWA), states, territories, and authorized tribes are required to develop lists of impaired waters as part of the Impaired Waters and Total Maximum Daily Load (TDML) Program. These are waters for which "technology-based regulations and other required controls are not stringent enough to meet the water quality standards set by states." Following the identification of these impaired waters, states calculate and allocate potential reduction levels necessary to meet approved water quality standards (EPA, 2023). Through our collection of data from secondary research, we found that the 303(d) list was not an accurate indicator of water quality due to the change in the methodology and criteria of forming the list. However, when accounting for these factors, we have seen little to no change in the number or acreage of impaired waterbody listings for the White Oak River Basin from 1998 to 2022.

North Carolina's 303(d) and 305(b) Lists

In North Carolina, this assessment of water quality is reported every two years as required under Sections 303(d) and 305(b) of the CWA. This assessment is also known as the Integrated Report, which is conducted in three parts:

1. *Collecting water quality data.* The Division of Water Resources (DWR) and the Monitoring Coalition Program collects thousands of surface water quality samples throughout NC lakes, rivers, and streams.
2. *Comparing water quality data.* Each water quality sample collected is compared to the North Carolina water quality standard. If enough samples exceed the standard for that parameter, then the waterbody could be considered impaired depending on the assessment methodology.

3. *Assessment methodology.* This describes how many exceedances of water quality standards a waterbody can have for a particular pollutant. The data window used, typically five years, and what integrated reporting category will be assigned to each waterbody-parameter combination. (NCDEQ, 2023)

Methods and Data Collection

We accessed the 303(d) lists and integrated reports from the years 1998 to 2022 on the NCDEQ water resources page. Due to the vast amount of data, we limited our search to the White Oak River Basin, the river basin that CCRW primarily works to protect. For each year, we counted the number of waterbody listings for the White Oak River Basin and totaled the acreage of impaired waters. We noted that between the years 2000 and 2002, the number of impaired water bodies dramatically increased, as did the acreage of impaired waters.

Upon discussing this change with resources at NCDEQ, we found that the methods used to identify impaired waters drastically changed during this time. Prior to 2002, the Division of Water Quality only identified prohibited shellfish waters as impaired and listed them in combined assessment units based on shellfish growing areas. Instead of listing the 25 or so prohibited waterbodies in the North River Area, only the North River Area was 303(d) listed. Starting in 2002, NCDEQ started listing by individual waterbodies thanks to improved GIS capabilities. Also at this time, the EPA began to require the listing of any shellfish water that was not approved for harvesting, which added even more assessment units and much larger areas. Due to this finding, we have concluded there has not been a big change in water quality - just how impaired waterbodies were identified and listed.

Statistical Analyses

- *Key Point.* Through analysis of two separate regressions by years 1998 to 2022 - one of the number impaired waters in the White Oak River Basin and one of the total acreage in each 303(d) report for the White Oak River Basin - we concluded that 303(d) listings of impaired water bodies has changed very little over the past 25 years. However, the change in methodology skewed our data, specifically for years 2000-2002, resulting in a seemingly large increase in impaired waterbody listings. Additionally, there is an unknown factor contributing to a large increase in listings for the year 2006. While the cause for this remains unknown to us, it can be seen that the number of listings remained consistent outside of this data point and the previously mentioned jump. While the 303(d) list has proven to be an inaccurate proxy for water quality, from what we can tell it has remained relatively consistent from 1998-2022.

Figure 14 and Table 7 summarize the results of the statistical analysis of the number of 303(d) listings for the White Oak River Basin and years. As seen in Table 7, there was a constant

of 113.110, indicating that it is expected for the White Oak River Basin to have approximately 113 impaired water bodies on the 303(d) list. According to the data in Table 7, the number of impaired water bodies included on the 303(d) list for the White Oak River Basin is expected to increase by approximately 11 (10.709) every two years. Figure 14 visually displays the projected increase in these listings, as impaired water bodies and years have a positive correlation. As seen in Figure 14, the number of listings for the White Oak River Basin dramatically increased from 2000 to 2002, and again from 2004 to 2006. From our data, we are not able to draw conclusions on the cause of the jump in listings from 2004-2006. We do know, however, that the increase in listings seen between 2000-2002 can be attributed to a change in methods to identify impaired waters during this time.

Figure 14 & Table 7: Impaired Listings Analysis

Figure 14: Impaired Listings by Year

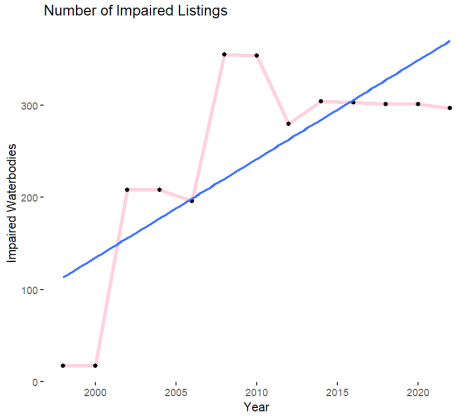


Table 7: Impaired Listings Regression

	Dependent variable: *impaired_listings*
Years	10.709***
	(2.882)
Constant	113.110**
	(40.753)
Observations	13
R2	0.557
Adjusted R2	0.516
Residual Std. Error	77.752 (df = 11)
F Statistic	13.810 (df = 1; 11)
Note:	*p<0.1; **p<0.05; ***p<0.01

Notes. Created using data from North Carolina 303(d) lists and integrated reports from even numbered years, 1998-2022. From NCDEQ Division of Water Resources.

Figure 15 and Table 8 summarize the results of the statistical analysis of the acreage of impaired listings in the White Oak River Basin and years. As seen in Table 8, there is a constant of 36,505.560, which is the expected total acreage of impaired water bodies within the White Oak River Basin for each 303(d) report. As seen in our data, this statistic is expected to increase by 408.864 acres every two years. Figure 15 visually displays our findings for this regression, and it can be seen that the impaired acreage for the White Oak River Basin has been increasing since 1998, and is expected to follow a similar trend. It is important to note, however, the externalities that have contributed to this positive trend. Two outliers - the total acreage for 2002 and 2006 - have skewed our data to show an anticipated increase in impaired acreage, even though this is not accurate. While we are aware of the cause of this for the year 2002, we are unsure of the reason for the increase from 2004-2006.

Figure 15 & Table 8: Impaired Acreage Analysis

Figure 15: Impaired Acreage by Year

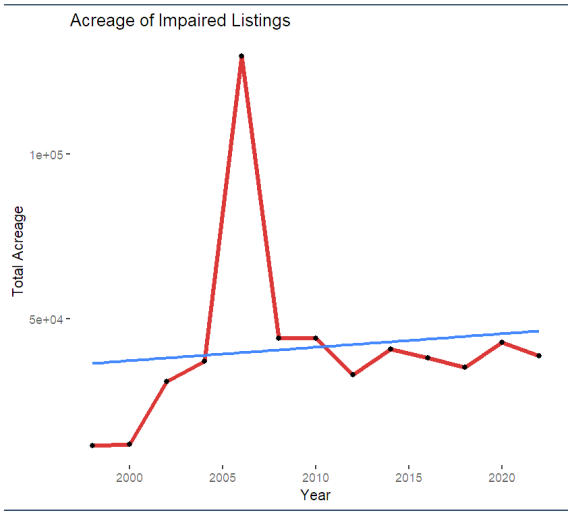


Table 8: Impaired Acreage Regression

Dependent variable: *impaired_acres*	
Years	408.864
	(1,100.226)
Constant	36,505.560**
	(15,559.540)
Observations	13
R2	0.012
Adjusted R2	-0.077
Residual Std. Error	29,685.710 (df = 11)
F Statistic	0.138 (df = 1; 11)
Note:	*p<0.1; **p<0.05; ***p<0.01

Notes. Created using data from North Carolina 303(d) lists and integrated reports from even numbered years, 1998-2022. From NCDEQ Division of Water Resources.

Economic Impacts of Recreation

- *Key point.* Carteret County's ocean economy relies heavily upon tourism and recreational activities. The tourism and recreational industry includes swimming, marine sports, and several other activities that can directly impact water quality and where human-environmental interaction is critical. We also see that different areas of Carteret County are experiencing varying levels of injustice according to the environmental justice index, indicating that economic development impacts on impaired surface waters, infrastructure, and potentially hazardous sites can contribute differently to different census tracts.

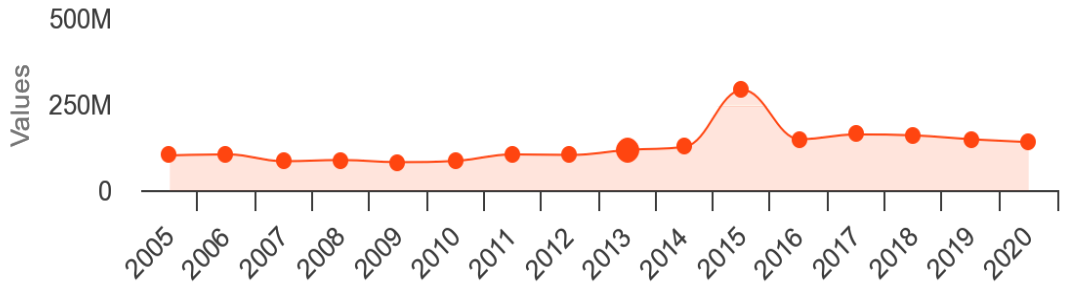
Economic growth is a characteristic of any time varying analysis, as population changes and new emerging industries create new opportunities. Water quality, as a result of economic growth, can suffer due to higher levels of impervious development and the loss of ecosystems due to expanding industries, as we have analyzed previously. However, it is crucial to note the reverse causality of water quality and economic growth. According to World Bank Group President David Malpass “Deteriorating water quality is stalling economic growth, worsening health conditions, reducing food production, and exacerbating poverty in many countries” (World Bank Group, 2019). It must be recognized that water quality and development is a two way relationship, and it is difficult to establish causality.

Carteret County is one of several coastal North Carolina counties. Carteret County’s geographical proximity to the Atlantic Ocean makes it an ideal location for sustainable oceanic

economic activities. Despite Carteret County's total ocean economy making up only roughly 6.7% of the county's 2020 GDP, nearly 94% of that year's total ocean economy can be attributed to tourism and recreation (NOAA 2023). Tourism and recreation ranges from hotels, boat dealers and charters, amusement, fishing services, and recreational activities that include swimming and marine sports. Since county level data has been collected in 2005, Carteret County has had at least 90% of its total ocean employment come from tourism and recreation and its ocean economic activity has comprised nearly 13.5 to 20% of total economic employment (NOAA 2020).

Carteret County's raw GDP from the tourism and recreation industry, as pictured in Figure 16 has remained relatively stable with the expectation of a substantial increase in 2015 from roughly 127 million to 290 million in output. After the 2015 spike, raw GDP has been slightly higher than pre-2015 levels but remained stable. Despite the impacts of Hurricane Arthur in early July 2014, this did not contribute to a decrease in 2014 GDP from 2013 and had a negative impact in total ocean economic activity in the years following.

Figure 16: **Tourism & Recreation Industry GDP in Carteret County (2005-2020)**

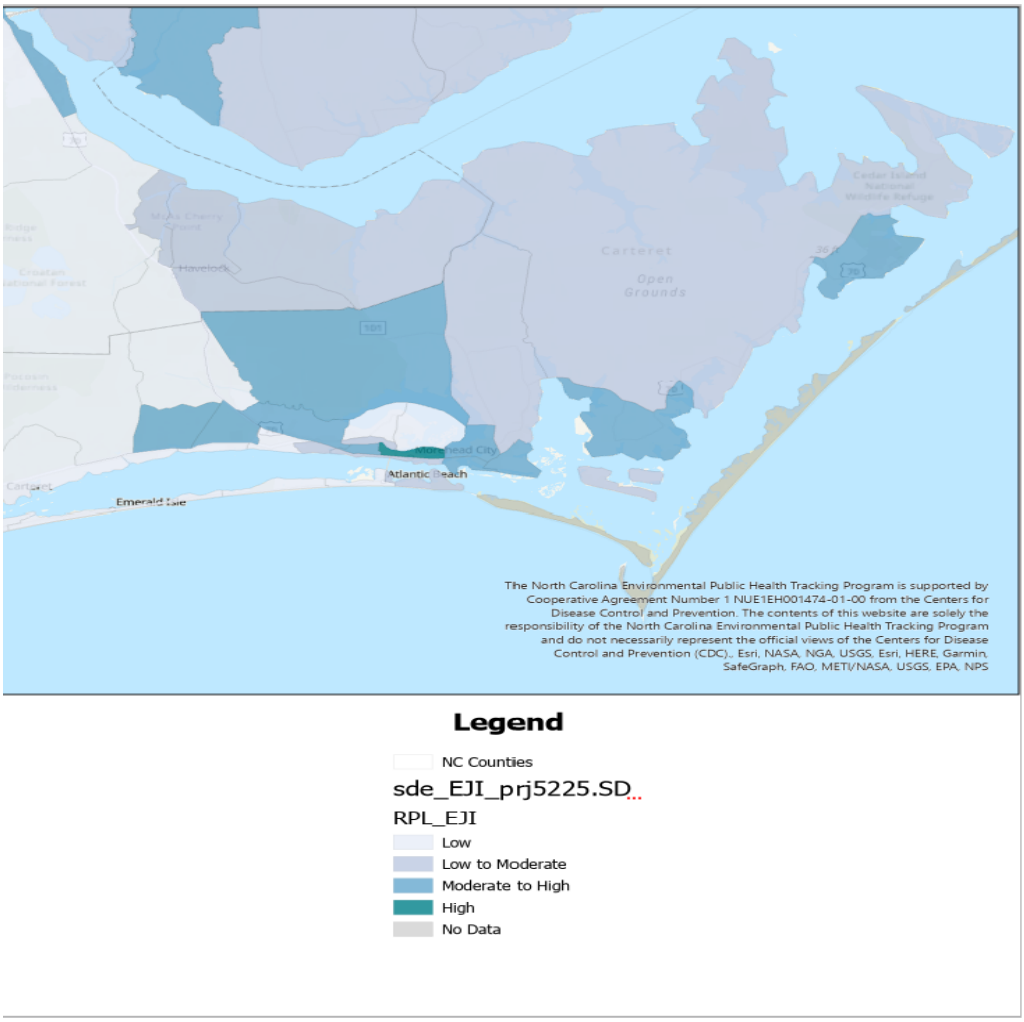


Notes. From the *NOAA Digital Coast ENOW Explorer* (2020). Values for each year are located in between individual markers and directly above the corresponding year.

