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NORTH CAROLINA
Environmental Quality

CRC-25-34

August 1, 2025

MEMORANDUM

TO: Coastal Resources Commission
FROM: Ken Richardson
SUBJECT: Ocean Erodible and Inlet Hazard Areas of Environmental Concern: 2025 Long-Term Average Annual Shoreline Change Rates and Setback Factor Update Studies

Background

Since 1979, the North Carolina Division of Coastal Management (DCM) has used long-term erosion data to determine construction setbacks in Ocean Hazard Areas and establish the landward boundaries of Ocean Erodible Areas of Environmental Concern (15A NCAC 07H.0304). However, due to limited data and resources, erosion rate setback factors within Inlet Hazard Areas (IHA) have been based on the rates of adjacent Ocean Erodible Areas, as specified in Rule 15A NCAC 07H.0310. Given the rapid changes that can occur at inlets, this method has often resulted in setback factors that underestimate the true erosion dynamics of these areas.

In addition, since 2013, shoreline change rates must be updated every five years to maintain North Carolina's compliance with Federal Emergency Management Administration (FEMA) guidelines for the Community Rating System (CRS). This requirement helps ensure that property owners in coastal communities participating in the National Flood Insurance Program can earn an additional 50 CRS points, potentially lowering insurance rates. The most recent erosion rate update took effect on December 1, 2020.

The Coastal Resources Commission's (CRC) setback rules are used to site oceanfront development based on the size of the structure according to the graduated setback provisions in 15A NCAC 7H .0306(a). In areas where there is a high rate of erosion, buildings must be located farther from the shoreline than in areas where there is less erosion. The construction setback equation depicted in Table 1 is used to site oceanfront development and determine the extent of the CRC's jurisdictional area for the Ocean Erodible Area of Environmental Concern (OEA) - the area where there is a substantial possibility of shoreline erosion. A minimum setback factor of two (2) is applied if the erosion rate is less than two feet per year or where there is accretion. This method of siting oceanfront development was initially established by the CRC in 1979. Again, erosion rate setback factors currently applied inside Inlet Hazard Areas are those carried over from its adjacent Ocean Erodible Area.

Structure Size (square feet)	Construction Setback Equation	Minimum Setback (calculated using Setback Factor = 2 ft./yr.)
Less than 5,000	30 x Setback Factor	60
=>5,000 and < 10,000	60 x Setback Factor	120
=>10,000 and < 20,000	65 x Setback Factor	130
=>20,000 and < 40,000	70 x Setback Factor	140
=>40,000 and < 60,000	75 x Setback Factor	150
=>60,000 and < 80,000	80 x Setback Factor	160
=>80,000 and < 100,000	85 x Setback Factor	170
Greater than 100,000	90 x Setback Factor	180

Table 1. *This table demonstrates an example of minimum construction setbacks based on structure size and the minimum setback factor of 2.*

Erosion rates have traditionally been determined by using the "end-point" method, which measures changes in shoreline position between the earliest available and most recent datasets. In March 2023, the CRC directed its Science Panel on Coastal Hazards to explore alternative approaches for calculating oceanfront erosion rates, alongside updating Inlet Hazard Area (IHA) boundaries and inlet erosion rates. These efforts align with the Panel's longstanding recommendations to the CRC and DCM and are now more feasible due to the Division's ongoing shoreline data collection efforts and advancements in spatial analysis tools designed for tracking shoreline changes over time.

Erosion rates for OEAs (oceanfront) and IHAs are documented in two separate reports. The oceanfront report compares results from the end-point and least squares regression methods, along with past studies. Based on a unanimous recommendation from the Science Panel, setback factors are calculated based on rates measured using the least squares regression method. For IHAs, the erosion rates that informed the Science Panel's Inlet Hazard Area Methodology (IHAM) and guided their recommended updates to IHA boundaries were also used to establish erosion setback factors within the revised boundaries using the same method.

Summary of Results

Ocean Erodible Areas (OEA): *North Carolina 2025 Oceanfront Setback Factors & Long-Term Average Annual Erosion Rate Update Study: Methods Report*

Statewide, the least squares regression method calculated an average erosion rate of -1.9 feet per year. Erosion rates below -2.0 feet per year were recorded at 4,343 transects, covering 134.9 miles (42.4% of the analyzed shoreline), while rates exceeding -2.0 feet per year were measured at 4,485 transects, spanning 139.3 miles (43.8%). Accretion was observed at 3,193 transects across 99.2 miles (31% of the analyzed shoreline). Despite using least squares regression, the results align closely with previous studies that employed the end-point method (Tables 2 and 3).

Relative to the current setback requirements established in 2020, the 2025 setback requirements within the Ocean Erodible Area (OEA) will remain unchanged along 201.4 miles of shoreline. In total, 70.3 miles will reflect a reduction in setback factors, with rates of change ranging from 0.5 to 14.0 feet per year (mean: 1.5 feet per year), while 12.6 miles will reflect an increase ranging from 0.5 to 32.0 feet per year (mean: 3.0 feet per year).

Focusing on segments of developed shorelines only (144.6 miles), within the OEA, and excluding areas within the proposed 2025 IHA updated boundaries:

- 124.9 miles (86%) will see no change in setback factors
- 17.7 miles (12%) will experience a decrease between 0.5 and 3.5 feet per year (average: 1.0 foot), and
- 2.0 miles (2%) will see an increase between 0.5 and 3.5 feet per year (average: 1.0 foot per year)

Parameter	Lengths of shoreline for each parameter	
	End-Point Method Miles of Shoreline (%)	**Least Squares Regression Method** Miles of Shoreline (%)
Miles of Shoreline Mapped & Analyzed	317.8	317.8
Measured Accretion	109 *(34.3%)*	99.2 *(31.2%)*
Measured Erosion	208.5 *(65.6%)*	218 *(68.6%)*
No Change or No Output *(no data)*	0.3 *(<1%)*	0.6 *(<1%)*
Setback Factor = 2.0	196.8 *(61.9%)*	193.7 *(61%)*
Setback Factor = 2.5 to 5.0	63.8 *(20.1%)*	66.5 *(20.9%)*
Setback Factor = 5.5 to 8.0	34.1 *(10.7%)*	33.7 *(10.6%)*
Setback Factor > 8.0	23.1 *(7.2%)*	23.8 *(7.5%)*

Table 2. *This table presents the length and percentage of the total shoreline, comparing the calculated erosion rate setback factors determined by both the least squares and end-point methods. It is important to note that the minimum setback factor is 2, as defined in Rule 15A NCAC 07H.0306. A setback factor of 2 indicates that erosion is either less than -2.4 feet per year or that accretion was measured. Setback factors greater than 2 correspond to calculated erosion rates.*

Statewide Summary	**2025** Miles (% of total)	**2020** Miles (% of total)	**2013** Miles (% of total)	**2004** Miles (% of total)	**1997** Miles (% of total)	**1986*** Miles (% of total)	**1980*** Miles (% of total)
Miles of Shoreline Mapped/Analyzed	**317.8**	**304.5**	**307.4**	**312**	**300**	**237***	**245***
Setback Factor (2 ft/yr.)	193.7 *(61%)*	174.6 *(57.3%)*	190.2 *(61.9%)*	193 *(62%)*	165 *(55%)*	144 *(61%)*	149 *(61%)*
Setback Factor (2.5 to 5.0 ft/yr.)	66.5 *(20.9%)*	67.1 *(22.1%)*	62.1 *(20.2%)*	64 *(21%)*	54 *(18%)*	43 *(18%)*	52 *(21%)*
Setback Factor (5.5 to 8.0 ft/yr.)	33.7 *(10.6%)*	38.7 *(12.7%)*	31.5 *(10.2%)*	28 *(9%)*	30 *(10%)*	20 *(8%)*	22 *(9%)*
Setback Factor (>8.0 ft/yr.)	23.8 *(7.5%)*	22.7 *(7.4%)*	20.8 *(6.8%)*	27 *(8%)*	32 *(10.7%)*	22 *(9%)*	22 *(9%)*
No Data	0.0	*1.4 (<0.5%)*	*2.8 (<1%)*	*0*	*19 (6%)*	*8 (4%)*	*0*

Table 3. *This table presents a summary of length of analyzed shoreline and blocked shoreline change rates (Setback Factors) relative to previous studies dating back to 1980. Where the study year is marked with an asterisk (*), the total shoreline length is lower because either some or all the National Seashore was not mapped and analyzed (e.g., Shackleford Banks, Core Banks).*

Inlet Hazard Areas (IHA): *North Carolina 2025 Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: Update Study*

As anticipated, the analysis of inlet shoreline change rates along the study area reveals a fluctuating trend of shoreline retreat (erosion) and accretion, with a collective average erosion rate of less than -2 feet per year within the 2025 IHAs. However, this average should not be misinterpreted as indicative of minimal risk at each inlet, as this average is heavily influenced by the balance between very high erosion rates exceeding -20 feet per year and significant accretion rates resulting in construction setback factors ranging between 2 and 18. These findings underscore the substantial impact of natural inlet processes, such as tides, wave action, storm events, and sea-level rise, compounded by anthropogenic influences like coastal development and engineering practices, including dredging, beach nourishment, and erosion control structures.

As noted, erosion rate setback factors within IHAs have historically been adopted from adjacent OEAs. While this approach has aligned with past setback requirements in some inlets, others will see increased setback requirements as they are now based on inlet-specific erosion rates rather than oceanfront-derived values.

For each proposed updated Inlet Hazard Area (IHA) boundary, the tables below illustrate the blocked setback factor sections within the 2025 IHAs and compares the calculated results to those from previous erosion rate studies for the same geographic areas. For example, in the **Shallotte**

Inlet–Ocean Isle table, the row corresponding to the section of beach with a 2025 erosion setback factor of **SBF=4** also summarizes the setback factors measured for that same section of beach in each prior study (*2020=2 to 4, 2013=4, 2004=2, 1997=2, 1986=2, 1983=3, & 1980=2*).

Tubbs Inlet - Sunset Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2

Tubbs Inlet - Ocean Isle:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 10	2	2	2	2	2	2	2
SBF = 2	2	2	2	2	2	2	2

Shallotte Inlet - Ocean Isle:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2 to 4	2	2	2	2 to 3	2
SBF = 4	2 to 4	4	2	2	2	3	2
SBF = 7	4	4 to 6.5	2 to 4.5	2	2	3	2
SBF = 10	5	6.5	4.5	2	2	3	2
SBF = 14	5	6.5	4.5	2	2	3	2
SBF = 17.5	5	6.5	4.5	2	2	3	2
SBF = 17	5	6.5	4.5	2	2	3	2
SBF = 9	5	6.5	4.5	2	2	3	2

Shallotte Inlet - Holden Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2
SBF = 9	2	2	2	2	2	2	2
SBF = 16	2	2	2	2	2	2	2

Lockwood Folly Inlet - Holden Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	4 to 6	3.5 to 7	6.5 to 7.5	4	3	4	2
SBF = 5	6	7	7.5	4	3	4	2

Lockwood Folly Inlet - Oak Island:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2 to 4	2

Carolina Beach Inlet - Carolina Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	3 to 7	3 to 6.5	2 to 8	2 to 5	7 to 10	5 to 10	2 to 10

Masonboro Island:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2 to 29	2 to 12.5	2 to 12	4 to 7	5 to 7	4 to 12.5	2.4

Masonboro Inlet - Wrightsville Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2

Mason Inlet - Wrightsville Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2

Mason Inlet - Figure Eight Island:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	5	2.3

Rich Inlet - Figure Eight Island:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2.3
SBF = 3.5	2	2	2	2	2	2	2.3
SBF = 5	2	2	2	2	2	2	2.3
SBF = 2	2	2	2	2	2	2	2.3

Lea-Hutaff Island:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 3 to 12.5	4 to 10	2 to 10	2 to 7	2 to 6	5 to 6	2 to 5	2 to 5.7

New Topsail Inlet - Topsail Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2

New River Inlet - North Topsail Beach:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2.5
SBF = 2.5	2	2	2	2	2	2	2.5
SBF = 5	2	2	2	2	2	2	2.5
SBF = 7	2	2	2	2	2	2	2.5
SBF = 6	2	2	2	2	2	2	2.5
SBF = 10	2	2	2	2	2	2	2.5

Bogue Inlet - Emerald Isle:

Area Inside 2025 IHA	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	3	5	3	NA

Staff Recommendation

DCM staff are requesting the CRC's approval of Science Panel's IHA Boundary Update recommendations, and the OEA and IHA Long-Term Average Annual Erosion Rate & Setback Factor update studies. If approved, DCM staff will follow up at your next meeting with rule amendments that reference the updated reports and fiscal analyses.

North Carolina 2025 Oceanfront Setback Factors & Long-Term Average Annual Erosion Rate Update Study: Methods Report

August 10, 2025

NORTH CAROLINA
Department of Environmental Quality

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Acknowledgements

The primary focus of this study is to refine and update foundational parameters used in NC's oceanfront coastal management, to include erosion rates, setback factors, and defining the landward boundary of the Ocean Erodible Area (OEA) within the Ocean Hazard System using up to date shoreline data. Based on a recommendation from the NC Coastal Resource Commission's Science Panel on Coastal Hazards, this update includes a comparison of erosion rate calculation methods which are informed by the latest scientific technology, incorporating long-term mapping data and advanced modeling techniques. This effort aims to support resilience to coastal hazards while continuing to serve as a robust foundation for oceanfront policy-making in North Carolina's dynamic coastal environment. This report provides a comprehensive analysis of shoreline change rates performed by Shoreline Management Specialist, Ken Richardson with the North Carolina Department of Environmental of Environmental Quality's Division of Coastal Management.

Executive Summary

Since 1979, the North Carolina Division of Coastal Management (NC DCM) has utilized long-term erosion data to establish oceanfront construction setbacks and define the landward boundaries of Ocean Erodible Areas of Environmental Concern. These rates have historically been determined using the "End-Point" method, which measures shoreline position changes between the earliest available and most recent datasets. While widely recognized for its simplicity, cost-effectiveness, and reliability, the method does not model or predict future shoreline changes.

Advancements in Geographic Information Systems (GIS) technology and the availability of more comprehensive and accurate shoreline datasets have prompted a recommendation by the NC Coastal Resources Commission's Science Panel to transition from the end-point method to the least squares regression method. Unlike the end-point approach, which relies on only two data points, the least squares regression method incorporates multiple shoreline positions over time, offering a more refined and robust analysis of long-term erosion trends. This transition allows for a more statistically rigorous approach to calculating erosion rates and setback factors, reducing potential anomalies caused by short-term fluctuations in shoreline position.

This report presents findings from an erosion and accretion analysis conducted along North Carolina's oceanfront using both the least squares regression and end-point methods. The study examined 10,232 transects spaced 50 meters apart, covering approximately 318 miles of shoreline. Additionally, it compares results with previous studies that relied on the end-point method to assess consistency across methodologies.

Key findings from the analysis include:

- **Statewide Erosion Trends:** Both the least squares regression and end-point methods produced an identical average erosion rate of -1.9 feet per year. This consistency reinforces the reliability of the updated methodology.
- **Setback Factor Implications:** Of the total 318 miles of analyzed shoreline, 214.1 miles (67.3%) will experience no change in setback requirements, while 74.1 miles (23.3%) will

see a decrease in setback factors ranging from 0.5 to 14 feet per year (averaging 1.5 feet). An increase in setback requirements of 0.5 to 35 feet per year (averaging 3.0 feet) will be observed in 21.7 miles (7.8%).

- **Erosion Hotspots:** The highest variability in erosion and accretion rates continue to be observed around inlets and capes, where processes create dynamic shoreline conditions.
- **Comparison of Methodologies:** The study reaffirms that both the least squares regression and end-point methods yield highly consistent results. However, the least squares regression method provides a more comprehensive assessment.

This report marks North Carolina's first long-term update of annual erosion rates and setback factors using the least squares regression method. By adopting this enhanced methodology, the state aims to improve the accuracy of erosion assessments and ensure that oceanfront construction setback regulations are based on the best available science. These findings will serve as a critical foundation for future coastal management decisions, helping to balance development needs with the long-term sustainability of North Carolina's shoreline.

Contents

1.0 Introduction

The coast of North Carolina continually changes in response to wind, waves, and fluctuating sea levels, as well as human influences. These coastal processes redistribute sand within the dune, beach, and nearshore systems. Geographic, geological and oceanographic differences collectively influence sediment availability, distribution, and transport, which when better understood can help to explain why trends of erosion and accretion differ along all portions of N.C.'s barrier island shorelines. Both short- and long-term changes can be dramatically different depending on where changes are measured and how much time passes between storm events. Factors used to try and predict short-term changes are less understood than those affecting long-term changes for a variety of reasons. Short-term changes are easily influenced by storm events and require routine monitoring, analyses, and modeling using high-resolution data to anticipate changes and anticipate where erosion will be the most extreme. Although factors affecting long-term changes are complex, the positions of the shoreline over a longer period can reveal trends in shoreline movement - unless beaches are nourished on a periodic cycle (NCDCM, 2016).

Because beaches gain sand (accrete), and lose sand (erode) through a variety of natural forces and human actions and can erode rapidly during a single event (hurricane), Ocean Hazard Setback Factors are established in an effort to minimize losses of life and property resulting from storms, long-term erosion, prevent encroachment of permanent structures on public beach areas, preserve the natural ecological conditions of the barrier dune and beach systems, and reduce public costs of inappropriately sited development.

It's essential to recognize that long-term erosion rates (over 50 years) can vary greatly from short-term rates. In 2000, the U.S. Geological Survey (USGS), East Carolina University (ECU), and the N.C. Geological Survey (NCGS) formed the Coastal Geology Research Cooperative to study the coastal geology of North Carolina, from Cape Lookout to Currituck County, and compare short- and long-term shoreline changes. While engineering efforts like dredging, erosion control structures, and beach nourishment can affect short-term erosion, in North Carolina, storm intensity and frequency play a larger role in shaping short-term changes. For example, beach nourishment can artificially lower erosion rates, while storm event frequency and intensity can cause higher short-term erosion rates that don't necessarily reflect long-term trends.

The purpose of this study is to update oceanfront erosion rates and setback factors (SBF) along 318 miles of North Carolina's Atlantic Ocean shoreline (**Figure 1**), as well as the landward extent of the Ocean Erodible Area (OEA) within the Ocean Hazard Area of Environmental Concern (AEC). This area is defined by a significant risk of excessive shoreline erosion, based on long-term average annual shoreline change rates - commonly referred to as "erosion rates." Initially established by the Coastal Resource Commission (CRC) under the Coastal Area Management Act (CAMA) in 1979, these long-term average annual shoreline change rates have been periodically updated, with the most recent update completed in 2019 and effective as of April 1, 2020. Oceanfront construction setback factors are used to determine appropriate siting for oceanfront development.

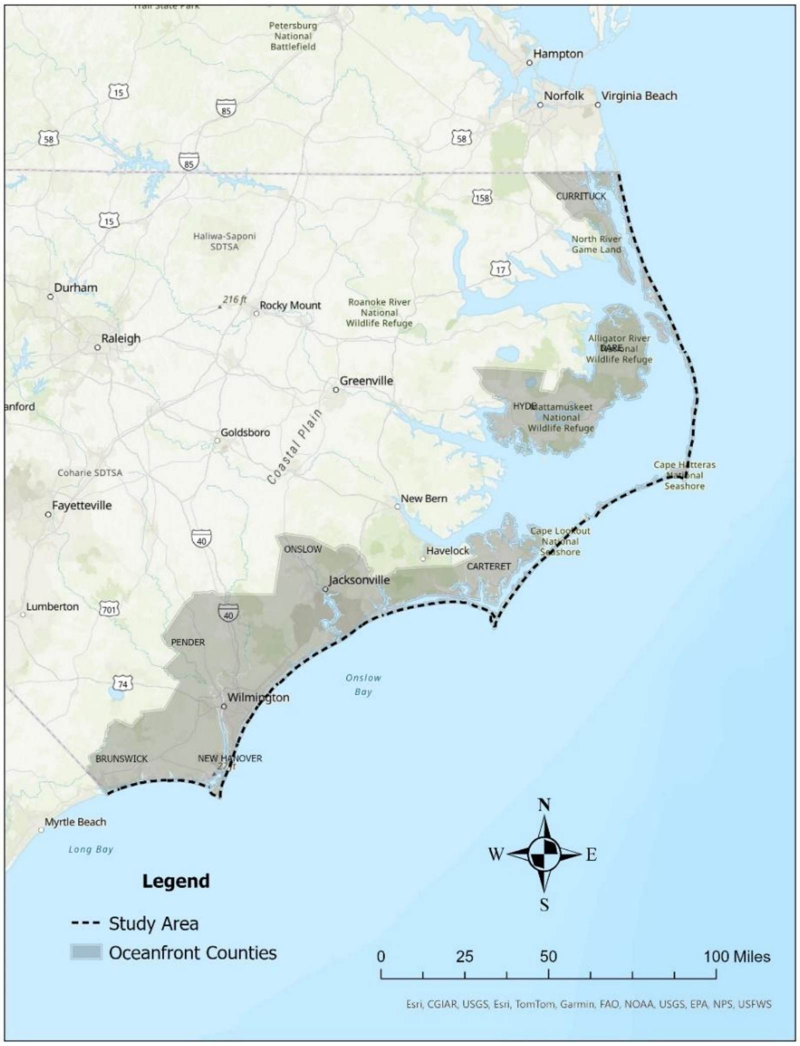

Figure 1. *The study area encompasses North Carolina's oceanfront, with 318 miles of shoreline analyzed.*

Since the first study in 1979 (Tafun, Rogers, and Langfelder, 1979), shoreline change rates for North Carolina's oceanfront have been calculated using the end-point method. This approach involves using the earliest and most recent shoreline data, along with shore-perpendicular transects, where the distance between the two shorelines is measured at each transect. The raw shoreline position change rates are then calculated by dividing the distance between the two shorelines (at the transect intersections) by the time elapsed, or the number of years between the two shoreline positions. To determine Setback Factors, these data are "smoothed" using a

17-point running average and "blocked" to identify shoreline segments, or "blocked areas," that exhibit similar erosion rates.

Over the past two decades, advancements in digital mapping technology have enabled the Division to develop a comprehensive shoreline database. By leveraging Geographic Information Systems (GIS) alongside the U.S. Geological Survey's Digital Shoreline Analysis System (DSAS), the Division can better streamline the process of analyzing and comparing shoreline change rates using multiple calculation methods. At the recommendation of the NC CRC's Science Panel on Coastal Hazards, this report presents shoreline change rates and setback factors derived from least squares regression. For context, these values are also compared with both current and historical results using the end-point method.

2.0 Methods

Since 1979, DCM has calculated long-term oceanfront shoreline change (erosion and accretion) using the end-point method. This approach focuses on the change in shoreline position between the earliest and most recent recorded shorelines. While useful for providing an overall picture of long-term shoreline movement, the method does not account for significant short-term fluctuations that may occur between those points in time, which can influence local shoreline behavior and differ from long-term trends. This limitation is particularly evident in inlet shorelines, where constant movement, tidal and storm influences, and sediment transport cause frequent position changes. The dynamic nature of these areas makes the end-point method less effective in accurately capturing the shoreline's behavior or estimating future trends.

To address this complexity, this study focuses on least squares regression, while still comparing the results to those generated using the end-point method. This statistical technique analyzes multiple shoreline positions over time, providing a more detailed view of shoreline variability and long-term trends (Thieler et al., 2009). By utilizing a broader dataset, the least squares regression method offers a more reliable and comprehensive analysis of shoreline dynamics, particularly in areas influenced by the unpredictable behavior of inlets. This approach enhances the understanding of erosion and accretion patterns, offering valuable insights that can inform coastal management strategies.

Shoreline data were analyzed using *ESRI's ArcPro® 3.x and ArcMap® 10.8x* Geographic Information System (GIS) and U.S. Geological Survey's (USGS) Digital Shoreline Analysis System (DSAS) versions 5.1 and 6.0. Geographic Information Systems (GIS) are a sophisticated suite of tools used to capture, store, analyze, manage, and visualize spatial or geographic data. These spatial mapping and analysis technologies combine layers of information about a location to help understand patterns, relationships, and trends.

The U.S. Geological Survey's (USGS) Digital Shoreline Analysis System (DSAS) is a specialized tool designed to calculate shoreline changes, including erosion and accretion rates. It tracks shoreline movement over time by analyzing both historical and recent data. The following is a general overview of how DSAS is used to calculate shoreline erosion rates:

1. Shoreline Data Input: DSAS requires a series of shoreline positions from different time periods. These shorelines can be digitized from historical maps, aerial imagery, or satellite data.
2. Baseline Creation: A baseline is established landward or seaward of the shorelines. It acts as a reference for the calculation of changes.
3. Transect Generation: Perpendicular transects are automatically generated at regular intervals from the baseline, extending across the shorelines. These transects are the points where shoreline change is measured.
4. Shoreline Change Calculation: For each transect, DSAS computes the distance between different shoreline positions over time, using methods like:
    a. End Point Rate (EPR): Measures the distance between the oldest and most recent shorelines divided by the time span between them.
    b. Linear Regression Rate (LRR): Fits a least-squares regression line through all shoreline points for each transect, estimating the average rate of change.
    c. Weighted Linear Regression (WLR): Like LRR, but weights more recent data more heavily to account for its higher relevance.
5. Output: DSAS generates statistical outputs for each transect, including the rate of shoreline change (in meters per year) and confidence intervals. These results help assess erosion risks, trends, and rates.

In summary, DSAS is used to calculate shoreline erosion rates by analyzing shoreline position changes over time, using automated transects and various statistical methods to provide precise and localized erosion rate data.

2.1 Shoreline Data

DCM's growing database shorelines facilitated this study by allowing use of more data that better reflects short-term fluctuations in shoreline position. Most of the shorelines analyzed were mapped using historic orthophotography to digitize the wet-dry line (**Figure 2**), considered a proxy for the Mean High Water (MHW) line; while others represented the location of MHW - either derived from lidar (1997 and 2004), or NOS T-Sheets (1930s and 1940s). Two studies carried out by DCM (Limber et al., 2007a; 2007b) indicated that the lidar-derived MHW line could be used interchangeably with the wet-dry shorelines without influencing long-term trends.

When interpreted from aerial photography, North Carolina's oceanfront shoreline is defined as the "wet-dry line". This "line in the sand" references an interpretation where the wet sand ends and the dry sand begins and is typically distinguished by contrasting sediment color or shade, hence "wet-dry." Wet-dry shoreline interpretation is the most readily identifiable and considered in the worst case to be between high and low tides (*e.g.*, Crowell, Leatherman, and Buckley, 1991; Dolan R. , Hayden, May, and May, 1980; Overton and Fisher, 2003).

Figure 2. Interpretation of the "wet-dry" shoreline using orthophotography.

The earliest shorelines used in this and subsequent studies (2004, 2013, 2020) were digitized by the North Carolina State University (NCSU) Kenan Natural Hazards Mapping Program, and represents a composite of both Mean High Water (MHW) shorelines digitized from National Ocean Survey Topographic Surveys (NOS T-sheets) (1933-1952), and wet-dry line interpretations made from historical (1940-1962) imagery (Overton and Fisher, 2003). Use of NOS T-sheet shorelines is accepted by other researchers and has been adopted by the USGS in their shoreline erosion studies. A statewide set of NOS T-sheets for a single year do not exist; therefore, early dates do vary between 1933 and 1952. For approximately 30 miles of the state’s oceanfront shoreline (north of Oregon Inlet to North Carolina/Virginia State line) T-sheets were not available when the early shoreline was digitized. For this portion of the coast, a collection of early photography (1940–1962) was used to digitize a wet-dry shoreline. By using this early shoreline, consistent comparisons at each transect can be made between the multiple shoreline change rate studies.

The most current shoreline used in this study is a wet-dry interpretation digitized at a map scale of 1:1,000 utilizing 2020 North Carolina color imagery (6-inch pixel resolution). However, at Onslow Beach and Brown's Island, 2021 imagery (1-meter pixel resolution) was available from ESRI's basemap webservices, and used due to a 2020-imagery data gap.

2.2 Transects (50-Meter)

Transects used in this study are generally perpendicular to the shoreline, spaced 50 meters (approximately 164 feet) apart (**Figure 3**), and spatially consistent with those used in previous update studies. It is expected that they are also spatially like those established by Dr. Robert Dolan in his early shoreline erosion rate studies since they have similar spacing and end-point coordinates (Dolan, Hayden, and Heywood, 1978); however, it is not possible to confirm since they did not exist in a digital form prior to the 1992 study (Overton and Fisher, 2003). For this reason, only comparisons of ocean hazard Setback Factors from this and earlier studies can be made, and not the actual shoreline change rates.

Figure 3. *This map illustrates an example of shore-perpendicular 50-Meter transects (dashed yellow line).*

For future studies, it is essential to evaluate the transect length to ensure they fully encompass the shoreline envelope, allowing for comprehensive data analysis. However, recasting the transects along the oceanfront will likely be unnecessary, as their current length of approximately 6,000 feet is sufficient. However, if needed, the transects can be extended further landward.

2.3 Shoreline Change Rates: Least Squares Regression

One limitation of the end-point method is its inability to account for significant short-term shoreline changes that occur between the two data points used in its analysis. Given the constant movement and fluctuation of ocean and inlet shorelines, this approach may not fully capture the dynamic changes that take place between the earliest and most recent shoreline positions. To address this limitation, and following the recommendation of the CRC's Science Panel, this study utilized the least squares regression method, a statistical approach that incorporates multiple shoreline positions over time for a more comprehensive analysis (Thieler et al., 2009).

At each transect, there are a series of shoreline-transect intersections that represent the shoreline's position through time (**Figure 4**). Least squares regression (LRR) minimizes the distance between the known values (actual shoreline positions) fitting a least-squares regression line through all shoreline points for each transect, estimating the average rate of change (**Figure 5**). The slope of this line is the least squares regression of shoreline change or the local erosion or accretion rate.

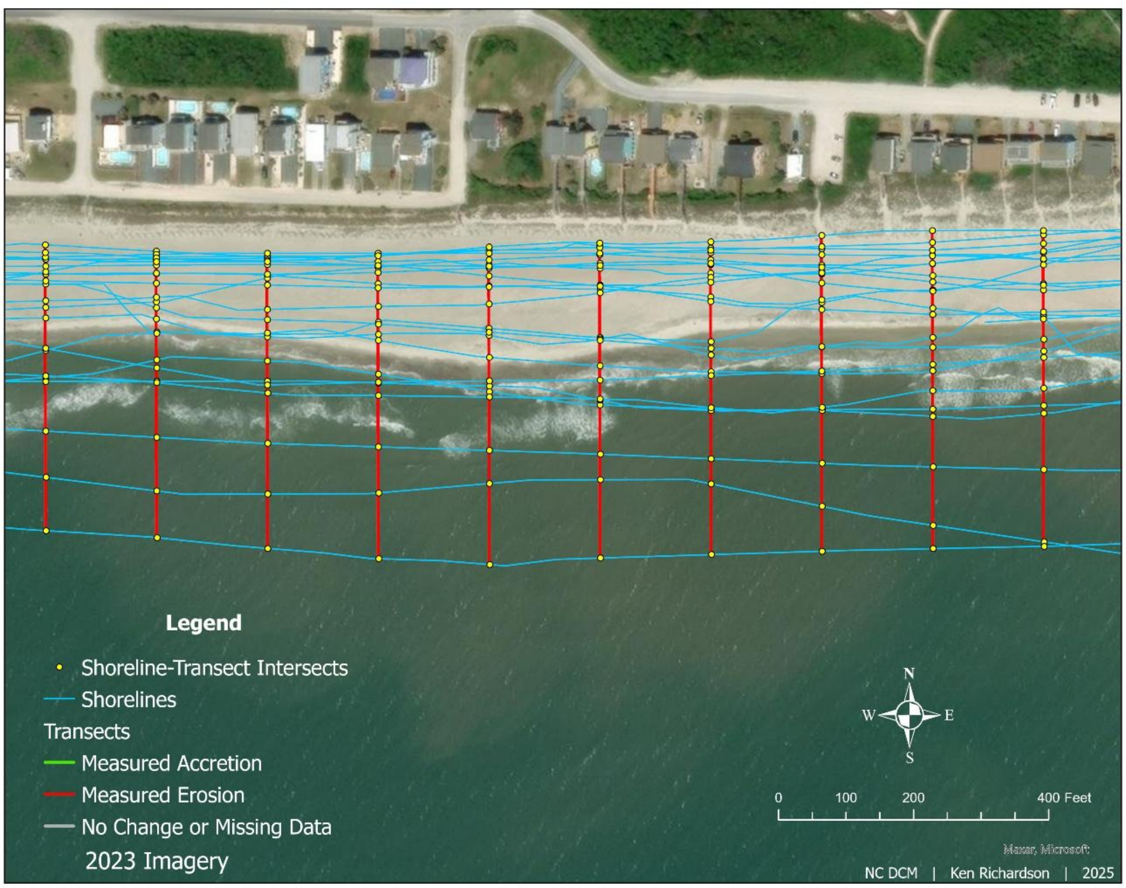

Figure 4. This map illustrates an example of point locations where shorelines intersect transects.

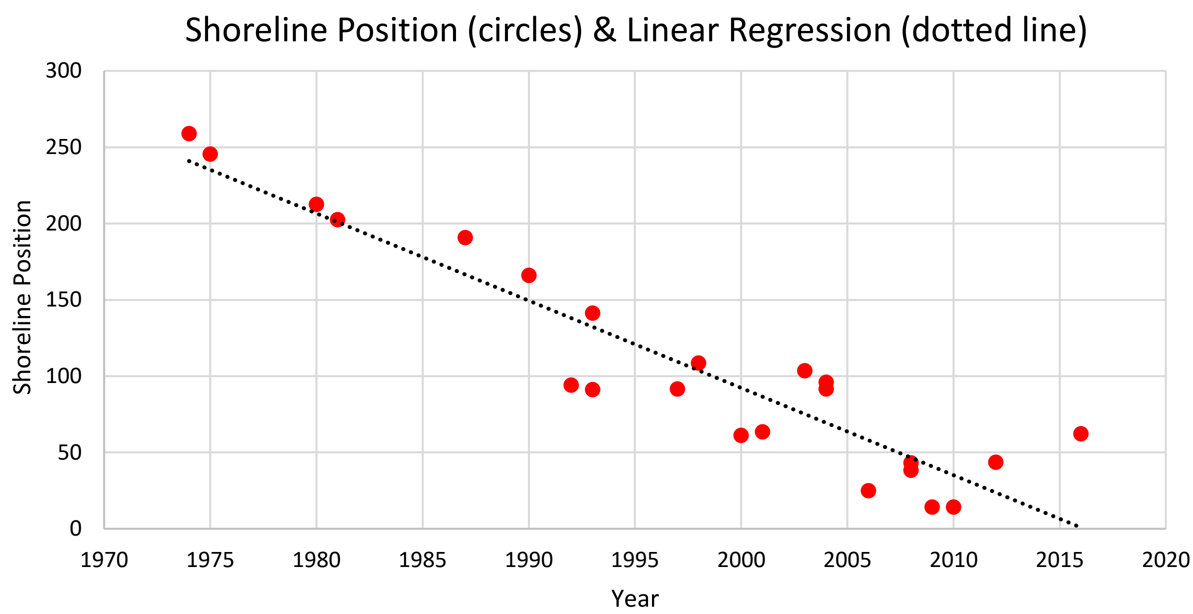

Figure 5. *Relative shoreline position as a function of time (circles). The slope of the best fit, dotted line is the linear regression rate (LRR) of shoreline change (in this case, it is eroding at 19 feet per year).*

The benefits of linear regression include (Dolan et al., 1991):

- All data is used, regardless of changes in trend or accuracy.
- The method is purely computational.
- The calculation is based on accepted statistical concepts.
- This method is easy to employ.

Although the least squares regression method is less sensitive to individual points, it is susceptible to outliers; it assumes that the computed trend is linear, and it tends to underestimate the rate of change relative to other statistics, such as the end-point rate (Dolan et al., 1991; Genz et al., 2007). To exclude outlier data, precautions were taken to avoid shorelines that reflect influences caused by a major storm event or beach nourishment. However, given that the practice of beach nourishment has become a frequently occurring common practice, avoidance of these shorelines is not always possible.

Once computed, the linear regression rate was then smoothed using a 17-transect running-average alongshore. This follows the blocking computation historically used for the oceanfront shoreline rates and further smooths the alongshore variation in the shoreline change rate.

2.4 Shoreline Change Rates: Smoothing

Smoothing raw data has been applied in all oceanfront shoreline position change studies since 1979 and serves as a method of removing high-frequency variations or noise, thereby highlighting the underlying trends and patterns. By doing so, short-term dynamic shoreline phenomena such as beach cusps, smaller sand waves, and the incorporation of landward migrating portions of offshore bar systems are effectively filtered out (**Figure 6**).

Figure 6. *This image shows an example of beach cusps and nearshore sandbars relative to 50-meter transects.*

Shoreline cusps and similar coastal features exhibit a wide range of sizes, from small formations approximately 5 feet in width to much larger structures reaching up to 5,000 feet. Their lifespans also vary considerably, with smaller features lasting only a few days, while larger ones, such as sand waves, can persist for entire seasons or even several years (Dolan and Ferm, 1968; Davis, 1978). This range in both size and duration reflects the dynamic and ever-changing nature of coastal environments, driven by processes like wave action, tidal patterns, and sediment transport.

Sandbars, another prominent coastal feature, typically measure more than 300 feet in length. These structures undergo migration and attachment processes, which unfold over time periods ranging from seasons to years (Davis, 1978). The shifting position of these bars, combined with their ability to attach to different points along the shoreline, underscores the fluidity of coastal landscapes, where no feature remains fixed indefinitely.

Unlike smaller, more transient formations, larger and more durable features such as capes are resistant to smoothing processes commonly applied in coastal analysis. These capes remain prominent even after filtering, highlighting their scale and resilience. Despite their size, capes and similar features are not permanently anchored to a single location. They can migrate along the shoreline, shaped by continuous interactions with natural forces like currents, wind, and wave energy. This movement further illustrates the complex and evolving nature of shorelines, where even the largest features remain subject to gradual change.

The procedure for spatially smoothing shoreline change rate data involves a simple moving average or running mean technique, as described by Davis in 1973. Commonly known as the "17-point running average," this method typically includes at least 17 transects, each spaced 50 meters apart, covering approximately 2,482 feet (0.47 mile) of shoreline. To calculate the smoothed rate, an average is computed for each group of 17 transects, with the calculation centered on the ninth transect - having eight transects on either side (**Figure 7**).

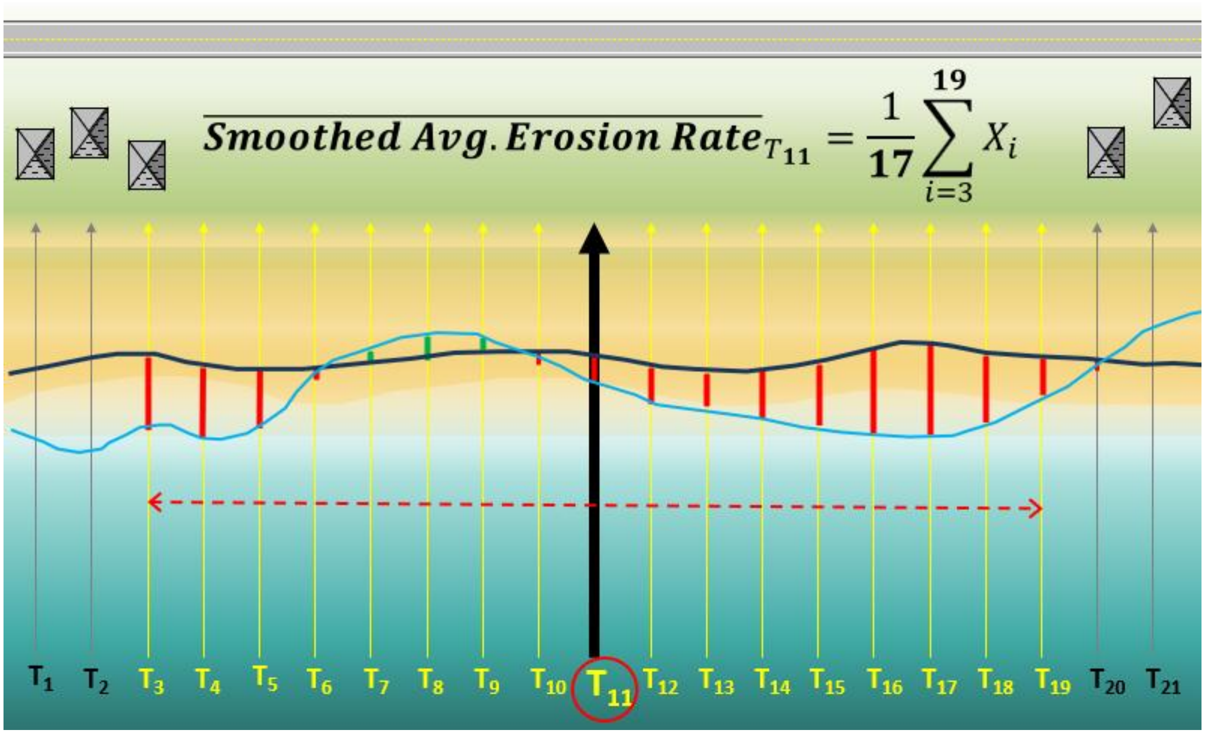

Figure 7. *This graphic illustrates an example of the 17-point running average algorithm, where the raw erosion rate at each transect is averaged with the values from eight transects on either side, totaling 17 data points.*

As the algorithm approaches an area with less than 17 transects, the number of transects used to calculate the average is reduced by two, dropping one from each side of the centered transect, until the end is reached. For the last value, a weighted average is calculated using only the final two transects. This approach ensures a smooth transition in areas with fewer available data points near shoreline boundaries or inlets.

$$\mathbf{R_s = (2 \times T_1 + T_2) / 3}$$

R_s *= smoothed rate*

T_1 *= erosion rate at last transect adjacent to the inlet*

T_2 *= erosion rate at second to last transect adjacent to inlet*

As shown in **Figure 8**, the effects of smoothing are most apparent in areas undergoing accelerated erosion or accretion, such as near inlets. For analyzing erosion rate data, this method is one of the simplest techniques for smoothing time-series data. Its effectiveness in these studies is largely due to the equal spacing between transects, making it well-suited for capturing consistent shoreline change patterns.

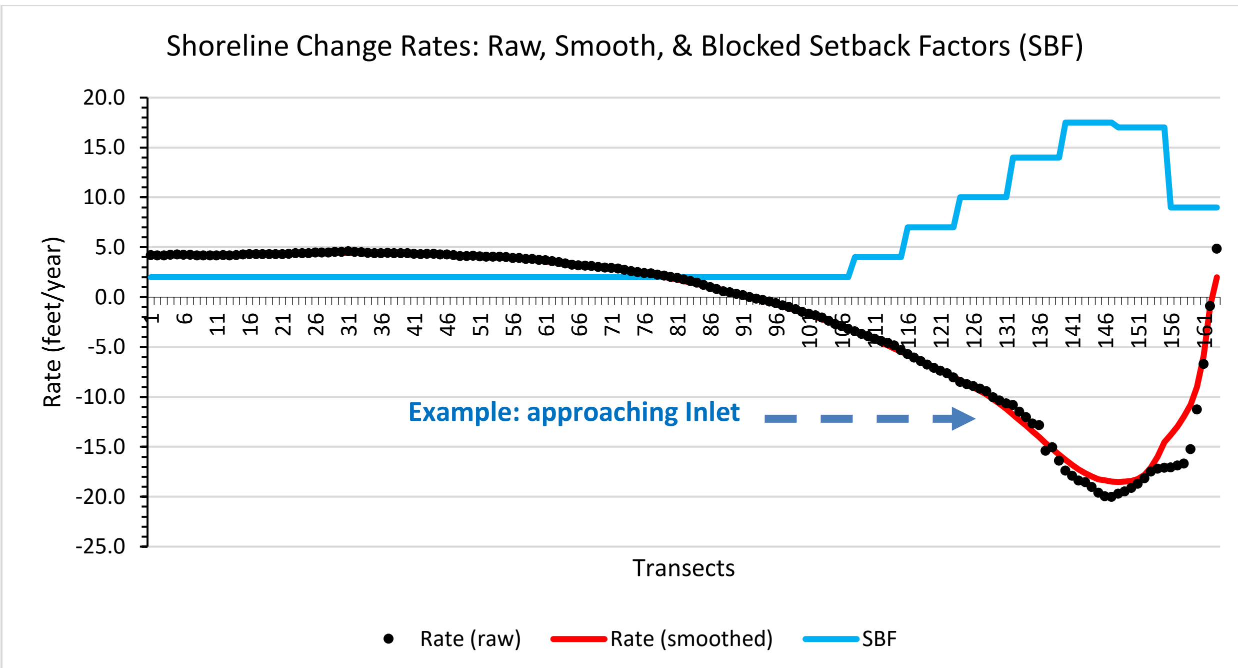

Figure 8. *This example illustrates the raw data (black points), smoothed data (red line), and blocked erosion setback factors (blue line). Note that in areas where erosion rates are less than 2 feet per year, or where accretion occurs, the minimum setback factor defaults to 2. While setback factors are recorded as positive values, they directly correspond to erosion rates, particularly when the values surpass -2 ft/yr.*

2.5 Shoreline Change Rates: Blocking

In late 1978 and early 1979, the North Carolina Coastal Resources Commission undertook an in-depth review and revision of the oceanfront regulations initially adopted in September 1977. One of the most significant updates introduced during this process was the concept of oceanfront development setbacks, which were then partially determined by the average annual long-term erosion rates. These rates, calculated based on transects, helped define how far inland development should be placed to minimize risk from coastal erosion. Where rates are higher, the setbacks are greater to help buffer the risk.

However, because these transects only capture data at specific points along the shoreline, a method was required to establish broader setback areas, or “blocks,” where similar erosion rates could be applied consistently across continuous coastal sections. Following a 1979 study (Tayfun et al., 1979) it was determined that if the blocks or segments were too long, the accuracy of the erosion rates could be compromised, particularly in regions where the rates change rapidly over short distances. Long segments tend to oversimplify the data, failing to reflect these localized variations, which could lead to inappropriate setback distances in areas prone to higher erosion.

It wasn’t until the CRC’s 1986 study that this issue was addressed by decreasing the transect spacing from the original intervals to 50 meters. This closer spacing allowed for a more precise calculation of erosion rates and has been the standard practice in all subsequent studies of oceanfront areas. This refinement enabled a more accurate understanding of how erosion affects different parts of the shoreline, leading to better-informed coastal management and development decisions.

The technique of "blocking" smoothed rate data creates spatially consistent rate segments along the shoreline. Essentially, blocking groups neighboring transects along the same shoreline segment that exhibit similar smoothed shoreline change rates. This approach enables more uniform and consistant management practices for sections of the shoreline that experience the same or similar rates of change, rather than relying on individual rates at each transect or risking misinterpretations in the areas between transects.

The blocked shoreline change rate data are used as setback factors, commonly referred to as "erosion rates," and are applied to determine construction setbacks within Ocean Hazard Areas of Environmental Concern (AECs), which include both Ocean Erodible Areas and Inlet Hazard Areas. This method ensures that setbacks are calculated consistently across similar shoreline segments, improving coastal management and reducing the risk of inappropriate development in high-erosion zones.

Blocking procedures, itemized below, represent refinments and clarifications of procedures established by and used in all previous update studies. These refinements and clarifications are the result of improved accuracy of the data brought about by improvements in the shoreline delineation methodology and quantitative requirements that allow for increased repeatabiltiy of results. In areas experiencing an accelerated change in rates, this refinement resulted in smaller blocked groups. The following list describes the process, or "rules" of blocking:

1. Group "like" erosion rate segments based on rate at transect (*e.g.,* 2.0, 2.2, 2.1, 2.5, 2.6, 2.1, . . . 2.9) and use the mean of each segment as the blocked rate. Transitioning at one-foot intervals are prefered for rate block boundaries. Fractional rates are rounded down to the nearest foot, or half foot interval for segments dominated by a half foot value and do not have values greater than the next highest one foot interval (*e.g.*, a rate segment equal to 5.4 would be rounded to 5.0; and 5.7 would be rounded to 6.0).

2. Blocked shoreline change rate segments must be comprised of at least eight (8) transects. In areas experiencing rapid erosion or accretion (*e.g.,* approaching inlets), it is not always possible achieve a one-foot transition from one blocked rate segment to the next, thus making it necessary to evaluate segments based on its mean so that transitions from one blocked segement to the next was as near to the one-foot interval as feasible.

3. In areas where blocked segments transition from one value to another (*e.g.*, from 3 to 4 feet per year) a determination must be made to select the transect that will serve as a delineation between the change in values. The lower rate would be applied towards the higher blocked segment.

4. Where two blocked boundaries meet and divide a property or parcel, the lower of the two blocked rates is applied in the direction of the higher rate in order to give the property owner the benefit of the lower rate.

Based on currentl rules (15A NCAC 07H.0304(1)[1]), segments of the shoreline that result in measured accretion, or where measured erosion rates are less than two (2.0) feet per year, are assigned the default minimum, a blocked rate value (Setback Factor) of two (2) in accordance with the minimum setback of 60 feet, or 30 times the Setback Factor based on blocked shoreline change rates.

[1] NC Administrative Code (NCAC), Title 15A – Environmental Quality, Chapter 7, Sub-Chapter 0304(1)

3.0 Results

Data analysis was conducted using the least squares regression method at 10,232 transects, spaced 50 meters apart, covering approximately 318 miles of oceanfront shoreline. Of these, 7,019 transects (218 miles) recorded erosion rates ranging from less than -1.0 to -234 feet per year, with an average rate of -4.2 feet per year. Accretion, ranging from less than +1.0 to +69.4 feet per year, was observed at 3,193 transects, averaging 3.1 feet per year. As expected, the highest erosion and accretion rates were found near inlets and capes.

Statewide, the least squares regression method calculated an average erosion rate of -1.9 feet per year. Erosion rates below -2.0 feet per year were recorded at 4,343 transects, covering 134.9 miles (42.4% of the analyzed shoreline), while rates exceeding -2.0 feet per year were measured at 4,485 transects, spanning 139.3 miles (43.8%). Accretion was observed at 3,193 transects across 99.2 miles (31% of the analyzed shoreline). Despite using least squares regression, the results align closely with previous studies that employed the end-point method.

When comparing methodologies (**Table 1**), both least squares regression and end-point methods produced similar results. Statewide, the end-point method measured an average erosion rate of -1.9 feet per year, with rates ranging from -262 to +114 feet per year. Erosion was recorded at 6,711 transects, covering 208.5 miles (66% of the analyzed shoreline), while accretion was measured at 3,509 transects across 109 miles (34.3%).

As with past studies (**Table 2**), areas where erosion rates frequently fluctuate above North Carolina's average (-2 ft/yr) often exhibit setback factor variations of 1 foot, ½ foot, or more between assessments. Despite using least squares regression for these calculations, the results remain highly consistent when compared to the end-point method and previous studies.

Across the total 318 miles of analyzed shoreline, compared to the current effective setback factors (2020), updating erosion rate setback factors using least squares regression will result in:

- No change for 214.1 miles (67.3%) of shoreline

- A decrease in setback requirements for 74.1 miles (23.3%), ranging from 0.5 to 14 feet per year (average: 1.5 feet per year)

- An increase for 21.7 miles (7.8%), ranging from 0.5 to 35 feet per year (average: 3.0 feet per year). The largest setback values are found at inlets and capes.

Within the 2025 Ocean Erodible Areas (OEA), excluding the proposed 2025 updated Inlet Hazard Areas (IHA), setback requirements will remain unchanged for 201.4 miles relative to 2020 requirements (**Table 3**). Meanwhile, 70.3 miles will experience a decrease in setback factors ranging from 0.5 to 14 feet per year (average: 1.5 feet per year), while 12.6 miles will see an increase between 0.5 and 32 feet per year (average: 3.0 feet per year).

Focusing segments of developed shorelines only (144.6 miles), within the OEA, and *excluding* the proposed 2025 IHA updated boundaries:

- 124.9 miles (86%) will see no change

- 17.7 miles (12%) will experience a decrease between 0.5 and 3.5 feet per year (average: 1.0 foot)

- 2.0 miles (2%) will see an increase between 0.5 and 3.5 feet per year (average: 1.0 foot)

Parameter	Lengths of shoreline for each parameter	
	End-Point Method Miles of Shoreline (%)	**Least Squares Regression Method** Miles of Shoreline (%)
Miles of Shoreline Mapped & Analyzed	317.8	317.8
Measured Accretion	109 *(34.3%)*	99.2 *(31.2%)*
Measured Erosion	208.5 *(65.6%)*	218 *(68.6%)*
No Change or No Output *(no data)*	0.3 *(<1%)*	0.6 *(<1%)*
Setback Factor = 2.0	196.8 *(61.9%)*	193.7 *(61%)*
Setback Factor = 2.5 to 5.0	63.8 *(20.1%)*	66.5 *(20.9%)*
Setback Factor = 5.5 to 8.0	34.1 *(10.7%)*	33.7 *(10.6%)*
Setback Factor > 8.0	23.1 *(7.2%)*	23.8 *(7.5%)*

Table 1. *This table presents the length and percentage of the total shoreline, comparing the calculated erosion rate setback factors determined by both the least squares and end-point methods. It is important to note that the minimum setback factor is 2, as defined in Rule 15A NCAC 07H.0306. A setback factor of 2 indicates that erosion is either less than -2.4 feet per year or that accretion was measured. Setback factors greater than 2 correspond to calculated erosion rates.*

Statewide Summary	2025 Miles (% of total)	2020 Miles (% of total)	2013 Miles (% of total)	2004 Miles (% of total)	1997 Miles (% of total)	1986* Miles (% of total)	1980* Miles (% of total)
Miles of Shoreline Mapped/Analyzed	**317.8**	**304.5**	**307.4**	**312**	**300**	**237***	**245***
Setback Factor (2 ft/yr.)	193.7 *(61%)*	174.6 *(57.3%)*	190.2 *(61.9%)*	193 *(62%)*	165 *(55%)*	144 *(61%)*	149 *(61%)*
Setback Factor (2.5 to 5.0 ft/yr.)	66.5 *(20.9%)*	67.1 *(22.1%)*	62.1 *(20.2%)*	64 *(21%)*	54 *(18%)*	43 *(18%)*	52 *(21%)*
Setback Factor (5.5 to 8.0 ft/yr.)	33.7 *(10.6%)*	38.7 *(12.7%)*	31.5 *(10.2%)*	28 *(9%)*	30 *(10%)*	20 *(8%)*	22 *(9%)*
Setback Factor (>8.0 ft/yr.)	23.8 *(7.5%)*	22.7 *(7.4%)*	20.8 *(6.8%)*	27 *(8%)*	32 *(10.7%)*	22 *(9%)*	22 *(9%)*
No Data	0.0	*1.4 (<0.5%)*	*2.8 (<1%)*	*0*	*19 (6%)*	*8 (4%)*	*0*

Table 2. *This table presents a summary of length of analyzed shoreline and blocked shoreline change rates (Setback Factors) relative to previous studies dating back to 1980. Where the study year is marked with an asterisk (*), the total shoreline length is lower because either some or all the National Seashore was not mapped and analyzed (e.g., Shackleford Banks, Core Banks).*

Study Update	No Change miles (%)	Increase miles (%)	Decrease miles (%)
From 2020 to 2025	124.9 (86%)	2 (1.4%)	17.7 (12%)
From 2013 to 2020	120.5 (86%)	20.3 (14%)	3.8 (2.6%)
From 2004 to 2013	118.3 (82%)	10.3 (7%)	16 (11%)
From 1997 to 2004	111.6 (77%)	10.4 (7%)	22.6 (16%)

Table 3. *This table compares the total length of developed shoreline (144.6 miles) with the distances and percentages of shoreline that experienced no change, increased change, or decreased change in setback requirements when transitioning from the effective rate to the updated rate since 1997. It is important to note that these comparisons are relative to developed shoreline within the 2025 OEA, excluding areas within the proposed 2025 IHA update boundary.*

The following sections present a comparison of end-point and least squares regression methods, supplemented with graphs and maps for visualization. While all data are included, setback factors are displayed on maps only within the Ocean Erodible Area (OEA) in relation to the proposed 2025 updates to Inlet Hazard Areas. Graphs show setback factors for each shoreline section, but mapped setback factors are limited to OEAs. For setback factors within the proposed 2025 Inlet Hazard Areas, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

In areas where erosion rates are less than -2 feet per year or where accretion occurs, the minimum setback factor defaults to 2 feet per year, per Rule NCAC 15A 07H.0304(1). Although setback factors are recorded as positive values, they directly correspond to erosion rates, particularly when exceeding -2 feet per year. For example, a setback factor of 3 indicates a shoreline section with a long-term average annual erosion rate between -2.6 and -3.4 feet per year.

3.1 Bird Island to Sunset Beach:

Bird Island and Sunset Beach are North Carolina's southernmost beaches and are considered to have low sloping south-facing beaches with approximately 3.3 miles of combined oceanfront shoreline. Sunset Beach has been naturally accreting and has not required any nourishment projects. Several factors have had significant influences in defining today's shoreline position; a navigation jetty constructed at Little River inlet (left side of graph) between 1981 and 1983, closing of Madd inlet in 1998 (transect IDs 35-40) which separated Bird Island from Sunset Beach, and artificially relocation of Tubbs Inlet in 1970 farther east (closer to Ocean Isle).

The analysis examined twenty-two shorelines (**Figure 9**) along this oceanfront section over an 87-year period, from 1933 to 2020. During this time, shoreline movement varied considerably, with the shoreline envelope, representing the range of movement along each transect, spanning from a minimum of 310 feet to a maximum of 2,829 feet, averaging 917 feet. A relative standard deviation of 113 feet highlights the broad dispersion of shoreline positions, which have been primarily influenced by the proximity to the Little River Inlet navigation jetty, Tubbs Inlet (both its current and former locations), and the now-closed Mad Inlet. These features have collectively shaped shoreline dynamics, affecting sediment transport and long-term coastal changes. Despite these fluctuations, much of the beach has experienced a net gain in sediment, leading to overall beach accretion over time.

For comparison, both the end-point and least squares regression methods produced similar results, with the end-point method yielding an average shoreline change of +6.7 feet per year and the least squares regression method averaging +6.2 feet per year (**Figure 10**). Both approaches resulted in blocked erosion rate setback factors of two (2), aligning with previous studies for this section of shoreline.

Transitioning to the least squares regression methodology provides a more accurate representation of long-term shoreline movement; however, it does not significantly impact the updated setback factors relative to earlier studies (**Figure 11** to **Figure 14** and ***Table 4***). Using this method, the calculated setback factors for both Bird Island and Sunset Beach remain at two feet per year, with no increases. For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *"NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Figure 9. *Shorelines included in the analysis (1933-2020) at Bird Island and Sunset Beach.*

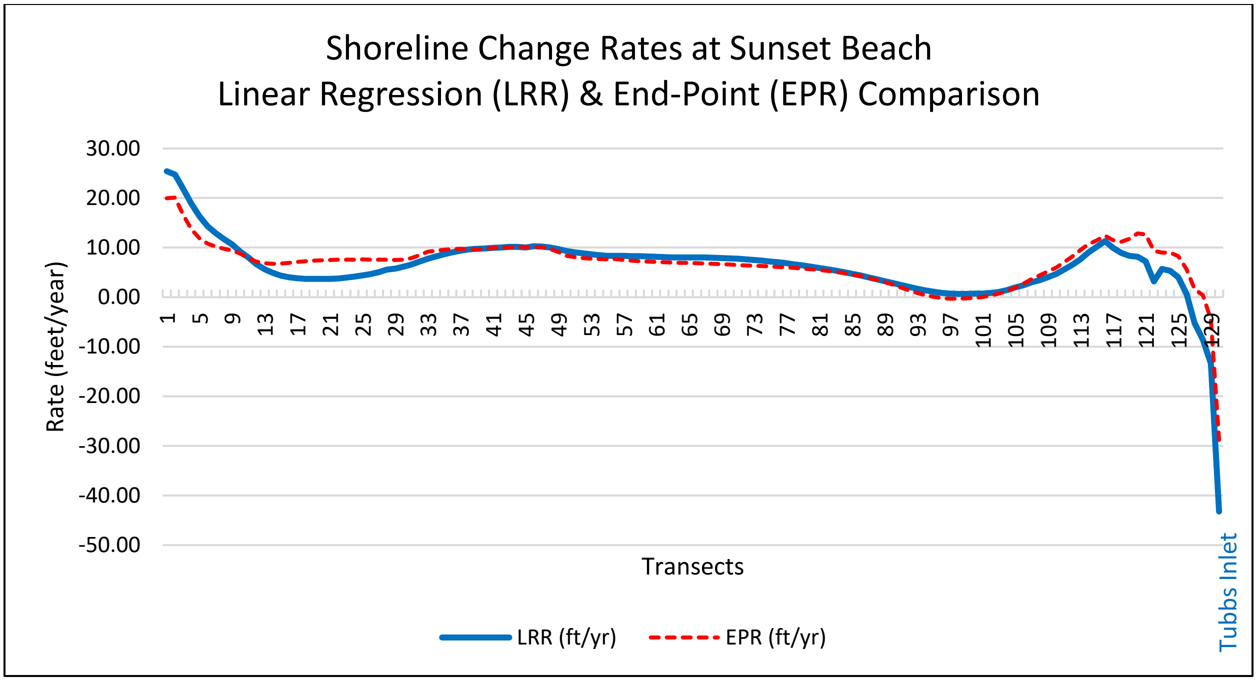

Figure 10. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

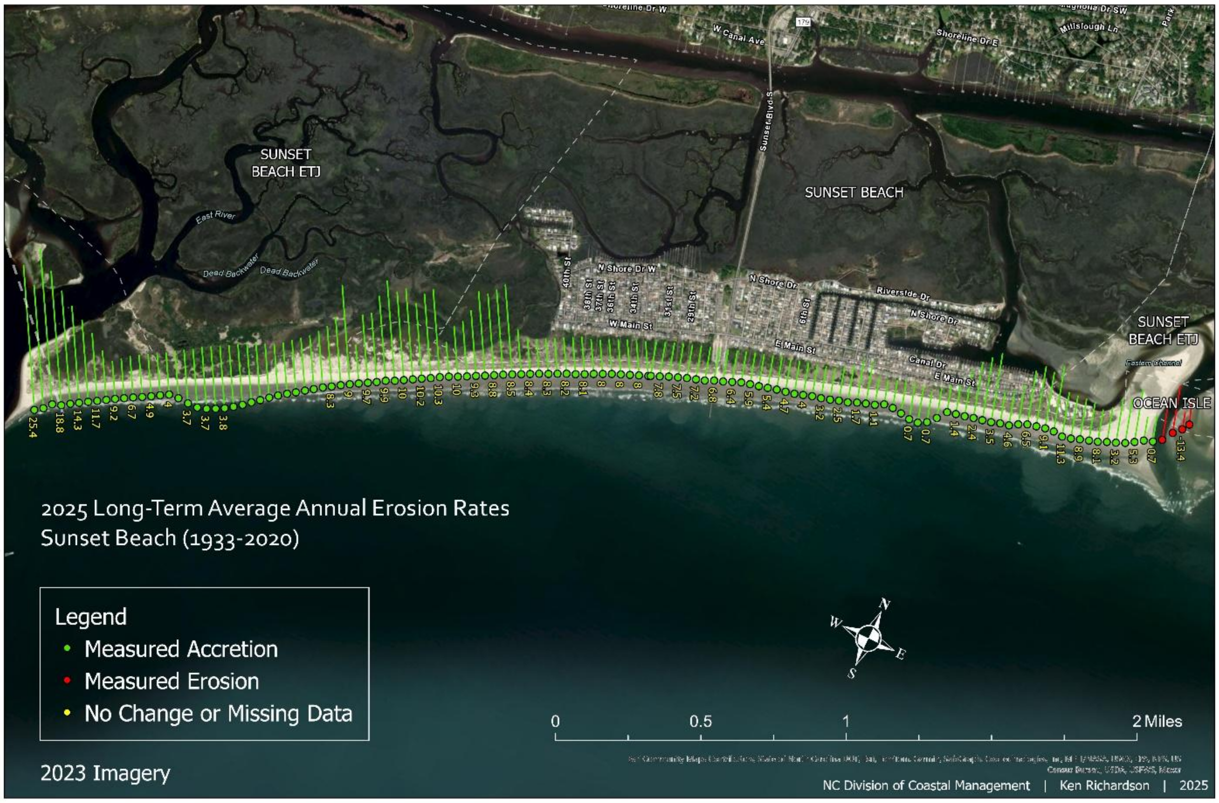

Figure 11. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

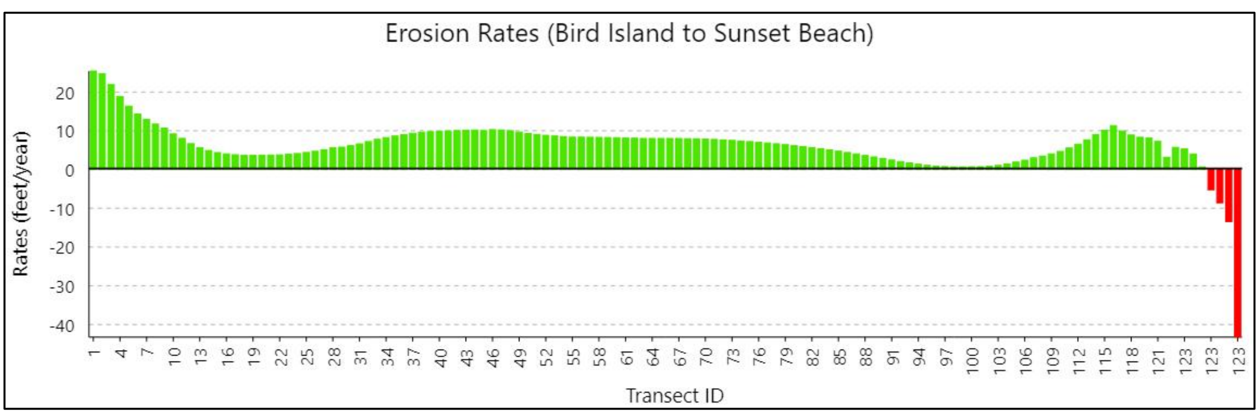

Figure 12. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

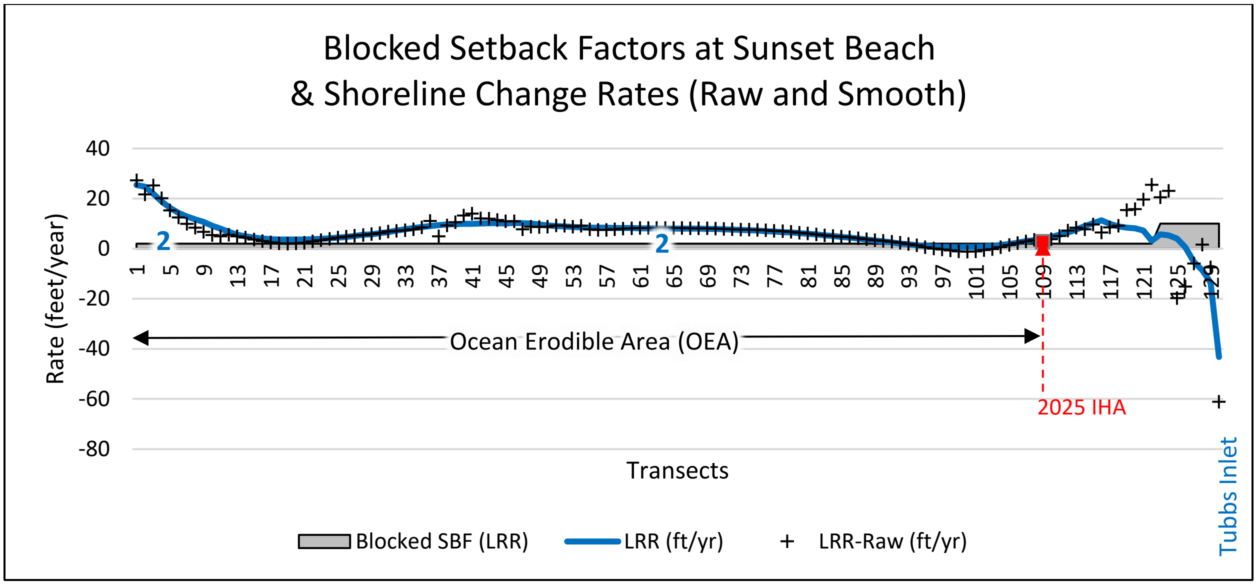

Figure 13. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

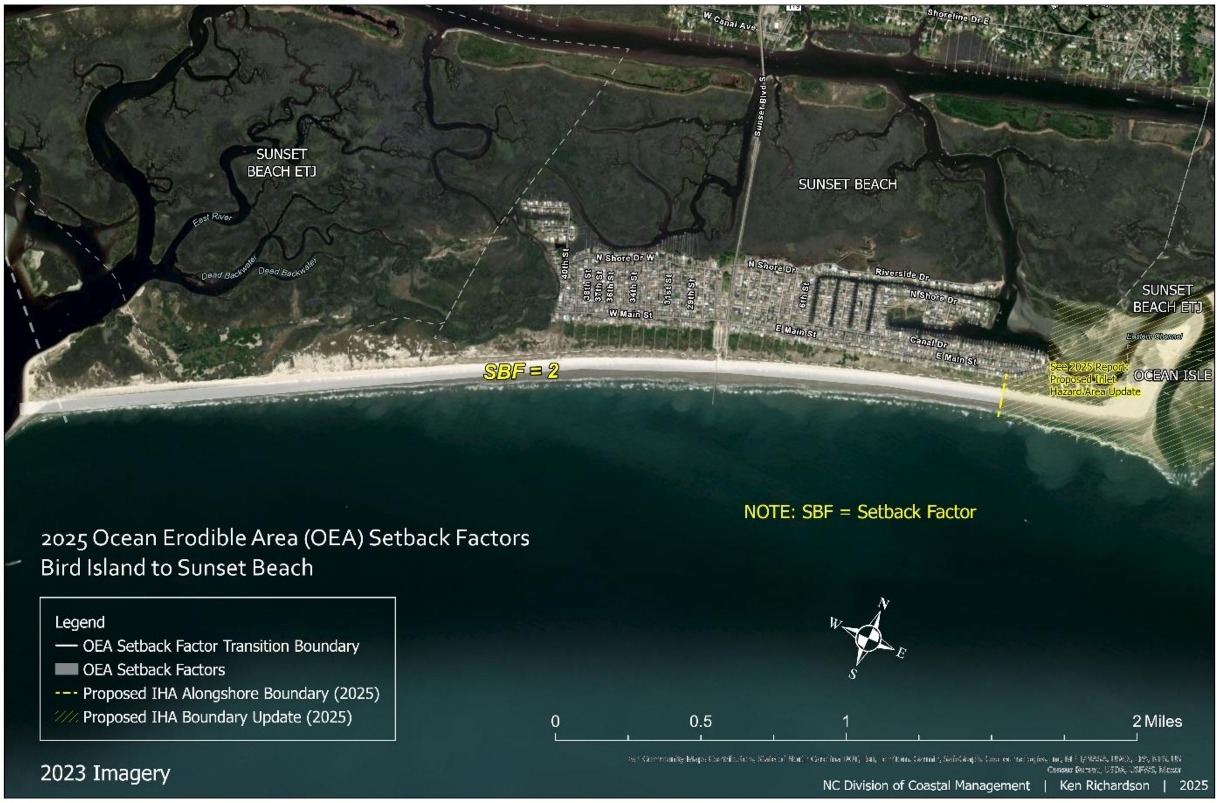

Figure 14. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Bird Island and Sunset Beach. For setbacks within the proposed updated IHA boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2

Table 4. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.2 Ocean Isle Beach

Ocean Isle Beach features a low-sloping, south-facing shoreline spanning approximately 5.7 miles. Since 1974, the oceanfront shoreline has undergone varying degrees of beach nourishment. The first large-scale nourishment project, exceeding 300,000 cubic yards, took place in 2001 as part of the Federal Coastal Storm Damage Reduction (CSDR) initiative between transects 180 and 284. This was followed by routine maintenance in 2006, 2009, 2014, 2018, 2021, and 2022 across different sections of the same area. Additionally, a terminal groin was installed in 2022 to address high erosion rates at Shallotte Inlet. While the structure is designed to reduce erosion on its western side, further time and data are required to fully evaluate its effectiveness.

The analysis assessed twenty-nine shorelines along this oceanfront section over an 87-year period, from 1933 to 2020 (**Figure 15**). Since 2001, shoreline positions have been artificially influenced by regular beach nourishment. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 115 feet (oceanfront) to a maximum of 1,847 feet (inlet), with an average of 383 feet for the entire shoreline between Tubbs and Shallotte Inlets. However, within the oceanfront area between the 2025 proposed updated Inlet Hazard Areas, specifically between transects 136 and 270, the shoreline envelope varied from 114 to 335 feet, averaging 244 feet. This contrast highlights the differing influences of oceanfront and inlet dynamics on shoreline position. For these same areas, the calculated average relative standard deviation of shoreline position was 108 feet overall and 68 feet for the oceanfront section alone. Of the 5.7 miles of shoreline analyzed, approximately 2.1 miles (37%) resulted in measured erosion where rates averaged -4.4 feet per year adjacent to Tubbs and Shallotte Inlets.

For comparison, both the end-point and least squares regression methods produced similar results. The end-point method indicated an average shoreline change of less than 1 foot per year, while the least squares regression method yielded a similar rate of less than 1 foot per year. Within the oceanfront area between the 2025 proposed IHA boundaries (transects 136 to 270), the end-point method calculated an average change of 1.4 feet per year, whereas the least squares regression method estimated 1.7 feet per year (**Figure 16**). Both approaches result in a blocked erosion rate setback factor of two (2), consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement; however, it does not impact on the updated setback factors compared to previous studies. Using this approach, the calculated setback factors for Ocean Isle's oceanfront, between the 2025 proposed updated Inlet Hazard Areas (approximately transects 136 to 270), remain at two feet per year, with no increases (**Figure 15** to **Figure 20**, and **Table 5**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

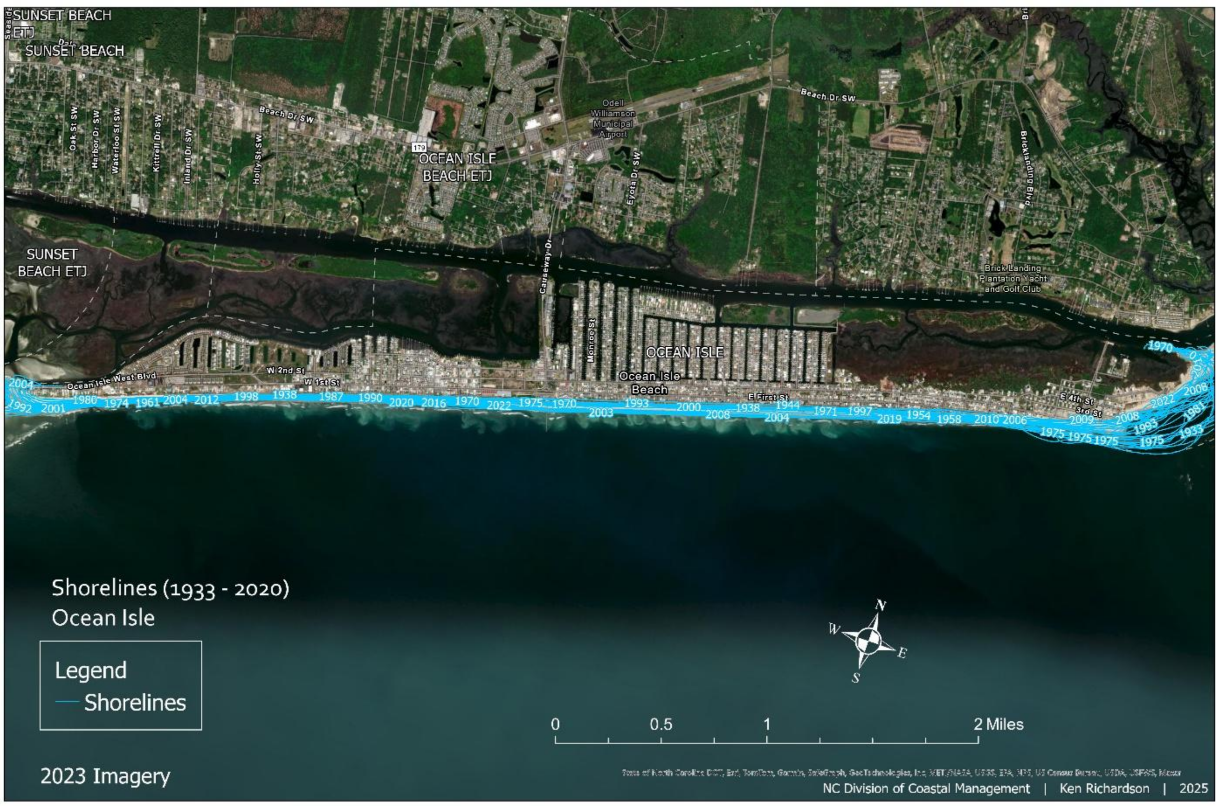

Figure 15. *Shorelines included in the analysis: 1933, 1938, 1944, 1954, 1958, 1961, 1970, 1974, 1975, 1980, 1981, 1987, 1990, 1992, 1993, 1997, 1998, 2000, 2001, 2003, 2004, 2006, 2008, 2009, 2010, 2012, 2016, 2019, and 2020.*

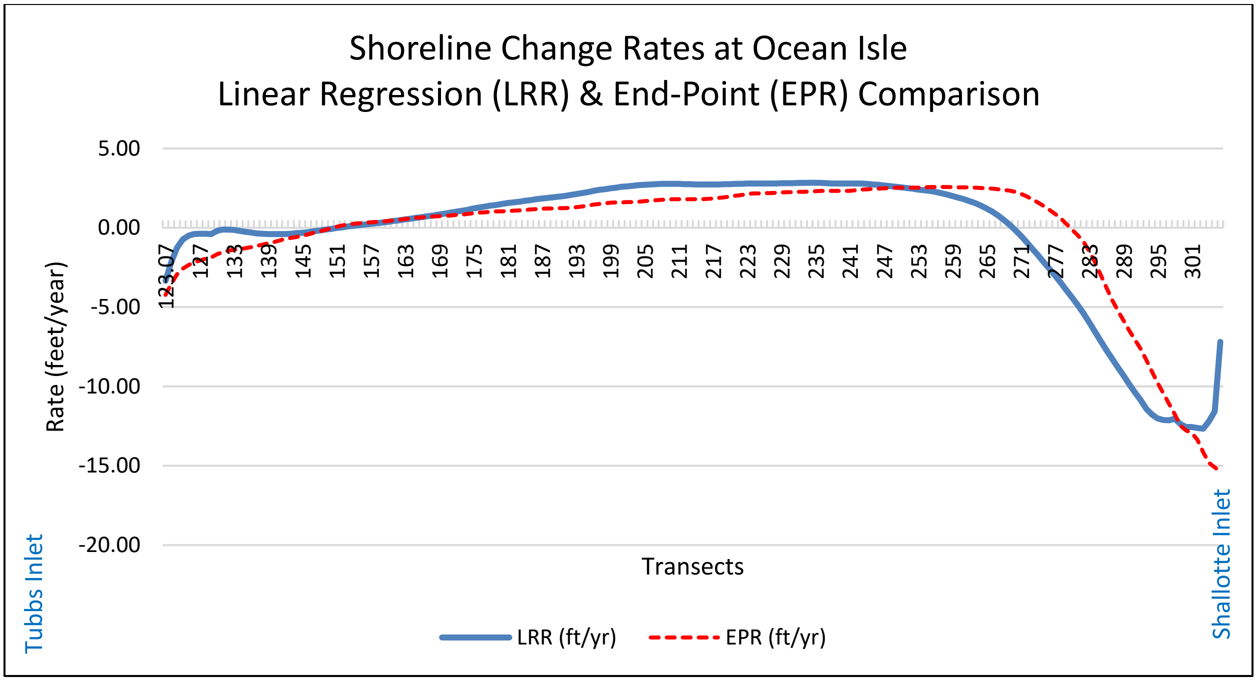

Figure 16. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 17. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

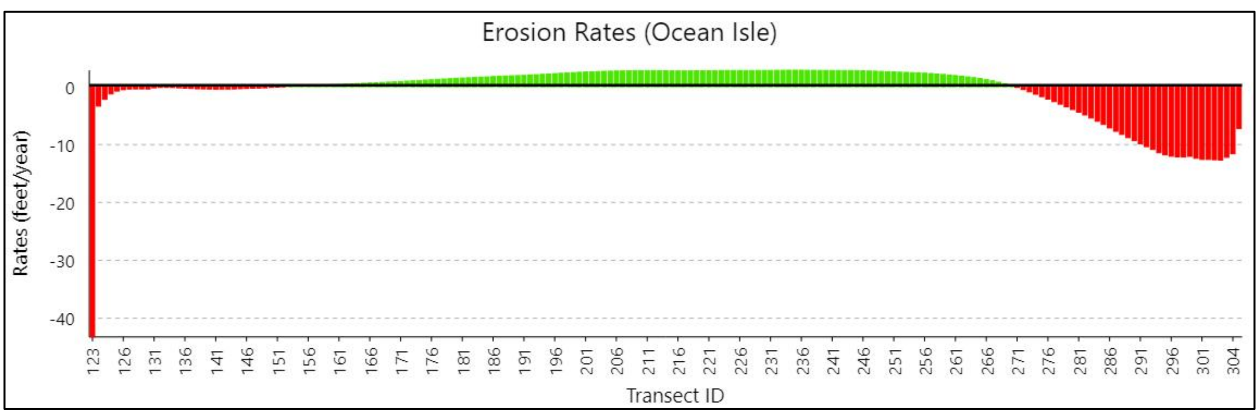

Figure 18. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

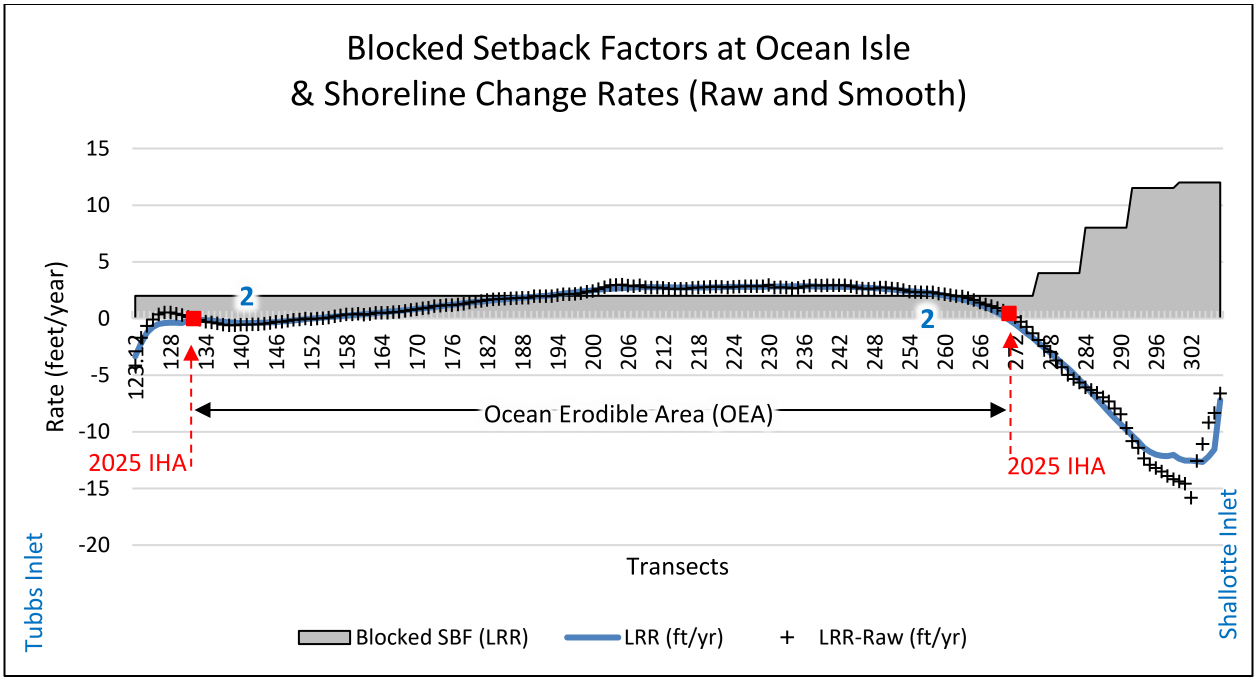

Figure 19. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors). For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

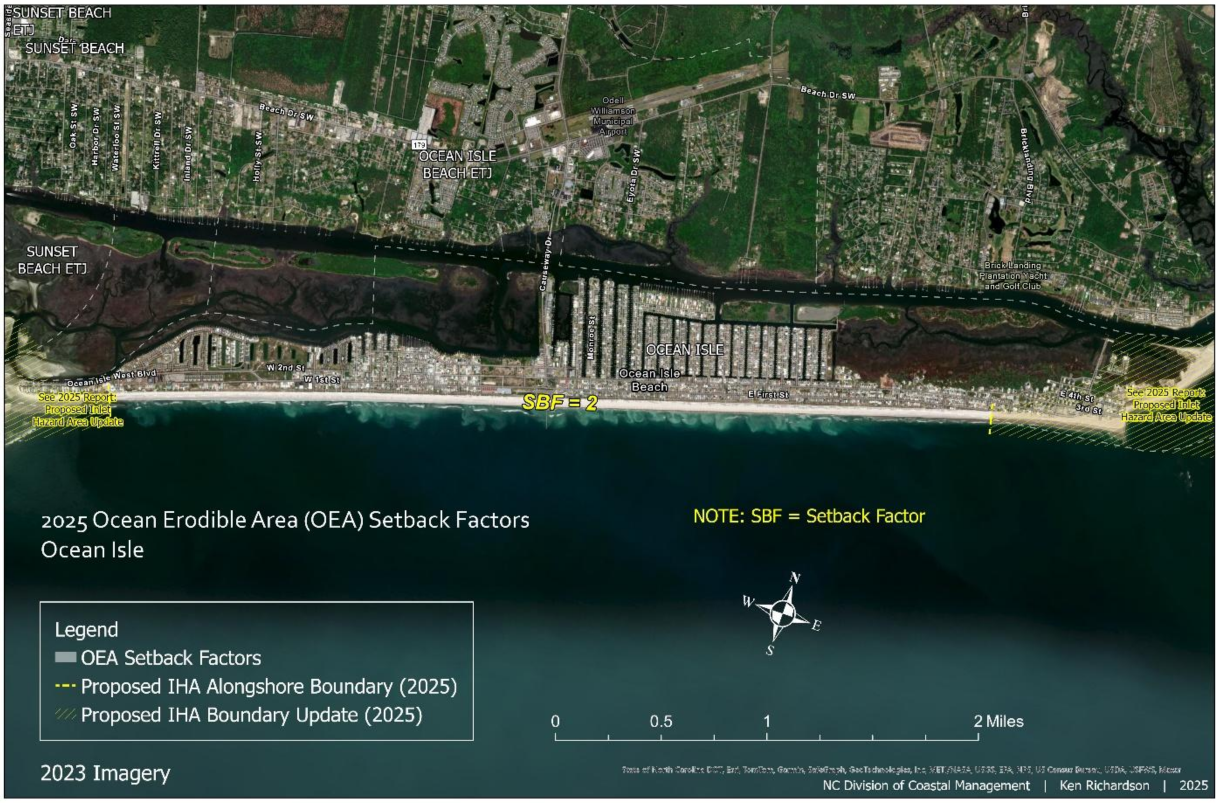

Figure 20. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Ocean Isle. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	2	2	2	2	2	2, 3	2	2

Table 5. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.3 Holden Beach

Holden Beach is considered low sloping and a south-facing, with approximately 8.0 miles of oceanfront shoreline. The first large-scale beach nourishment, involving over 300,000 cubic yards of sand, took place in 2001 as part of the Federal Coastal Storm Damage Reduction (CSDR) project between transects 395 and 542, and has been followed by routine maintenance efforts in 2006, 2009, 2014, 2018, 2021, and 2022 along various portions of the same section of shoreline.

The analysis assessed twenty-four shorelines (**Figure 21**) along this oceanfront section over an 87-year period, from 1933 to 2020. Since 2001, shoreline positions have been artificially influenced by regular beach nourishment. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 109 feet (oceanfront) to a maximum of 1,619 feet (inlet), with an average of 357 feet for the entire shoreline between Shallotte and Lockwood Folly Inlets. However, within the oceanfront area between the 2025 proposed updated Inlet Hazard Areas, specifically between transects 370 and 537, the shoreline envelope varied from 109 to 362 feet, averaging 179 feet. This contrast highlights the differing influences of oceanfront and inlet dynamics on shoreline position. For these same areas, the calculated average relative standard deviation of shoreline position was 103 feet overall and 49 feet for the oceanfront section alone. Of the 8.0 miles of shoreline analyzed, approximately 5.5 miles (69%) resulted in measured erosion where rates averaged less than -2 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 22**). The end-point method indicated an average shoreline change of less than 1 foot per year, while the least squares regression method yielded a similar rate of less than 1 foot per year. Within the oceanfront area between the 2025 proposed IHA boundaries (transects 370 to 537), the end-point method calculated an average change less than 1 foot per year, and the least squares regression method estimated less than 1 foot per year. Both approaches measured erosion rates between -2.4 and -2.8 feet per year within the OEA, leading to a blocked erosion rate setback factor of two (2), which is consistent with previous studies for most of the same section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. For most of the shoreline (between transects 370 and 518) the updated setback factors continue to be 2 feet per year making it consistent with previous studies; however, for the section approaching the Lockwood Folly Inlet 2025 proposed updated IHA boundary, between transects 319 and 519), the setback factors will decrease from 3 and 4 to 2 feet per year. Using this approach, the calculated setback factors for Ocean Isle's oceanfront, between the 2025 proposed updated Inlet Hazard Areas (approximately transects 370 to 537), remain at two feet per year (**Figure 23** to **Figure 26** & **Table 6**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

Figure 21. *Shorelines included in the analysis (1933-2020) at Holden Beach.*

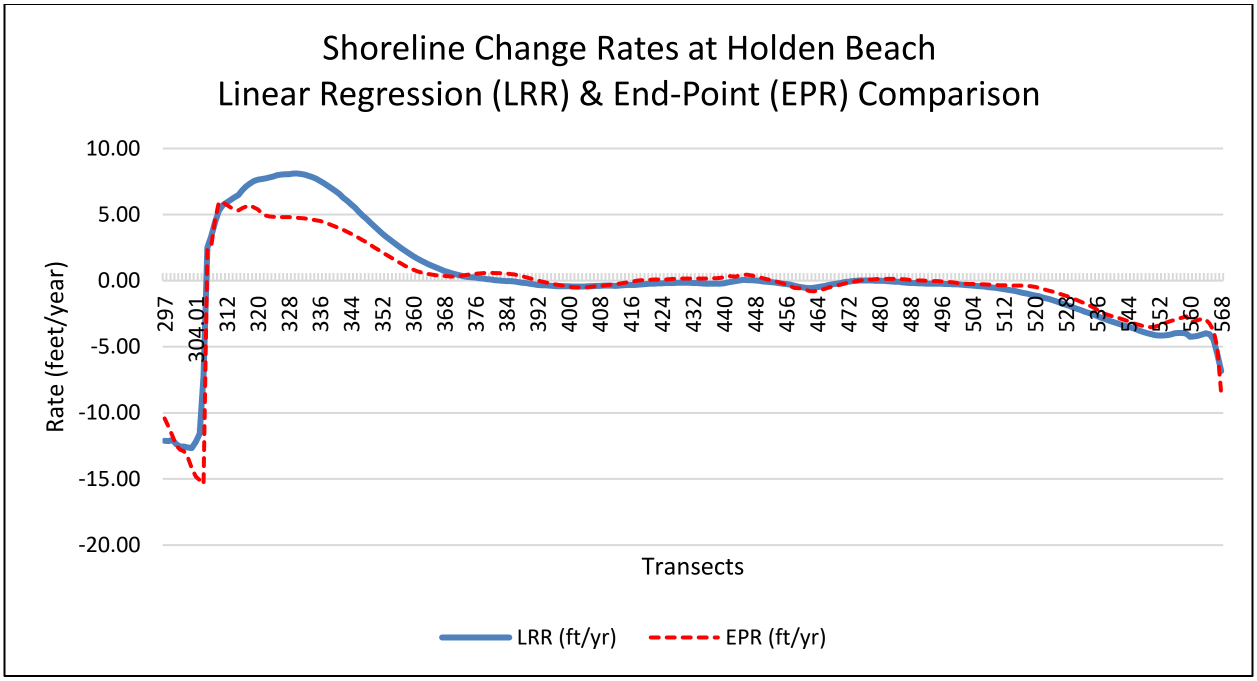

Figure 22. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 23. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

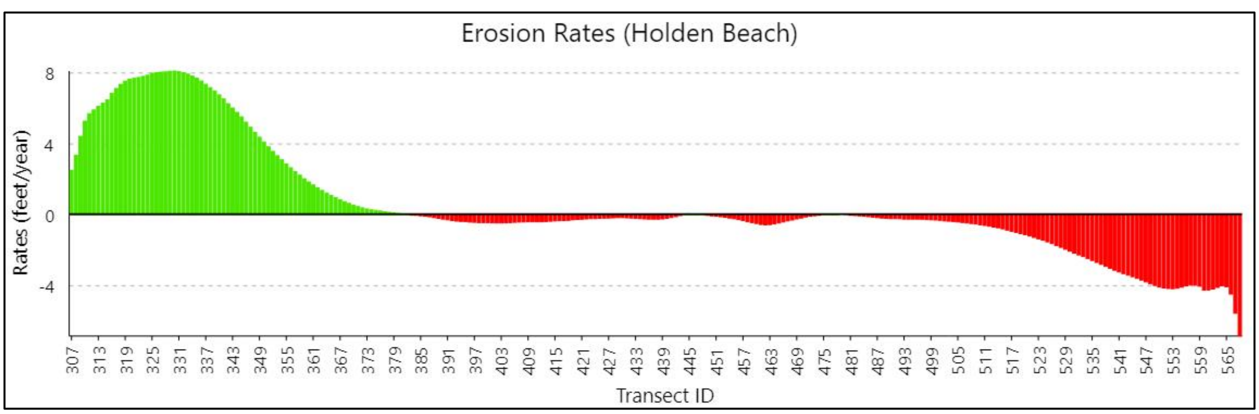

Figure 24. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

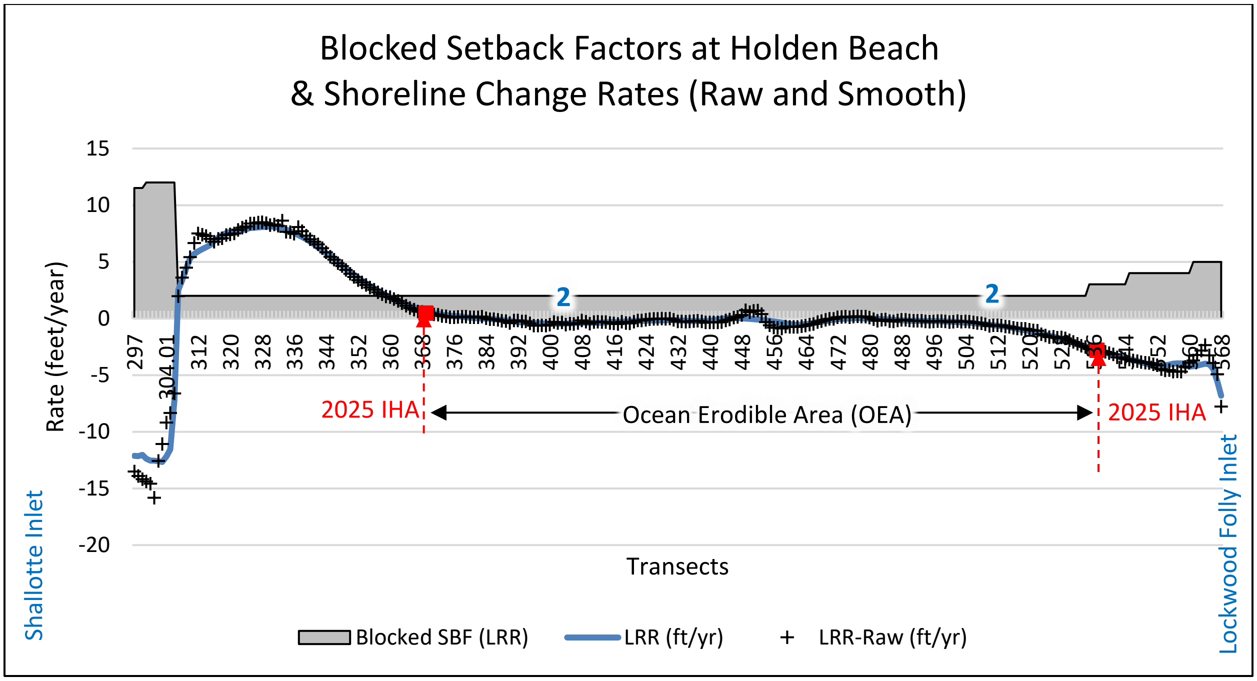

Figure 25. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

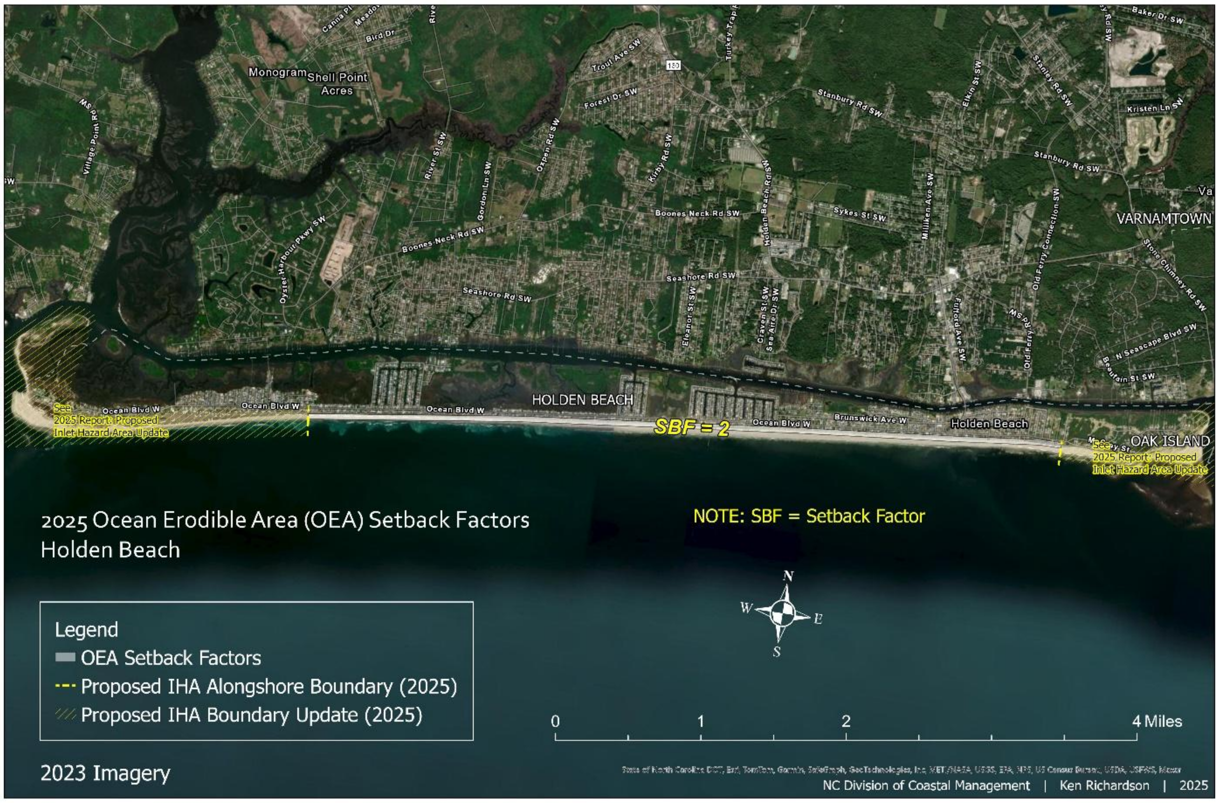

Figure 26. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Holden Beach. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	2	2,3 & 4	2, 2.5, & 3.5	2, 3, 4, 5, & 6.5	2 & 4	2	2	2

Table 6. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.4 Oak Island

The Town of Oak Island has a south-facing beach with approximately 9.3 miles of oceanfront shoreline. The Town installed its first large-scale beach nourishment project in 2001 where the western end of the project tapered off in the area just inside the proposed 2025 IHA boundary, approximately at transect 600. In 2019 and 2022, beneficial use of dredged material from the inlet, AIWW crossing and eastern channel was completed by the USACE's navigation initiatives resulting in material being placed along the western end of Oak Island stopping short of Lockwood Folly Inlet at near transect 577. Since 2001, several small-scale maintenance projects occurred in 2009, 2016, 2017, 2018, and 2019 for various segments of shoreline within the initial large-scale project area.

The analysis assessed thirty-five shorelines (**Figure 27**) along this oceanfront section over an 87-year period, from 1933 to 2020. Since 2001, shoreline positions have been artificially influenced by beach nourishment for portions of the beach. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 88 feet (oceanfront) to a maximum of 1,891 feet (inlet), with an average of 272 feet for the entire shoreline between Lockwood Folly Inlet and the Town's eastern limit near transect 869. Focusing specifically on the OEA, between transects-609 and -869, the shoreline envelope varied from 88 to 381 feet, averaging 218 feet. This contrast highlights the differing influences of oceanfront and inlet dynamics on shoreline position. For these same areas, the calculated average relative standard deviation of shoreline position was 66 feet overall and 55 feet for the oceanfront section alone. Of the 9.3 miles of shoreline analyzed, approximately 3.0 miles (32%) resulted in measured erosion where rates averaged less than -2 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 28**). The end-point method indicated an average shoreline change of less than 1 foot per year, while the least squares regression method yielded a similar rate of less than 1 foot per year. Within the oceanfront area between transects 609 and 869, the end-point method calculated an average change less than 1 foot per year, and the least squares regression method estimated less than 1 foot per year. Both approaches measure erosion rates less than 2 feet per year within the OEA, leading to a blocked erosion rate setback factor of two (2), which is consistent with previous studies for most of the same section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. For most of the shoreline (between transects-609 and -869) the updated setback factors continue to be 2 feet per year making it consistent with the previous two studies (2020 and 2013); but it is lower in comparison to setback factors calculated for studies before 2013 (2004, 1997, 1986, 1983, and 1980) on the Town's eastern end between approaching SE 70th Street near transect 829. Using this method, the calculated setback factors for Oak Island's OEA, between transects 609 and 869, remain at two feet per year (**Figure 29** to **Figure 32** & **Table 7**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

Figure 27. *Shorelines included in the analysis (1933-2020) at Oak Island.*

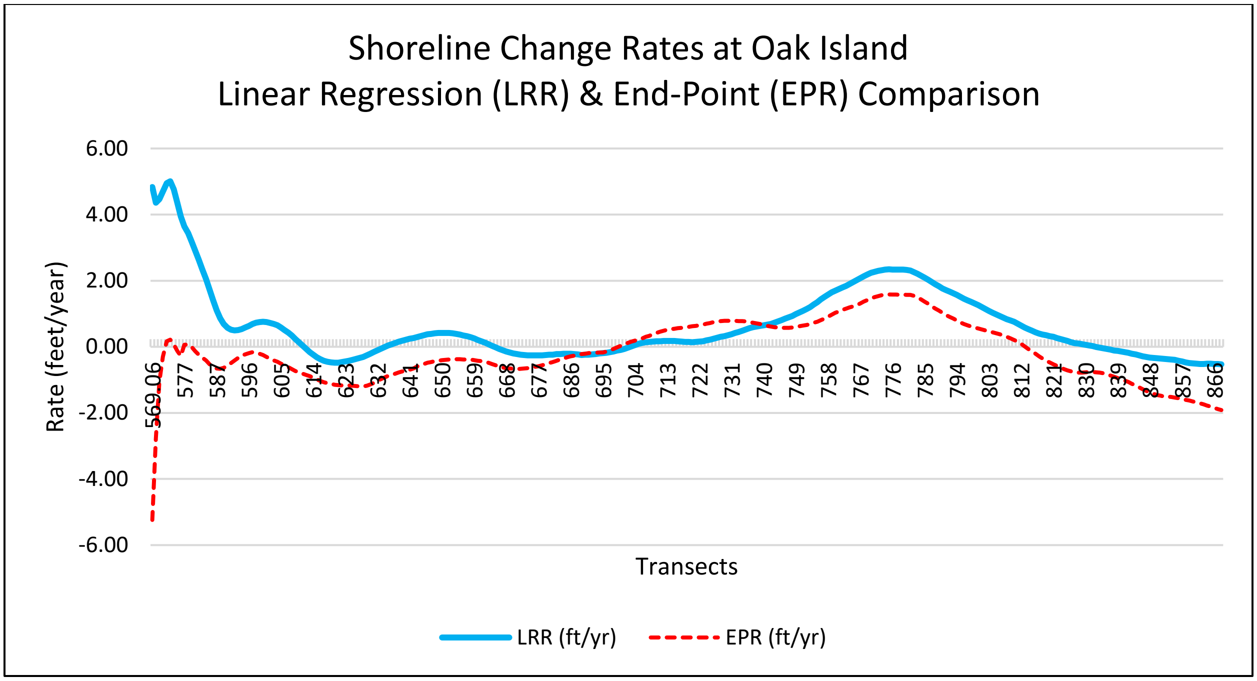

Figure 28. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

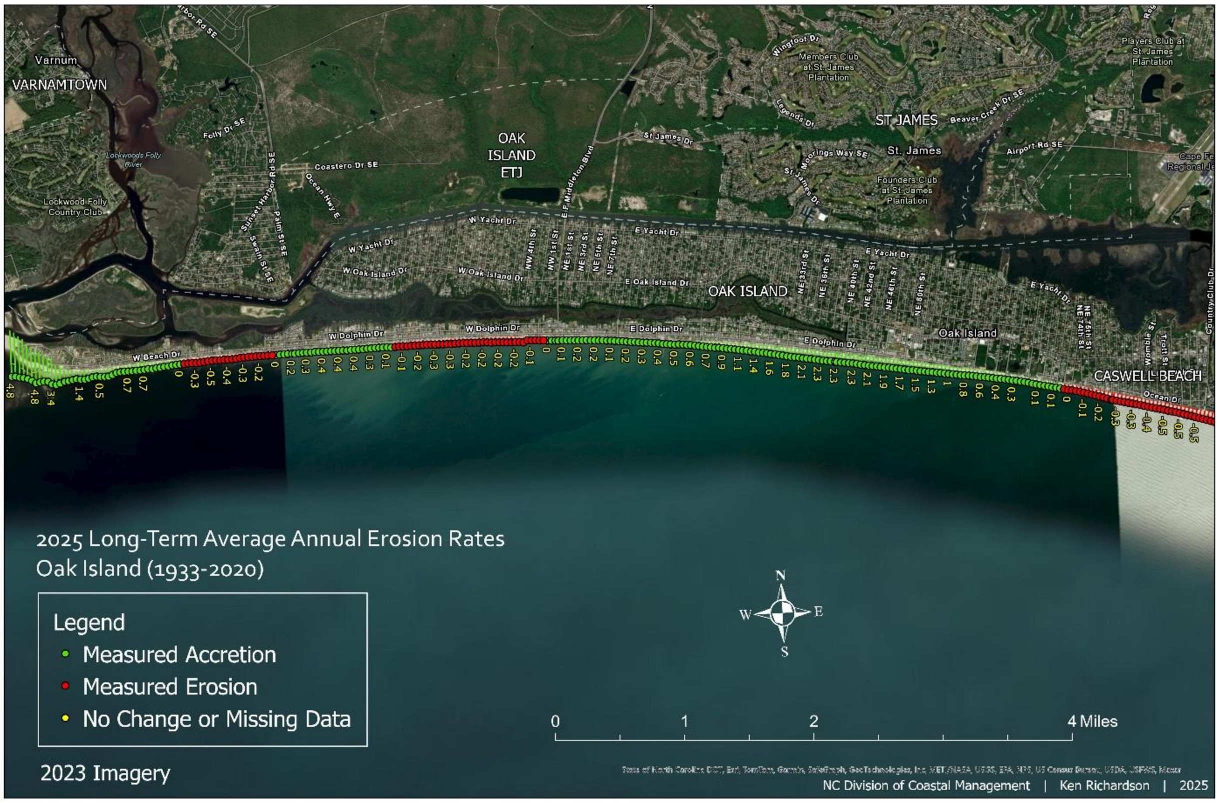

Figure 29. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

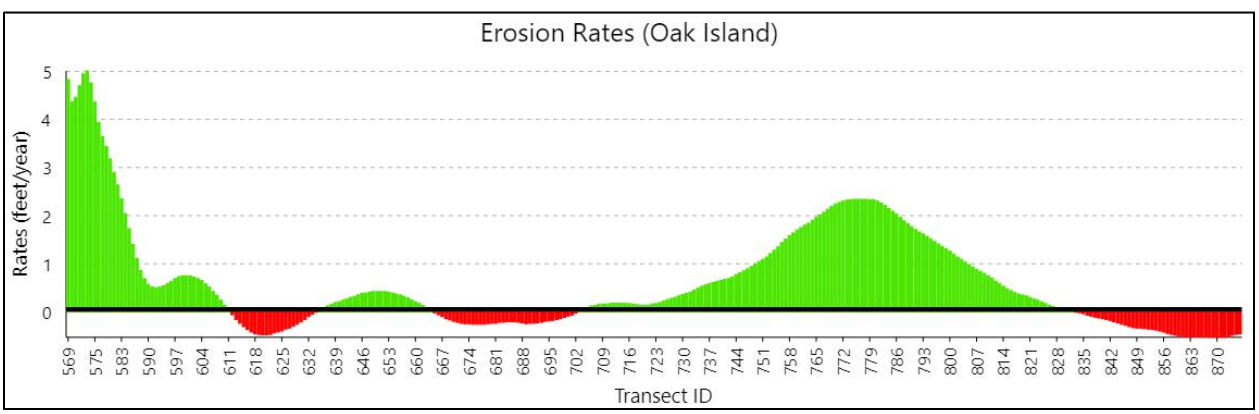

Figure 30. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

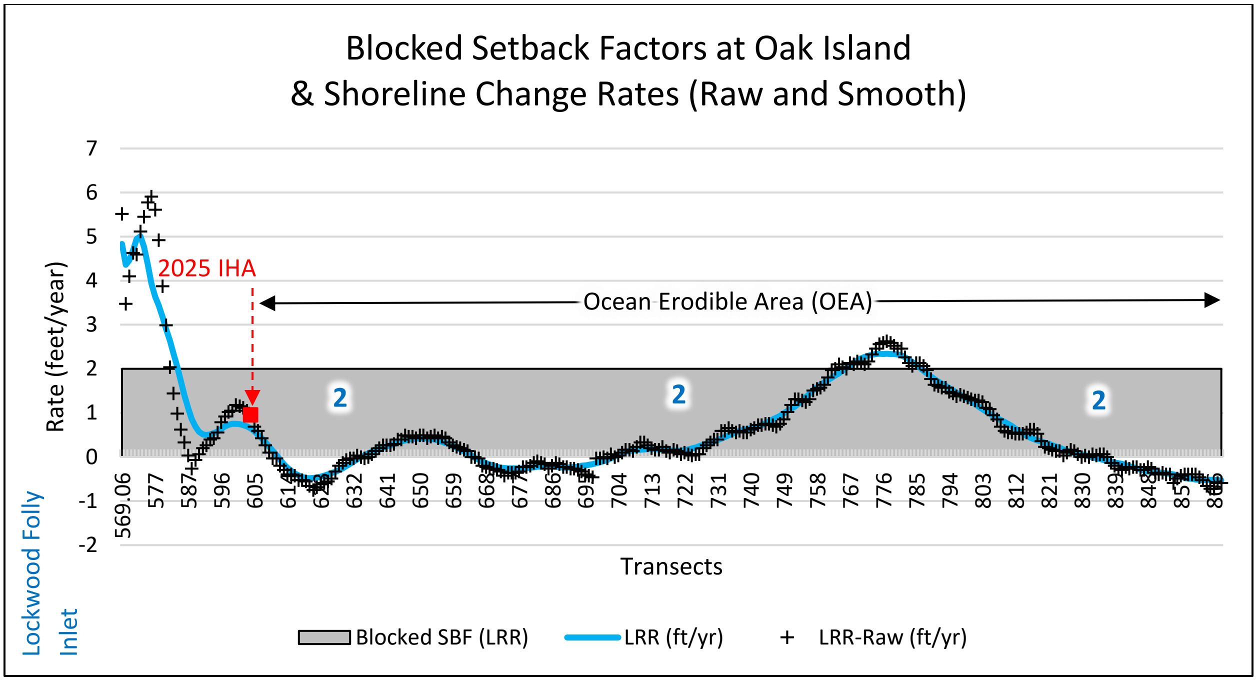

Figure 31. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 32. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Oak Island. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2, 3, 4, & 5	2, 3, 4.5 & 6	2, 3, & 5	2, 3, 3.5, 4, & 5	2 & 5

Table 7. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.5 Caswell Beach and Fort Caswell

Caswell Beach and Fort Caswell have combined oceanfront shorelines totaling 3.5 miles. The Town is a recipient of sediment placed by the USACE through the Wilmington Harbor Sand Management Plan (SMP). In 2009, the Town received its first large-scale beach fill project along most of its oceanfront shoreline, followed by maintenance projects in 2018 and 2021.

The analysis assessed thirty-five shorelines (**Figure 33**) along this oceanfront section over an 86-year period, from 1934 to 2020. Since 2009, shoreline positions have been artificially influenced by beach nourishment for portions of the beach. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 228 feet (oceanfront) to a maximum of 3,026 feet (inlet), with an average of 399 feet for the entire shoreline between Town's western limit near transect 869 to the Cape Fear Inlet. This contrast highlights the differing influences of oceanfront and inlet dynamics on shoreline position. For the same area, the calculated average relative standard deviation of shoreline position was 95 feet. Of the 3.5 miles of shoreline analyzed, approximately 4,000 feet (19%) resulted in measured erosion where rates averaged less than -2 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 34**). The end-point method indicated an average shoreline change of +2 feet per year, and the least squares regression method yielded a similar rate of +2 feet per year also. Both approaches measure erosion rates less than 2 feet per year within the OEA, leading to a blocked erosion rate setback factor of two (2), which is consistent with previous studies for most of the same section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. The updated setback factors continue to be 2 feet per year making it consistent with the previous two studies (2020 and 2013); but it is lower in comparison to setback factors calculated for studies before 2013 (2004, 1997, 1986, 1983, and 1980) on the Town's western end between transect 869 and 911 along Caswell Beach Road. Using this method, the calculated setback factors for Caswell Beach and Fort Caswell, between transects 869 and 981, remain at two feet per year (**Figure 35** to **Figure 38** & **Table 8**).

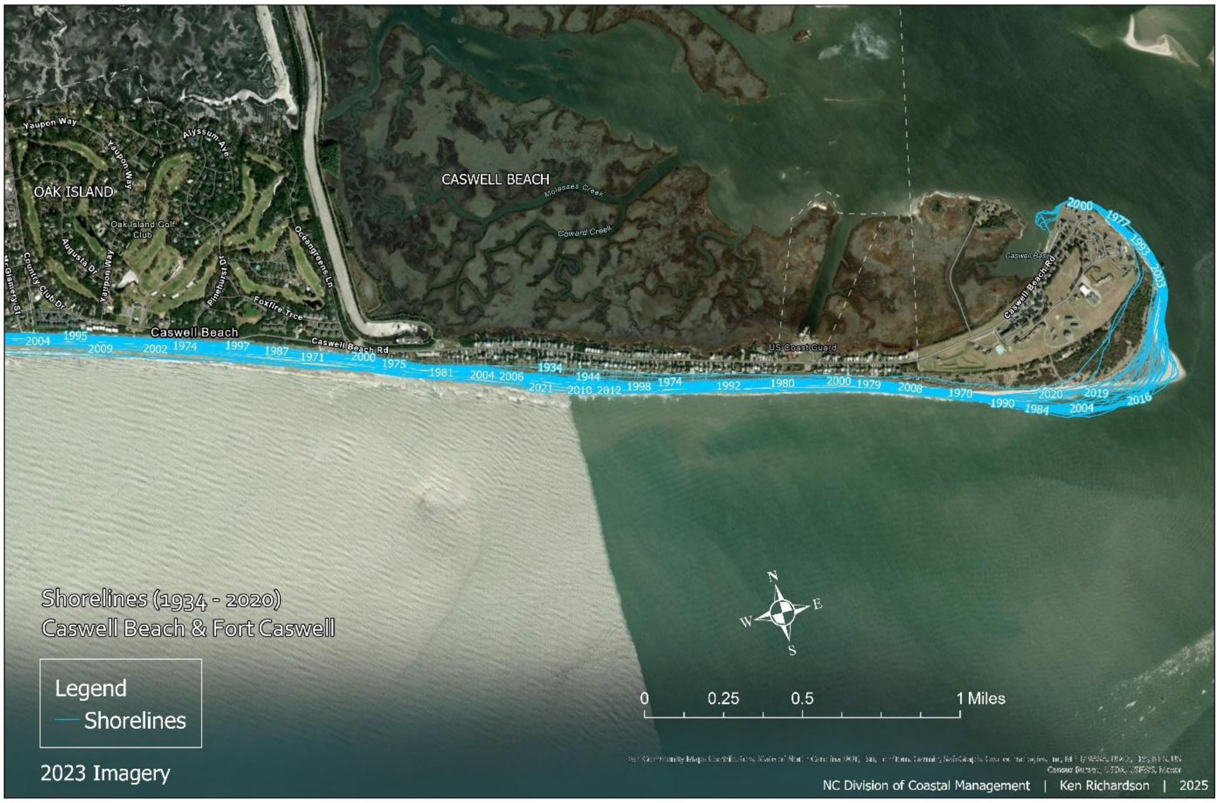

Figure 33. *Shorelines included in the analysis (1934-2020) at Caswell Beach and Fort Caswell.*

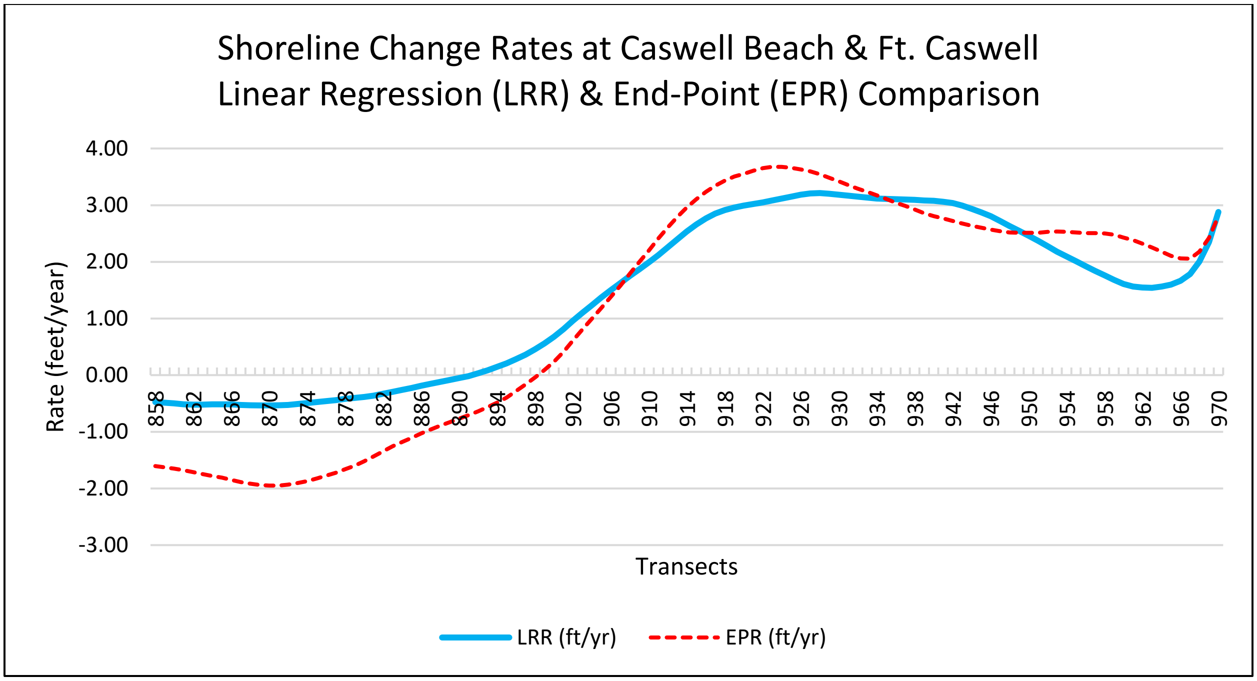

Figure 34. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 35. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

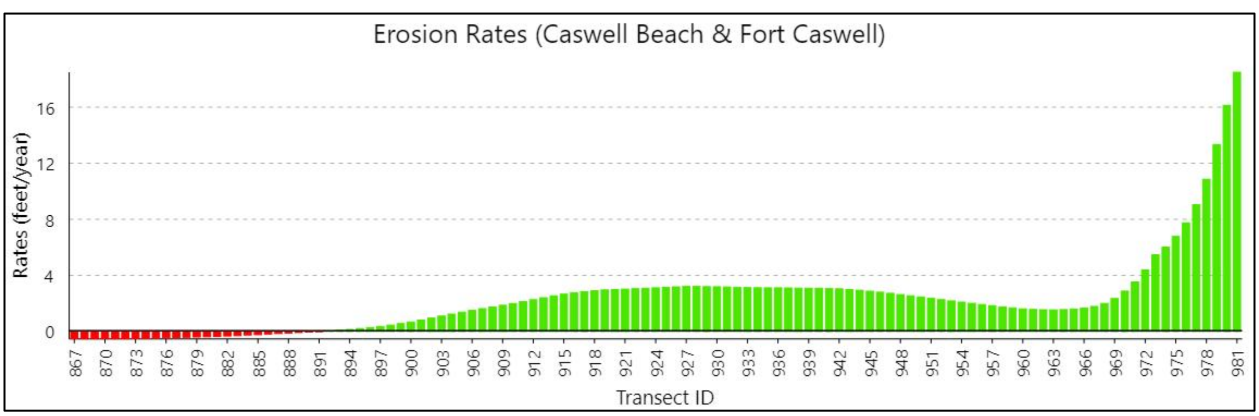

Figure 36. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

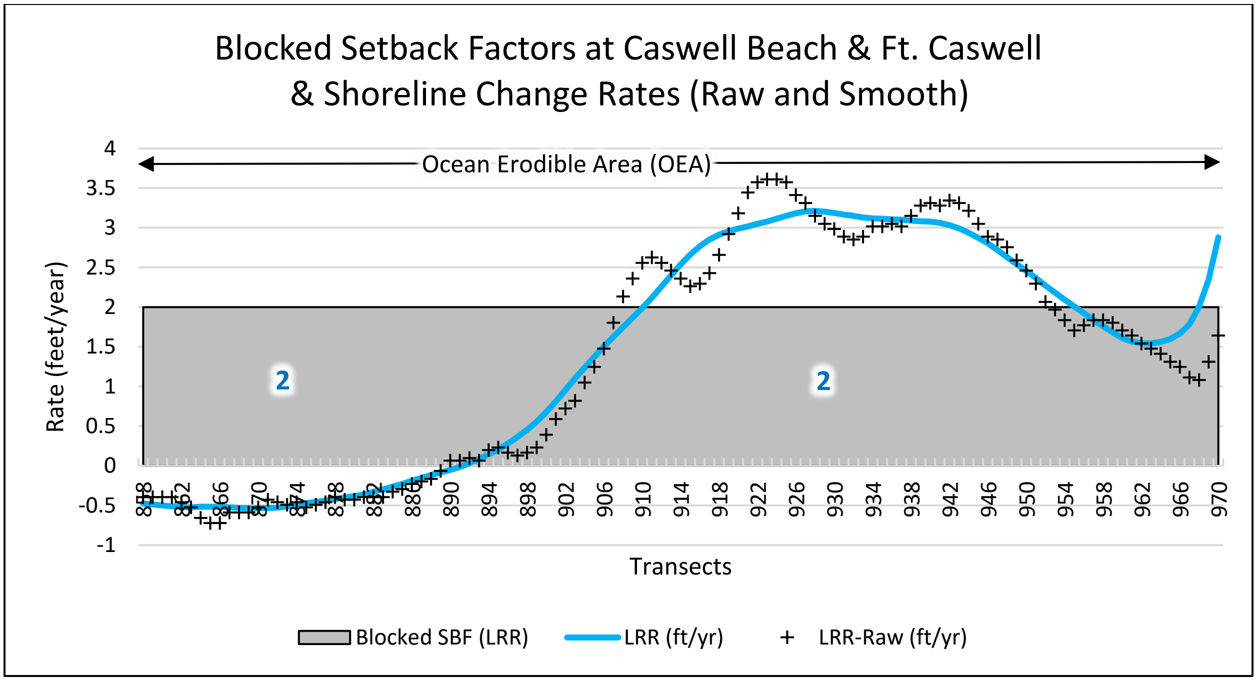

Figure 37. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 38. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Caswell Beach and Fort Caswell.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2 & 3.5	2 & 4	2 & 4	2 & 3.5	2 & 5

Table 8. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.6 Bald Head Island (South-Beach)

Bald Head Island's "south-beach" is the last south-facing shoreline in Brunswick County just before transitioning to east-facing beaches at Cape Fear. This 3.2-mile oceanfront shoreline has a history of being very dynamic as it is heavily influenced by inlet and cape processes, erosion mitigation efforts, and engineering practices (dredging, sandbags, terminal groin, groin tubes and beach nourishment). Starting in 1991 the Town installed its first small-scale beach fill project, followed by fourteen subsequent projects from 1996 to 2023. The Town installed its first large-scale beach fill project along its south-beach in 2007.

Since 1994, various erosion mitigation efforts have supplemented beach nourishment along south-beach, specifically adjacent to the Cape Fear Inlet. These began with the installation of a sandbag revetment, followed by the placement of sixteen soft groins (geotextile sandbag tubes) in 1996, along with ongoing rehabilitation and replacement efforts. Then a rock terminal groin was added in 2015, and in 2019, the remaining thirteen original geotextile sandbag tubes were removed and replaced. Collectively, these measures, along with routine beach nourishment, appear to have slightly reduced erosion rates along the approximately half mile stretch at the west end of South Beach compared to earlier studies.

The analysis assessed twenty-two shorelines (**Figure 39**) along this oceanfront section over an 86-year period, from 1934 to 2020. Since 1991, shoreline positions have been artificially influenced by beach nourishment and erosion mitigation efforts for portions of the beach. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 239 feet (oceanfront) to a maximum of 1,355 feet (cape), with an average of 579 feet for the entire shoreline between Town's western limit near Cape Fear Inlet to its eastern end at Cape Fear. This contrast highlights the differing influences of oceanfront and both inlet and cape dynamics on shoreline position. For the same area, the calculated average relative standard deviation of shoreline position was 159 feet. Of the 3.2 miles of shoreline analyzed, nearly all 3.1 miles (97%) resulted in measured erosion where rates averaged approximately -4 feet per year.

