Erosion Rate Update Study

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Summary

The determination of the long-term average annual erosion rates for the North Carolina (NC) Division of Coastal Management's (DCM) construction setback program was consistent with earlier studies used by DCM. First, the wet/dry line was used to delineate the shoreline position from aerial photography, second, the end point method was used for the rate calculations and finally, the original transect locations and original nomenclature established using the Orthogonal Grid Mapping System (OGMS) was used (Benton et al. 1997). These consistencies allow DCM to evaluate shoreline change at the same locations as those used in earlier studies.

However, several modifications were adopted in the 1998 study in order to utilize modern technology in working with aerial photography, to improve the accuracy of the results and to provide a product to DCM that is geographic information systems (GIS) compatible. Many of these methodological improvements were recommended by the NC Coastal Hazards Science Panel and were enabled by the coordinated efforts of NC DCM, NC Division of Emergency Management, NC Department of Transportation (DOT) and the NC State University (NCSU) Kenan Natural Hazards Mapping Program.

These modifications include:

1. The 1998 photo base is a set of digital orthophotos, improving the accuracy of the location of the shoreline and providing a GIS compatible data source.

2. Shoreline is delineated digitally in GIS format and is archived in a coordinate based database.

3. Digital NOS T-sheets are used for the "early date". This provides the state with a standardized early date used by other researchers and adopted by the USGS in their recent shoreline erosion studies. In addition, using the NOS T-sheets for the "early date" eliminates the problems introduced by the variable error in the early date in the COAST database as discussed in the supplementary report to the 1992 Methods Report (Benton et al. 1997).

4. T-sheets do not exist for approximately 30 miles of shoreline north of Oregon Inlet. For approximately 20 miles of this shoreline, the early date was established by rectification of the 1940 photoset using ERDAS Imagine OrthoBASE. This method of photorectification provides digitally rectified mosaiced images with continuous coverage over the project area. The accuracy of the rectified images is a function of the photo scale, the map scale and the number, distribution and quality of the ground control points used.

5. Coordinates are archived for the 1998 shoreline and the early date shoreline so that rate data associated with specific transects can be geo-referenced directly to shoreline position in a GIS.

These improvements provide DCM with a statewide coastal shoreline digital database of shoreline position and rate that represents up to date technology with respect to the use of aerial photography for shoreline change analysis. As an example, the displacement error associated with identifying the wet/dry line from the 1998 orthophotos is estimated to be 4 to 7 ft, an improvement over the 50 ft displacement error estimated for the COAST database.

DATA SOURCES

1998 Orthophotos

Orthophotos were produced for used by this project under contract between DCM and SURDEX. Accuracy standards were developed under advice from the DOT Photogrammetry Branch. The orthophoto images shall meet or exceed the American Society of Photogrammetry and Remote Sensing (ASPRS) *Accuracy Standards for Large-Scale Maps* for Class 1 Maps and well-defined points at the output scale of 1:1200. The horizontal accuracy (both x and y) for well-defined points at the 1:1200 scale is 1.0 feet limiting root mean square (RMS) error. The RMS error is the cumulative result of all mapping errors.

The orthophotos were delivered to NCSU by DCM in geoTiff format. Delivery of the orthophotos was delayed due poor quality image contrast on the beach. While some images were improved, contrast issues remained in many of the photos required that NCSU digitally manipulate the images to aid in identifying the wet/dry line. This processing was done alternatively in ERDAS Imagine and Adobe Photoshop in order to produce the best possible results.

NOAA T-sheets

Digital National Ocean Survey Topographic Surveys (NOS T-sheets) were provided by DCM to NCSU in ArcGIS format. These files were obtained by DCM from the National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC). Table 1 below provides information about the original files obtained. Individual T-sheets were grouped together by CSC into the same file as indicated by the folder name and spatial coverage in the table below. NCSU converted these files to ArcView shape files and evaluated them for use in the erosion rate project. The metadata provided by CSC was useful in this determination. The metadata included on the shoreline CDs provided by NOAA CSC details accuracy estimates relative to the digitization procedures adopted by the project as well as basic information about the T-sheets themselves.

Table 1. Original files obtained from DCM for T-sheet coverage.

Folder name	Dates of Shoreline	Approximate Spatial Coverage	Scale
cm7219	Jan 1973-Nov 1973	3 small areas around Bald Head Island, Carolina Beach, and Atlantic Beach	1:20K
cm7305	Apr 1974	most of Cape Hatteras to Cape Lookout (2 disjoint areas)	1:20K
idx126f	Jan 1933	South Carolina line through Bald Head Island	1:20K
idx134l	unknown	just south of Ocracoke through Cape Lookout	1:20K
ph45	Jan 1949-Mar 1951	Nags Head to 2 miles South of Oregon Inlet	1:20K
ph5	Jan 1946-Jul 1947	2 miles S of Oregon Inlet to Emerald Isle	1:10K
ph58	Nov 1949-Jul 1952	Emerald Isle to mid-Topsail	1:10K
ldx134k	Jan 1933-Jan 1944	Bald Head Island to Emerald Isle	1:20K
ph20	Jan 1948-Mar 1949	Pamlico Sound (no ocean front coverage)	no ocean shoreline
cs275	Jan 1942-Jan 1944	South Carolina line through Bald Head Island	1:20K

In some areas, no ocean shorelines were available while in other areas duplicate shorelines were available. Because the accuracy of the 1940s NOS T-sheets was better and because the 1940s dates were closer to the desired approximate 50-year time frame for the long-

term erosion rate, the 1930s era shorelines were not used in the erosion rate update study. Table 2 provides information on the T-sheet used in this study.

Table 2. NOS T-sheet files used in the erosion rate study.

T-sheet group name	Approximate Location
cs275	Brunswick County through Kure Beach
idx134k	Carolina Beach through mid-Topsail Island
ph58	Topsail Island through mid-Bogue Banks
ph5	Mid-Bogue Banks through Oregon Inlet
ph45	Oregon Inlet to Kitty Hawk

In addition, NCSU acquired the Descriptive Reports for various T-sheets in order to verify photo dates for certain shoreline segments. These Descriptive Reports were provided by staff at the National Geodetic Survey (NGS).

Historical photography

The 1949 NOS T-sheets used north of Oregon Inlet terminated about eight miles north of the inlet in South Nags Head. North of this area to the Virginia border, T-sheets of this time period are not available. Therefore, one task of the project was to acquire and geo-rectify appropriate historical photography for this area. Historical photography was located at the Corps of Engineers, Wilmington District, and borrowed for use on this project. Suitable photography was defined as that originating in the 1940s, having a shore parallel flight line, having a minimum of 30 percent overlap, having less than 1:24,000 scale, providing coverage in the appropriate area and not being associated with a storm. Photos taken in October of 1940 fulfilled these requirements with the exception of coverage. The 1940 photos stop about 10 miles south of Virginia requiring that additional work would have to be done to fill in a shoreline in this area. Because of the lack of readily identifiable features suitable for use as control points on the 1940 photos or the area, an intermediate set of photographs was rectified. This enabled the technician to follow features through time to determine the best possible the ground control points. The 1962 post Ash Wednesday Storm photo coverage was used for this “step-back” procedure. Though not suitable for long-tem erosion analysis, this set is ideal for assisting in determining ground control points for use in rectifying the 1940 photos.

The northernmost 10 miles of shoreline was not covered by either the NOS t-sheets or the 1940 photos. While the 1962 photos did extend through this area, an examination of the rectified images confirmed that the post-storm shoreline was not suitable for the long-term shoreline erosion rate update. Therefore, on consultation with DCM staff, the determination was made to use the COAST data for this small stretch.

Procedures

Photo rectification procedure

In this study, IMAGINE OrthoBASE Pro was used to process the historical photography for the study area north of Oregon Inlet. This software proved to be useful in dealing with historical photos on the coast of NC in an unfunded study undertaken in the NCSU-Kenan Natural Hazards Mapping Program (Zink, 2002). IMAGINE OrthoBASE is a Window's based digital mapping software package by ERDAS that handles complex photogrammetric procedures enabling the orthorectification of images. These procedures represent tremendous improvement over simple "rubber-sheeting" algorithms used in the earlier erosion update studies. Images rectified using "rubber-sheeting" algorithms have non-uniform horizontal accuracy and are not geometrically precise. Fully orthorectified images, or orthophotos, are images that have been corrected for scale variation, airplane tilt, radial lens distortion and relief displacement. Because elevation data for the 1940 and 1962 aerial photosets are not available, only the first three sources of photogrammetric error were corrected. However, the terrain within the study area (exclusive of Jockey's Ridge and the Kill Devil Hills area) is relatively flat; therefore, relief displacement was determined to be a minimal problem.

First, each 9"x9" aerial photos was scanned at 1200 dots per inch (dpi) or 21.667 μm (microns) using an EPSON Expression 1640XL flatbed scanner. Table 2 lists the photo date, photo scale, the equivalent ground coverage size of each for each of the photo sets used in processing the mosaics in this study. The 1998 orthophotography, which was used as ground control for the 1962 photos, is included for comparison.

Table 3: Photos used in creating 1940 Mosaic

Photo Date	Photo Scale	Ground Pixel Coverage
June-August 1998	1:7200	0.5 ft
March 14, 1962	1:9600	0.667 feet
October 21, 1940	1:24,000	1.667 feet

OrthoBASE Pro requires camera information in order to compute the interior orientation (photo coordinate system) for each of the scanned photos. Since no camera information was available, a focal length of 6 inches (152.4 mm) was specified for both the 1962 and the 1940 photography as it was an industry standard used during the historical time frame when the photographs were taken. In addition, fiducials (marks visible in the border area of the photos) are intended to be used in the computation of the interior orientation. However, the fiducials had previously been trimmed off the 9x9's acquired from COE. Therefore, an alternative procedure of back-calculating the interior orientation using an assumed camera focal length and a pixel size of the scanned images was adopted.

A minimum of two manually selected tie points (corresponding image positions on two or more photos) for each area of overlap were determined. Once these manually selected points were determined, OrthoBASE Pro generates additional tie points automatically. Approximately 50 points are preferred to process the photos. The number of resulting tie points depends on the photo quality and the amount of overlap. Additional manual tie points are determined when necessary.

Photogrammetric procedure specifies that two well-distributed ground control points are chosen for every third image in a strip of adjacent images. Ground control points were determined by establishing photo-identifiable features common to both the 1998 and 1962 photography and the 1962 and 1940 photography. Suitable points for ground control included road intersections, piers, and corners of structures at ground elevation. When no other points were available, stable points on the estuarine shoreline were chosen.

The next step is to run the triangulation procedure on the entire strip of images to model and estimate the exterior orientation parameters for each image. Following the acceptance of a triangulation model, a transformation equation is applied to the images and each photo is

calibrated to save the absolute orientation information with each digital image. The calibrated digital images were then mosaicked into one continuous image. This image was then broken into smaller files to reduce the file size for archival purposes.

Shoreline Identification

The 1998 shorelines were digitized in ArcView using the 1998 orthophotos. Identification of the photo identifiable feature that represents the shoreline proved to be more time-consuming than anticipated. Previous studies worked from 1:4800 photo enlargements printed on mylar. The wet/dry line (feature that appears to be contrasted in the photo as wet and dry sand) was drawn and digitized. The map scale of the 1998 orthophotos is 1:1200 providing four times the detail on the beach face. In addition, the ability to infinitely scale the photo and to modify the contrast allowed the visualization of many more lines of contrast on the beach as compared to what could be visualized in the 1:4800 enlargements. In order to systematically examine the orthophotos to determine the shoreline position, the following procedure was adopted. The photos were digitally displayed at 1:600 while digitizing. In order to "error check" difficult shorelines, alternate views at 1:1200 (the print scale) and 1:4800 (the print scale of the 1992 erosion rate study) were displayed to review the interpreted shoreline. In some cases, particularly on narrow steep beaches, the contours were displayed as well to visualize the "shoreline" relative to elevation features.

Transect Locations

The Orthogonal Grid Mapping System (OGMS) was established by Dr. Robert Dolan in his early shoreline change studies (Dolan, Hayden, and Heywood, 1978) using USGS topographic quadrangles and enlarged to 1:5000 scale to provide a series of base maps along this shoreline. A set of basemaps and transects were developed for NC under contract with Dolan in the first long-term erosion rate study. The locations of the basemaps were recorded by digitizing the corners of the basemaps, however, transect location and shoreline position was not recorded in a coordinate-based database. In order to provide to DCM data consistent with these earlier studies, transect locations have been established using notes provided from earlier erosion rate update studies and coordinate geometry. Because these transects did not exist in a coordinate database prior to this study, absolute verification of location is not possible. However, the transect locations used in this study are consistent with those used in 1992 study contracted with NCSU because similar methodologies were used to compute locations.

The OGMS has served NC well through the last four erosion rate updates. The OGMS system was developed such that basemaps were essentially shore parallel and transects were shore perpendicular. Each basemap is 3600 m in length with 72 transects 50 m apart. At the time of the original study, Dolan established "good" and "bad" transects to delineate which transects should be used in the overlap area of each basemap. Further, DCM has rejected the use of data from transects near inlets in which the shoreline orientation deviates significantly. For the most part, these general criterion are still met. However, near rapidly changing shorelines such as capes and inlets, better data may be captured if new transects are established meeting the shore perpendicular criterion. In addition, some shorelines have accreted significantly such that transects needed to be extended seaward of the original location in order to intersect with the shoreline. Working in a digital GIS environment enables the use of transects grouped in segments either shorter or longer than 3600 m using variable angles and variable lengths which can be visually checked for accuracy and relevance.

Shoreline Change Rate Calculations

Rate Calculations

The procedure for determining the raw shoreline change rates is as follows.

1. Open the 1998 shoreline shapefile and the transect shapefile.
2. Use the script named *polyint2pnt*, Table 4, to determine the coordinates of the intersection of the transect with the shoreline.
3. Use the script named *addxy***,** Table 4**,** to add coordinates to the attribute table of the intersection point shapefile.
4. Save the intersection coordinates to a *.dbf file.
5. Bring the *.dbf coordinate file into Excel.
6. Repeat steps 1 through 5 using the early date shapefile.
7. Calculate the distance between the two intersection points using the following formula:

$$dist = \sqrt{\left(x_{98} \_ x_{early}\right)^2 + \left(y_{98} - y_{early}\right)^2}$$

where x and y are the coordinates of the intersection points.

8. For each transect, determine the correct date for the 1998 orthophotos and enter data into a column in Excel.
9. For each transect, determine the correct date for the early date used and enter data into a column in Excel.

10. Calculate the change in date by subtracting the two dates in excel (the number of days will be computed) and dividing by 365.25 (to convert from days to years and to account for leap years.)
11. Compute the shoreline change rate by dividing the dist computed in step 7 by the change in time computed in step 10.
12. Compute the orientation of the shoreline and determine if the shoreline change rate is positive (erosion) or negative (accretion).
13. Multiply rate by +1 for erosion and -1 for accretion.
14. Set the format to 1 decimal place to display rate.