Figure 17 serves as a geospatial representation of the environmental justice index. The 2023 EJI ranks each census tract utilizing 36 indicators subdivided into social vulnerability, environmental burden, and health vulnerability (ATSDR 2021). In Carteret County, there is variation among census tracts based on the aggregated ordinal categorization of index, with the "low" symbology on the legend meaning lower environmental injustice relative to the other areas. Inversely, the "high" symbology on the legend indicates a particular census tract with high levels of environmental injustice relative to the other tracts. According to Figure 17 we observe the highest environmental injustice in the census tracts near Morehead City and moderate levels in the sparsely populated regions of the county. This spatial representation serves as an area of relevance and consideration because the EJI utilizes indicators of water pollution by impaired surface waters, infrastructure, and potentially hazardous and toxic sites. Loss of wetlands due to infrastructure development and impervious surface expansion will negatively impact the index, contributing to higher environmental injustice in census tracts where wetlands are impacted.

Additionally, due to the negative impacts of impervious surface development on nearby surface waters, this provides a further negative impact on the index.

Figure 17: Environmental Justice Index in Carteret County (2023)



Notes. Adapted from NCDHHS Dashboard (2023). This ArcGIS map's symbology is described by the associated legend. This map does not visualize any individual indicators, only the index.

Multivariate Regressions

Next, we evaluated the relationship between wetland degradation and water quality. In order to analyze this relationship, we performed two multivariate regressions. The first multivariate regression involved analyzing what water quality indicator previously discussed has the most influence over changes in impaired waterbody listings. We did this by regressing the number of impaired bodies of water by the number of harmful algae blooms, number of days under swim advisories, and time (going by every 2 years). The second multivariate regression looked at the relationship between dredge-and-fill permits and the proxies we used as proxies for

water quality. We did this by regressing the number of dredge-and-fill permits by impaired listings, harmful algae blooms, days of swim advisories, and years (going by every 2 years).

Impaired Water Bodies and Water Quality

- *Key point.* After performing a multivariate regression utilizing the variables of Harmful Algae Blooms, Swim Advisories, and Time, we concluded that only two of these variables are statistically significant in relation to waters designated as "Impaired" under CWA Section 303(d).

Using the previously mentioned data on *Harmful Algae Blooms*, *Swim Advisories*, and "Impaired" water bodies from *Clean Water Act: Section 303(d)*, Table 9 summarizes the results of our Multivariate Regression on Impaired Water Bodies. We sought to determine whether swim advisories, algae blooms, or time were more responsible for changes in impaired listings. This analysis helped us determine the relationship between water quality and wetland degradation. To do this, we analyzed the coefficients and the p-values for each independent variable to ascertain how statistically significant each relationship is.

Table 9: Multivariate Regression for Impaired Water Bodies

Dependent Variable: # of Impaired Bodies of Water	
Harmful Blooms	8.184**
	(3.438)
# of days with swim advisories	0.101
	(0.234)
Time (every 2 years)	11.765**
	(2.697)
Constant	44.621
	(39.320)
Observations	13
R2	0.778
Adjusted R2	0.703
Residual Std. Error	60.884 (df = 9)
F Statistic	10.487*** (df = 3; 9)

. *p<0.1; **p<0.05; ***p<0.01.
Notes. Data sourced from NCDEQ Division of Marine Fisheries and NCDEQ Division of Water Resources

Looking first at harmful algae blooms, the coefficient is 8.184 with a standard error of 3.438. The two stars (**) indicate that the p-value is less than 0.05. This means that the positive

effect of algae blooms on impaired listings is statistically significant with 95% confidence. Every time harmful algae blooms increase by one, the expected increase in impaired listings is 8.184.

Next analyzing the number of days under a swim advisory, the coefficient is 0.101 with a standard error of 0.324. The p-value is not less than 0.1, which indicates that the correlation between the two variables is *not* statistically significant at any meaningful level. Additionally, the coefficient is so small that it is unlikely there is any relationship at all.

Lastly, time (measured every two years) has a coefficient of 11.765 with a standard error of 2.697. The three stars (***) indicate that the p-value is less than 0.01. This means that the positive effect of time on impaired listings is statistically significant with a 99% confidence level. Whenever time increases by two years, it is expected that the number of impaired water bodies will increase by 11.765.

To summarize, this regression suggests that the number of harmful algae blooms and time are statistically significant to the number of impaired bodies of water. Both of these variables have a positive relationship with the number of impaired listings. This means we could possibly use one to predict the other. However, the number of swim advisories appears to be irrelevant in this relationship. The constant is 44.621 and the R^2 value is 0.778. This suggests that the expected number of impaired water bodies is 44.621 when all independent variables are zero. The R^2 value is high which suggests that the model is a good fit, meaning we can use it to draw further conclusions.

Dredge-and-Fill and Water Quality

After analyzing different water quality indicators' impact on the number of impaired 303(d) listings, we wanted to see whether there was a correlation between these indicators and wetland degradation. The best data for us to conduct this analysis with was the existing dredge-and-fill (D&F) data collected by the NCDEQ Division of Coastal Management. We had previously conducted a regression between the number of permits and time, indicating that there was little positive relationship between the two variables. In this regression, we keep time and add the number of impaired 303(d) listings, harmful algae blooms, and days of swim advisories. To analyze the variables, we looked at coefficients and p-values to determine the strength of relationships, and the R^2 value to understand the general fit of the model.

- *Key point.* After performing a multivariate analysis, we are unable to determine a strong relationship between our water quality indicators of choice and our previous research pertaining to D&F permits / wetland degradation.

Table 10: **Multivariate Regression of Water Quality Impact on Dredge and Fill**

Dependent Variable: Dredge and Fill Permit Numbers	
Impaired Listing	-2.897 (2.101)
Harmful Blooms	54.280* (27.668)
Days of Swim Advisory	-1.487 (2.056)
Time (every 2 years)	43.957 (30.005)
Constant	800.253** (265.025)
Observations	13
R2	0.329
Adjusted R2	-0.006
Residual Std. Error	383.828 (df = 8)
F Statistic	0.981 (df = 4; 8)

Notes. Data sourced from NCDEQ Division of Coastal Management, NCDEQ Division of Marine Fisheries, NCDEQ Division of Water Resources. *p<0.1; **p<0.05; ***p<0.01.

Unlike the last multivariate regression, only one of the independent variables has a statistically significant relationship with the dependent variable. Impaired listings have a coefficient of -2.897 and a standard error of 2.101; Days of swim advisory has a coefficient of -1.487 and a standard error of 2.056; time(measured every 2 years) has a coefficient of 43.957 and a standard error of 30.005; However, none of these variables have a p-value that indicates the relationship is statistically significant. Thus, we can assume they have no real correlation with the number of D&F permits. Harmful algae blooms has a coefficient of 54.280 and a standard error of 54.280. This variable is the only one to have any kind of significant relationship, with a p-value that indicates significance at a 90% confidence level.

Though the coefficient of harmful algae indicates that for every single new algae bloom, D&F permits are expected to increase by roughly 54 permits, the constant and R^2 reveal more about the model. The constant is 800.253, which means that every two years, it is expected there will be roughly 800 permits. The coefficient of 54 for Harmful Blooms represents a relatively small increase in the number of permits. Secondly, the R^2 value is 0.329 which indicates that the model is not a good fit.

Taking the results of the regression into account, it appears that the variables we measured have little correlation with the number of D&F permits each year. This makes a direct comparison between wetland degradation and water quality more difficult on the basis of D&F permits. We still expect there may be a connection, but for now, our data shows no correlation.

Summary of Part 2 Findings

We analyzed five potential proxies for water quality: harmful algae blooms, swim advisories, shellfish closures, "Impaired" / CWA Section 303(d) waters, and economic impacts. Through data analysis softwares, we determined each of these had significant limitations that resulted in our inability to reliably ascertain changes in water quality over time in Carteret County. Adding our water quality data to wetland degradation, we conducted multivariate regressions to determine a further connection between wetland degradation and water quality. Though we determined that time and algae blooms are correlated with an increase in impaired water bodies, the connection to wetland degradation was less concrete. We found little correlation between any of our indicators and the amount of Dredge-and-Fill permits.

PART 3

A Review of Federal & North Carolina Policy Changes

Key Points

Main Findings:

1. Wetlands remained consistently protected under the 1980s definition of WOTUS, which remained in place until 2015. Subsequent changes to WOTUS' interpretation have resulted in significantly reduced protections for isolated, adjacent, and interstate wetlands.
2. Notable court cases such as *Rapanos v. US* and *Sackett v. EPA* have influenced federal and state interpretations of the wetlands under WOTUS.
3. North Carolina has had stringent wetland protections until recent legislation.

To provide broad historical and contemporary contexts for Carteret County's wetland degradation, water quality, and protection landscape, we conducted an extensive review of the most-recent changes to federal and NC-level policies.

Federal Policy

Since the passing of the Federal Water Pollution Control Act (FWPCA) in the 1940s, the protection and promotion of key waterways within the United States has been seen as a crucial means for preserving human health (Walsh & Ward, 2022, p. 2). In 1972, the FWPCA was effectively rebranded (and significantly expanded) into the Clean Water Act (CWA). Despite the widespread destruction of wetlands contributing to and exacerbating detrimental pollution within many of the nation's rivers, lakes, and streams, wetlands were not considered to be jurisdictional until 1985 (Kozlowski, 2023).

In this section, we will explore the ways in which the CWA - and its classifications for "waters of the United States" (or WOTUS) - have changed since its implementation over 50 years ago. These fluctuations, particularly those related to wetland protections, provide important foundational context for the history of Carteret County's wetlands and potential implications for their future.

A timeline of federal-level policy changes and important court cases can be viewed in Appendix D.

The Clean Water Act

The Clean Water Act (CWA), signed into law in October 1972, aimed to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (Federal Water Pollution Control Act, 2002, § 1251). Given the historical context of nearly 60 percent of US waterways being deemed not "fishable or swimmable" and the consequential public outcry at the time of the CWA's enactment (Ohio, 2016), Congress developed 7 key initial objectives to ensure the actionability of the Act:

1. It is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;
2. It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;
3. It is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;
4. It is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works;
5. It is the national policy that areawide treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each state;
6. It is the national policy that a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into navigable waters, waters of the contiguous zone, and the oceans; and
7. It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution. (Federal Water Pollution Control Act, 2002, § 1251).

The US Environmental Protection Agency (EPA) was declared the primary authority in the effort to meet the goals of the CWA, with specific orders to work alongside other Federal agencies, state authorities, and local municipalities (Federal Water Pollution Control Act, 2002). The US Army Corps of Engineers (Corps) was later granted authority specifically over Section 404, which manages the permit program that regulates the discharge of dredged or fill material into jurisdictional waters (United States Environmental, 2023b).

Waters of the United States

These waters placed under the direct management of the EPA and Corps were designated to be the "waters of the United States," or more commonly known as WOTUS. Throughout the legal document, the term "navigable" was repeatedly emphasized as the threshold of determining federal jurisdiction. Navigability was measured as waters that were: "1) subject to the ebb and flow of the tide; 2) presently used, used in the past, or susceptible for use to transport interstate or foreign commerce; or 3) navigable in fact" (Hawkins, 2015, p. 1585). Despite the focus on "navigable waters," the language of the law itself is ambiguous and does not provide any explicit definition as to what WOTUS includes, thus leading to repeated discussions and challenges as to what bodies of water should (or should not) be included under the protection of the CWA (Mihelcic & Rains, 2020).

One such body of water continuously under debate are wetlands. Within both initial 1972 Congress rulings and 1982 Supreme Court (SCOTUS) verdicts, it was determined that wetlands did not meet the navigability requirements to be considered WOTUS (Walsh & Ward, 2022). In the mid-1980s, the EPA and Corps abandoned their individual interpretations of WOTUS in favor of a singular definition (see Table 11), which remained in place until the 2010s (Mihelcic & Rains, 2020).

Specific changes to WOTUS classification of wetlands will be further discussed under *Recent Changes to CWA and WOTUS* and *Influential Court Cases*. However, it is important to note that the 1980s definition included both adjacent and interstate wetlands under jurisdictional protection.

Table 11: WOTUS Definition

TABLE 1. DEFINITION OF "WATERS OF THE UNITED STATES" USED FROM THE LATE 1980S TO THE MIDDLE 2010S

40 CFR 230.3(s) indicates that the term "waters of the United States" means:

1. All waters that are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide.
2. All interstate waters including interstate wetlands.
3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters:
   i. Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
   ii. from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
   iii. which are used or could be used for industrial purposes by industries in interstate commerce.
4. All impoundments of waters otherwise defined as waters of the United States under this definition.
5. Tributaries of waters identified in paragraphs (s)(1) through (4) of this section.
6. The territorial sea.
7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section.

Notes. From Where's the Science? Recent Changes to Clean Water Act Threaten Wetlands and Thousands of Miles of Our Nation's Rivers and Streams (Mihelcic & Rains, 2020).

(Wetland) Water Quality Standards Program for States

The CWA also mandated states to implement, meet, and maintain EPA-defined water quality standards (WQS) in order to ensure the control of pollution of WOTUS from both point and nonpoint sources (Federal Water Pollution Control Act, 2002, § 1251-1285). Immediately following the enactment of the 1972 CWA, WQS had only applied to rivers, lakes, estuaries, and

oceans due to the lack of recognition of wetlands as WOTUS (United States Environmental, 2023a). In 1990, the EPA expanded WQS to wetlands through the addition of Appendix D to the national Water Quality Standard Handbook. WQS attempt to ensure the application of the CWA to jurisdictional wetlands within state boundaries, as well as provide scientific foundations for CWA application (United States Environmental, 2023a). According to Appendix D, states must meet specific requirements for utilizing WQS within their own territory, including:

- Include wetlands in the definition of "State waters"
- Designate uses for all wetlands
- Adopt aesthetic narrative criteria (the "free forms") and appropriate numeric criteria for wetlands
- Adopt narrative biological criteria for wetlands
- Apply the State's antidegradation policy and implementation methods to wetlands (United States Environmental, 2023a)

By enabling states the ability to choose between developing their own definition of "State waters" or adopting that of WOTUS, state WQS programs serve to "protect and enhance the Nation's wetland resources and [provide] a regulatory basis [to] meet this goal" (United States Environmental, 2023a). Additionally, states are also granted the authority to alter the language of regulatory definitions that explicitly or implicitly limit protection of wetlands (United States Environmental, 2023a). This enables states to implement additional regulatory measures to further preserve, maintain, and improve jurisdictional wetlands while simultaneously preventing states from undermining federal standards.

We continue to explore wetland WQS programs through the historical analysis of North Carolina's "waters of the state" within *NC State Policy*.

Recent Changes to the CWA and WOTUS

The longevity of the 1980s definition of WOTUS used by both the EPA and the Corps, as previously defined in Table 1, remained unchallenged until the Obama administration proposed an unprecedented change to how waters are categorized as under CWA protection in 2015 (Hawkins, 2015). In the 8 years following this historical ruling, wetlands have continued to be a focal point of political and public outcry due the difficulty in determining whether a given private property contains WOTUS, placing landowners at risk of criminal prosecution or civil penalties related to mundane property activities (Kozlowski, 2023).

The Clean Water Rule

In 2015, the EPA published the *Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence*, an extensive report that analyzes more than 1,200 peer-reviewed scientific publications to summarize the most up-to-date

understandings of the ways in which streams and wetlands impact the physical, chemical, and biological qualities of downstream waters (Office of Research, 2015). The evidence collected from this review supported 5 major conclusions, as outlined below.