A comparison of the end-point and least squares regression methods showed slight differences in results (**Figure 40**). The end-point method indicated an average shoreline change of -2 feet per year (ranging from -13 to +5 feet per year) and calculated setback factors between 2 and 11 feet per year. In contrast, the least squares regression method produced an average change of -4 feet per year (ranging from -9.8 to +4 feet per year) with setback factors between 2 and 9.5 feet per year. While some variations were observed between the two methods, the results align with previous studies and remain consistent for most of the same shoreline section given the engineering practices and dynamic cape and inlet influences on shoreline position.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement. The updated setback factors, ranging from 2 to 9.5 feet per year, remain consistent with previous studies (2020, 2013, 2004, 1997, and 1986). Along South Beach, starting at Cape Fear Inlet and moving west toward Cape Fear, erosion setbacks progress as follows: 3.5 feet per year at the eastern end, increasing to 6.5 feet per year at transect-992, decreasing to 4.0 feet per year at transect 1001, 2.0 feet per year at transect 1009, then increasing again to 3.5 feet per year at transect 1047, 5.0 feet per year at transect 1055, 6.5 feet per year at transect 1063, 8.5 feet per year at transect 1071, and reaching 9.5 feet per year at transect 1079 near Cape Fear. Compared to the current effective setback factors (2020), the areas between transects 984.2 and 1008, as well as transects 1047 and 1054, will experience an increase of 0.5 to 1 foot per year (**Figure 39** to **Figure 44** & **Table 9**).

Figure 39. *Shorelines included in the analysis (1933-2020) at Bald Head Island's South-Beach.*

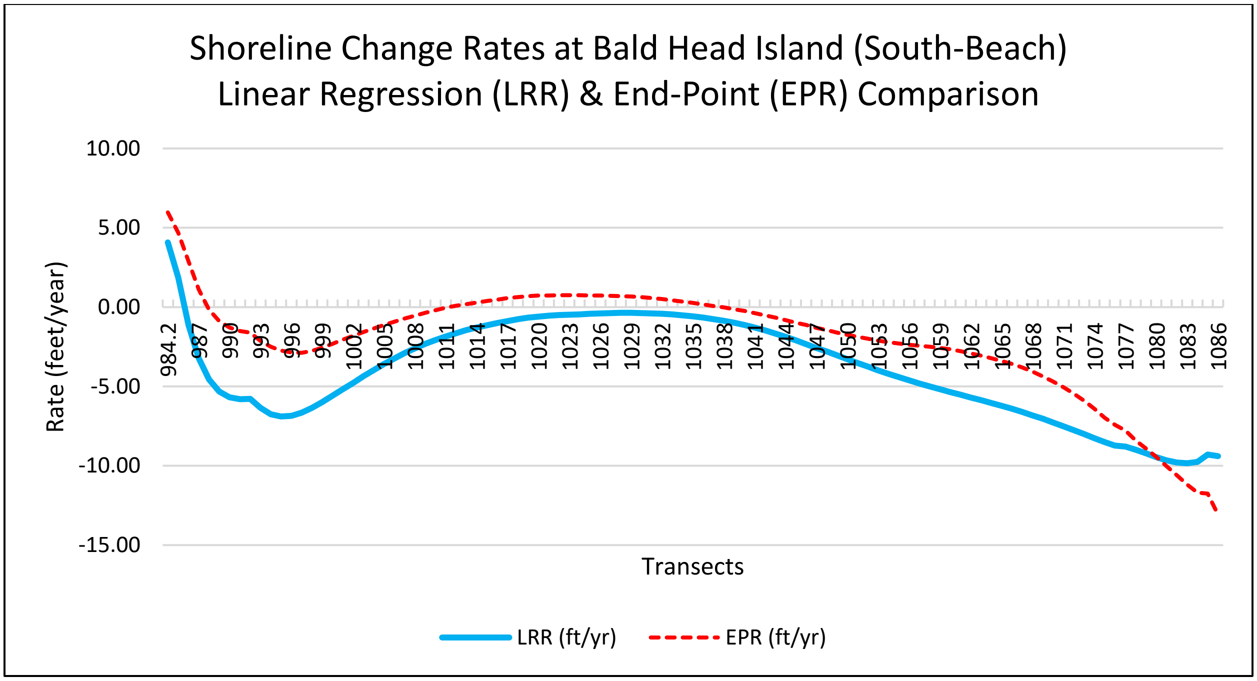

Figure 40. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 41. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

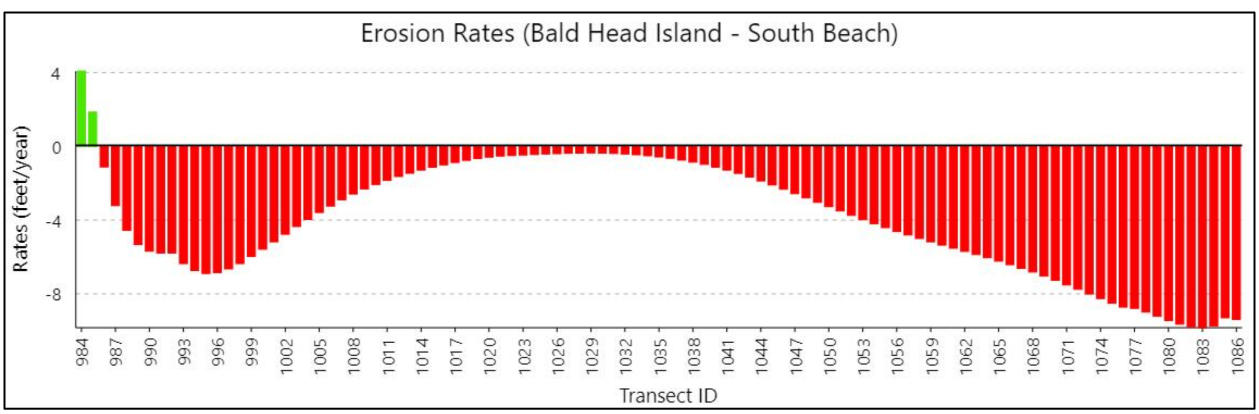

Figure 42. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

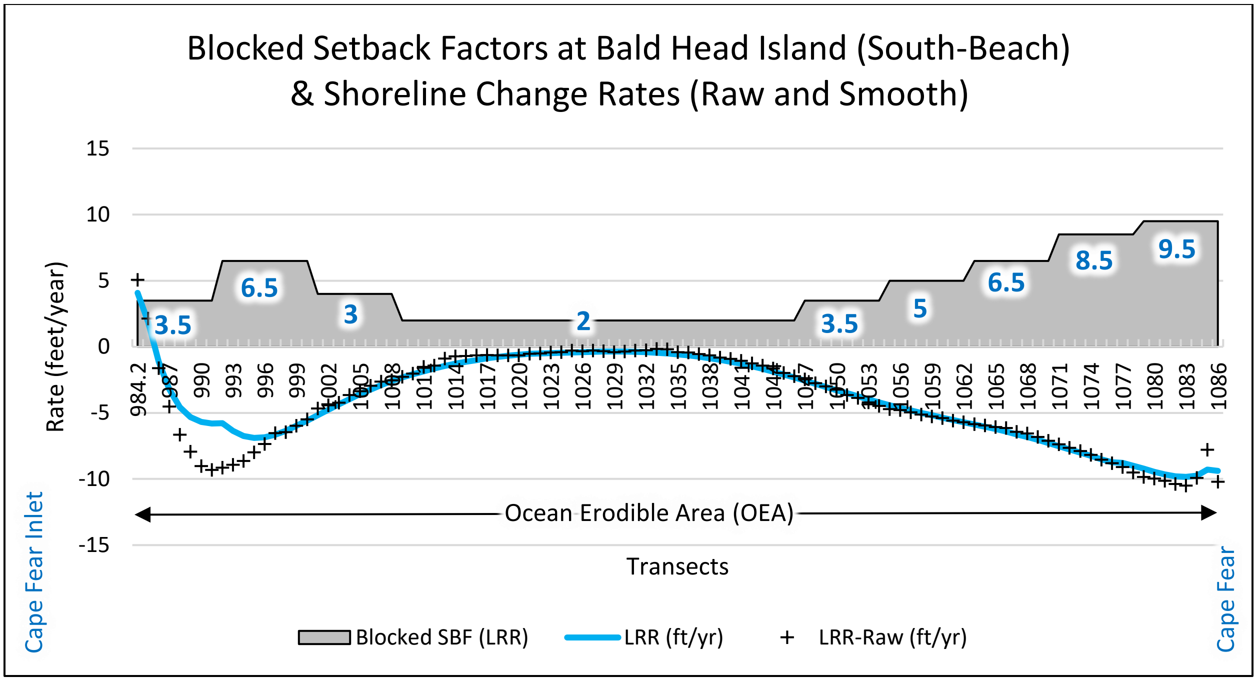

Figure 43. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 44. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Bald Head Island (south-beach).*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	2 to 9.5	2 to 13	2 to 10.5	2 to 15	2 to 11.5	3 to 11	2 to 7	N\A

Table 9. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.7 Bald Head Island (East-Beach)

As the shoreline transitions from Bald Head Island's South Beach to East Beach around Cape Fear, the data indicate an erosion-accretion pivot point. Historically, east-beach has remained relatively stable, as evidenced by long-term data trends. The analysis assessed twenty-two shorelines (**Figure 45**) along this oceanfront section over an 86-year period, from 1934 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 327 feet (oceanfront) to a maximum of 824 feet (at Cape Fear), with an average of 524 feet for the entire shoreline between Cape Fear and the Town's northern limit. For the same area, the calculated average relative standard deviation of shoreline position was 142 feet and ranged between 90 and 234 feet.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 46**). The end-point method indicated an average shoreline change of +2.5 feet per year, and the least squares regression method yielded a similar rate of +2.6 feet per year also. Both approaches measure erosion rates less than 2 feet per year within the OEA, leading to a blocked erosion rate setback factor of two (2), which is consistent with previous studies for most of the same section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. The updated setback factors continue to be 2 feet per year making it consistent with the previous studies (2020, 2013, 2004, 1997, 1986, and 1983); Using this method, the calculated setback factors for Bald Head Island's east-beach remain at two (2) feet per year (**Figure 47** to **Figure 50** & **Table 10**).

Figure 45. *Shorelines included in the analysis (1934-2020) at Bald Head Island (east-beach).*

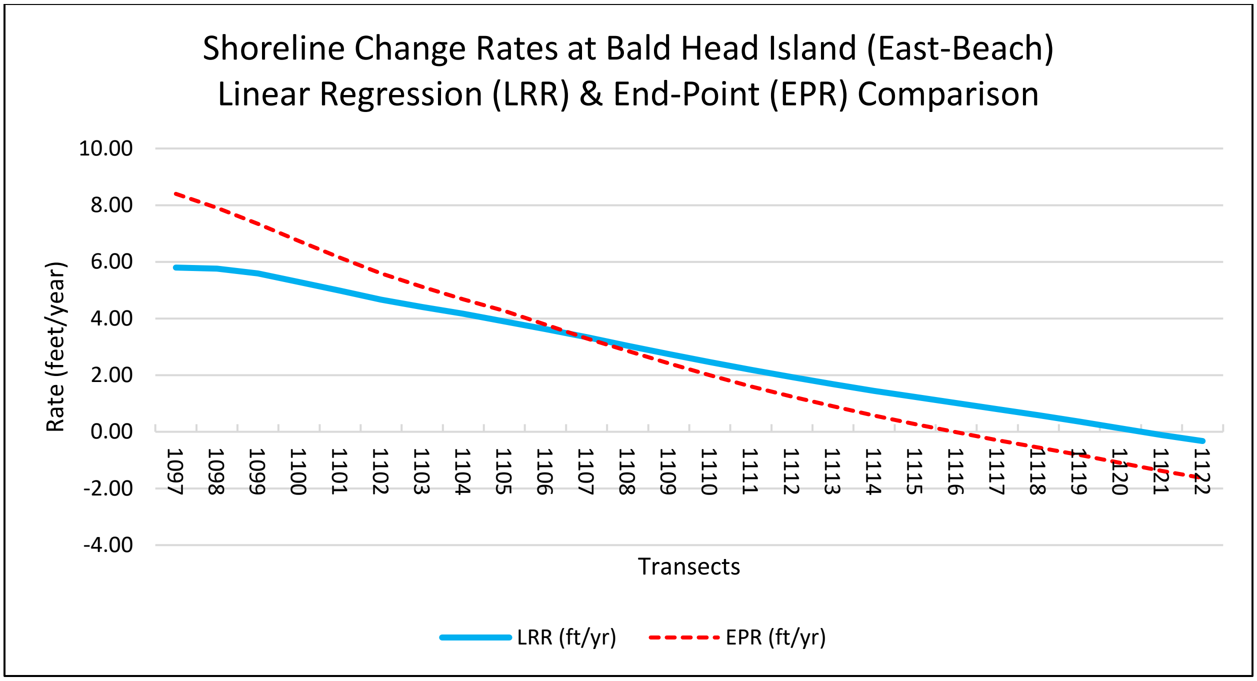

Figure 46. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

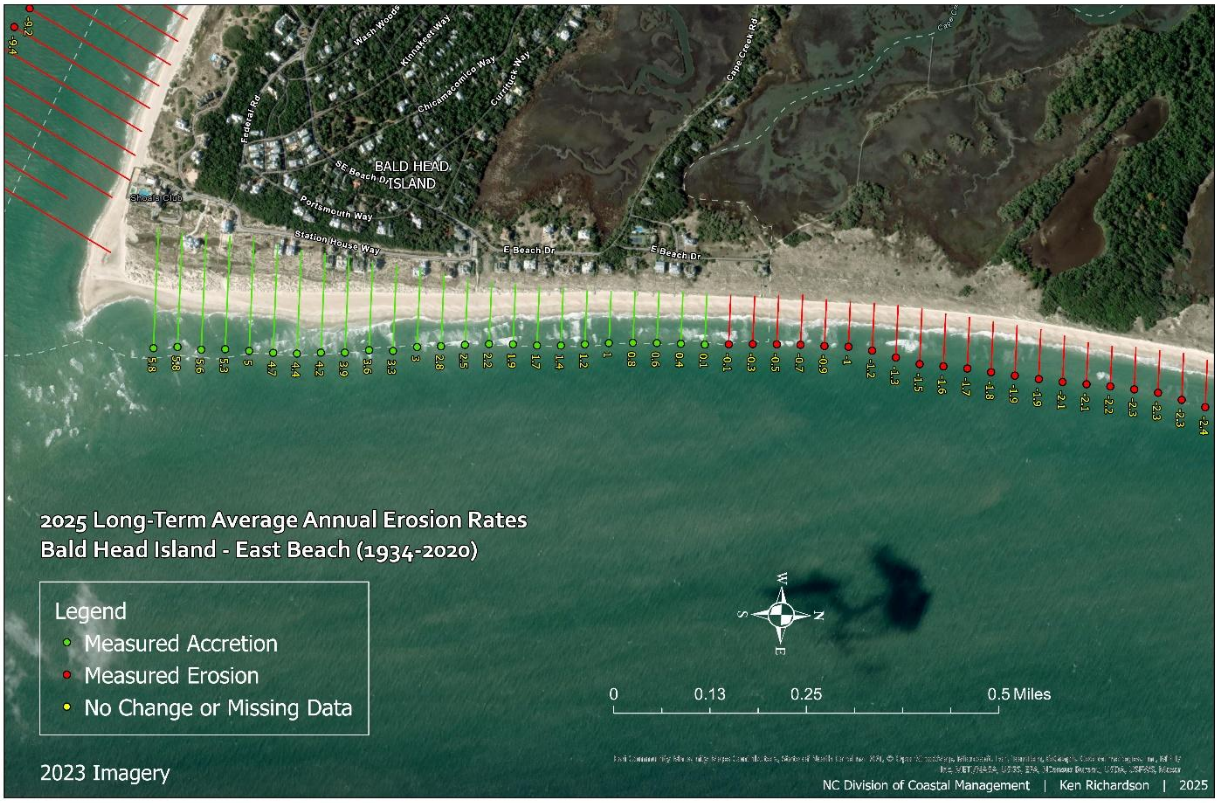

Figure 47. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

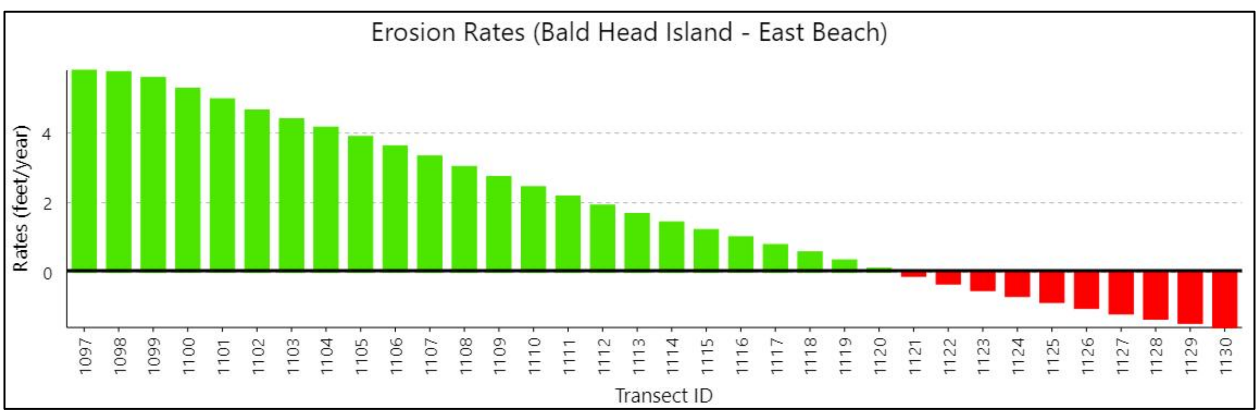

Figure 48. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

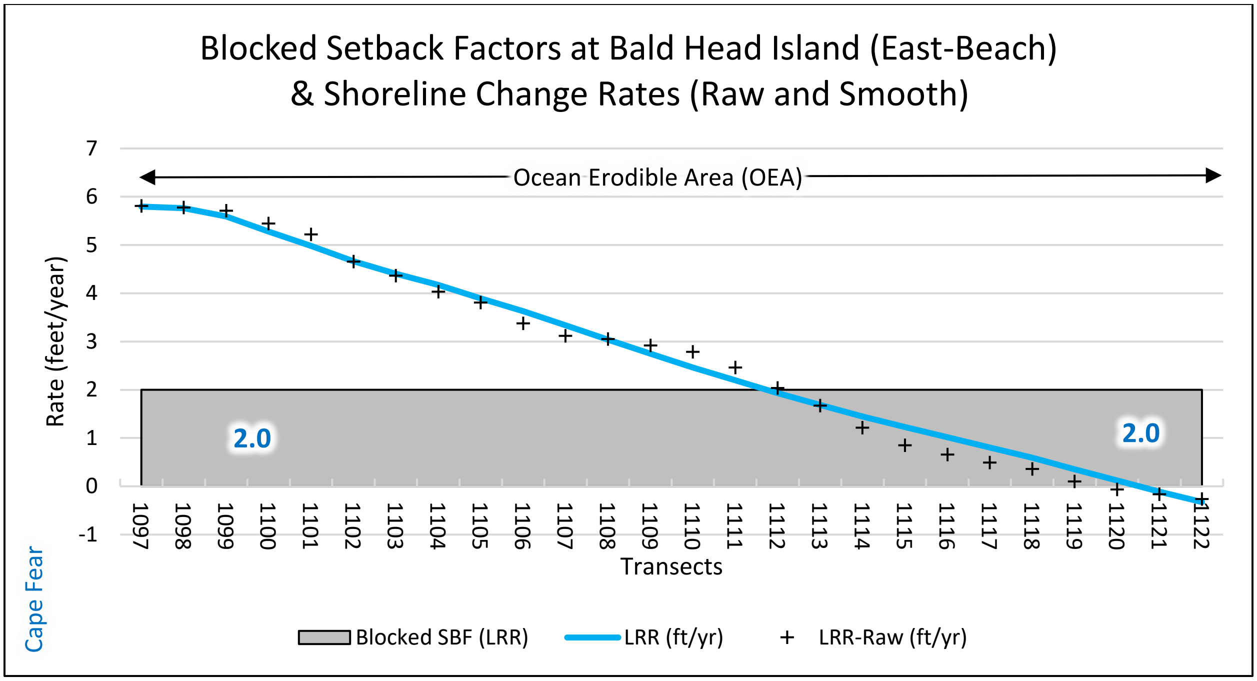

Figure 49. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

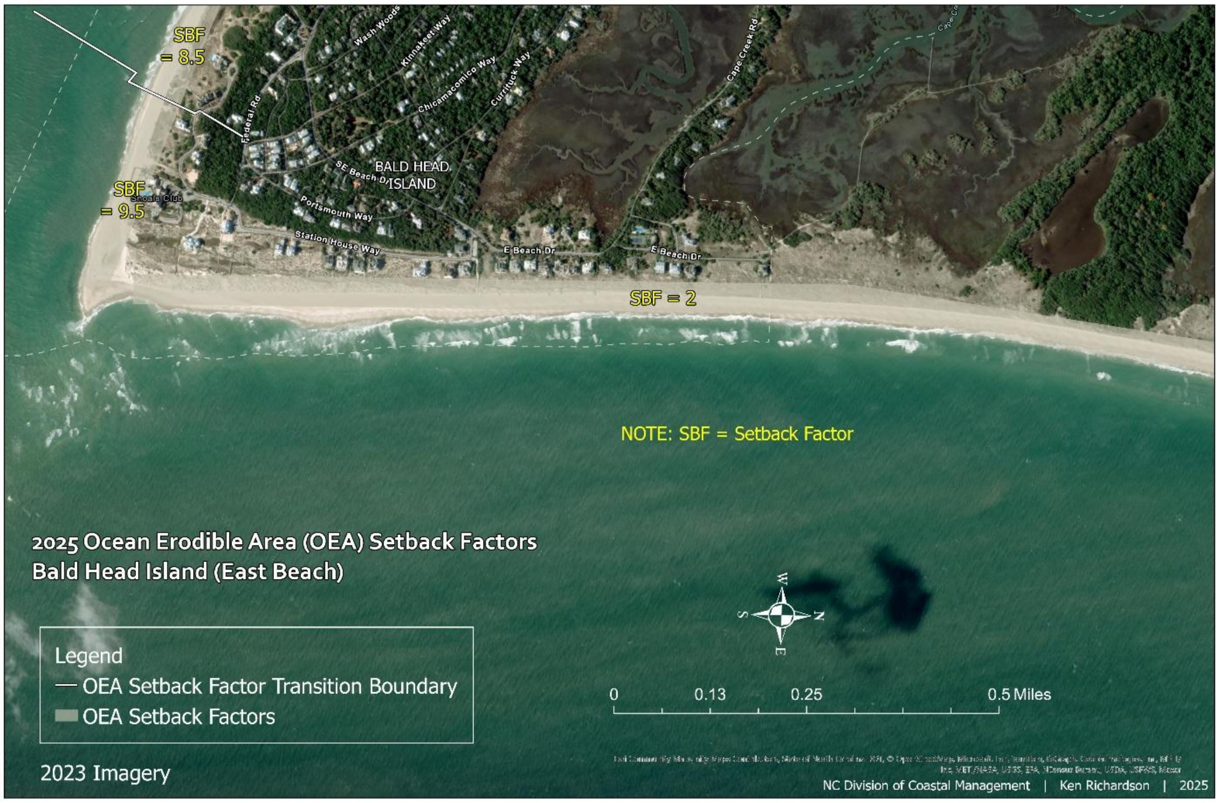

Figure 50. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Bald Head Island (east-beach).*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2	N\A

Table 10. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.8 Zeke's Island to Fort Fisher State Park

Historically, this 8.4 miles of shoreline has been influenced by New Inlet that closed in the late 1800s and Corncake Inlet that closed in the late 1990s due to Hurricane Bonnie (1998) and Floyd (1999). Although no beach fill projects have occurred since it is public land and not developed, a 3,040-foot rock revetment was installed in 1996 along the shoreline adjacent to Kure Beach to protect a Civil War earthworks historic site at Fort Fisher State Park.

The analysis assessed twenty-two shorelines (**Figure 51**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 182 feet to a maximum of 1,484 feet (at now closed Corncake Inlet), with an average of 631 feet. For the same area, the calculated average relative standard deviation of shoreline position was 164 feet and ranged between 56 and 335 feet. Of the 8.4 miles of shoreline analyzed, approximately 4.8 miles (57%) resulted in measured erosion where rates averaged -4.2 feet per year.

Both the end-point and least squares regression methods produced similar results (***Figure 52***). The end-point method showed shoreline change rates ranging from -6.4 to +11.3 feet per year, with an average of less than 1.0 foot per year. Similarly, the least squares regression method produced a range of -7.0 to +9.5 feet per year, also averaging less than 1.0 foot per year. Both approaches yielded comparable blocked erosion rate setback factors, averaging 3 feet per year, which aligns with previous studies for most of the same shoreline section.

Adopting the least squares regression methodology provides a more precise representation of long-term shoreline movement. The updated setback factors, ranging from 2 to 7 feet per year, remain consistent with previous studies (2020, 2013, 2004, 1997, 1986, and 1983) (**Figure 52** to **Figure 56** & **Table 11**).

Figure 51. *Shorelines included in the analysis (1933-2020) from Zeke's Island to Fort Fisher State Park.*

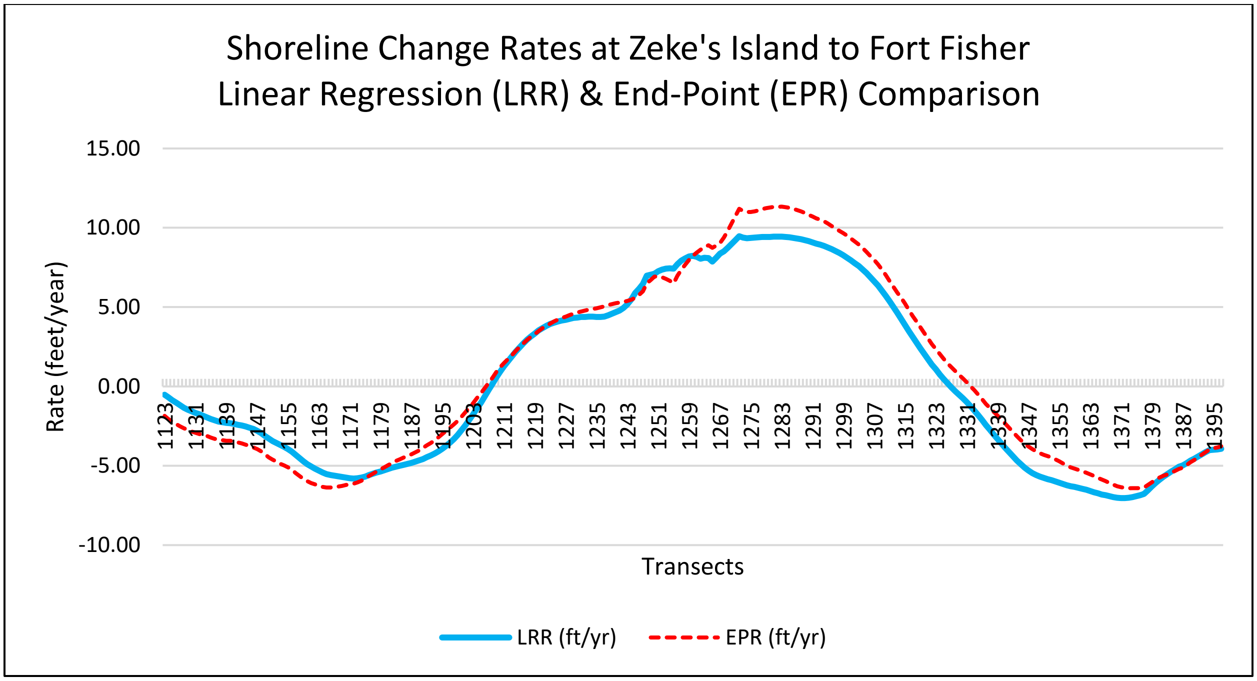

Figure 52. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 53. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

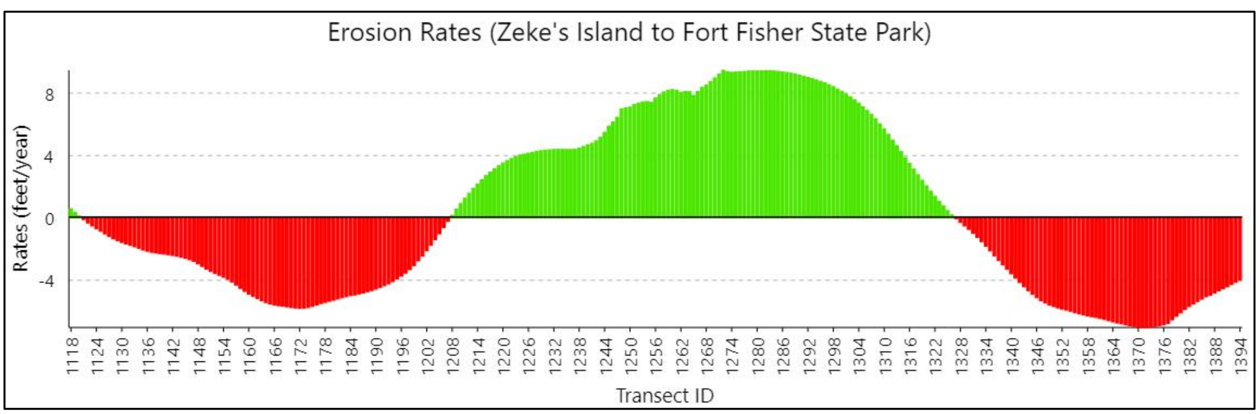

Figure 54. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

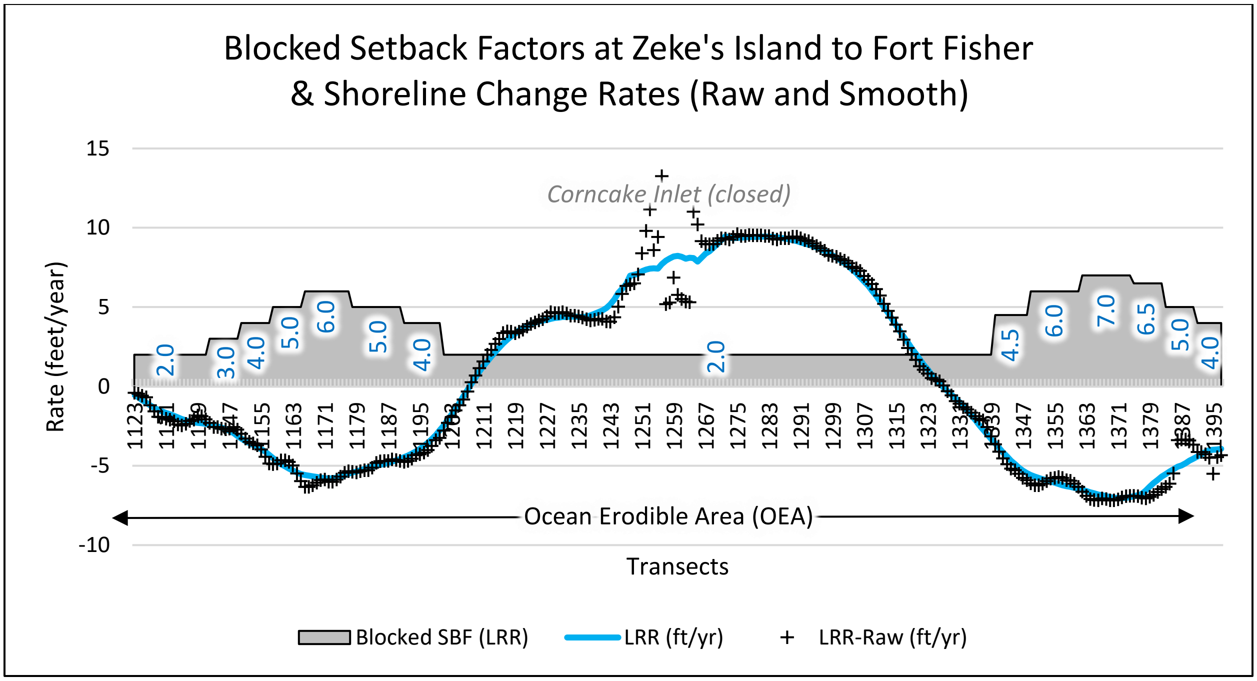

Figure 55. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

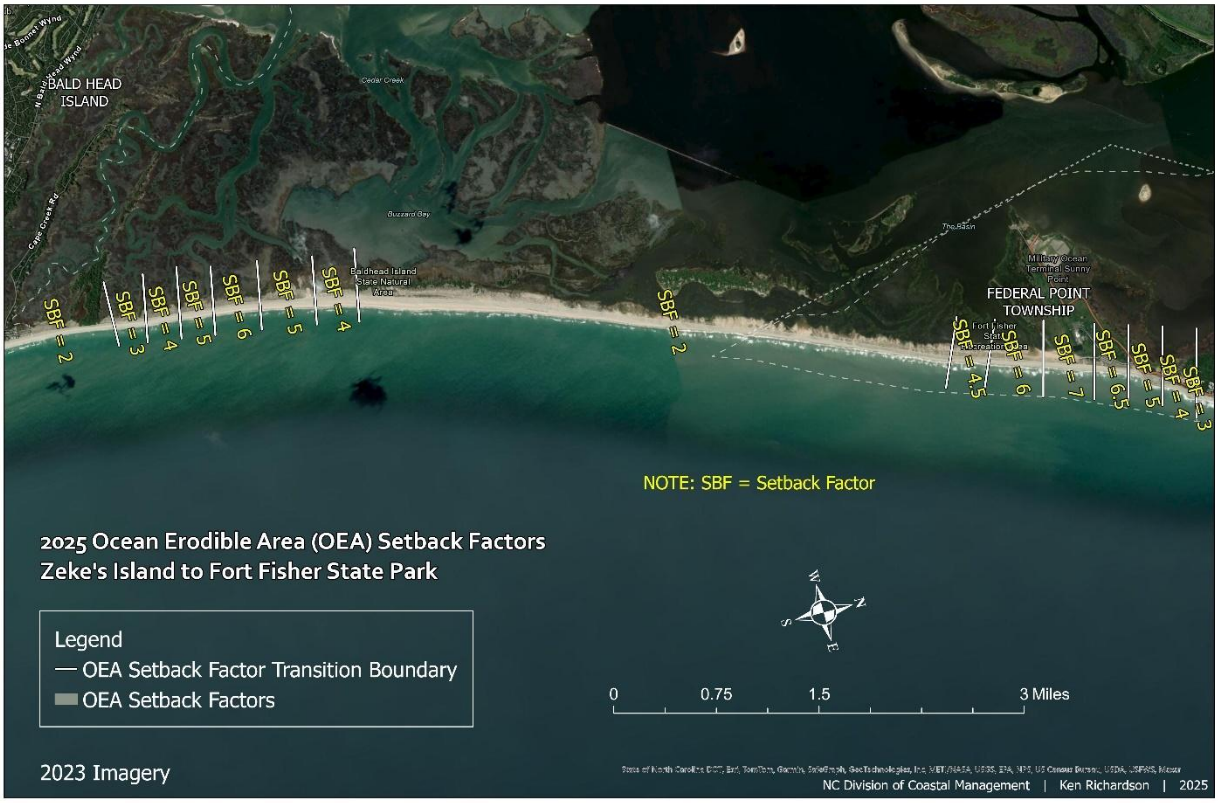

Figure 56. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area from Zeke's Island to Fort Fisher State Park.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2 to 7	2 to 8	2 to 9	2 to 11	2 to 8	2 to 10	2 to 9	N/A

Table 11. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.9 Kure Beach

Kure Beach is an east-facing beach with 2.9 miles of oceanfront shoreline. The Town installed its first beach fill project in 1997 followed by its first large-scale project in 2001. Since then, maintenance projects have been installed along portions of the shoreline in 2004, 2006-2007, 2010, 2013-2014, 2016, 2019 and 2022.

The analysis assessed fifteen shorelines (**Figure 57**) along this oceanfront section over an 87-year period, from 1933 to 2020. Since 1997, shoreline positions have been artificially influenced by regular beach nourishment. The shoreline envelope, representing the extent of movement along each transect, ranged from 197 feet to 428 feet, with an average of 250 feet for the entire shoreline between transects 1398 and 1491. For this same area, the calculated average relative standard deviation of shoreline position ranged from 52 feet to 120 feet and averaged 65 feet. Of the 2.9 miles of shoreline analyzed, approximately 3,500 feet (22%) resulted in measured erosion where rates averaged -2 feet per year, and as high as -4 feet per year along the Town's southern-most section of shoreline.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 58**). The end-point method resulted in a range of shoreline line change rates between -3.7 and +1.6 feet per year, averaging less than 1 foot per year; and the least squares regression method resulted in a range of shoreline line change rates between -3.9 and 1.6 feet per year, averaging less than 1 foot per year also. Both approaches result in a blocked erosion rate setback factors of three (3) on the Town's southern limit adjacent to Fort Fisher State Park (transects 1398 to 1406), and two (2) through most of its oceanfront, which is consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. For most of the shoreline (between transects 1407 and 1491) the updated setback factors continue to be 2 feet per year making it consistent with the previous two studies (2020, 2013, 2004, 1997, and 1986); but is lower between transects 1398 to 1404 where setback factors will decrease from 4 to 3 feet per year (**Figure 59** to **Figure 62** & **Table 12**).

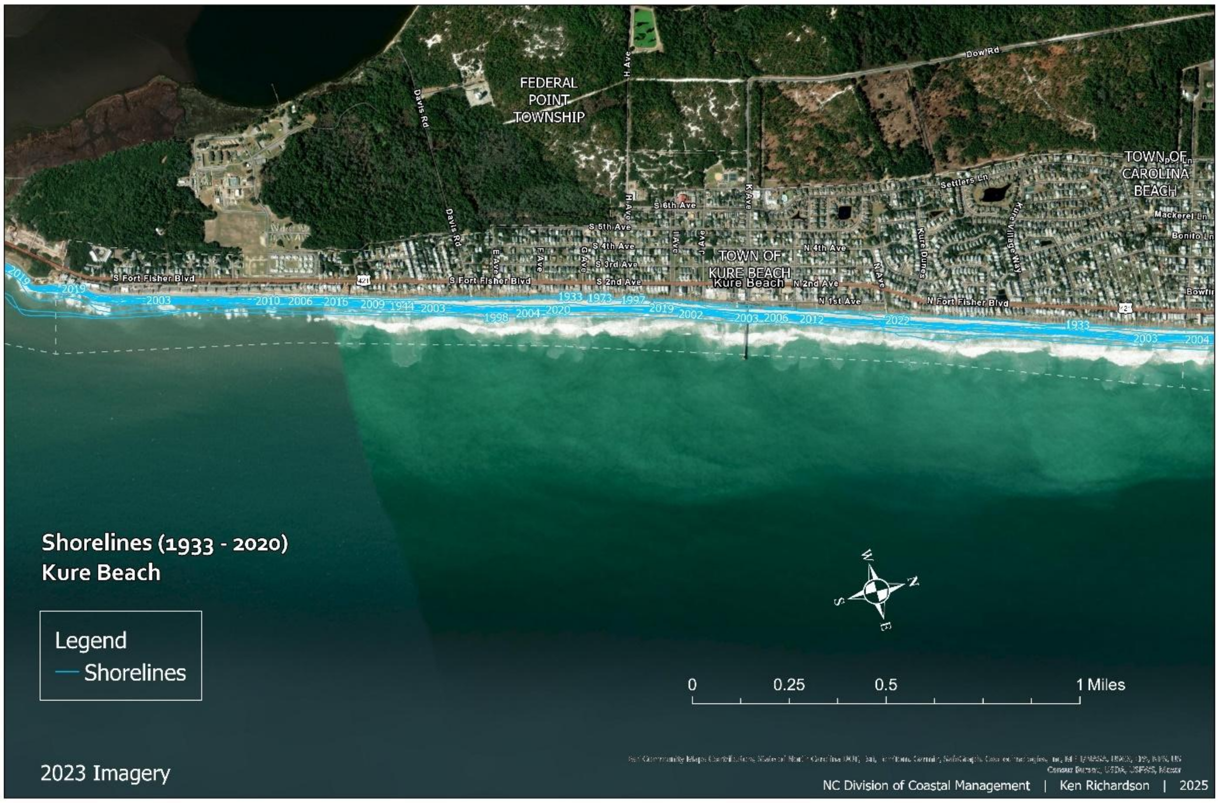

Figure 57. *Shorelines included in the analysis (1933-2020) at Kure Beach.*

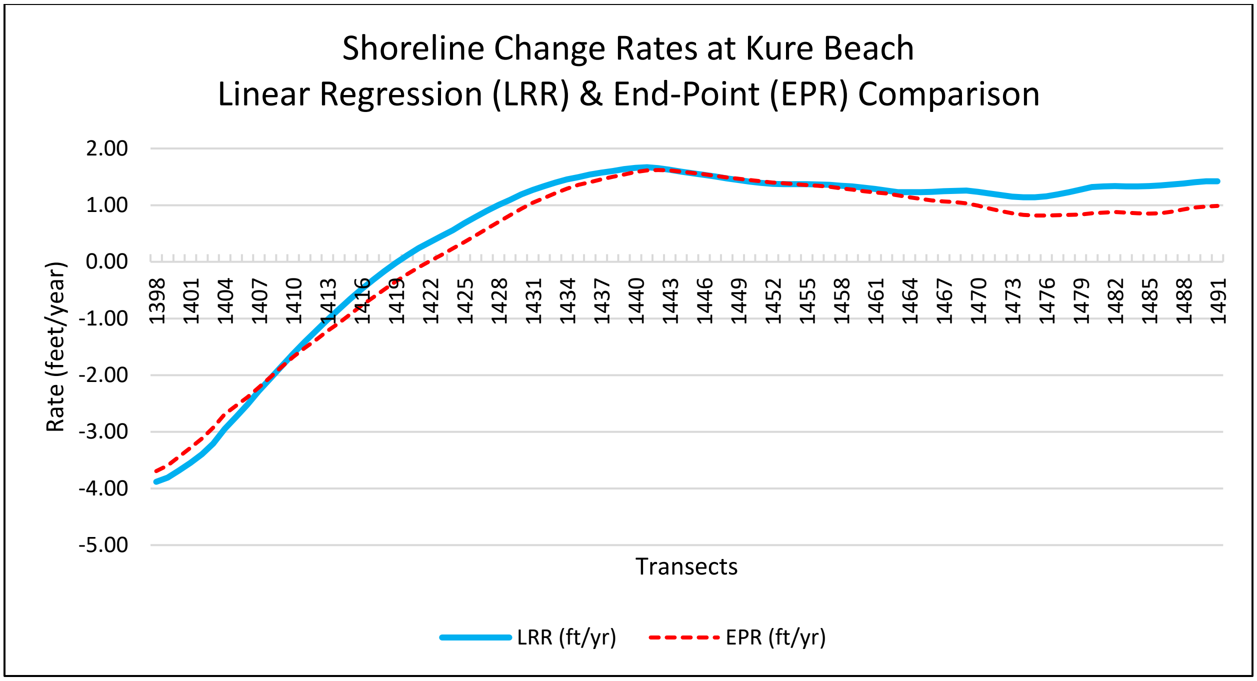

Figure 58. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 59. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

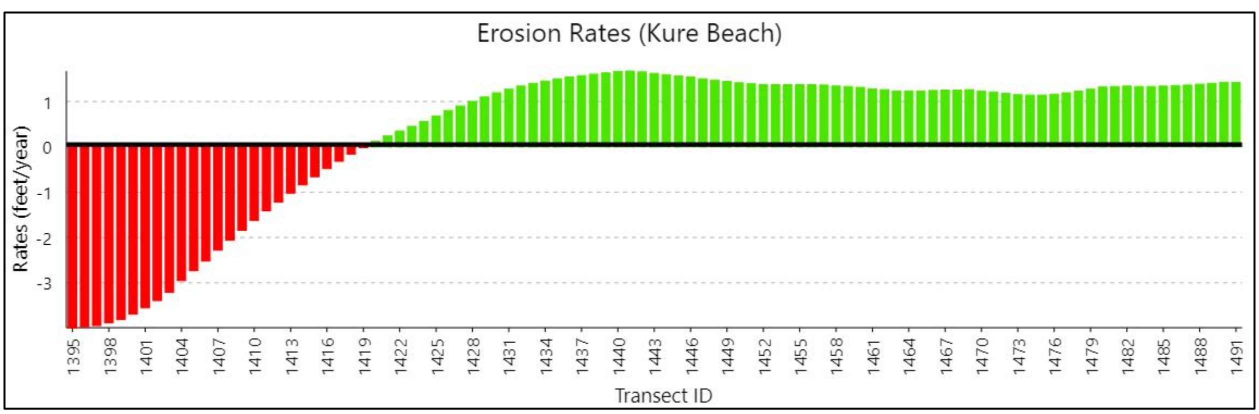

Figure 60. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

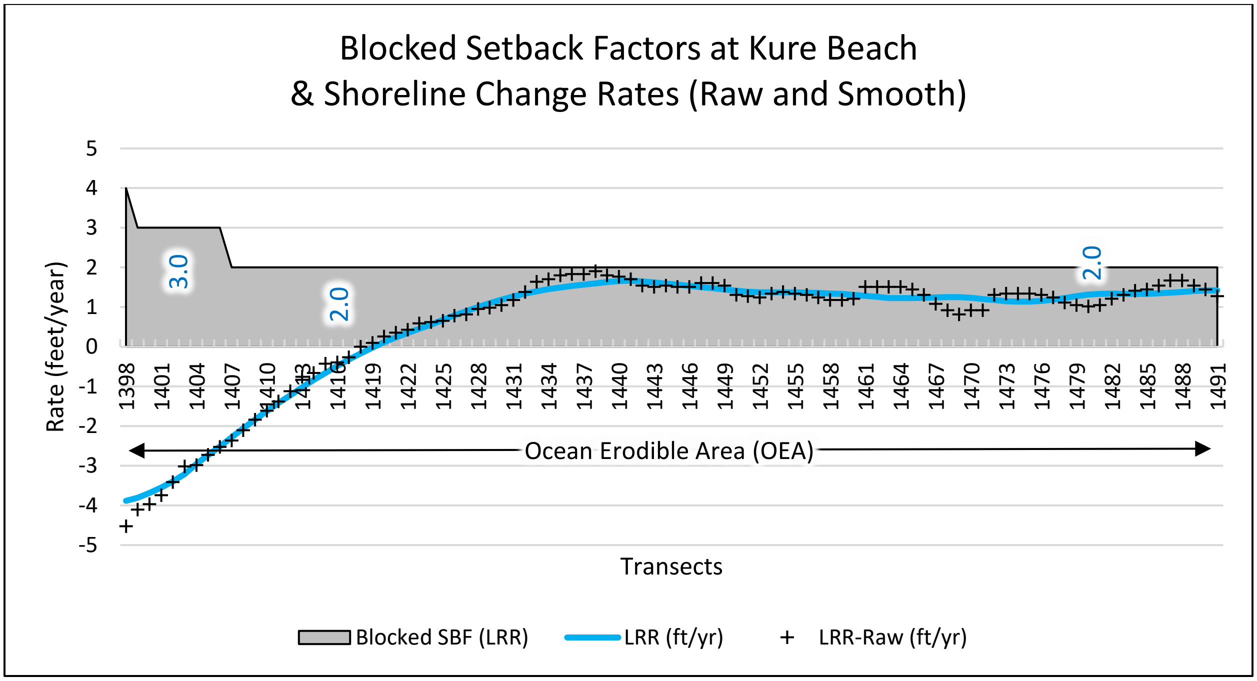

Figure 61. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

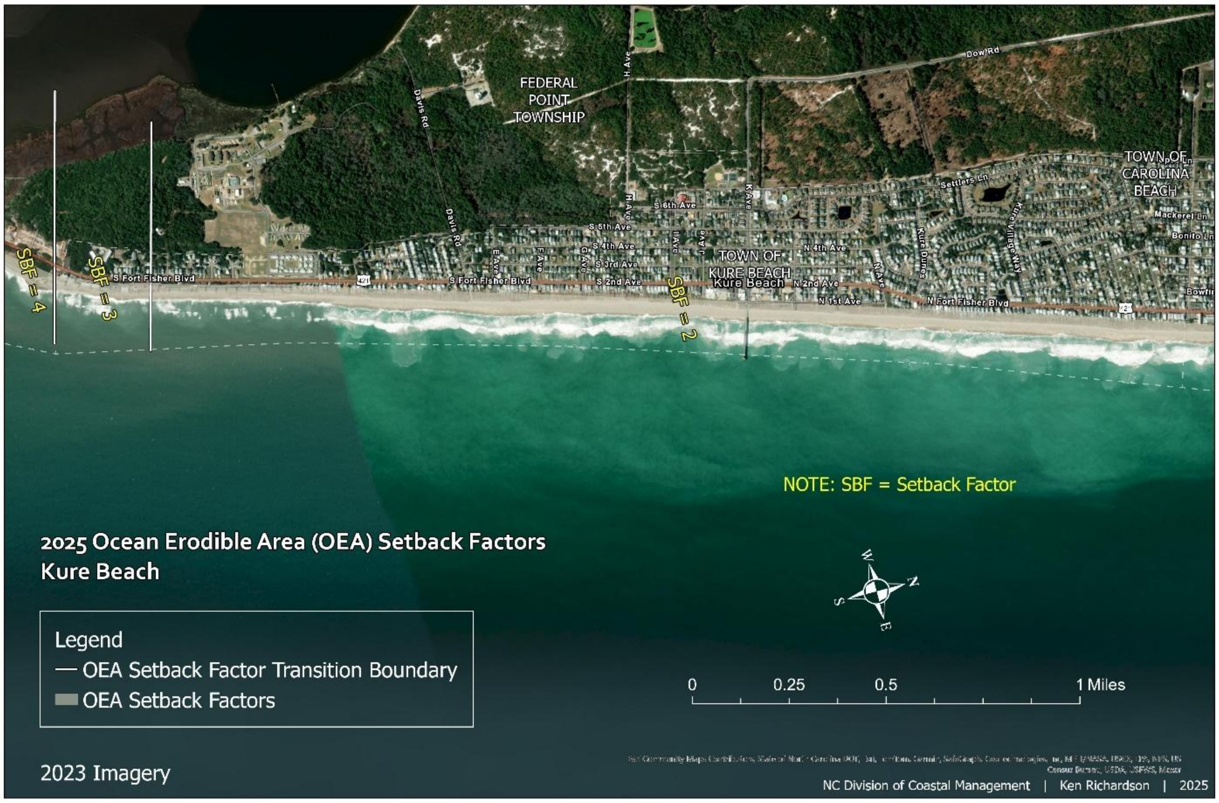

Figure 62. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Kure Beach.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2, 3	2, 3, 4	2, 3.5	2, 3.5	2, 4.5	2, 3.5, 5.5	2, 3, 3.5, 4, 5.5	2

Table 12. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.10 Carolina Beach

Carolina Beach is an east-facing shoreline spanning approximately four miles along the oceanfront. In 1952, the Carolina Beach Inlet was opened to support private interests. Following the inlet's opening, chronic erosion impacted both Carolina Beach and Masonboro Island. To mitigate this, the USACE constructed an initial 1,100-foot rock revetment in 1970, followed by an additional 950-foot section in 1973, extending the total structure to 2,050 feet. Between 1955 and 1998, relatively small-scale beach fill projects occurred that were primarily linked to navigational channel maintenance. However, in 2001, the U.S. Army Corps of Engineers (USACE) completed the Town’s first large-scale project under the Coastal Storm Damage Reduction (CSDR) program, now known as Coastal Storm Risk Management (CSRM). Subsequent large-scale projects followed in 2006-2007, 2009-2010, 2014, 2018, and 2022.

The analysis assessed fifteen shorelines (**Figure 63**) along this oceanfront section over an 87-year period, from 1933 to 2020. Since 2001, shoreline positions have been routinely influenced by beach nourishment for portions of Carolina Beach. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 179 feet (oceanfront) to a maximum of 1,516 feet (inlet), with an average of 443 feet for the entire shoreline between Town’s southern limit near transect 1492. Focusing specifically on the OEA, between transects 1492 and 1592, the shoreline envelope varied from 179 to 335 feet, averaging 263 feet. This contrast highlights the differing influences of oceanfront and inlet dynamics on shoreline position. For these respective areas, the calculated average relative standard deviation of shoreline position was 106 feet overall and 66 feet for the oceanfront section alone. Of the 4.0 miles of shoreline analyzed, approximately 1.7 miles (43%) resulted in measured erosion where rates averaged less than -2 feet per year approaching Carolina Beach Inlet.

For comparison, within the Ocean Erodible Area, between transects 1492 and 1583, both the end-point and least squares regression methods produced similar results (**Figure 64**). The end-point method indicated an average shoreline change of less than +2 feet per year, and the least squares regression method yielded a similar rate of less than +2 feet per year also. Both approaches measure erosion rates less than 2 feet per year within the OEA, leading to a blocked erosion rate setback factor of two (2), which is consistent with previous studies for most of the same section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement. For most of the shoreline (between transects 1492 and 1583), and outside of the 2025 updated IHA boundary proposed, the updated setback factors continue to be 2 feet per year making it consistent with earlier studies (2020, 2013, 2004, 1997, and 1986). Using this method, the calculated setback factors for Carolina Beach's OEA, between transects 1492 and 1583, remain at two feet per year (**Figure 65** to **Figure 68** & **Table 13**). For setbacks within the proposed updated IHA boundary, refer to the report titled "*NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*"

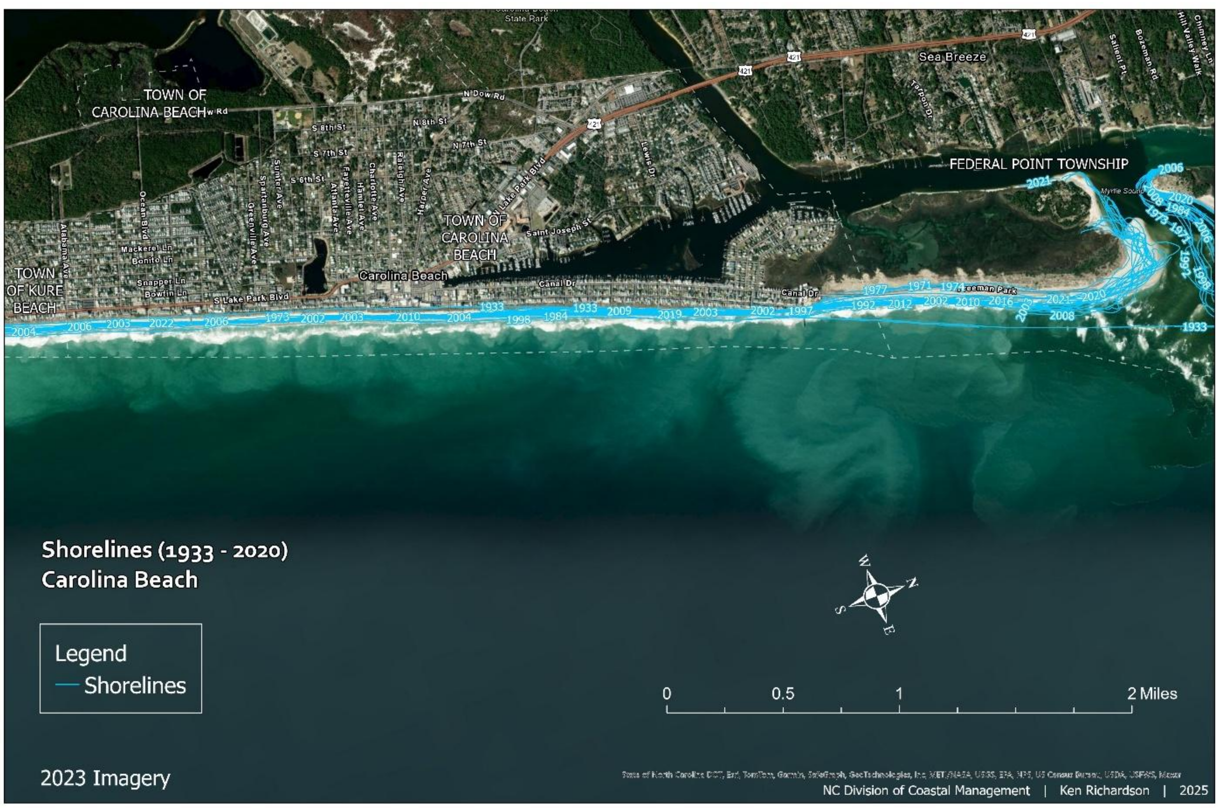

Figure 63. *Shorelines included in the analysis (1933-2020) at Carolina Beach.*

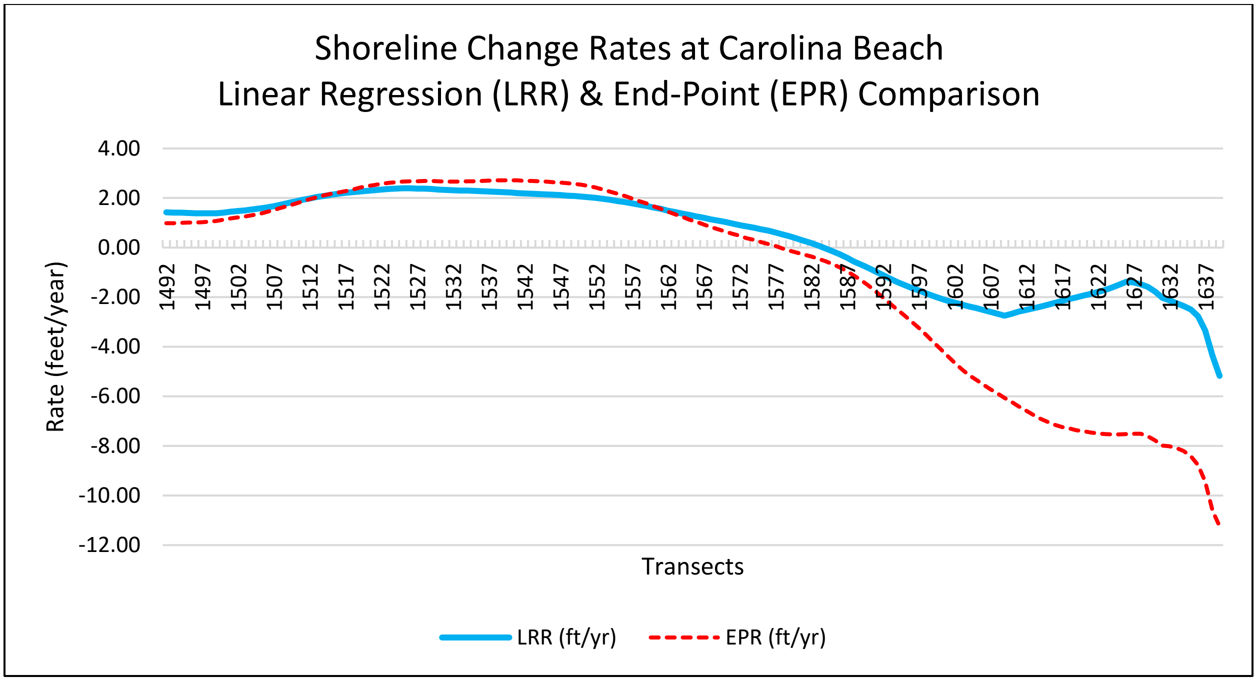

Figure 64. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 65. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

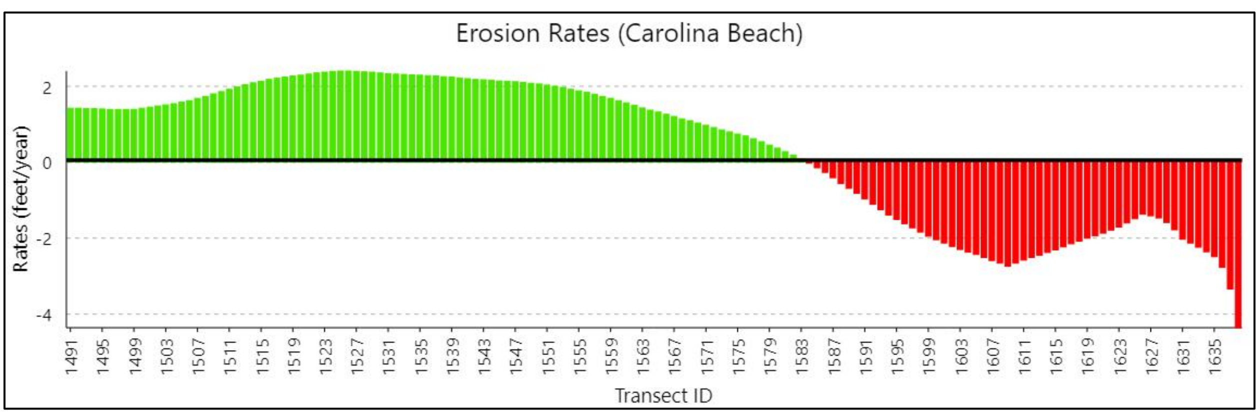

Figure 66. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

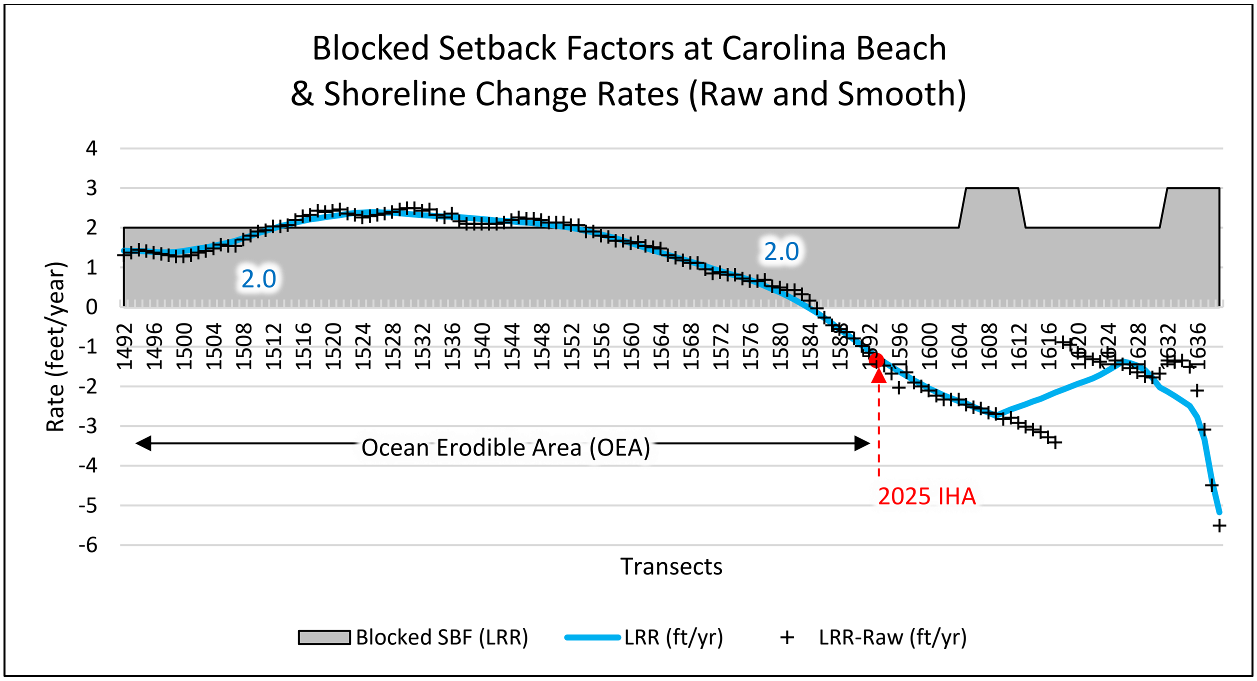

Figure 67. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

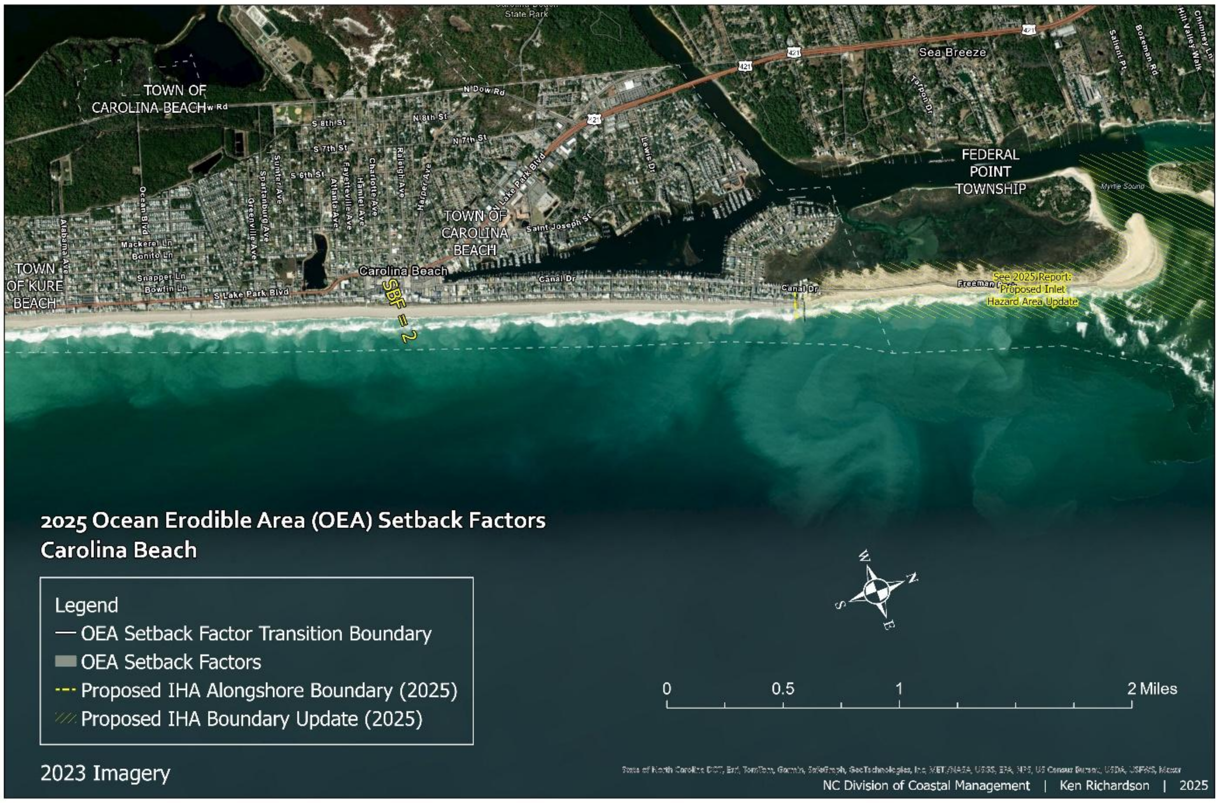

Figure 68. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Carolina Beach. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2, 5	2

Table 13. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.11 Masonboro Island

Erosion setback factors for Masonboro Island are not included in this report, as they can be obtained from the *NC Inlet Hazard Area (IHA) Erosion Rate and Setback Factors: 2025 Update* report. However, shoreline change rates are provided here for reference only.

Masonboro Island is an undeveloped barrier island and part of NC's Coastal Reserve system making it public land. Its oceanfront shoreline is east facing and extends 8 miles with Carolina Beach inlet on its southern end, and Masonboro inlet on its northern flank. While the island doesn't receive beach fill, the fillet area adjacent to the rock navigation jetty that was installed in 1980 at Masonboro Inlet, is regularly maintained; thus, artificially influencing shoreline change next to the jetty. It is estimated that the fillet has stabilized at least 3000 feet of Masonboro Island shoreline immediately south of the jetty.

The analysis assessed twenty-one shorelines (**Figure 69**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 331 feet to a maximum of 2,958 feet, with an average of 707 feet for the entire shoreline between Carolina Beach Inlet and Masonboro Inlet. The calculated standard deviation of relative shoreline change ranged between 101 and 918 feet, with an average of 219 feet. Of the 8.0 miles of shoreline analyzed, approximately 7.5 miles (94%) resulted in measured erosion where rates averaged -7.2 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results. The end-point method resulted in shoreline change rates that ranged between -25.3 and +16.5 feet per year, with an average of -6.4 feet per year, and the least squares regression method yielded similar rates that ranged between -24 and +15.7 feet per year, with an average of -6.5 feet per year (**Figure 70** to **Figure 72**).

Figure 69. *Shorelines included in the analysis (1933-2020) at Masonboro Island.*

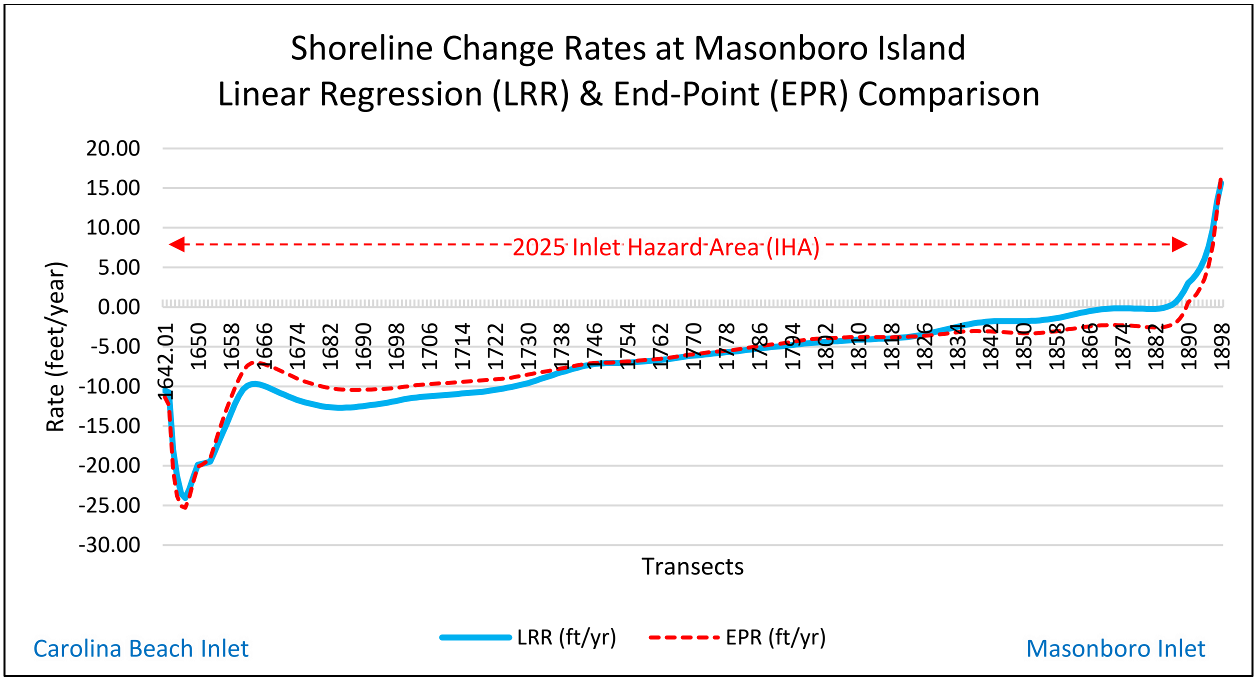

Figure 70. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

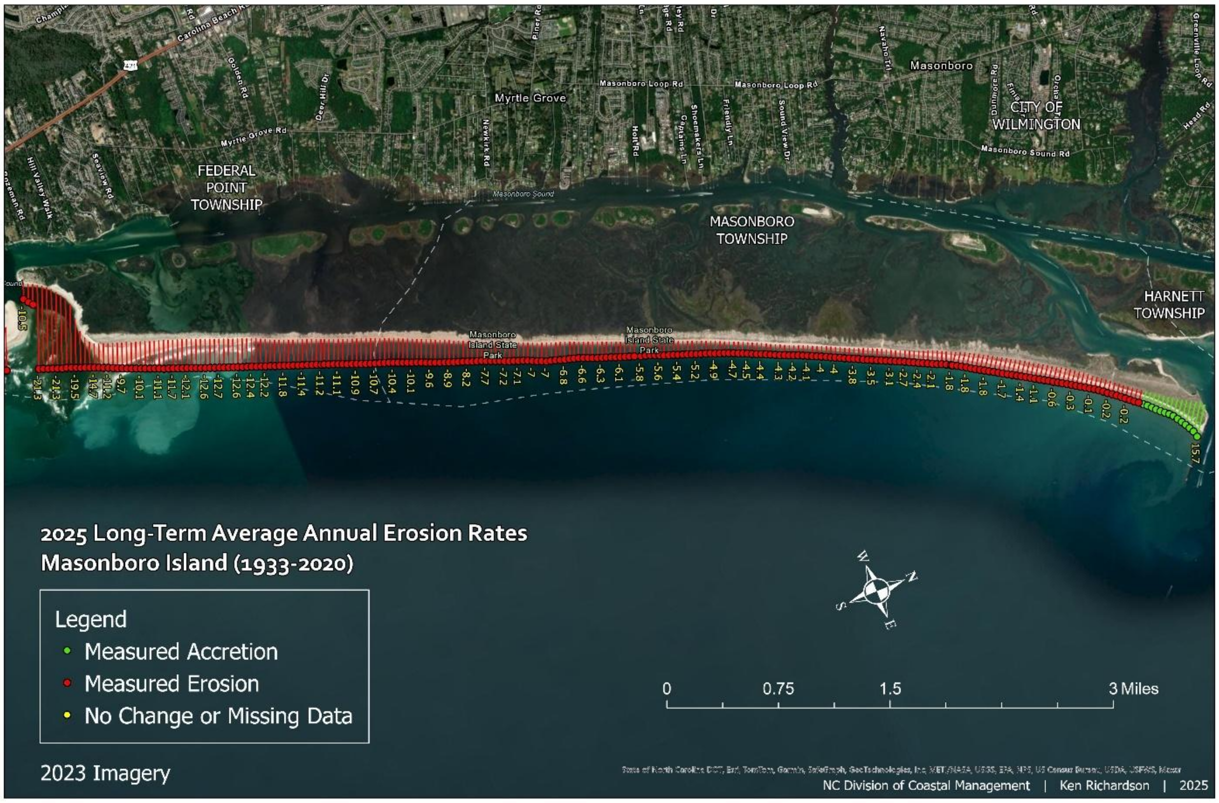

Figure 71. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

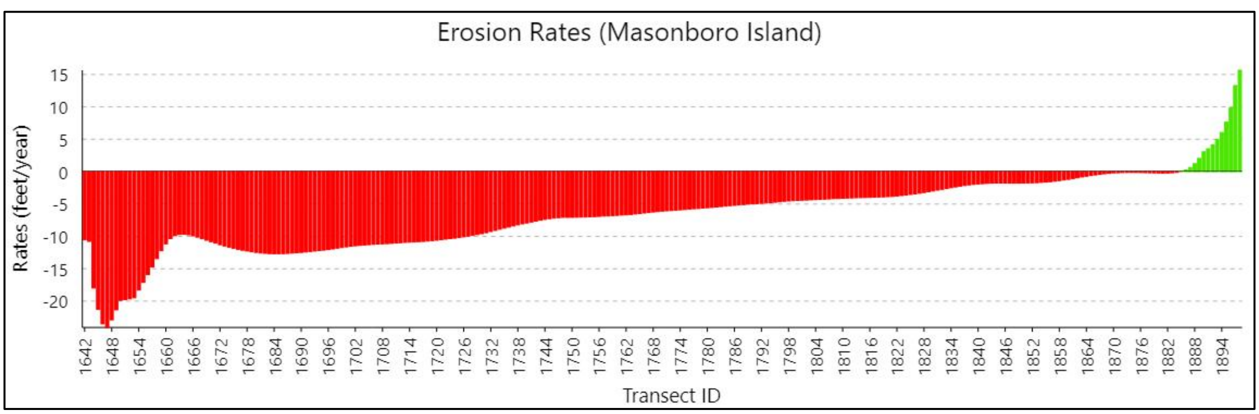

Figure 72. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

3.12 Wrightsville Beach

Wrightsville Beach spans approximately 4.5 miles of east-facing oceanfront shoreline, bordered by Masonboro Inlet to the south and Mason Inlet to the north. Masonboro Inlet is reinforced with two rock navigational jetties, one on each side (north jetty installed in 1965 and southern jetty installed in 1980), which provide stability for the inlet and aiding in navigation; and Mason Inlet was relocated approximately 3,000 feet to the north in 2001-2002 with its new position regularly maintained. The shoreline at Wrightsville Beach is regularly maintained through a U.S. Army Corps of Engineers (USACE) Storm Damage Reduction project.

Small-scale maintenance efforts associated with navigational channel upkeep began as early as 1939. However, larger-scale beach nourishment projects were not implemented until 1965-1966, following Congressional authorization in 1962. This coincided with the completion of the north jetty in 1966, which played a key role in stabilizing the shoreline. Despite these early efforts, North Carolina recognizes the first large-scale beach nourishment project at Wrightsville Beach as occurring in 1980-1981. Since then, regular maintenance and renourishment projects have taken place in 1986, 1991, 1994, 1998, 2002, 2006, 2010, 2014, 2018, and 2024, which have all artificially influenced shoreline position and lowering the effects of natural erosion.

This analysis assessed twenty-three shorelines (**Figure 73**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 223 feet (oceanfront) to a maximum of 1,836 feet (inlet), with an average of 475 feet for the entire shoreline between Masonboro and Mason Inlets. However, within the Ocean Erodible Area between transects 1906 and 2019 (excluding areas inside the 2025 updated IHA proposed boundaries), the shoreline envelope varied from 223 to 676 feet, averaging 365 feet. For the same respective areas, the calculated average relative standard deviation of shoreline position was 121 feet overall and 92 feet for the oceanfront section alone. Of the 5.7 miles of shoreline analyzed, approximately 2.1 miles (37%) resulted in measured erosion where rates averaged -4.4 feet per year adjacent to Tubbs and Shallotte Inlets.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 74**).

The end-point method resulted in a range of shoreline line change rates between +1.0 and +4.1 feet per year, averaging +2.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between +1.5 and +4.5 feet per year, averaging +2.9 feet per year. Both approaches result in a blocked erosion rate setback factors of two (2), which are consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement; however, it does not impact on the updated setback factors compared to previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 1906 and 2019, and outside of the 2025 updated Inlet Hazard Areas proposed boundaries (**Figure 75** to **Figure 78** & **Table 14**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

Figure 73. *Shorelines included in the analysis (1933-2020) at Wrightsville Beach.*

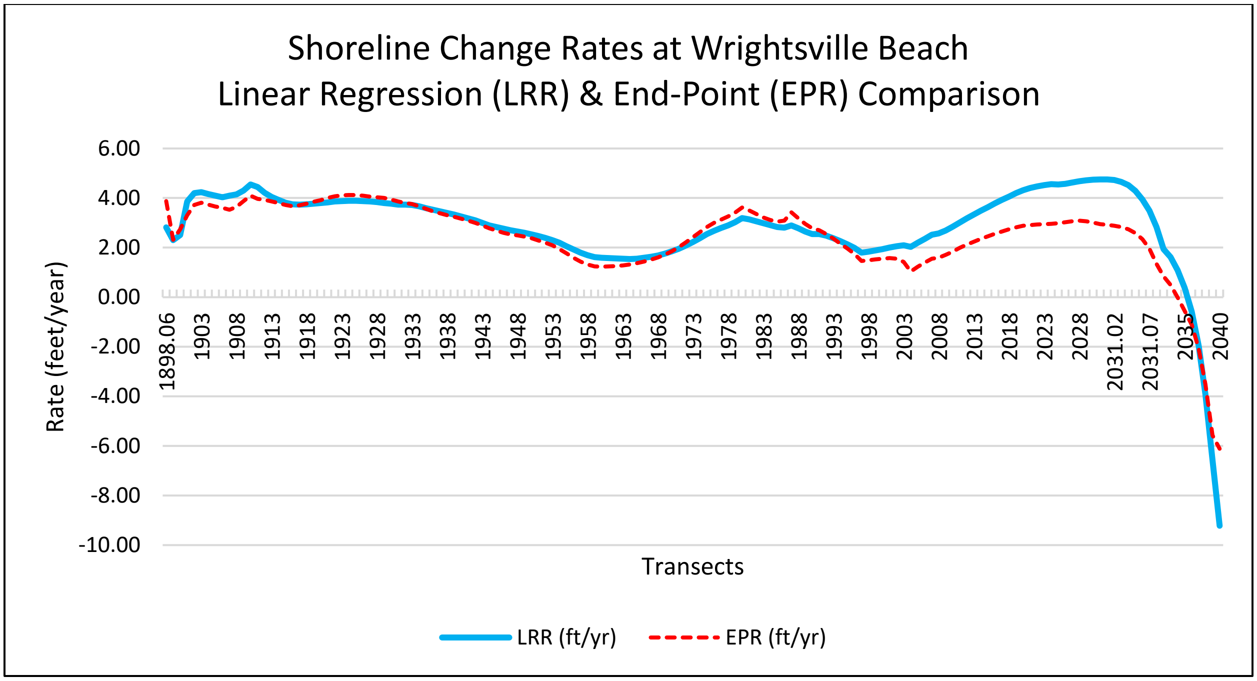

Figure 74. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

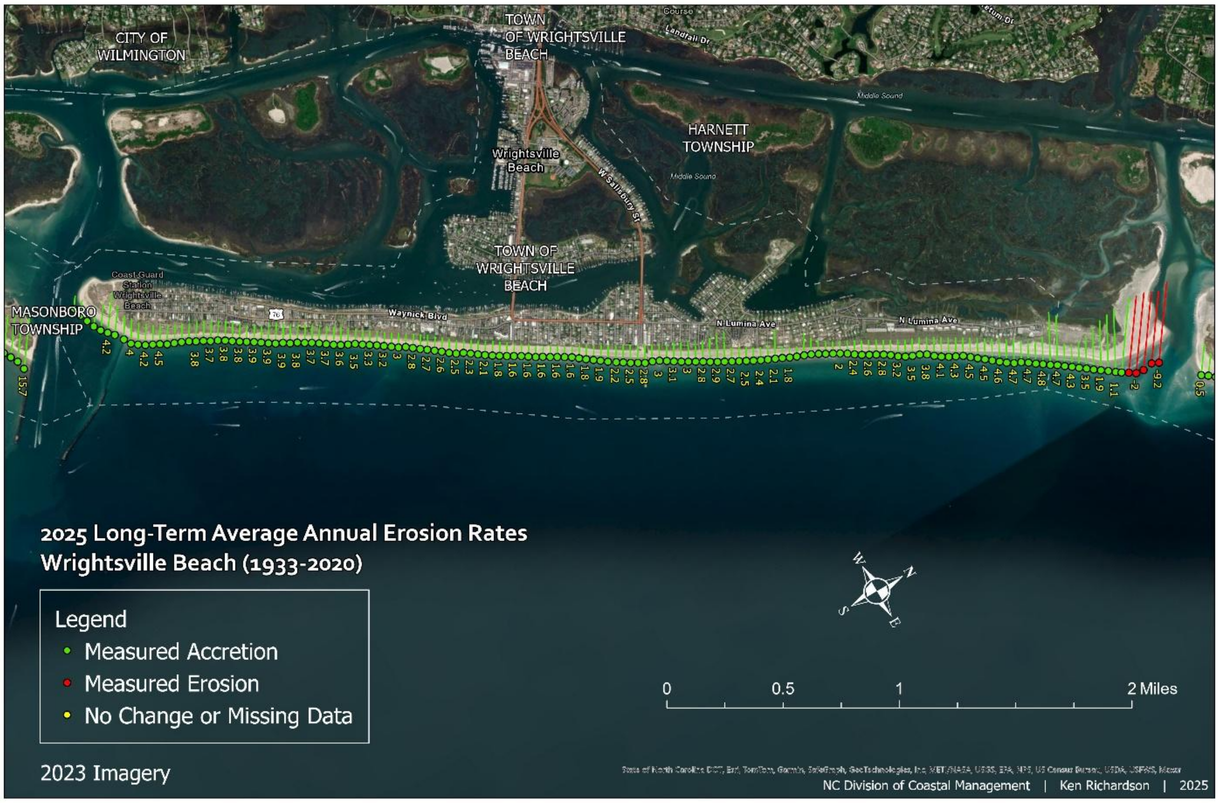

Figure 75. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

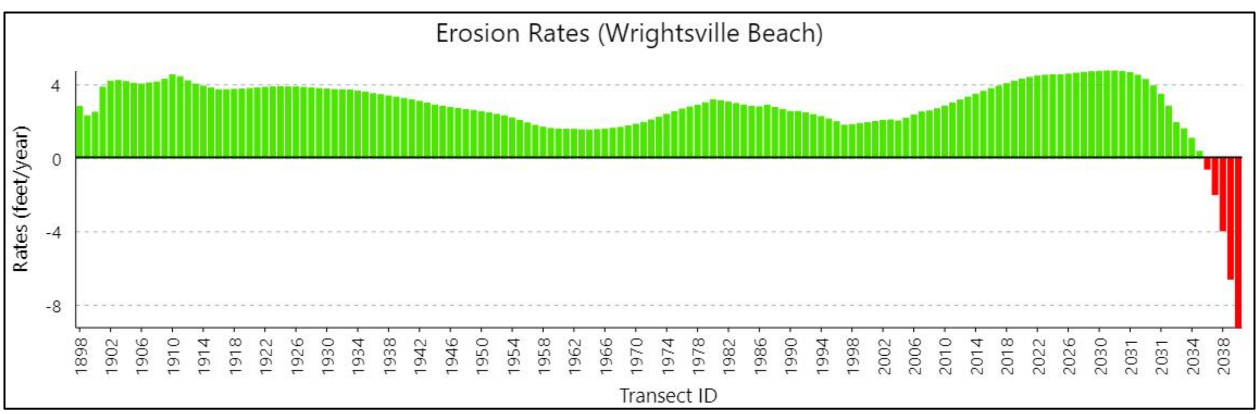

Figure 76. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

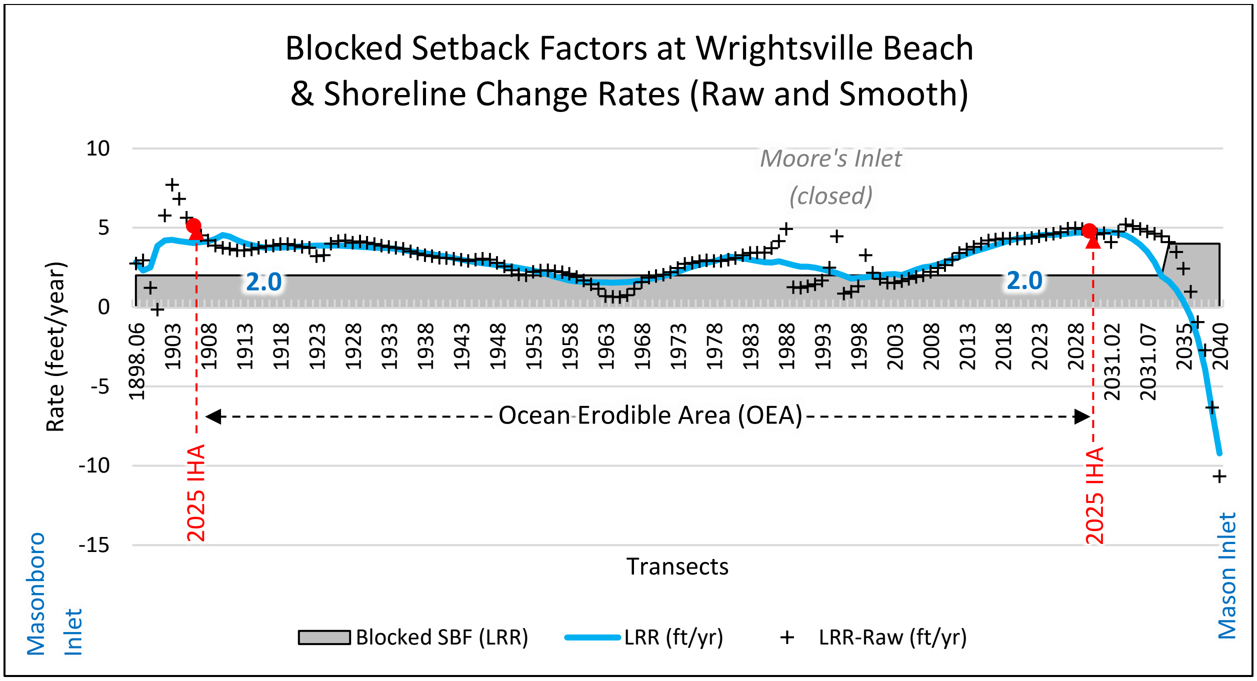

Figure 77. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

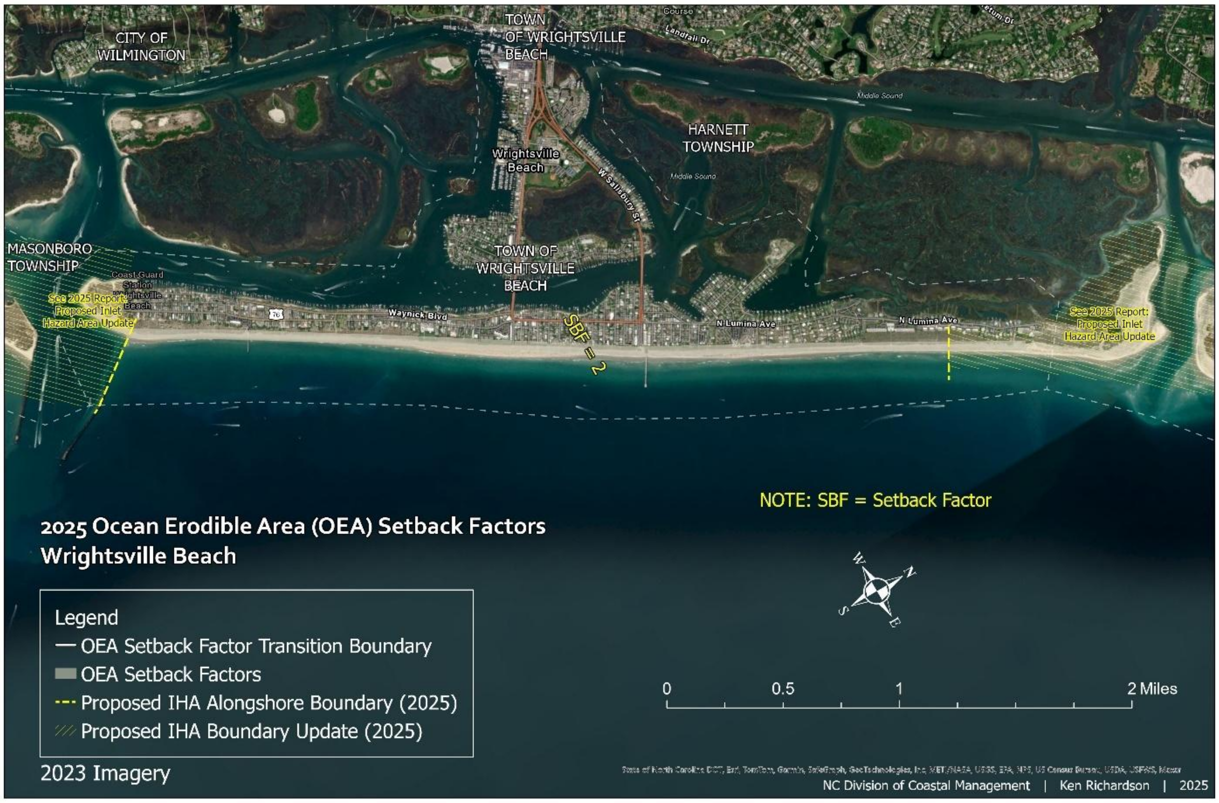

Figure 78. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Wrightsville Beach. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2	2

Table 14. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.13 Figure Eight Island

Figure Eight Island has approximately 3.6 miles of oceanfront shoreline, is east facing, and flanked by two inlets (Mason and Rich), and has been the recipient of small-scale beach nourishment projects that started in 1977 followed by others in 1983, 1985, 1986, 1987, 1990, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2005, 2006, 2009, 2011, 2013, 2016, 2019, and 2020. Collectively, while each did not span the full length of shoreline, they have contributed to artificial influences on shoreline position over time, thus reducing erosion rates.

This analysis assessed twenty-four shorelines (**Figure 79**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 176 feet (oceanfront) to a maximum of 1,655 feet (inlet), with an average of 379 feet for the entire shoreline between Mason and Rich Inlets. However, within the Ocean Erodible Area between transects 2064 and 2160 (excluding areas inside the 2025 updated IHA proposed boundaries), the shoreline envelope varied from 176 to 566 feet, averaging 256 feet. For the same respective areas, the calculated average relative standard deviation of shoreline position was 121 feet overall and 63 feet for the OEA alone. Of the 3.6 miles of shoreline analyzed, approximately 0.9 miles (25%) resulted in measured erosion where rates averaged less than one (-1) foot per year between transects-2067 and -2095.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 80**). The end-point method resulted in a range of shoreline line change rates between less than 1 foot and +3.6 feet per year, averaging +1.3 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between less than 1 foot and +3.1 feet per year, averaging less than 1 foot per year. Both approaches result in a blocked erosion rate setback factors of two (2), which are consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement; however, it does not impact on the updated setback factors compared to previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 2064 and 2160, and outside of the 2025 updated Inlet Hazard Areas proposed boundaries (**Figure 80** to **Figure 84** & **Table 15**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

Figure 79. *Shorelines included in the analysis (1933-2020) at Figure Eight Island.*

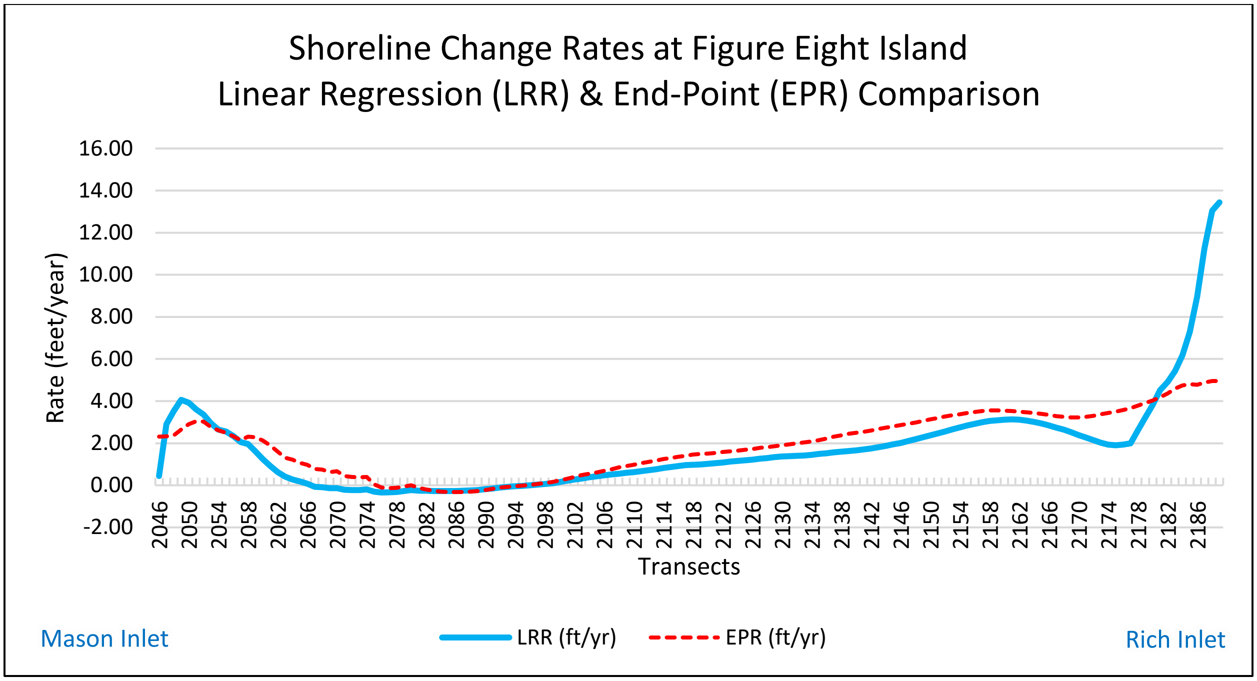

Figure 80. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

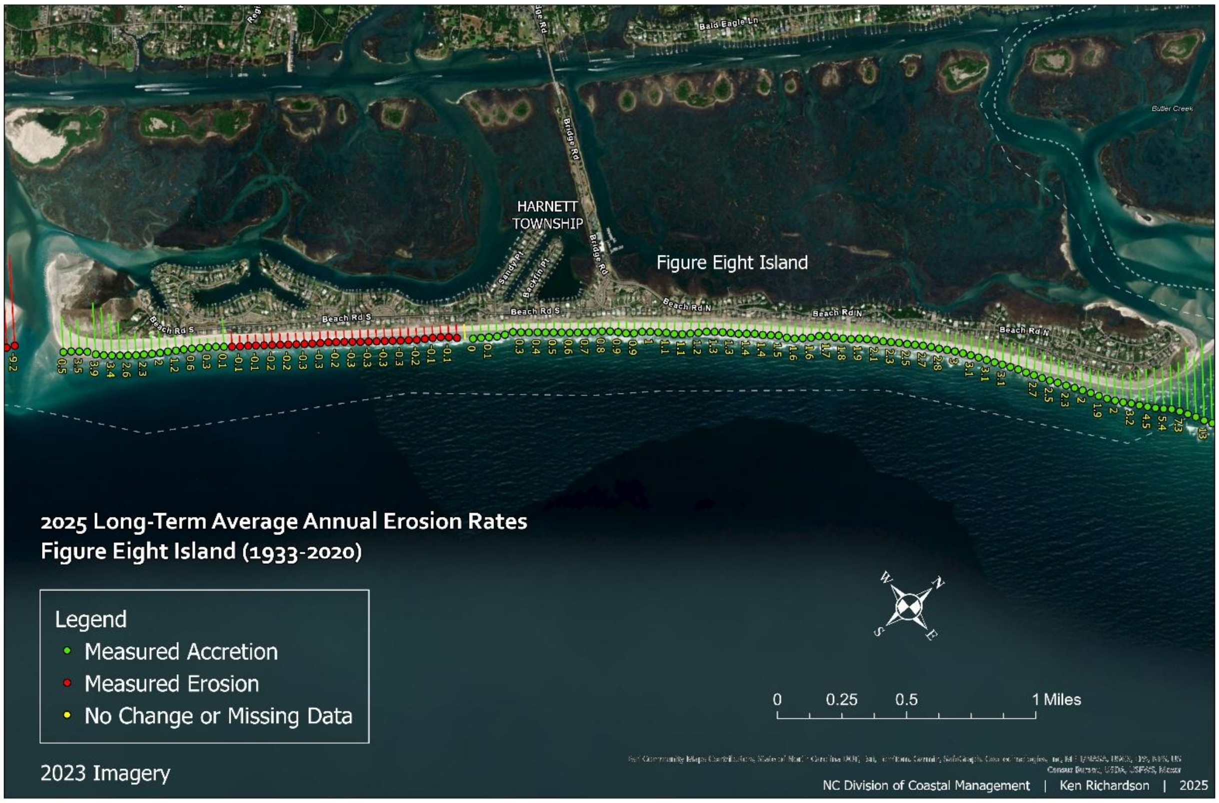

Figure 81. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

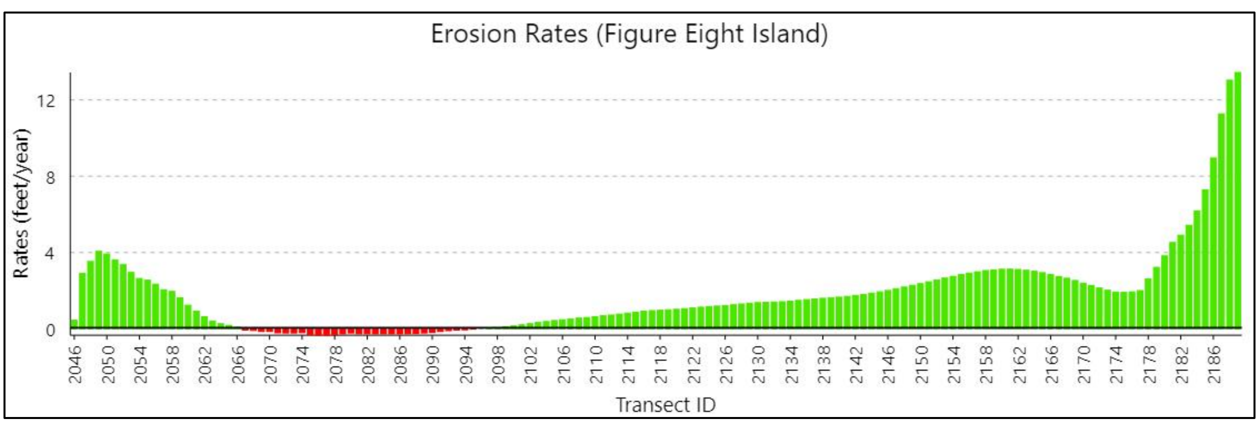

Figure 82. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

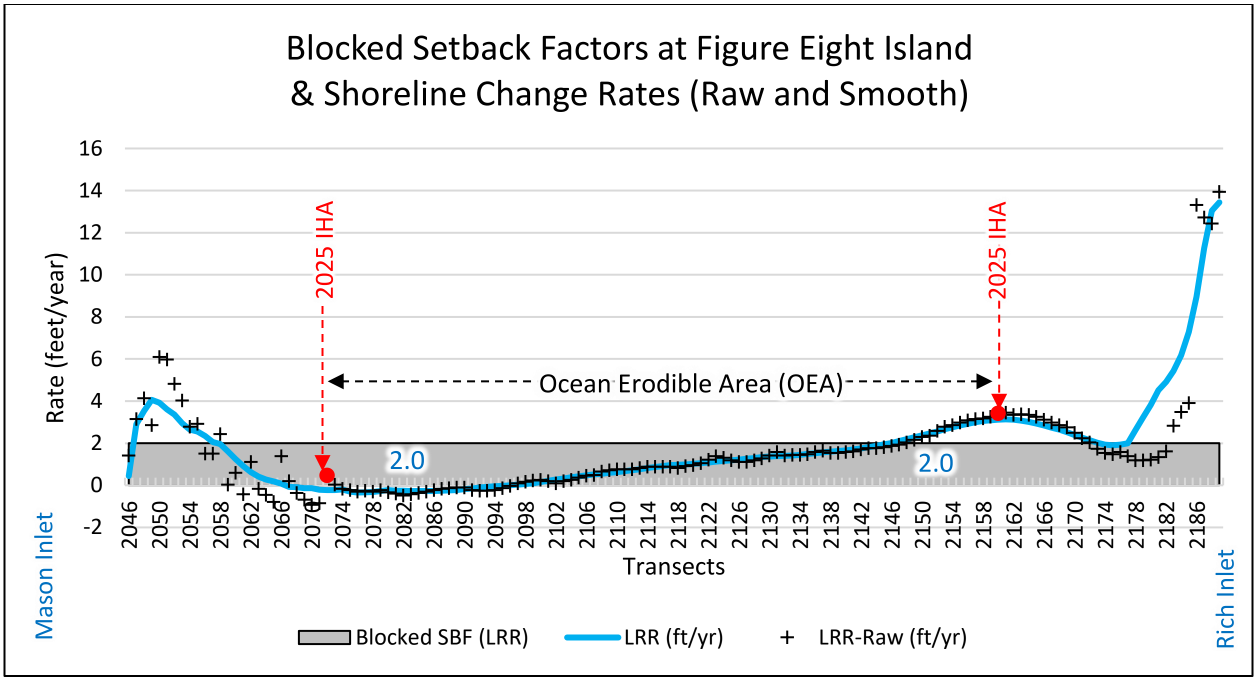

Figure 83. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 84. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Figure Eight Island. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2, 5	2.3

Table 15. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.14 Lea-Hutaff Island

Erosion setback factors for Lea-Hutaff Island are not included in this report, as can be obtained from the *NC Inlet Hazard Area (IHA) Erosion Rate and Setback Factors: 2025 Update* report. However, shoreline change rates are provided here for reference only.

Following the closure of Old Topsail Inlet in 1997, Lea and Hutaff Islands merged, forming Lea-Hutaff Island. Its east-facing oceanfront shoreline now extends approximately 3.6 miles, bordered by Rich Inlet to the south and New Topsail Inlet to the north. While portions of the island are privately owned, it is still undeveloped.

The analysis assessed twenty-seven shorelines (**Figure 85**) along this oceanfront section over an 86-year period, from 1934 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 503 feet to a maximum of 1,399 feet, with an average of 762 feet for the entire shoreline between Rich Inlet and New Topsail Inlet. The calculated standard deviation of relative shoreline change ranged between 139 and 387 feet, with an average of 210 feet. Of the 3.6 miles of shoreline analyzed, all 3.6 miles (100%) resulted in measured erosion where rates ranged from -11 to -3.7 feet per year and averaged -7.5 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results. The end-point method resulted in shoreline change rates that ranged between -10 and -2.7 feet per year, with an average of -6.4 feet per year, and the least squares regression method yielded similar rates that ranged between -11 and -3.7 feet per year, with an average of -7.5 feet per year (**Figure 86** to **Figure 88**).

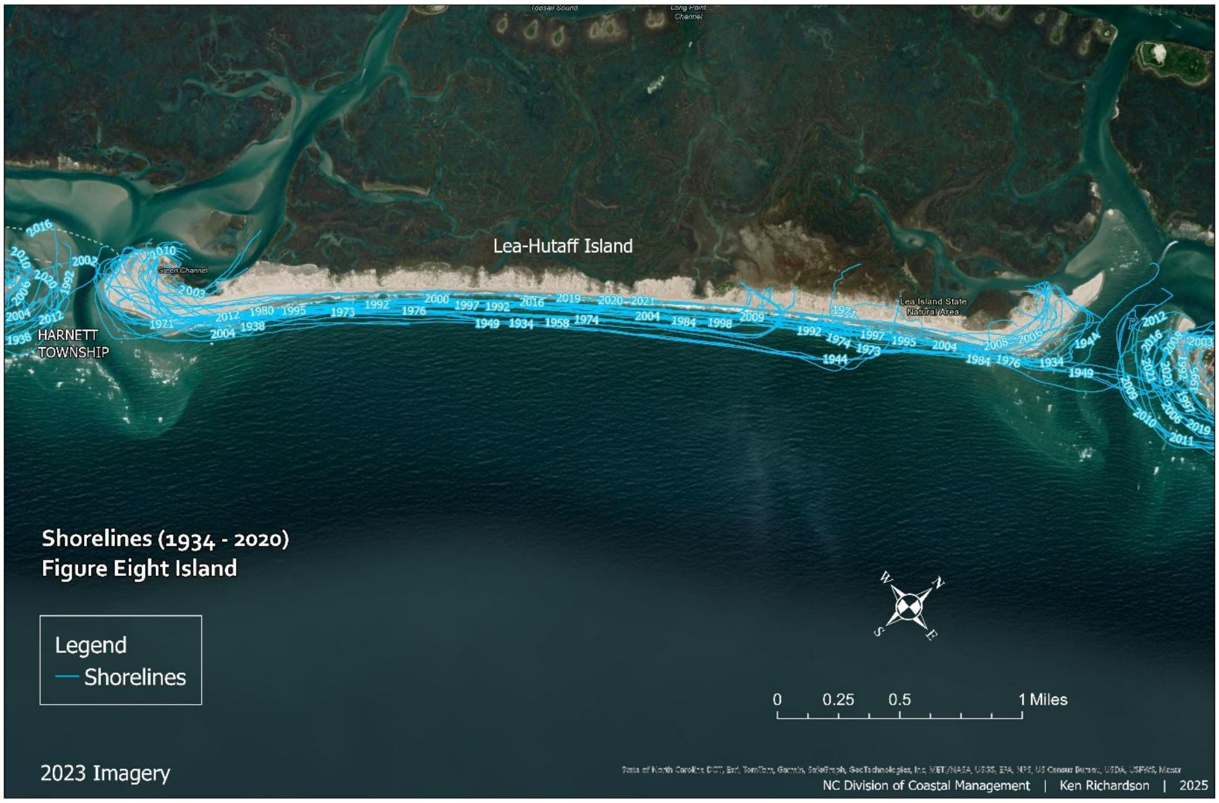

Figure 85. *Shorelines included in the analysis (1933-2020) at Lea-Hutaff Island.*

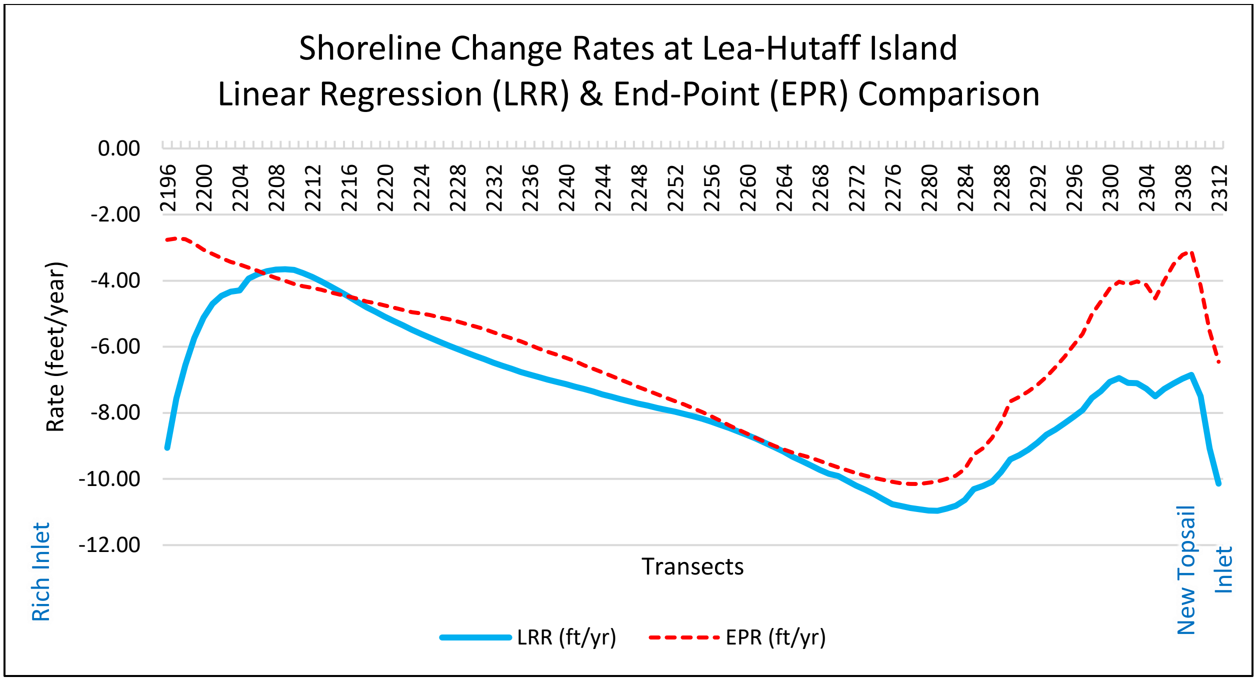

Figure 86. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

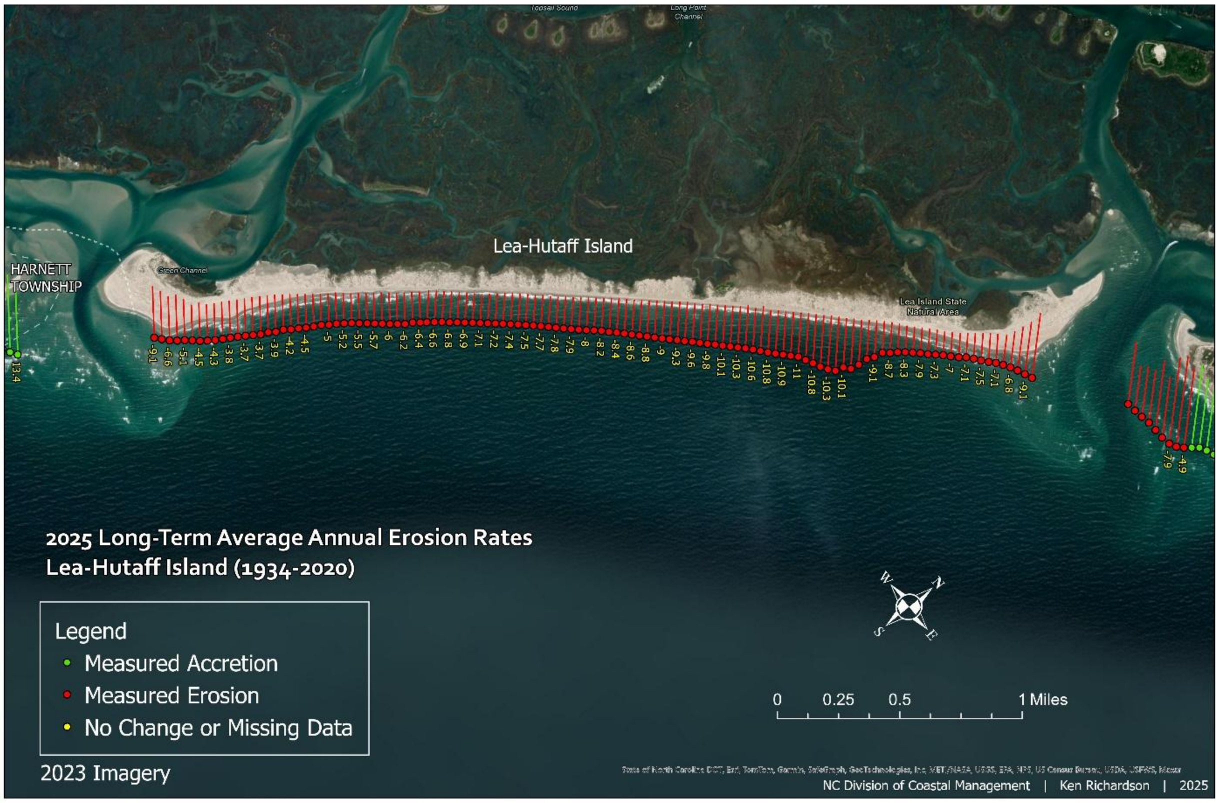

Figure 87. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

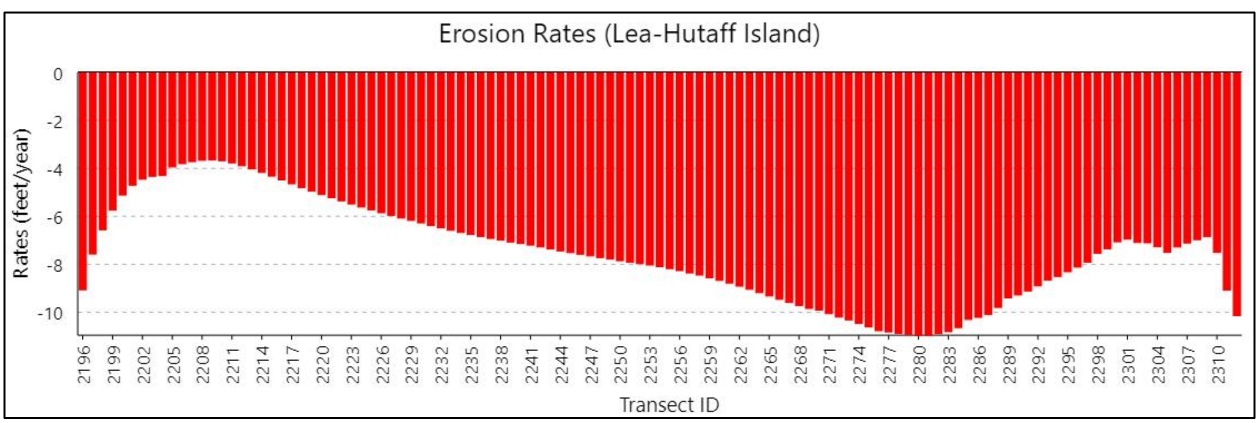

Figure 88. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled "*NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*"

3.15 Topsail Beach

Topsail Island has approximately 22 miles of oceanfront shoreline and is an east-facing barrier island flanked by two inlets (New Topsail and New River). Topsail Beach makes up 28.1 percent (4.8 miles) of its shoreline, Surf City 27.3 percent (6.0 miles), and North Topsail Beach 50.1 percent (11.1 miles).

Topsail Beach has been the recipient of small-scale beach fill projects that started in 1982; however, it wasn't until 2011 when a large-scale project was installed that span most of the Town's ocean shoreline. Since, the project area has received maintenance that occurred in 2015 and 2019. Collectively, these projects have artificially influenced shoreline position over time.

This analysis assessed twenty-five shorelines (**Figure 89**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 189 feet (oceanfront) to a maximum of 1,946 feet (inlet), with an average of 475 feet for the entire shoreline between New Topsail Inlet and the Town's northern limit near transect 2478. However, within the Ocean Erodible Area between transects 2342 and 2478 (excluding areas inside the 2025 updated IHA proposed boundary), the shoreline envelope varied from 189 to 1,472 feet, averaging 299 feet. For the same respective areas, the calculated average relative standard deviation of shoreline position was 123 feet overall and 67 feet for the OEA alone. Of the 4.8 miles of shoreline analyzed, approximately 1 mile (48%) resulted in measured erosion where rates averaged less than one (-1) foot per year between transects-2355 and -2386.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 90**). The end-point method resulted in a range of shoreline line change rates between +1.2 and +8.3 feet per year, averaging +2.8 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -1.1 and +6.2 feet per year, averaging less than 1 foot per year. Both approaches result in a blocked erosion rate setback factors of two (2), which are consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement; however, it does not impact on the updated setback factors compared to previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 2342 and 2478, and outside of the 2025 updated Inlet Hazard Areas proposed boundaries (**Figure 91** to **Figure 94** & **Table 16**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled "*NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*"

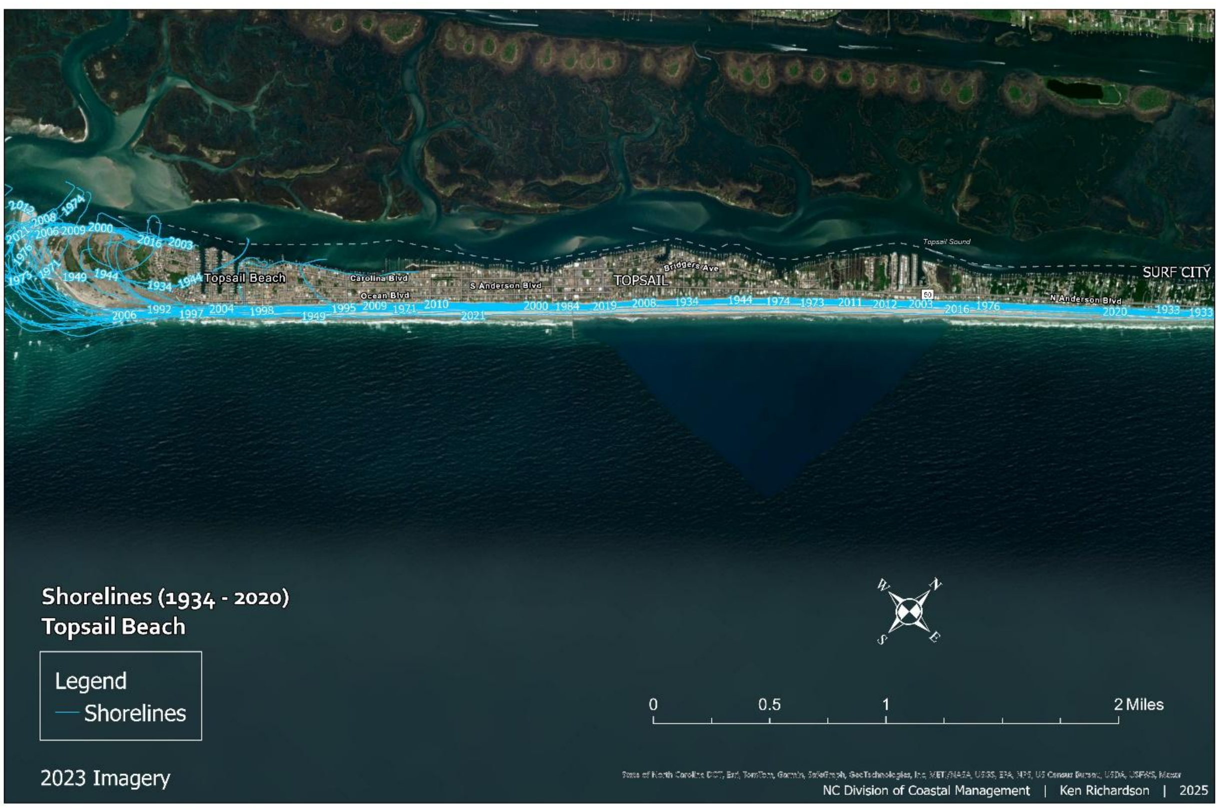

Figure 89*. Shorelines included in the analysis (1934-2020) at Topsail Beach.*

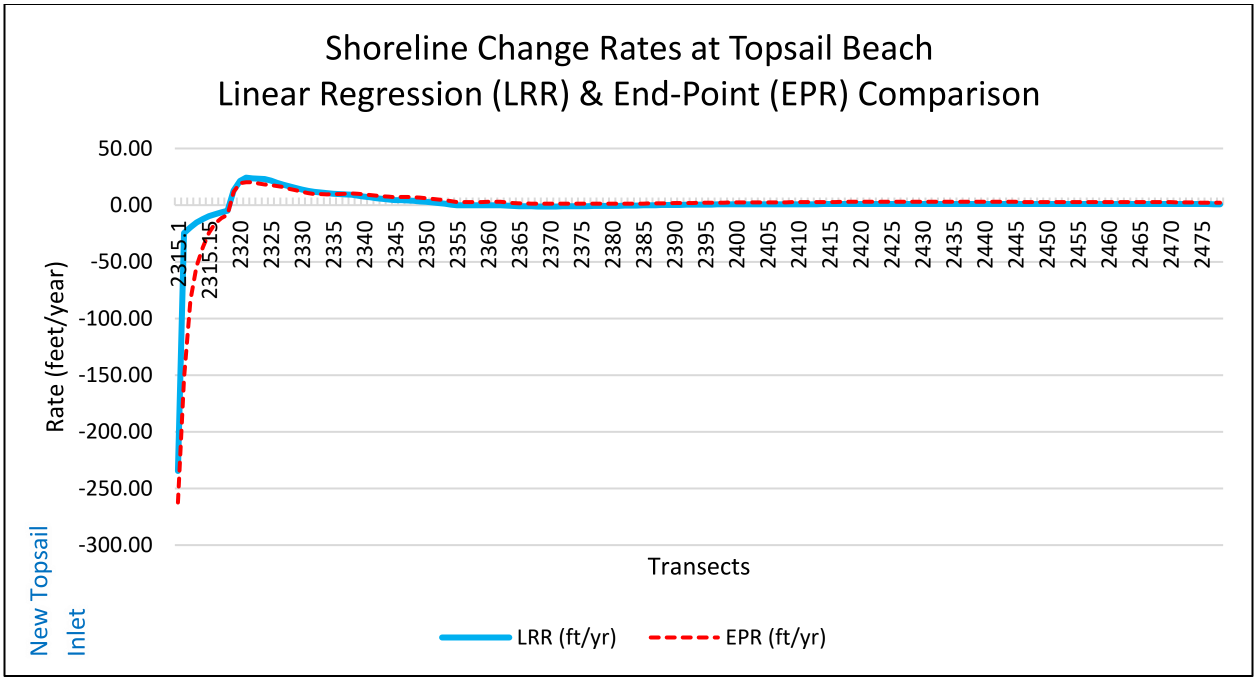

Figure 90. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

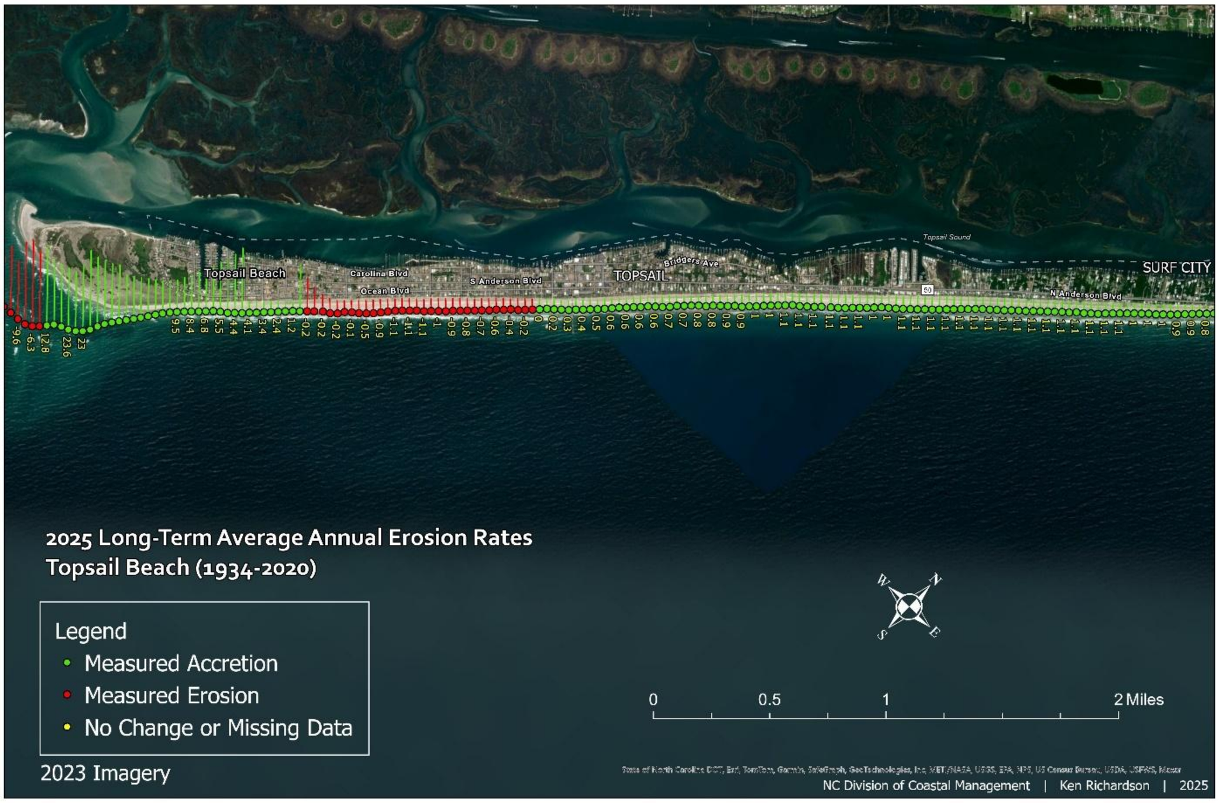

Figure 91. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

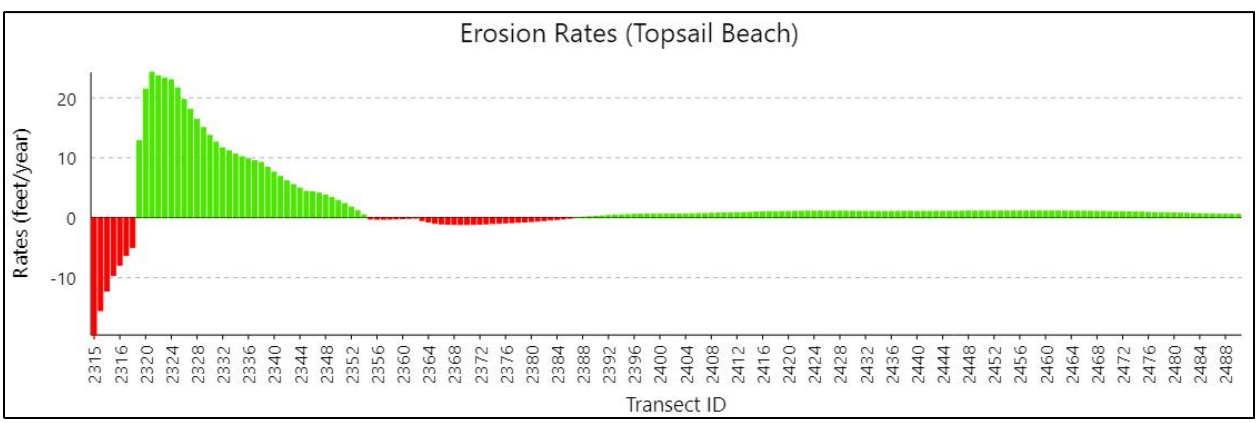

Figure 92. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

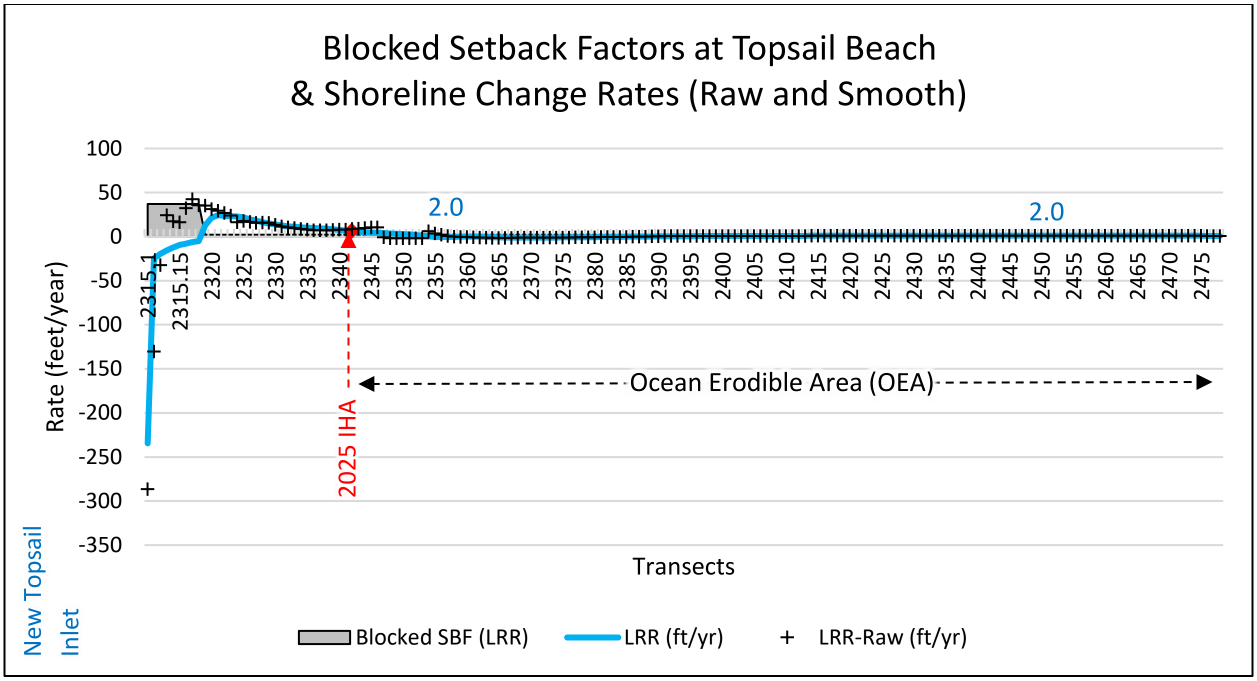

Figure 93. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 94. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Topsail Beach. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2	2

Table 16. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.16 Surf City

The ocean shoreline at Surf City spans approximately 6.0 miles. In 2020 a portion was the recipient of its first and only large-scale beach fill project.