Table 4. ArcView scripts used to determine intersection coordinates.

Name	***Type***	***Creator***	***Source***
polyint2pnt	Avenue Script	Dirk Vandervoort May 12, 1999	Environmental Systems Research Institute (ESRI) ArcScripts website <http://arcscripts.esri.com/>
AddXY	Avenue User Extension	Zachary L. Stauber May 4, 2000	Collection of ArcView Extensions <http://horta.ulb.ac.be/cours/sis/SeqTraitement/ExtensionsAV/extensionsAV.htm >

Smoothing

The procedure for spatially smoothing the rate data is a simple moving average or running mean techniques described by Davis, 1973. For shoreline segments consisting of at least 17 transects (approximately 0.5 miles), an average is calculated for the 17 transects and centered on the ninth transect. This spatially averaged valued is the “smoothed” rate. In the vicinity of inlets, the number of transects used in the average is decreased by two (dropping one from each side of the centered calculation) until the end transect is reached. The last value is calculated by taking the weighted average using the last two transects $(2*T_1+T_2)/3$ where T_1 is the last transect before the inlet and the T_2 is its neighbor.

The use of 17 transects was established in earlier studies following the work of Dolan, 1968 and Davis, 1978. They note that cusps and other similar features range in size from 1.5 meter to 1500 m. Using 17 transects filters these small scale dynamic shoreline phenomena.

Figure 1 below illustrates the impact of the smoothing procedure on the raw rates. The largest differences between the smoothed and raw rates are in the regions of rapidly changing rates, e.g., near Ocracoke Inlet. For the more gradually varying rates, the difference between raw and smooth is about +/- 1 ft/yr.

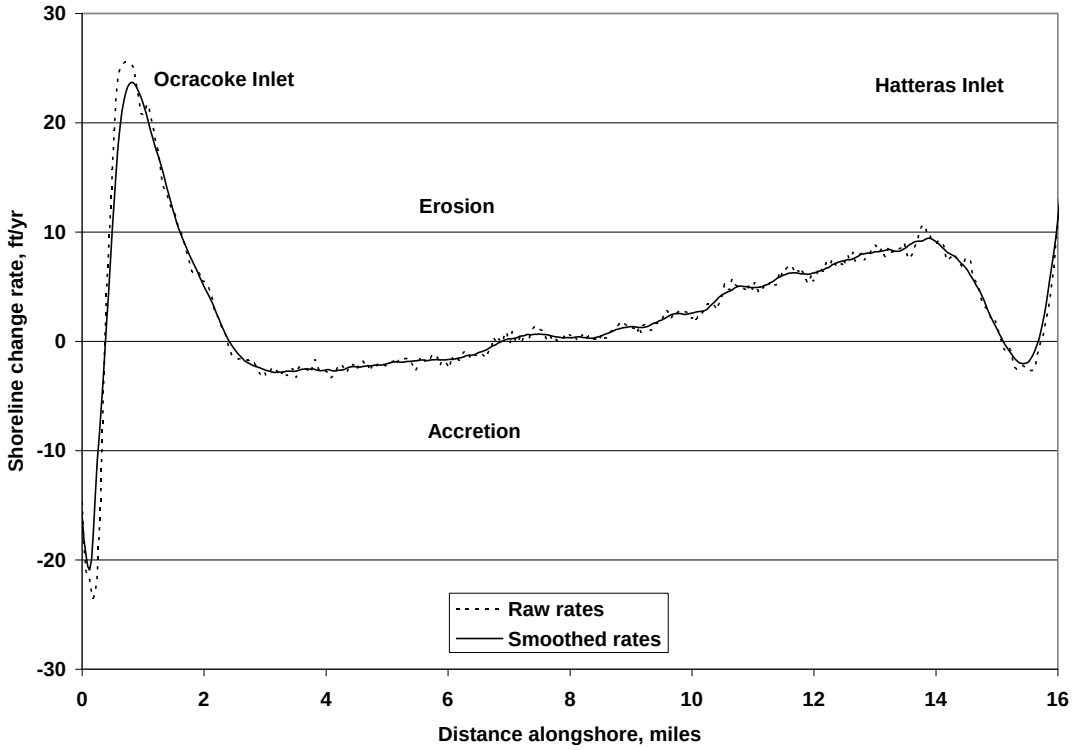

Figure 1. Raw and smoothed shoreline change rates on Ocracoke Island.

Blocking

Blocking procedures have been established by senior staff at DCM. The procedures itemized below represent refinements and clarifications of procedures established and used in all the previous studies. In many cases, procedures are specified using quantitative requirements that allow for increased repeatability of results. The blocked rates are reviewed and corrected using "expert judgment" improving determinations made by blind calculations. In this manner the final client, the property owner, is best served.

1. Erosion rate segments must be at least eight transects long (approximately one-quarter mile).

2. Segments that have accreted or have erosion rates less than 2 ft/yr are assigned a value of 2 ft/yr erosion factor.

3. The actual rate boundaries fall at an unknown location between transects spaced every 50 meters along the oceanfront shoreline. In determining the transect to use for a rate boundary, always slide the lower blocked rate toward the transect with the higher erosion rate value

4. One foot intervals are preferred for rate block boundaries.

   (a) However, a 1/2 foot rate interval is appropriate for a rate "hilltop" where the maximum value on the "hilltop" does not reach the next full number erosion rate.

   (b) A 1/2 foot rate interval is also appropriate for short blocks (8 to 10 transects) where the average value for the short block is closer to the 1/2 foot rate value than the nearest whole foot interval.

5. When a rate "hilltop" is approached which requires use of minimum eight transect average block values, the hill must be approached using this method from both down-coast of the "hilltop" and up-coast of the "hilltop". If adjustments must be made to fit the data, the adjustment should be made to the "hilltop" and immediately adjacent blocks.

   (a) If a rate data “hilltop” has less than 8 transects when approached from both up and down coast, use the unidirectional average both up and over the hilltop.

   (b) In the case of a 5a procedure, if the smoothed value of the last transect is less than the adjacent erosion rate segment value, use the value for determining the average erosion rate in its 8 transect segment but include it with the adjacent lower erosion segment.

6. When delineating a rate boundary on large-scale photo base maps, always slide the boundary toward an apparent property boundary in a direction that

the lower rate is expanded toward the higher rate (give the property owner the benefit of the doubt).

Figure 2 below illustrates the use of these blocking procedures on the Ocracoke data. The blocking procedure captures the variation in rate while meeting the management goal of having common rates among property owners within specified distances. In addition, this figure illustrates the portion of the island that is has a less than 2 ft/yr erosion rate, but that is blocked at 2 ft/yr. Finally, the application of the blocked rate into the Inlet Hazard Area is also illustrated.

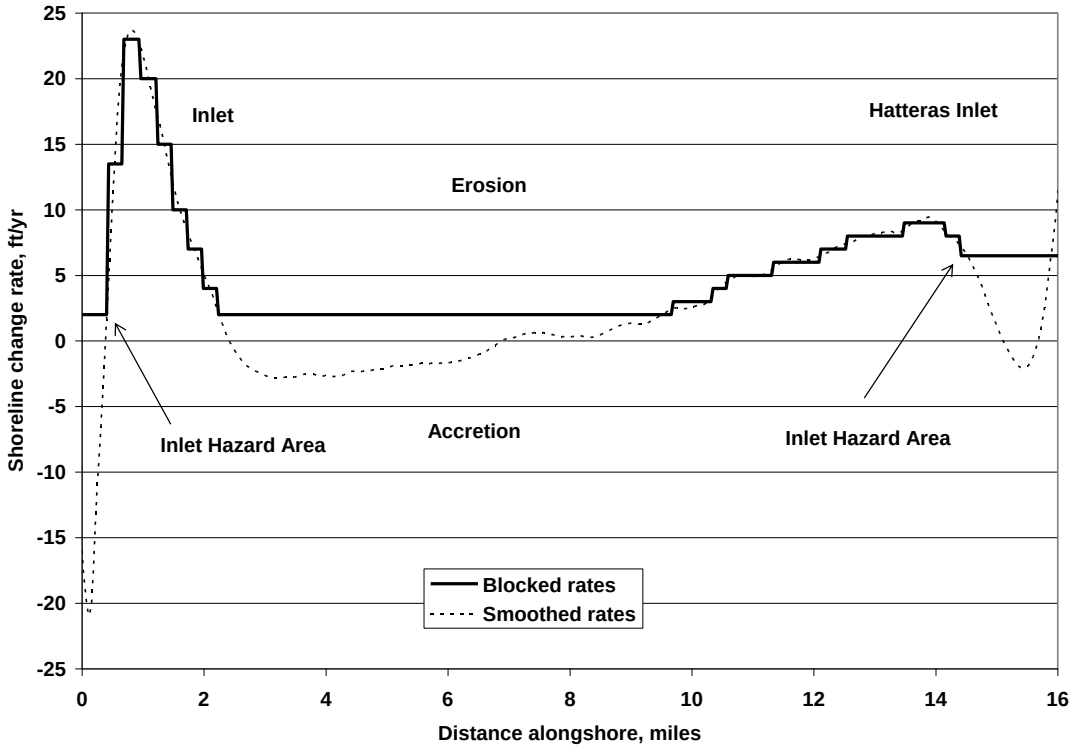

Figure 2. Blocked and smoothed shoreline change rates on Ocracoke Island.

Results

The statistics of the blocked rates as computed in the earlier studies have been computed for the 1998 study. These data are presented in Table 5 below.

These data can be compared to the data presented in the 1992 Methods Report (Benton, et al. 1997) Table 6. However, these should be used for rough qualitative comparison only. They cannot be compared directly because (1) there is a difference in the miles of shoreline in each study (probably due to approximations made near inlets and capes), (2) the early date is not the same in the two studies and (3) refinements have been made in the blocking methodologies that may impact the statistics below. Better comparison can be made if these factors are taken into account; however, such analysis is beyond the scope of this study.

Table 5. Summary of 1998 shoreline change.

	South facing	East Facing	Total
Miles	96	216	312
Accretion	37 (39%)	62 (29%)	99 (32%)
<2 ft/yr (including accretion)	69 (72%)	124 (58%)	193 (62%)
2-5 ft/yr	14 (14%)	50 (23%)	64 (20%)
5-8 ft/yr	9 (9%)	19 (9%)	28 (9%)
>8 ft/yr	5 (5%)	22 (10)	27 (9%)
Maximum rate	23 ft/yr	30 ft/yr	30 ft/yr
Mean rate	3.9 ft/yr	4.4 ft/yr	4.3 ft/yr

Table 6. Comparison of the 1998 summary to the 1992 summary.

	1992	1998
Total Miles	281	312
Accretion	79 (26%)	99 (32%)
<2 ft/yr (including accretion)	165 (59%)	193 (62%)
2-5 ft/yr	54 (19%)	64 (20%)
5-8 ft/yr	30 (11%)	28 (9%)
>8 ft/yr	32 (11%)	27 (9%)
Maximum rate	16 ft/yr	30 ft/yr
Mean rate	3.8 ft/yr	4.3 ft/yr

Comments and Recommendations

Delineating a shoreline position for the early date remains problematic for DCM. While the use of the T-sheets brings to the coastal management program a shoreline position that is endorsed by other researchers and is used by federal agencies, there remains a debate in the literature on how the T-sheet shoreline compares to the photo-interpretation of the wet/dry line used in the modern date. In addition, the T-sheet does not provide a photobase map for the shoreline position that could be used to highlight other geo-morphological changes. It is recommended that DCM work to acquire the historical photos associated with the development of the T-sheets and geo-rectify them using photogrammetric standards for two-dimensional rectification as discussed above. In some cases, the Descriptive Reports associated with the NOS T-sheets may also provide elevation data to be used for three dimensional ground control points, information required to create fully rectified orthophotos. With these mosaics, DCM could answer questions relating to the whether the wet/dry line is a like photo-identifiable feature as delineated by the T-sheet. Furthermore, other geo-morphological features could also be used in future studies.

The wet/dry line as a delineation of the shoreline represents a best estimate of shoreline position when the data source for shoreline interpretation are limited to aerial photographs. Photo-identifiable features are often argued to represent the high water line (HWL) or the mean high water (MHW) (Pajak and Leatherman, 2002). However, these interpretations are highly dependent on variations in photo scale, quality of image contrast, mineralogy, sedimentology, geomorphology, tide and wind/wave conditions at the time of the photograph (Fisher and Overton, 1994). In addition, coastal engineers and scientists are escalating the debate of “what is the shoreline?” as remote sensing technologies and three dimensional visualization techniques have greatly improved our ability to map the coastal environment (Overton and Fisher, 1996 and Stockdon et al., 2002). Therefore, we recommend that DCM explore the use of these alternative technologies in future updates. Datum-based shorelines are rapidly becoming the standard in defining shoreline position (though which datum is still being debated). While issues of merging two-dimensional and three-dimensional data sets exist, the problems posed are not insurmountable (Judge et al., 2001).

While future shorelines may be delineated from technologies not represented in this study, the capture of historical shorelines will always depend heavily on the use of historical aerial photography. In addition to rectifying the early date for the end point calculations used to capture the long term annual average erosion rate, we recommend that temporally variable shorelines are developed from geo-rectified photography using photogrammetric grade software. Once a

suitable database is acquired, we recommend that DCM explore the use of alternative analysis in determining the rate used for management purposes. A review of current literature reveals a robust debate on analysis techniques to deal with predictions (e.g., Douglas et al. 1998, Douglas et al. 2000, Douglas et al., 2002, Fenster et al. 2001, and Honeycutt et al., 2001). Examples of alternative analysis include linear regression with prediction intervals over the long term (50 years or more) as well as a comparable analysis of short-term rates (10-20 year period).