1. Streams, regardless of their size or the frequency of water flow, significantly (and "unequivocally") influence the function of downstream waters.
2. Wetlands, open waters in riparian areas, and floodplains influence downstream water quality in connected rivers due to the ability of these systems to act as a buffer from pollution, exchange of organic matter and organisms, and retain / prevent the dispersion of stormwaters.
3. Wetlands, open waters located outside of riparian areas, and floodplains influence the functions and quality downstream waters regardless of their surface water connectivity.
4. Degree of connectivity is determined not only by naturally-occurring physical, chemical, and biological environmental characteristics, but also by human activities that impact the integrity and sustainability of downstream waters.
5. The small contributions of individual streams and wetlands impact entire watersheds, and their consequential effects on downstream waters must be considered in the cumulative context.

These 5 conclusions ultimately suggest that the effects of streams, wetlands, and open waters are determined by "1) physical, chemical, or biological pathways that enable (or inhibit) the transport of materials and organisms to downstream waters; and 2) functions within [water bodies] that alter the quantity and quality of materials and organisms transported along those pathways to downstream waters" (Office of Research, 2015, p. 36). This report served to support the integration of scientific rationale into future policy and regulatory decisions, including the development of the Clean Water Rule (CWR) by the EPA's Office of Water and the Corps (Office of Research & Alexander, 2015)

The CWR, proposed during the Obama Administration, was intended to alter the classifications of WOTUS to be rooted in the scientific evidence as well as in the "technical expertise and extensive experience [developed by] implementing the CWA over the past four decades" (Clean Water Rule, 2015, p. 37055). As discussed further in *Influential Court Cases*, the "significant nexus" ruling of *Rapanos v. United States* provided the foundation for the applicability of the CWA for wetlands adjacent and/or hydrologically connected to predetermined navigable waters (Adler, 2015). The CWR directly stated that the CWA would no longer be interpreted on the basis of navigability, but rather upon protecting waters required to "restore and maintain the chemical, physical, or biological integrity" of WOTUS (Clean Water Rule, 2015).

Under the CWR, jurisdictional waters were divided into 8 categories: traditional navigable waters; interstate waters; territorial seas; impoundments; tributaries; adjacent waters; "similarly situated" case-specific significant nexus determinations; and non "similarly situated"

case-specific significant nexus determinations (Clean Water Rule, 2015, p. 37058; U.S. Environmental, 2015). The final two allowed for the inclusion of isolated lakes and wetlands within the protection of the CWA if they were within 100 ft. of WOTUS, within the 100-year floodplain, or within 1500 ft of "traditionally navigable water" (Walsh & Ward, 2022). Of these categories, only the final two expanded the previous 1980s definition of WOTUS, and it is these categories that sparked significant controversy regarding perceptions of governmental overreach by the EPA to waters that should not be protected by the CWA (Collaku, 2016).

The primary argument against the CWR and its allowance of case-specific, open-ended decision making was what some scholars designated as the "Landowner Dilemma." Many feared that the expansion of the CWR and the newfound breadth of CWA jurisdiction would result in uncertainty around whether a given private property contains WOTUS, thus placing landowners at risk of criminal prosecution or civil sanctions due to violating the CWA through typically mundane property modifications involving isolated wetlands (Kozlowski, 2023).

By 2017, the EPA and Corps were ordered to revise or rescind the CWR, foreshadowing the 2020 proposal of the Navigable Waters Protection Rule.

The Navigable Waters Protection Rule

The Navigable Waters Protection Rule (NWPR) was created to be the antithesis of the expansion to wetland protection policies within the CWR. Similar to the CWR, the NWPR also sought to clarify the scope of WOTUS while simultaneously increasing the predictability of WOTUS determinations.

The NWPR dramatically reduced the amount of wetlands and other waterways protected by the CWA, compared to both the CWR and the 1980s regulations. Adjacent and isolated wetlands were particularly impacted by this reduction in scope, following the concurring opinion within *Rapanos v United States* which advocated for the two-step evaluation for determining WOTUS. Justice Scalia's approach, which is further elaborated upon in *Influential Court Cases*, requires that wetlands must be adjacent to WOTUS and maintain continuous hydrological connectivity with the water source (The Navigable Waters Protection Rule, 2020). This definition of WOTUS and the loss of wetland protections blatantly departs from the EPA and the Corps' prior initiatives to introduce scientific groundings within jurisdictional authority.

Ultimately, the final rule of the NWPR was issued on January 18, 2023, and became effective on March 20, 2023. Following revisions related to *Sackett v. EPA* (see *Influential Court Cases*), the EPA and Corps had to even further limit their authority over wetlands. Under the decision of SCOTUS to remove the "significant nexus" standard to WOTUS classification, wetlands can no longer qualify for CWA protection for their environmental significance nor their geographical "adjacency" to other WOTUS. In addition to the removal of adjacent wetlands from the definition of WOTUS, wetlands no longer meet the requirements for "interstate waters," which now only apply to "open waters" such as all rivers, lakes, and other water bodies that flow

across or contribute to a segment of a state boundary (Revised Definition of "Waters of the United States", 2023).

The recent and severe reduction of wetland protection policies under the CWA and WOTUS reflect a critical turning point in environmental policy, with the progress of over 40 years of wetland restoration and maintenance initiatives being undermined by economic motivations.

Influential Court Cases

Analyzing influential court cases gives important insight into how the protection of wetlands has shifted throughout time. In the majority of cases involving wetlands, the courts are attempting to define the scope of WOTUS in the CWA. Many of the influential court cases that have occurred in the past 25 years have been over who has authority to control and protect wetlands. However, embedded in these cases is the defining and redefining of WOTUS and navigable waters. Various courts and judges interpret the CWA differently. Consequently, the protection of wetlands has changed considerably, whether it be expanding protection, limiting protection, or redefining which types of wetlands get protection.

United States v. Riverside Bayview Homes (1985).

Although this case occurred outside of the scope of our research, the interpretation of WOTUS that stemmed from this case laid the foundation of wetland protection for the years following. Riverside Bayview Homes was sued by the Army Corps of Engineers (Corps) because they filled a wetland on their property, which was adjacent to navigable waters, without obtaining a permit from Corps first (vLex, n.d.). While the District Court upheld the Corps argument, the Court of Appeals ruled that the Corps' regulation does not include adjacent wetlands "... that are not subject to flooding by adjacent navigable waters at a frequency sufficient to support the growth of aquatic vegetation." (vLex, n.d.). The Court of Appeals held that Riverside Bayview's property didn't support aquatic vegetation due to flooding by navigable waters and thus didn't need a permit to fill their property (vLex, n.d.). The case appeared in SCOTUS who contradicted the Court of Appeals' decision and ruled in favor of the Corp's interpretation of WOTUS and navigable waters (Todd, 2023). They held that wetlands adjacent to navigable waters are included in the definition of WOTUS and thus protected under the CWA (Holland & Knight LLP, 2023).

Solid Waste Agency of Northern Cook County v. US Army Corps of Engineers (2001)

The Solid Waste Agency of Northern Cook County (SWANCC) designated an abandoned excavation site as the location to dispose of solid waste (Oyez, n.d.c). To prepare the landscape to be a solid waste disposal site, SWANCC wished to fill the trenches, one of which was a

seasonal pond that was a habitat for migratory birds (Oyez, n.d.c & Todd, 2023). Subsequently, they reached out to the Corps to inquire if they needed a permit under the CWA (Oyez, n.d.c). The Corps denied SWANCC from obtaining a permit. After appearing in the District Court and Court of Appeals, the case went to SCOTUS (Oyez, n.d.c). They ruled in favor of SWANCC and held that they didn't need a permit to fill in their property. Since the pond was isolated and there was no significant nexus to navigable waters, the property is not protected under the CWA (Oyez, n.d.c & Todd, 2023).

Rapanos v. United States (2006)

John Rapanos, a real estate developer, was sued by the United States when he filled three wetlands on his property (Oyez, n.d.a & Environment and Natural Resource Division, 2021). The Michigan Department of Environmental Quality warned Rapanos that his property contained wetlands that were protected under the CWA (Oyez, n.d.a). The United States then sued Rapanos when he ignored this warning and as well as a cease and desist order issued by the EPA (Oyez, n.d.a). Rapanos argued that the wetlands on his property were not protected under the CWA because there were not "navigable waters" (Oyez, n.d.a). The US argued that they were protected under the CWA and his land was adjacent to "navigable waters" because the land was connected to drains which empty into rivers and lakes (Oyez, n.d.a). The District Court for Eastern District of Michigan ruled in favor of the US and held that the "hydrological connection" to navigable waters constitutes Rapanos' property as WOTUS (Oyez, n.d.a). This decision was also upheld in the Sixth Circuit Court of Appeals (Oyez, n.d.a).

SCOTUS then granted certiorari to the Rapanos case, meaning they wanted to review the decision made by the lower courts regarding the scope of the CWA (Environment and Natural Resource Division, 2021). No majority opinion was found, and resulted in a 4-1-4 vote (Environment and Natural Resource Division, 2021). From this split vote emerged two different opinions on how to judge whether a property is WOTUS and protected under the CWA (Todd, 2023). The first is the two-step test, emerging from Justice Scalia's opinion which states that " … navigable waters, and thus WOTUS, cannot refer to channels that carry intermittent water, like ditches, because other sections of the CWA define such conduits as point sources.", which are different classifications in the CWA (Todd, 2023). The two-step test involves: "first, that the adjacent channel contains [WOTUS] (i.e., a relatively permanent body of water connected to traditional interstate navigable waters); and second, that the wetland has a continuous surface connection with the water, making it difficult to determine where the 'water' ends and the 'wetland' begins." (Todd, 2023). The other way to judge whether a piece of land is WOTUS is the significant nexus test, stemming from Justice Kennedy's opinion (Todd, 2023). This states that "there needs to be 'a significant nexus between the wetlands in question and navigable waters in the traditional sense' and that the nexus needs to be assessed with regard to the CWA's purpose and goals." (Todd, 2023). The differing opinions left lower courts confused as to how to interpret WOTUS in the future (Todd, 2023).

Sackett v. Environmental Protection Agency (2023)

The most recent influential court case involving wetlands was *Sackett v. Environmental Protection Agency (EPA)*. This case originated in 2007 when Chantell and Mike Sackett filled half an acre of their property with materials in order to lay the foundation for a house (Oyez, n.d.b). A few months later, the EPA issued a compliance order, claiming that their property is classified as a wetland and they didn't get a permit to fill it, thus infringing upon the CWA (Oyez, n.d.b). The Sacketts originally filed a lawsuit in the US District Court for District of Idaho, who upheld the EPA's claim that the wetlands on their property are classified as WOTUS under the CWA because they "... were adjacent to a navigable body of water and connected by a 'shallow subsurface' flow to the adjacent lake." (Oyez, n.d.b & Todd, 2022). Additionally, they applied the Justice Kennedy test (discussed previously in *Rapanos v. United States*), and further agreed with the EPA's claim (Todd, 2022). The case then went to the US Court of Appeals for the Ninth Circuit, who affirmed the lower court's decision (Oyez, n.d.b.).

SCOTUS petitioned for certiorari to review the lower court's decisions (SCOTUSblog, n.d.). Specifically, they wanted to look at whether Justice Kennedy's or Justice Scalia's opinion should determine the scope of WOTUS (Todd, 2022). The Sacketts argued that Justice Kennedy's test should not be used and rather apply Justice Scalia's two-step test (Todd, 2022). In a 9-0 decision, the court held that "... the mere presence of water is not enough for federal agencies to assert jurisdiction over wetlands as 'waters'." (Hale, 2023). Thus, they upheld Justice Saclia's opinion and argued that the EPA doesn't have the jurisdiction to impose Kennedy's significant nexus test and that wetlands are only protected under the CWA if they have a continuous surface connection to WOTUS (Hale, 2023 & SCOTUSblog, n.d.).

North Carolina State Policy

Definitions of State Waters & Wetlands

States can implement wetland protection policies where federal jurisdiction ends. In the state of North Carolina, no single statute exists to specifically focus on wetland protection. These protections are found in various statutes prioritizing the protection of state waters. NC defines "State waters" in the Air and Water Resources Statute as: "any stream, river, brook, swamp, lake, sound, tidal estuary, bay, creek, reservoir, waterway, or other body or accumulation of water, whether surface or underground, public or private, or natural or artificial, that is contained in, flows through, or borders upon any portion of this state, including any portion of the Atlantic Ocean over which the state has jurisdiction" (N.C.G.S., § 143-212-6). In North Carolina Administrative Code 02B, wetlands are defined as "waters" that are protected by the state (15A N.C.A.C., 02B .0202 (64)).

While this definition of "waters" is broad, it has historically been interpreted to include wetlands, and specifically "isolated" wetlands. In September 2001, the Environmental Management Commission extended the definition of North Carolina "State waters" provided in §

143-212 (6) to isolated wetlands in order to protect them from development. On the federal level, the Clean Water Act protects water bodies with connections to "navigable" waters; isolated wetlands do not have a nexus to larger bodies of water, thus excluding them from these protections at the federal level. However, the Environmental Management Commission confirmed that the NC definition of "State waters" was not constrained by the inclusion of the word "navigable," allowing the state to implement protections for these isolated wetlands (Peterson & Sullins, 2001).

NC Coastal Area Management Act (CAMA)

The North Carolina Coastal Area Management Act (CAMA) was passed by the General Assembly in 1974. The legislation established the Coastal Resources Commission (CRC), the governing body for CAMA. The objective of this legislation is to protect North Carolina's coastal natural resources from the negative effects of development. 20 coastal counties in NC are subject to CAMA rules and regulations, including Carteret County. Under this act, excavation of estuarine waters, tidelands, marshlands, or state-owned lakes in counties designated as Areas of Environmental Concern (AEC) requires a permit from the North Carolina Department of Environmental Quality (NCDEQ). Areas of Environmental Concern are areas of natural importance that may be easily destroyed by erosion or flooding, or may have environmental, social, economic, or aesthetic value (*Coastal Area Management Act (CAMA)*, n.d.). CAMA permits are generally required for any development within designated Areas of Environmental Concern.

Government Programs for Wetland Restoration

In 1987, the National Estuary Program (NEP) was established by Congress and authorized in section 320 of the Clean Water Act (CWA). The program was founded to protect and restore water quality and ecological integrity of nationally significant estuaries (EPA, n.d.). One of the first NEP programs established was the Albemarle-Pamlico National Estuary Program (APNEP). APNEP's mission is to identify, protect, and restore the significant natural resources of the Albemarle-Pamlico estuarine system. This estuarine system is the second largest in the US, includes 3,000 square miles of estuarine waters, and has a land area of 28,000 square miles. The White Oak and Neuse River Basins are a part of the Albemarle-Pamlico estuarine system. The APNEP works alongside the NCDEQ to achieve its Comprehensive Conservation Management Plan (CCMP). The program's staff collaborates with stakeholder committees consisting of citizens, business leaders, environmental organizations, and local, state, and federal agencies. In 2017, NC Governor Roy Cooper's Executive Order #26 authorized a Management Conference to advise APNEP efforts; this conference included a Leadership Council, Science and Technical Advisory Committee, and an Implementation Advisory Committee. Through this conference, APNEP established its 2012-2022 CCMP with goals of supporting regions where human communities are sustained by a functioning ecosystem; regions where aquatic, wetland, and upland habitats support viable populations of native species; and regions where water

quantity and quality maintain ecological integrity (Albemarle-Pamlico National Estuary Program (*About APNEP*, n.d.).