This analysis assessed twenty-five shorelines (**Figure 95**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 63 feet to a maximum of 173 feet, with an average of 98 feet. For the same area, the calculated standard deviation of relative shoreline position ranged between 19 and 39, with an average of 26 feet. Of the 4.8 miles of shoreline analyzed, approximately 1 mile (48%) resulted in measured erosion where rates averaged less than one (-1) foot per year between transects-2355 and -2386.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 96**). The end-point method resulted in a range of shoreline line change rates between less than 1 and +2.0 feet per year, averaging less than 1 foot per year; and the least squares regression method resulted in an average of less than 1 foot per year. Both approaches result in a blocked erosion rate setback factors of two (2), which are consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement; however, it does not impact on the updated setback factors compared to previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 2479 and 2672 (**Figure 97** to **Figure 100** & **Table 17**).

Figure 95. *Shorelines included in the analysis (1933-2020) at Surf City.*

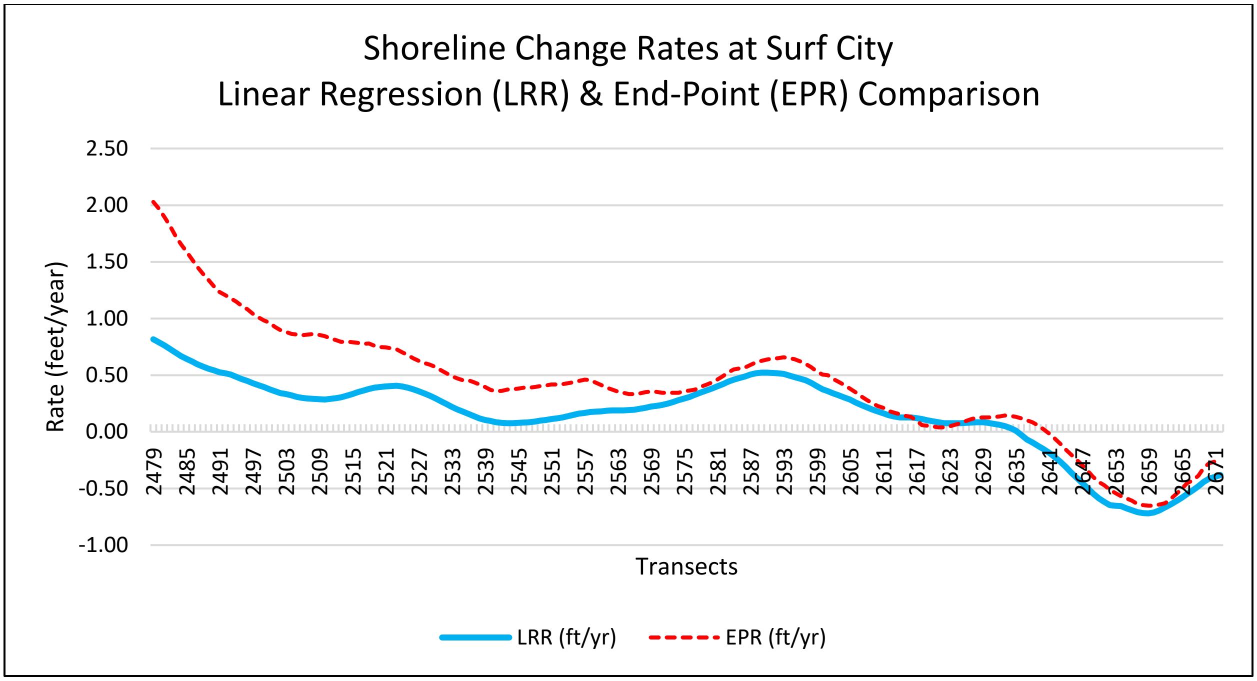

Figure 96. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

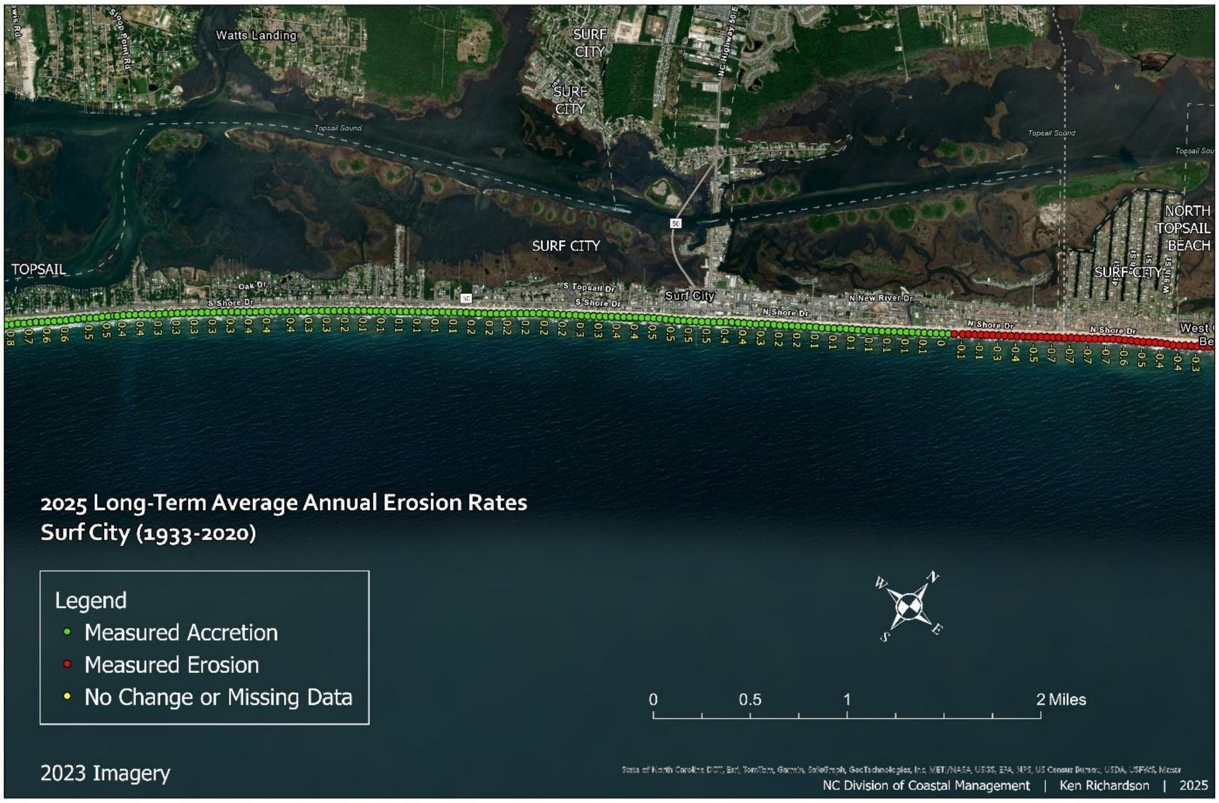

Figure 97. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

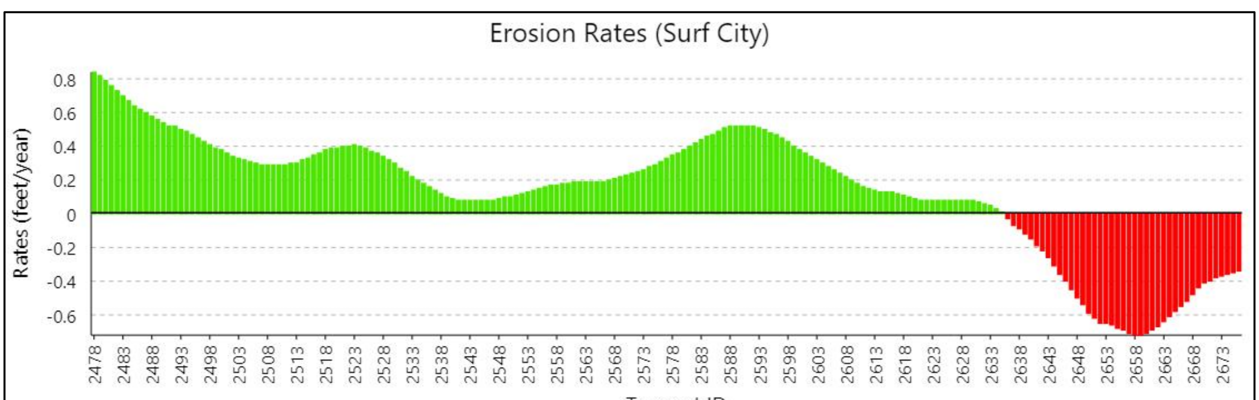

Figure 98. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

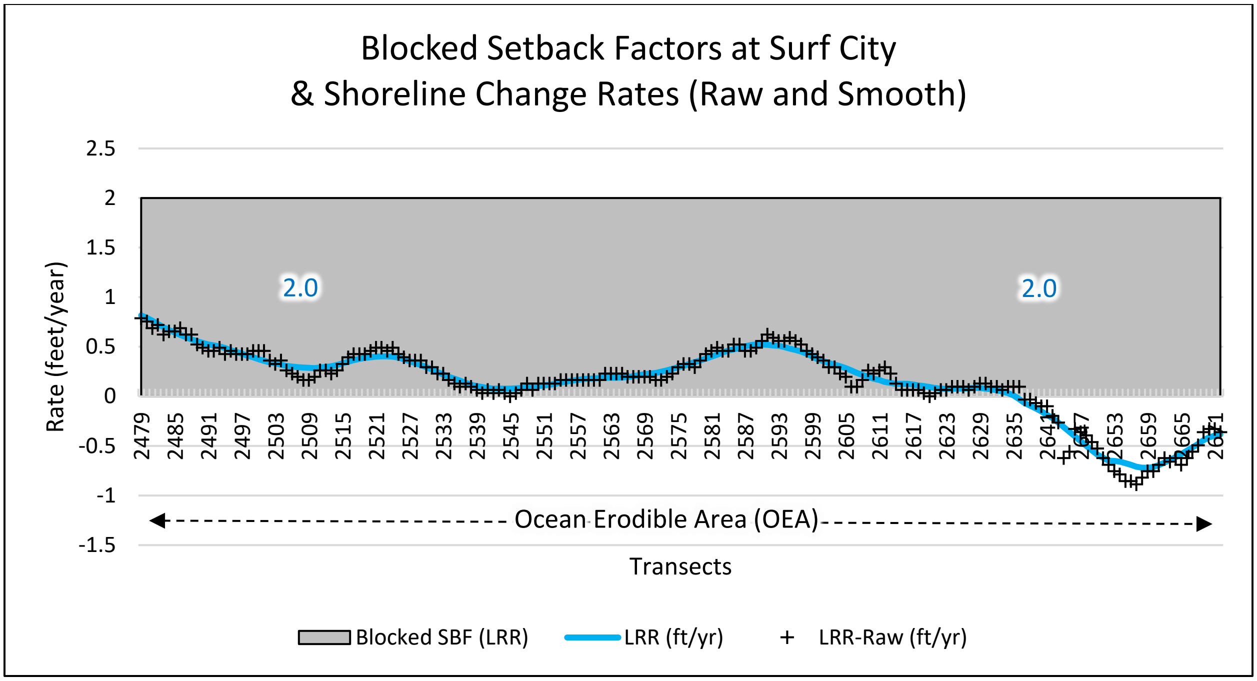

Figure 99. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

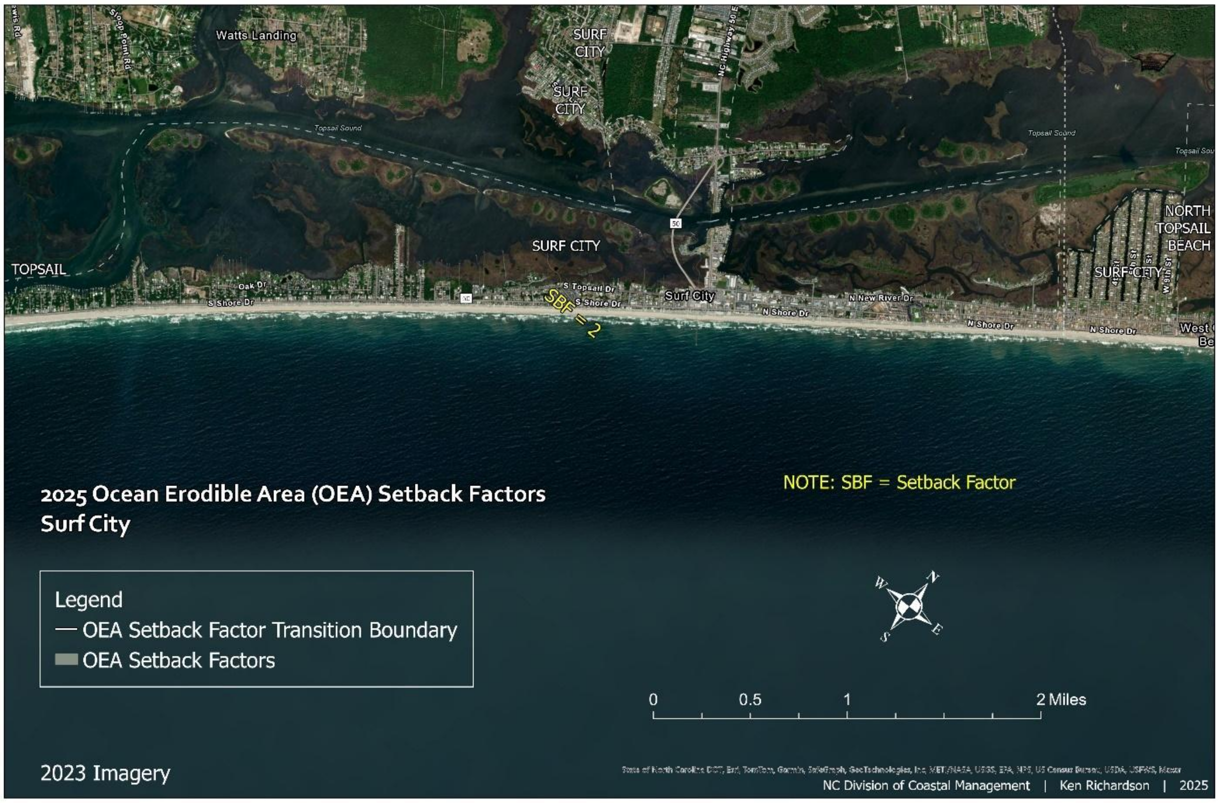

Figure 100. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Surf City. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2	2

Table 17. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.17 North Topsail Beach

The oceanfront shoreline at North Topsail Beach stretches approximately 11.1 miles. While a few localized small-scale beach fill projects were implemented on portions of the shoreline beginning in 1997, large-scale beach nourishment did not occur until 2013. This was followed by maintenance efforts in 2015 and 2016. In addition to the installation of sandbag structures near New River Inlet, these projects have artificially altered shoreline positions over time, consequently affecting shoreline change rates.

This analysis assessed twenty-three shorelines (**Figure 101**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 68 feet (oceanfront) to a maximum of 2,838 feet (inlet), with an average of 184 feet for the entire shoreline between the Town's southern limit and New River Inlet. However, within the Ocean Erodible Area between transects-2673 and -2999 (excluding areas inside the 2025 updated IHA proposed boundary), the shoreline envelope varied from 68 to 257 feet, averaging 152 feet. For the same respective areas, the calculated average relative standard deviation of shoreline position was 52 feet overall and 44 feet for the OEA alone. Of the 11.1 miles of shoreline analyzed, all (100%) resulted in measured erosion where rates averaged less than two (-2) feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 102**). The end-point method resulted in a range of shoreline line change rates between -2.0 and less than +1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -2.8 and less than -1.0 feet per year, averaging -1.1 feet per year. Both approaches resulted in a blocked erosion rate setback factors of two (2); however, least squares regression resulted in a small section where erosion setback factors equaled three (3) feet per year. This was the only difference between the two methods; however, these results remain consistent with previous studies for this section of shoreline.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement and does not influence results for this section of shoreline that make this study different compared to previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 2342 and 2940, transitions to three (3) feet per year between transects 2940 and 2967, then back to two (2) feet per year at transect 2967 and outside of the 2025 updated Inlet Hazard Areas proposed boundary. Compared to the current effective setback factors (2020), the areas between transects 2924 and 2939 will experience an increase of 1 foot per year, while the area between transects 2962 and 2967 will experience a 1 foot per year increase (**Figure 103** to **Figure 106** & **Table 18**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled, "*NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*"

Figure 101. *Shorelines included in the analysis (1933-2020) at North Topsail Beach.*

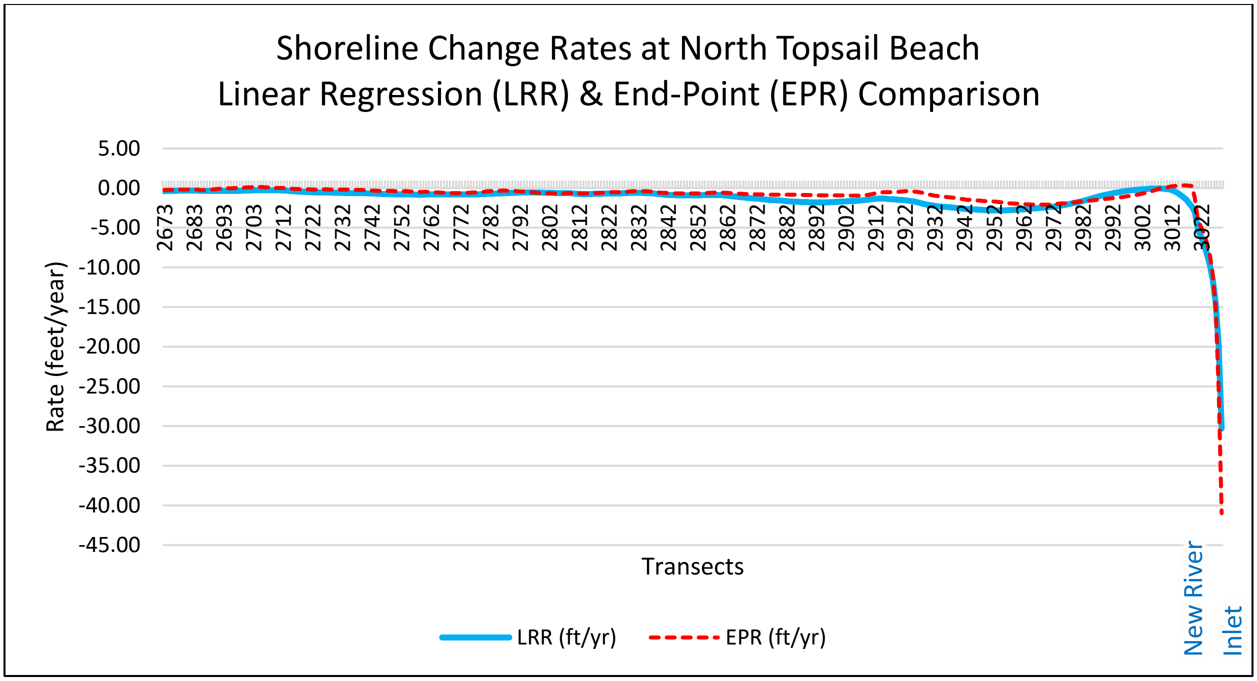

Figure 102. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

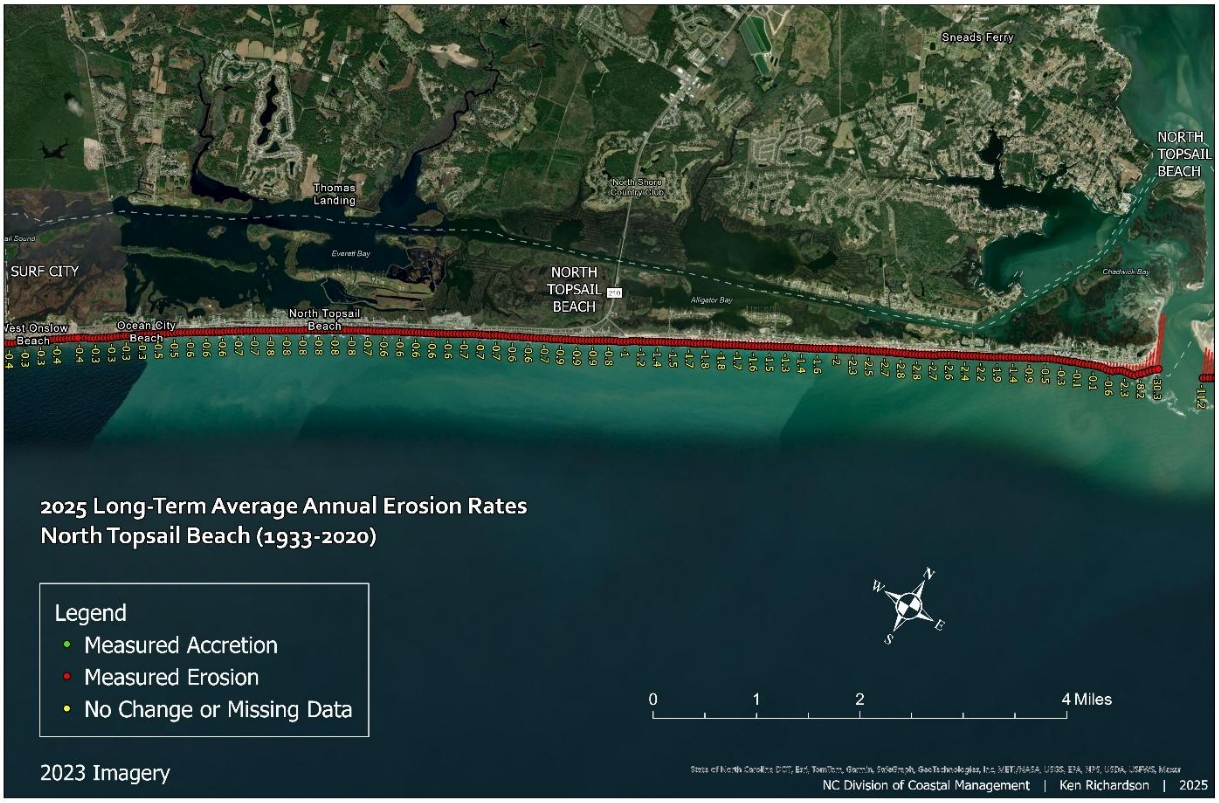

Figure 103. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

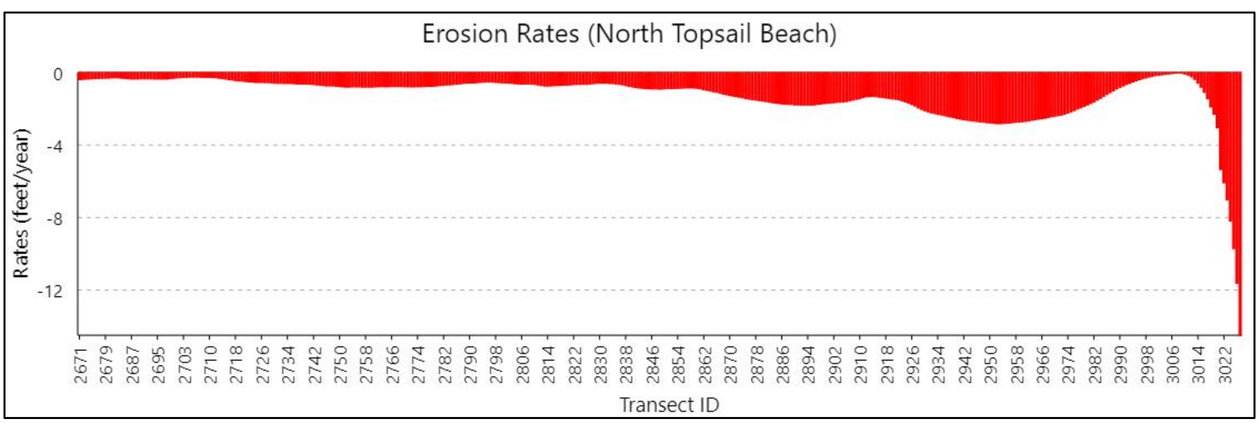

Figure 104. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

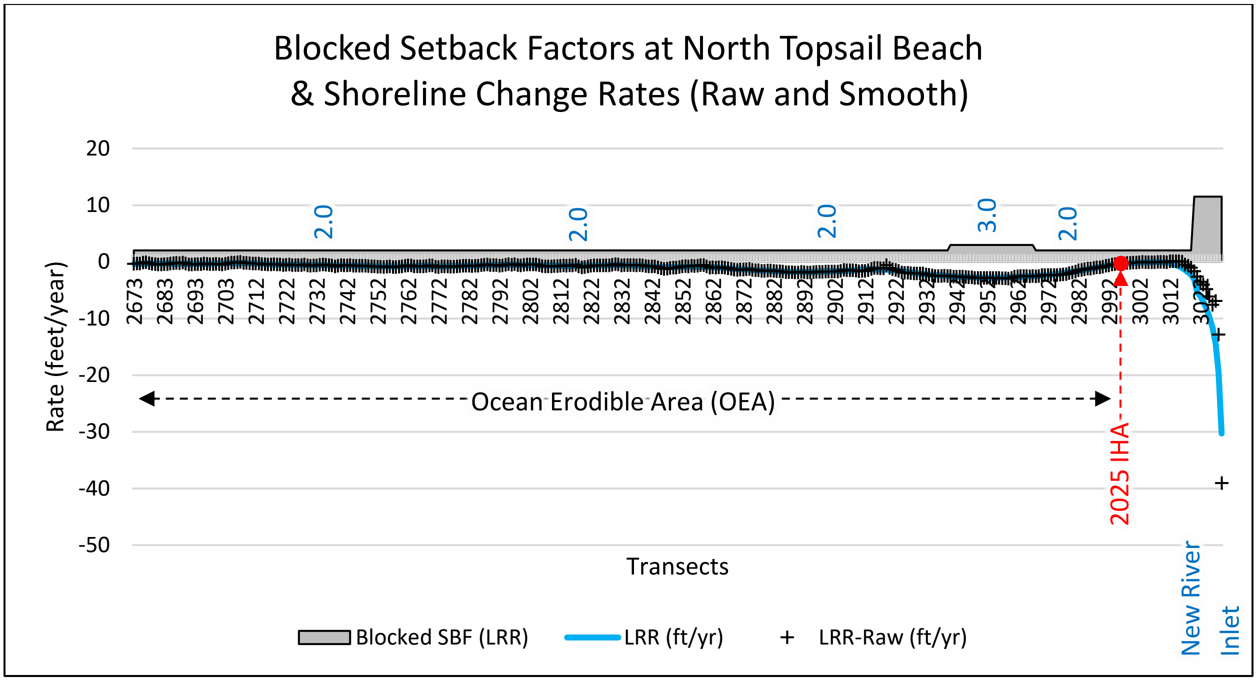

Figure 105. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

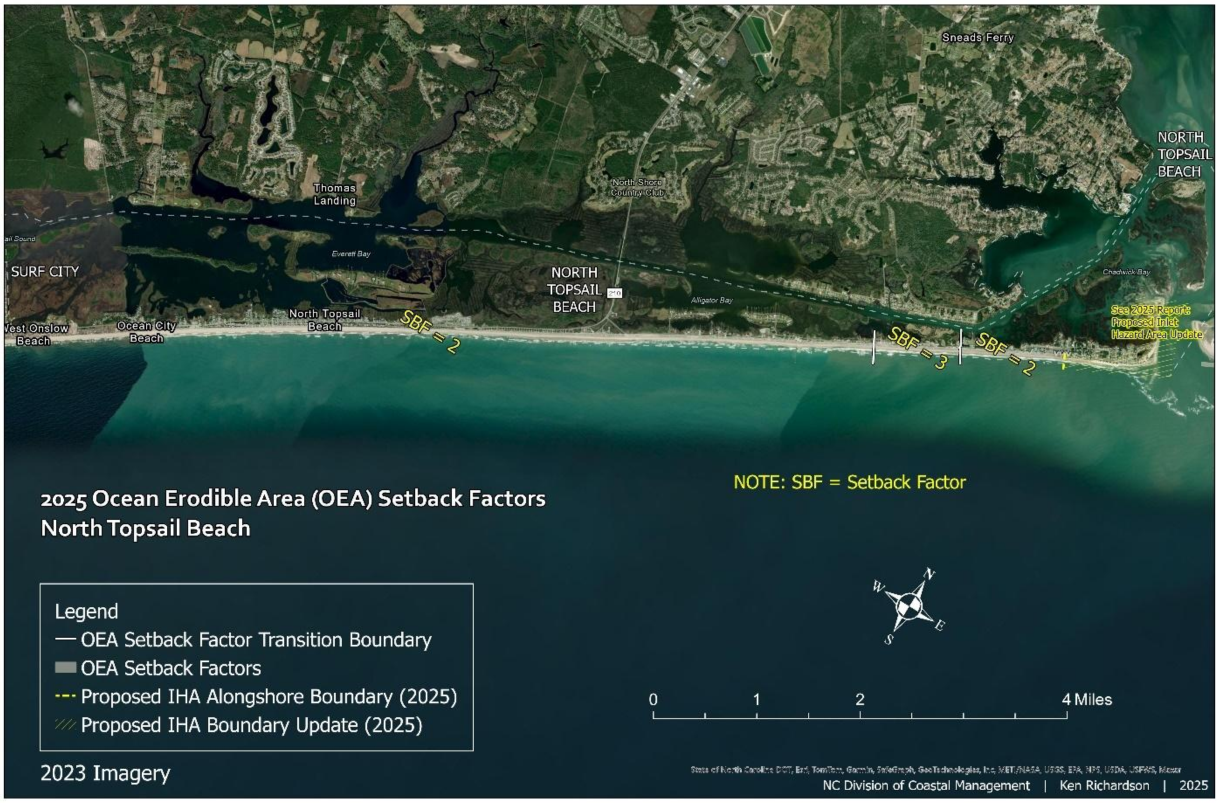

Figure 106. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at North Topsail Beach. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2, 3	2, 3	2, 2.5	2, 3, 3.5	2, 3	2, 3, 4, 5	2, 3	2.5

Table 18. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3. 18 Onslow Beach

Onslow Beach has approximately 7.3 miles of oceanfront shoreline, is east-facing and flanked by New River Inlet to the south and Brown's Inlet to the north. Here, the analysis assessed nineteen shorelines (**Figure 107**) along this oceanfront section over an 86-year period, from 1934 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 68 feet (oceanfront) to a maximum of 1,561 feet (inlet), with an average of 470 feet for the entire shoreline between New River Inlet and Brown's Inlet. The calculated relative standard deviation of shoreline position ranged between 21 and 412 feet, and an average of 130 feet. Of the 7.3 miles of shoreline analyzed, approximately 5.5 (75%) resulted in measured erosion where rates ranged between -12.6 and less than -1 feet per year and averaged five (-5) feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 108**). The end-point method resulted in a range of shoreline line change rates between -16.8 and +4.2 feet per year, averaging -3.3 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -12.6 and +6.5 feet per year, and averaging -3.0 feet per year. Both approaches resulted in similar blocked erosion rate setback factors. End-point setback factors ranged from two (2) to eleven (11) feet per year, and least squares regression ranged from two (2) to thirteen (13) feet per year.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement and does not influence results for this section of shoreline that make this study significantly different compared to previous studies. Using this approach, the calculated setback factors within the OEA range from two (2) to thirteen (13) feet per year (**Figure 109** to **Figure 112** & **Table 19**).

Figure 107. *Shorelines included in the analysis (1934-2021) at Onslow Beach.*

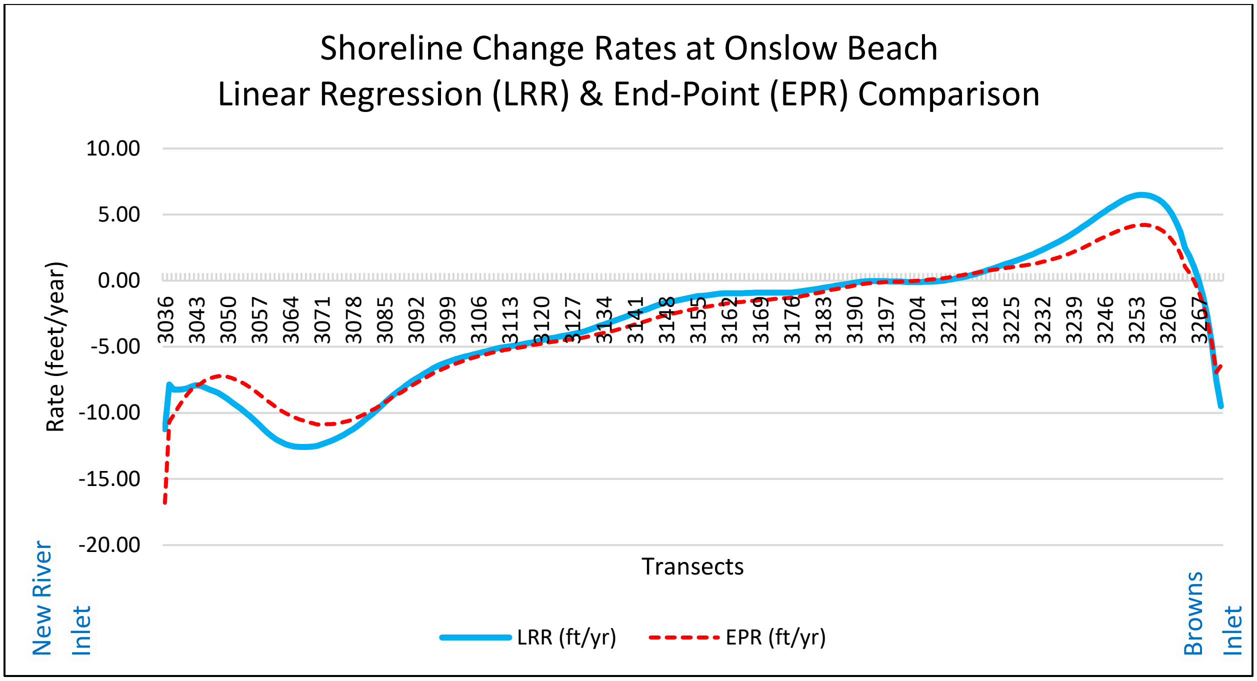

Figure 108. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 109. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

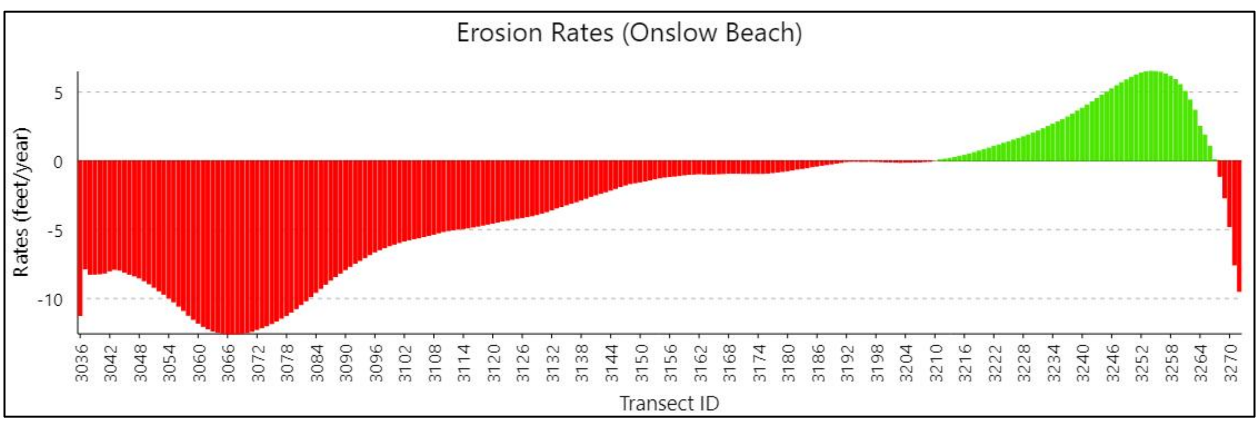

Figure 110. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

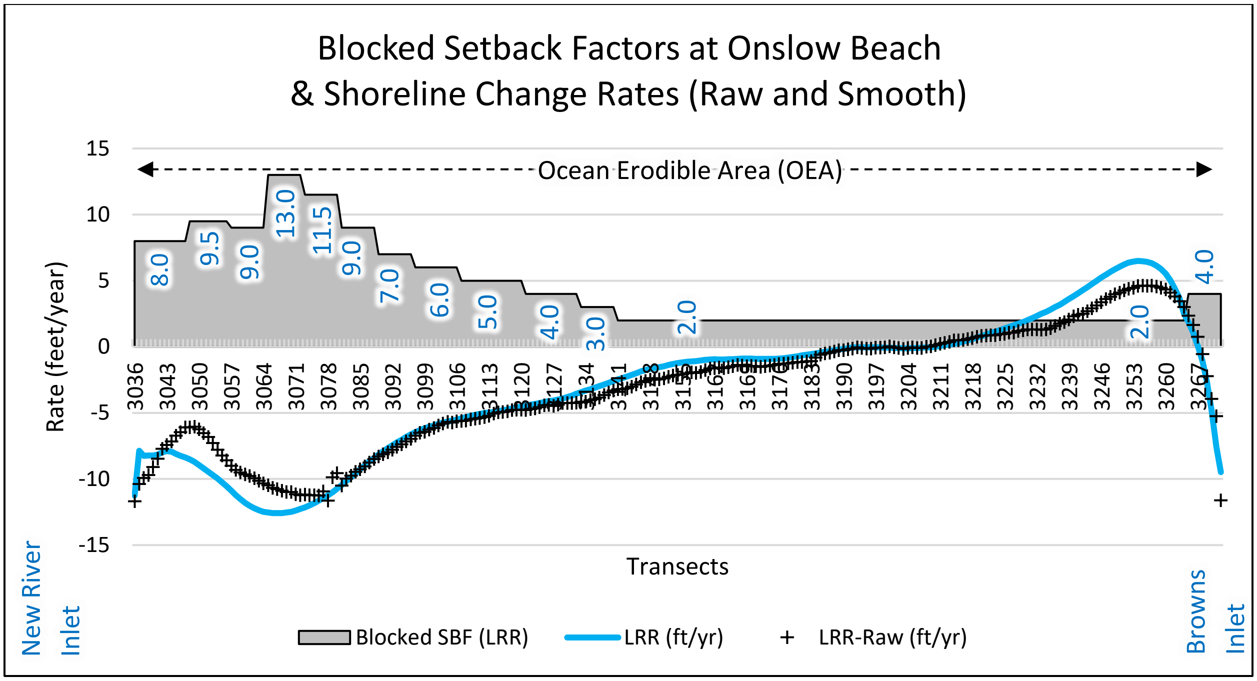

Figure 111. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 112. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Onslow Beach.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 13	Range 2 to 11	Range 2 to 11	Range 2 to 12	Range 2 to 13.5	Range 2 to 11.5	Range 2 to 8	2.7

Table 19. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.19 Brown’s Island

Brown’s Island features approximately 3.3 miles of east-facing oceanfront shoreline, bordered by Brown’s Inlet to the south and Bear Inlet to the north. As the coastline transitions from Cape Fear to Cape Lookout, this area marks the point where the shoreline begins to shift to a more southerly orientation.

Here, the analysis assessed sixteen shorelines (**Figure 113**) along this oceanfront section over an 86-year period, from 1934 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 229 feet (oceanfront) to a maximum of 1,010 feet (inlet), with an average of 363 feet for the entire shoreline between Brown’s Inlet and Bear Inlet. The calculated relative standard deviation of shoreline position ranged between 63 and 279 feet, and an average of 104 feet. Of the 3.3 miles of shoreline analyzed, all 3.3 (100%) resulted in measured erosion where rates ranged between -5.4 and less than -1 feet per year and averaged -3.1 feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 114**). The end-point method resulted in a range of shoreline line change rates between -4.7 and less than 1 feet per year, averaging -2.5 feet per year. Both approaches resulted in similar blocked erosion rate setback factors. End-point setback factors ranged from two (2) to four (4) feet per year, and least squares regression ranged from two (2) to five (5) feet per year.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement and does not influence results for this section of shoreline that make this study significantly different compared to previous studies. Using this approach, the calculated setback factors within the OEA range from two (2) to five (5) feet per year (**Figure 115** to **Figure 118** & **Table 20**).

Figure 113. *Shorelines included in the analysis (1934-2021) at Brown's Island.*

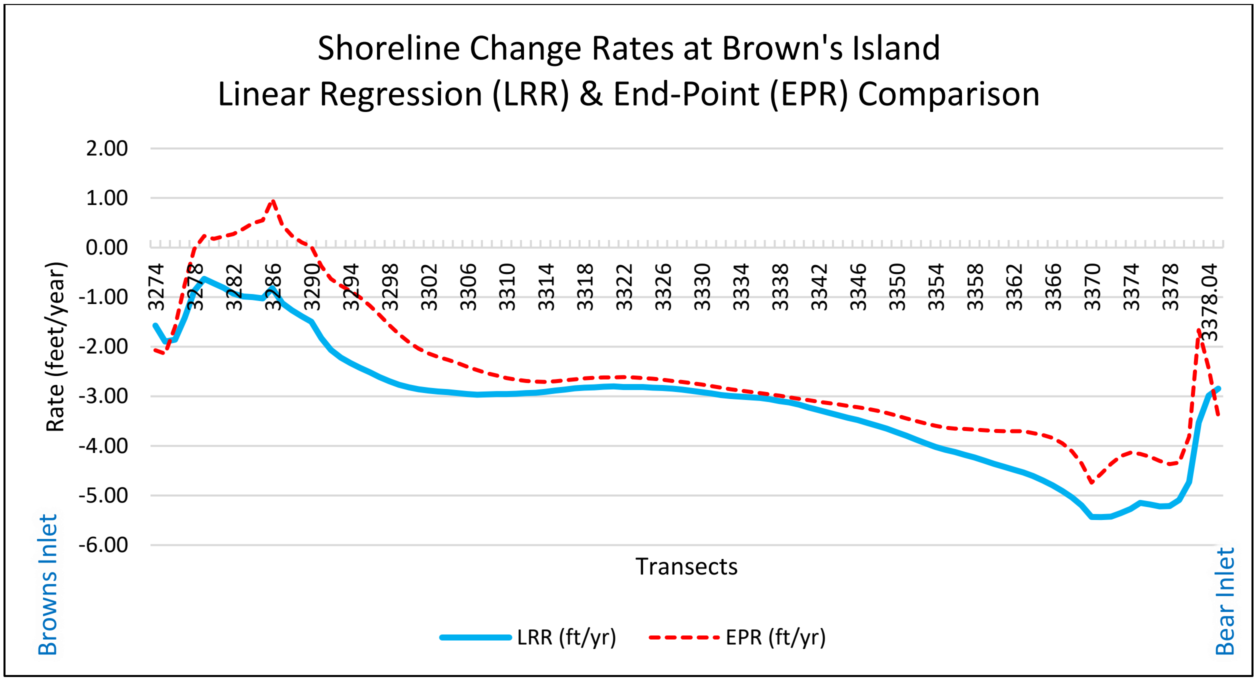

Figure 114. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

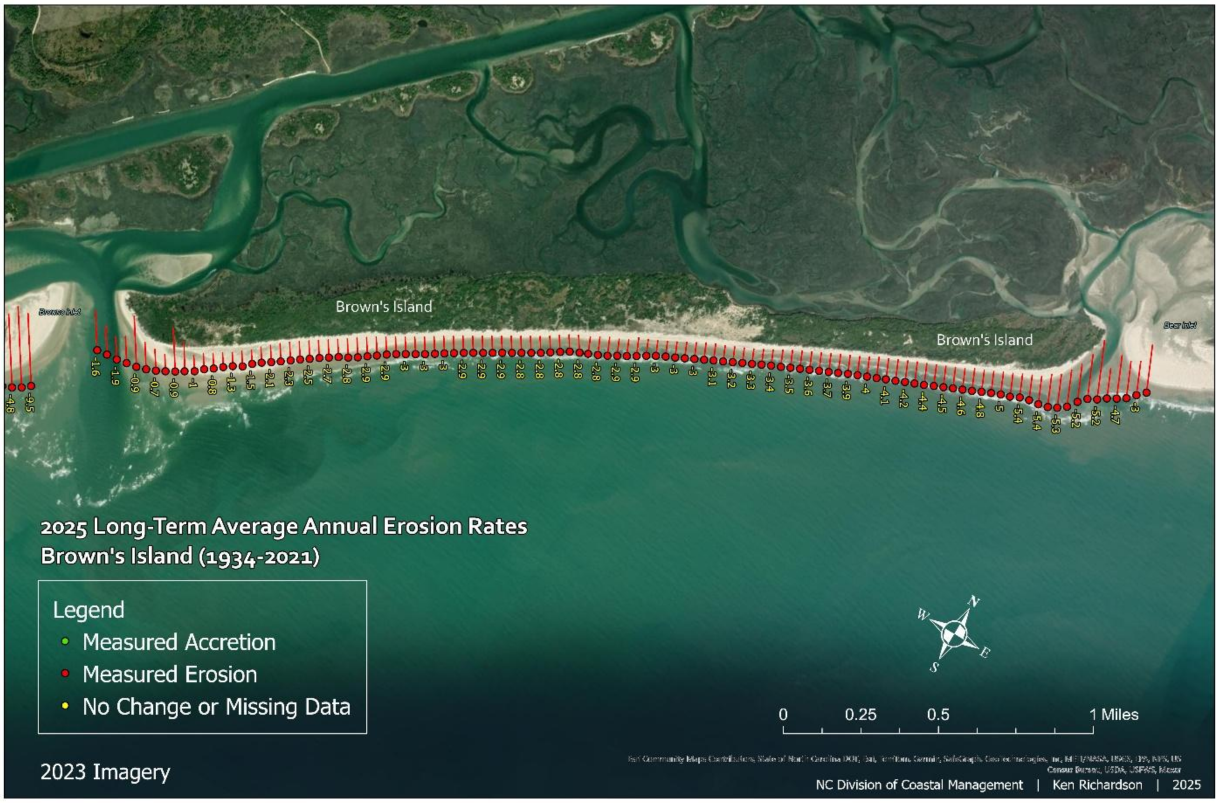

Figure 115. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

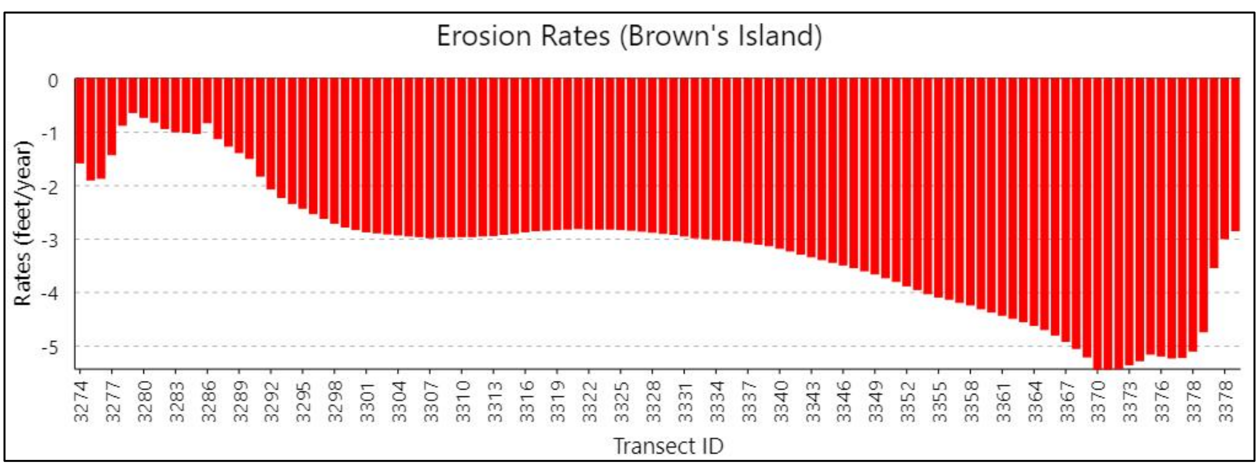

Figure 116. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

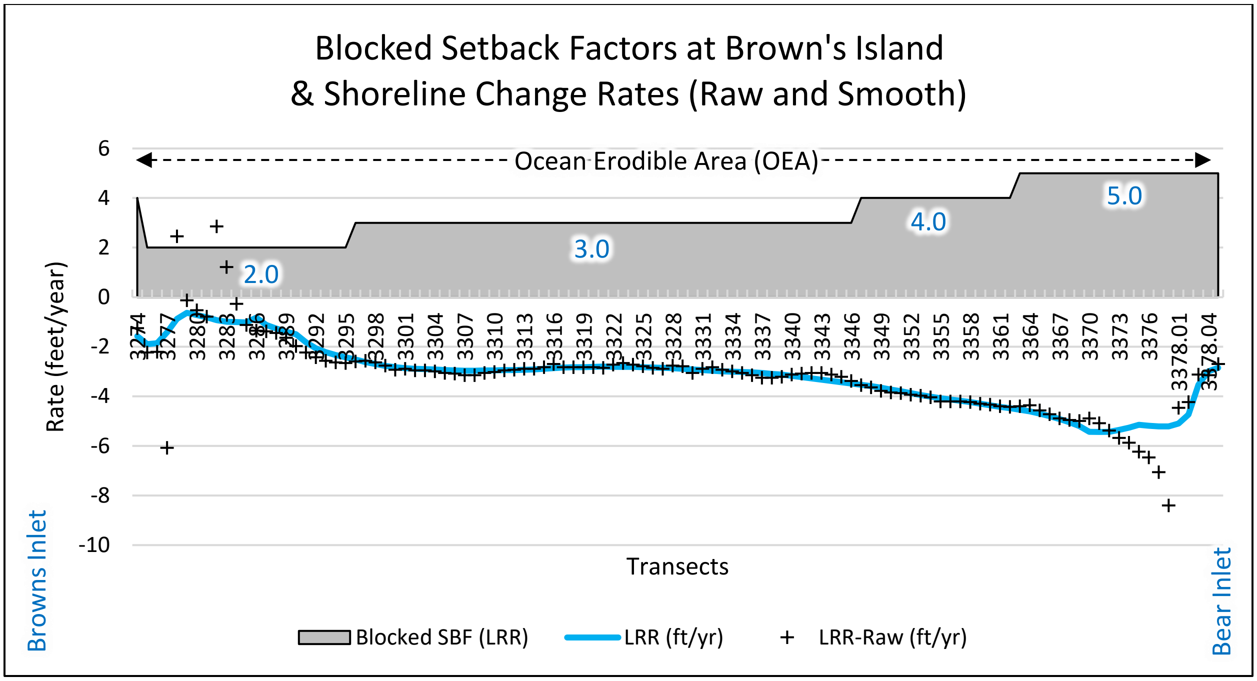

Figure 117. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

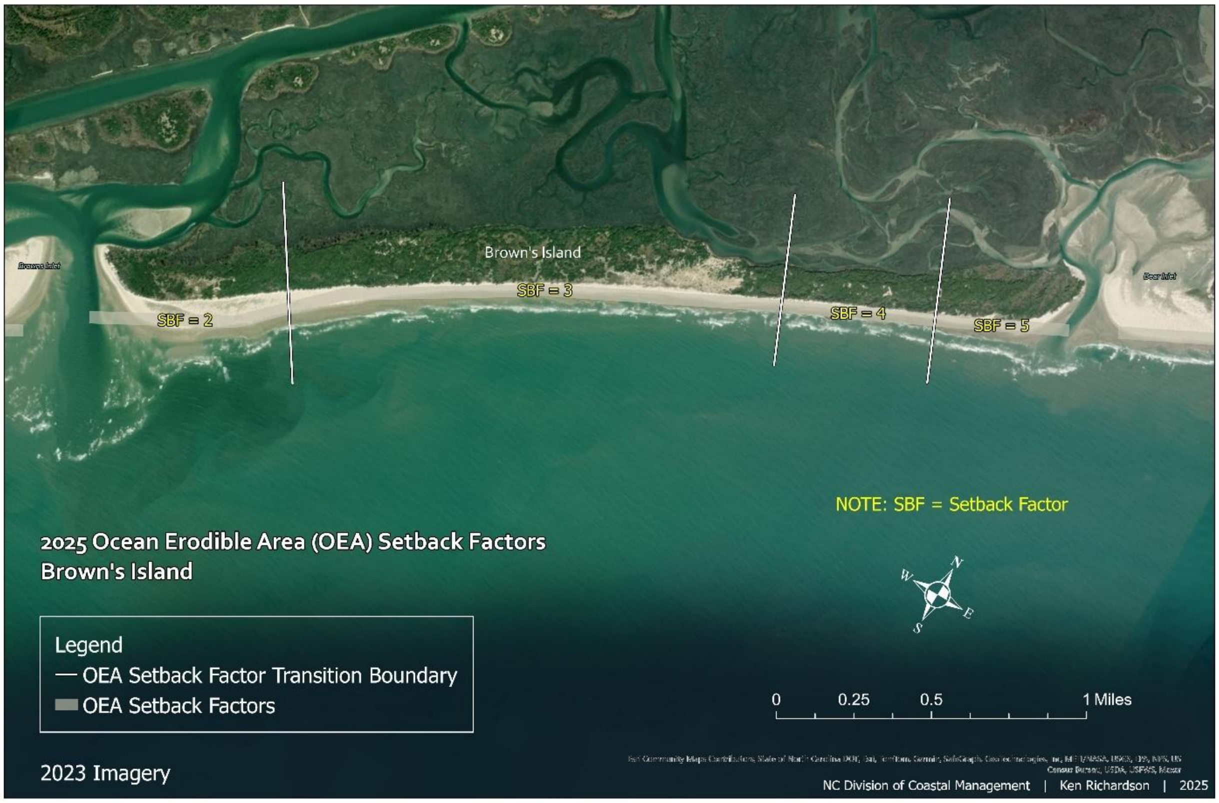

Figure 118. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Brown's Island.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 5	Range 2 to 14	Range 2 to 6	Range 2 to 7	Range 3 to 7.5	Range 3 to 5	Range 2 to 3	2

Table 20. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.20 Bear Island (Hammocks Beach State Park)

Bear's Island (Hammocks Beach State Park) features approximately 3.0 miles of south-facing oceanfront shoreline, bordered by Bear Inlet to the south and Bogue Inlet to the north.

Here, the analysis assessed sixteen shorelines (**Figure 119**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 280 feet (oceanfront) to a maximum of 2,515 feet (inlet), with an average of 810 feet for the entire shoreline between Bear Inlet and Bogue Inlet. The calculated relative standard deviation of shoreline position ranged between 69 and 922 feet, and an average of 222 feet. Of the 3.0 miles of shoreline analyzed, approximately 2.3 miles (77%) resulted in measured erosion.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 120**). However, the area near Bogue Inlet exhibited exceptionally high erosion rates due to the presence of spit formations, which are often temporary features and likely skew the results. To account for this, data from transects 3483.01 and 3483.19 (the last 18 transects) has been excluded from this comparison. Between transects 3379 and 3481, the end-point method resulted in a range of shoreline line change rates between -1.9 and +11.3 feet per year, averaging +1.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -4.7 and +21.8 feet per year, averaging less than 1 foot per year. Both approaches resulted in similar blocked erosion rate setback factors. End-point setback factors equaled two (2) feet per year and the least squares regression ranged from two (2) to four (4) feet per year.

Adopting the least squares regression methodology offers a more accurate representation of long-term shoreline movement and does not influence results for this section of shoreline that make this study significantly different compared to previous studies. Using this approach, the calculated setback factors within the OEA range from two (2) to four (4) feet per year. By including the shoreline positions transitioning into Bogue Inlet (transects 3482 to 3483.19), setback factors increase significantly from 4.5 to 25 feet per year (**Figure 121** to **Figure 124** & **Table 21**).

Figure 119. Shorelines included in the analysis (1933-2020) at Bear Island (Hammocks Beach State Park).

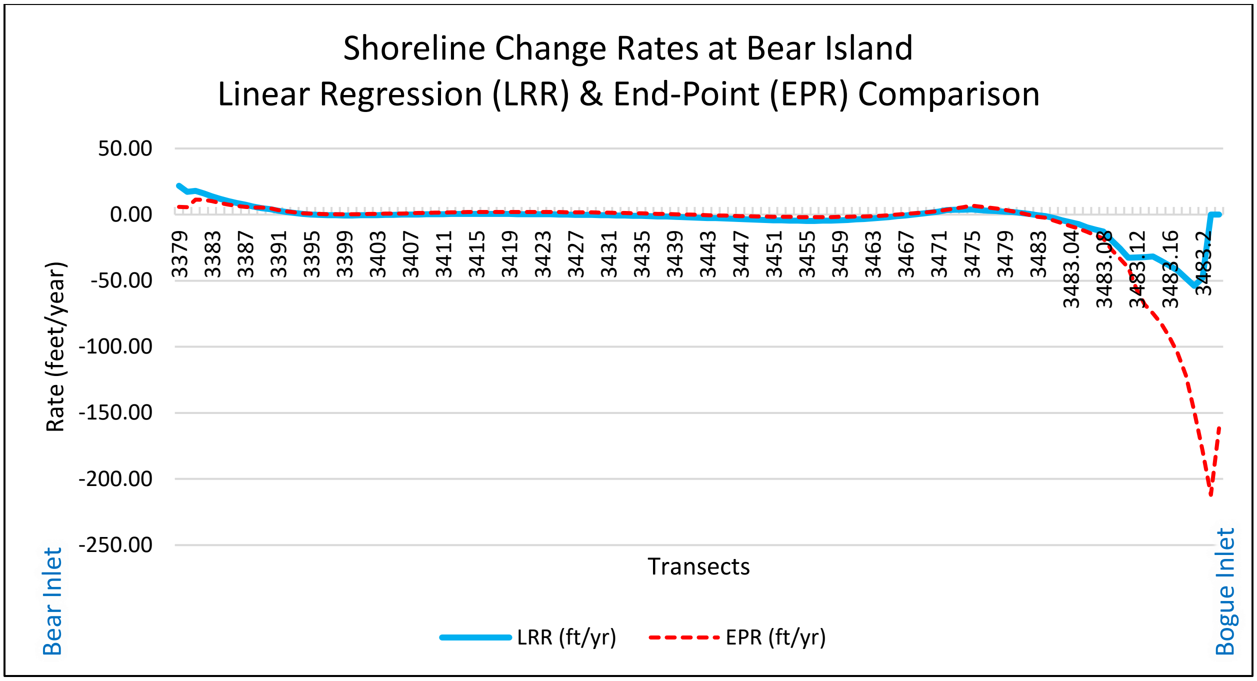

Figure 120. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

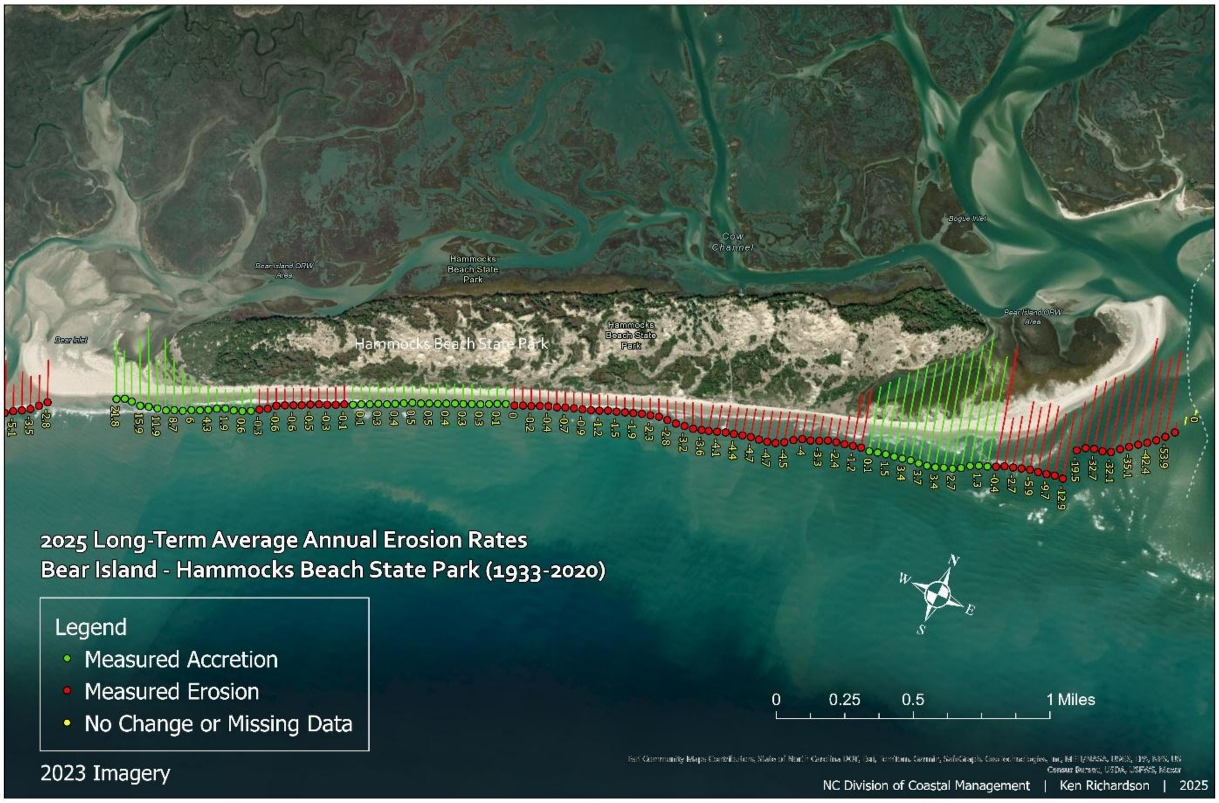

Figure 121. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

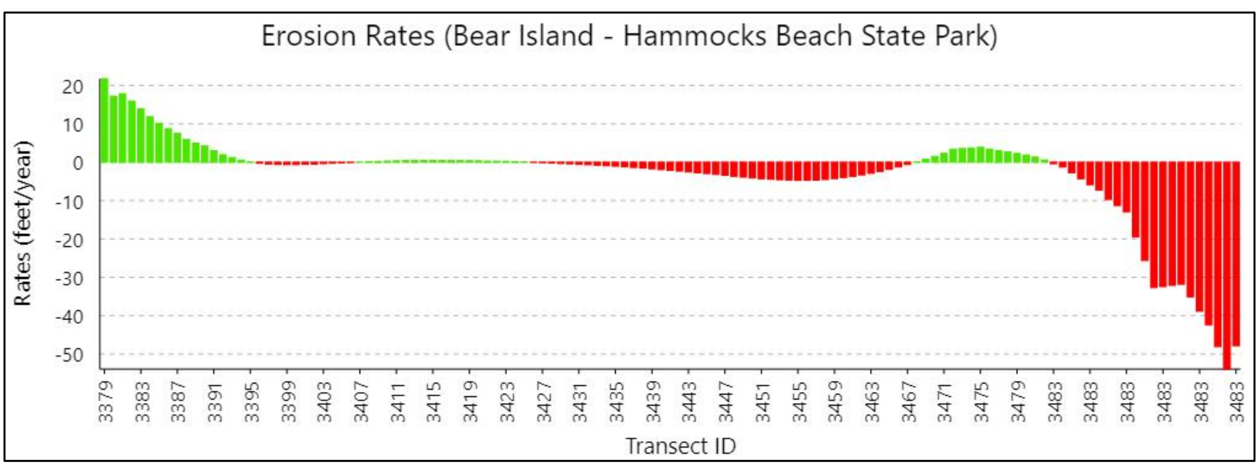

Figure 122. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

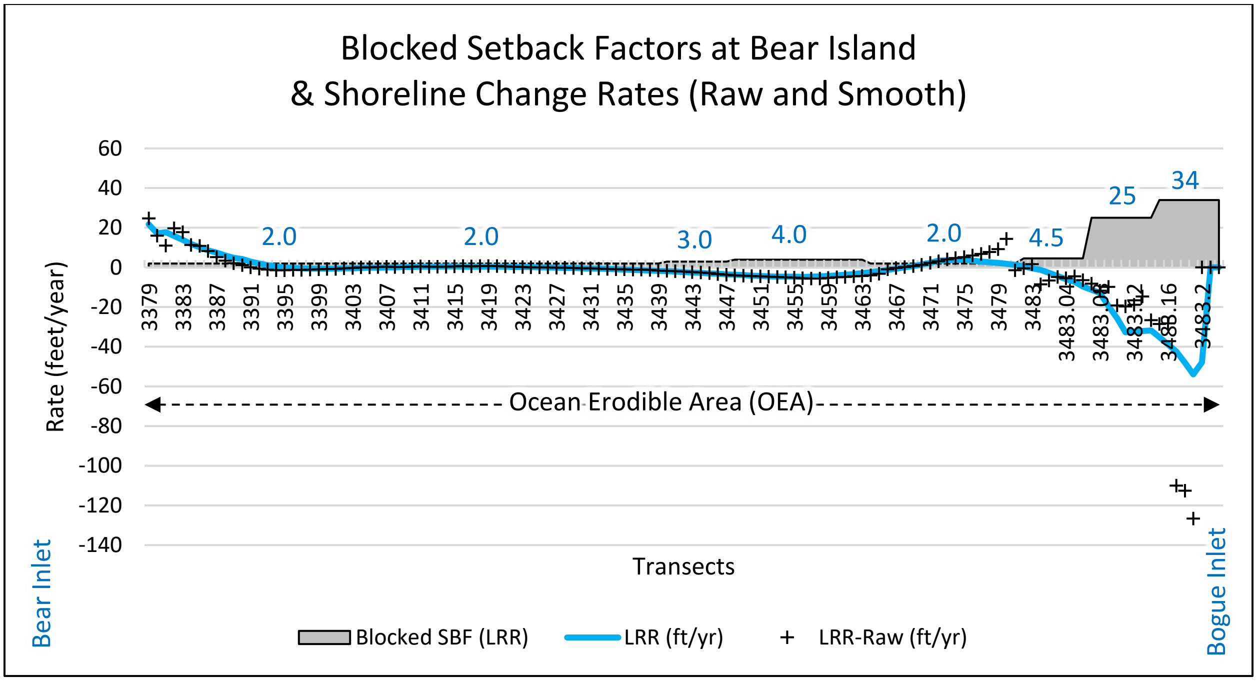

Figure 123. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 124. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Bear Island (Hammocks Beach State Park). For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 4 *(Note: 25 at inlet)*	Range 2 to 4.5	Range 2 to 3.5	Range 2 to 4	2	2	2	2

Table 21. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.21 Emerald Isle

Bogue Banks is a south-facing barrier island featuring nearly 25 miles of oceanfront shoreline, encompassing five townships and a state park. Emerald Isle accounts for approximately 11.2 miles (49%) of this shoreline. As part of the Bogue Banks Restoration Project, the eastern portion of Emerald Isle has undergone nourishment four times (2004, 2007, 2013, and 2019) following the initiation of a large-scale project in 2003. In 2020, a similar large-scale project was implemented on the western portion. Collectively, these efforts have helped shape shoreline positions and reduce erosion rates.

This analysis assessed nineteen shorelines (**Figure 125**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 97 feet (oceanfront) to a maximum of 2,996 feet (inlet), with an average of 226 feet for the entire shoreline between Bogue Inlet and the Town's eastern limit near transect-3846. However, within the Ocean Erodible Area between transects-3526 and -3846 (excluding areas inside the 2025 updated IHA proposed boundary), the shoreline envelope varied from 97 to 326 feet, averaging 149 feet. For the same respective areas, the calculated average relative standard deviation of shoreline position was 63 feet overall and 42 feet for the OEA alone. Of the 11.2 miles of shoreline analyzed, 2.8 miles (25%) resulted in measured erosion where rates averaged less than two (-2) feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 126**). The end-point method resulted in a range of shoreline line change rates between -1.7 and less than +2.0 feet per year, averaging less than 1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -1.1 and less than -1.1 feet per year, averaging less than 1.0 feet per year. Between transects 3526 and 3846, and outside the 2025 updated IHA boundary proposed, each method resulted in blocked erosion rate setback factors of two (2), making these results consistent with previous studies for this section of shoreline; specifically, after beach nourishment began.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement; however, it does not alter the setback factor results for this section of shoreline in a way that distinguishes it from previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 3526 and 3846 (**Figure 127** to **Figure 130** & **Table 22**). For setback factors within the proposed updated Inlet Hazard Area, refer to the report titled *NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update.*

Figure 125. *Shorelines included in the analysis (1933-2020) at Emerald Isle.*

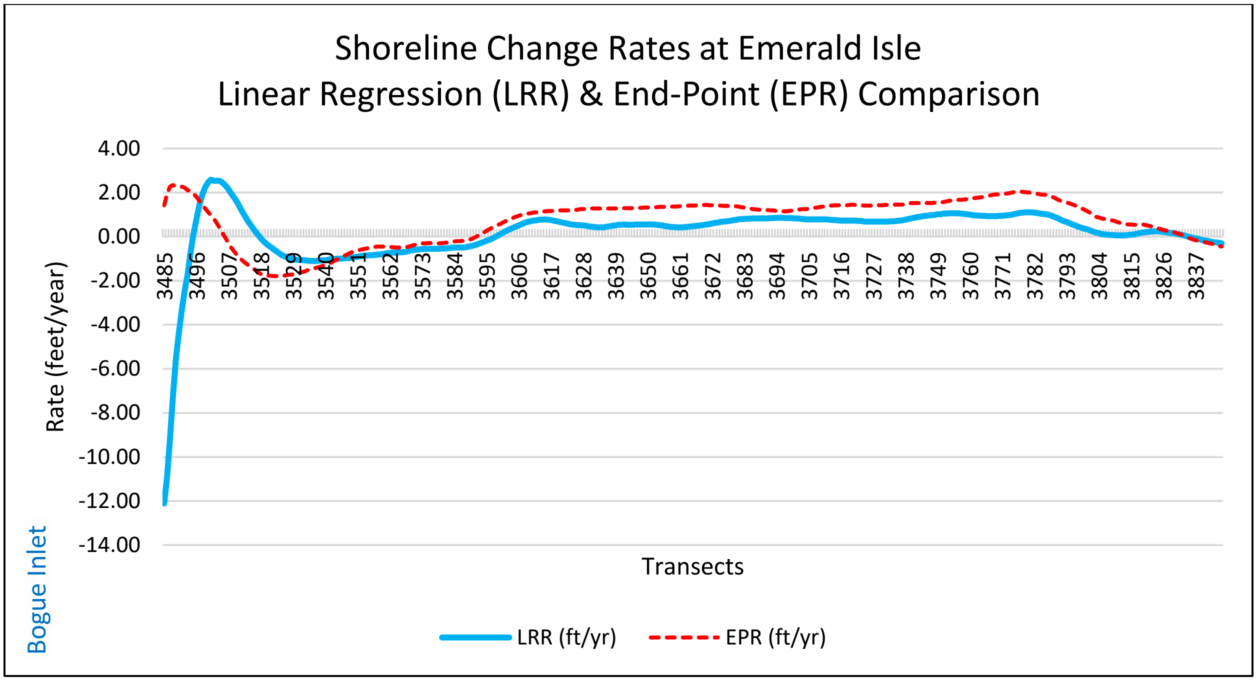

Figure 126. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

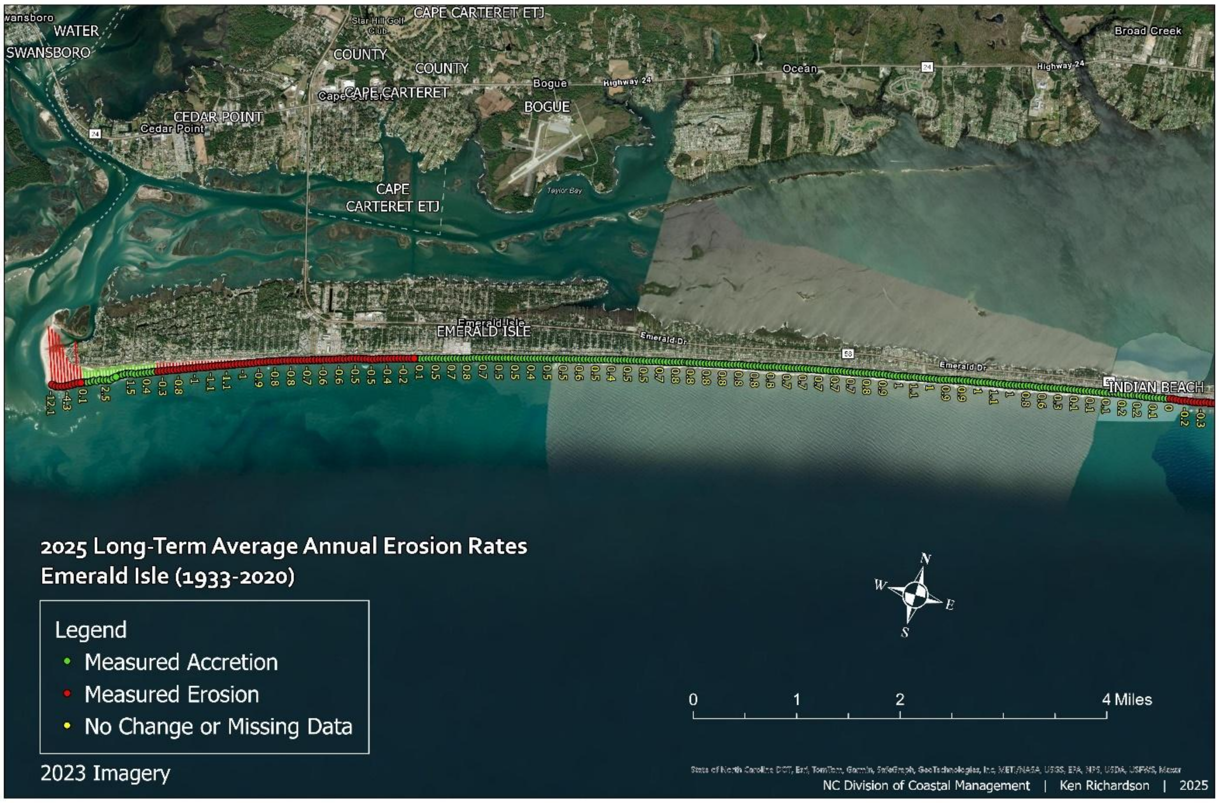

Figure 127. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

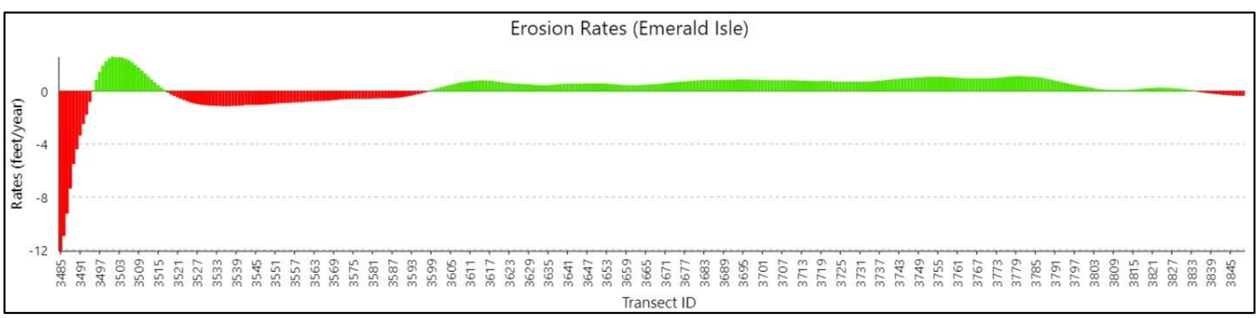

Figure 128. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

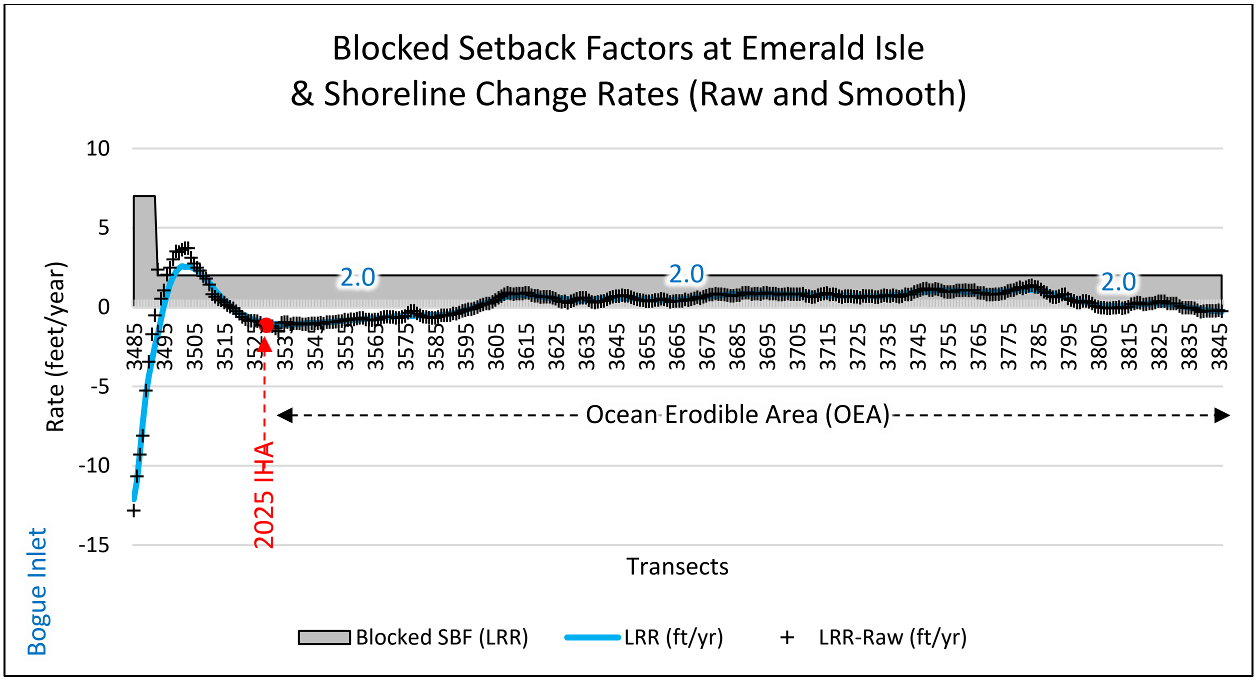

Figure 129. This *graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

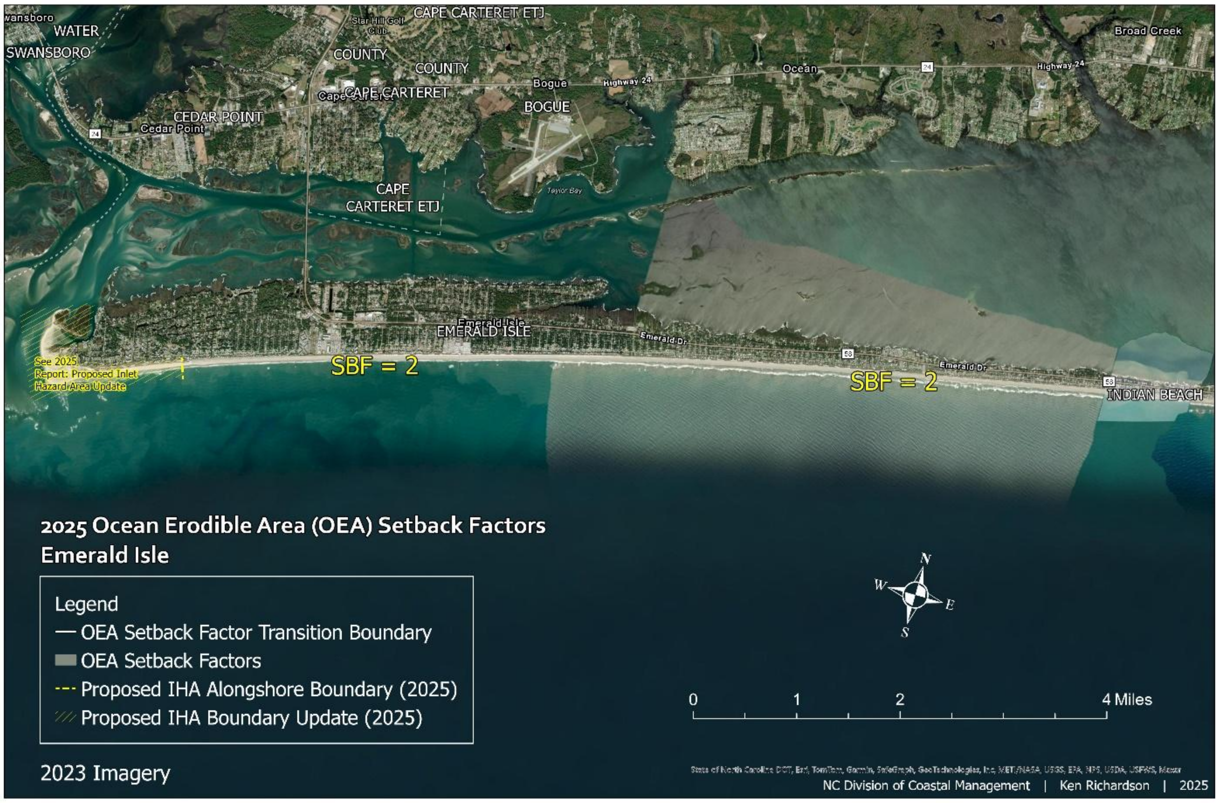

Figure 130. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Emerald Isle. For setbacks within the proposed updated* IHA *boundary, refer to the report titled "NC Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: 2025 Update."*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2, 2.5	2, 3	2, 3.5, 5	2, 3	N/A

Table 22. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.22 Indian Beach and Salter Path

Indian Beach and Salter Path accounts for approximately 2.5 miles (10%) of the shoreline along Bogue Banks. As part of the Bogue Banks Restoration Project, this area was the recipient of a large-scale beach nourishment project in 2001-2002, followed by four maintenance projects in 2004, 2007, 2019 and 2020. Collectively, these efforts have helped shape shoreline positions and reduce erosion rates.

This analysis assessed nineteen shorelines (**Figure 131**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 103 feet to a maximum of 160 feet, with an average of 128 feet for the shoreline between transects 3847 and 3927. The calculated relative standard deviation of shoreline position ranged from 29 to 47 feet and averaged 38 feet. Of the 2.5 miles of shoreline analyzed, all (100%) resulted in measured erosion where rates averaged less than one (-1) feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 132**). The end-point method resulted in a range of shoreline line change rates between -1.0 and less than -1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between less than -1.0 and less than -0.5 feet per year, averaging less than -1.0 feet per year. Each method resulted in blocked erosion rate setback factors of two (2), making these results consistent with previous studies for this section of shoreline; specifically, after beach nourishment began.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement; however, it does not alter the setback factor results for this section of shoreline in a way that distinguishes it from previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 3847 and 3927 (**Figure 133** to **Figure 136** & **Table 23**).

Figure 131. *Shorelines included in the analysis (1933-2020) at Indian Beach and Salter Path.*

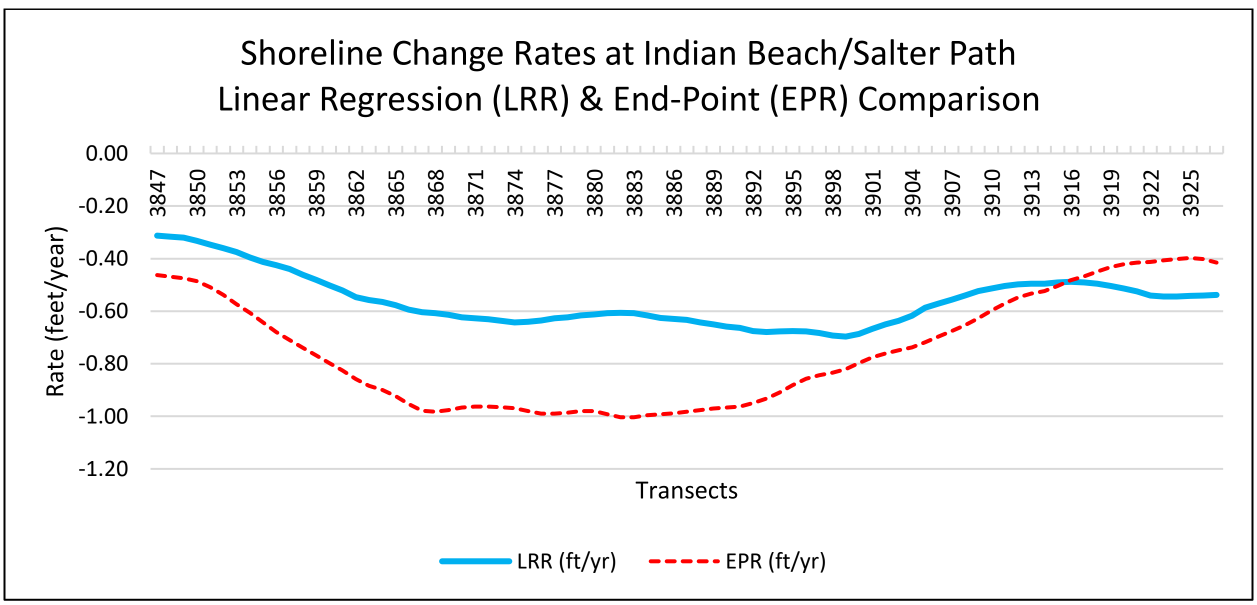

Figure 132. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

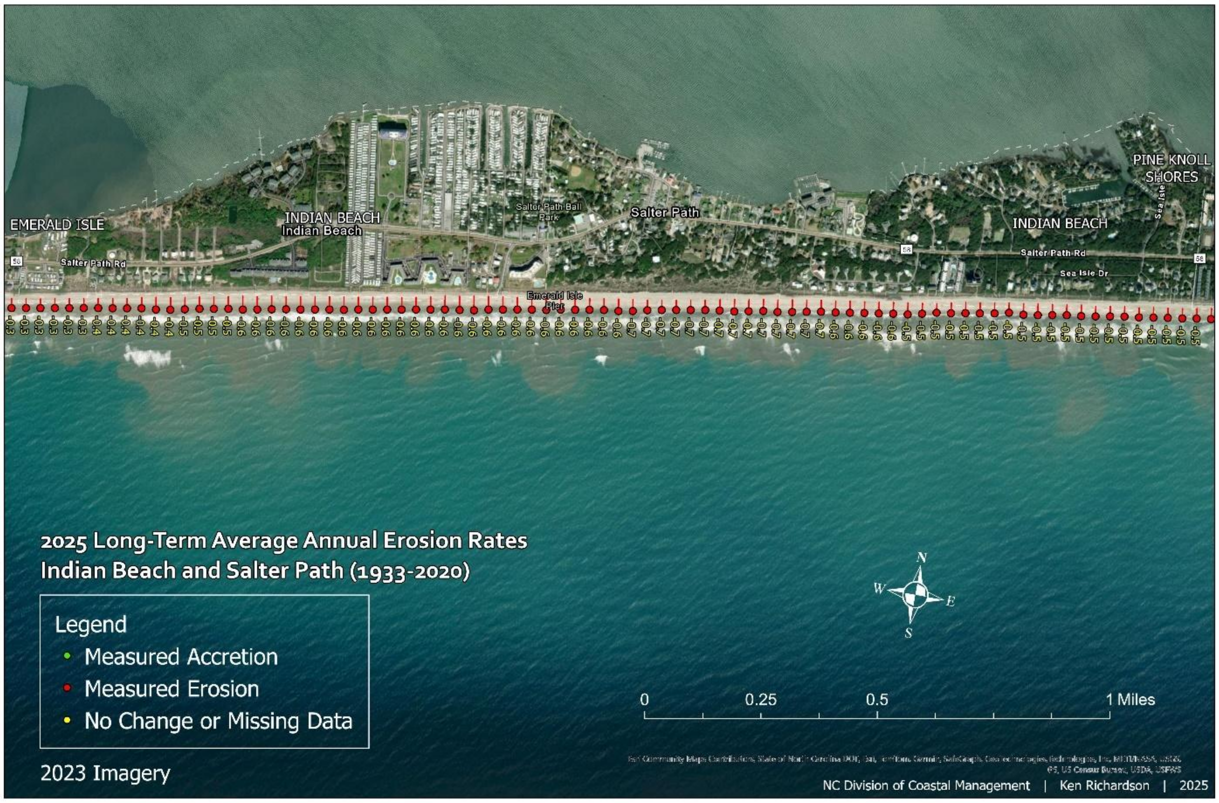

Figure 133. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

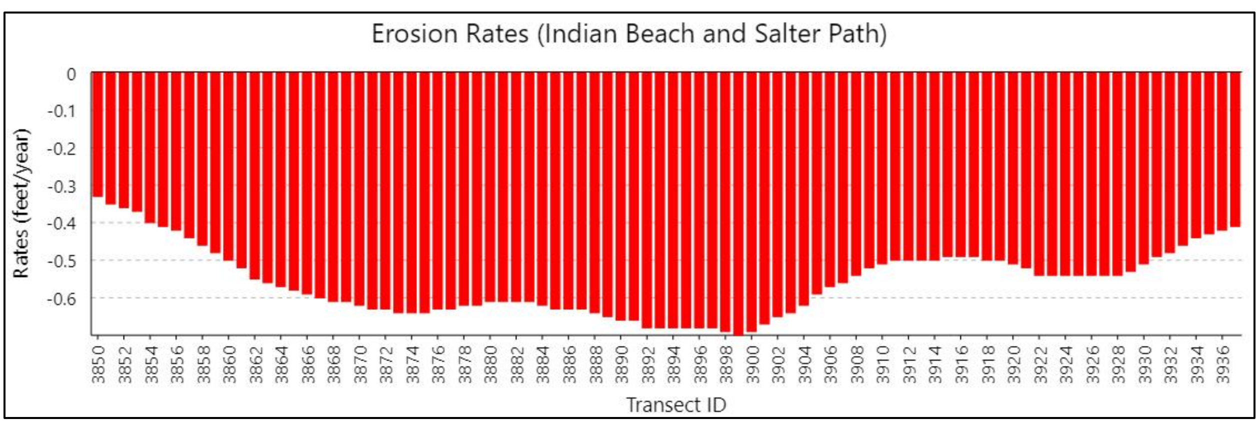

Figure 134. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

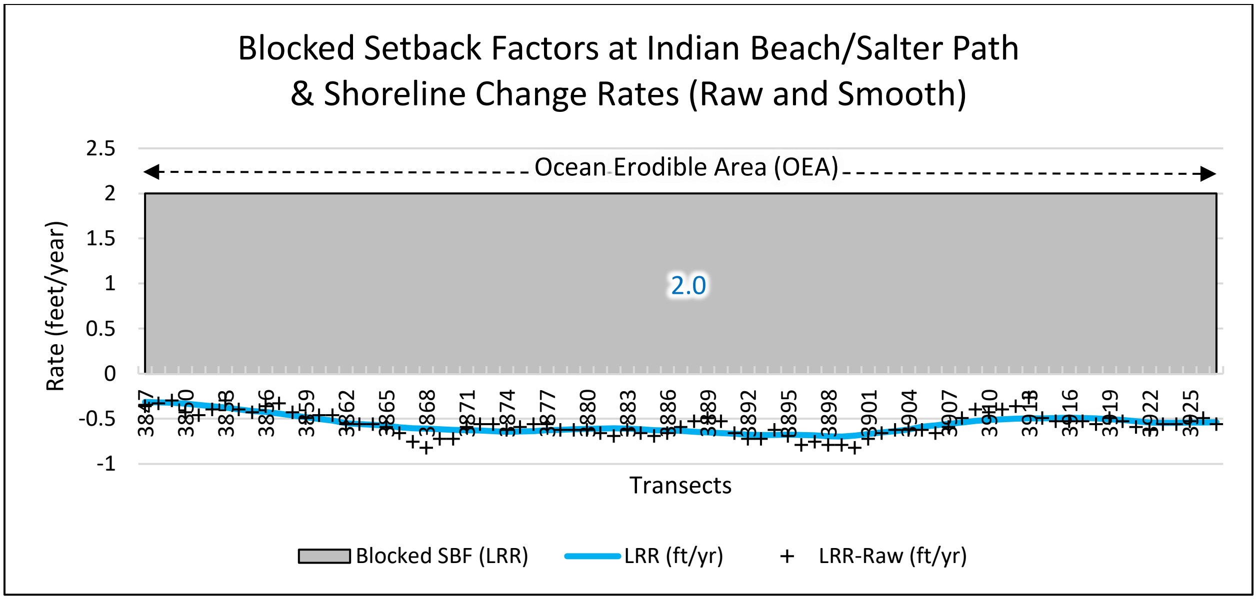

Figure 135. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

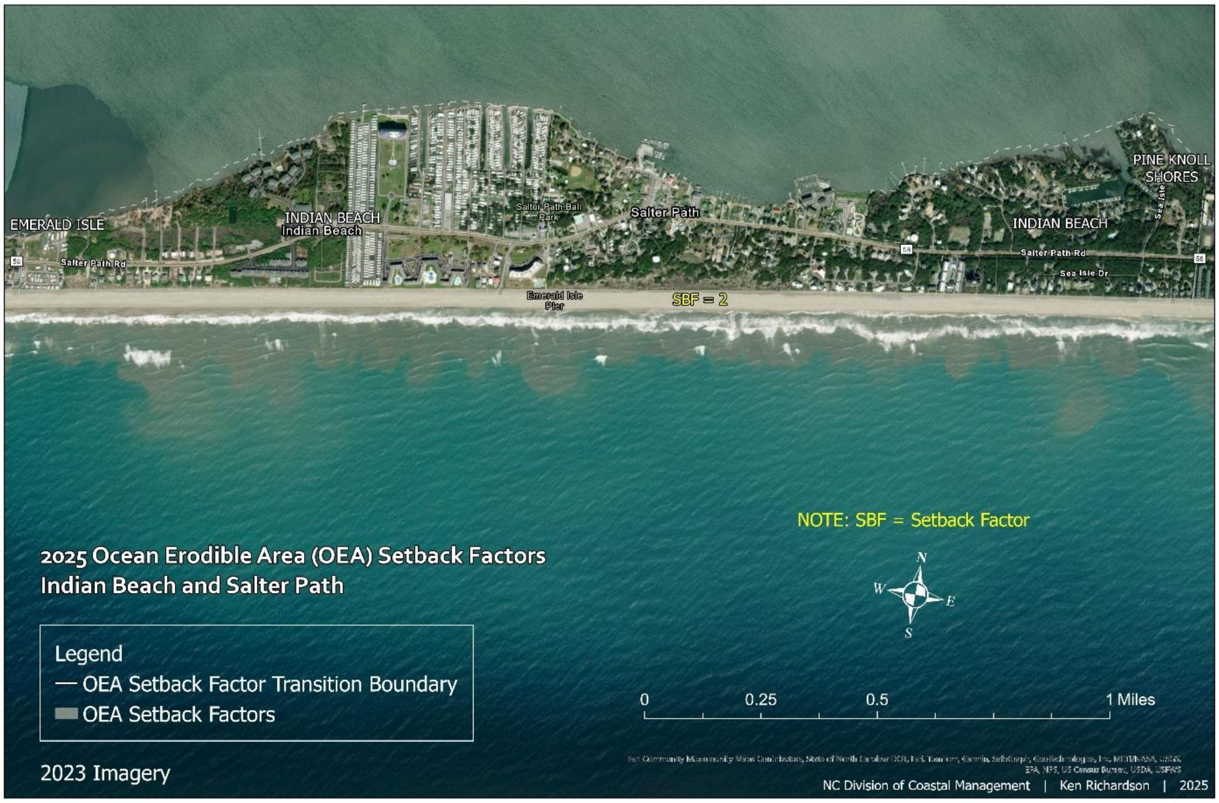

Figure 136. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Indian Beach and Salter Path.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2	2	2	N/A

Table 23. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.23 Pine Knoll Shores

Pine Knoll Shores accounts for approximately 4.8 miles (19%) of the shoreline along Bogue Banks. As part of the Bogue Banks Restoration Project, this area was the recipient of a large-scale beach nourishment project in 2001-2002, followed by four maintenance projects in 2004, 2007, 2013, and 2020. Collectively, these efforts have helped shape shoreline positions and reduce erosion rates.

This analysis assessed eleven shorelines (**Figure 137**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 77 feet to a maximum of 197 feet, with an average of 130 feet for the shoreline between transects 3928 and 4082. The calculated relative standard deviation of shoreline position ranged from 22 to 48 feet and averaged 35 feet. Of the 4.8 miles of shoreline analyzed, 2.4 miles (50%) resulted in measured erosion where rates averaged less than one (-1.0) feet per year.

For comparison, both the end-point and least squares regression methods produced similar results (**Figure 138**). The end-point method resulted in a range of shoreline line change rates between -1.0 and less than +1.0 feet per year, averaging less than +1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between less than -1.0 and less than +1.0 feet per year, averaging less than +1.0 feet per year. Each method resulted in blocked erosion rate setback factors of two (2), making these results consistent with previous studies for this section of shoreline; specifically, after beach nourishment began.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement; however, it does not alter the setback factor results for this section of shoreline in a way that distinguishes it from previous studies. Using this approach, the calculated setback factors within the OEA remain at two (2) feet per year between transects 3928 and 4082 (**Figure 138 to Figure 142** & **Table 24**).

Figure 137. *Shorelines included in the analysis (1933-2020) at Pine Knoll Shores.*

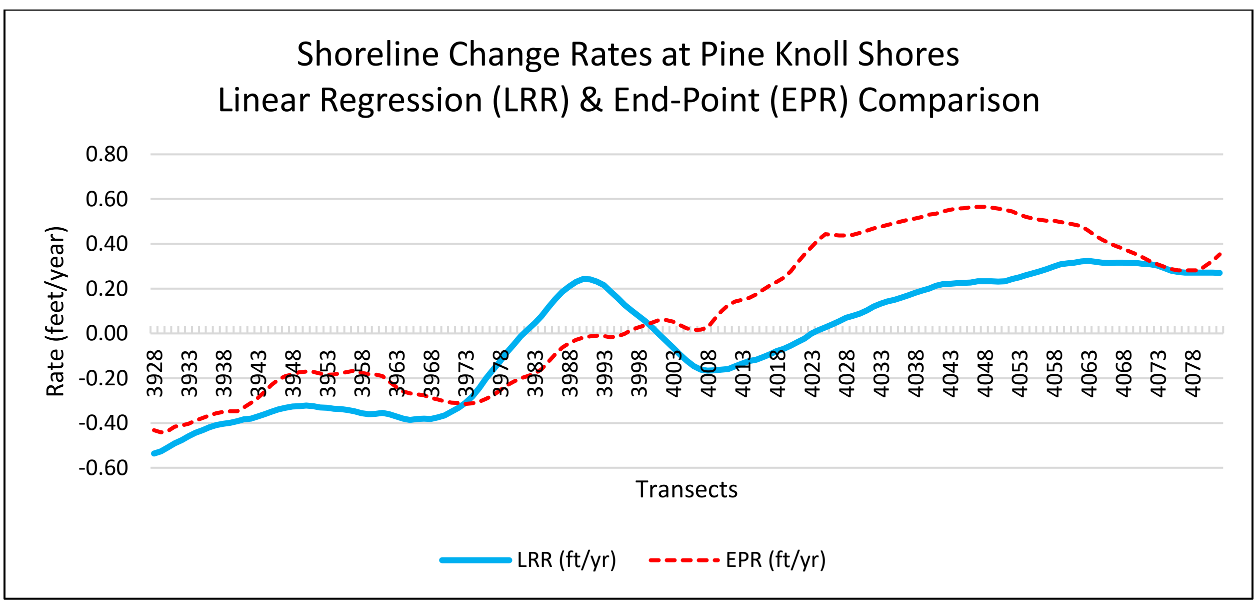

Figure 138. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 139. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

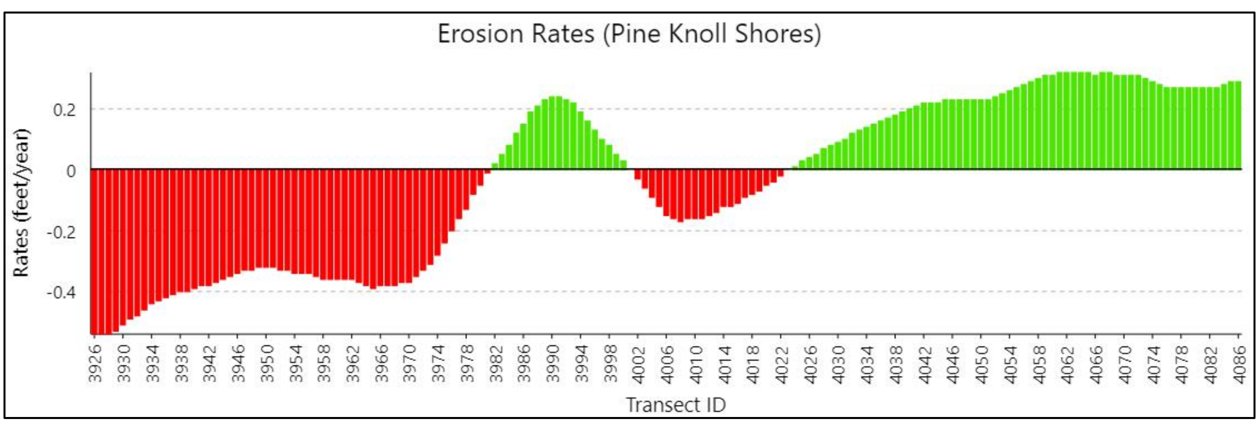

Figure 140. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

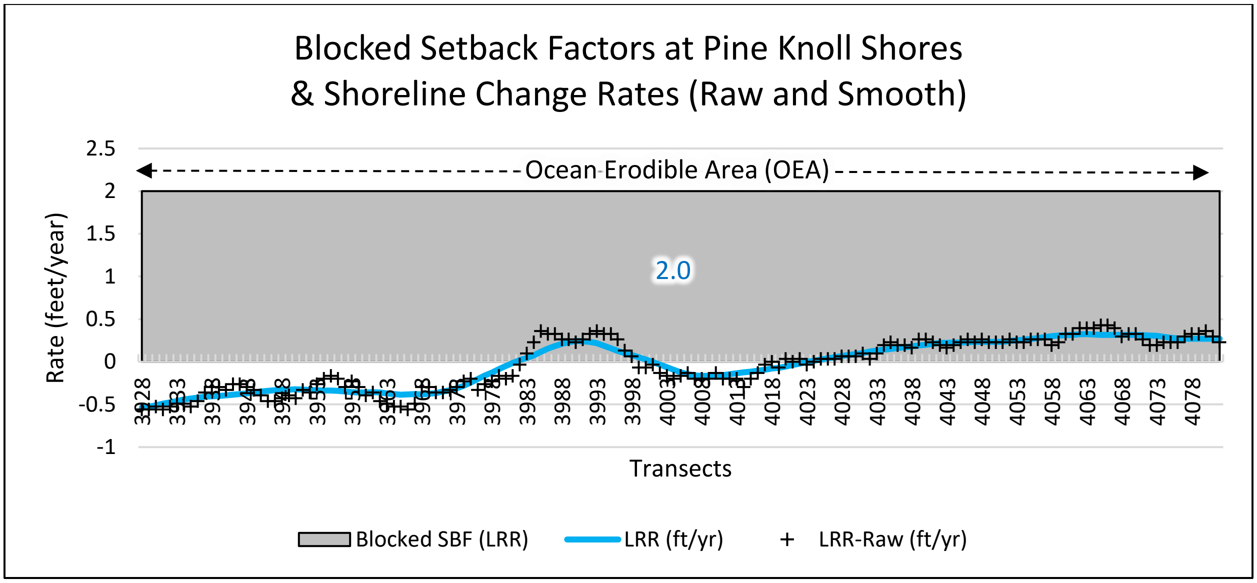

Figure 141. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 142. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Pine Knoll Shores.*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	2	2	2	2	2, 3	2, 3, 4	2	N/A

Table 24. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.24 Atlantic Beach and Fort Macon State Park

Atlantic Beach and Fort Macon State Park account for approximately 6.1 miles (24.4%) of the shoreline along Bogue Banks. This portion of the Bogue Banks shoreline has a broader history of being a recipient of beach nourishment in association with the Morehead City Harbor federal navigation project. Starting in 1978 followed by a 1986 project that served as the areas first as a large-scale project. Since maintenance projects occurred in 1994, 2002, 2005, 2007, 2011, 2014, 2015, 2017 and 2020. Collectively, these efforts have helped shape shoreline positions and reduce erosion rates.

This analysis assessed eleven shorelines (**Figure 143**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 67 feet (oceanfront) to a maximum of 948 feet (inlet area), with an average of 356 feet for the entire shoreline between transect-4083 and transect-4275. The calculated relative standard deviation of shoreline position ranged from 20 to 208 feet and averaged 93 feet. Of the 6.1 miles of shoreline analyzed, 1.2 miles (20%) resulted in measured erosion where rates ranged between -3.2 and less than -1.0 feet per year and averaged -2.1 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 144**). The end-point method produced shoreline change rates ranging from -6.2 to +3.7

feet per year, with an average of +1.0 feet per year. The least squares regression method showed a range from -3.2 to +3.3 feet per year, averaging +1.3 feet per year. In Atlantic Beach, both methods resulted in a blocked erosion rate setback factor of two (2). At Fort Macon State Park, historical setback factors have ranged from 2 to as much as 5 feet per year. These results remained consistent, with the end-point method ranging from 2 to 6 feet per year and the least squares regression method ranging from 2 to 3 feet per year. Overall, the findings align with previous studies for this section of the shoreline.

The least squares regression methodology offers a more accurate representation of long-term shoreline movement. At Atlantic Beach (transects 4083 and 4231), the results remain at two (2) feet per year. At Fort Macon State Park, most of the shoreline also maintains a rate of two (2) feet per year, except for an approximate half-mile section between transects 4249 and 4265, where the rate increases to three (3) feet per year. Relative to the current effective setback factors (2020), only the area between transects 4249 and 4265 at Fort Macon State Park will experience an increase of 1 foot per year. These findings do not alter the setback factor results in a way that differentiates them from previous studies (**Figure 145** to **Figure 148** & **Table 25**).

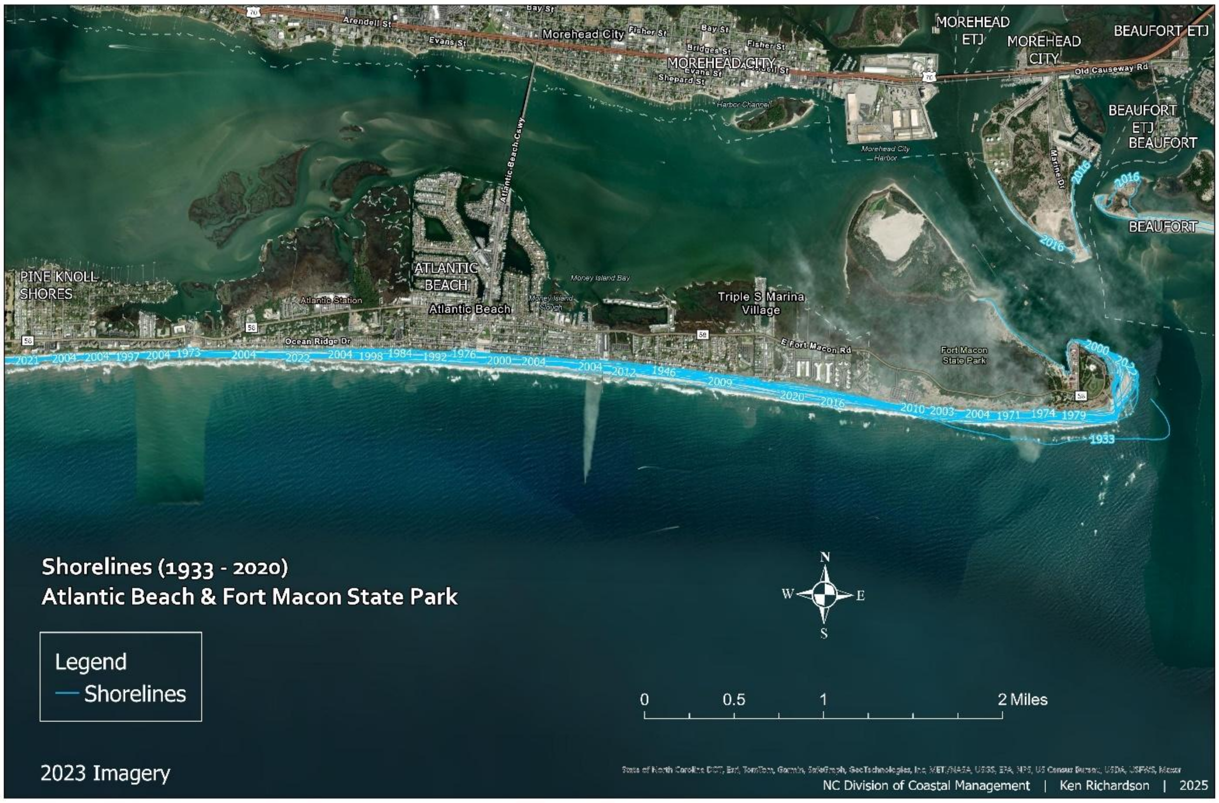

Figure 143. *Shorelines included in the analysis (1933-2020) at Atlantic Beach and Fort Macon State Park.*

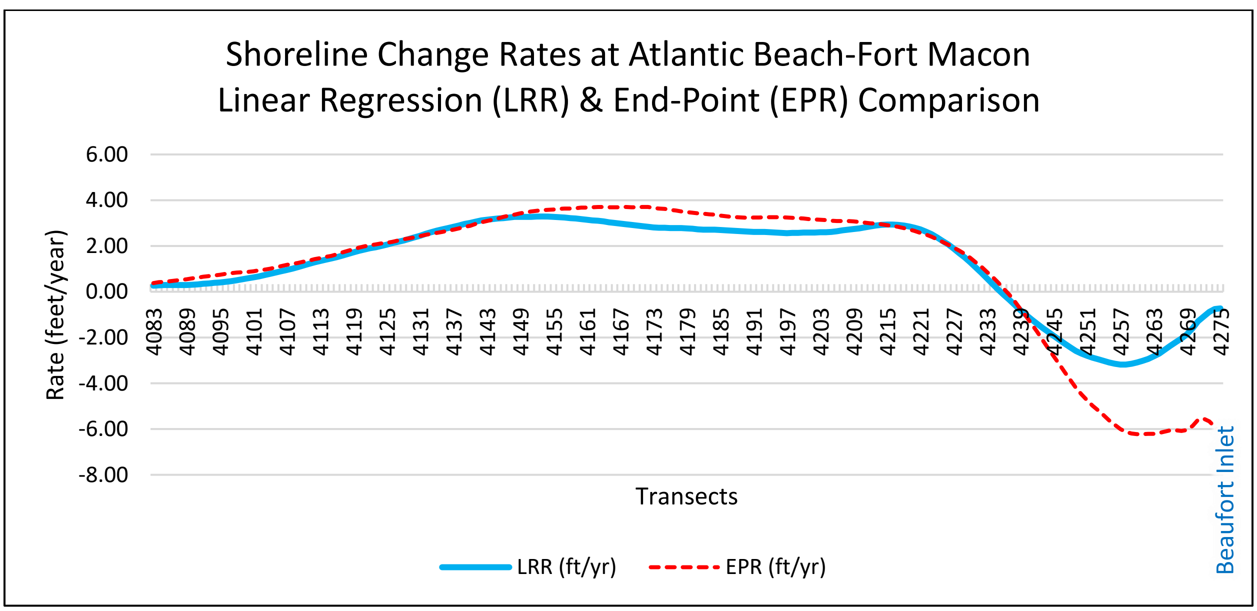

Figure 144. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 145. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

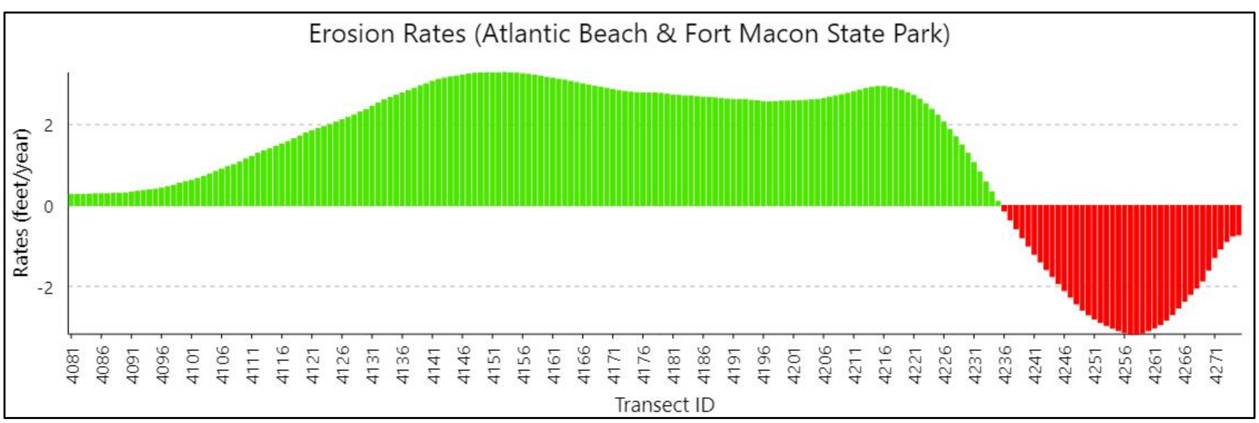

Figure 146. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

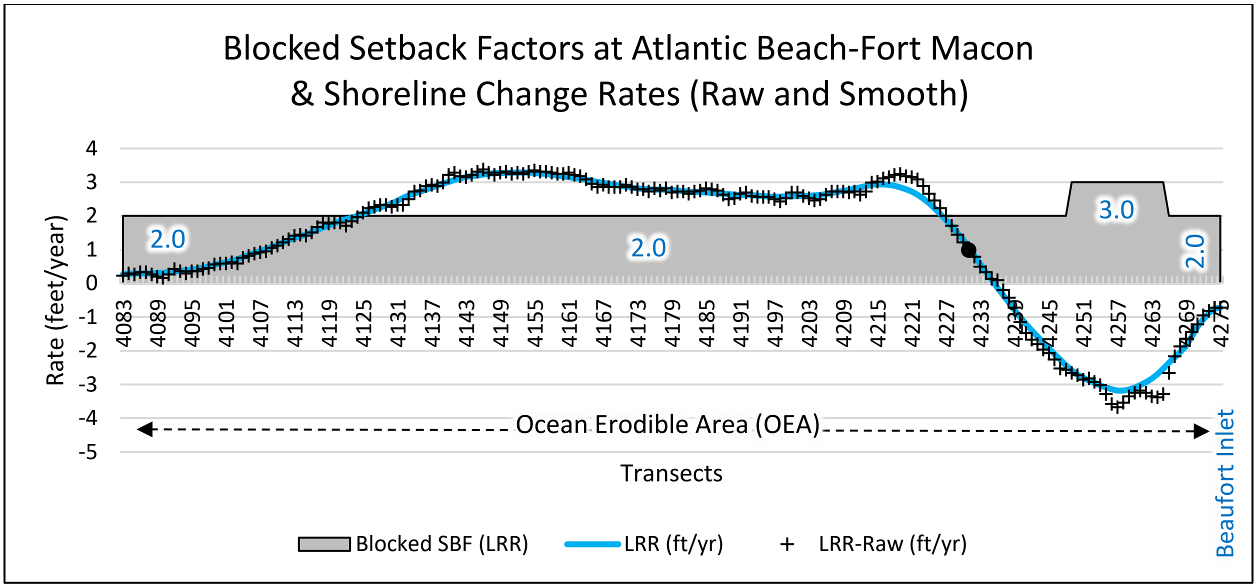

Figure 147. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 148. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Atlantic Beach and Fort Macon State Park.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2, 3	2	2, 2.5	2, 2.5	2, 3	2, 5	2	N/A

Table 25. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.25 Shackleford Banks

Shackleford Banks is an undeveloped south-facing barrier island with approximately 8.1 miles of oceanfront shoreline and is flanked by two inlets (Beaufort and Barden).

Here, the analysis assessed seventeen shorelines (**Figure 149**) along this oceanfront section over an 87-year period, from 1933 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 160 feet (oceanfront) to a maximum of 2,622 feet (inlet), with an average of 593 feet for the entire shoreline between Beaufort Inlet and Barden Inlets. The calculated relative standard deviation of shoreline position ranged between 57 and 866 feet, and an average of 186 feet. Of the 8.1 miles of shoreline analyzed, approximately 7.6 miles (94%) resulted in measured erosion where rates ranged between -18.5 and less than -1 feet per year and averaged -5.0 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (***Figure 150***). Between transects 4279 and 4563, the end-point method resulted in a range of shoreline line change rates between -32.6 and +4.9 feet per year, averaging -5.5 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -18.5 and +9.0 feet per year, averaging -3.6 foot per year. The highest rates were measured adjacent to Beaufort Inlet where rapid erosion has occurred since 2010. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 28.5 feet per year, and least squares regression ranged from 2 to 16 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 4279 and 4563 range from 2 to 16 feet per year (**Figure 151** to **Figure 154** & **Table 26**).

Figure 149. *Shorelines included in the analysis (1933-2020) at Shackleford Banks.*

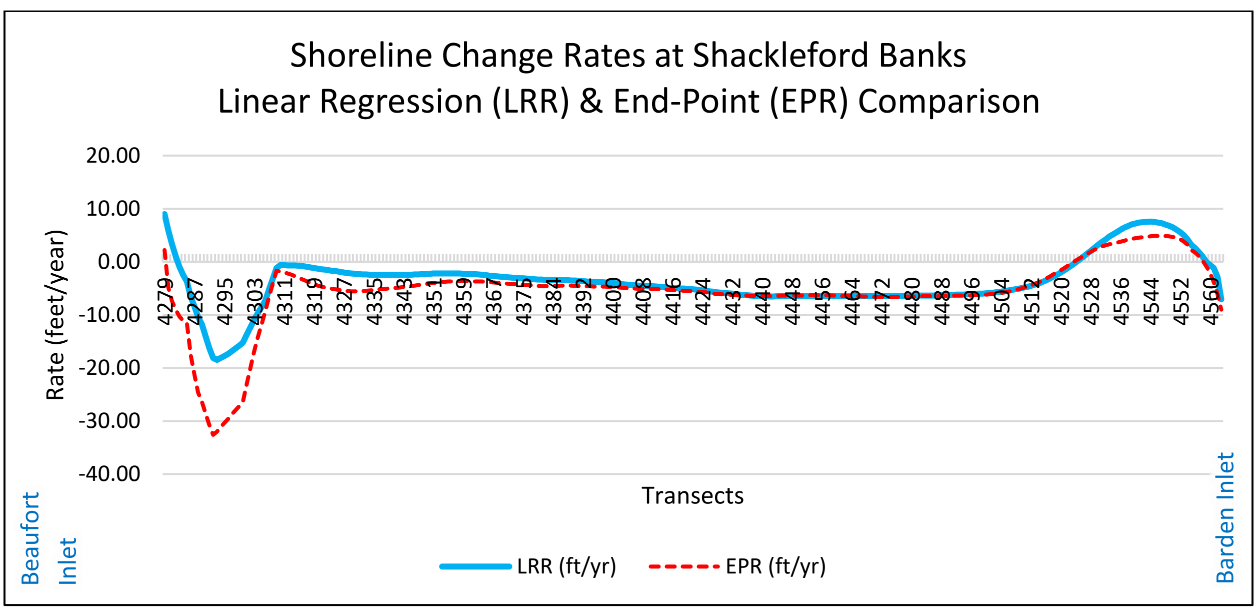

Figure 150. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 151. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

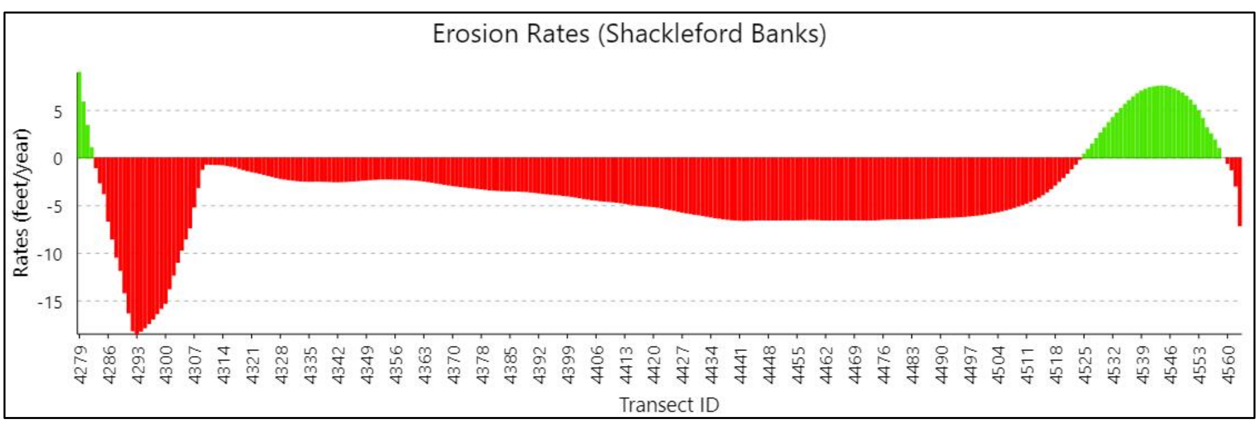

Figure 152. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

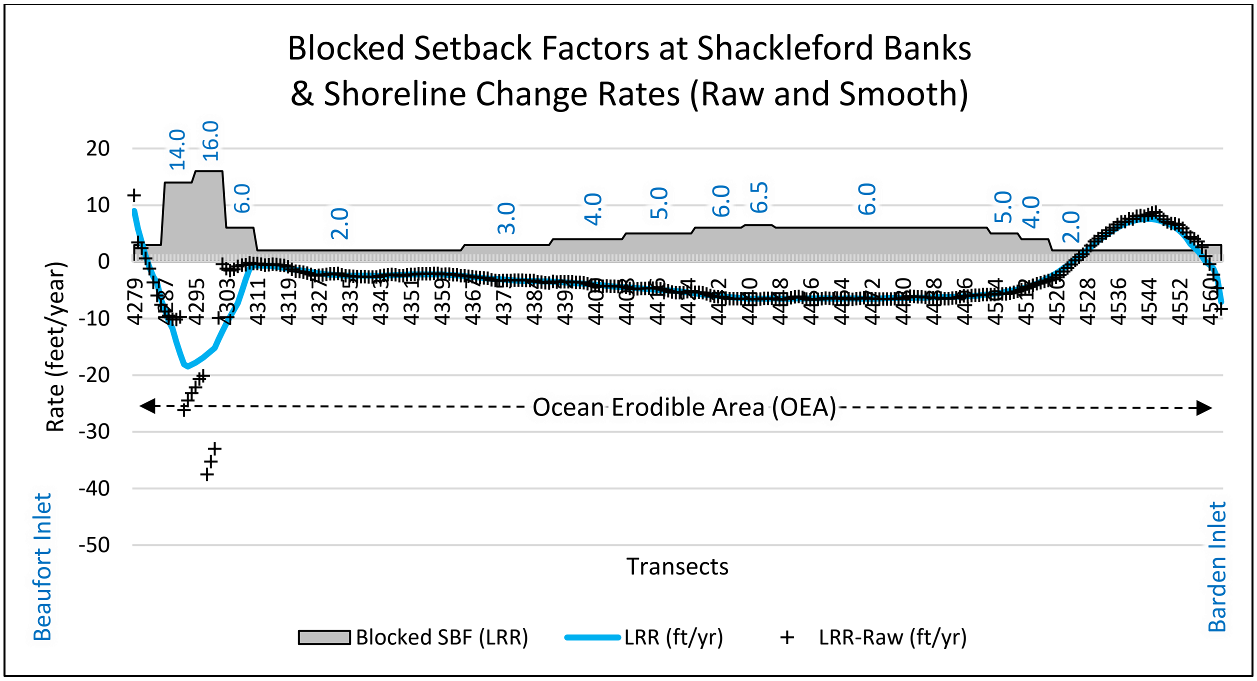

Figure 153. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 154. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Shackleford Banks.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 16	Range 2 to 7	Range 2 to 5.5	Range 2 to 6	Range 2 to 9.5	N\A	N\A	N\A

Table 26. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.26 Cape Lookout

At Cape Lookout starting at Barden Inlet moving towards the point at the cape is an undeveloped south-facing part of the Core Banks, with approximately 3.2 miles of oceanfront shoreline.