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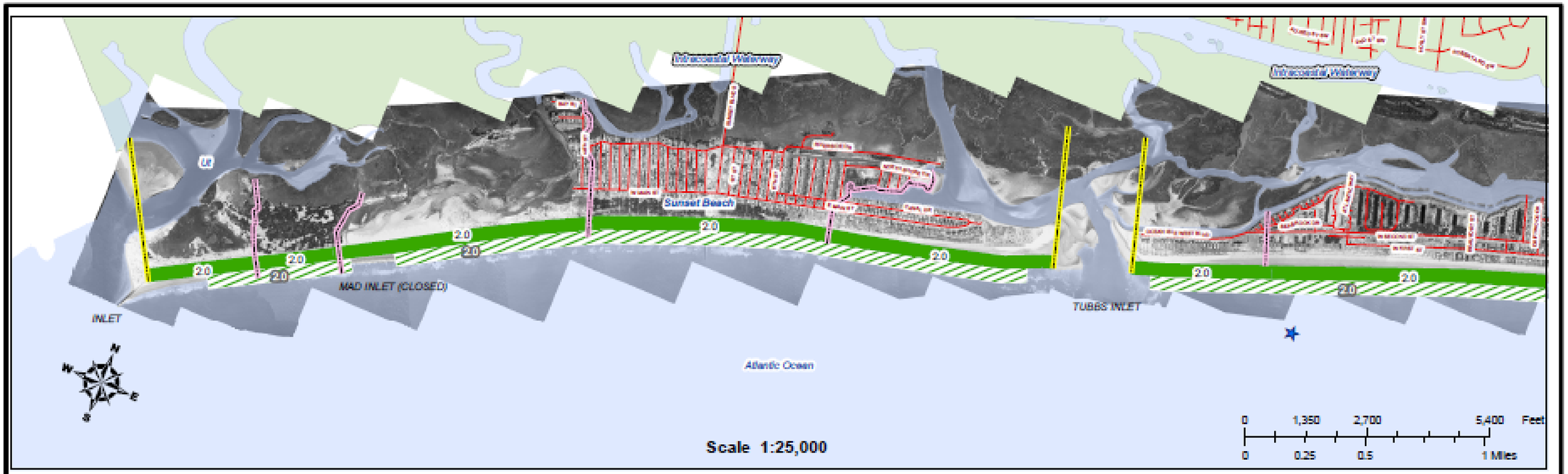
APPENDIX A. Oceanfront Erosion Rate Setback Factor Maps Prepared by the North Carolina Division of Coastal Management (DCM)

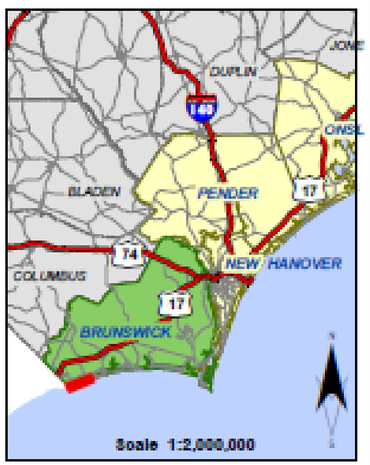


Sunset Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

This map is for general information only. The map illustrates average rates of shoreline change over approximately 50 years. The information presented here is not predictive nor does it reflect the short-term erosion that occurs during storms. This map may not be suitable for property-specific determination of erosion rate factors due to its small scale. For a site-specific determination contact your CAMA Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

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1998 Long-term average annual shoreline change rate developed by:

NC State University's Kenan Natural Hazards Mapping Program and North Carolina Division of Coastal Management

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1638 Mail Service Center
Raleigh, NC 27699-1638
(919) 733 – 2293

Or visit:

www.nccoastalmanagement.net

How to read Erosion Factors

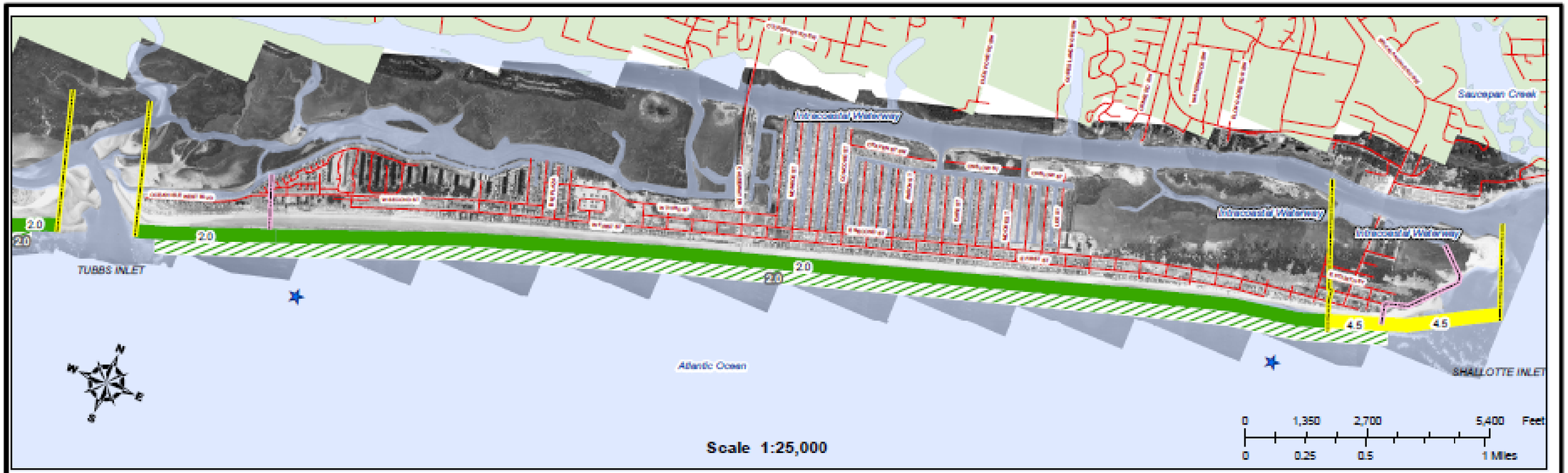
2.0 → "2.0" Indicates a 1998 Erosion Factor of 2.0 Feet / Year

2.0 → "2.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
★ This general area has been influenced by beach nourishment either for beach protection or dredge disposal. This action artificially lowers the erosion rate in this area.

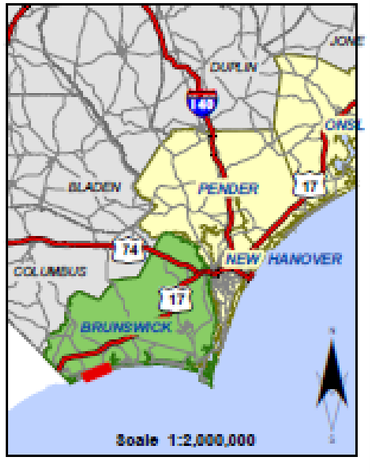


Ocean Isle

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

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How to read Erosion Factors

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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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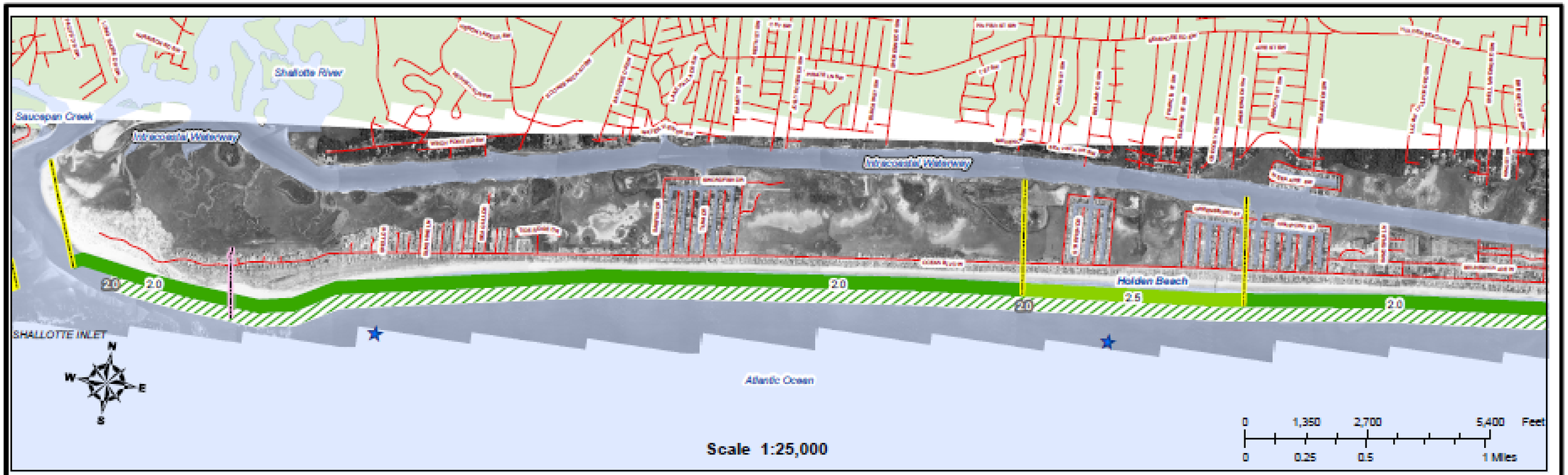
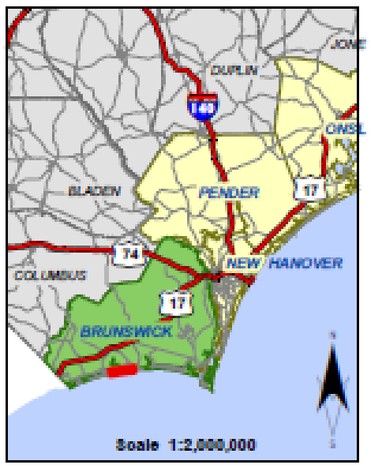


Holden Beach - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Legend

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2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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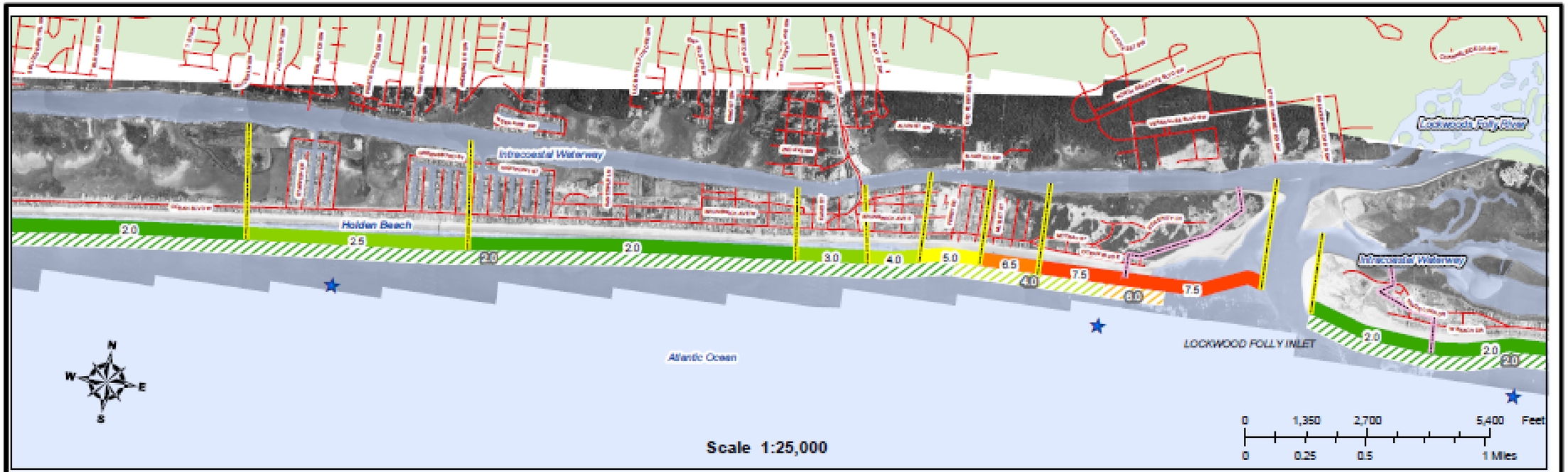
NC Division of Coastal Management GIS - Printed: April 2005



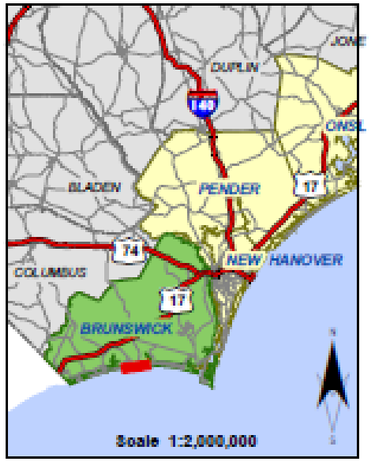
Scale 1:25,000

Holden Beach - East

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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Legend

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2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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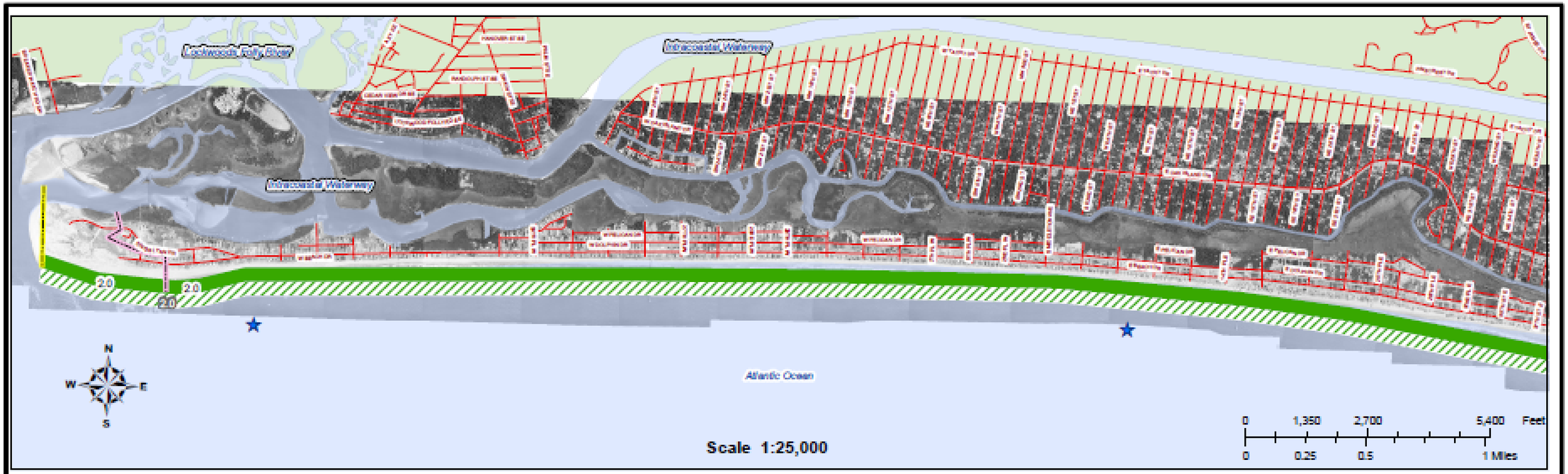
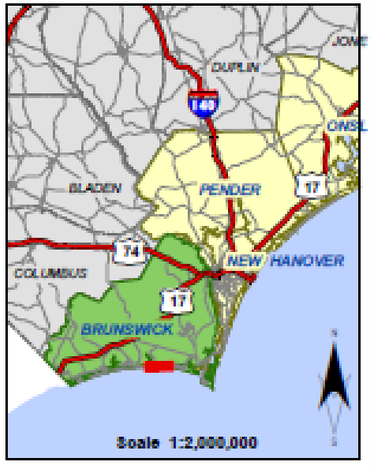