In 1996, the NC General Assembly created the North Carolina Wetlands Restoration Program (NCWRP). The NCWRP is an "innovative, non-regulatory program intended to help restore wetlands, streams, and riparian buffer areas throughout the state" (Duncan, 2001). The NCWRP was established through the Department of Environmental Quality. This program worked to protect and improve water quality through the restoration of wetlands, increase net acreage of wetlands, and increase the ecological effectiveness of mitigation projects. Through the NCWRP, the DEQ initiated the Watershed Assessment and Restoration Project (WARP) - an effort to restore 11 watersheds across the state from 2000 to 2002 and understand why impaired streams do not meet expectations for aquatic life. The NCWRP later transitioned to become the Ecosystem Enhancement Project (EEP) after a 2001 initiative to limit the mitigation abilities of the NC Department of Transportation (NCDOT) and reduce the environmental cost of their projects (NCDEQ, n.d.).

In 2011, NC's Air and Water Resources statute established the Division of Mitigation Services (formerly known as the previously discussed EEP). The Division of Mitigation Services is dedicated to the "acquisition, maintenance, restoration, enhancement, and creation of wetland and riparian resources that contribute to the protection and improvement of water quality, flood prevention, fisheries, wildlife habitat, and recreational opportunities" (N.C.G.S., § 143-214.8). The DMS continues to protect North Carolina's natural resources today while also supporting responsible and sustainable economic development.

North Carolina Administrative Code (NCAC)

Protections for isolated wetlands were expanded in October 2001 with North Carolina Administrative Code's (NCAC) "Discharges to Isolated Wetlands and Isolated Waters" section. This section of the NCAC required permits for activities that deposit harmful discharge into isolated wetlands (ie., dredged or fill material, fill, earth, construction, debris, soil, etc.) (15A N.C.A.C. 02H .1301). Title 15A of the NCAC also establishes wetland classifications and additional protections. The code enumerates specific water quality standards to "preserve, protect, restore, and enhance the quality and uses of wetlands and other waters of the state influenced by wetlands." The state lists and defines "uses of wetlands and other waters," to include storm and floor water storage and retention, moderation of water level fluctuations, and habitat for various aquatic life. The listed standards to protect wetland use include but are not limited to the prohibition of liquids, fills, other solids, or dissolved gasses that have negative effects on wetlands, materials that adversely affect fish or aesthetic quality of the wetland, and excessive floating or submerged debris and oil (15A N.C.A.C. 02H .1301).

The Regulatory Reform Act of 2015

Despite historical interpretation of wetlands and isolated wetlands as state waters, these bodies have still been vulnerable due to their lack of surface-water connection. Wetlands and isolated wetlands have often become subject to development due to language changes in policy

text or changes in interpretations. For example, the Regulatory Reform Act of 2015 (H.B. 765) modified isolated wetland rules established in 2001's Discharges to Isolated Wetlands and Isolated Waters section of the NCAC. H.B. 765 removed provisions defining isolated wetlands and significantly increased the number of wetlands that do not require permits (H. 765, 2015).

North Carolina Farm Act of 2023

As previously mentioned, the US Supreme Court's ruling on *Sackett v. Environmental Protection Agency (EPA)* determined that isolated wetlands that do not border larger bodies of water are no longer considered "navigable waters" and thus are no longer protected under the CWA (*Sackett v. EPA*, n.d.). Previously, North Carolina had its own legal protections for wetlands in addition to the CWA, but these too have recently been overturned. On June 27, 2023, the NC Senate overruled Governor Cooper's veto on the NC Farm Act of 2023 (Senate Bill 582). The bill, among many other clauses, reclassified the definition of wetlands to be consistent with the federal definition (S. 582, 2023). With the recent ruling in *Sackett v. EPA*, North Carolina's isolated wetlands are no longer protected under the CWA or state-level policies. Over 2.5 million acres of NC wetlands have been put at risk, and without new legislation to protect these at-risk wetlands, new developments could potentially pollute their waters. Though isolated wetlands may not border primary drinking sources, their water quality can still impact groundwater sources (Sorg, 2023). The effects of this recent legislation have not been seen yet in North Carolina, however, it is projected that it will result in mass destruction of NC wetlands by builders and developers, who now have the opportunity to exploit these key water bodies.

Summary of Part 3 Findings

We researched federal and NC-level environmental policies, primarily analyzing changes to the definitions of both "waters of the United States" and "State waters," and the ways in which these changes have impacted the legal protections of wetlands under the CWA. The opposition to the 2015 shift of WOTUS definition away from "navigability" to scientific indicators of environmental importance ultimately led to the drastic reduction of wetland protections in 2018. Four influential court cases were identified which gives context to the varying interpretations of the interpretation of WOTUS on the federal level. Analysis on NC state level policies revealed stringent wetland protections, which have been limited due to recent legislation.

PART 4

A Review of Implementable County-Level Policies

Key Points

Main Findings:

1. Currently, Carteret County only protects wetlands under one county ordinance. All other protective policies and programs within the county operate at the state and NGO level.
2. Analysis of other coastal NC counties revealed a lack of wetland protections at the county level, but programs available for participation.
3. Counties in MD revealed to have wetland policies that could be implementable in Carteret County.

We narrowed our protective policy review to include the county-level, specifically within three categories: Carteret County itself, other coastal NC counties, and counties in another coastal state with effective wetland legislation. Through our research, we determined that Carteret County could benefit by referencing the well-established programs and policies used in Anne Arundel and Cecil Counties (MD).

NC County-Level Policies

We first researched current and historical wetland-related protections implemented in Carteret County and other coastal counties in NC, which provided us with a comprehensive understanding of the preservation landscape within the state that would form the foundation for our future development of implementable policy recommendations.

Carteret County

Carteret County is one of twenty coastal counties within NC, contributing to the thousands of miles of coastline and estuarine shoreline inside state boundaries. With over 40% of parcels remaining undeveloped, significant portions of the county's land cover remains occupied by wetlands or adjacent / hydrologically connected water bodies (Pamlico Sound, 2020). In order to provide actionable policy recommendations for Coastal Carolina Riverwatch and local municipalities, we first conducted a thorough review of the county's current policies, programs, and protected areas.

County Ordinances

Within Carteret County's Code of Ordinances, there is one subsection under *Article IV - Standards of Design* that directly impacts wetland preservation, promotion, protection, and potential development: Sec. 4-18. Planned Conservation Development (PCD).

According to local law, the PCD plan is to "provide the developer with greater flexibility and creativity necessary to plan development around identified Conservation Areas without

compromising the economic value of the development, as well as to minimize the total amount of disturbance on the site" (Code of Ordinances, n.d., § 4-18.1). If the acreage of a proposed subdivision is composed of at least 20% Conservation Area, the county-level Planning Commision is authorized to decide whether the PCD is necessary. Once the acreage identified as Conservation Areas exceeds 40%, the PCD becomes the only option available for developers to utilize (Code of Ordinances, n.d., § 4-18.1). This plan is not required for major subdivisions that lack Conservation Areas, major subdivisions that are not undergoing improvements, minor subdivisions, and family subdivisions (Carteret, n.d.).

PCDs allow for residential density to increase up to 12% so long as more than 50% of total acreage is devoted to the use of buffers, common areas, open space, and amenities. Undeveloped lands designated as common areas or open spaces are encouraged to include a variety of recreational elements, including wetlands, marshes, wildlife habitats alongside pathways and walking trails (Carteret, n.d.). For all properties, a minimum 30 ft buffer is required. This extends to 50 ft when development occurs within Conservation Areas (Code of Ordinances, n.d., § 4-18.4).

The Code of Ordinances defines Conservation Areas as any natural areas protected by law, shorelines, endangered or threatened species and their habitats, sites of historical or cultural significance, and other elements of natural or scenic value (Code of Ordinances, n.d., § 4-18.1). This definition coincides with lands that the Coastal Resource Commission (CRC) designates as "Areas of Environmental Concern" (AEC). AEC's are areas substantially impacted by erosion or flooding, as well as lands of environmental, social, economic, or aesthetic importance (Division, 2014). The CRC divides these areas into four distinct categories: Estuarine and Ocean System; Ocean Hazard System; Public Water Supplies; and Natural and Cultural Resource Areas (Division, 2014). Currently, AECs include most waters but less than 3% of land area within coastal NC (Carteret, 2021). Wetlands mostly fall into the category of Estuarine and Ocean System AEC, as we will explore in more depth below.

Estuarine and Ocean System AECs

Estuarine and Ocean System (EOS) AECs include brackish sounds, marshes, and surrounding shorelines that are generally protected by barrier islands, such as those of the Crystal Coast / Southern Outer Banks that fall under Carteret County's jurisdiction (Division, 2014). This system is composed of four components: public trust areas; estuarine waters; coastal shorelines; and coastal wetlands.

The CRC defines coastal wetlands as "any marsh in the 20 coastal counties that regularly or occasionally floods by lunar or wind tides," as well as having at least one of ten critical plant species growing within the ecosystem (Division, 2014, p. 6). Despite not including freshwater or inland wetlands under its classifications, the EOS AEC could still apply to these water bodies due to the public trust clause, or the "coastal waters and submerged lands that every North

Carolinian has the right to use for recreational activities such as boating, swimming, or fishing" (Division, 2014, p. 5).

Wetlands and other ecosystems within the EOS are important sites for local economies of fishing, shellfish aquaculture, and tourism in addition to providing settings for recreational activities. In fact, according to the NC Division of Marine Fisheries, over 90% of the state's commercial harvesting species (and over 60% of its recreational species) are dependent on these habitats (NC Department, 2021a). Wetlands and transitional lands between water bodies are seen to be particularly important to the juveniles of commercially / recreationally valuable species, as these often congregate within marshes and other shallow habitats that promote survivorship through increased food sources and protection from predators (NC Department, 2021a). These habitats also maintain a variety of waterfowl and wildlife, guard against erosion and flooding, and contribute heavily to the economy through tourism (Division, 2014).

The importance of wetlands and other estuarine systems is further evidenced in Carteret County, where the Newport River is one of the most valuable yet simultaneously threatened oyster-growing estuaries in the state (Strong, 2022). We explored these characteristics of the Newport River in *Part 2* through analyses of shellfish growing areas, and documented the continuous closure of major areas to harvesting. In 2005, Carteret County's Land Use Plan acknowledged the waters and tributaries of the Newport River to be AECs, along with those of the White Oak, Neuse, and North Rivers, major sounds, and extensive coastal wetlands across the county (Carteret, 2009). 17 years later, the county's 2021 CAMA and Land Use Plan references the same AECs (Carteret, 2021).

It is important to note that local governments have the jurisdiction to establish protection standards for AECs that are more rigorous than those ordered by the state / CRC. Currently, Carteret County simply implements and promotes CRC guidelines, which include not diminishing or destroying natural barriers to erosion, limiting impervious surface coverage, and maintaining buffer zones (Carteret, 2021). This is representative of an opportunity for Carteret County authorities to increase wetland protections in order to maintain and preserve important aspects of local economy and recreation.

Wetland-Related Preservation Areas

Carteret County is home to three significant nature / wildlife preservation areas: the Rachel Carson National Wildlife Refuge, the North River Wetlands Preserve, and the Croatan National Forest. Each of these locations not only demonstrate the environmental importance of wetlands in larger ecosystems, but also reflect the broad network of interconnected wetland protection mechanisms and levels of governance that are at play within county lines.

The Rachel Carson Reserve

As one of ten NC National Estuarine Research Reserve sites, the Rachel Carson Reserve (RCR) is composed of 2,315 acres of important habitats for native species, such as islands, wetlands, and marshes (Town, 2022; NC Division, n.d.-a). The main islands - Carrot Island, Town Marsh, Bird Shoal, and Horse Island - are each long and narrow, with the longest being over three miles long and less than a mile wide (NC Division, n.d.-a). This area is under additional protections due to being classified as a Dedicated Nature Preserve by the Natural Heritage Program (NC Department, n.d.).

The estuarine systems of scrub-scrub and emergent wetlands dominate significant portions of the RCR (NC Department, 2021b), as is further seen in the environmental composition of Middle Marsh, the saltmarsh complex located in the eastern portion of the reserve. According to a study conducted between 2004 and 2017 by researchers from Duke University, the emergent wetlands of the RCR have remained generally stable despite significant changes to shoreline (Gray et al, 2018). During this time period, Middle Marsh lost 9% of its emergent wetlands, which were replaced by increases of upland scrub-shrub and intertidal sand (Gray et al, 2018). With rising sea levels and increasing occurrence of hurricane events within the past decade, the degradation of wetlands and erosion of islands within the RCR may not be reversible. These threats and stressors place both the neighboring town of Beaufort and native species at risk of increasing vulnerability, whether it be due to habitat loss, water quality risks, flooding, or other factors (Gray et al, 2018; Town, 2022; NC Coastal, n.d.).

The North River Wetlands Preserve

Managed by the NC Coastal Federation, the North River Wetlands Preserve (NRWP) in eastern Carteret County is one of the largest wetland restoration projects in both the state and in the country (North Carolina Coastal Federation, 2023c). The NRWP, composed of 6,000 restored acres of prior agricultural lands, was established in 1999 to re-create forested, freshwater, and tidal wetlands that could “improve the water quality of degraded downstream estuaries and reopen these waters for shellfishing” (North Carolina Coastal Federation, 2023c). The Federation has received assistance from a multitude of state and non-state stakeholders, including environmental mitigation companies, private hunting clubs, private and public universities, NC Shellfish Sanitation Section, and the Nature Conservancy among others. In addition, the NRWP received funding through a variety of programs, such as the USDA Agricultural Conservation Easement Program, the NC Land and Water Fund, the Atlantic Coastal Fish Habitat Program, and the NC Natural Heritage Program (North Carolina Coastal Federation, 2023c).

Through the NRWP, the Federation has promoted the relationship between human health / well-being and coastal ecosystems by including wetlands at the heart of the organization's main goals: to improve water quality and reduce flooding; to better protect shorelines from erosion (see *Living Shorelines*); revitalize oyster harvesting for the environment and the economy;

sustainable coastal management; and removal of debris from coastal habitats (North Carolina Coastal Federation, 2023a).

The Croatan National Forest

The Croatan National Forest (CNF) is one of four national forests in NC and is the only coastal forest in the eastern United States (US Forest, n.d.). The CNF and its corresponding 160,000 acres are characterized by proximity and connectivity to water, with pine forests bleeding into wetlands such as saltwater marshes, bogs, and raised swamps (Pamlico Sound, 2020, p. 46).