Here, the analysis assessed seventeen shorelines (**Figure 155**) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 161 feet to a maximum of 1,558 feet, with an average of 642 feet for the entire shoreline between Barden Inlet and Cape Lookout. The calculated relative standard deviation of shoreline position ranged between 47 and 540 feet, and an average of 208 feet. Of the 3.2 miles of shoreline analyzed, approximately 2.2 miles (69%) resulted in measured erosion where rates ranged between -11.8 and less than -1 feet per year and averaged -5.5 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 156**). Between transects-4566 and -4685, the end-point method resulted in a range of shoreline line change rates between -12.3 and +45.1 feet per year, averaging +1.3 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -11.8 and +44.3 feet per year, averaging +1.3 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 12 feet per year, and the least squares regression ranged from 2 to 12 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 4566 and 4685 range from 2 to 12 feet per year (**Figure 157** to **Figure 160** & **Table 27**).

Figure 155. *Shorelines included in the analysis (1946-2020) at Cape Lookout.*

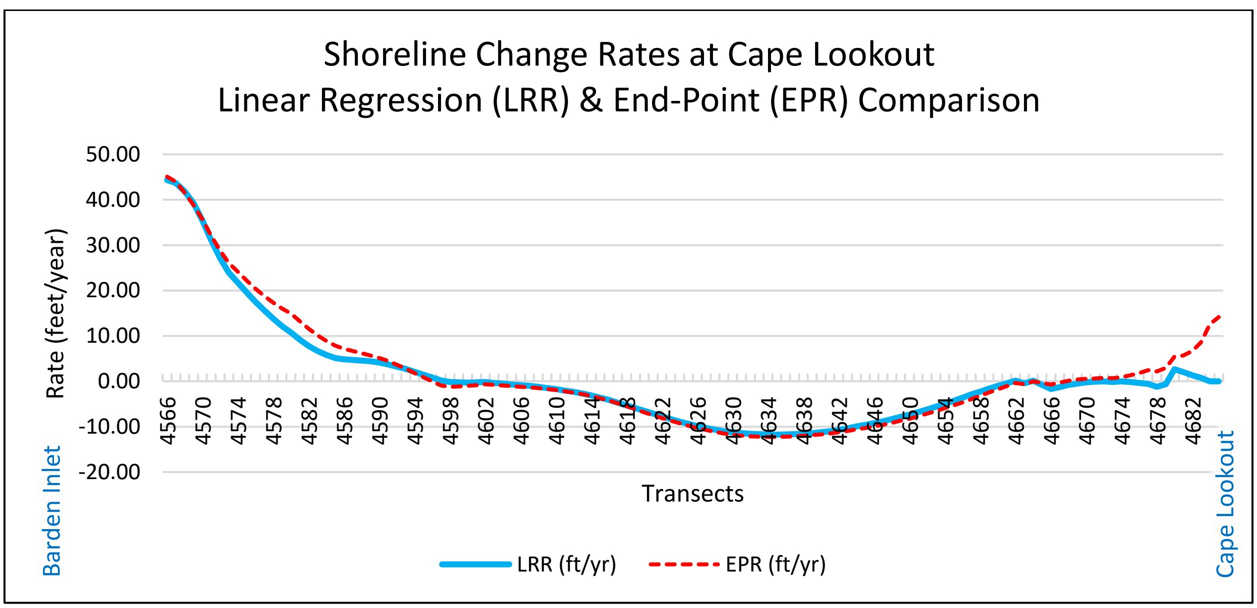

Figure 156. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

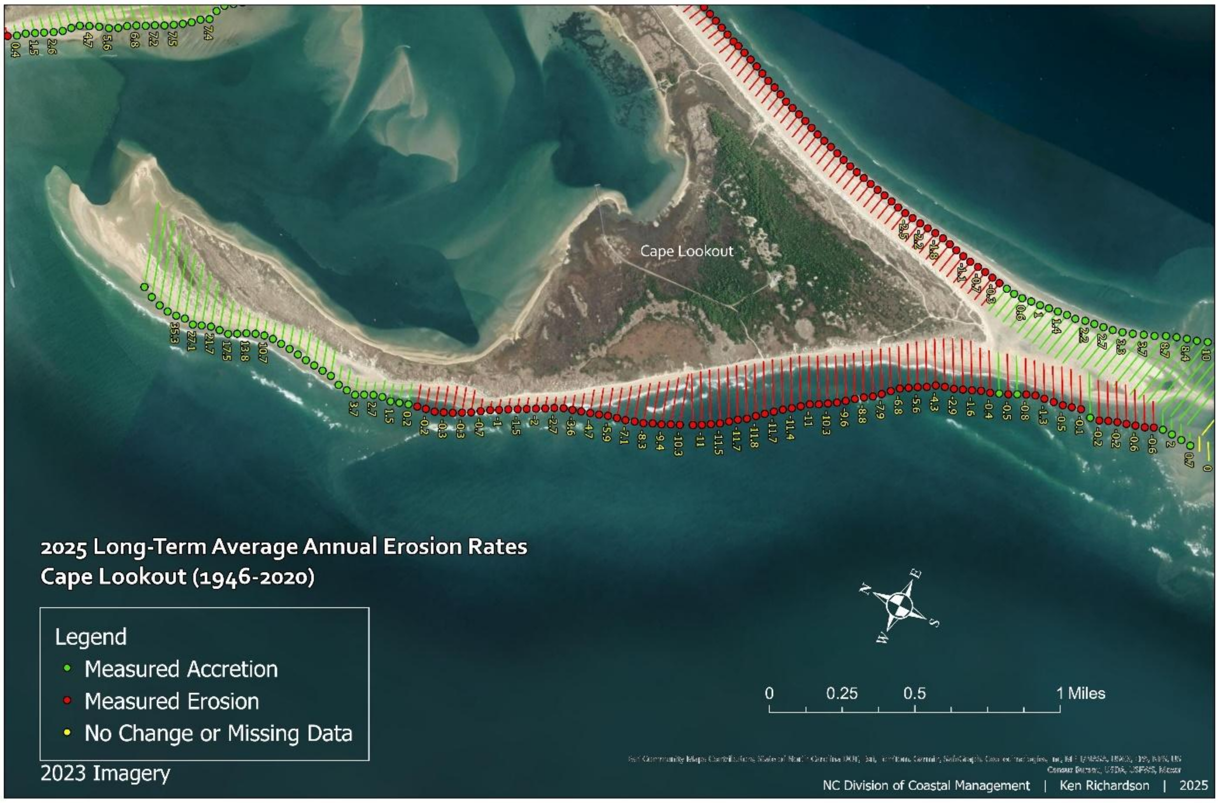

Figure 157. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

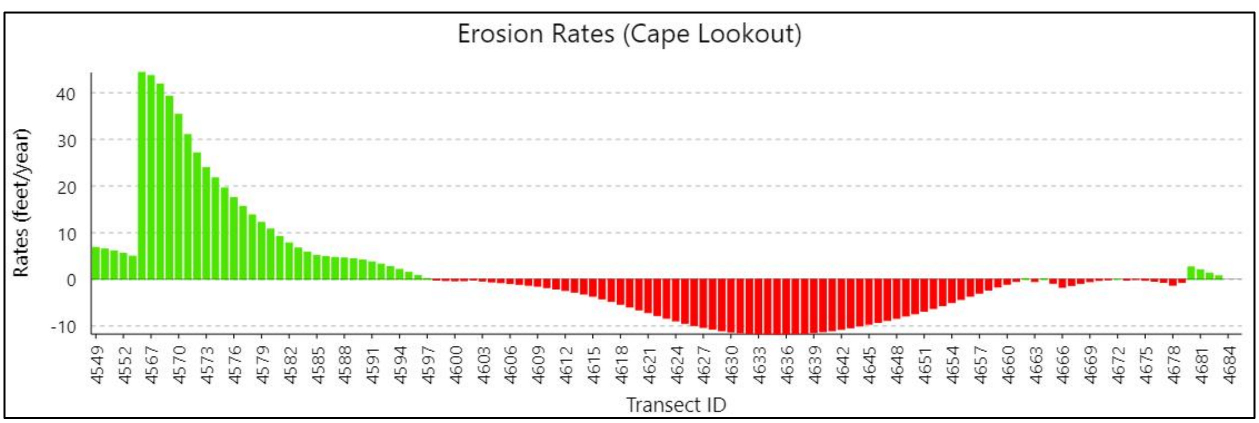

Figure 158. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

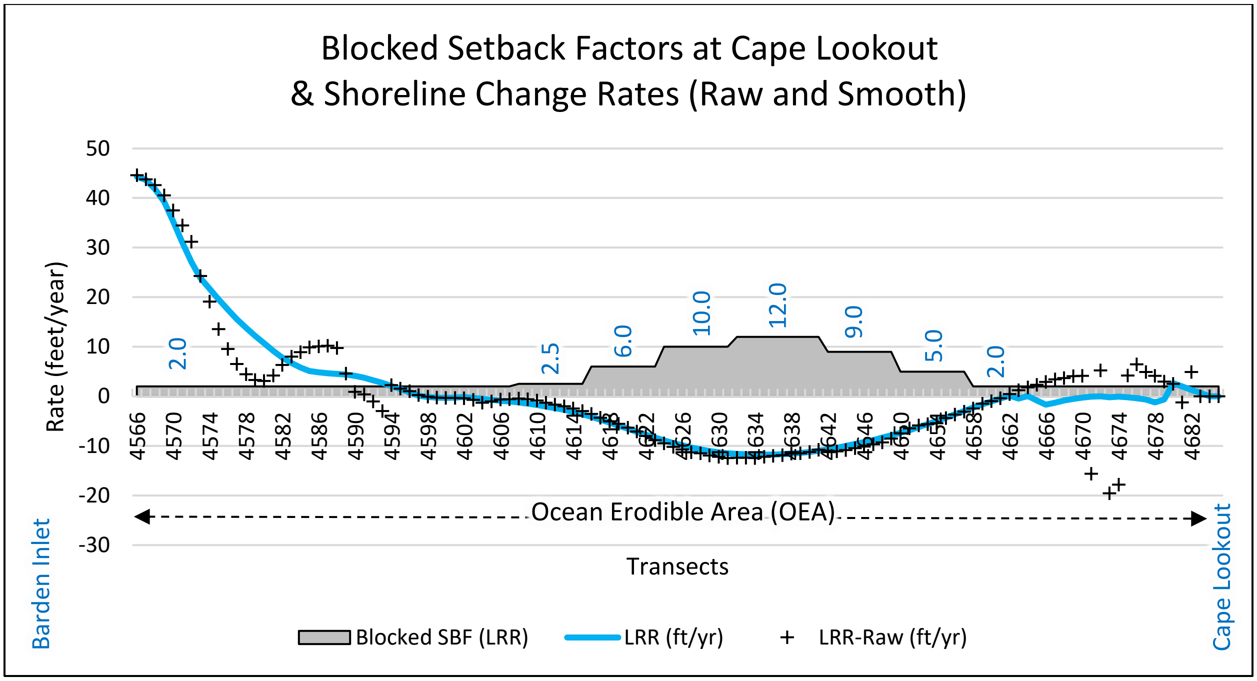

Figure 159. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 160. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Cape Lookout.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 12	Range 2 to 12	Range 2 to 11	Range 2 to 14.5	Range 2 to 16	N\A	N\A	N\A

Table 27. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.27 Core Banks (Cape Lookout to Drum Inlet)

The shoreline spans 21.6 miles from Core Banks from Cape Lookout to Drum Inlet. Here, the analysis assessed ten shorelines (**Figure 161**) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 61 feet to a maximum of 3,800 feet, with an average of 501 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between less than 1 and 1,399 feet, and an average of 159 feet. Of the 21.6 miles of shoreline analyzed, approximately 18.8 miles (87%) resulted in measured erosion where rates ranged between -25.7 and less than -1 feet per year and averaged -5.6 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 162**). Between transects 4686 and 5381, the end-point method resulted in a range of shoreline line change rates between -37.2 and +75.6 feet per year, averaging -5.1 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -25.7 and +18.7 feet per year, averaging -4.5 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 36 feet per year, and least squares regression ranged from 2 to 25 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 4566 and 4685 range from 2 to 25 feet per year ***(Figure 162 to Figure 166*** *&* ***Table 28****).*

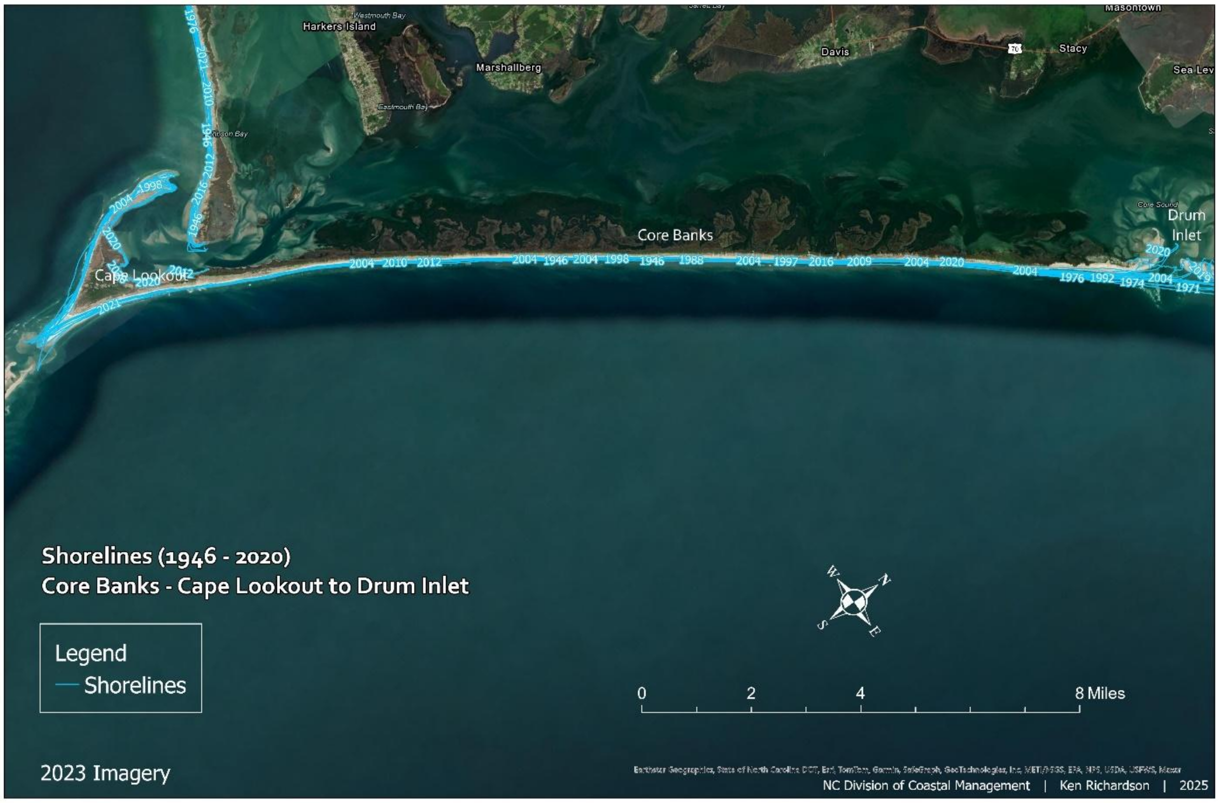

Figure 161. *Shorelines included in the analysis (1933-2020) at Cape Lookout to Drum Inlet.*

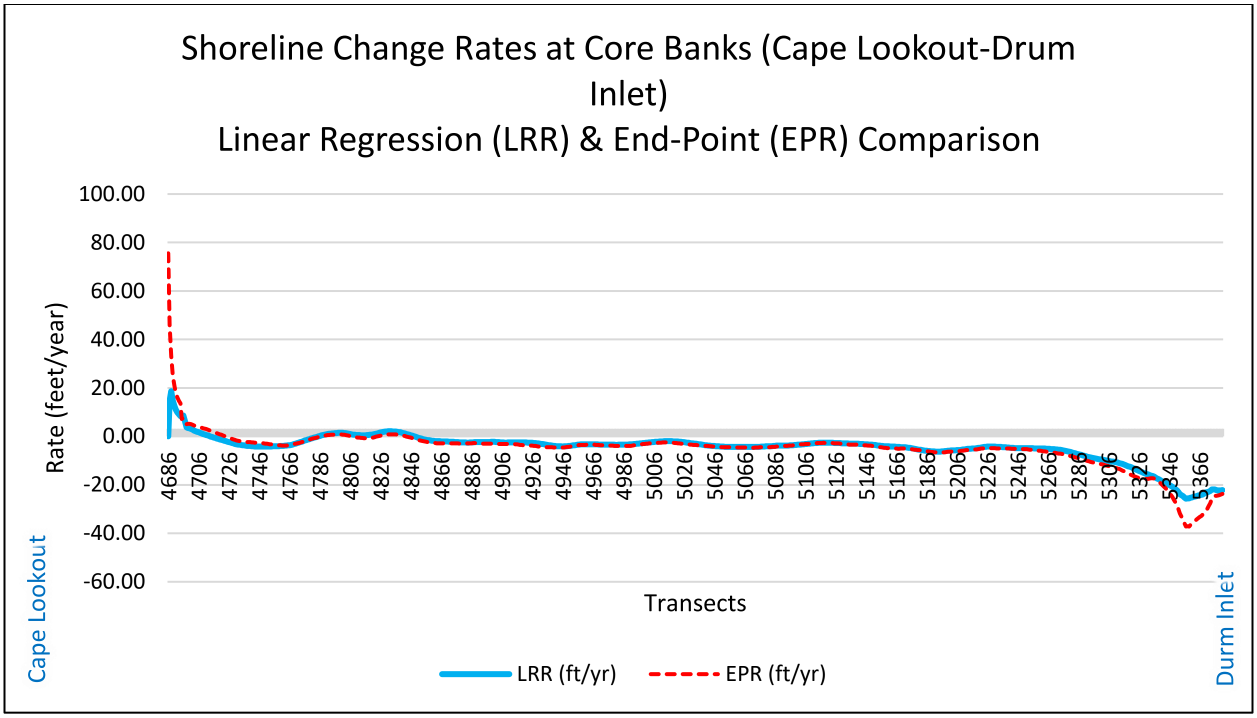

Figure 162. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

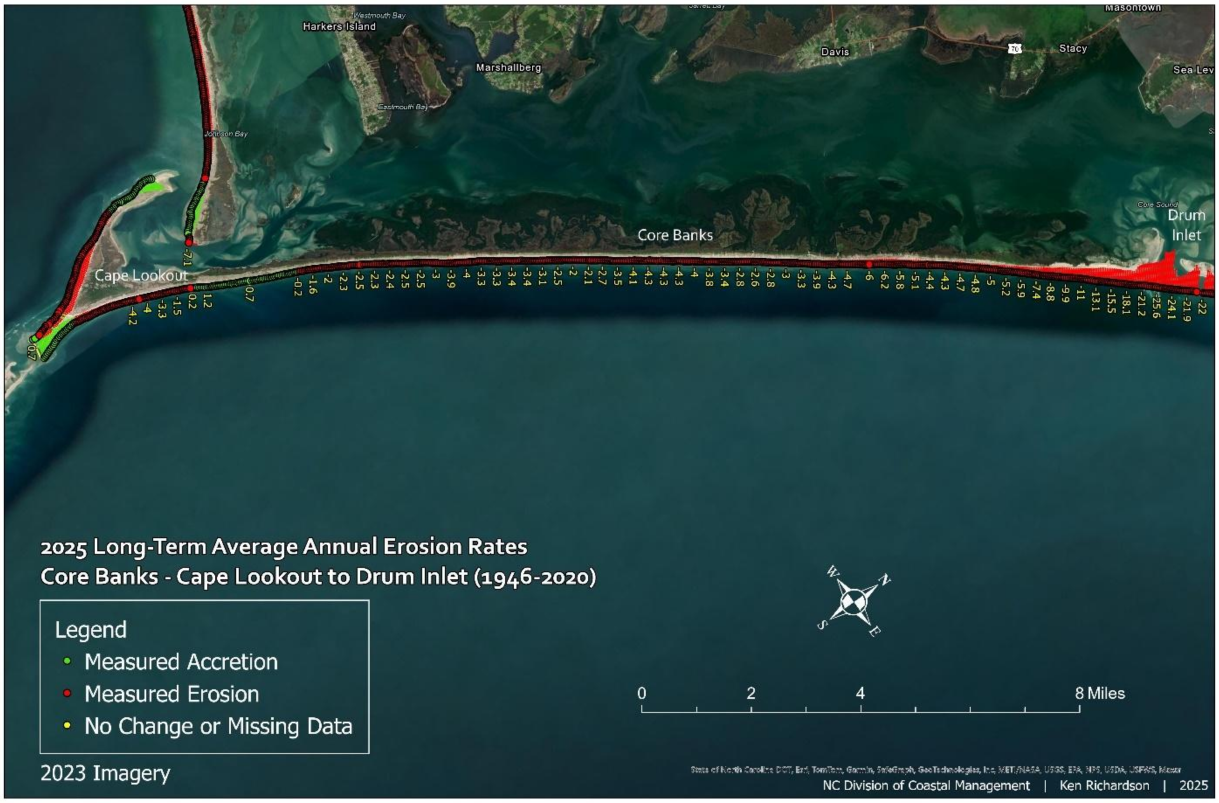

Figure 163. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

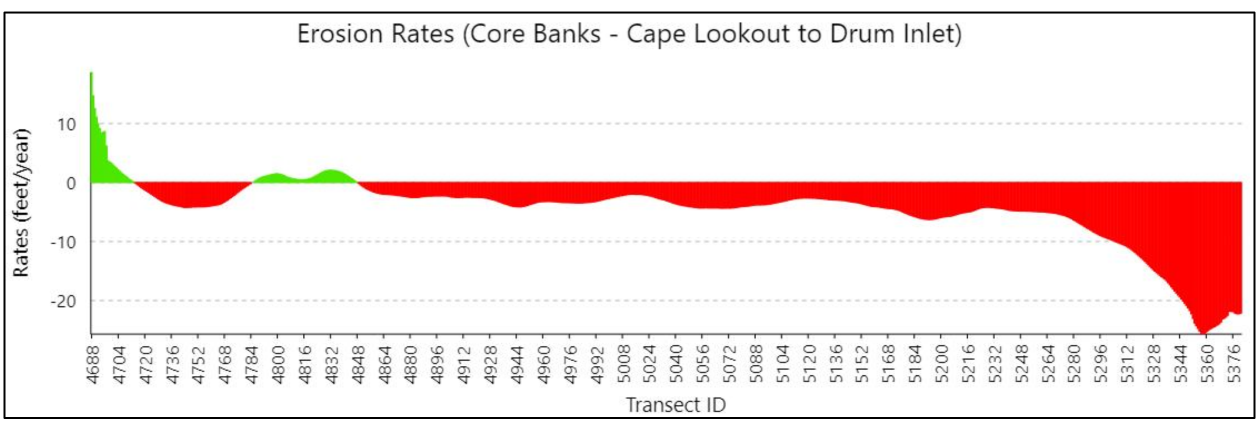

Figure 164. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

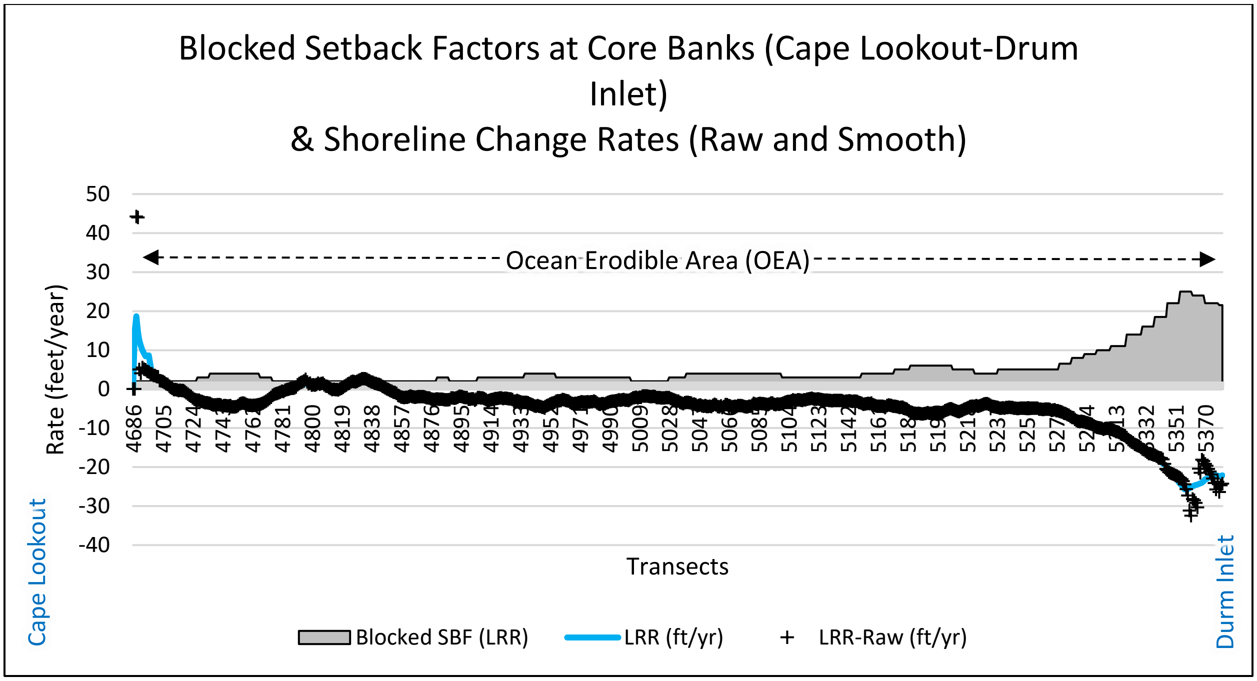

Figure 165. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 166. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Cape Lookout to Drum Inlet.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 25	Range 2 to 28.5	Range 2 to 18	Range 2 to 16	Range 2 to 14.5	N\A	N\A	N\A

Table 28. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.28 Core Banks (Drum Inlet to Ocracoke Inlet)

The shoreline spans 22.8 miles from Core Banks from Drum Inlet to Ocracoke Inlet. Here, the analysis assessed ten shorelines (***Figure 167***) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 86 feet to a maximum of 3,057 feet, with an average of 586 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 30 and 885 feet, and an average of 183 feet. Of the 22.8 miles of shoreline analyzed, approximately 20.8 miles (91%) resulted in measured erosion where rates ranged between -22 and less than -1 feet per year and averaged -5.1 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 168**). Between transects 5385 and 6116, the end-point method resulted in a range of shoreline line change rates between -23.4 and +10.3 feet per year, averaging -4.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -22 and +7.9 feet per year, averaging -4.3 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 23 feet per year, and the least squares regression ranged from 2 to 21.5 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 5385 and 6116 range from 2 to 21.5 feet per year (**Figure 169** to **Figure 172** & **Table 29**).

Figure 167. *Shorelines included in the analysis (1946-2020) at Drum Inlet to Ocracoke Inlet.*

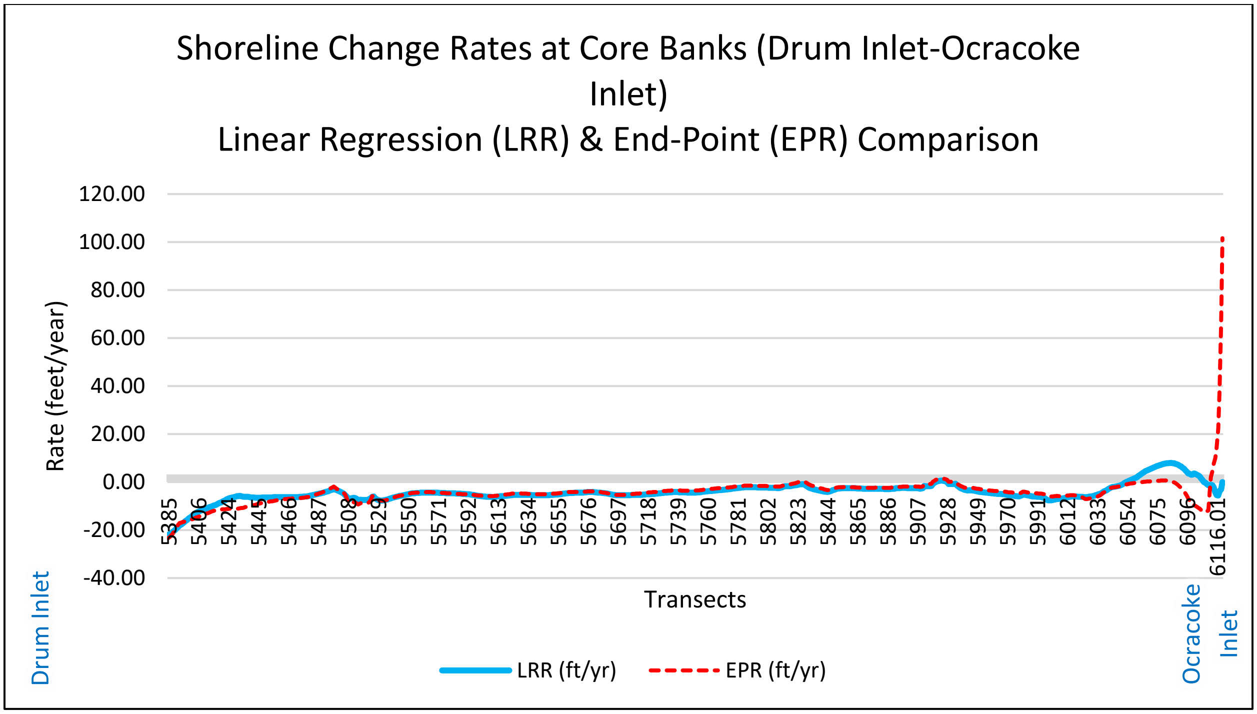

Figure 168. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 169. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

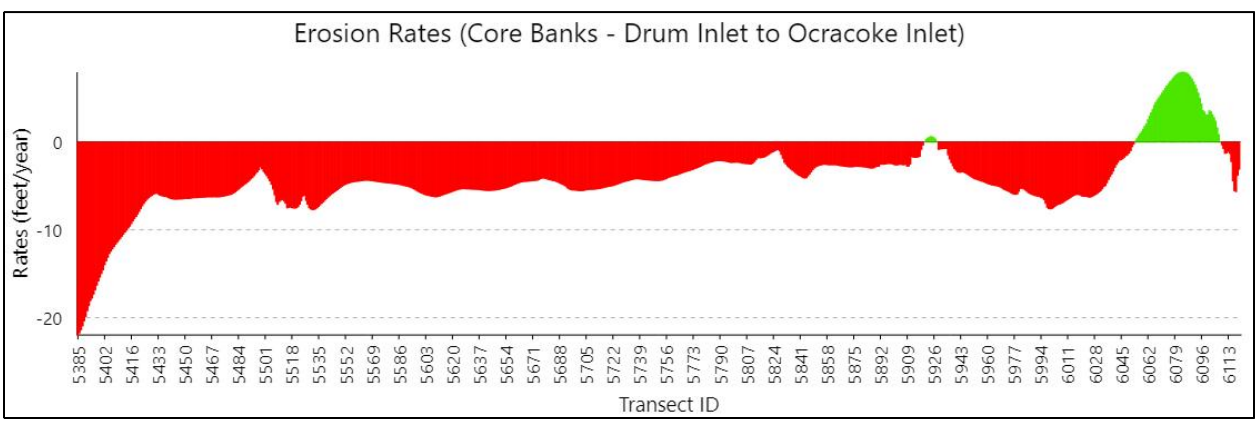

Figure 170. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

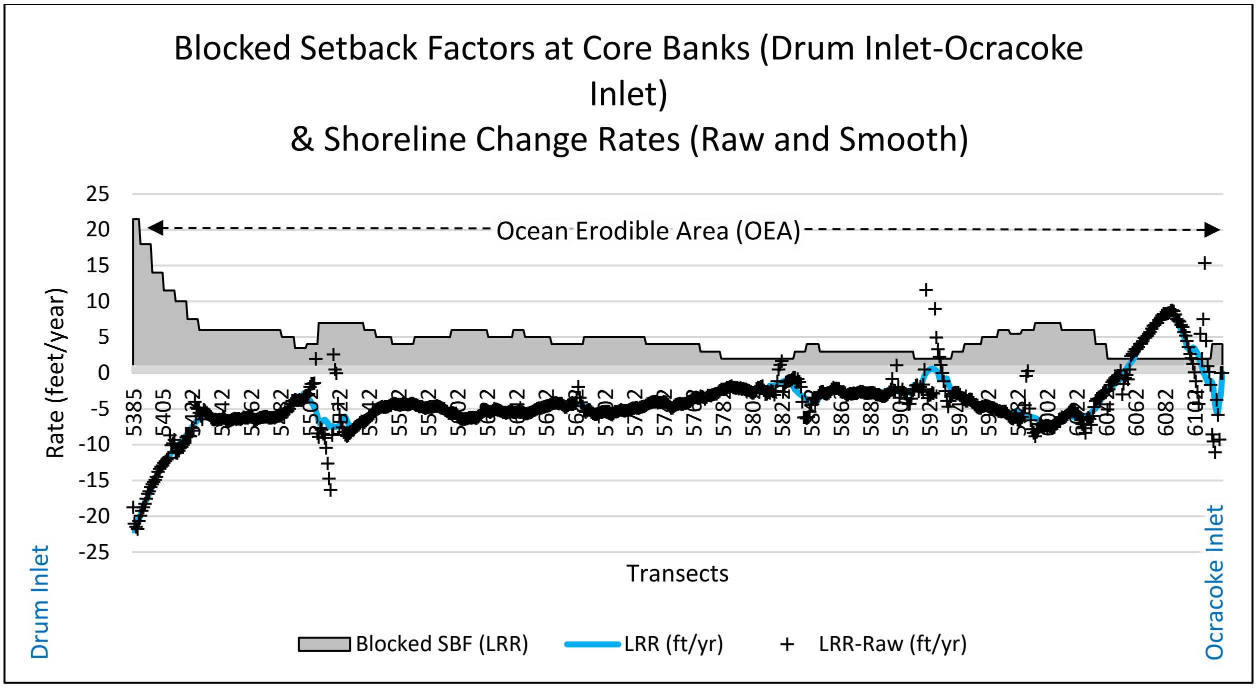

Figure 171. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

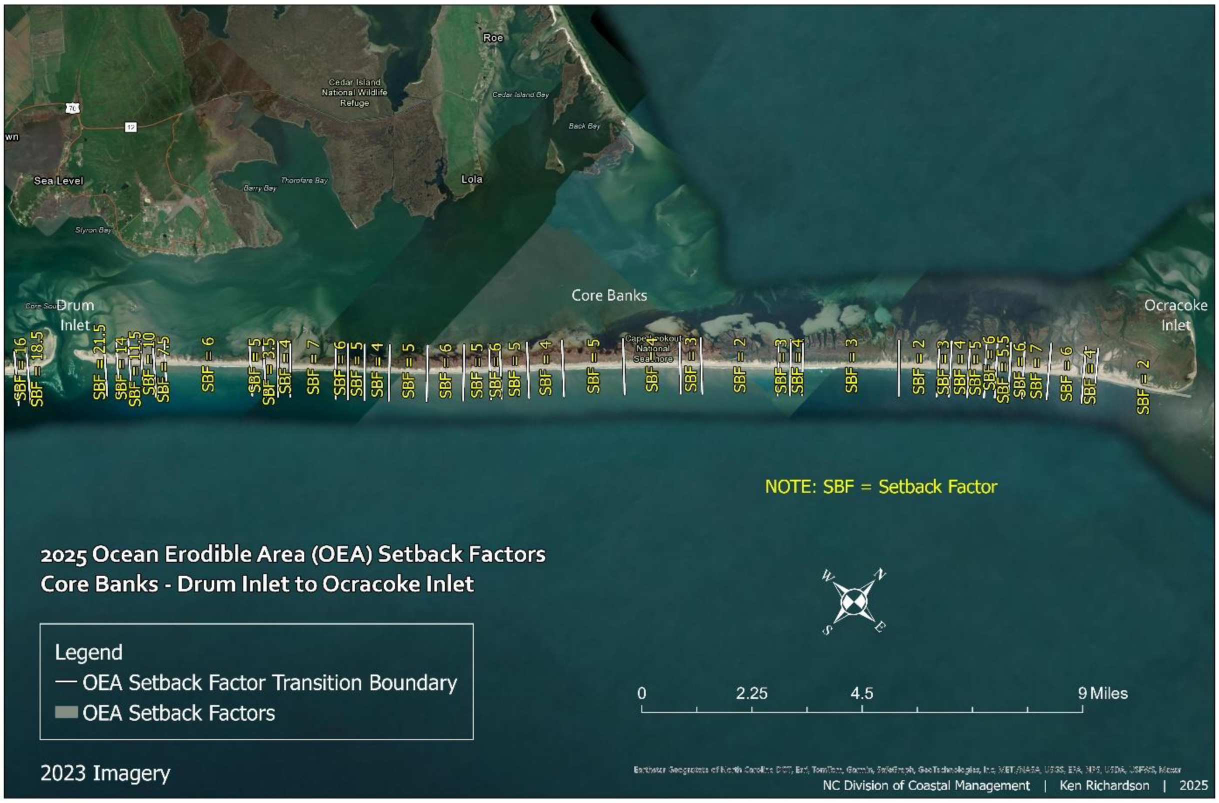

Figure 172. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Drum Inlet to Ocracoke Inlet.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 21.5	Range 2 to 11	Range 2 to 8.5	Range 2 to 30	Range 2 to 17	N\A	N\A	N\A

Table 29. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.29 Ocracoke

At Ocracoke Island, the oceanfront shoreline spans 16.2 miles between Ocracoke Inlet to the south and Hatteras Inlet to the north. Here, the analysis assessed ten shorelines (***Figure 173***) along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 83 feet to a maximum of 3,910 feet, with an average of 568 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 26 and 1,073 feet, and an average of 172 feet. Of the 16.22 miles of shoreline analyzed, approximately 11.9 miles (73%) resulted in measured erosion where rates ranged between -16.8 and less than -1 feet per year and averaged -4.4 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 174**). Between transects 6117 and 6636, the end-point method resulted in a range of shoreline line change rates between -16.7 and +9.3 feet per year, averaging -2.4 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -16.8 and +14.6 feet per year, averaging -3.0 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 16 feet per year, and the least squares regression ranged from 2 to 28 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 6117 and 6636 range from 2 to 28 feet per year (**Figure 175** to **Figure 178** & **Table 30**).

Figure 173. *Shorelines included in the analysis (1940-2020) at Ocracoke Island.*

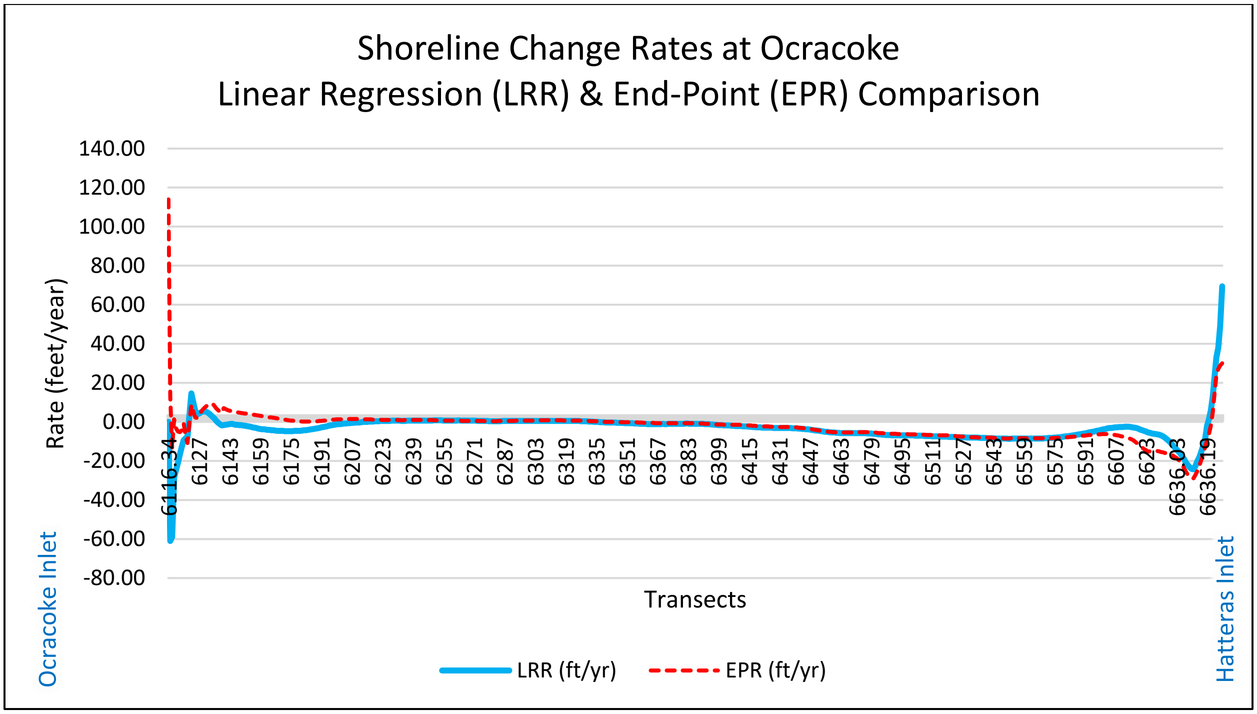

Figure 174. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 175. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

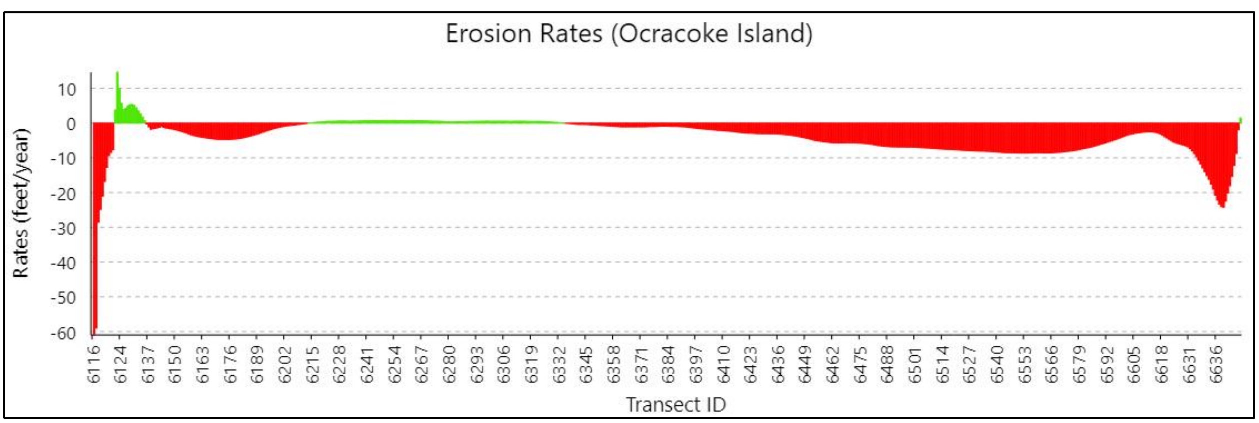

Figure 176. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

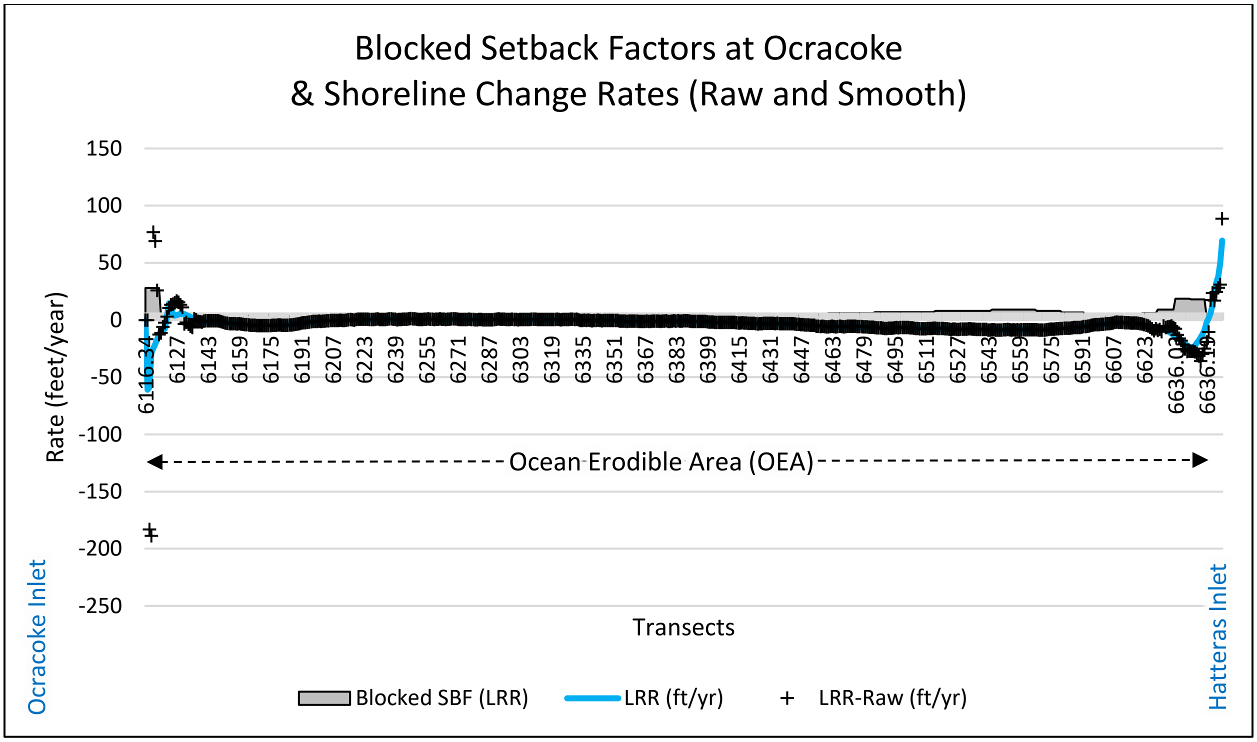

Figure 177. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 178. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Ocracoke Island.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 28	Range 2 to 9	Range 2 to 8.5	Range 2 to 9	Range 2 to 43	Range 2 to 17	2	2

Table 30. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.30 Hatteras Village to Cape Hatteras

From Hatteras Inlet to Cape Hatteras, the analyzed oceanfront shoreline spanned 13.3 miles, including Hatteras Village and Frisco. Here, the analysis assessed sixteen shorelines (***Figure 179***) along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 97 feet to a maximum of 5,452 feet, with an average of 785 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 33 and 4,051 feet, and an average of 238 feet. Of the 13.3 miles of shoreline analyzed, approximately 7.3 miles (55%) resulted in measured erosion where rates ranged between -15.1 and less than -1 feet per year and averaged -4.2 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 180**). Between transects 6640 and 7077, the end-point method resulted in a range of shoreline line change rates between -20.3 and +30 feet per year, averaging +2.4 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -15.1 and +69.4 feet per year, averaging +3.2 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 16 feet per year, and the least squares regression ranged from 2 to 15 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 6640 and 7077 range from 2 to 15 feet per year. Compared to current effective setback factors (2020), this portion of the shoreline between transects 6789 and 6800 will experience an decrease by 1 foot per year (**Figure 181** to **Figure 185** & **Table 31**).

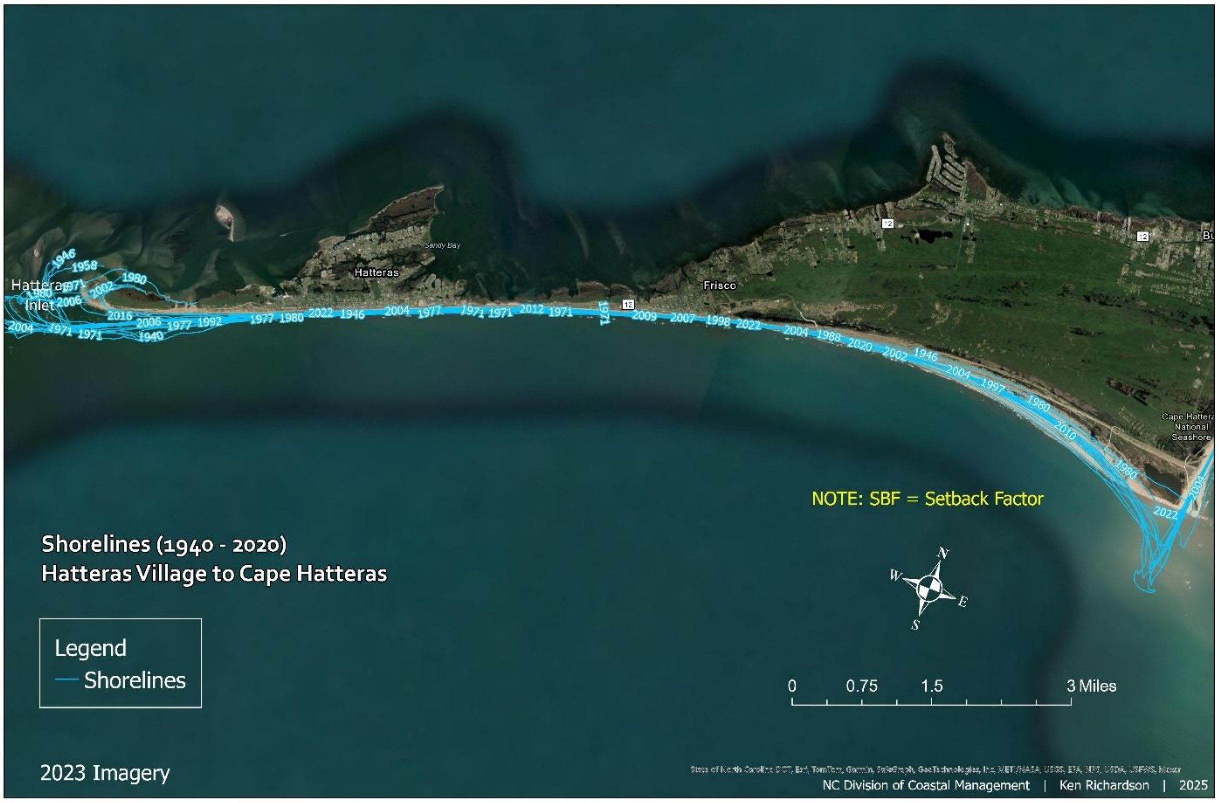

Figure 179. Shorelines included in the analysis (1940-2020) at Hatteras Inlet to Cape Hatteras.

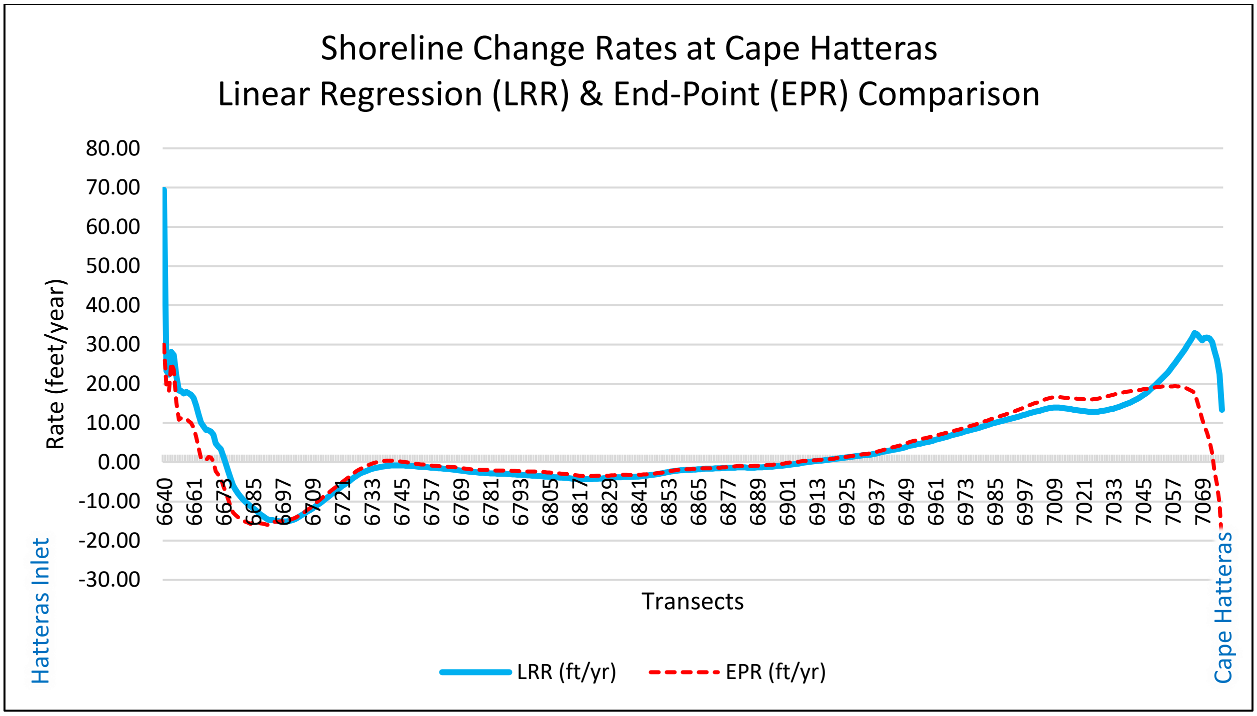

Figure 180. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

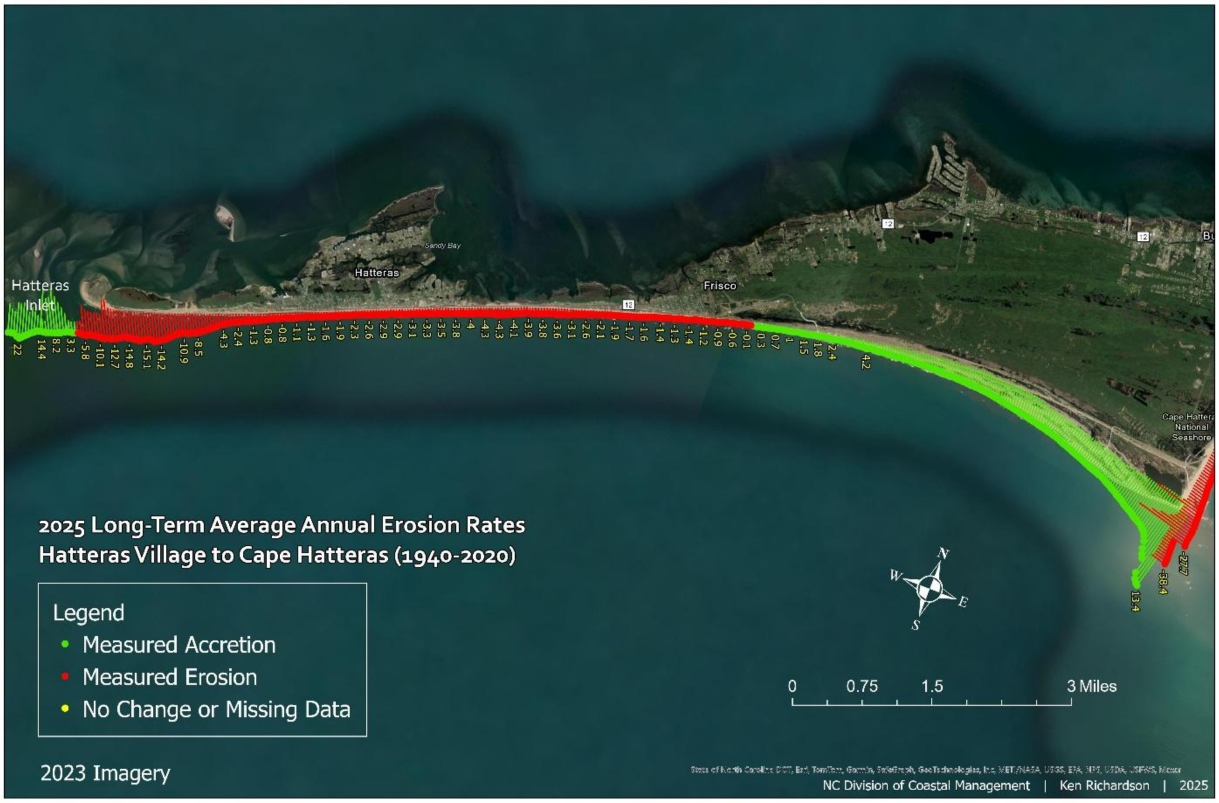

Figure 181. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

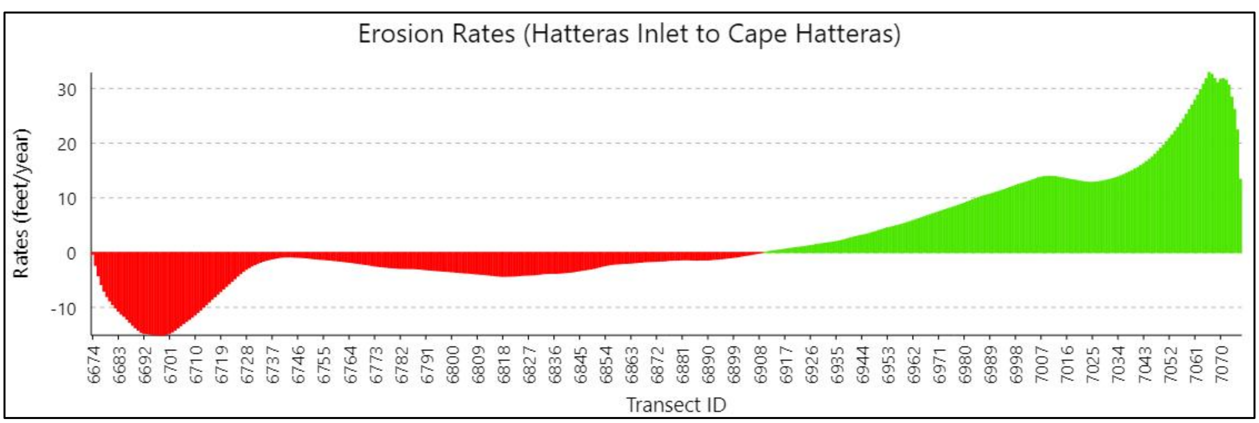

Figure 182. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

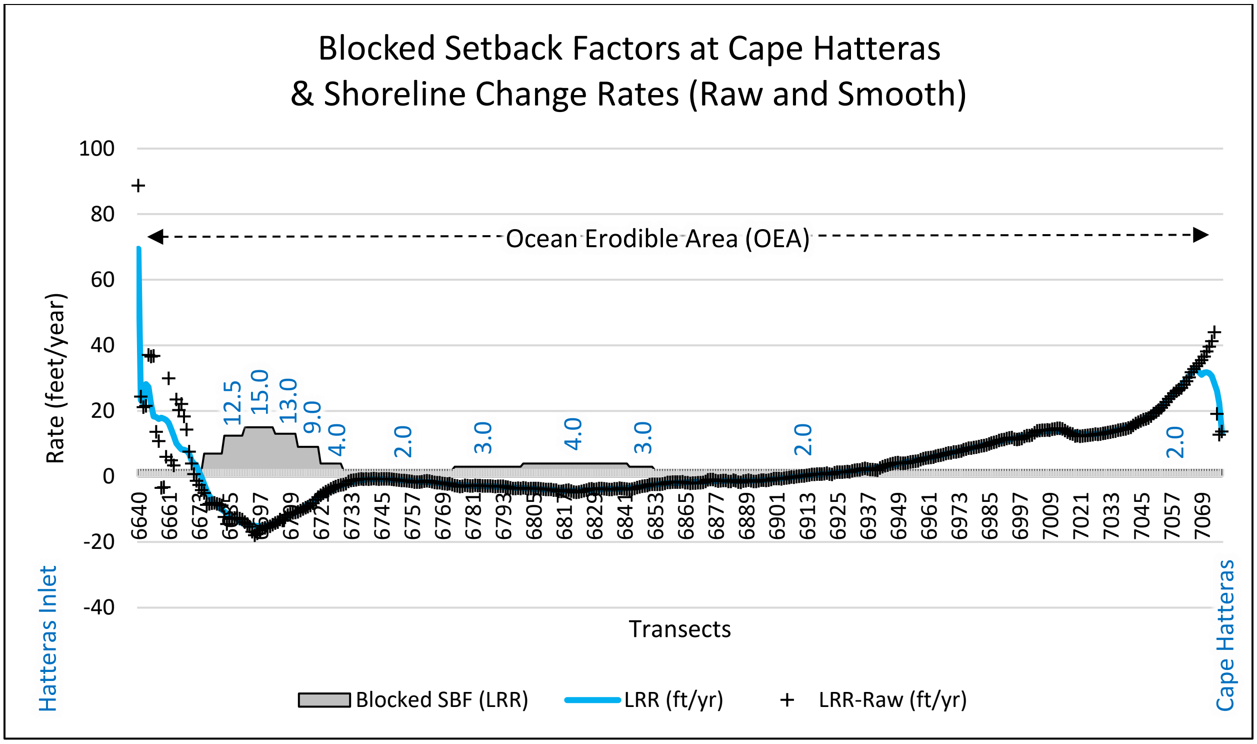

Figure 183. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 184. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Hatteras Village.*

Figure 185. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Hatteras Inlet to Cape Hatteras.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 15	Range 2 to 16.5	Range 2 to 11.5	Range 2 to 13.5	Range 2 to 13	Range 2 to 10	2	N/A

Table 31. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.31 Cape Hatteras to Buxton

The analyzed shoreline extends 3.5 miles from Cape Hatteras to the northern boundary of Buxton, an area with a long history of significant erosion. Although this stretch has not been regularly nourished, numerous efforts have been made to mitigate erosion due to the areas historical and infrastructural significance of the Cape Hatteras Lighthouse, former U.S. Naval Facility and Coast Guard Station located just north of the lighthouse, and Highway-12.

Efforts to address erosion date back to 1966, when a small-scale project was implemented to protect the most vulnerable areas. In 1967, sandbags were introduced to safeguard the lighthouse, and three permanent groins were constructed near the lighthouse and naval base to stabilize the shoreline. However, despite these measures, erosion persisted along the adjacent shorelines to the north and south of the groin field, with rates equal to or exceeding those recorded before construction.

In the early 1970s, additional smaller beach fill projects were undertaken in 1971 and 1972 to provide temporary relief, though these efforts had limited long-term impact. Over the decades, the shoreline continued to experience erosion, posing ongoing threats to infrastructure, natural habitats, and historical landmarks. It wasn't until 2017–2018 that a large-scale beach nourishment project was installed. To maintain the effectiveness of this large-scale effort, a maintenance nourishment project was carried out in 2022. These interventions have played a crucial role in trying to slow erosion and have served to artificially influence the natural shoreline position, but the area remains highly dynamic.

Here, the analysis assessed twelve shorelines (**Figure 186**) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 332 feet to a maximum of 3,405 feet, with an average of 774 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 103 and 804 feet, and an average of 219 feet. Of the 3.5 miles of shoreline analyzed, all 3.5 miles (100%) resulted in measured erosion where rates ranged between –38.4 and -1.5 feet per year and averaged -10.3 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 187**). Between transects 7078 and 7190, the end-point method resulted in a range of shoreline line change rates between -42.1 and +1.0 feet per year, averaging -10.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -38.4 and -1.5 feet per year, averaging -10.3 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 33 feet per year, and the least squares regression ranged from 2 to 31 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7078 and 7190 range from 3 to 31 feet per year. Compared to current effective setback factors (2020), between transects 7174 to Buxton's northern boundary, this area will experience a decrease of 1 to 2 feet per year (**Figure 188** to **Figure 191** & **Table 32**).

Figure 186. *Shorelines included in the analysis (1946-2020) at Cape Hatteras and Buxton.*

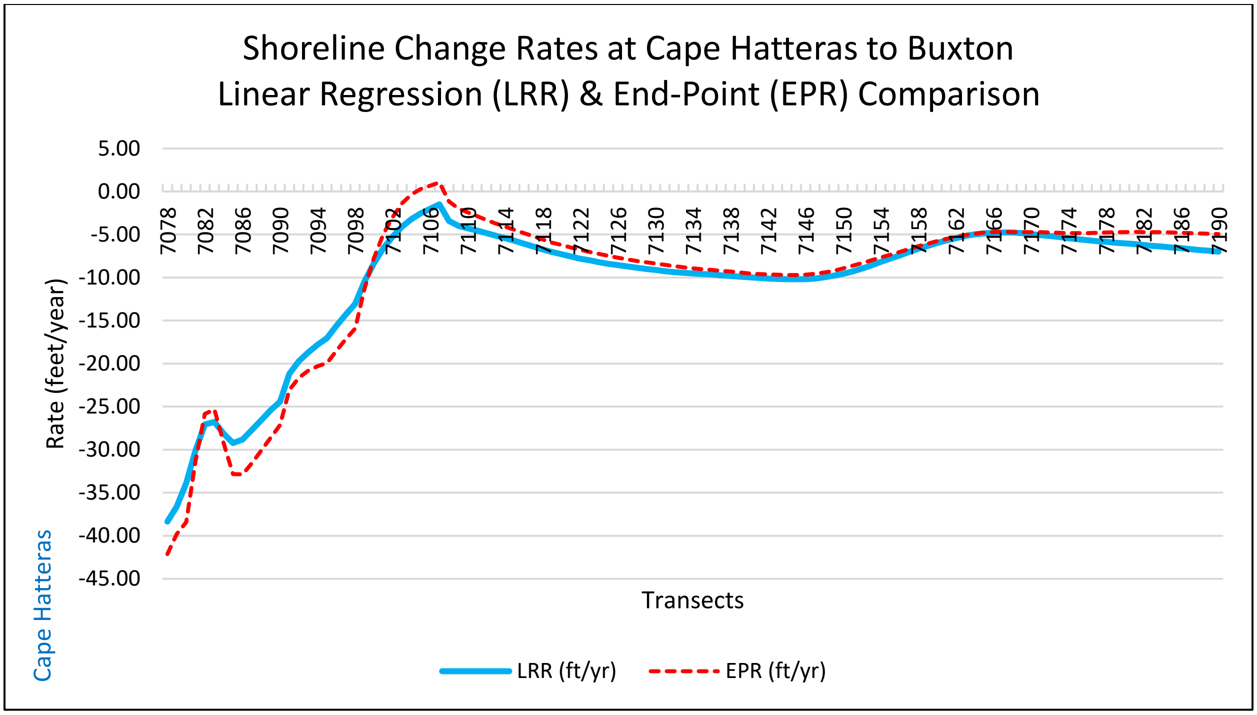

Figure 187. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

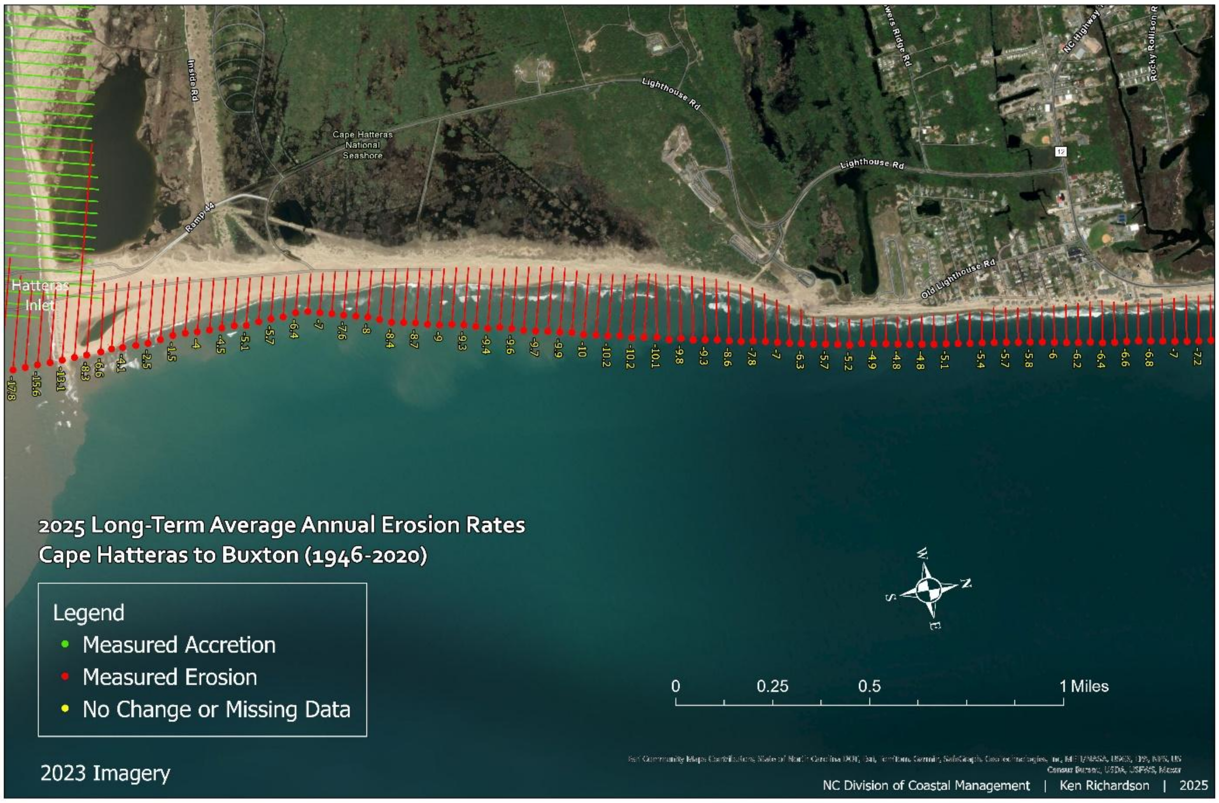

Figure 188. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

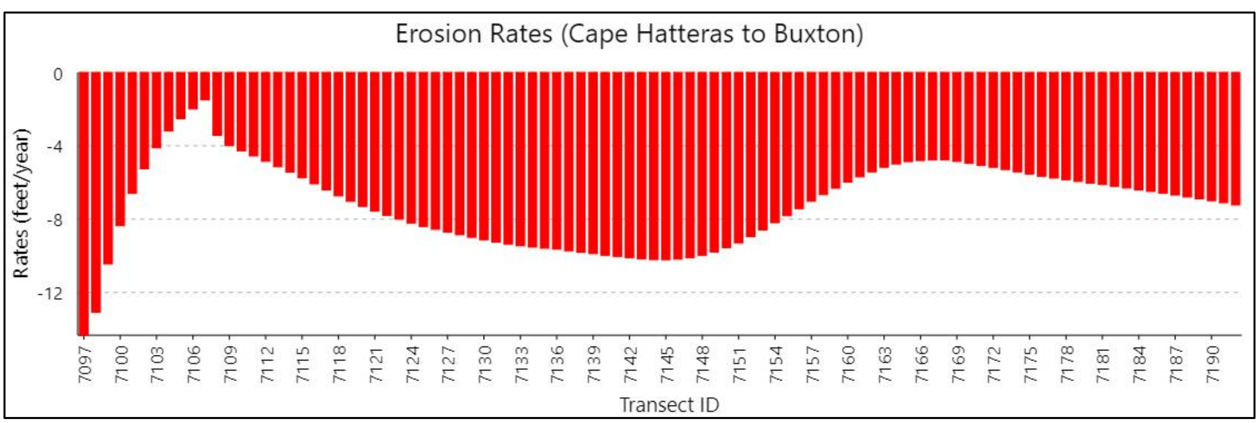

Figure 189. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

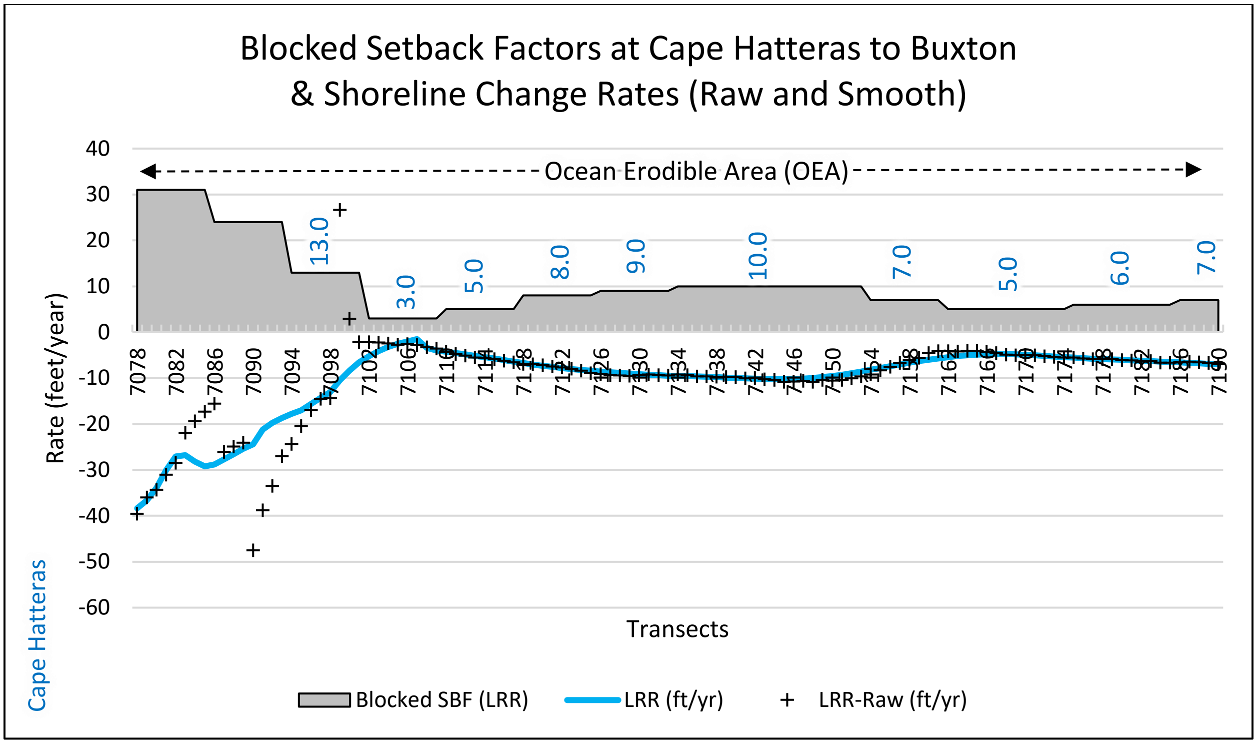

Figure 190. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 191. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Cape Hatteras and Buxton.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 3 to 31	Range 3 to 12	Range 2 to 11	Range 2 to 15.5	Range 6 to 11	Range 6 to 10.5	7.5 to 9	N/A

Table 32. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.32 National Seashore (Buxton to Avon)

Between Buxton and Avon, the oceanfront shoreline spans 3.9 miles. Here, the analysis assessed twelve shorelines (**Figure 192**) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 127 feet to a maximum of 715 feet, with an average of 472 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 40 and 232 feet, and an average of 145 feet. Of the 3.9 miles of shoreline analyzed, all 3.9 miles (100%) resulted in measured erosion where rates ranged between -9.0 and -1.4 feet per year and averaged -5.7 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 193**). Between transects 7191 and 7316, the end-point method resulted in a range of shoreline line change rates between -7.8 and -1.1 feet per year, averaging -4.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -9.0 and -1.4 feet per year, averaging -5.7 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 8 feet per year, and the least squares regression ranged from 2 to 9 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7191 and 7316 range from 2 to 9 feet per year (**Figure 193** to **Figure 197** & **Table 33**).

Figure 192. *Shorelines included in the analysis (1946-2020) between Buxton and Avon.*

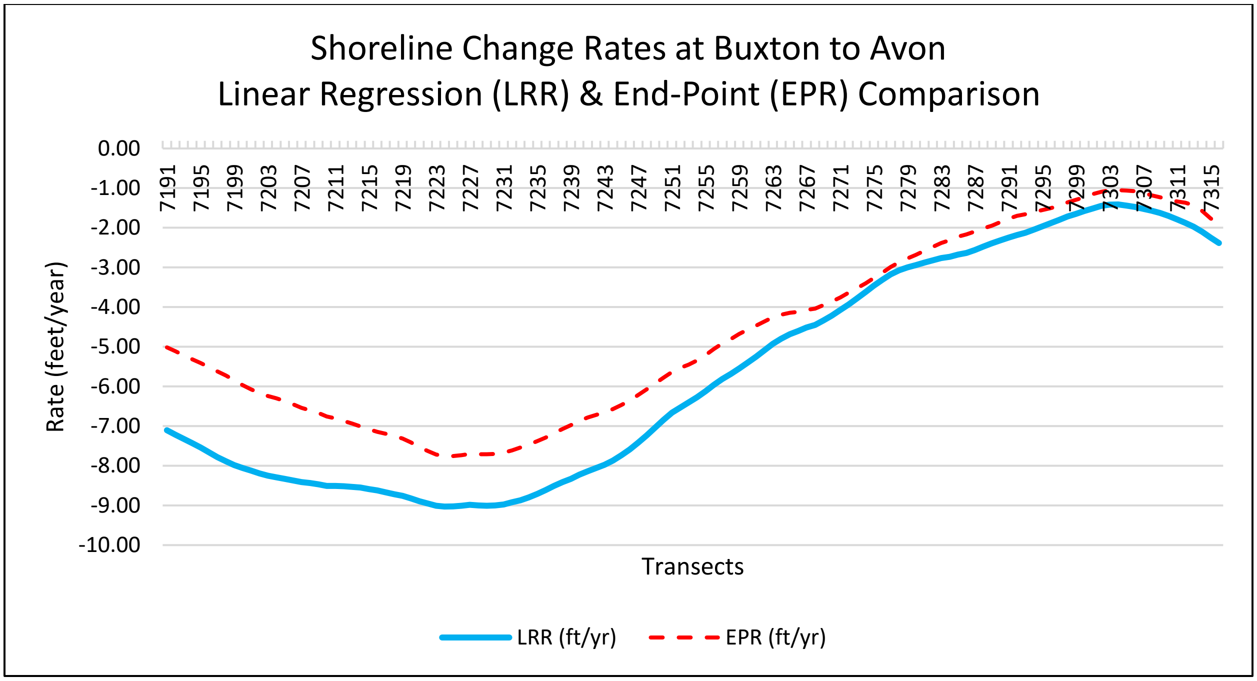

Figure 193. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

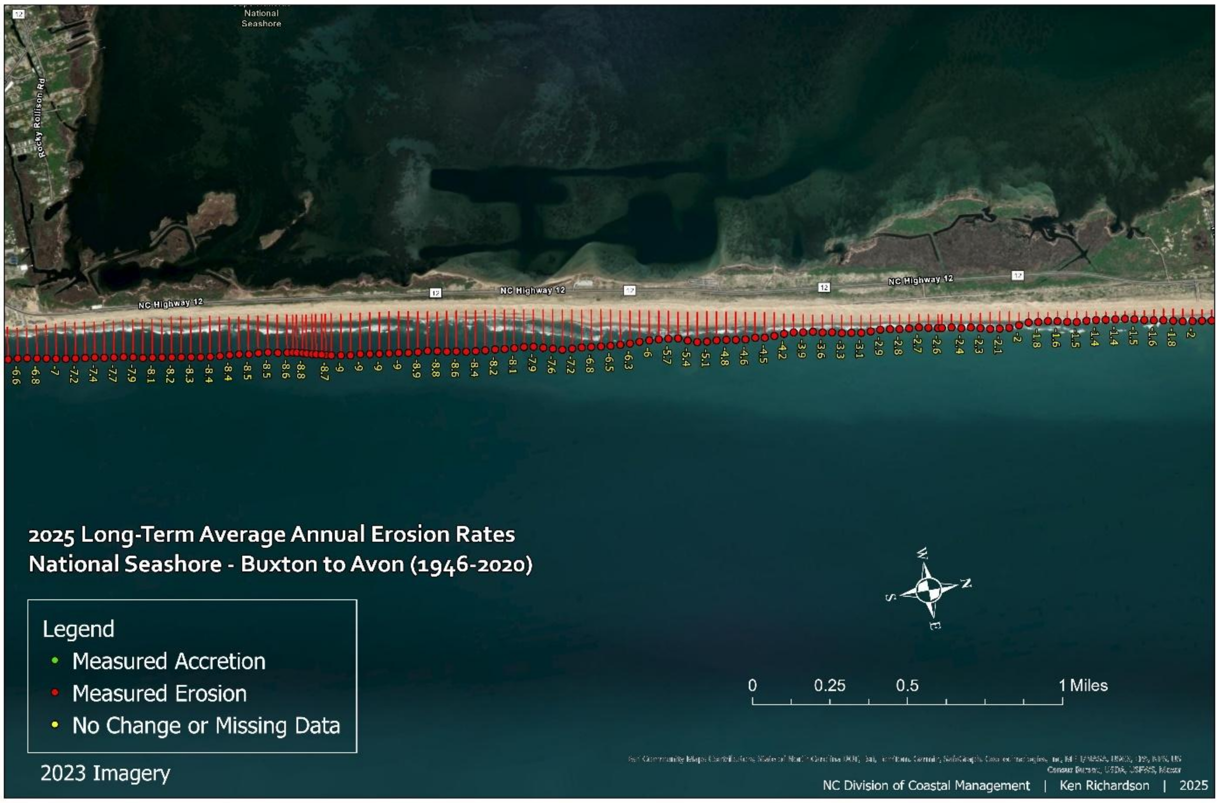

Figure 194. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

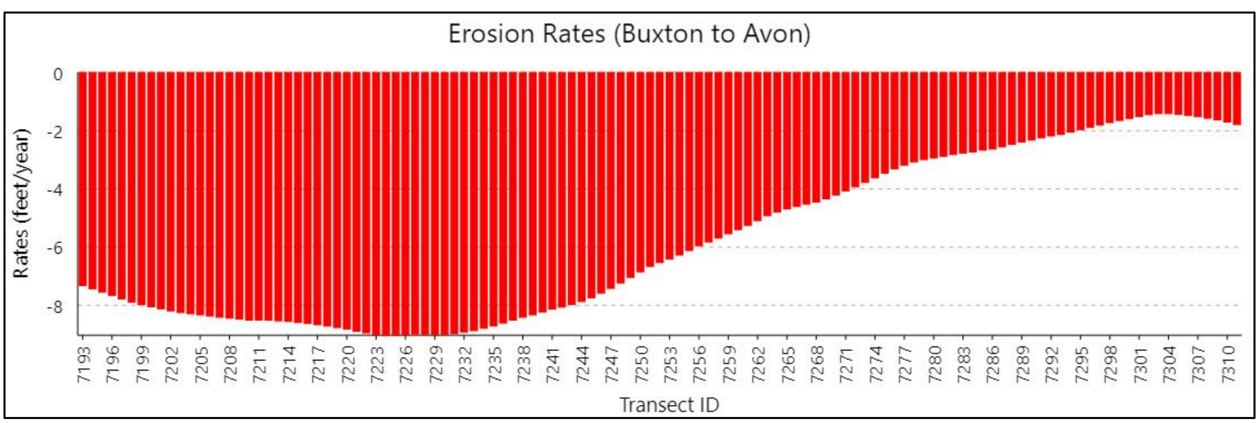

Figure 195. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

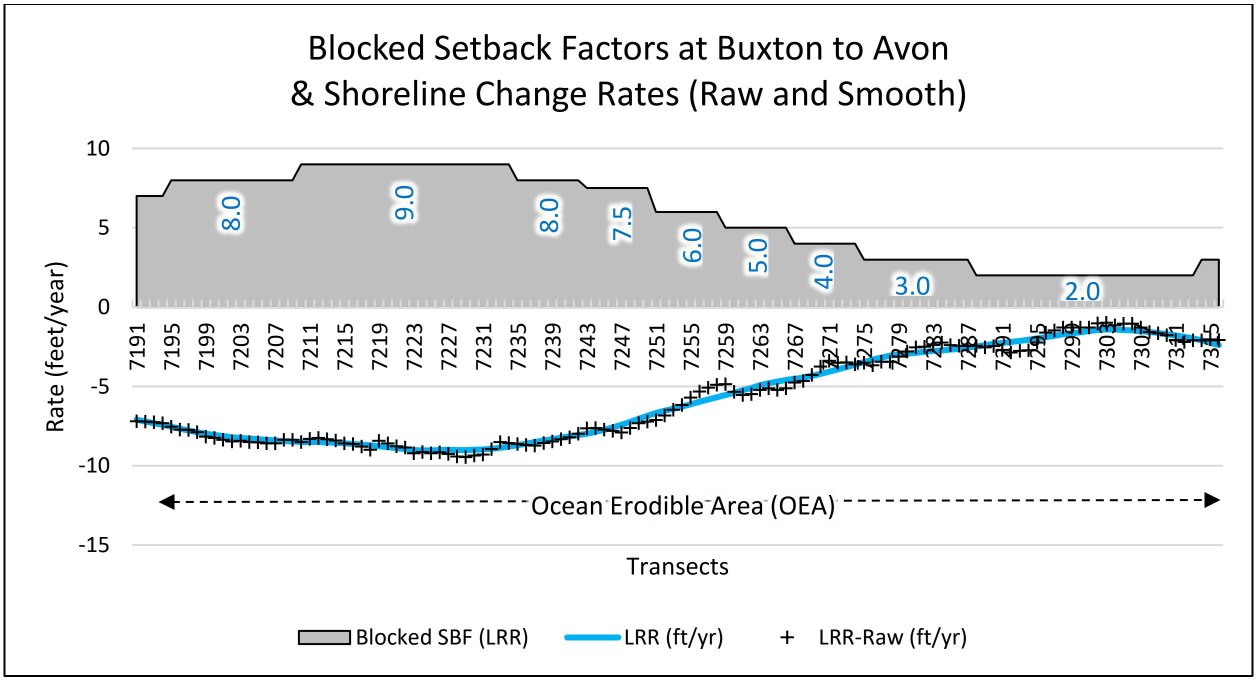

Figure 196. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 197. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Buxton and Avon.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 9	Range 2 to 10	Range 2 to 10	Range 2 to 10.5	Range 4.5 to 10	Range 4 to 10	Range 5 to 9	N/A

Table 33. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.33 Avon

The oceanfront shoreline at Avon extends 3.4 miles and was the site of a large-scale beach nourishment project in 2022. However, this project did not impact the findings of this study, as it took place after the most recent shoreline data used in the analysis.

Here, twelve shorelines (**Figure 198**) were assessed along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 110 feet to a maximum of 528 feet, with an average of 329 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 37 and 159 feet, and an average of 100 feet. Of the 3.4 miles of shoreline analyzed, 2.4 miles (71%) resulted in measured erosion where rates ranged between -5.4 and less than -1.0 feet per year and averaged -3.6 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 198**). Between transects 7317 and 7428, the end-point method resulted in a range of shoreline line change rates between -4.8 and +3.7 feet per year, averaging -1.1 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -5.4 and +3.8 feet per year, averaging -1.7 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 5 feet per year, and the least squares regression ranged from 2 to 5 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7317 and 7428 range from 2 to 5 feet per year. Compared to current effective setback factors (2020), most of the area between transects 7323 to 7382 will experience a 1 foot per year decrease (**Figure 200** to **Figure 203** & **Table 34**).

Figure 198. *Shorelines included in the analysis (1946-2020) at Avon.*

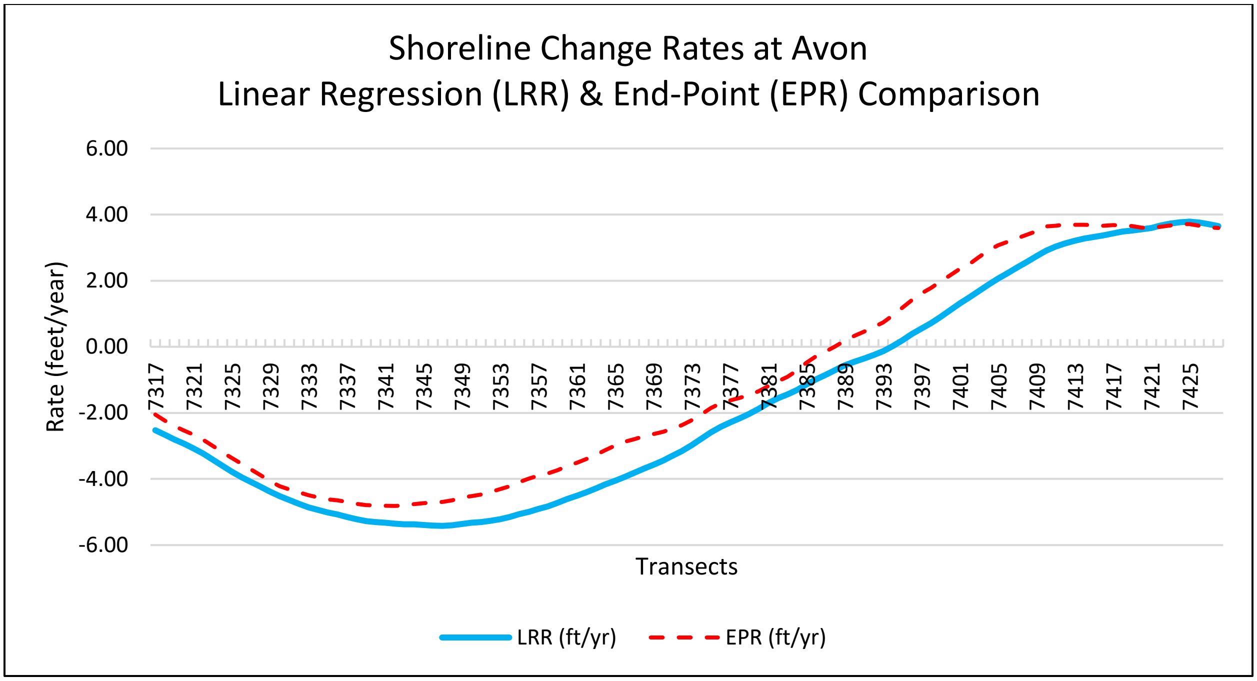

Figure 199. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

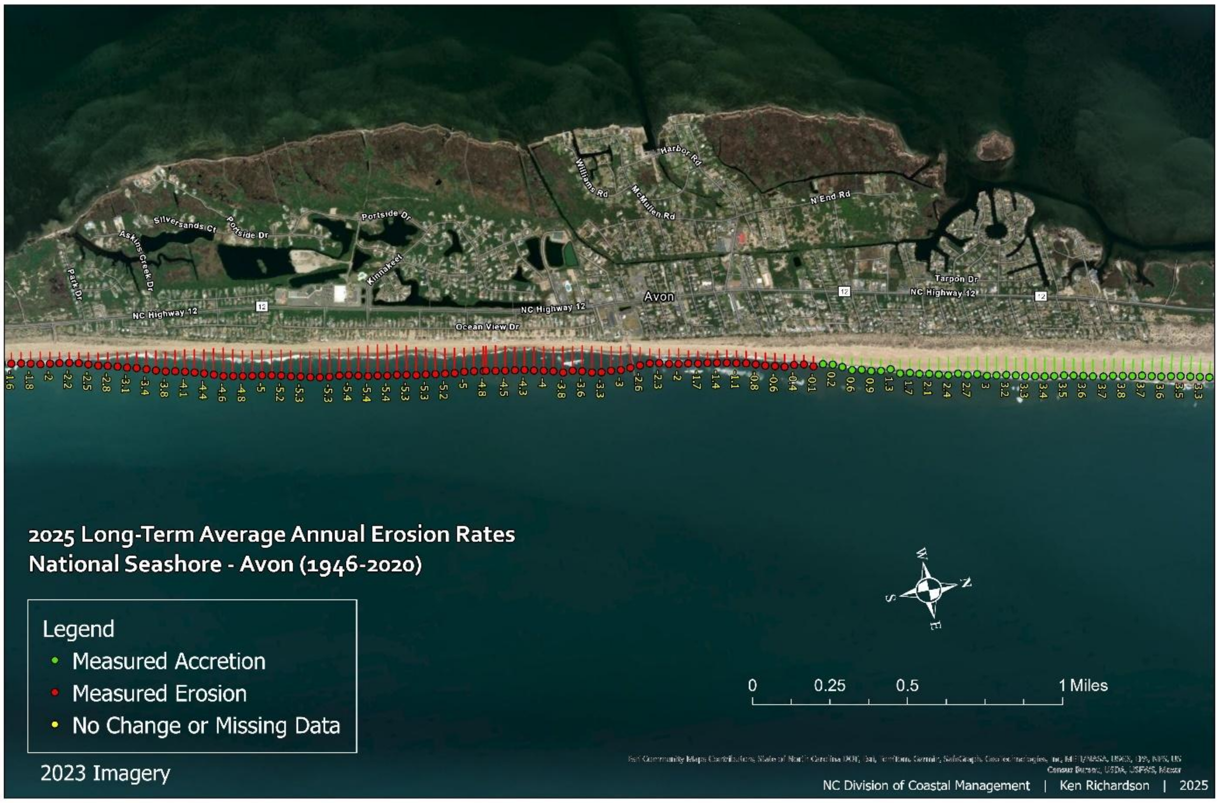

Figure 200. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

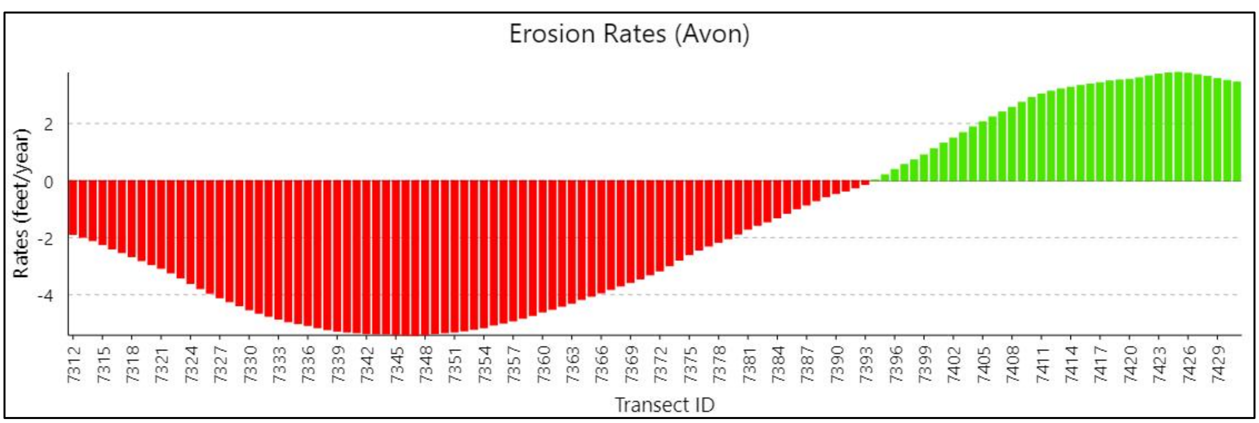

Figure 201. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

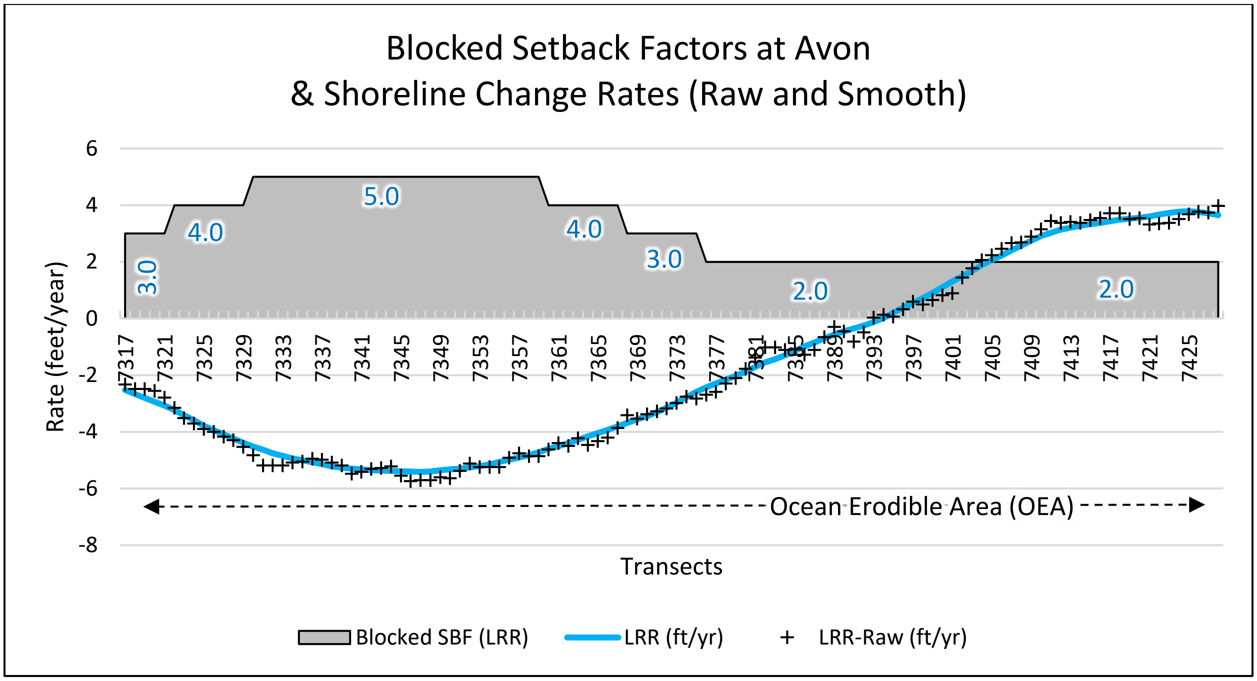

Figure 202. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

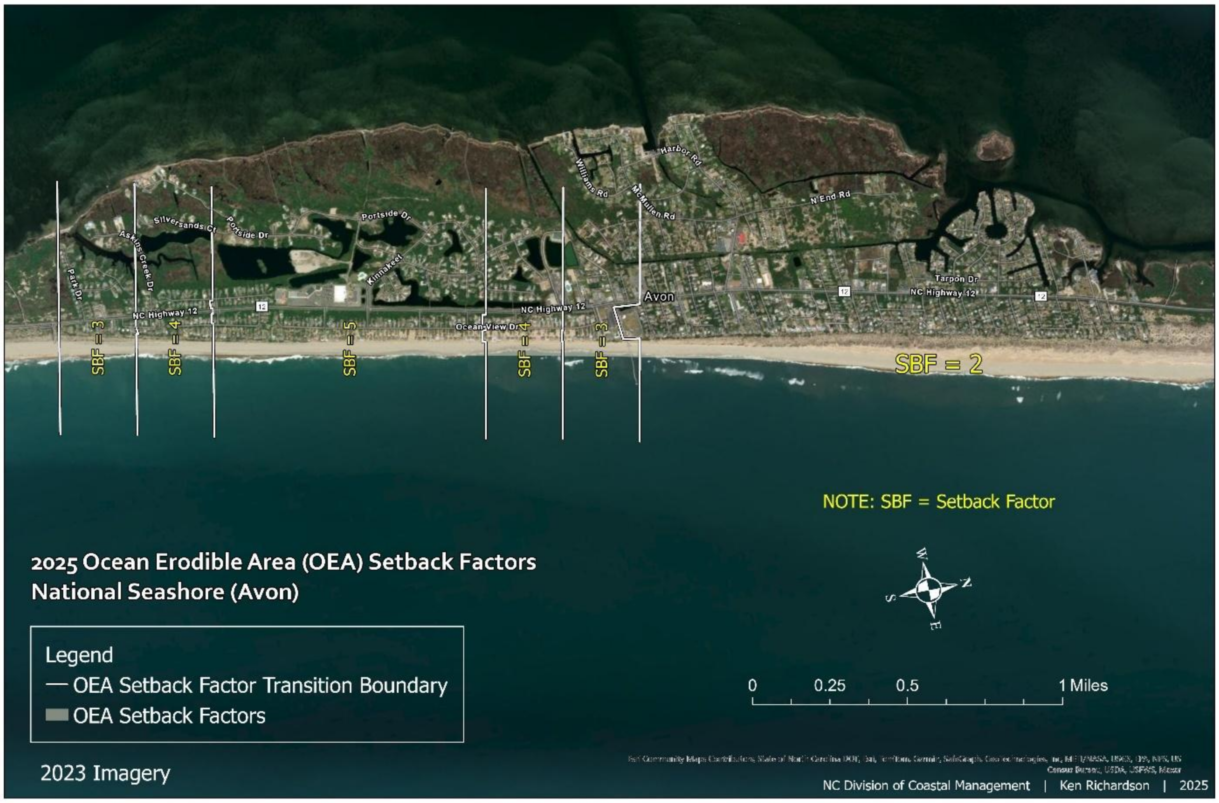

Figure 203. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Avon.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 5	Range 2 to 6	Range 2 to 4.5	Range 2 to 3	Range 2 to 4.5	Range 2 to 6	Range 2 to 5	N/A

Table 34. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.34 National Seashore (Avon to Salvo)

Between Avon and Salvo, the oceanfront shoreline spans 11.5 miles. Here, the analysis assessed twelve shorelines (**Figure 204**) along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 134 feet to a maximum of 445 feet, with an average of 282 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 41 and 132 feet, and an average of 84 feet. Of the 11.5 miles of shoreline analyzed, 8.4 miles (73%) resulted in measured erosion where rates ranged between -4.8 and less than -1.0 feet per year and averaged -2.7 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 205**). Between transects 7429 and 7799, the end-point method resulted in a range of shoreline line change rates between -5.0 and +5.0 feet per year, averaging -1.1 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -4.8 and +4.1 feet per year, averaging -1.3 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 5 feet per year, and the least squares regression ranged from 2 to 5 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7429 and 7799 range from 2 to 5 feet per year (**Figure 206** to **Figure 209** & **Table 35**).

Figure 204. *Shorelines included in the analysis (1946-2020) between Avon and Salvo.*

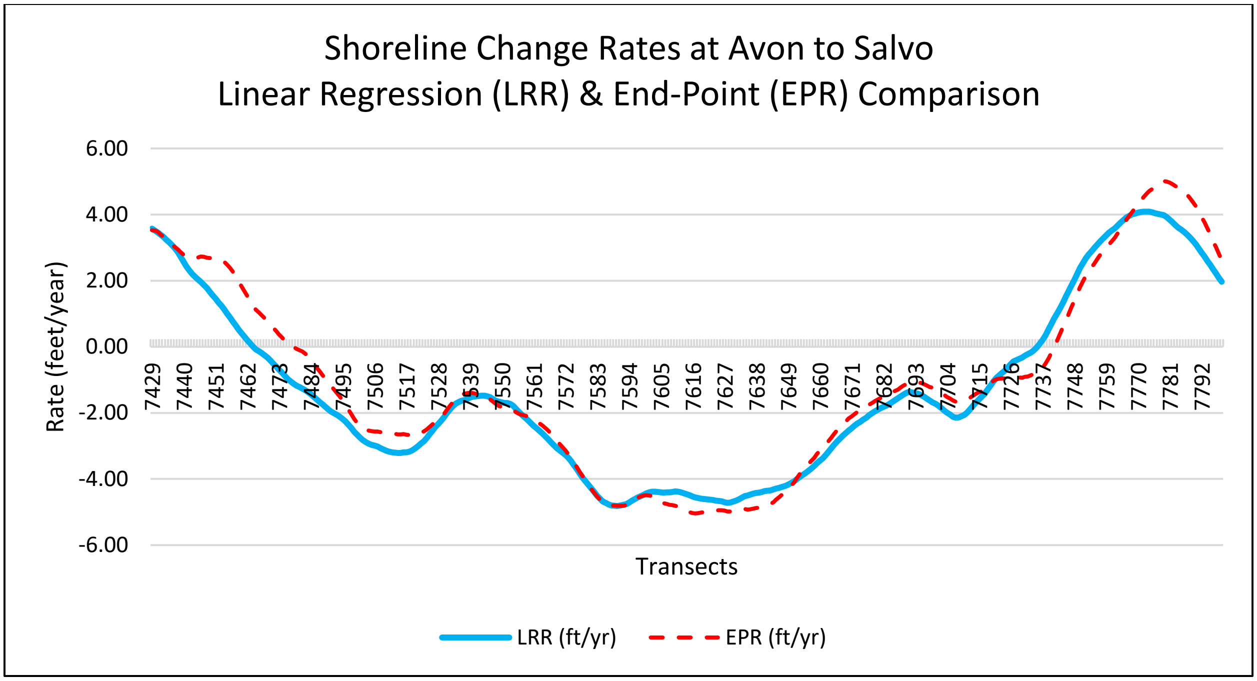

Figure 205. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 206. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

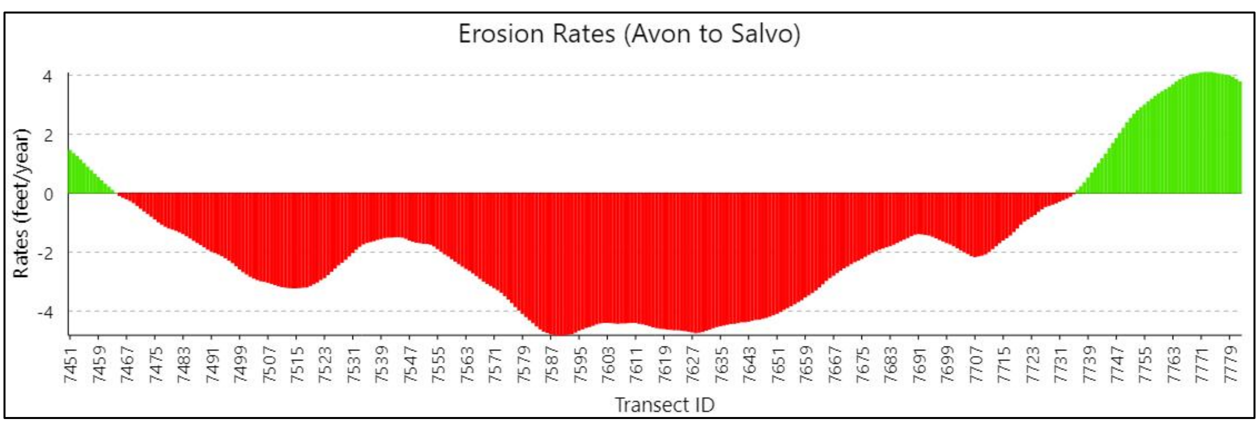

Figure 207. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

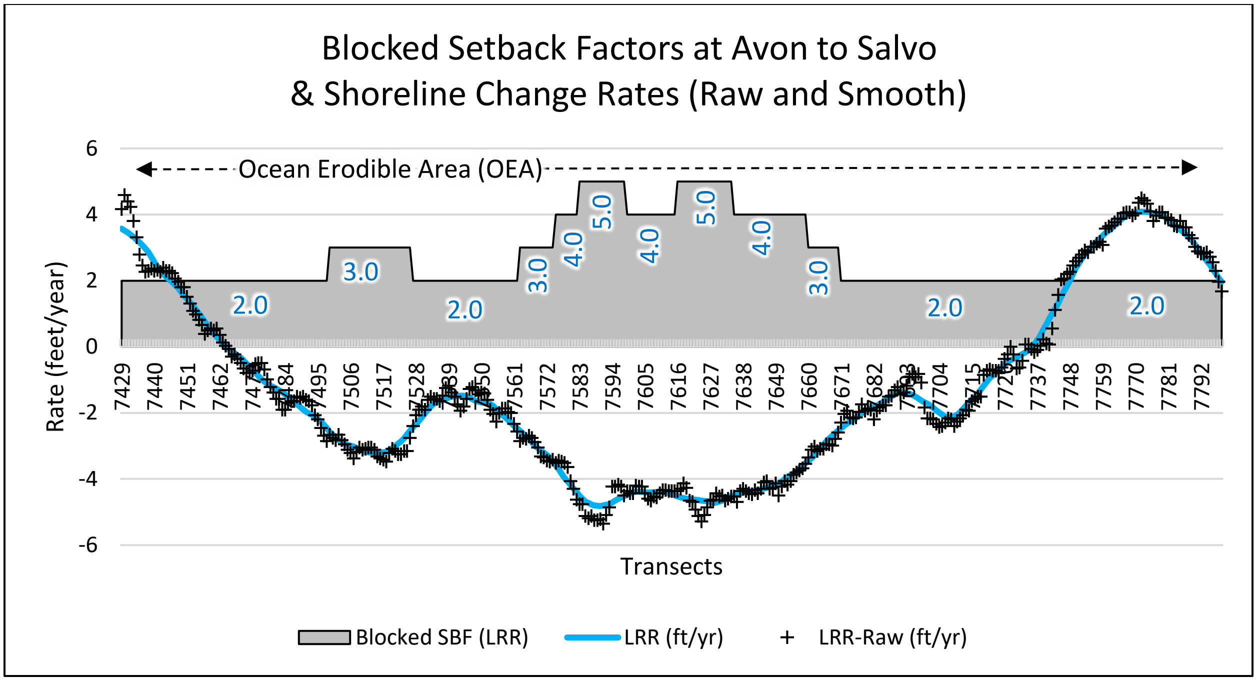

Figure 208. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 209. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Avon and Salvo.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 5	Range 2 to 6	Range 2 to 4	Range 2 to 4.5	Range 2 to 4	Range 2 to 6.5	Range 2 to 4	N/A

Table 35. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.35 Salvo, Waves and Rodanthe

The oceanfront shoreline at Salvo, Waves and Rodanthe extends 5.0 miles. The northern portion of this shoreline at the north end of Rodanthe at Mirlo Beach and NC Highway 12 was the site of a large-scale beach nourishment project in 2014.

Here, twelve shorelines (**Figure 210**) were assessed along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 126 feet to a maximum of 1,022 feet, with an average of 437 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 37 and 324 feet, and an average of 137 feet. Of the 5.0 miles of shoreline analyzed, 2.6 miles (52%) resulted in measured erosion where rates ranged between -12.6 and less than -1.0 feet per year and averaged -8.1 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 211**). Between transects 7800 and 7961, the end-point method resulted in a range of shoreline line change rates between -12.4 and +2.5 feet per year, averaging -3.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -12.6 and +1.9 feet per year, averaging -3.9 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 12 feet per year, and the least squares regression ranged from 2 to 13 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7800 and 7961 range from 2 to 13 feet per year. Compared to current effective setback factors (2020), areas between transects 7881 and 7887, transects 7938 and 7941, and transects 7946 and 7950 will experience a 1 foot per year decrease; while the area between transects 7896 and 7905 will experience a 1 foot per year increase (**Figure 211** to **Figure 216** & **Table 36**).

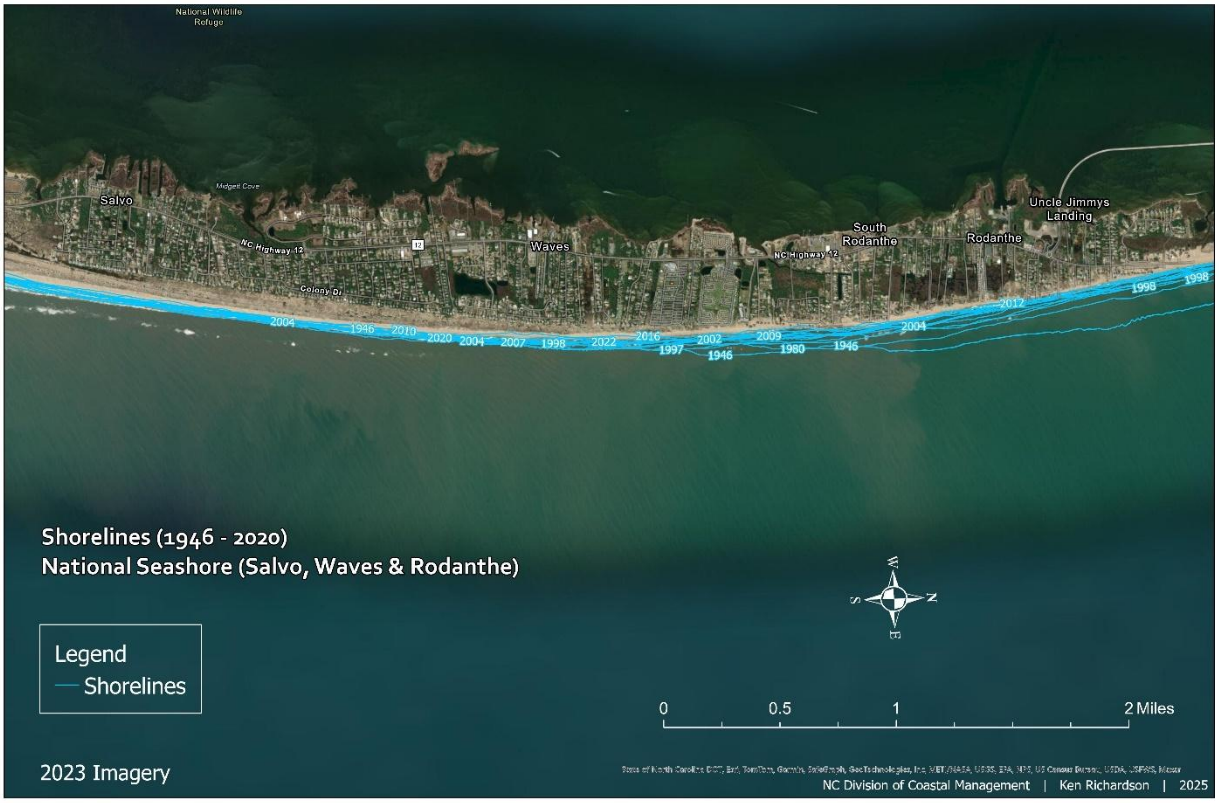

Figure 210. *Shorelines included in the analysis (1946-2020) at Salvo, Waves and Rodanthe.*

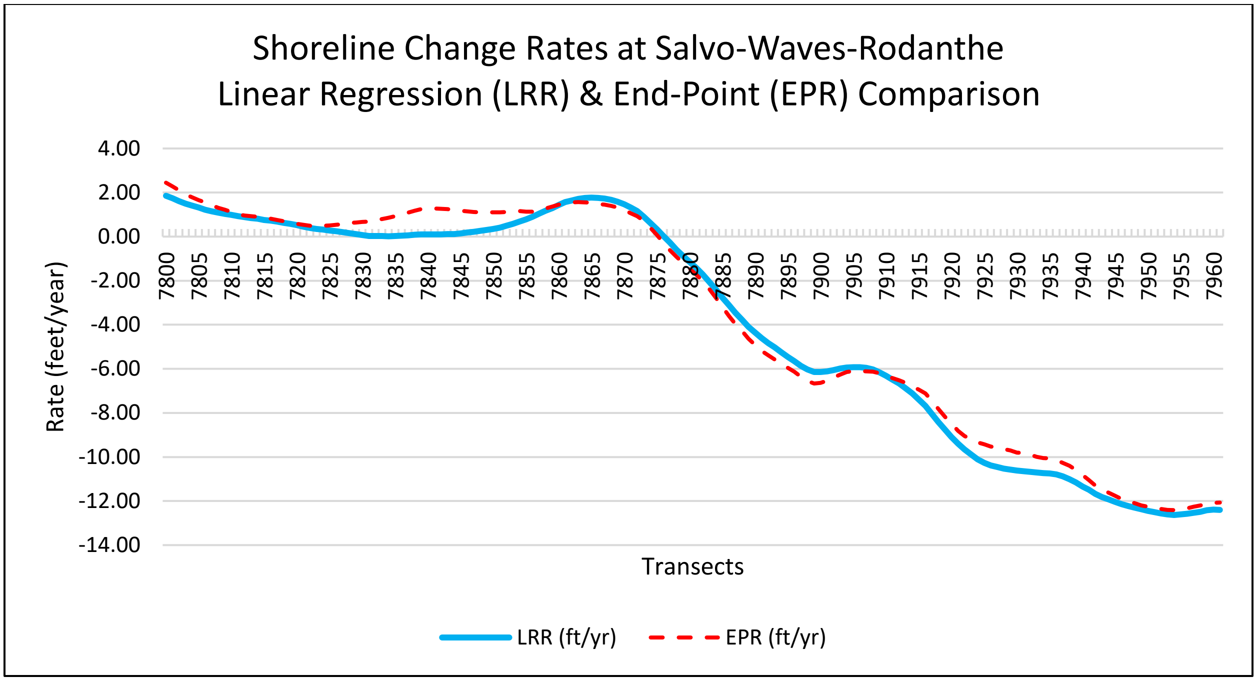

Figure 211. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 212. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

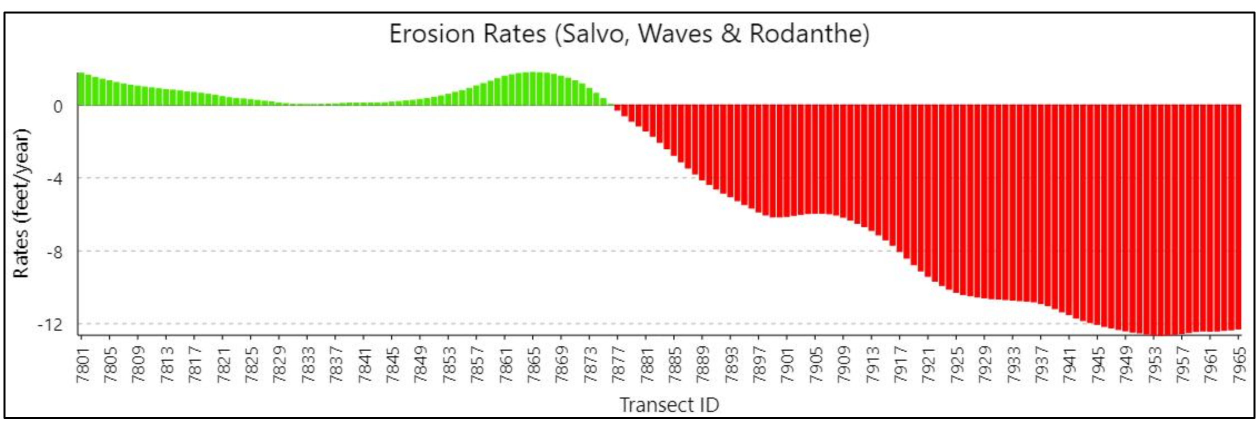

Figure 213. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

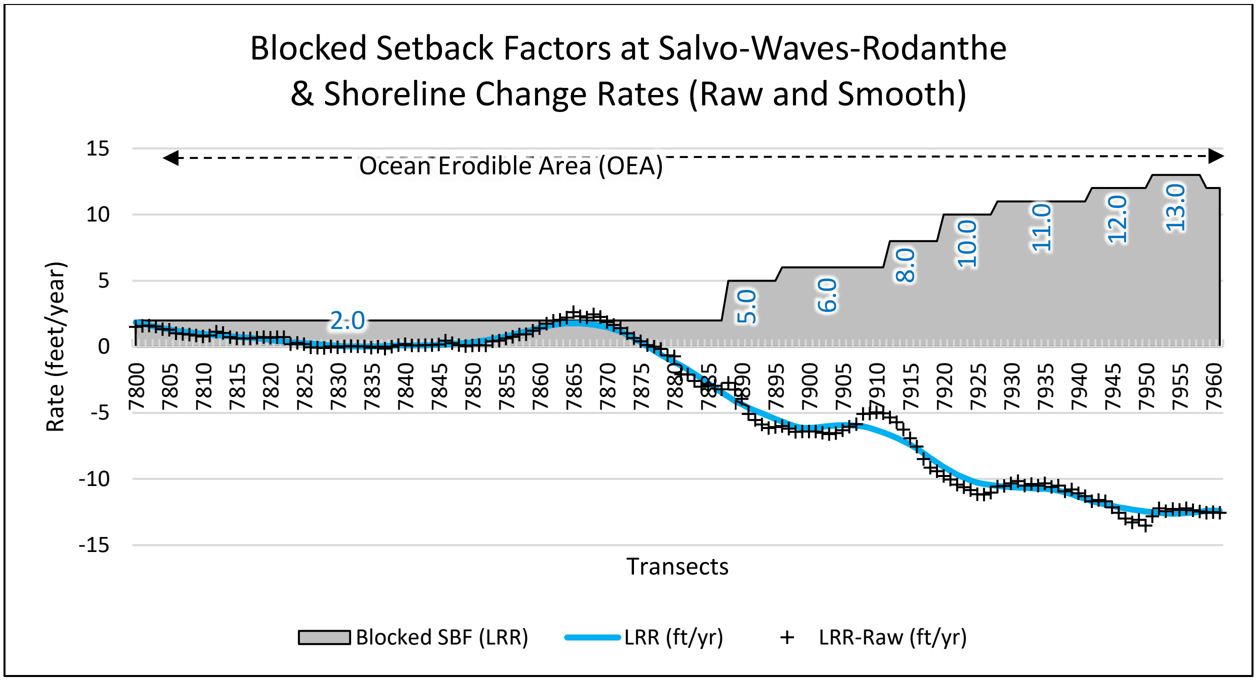

Figure 214. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

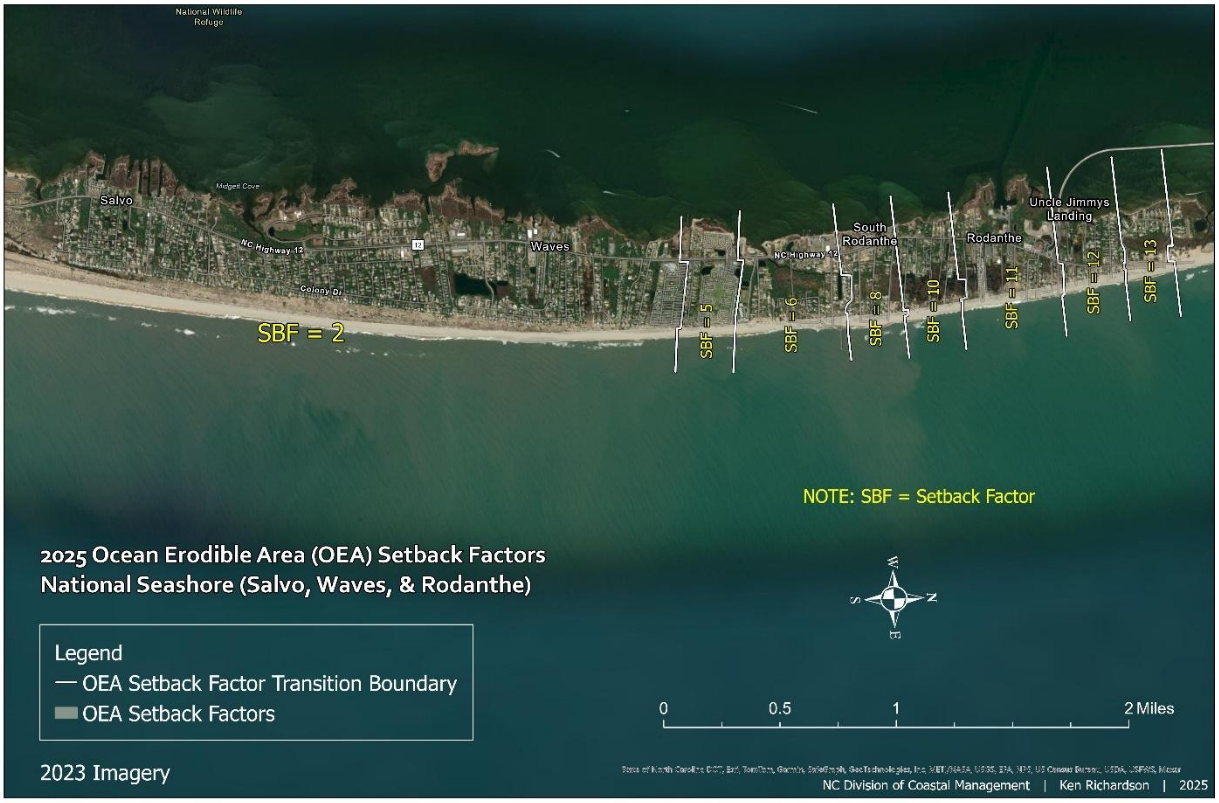

Figure 215. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Salvo, Waves, and Rodanthe.*

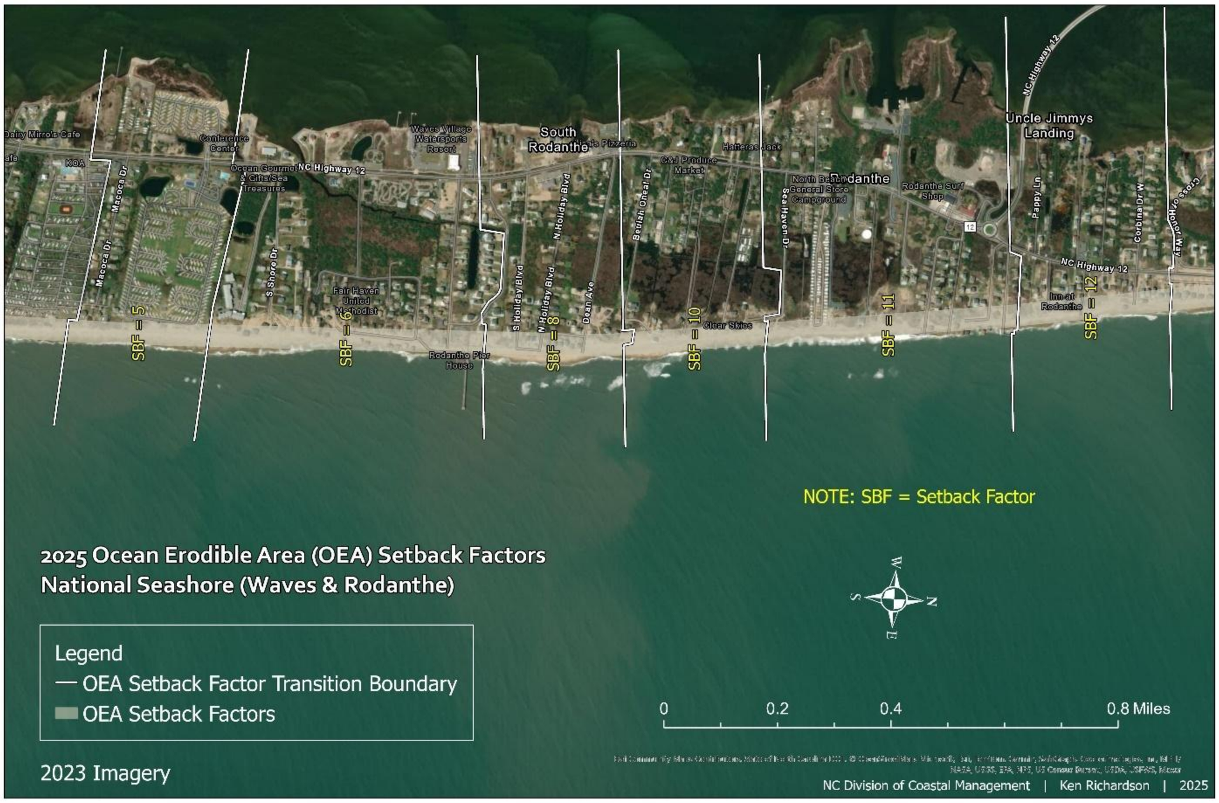

Figure 216. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Salvo, Waves and Rodanthe.*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	Range 2 to 13	Range 2 to 13	Range 2 to 12.5	Range 2 to 14	Range 2 to 16	Range 2 to 15	Range 2 to 19	N/A

Table 36. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.36 National Seashore (Rodanthe to Oregon Inlet)

The oceanfront shoreline from Rodanthe to Oregon Inlet (Pea Island) extends 12.1 miles. Here, twelve shorelines (**Figure 217**) were assessed along this oceanfront section over a 74-year period, from 1946 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 104 feet to a maximum of 1,577 feet, with an average of 548 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 30 and 668 feet, and an average of 174 feet. Of the 12.1 miles of shoreline analyzed, 10.4 miles (86%) resulted in measured erosion where rates ranged between -29.5 and less than -1.0 feet per year and averaged -7.1 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 218**). Between transects 7962 and 8349, the end-point method resulted in a range of shoreline line change rates between -26.7 and +4.9 feet per year, averaging -5.4 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -29.5 and +5.0 feet per year, averaging -5.0 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 27 feet per year, and the least squares regression ranged from 2 to 29 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 7962 and 8349 range from 2 to 29 feet per year (**Figure 218** to **Figure 222** & **Table 37**).