Oak Island - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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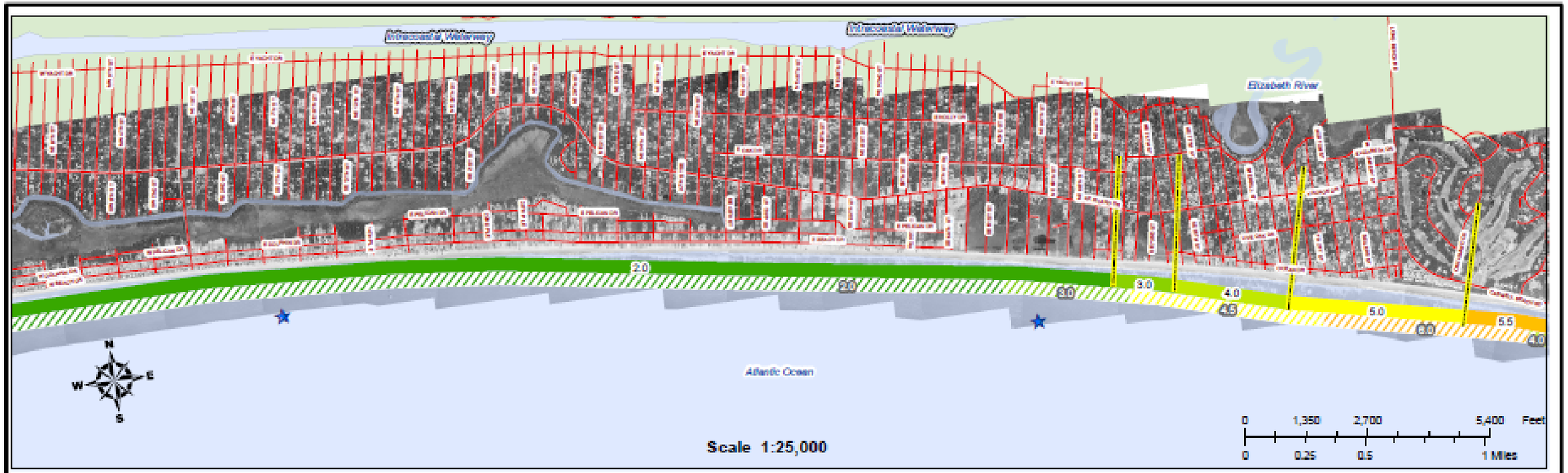
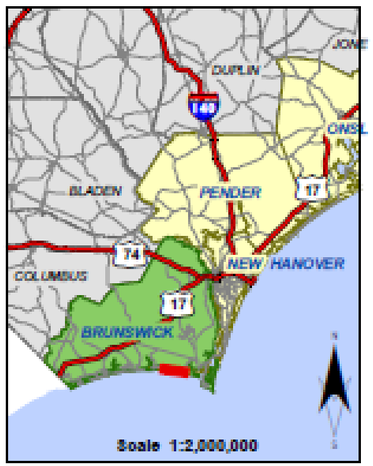


Oak Island - Central

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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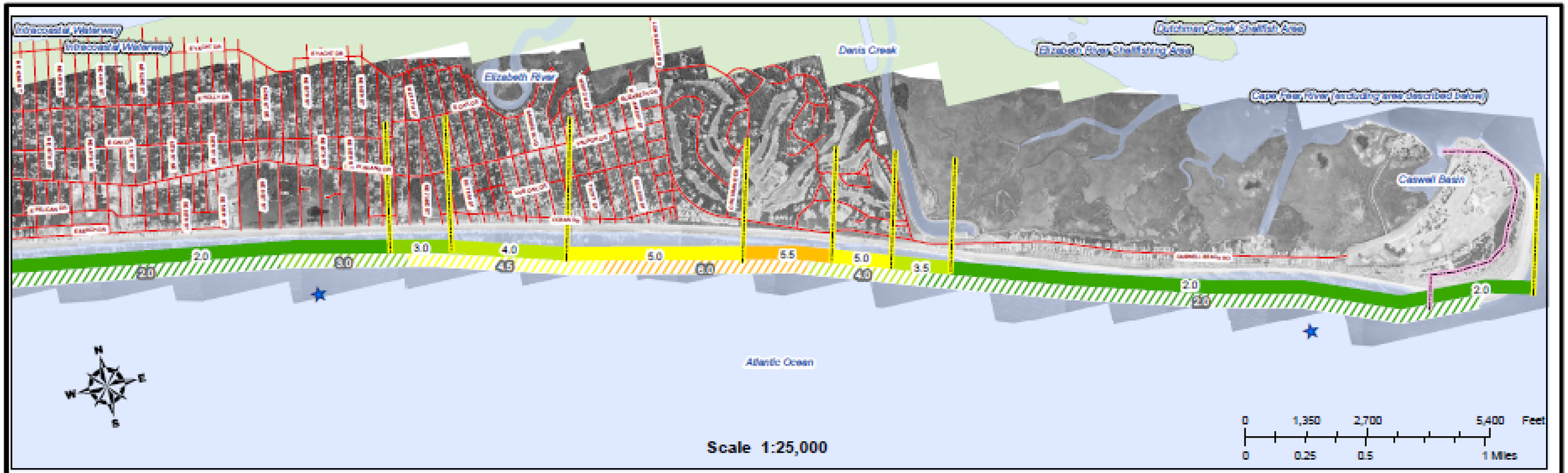
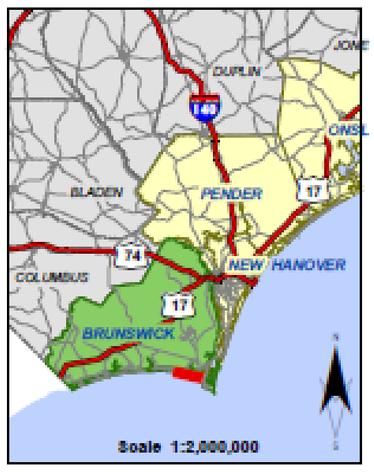


Oak Island - East

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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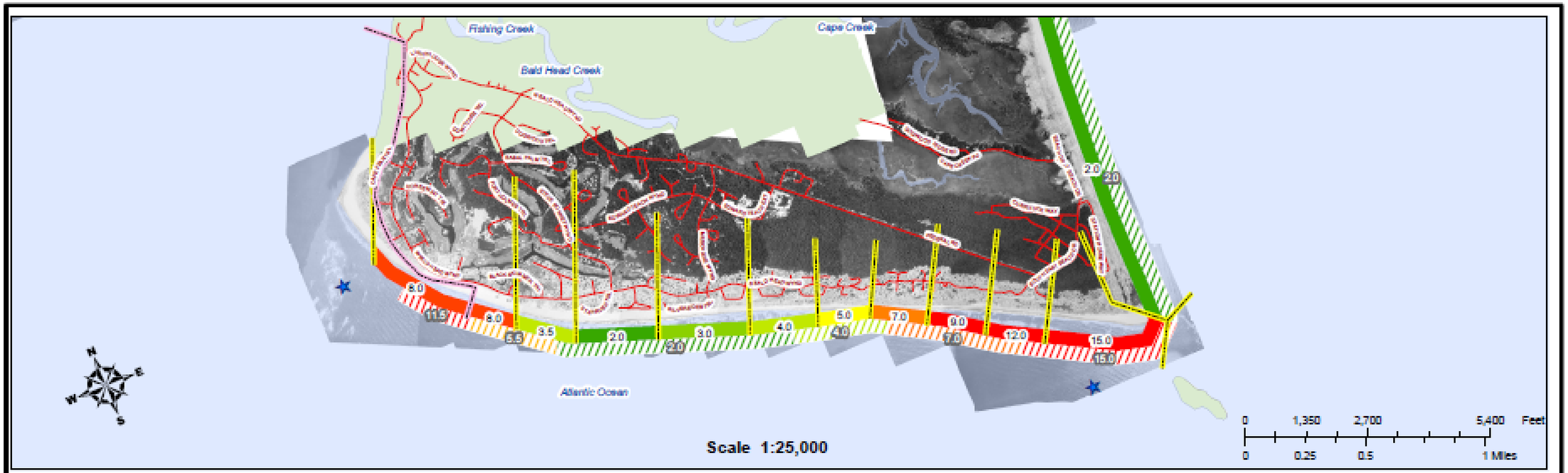
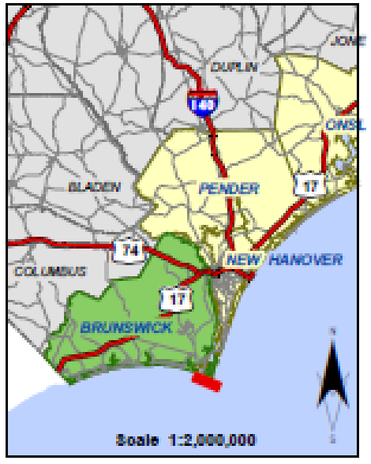


Bald Head Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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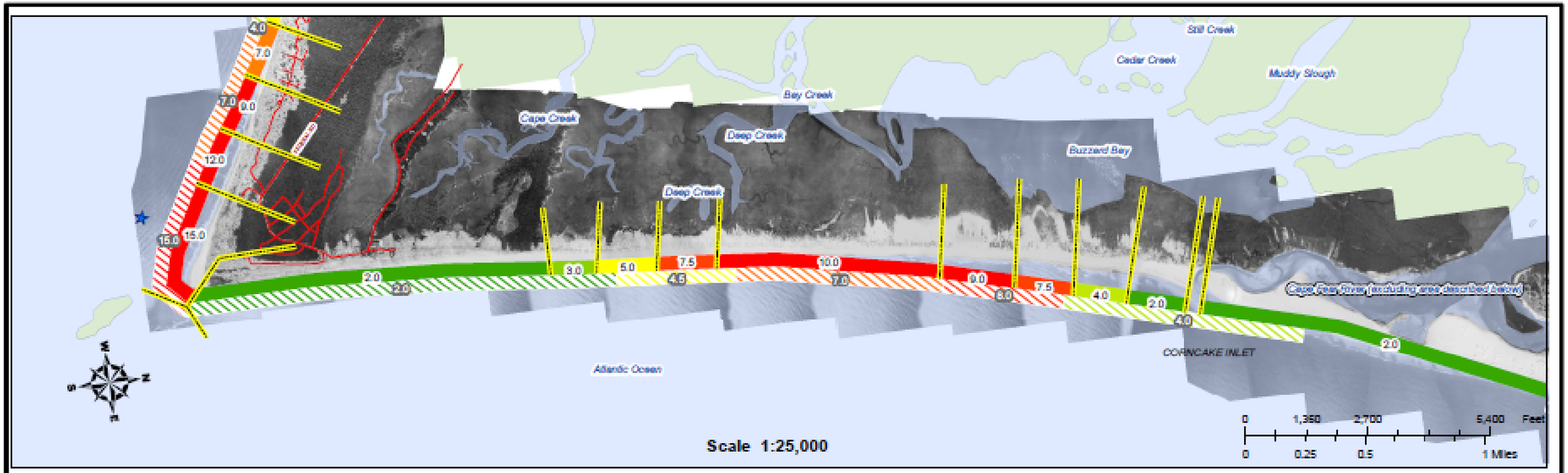

Cape Fear

Long-Term Average Annual Shoreline Study & Erosion Factors

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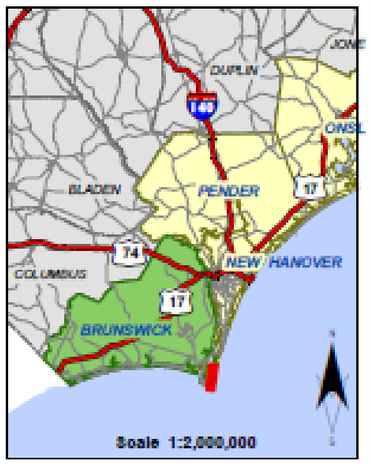
Regional Map



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Legend

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2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
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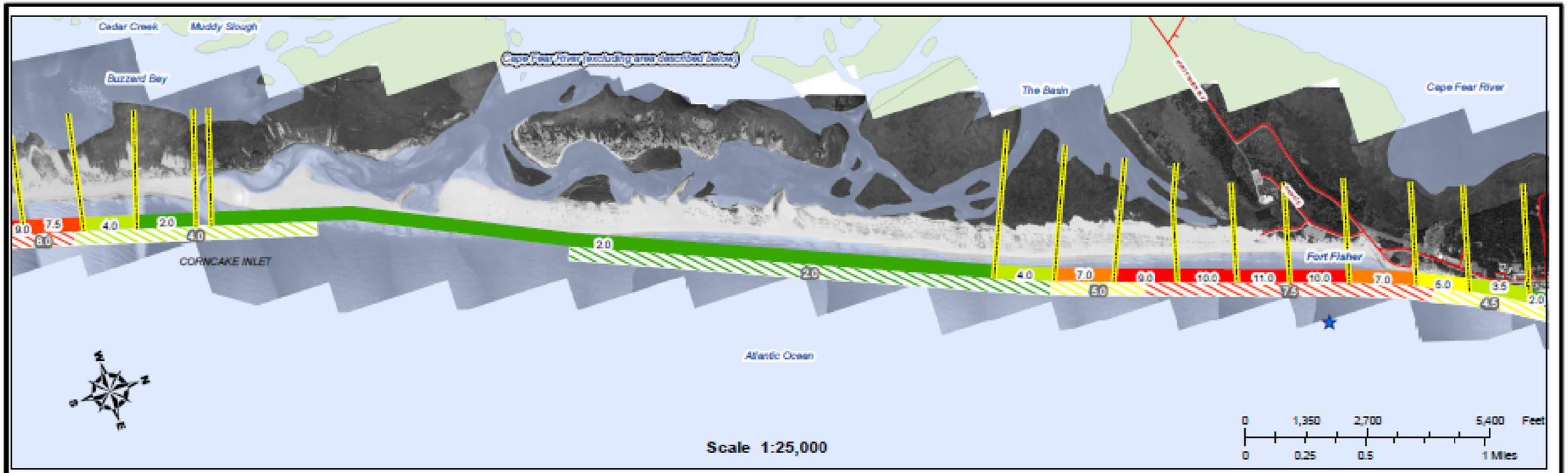
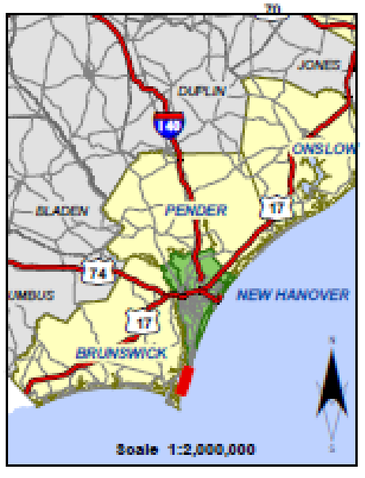