The 2002 Revised Land and Resource Management Plan for the CNF emphasizes its reliance on wetlands for biological diversity, such as their provision of habitats for forest species, travel corridors for wildlife between fragmented landscapes, and promoting migratory bird visitation (US Department of Agriculture, 2002). This plan also described goals to maintain and restore hardwood cypress wetlands and sustain aquatic ecosystems, especially pocosins. Over eight million people visit the national forest annually, seeking to engage in the wide range of recreational activities the pines and wetlands provide, such as fishing, hunting, boating, and swimming (US Forest Service, n.d.).

Participation in Wetland-Related Programs

As we discovered in *Part 1*, Carteret County has not experienced significant wetland degradation within the last 25 years. Currently, wetlands account for 143,952 acres or 16.8% of total county acreage (Pamlico Sound, 2020). Expanding beyond federal, state, and local laws and the long-term maintenance of nature reserves, we chose to explore potential programs that county municipalities or other wetland-related actors have participated in. Throughout our research, we found that Carteret County has not taken a substantially active role in protecting its jurisdictional wetlands, instead documenting the heavy participation of non-profit organizations and town entities in various programs funded by both state and federal agencies.

The Resilient Coastal Communities Program

Funded by NC State Legislature and the National Fish and Wildlife Foundation, the Resilient Coastal Communities Program (RCCP) provides financial resources and expert guidance for local governments to “overcome barriers in coastal resilience and adaptation planning, boost local government capacity, and support a proactive, sustainable, and equitable approach to coastal resilience planning and project implementation” (NC Department, n.d.). This community-driven program was piloted by five coastal towns, including Pine Knoll Shores in Carteret County (Division, 2023). The RCCP is the first of its kind in NC, and recognizes the

importance of wetlands in holistic hazard mitigation that protects the economy, the environment, and society (Division, 2023).

The RCCP Handbook (2023) provides guidance for local governments to implement the first two phases: *Community Engagement & Risk/Vulnerability Assessment* and *Planning, Project Identification, and Prioritization*. Step 5 of Phase 1 - identifying and mapping critical assets, natural infrastructure, and socially vulnerable populations - explicitly discusses the vitality of wetlands to coastal resiliency, including their ability to act as natural buffers and absorb stormwater (Division, 2023). Wetlands are further discussed in Step 1 of Phase 2: identifying potential solutions. In this step, wetland conservation and restoration projects are described as meeting all three principles resiliency approaches should hold:

- [Support] essential community functions that are critical for absorbing, rebounding from, and adapting to hazards;
- [Facilitate] hazard-focused community preparedness, risk management, and mitigation actions that reduce long-term vulnerabilities; and
- [Enable] post-disaster community recovery and redevelopment that integrates specific community-based resilience objectives. (Division, 2023, p. 40)

Wetland-related projects are also seen to provide co-benefits to the environment and serve to combat climate-related impacts through carbon sequestration, wave energy reduction, preventing erosion, and alleviating flooding (Division, 2023).

During its initial stages of official implementation between 2020 and 2022, the RCCP had three Carteret County towns participate: Cape Carteret, Pine Knoll Shores, and Beaufort (further discussed in *Case Study: Beaufort*). Two more of the county's communities - Atlantic Beach and Cedar Island - were awarded funds for the 2023/2024 cycle (NC Department, n.d.).

The Pamlico Sound Regional Hazard Mitigation Plan

The Coastal Plains of eastern NC accounts for 20,000 square miles - or nearly 50% of the state's total area (Pamlico Sound, 2020; Hoffman, 1986). Of this, 3,640 square miles are designated as the Pamlico Sound Region, with Carteret County accounting for the vast majority of land cover in comparison to other participating jurisdictions (Beaufort, Craven, and Pamlico Counties) (Pamlico Sound, 2020). The 2020 Pamlico Sound Regional Hazard Mitigation Plan (RHMP) was developed as a way to coordinate environmental disaster responses and preparation / vulnerability reduction techniques to promote cohesive and cost-effective approaches (Pamlico Sound, 2020).

The RHMP notes the importance of wetland presence and preservation for hazard mitigation as being "hard to overestimate" (Pamlico Sound, 2020, p. 34). Some of the factors listed include maintaining threatened / endangered plant and animal species, storing stormwater, reducing floods, replenishing aquifers, and absorbing various pollutants from surrounding water

sources. While Carteret County itself is a member of the RHMP, not all town-level jurisdictions opted in. Participating towns include: Atlantic Beach, Beaufort, Bogue, Cape Carteret, Cedar Point, Emerald Isle, Indian Beach, Morehead City, Newport, Peletier, and Pine Knoll Shores (Pamlico Sound, 2020).

Shoreline Restoration Projects

Shoreline and estuarine erosion continues to be an environmental concern within Carteret County, especially when compounded by rising sea levels and increased flooding due to climate change. At Cape Lookout, erosion rates along the north shore are estimated to be between -0.25 and -8.8 meters per year (Currin, 2010). Historically, the most common approach to shoreline stabilization has been the construction of bulkheads, or barriers created from materials like wood, stone or vinyl (Talton, 2016).

Research has extensively shown the ways in which bulkheads are detrimental to wetlands and other transitional vegetation. These barriers not only obstruct natural landward migration of emergent wetlands, but they also impact the survivorship of keystone species by increasing predation through the degradation of shallow nursery habitats and the reduction of sediment transfer that promotes nutrient sharing and vegetative growth. The creation of bulkheads and other physical barriers is referred to as the "hardening" of shorelines (Currin, 2010). Despite the publication and promotion of these adverse effects by various academic and environmental advocacy groups, NC property owners continue to construct bulkheads in large quantities (Talton. 2016; Currin, 2010).

One alternative to bulkheads are living shorelines, which integrate natural materials like oyster shells, sand, and native wetland plants and other aquatic species (Talton, 2016). According to the National Oceanic and Atmospheric Administration (NOAA), living shorelines are one of the most innovative and cost-effective methods for sustainable coastal management, costing between $1,000 and $5,000 per foot to install but less than $100 to maintain annually (NOAA, n.d.). Living shorelines "incorporate natural habitats into a shoreline stabilization design, maintain the connectivity between aquatic, intertidal and terrestrial habitats, and minimize the adverse impacts of shoreline stabilization on the estuarine ecosystem" (Currin, 2010, p. 95).

In Carteret County, the NC Coastal Federation has been a long-term leading advocate for the establishment of living shorelines to reduce coastal erosion, to restore fringing wetlands, and to improve water quality throughout the region (Huffman, 2021). Over the past 20 years, the Federation has designed both public and private living shorelines - over 20 of which are located within the county (North Carolina Coastal Federation, 2023b). Most recently, the organization has received funding to establish two living shorelines between 2020 and 2021: one at the Pine Knoll Shores Town Hall (460 ft) and one near Bogue Sound (971 ft) (North Carolina Coastal Federation, 2023b; Huffman, 2021).

Case Study: Beaufort

Beaufort, NC, is located in the southern portion of Carteret County. Tucked behind the barrier islands of the Rachel Carson Reserve (RCR), the town's identity is closely linked not only to the ocean, but to a variety of estuarine habitats and their environmental systems (Town, 2022). Beginning in the mid-1990s, Beaufort has been subjected to a dramatic intensification of climate-driven coastal flooding, increasing from nearly 80 total flood days between 1985 and 1994 to almost 400 between 2005 and 2014. This 400% increase in flood days is compounded by the town's low elevation, with almost 10% of the population living in areas that are less than 4 feet above sea level (Climate, n.d.). The repercussions of sea level rise - such as storm / flood run-off, erosion, and loss of native vegetation - continue to be one of the town's greatest environmental concerns. Given that over 50% of the population's minority and low socioeconomic groups reside near Town Creek (one of the lowest geographical locations in Beaufort), the impacts of sea level rise and loss of estuarine habitats will prove most detrimental to the town's most vulnerable citizens (Town, 2022).

Wetlands continue to be a focal point in town policies and programs, with community members and local officials recognizing the important role the ecosystem plays in ensuring the social, environmental, and economic well-being of the town. This is further represented in recent advocacy for the Gibbs Creek area to be a designated AEC - the first nomination in over 30 years (Kenworthy, 2023). Beaufort already has a number of other coastal wetlands / shorelines that are confirmed AECs, including those near Taylor Creek, North River, Newport River, and various estuarine water sites (Town, 2022).

In 2017, Beaufort partnered with the Eastern Carolina Council, the NC Coastal Federation, various divisions within the NC Department of Environmental Quality, the NC Department of Transportation, and UNC Wilmington to create the Beaufort Watershed Restoration Plan (BWRP). The plan detailed community desires to improve the local water quality and reduce the presence of bacterial and chemical pollutants through three goals:

1. Restoring and maintaining the water quality of three Beaufort Watersheds;
2. Reduce instances of localized flooding to improve safety and protect property;
3. Prioritize cost effective Low Impact Development and stormwater retrofit techniques to address stormwater management. (Town, 2017, p. 9)

The BWRP acknowledges wetlands to be a vital stormwater management technique that can be easily incorporated in a variety of settings, such as converting retention ponds into artificial wetlands (Town, 2017). These purposefully designed wetlands are also referred to as "stormwater wetlands," and are considered by the EPA to be "the most effective post-construction stormwater controls in terms of pollutant removal [and] habitat value" (Office of Water, 2021, p. 1). Without substantial stormwater mitigation techniques, notable areas within Beaufort will eventually become permanently or frequently submerged, including natural coastal

wetlands near the North River Bridge and of the RCR (Town, 2022). The plan also highlights how wetlands and other coastal / estuarine habitats are important for wildlife and regional biodiversity and the prevention of shoreline erosion, which further contributes to the maintaining of water quality and flood prevention via natural filtration systems within the ecosystem (Town, 2017).

In addition to the BWRP, the town of Beaufort is an active participant in multiple resiliency and mitigation plans, including the Resilient Coastal Communities Program and the Pamlico Sound Regional Hazard Mitigation Plan (see *Participation in Wetland-Related Programs*). Beaufort has also acknowledged the opportunity to engage in collaborative resiliency efforts with the nearby RCR, whose wetlands and marshes greatly protect the town's waterfront recreational sites and businesses (Town, 2022).

Beaufort has had two living shorelines designed by the NC Coastal Federation since the early 2000s: the Maritime Museum (Gallants Channel) and the Duke University Marine Laboratory (Talton, 2016). The former, described as replacing a steel bulkhead with two stone sills and marsh grasses, restored half an acre of wetland habitat between 2000 and 2002. Similarly, the living shoreline at Duke's laboratory, which is described as replacing a 260 ft bulkhead and 175 ft flounder pen wall with a 300 ft stone sill and 485 ft stone barricade, also restored half an acre of wetland habitat in 2003 (Talton, 2016).

Looking to Beaufort's recent Comprehensive and CAMA Land Use Plan (2023) and its continuous implicit and explicit reference to the significance of wetlands, as well as the town's diverse efforts to maintain and restore estuarine habitats, Carteret County is home to a community that is a leading force for wetland protection policies and program implementation.

Other NC Counties

Examining wetland policies and programs in other coastal counties in NC is beneficial for our analysis given their similar environmental characteristics to those of Carteret.
We selected several coastal NC Counties that were listed on the Department of Environmental Quality (DEQ) as CAMA Counties (NCDEQ, n.d.). Through conducting secondary research on these counties, we decided to include counties that have the best policies and programs that could be beneficial to protecting Carteret County wetlands. The research revealed that most coastal NC counties do not have wetland policies that go beyond the state and federal level. Many of the counties' ordinances were in line with the Clean Water Act (CWA) and define and protect wetlands according to those guidelines (*Zoning Ordinance: Onslow*, 2021 & New Hanover County, n.d.a). As a result, we decided to include programs and projects that protect wetlands in various counties. These aren't necessarily programs run by the county, but are conducted within the county. Our analysis of programs and projects in other NC counties include programs specific to Craven, Dare, and New Hanover County as well as those that span across several coastal NC counties including, but not limited to, Onslow, Hyde, and Pasquotank County.

Programs Across NC Counties

The Habitat Conservation Program is an environmental conservation program that spans across multiple counties in NC. This program is run by the NC Wildlife Resources Commission and has many objectives related to habitat conservation, two of which are specifically focused on wetland conservation (NC Wildlife Resources Commission, n.d.). For the first goal, the NC Wildlife Resources Commission is partnered with the Natural Heritage Program and the NC Forest Service. Their aim is to protect forested wetlands and associated water quality by influencing Forestry Best Management Practices (BMP). The forestry BMP were created by NC Forest Service and are "... actions that should be implemented to protect water quality and conserve soil when conducting forestry/silviculture operations." (North Carolina Forest Service, n.d). For the second goal involving wetlands, NC Wildlife Resources Commission is partnered with the NC Department of Transportation (NCDOT), focusing on the potential environmental impacts of the US 17 bypass improvements (NC Wildlife Resources Commission, n.d.). These improvements are estimated to affect around 1,100 acres of wetlands. NC Wildlife Resources Commission has offered NCDOT mitigation advice for wetlands in Craven, Onslow, New Hanover, Dare, Currituck, Martin, Brunswick, Wayne, Wilson, and Wake counties. This advice will aid in preserving the wetlands at these sites (NC Wildlife Resources Commission, n.d.).

Another program that is present in multiple NC counties is the Community Conservation Assistance Program (CCAP), which is a cost share program concentrating on water quality priorities. CCAP is an incentive-based program whose goal is to improve water quality through BMPs (Dare County, n.d.). For CCAP specifically, the land eligible is urban, suburban, and rural lands not associated with agriculture. Applications to enroll in the program are given priority based on the status of their water quality. Once accepted, a conservation plan is prepared and the CCAP provides financial assistance to the owner to complete the desired BMPs up to 75% of the cost. There is a diverse array of BMPs that are eligible under CCAP, one of which is the Stormwater Wetland. This BMP involves producing a system that would mimic natural wetlands to alleviate the effects that development has on local water quality. Much like natural wetlands, the stormwater wetland serves to remove a number of pollutants from the water. While this isn't a program directly aimed at protecting wetlands, it offers solutions to improve water quality through mimicking wetland functions (Dare County, n.d.). NC coastal counties that are enrolled in CCAP include Dare, New Hanover, Onslow, and Hyde (New Hanover County, n.d.b; Onslow County, n.d.; Dare County, n.d.; & County of Hyde, n.d.). This program is supervised by county specific Soil and Water Conservation Districts, which are present in every NC county (Brunswick County Government, n.d & Washington County, n.d.).