Figure 217. *Shorelines included in the analysis (1946-2020) between Rodanthe and Oregon Inlet (Pea Island).*

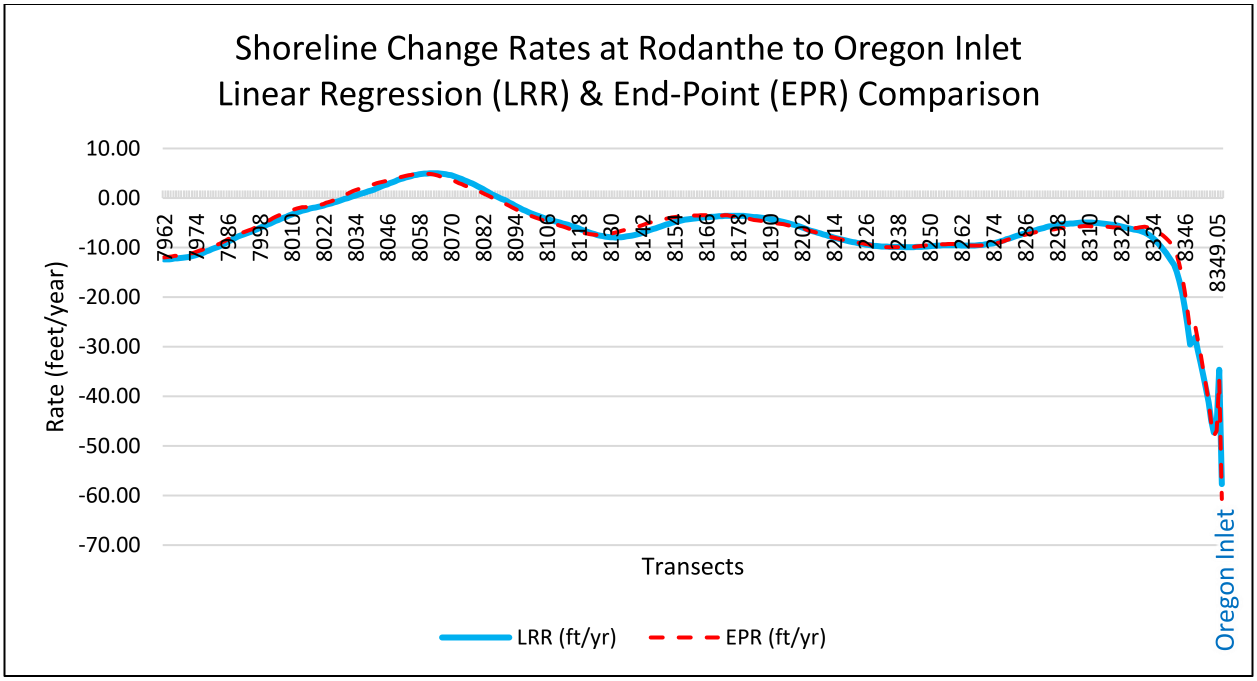

Figure 218. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 219. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

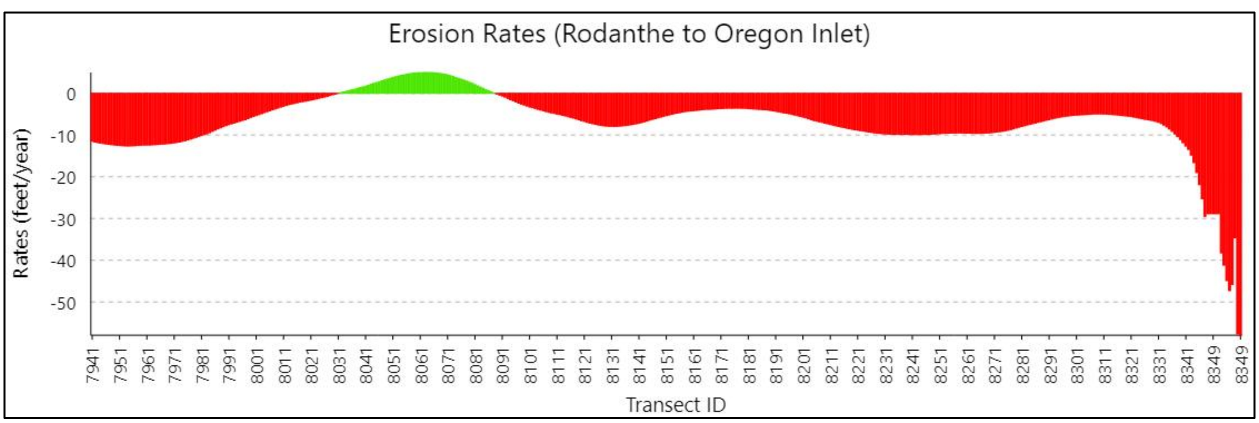

Figure 220. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

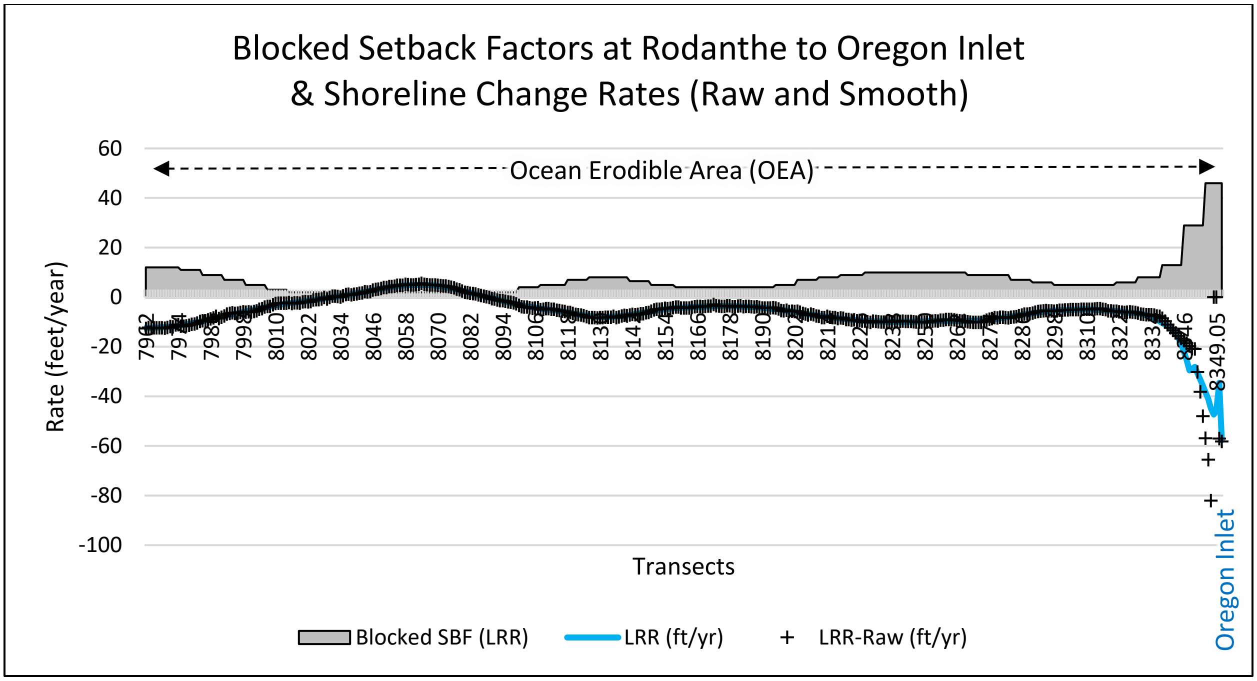

Figure 221. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 222. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Rodanthe and Oregon Inlet (Pea Island).*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	Range 2 to 29	Range 2 to 19	Range 2 to 16.5	Range 2 to 16	Range 2 to 15.5	Range 2 to 16	Range 2 to 19	N/A

Table 37. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.37 Oregon Inlet to Nags Head

The oceanfront shoreline from Oregon Inlet to Nags Head (Bodie Island) extends 5.0 miles. Here, twelve shorelines (**Figure 223**) were assessed along this oceanfront section over a 71-year period, from 1949 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 518 feet to a maximum of 2,384 feet, with an average of 839 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 151 and 750 feet, and an average of 254 feet. Of the 5.0 miles of shoreline analyzed, 4.1 miles (82%) resulted in measured erosion where rates ranged between -8.8 and less than -1.0 feet per year and averaged -6.5 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 224**). Between transects 8350 and 8511, the end-point method resulted in a range of shoreline line change rates between -8.5 and +24.3 feet per year, averaging -2.7 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -8.8 and +14.8 feet per year, averaging -3.8 feet per year. Like previous studies, both approaches resulted in a broad range of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 8.5 feet per year, and the least squares regression ranged from 2 to 9 feet per year.

Adopting the least squares regression methodology provides a more accurate representation of long-term shoreline movement and does not significantly alter results for this section of shoreline compared to previous studies. Using this approach, the calculated setback factors within the OEA between transects 8350 and 8511 range from 2 to 9 feet per year (**Figure 224** to **Figure 228** & **Table 38**).

Figure 223. *Shorelines included in the analysis (1946-2020) between Oregon Inlet and Nags Head (Bodie Island).*

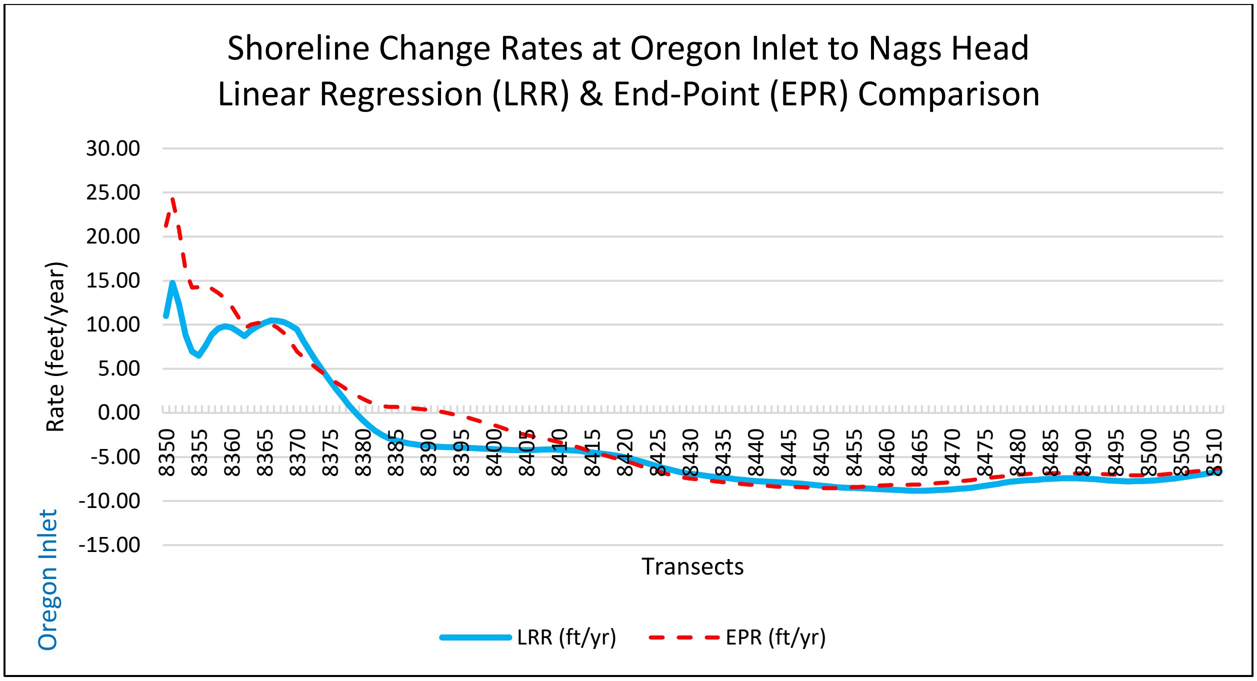

Figure 224. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 225. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

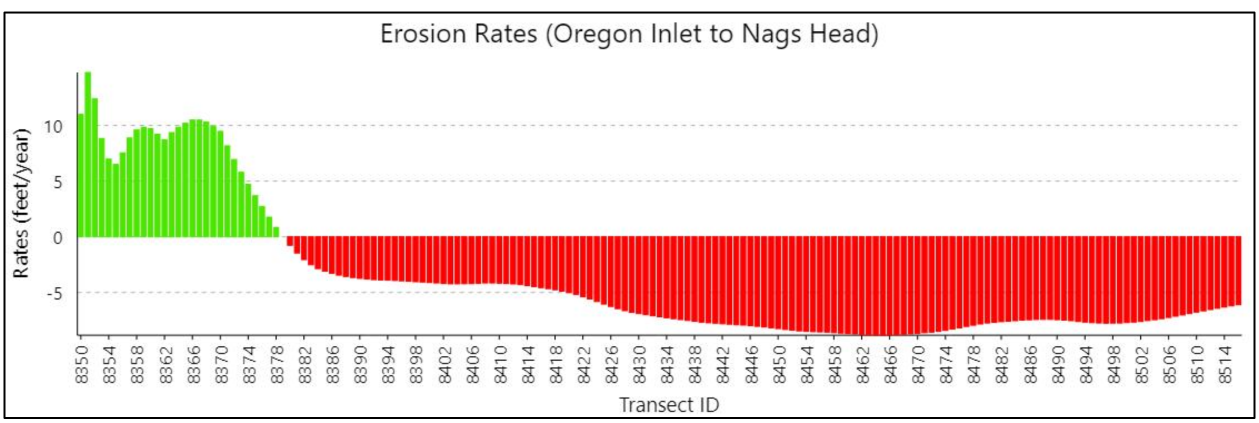

Figure 226. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

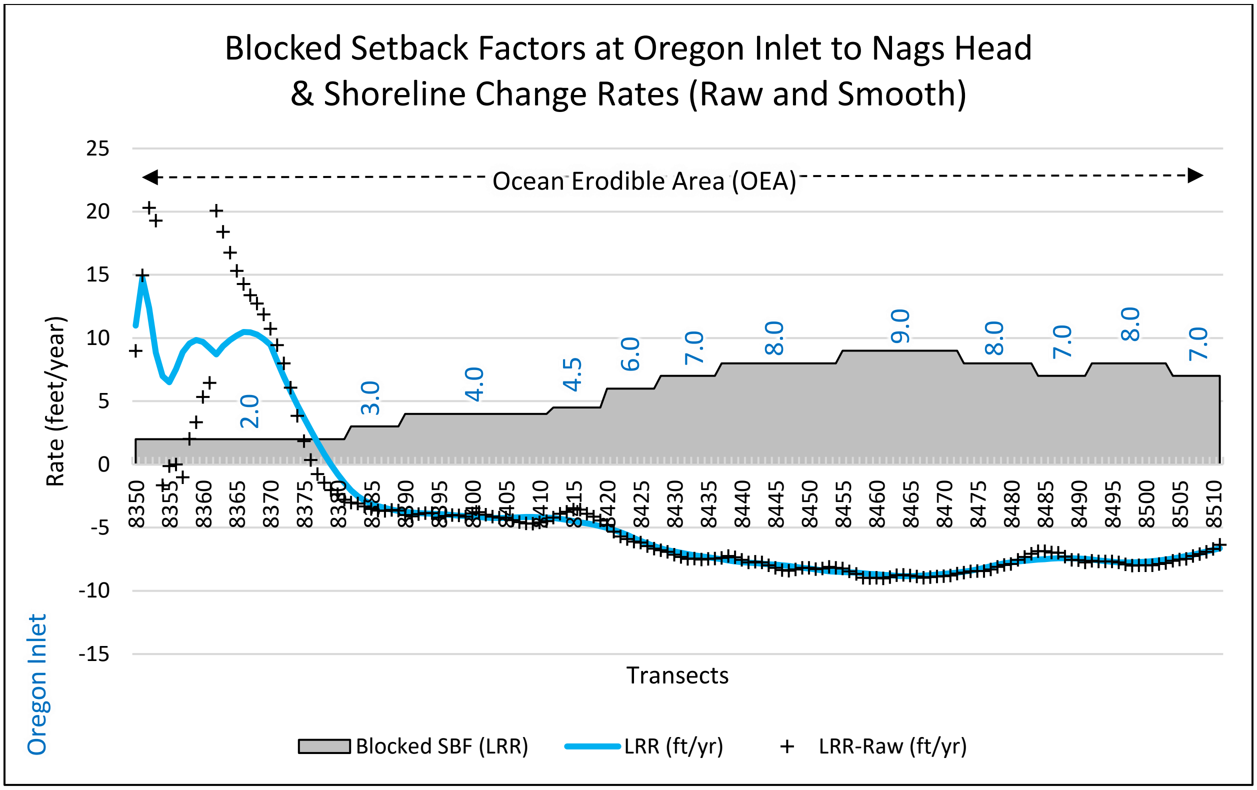

Figure 227. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

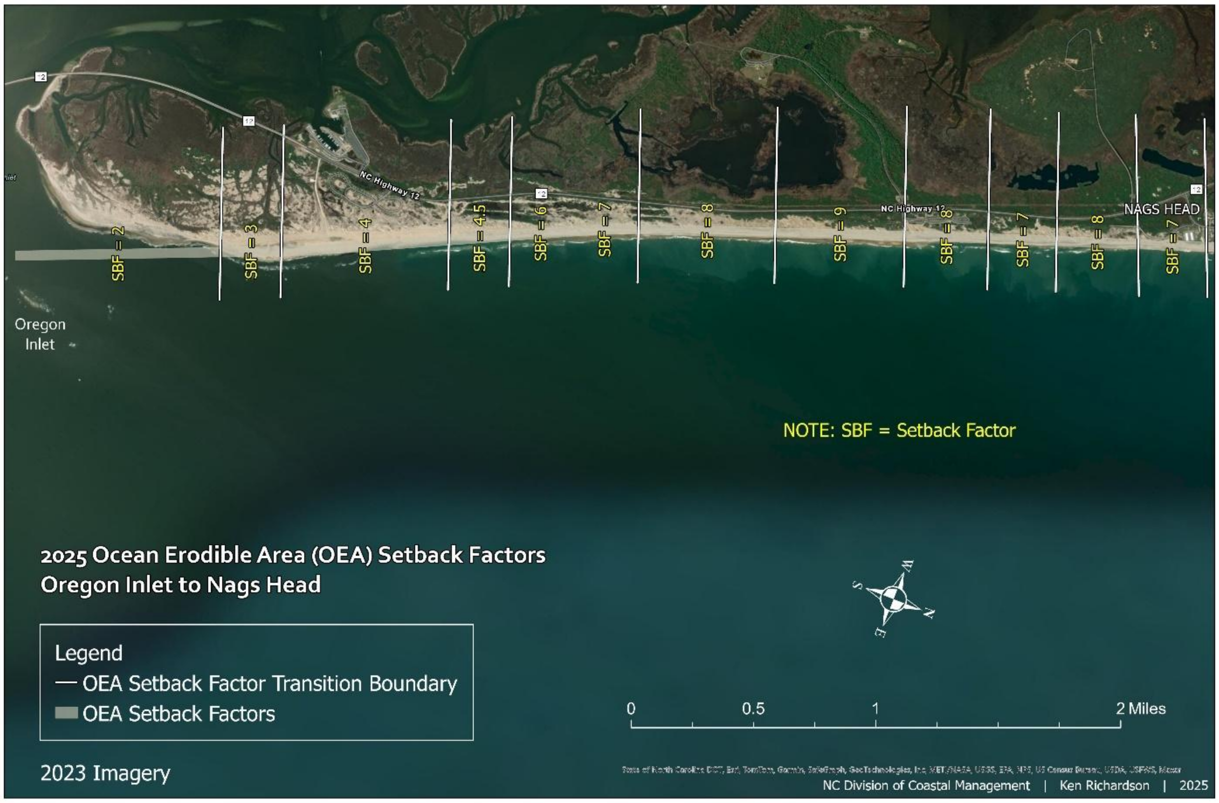

Figure 228. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Oregon Inlet and Nags Head (Bodie Island).*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	Range 2 to 9	Range 2 to 11	Range 2 to 10	Range 2 to 10	Range 7 to 10	N/A	N/A	N/A

Table 38. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.38 Nags Head

The oceanfront shoreline at Nags Head stretches 11.2 miles. In 2011, approximately 10 miles of this shoreline underwent a large-scale beach nourishment project, followed by a 4.5-mile restoration project in 2022. Since the most recent shoreline data used in this study is from 2020, only the initial nourishment project has artificially influenced shoreline position, and potentially lowering shoreline change rates.

Here, twelve shorelines (**Figure 229**) were assessed along this oceanfront section over a 71-year period, from 1949 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 77 feet to a maximum of 533 feet, with an average of 238 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 24 and 533 feet, and an average of 238 feet. Of the 11.2 miles of shoreline analyzed, 10.9 miles (97%) resulted in measured erosion where rates ranged between -6.5 and less than -1.0 feet per year and averaged -1.9 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 230**). Between transects 8512 and 8873, the end-point method resulted in a range of shoreline line change rates between -6.1 and less than 1.0 feet per year, averaging -1.4 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -6.5 and less than 1.0 feet per year, averaging -1.9 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 6 feet per year, and the least squares regression ranged from 2 to 7 feet per year – where higher result was measured in the southern portion of the Town's limit.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 8512 and 8873 range from 2 to 9 feet per year.

Beginning at the Town's southernmost boundary near transect 8512 and progressing north, setback factors are initially 6 feet per year, decreasing to 5 feet per year at transect 8523, 4 feet per year at transect 8543, and 3 feet per year at transect 8554. From transect 8592 through the Town's northern boundary near transect 8873, covering approximately 8.7 miles, the setback factor remains at 2 feet per year. Compared to current effective setback factors (2020), the areas between transects 8507 and 8646 (4.3 miles), and transects 8699 and 8780 (2.5 miles) will experience a 1 to 2 feet per year decrease (**Figure 231** to **Figure 235** & **Table 39**).

Figure 229. *Shorelines included in the analysis (1949-2020) at Nags Head.*

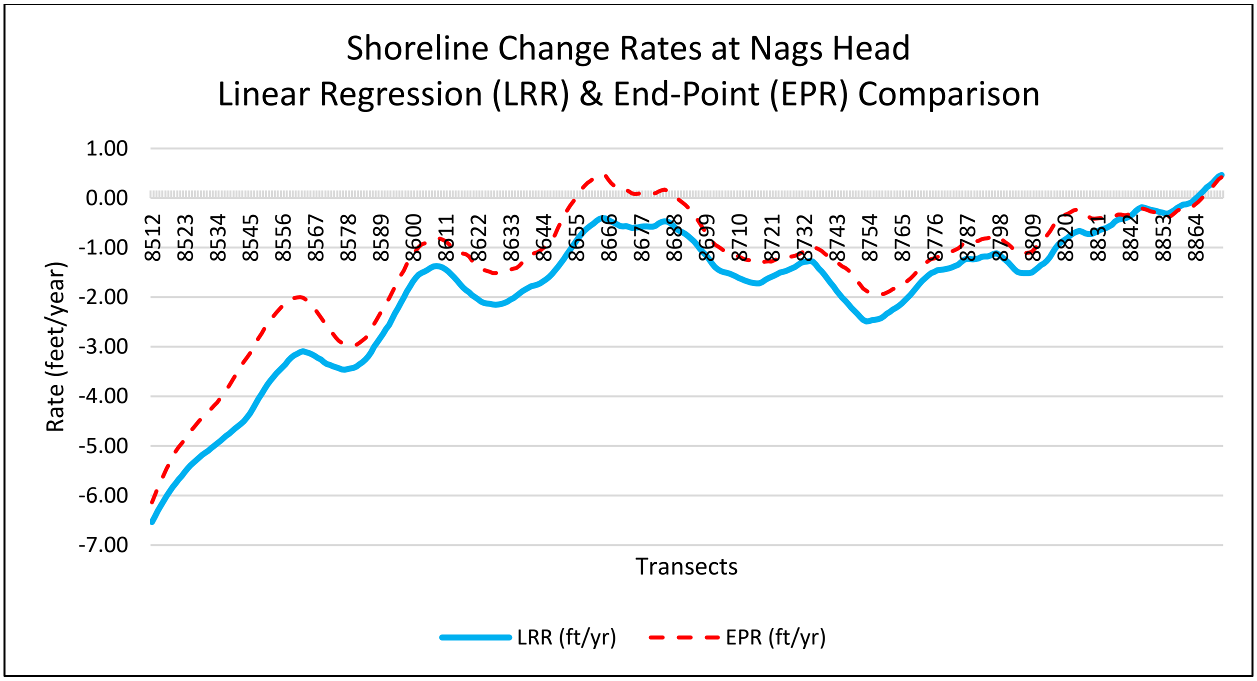

Figure 230. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 231. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

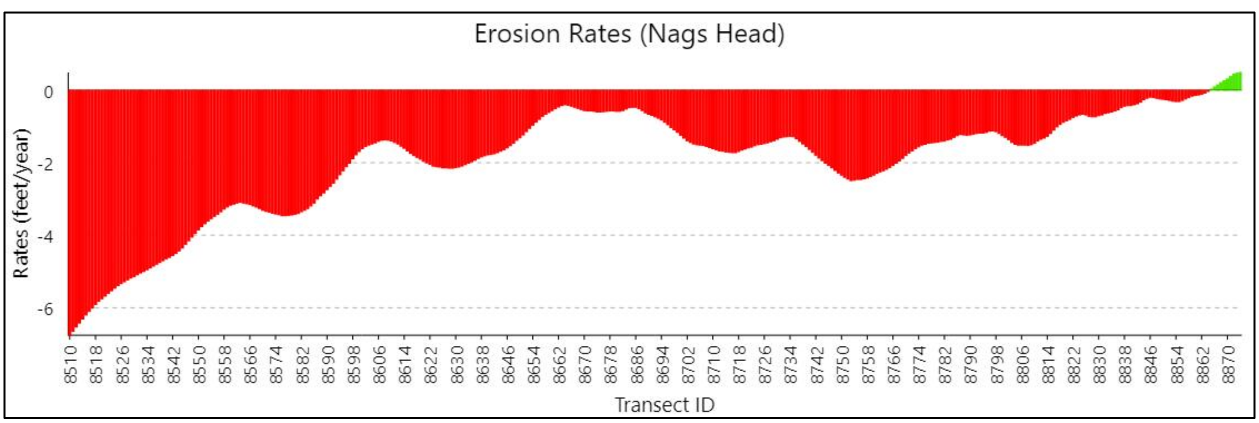

Figure 232. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

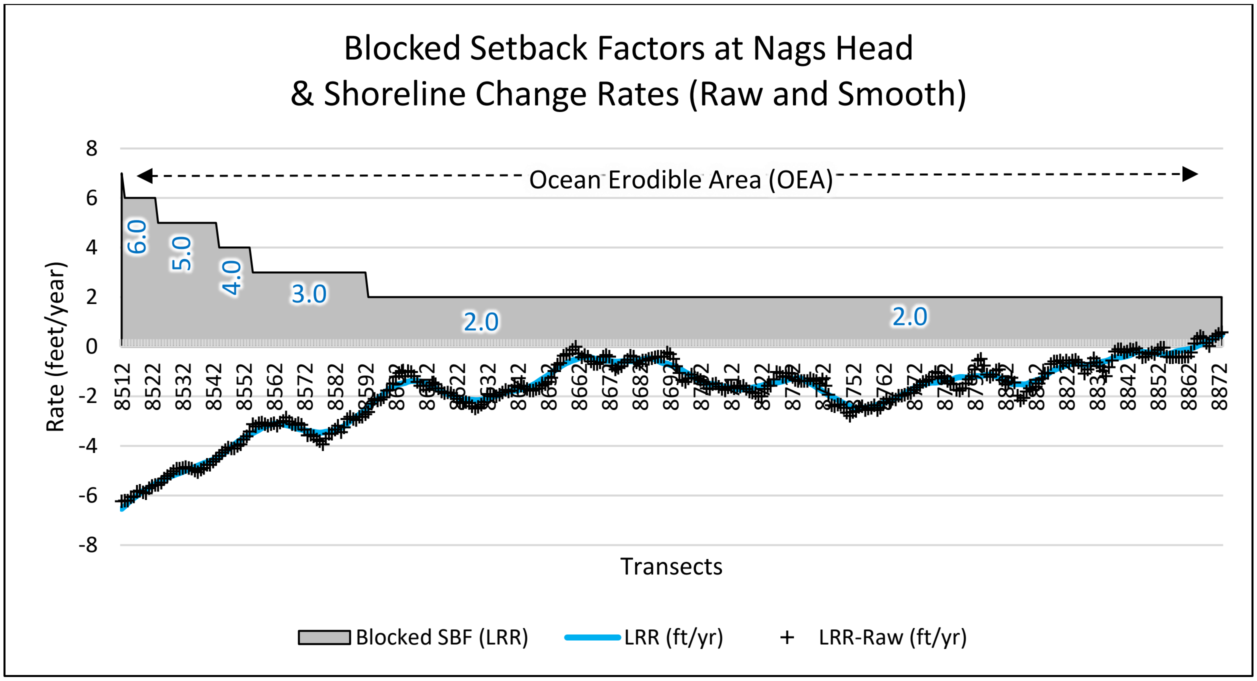

Figure 233. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 234. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Nags Head.*

Figure 235. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Nags Head.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 6	Range 2 to 8	Range 2 to 7.5	Range 2 to 7.5	Range 2 to 10	Range 2 to 7	N/A	N/A

Table 39. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.39 Kill Devil Hills

The oceanfront shoreline at Kill Devil Hills spans 4.7 miles. In 2017, a large-scale beach nourishment project was completed along approximately 2.9 miles of the northern section, starting near transect 8942 and extending beyond the town's northern boundary. This area later underwent a maintenance project in 2022.

Here, twelve shorelines (**Figure 236**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 71 feet to a maximum of 339 feet, with an average of 166 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 26 and 109 feet, and an average of 49 feet. Of the 4.7 miles of shoreline analyzed, 2.5 miles (53%) resulted in measured erosion where rates ranged between -3.1 and less than -1.0 feet per year and averaged -1.7 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 237**). Between transects 8874 and 9026, the end-point method resulted in a range of shoreline line change rates between -2.9 and less than 1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -3.1 and 1.0 feet per year, averaging less than -1.0 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 3 feet per year, and the least squares regression ranged from 2 to 3 feet per year.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 8874 and 9026 range from 2 to 3 feet per year. Starting at the Town's southernmost boundary near transect 8874 and progressing north, setback factors start at 2 feet per year, increase to 3 feet per year at transect 8968, then decrease to 2 feet per year at transect 8984 and to the Town's northern boundary.

Compared to current effective setback factors (2020), the areas between transects 8963 and 8967, transects 8971 and 8979, and transects 8985 and 8987 will experience a 1 foot per year decrease (**Figure 238** to **Figure 241** & **Table 40**).

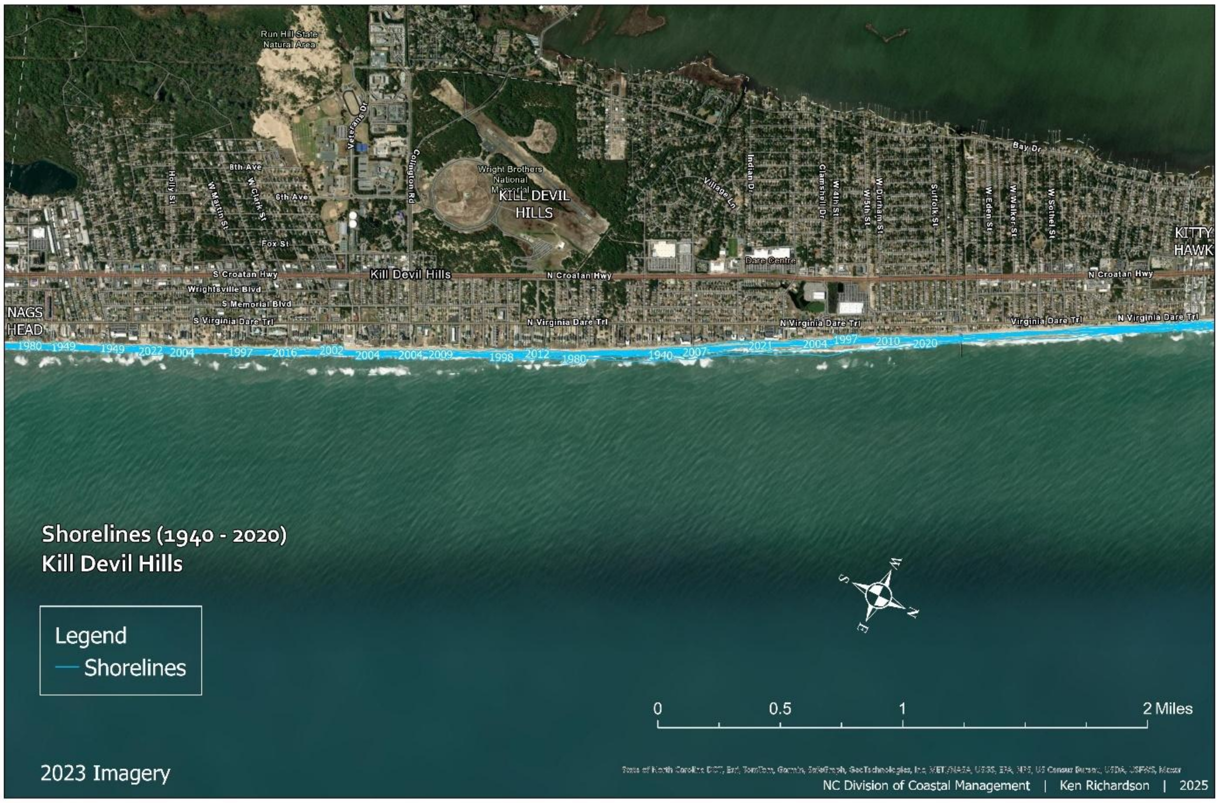

Figure 236. *Shorelines included in the analysis (1940-2020) at Kill Devil Hills.*

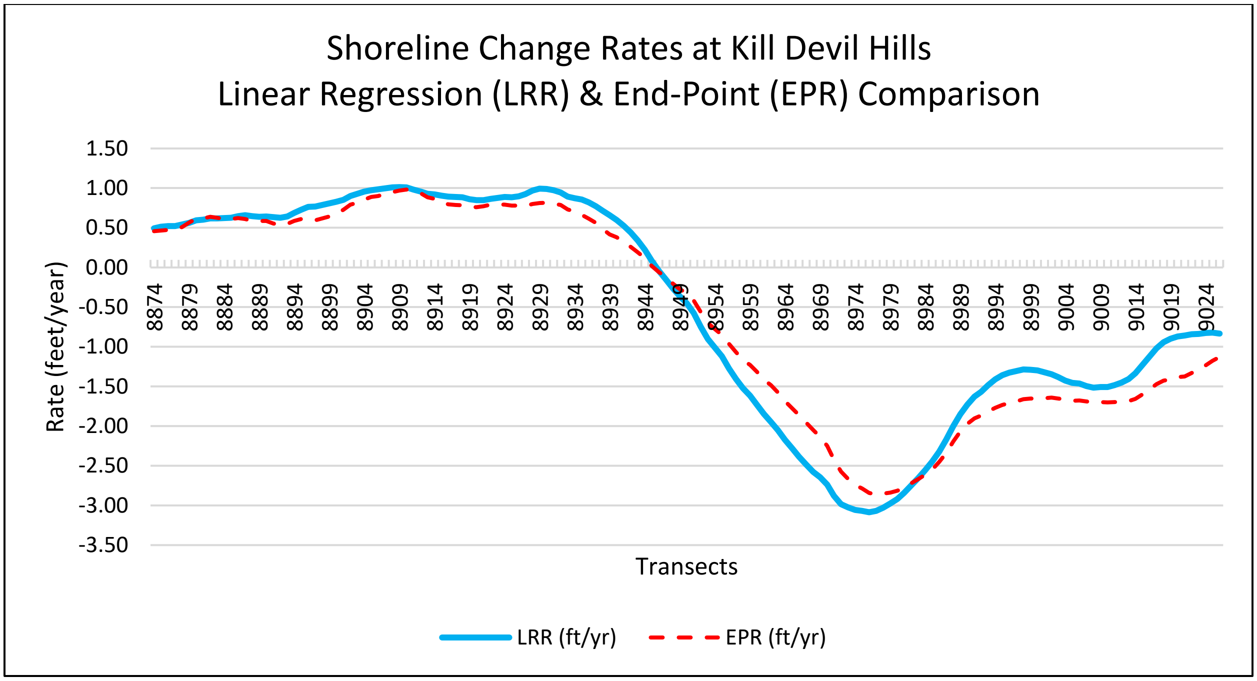

Figure 237. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 238. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

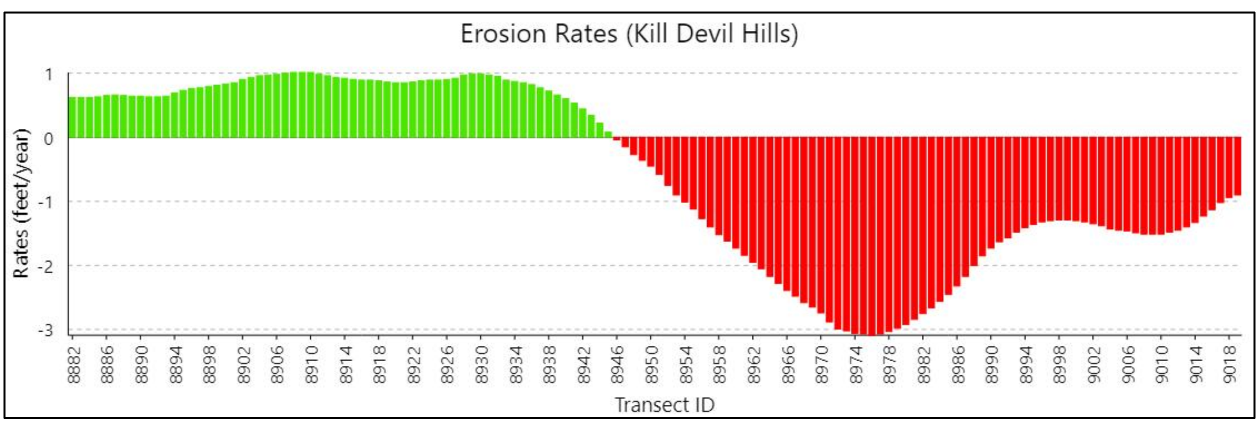

Figure 239. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

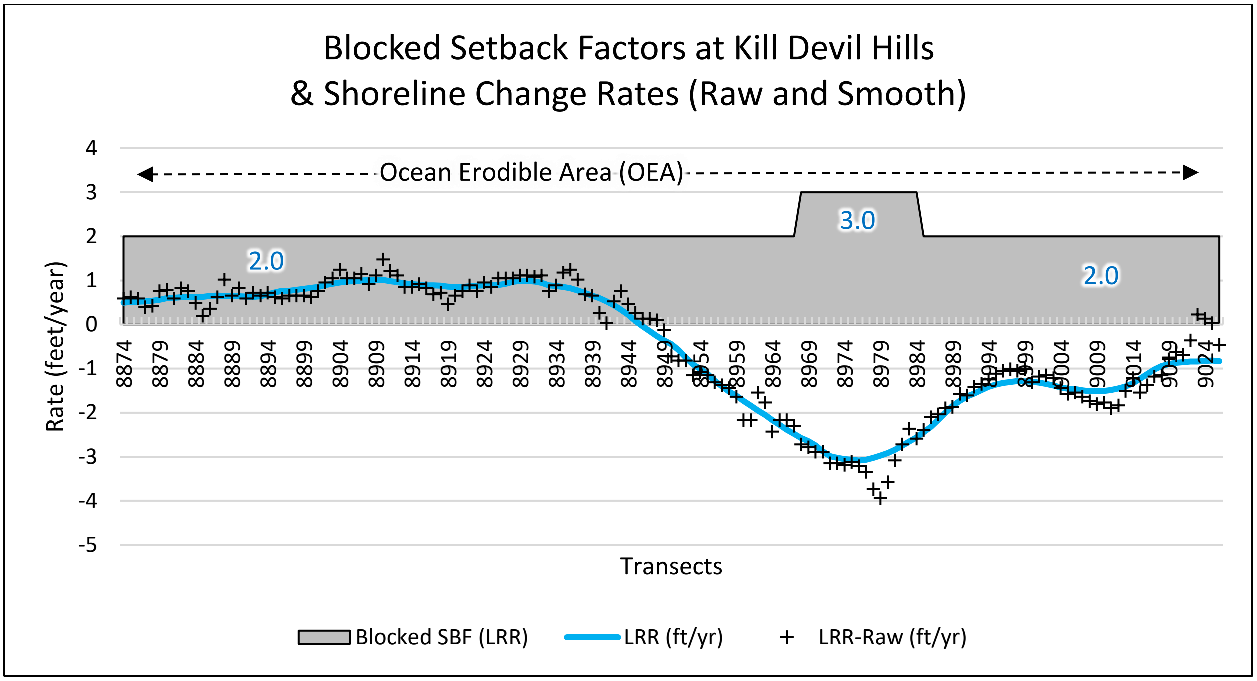

Figure 240. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

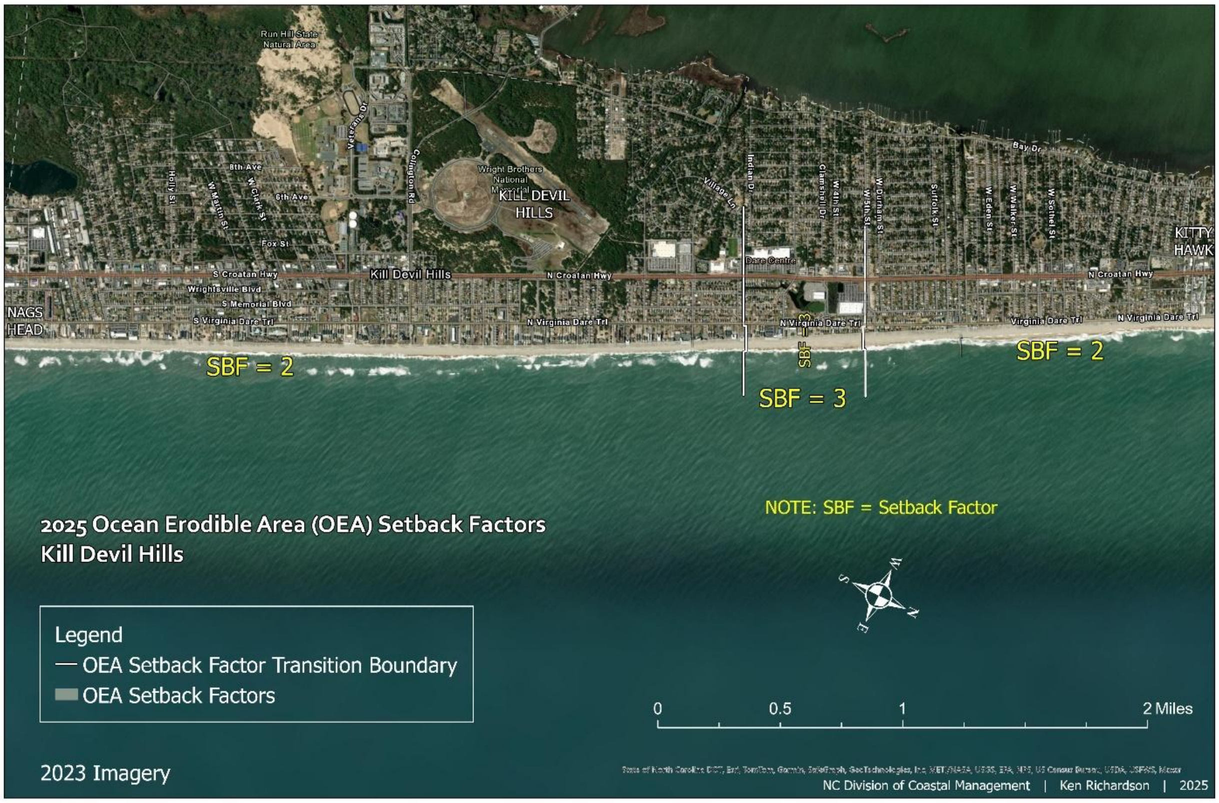

Figure 241. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Kill Devil Hills.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 3	Range 2 to 4	Range 2 to 2.5	Range 2 to 3.5	Range 2 to 6.5	Range 2 to 4.5	N/A	N/A

Table 40. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.40 Kitty Hawk

The oceanfront shoreline at Kitty Hawk spans 3.5 miles. In 2017, a large-scale beach nourishment project was completed along this section of shoreline, followed by a maintenance project in 2022.

Here, twelve shorelines (**Figure 242**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 102 feet to a maximum of 323 feet, with an average of 210 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 34 and 89 feet, and an average of 62 feet. Of the 3.5 miles of shoreline analyzed, all (100%) resulted in measured erosion where rates ranged between -2.7 and less than -1.0 feet per year and averaged -1.9 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 243**). Between transects 9027 and 9140, the end-point method resulted in a range of shoreline line change rates between -2.6 and -1.0 feet per year, averaging -1.9 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -2.7 and less than -1.0 feet per year, averaging less than -1.9 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors equaled 2 feet per year, and the least squares regression equaled 2 feet per year.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 9027 and 9140 equaled feet per year. Compared to current effective setback factors (2020), the area between transects 9059 and 9109 (1.5 miles) will experience a 1 foot per year decrease (**Figure 243** to **Figure 247** & **Table 41**).

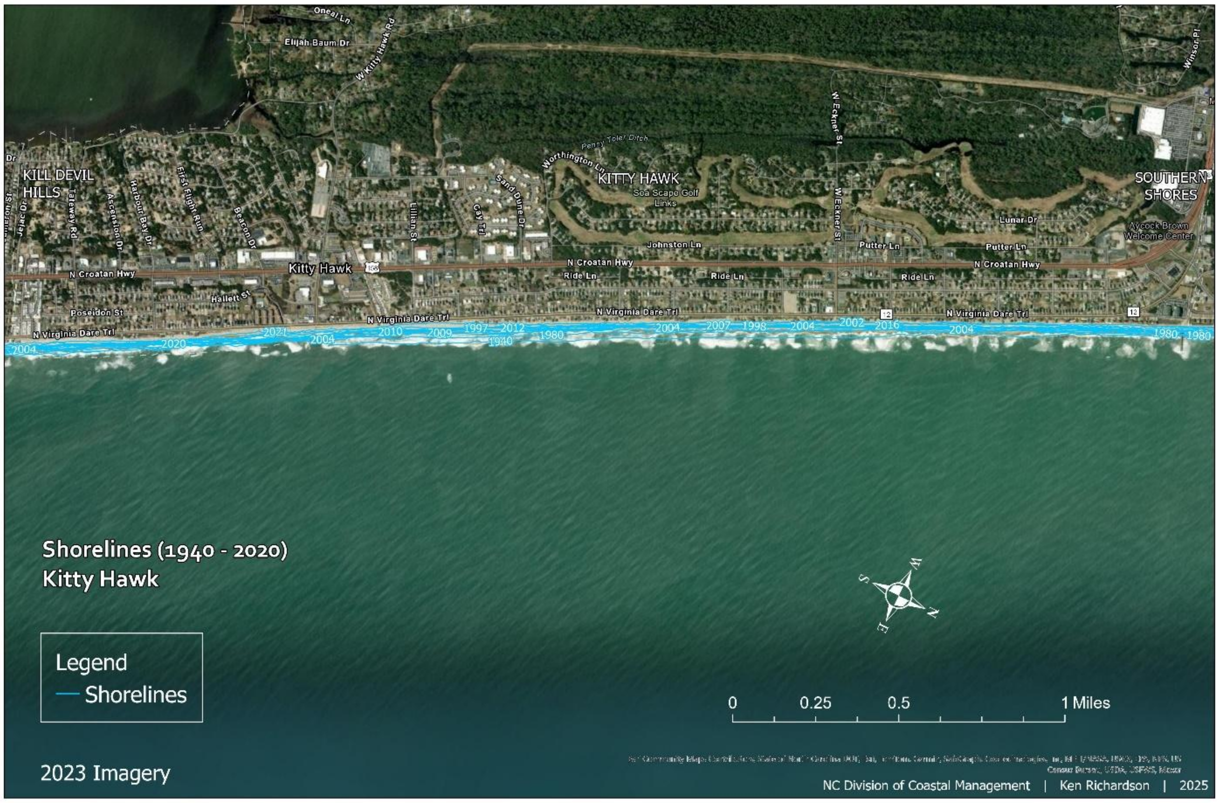

Figure 242. *Shorelines included in the analysis (1940-2020) at Kitty Hawk.*

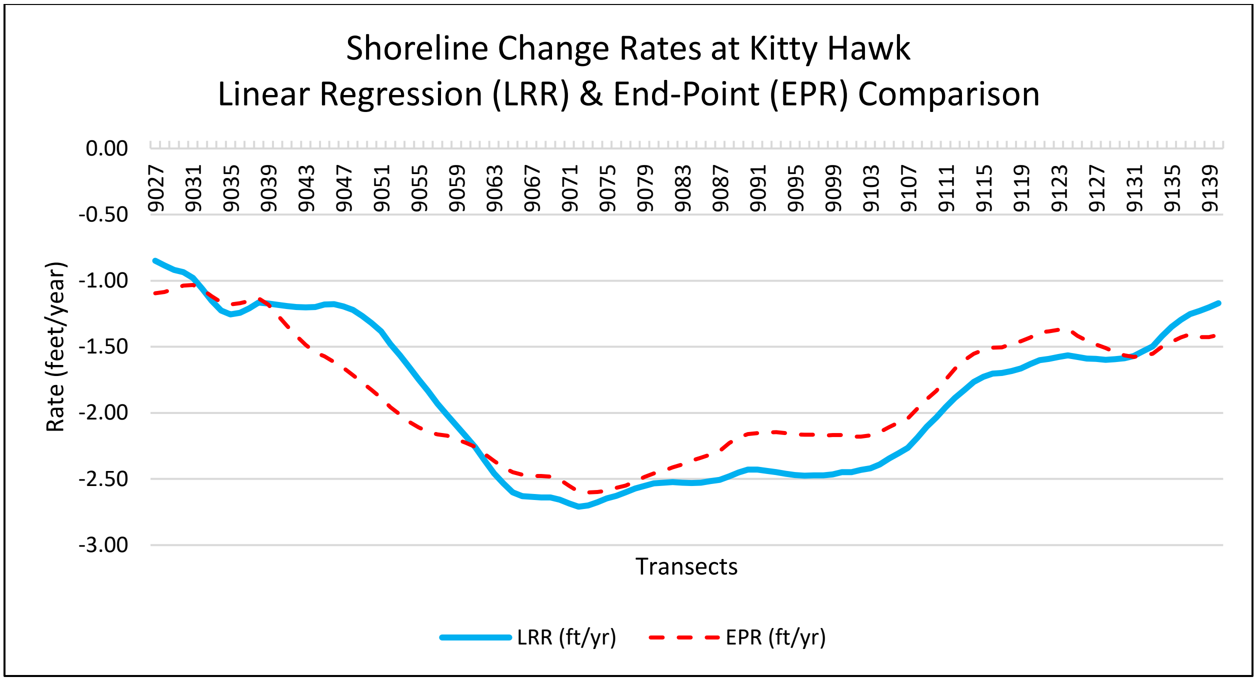

Figure 243. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 244. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

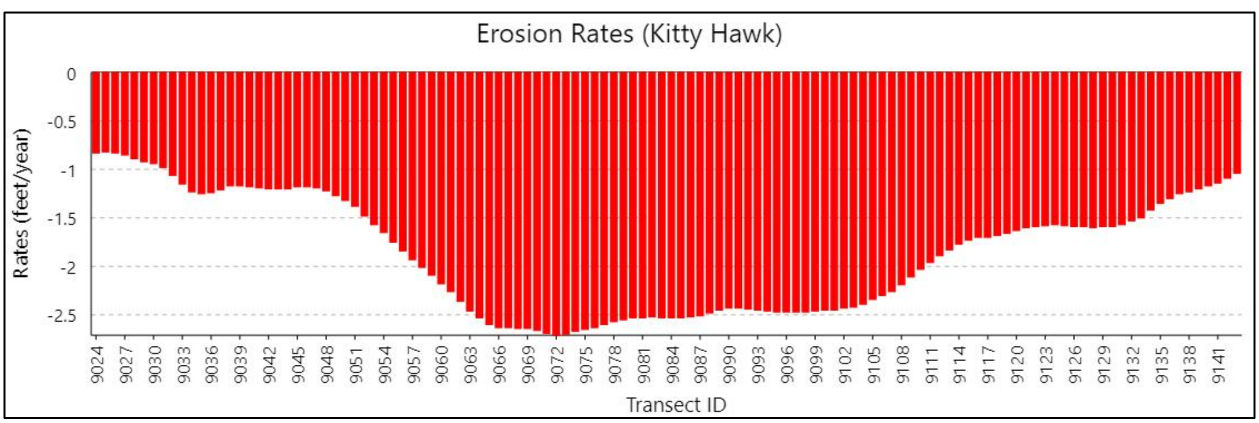

Figure 245. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

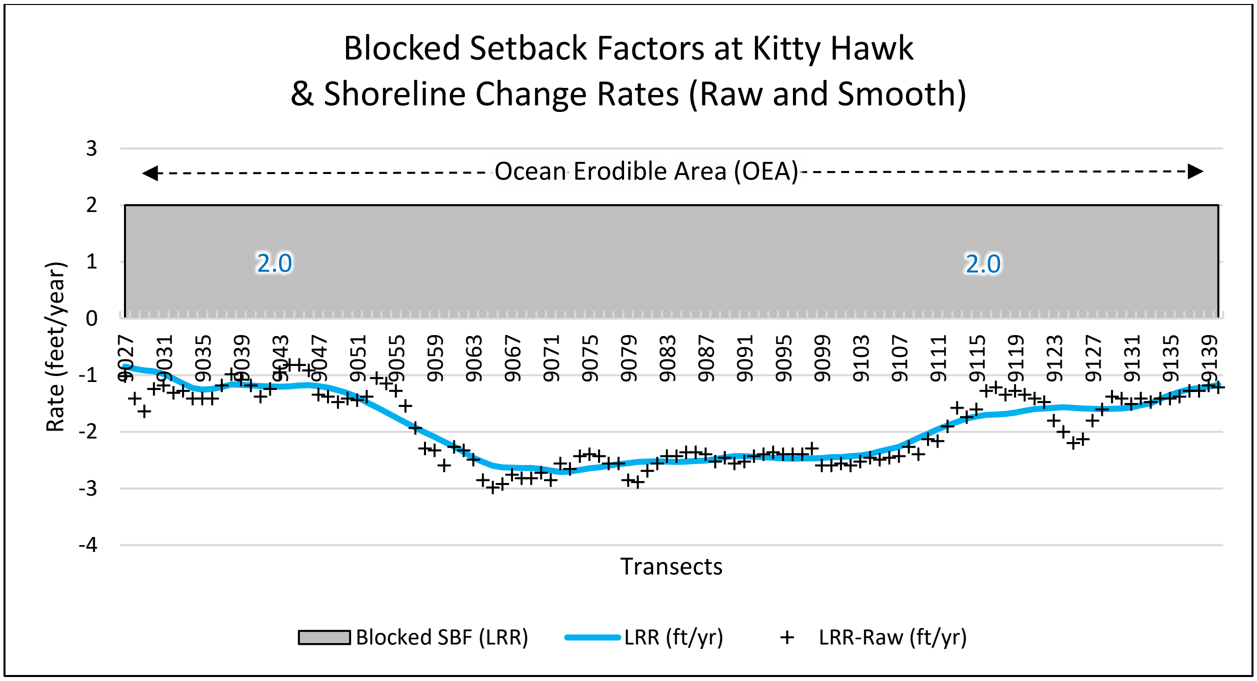

Figure 246. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

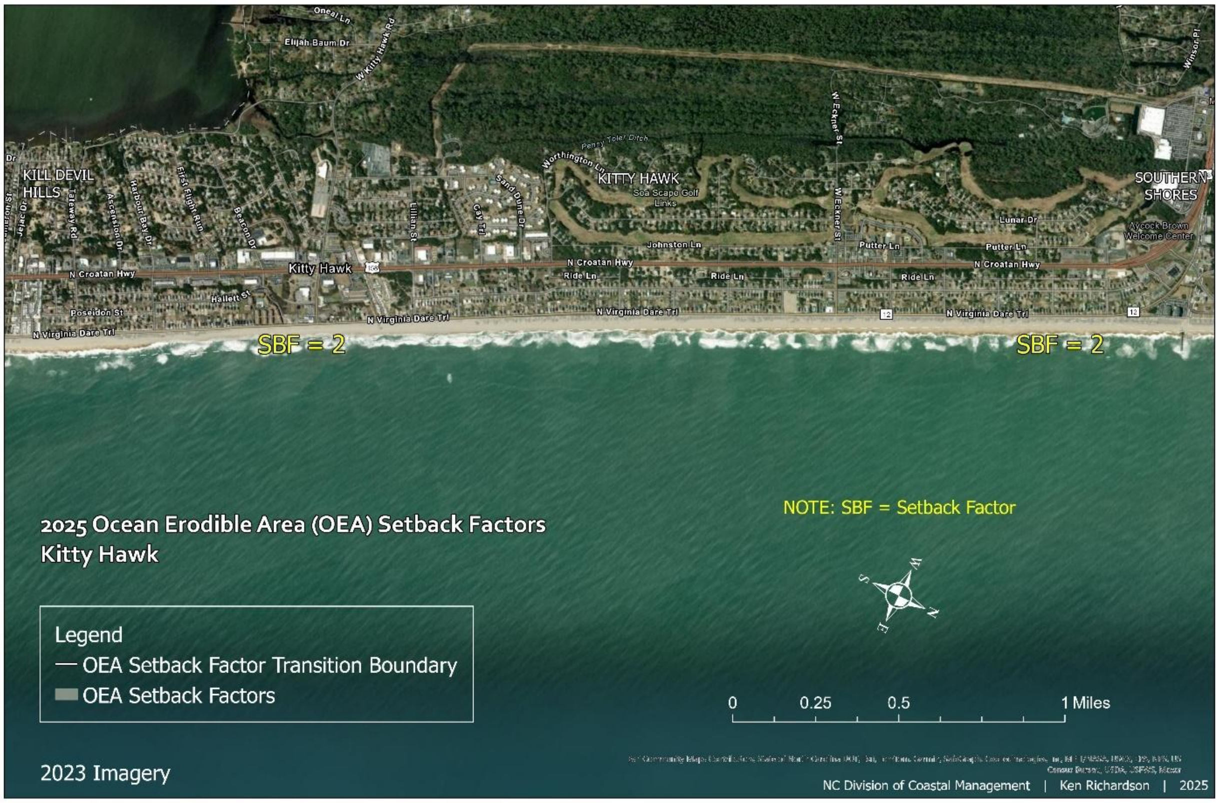

Figure 247. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Kitty Hawk.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2 to 3	2 to 2.5	2 to 4	2 to 4	2 to 4	N/A	N/A

Table 41*. This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.41 Southern Shores

At Southern Shores, the oceanfront shoreline extends for 3.7 miles. In 2017, a large-scale beach nourishment project was installed that covered the southern portion of this shoreline spanning approximately 0.5-mile between transects 9141 and 9157; and then in 2022, another large-scale project was installed for the remaining portion of this shoreline section from transect 9158 to the Town's northern boundary near transect 9260.

Here, twelve shorelines (**Figure 248**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 86 feet to a maximum of 152 feet, with an average of 115 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 24 and 45 feet, and an average of 33 feet. Of the 3.7 miles of shoreline analyzed, 3.7 miles (100%) resulted in measured erosion where rates ranged between -1.1 and less than -1.0 feet per year and averaged less than -1.0 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 249**). Between transects 9141 and 9260, the end-point method resulted in a range of shoreline line change rates between -1.3 and less than -1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -1.1 and less than -1.0 feet per year, averaging less than -1.0 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors equaled 2 feet per year, and the least squares regression equaled 2 feet per year.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 9141 and 9260 equaled 2 feet per year (**Figure 249** to **Figure 253** & **Table 42**).

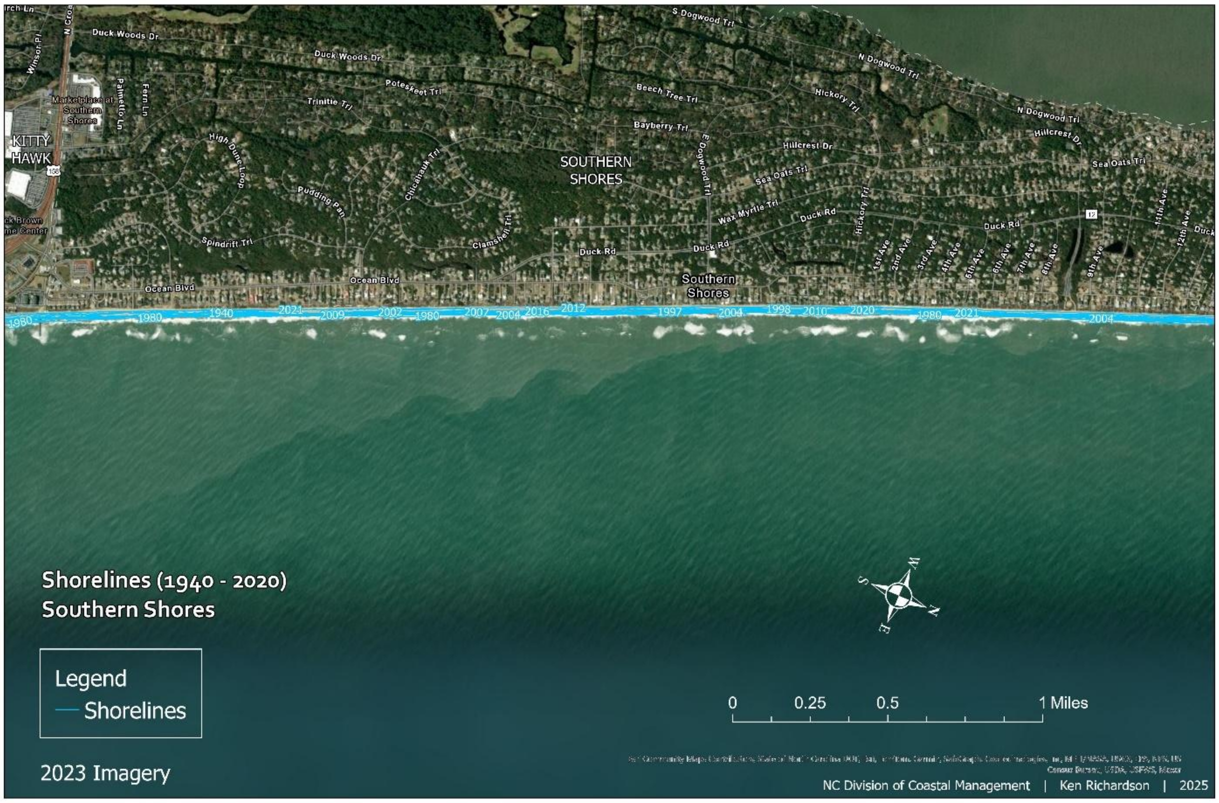

Figure 248. *Shorelines included in the analysis (1940-2020) at Southern Shores.*

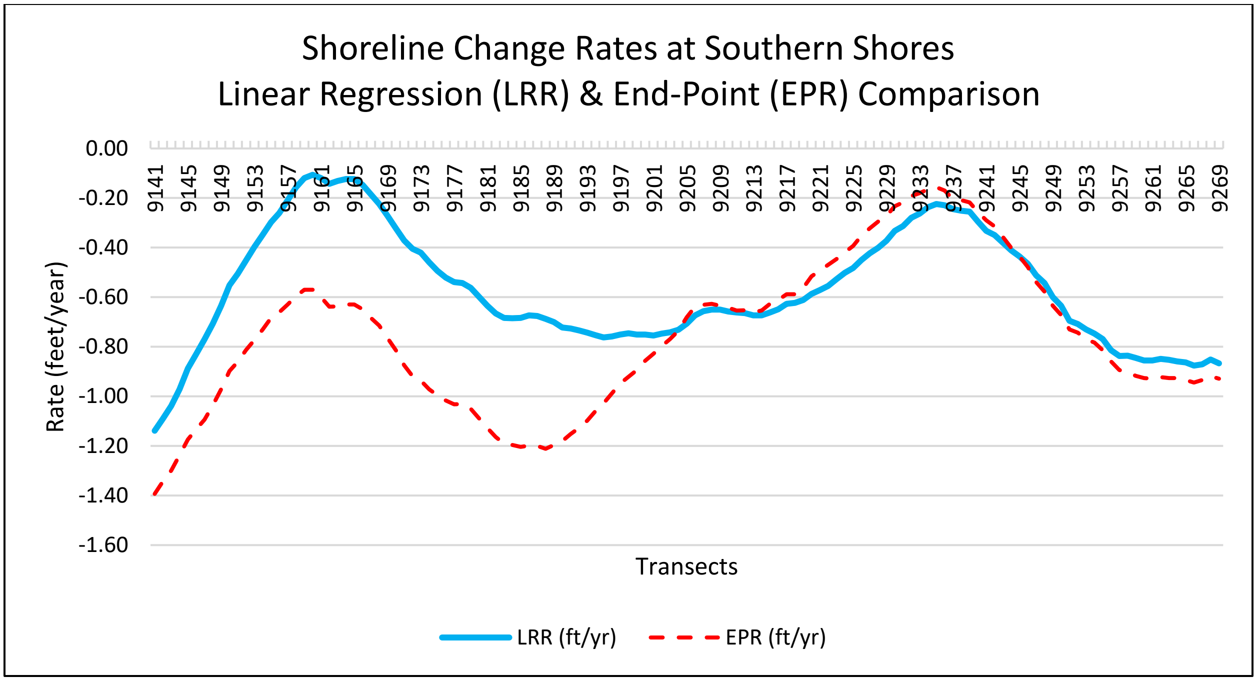

Figure 249. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

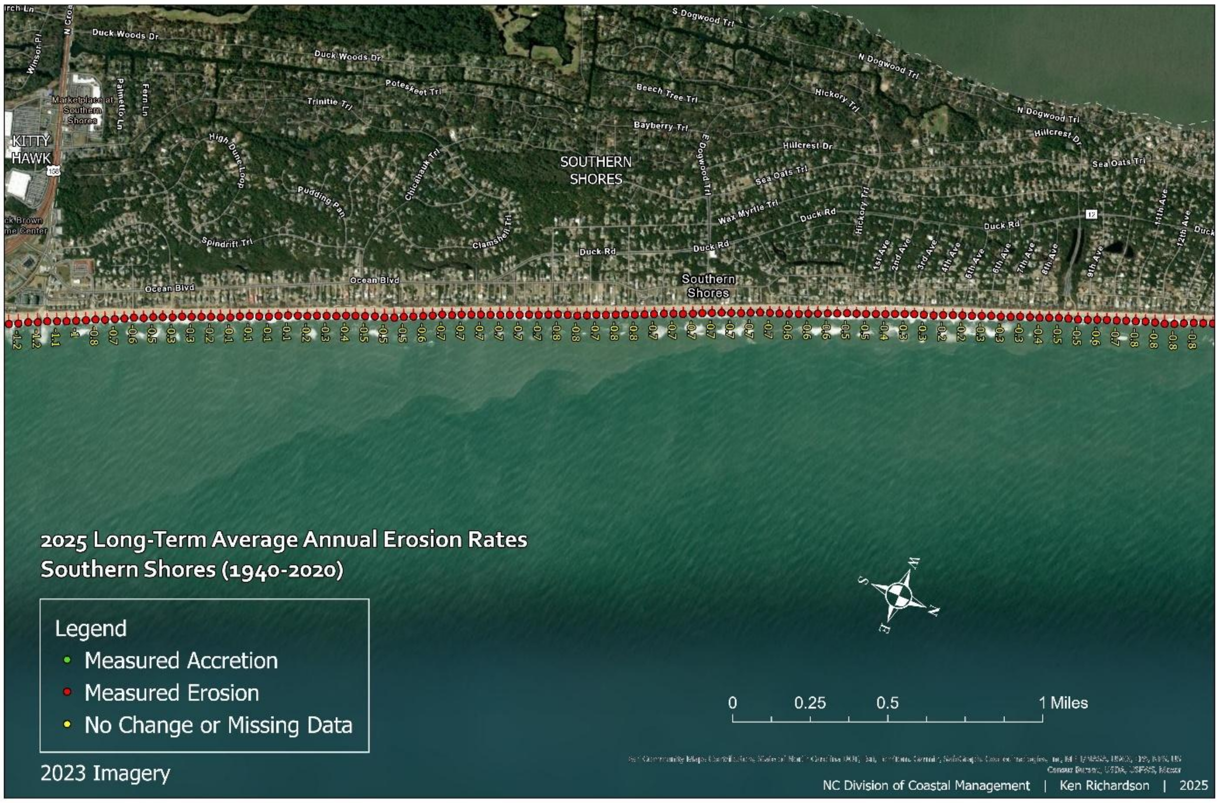

Figure 250. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

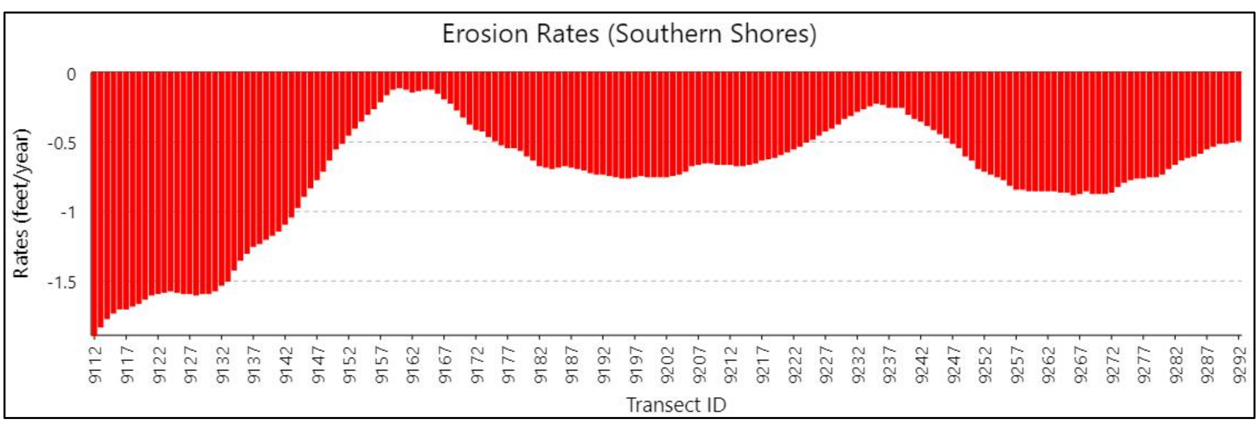

Figure 251. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

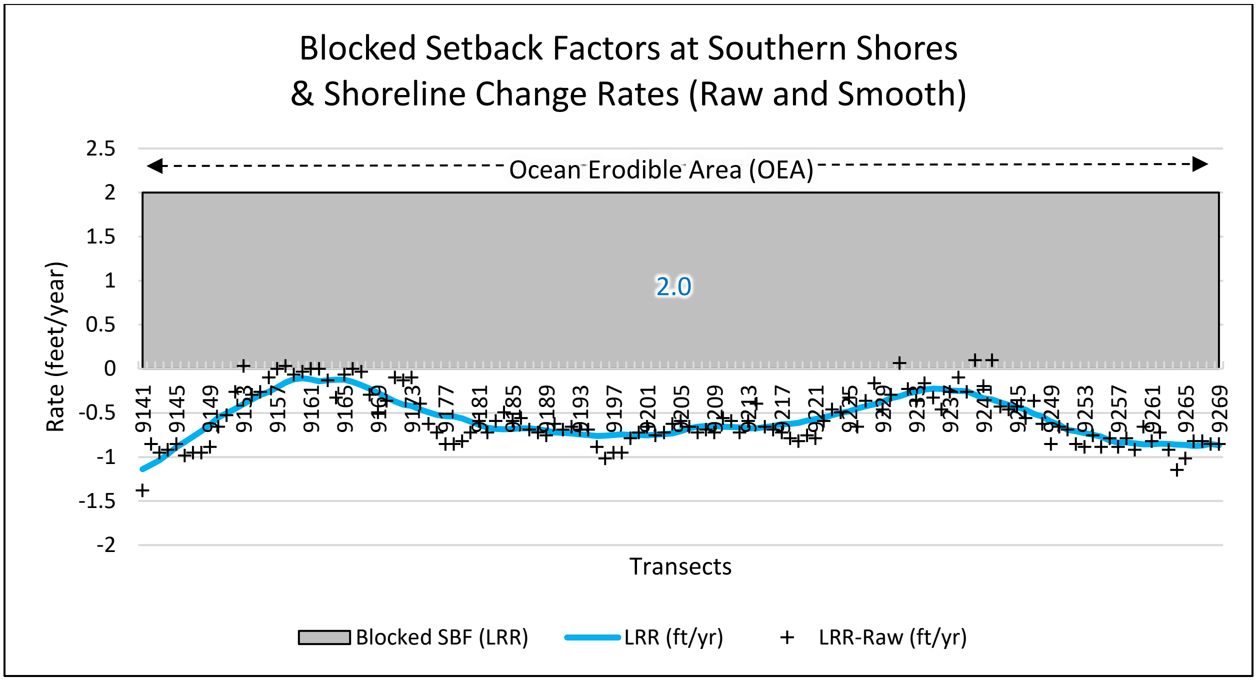

Figure 252. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 253. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Southern Shores.*

Ocean Erodible Area (OEA)	**2025**	**2020**	**2013**	**2004**	**1997**	**1986**	**1983**	**1980**
Setback Factor (SBF)	2	2	2	2	2	2	N/A	N/A

Table 42. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.42 Duck

In the area of Duck to the Dare and Currituck County line, this section of oceanfront shoreline extends for 5.9 miles. In 2017, a large-scale beach nourishment project was installed that covered 1.7 miles of shoreline between transects 9345 and 9396 (at Duck), followed by a maintenance project in 2023.

Here, twelve shorelines (**Figure 254**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 78 feet to a maximum of 258 feet, with an average of 153 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 26 and 68 feet, and an average of 44 feet. Of the 5.9 miles of shoreline analyzed, 5.0 miles (85%) resulted in measured erosion where rates ranged between -2.1 and less than -1.0 feet per year and averaged -1.1 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 255**). Between transects 9261 and 9452, the end-point method resulted in a range of shoreline line change rates between -1.8 and less than -1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -2.1 and less than -1.0 feet per year, averaging less than -1.0 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors equaled 2 feet per year, and the least squares regression equaled 2 feet per year.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 9261 and 9452 equaled 2 feet per year (**Figure 255** to **Figure 259** & **Table 43**).

Figure 254. *Shorelines included in the analysis (1940-2020) at Duck.*

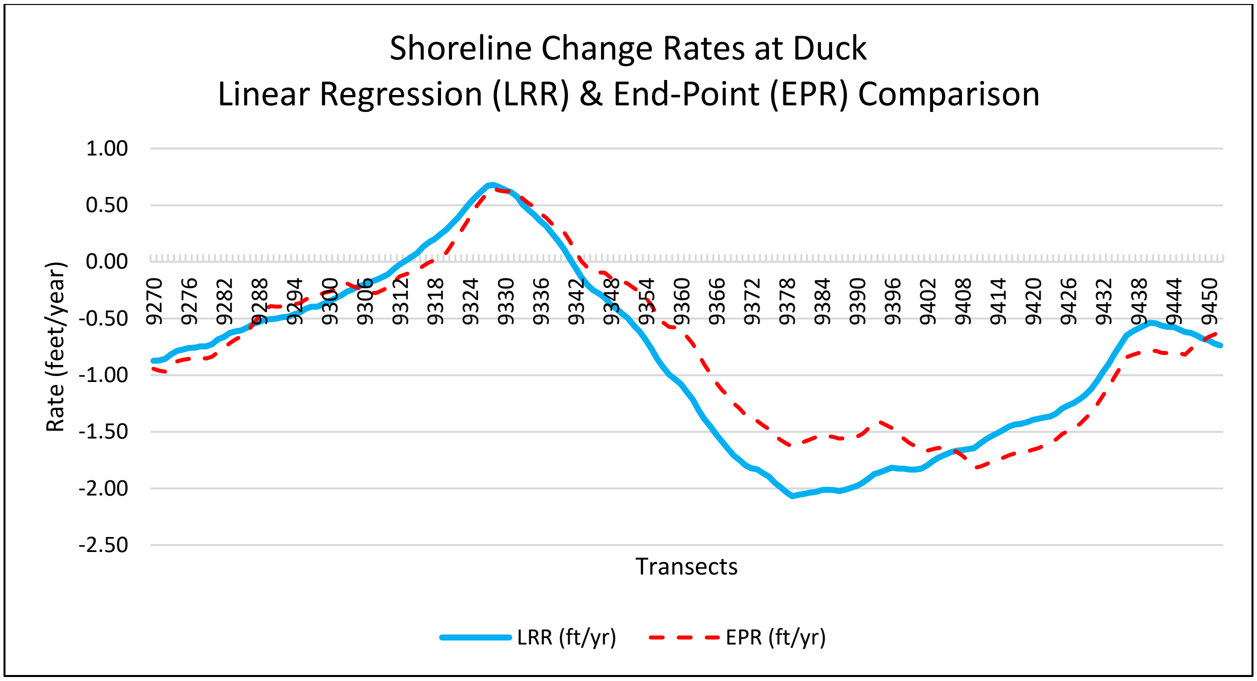

Figure 255. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

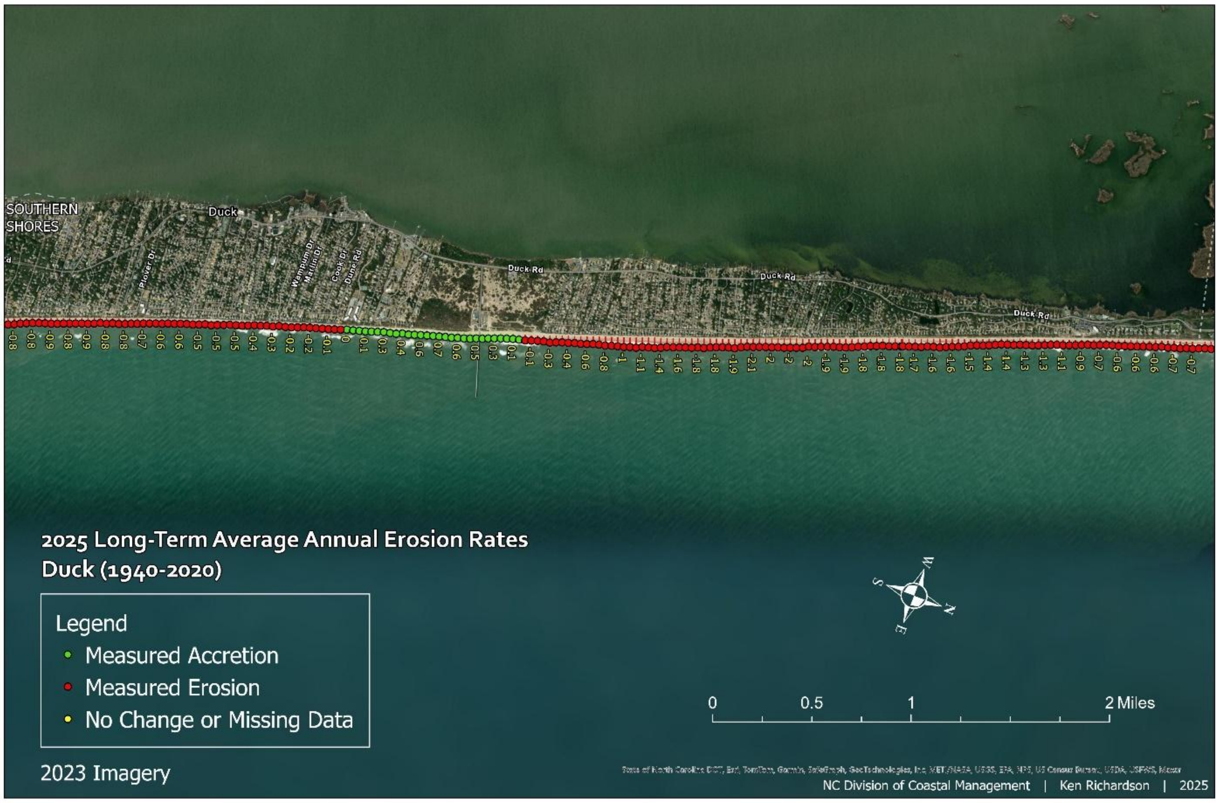

Figure 256. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

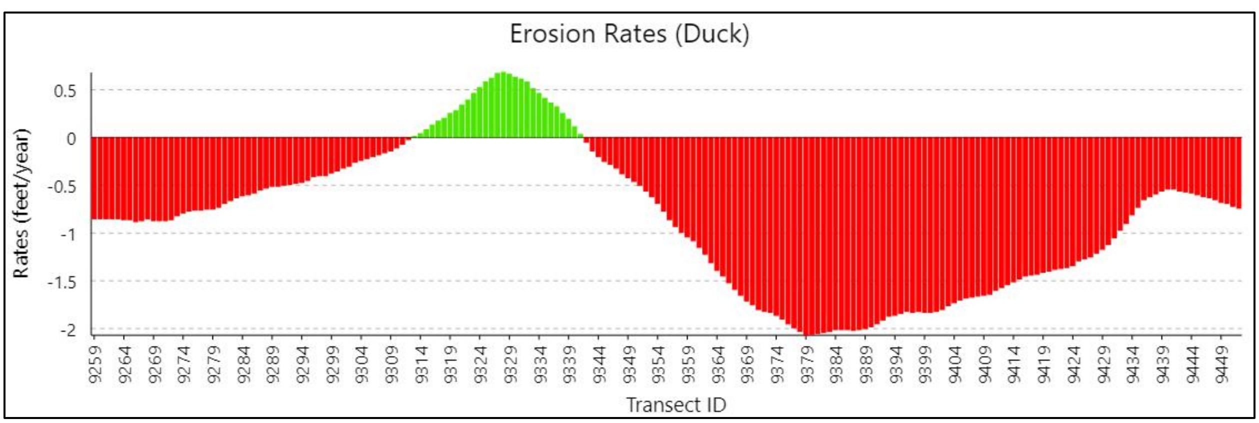

Figure 257. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

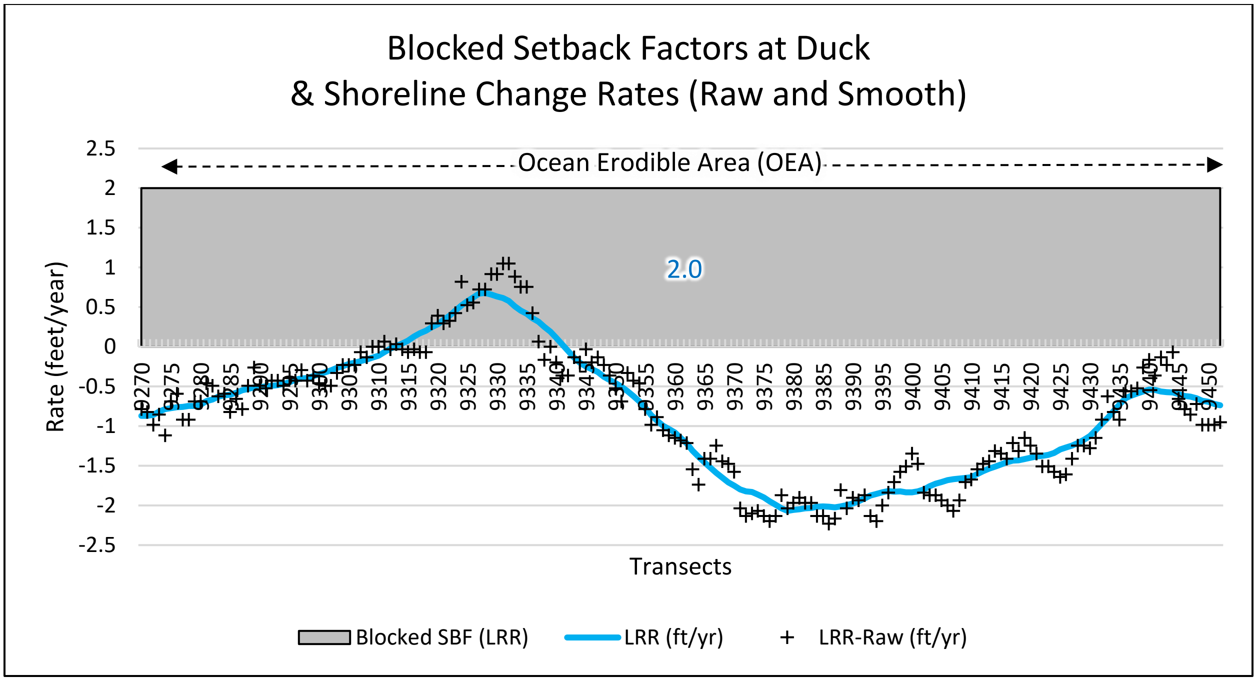

Figure 258. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 259. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Duck.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2 to 3	2	2	2	2

Table 43. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.43 Duck to Corolla

In the area from Duck to Corolla, this section of oceanfront shoreline extends for 7.0 miles. Here, twelve shorelines (***Figure 260***) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 60 feet to a maximum of 227 feet, with an average of 142 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 17 and 73 feet, and an average of 43 feet. Of the 7.0 miles of shoreline analyzed, 6.2 miles (89%) resulted in measured erosion where rates ranged between -2.2 and less than -1.0 feet per year and averaged less than -1.0 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 261**). Between transects 9453 and 9679, the end-point method resulted in a range of shoreline line change rates between -2.5 and less than +1.0 feet per year, averaging less than -1.0 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -2.2 and less than +1.0 feet per year, averaging less than -1.0 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors equaled 2 feet per year, and the least squares regression equaled 2 feet per year.

Utilizing the least squares regression methodology provides a more precise representation of long-term shoreline movement and yields results consistent with previous studies for this section of shoreline. Based on this approach, the calculated setback factors within the OEA between transects 9453 and 9679 equaled 2 feet per year (**Figure 261** to **Figure 265** & **Table 44**).

Figure 260. *Shorelines included in the analysis (1940-2020) at between Duck and Corolla.*

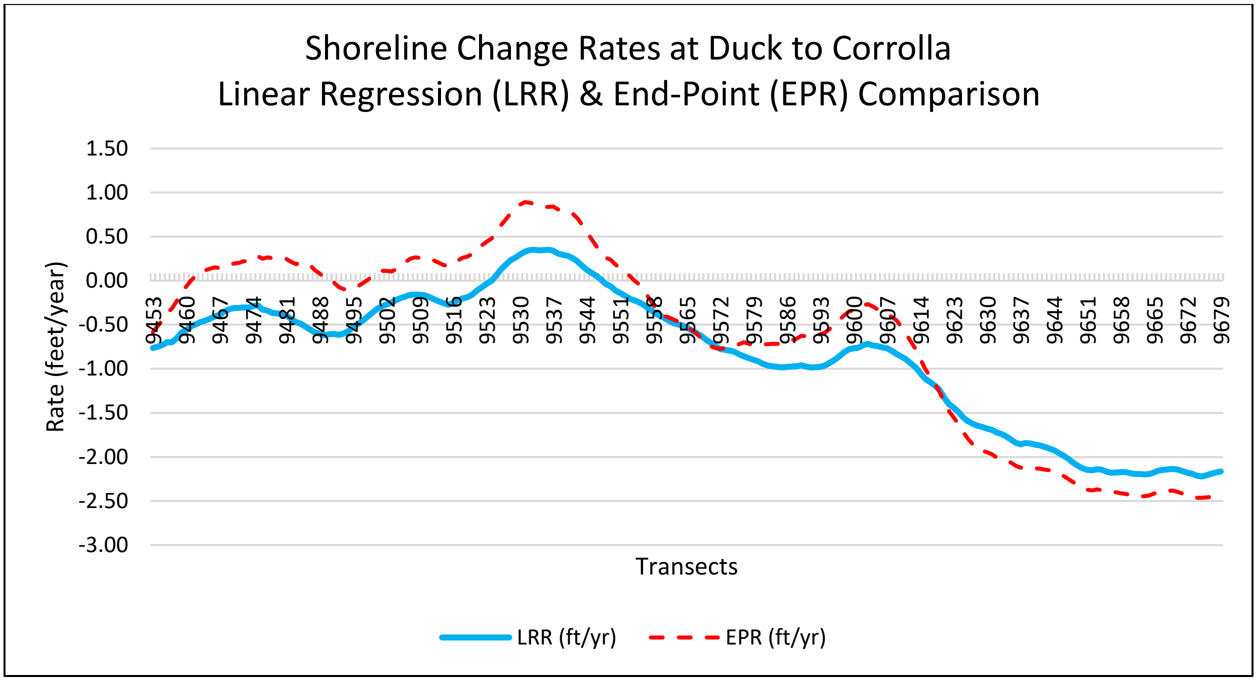

Figure 261. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

Figure 262. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

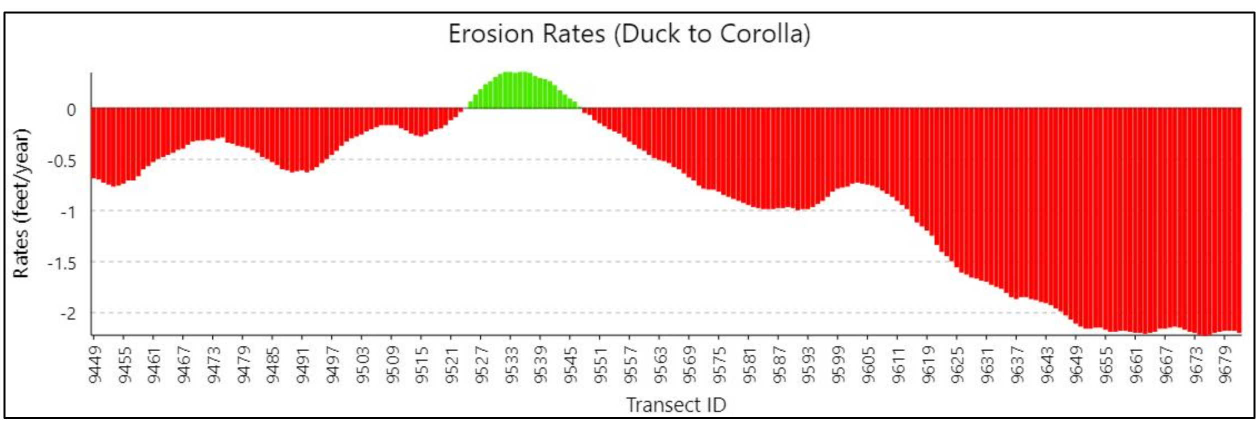

Figure 263. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

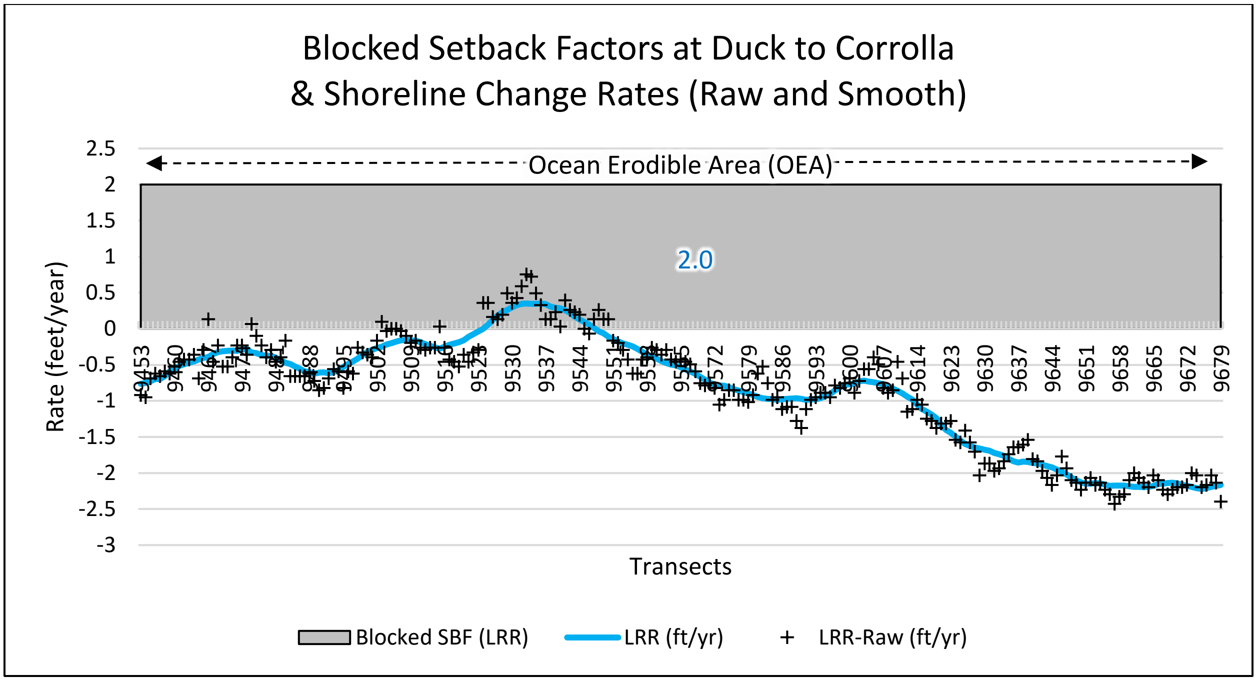

Figure 264. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

Figure 265. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Duck and Corolla.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	2	2	2	2	2 to 3	2 to 6	N/A	N/A

Table 44. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.44 Corolla

In the area of Corolla, this section of oceanfront shoreline extends for 4.8 miles. Here, twelve shorelines (**Figure 266**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 148 feet to a maximum of 378 feet, with an average of 234 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 57 and 106 feet, and an average of 77 feet. Of the 4.8 miles of shoreline analyzed, all 4.8 miles (100%) resulted in measured erosion where rates ranged between -4.2 and -1.9 feet per year and averaged -2.5 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 267**). Between transects 9680 and 9833, the end-point method resulted in a range of shoreline line change rates between -3.4 and -2.1 feet per year, averaging -2.6 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -4.2 and -1.9 feet per year, averaging -2.5 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 3 feet per year, and the least squares regression ranged from 2 to 4 feet per year.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement and produces results consistent with previous studies for this shoreline section. Based on this approach, the calculated setback factors within the OEA between transects 9680 and 9833 range from 2 to 4 feet per year. Rates begin at 2 feet per year near Corolla's southernmost boundary at transect 9680, increase to 3 feet per year near transect 9781, and reach 4 feet per year approaching the end of the paved surface of N Beach Access Road near transect 9828 (**Figure 268** to **Figure 271** & **Table 45**).

Figure 266. *Shorelines included in the analysis (1940-2020) at Corolla.*

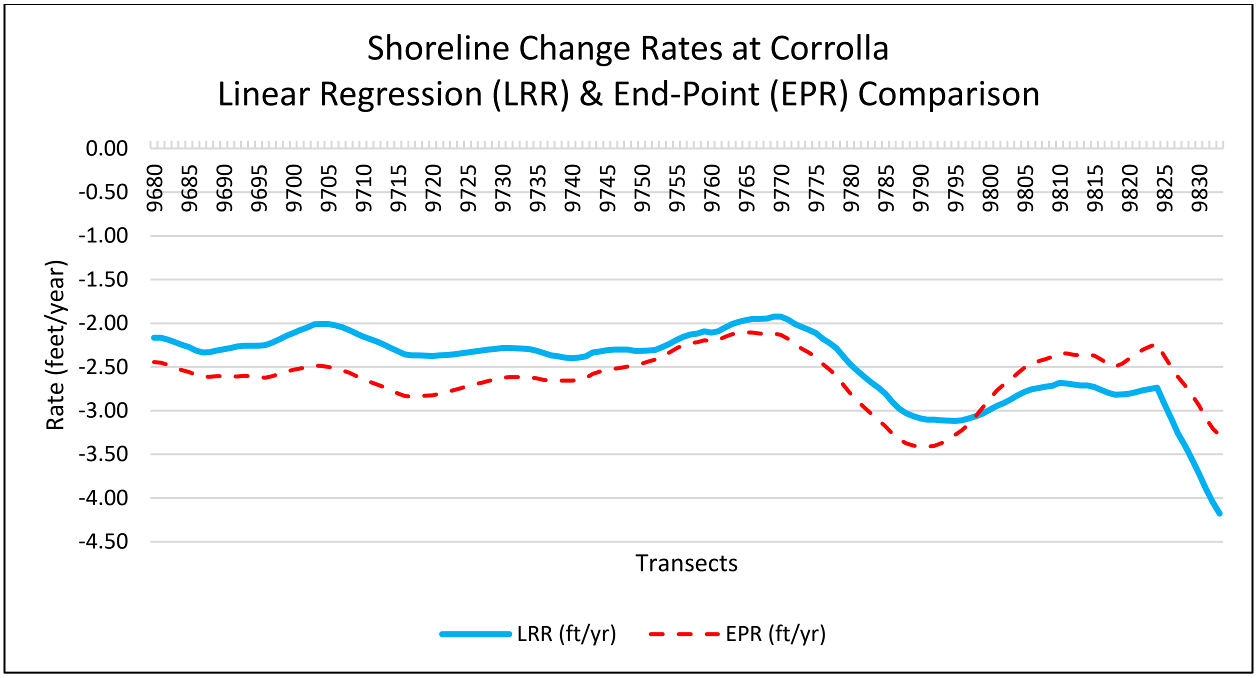

Figure 267. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

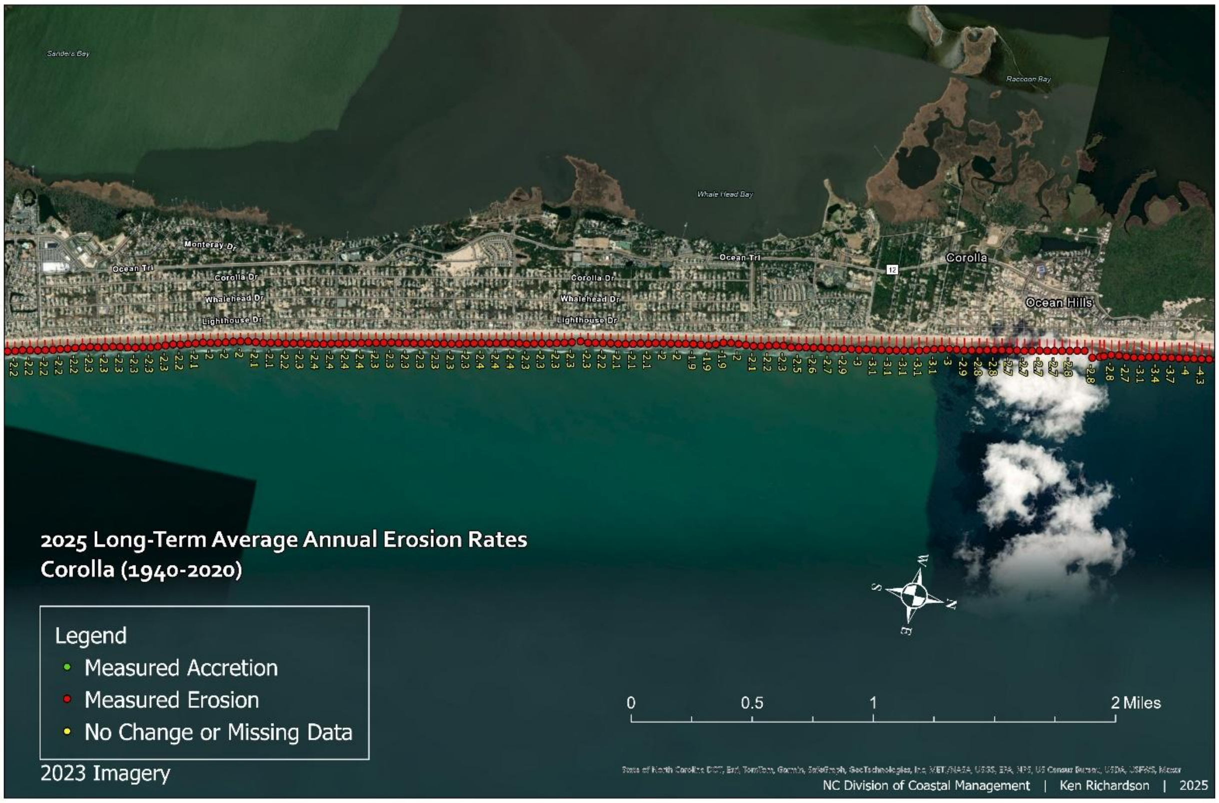

Figure 268. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

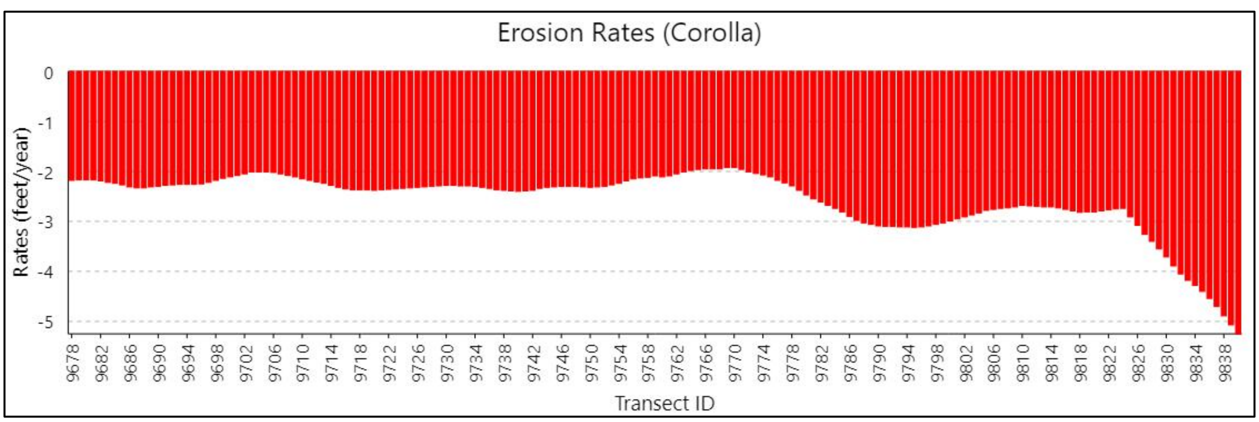

Figure 269. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

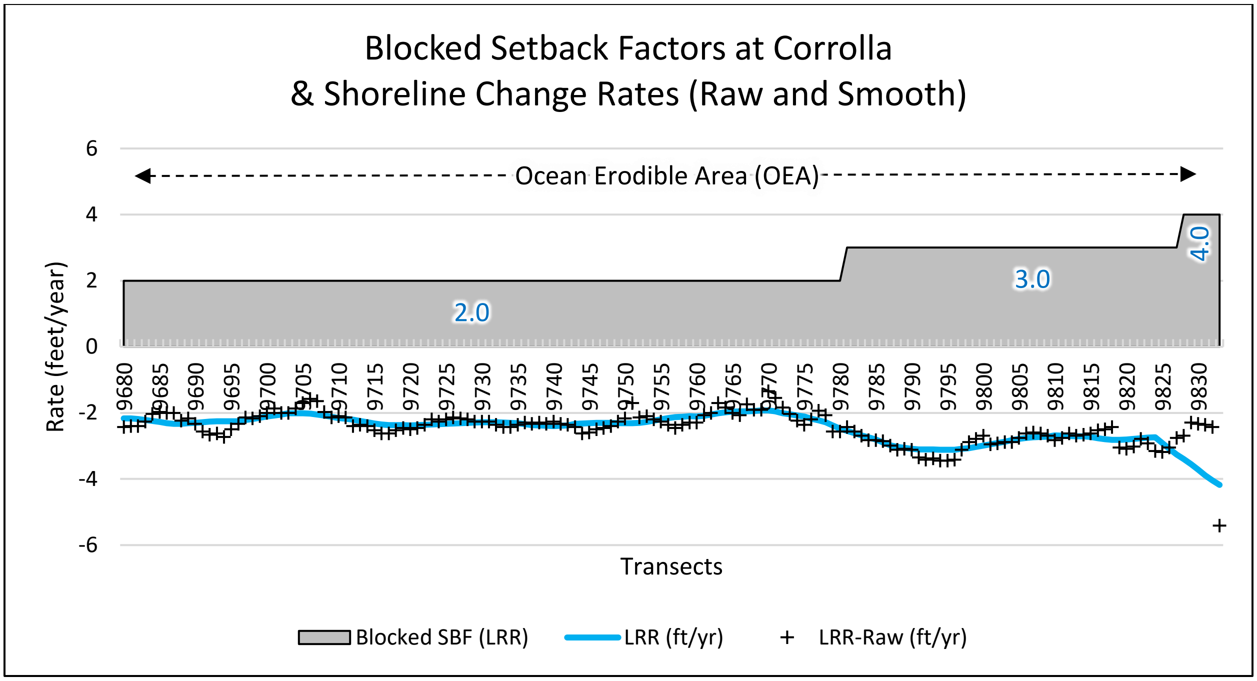

Figure 270. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

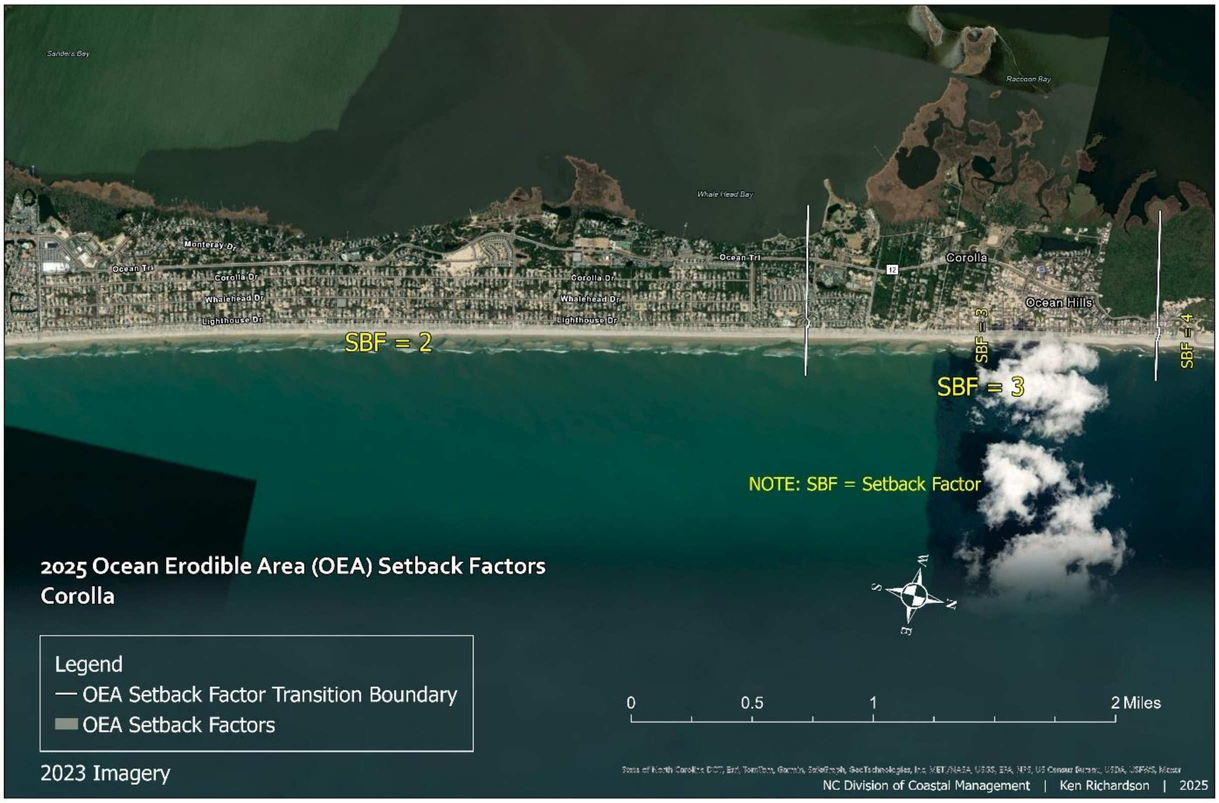

Figure 271. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Corolla.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 4	Range 2 to 3	Range 2 to 3	2	Range 2 to 7	Range 2 to 8	N/A	N/A

Table 45. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.45 Currituck National Wildlife Refuge

In the area of the Currituck National Wildlife Refuge, this section of oceanfront shoreline extends for 1.7 miles. Here, twelve shorelines (**Figure 272**) were assessed along this oceanfront section over an 80-year period, from 1940 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 286 feet to a maximum of 458 feet, with an average of 385 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 93 and 143 feet, and an average of 120 feet. Of the 1.7 miles of shoreline analyzed, all 1.7 miles (100%) resulted in measured erosion where rates ranged between -7.7 and -4.9 feet per year and averaged -6.5 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 273**). Between transects 9834 and 9890, the end-point method resulted in a range of shoreline line change rates between -6.6 and -3.3 feet per year, averaging -5.4 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -7.7 and -4.9 feet per year, averaging -6.7 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors ranged from 3 to 6.5 feet per year, and the least squares regression ranged from 4 to 8 feet per year.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement and produces results consistent with previous studies for this shoreline section. Based on this approach, the calculated setback factors within the OEA between transects 9834 and 9890 range from 4 to 8 feet per year. Starting at transect 9834 and moving north, rates begin at 4 feet per year, increase to 5 feet per year near transect 9836, increase to 6 feet per year near transect 9845, increase to 7 feet per year near transect 9859, and reach 8 feet per year at transect 9881 (**Figure 273** to **Figure 277** & **Table 46**).

Figure 272. *Shorelines included in the analysis (1940-2020) at Currituck National Wildlife Refuge.*

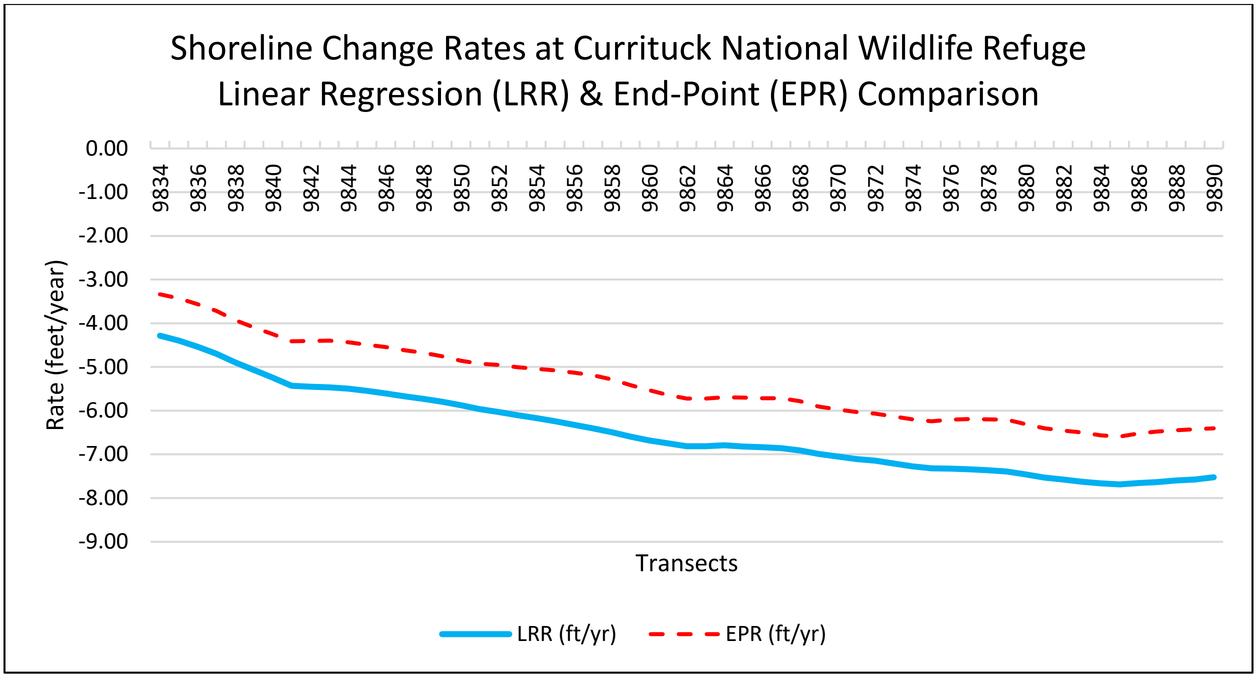

Figure 273. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

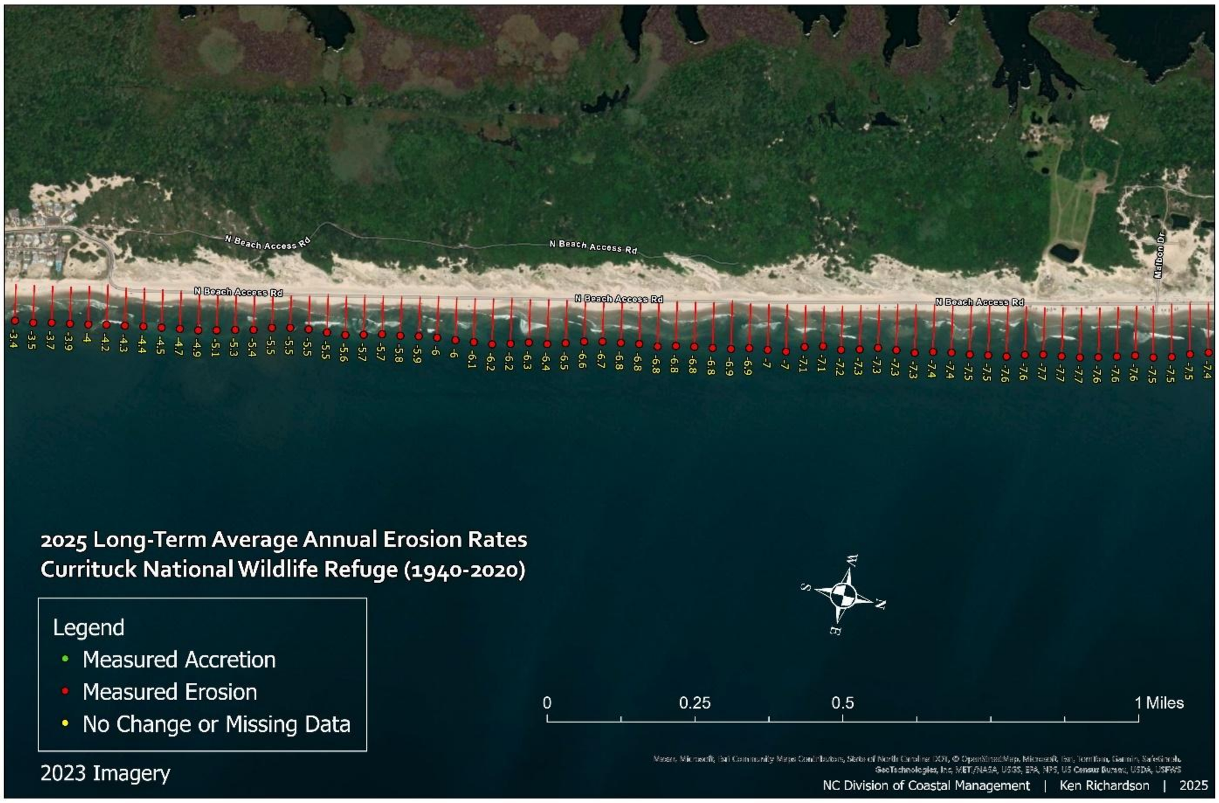

Figure 274. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

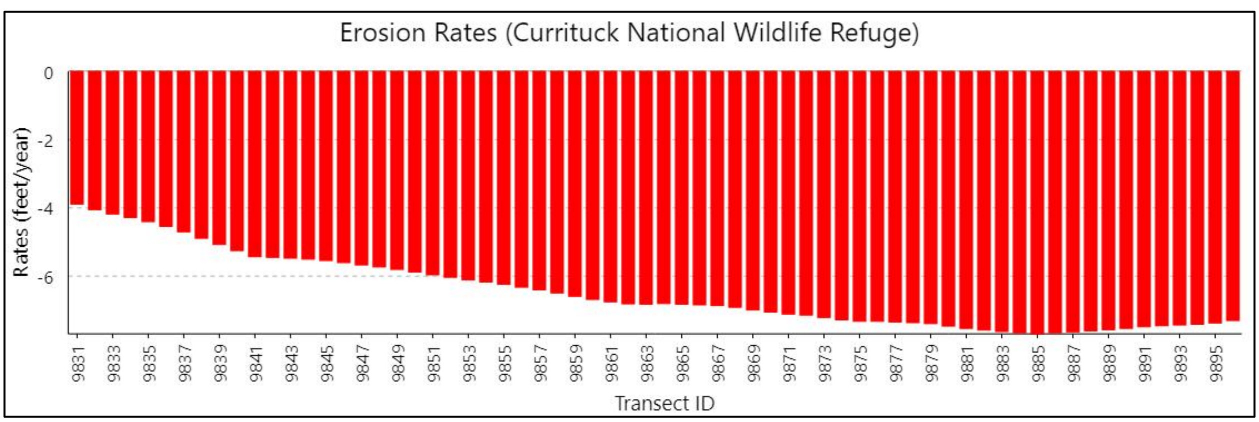

Figure 275. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

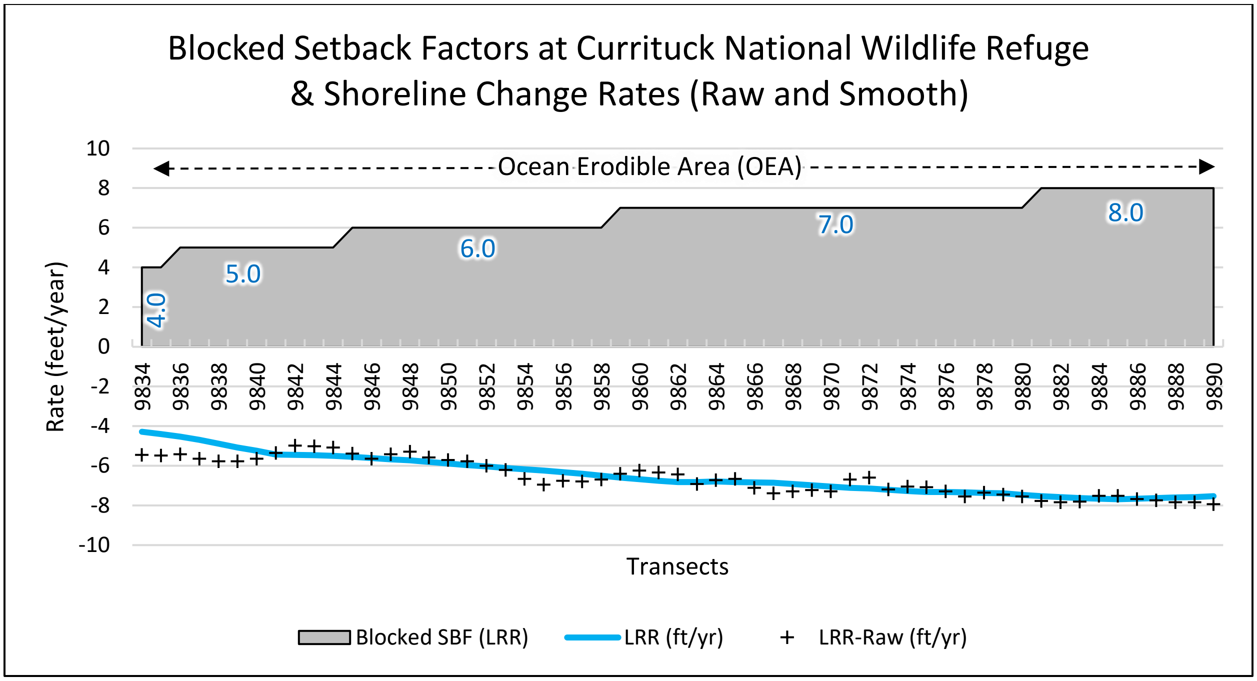

Figure 276. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

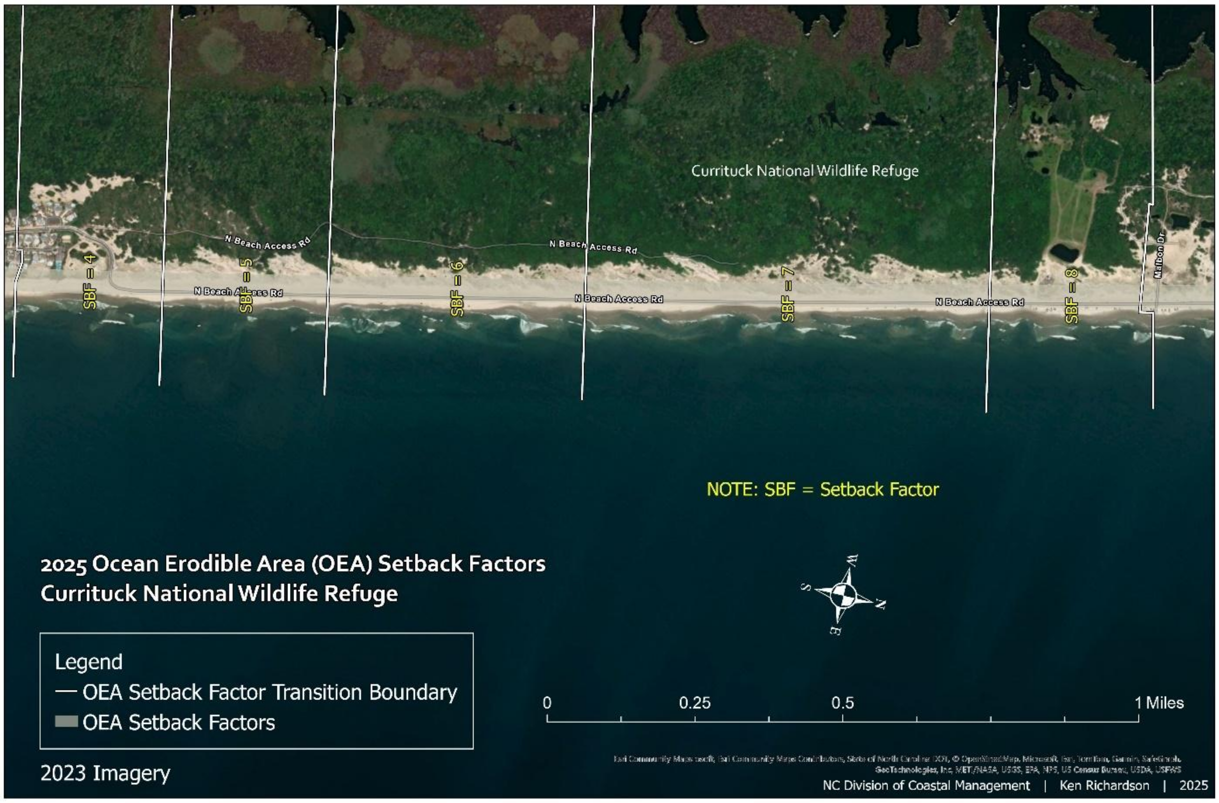

Figure 277. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Currituck National Wildlife Refuge.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 4 to 8	Range 4 to 8	Range 3 to 6	Range 2 to 4.5	Range 5 to 6	Range 2 to 6	N/A	N/A

Table 46. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.46 Currituck County (Currituck National Wildlife Refuge to Carova)

In the area between Currituck National Wildlife Refuge and Carova, this section of oceanfront shoreline extends for 4.8 miles. Here, twelve shorelines (**Figure 278**) were assessed along this oceanfront section over a 58-year period, from 1962 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 240 feet to a maximum of 510 feet, with an average of 382 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 79 and 144 feet, and an average of 113 feet. Of the 4.8 miles of shoreline analyzed, all 4.8 miles (100%) resulted in measured erosion where rates ranged between -7.5 and -3.1 feet per year and averaged -5.8 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 279**). Between transects 9891 and 10045, the end-point method resulted in a range of shoreline line change rates between -6.6 and -1.8 feet per year, averaging -4.9 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -7.5 and -3.1 feet per year, averaging -5.8 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors ranged from 2 to 7 feet per year, and the least squares regression ranged from 3 to 7 feet per year.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement and produces results consistent with previous studies for this shoreline section. Based on this approach, the calculated setback factors within the OEA between transects 9891 and 10045 range from 3 to 7 feet per year. Starting at transect 9891 and moving north, rates begin at 7 feet per year, decrease to 6 feet per year near transect 9956, decrease to 5 feet per year near transect 9985, decrease to 4 feet per year near transect 10010, and then decrease to 3 feet per year at transect 10039 (**Figure 280** to **Figure 283** & **Table 47**).