Zeeks Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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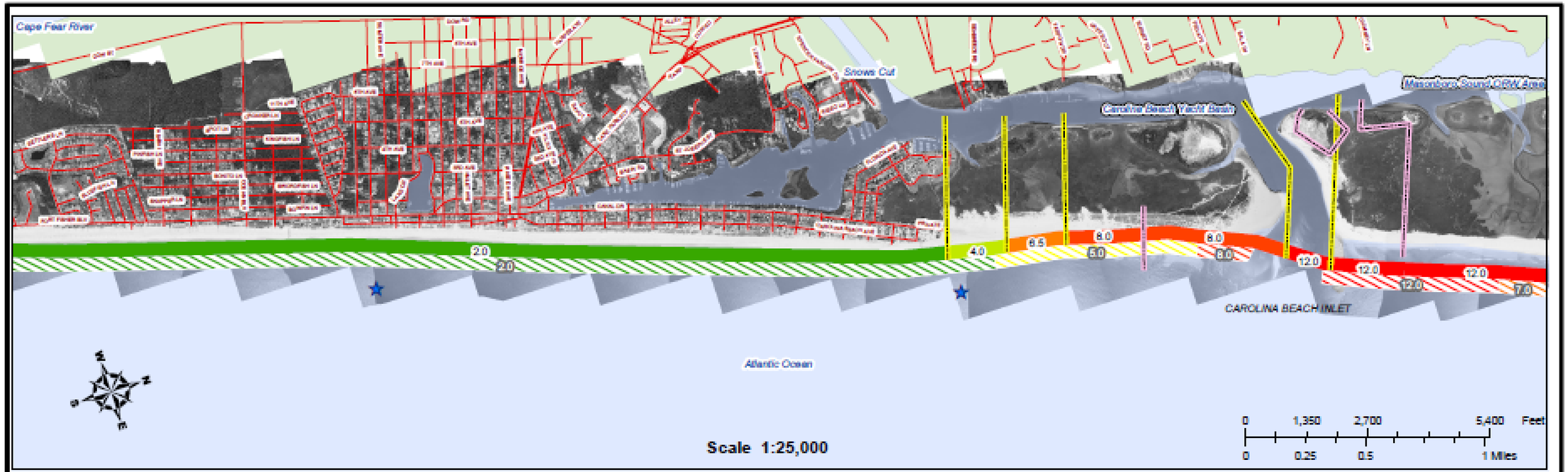
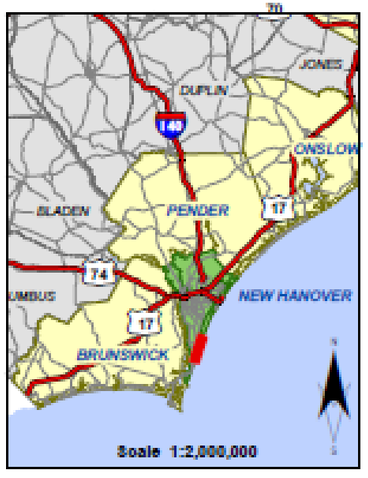


Carolina Beach - North

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

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Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
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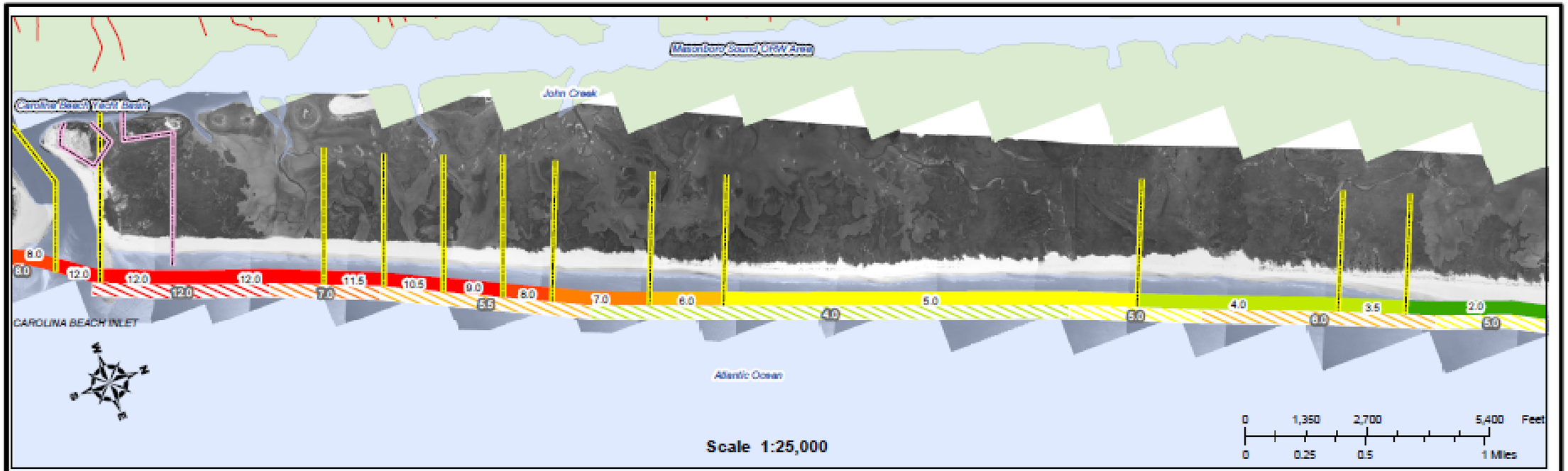
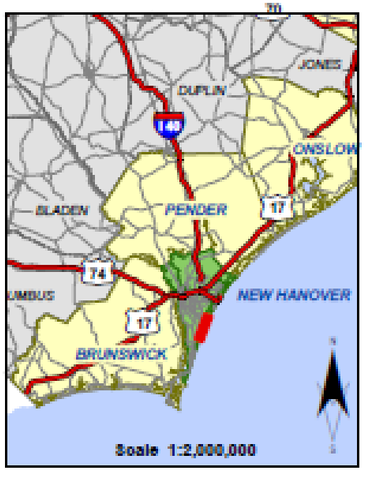


Masonboro Island - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

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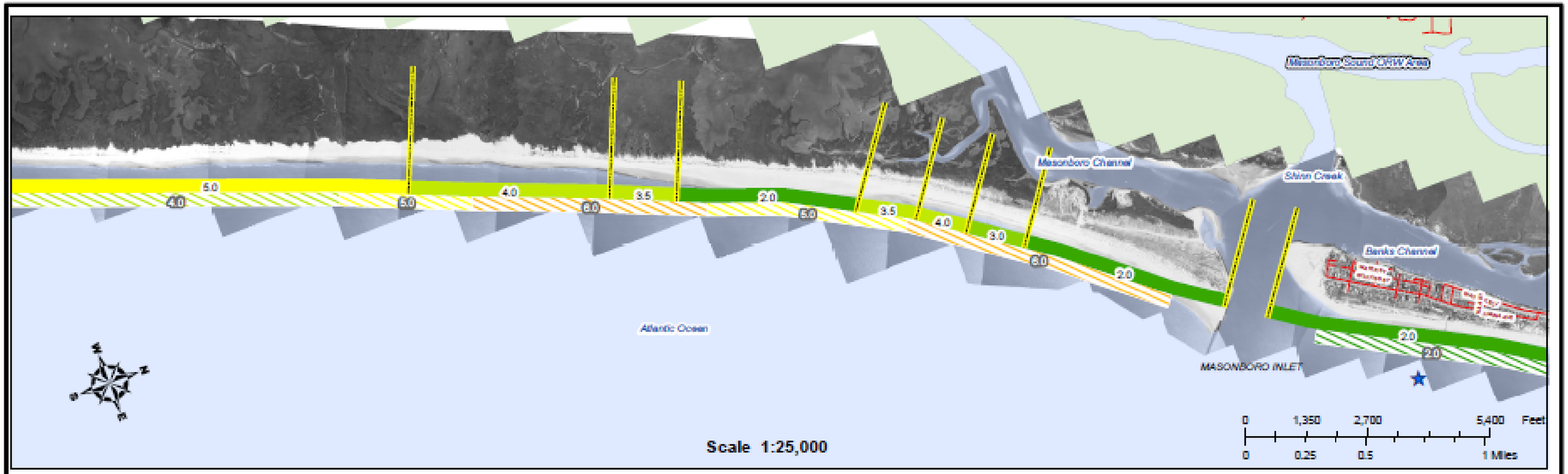

Masonboro Island - North

Long-Term Average Annual Shoreline Study & Erosion Factors

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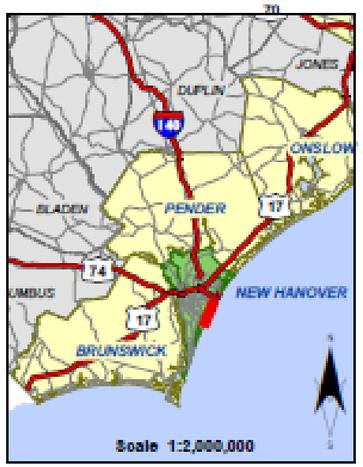
Regional Map



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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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Roads
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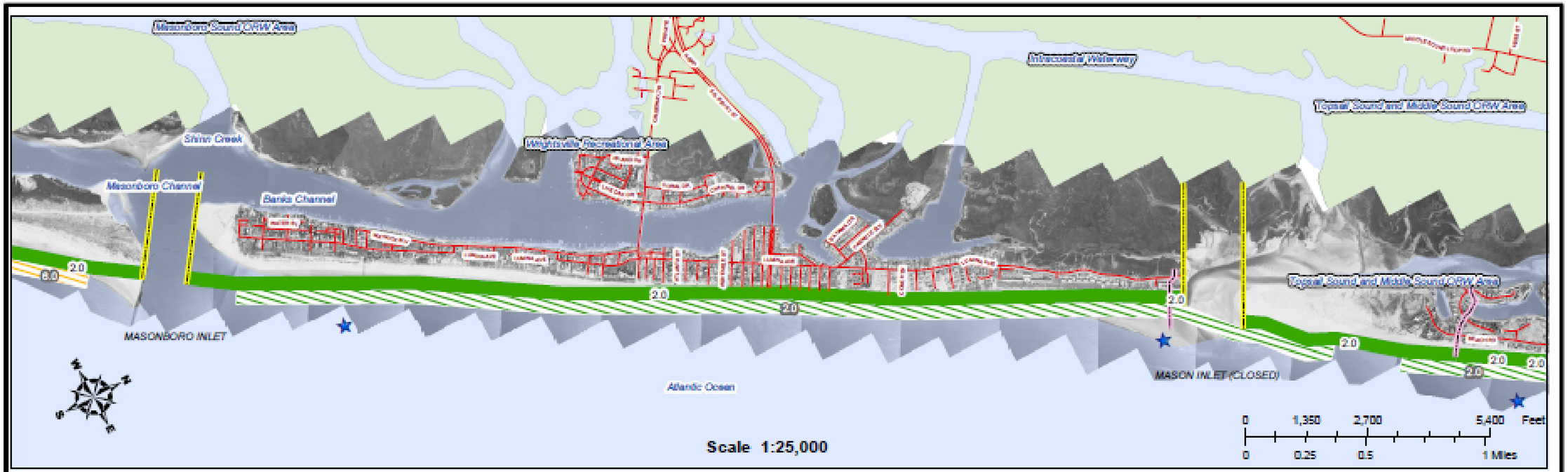
NC Division of Coastal Management GIS Group, April 2005

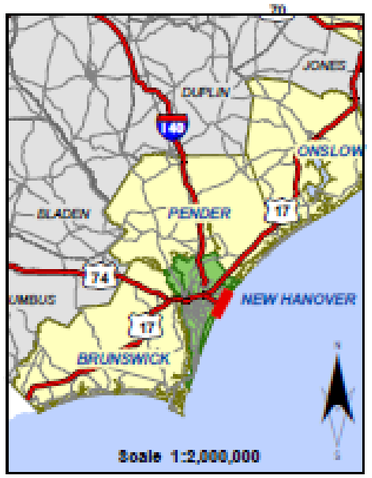


Wrightsville Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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NC Division of Coastal Management GIS - Printed: April - 2008

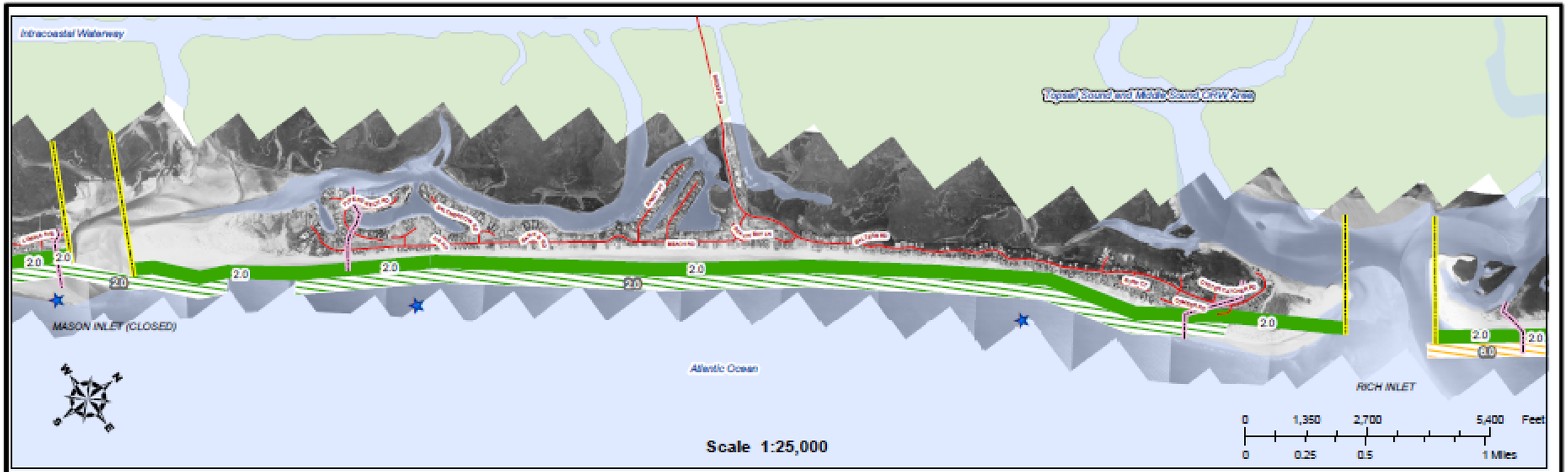
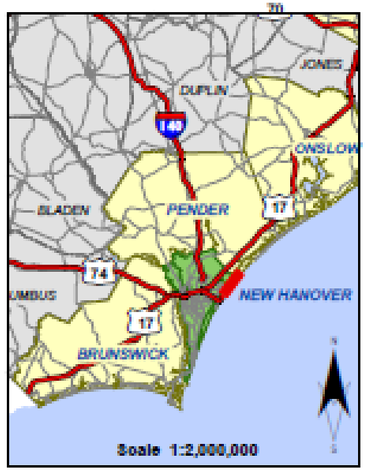