The Pasquotank River Basin Resource Plan

The Pasquotank River Basin Water Resources Plan was developed by the NC Department of Environmental Quality's (NCDEQ) Division of Water Resources (DWR) to address water

quality issues in the Pasquotank Basin (DEQ, 2023). The Pasquotank River basin spans across several NC counties, including Camden, Chowan, Currituck, Dare, Gates, Hyde, Northampton, Pasquotank, Perquimans, Tyrrell, and Washington County (Pasquotank, n.d.). The basin contains a number of different sounds, rivers, and watersheds, making this the largest freshwater estuary in NC. The plan was developed through analyzing water quality data collected between 2006 and 2019. The goal of the plan is to identify water resources and areas that are in need of protection, preservation, or restoration. Wetlands account for approximately 33.1% of the Pasquotank River basin and have experienced only minute changes in total area, decreasing by roughly ~.1% between 2001 and 2016 (DEQ, 2023). Nonetheless, the NC DWR advocates for the importance of preserving wetlands for habitats and water quality. They report that the wetlands' ability to function properly has been affected by many stressors in the Pasquotank basin, such as ditching and drainage tile installation (NCDEQ, 2021). In their outlined plans to protect wetlands, they include "The State of NC Wetland Program Plan 2021-2025" (NC WPP), which is a 5-year plan with goals related to:

- *Monitoring and assessing wetland trends and status through collecting and analyzing NC wetlands.*
- *Regulations regarding administering and evaluating activities of enforcement and compliance to NC's wetland requirements.*
- *Assistance with public outreach of voluntary wetland restoration.*
- *Promoting voluntary restoration and protection of wetland function, acreage, and conditions.*
- *Provide consistency of wetland standards (NCDEQ, 2021 & NC DRW, n.d.).*

In addition to upholding the goals of the NC WPP, the Pasquotank River Basin Water Resources Plan addresses additional goals for restoration and preservation of wetlands. The goals for restoration activities include those that prioritize improving water quality and focusing on areas that are associated with wetlands. Areas of priority for wetland preservation include those that protect water quality and serve to protect the area from storm surges or other flooding (NCDEQ, 2021).

Craven

The Brice Creek Wetland Mitigation Bank is one method Craven County utilizes to protect wetlands. This program covers 636 acres in the county and was developed by Weyerhaeuser, who is committed to the preservation of the Neuse River Basin and associated wetlands (Land Conservation Assistance Network, n.d.). The overall goal of mitigation banks is to ensure there is no net loss to the environment when working on development projects (Jhawar, 2022). To ensure there is no net loss, the mitigation bank has credits and debits for preserved wetlands which, when purchased, "... provides compensation for unavoidable impacts to aquatic

resources permitted under Section 404 [of CWA] or a similar state or local wetland regulation." (Jhawar, 2022; *Mitigation Banks*, 2023). This program can be a better alternative to wetland permitting because it reduces permit processing times, it is more cost effective, and there is a higher chance of mitigating the environmental impacts of development projects (*Mitigation Banks*, 2023).

Dare

The South Atlantic Salt Marsh Initiative is potentially developing a wetland program in Dare County. In October of 2022, residents of Dare County whose property contained salt marshes were asked to take a survey for the South Atlantic Salt Marsh Initiative. The purpose of this survey was to help the Initiative develop potential programs to conserve wetlands in Dare County (Coastal Review, 2022). One of the proposed programs that could be developed in response to this survey is the Salt Marsh Reserve Program. This would be an incentive-based program for residents whose property contains salt marshes. These residents would be paid to protect the wetlands on their property for a set number of years (Coastal Review, 2022). At the time of our research, a program has not yet been initiated in Dare County as a result of the South Atlantic Salt Marsh Initiative survey.

New Hanover

In 2005, the County of New Hanover initiated a project which entailed construction of a stormwater wetland (City of Wilmington, 2022).The goal of this project was to use this constructed wetland to improve the water quality of Hewletts Creek (City of Wilmington, 2022). Discussed previously in *Across NC Counties*, stormwater wetlands work to improve water quality through removing pollutants from the water, similar to a natural wetland (*Cost Share*, n.d.). With funding from the NC Clean Water Management Trust Fund, New Hanover County purchased a 17 acre parcel of land for this project (City of Wilmington, 2022). The County partnered with the City of Wilmington, and the state to complete this project (Gannon, 2009). The construction was completed in 2007 and resulted in a 12-acre stormwater wetland that treats around 10% of the Hewletts Creek Watershed. The area is now known as the J.E.L. Wade Park, and is the largest constructed stormwater wetland in Wilmington (City of Wilmington, 2022). The Aquatic Ecology Laboratory at the University of North Carolina Wilmington tested this wetland and concluded that it has been effective at reducing a wide variety of pollutants from entering the water. Additionally, they state that these constructed wetlands will be beneficial in protecting water quality across NC as urbanization increases (UNCW, n.d.).

Other Coastal State: MD County-Level Policies

Our team decided to evaluate state and county laws in MD in hopes of discovering policies that could be implemented in NC's Carteret County. We chose MD because of its relative abundance of county-level wetland policies compared to other states. It was initially quite difficult to figure out which states had the best county-level policies because it required searching through state-level policies beforehand. Preliminary research led us to states with especially strong protections, like Michigan, Minnesota, and New York, but a further look revealed that there were few county policies in these states. If these states had any county-level policies they were relatively weak or just furthered an existing state program. Unlike other states, MD not only had more unique county-level policies, but they also had a highly organized website, summarizing and linking county-level policies. This streamlined our research and made the policies much easier to analyze. Conveniently, MD's wetlands are also much more similar to Carteret County's than a Great Lake State or non-coastal state.

In 1984, the MD General Assembly passed the Critical Area Act, establishing the Critical Area Program. The program is a comprehensive approach to protect the natural resources of the Chesapeake Bay and its tidal shorelines. The definition of an Area of Critical State Concern is, "specific geographic area of the State which, based on studies of physical, social, economic, and governmental conditions and trends, is demonstrated to be so unusual or significant to the State that the Secretary designates it for special management attention to ensure the preservation, conservation, or utilization of its special values" (Maryland Department of the Environment, n.d.). The main goals of the Critical Area Act are to:

- *Minimize adverse impacts on water quality from pollutants that are discharged from point sources or runoff from surrounding lands.*
- *Conserve fish, wildlife and plant habitat in the Critical Area.*
- *Establish land-use policies for development that accommodate growth, yet address the environmental impacts associated with the number and activities of people in the Critical Area.*

While the law does not prohibit development within the designated territory, it regulates and restricts land development to conserve resources and protect the Chesapeake Bay. The critical area includes all lands within 1,000 feet of the mean high water line of tidal waters or the landward edge of tidal wetlands of the Chesapeake and Coastal Bays and their tidal tributaries. Official maps establish the exact limits of the Critical Area.

While this policy was passed through the state government, cities and counties implement their respective Critical Area Programs which are overseen by the Critical Area Commission - a statewide body formed in the Critical Area Act of 1984. The Commission develops a set of standards - Critical Area Criteria - which is adopted into local ordinances that govern land uses and development. Local programs are approved by the Commission and renewed every six years.

Ultimately, individual counties make decisions on how they implement regulations for land development in their respective Critical Areas (Delfs, 2004).

Case Study: Anne Arundel County, MD

Anne Arundel County's Critical Area Program

Anne Arundel County is home to MD's state capital, Annapolis. Located on the Chesapeake Bay, Anne Arundel County is known for water activities such as boating, fishing, swimming, and sailing. The county's Critical Area Program, first approved in 1988, provides extensive protections to the outlined Critical Area and the Chesapeake Bay's surrounding habitat. The county's program designated three categories of land development within the Critical Area, including intense development areas (IDA), limited development areas (LDA), and resource conservation areas (RCA). Grading, building, and land use must follow Critical Area Criteria specific to these designations.

IDAs can be developed with medium to high-density housing, commercial, or industrial uses according to the underlying zoning designation. Pollutant loadings must be reduced by 10%, Habitat Protections Areas (HPA)[1] must be protected, and a minimum 100 foot buffer[2] is required around developments. LDAs can be developed with low to medium density housing, with a maximum of less than four units per acre. Commercial and small industrial uses may be developed according to underlying zoning designations. Development in RCAs is limited to one dwelling unit per 20 acres, and agricultural and forest uses and resource utilization must occur according to the permitted use list. Both LDAs and RCAs must limit impervious surfaces to 15-31% of the site, require a minimum 100 foot buffer, limit forest clearing, replace any forest that is removed, and require unforested developments to establish 15% of the site in forest. The Critical Area program has special regulations for water dependent facilities, shore erosion protection works, forest and woodlands, agriculture, surface mining, and natural parks (Critical Area | Anne Arundel County Government, n.d.).

Anne Arundel County's Natural Features Green Notices

Additional protections for wetlands exist in the Anne Arundel County Office of Planning and Zoning (OPZ) Natural Features Green Notices. These notices increased protection of nontidal wetlands beginning March 6, 2020. These notices are part of Anne Arundel County's new initiative to improve "transparency in the development and construction review process,"

[1] *Note:* Habitat Protection Areas (HPAs) include a minimum 100 foot buffer from tidal wetlands and waterways, areas home to endangered or threatened species, water bird nesting sites, fish spawning areas, riparian buffers, forest areas used by forest interior dwelling birds, nontidal wetlands, and other areas of local significance.

[2] *Note:* The minimum 100 foot buffer is a "naturally wooded area or a forested area specifically established or managed to protect aquatic, wetland, shoreline, and terrestrial environments from man-made disturbances."

which Wetland Studies and Solutions, Inc. (WSSI) is monitoring. WSSI recommends considering environmental features, including wetlands, early in the development process, and reviewing development sites with county staff to allow for a smoother development process. These green notices include four ordinances by the OPZ, described in further detail as follows.

OPZ-20-04: Identifying Existing Conditions and Natural Resources through the Sketch and Preliminary Planning Process

OPZ-20-04 focuses on identifying existing conditions and natural resources through the sketch and preliminary planning process. The purpose of this ordinance is to provide updated checklists to "ensure natural resources are appropriately mapped at the onset of the review process." The OPZ updated the sketch and preliminary plan checklists and submittal requirements to meet the objective of this policy. All sketch and preliminary plan applications submitted on or after April 3, 2020 must use updated checklists in the planning process for development.

OPZ-20-05: Verifying the Existence or Absence of Nontidal Wetlands and their Buffers

OPZ-20-05 focuses on verifying the existence or absence of nontidal wetlands and their buffers. The purpose of this policy is to establish "standard operating procedures to verify the existence or absence of nontidal wetlands and their buffers on a project site." Upon a proposed development application, Anne Arundel County OPZ staff will assess the site to determine if State-regulated resources, specifically nontidal wetlands, are present in the area. If State-regulated resources are found to be present within 100 feet of the proposed development, a formal wetland report must be performed by a "qualified professional" and submitted to the County. If the potential wetlands exist within 25 feet of the proposed limit of disturbance or within 100 feet of a Wetland of Special State Concern, the applicant must conduct a pre-application meeting with the MD Department of the Environment. Altogether, this ordinance formalizes the process for a developer to obtain written MDE confirmation of the wetland limits early on in the development process.

OPZ 20-06: Protections and Minimum Mitigation Conditions for Nontidal Wetlands

OPZ-20-06 outlines protections and minimum mitigation conditions for nontidal wetlands. This ordinance prohibits any avoidable disturbance of nontidal wetlands and their buffers. If impacts are unavoidable after considering alternative site design options, applicants must apply for a modification to justify the impact, according to Section 17-2-108 of the County Code. As part of the modification application, a potential developer must provide a wetland permit from the appropriate state and federal agencies (ie. MDE and U.S. Army Corps of

Engineers (USACE)). The application process may experience a significant time delay of up to several years depending on the project and size of the impact. The OPZ does not guarantee the approval of modifications, and if the request is approved, minimum mitigation requirements for any modification to the nontidal wetland or 25-foot wetland buffer is as indicated in Figure 18.

Figure 18: **Minimum Mitigation Requirements for Modifications to Wetlands**

Type of Disturbance	Proposed Mitigation Type: Onsite Wetland Creation **OR** Onsite Native Tree Planting	Proposed Mitigation Type: Offsite Wetland Creation or Purchase **OR** Offsite Native Tree Planting
Nontidal Wetlands of Special State Concern (WSSC)	3:1	6:1
WSSC Buffers	2:1	4:1
Other Nontidal Wetlands (*i.e.,* not WSSC)	2:1	4:1
Other Nontidal Wetland Buffers	1:1	2:1

Notes. From Wetlands in Anne Arundel County, Wetland Studies and Solutions, Inc. (WSSI) (2022). Ratios refer to amount of mitigation category per square footage of disturbance.

Based on the guidance provided in the chart, mitigation is required by the county even if it is not required by the MDE or USACE. All mitigation must be performed in the same watershed as the impact, but additional guidance is needed to determine the level of the watershed. Permitting delays can result from locating a suitable site and designing permitting mitigation projects (WSSI, 2020).

Through these Green Notices, Anne Arundel County OPZ staff demonstrated their commitment to limiting the impact of development on significant environmental resources such as nontidal wetlands. The county set these standards to further protect the area's wetlands and create concrete criteria that potential developers must follow in obtaining permits.

Anne Arundel County Watershed Protection and Restoration Fee

Another program used by the Anne Arundel Department of Public Works (DPW) is the Watershed Protection and Restoration Fee (WPRF). This fee is administered by the county to property owners with impervious surfaces, which are especially susceptible to the threat of pollution from flooding during high rain events. MD's State Legislature passed a law in 2015 allowing for large jurisdictions to have their own county-level stormwater management programs. Properties are taxed according to their classification in the zoning code, with 21

different codes with their own fee calculations. Anne Arundel County uses the WPRF as a way to fairly tax properties with pollution potential, while also offering property owners the chance for a credit by using good management practices (*Watershed Protection & Restoration Fee*, 2023).

As mentioned, the way of calculating the fee for each property is determined by the property's zoning code. To start, the Anne Arundel Department of Public Works established a base rate that could be used in fee calculations for all property types. This base rate was calculated by analyzing GIS data on impervious services for three of the primary residential zones: R1, R2, and R5. After analyzing the data for each residential zone, the median amount of impervious surface was measured to be 2,940 square feet. This 2,940 square feet figure is known as the Equivalent Residential Unit or ERU. Currently, the base price for every ERU is set at $93.71. This means for every 2,940 square feet of impervious surface, the property owner must pay about $94 in tax. Using the ERU, the DPW created different calculations for each zoning code. For instance, Rural Agriculture and Low-Density residential properties are grouped together, and must pay twice the base rate property rate. Other properties that are not as clearly residential are just charged based on the ERU x Base Rate, being charged the base rate for about every 3000 sq. ft. of impervious surface. Property owners who would rather not pay the fee have options to mitigate the charge, however (*Watershed Protection & Restoration Fee*, 2023).