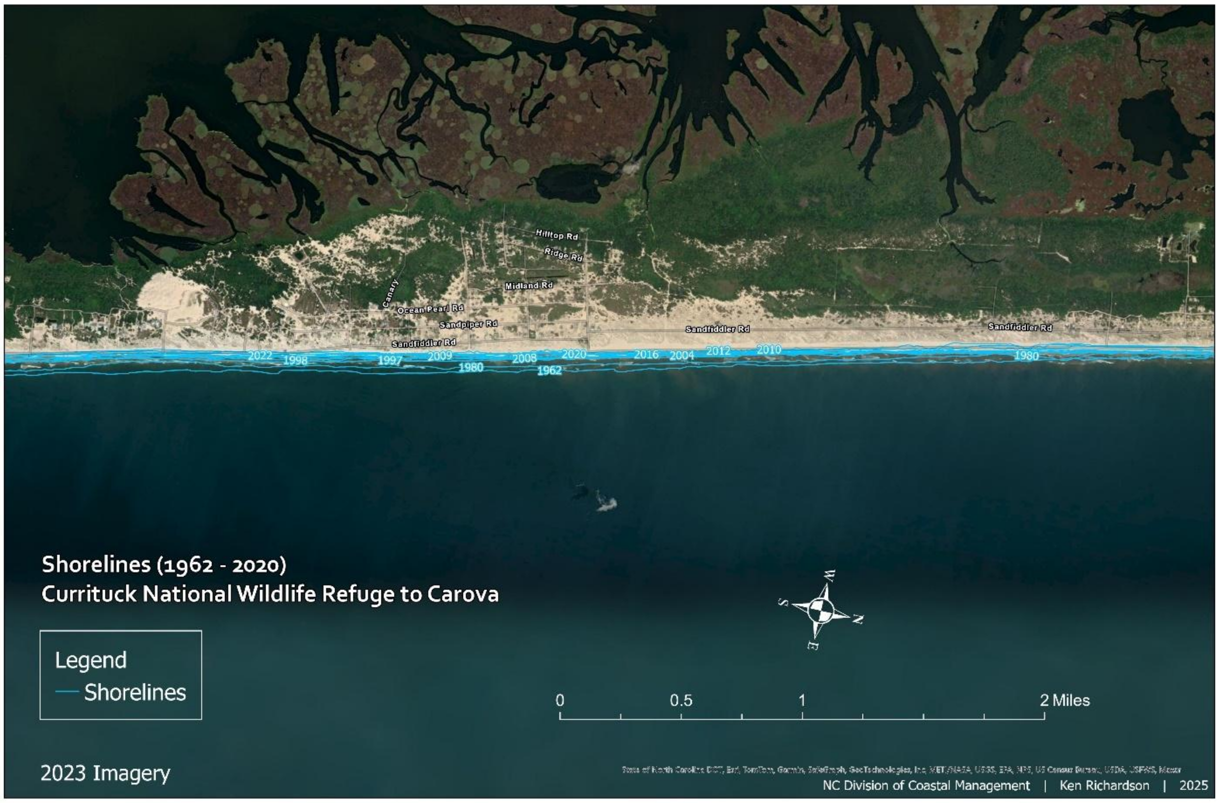

Figure 278. *Shorelines included in the analysis (1962-2020) between Currituck National Wildlife Refuge to Carova.*

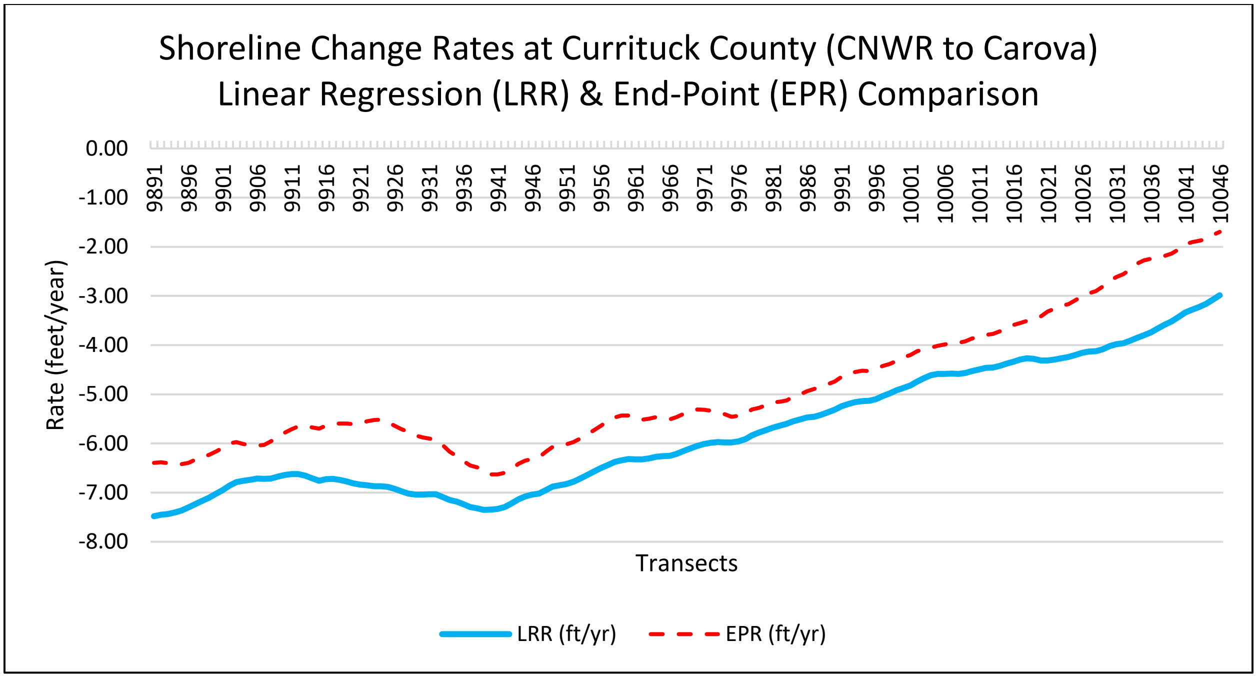

Figure 279. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

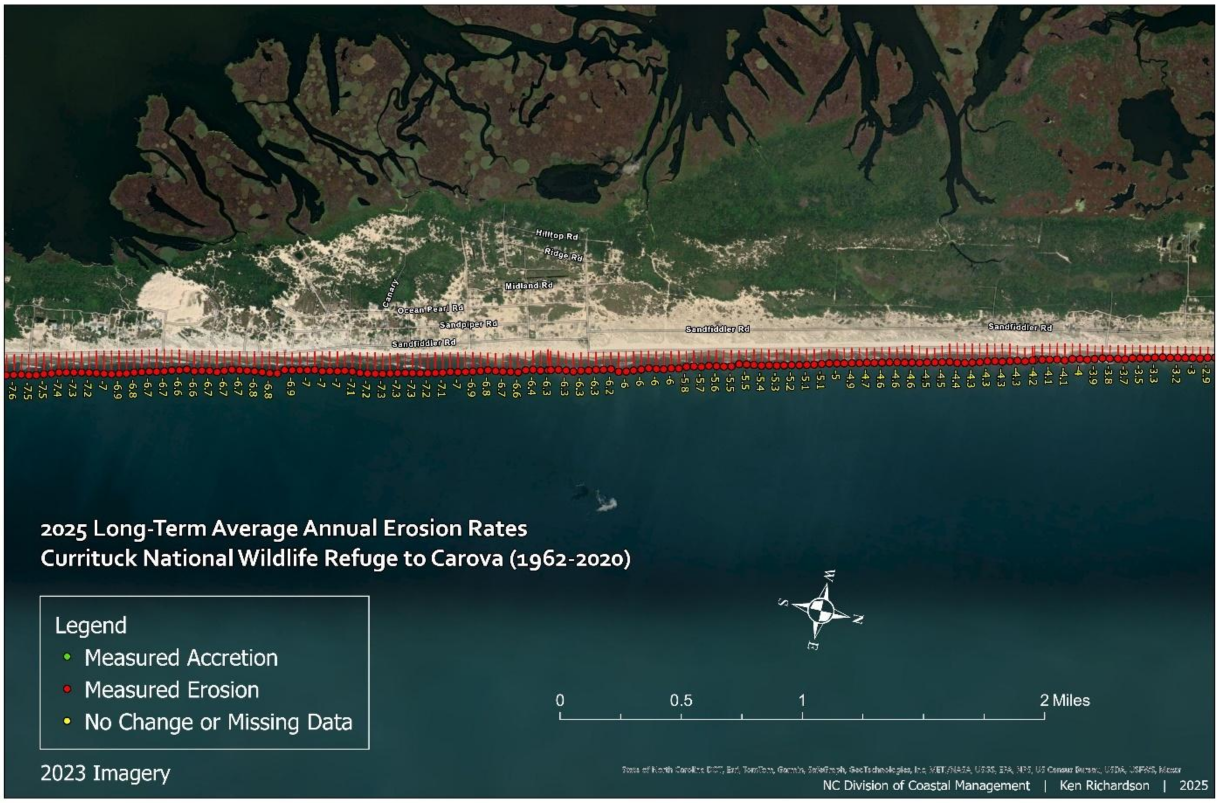

Figure 280. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

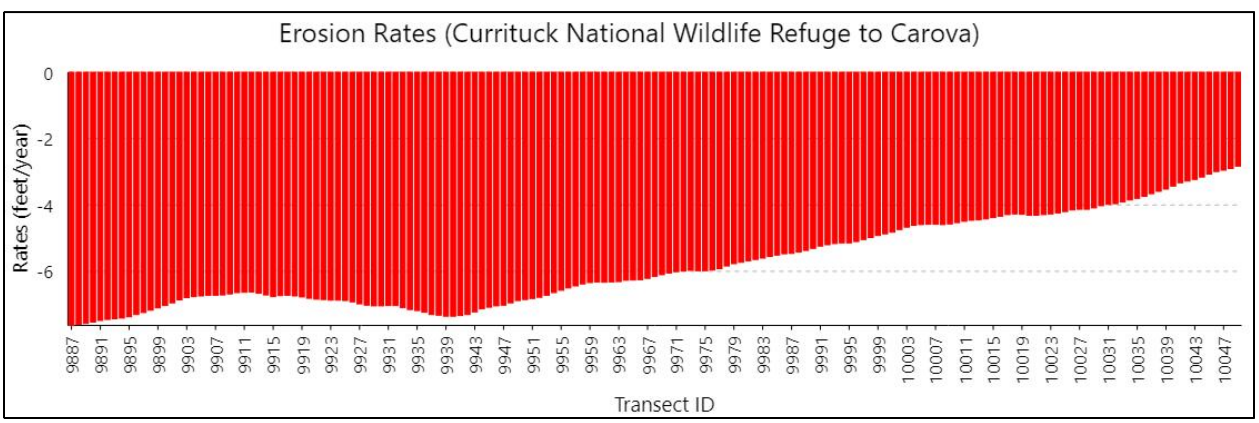

Figure 281. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

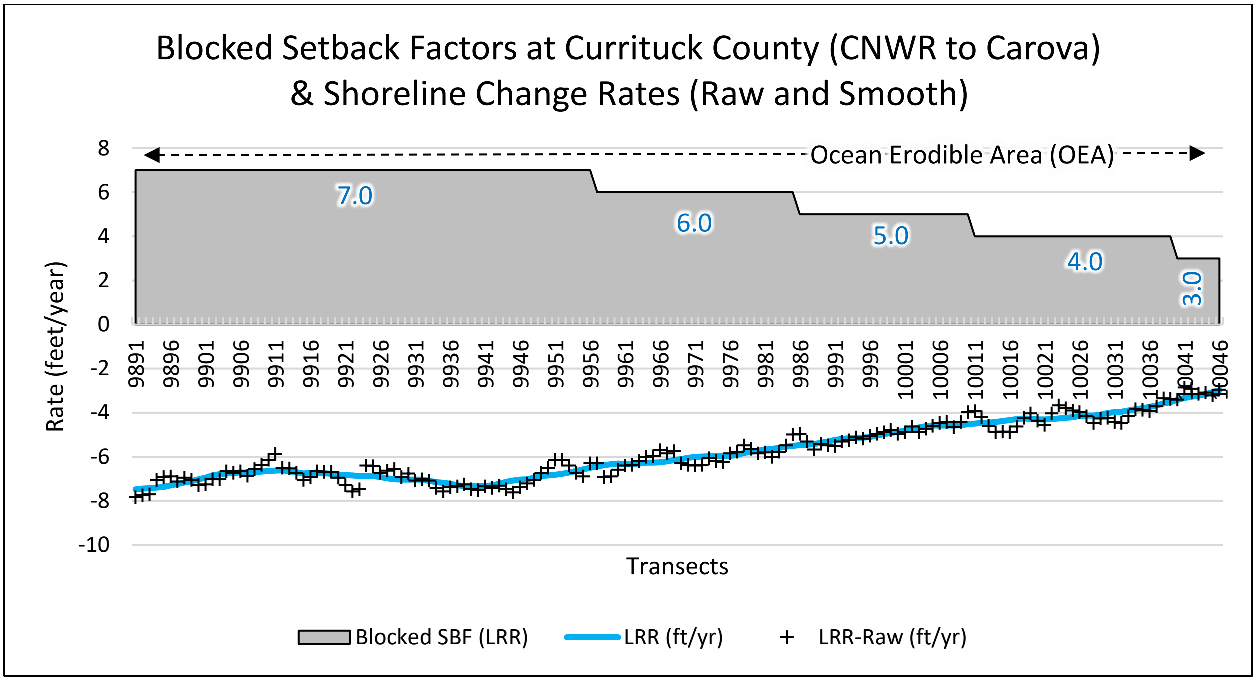

Figure 282. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

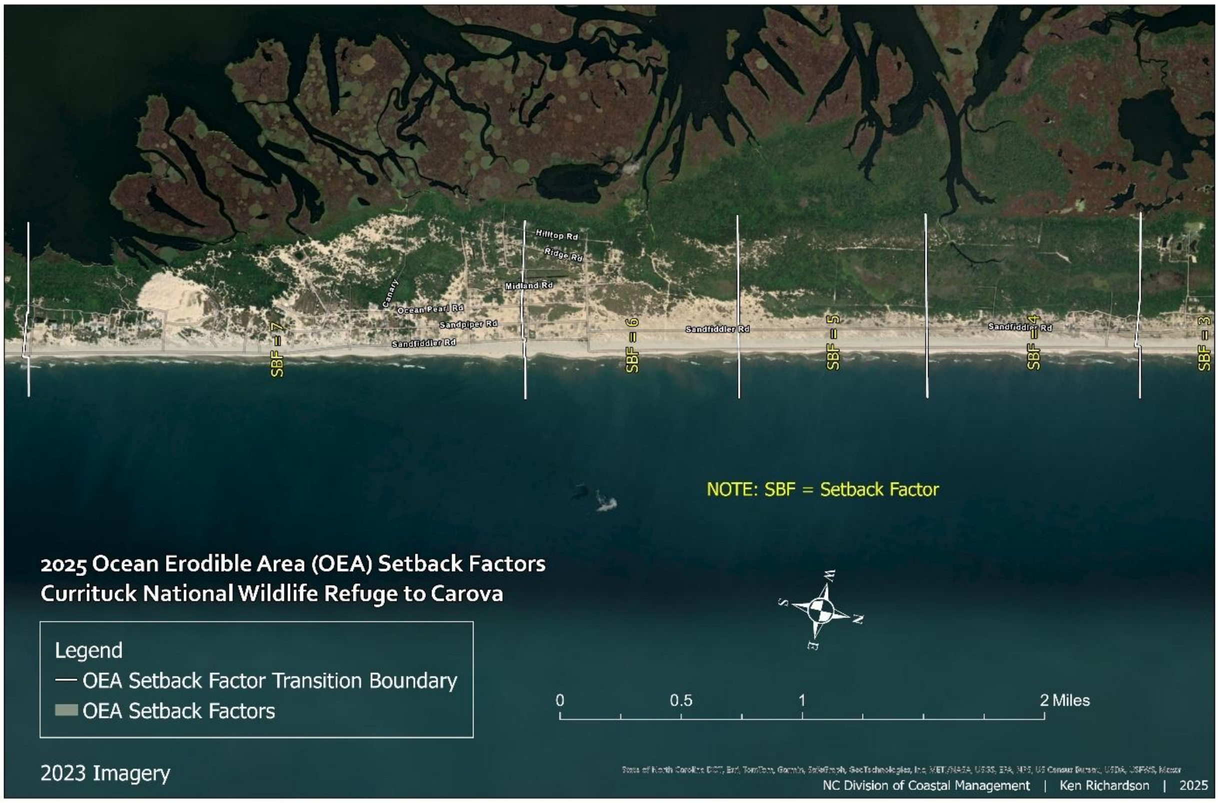

Figure 283. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area between Currituck National Wildlife Refuge and Carova.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 3 to 7	Range 4 to 8	Range 3 to 7	Range 2 to 8	Range 3 to 9.5	Range 2 to 9	N/A	N/A

Table 47. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

3.47 Currituck County (Carova)

In the area from Carova to the NC-VA boundary, this section of oceanfront shoreline extends for 4.3 miles. Here, twelve shorelines (**Figure 284**) were assessed along this oceanfront section over a 95-year period, from 1925 to 2020. The shoreline envelope, representing the extent of movement along each transect, ranged from a minimum of 103 feet to a maximum of 329 feet, with an average of 230 feet for this segment of shoreline. The calculated relative standard deviation of shoreline position ranged between 32 and 96 feet, and an average of 65 feet. Of the 4.3 miles of shoreline analyzed, less than 1.0 mile (22%) resulted in measured erosion where rates ranged between -3.0 and less than 1.0 feet per year and averaged -1.7 feet per year.

For comparison, both the end-point and least squares regression methods yielded similar results (**Figure 285**). Between transects 10046 and 10185, the end-point method resulted in a range of shoreline line change rates between -1.7 and +3.0 feet per year, averaging +1.5 feet per year; and the least squares regression method resulted in a range of shoreline line change rates between -3.0 and +2.7 feet per year, averaging less than +1.0 feet per year. Like previous studies, both approaches yielded similar results of blocked erosion rate setback factors. End-point setback factors equaled 2 feet per year, and the least squares regression ranged from 2 to 3 feet per year.

Using the least squares regression methodology provides a more accurate depiction of long-term shoreline movement and produces results consistent with previous studies for this shoreline section. Based on this approach, the calculated setback factors within the OEA between transects 10046 and 10185 range from 2 to 3 feet per year. Starting at transect 10046 and moving north, rates begin at 3 feet per year, and then decrease to 2 feet per year at transect 10056 (**Figure 285** to **Figure 289** & **Table 48**).

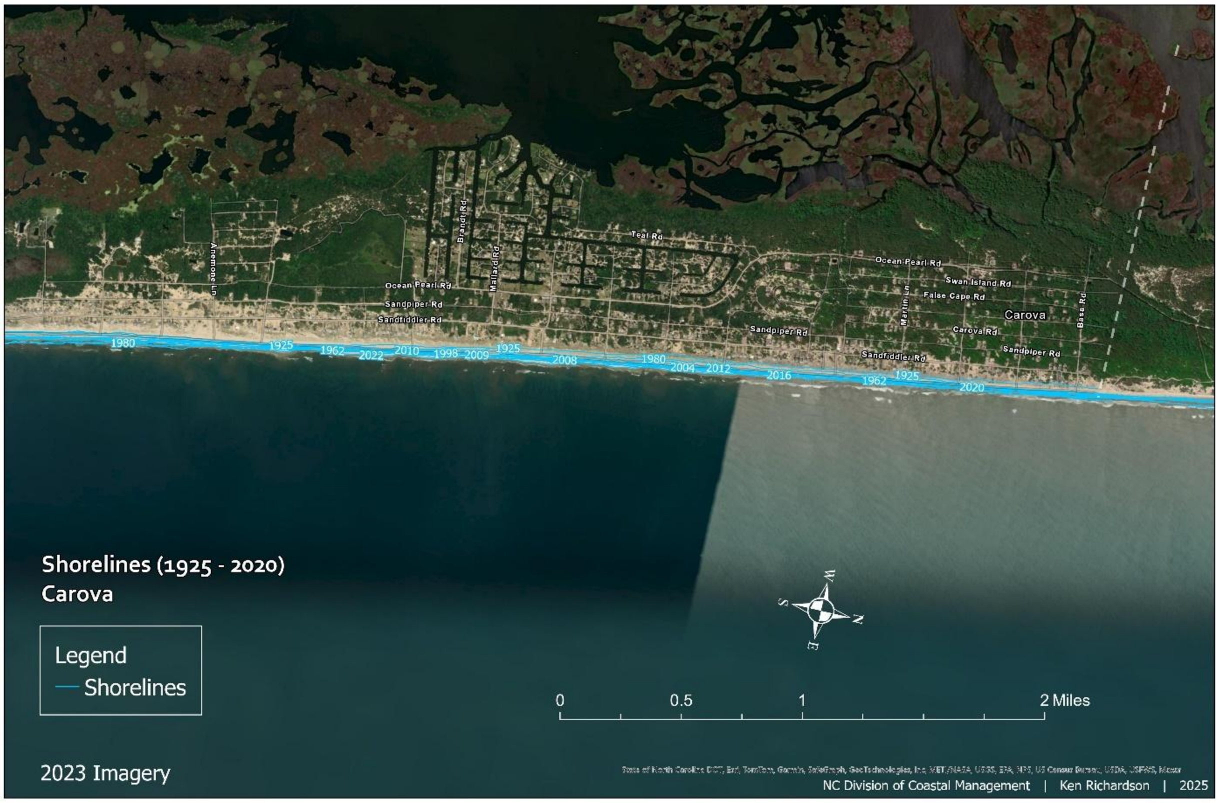

Figure 284. *Shorelines included in the analysis (1925-2020) at Carova.*

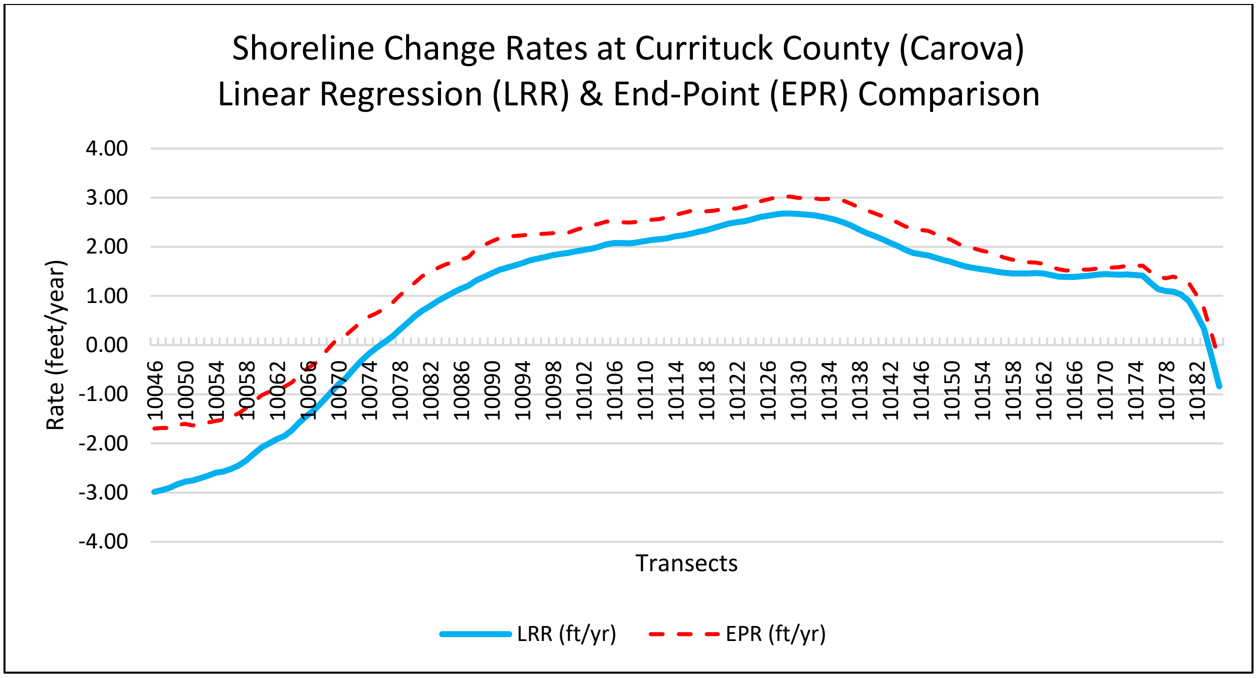

Figure 285. *This graph compares erosion rates calculated using least squares regression (blue line) and end-point (dashed red line).*

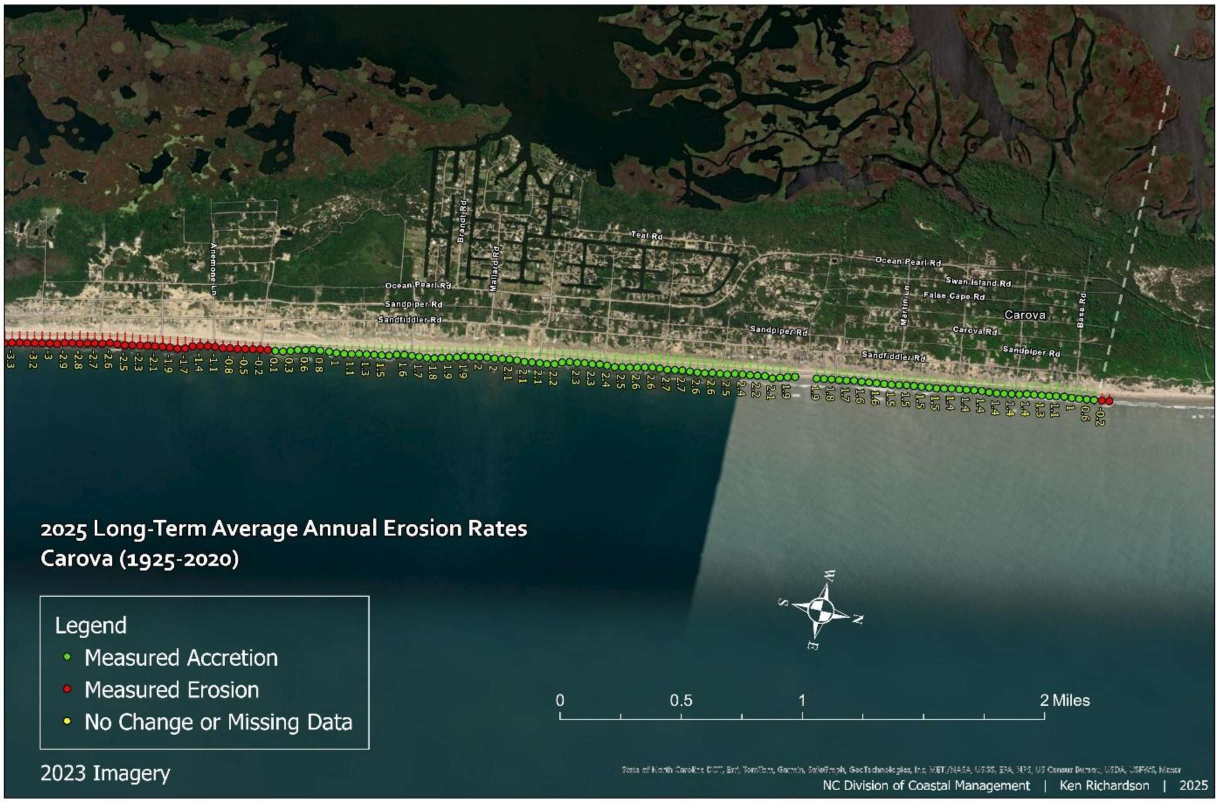

Figure 286. *This map image illustrates the shoreline envelope at each transect, showing the area between the most oceanward and landward shorelines, labeled with erosion rates. Green lines indicate areas where accretion is measured, while red lines represent areas where erosion is measured using least squares regression.*

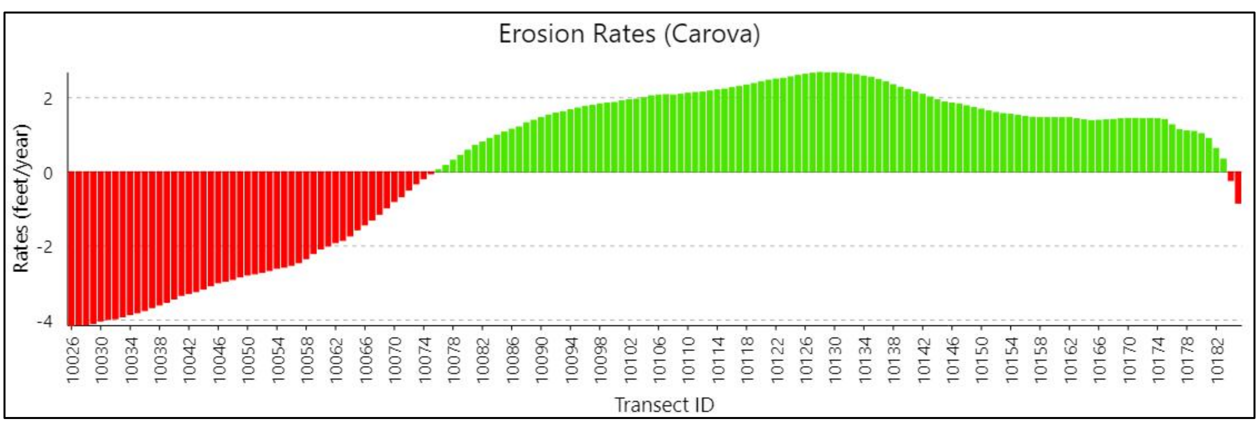

Figure 287. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

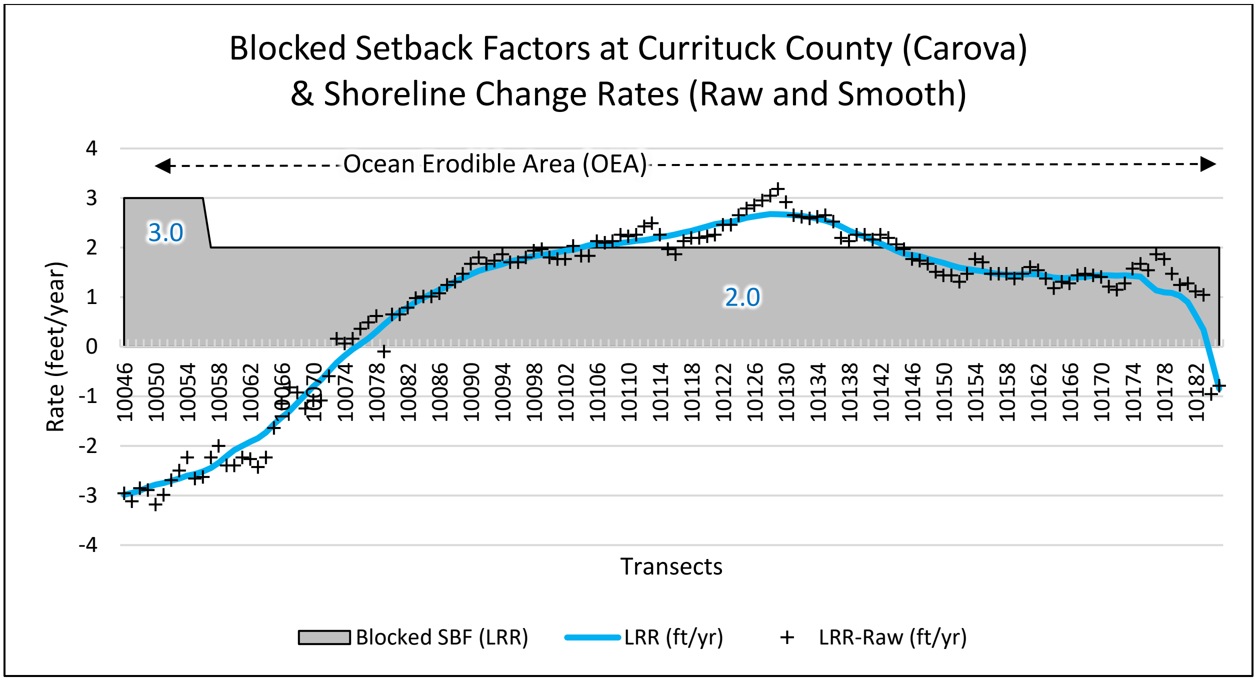

Figure 288. *This graph illustrates shoreline change rates (erosion and accretion) and blocked rates (setback factors) calculated at each transect. Black cross points represent raw rates, the solid blue line shows the smoothed rates, and the gray area represents the blocked rates (setback factors).*

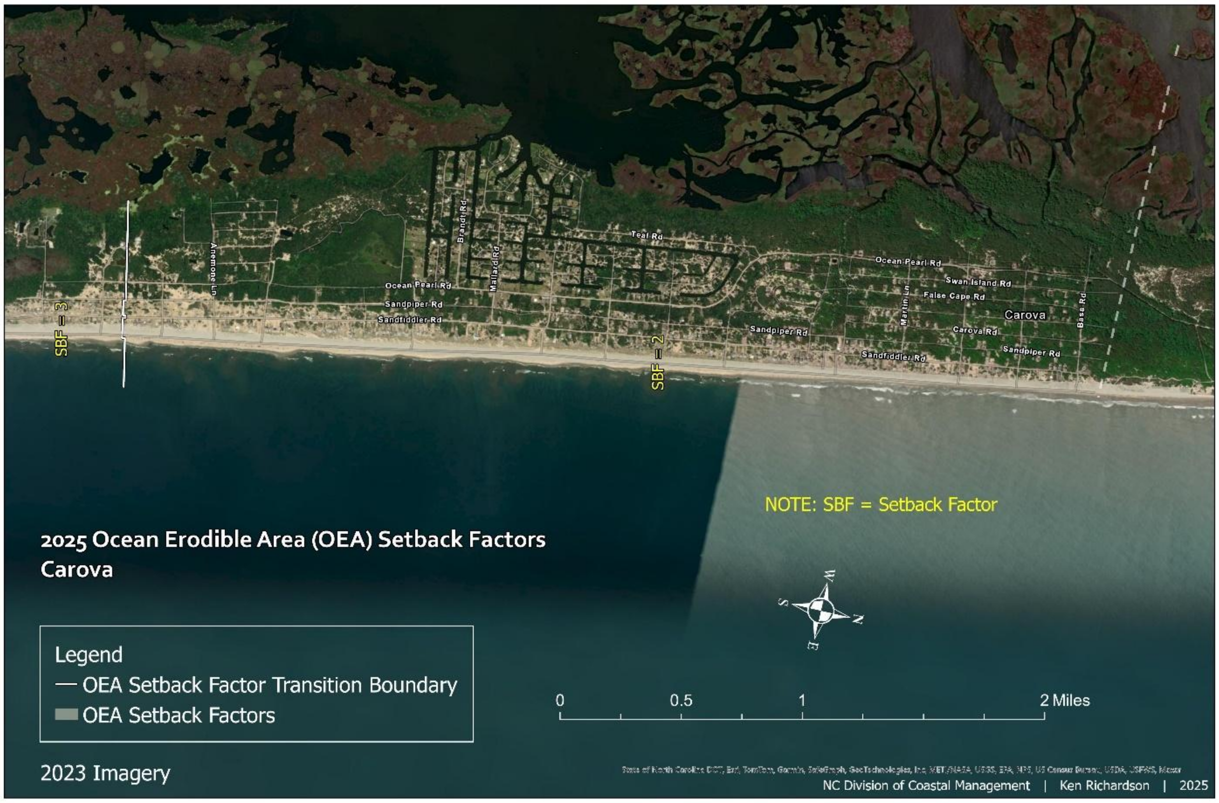

Figure 289. *This map illustrates the erosion rate setback factors within the Ocean Erodible Area at Carova.*

Ocean Erodible Area (OEA)	2025	2020	2013	2004	1997	1986	1983	1980
Setback Factor (SBF)	Range 2 to 3	Range 2 to 3	2	2	Range 2 to 4	2	N/A	N/A

Table 48. *This table compares setback factors from this study to those from previous studies. The 2025 values are derived from erosion rates calculated using the least squares regression method.*

4.0 Summary

This analysis confirmed that erosion and accretion patterns align with previous studies, with both the least squares regression and end-point methods yielding consistent results. While most shoreline areas will maintain their current setback requirements, some locations will undergo minor adjustments. Inlets and capes remain the most dynamic regions, exhibiting the greatest variability in erosion and accretion rates. These findings will guide oceanfront construction setback factors for future development.

Although both methods produced comparable outcomes, this report marks North Carolina's first long-term update of annual erosion rates and setback factors using the least squares regression method.

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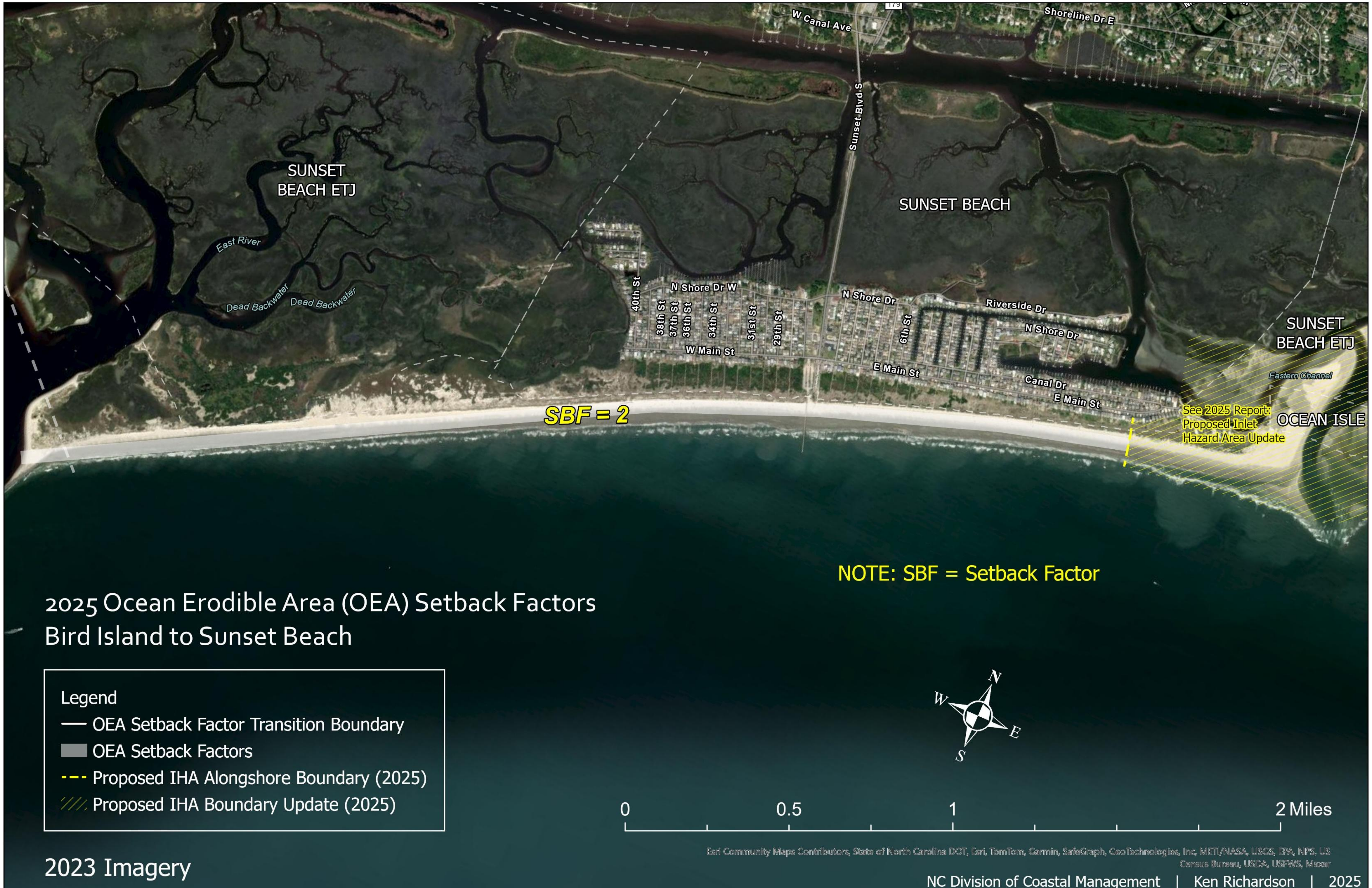
Appendix A: Inlet Hazard Area Setback Factor Maps



W Canal Ave
Shoreline Dr E
Sunset Blvd S
SUNSET BEACH ETJ
SUNSET BEACH
East River
Dead Backwater
Dead Backwater
N Shore Dr W
40th St
38th St
37th St
36th St
34th St
31st St
29th St
N Shore Dr
6th St
Riverside Dr
N Shore Dr
W Main St
E Main St
Canal Dr
E Main St
SUNSET BEACH ETJ
Eastern Channel
See 2025 Report: Proposed Inlet Hazard Area Update
OCEAN ISLE
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Bird Island to Sunset Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
N
W
E
S
0
0.5
1
2 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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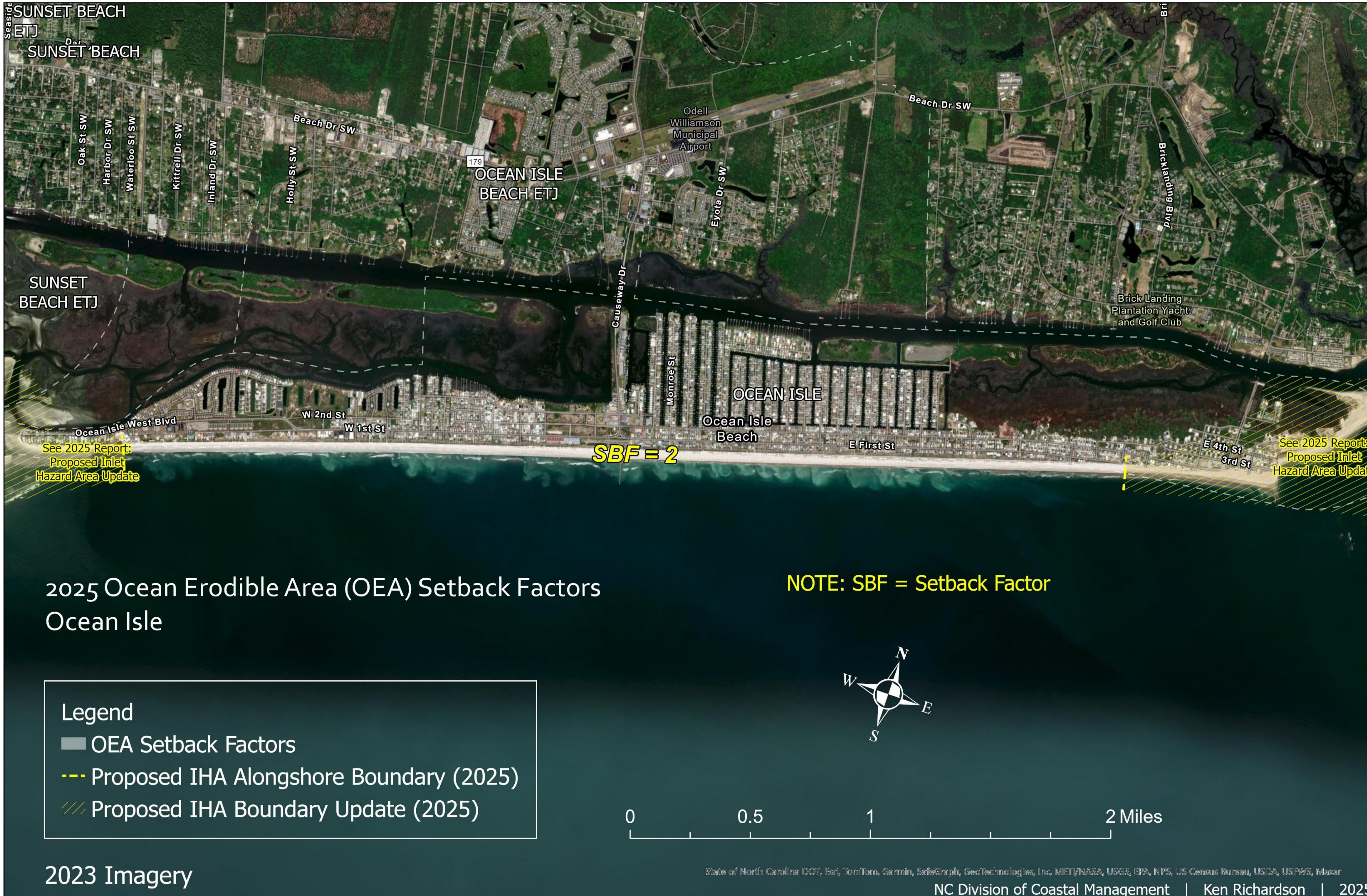
SUNSET BEACH ETJ
SUNSET BEACH
Beach Dr SW
Oak St SW
Harbor Dr SW
Waterloo St SW
Kittrell Dr SW
Inland Dr SW
Holly St SW
179
OCEAN ISLE BEACH ETJ
Odell Williamson Municipal Airport
Eyota Dr SW
Brick Landing Blvd
Brick Landing Plantation Yacht and Golf Club
SUNSET BEACH ETJ
Causeway Dr
Monroe St
OCEAN ISLE
Ocean Isle Beach
Ocean Isle West Blvd
W 2nd St
W 1st St
E First St
E 4th St
3rd St
See 2025 Report: Proposed Inlet Hazard Area Update
SBF = 2
See 2025 Report: Proposed Inlet Hazard Area Update
2025 Ocean Erodible Area (OEA) Setback Factors
Ocean Isle
NOTE: SBF = Setback Factor
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W
E
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Legend
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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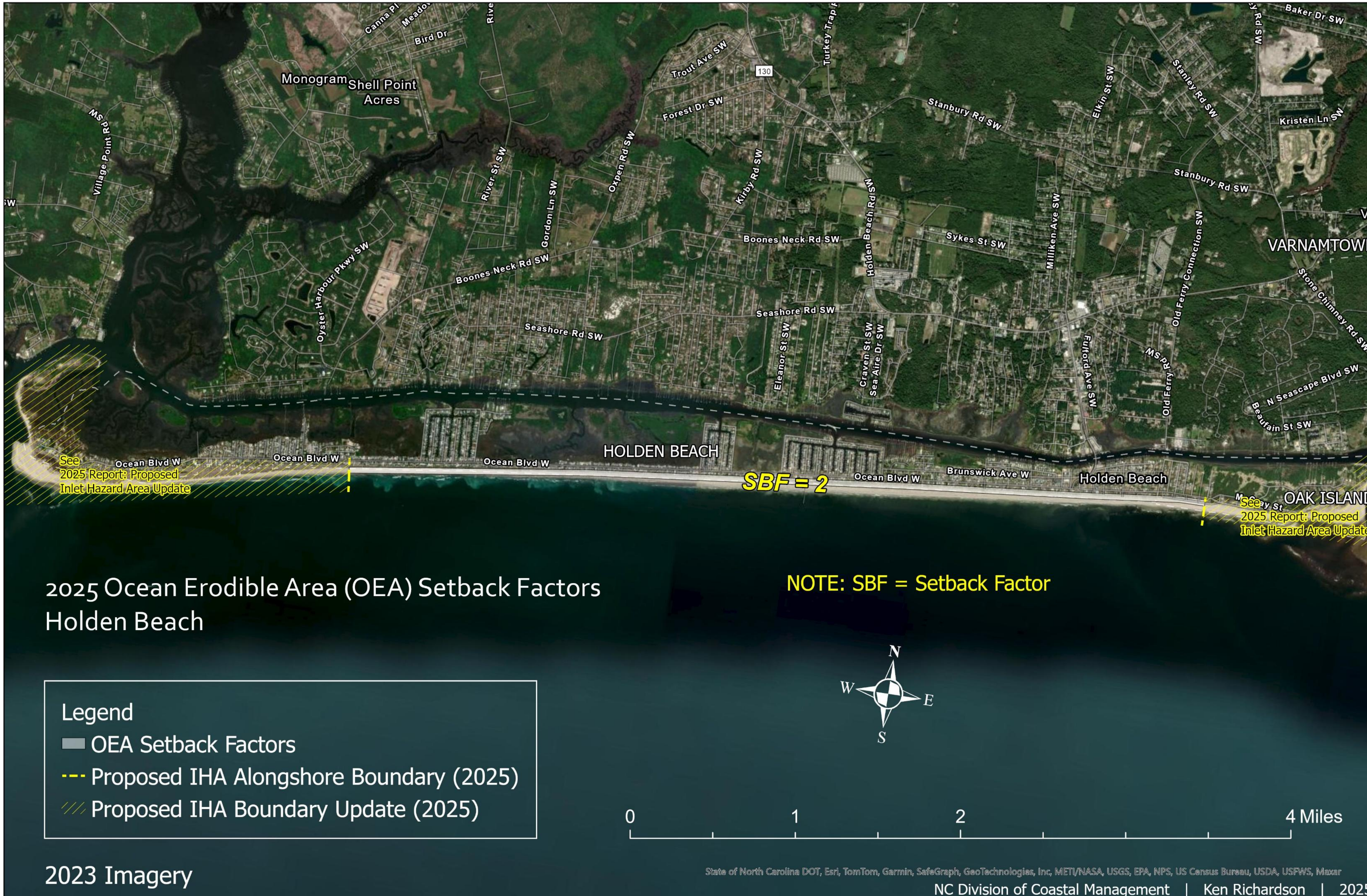
2025 Ocean Erodible Area (OEA) Setback Factors
Holden Beach
NOTE: SBF = Setback Factor
SBF = 2
See 2025 Report: Proposed Inlet Hazard Area Update
See 2025 Report: Proposed Inlet Hazard Area Update
HOLDEN BEACH
Holden Beach
OAK ISLAND
VARNAMTOWN
Monogram
Shell Point Acres
Ocean Blvd W
Brunswick Ave W
Seashore Rd SW
Boones Neck Rd SW
Stanbury Rd SW
Sykes St SW
Holden Beach Rd SW
Stone Chimney Rd SW
N Seascape Blvd SW
Beaufain St SW
Kristen Ln SW
Baker Dr SW
Trout Ave SW
Forest Dr SW
Bird Dr
Village Point Rd SW
Oyster Harbour Pkwy SW
River St SW
Gordon Ln SW
Oxpen Rd SW
Kirby Rd SW
Eleanor St SW
Craven St SW
Sea Aire Dr SW
Milliken Ave SW
Elkin St SW
Fulford Ave SW
Old Ferry Connection SW
Stanley Rd SW
130
Legend
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
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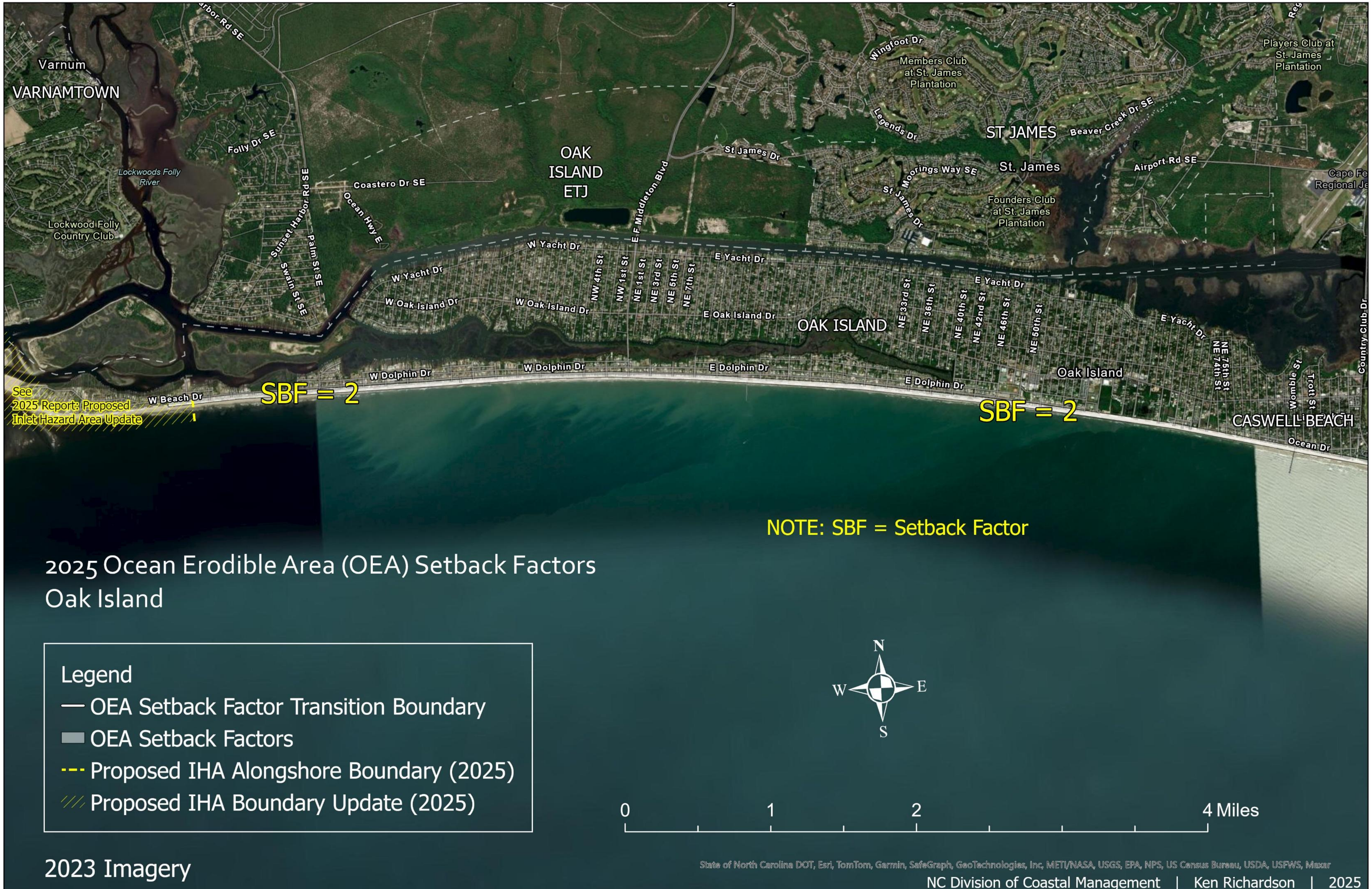
2
4 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
NC Division of Coastal Management | Ken Richardson | 2025


2025 Ocean Erodible Area (OEA) Setback Factors
Oak Island
SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
See 2025 Report: Proposed Inlet Hazard Area Update
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
VARNAMTOWN
OAK ISLAND ETJ
ST JAMES
OAK ISLAND
CASWELL BEACH
0
1
2
4 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
NC Division of Coastal Management | Ken Richardson | 2025


SBF = 2
Yaupon Way
Alyssum Ave
Yaupon Way
OAK ISLAND
Oak Island Golf Club
Augusta Dr
Yaupon Way
Country Club Dr
McGlamery St
Pinehurst Dr
Oceangreens Ln
Foxfire Trce
Caswell Beach
Caswell Beach Rd
CASWELL BEACH
Molasses Creek
Coward Creek
US Coast Guard
Caswell Basin
Caswell Beach Rd
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Caswell Beach & Fort Caswell
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
E
W
S
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
NC Division of Coastal Management | Ken Richardson | 2025

Bald Head Island
N Bald Head Wynd
Cape Creek Rd
Federal Rd
BALD HEAD ISLAND
W Bald Head Wynd
Stede Bonnet Wynd
Edward Teach Wynd
Muscadine Wynd
Bald Head Island Country Club
Chicamacomico Way
Kinnakeet Way
SE Beach Dr
S Bald Head Wynd
SBF = 2
SBF = 3.5
SBF = 6.5
SBF = 4
SBF = 2
SBF = 3.5
SBF = 5
SBF = 6.5
SBF = 8.5
SBF = 9.5
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Bald Head Island (south-beach)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
E
S
W
0
0.25
0.5
1 Miles
2023 Imagery
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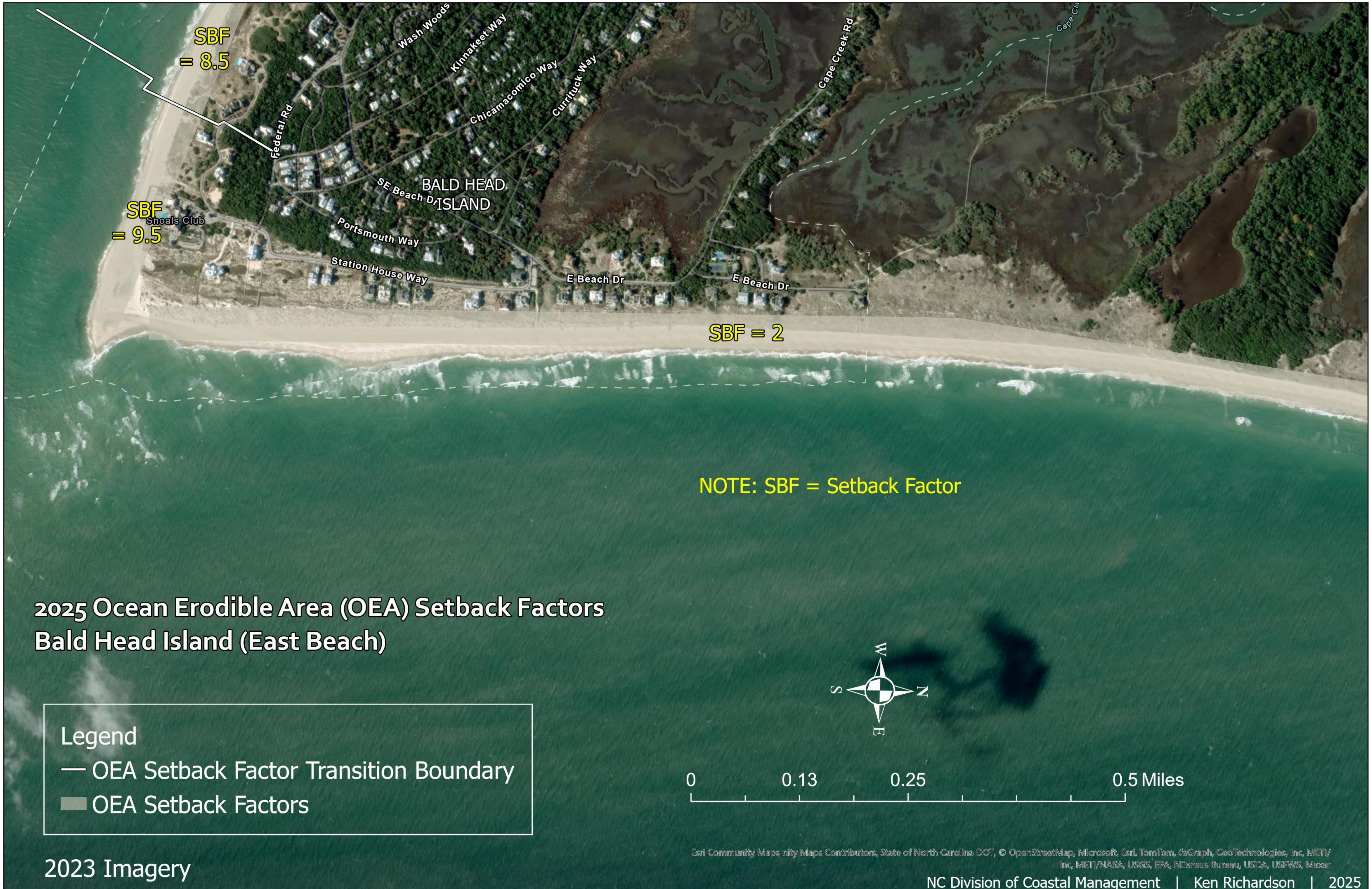
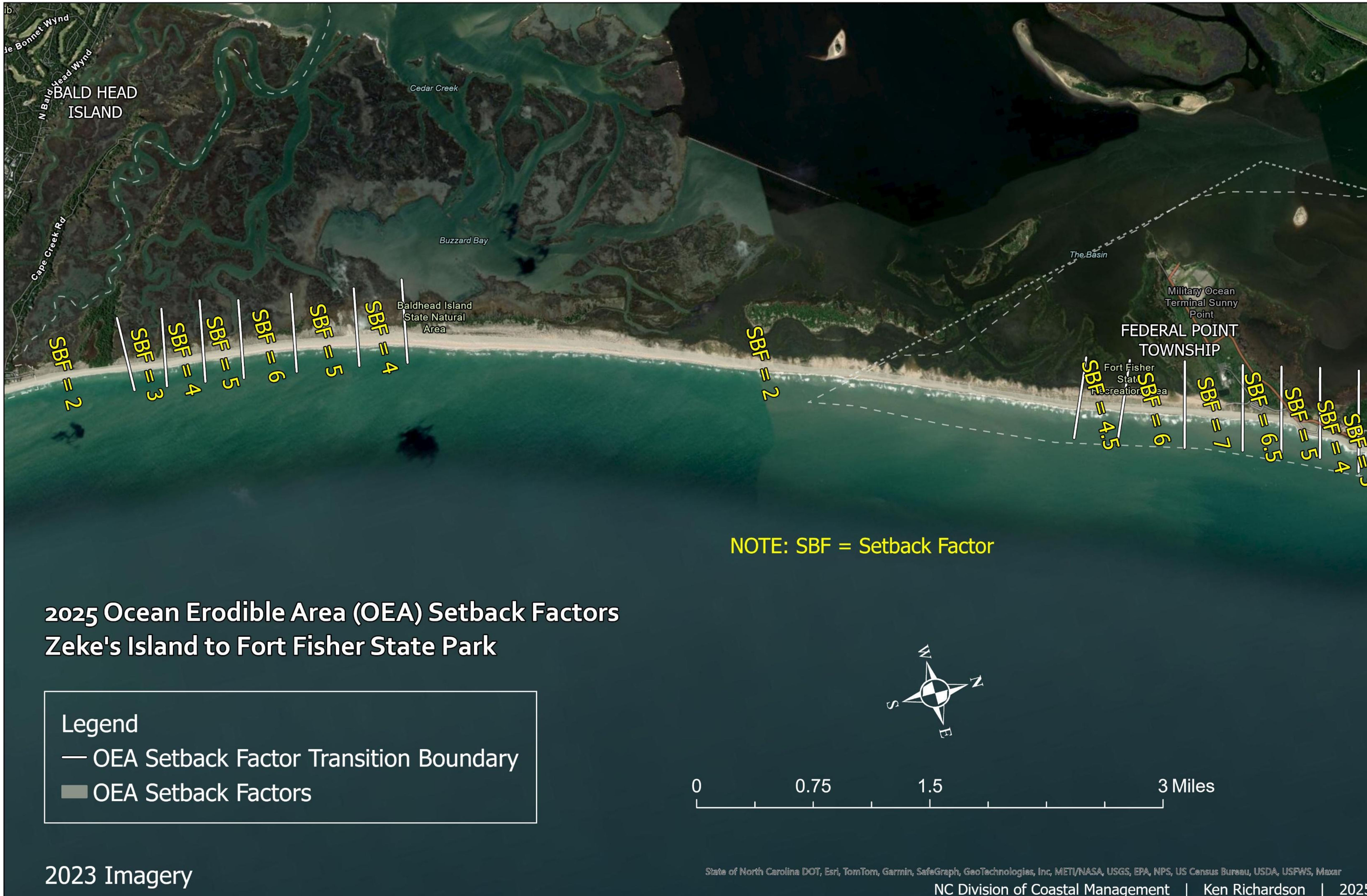
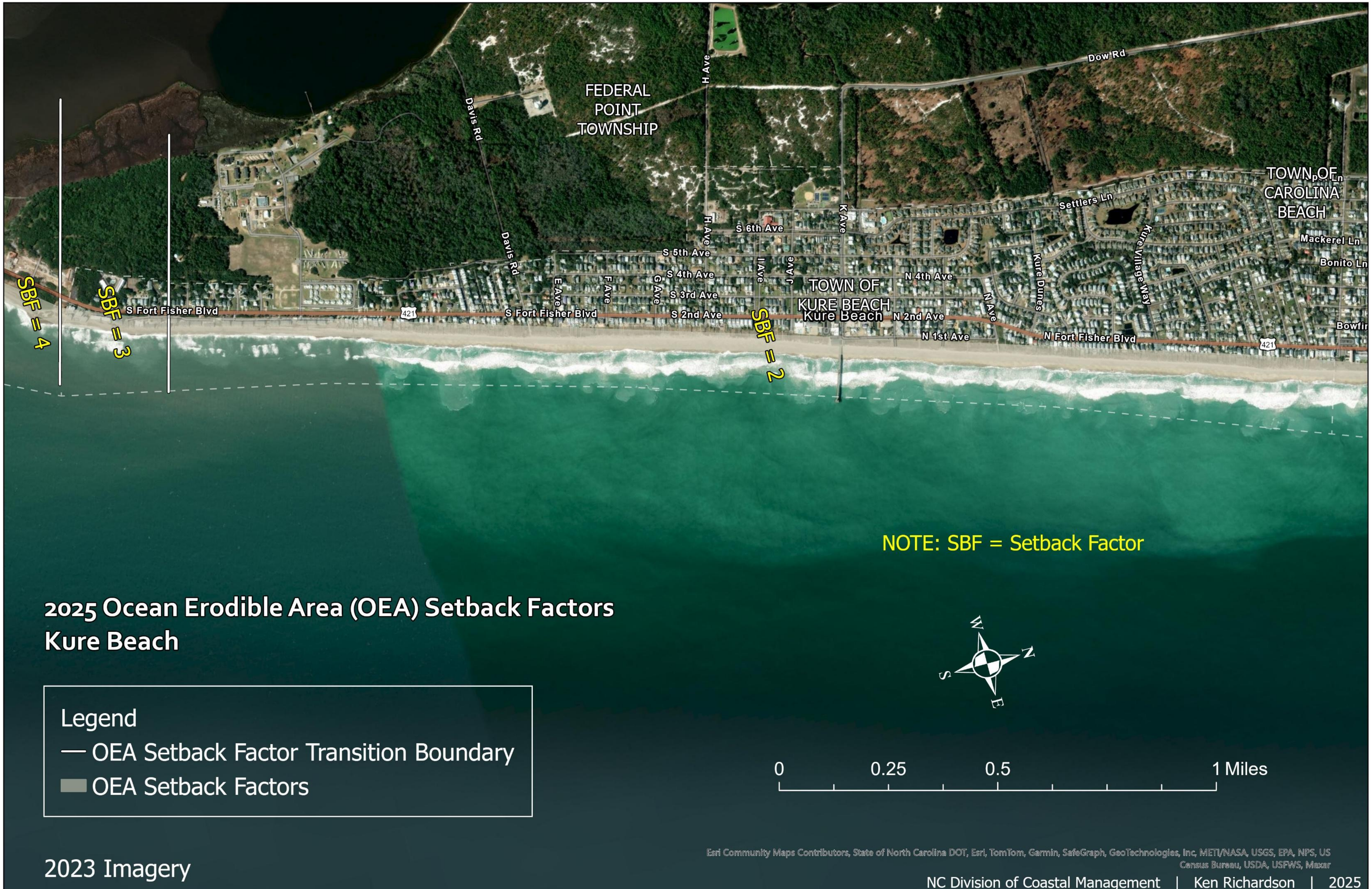

SBF
= 8.5
SBF
= 9.5
SBF = 2
Snoals Club
BALD HEAD
ISLAND
Wash Woods
Kinnakeet Way
Chicamacomico Way
Currituck Way
Cape Creek Rd
Federal Rd
SE Beach Dr
Portsmouth Way
Station House Way
E Beach Dr
E Beach Dr
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Bald Head Island (East Beach)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
S
N
E
0
0.13
0.25
0.5 Miles
2023 Imagery
NC Division of Coastal Management | Ken Richardson | 2025


2025 Ocean Erodible Area (OEA) Setback Factors
Zeke's Island to Fort Fisher State Park
BALD HEAD ISLAND
Cedar Creek
Buzzard Bay
Baldhead Island State Natural Area
The Basin
Military Ocean Terminal Sunny Point
FEDERAL POINT TOWNSHIP
Cape Creek Rd
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 6
SBF = 5
SBF = 4
SBF = 2
SBF = 4.5
SBF = 6
SBF = 7
SBF = 6.5
SBF = 5
SBF = 4
SBF = 3
NOTE: SBF = Setback Factor
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
N
S
E
0
0.75
1.5
3 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
NC Division of Coastal Management | Ken Richardson | 2025


FEDERAL POINT TOWNSHIP
TOWN OF CAROLINA BEACH
TOWN OF KURE BEACH
Kure Beach
SBF = 4
SBF = 3
SBF = 2
S Fort Fisher Blvd
N Fort Fisher Blvd
Dow Rd
Davis Rd
H Ave
K Ave
S 6th Ave
S 5th Ave
S 4th Ave
S 3rd Ave
S 2nd Ave
N 4th Ave
N 2nd Ave
N 1st Ave
Settlers Ln
Mackerel Ln
Bonito Ln
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Kure Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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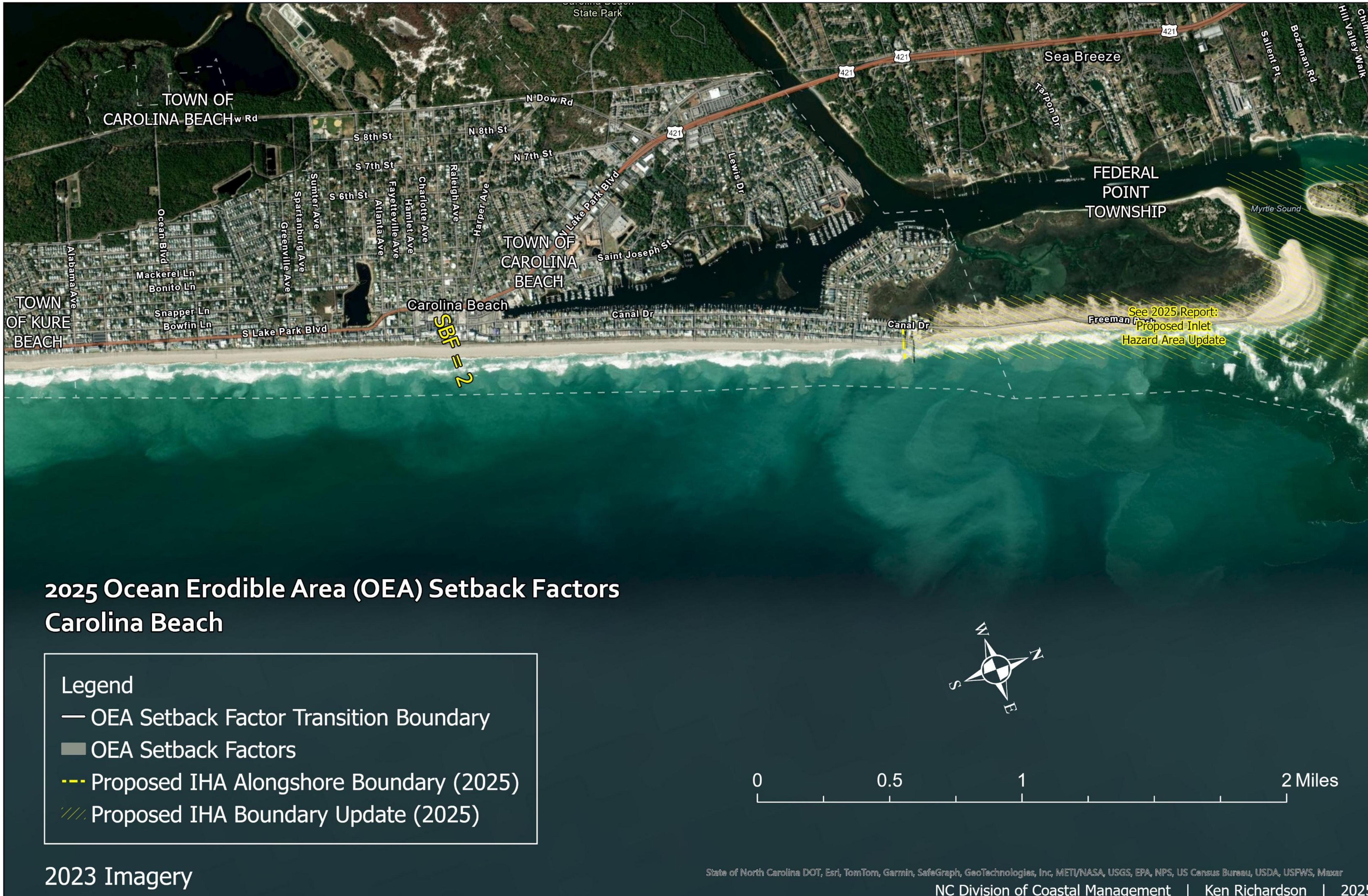

2025 Ocean Erodible Area (OEA) Setback Factors
Carolina Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
2023 Imagery
0
0.5
1
2 Miles
W
N
S
E
SBF = 2
See 2025 Report:
Proposed Inlet
Hazard Area Update
TOWN OF CAROLINA BEACH
TOWN OF KURE BEACH
FEDERAL POINT TOWNSHIP
Sea Breeze
Carolina Beach
State Park
Myrtle Sound
N Dow Rd
S 8th St
N 8th St
S 7th St
N 7th St
S 6th St
N Lake Park Blvd
S Lake Park Blvd
Saint Joseph St
Canal Dr
Freeman Park
Lewis Dr
Tarpon Dr
Alabama Ave
Ocean Blvd
Mackerel Ln
Bonito Ln
Snapper Ln
Bowfin Ln
Greenville Ave
Spartanburg Ave
Sumter Ave
Atlanta Ave
Fayetteville Ave
Hamlet Ave
Charlotte Ave
Raleigh Ave
Harper Ave
Salient Pt
Bozeman Rd
Hill Valley Walk
Chimney Ln
421
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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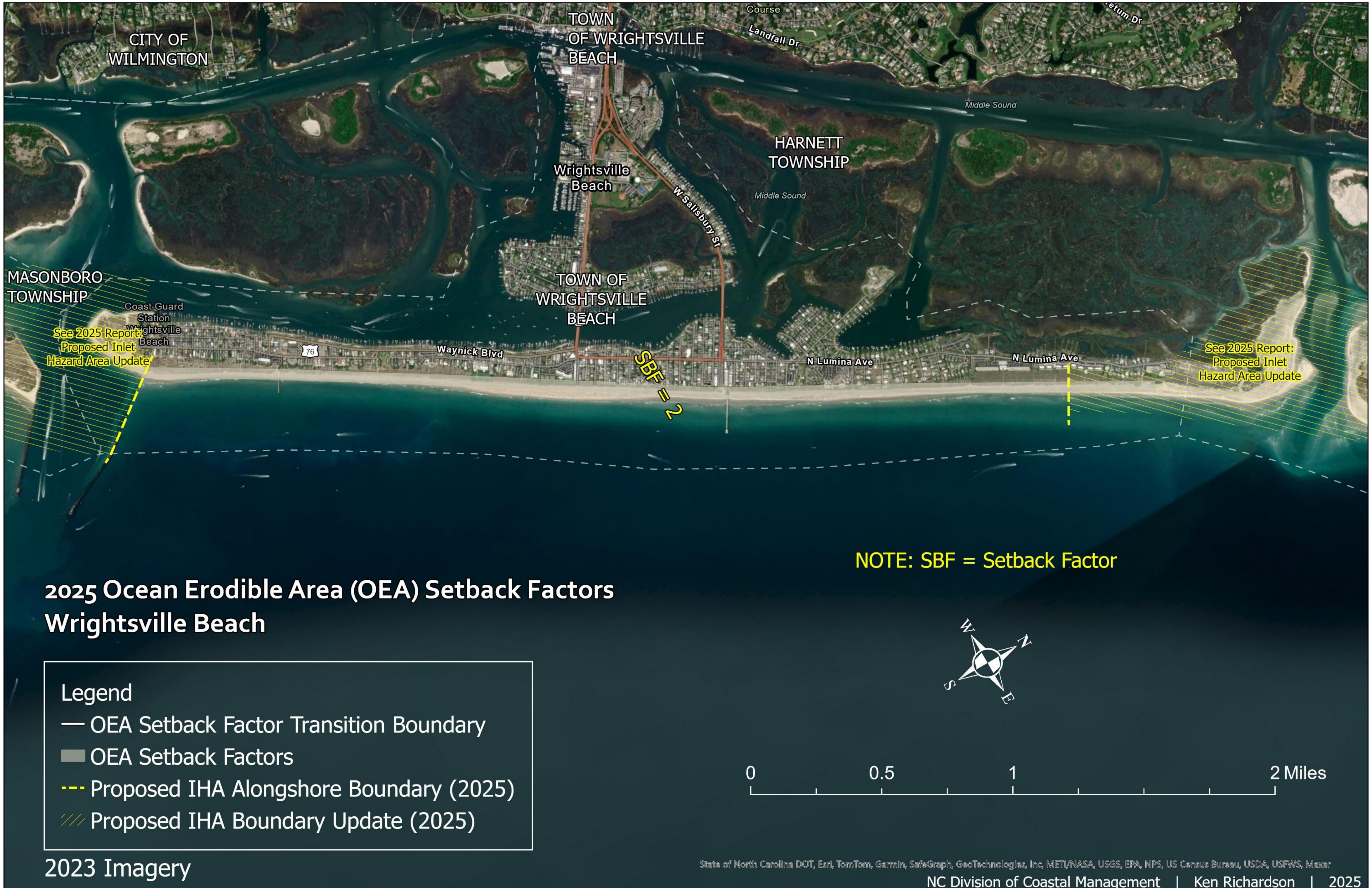

TOWN OF WRIGHTSVILLE BEACH
CITY OF WILMINGTON
Course
Landfall Dr
Middle Sound
HARNETT TOWNSHIP
Wrightsville Beach
W Salisbury St
Middle Sound
MASONBORO TOWNSHIP
Coast Guard Station Wrightsville Beach
TOWN OF WRIGHTSVILLE BEACH
See 2025 Report: Proposed Inlet Hazard Area Update
Waynick Blvd
76
SBF = 2
N Lumina Ave
N Lumina Ave
See 2025 Report: Proposed Inlet Hazard Area Update
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Wrightsville Beach
W N S E
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
0 0.5 1 2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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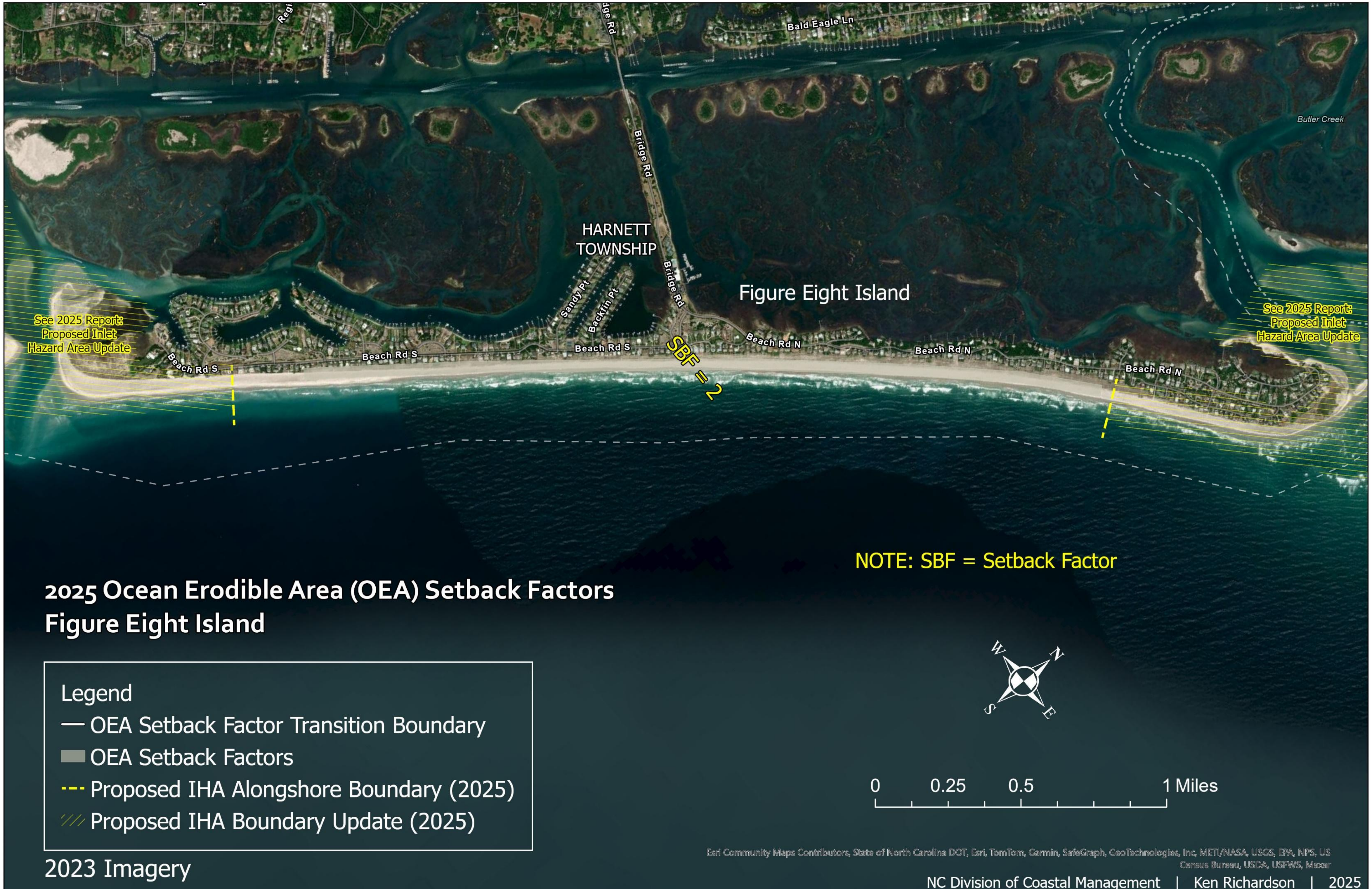

Bald Eagle Ln
Butler Creek
Bridge Rd
HARNETT TOWNSHIP
Sandy Pt
Backfin Pt
Figure Eight Island
See 2025 Report: Proposed Inlet Hazard Area Update
Beach Rd S
Beach Rd N
SBF = 2
See 2025 Report: Proposed Inlet Hazard Area Update
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Figure Eight Island
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
2023 Imagery
W N S E
0 0.25 0.5 1 Miles
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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See 2025 Report: Proposed Inlet Hazard Area Update
Topsail Beach
Carolina Blvd
Ocean Blvd
S Anderson Blvd
TOPSAIL
Bridgers Ave
SBF = 2
Topsail Sound
SURF CITY
N Anderson Blvd
50
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Topsail Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
W
N
S
E
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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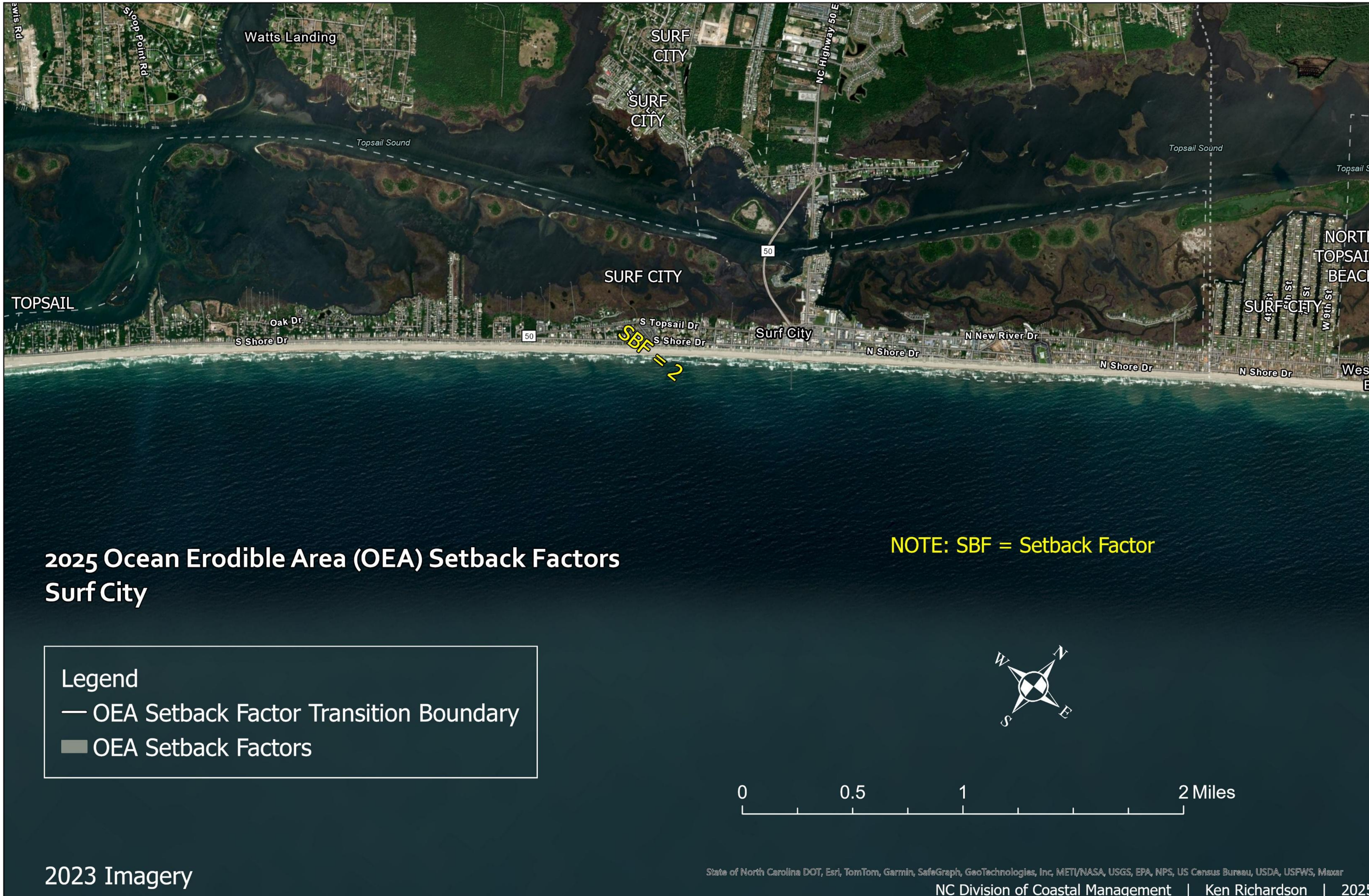
Watts Landing
SURF CITY
SURF CITY
Topsail Sound
Topsail Sound
NC Highway 50 E
Sloop Point Rd
50
SURF CITY
NORTH TOPSAIL BEACH
TOPSAIL
Oak Dr
S Shore Dr
S Topsail Dr
S Shore Dr
Surf City
N New River Dr
N Shore Dr
N Shore Dr
N Shore Dr
SURF CITY
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Surf City
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.5
1
2 Miles
N
E
S
W
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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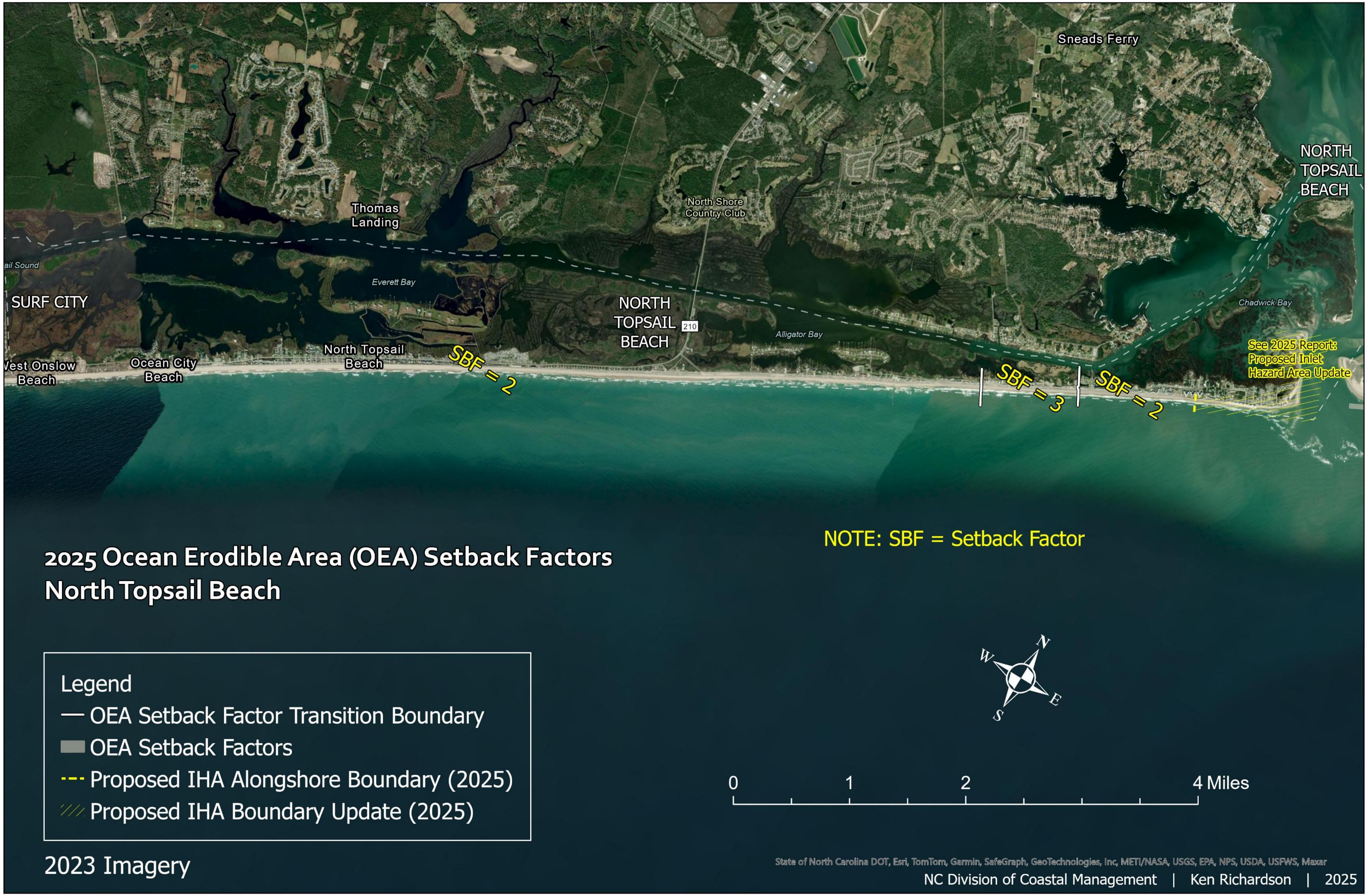
Sneads Ferry
NORTH TOPSAIL BEACH
Thomas Landing
North Shore Country Club
ail Sound
Everett Bay
SURF CITY
NORTH TOPSAIL BEACH
210
Alligator Bay
Chadwick Bay
See 2025 Report: Proposed Inlet Hazard Area Update
West Onslow Beach
Ocean City Beach
North Topsail Beach
SBF = 2
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
North Topsail Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
N
W
E
S
0
1
2
4 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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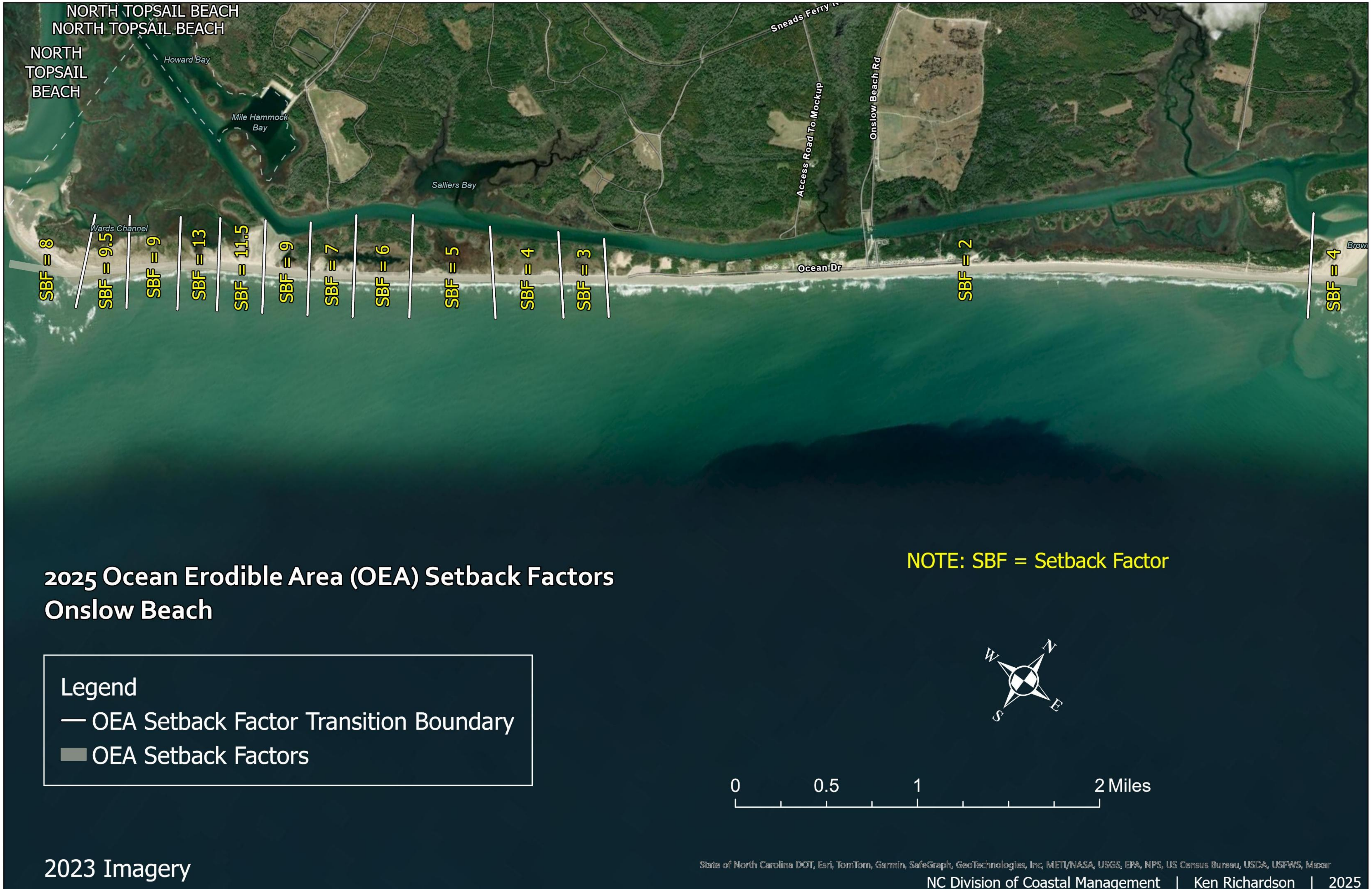
NORTH TOPSAIL BEACH
NORTH TOPSAIL BEACH
NORTH TOPSAIL BEACH
Howard Bay
Mile Hammock Bay
Salliers Bay
Wards Channel
Sneads Ferry
Access Road To Mockup
Onslow Beach Rd
Ocean Dr
SBF = 8
SBF = 9.5
SBF = 9
SBF = 13
SBF = 11.5
SBF = 9
SBF = 7
SBF = 6
SBF = 5
SBF = 4
SBF = 3
SBF = 2
SBF = 4
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Onslow Beach
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
E
S
W
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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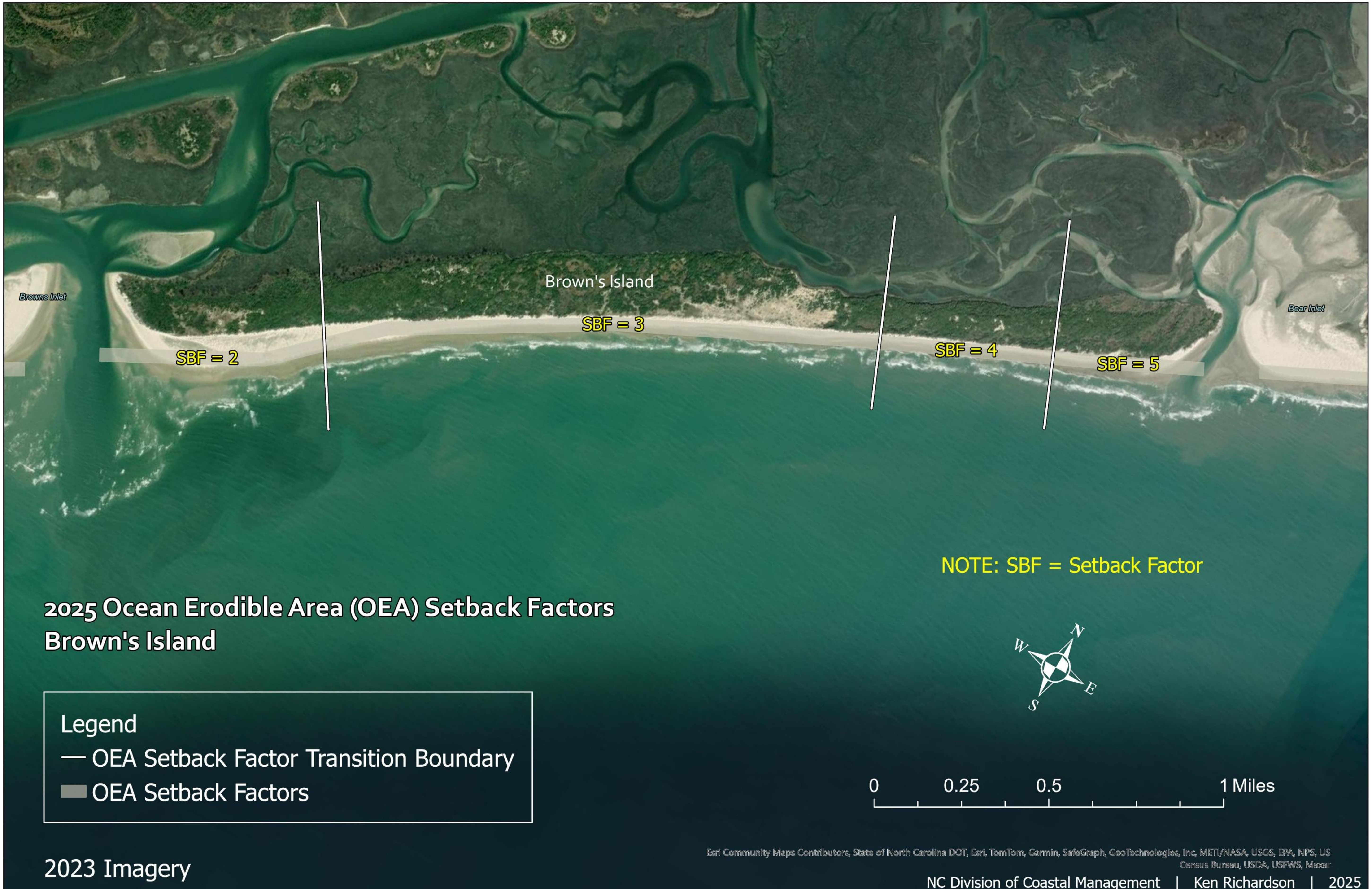

Browns Inlet
Brown's Island
SBF = 2
SBF = 3
SBF = 4
SBF = 5
Bear Inlet
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Brown's Island
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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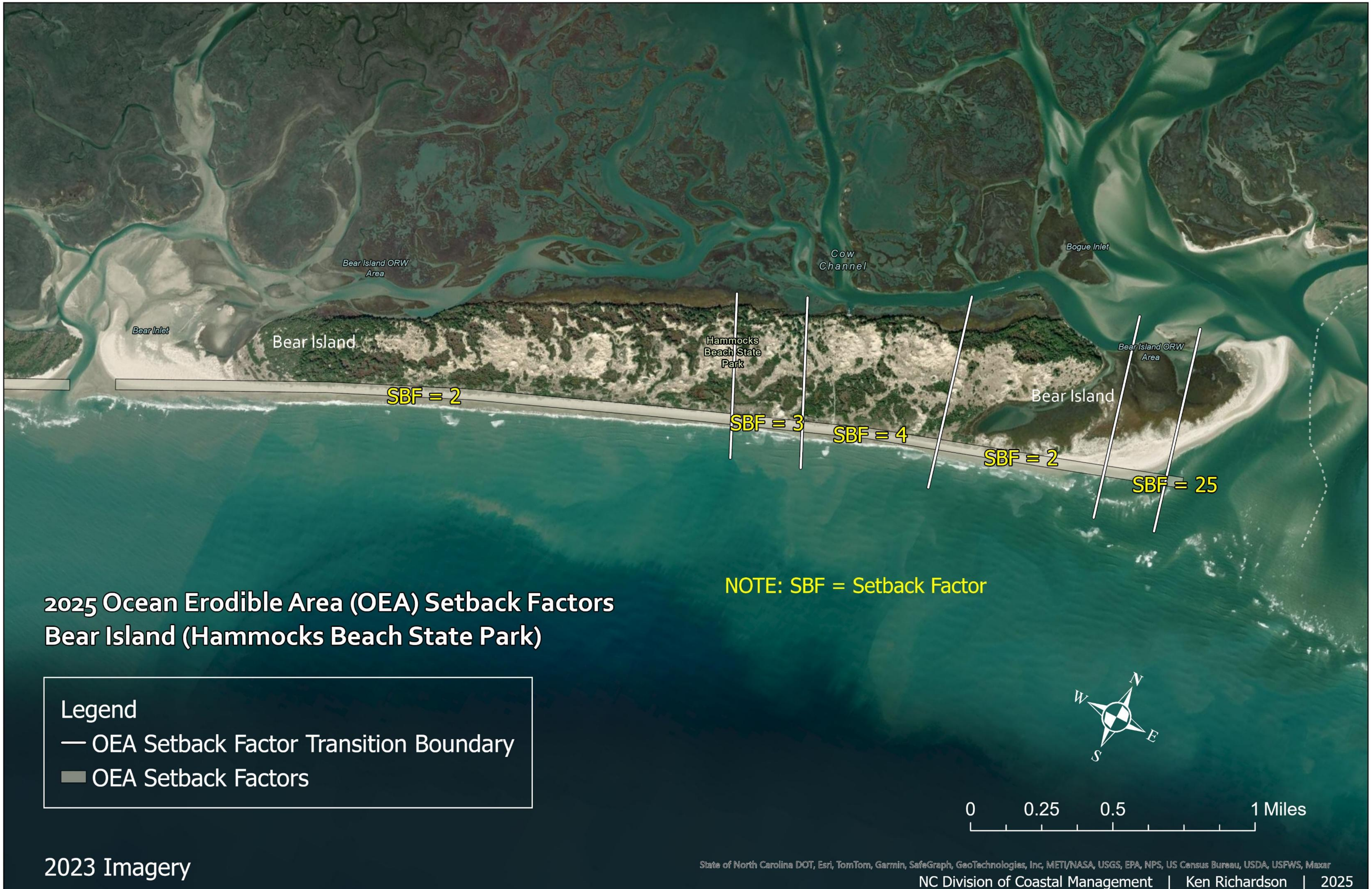
Bear Island ORW Area
Cow Channel
Bogue Inlet
Bear Inlet
Bear Island
Hammocks Beach State Park
Bear Island ORW Area
Bear Island
SBF = 2
SBF = 3
SBF = 4
SBF = 2
SBF = 25
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Bear Island (Hammocks Beach State Park)
Legend
— OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0 0.25 0.5 1 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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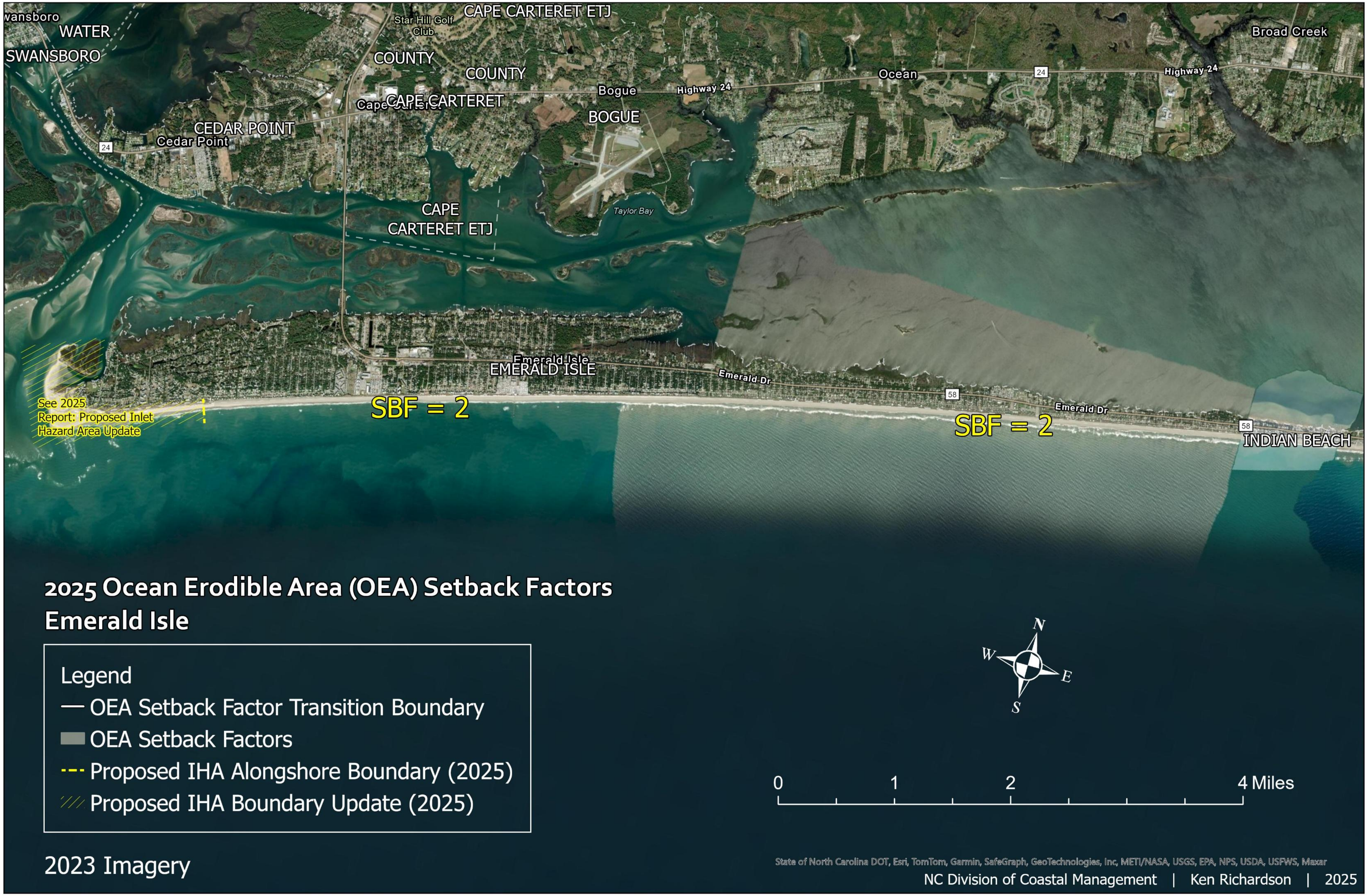

Swansboro
WATER
SWANSBORO
Star Hill Golf Club
CAPE CARTERET ETJ
COUNTY
COUNTY
CAPE CARTERET
Cape Carteret
Bogue
BOGUE
Highway 24
Ocean
24
Highway 24
Broad Creek
CEDAR POINT
Cedar Point
24
Taylor Bay
CAPE CARTERET ETJ
Emerald Isle
EMERALD ISLE
Emerald Dr
58
Emerald Dr
58
INDIAN BEACH
See 2025 Report: Proposed Inlet Hazard Area Update
SBF = 2
SBF = 2
2025 Ocean Erodible Area (OEA) Setback Factors
Emerald Isle
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
Proposed IHA Alongshore Boundary (2025)
Proposed IHA Boundary Update (2025)
N
W
E
S
0
1
2
4 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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EMERALD ISLE
INDIAN BEACH
Indian Beach
Salter Path Ball Park
Salter Path
INDIAN BEACH
PINE KNOLL SHORES
Sea Isle
58
Salter Path Rd
Salter Path Rd
Sea Isle Dr
Emerald Isle Pier
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Indian Beach and Salter Path
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Mcommunity Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS
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INDIAN BEACH
Coral Dr
Theodore Roosevelt Natural Area
Salter Path Rd
58
PINE KNOLL SHORES
Pine Knoll Shores
Oakleaf Dr
Cedar Rd
Holly Rd
The Country Club of the Crystal Coast
ATLANTIC BEACH
SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Pine Knoll Shores
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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MOREHEAD ETJ
MOREHEAD CITY
BEAUFORT ETJ
Morehead City
MOREHEAD CITY
BEAUFORT ETJ
BEAUFORT
BEAUFORT
ATLANTIC BEACH
Atlantic Beach
Atlantic Station
Money Island Bay
Triple S Marina Village
PINE KNOLL SHORES
Ocean Ridge Dr
E Fort Macon Rd
Fort Macon State Park
Arendell St
Evans St
Bay St
Fisher St
Bridges St
Shepard St
Old Causeway Rd
Atlantic Beach Cswy
Marine Dr
Harbor Channel
Morehead City Harbor
SBF = 2
SBF = 2
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Atlantic Beach & Fort Macon State Park
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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2025 Ocean Erodible Area (OEA) Setback Factors
Shackleford Banks
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
2023 Imagery
NOTE: SBF = Setback Factor
SBF = 16
SBF = 6
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 6
SBF = 6.5
SBF = 6
SBF = 5
SBF = 4
SBF = 2
SBF = 3
SBF = 2
Shackleford Banks
BEAUFORT ETJ
BEAUFORT
Harkers Island
Cape Lookout National Seashore
Back Sound
Bald Hill Bay
Johnson Bay
Blinds Hammock Bay
The Ditch
Davis Bay
Mullens Dr
Cape Lookout Dr
Island Rd
Bayview Dr
Diamond City Dr
Lennoxville Rd
Front St
0 0.75 1.5 3 Miles
N E S W
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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SBF = 4
SBF = 3
SBF = 2
Cape Lookout
SBF = 2
SBF = 2.5
SBF = 9
SBF = 10
SBF = 12
SBF = 9
SBF = 5
SBF = 2
2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore - Cape Lookout
N
E
S
W
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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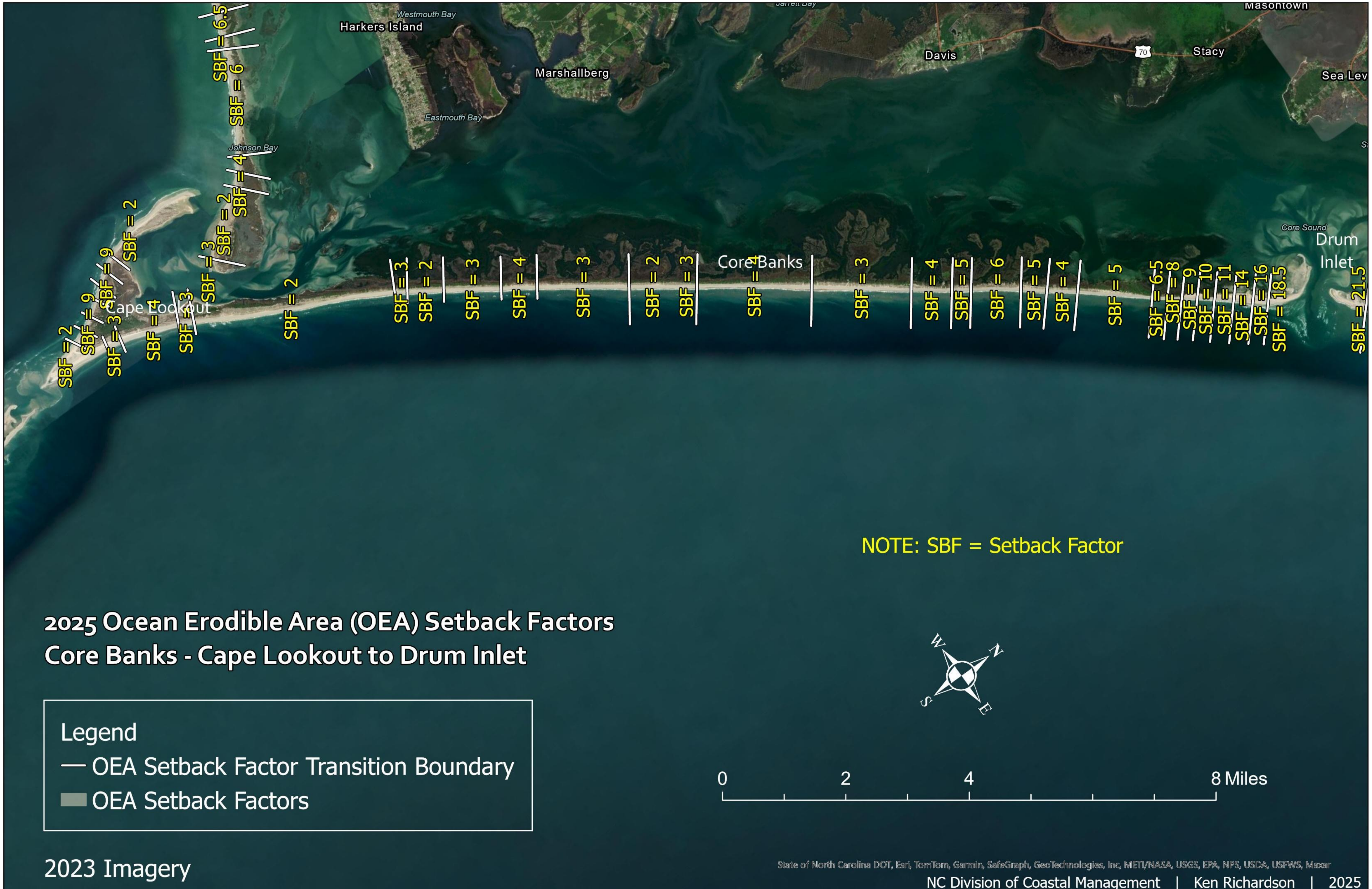
2025 Ocean Erodible Area (OEA) Setback Factors
Core Banks - Cape Lookout to Drum Inlet
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
2023 Imagery
NOTE: SBF = Setback Factor
Harkers Island
Marshallberg
Davis
Stacy
Sea Lev
Drum Inlet
Core Banks
Cape Lookout
0
2
4
8 Miles
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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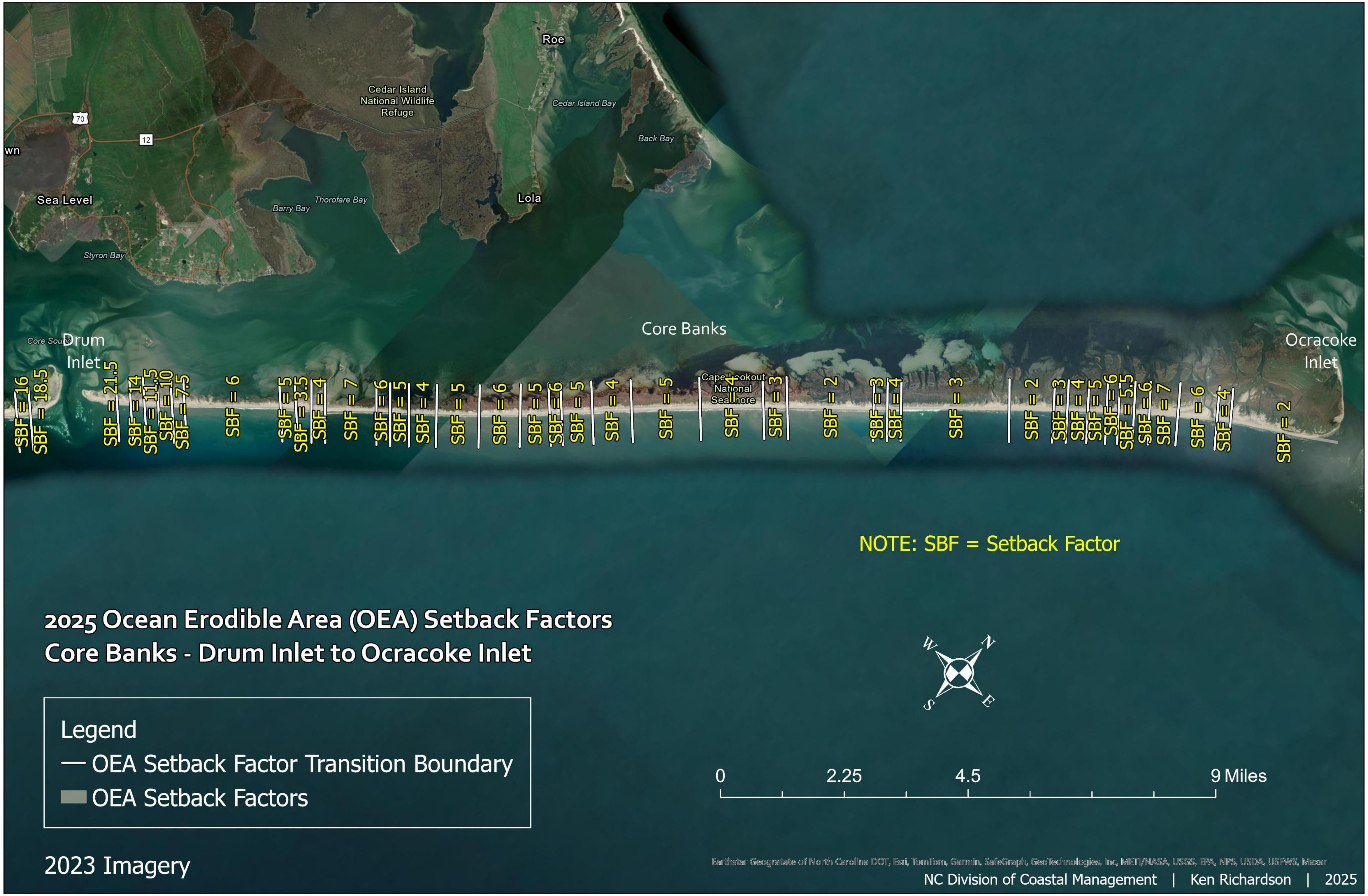

2025 Ocean Erodible Area (OEA) Setback Factors
Core Banks - Drum Inlet to Ocracoke Inlet
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
2023 Imagery
NOTE: SBF = Setback Factor
0
2.25
4.5
9 Miles
W
N
S
E
Roe
Cedar Island National Wildlife Refuge
Cedar Island Bay
Back Bay
Sea Level
Barry Bay
Thorofare Bay
Lola
Styron Bay
Core Sound
Drum Inlet
Core Banks
Cape Lookout National Seashore
Ocracoke Inlet
70
12
SBF = 16
SBF = 18.5
SBF = 21.5
SBF = 14
SBF = 11.5
SBF = 10
SBF = 7.5
SBF = 6
SBF = 5
SBF = 3.5
SBF = 4
SBF = 7
SBF = 6
SBF = 5
SBF = 4
SBF = 5
SBF = 6
SBF = 5
SBF = 6
SBF = 5
SBF = 4
SBF = 5
SBF = 4
SBF = 3
SBF = 2
SBF = 3
SBF = 4
SBF = 3
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 6
SBF = 5.5
SBF = 6
SBF = 7
SBF = 6
SBF = 4
SBF = 2
Earthstar Geographics State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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Pamlico Shores
Ocracoke
Ocracoke Inlet
Ocracoke Island Airport
OCRACOKE
Hatteras Inlet
SBF = 4
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 4.5
SBF = 3
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 6
SBF = 7
SBF = 8
SBF = 9
SBF = 8
SBF = 6.5
SBF = 4.5
SBF = 3
SBF = 6
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Ocracoke Island
N
W
E
S
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
1
2
4 Miles
2023 Imagery
Sphics, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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Hatteras Inlet
SBF = 12.5
SBF = 15
SBF = 13
SBF = 9
SBF = 4
SBF = 2
SBF = 3
Pole Rd
Pamlico Sound
Kohler Dr
Sandy Bay
NC Highway 12
Hatteras
Eagle Pass Rd
C Deering Ridge Rd
Flambeau Rd
Isaac Pond
Duck Ponds
Lighthouse Rd
12
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Hatteras Village at Cape Hatteras
Legend
— OEA Setback Factor Transition Boundary
OEA Setback Factors
N
W
E
S
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
NC Division of Coastal Management | Ken Richardson | 2025

Hatteras Inlet
SBF = 12.5
SBF = 15
SBF = 13
SBF = 9
SBF = 4
SBF = 2
Hatteras
Sandy Bay
SBF = 3
SBF = 4
SBF = 3
Frisco
12
SBF = 2
Cape Hatteras National Seashore
SBF = 3
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Cape Hatteras
N
W
E
S
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.75
1.5
3 Miles
2023 Imagery
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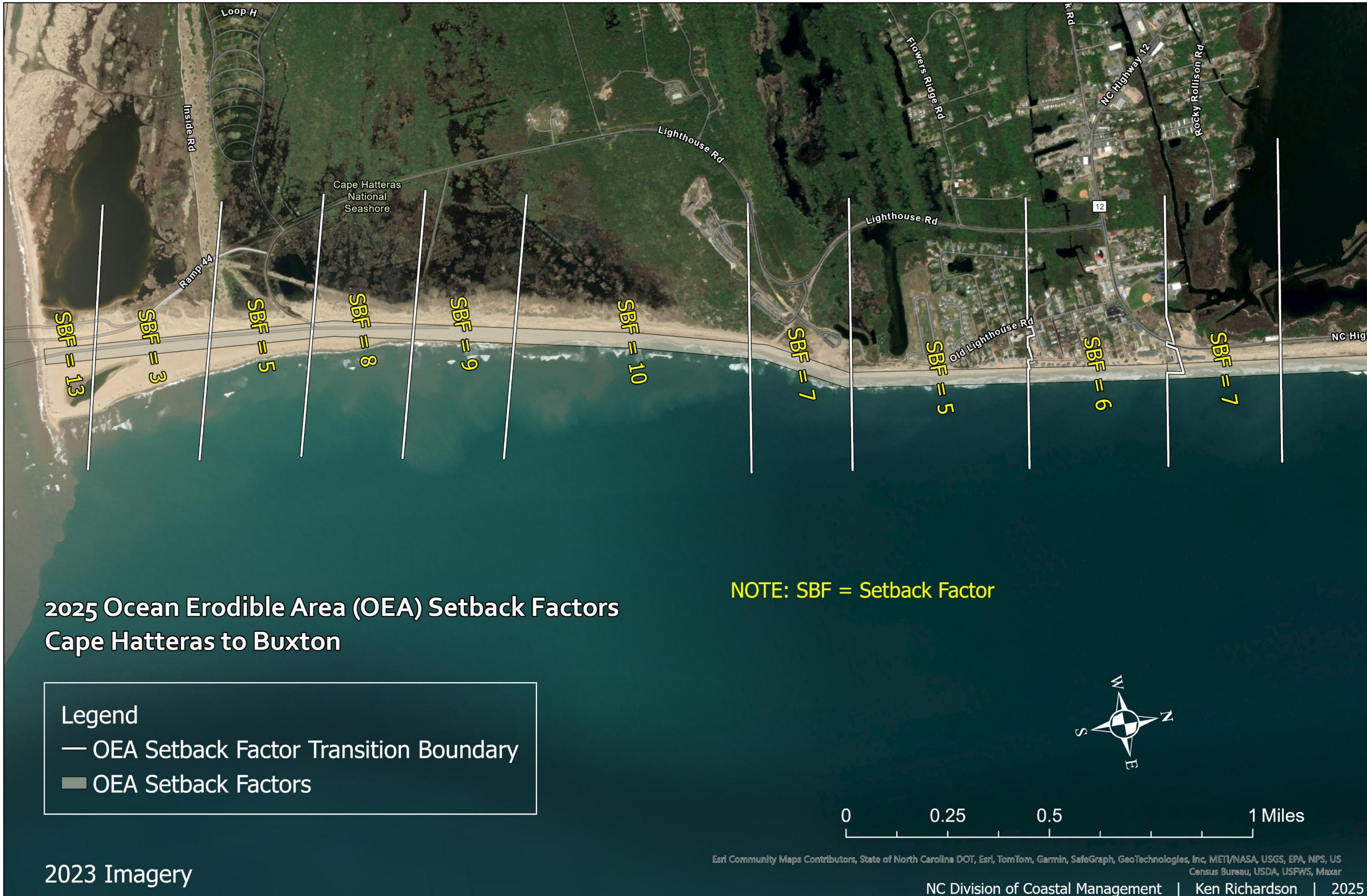
2025 Ocean Erodible Area (OEA) Setback Factors
Cape Hatteras to Buxton
NOTE: SBF = Setback Factor
SBF = 13
SBF = 3
SBF = 5
SBF = 8
SBF = 9
SBF = 10
SBF = 7
SBF = 5
SBF = 6
SBF = 7
Loop H
Inside Rd
Ramp 44
Cape Hatteras National Seashore
Lighthouse Rd
Lighthouse Rd
Flowers Ridge Rd
NC Highway 12
Rocky Rollison Rd
Old Lighthouse Rd
12
NC Highw
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
N
S
E
0
0.25
0.5
1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore (Buxton to Avon)
National Seashore
Rocky Rollison Rd
NC Highway 12
SBF = 7
SBF = 8
SBF = 9
SBF = 8
SBF = 7.5
SBF = 6
SBF = 5
SBF = 4
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
W
N
S
E
0
0.25
0.5
1 Miles
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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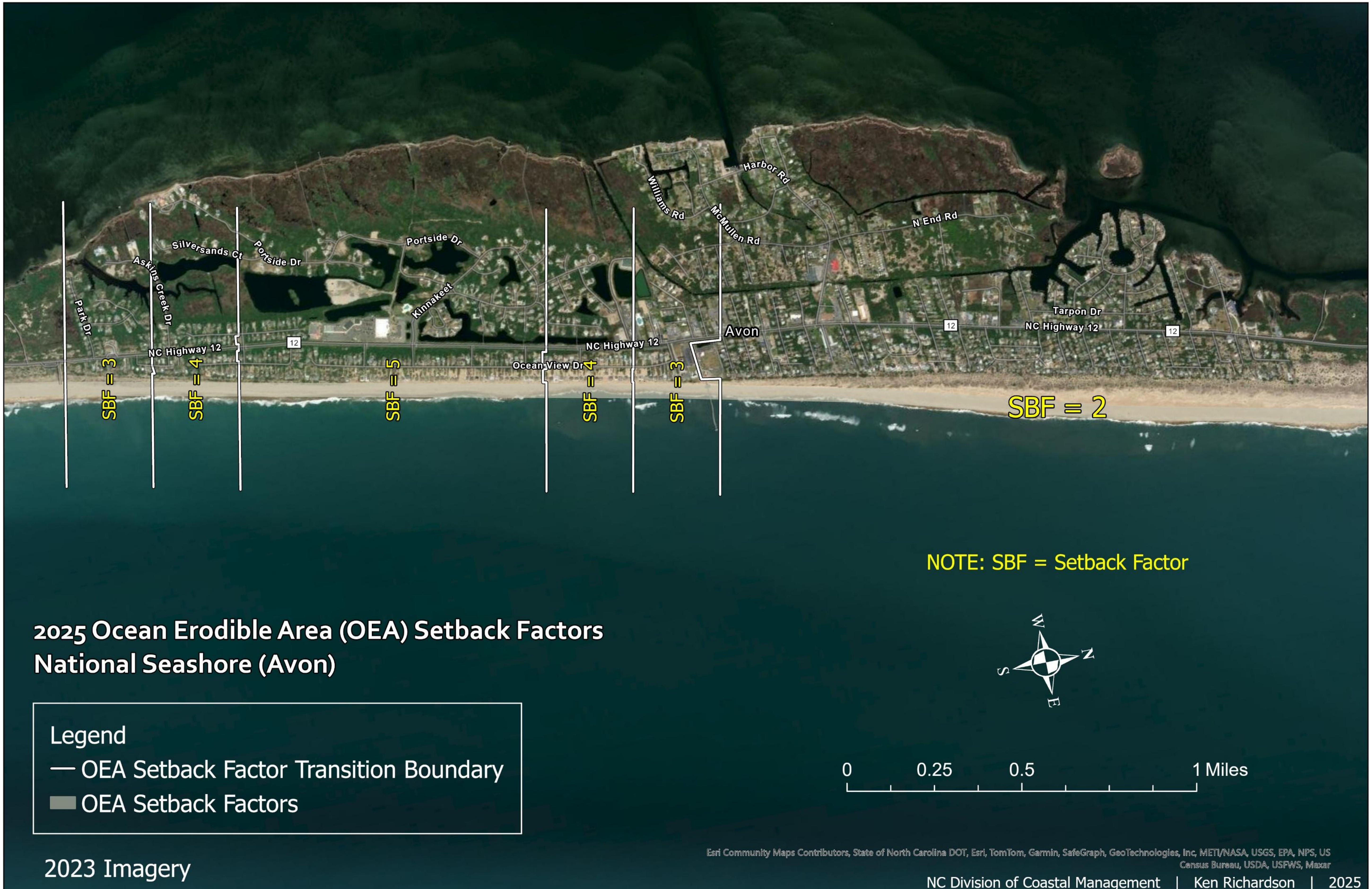