Figure Eight Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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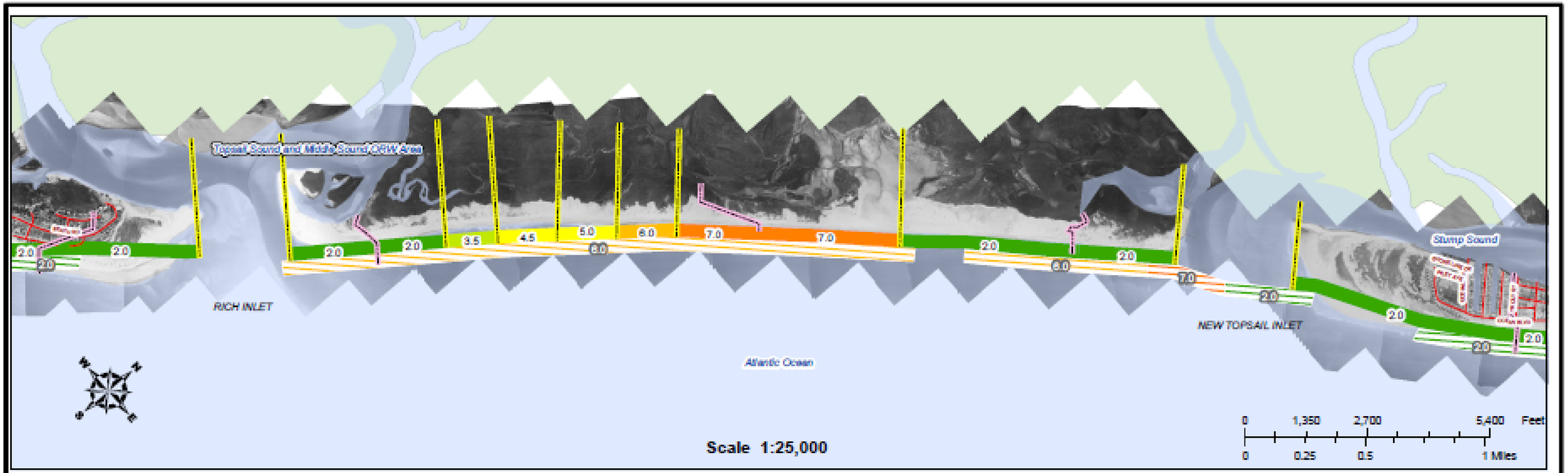
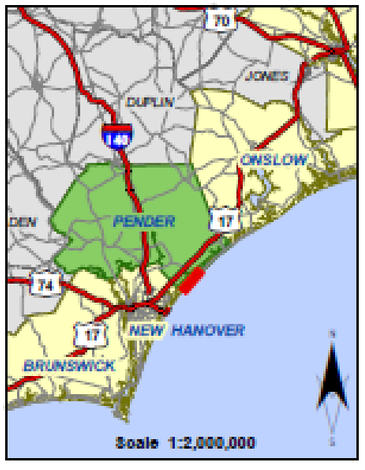


Hutafs Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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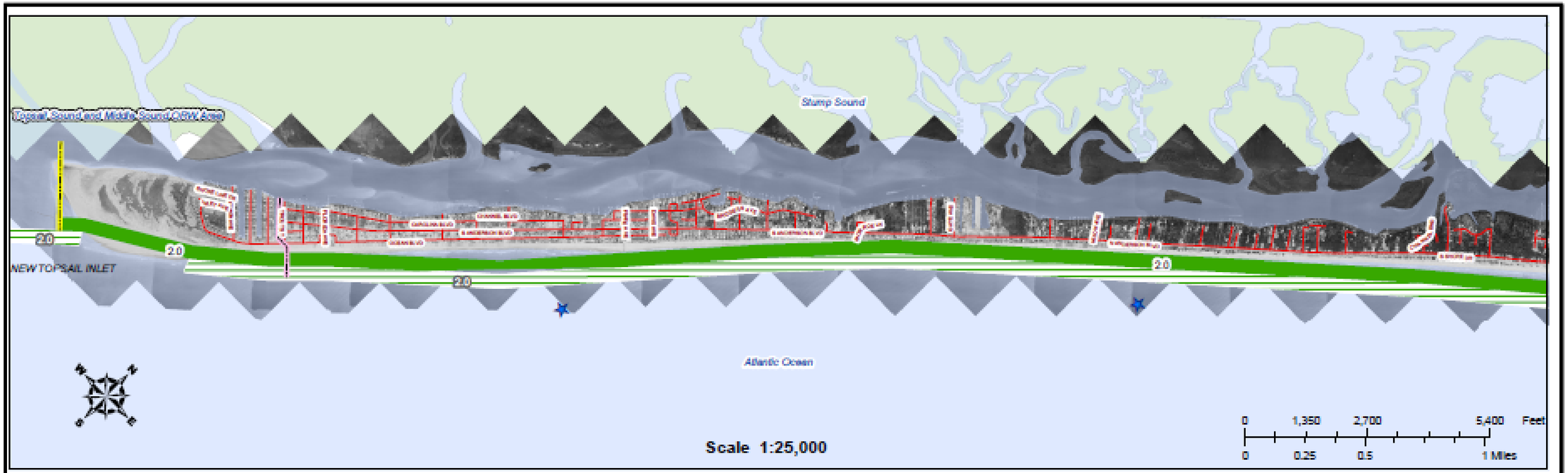
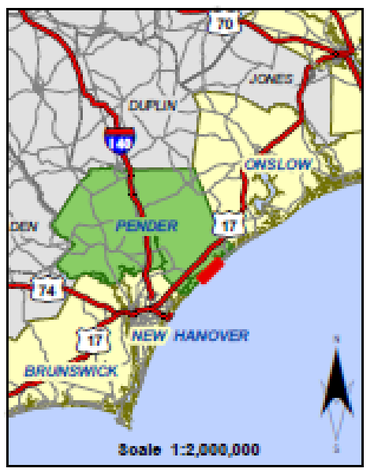


Topsail Island at Topsail Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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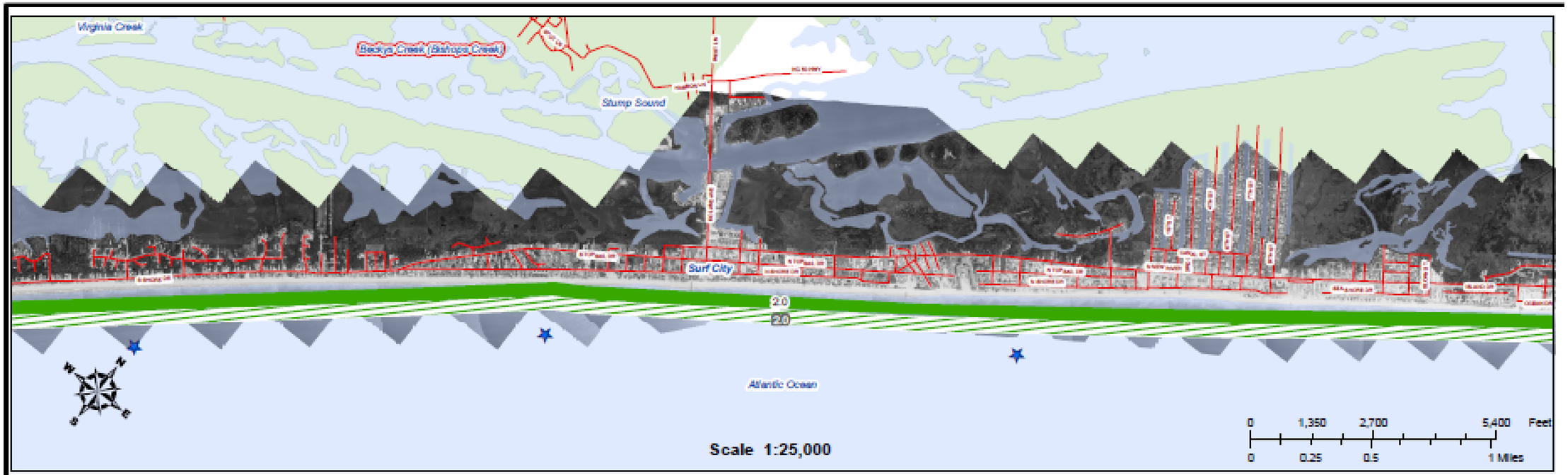
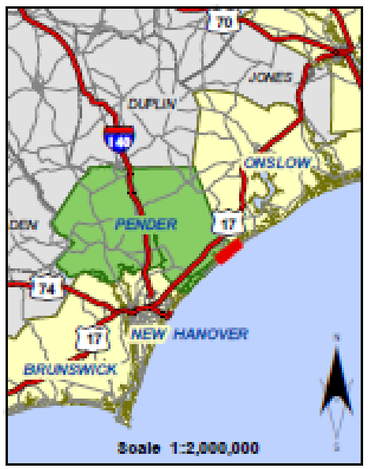


Topsail Island at Surf City

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
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7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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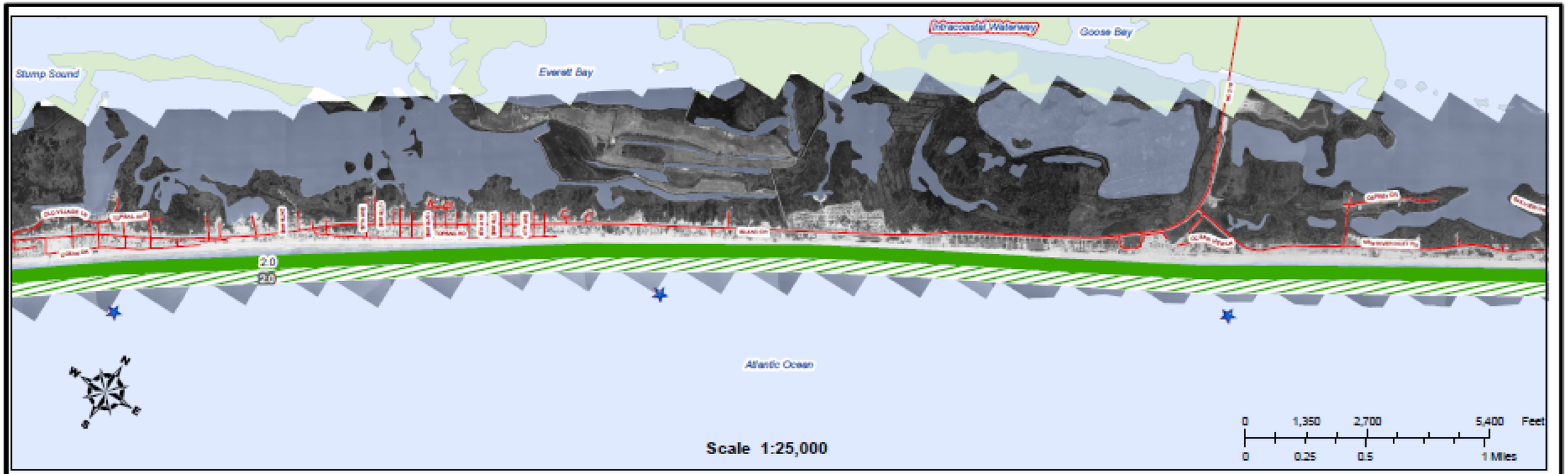

Topsail Island at North Topsail Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

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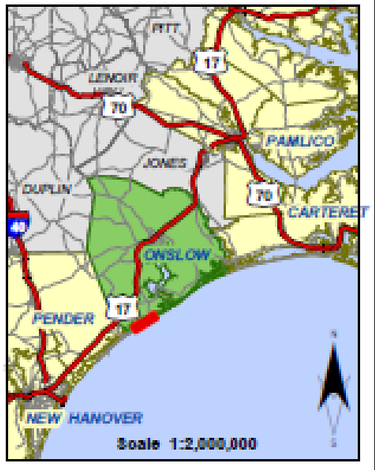

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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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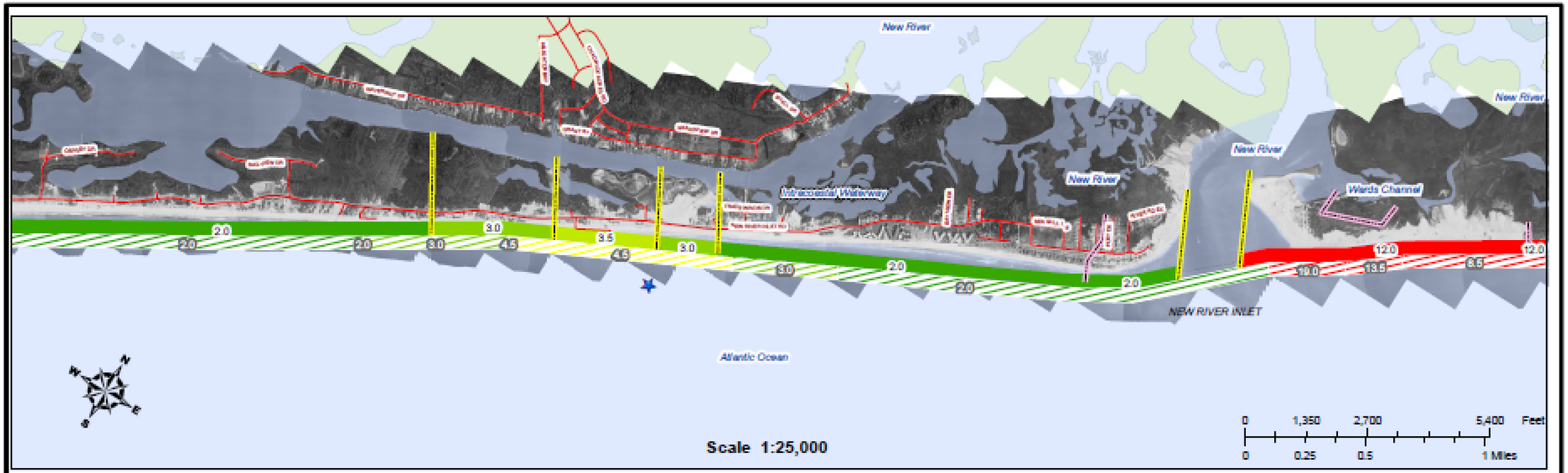
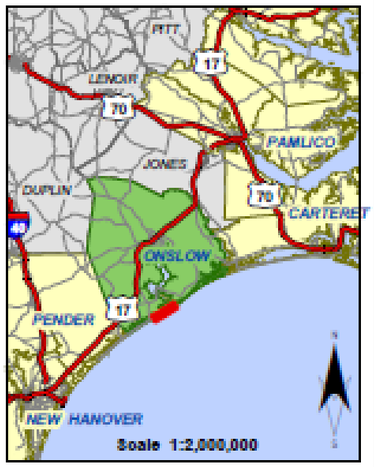