The way that property owners can avoid paying higher fees is the Stormwater Remediation Fee Credit (SRFC). This credit is available to owners of multi-family, residential or non-residential properties if they adopt stormwater best management practices or BMPs. Some BMPs include, but are not limited to; adding permeable pavements or green roofs; creating rain gardens or retention ponds; and adding rain barrels, cisterns, or dry wells. These practices work to disconnect potential pollution points and give the rain a better chance of getting back to the groundwater before runoff occurs. BMPs are defined according to the must be documented, inspected, and approved by the County before any credit is given. If proper BMPs are being used, the property owner can recompense up to 50% of their Watershed Protection and Restoration Fee (Anne Arundel, 2019)

Watershed Master Plan

Watershed-Based Planning or Watershed Master Plans (WMPs) are projects utilized by municipalities for managing watershed health for future land use scenarios and precipitation events. A checklist component of these projects include mapping physical attributes of wetlands and other sensitive topographical features. One of the primary purposes of these projects is to identify appropriate changes to stormwater infrastructure and management regulations necessary to maintain the health of analyzed watersheds. Additionally, their assessment discoveries play a key role in pinpointing areas sensitive to flooding, which is relevant to Carteret County's coastally concentrated population. According to Wetlands Watch, a comprehensive analysis would include data on:

Future land-use and land cover including runoff potential, impervious surfaces, recreational and open space areas, conservation easements, large intact forested lands, existing grey infrastructure stormwater system (point and nonpoint pollution sources) and existing SW facilities, an inventory of hydraulic structures, and significant water storage areas, drinking water supply features, protected areas and flood mitigation areas (Cecil County, 2019).

Cecil County, MD is a case study for a Master Plan, as they developed one recently for Lower North East Creek. What distinguishes Cecil County from other counties with WMPs, is that they combine the Lower North East Creek WMP with their Green Infrastructure Plan. Their description of the Green Infrastructure Plan is "an interconnected network of forests, wetlands, beach grasses, waterways, and floodplains, which includes parks and other conservation lands, such as farms (Cecil County, 2019). By incorporating their Green Infrastructure Plan with the WMP, restoration projects can be combined with community development so that trade-offs between economic expansion and watershed protection are minimalized. The planning process for the Lower North East Creek WMP is outlined in the Figure 19 timeline listed below. Cecil County has explicitly stated that "planning process is intended to serve as a demonstration project for other local jurisdictions with similar concerns and interests" (2021).

Figure 19: Lower North East Creek Watershed Master Plan Timeline

Notes. From Land Use & Development Services | Cecil County. Green Infrastructure (2021).

Summary of Part 4 Findings

We researched county-level ordinances and wetland protection programs in Carteret County, other coastal NC counties, and counties in MD. Due to Carteret County's passive role in wetland protections, these ecosystems remain vulnerable under local law. Advocacy in local townships and effective wetland policies implemented elsewhere could provide guidance for Carteret County's own expansion of wetland protections, as we explore in *Part 5: Policy Recommendations.*

PART 5
Policy Recommendations

Our research culminates in three policy recommendations: (1) better collection and organization practices of wetland data; (2) the implementation of two comparative county-level policies from Maryland; and (3) the expansion of Carteret County-level wetland protections beyond federal and NC mandates. These recommendations utilize knowledge compiled in *Part 1* through *Part 4* to generate a comprehensive approach for combating wetland degradation and consequential impacts on local water quality, biodiversity, economies, and shorelines. Each of these recommendations represents policy changes that Carteret County can implement itself or advocate for at the state level.

Recommendation 1: Data Collection and Storage Improvements

Our first and most broad recommendation is an overhaul of the data collection and organization practices surrounding wetlands. During the preliminary stages of our project, we spent time trying to find the best data to analyze wetland degradation and changes in water quality. As discussed in *Part 1* and *Part 2*, the data that we most needed was not always easy to access, and if it was, the way it was cataloged presented difficulties. In our first step of the project, we sought to analyze Dredge-and-Fill permits, but ran into large difficulties when the permits could not easily be downloaded, read, and cataloged. Similar problems persisted when trying to locate data on water quality; While these sources were easier to analyze at first, they came from many different sources, across agencies and levels of government. Without more organized data, the outlook on wetland health is more cloudy. This makes it harder to analyze and recommend wetland policies confidently.

To respond, Carteret County leaders and other stakeholders should lobby the state government, especially the NCDEQ, to update their data collection and management practices. In our research, we found that multiple DEQ departments collect data that is relevant to wetland health; Though being connected under the title of DEQ, these departments have no shared database. We believe that it would be relatively easy and cheap for the DEQ to standardize its data collection and create a digital database where different sources can input their data. Though it may be tedious to re-enter old data, this is no reason that practices should not be improved now. Additionally, county and local governments could be given access to the database and record their data, as well. This may require careful consideration when rolling out the website, but it would greatly improve all stakeholder's understanding of wetlands.

A problem with this recommendation is that a comprehensive database would be most helpful at a state-level, where it may be less feasible. Carteret County leaders should work with local stakeholders, non-profit organizations, and other coastal counties to apply pressure to the DEQ. All actors involved in wetland policy would benefit from this type of change, so collective action will hopefully be easier to organize.

We acknowledge that this recommendation is more internally targeted and less concrete than the following recommendations. Despite this, it is just as important as our specific policy

recommendations. Making improvements to the way that wetland data is stored and organized will help policymakers and citizens alike understand the importance and outlook for the future of North Carolina's wetlands.

Recommendation 2:
Mirror Other Coastal County Policies

Our second recommendation is based on a comparative look at Maryland policies that have been implemented in Cecil County and Anne Arundel County to protect the future of wetlands for community stakeholders. A Watershed Master Plans (WMP) is a local policy utilized by Cecil County to prioritize community partnerships and infrastructure improvements necessary to address community concerns. Anne Arundel's Natural Features Green Notices are implemented through the Office of Planning and Zoning (OPZ), and serve as a way to improve "transparency in the development and construction review process," (WSSI, 2020).

A Carteret County Watershed Master Plan wouldn't significantly diverge from the Watershed Management Plan implemented in Cecil County. Apart from the specific stakeholders involved and county-specific wetland characteristics, the WMP's framework can draw inspiration from Cecil County, requiring minimal adjustments. As illustrated in Figure 19 of *Part 4*, the timeline for completing foundational work involves collaborative sessions with community members, an analysis of the study area, and the development of a draft plan. This draft will be promptly presented to county officials. These collaborative sessions, referred to as community workshops and information sessions, play a pivotal role in soliciting feedback, identifying areas of concern, reviewing modeling results for flooding or precipitation scenarios, and fostering dialogue that energizes community advocacy and partnerships essential for the successful implementation of new practices. The WMP timelines are relatively short, typically spanning a little over a year from the initial community workshop to the final draft presentation to county officials. Factors that might extend the duration of a potential Carteret County WMP include the scale of hydrologic and hydraulic analysis, the ongoing addition of community workshops, or the impact of natural weather events such as hurricanes temporarily altering the watershed. Crucially, in preparation for initiating the timeline, it is imperative that pertinent historical county-level data is available. This process can be extensive and time-consuming, as encountered in our research.

Implementing ordinances similar to Anne Arundel County's Natural Features Green Notices would help to protect natural resources, including wetlands, in Carteret County. As described in *Part 4*, these ordinances require the consideration of environmental features, including wetlands, early in the development process, and a review of development sites by county staff. These green notices increase the protection of nontidal wetlands and specifically require developers to verify the existence or absence of these ecosystems prior to development. These notices in Carteret County would not look too different from those implemented by the Anne Arundel OPZ. Currently, Carteret County ordinances regarding development refer to

wetlands and areas of conservation very broadly and also do not fully protect these ecosystems. This leaves room for interpretation on what is and isn't allowed for developers. Wetlands in Carteret County, specifically nontidal or isolated wetlands, can be protected through the implementation of ordinances mirroring the Natural Features Green Notices. Our recommendation is for Carteret County officials to consider putting more specific requirements in place for the development process. By specifying what is permissible and what is not for new developments, Carteret County can protect crucial ecosystems such as isolated wetlands from harm in the midst of legislation that strips protections.

Recommendation 3: Expansion of Local Wetland Protections

Our third and final recommendation focuses on altering and expanding policies that Carteret County already utilizes in regards to wetland conservation, preservation, and protection. This can be done by recognizing all wetlands as environmentally-important waterways through authority granted by the Clean Water Act (CWA) and by the NC Coastal Resource Commission (CRC).

Going Beyond Definitions of Federal and State Waters

As previously discussed in *Part 3: A Review of Federal and North Carolina Policy Changes,* the CWA was enacted in 1972 in order to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (Federal Water Pollution Control Act, 2002, § 1251). Under the guidance of the EPA and the Corps, specific "waters of the United States" - or WOTUS - were designated in order to legally determine federal jurisdiction over point and nonpoint sources of pollution (Federal Water Pollution Control Act, 2002, § 1251-1285). From the mid-1980s (see Table 11) until the 2015 proposal of the Clean Water Rule (CWR), wetlands were an unchallenged element of the WOTUS definition. The CWR and its 2018 counterpart, the Navigable Waters Protection Rule (NWPR), marked the beginning of a new era in CWA implementation by ultimately reducing the amount of federally-protected wetlands by drastic proportions.

In addition to providing states the jurisdiction to enforce, meet, and maintain EPA-defined water quality standards (WQS) through the development of individual definitions of "State waters" / "waters of the state", the CWA also grants local municipalities the ability to implement more restrictive wetland regulations than those of higher levels of government (Kusler, 2006). Given recent changes to federal CWA regulations and the passing of the 2023 NC Farm Act, it is now paramount that greater responsibility be assumed by regional and local governments to adopt their own protective wetland policies and programs.

There are multiple ways that local governments can expand their own wetland protections beyond that of federal and state jurisdictions. Most importantly, this would at minimum entail

utilizing the 1980s WOTUS definition to determine basic wetlands with environmental significance. When compared to current federal and NC statutes, this definition would reintroduce protections to wetlands in Carteret County that are geographically adjacent to waterways protected by the authority of the EPA and the Corps. Looking at the changes the Obama Administration made to WOTUS, local level protections could be further expanded by adopting the scientific wetland policies developed within the CWR. On a local level, the CWR definition would allow for Carteret County to utilize exhaustive peer-reviewed research and recommendations produced by the EPA to determine which wetlands "restore and maintain the chemical, physical, or biological integrity" of county waters. The scientific approach to wetland policy presents the potential for isolated wetlands to be included within local protections, ensuring that the majority of Carteret County's wetlands remain safeguarded against unconstrained urban development.

In addition to expanding the operational definition for protective policies and programs, Carteret County can increase conservancy zoning. Areas of Environmental Concern (AECs), regulated by the CRC, provide local policymakers the ability to circumvent restrictions related to the NC Farm Act and increase the protections applied to county wetlands.

"Areas of Environmental Concern" - A Gateway to Wetland Protections

In *Part 4: A Review of Implementable County-Level Policies*, we discussed Estuarine and Ocean System (EOS) AECs in depth. More broadly, AECs are simply areas substantially impacted by natural hazards, as well as any lands deemed important for environmental, social, economic, or aesthetic purposes (Division, 2014). The EOS AEC specifically encompasses brackish sounds, marshes, and shorelines. Carteret County contains many waterways and wetlands that could qualify for additional state-level protections under the CRC's four EOS classifications: public trust areas; estuarine waters; coastal shorelines; and coastal wetlands. As previously described, the public trust clause in particular provides an avenue for local municipalities to advocate for wetlands to be protected due to their significant provision of recreational activities - the access to which are recognized by the CRC as a right for all North Carolinians (Division, 2014).

Currently, Carteret County considers the waters and tributaries of the Newport, White Oak, Neuse, and North Rivers, major sounds, and extensive coastal wetlands to be AECs (Carteret, 2021). The EOS classification allows for these areas to be protected on the basis of the validation of their importance for local economic production, biodiversity, and mitigation against erosion (Division, 2014). Given that the town of Beaufort was the first municipality in Carteret County for over 30 years to advocate for a waterway and its surrounding marshes to be considered an EOS AEC (Kenworthy, 2023), the county itself could conduct a review of its unprotected wetlands to determine which meet the criteria for EOS protections.

However, not all wetlands are protected by these standards. The CRC's classification of Natural and Cultural Resources Areas (NCRA) could provide a pathway for local wetlands to be

acknowledged for their significance in not only contemporary life in Carteret County, but for their historic ties to indigenous culture.

NCRA is divided into four categories: coastal complex natural areas; coastal areas that sustain remnant species; unique coastal geologic formations; and significant coastal archaeological and resources. The second category is particularly applicable to Carteret County's wetlands, as it provides protections to habitats that support native species deemed rare, threatened, or endangered by the N.C. Wildlife Resources Commision, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service (Division, 2014). As previously described in *Importance of Wetlands,* approximately 75% of endangered, threatened, or rare species in NC rely heavily on wetlands for survival (NC Division, n.d.-b). In Carteret County alone, wetlands are home to over 40 of such species, including the American alligator, the piping plover, and the Alabama vertigo mollusks (Ratcliffe, 2020). Protecting these species is crucial for protecting the livelihood and economy of Carteret County, as well as NC more broadly. Biodiversity allows for coastal NC wetlands to be amongst the most productive systems on Earth, with the county's Newport River marshes to be one of the state's most economically valuable shellfish-growing areas (NC Division, n.d.-b; Strong, 2022)

Furthermore, the NCRA category related to archaeological and historical resources provides an opportunity for the county's wetlands to be acknowledged for their "[association] with the lives of historically important people" and overall contributions to local heritage (Division, 2014). Carteret County is the site of three overlapping Indigenous cultures: the Cashie, the Colington, and the Oak Island / White Oak traditions (US Department, 2015). In particular, the peoples of the Tuscarora Nation settled around the Neuse River and other waterways across coastal NC (Carteret County Historical, 2016). The Tuscarora have relied on swamps, marshes, and other wetlands for centuries as sources of food, wood, and materials for tools or cultural objects. Even today, Tuscarora artists and artisans still utilize native species as the medium for their crafts (Maxwell, 2019).

The NCRA presents Carteret County with the ability to collaborate with the Tuscarora and other Aboriginal voices to protect wetlands that are not only integral to their culture, but simultaneously support the environmental health of the county. In addition, an NCRA can be nominated by any individual - not just a governing authority (Division, 2014). Local wetland protection groups, including Coastal Carolina Riverwatch, can also help empower Indigenous people to advocate for the recognition of wetlands as NCRAs.

Conclusion

In the hope of future enhanced data collection practices and organization at the state and county levels, there exists the opportunity for more comprehensive research on wetland degradation. Though our analysis did not indicate any wetland degradation or issues with water quality, it's plausible to assume this is due to past wetland protections at the federal, state, and county levels. In light of recent policy shifts at the federal and state levels that diminish these

protections, future research can delve into examining the repercussions of these policy changes on the status of wetlands in North Carolina, particularly in the coastal region.