Park Dr
Askins Creek Dr
Silversands Ct
Portside Dr
Portside Dr
Kinnakeet
Williams Rd
McMullen Rd
Harbor Rd
N End Rd
Tarpon Dr
NC Highway 12
NC Highway 12
NC Highway 12
Ocean View Dr
Avon
SBF = 3
SBF = 4
SBF = 5
SBF = 4
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore (Avon)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.25
0.5
1 Miles
W
N
S
E
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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Little Kinnakeet
Phipps Cove
Gull Island Bay
Clarks Ba
12
SBF = 2
SBF = 3
SBF = 2
SBF = 3
SBF = 4
SBF = 5
SBF = 4
SBF = 5
SBF = 4
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore (Avon to Salvo)
Legend
— OEA Setback Factor Transition Boundary
OEA Setback Factors
W
N
S
E
0
1
2
4 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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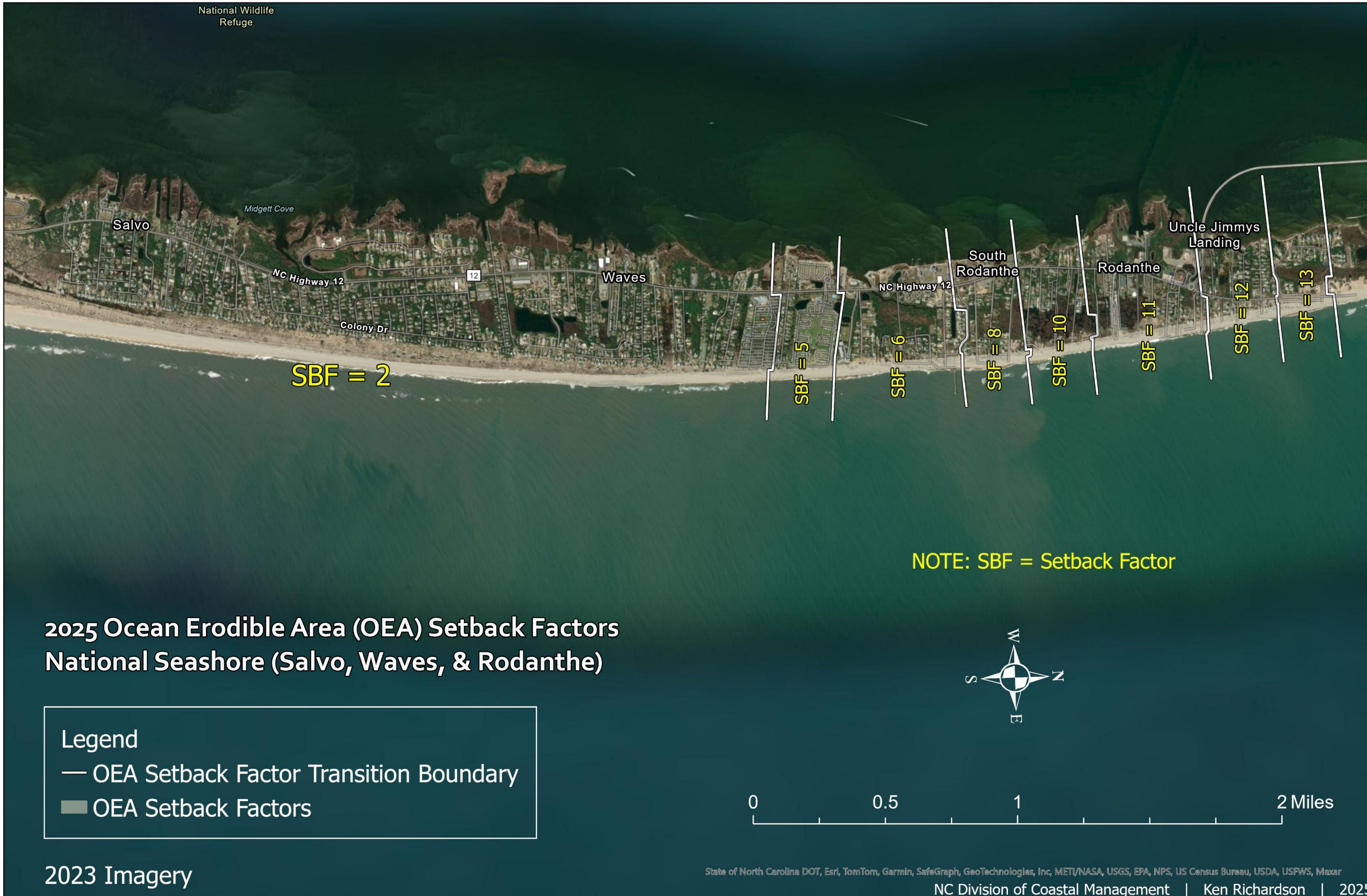
National Wildlife Refuge
Midgett Cove
Salvo
NC Highway 12
12
Waves
Colony Dr
South Rodanthe
Rodanthe
Uncle Jimmys Landing
SBF = 2
SBF = 5
SBF = 6
SBF = 8
SBF = 10
SBF = 11
SBF = 12
SBF = 13
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore (Salvo, Waves, & Rodanthe)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
S
N
E
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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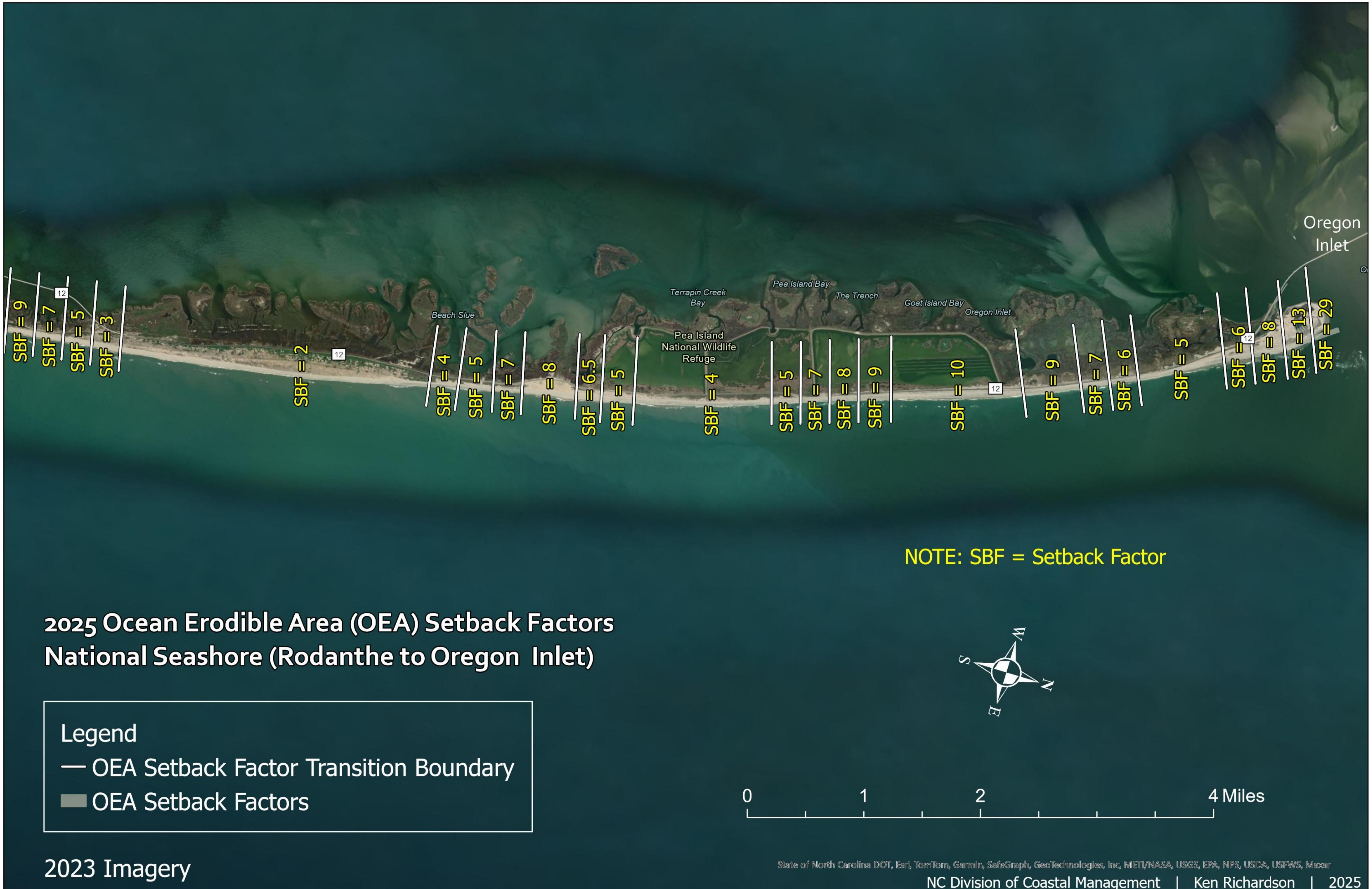

SBF = 9
SBF = 7
SBF = 5
SBF = 3
SBF = 2
SBF = 4
SBF = 5
SBF = 7
SBF = 8
SBF = 6.5
SBF = 5
SBF = 4
SBF = 5
SBF = 7
SBF = 8
SBF = 9
SBF = 10
SBF = 9
SBF = 7
SBF = 6
SBF = 5
SBF = 6
SBF = 8
SBF = 13
SBF = 29
Oregon Inlet
Beach Slue
Terrapin Creek Bay
Pea Island Bay
The Trench
Goat Island Bay
Oregon Inlet
Pea Island National Wildlife Refuge
12
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
National Seashore (Rodanthe to Oregon Inlet)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
2023 Imagery
W
S
N
E
0
1
2
4 Miles
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS, Maxar
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12
12
12
12
NC Highway 12
NC Highway 12
NAGS HEAD
Oregon Inlet
SBF = 2
SBF = 3
SBF = 4
SBF = 4.5
SBF = 6
SBF = 7
SBF = 8
SBF = 9
SBF = 8
SBF = 7
SBF = 8
SBF = 7
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Oregon Inlet to Nags Head
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.5
1
2 Miles
W
S
N
E
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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Cape Hatteras National Park Rd
12
S Colony South Dr
S Old Oregon Inlet Rd
NAGS HEAD
Juncos Street
SBF = 7
SBF = 6
SBF = 5
SBF = 4
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Nags Head (1 of 2)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.25
0.5
1 Miles
W
S
N
E
2023 Imagery
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Pond Island
Roanoke Sound
KILL DEVIL HILLS
Old Nags Head Woods Rd
S Virginia Dare Trl
NAGS HEAD
Nags Head Golf Links
Nags Head
S Croatan Hwy
158
S Virginia Dare Trl
Hargrove Street
Gulfstream Street
Glidden Street
Conch Street
SBF = 2
SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Nags Head (2 of 2)
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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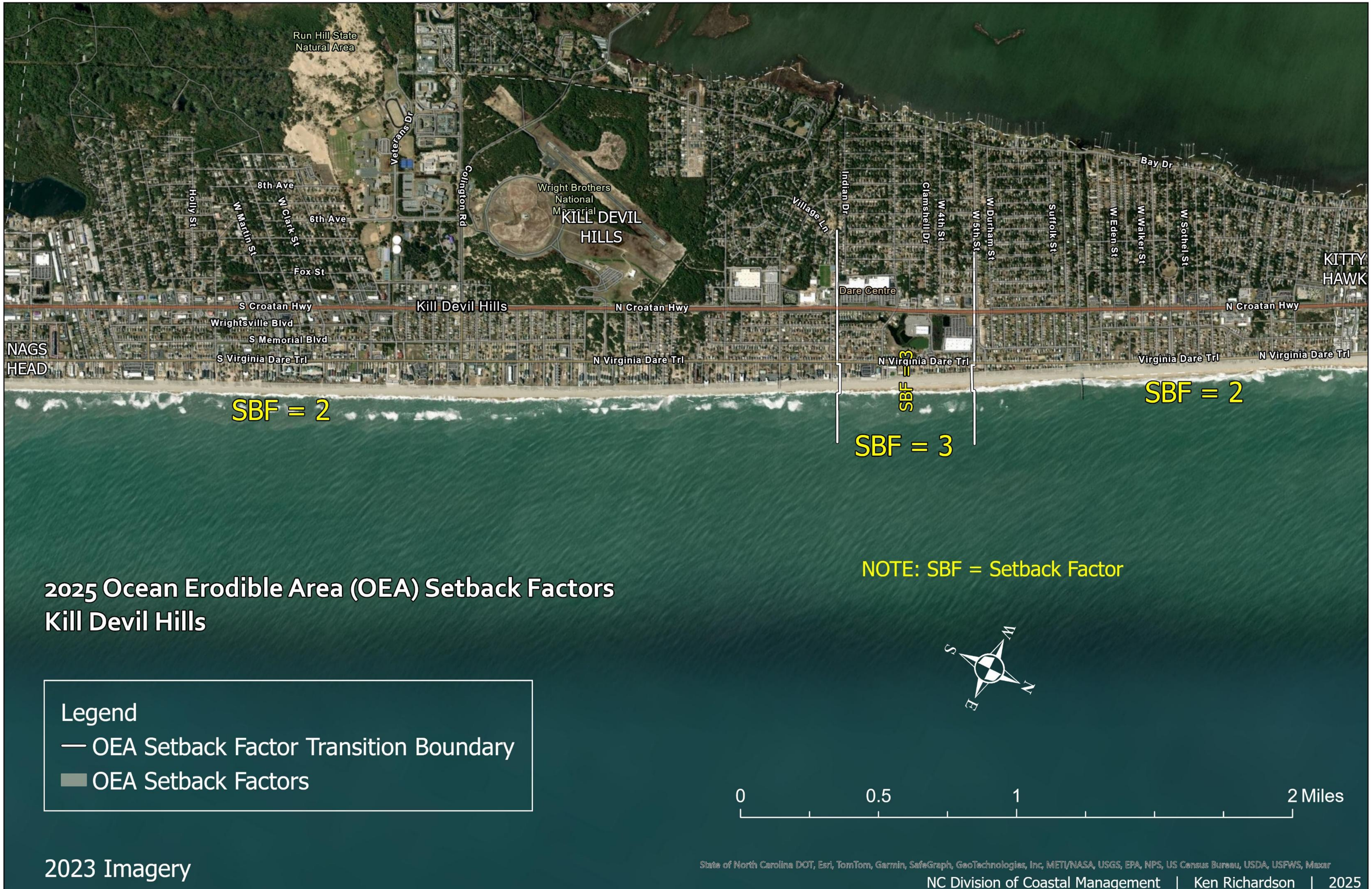

Run Hill State Natural Area
Veterans Dr
8th Ave
6th Ave
Holly St
W Martin St
W Clark St
Fox St
Colington Rd
Wright Brothers National Memorial
KILL DEVIL HILLS
Village Ln
Indian Dr
Clamshell Dr
W 4th St
W 5th St
W Durham St
Suffolk St
W Eden St
W Walker St
W Sothel St
Bay Dr
KITTY HAWK
Dare Centre
S Croatan Hwy
Kill Devil Hills
N Croatan Hwy
Wrightsville Blvd
S Memorial Blvd
S Virginia Dare Trl
N Virginia Dare Trl
Virginia Dare Trl
NAGS HEAD
SBF = 2
SBF = 3
SBF = 3
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Kill Devil Hills
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
S
N
E
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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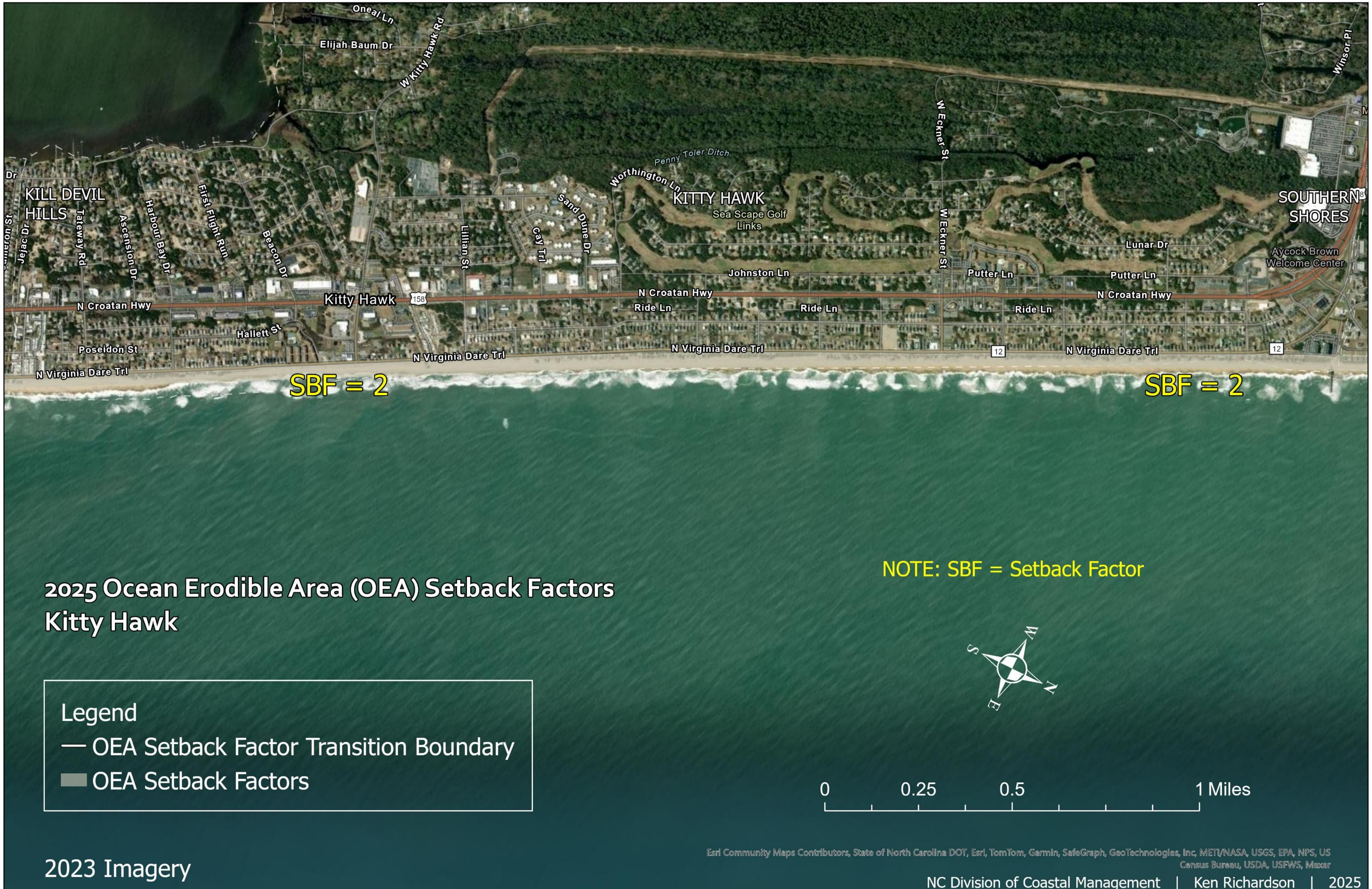

SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Kitty Hawk
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.25
0.5
1 Miles
2023 Imagery
KILL DEVIL HILLS
KITTY HAWK
SOUTHERN SHORES
Kitty Hawk
Sea Scape Golf Links
Aycock Brown Welcome Center
N Croatan Hwy
N Virginia Dare Trl
Ride Ln
Putter Ln
Johnston Ln
Lunar Dr
W Eckner St
W Kitty Hawk Rd
Elijah Baum Dr
Oneal Ln
Penny Toler Ditch
Worthington Ln
Sand Dune Dr
Cay Trl
Lillian St
Beacon Dr
First Flight Run
Harbour Bay Dr
Ascension Dr
Tateway Rd
Jejac Dr
Hallett St
Poseidon St
Winsor Pl
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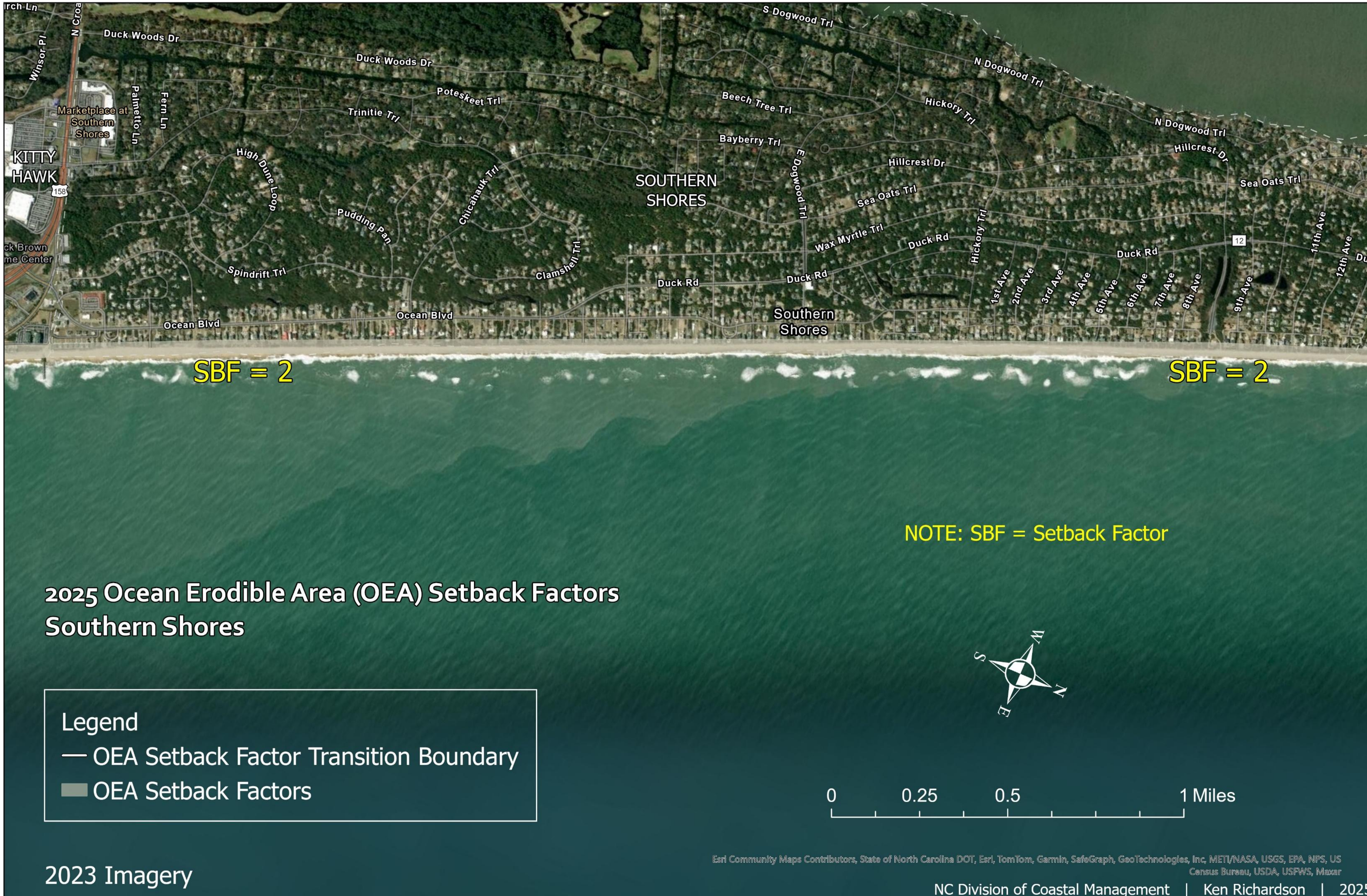

SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Southern Shores
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0 0.25 0.5 1 Miles
2023 Imagery
Esri Community Maps Contributors, State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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SOUTHERN SHORES
KITTY HAWK
Southern Shores
Marketplace at Southern Shores
Duck Woods Dr
Ocean Blvd
Duck Rd
N Dogwood Trl
S Dogwood Trl


SOUTHERN
SHORES
Duck
Plover Dr
Wampum Dr
Marlin Dr
Cook Dr
Dune Rd
Duck Rd
Duck Rd
Duck Rd
SBF = 2
SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Duck
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
S
N
E
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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Sanders Bay
Beasley Bay
Audubon Dr
Pine Island Airport
Ocean Trl
Ocean Trl
12
Ocean Trl
The Currituck Club
Ocean Trl
12
Ocean Trl
Ocean Trl
SBF = 2
SBF = 2
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Duck to Corolla
W
S
N
E
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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Sanders Bay
Raccoon Bay
Whale Head Bay
Monteray Dr
Ocean Trl
Corolla Dr
Whalehead Dr
Lighthouse Dr
Ocean Trl
Corolla Dr
Whalehead Dr
Lighthouse Dr
Ocean Trl
12
Corolla
Ocean Hills
SBF = 2
SBF = 3
SBF = 3
SBF = 4
NOTE: SBF = Setback Factor
2025 Ocean Erodible Area (OEA) Setback Factors
Corolla
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
W
S
N
E
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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2025 Ocean Erodible Area (OEA) Setback Factors
Carova
NOTE: SBF = Setback Factor
SBF = 3
SBF = 2
Teal Rd
Brant Rd
Mallard Rd
Anemone Ln
Ocean Pearl Rd
Sandpiper Rd
Sandfiddler Rd
Swan Island Rd
False Cape Rd
Martin Ln
Carova
Carova Rd
Bass Rd
W
S
N
E
Legend
OEA Setback Factor Transition Boundary
OEA Setback Factors
0
0.5
1
2 Miles
2023 Imagery
State of North Carolina DOT, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS, Maxar
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NC COASTAL AREA MANAGEMENT ACT
CAMA
50 Years
1974-2024

North Carolina 2025 Inlet Hazard Area (IHA) Erosion Rate & Setback Factors: Update Study

North Carolina Division of Coastal Management - August 10, 2025

NC Division of Coastal Management | Department of Environmental Quality
400 Commerce Avenue, Morehead City, NC 28557 | 252-515-5400 | Ken Richardson

Cover. *Image source - NC Division of Coastal Management; Top-Left: terminal groin installed in 2022 at Ocean Isle Beach; Top-Right: terminal groin installed in 2016 at Bald Head Island; Bottom-Left: Sandbag structure installed at North Topsail Beach adjacent to New River Inlet, and: Bottom-Right: Sandbag structure at Ocean Isle Beach adjacent to Tubbs Inlet.*

Acknowledgements

The shoreline change rates (erosion rates) documented in this report represent the outcome of a coordinated technical analysis conducted by the North Carolina Division of Coastal Management in partnership with the Coastal Resources Commission's (CRC) Science Panel on Coastal Hazards. These rates, derived through rigorous geospatial and statistical methodologies, directly informed the recalibration of inlet-based erosion setback factors and served as a foundational dataset for delineating the revised 2025 Inlet Hazard Areas (IHAs).

Summary

Since 1979, the North Carolina Division of Coastal Management (NC DCM) has utilized long-term erosion data to calculate oceanfront construction setbacks and establish landward boundaries for Ocean Erodible Areas of Environmental Concern. These rates are derived from changes in shoreline position, employing the least squares regression method. This approach reflects historical shoreline change trends rather than modeling or predicting future changes or shoreline locations.

Historically, due to limited data and resources, setback factors for Inlet Hazard Areas (IHAs) have been based on those of adjacent Ocean Erodible Areas, as specified in Rule 15A NCAC 07H.0310. However, shoreline change at inlets can occur more rapidly and dramatically relative to the oceanfront, often over short time periods. As a result, the setback factors may underestimate the true erosion dynamics of these areas.

With advancements in Geographic Information Systems (GIS) technology and the availability of more comprehensive and highly accurate shoreline datasets, NC DCM is transitioning from the end-point method to the least-squares regression method. This updated approach incorporates multiple shoreline positions, providing a more robust analysis of erosion trends.

While some property owners near inlets may see no changes to their erosion rate setback factors, others may experience increases. It is important to note that these updated setback factors are

determined based on inlet-specific erosion rates, rather than those of the adjacent Ocean Erodible Areas.

Contents

1.0 Introduction

Inlet Hazard Areas (IHAs) are one of three Areas of Environmental Concern (AEC) within the broader Ocean Hazard Area system. Since 1979, construction setbacks within IHAs use the setback factor from its adjacent Ocean Erodible AEC (oceanfront) as specified in Rule 15A NCAC 07H.0310, which have been calculated based on oceanfront shoreline long-term change methodology (end-point) and data from two shorelines. However, this method may not accurately reflect erosion hazards within inlet areas.

In 2019, the Coastal Resources Commission's Science Panel on Coastal Hazards, along with the North Carolina Division of Coastal Management (DCM), presented findings from the study titled "*Inlet Hazard Area Boundary, 2019 Update: Science Panel Recommendations to the North Carolina Coastal Resources Commission*." That study aimed to develop methods for analyzing inlet shoreline changes and to provide the CRC with inlet erosion rates and updated IHA boundaries for ten active, developed tidal inlets in North Carolina, including Tubbs, Shallotte, Lockwood Folly, Carolina Beach, Masonboro, Mason, Rich, New Topsail, New River, and Bogue Inlets (**Figure 1**).

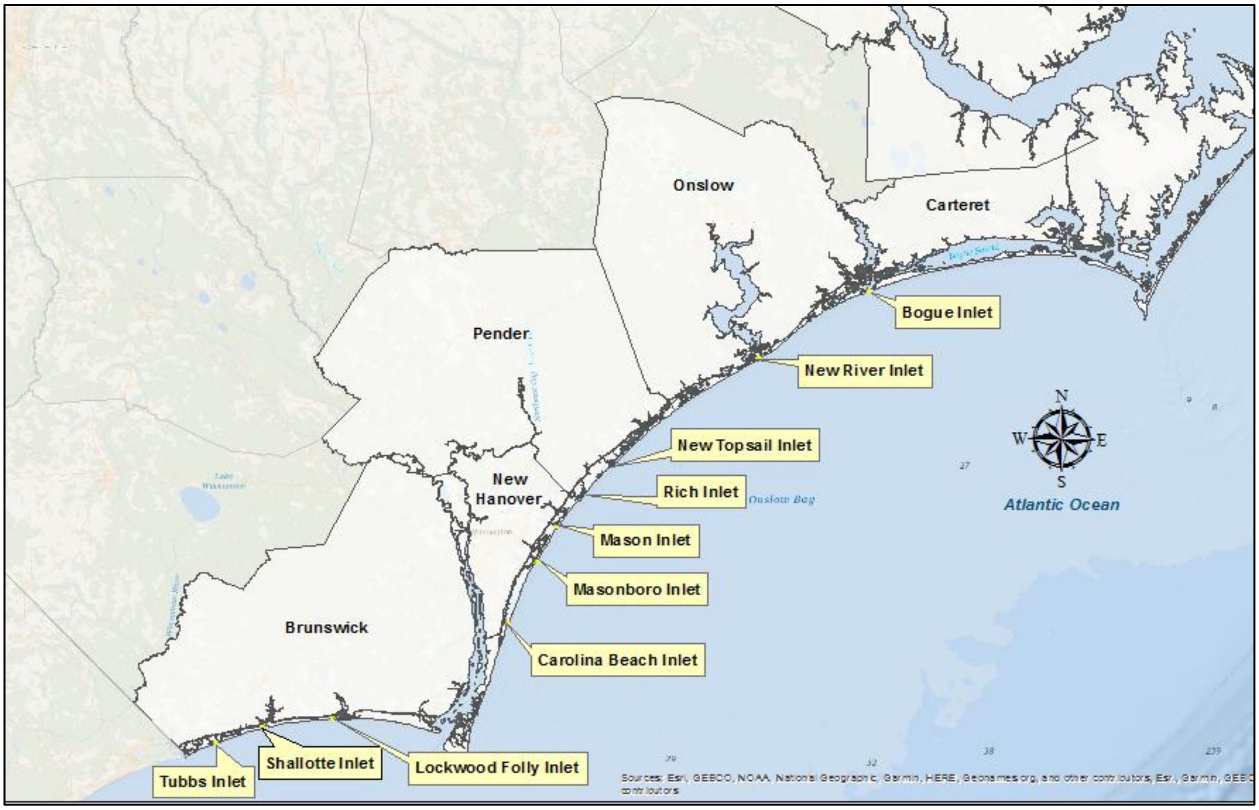

Figure 1. *Study areas include (south to north): Tubbs, Shallotte, Lockwood Folly, Carolina Beach, Masonboro, Mason, Rich, New Topsail, New River, and Bogue Inlets. At least one side of each inlet is developed.*

Although the erosion rates from this study were not implemented, the current update proposal aligns with the oceanfront's long-term average annual erosion rate and introduces newly proposed updates to the Inlet Hazard Area boundaries defined in the CRC's Science Panel on Coastal Hazards 2025 report; "*Inlet Hazard Area Boundary, 2025 Update: Science Panel Recommendations to the North Carolina Coastal Resources Commission*."

NC DCM is proposing inlet setback factors calculated using inlet shoreline change rates for the IHAs.

2.0 Methods

Since 1979, DCM has calculated long-term oceanfront shoreline change (erosion and accretion) using the end-point method. This approach focuses on the change in shoreline position between the earliest and most recent recorded shorelines. While useful for providing an overall picture of long-term shoreline movement, the method does not account for significant short-term fluctuations that may occur between those points in time, which can influence local shoreline behavior and differ from long-term trends. This limitation is particularly evident in inlet shorelines, where constant movement, tidal and storm influences, and sediment transport cause frequent position changes. The dynamic nature of these areas makes the end-point method less effective in accurately capturing the shoreline's behavior or estimating future trends.

To address this complexity in the current study, least squares regression was employed. This statistical technique analyzes multiple shoreline positions over time, offering a more nuanced view of the shoreline's variability and long-term trends (Thieler et al., 2009). By incorporating a broader dataset, least squares regression provides a more reliable and comprehensive analysis of shoreline dynamics, especially in regions affected by the unpredictable behavior of inlets. This approach allows for better understanding of erosion and accretion patterns and offers insights that can inform coastal management strategies.

Shoreline data were analyzed using *ESRI's ArcPro® 3.x and ArcMap® 10.8x* Geographic Information System (GIS) and U.S. Geological Survey's (USGS) Digital Shoreline Analysis System (DSAS) versions 5.1 and 6.0. Geographic Information Systems (GIS) are a sophisticated suite of tools used to capture, store, analyze, manage, and visualize spatial or geographic data. They combine layers of information about a location to help understand patterns, relationships, and trends.

The U.S. Geological Survey's (USGS) *Digital Shoreline Analysis System* (DSAS) is a specialized spatial analysis tool designed to calculate shoreline changes, including erosion and accretion rates. It tracks shoreline movement over time by analyzing both historical and recent data. The following is a general overview of how DSAS is used to calculate shoreline erosion rates:

1. Shoreline Data Input: DSAS requires a series of shoreline positions from different time periods. These shorelines can be digitized from historical maps, aerial imagery, or satellite data.
2. Baseline Creation: A baseline is established landward or seaward of the shorelines. It acts as a reference for the calculation of changes.
3. Transect Generation: Perpendicular transects are automatically generated at regular intervals from the baseline, extending across the shorelines. These transects are the points where shoreline change is measured.
4. Shoreline Change Calculation: For each transect, DSAS computes the distance between different shoreline positions over time, using methods like:
    a. End Point Rate (EPR): Measures the distance between the oldest and most recent shorelines divided by the time span between them.
    b. Linear Regression Rate (LRR): Fits a least-squares regression line through all shoreline points for each transect, estimating the average rate of change.
    c. Weighted Linear Regression (WLR): Like LRR, but weights more recent data more heavily to account for its higher relevance.
5. Output: DSAS generates statistical outputs for each transect, including the rate of shoreline change (in meters per year) and confidence intervals. These results help assess erosion risks, trends, and rates.

In summary, DSAS is used to calculate shoreline erosion rates by analyzing shoreline position changes over time, using automated transects and various statistical methods to provide precise and localized erosion rate data.

2.1 Shoreline Data

DCM's growing database of oceanfront and inlet shorelines facilitated this study by allowing many different approaches to be tried and tested. Most of the shorelines used were mapped using historic orthophotography to digitize the wet-dry line (**Figure 2**), considered a proxy for the

Mean High Water (MHW) line. Three shorelines represented the location of MHW, either derived from lidar (1997 and 2004), or NOS T-Sheets (either from the 1930s or 1940s). Two studies carried out by DCM (Limber et al., 2007a; 2007b) indicated that the lidar-derived MHW line could be used interchangeably with the wet-dry shorelines.

Although shoreline data existed between 1930 and 2022, the temporal focus here is on shorelines between 1970 and 2022 for several reasons:

- The 1930 to 1940 shorelines were excluded at most inlets because of uncertainties on the hydrodynamics at each inlet associated with the construction and maintenance dredging of the Atlantic Intracoastal Waterway (AIWW) and other waterways. This specifically affected the inlets in the southern portion of the State, where one to four shorelines were excluded.
- Shorelines based on photography taken immediately or within one year after major storms or beach nourishment projects were avoided.
- The primary imagery used were NC Department of Transportation (DOT) shoreline images between 1970 and 2000, and post-2000 images acquired from a variety of agencies (USDA NAIP, NOAA, USGS, & NC Emergency Management).

These criteria resulted in the number of shorelines used, ranging between 10 and 24 at each inlet. Oceanfront and inlet shorelines were analyzed along a series of numbered, shore-perpendicular transects spaced at 25-meter (82-foot) intervals using USGS's Digital Shoreline Analysis System (DSAS) with ESRI's ArcGIS. Due to the curvature of inlet shorelines where there is a transition from the oceanfront into the inlet throat, transects were cast from an onshore baseline to create radial transects that retained shore-perpendicular orientation and spacing. Radial transects were used to compute shoreline changes inside the inlet.

Figure 2. *Interpretation of the "wet-dry" shoreline using orthophotography.*

2.2 Transects (25-Meter)

Shoreline positions along oceanfront were assessed using a series of numbered transects that are generally perpendicular to the shore and spaced at 25-meter intervals, and to ensure a consistent shoreline-perpendicular orientation and spacing, transects were extended from an onshore baseline (**Figure 3**). This alignment followed the overall positional trend of shoreline locations, particularly where the inlet shorelines curved from the oceanfront to the inlet throat. This approach was crucial for best capturing the complex geometries and variations in shoreline shape, allowing for accurate analysis of coastal inlet dynamics where the inlet's curvature a spatial disbursement introduced significant variability. At each intersection between shorelines and transects, shoreline change rates, and additional statistical measures were computed. The analysis utilized the US Geological Survey’s (USGS) Digital Shoreline Analysis System (DSAS) (Thieler et al., 2009) in conjunction with ESRI's ArcGIS.

Figure 3. *This map illustrates an example of casting 25-Meter transects (yellow line) from an onshore baseline (red line) that follows the general trend of shoreline positions.*

Future update studies are advised to reassess baselines and transects and recasting them if needed to ensure that any newly added shorelines in subsequent analyses remain seaward of the baseline. This will ensure that transects intersect each shoreline; otherwise, any missed shoreline-transect intersections will be excluded from the analysis.

2.3 Shoreline Change Rates: Linear Regression (Least Squares Regression)

DCM has calculated long-term oceanfront shoreline change (erosion/accretion) rates since 1979 using the end-point method, which is based on the change between the earliest and most recent dates. Any short-term change between those dates, no matter how significant, is not directly captured. Because inlet shorelines are constantly moving and fluctuating in position, the end-point method is less effective in capturing the dynamics of an inlet or for quantifying its long-term trends. Instead, least squares regression, a statistical measure using multiple shorelines, was used for this study (Thieler et al., 2009).

At each transect, there are a series of shoreline-transect intersections that represent the shoreline's position through time (**Figure 4**). Least Squares Regression - Linear regression (LRR) minimizes the distance between the known values (actual shoreline positions) fitting a least-squares regression line through all shoreline points for each transect, estimating the average rate of change (**Figure 5**). The slope of this line is the least squares regression of shoreline change or the local erosion or accretion rate.

Figure 4. *This map illustrates an example of radial transects (green and red lines) and point locations where shorelines intersect transects.*

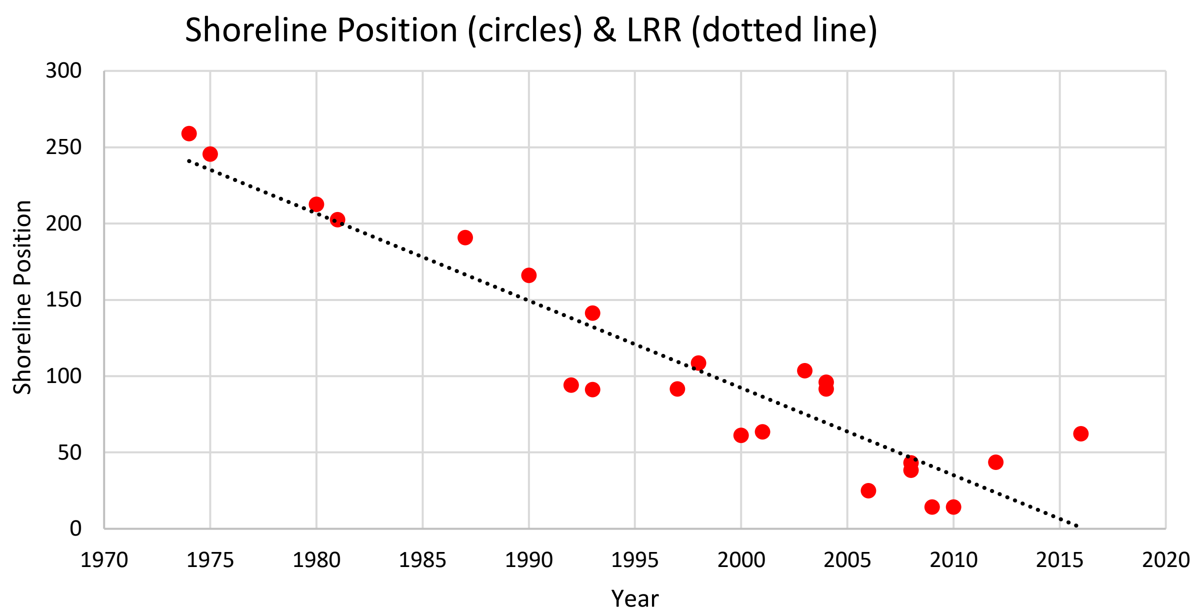

Figure 5. *Relative shoreline position as a function of time (circles). The slope of the best fit, dotted line is the linear regression rate (LRR) of shoreline change (in this case, it is eroding at 19 feet per year).*

The benefits of this method include (Dolan et al., 1991):

- All data can be used, regardless of changes in trend.
- The method is purely computational.
- The calculation is based on accepted statistical concepts.
- The method is easy to employ.

Although the least squares regression method is less sensitive to individual points, it is susceptible to outliers; it assumes that the computed trend is linear, and it tends to underestimate the rate of change relative to other statistics, such as the end-point rate (Dolan et al., 1991; Genz et al., 2007). To exclude outlier data, precautions were taken in this study to avoid shorelines that reflect influences caused by a major storm event or beach nourishment. However, given that the practice of beach nourishment has become a frequently occurring common practice, avoidance of these shorelines is not always possible.

Once computed, the linear regression rate was then smoothed using a 17-transect running-average alongshore. This follows the blocking computation historically used for the oceanfront shoreline rates and further smooths the alongshore variation in the shoreline change rate.

2.4 Shoreline Change Rates: Smoothing

Smoothing raw data has been applied in all oceanfront shoreline position change studies since 1979 and serves as a method of removing high-frequency variations or noise, thereby highlighting the underlying trends and patterns. By doing so, short-term dynamic shoreline phenomena such as beach cusps, smaller sand waves, and the incorporation of landward migrating portions of offshore bar systems are effectively filtered out (**Figure 6**).

Figure 6. *This image shows an example of beach cusps and nearshore sandbars relative to 50-meter transects.*

Shoreline cusps and similar coastal features exhibit a wide range of sizes, from small formations approximately 5 feet in width to much larger structures reaching up to 5,000 feet. Their lifespans also vary considerably, with smaller features lasting only a few days, while larger ones, such as sand waves, can persist for entire seasons or even several years (Dolan and Ferm, 1968; Davis, 1978). This range in both size and duration reflects the dynamic and ever-changing nature of coastal environments, driven by processes like wave action, tidal patterns, and sediment transport.

Sandbars, another prominent coastal feature, typically measure more than 300 feet in length. These structures undergo migration and attachment processes, which unfold over time periods ranging from seasons to years (Davis, 1978). The shifting position of these bars, combined with their ability to attach to different points along the shoreline, underscores the fluidity of coastal landscapes, where no feature remains fixed indefinitely.

Unlike smaller, more transient formations, larger and more durable features such as capes are resistant to smoothing processes commonly applied in coastal analysis. These capes remain prominent even after filtering, highlighting their scale and resilience. Despite their size, capes and similar features are not permanently anchored to a single location. They can migrate along the shoreline, shaped by continuous interactions with natural forces like currents, wind, and wave energy. This movement further illustrates the complex and evolving nature of shorelines, where even the largest features remain subject to gradual change.

The procedure for spatially smoothing shoreline change rate data involves a simple moving average or running mean technique, as described by Davis in 1973. Commonly known as the "17-point running average," this method typically includes at least 17 transects, each spaced 25 meters apart, covering approximately 0.25 miles of shoreline. To calculate the smoothed rate, an average is computed for each group of 17 transects, with the calculation centered on the ninth transect (having eight transects on either side).

As the algorithm approaches the inlet at the last 17 transects, the number of transects used to calculate the average is reduced by two, dropping one from each side of the centered transect, until the end is reached. For the last value, a weighted average is calculated using only the final two transects. This approach ensures a smooth transition in areas with fewer available data points near shoreline boundaries or inlets.

$$\mathbf{R_s = (2 \times T_1 + T_2) / 3}$$

R_s = *smoothed rate*

T_1 = *erosion rate at last transect adjacent to the inlet*

T_2 = *erosion rate at second to last transect adjacent to inlet*

As shown in **Figure 7**, the effects of smoothing are most apparent in areas undergoing accelerated erosion or accretion, such as near inlets. For analyzing erosion rate data, this method is one of the simplest techniques for smoothing time-series data. Its effectiveness in these studies is largely due to the equal spacing between transects, making it well-suited for capturing consistent shoreline change patterns.

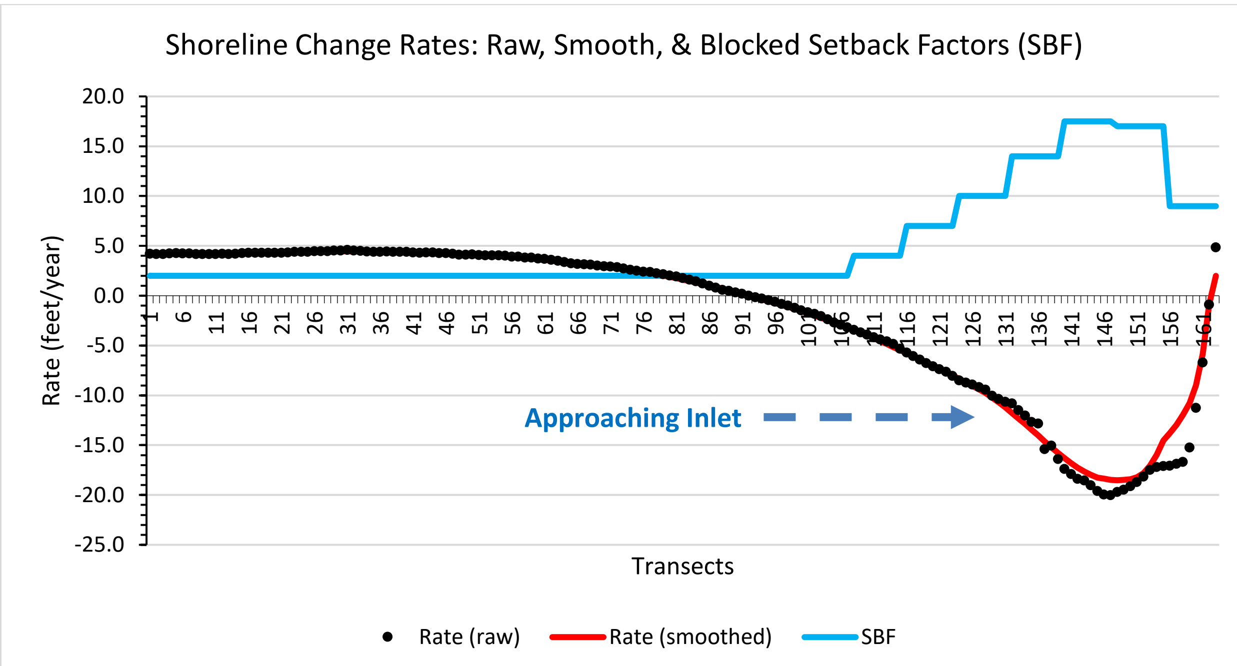

Figure 7. *This example illustrates the raw data (black points), smoothed data (red line), and blocked erosion setback factors (blue line). Note that in areas where erosion rates are less than 2 feet per year, or where accretion occurs, the minimum setback factor defaults to 2. While setback factors are recorded as positive values, they directly correspond to erosion rates, particularly when the values surpass -2 ft/yr.*

2.5 Shoreline Change Rates: Blocking

In late 1978 and early 1979, the North Carolina Coastal Resources Commission undertook an in-depth review and revision of the oceanfront regulations initially adopted in September 1977. One of the most significant updates introduced during this process was the concept of oceanfront development setbacks, which were then partially determined by the average annual long-term erosion rates. These rates, calculated based on transects, helped define how far inland development should be placed to minimize risk from coastal erosion. Where rates are higher, the setbacks are greater to help buffer the risk.

However, because these transects only capture data at specific points along the shoreline, a method was required to establish broader setback areas, or “blocks,” where similar erosion rates could be applied consistently across continuous coastal sections. Following a 1979 study (Tayfun et al., 1979) it was determined that if the blocks or segments were too long, the accuracy of the erosion rates could be compromised, particularly in regions where the rates change rapidly over short distances. Long segments tend to oversimplify the data, failing to reflect these localized variations, which could lead to inappropriate setback distances in areas prone to higher erosion.

It wasn’t until the CRC’s 1986 study that this issue was addressed by decreasing the transect spacing from the original intervals to 50 meters. This closer spacing allowed for a more precise calculation of erosion rates and has been the standard practice in all subsequent studies of oceanfront areas. This refinement enabled a more accurate understanding of how erosion affects different parts of the shoreline, leading to better-informed coastal management and development decisions.

In inlet areas, where shoreline dynamics are far more volatile than on the oceanfront, erosion rates can change dramatically over much shorter distances. While oceanfront rates typically increase or decrease gradually over longer stretches, inlet areas require a much finer level of detail. To capture these rapid variations, a transect spacing of 25 meters is applied in Inlet Hazard Areas (IHAs). This smaller spacing allows for a more detailed and accurate representation of the localized erosion patterns, ensuring that setback lines and management strategies are tailored to the unique and dynamic conditions of inlets.

The technique of "blocking" smoothed rate data creates spatially consistent rate segments along the shoreline. Essentially, blocking groups neighboring transects along the same shoreline segment that exhibit similar smoothed shoreline change rates. This approach enables more uniform and consistant management practices for sections of the shoreline that experience the same or similar rates of change, rather than relying on individual rates at each transect or risking misinterpretations in the areas between transects.

The blocked shoreline change rate data are used as Setback Factors, commonly referred to as "erosion rates," and are applied to determine construction setbacks within Ocean Hazard Areas of Environmental Concern (AECs), which include both Ocean Erodible Areas and Inlet Hazard Areas. This method ensures that setbacks are calculated consistently across similar shoreline segments, improving coastal management and reducing the risk of inappropriate development in high-erosion zones.

Blocking procedures, itemized below, represent refinments and clarifications of procedures established by and used in all previous update studies. These refinements and clarifications are the result of improved accuracy of the data brought about by improvements in the shoreline delineation methodology and quantitative requirements that allow for increased repeatabiltiy of results. In areas experiencing an accelerated change in rates, this refinement resulted in smaller blocked groups. The following list describes the process, or “rules” of blocking:

1. Group “like” erosion rate segments based on rate at transect (*e.g.,* 2.0, 2.2, 2.1, 2.5, 2.6, 2.1, . . . 2.9) and use the mean of each segment as the blocked rate. Transitioning at one-foot intervals are prefered for rate block boundaries. Fractional rates are rounded down to the nearest foot, or half foot interval for segments dominated by a half foot value and do not have values greater than the next highest one foot interval (*e.g.*, a rate segment equal to 5.4 would be rounded to 5.0; and 5.7 would be rounded to 6.0).

2. Blocked shoreline change rate segments must be comprised of at least eight (8) transects. In areas experiencing rapid erosion or accretion (*e.g.,* approaching inlets), it is not always possible achieve a one-foot transition from one blocked rate segment to the next, thus making it necessary to evaluate segments based on its mean so that transitions from one blocked segement to the next was as near to the one-foot interval as feasible.

3. In areas where blocked segments transition from one value to another (*e.g.*, from 3 to 4 feet per year) a determination must be made to select the transect that will serve as a delineation between the change in values. The lower rate would be applied towards the higher blocked segment.

4. Where two blocked boundaries meet and divide a property or parcel, the lower of the two blocked rates is applied in the direction of the higher rate in order to give the property owner the benefit of the lower rate.

Based on currentl rules (15A NCAC 07H.0304(1)[1]), segments of the shoreline that result in measured accretion, or where measured erosion rates are less than two (2.0) feet per year, are assigned the default minimum, a blocked rate value (Setback Factor) of two (2) in accordance with the minimum setback of 60 feet, or 30 times the Setback Factor based on blocked shoreline change rates.

[1] NC Administrative Code (NCAC), Title 15A – Environmental Quality, Chapter 7, Sub-Chapter 0304(1)

3.0 Results

The following graphs and maps illustrate proposed inlet setback factors calculated using inlet shoreline change rates associated with 2025 Inlet Hazard Area Boundary update proposal. Where erosion rates are less than 2 feet per year, or where accretion is measured, the minimum setback factor defaults to 2 (Rule NCAC 15A 07H.0304(1)). While setback factors are recorded as positive values, they directly correspond to erosion rates, particularly when the values surpass -2 ft/yr. For example, if a setback factor equals 3, then it corresponds to an area of shoreline that has a long-term average annual erosion rate of approximately -3 feet/year.

It’s important to understand that long-term (50+ years) average erosion rates can differ significantly from short-term rates. In 2000, the U.S. Geological Survey (USGS), East Carolina University (ECU), and the N.C. Geological Survey (NCGS) formed the Coastal Geology Research Cooperative to study the coastal geology of North Carolina, from Cape Lookout to Currituck County, and compare short- and long-term shoreline changes. While engineering efforts like dredging, erosion control structures, and beach nourishment can affect short-term erosion, in North Carolina, storm intensity and frequency play a larger role in shaping short-term changes. For example, beach nourishment can artificially lower erosion rates, while storm event frequency and intensity can cause higher short-term erosion rates that don’t necessarily reflect long-term trends.

Based North Carolina’s 2019 oceanfront erosion rate study, the statewide average erosion rate along the coast is -2.1 feet per year, with a median rate of -1.6 feet per year (NC DCM, 2019). This provides a general view of erosion across the state’s oceanfront, but localized conditions can vary significantly, especially near inlets. When considering all NC inlets and not just those analyzed for this study, erosion rates are much higher, with an average rate of -8.4 feet per year and a median rate of -9.7 feet per year.

However, it’s equally important to recognize that inlets can also experience significant accretion, where sand is deposited rather than eroded. Where shoreline accretion was measured, the average rate is 5.8 feet per year, and the median is 4.9 feet per year. This substantial buildup of sediment, particularly at oscillating and migrating inlets, highlights the dual nature of these coastal zones—while erosion can be 4 to 5 times higher at inlets compared to other areas, accretion can also be far more pronounced. These rapid and sometimes dramatic changes in shoreline position underscore the highly dynamic and unpredictable nature of inlets, where sediment can shift quickly, creating both erosion and accretion with significant potential to reverse trends.

Although all oceanfront and inlet areas were analyzed, these findings focus only on the regions within the 2025 updated Inlet Hazard Areas. The following sections summarize erosion and accretion for each side of each inlet.

3.1 Tubbs Inlet: Sunset Beach

Likely due to several factors, including the relocation of Tubbs Inlet to the northeast in 1970, the construction of a dual jetty system at Little River Inlet to the south in 1980, and the closure of Mad Inlet in 1997, Sunset Beach has benefited from a more abundant sediment supply. More sediment in the system has resulted in natural accretion along the shoreline, and thus far, eliminating the need for beach nourishment.

In the 2025 updated Inlet Hazard Area, covering approximately one-third of a mile (1,805 feet) from transect 213 to Tubbs Inlet, the analysis included sixteen shorelines from 1981 to 2020 (**Figure 8**). The spit adjacent to the inlet channel is continuously shifting and has more recently extended further landward toward the northeast and contributing to significant shoaling in Jinks Creek (**Figure 11**). According to the measurements from this study, the average shoreline change rate within the IHA is 6.5 feet per year (accretion), with a median of 3.5 feet per year (**Figure 10**). As a result, the erosion setback factor defaults to 2 (**Figure 12**).

Figure 8. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Tubbs Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

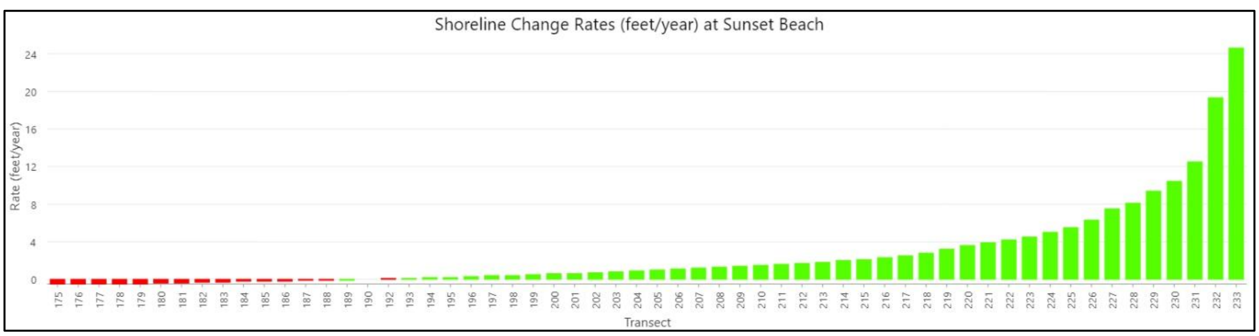

Figure 9. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

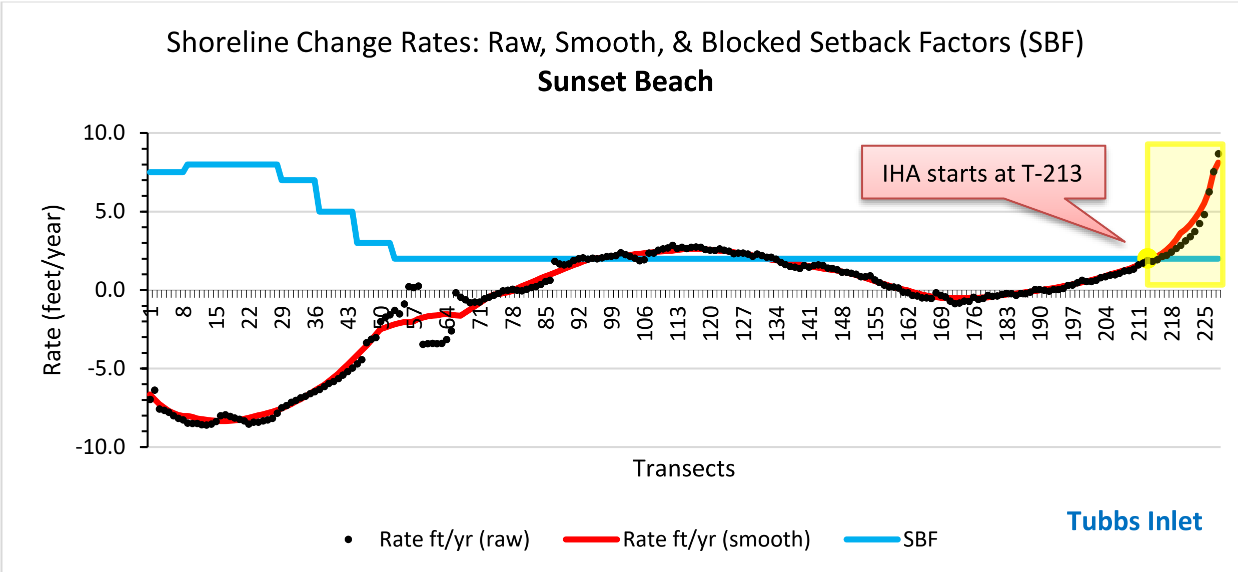

Figure 10. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 11. *This image shows the spit at Sunset Beach extending into the inlet in a northeast direction, and the shoaling within Jinks Creek. Photo source: Sunset Beach Environmental Resource Committee, 2024.*

Figure 12. *This map image illustrates 2025 inlet erosion rate setback factors in relation to the 2025 updated IHA boundary.*

For the same area inside the 2025 updated IHA, **Table 1** compares resulting erosion setback factors to those measured and calculated in previous oceanfront erosion rate and setback factor update studies. Here, the application of existing Rule 15A NCAC 07H.310 requiring the use of the adjacent OEA has not influenced setbacks. Given the general trend of accretion since 1981, setbacks have remained consistent with those calculated in previous studies.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2

Table 1. This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.

3.2 Tubbs Inlet: Ocean Isle

The Ocean Isle side of Tubbs Inlet has experienced varying rates of erosion. However, the historical use of sandbag structures along the inlet's shoreline has likely reduced these rates by temporarily stabilizing the shoreline and preventing further erosion. While not within the updated IHA, the oceanfront shoreline has been nourished to varying degrees since 1974. The first large-scale (>300,000 cubic yards) beach nourishment occurred in 2001 as part of the Federal Coastal Storm Damage Reduction (CSDR) project; subsequently followed by routine maintenance in 2006, 2009, 2014, 2018, 2021 and 2022.

In the 2025 updated Inlet Hazard Area, covering approximately one-half mile (2,500 feet) from transect 27 to Tubbs Inlet, the analysis included twenty-five shorelines from 1970 to 2022 (**Figure 13**). According to the measurements from this study, the average shoreline change rate within the IHA is -1.8 feet per year (erosion), while rates within the inlet exceed -20 feet per year (**Figure 14**). As a result, the erosion setback factor nearest the inlet is 10 and quickly transitions to 2 at transect 9 (**Figure 16**).

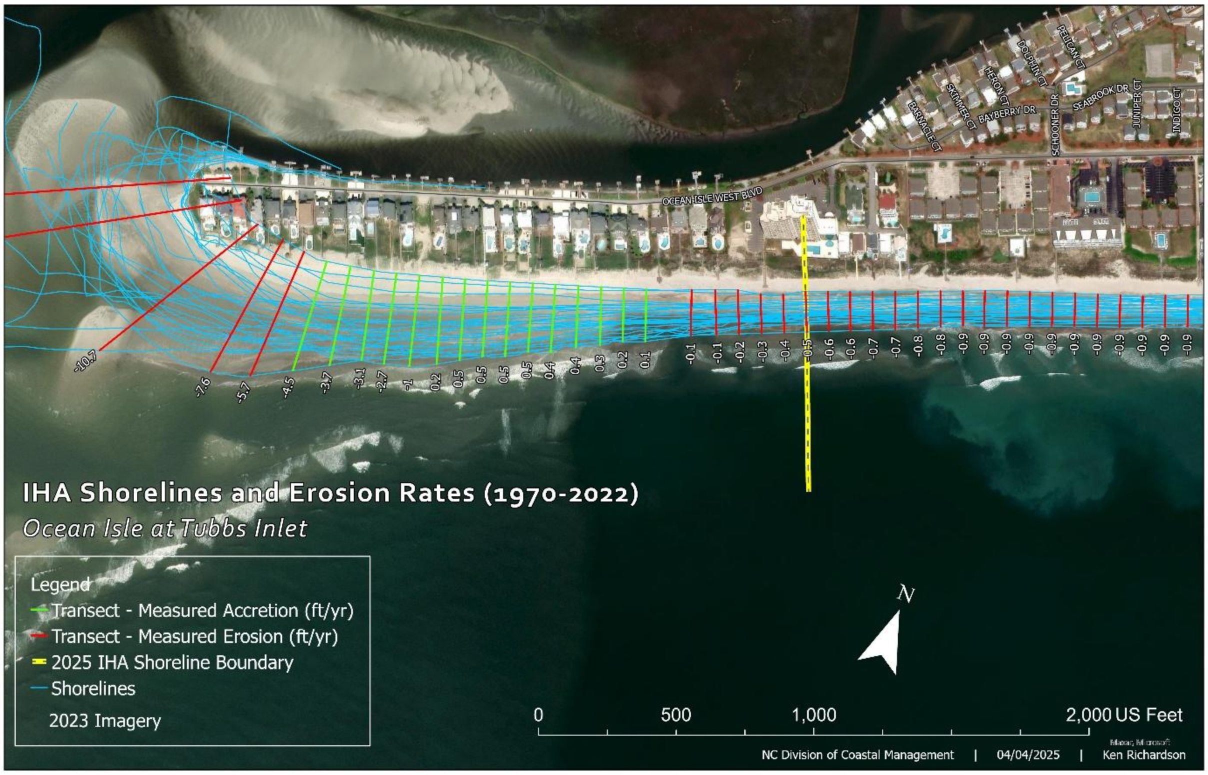

Figure 13. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Tubbs Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

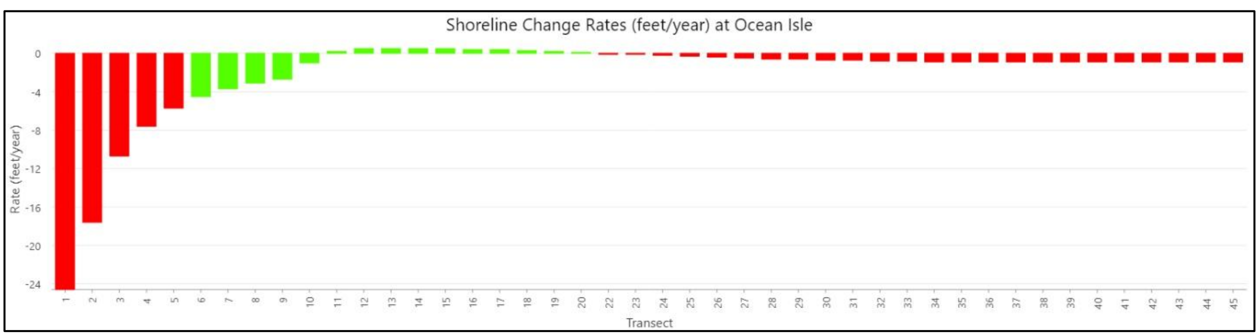

Figure 14. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

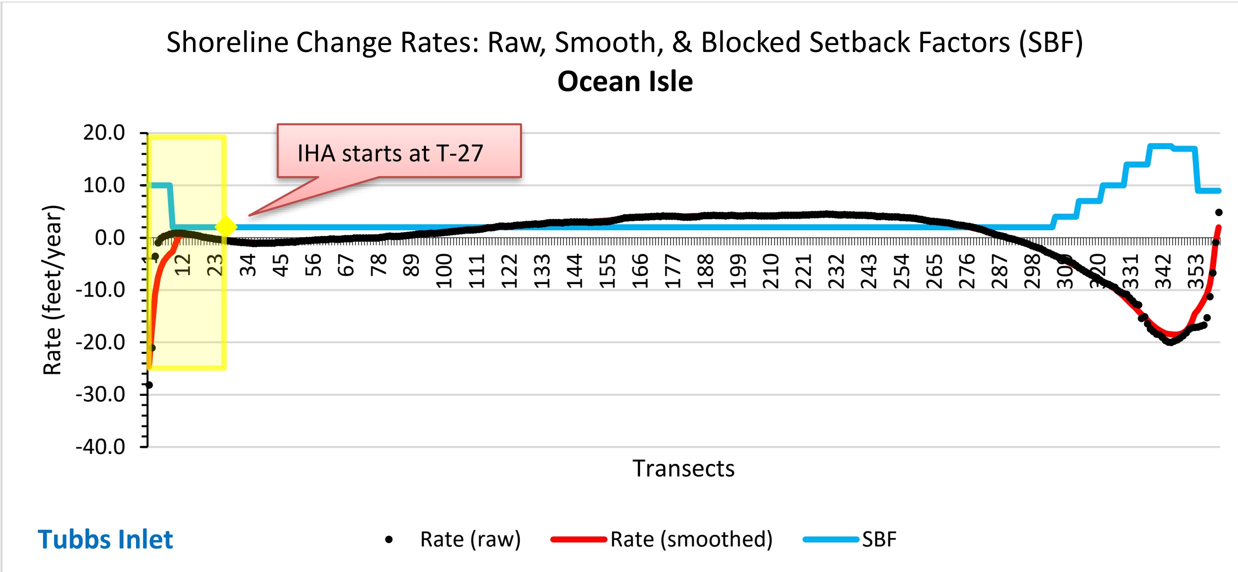

Figure 15. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

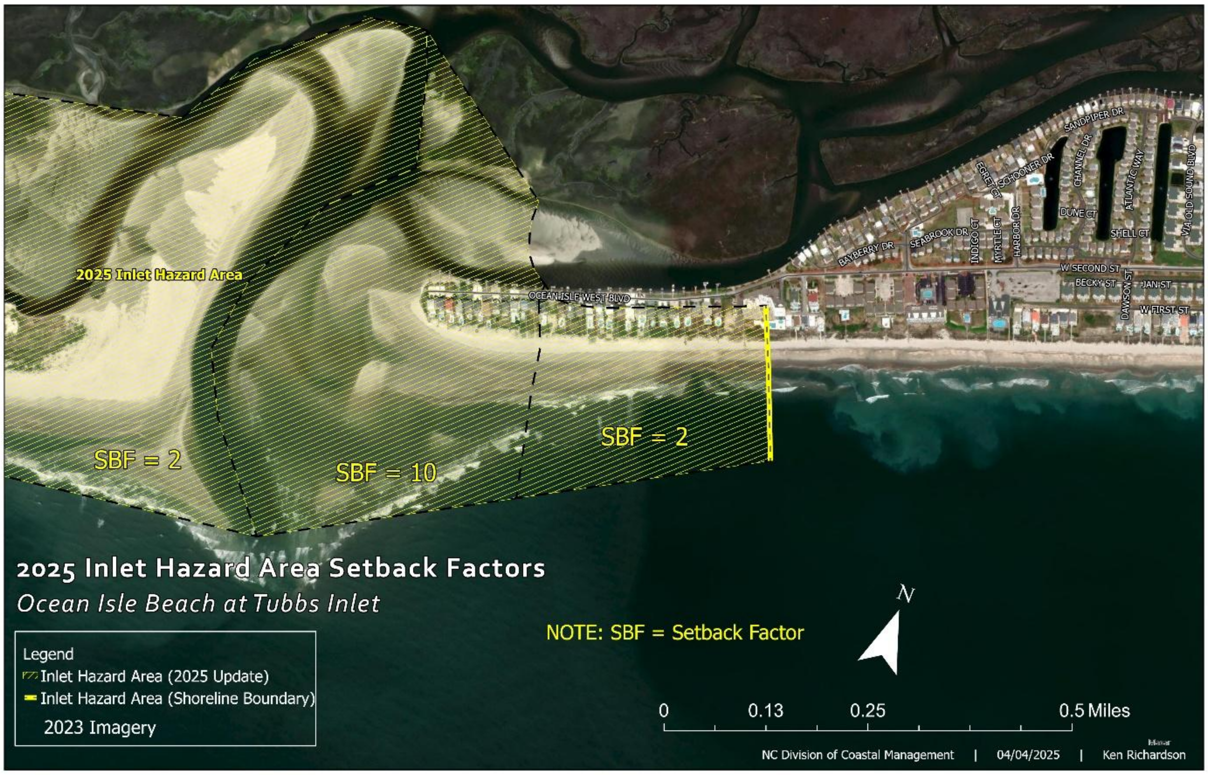

Figure 16. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

For the same area within the 2025 updated IHA, **Table 2** compares the resulting erosion setback factors with those from previous oceanfront erosion rates and setback factors studies. Although earlier studies have measured various degrees of erosion near the inlet, the use of ocean-perpendicular transects ending at the inlet, combined with the application of existing Rule 15A NCAC 07H.310, which requires using the adjacent Ocean Erodible Area (OEA), has affected the resulting setbacks. Historically, for the area where the setback factor is ten (SBF=10) (**Figure 16**), applying the setback factor from the adjacent OEA has consistently reduced the setback factor to two. While the setback factor is higher, it is reflective of inlet erosion rates, and without the use of sandbags it is expected that the erosion would have a greater impact on structures along this section of shoreline.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 10	10	2	2	2	2	2	2	2
SBF = 2	2	2	2	2	2	2	2	2

Table 2. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.3 Shallotte Inlet: Ocean Isle

The Ocean Isle side of Shallotte Inlet has faced persistent erosion, leading to the loss of property, homes, and infrastructure. Before the completion of the terminal groin in 2022, sandbag structures and beach nourishment efforts helped slow erosion at and near the island's east end, though they couldn't fully stop it. If the groin performs as intended, it is expected to significantly reduce erosion rates on its west side. However, continued erosion is anticipated to persist along the east side, near the inlet. More time and data area needed to measure long-term performance.

The first large-scale beach nourishment, involving over 300,000 cubic yards of sand, took place in 2001 as part of the Federal Coastal Storm Damage Reduction (CSDR) project, and has been followed by routine maintenance efforts in 2006, 2009, 2014, 2018, 2021, and 2022. While portions of sediment from some of these projects have been allocated to the shoreline within the west side of the Inlet Hazard Area (IHA), the area closest to the inlet itself has not received direct sediment replenishment.

In the 2025 updated Inlet Hazard Area, covering approximately 1 mile (5,578 feet) from transect-296 to Shallotte Inlet, the analysis included twenty-five shorelines from 1970 to 2022 (**Figure 17**). According to the measurements from this study, the average shoreline change rate within the IHA is -9.9 feet per year (erosion), ranging between -2 and -20 feet per year (**Figures 18 & 19**). As a result, erosion setback factors range from 2 starting at transect 296 and gradually increasing to 17.5 approaching the inlet (**Figure 20**).

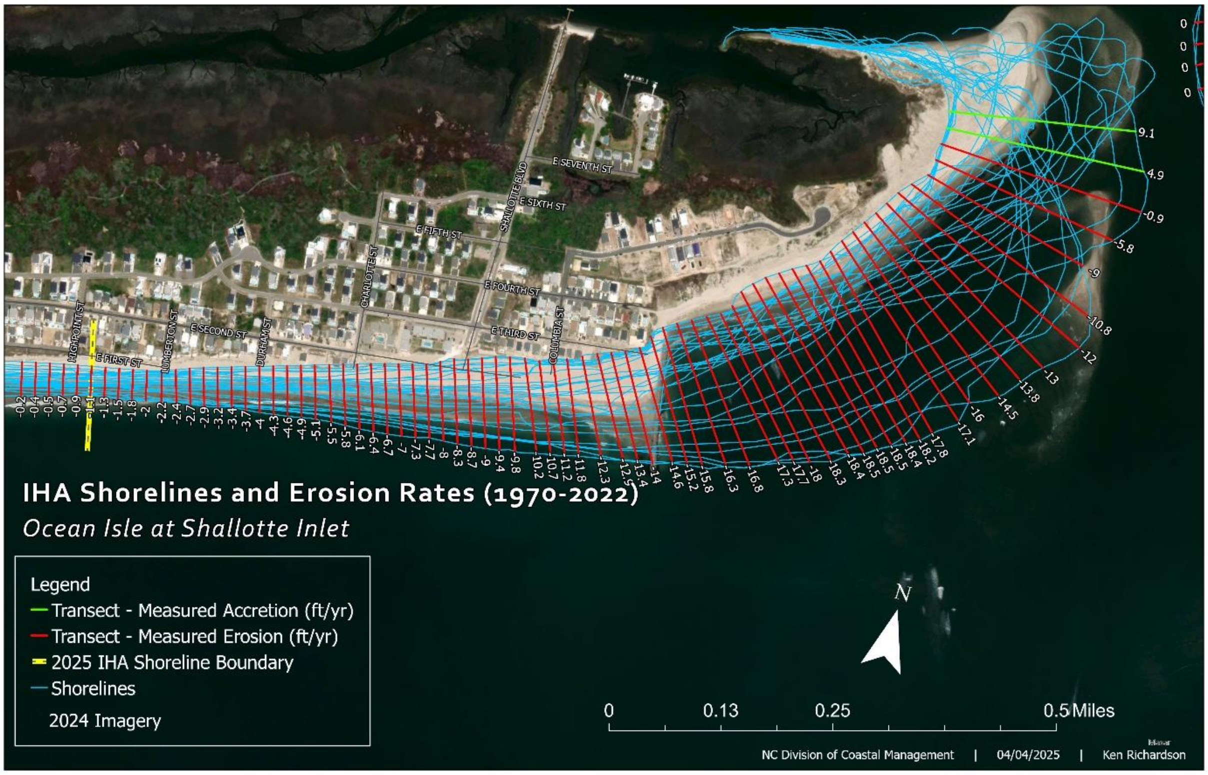

__Figure 17.__ This map illustrates shorelines and erosion rates measured at each transect for the area approaching Shallotte Inlet from the 2025 updated IHA alongshore boundary (yellow transect).

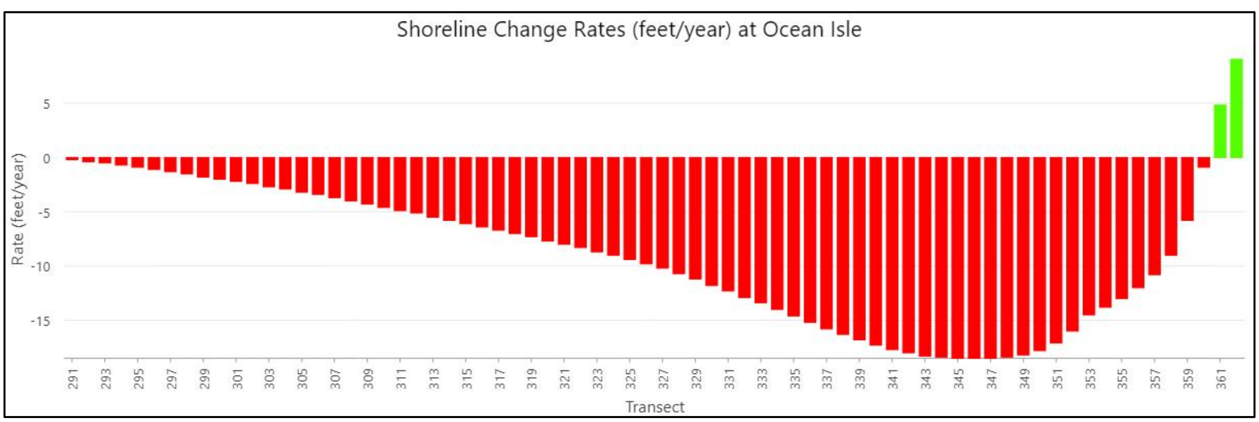

Figure 18. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

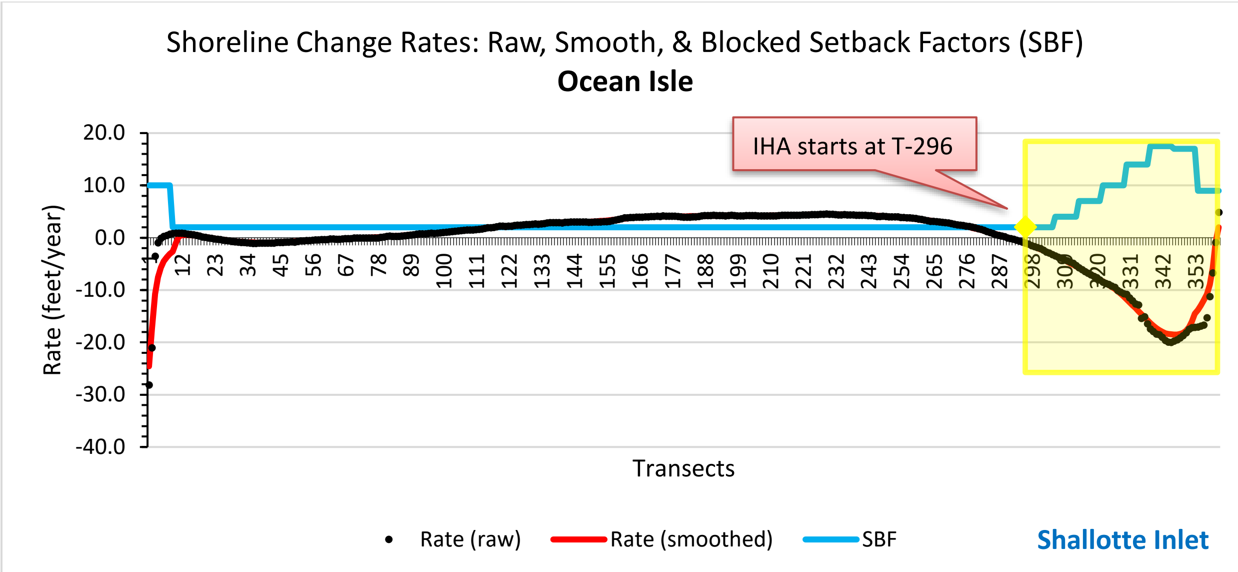

Figure 19. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

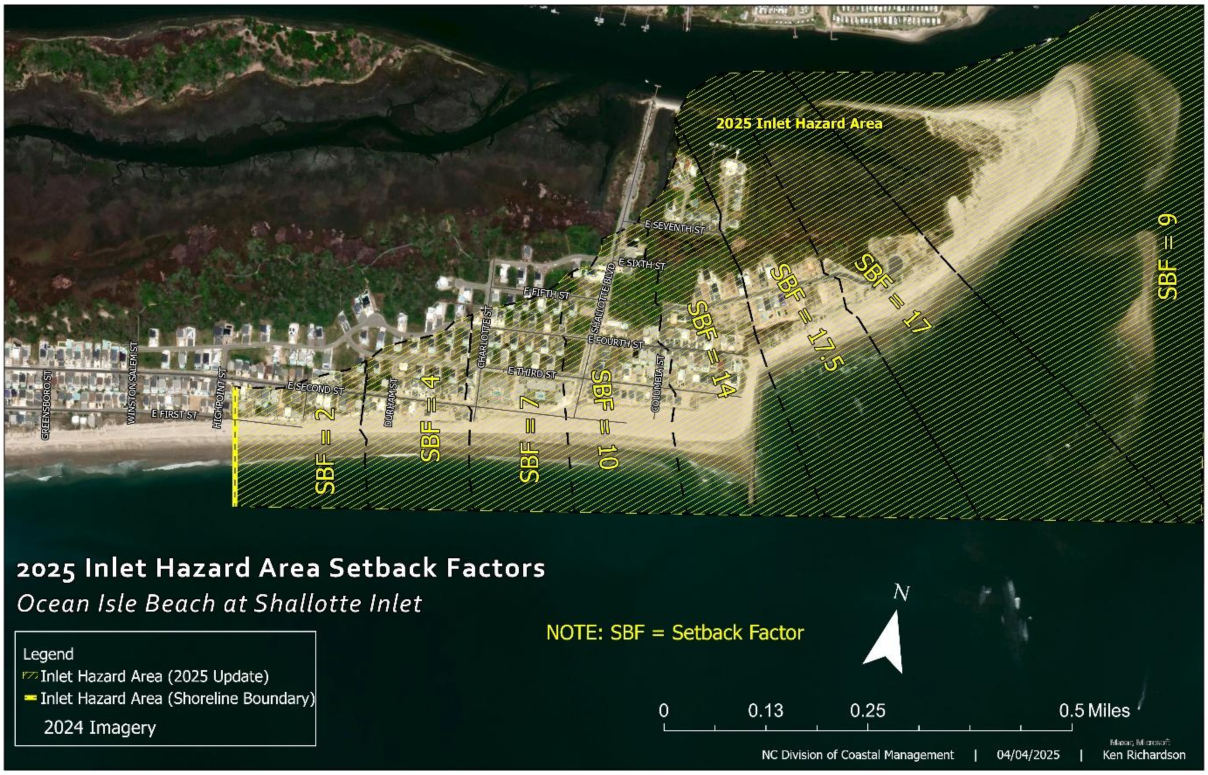

Figure 20. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

For the same area within the 2025 updated IHA, **Table 3** compares the resulting erosion setback factors with those from previous oceanfront erosion rates and setback factors studies. While earlier studies have measured various degrees of erosion near the inlet, the use of ocean-perpendicular transects ending at the inlet, combined with the application of existing Rule 15A NCAC 07H.310, which requires using the adjacent Ocean Erodible Area (OEA), has affected resulting setbacks by lowering them. Historically, for the area where the setback factor is ten (SBF=10) (**Figure 20**), it is approximately where the OEA meets the existing IHA, and the OEA's setback factor is applied throughout the IHA; which can be seen in the table. While setback factors are higher at the inlet, they are reflective of inlet erosion rates for the period of study. As mentioned, it is anticipated that in time, the terminal groin will likely reduce rates on its west side where setbacks range between 2 and 14; however, the pattern of erosion is expected to continue at the structure's east side facing the inlet.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2 to 4	2	2	2	2 to 3	2
SBF = 4	4	2 to 4	4	2	2	2	3	2
SBF = 7	7	4	4 to 6.5	2 to 4.5	2	2	3	2
SBF = 10	10	5	6.5	4.5	2	2	3	2
SBF = 14	14	5	6.5	4.5	2	2	3	2
SBF = 17.5	17.5	5	6.5	4.5	2	2	3	2
SBF = 17	17	5	6.5	4.5	2	2	3	2
SBF = 9	9	5	6.5	4.5	2	2	3	2

Table 3. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.4 Shallotte Inlet: Holden Beach

While several small-scale beach nourishment projects occurred between 1971 and 1998, the first large-scale beach nourishment, involving the placement of over 300,000 cubic yards of sand, was completed in 2002 as part of the Federal Coastal Storm Damage Reduction (CSDR) project, and has been followed by routine maintenance efforts in 2003, 2004, 2006, 2008, 2009, 2011, 2014, 2015, 2017, 2019, 2020 and 2022[2].

Although Shallotte Inlet is classified as an oscillating inlet, its erosion-accretion cycle is among the longest of North Carolina's inlets. Since the 1970s, this cycle has trended towards accretion, eliminating the need for nourishment along the west end of Holden Beach and within the area covered by the 2025 IHA. However, it’s essential to understand that this extended period of accretion, while beneficial to current oceanfront structures, is unlikely to be permanent. Broader

[2] American Shore and Beach Preservation Association’s Beach Nourishment Database, 2024; Elko, N., Briggs, T.R., Benedet, L., Robertson, W., Thomson, G., Webb, B.M., Garvey, K., 2021. A Century of U.S. Beach Nourishment. Ocean & Coastal Management, 199(2021) 105406, ISSN 0964-5691.

erosion trends will eventually affect the shoreline position across much of the area inside the 2025 IHA.

In the 2025 updated Inlet Hazard Area, covering approximately 2.3 miles (11,894 feet) from transect-144 to Shallotte Inlet, the analysis included seventeen shorelines from 1970 to 2022 (**Figure 21**). According to the measurements from this study, the average shoreline change rate within the IHA is 5.6 feet per year (accretion); however, the analysis did show erosion rates approaching -20 feet per year adjacent to the inlet (**Figures 22 & 23**). As a result, erosion setback factors range from 2 starting at transect 144, then rapidly increasing to 9.5 between transects 9 and 17, and 16 between transects 1 and 9 adjacent to the inlet (**Figure 24**).

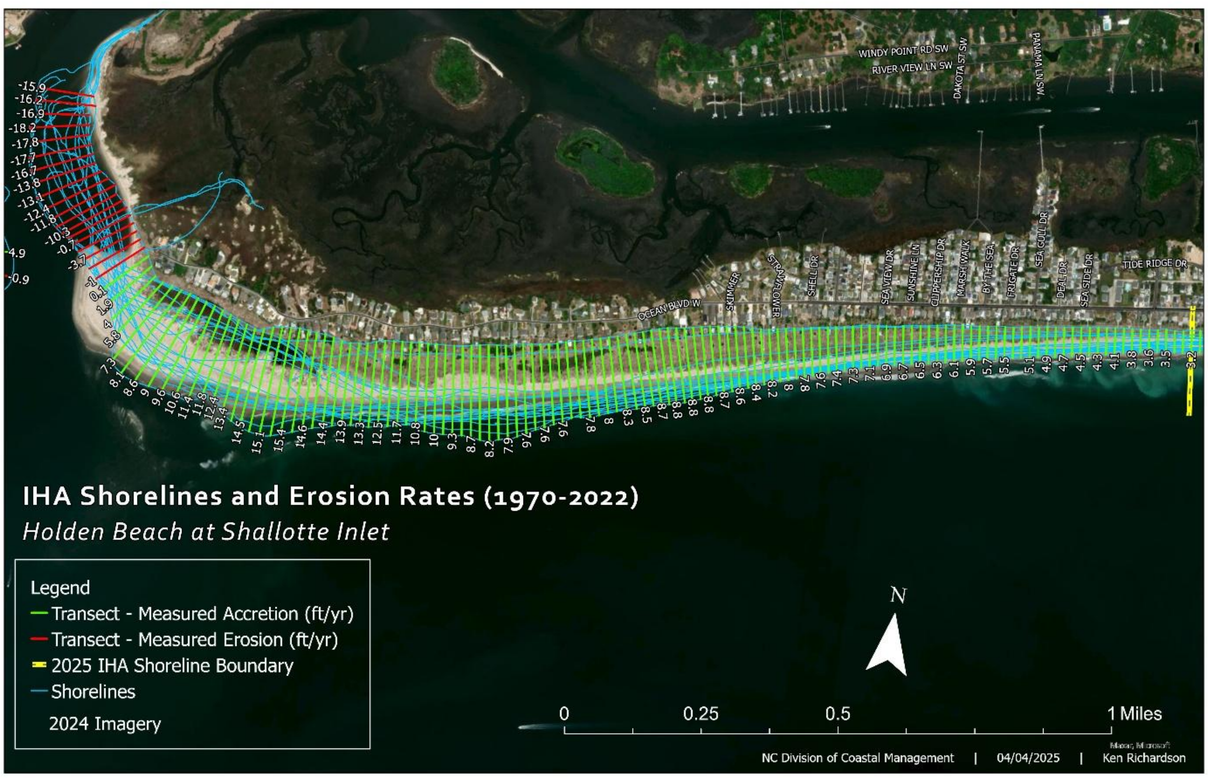

Figure 21. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Shallotte Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

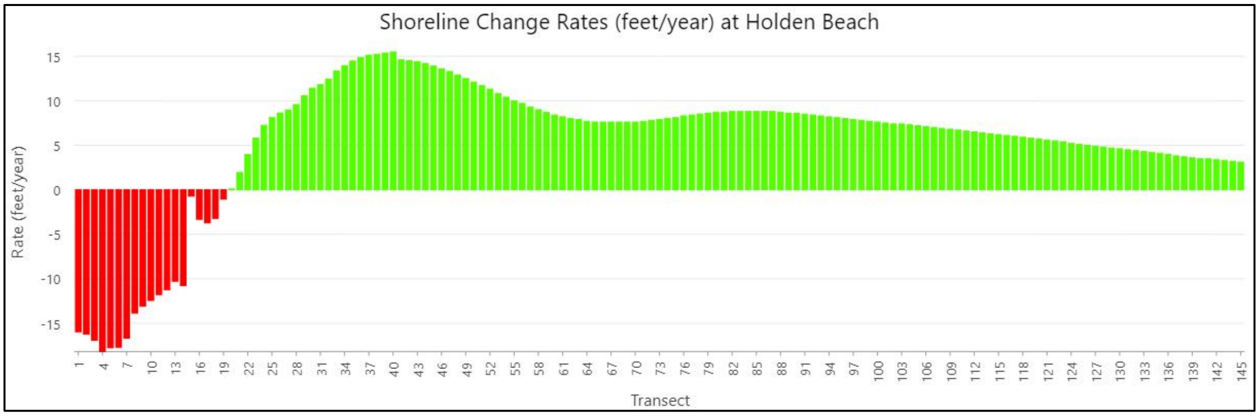

Figure 22. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

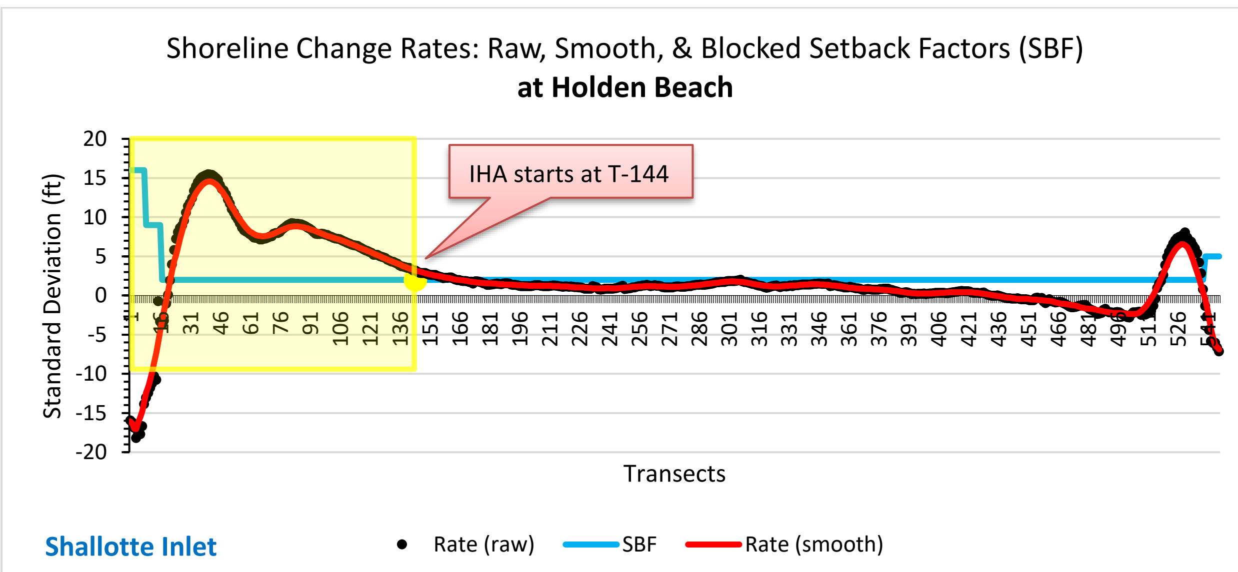

Figure 23. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 24. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

For the same area within the 2025 updated IHA, **Table 4** compares the resulting erosion setback factors with those from previous oceanfront erosion rates and setback factors studies. Because earlier studies used ocean-perpendicular transects which stopped short of the inlet, the areas where high erosion rates were measured between transects 1 and 19 were not included in previous oceanfront updates. Nevertheless, this area would have assumed its adjacent OEA's erosion setback factor which has been two based on erosion rate measurements and standards specified in current Rule 15A NCAC 07H.310. While setback factors are higher at the inlet, they are reflective of inlet erosion rates for the period of study.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2
SBF = 9	9	2	2	2	2	2	2	2
SBF = 16	16	2	2	2	2	2	2	2

Table 4. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.5 Lockwood Folly Inlet: Holden Beach

As mentioned in the previous section, several small-scale beach nourishment projects occurred along the ocean shoreline between 1971 and 1998, but the first large-scale beach nourishment, involving the placement of over 300,000 cubic yards of sand, was completed in 2002 as part of the Federal Coastal Storm Damage Reduction (CSDR) project, and has been followed by routine maintenance efforts in 2003, 2004, 2006, 2008, 2009, 2011, 2014, 2015, 2017, 2019, 2020 and 2022. However, the initial project did not extend throughout the 2025 IHA; however, it did taper off near the alongshore IHA boundary approximately between transects 478 and 487.

In the updated 2025 Hazard Area (IHA), which spans approximately 1.2 miles (6,239 feet) from transect 478 to Lockwood Folly Inlet, the analysis examined eighteen shorelines from 1970 to 2021 (**Figure 25**). The study found an average shoreline change rate of less than -2 feet per year across the IHA. However, localized erosion rates were observed, approaching -3 feet per year along the ocean side IHA boundary and as much as -7 feet per year within the inlet. A transitional area of accretion between the oceanfront and the inlet helped reduce the overall average rate of change (**Figure 26**). As a result, erosion setback factors range from 2 throughout most of the IHA until increasing to 5 along the shoreline adjacent to the inlet channel between transect 540 and the Intracoastal Waterway (**Figure 27**).

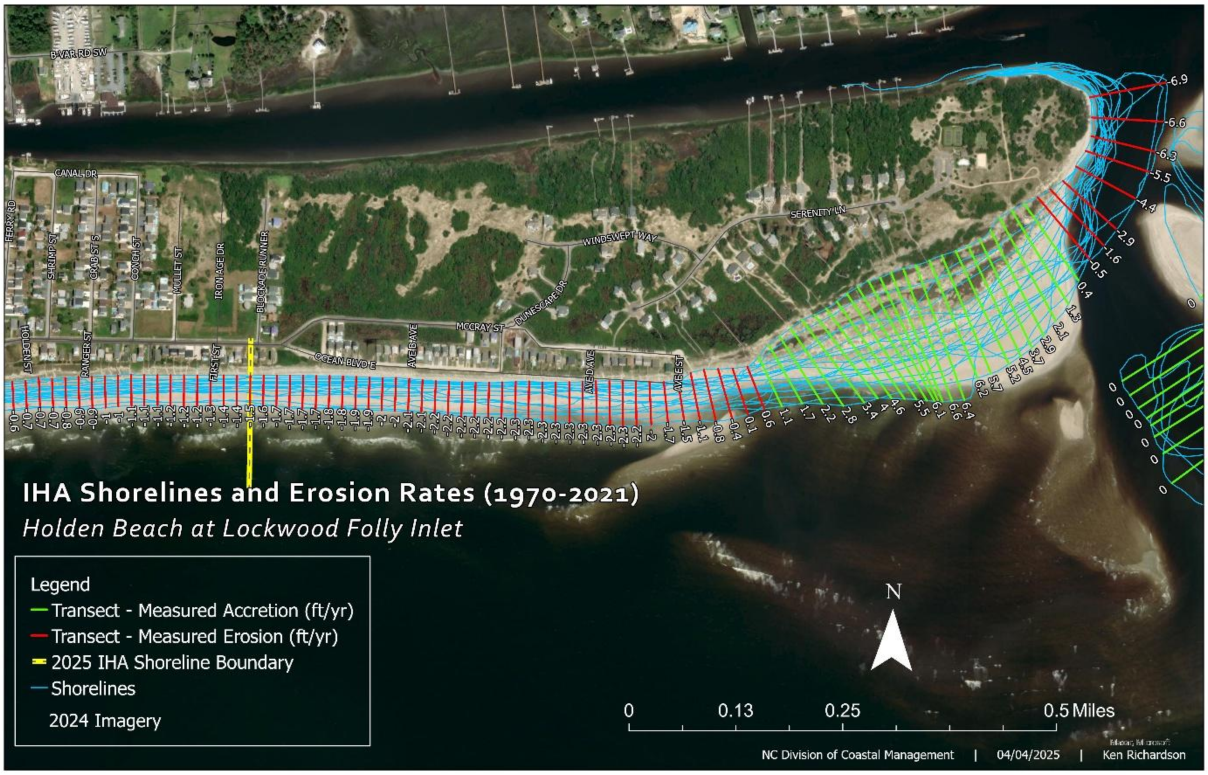

Figure 25. This map illustrates shorelines and erosion rates measured at each transect for the area approaching Lockwood Folly Inlet from the 2025 updated IHA alongshore boundary (yellow transect).

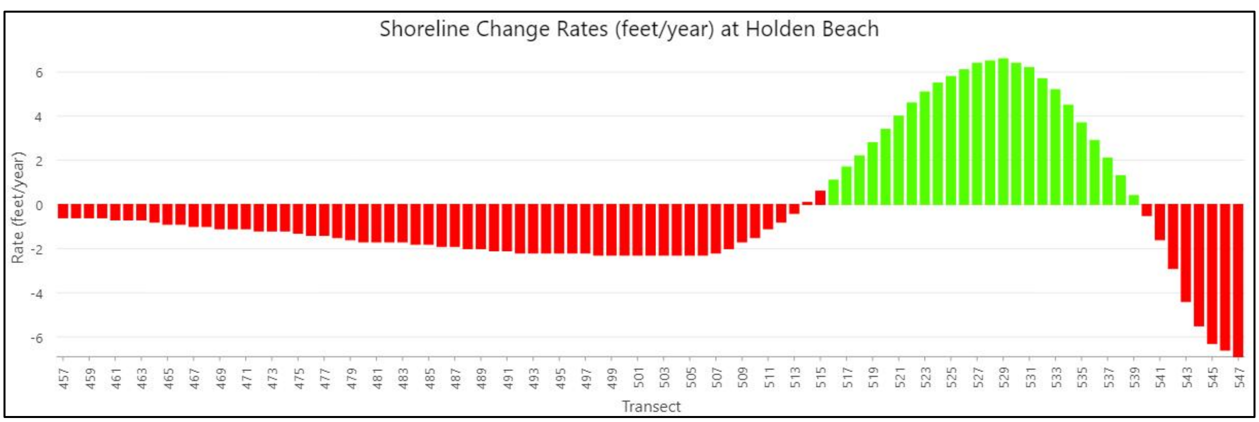

Figure 26. This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.

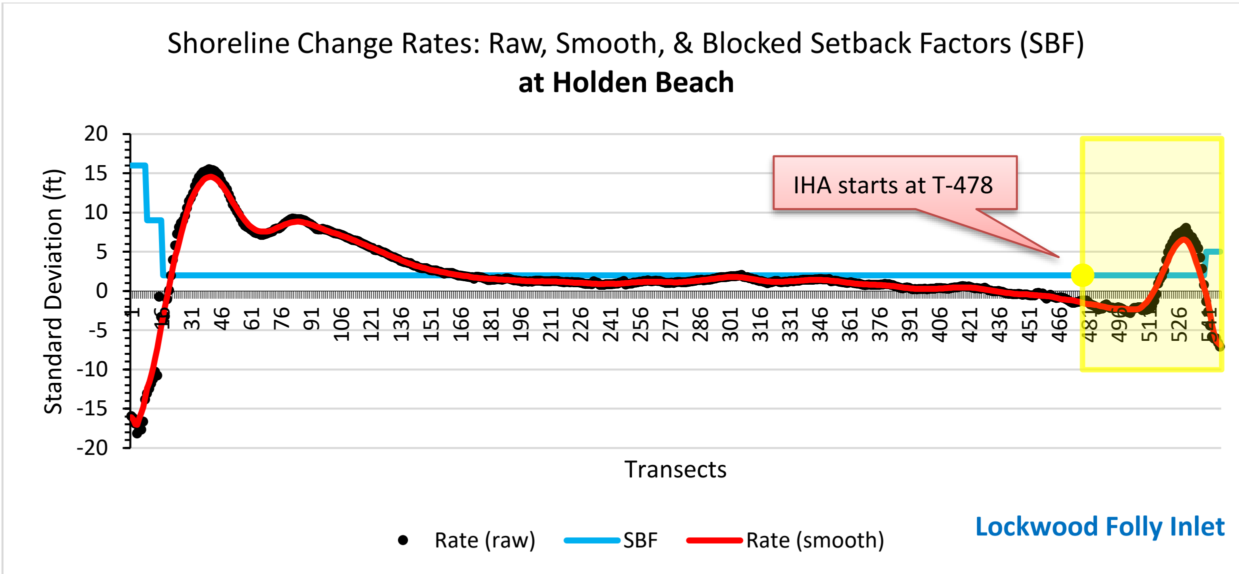

***Figure 27**. This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 28. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

In the same area within the 2025 updated Inlet Hazard Area (IHA), **Table 5** compares the erosion setback factors derived from this analysis with those from previous oceanfront erosion rate and setback factor studies. Earlier studies, which used ocean-perpendicular transects that terminated before reaching the inlet, excluded areas with high erosion rates measured between transect 540 and the Intracoastal Waterway. Additionally, those earlier studies analyzed a longer period and applied the end-point method, resulting in higher erosion rate estimates between 1983 and 2020. This methodological difference complicates direct comparisons with the current analysis. However, this area would have adopted the erosion setback factor of its adjacent Ocean Erodible Area (OEA), based on standards outlined in current Rule 15A NCAC 07H.310.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	4 to 6	3.5 to 7	6.5 to 7.5	4	3	4	2
SBF = 5	5	6	7	7.5	4	3	4	2

Table 5. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.6 Lockwood Folly: Oak Island

Oak Island installed its first large-scale beach nourishment project in 2001 where the western end of the project tapered off in the area inside the 2025 IHA boundary approximately between transects 61 and 81. In 2019 and 2022, beneficial use of dredged material from the inlet, AIWW crossing and eastern channel was completed by the USACE's navigation initiatives resulting in material being placed along the western end of Oak Island stopping short of the inlet at approximately transect-20.

In the updated 2025 Hazard Area (IHA), which spans approximately 1.4 miles (7,500 feet) from transect 81 to Lockwood Folly Inlet, the analysis examined twenty-seven shorelines from 1970 to 2021 (**Figure 29**). The study found an average shoreline change rate equal to 3.5 feet per year (accretion) across the IHA (**Figure 30**). However, localized erosion rates less than -2 feet per year were observed between transects 34 and 55 (**Figures 30 & 31**). As a result, the erosion setback factor is 2 throughout the IHA (**Figure 32**).

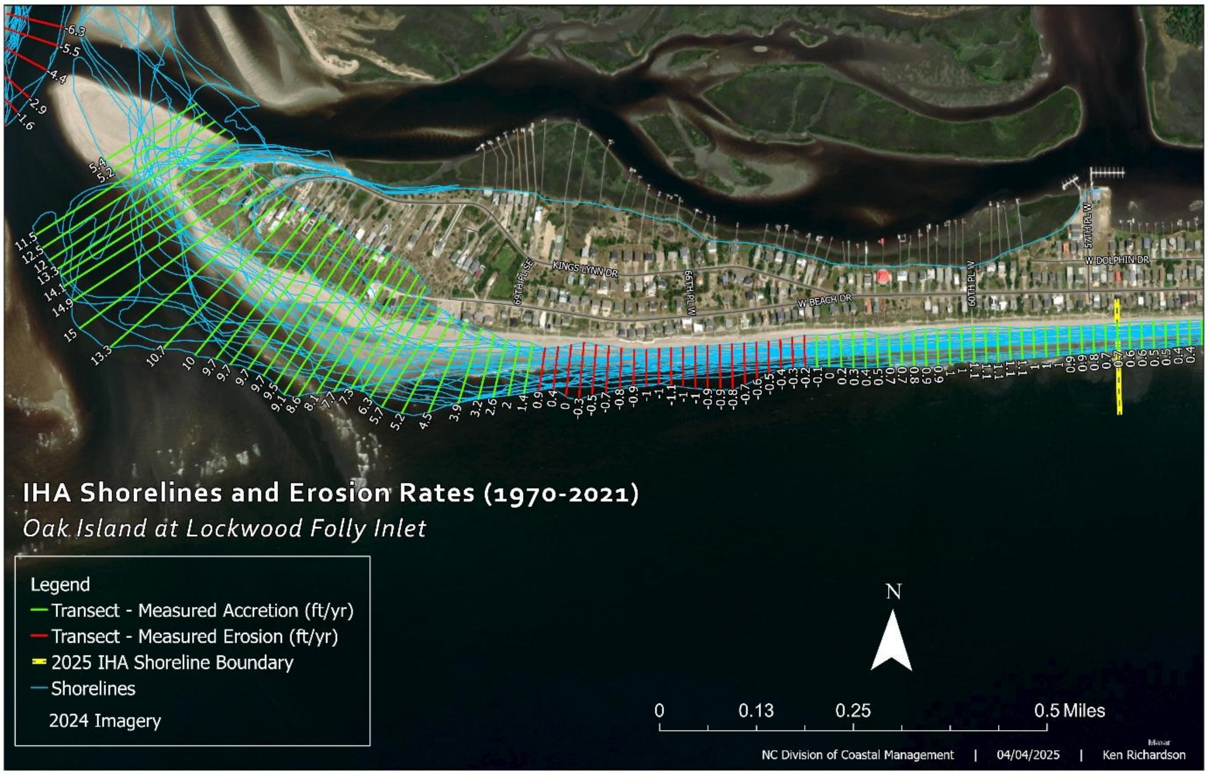

Figure 29. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Lockwood Folly Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

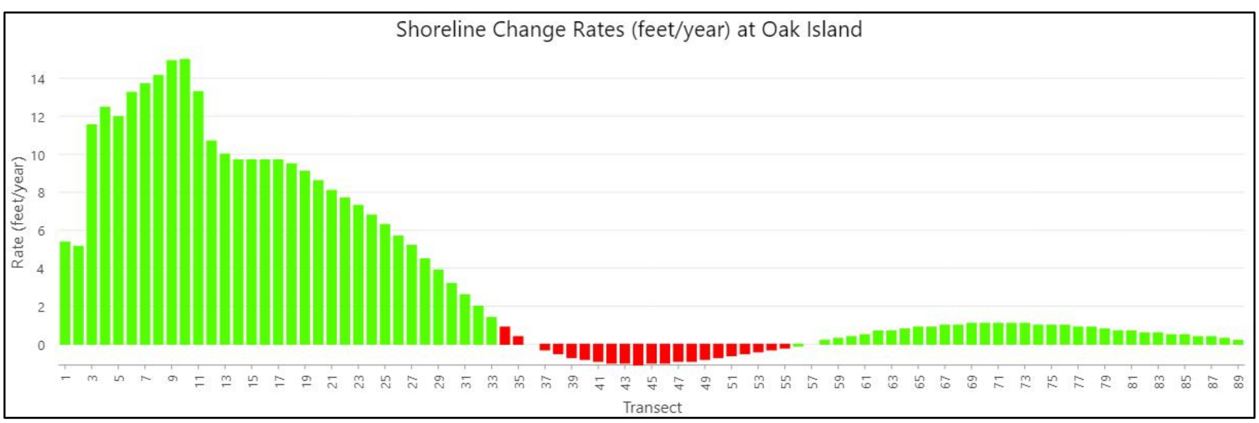

Figure 30. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

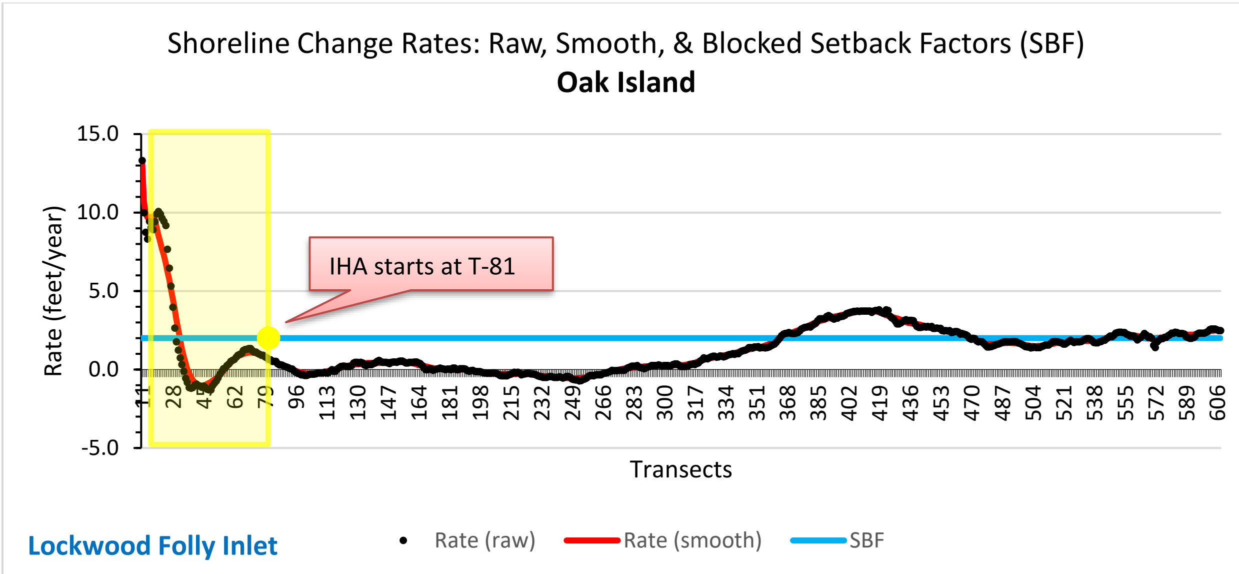

Figure 31*. This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 32. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

In the same area within the 2025 updated Inlet Hazard Area (IHA), **Table 6** compares the erosion setback factors derived from this analysis with those from previous oceanfront erosion rate and setback factor studies. While methodologies and periods of study differ, the erosion setback factors have generally remained consistent for the area inside the 2025 IHA boundary.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2 to 4	2

Table 6. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.7 Carolina Beach Inlet: Carolina Beach

Carolina Beach Inlet, opened in 1952 to serve private interests, has undergone numerous beach fill projects over the years. Between 1955 and 1998, these projects were relatively small in scale and associated with navigational channel maintenance. However, in 2001, the U.S. Army Corps of Engineers (USACE) completed the Town's first large-scale project under the Coastal Storm Damage Reduction (CSDR) program, now referred to as Coastal Storm Risk Management (CSRM). Since then, additional large-scale projects were completed in 2006-2007, 2009-2010, 2014, 2018, and 2022. Following the inlet's opening, chronic erosion affected both the Carolina Beach side and the Masonboro Island side. To address this, the U.S. Army Corps of Engineers (USACE) constructed an initial 1,100-foot rock revetment in 1970, followed by an additional 950-foot section in 1973, bringing the total length to 2,050 feet.

In the updated 2025 Hazard Area (IHA), which spans approximately 1.6 miles (8,500 feet) from transect 2119 to Carolina Beach Inlet, the analysis examined twenty shorelines from 1971 to 2021 (**Figure 33**). The study found an average shoreline change rate equal to 4.1 feet per year (accretion) across the IHA. However, localized erosion rates approaching -5 feet per year were observed within the inlet between transects 2210 and 2225 (**Figures 34 & 35**). As a result, the erosion setback factor is 2 throughout the IHA (**Figure 36**).

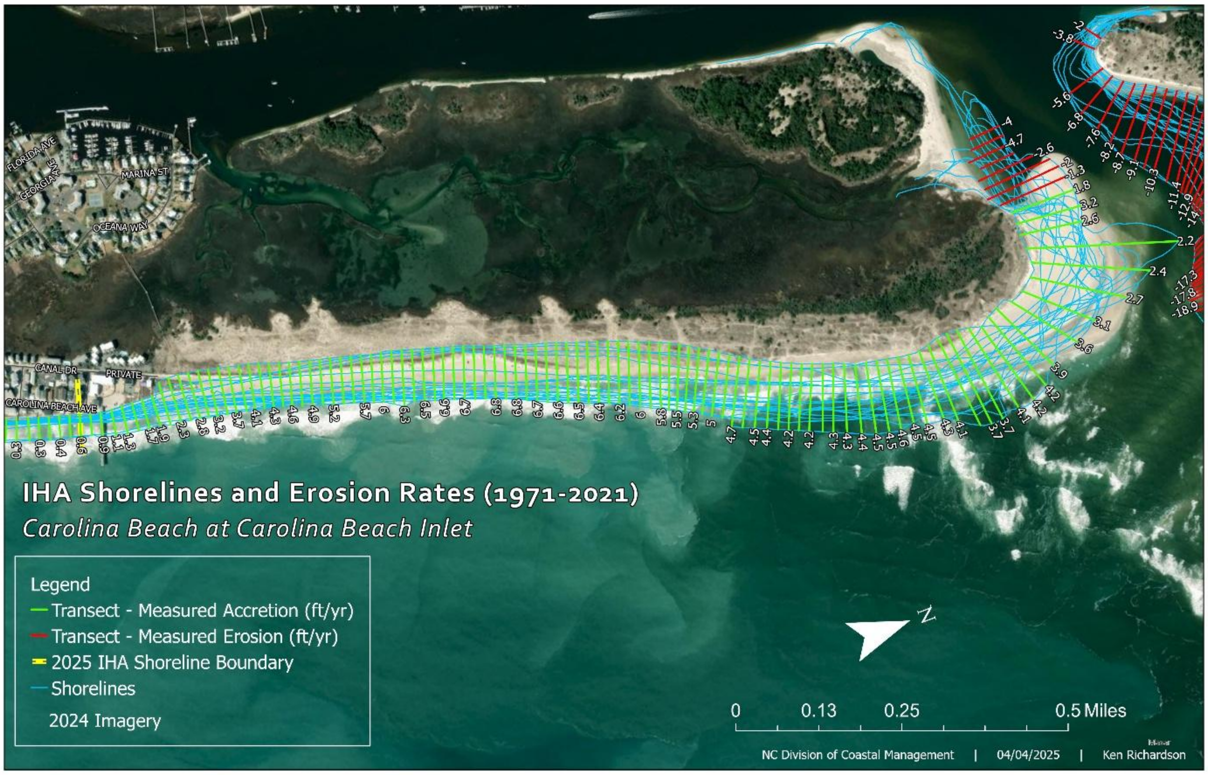

Figure 33. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Carolina Beach Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

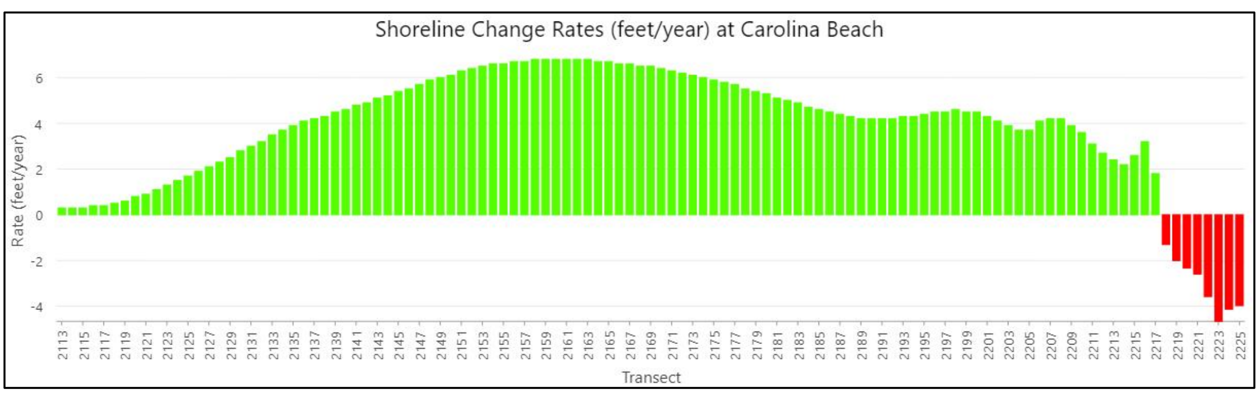

Figure 34. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

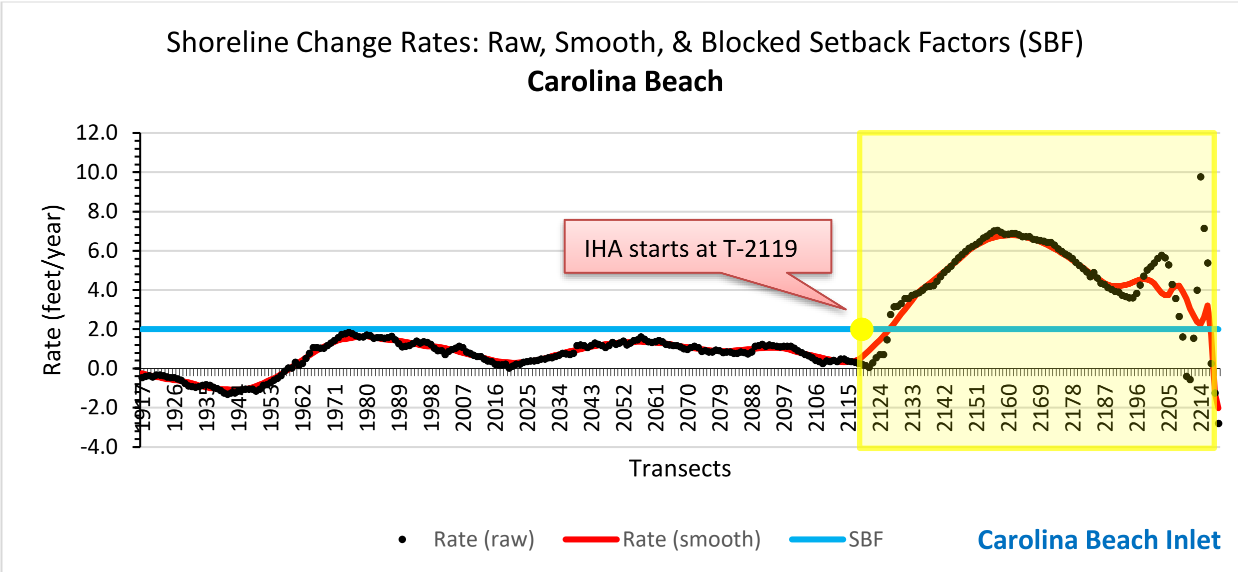

Figure 35. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 36. This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.

In the same area within the 2025 updated Inlet Hazard Area (IHA), **Table 7** compares the erosion setback factors derived from this analysis with those from previous oceanfront erosion rate and setback factor studies. It's important to note that at this location, the differences can be explained by the differences associated with calculation methodologies, periods of study, and pre-inlet conditions considered in earlier studies.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	3 to 7	3 to 6.5	2 to 8	2 to 5	7 to 10	5 to 10	2 to 10

Table 7. This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.

3.8 Carolina Beach & Masonboro Inlets: Masonboro Island

The updated 2025 Hazard Area (IHA) spans the entirety of Masonboro Island (8 miles) given the influences of Carolina Beach Inlet and navigational jetties at Masonboro Inlet on the island's north end. The study found an average shoreline change rate equal to -6.8 feet per year (erosion) across the IHA. However, localized results varied significantly ranging between 13.5 (accretion) and -22.5 (erosion) feet per year (**Figure 45**). Measured accretion adjacent to the Masonboro Inlet south-jetty is a result of construction of the south jetty in 1980 trapping sand on the northern oceanfront of Masonboro Island, reversing the rapid erosion that followed construction of the north jetty. Within the next decade, the fillet created south of the new jetty accreted over 420 feet and eventually stabilized. The fillet has stabilized at least 3000 feet of Masonboro Island shoreline immediately south of the jetty. Erosion setback factors range from 2 on the island's north end and increase moving south up to 18 at Carolina Beach Inlet (**Figure 46** to **Figure 49**).