Topsail Island - NorthEast

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

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1638 Mail Service Center
Raleigh, NC 27699-1638
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How to read Erosion Factors

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Legend

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2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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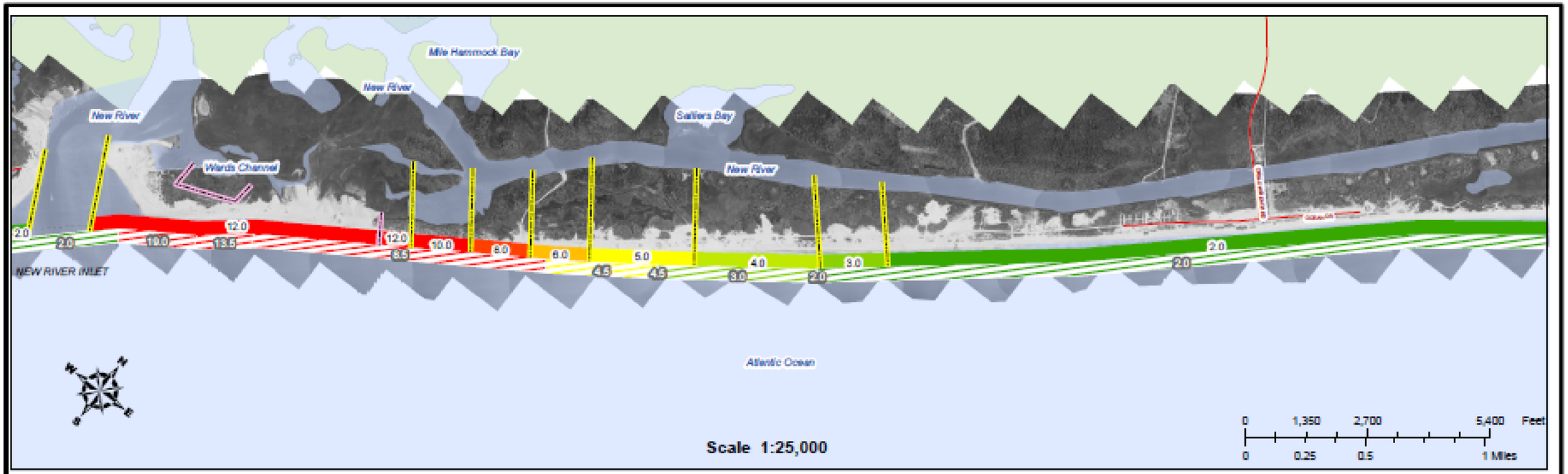
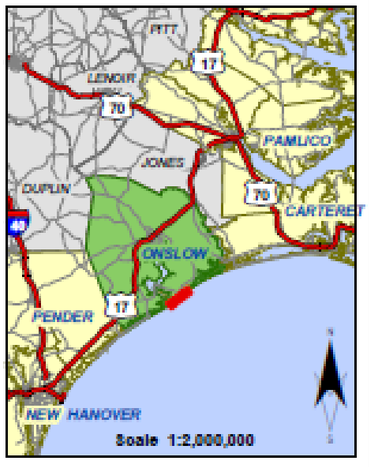


Onslow Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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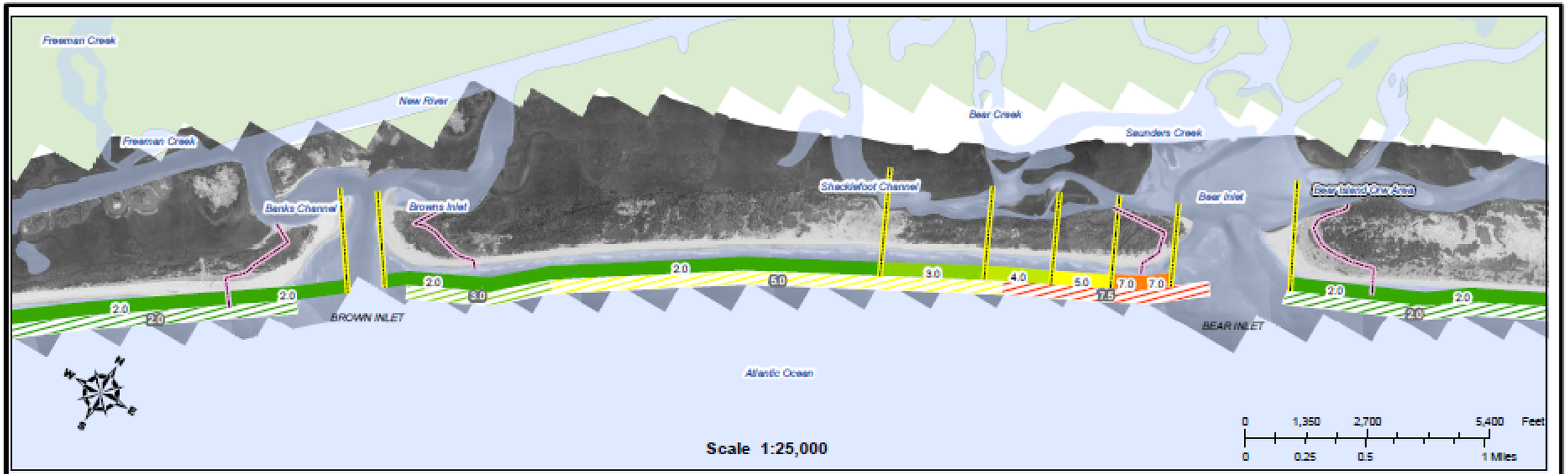
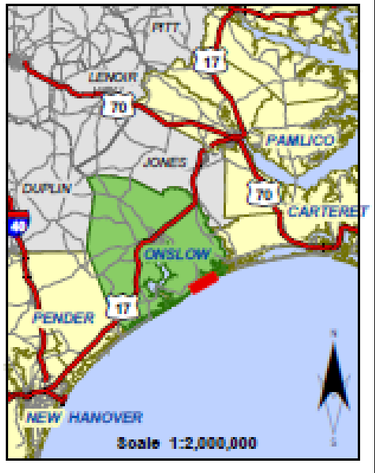


Brown's Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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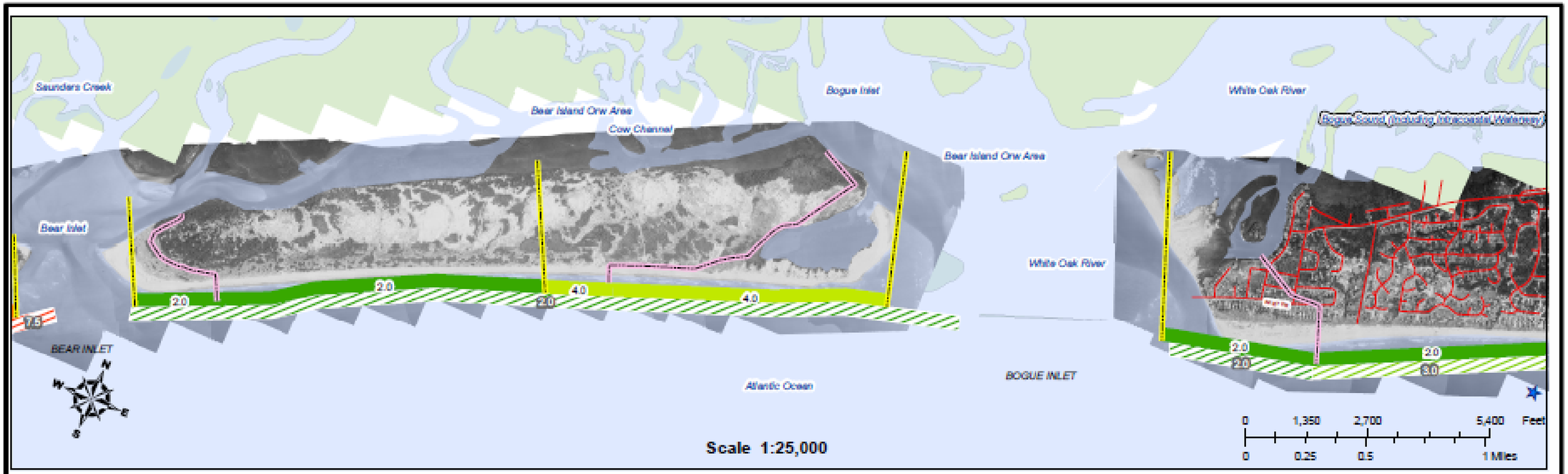
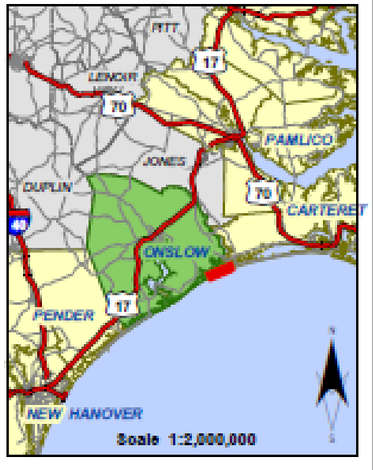


Bear Island

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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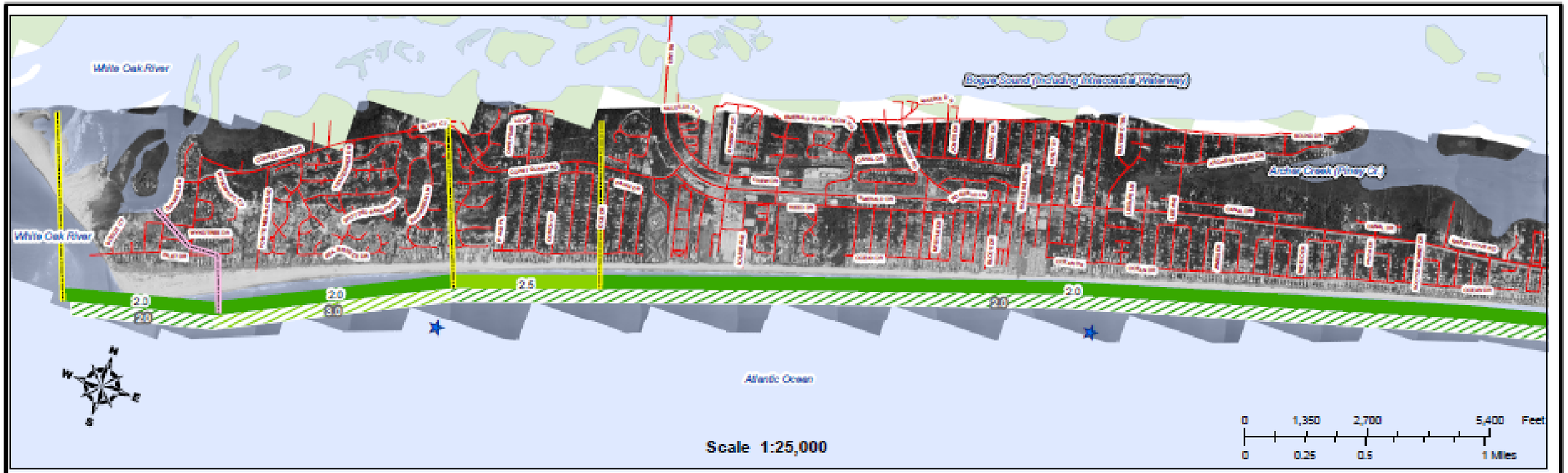
NC Division of Coastal Management 401 Permit April 2008

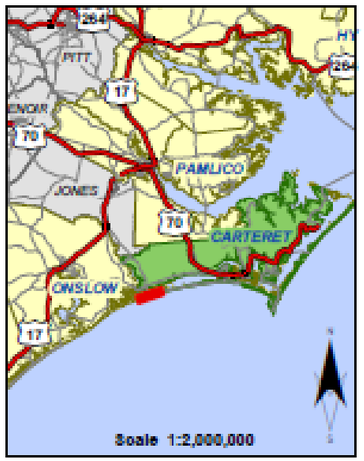


Bogue Banks at Emeral Isle

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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Roads
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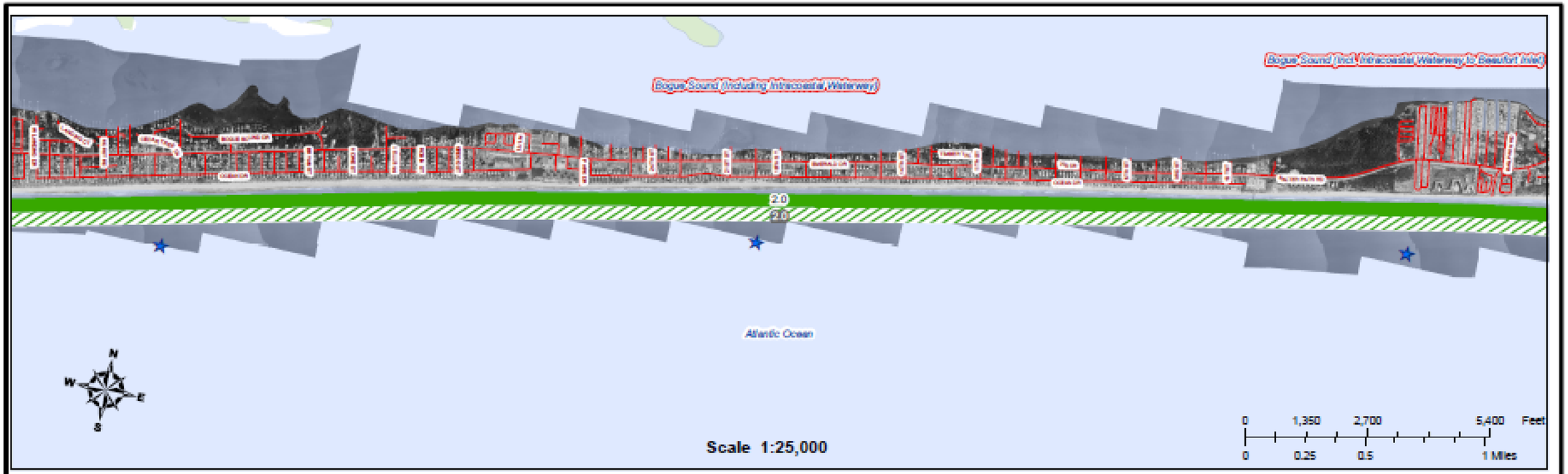
NC Division of Coastal Management GIS Unit, April 2000