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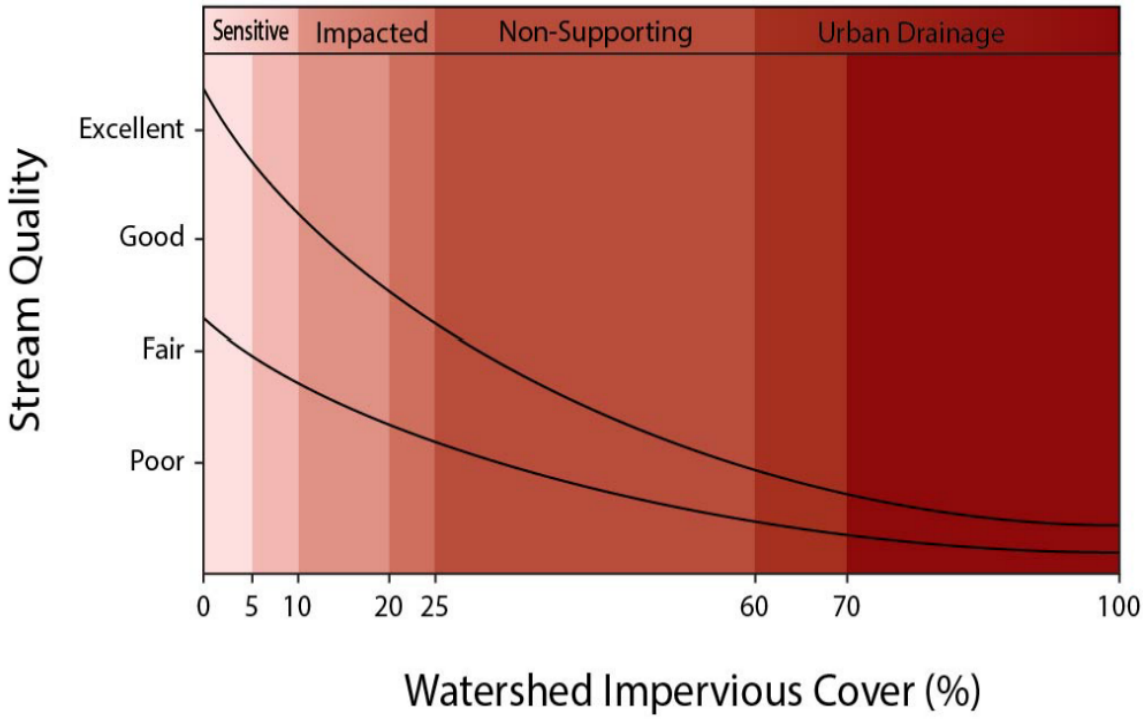
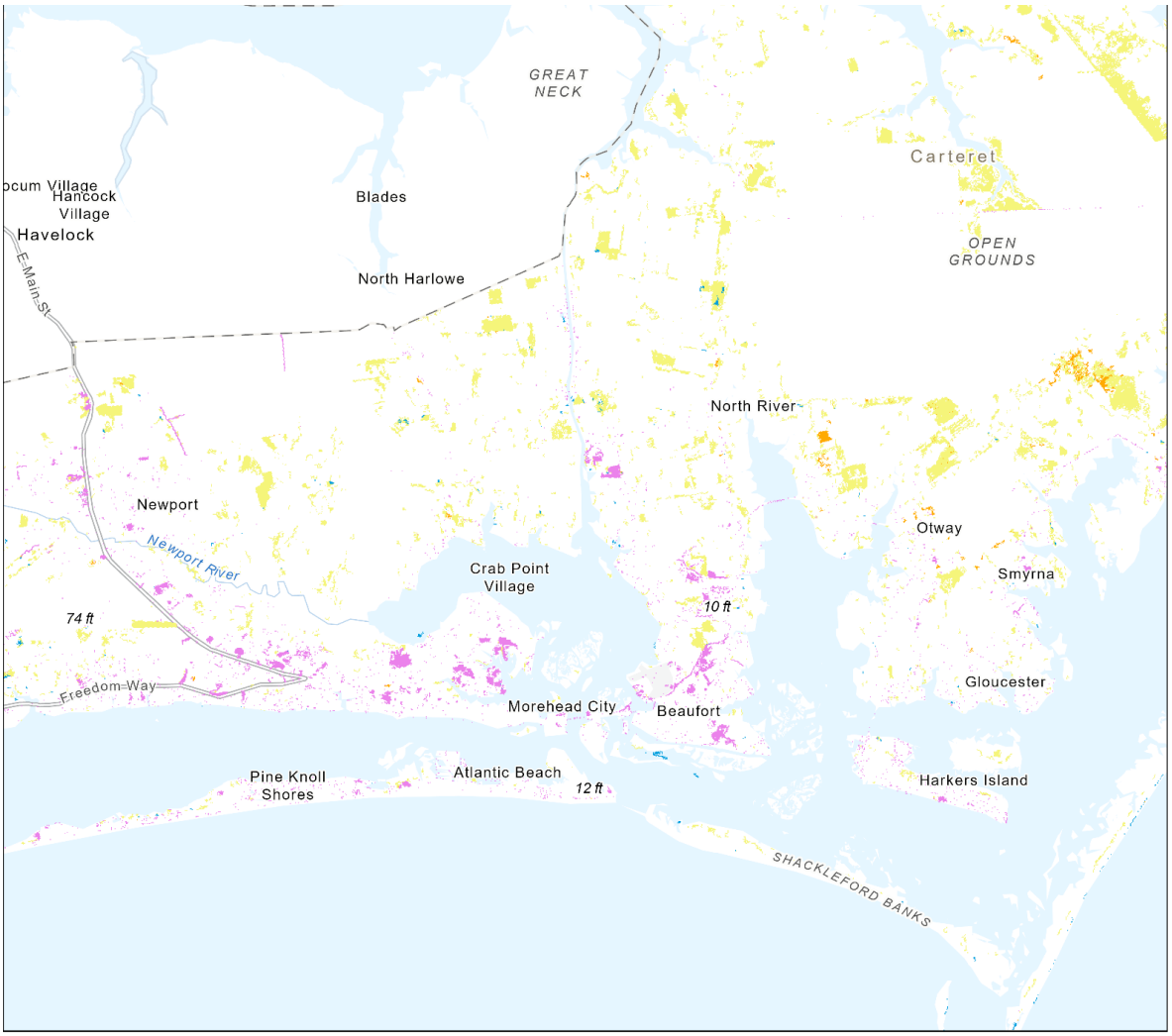
Appendix A
The Relationship Between Impervious Surfaces & Water Quality



Notes. Adapted from *NC State University Libraries (n.d.-b)*. This ArcGIS map's symbology is described by the associated legend. Light gray shading includes all non-wetland and non-impervious surfaces geographical features. This map does not represent the full extent of Carteret County, but rather scaled to see more detailed symbology.

Appendix B
Individual GIS Layer of NCLD 2001-2019 Change Index



Legend

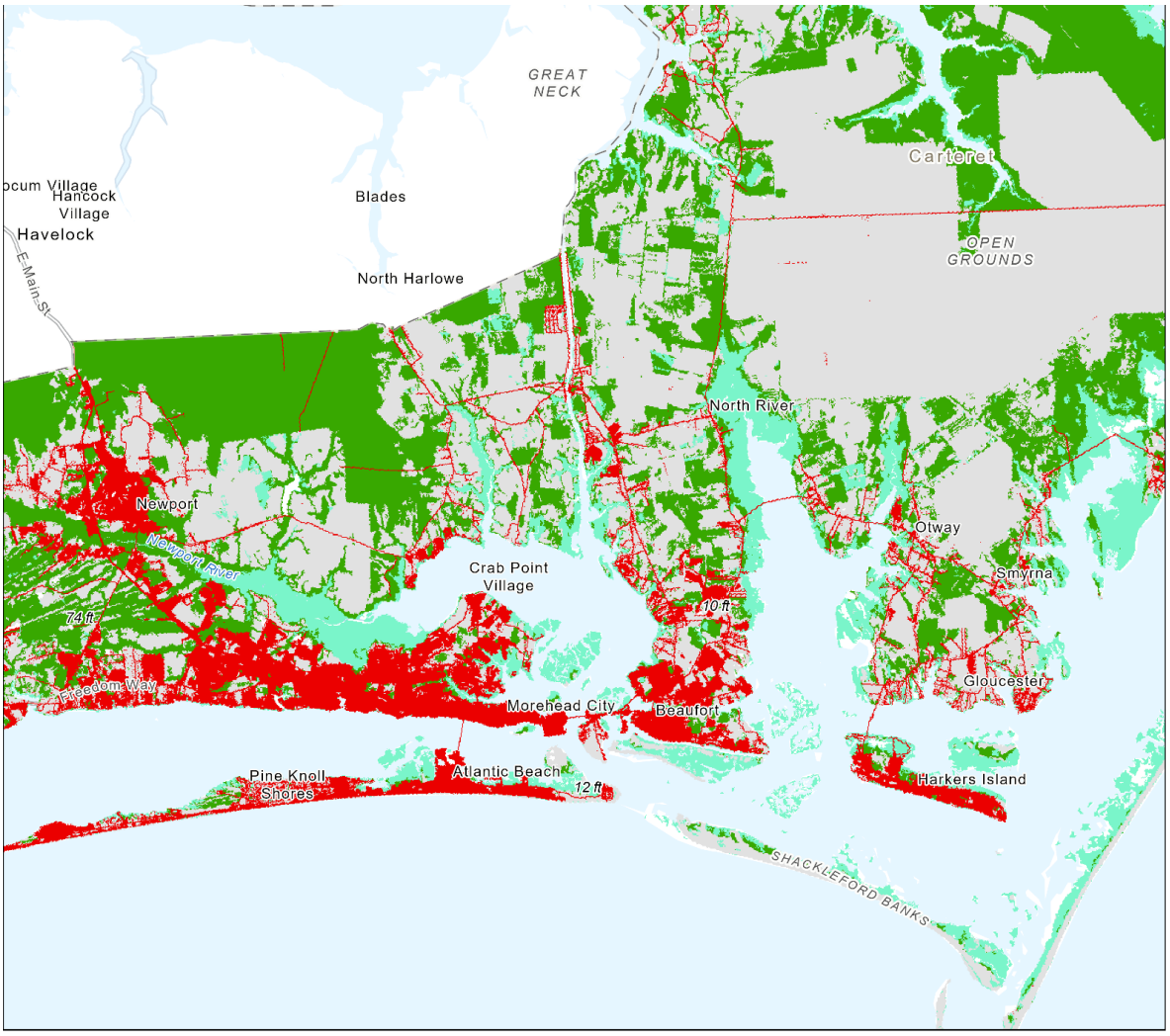
NCLD Change Index

Land Use Change Type

- urban change
- wetland within class change
- herbaceous wetland change
- woody wetland change

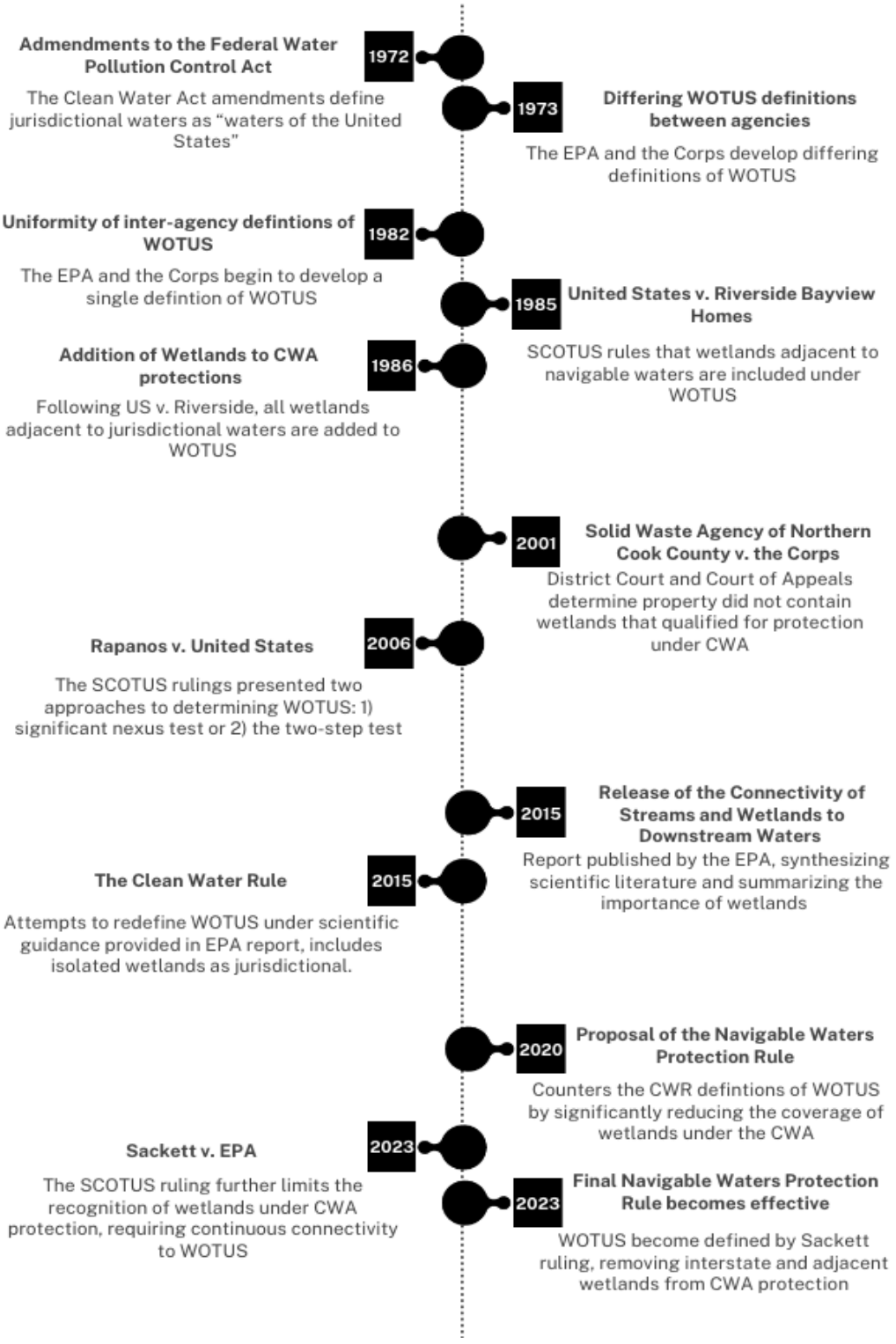
Notes. Adapted from *NC State University Libraries (n.d.-b)*. This ArcGIS map's symbology is described by the associated legend. Light gray shading includes all non-wetland and non-impervious surfaces geographical features. This map does not represent the full extent of Carteret County, but rather scaled to see more detailed symbology.

Appendix C
Individual GIS Layer of 2019 Land Cover Classification



Notes. Adapted from *NC State University Libraries (n.d.-b)*. This ArcGIS map's symbology is described by the associated legend. Light gray shading includes all non-wetland and non-impervious surfaces geographical features. This map does not represent the full extent of Carteret County, but rather scaled to see more detailed symbology.

Appendix D
Major Events in the Inclusion of Wetlands Under Federal Protection



Notes. Adapted from *Where's the Science? Recent changes to CWA threaten wetlands and thousands of miles of our nation's rivers and streams* (Mihelcic & Rains, 2020).