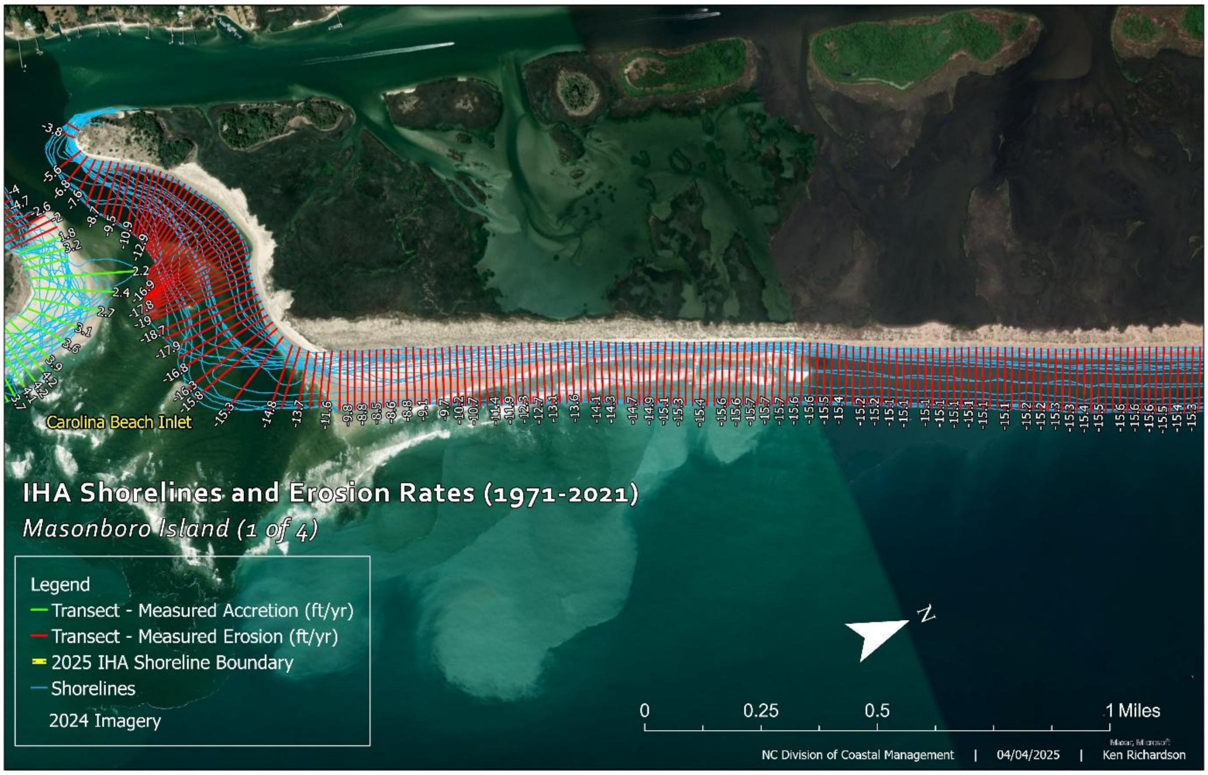

Figure 37. *This map illustrates shorelines and erosion rates measured at each transect.*

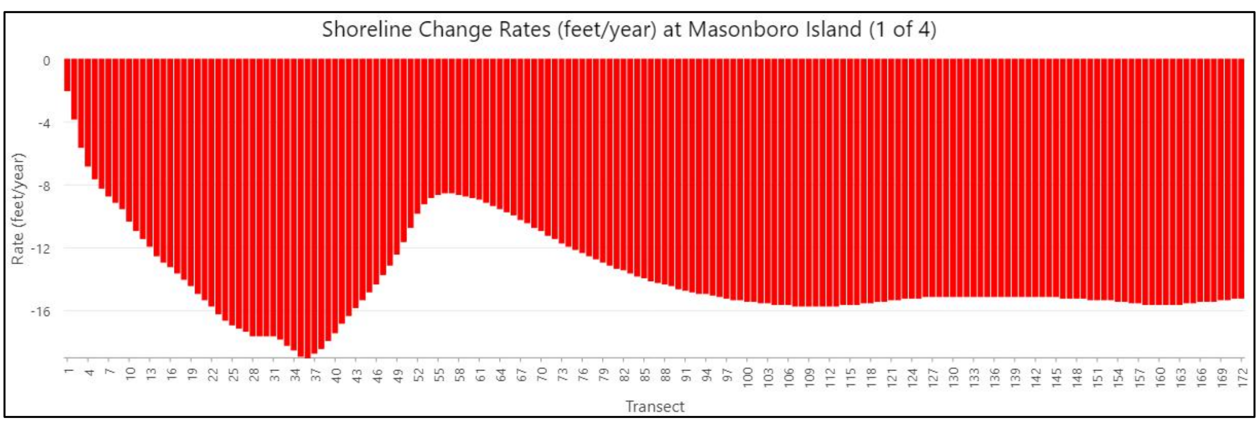

Figure 38. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

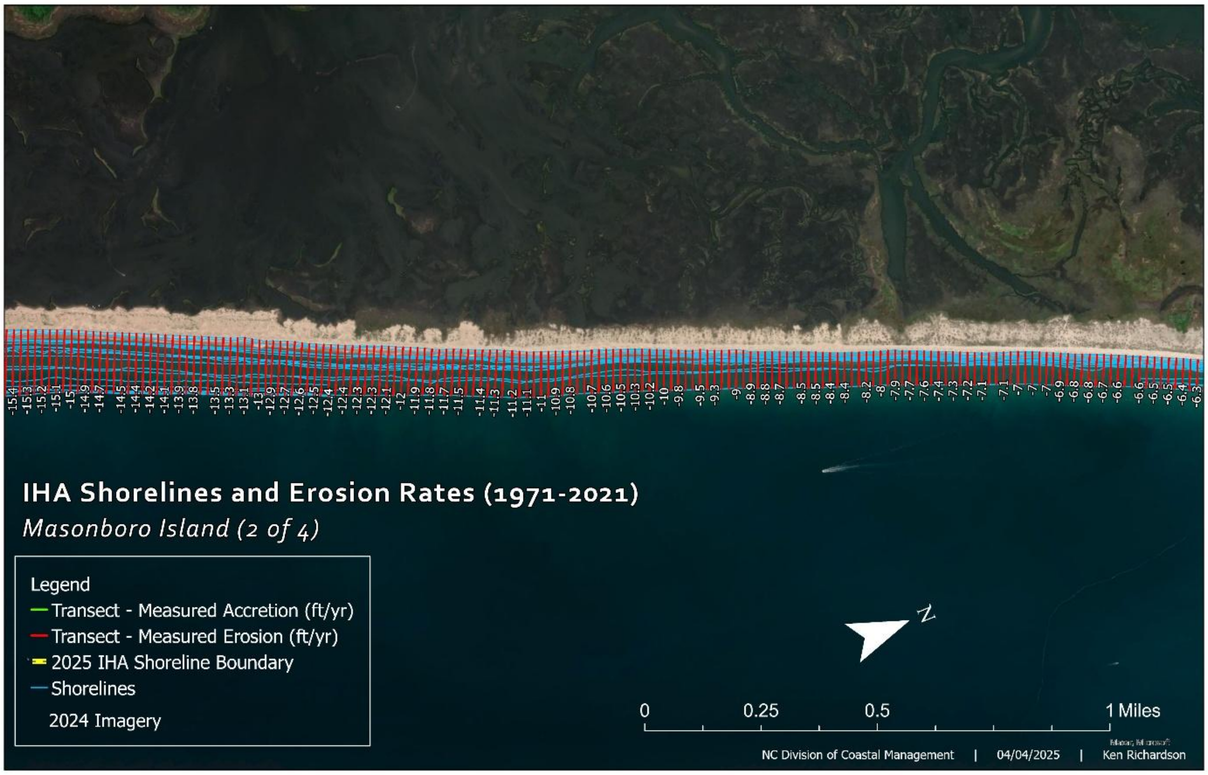

Figure 39. *This map illustrates shorelines and erosion rates measured at each transect.*

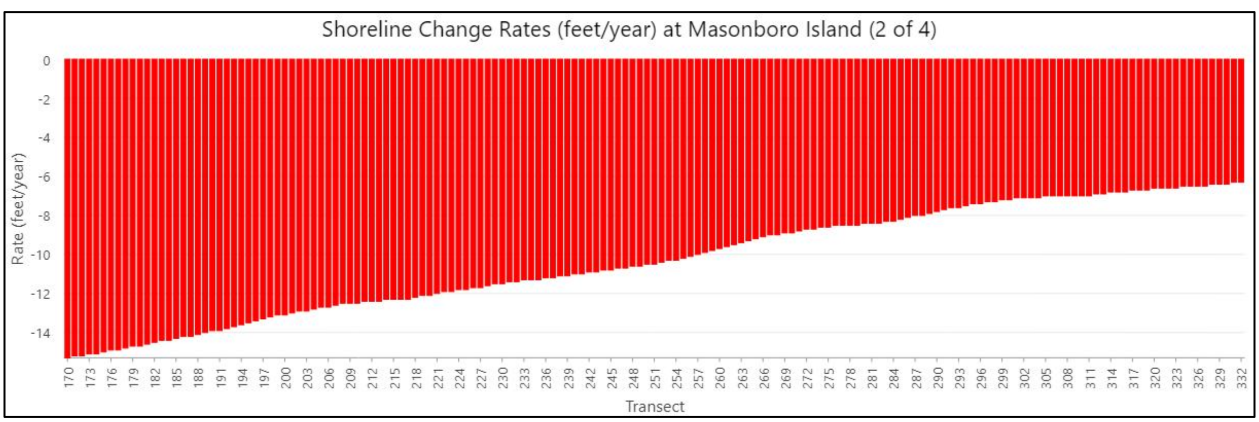

Figure 40. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

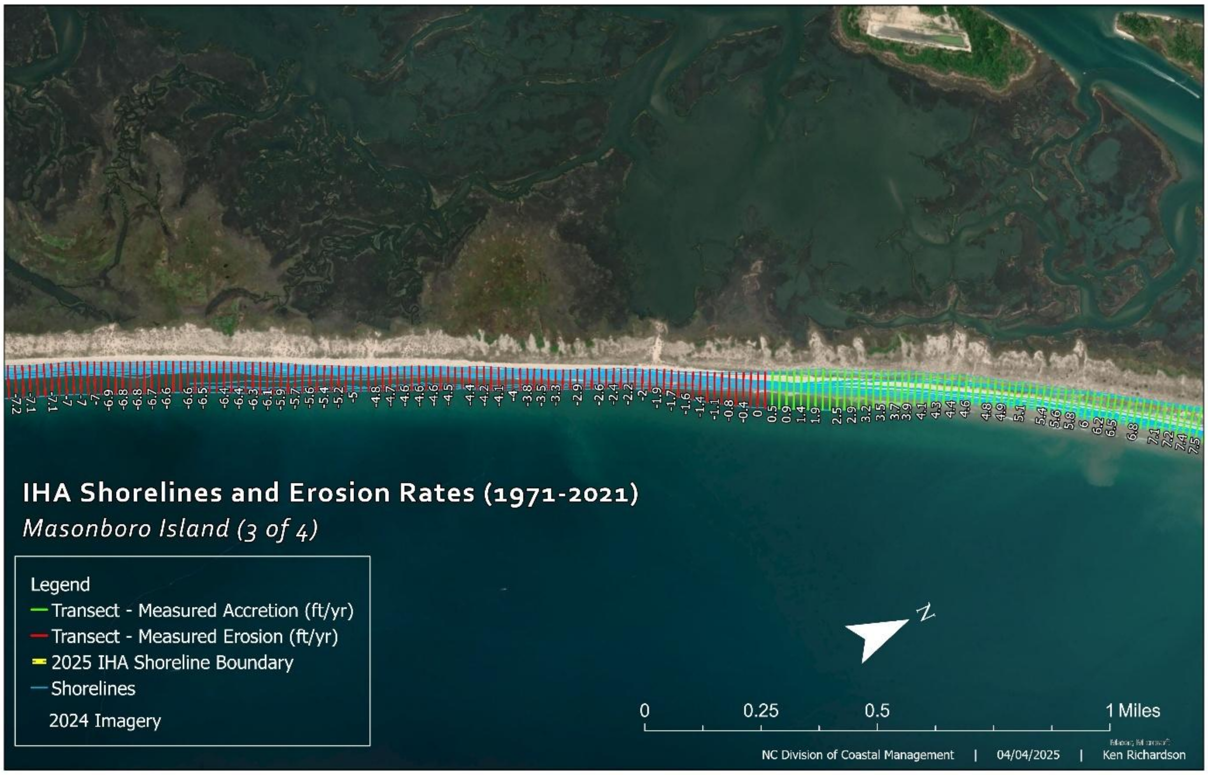

Figure 41. *This map illustrates shorelines and erosion rates measured at each transect.*

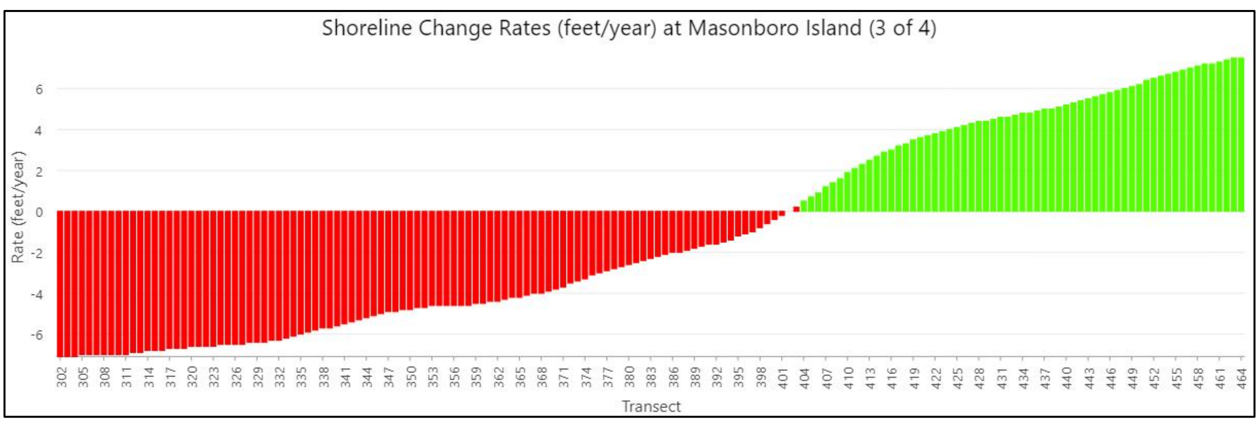

Figure 42. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

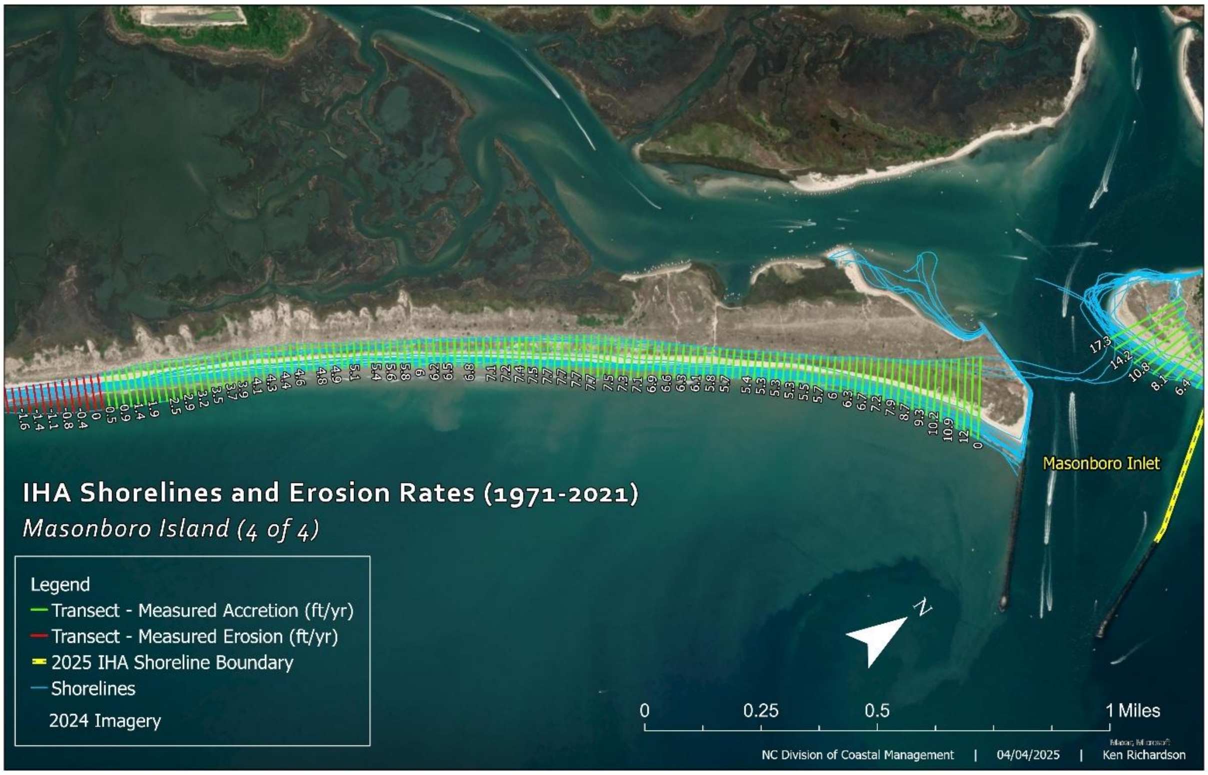

Figure 43. This map illustrates shorelines and erosion rates measured at each transect.

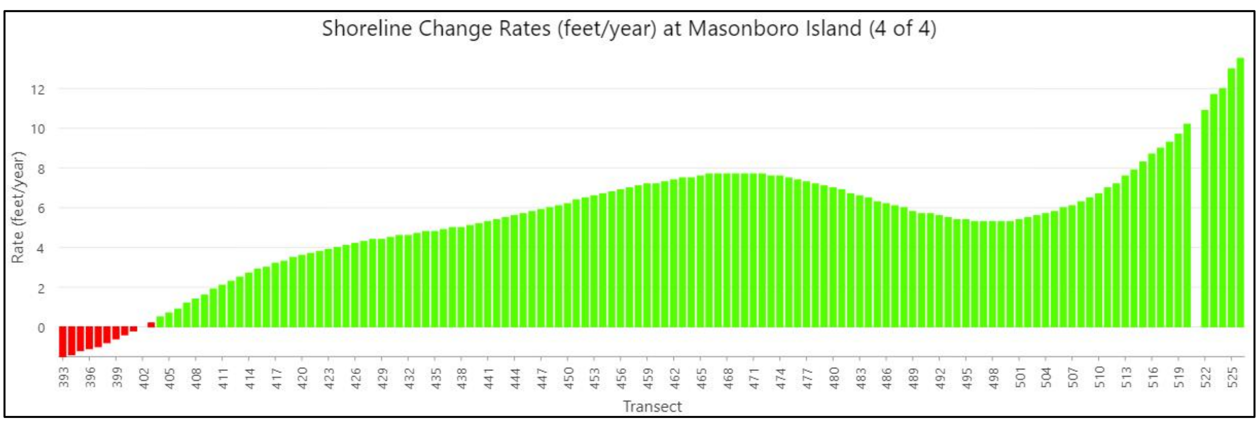

Figure 44. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

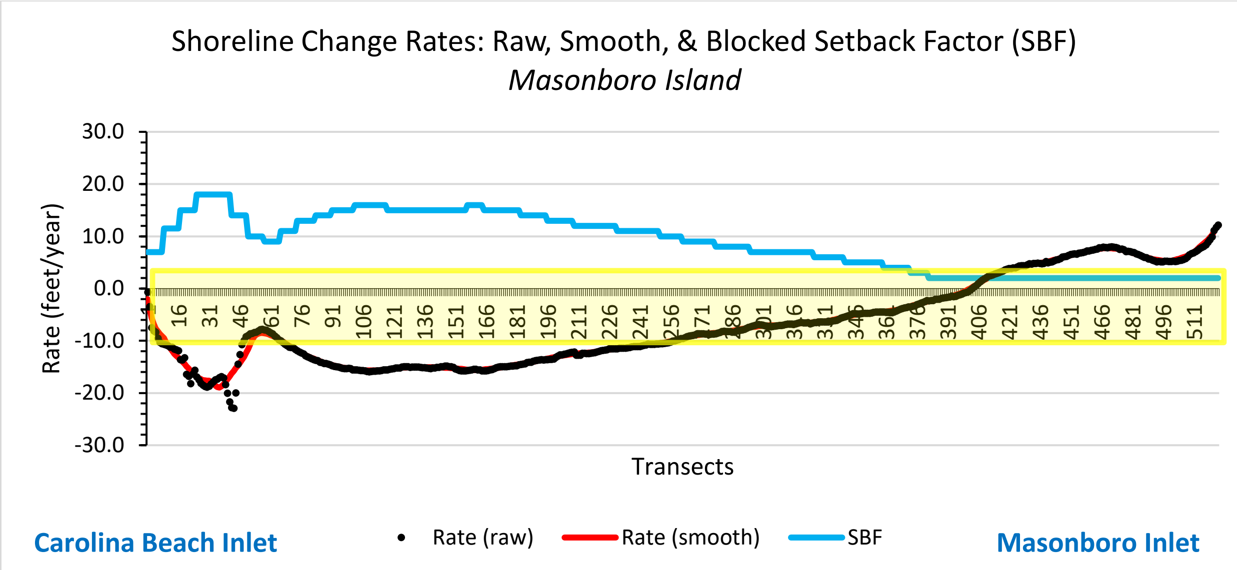

Figure 45. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 46. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Figure 47. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Figure 48. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Figure 49. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 8** compares erosion setback factors from this analysis to those from earlier oceanfront erosion rate and setback factor studies. Prior to the 2004 oceanfront study, the results were predominately influenced by the newly constructed south jetty at Masonboro Island, which shifted the area's dynamics from high erosion to accretion. Since 2004, studies have consistently shown accretion near the jetty, transitioning to erosion further south. Despite differing calculation methods and study periods, the findings in this study remain generally consistent with post-2004 studies.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2 to 18	2 to 29	2 to 12.5	2 to 12	4 to 7	5 to 7	4 to 12.5	2.4

Table 8. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.9 Masonboro Inlet: Wrightsville Beach

Wrightsville Beach holds NCs record for the most completed projects over the longest period. Small-scale efforts associated with navigational channel maintenance began as early as 1939. However, larger projects were not installed until 1965-1966, following Congressional authorization in 1962, and coinciding with the completion of the north jetty in 1966. However, NC considers the first large-scale project at Wrightsville Beach occurred in 1980-1981, and has been followed by routine maintenance since then, culminating in the most recent project completed in 2024. Collectively, the installation of the jetty and routine beach fill practices has been effective at stabilizing the inlet and resulting measured accretion.

In the updated 2025 Inlet Hazard Area (IHA), the boundary ends at the north jetty between transects 11 and 12. An analysis of nineteen shorelines from 1973 to 2020 (**Figure 50**) revealed an average shoreline change rate of 9.3 feet per year (accretion) across the IHA (**Figures 51 & 52**). Consequently, the erosion setback factor is set at 2 throughout the area (**Figure 53**).

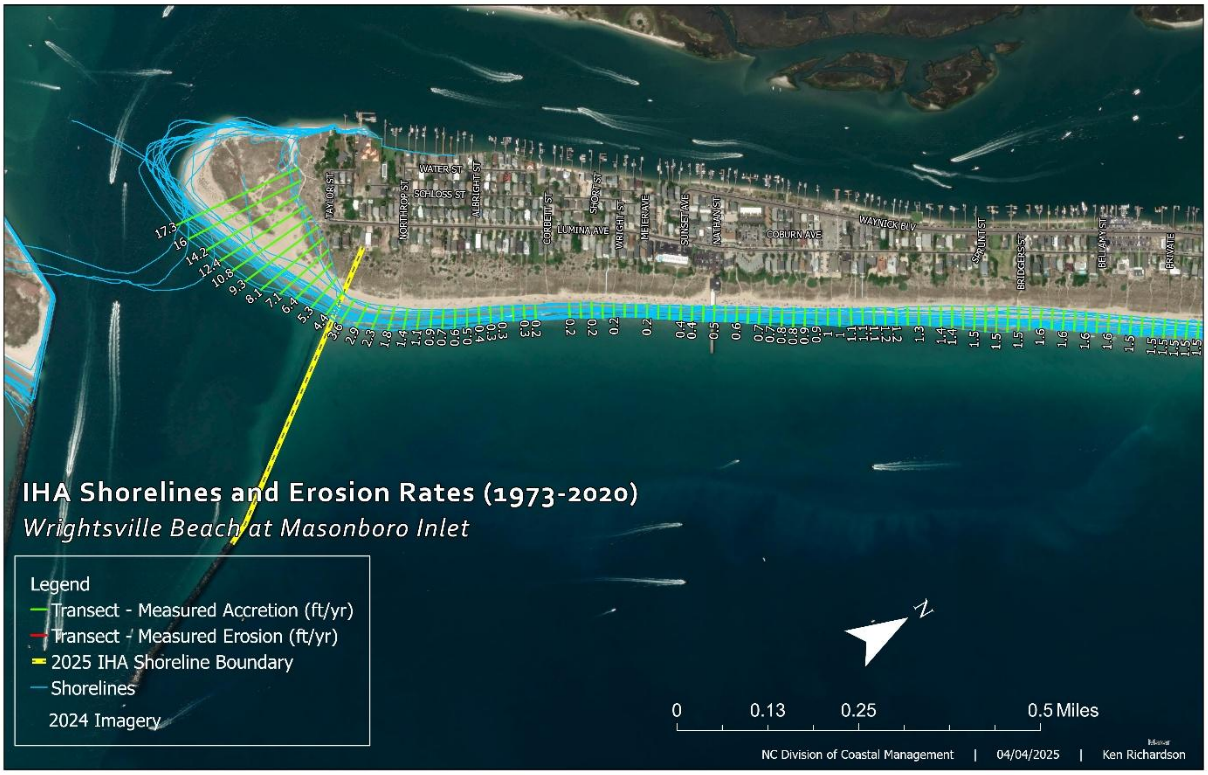

Figure 50. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Masonboro Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

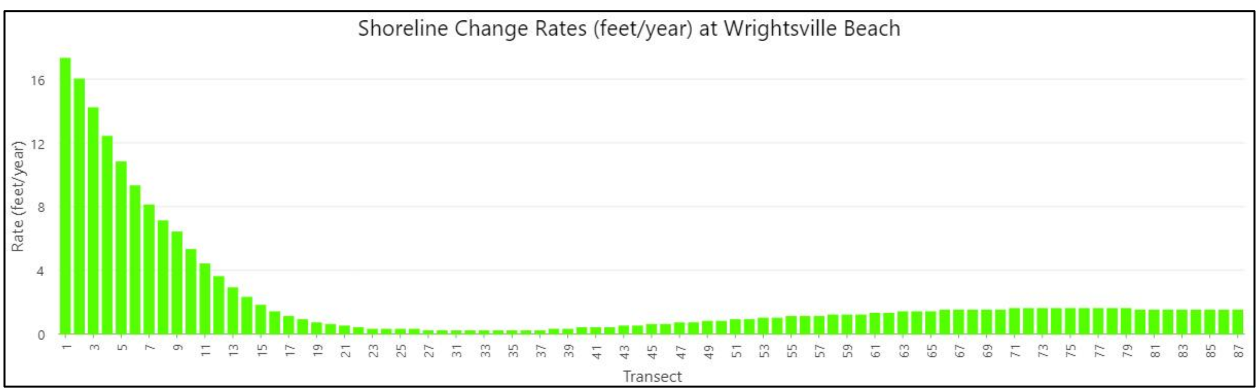

Figure 51. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

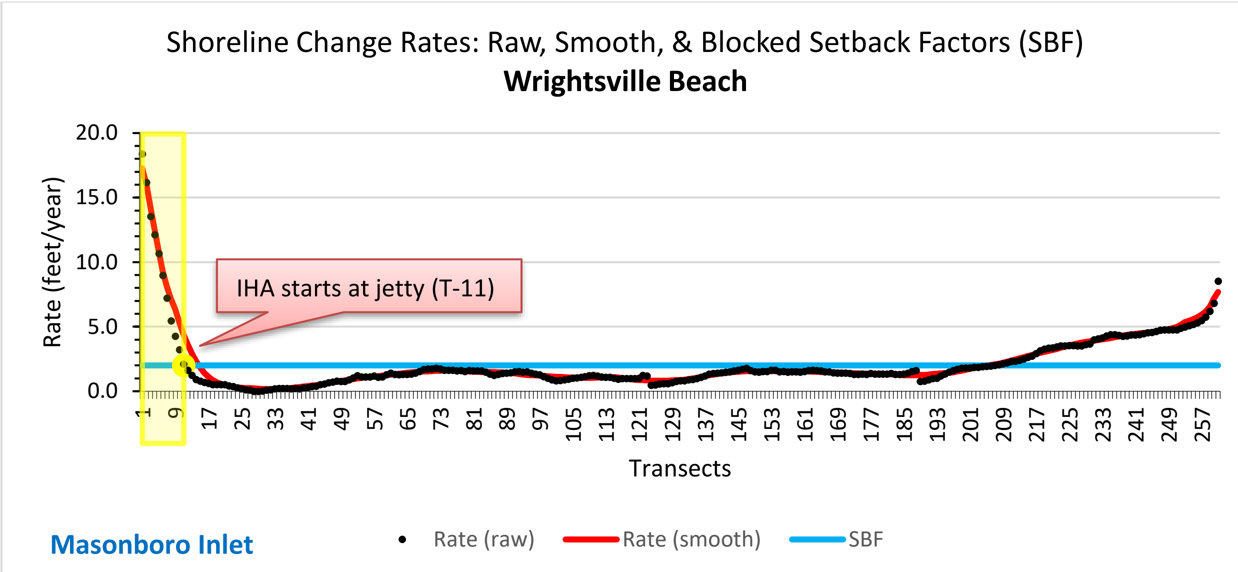

Figure 52. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 53. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 9** compares erosion setback factors from this analysis to those from earlier oceanfront erosion rate and setback factor studies. Despite differing calculation methods and study periods, the findings in this study remain generally consistent with earlier studies.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2

Table 9. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.10 Mason Inlet: Wrightsville Beach

Mason Inlet is a small migrating system that opened in the early 1880s 1.8 miles northeast of its current location. For the period between 1971 and 2020, and while the inlet shoreline consistently migrated toward Wrightsville Beach, the oceanfront shoreline near Shell Island Resort (last structure closest to the inlet) remained generally stable and accretional due to pre-relocation inlet influences **Figure 54**. However, the post-2002 analysis highlights significant erosion as the oceanfront shoreline adjusted to the relocated inlet's stabilized position **Figure 56**. While post-2002 data were utilized to delineate the alongshore IHA boundary at transect 249, 1971 to 2020 data more accurately reflect long-term erosion rates **Figure 57**. This trend is expected to continue with the routine beach nourishment and maintenance dredging activities at Mason Inlet to limit its migration.

As mentioned in Section 3.9, Wrightsville Beach has an extensive history of managing its oceanfront shoreline with beach nourishment. However, the area within the 2025 IHA at Mason Inlet was not included in the Town's initial large-scale project. Within the updated 2025 Inlet Hazard Area (IHA), the analysis included seventeen shorelines from 1971 to 2020 (**Figure 54**) revealed an average shoreline change rate of 5.2 feet per year (accretion) across the IHA (**Figure 55**). Consequently, the erosion setback factor is set at 2 throughout the area (**Figure 59**).

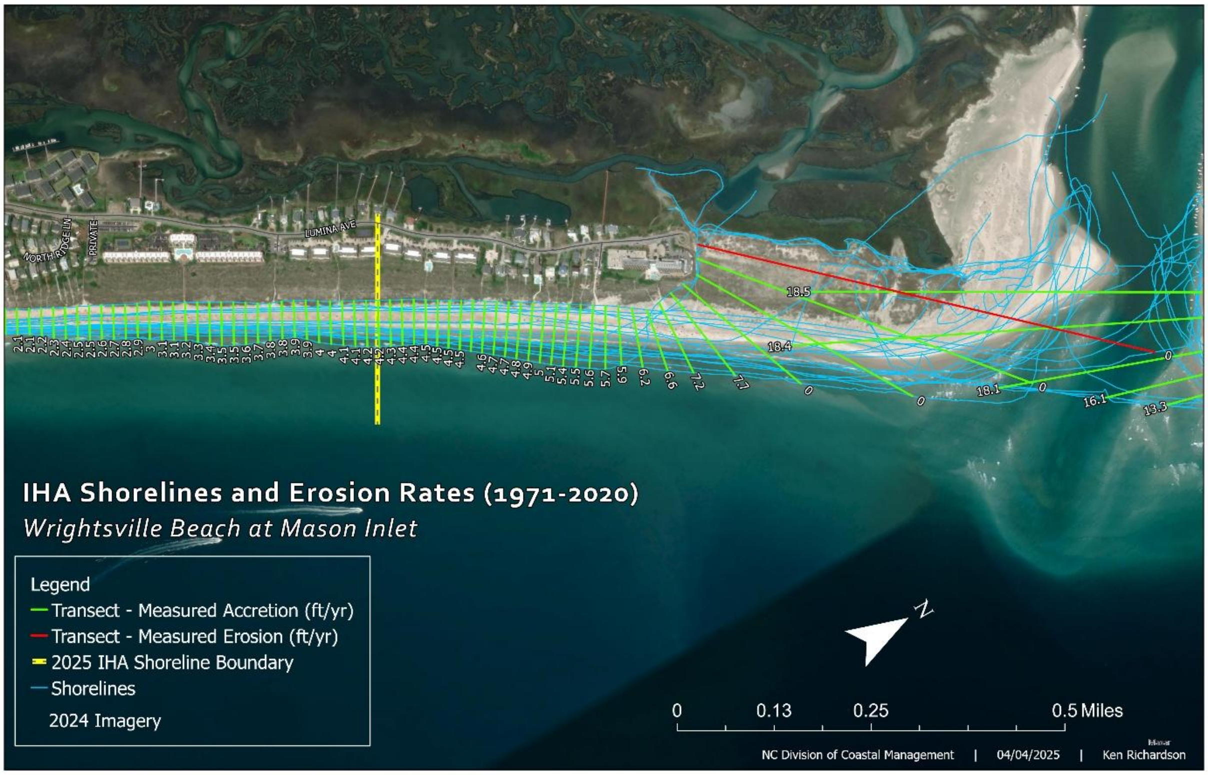

Figure 54. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Mason Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

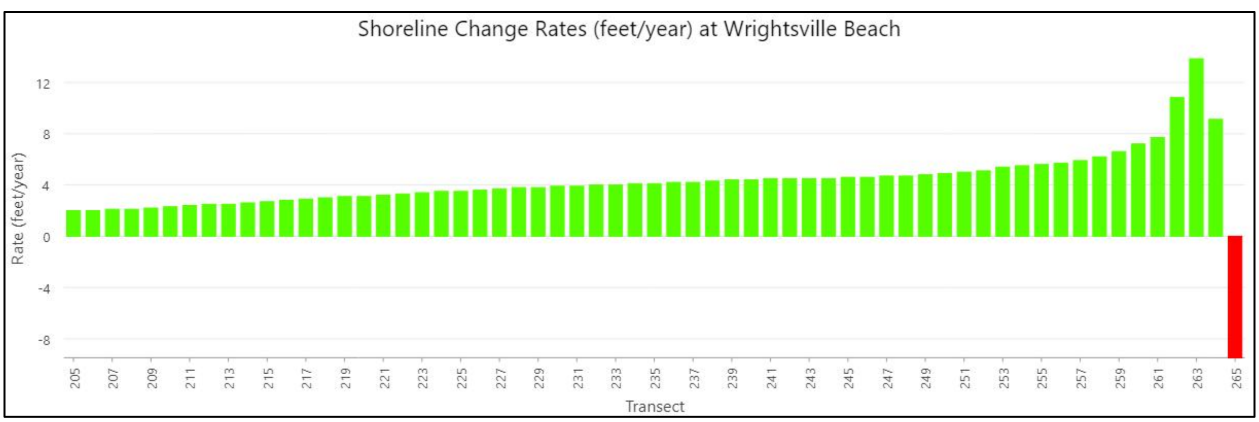

Figure 55. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

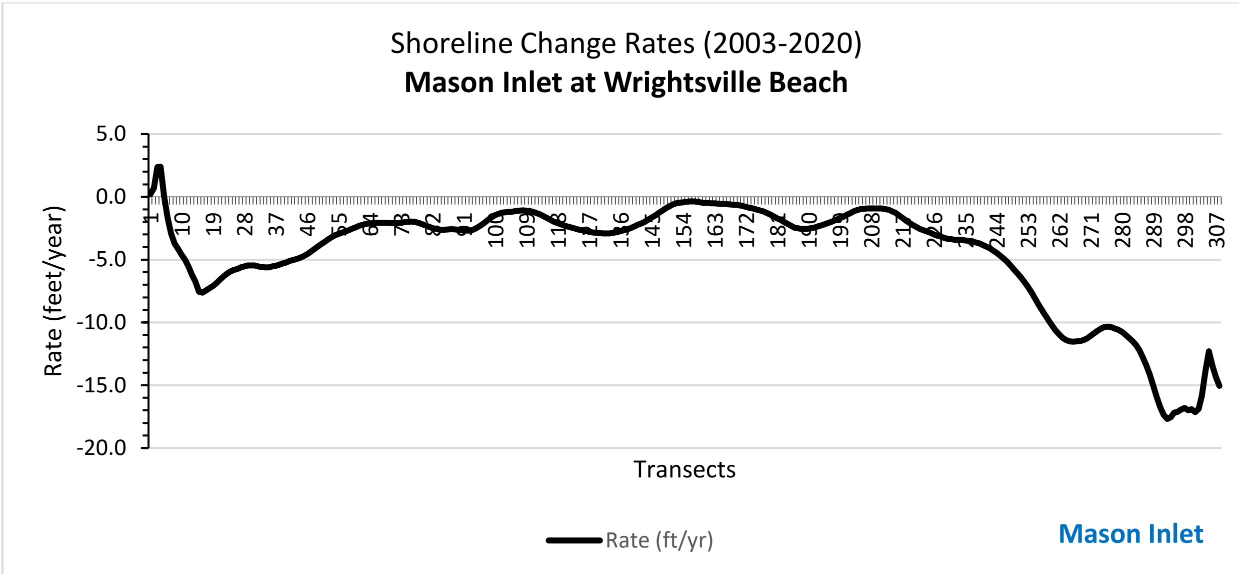

Figure 56. *This graph shows post-2002 shoreline change rates. Notice measured erosion significantly increases between transects 208 and 307 approaching Mason Inlet following the inlets relocation.*

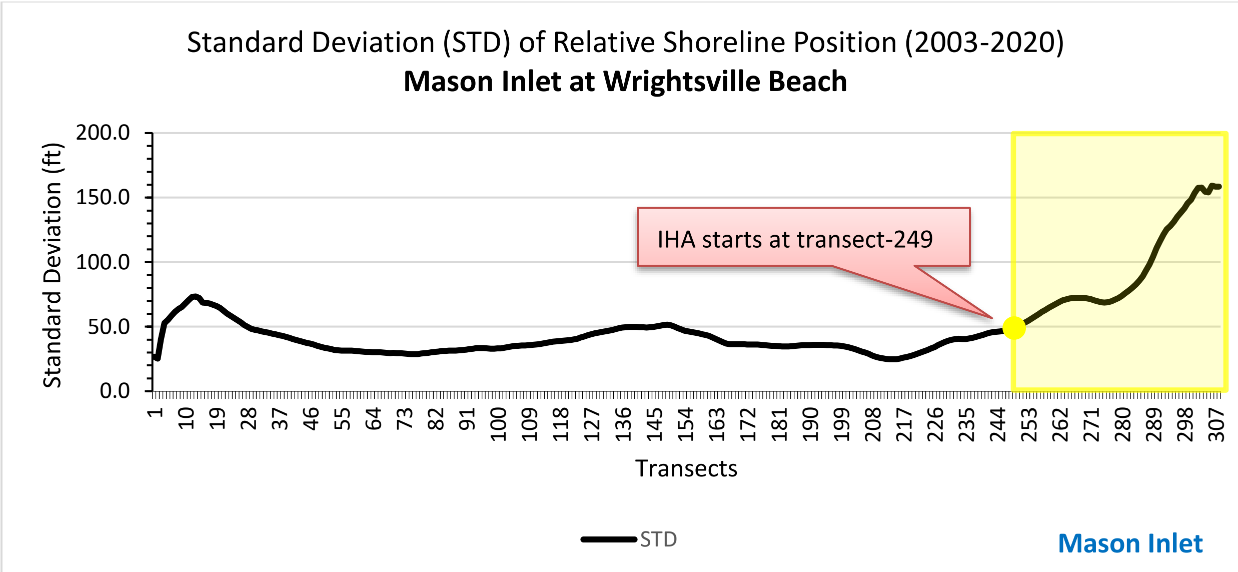

Figure 57. *This graph shows the standard deviation of relative shoreline position using post-2002 data. The IHA alongshore boundary is defined at transect 249.*

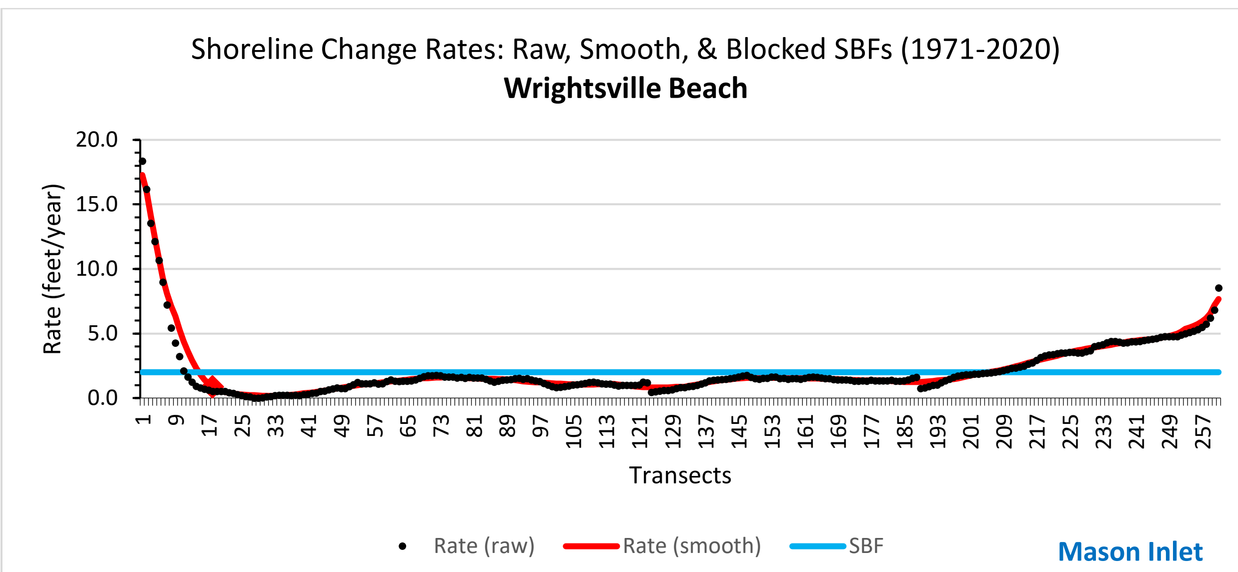

Figure 58. *This graph displays shoreline change rates for the period between 1971 and 2020 represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs.*

Figure 59. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 10** compares erosion setback factors from this analysis to those from earlier oceanfront erosion rate and setback factor studies. Despite differing calculation methods and study periods, the findings in this study remain generally consistent with earlier studies.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2

Table 10. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.11 Mason Inlet: Figure Eight Island

Within the 2025 updated Inlet Hazard Area (IHA), spanning less than one mile (4,429 feet) from transect 42 to Mason Inlet, the analysis considered seventeen shorelines from 1971 to 2020 (**Figure 60**). Like the Wrightsville Beach side of Mason Inlet and considering long-term engineering measures to stabilize the inlet's location, post-2002 data were used to define the alongshore IHA boundary at transect 42 (**Figure 62**). However, the full 1971–2020 dataset better captures the long-term erosion rate trends (**Figure 64**). These trends are anticipated to persist, supported by ongoing beach nourishment and maintenance dredging at Mason Inlet to offset it natural migration.

The analysis measured an average shoreline change rate of 18.5 feet per year, indicating accretion. This high average is primarily influenced by significant accretion rates along the inlet channel shoreline, while erosion near the alongshore boundary had a minimal impact on reducing the overall average. As a result, the erosion setback factor for the area is uniformly set at 2 (**Figure 65**).

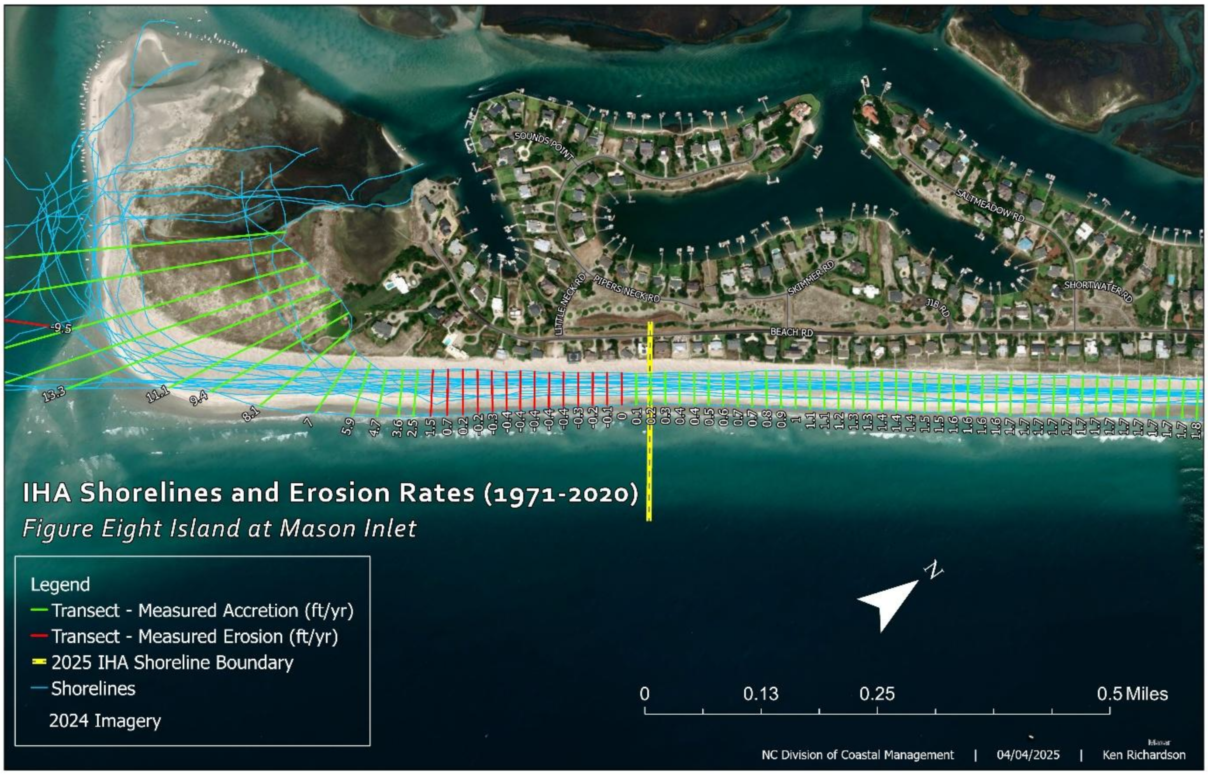

Figure 60. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Mason Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

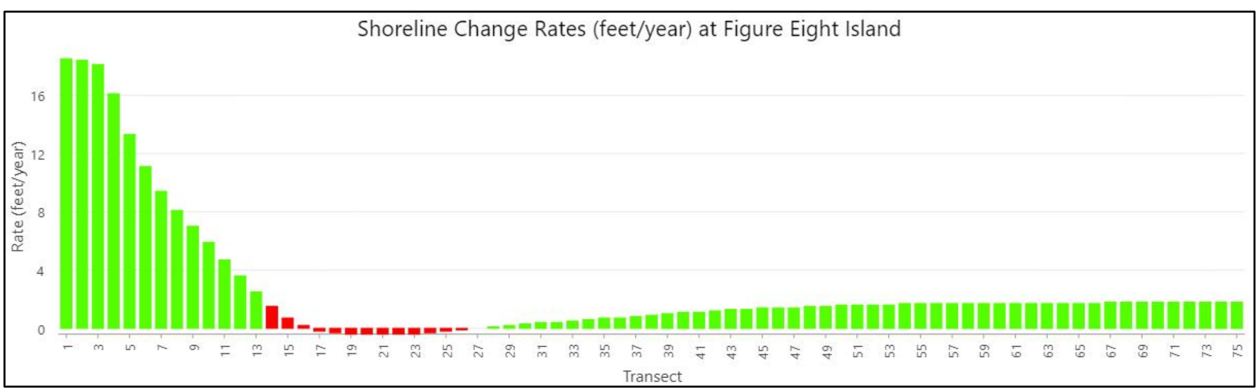

Figure 61. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

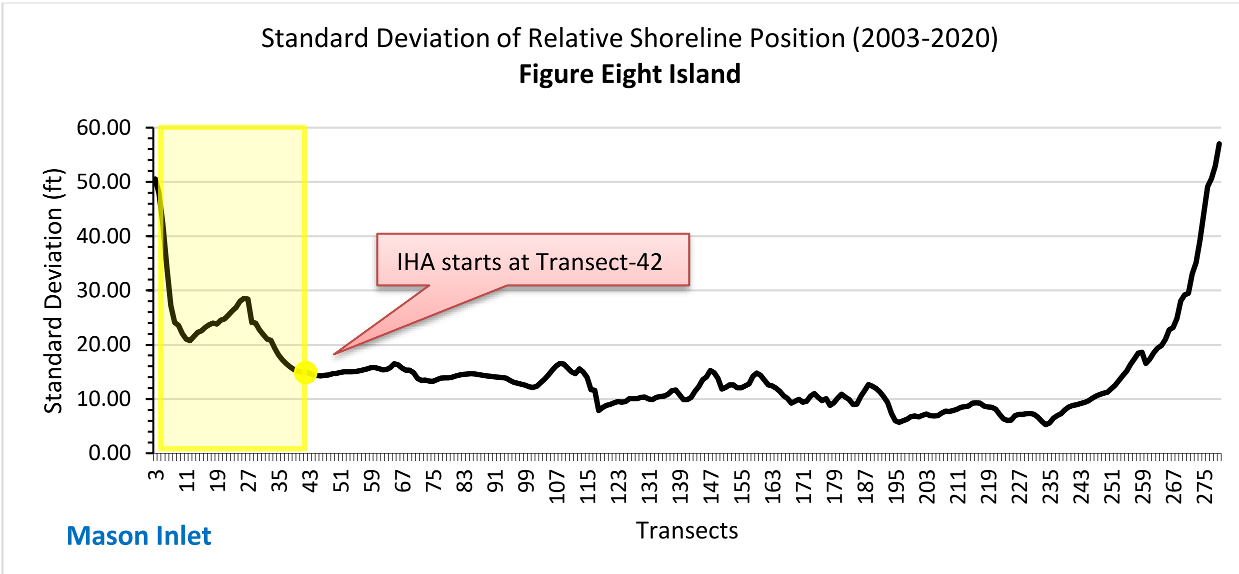

Figure 62. *This graph shows the standard deviation of relative shoreline position using post-2002 data. The IHA alongshore boundary is defined at transect 42.*

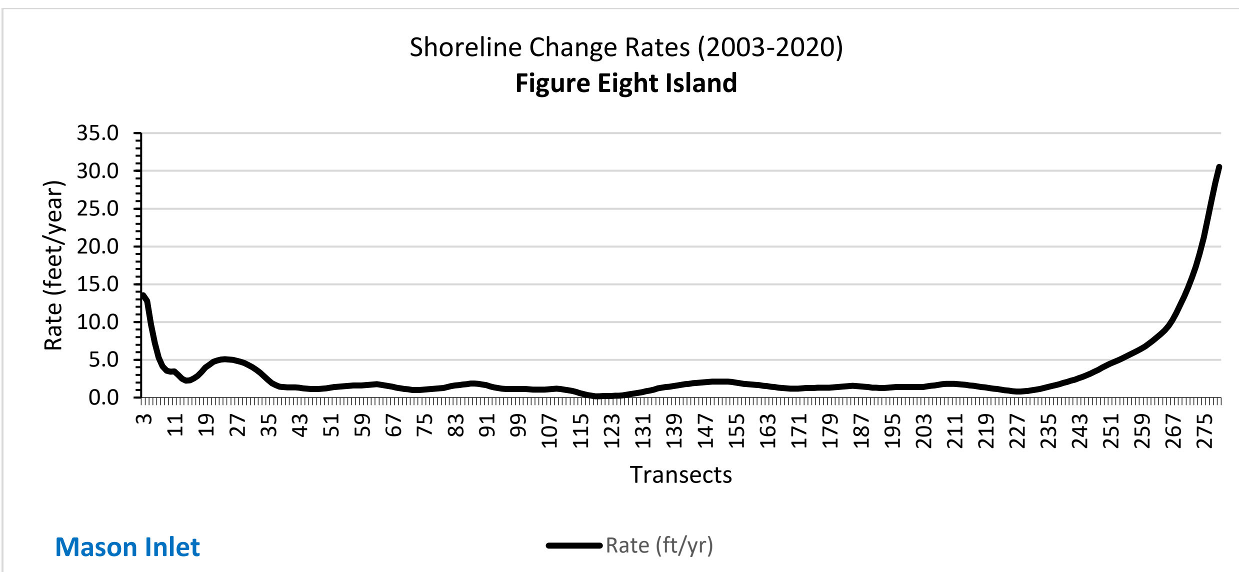

Figure 63*. This graph shows post-2002 shoreline change rates.*

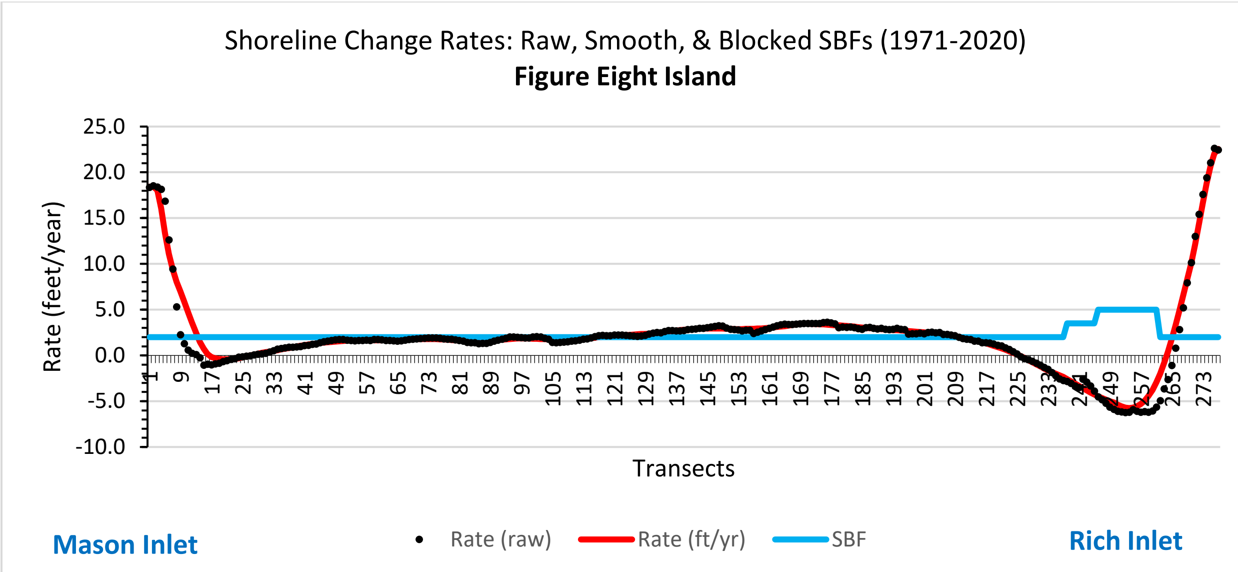

Figure 64. *This graph displays shoreline change rates for the period between 1971 and 2020 represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs.*

Figure 65. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 11** compares erosion setback factors from this analysis to those from earlier oceanfront erosion rate and setback factor studies. Despite different calculation methods and study periods, the findings of this study remain broadly consistent with earlier studies conducted after beach nourishment projects became more commonplace in the 1980s.

Area Inside IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	5	2.3

Table 11. This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.

3.12 Rich Inlet: Figure Eight Island

Within the 2025 updated Inlet Hazard Area, covering less than 1 mile (5,000 feet) of shoreline from transect-225 to Rich Inlet, the analysis included eighteen shorelines from 1971 to 2020 (**Figure 66**). Although the average shoreline change rate within the IHA is less than 2 feet per year for the period of study, the range varies significantly from 22.5 feet per year (accretion) inside the inlet and -6.2 feet per year (erosion) in ocean to inlet transition area (**Figure 68**). As a result, erosion setback factors range from 2 and 5 (**Figure 69**).

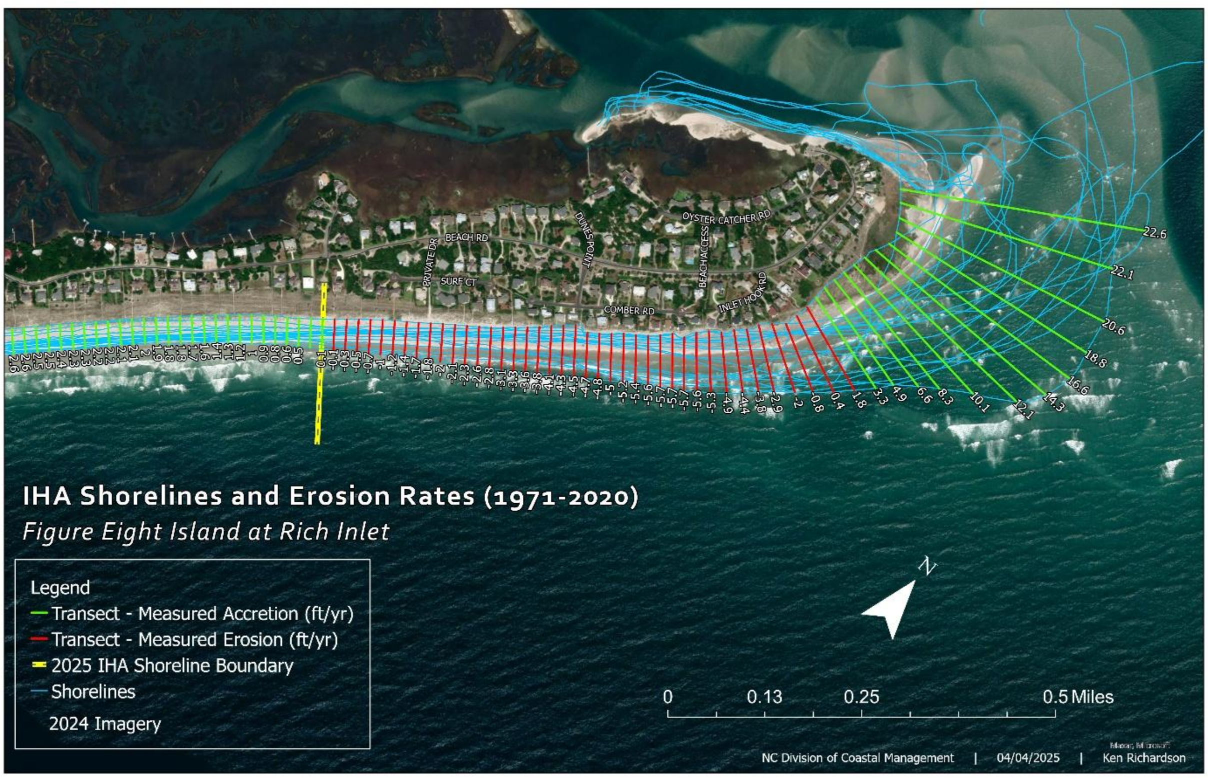

Figure 66. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Rich Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

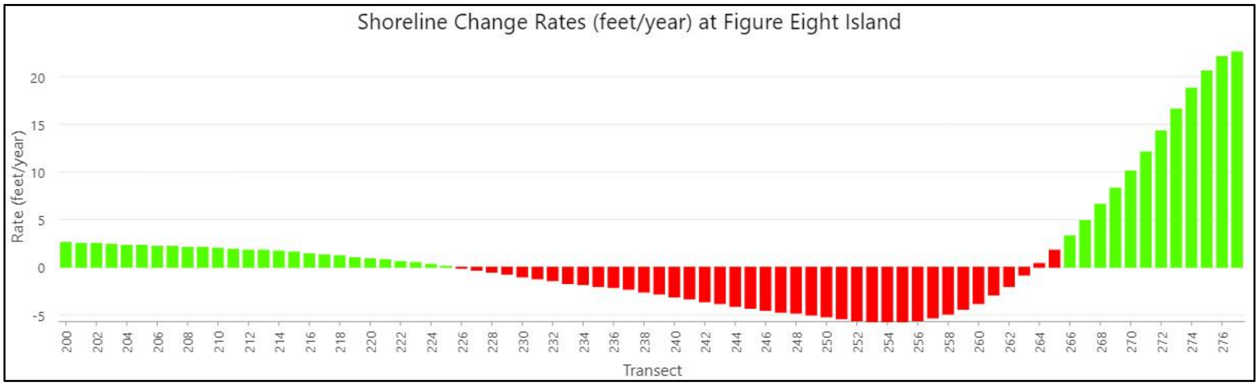

Figure 67. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

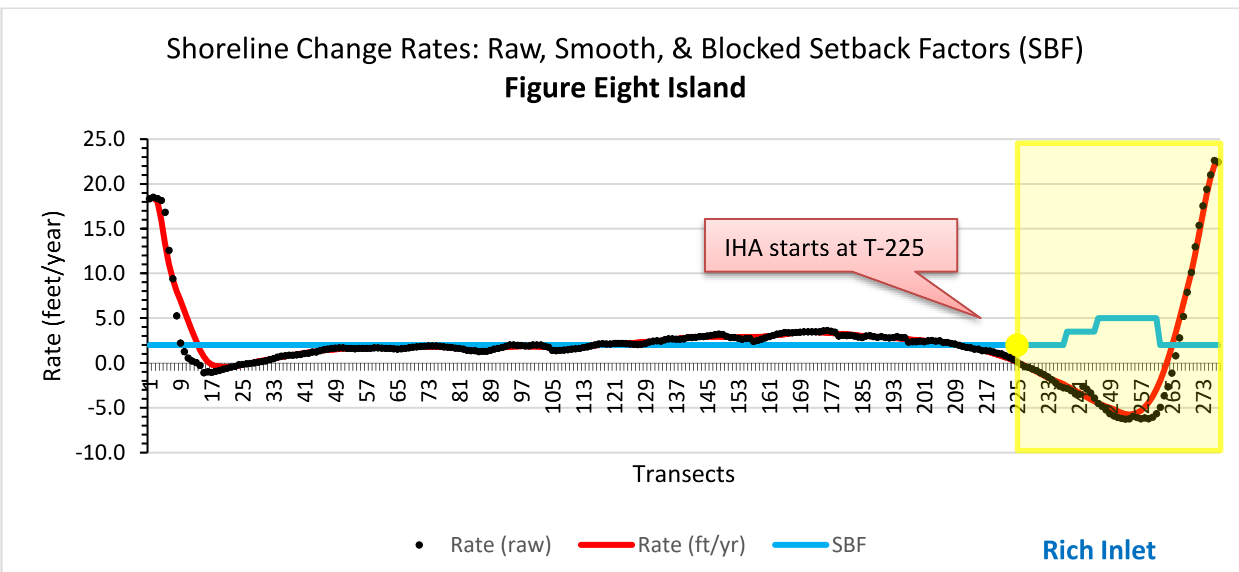

Figure 68. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 69. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 12** compares erosion setback factors from this analysis to those from earlier oceanfront erosion rate and setback factor studies. The area where setback factors are 3.5 and 5 reflect erosion trends between 1971 and 2020. However, earlier reports do not reflect high erosion rates due to the more landward position of pre-1970s shorelines, which capture accretion, and the application of Rule 15A NCAC 07H.310 requiring use of the adjacent Ocean Erodible Area's (OEA) setback factor, both of which collectively reduce historic factors for the same area.

Area Inside 2025 IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2.3
SBF = 3.5	3.5	2	2	2	2	2	2	2.3
SBF = 5	5	2	2	2	2	2	2	2.3
SBF = 2	2	2	2	2	2	2	2	2.3

***Table 12**. This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.13 Rich & New Topsail Inlets: Lea-Hutaff Island

The updated 2025 Hazard Area (IHA) spans the entirety of Lea-Hutaff Island (4 miles) considering the islands joined together with the closure of Old Topsail Inlet in 1997 and given the strong influences of both Rich and New Topsail Inlets. The study found an average shoreline change rate equal to -8.4 feet per year (erosion) across the IHA, but ranged from -2.1 to -19.8 feet per year (erosion) (**Figures 71 & 72**). As a result, erosion setback factors ranged from 3 to 12.5 (**Figures 73 & 74**).

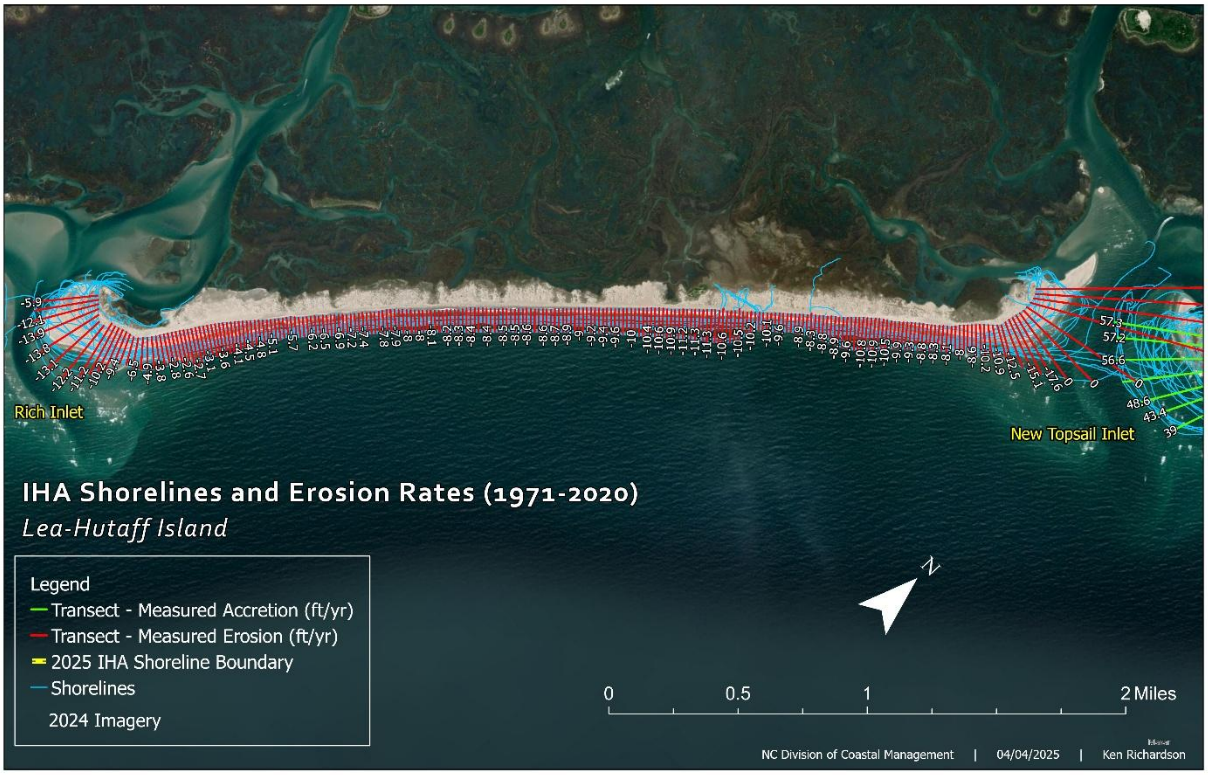

Figure 70. *This map illustrates shorelines and erosion rates measured at each transect.*

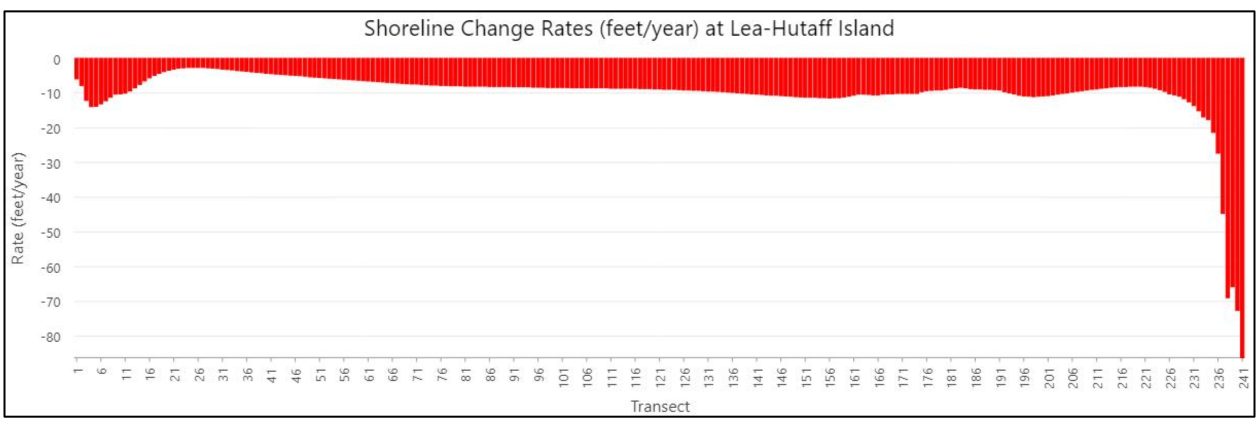

Figure 71. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

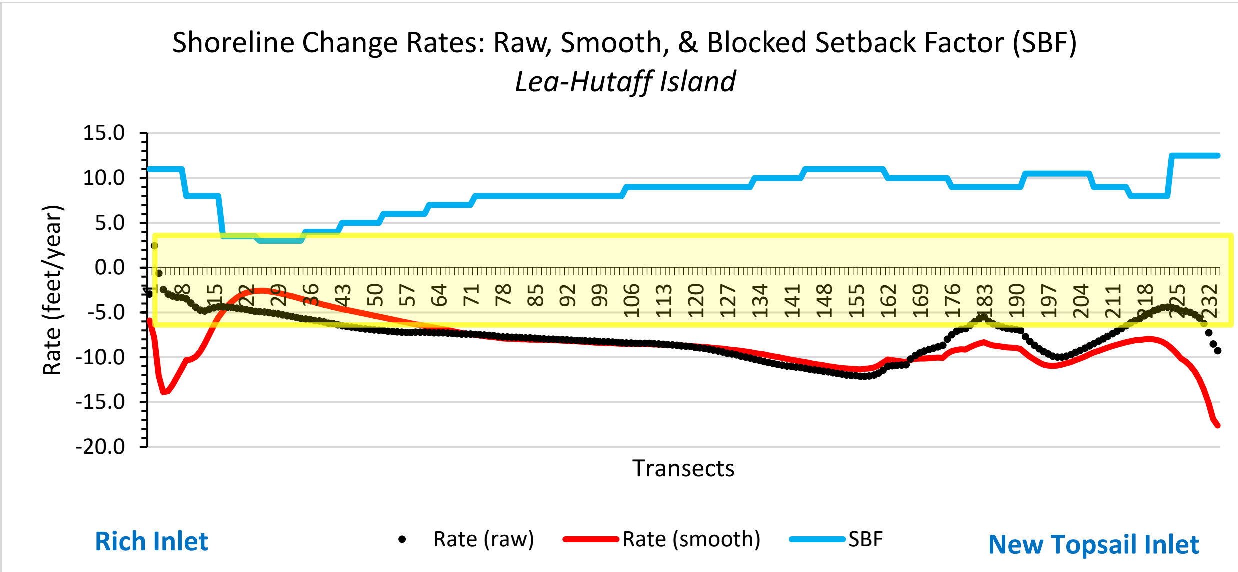

Figure 72. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

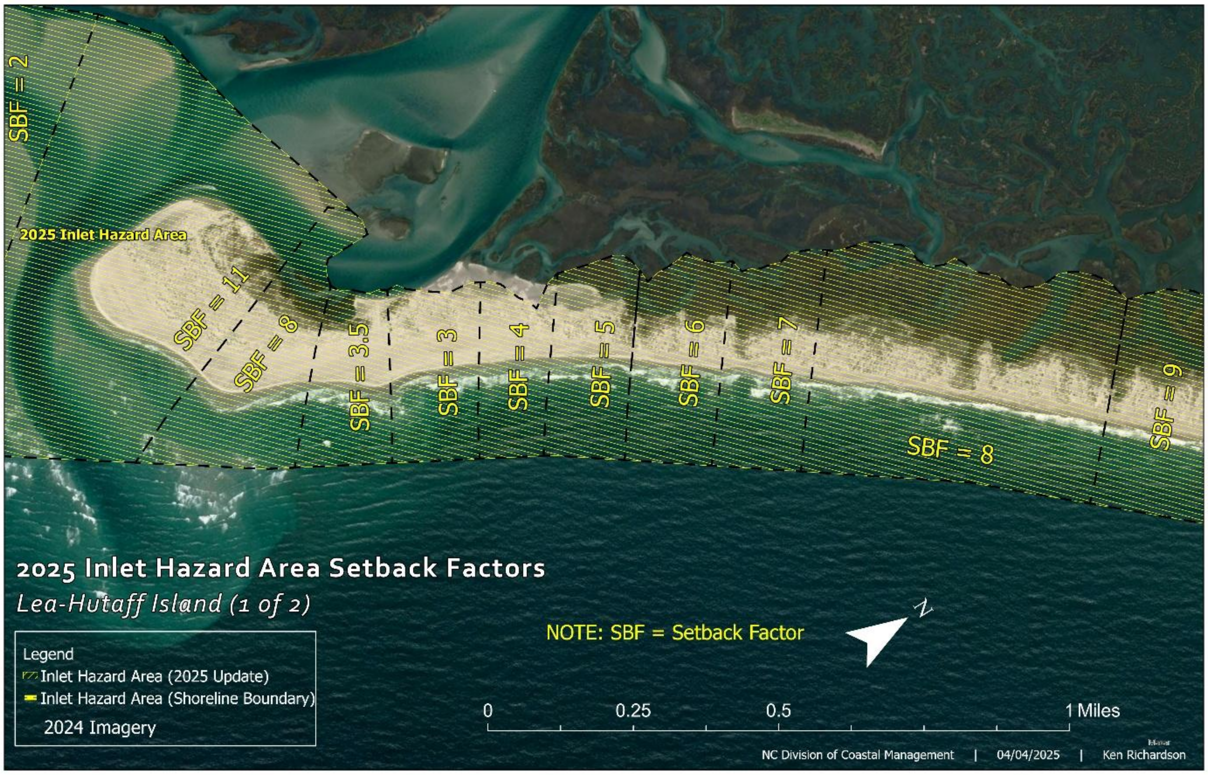

Figure 73. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

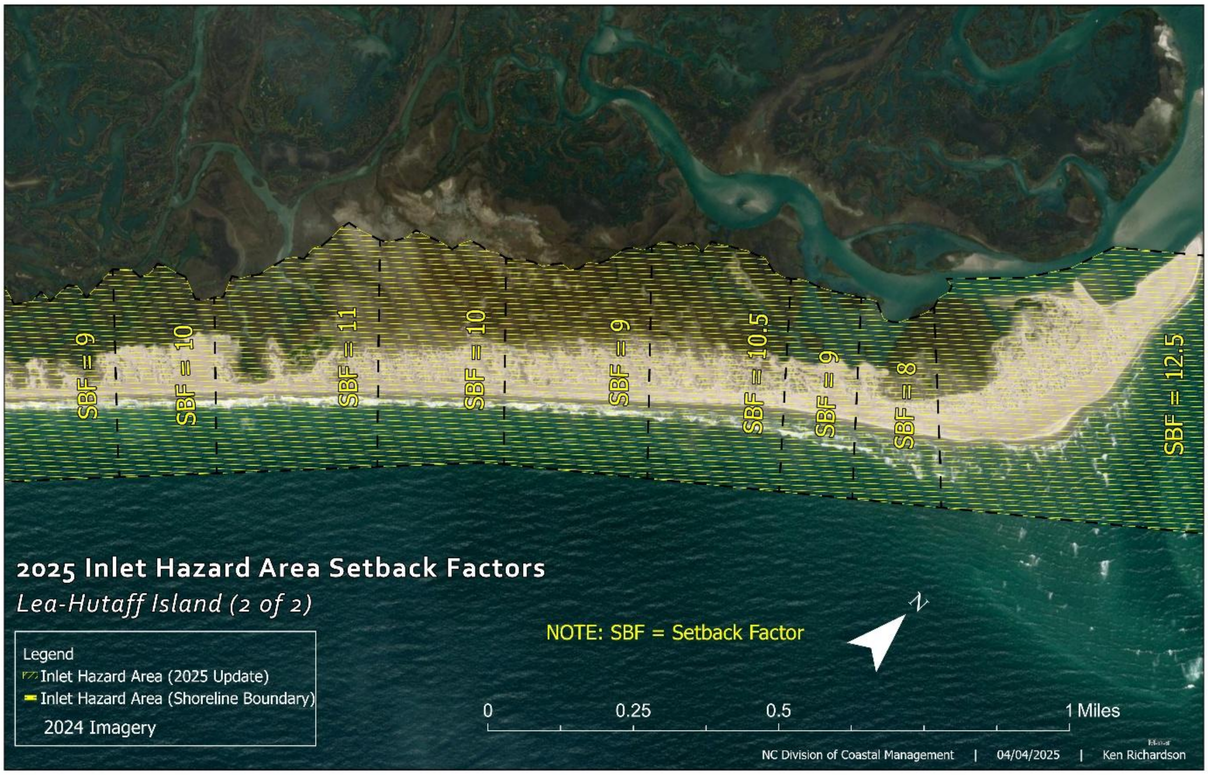

Figure 74. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 13** compares erosion setback factors from this analysis to those derived from earlier oceanfront erosion rate and setback factor studies. However, direct comparisons are not feasible because the existing (1979) IHAs encompasses a significant portion of the island, including areas around the now closed Old Topsail Inlet, and application of Rule 15A NCAC 07H.310, which requires the use of setback factors from the adjacent Ocean Erodible Area (OEA), means that actual erosion rates within IHAs were not translated into specific setback factors prior to this study.

Area Inside 2025 IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 3 to 12.5	3 to 12.5	4 to 10	2 to 10	2 to 7	2 to 6	5 to 6	2 to 5	2 to 5.7

Table 13. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.14 New Topsail Inlet: Topsail Beach

New Topsail Inlet is recognized as North Carolina's most consistently migrating inlet, shifting approximately 6.2 miles to the southwest over its history. This migration has contributed to significant accretion along the Topsail Beach shoreline, fostering the natural growth of the beachfront. However, this pattern of accretion diminishes once the inlet progresses farther southwest. In addition, direct or near-direct strikes from tropical storm systems have had compounding negative influences on shoreline position and dune system over time. Consequently, loss of beach along the oceanfront required the Town to install its first large-scale beach nourishment in 2011, followed by one maintenance project in 2024. The initial project extended along the Town’s oceanfront, encompassing a 1,100-foot portion of the beach within the 2025 IHA. It tapered off and concluded at the point where development along Ocean Boulevard ends, adjacent to the ocean shoreline.

In the updated 2025 Hazard Area (IHA), which spans approximately half a mile (2,900 feet) from transect 33 to New Topsail Inlet, the analysis examined twenty-two shorelines from 1971 to 2021 (**Figure 75**). The study found an average shoreline change rate equal to 18.5 feet per year (accretion) across the IHA (**Figure 76**). As a result, the erosion setback factor is 2 throughout the IHA (**Figure 78**).

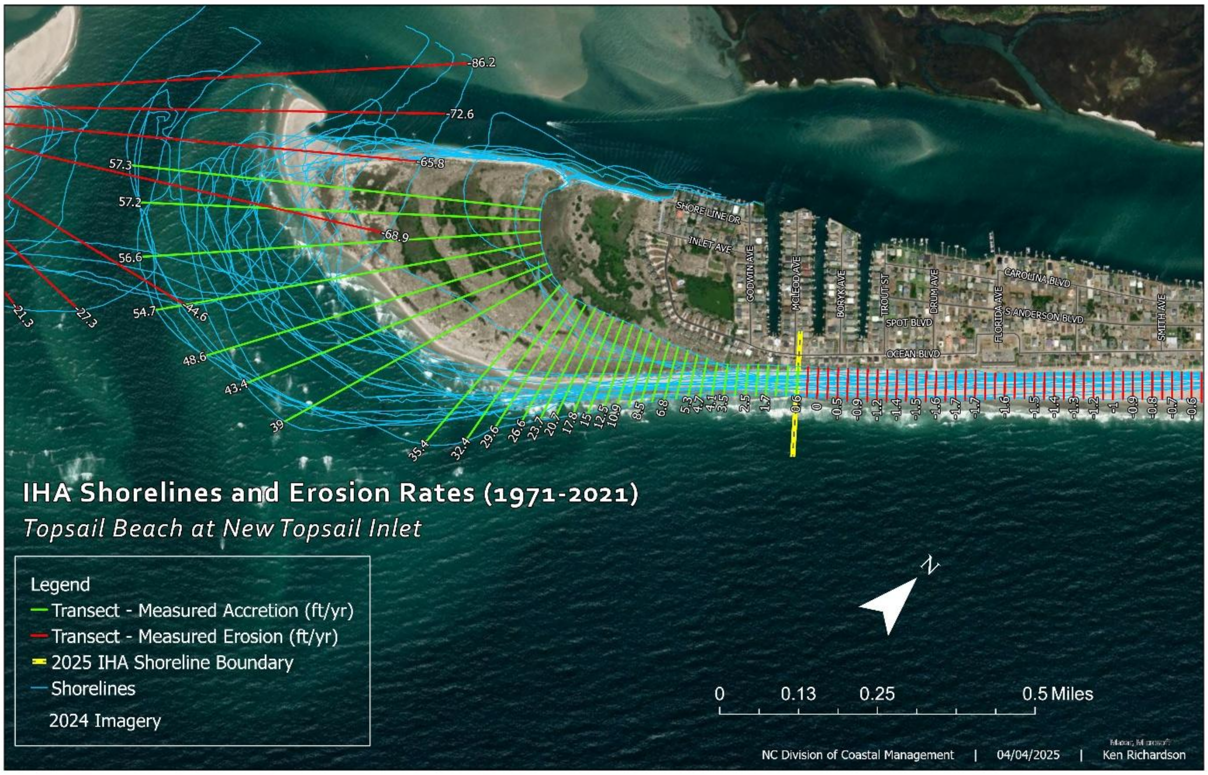

Figure 75. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching New Topsail Inlet from the 2025 updated IHA alongshore boundary (yellow transect)*.

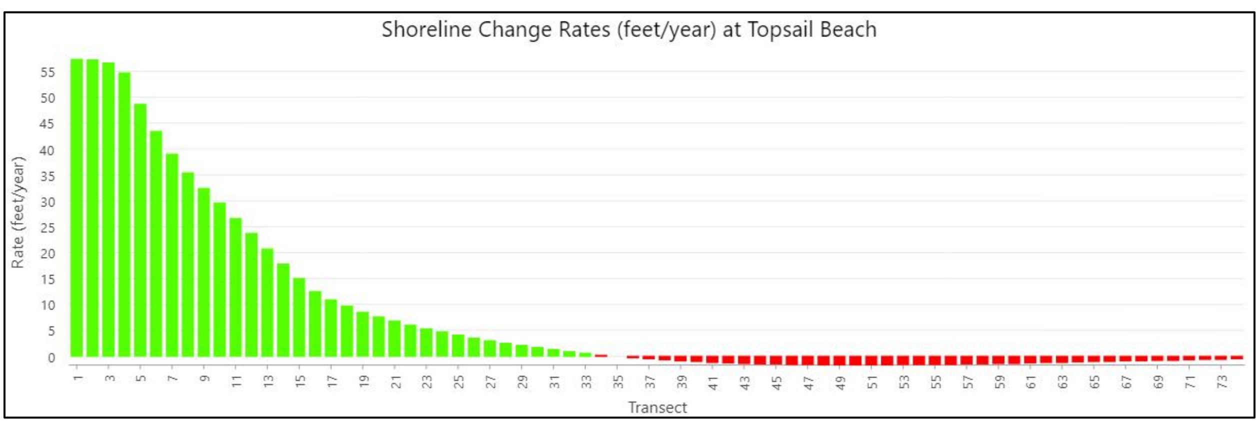

Figure 76. This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.

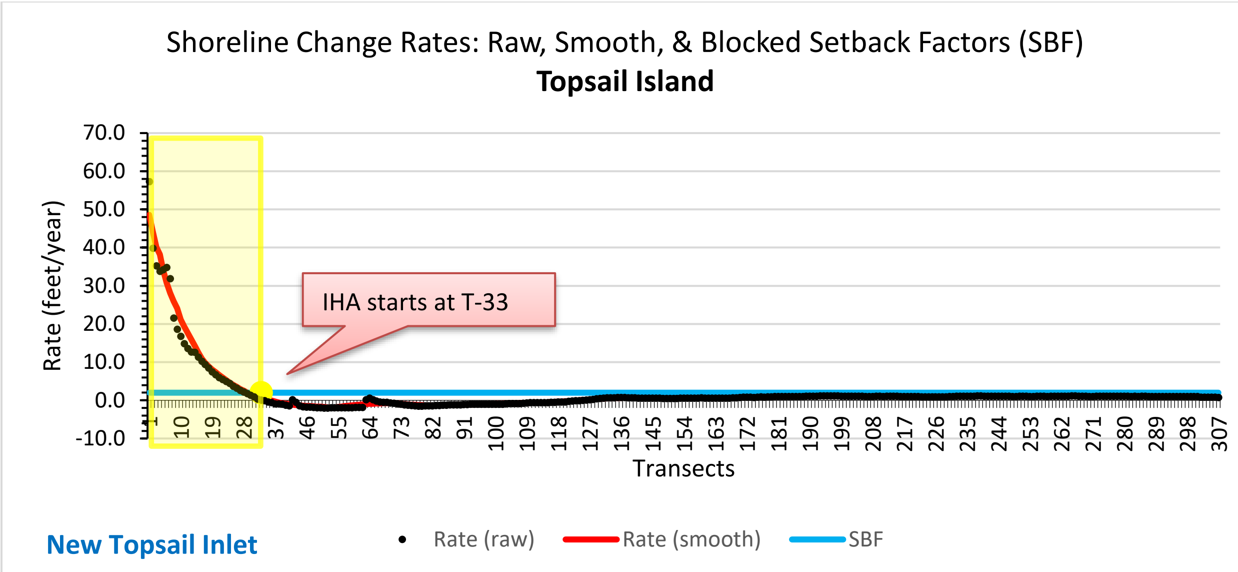

Figure 77. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 78. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 14** compares erosion setback factors from this analysis to those derived from earlier oceanfront erosion rate and setback factor studies. Given the history of inlet migration and accretion, the erosion setback factors default to 2 as per Rule 15A NCAC 07H.0304(1).

Area Inside 2025 IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2

Table 14. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.15 New River Inlet: North Topsail Beach

The New River Inlet is classified as a migrating inlet, and over the past 25 years, North Topsail Beach has faced persistent erosion issues along the ocean-inlet shoreline. To challenge this, approximately 3,000 feet of shoreline have been reinforced with sandbag structures designed to halt or slow the erosion process. In 2013, the town undertook a large-scale beach nourishment project, which covered most of the oceanfront shoreline within the 2025 IHA, providing a much-needed erosion buffer, but unfortunately, this project was short-lived due to a series of tropical storm systems.

Between 2019 and 2024 truck-hauled sediments were placed to address erosion damage and restore compromised sections of dunes and beaches. These measures were part of FEMA-supported erosion mitigation projects initiated in response to damage from Hurricanes Matthew (2016), Florence (2018), and Dorian (2019).

In the updated 2025 Hazard Area (IHA), which spans approximately 1.4 miles (7,100 feet) from transect 1353 to New River Inlet, the analysis examined twenty shorelines from 1971 to 2021 (Figure 79). The study found an average shoreline change rate equal to -9.6 feet per year (erosion) across the IHA (**Figures 80 & 81**); however, rates ranged from less than -2 feet per year to -16 feet per year. It is expected that without the sandbag structures in place, that erosion rates would have measured significantly higher. As a result, the erosion setback factors range from 2 to 10 within the 2025 IHA (**Figure 82**).

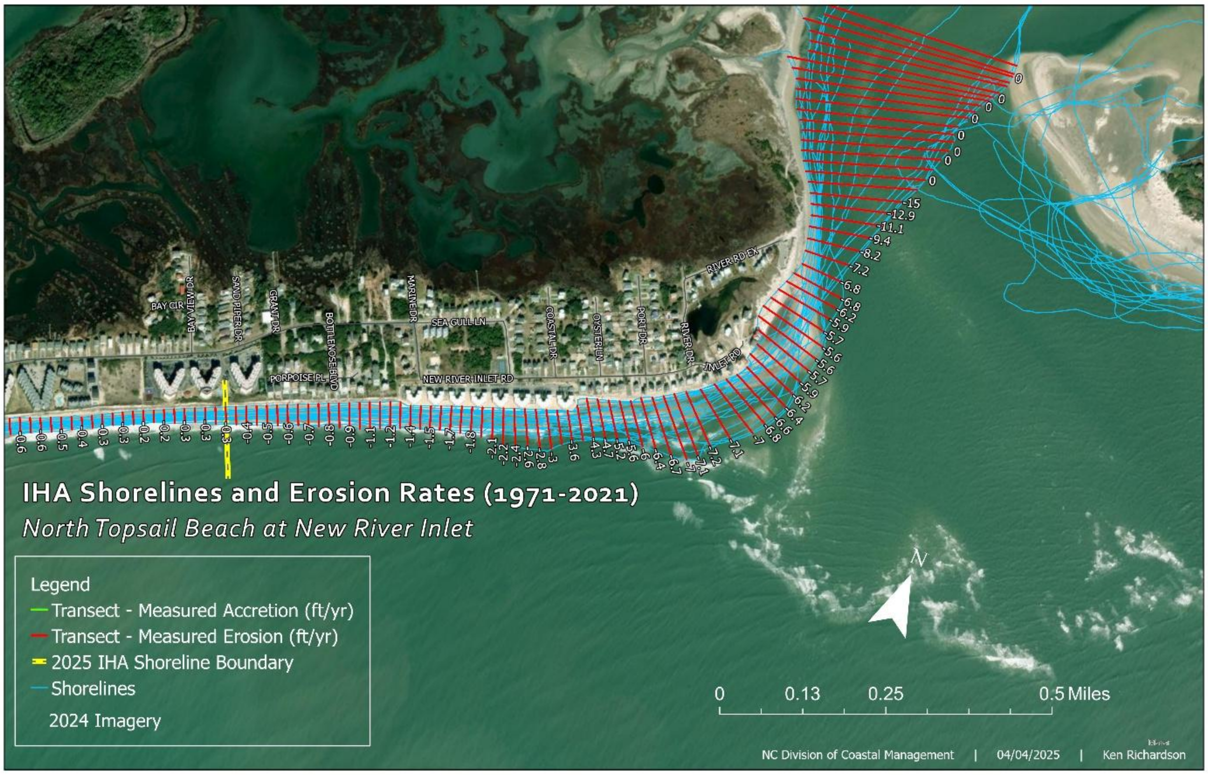

Figure 79. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching New River Inlet from the 2025 updated IHA alongshore boundary (yellow transect).*

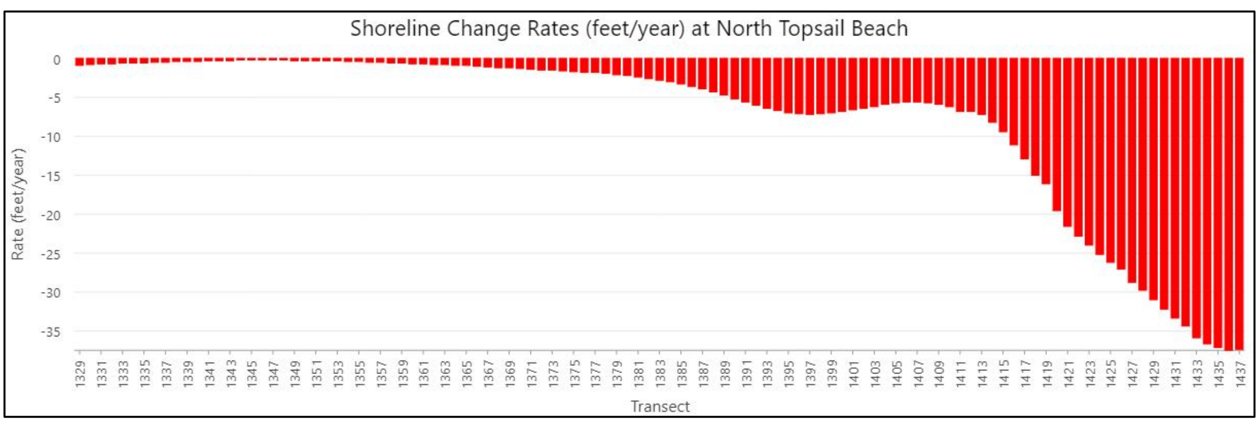

Figure 80. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

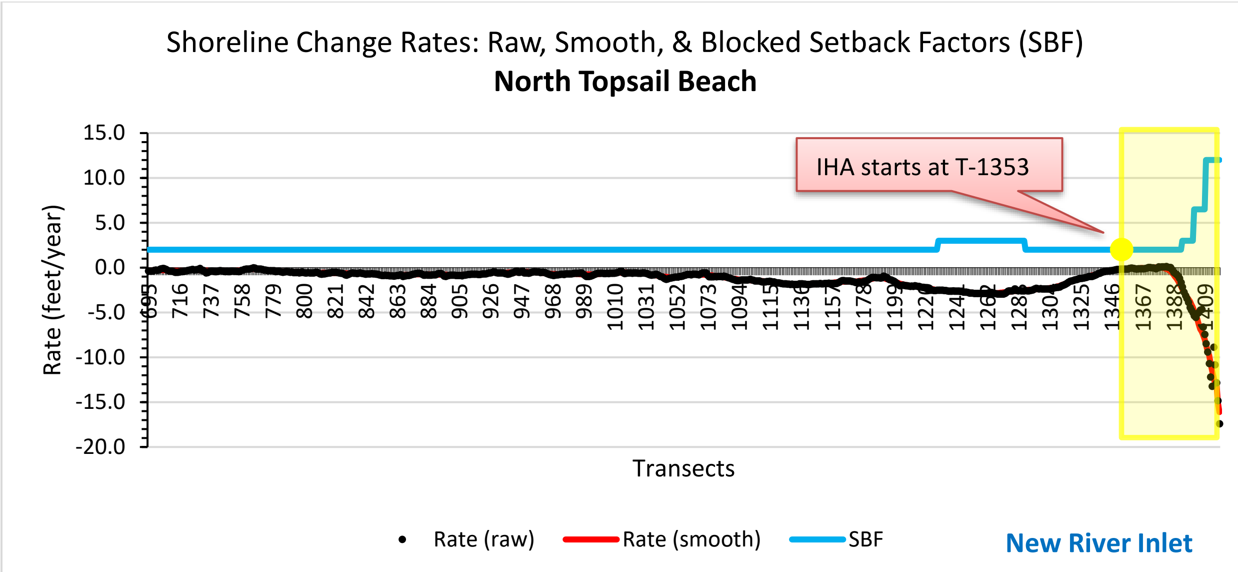

Figure 81. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 82. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

For the same area within the 2025 updated IHA, **Table 15** compares the resulting erosion setback factors with those from previous oceanfront erosion rates and setback factors studies. Although earlier studies have measured various degrees of erosion near the inlet, the use of ocean-perpendicular transects ending at the inlet, combined with the application of existing Rule 15A NCAC 07H.310, which requires using the adjacent Ocean Erodible Area (OEA), has affected the resulting setbacks by consistently reducing the setback factor to two. While the setback factor is higher, it is reflective of inlet erosion rates, and without the use of sandbags it is expected that the erosion would have a greater impact on structures along this section of shoreline.

Area Inside 2025 IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	2	2	2	2.5
SBF = 2.5	2.5	2	2	2	2	2	2	2.5
SBF = 5	5	2	2	2	2	2	2	2.5
SBF = 7	7	2	2	2	2	2	2	2.5
SBF = 6	6	2	2	2	2	2	2	2.5
SBF = 10	10	2	2	2	2	2	2	2.5

Table 15. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

3.16 Bogue Inlet: Emerald Isle

Bogue Inlet, a dynamic and oscillatory inlet, has been continuously open in its general location since it was first mapped in 1585. However, in 2005, chronic erosion along the shoreline of Bogue Banks near Emerald Isle had become a significant concern, threatening structures, habitats, and recreational areas. To address this, an extensive relocation project was undertaken, shifting the ebb channel approximately 3,200 feet westward. This engineering intervention was designed to reduce erosion impacts and improve sediment distribution along the adjacent shoreline.

Since the relocation, Bogue Inlet has been subject to regular monitoring and detailed hydrographic surveys to track changes in channel morphology and shoreline conditions. When necessary, further realignment of the channel is implemented to maintain the delicate balance between natural inlet dynamics and shoreline stability.

In the updated 2025 Hazard Area (IHA), which spans approximately 1.2 miles (6,234 feet) from transect 75 to Bogue Inlet, the analysis examined seventeen shorelines from 1971 to 2022. The study found an average shoreline change rate equal to 5.8 feet per year (accretion) across the IHA (**Figure 85**); however, it is expected that without inlet management that shoreline change rates would trend erosional. As a result, the erosion setback factors default to 2 within the 2025 IHA (**Figure 86**).

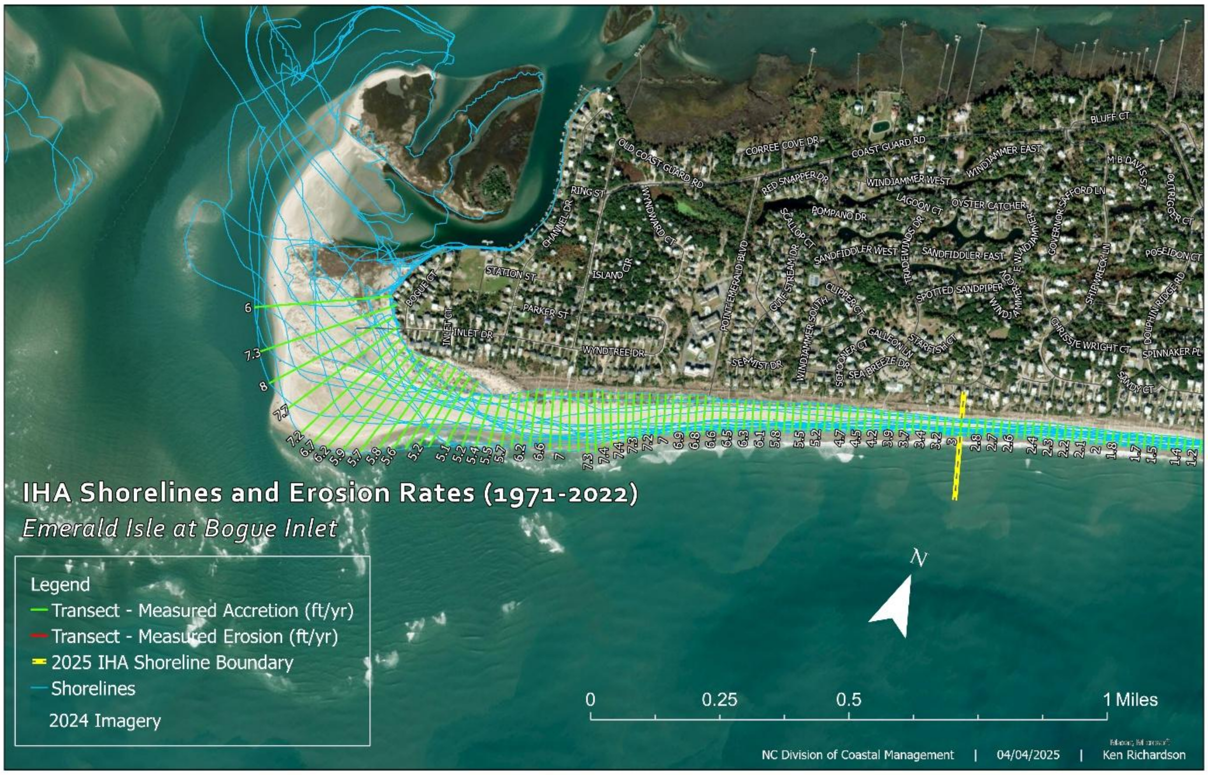

Figure 83. *This map illustrates shorelines and erosion rates measured at each transect for the area approaching Bogue Inlet from the 2025 updated IHA alongshore boundary (yellow transect)*.

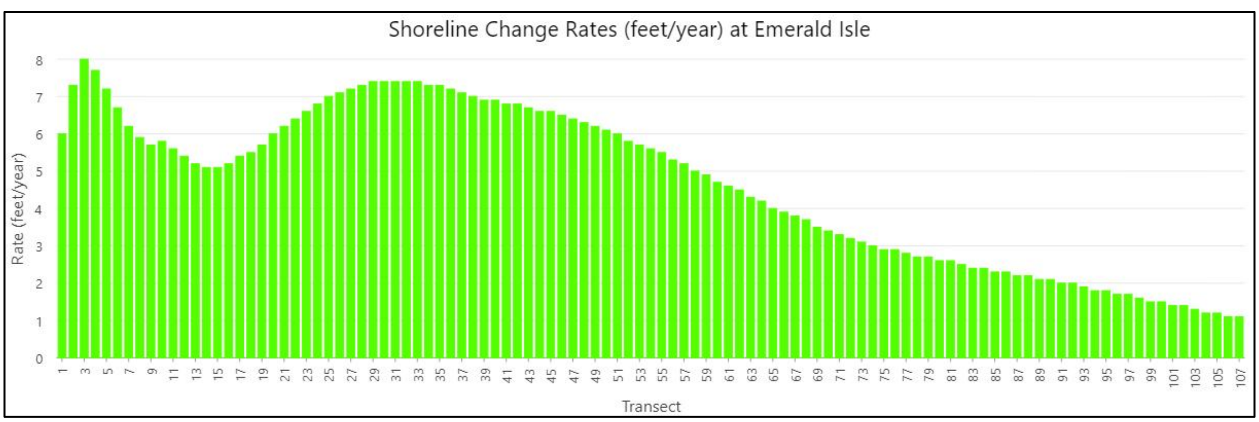

Figure 84. *This graph illustrates shoreline change rates measured at each transect, with green bars representing areas of accretion and red lines indicating areas of erosion.*

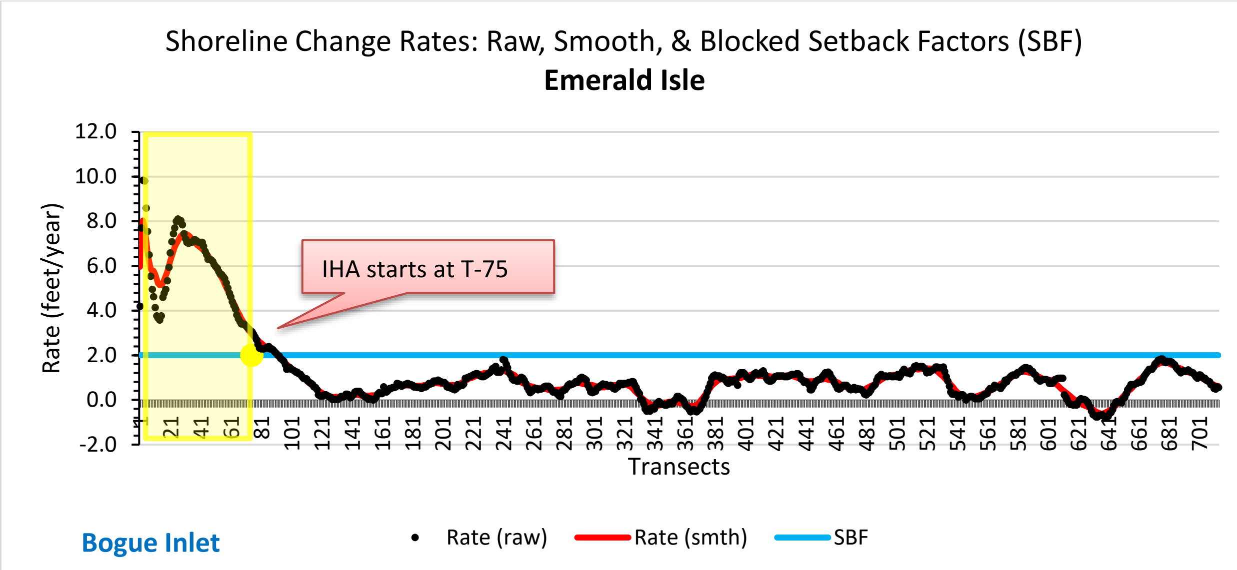

Figure 85. *This graph displays shoreline change rates represented by raw data (black dots), smoothed trends (red line), and blocked rates (blue line). Negative values indicate erosion, while positive values represent accretion. For illustration purposes, the blocked erosion setbacks are shown as positive but correspond to the actual erosion rate. The default erosion setback is set to 2 where erosion is less than -2 feet per year or where accretion occurs. The yellow box represents IHA's spatial extent along the shoreline.*

Figure 86. *This map image illustrates 2025 inlet erosion setback factors in relation to the updated IHA boundary.*

Within the 2025 updated Inlet Hazard Area (IHA), **Table 16** compares erosion setback factors from this analysis to those derived from earlier oceanfront erosion rate and setback factor studies. Prior to 2005, studies measured various degrees of erosion near the inlet; however, the use of ocean-perpendicular transects ending at the inlet, combined with the application of existing Rule 15A NCAC 07H.310, which requires using the adjacent Ocean Erodible Area (OEA), has affected the resulting setbacks. Given the history of inlet management since 2005 and its influences on the adjacent shoreline, the erosion setback factors default to 2 as per Rule 15A NCAC 07H.0304(1).

Area Inside 2025 IHA	2025	2020	2013	2004	1997	1986	1983	1980
SBF = 2	2	2	2	2	3	5	3	NA

Table 16. *This table compares 2025 results to previous oceanfront erosion rate and setback factor updates.*

4.0 Summary

As anticipated, the analysis of inlet shoreline change rates along the study area reveals a fluctuating trend of shoreline retreat (erosion) and accretion, with a collective average erosion rate of less than -2 feet per year within the 2025 IHAs. However, this average should not be misinterpreted as indicative of minimal risk at each inlet, as this average is heavily influenced by the balance between very high erosion rates exceeding -20 feet per year and significant accretion rates resulting in construction setback factors ranging between 2 and 18. These findings underscore the substantial impact of natural inlet processes, such as tides, wave action, storm events, and sea-level rise, compounded by anthropogenic influences like coastal development and engineering practices, including dredging, beach nourishment, and erosion control structures.

The spatial variability in erosion rates highlights the critical roles of local geomorphology, sediment availability, and human interventions. Since 1979, construction setbacks have been instrumental in creating a buffer zone between structures and the dynamic coastal environment, allowing natural processes like erosion and accretion to occur without posing immediate short-term risks in some areas. However, longer-term risks remain inevitable when natural processes outpace engineering efforts. By consistently updating erosion rate setbacks based on current data, setbacks can reduce the need for costly erosion mitigation measures when development is properly sited. Additionally, they provide a critical margin for future changes in erosion rates driven by sea-level rise and extreme weather events, ultimately enhancing long-term resilience and minimizing economic losses.

Future studies should prioritize determining optimal setback distances tailored to specific shoreline conditions and integrating adaptive management strategies. These documented rates of erosion pose significant risks to coastal ecosystems, infrastructure, and property owners. Therefore, understanding and mitigating these risks is essential to ensuring the long-term sustainability and resilience of the coastal environment.

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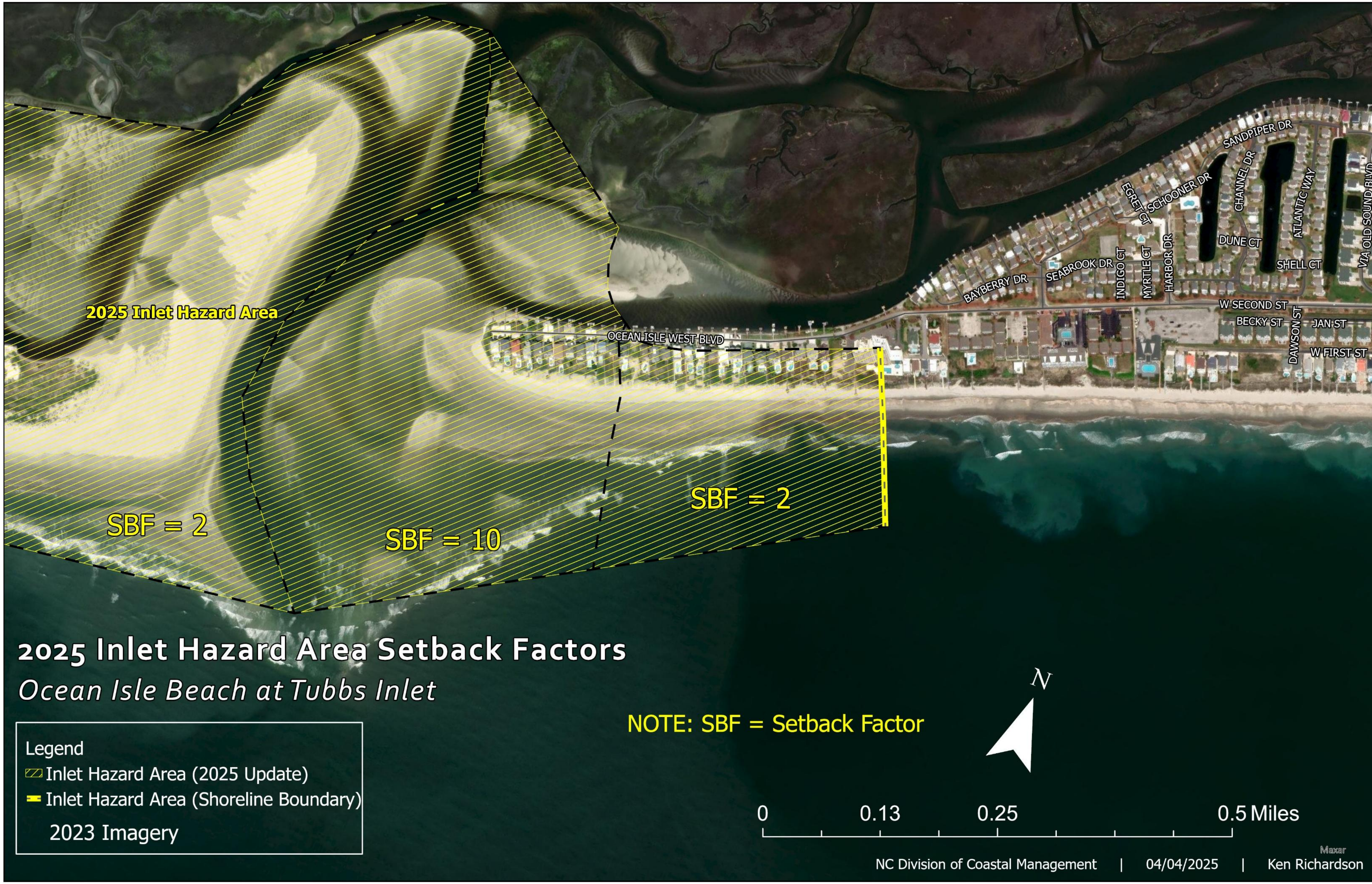
Appendix A: Inlet Hazard Area Setback Factor Maps


CEDAR PT DR
RIVERSIDE DR
NORTH SHORE DR
16TH ST
17TH ST
18TH ST
19TH ST
5TH ST SW
6TH ST
MARLIN ST
SAILFISH ST
DOLPHIN ST
COBIA ST
CANAL DR
7TH ST
8TH ST
9TH ST
10TH ST
11TH ST
E MAIN ST
2025 Inlet Hazard Area
SBF = 10
SBF = 2
2025 Inlet Hazard Area Setback Factors
Sunset Beach at Tubbs Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2023 Imagery
0
0.13
0.25
0.5 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson



2025 Inlet Hazard Area
OCEAN ISLE WEST BLVD
SANDPIPER DR
CHANNEL DR
ATLANTIC WAY
VIA OLD SOUND BLVD
SCHOONER DR
EGRET CT
DUNE CT
SHELL CT
SEABROOK DR
BAYBERRY DR
INDIGO CT
MYRTLE CT
HARBOR DR
W SECOND ST
BECKY ST
JAN ST
DAWSON ST
W FIRST ST
SBF = 2
SBF = 10
SBF = 2
2025 Inlet Hazard Area Setback Factors
Ocean Isle Beach at Tubbs Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2023 Imagery
0
0.13
0.25
0.5 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area
E SEVENTH ST
E SIXTH ST
E FIFTH ST
SHALLOTTE BLVD
E FOURTH ST
CHARLOTTE ST
E THIRD ST
E SECOND ST
E FIRST ST
GREENSBORO ST
WINSTON SALEM ST
HIGHPOINT ST
DURHAM ST
COLUMBIA ST
SBF = 2
SBF = 4
SBF = 7
SBF = 10
SBF = 14
SBF = 17.5
SBF = 17
SBF = 9
2025 Inlet Hazard Area Setback Factors
Ocean Isle Beach at Shallotte Inlet
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.13
0.25
0.5 Miles
Maxar, Microsoft
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SBF = 16
SBF = 9
SBF = 2
2025 Inlet Hazard Area
WINDY POINT RD SW
LANDS END WAY SW
RUSSELL HEWETT RD SW
WINDY TERRACE SW
LAKEVIEW DR SW
MARTIN LN SW
RIVER VIEW LN SW
DAKOTA ST SW
REDFISH RUN SW
PANAMA LN SW
OYSTER HARBOUR PKWY SW
BOONES NECK RD SW
BOWMAN ST SW
OCEAN BLVD W
SKIMMER
SHELL DR
SEA VIEW DR
SUNSHINE LN
CLIPPERSHIP DR
MARSH WALK
BY THE SEA
FRIGATE DR
SEA GULL DR
DEAL DR
SEA SIDE DR
TIDE RIDGE DR
2025 Inlet Hazard Area Setback Factors
Holden Beach at Shallotte Inlet
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


B-VAR RD SW
ISLAND VIEW RD SW
CANAL DR
SHRIMP ST
CRAB ST S
CONCH ST
MULLET ST
IRON AGE DR
BLOCKADE RUNNER
RANGER ST
ELIZABETH ST
FIRST ST
OCEAN BLVD E
AVE B AVE
MCCRAY ST
DUNESCAPE DR
WINDSWEPT WAY
SERENITY LN
AVE D AVE
AVE E ST
2025 Inlet Hazard Area
SBF = 5
SBF = 2
2025 Inlet Hazard Area Setback Factors
Holden Beach at Lockwood Folly Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.13
0.25
0.5 Miles
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

2025 Inlet Hazard Area Setback Factors
Oak Island at Lockwood Folly Inlet
SBF = 2
2025 Inlet Hazard Area
NOTE: SBF = Setback Factor
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
N
0
0.25
0.5
1 Miles
CEDAR VIEW DR SE
BRUNSWICK ST SE
RIVERVIEW DR SE
HOLLYVIEW DR SE
PINEVIEW DR SE
LOCKWOOD FOLLY RD SE
SUNSET HARBOR RD SE
ROXBORO ST SE
CROSS ST SE
KINGS LYNN DR
69TH PL SE
66TH PL W
60TH PL W
57TH PL W
W DOLPHIN DR
W BEACH DR
54TH PL W
51ST PL W
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

GROUPER CT
STATE AVE
ROSCOE FREEMAN RD
PARK AVE
SEABREEZE RD
ELM ST
FLORIDA AVE
MARYLAND AVE
MARINA ST
GEORGIA AVE
OCEANA WAY
VIRGINIA AVE
SANDFIDDLER LN
CANAL DR
PRIVATE
CAROLINA BEACH AVE
SBF = 7
SBF = 11.5
SBF = 15
SBF = 18
2025 Inlet Hazard Area
SBF = 2
2025 Inlet Hazard Area Setback Factors
Carolina Beach at Carolina Beach Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


SBF = 7
SBF = 11.5
SBF = 15
SBF = 2
SBF = 18
SBF = 14
SBF = 10
SBF = 9
SBF = 11
SBF = 13
SBF = 14
SBF = 15
SBF = 16
SBF = 15
SBF = 16
SBF = 15
2025 Inlet Hazard Area Setback Factors
Masonboro Island (1 of 4)
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar, Microsoft
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


SBF = 15
SBF = 14
SBF = 13
SBF = 12
SBF = 11
SBF = 10
SBF = 9
SBF = 8
SBF = 7
SBF = 6
2025 Inlet Hazard Area
2025 Inlet Hazard Area Setback Factors
Masonboro Island (2 of 4)
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

2025 Inlet Hazard Area
SBF = 7
SBF = 6
SBF = 5
SBF = 4
SBF = 3
SBF = 2
2025 Inlet Hazard Area Setback Factors
Masonboro Island (3 of 4)
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

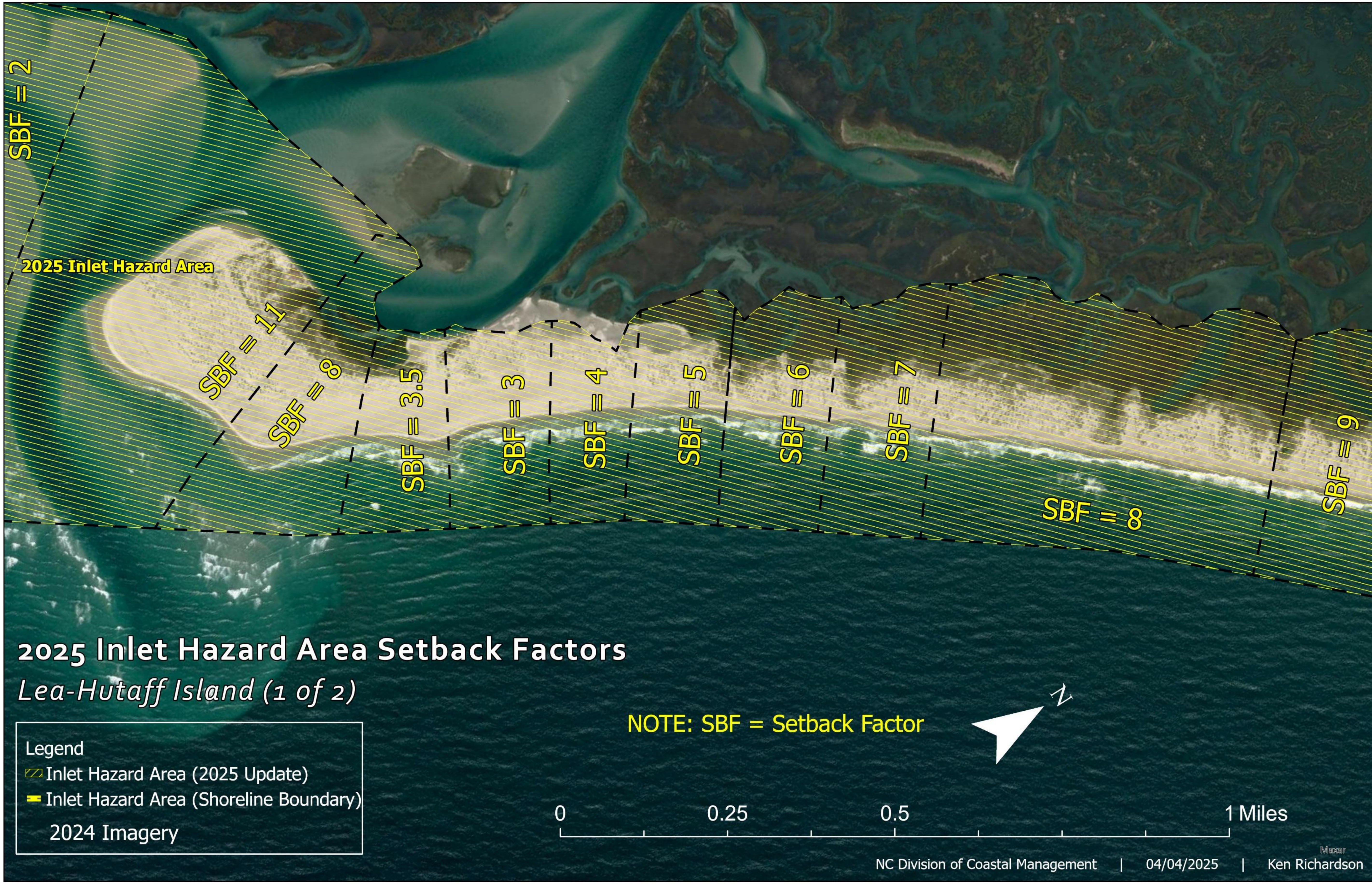

2025 Inlet Hazard Area
SBF = 2
SBF = 2
2025 Inlet Hazard Area Setback Factors
Masonboro Island (4 of 4)
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

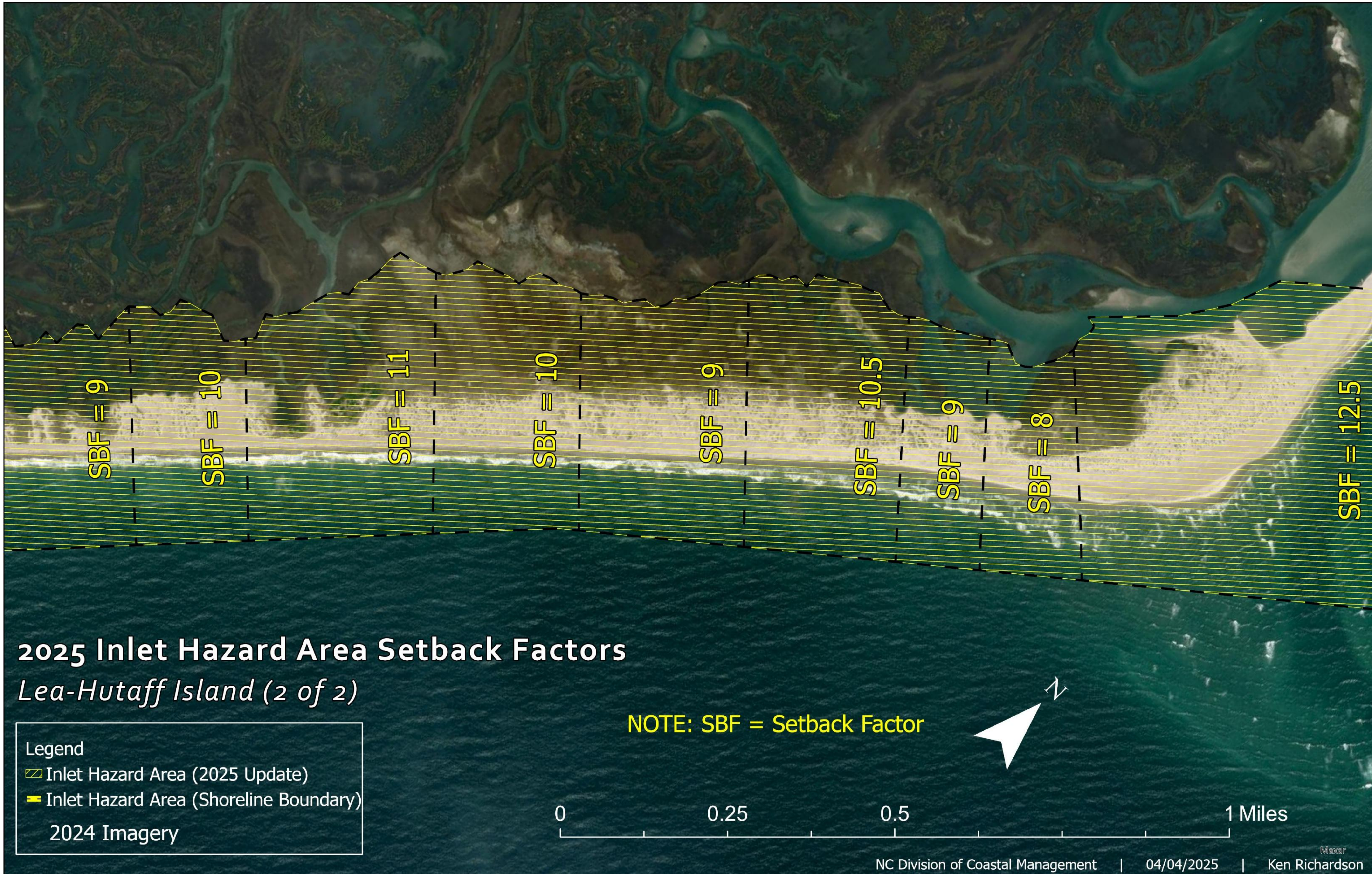
2025 Inlet Hazard Area Setback Factors
Wrightsville Beach at Masonboro Inlet
SBF = 2
SBF = 2
2025 Inlet Hazard Area
WATER ST
SCHLOSS ST
ALBRIGHT ST
NORTHROP ST
TAYLOR ST
CORBETT ST
LUMINA AVE
SHORT ST
WRIGHT ST
MEIER AVE
SUNSET AVE
NATHAN ST
IULA ST
COBURN AVE
WAYNICK BLV
SPRUNT ST
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.13
0.25
0.5 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson

PRIVATE
LUMINA AVE
2025 Inlet Hazard Area
SBF = 2
SBF = 2
2025 Inlet Hazard Area Setback Factors
Wrightsville Beach at Mason Inlet
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.13
0.25
0.5 Miles
Maxar, Microsoft
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area
SOUNDS POINT
LITTLE NECK RD
PIPERS NECK RD
SKIMMER RD
JIB RD
BEACH RD
SALTMEADOW RD
SHORTWATER RD
BANKS RD
SBF = 2
2025 Inlet Hazard Area Setback Factors
Figure Eight Island at Mason Inlet
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.13
0.25
0.5 Miles
Maxar, Microsoft
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area
BEACH RD
PRIVATE DR
SURF CT
DUNES POINT
BEACH ACCESS
OYSTER CATCHER RD
COMBER RD
INLET HOOK RD
SBF = 2
SBF = 3.5
SBF = 5
SBF = 2
2025 Inlet Hazard Area Setback Factors
Figure Eight Island at Rich Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.13
0.25
0.5 Miles
Maxar, Microsoft
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


SBF = 2
2025 Inlet Hazard Area
SBF = 11
SBF = 8
SBF = 3.5
SBF = 3
SBF = 4
SBF = 5
SBF = 6
SBF = 7
SBF = 8
SBF = 9
2025 Inlet Hazard Area Setback Factors
Lea-Hutaff Island (1 of 2)
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


SBF = 9
SBF = 10
SBF = 11
SBF = 10
SBF = 9
SBF = 10.5
SBF = 9
SBF = 8
SBF = 12.5
2025 Inlet Hazard Area Setback Factors
Lea-Hutaff Island (2 of 2)
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
NOTE: SBF = Setback Factor
N
0
0.25
0.5
1 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area
SBF = 2
SHORE LINE DR
INLET AVE
GODWIN AVE
MCLEOD AVE
BORYK AVE
TROUT ST
CAROLINA BLVD
DRUM AVE
FLORIDA AVE
S ANDERSON BLVD
CLARK AVE
SPOT BLVD
OCEAN BLVD
2025 Inlet Hazard Area Setback Factors
Topsail Beach at New Topsail Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.13
0.25
0.5 Miles
Maxar
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area
SBF = 10
SBF = 6
SBF = 7
SBF = 5
SBF = 2.5
SBF = 2
RIVER RD EX
INLET RD
RIVER DR
PORT DR
OYSTER LN
COASTAL DR
SEA GULL LN
MARINE DR
BOTTLENOSE BLVD
GRANT DR
SAND PIPER DR
BAY VIEW DR
PORPOISE PL
NEW RIVER INLET RD
2025 Inlet Hazard Area Setback Factors
North Topsail Beach at New River Inlet
NOTE: SBF = Setback Factor
N
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
0
0.13
0.25
0.5 Miles
NC CGIA, Maxar, Microsoft
NC Division of Coastal Management | 04/04/2025 | Ken Richardson


2025 Inlet Hazard Area Setback Factors
Emerald Isle at Bogue Inlet
2025 Inlet Hazard Area
SBF = 2
NOTE: SBF = Setback Factor
Legend
Inlet Hazard Area (2025 Update)
Inlet Hazard Area (Shoreline Boundary)
2024 Imagery
N
0
0.13
0.25
0.5 Miles
NC Division of Coastal Management | 04/04/2025 | Ken Richardson
Maxar
BLUFF CT
CORREE COVE DR
COAST GUARD RD
OLD COAST GUARD RD
TRADEWINDS DR
WINDJAMMER EAST
M B DAVIS ST
OUTRIGGER CT
RED SNAPPER DR
WINDJAMMER WEST
RING ST
LAGOON CT
OYSTER CATCHER
GOVERNOR SAFFORD LN
WYNDWARD CT
POMPANO DR
SCALLOP CT
CHANNEL DR
E WINDJAMMER
ISLAND CIR
SANDFIDDLER WEST
SANDFIDDLER EAST
POSEIDON CT
STATION ST
POINT EMERALD BLVD
WHITE SANDS DR
GULF STREAM DR
LOBSTER LN
SHIPWRECK LN
DOLPHIN RIDGE RD
BOGUE CT
SPOTTED SANDPIPER
CLIPPER CT
ABERLADY BAY
WINDJAMMER COV
PARKER ST
WINDJAMMER SOUTH
INLET CT
INLET DR
GALLEON LN
STARFISH CT
CHRISSIE WRIGHT CT
SPINNAKER PL
WYNDTREE DR
SEA MIST DR
SCHOONER CT
SEA BREEZE DR
SANDY CT