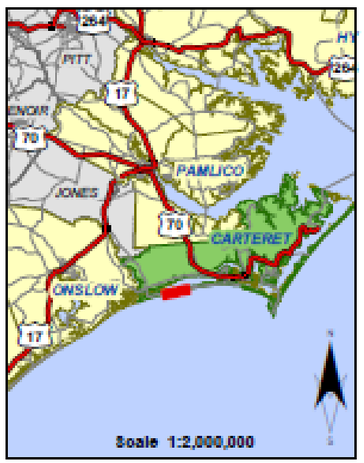


Bogue Banks at Salter Path

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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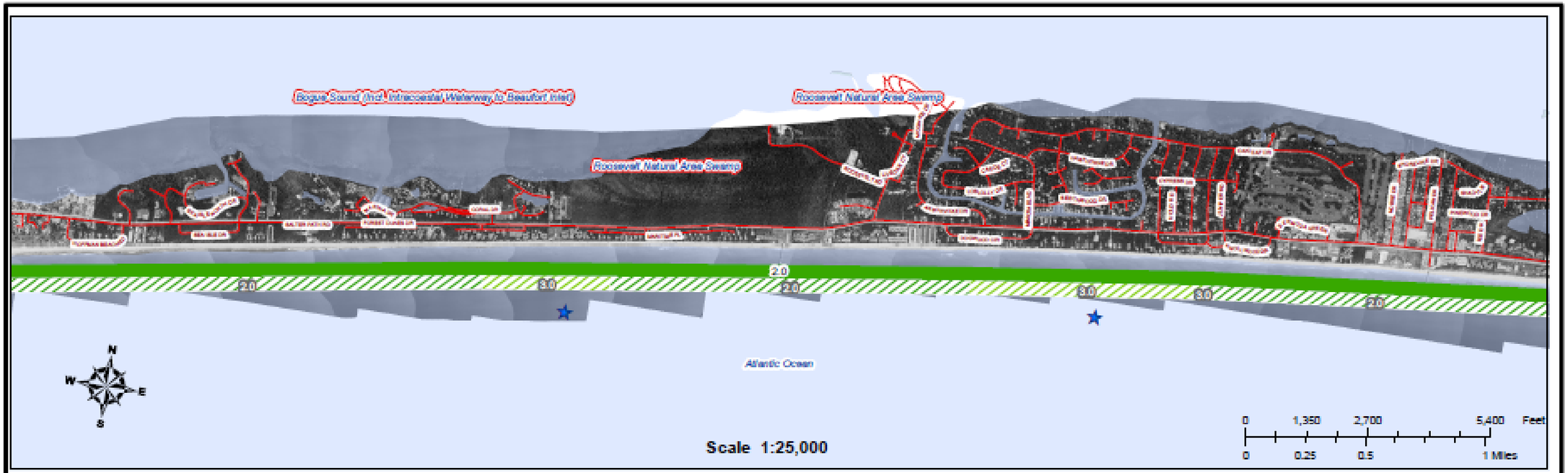
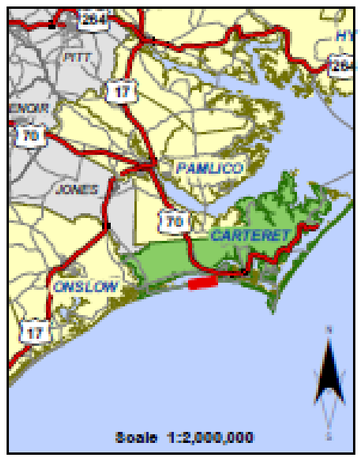


Bogue Banks at Atlantic Beach - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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Roads
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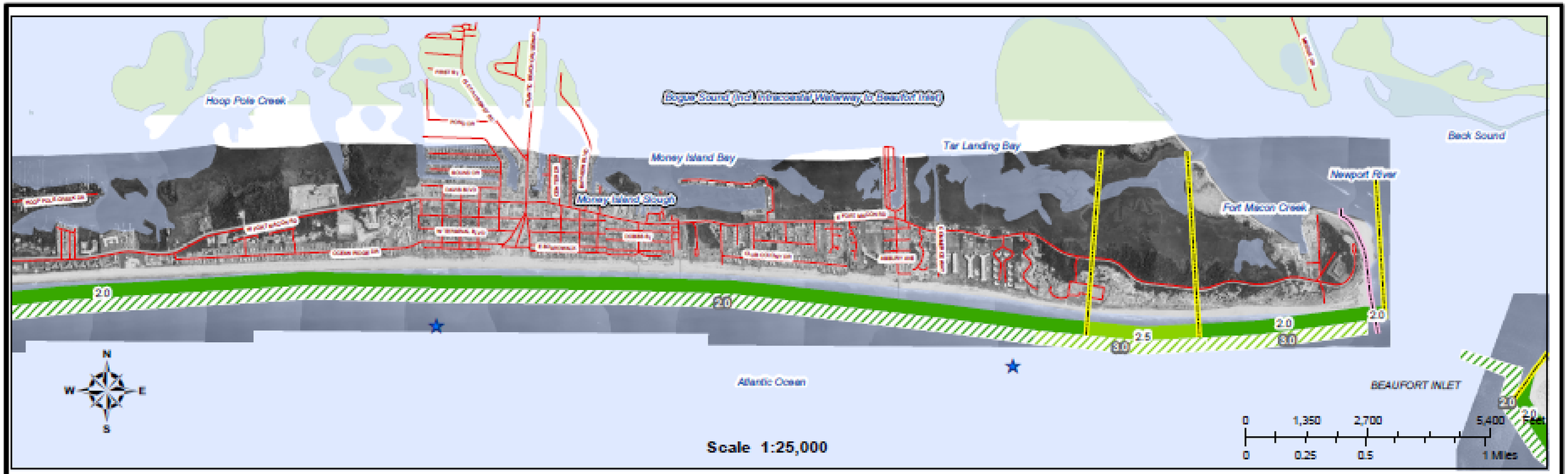
NC Division of Coastal Management GIS - Printed: April, 2000

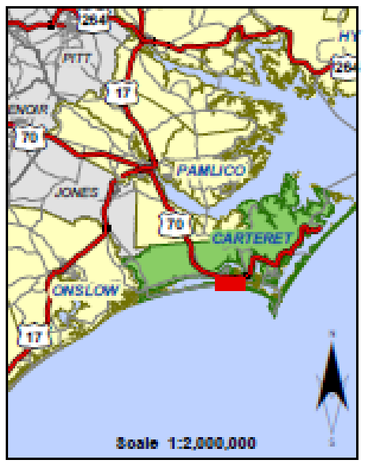


Bogue Banks at Atlantic Beach

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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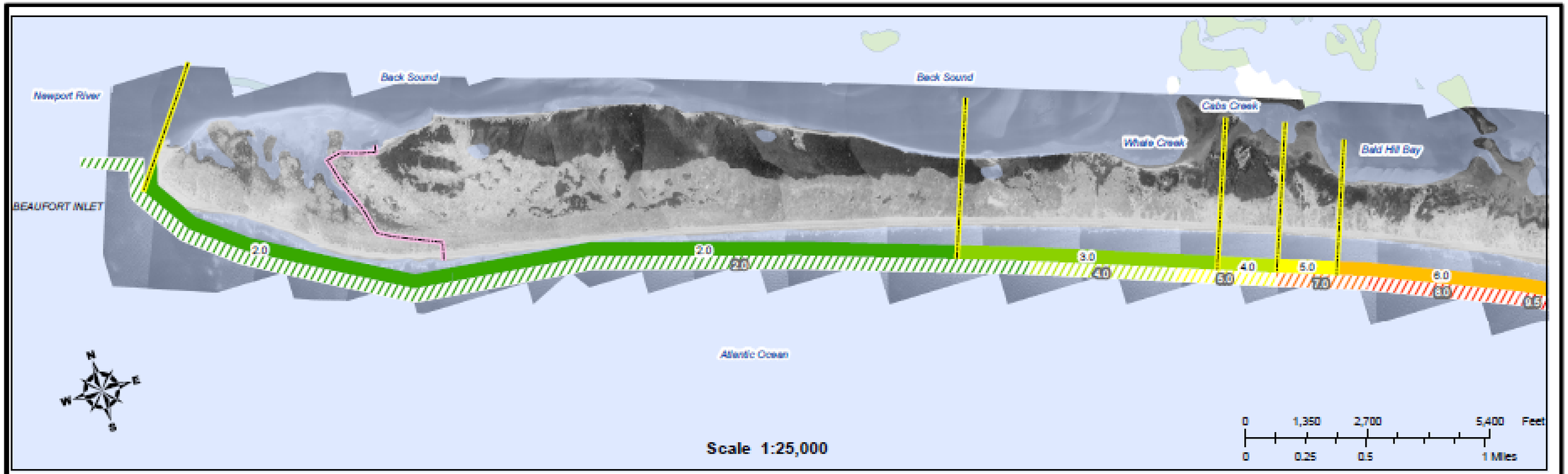
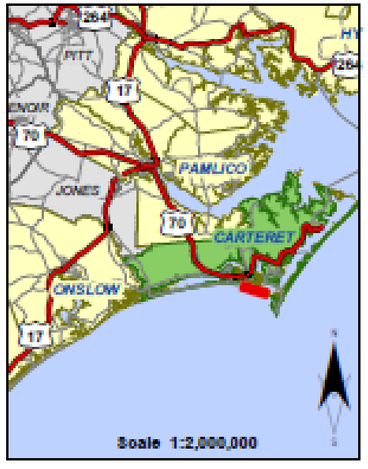


Shackleford Banks - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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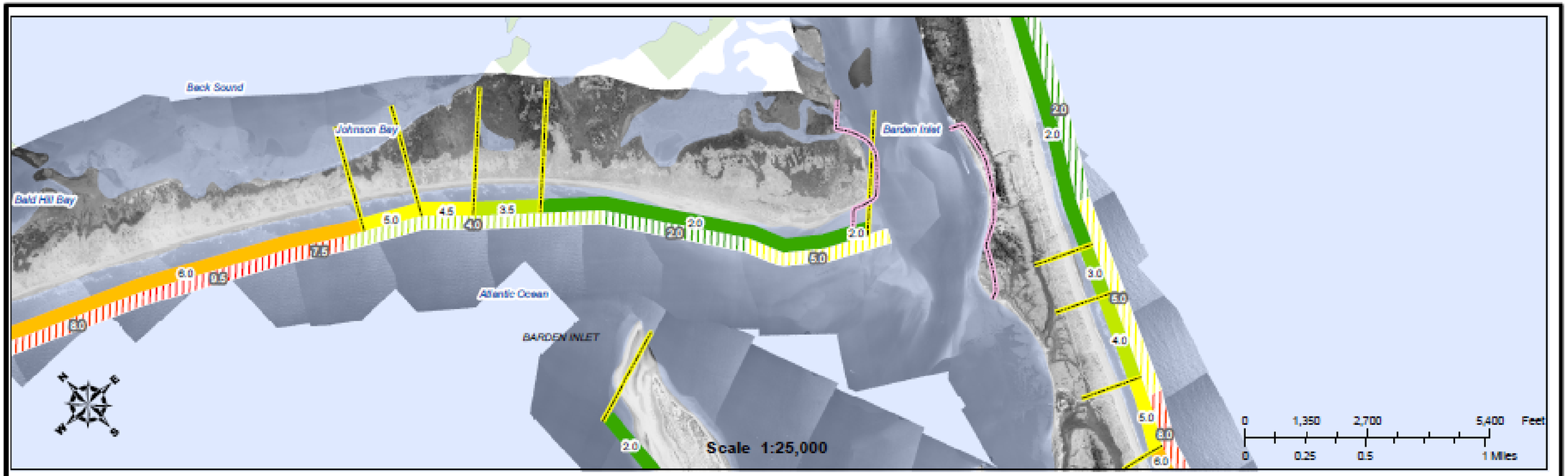

Shackleford Banks - East

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map

North Carolina
Division of Coastal Management

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1998 Long-term average annual shoreline change rate developed by:

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How to read Erosion Factors

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Legend

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7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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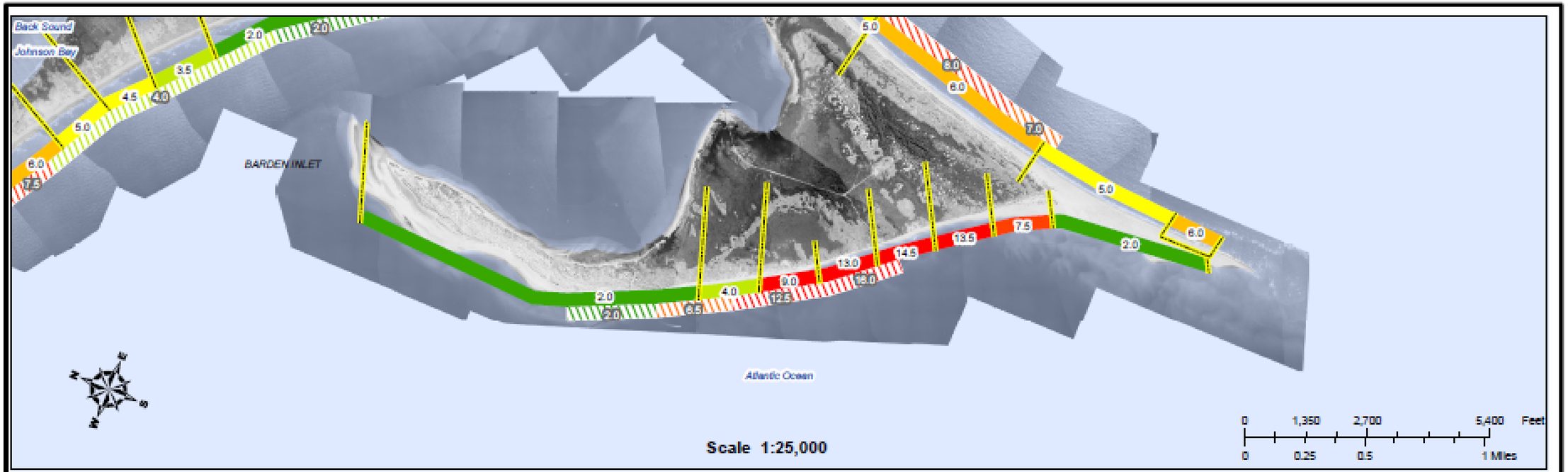
NC Division of Coastal Management GIS Project: April 2005

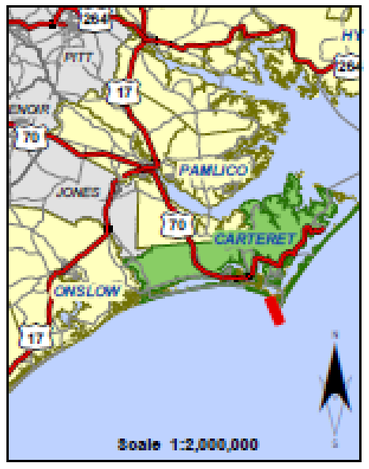


Cape Lookout - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
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6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
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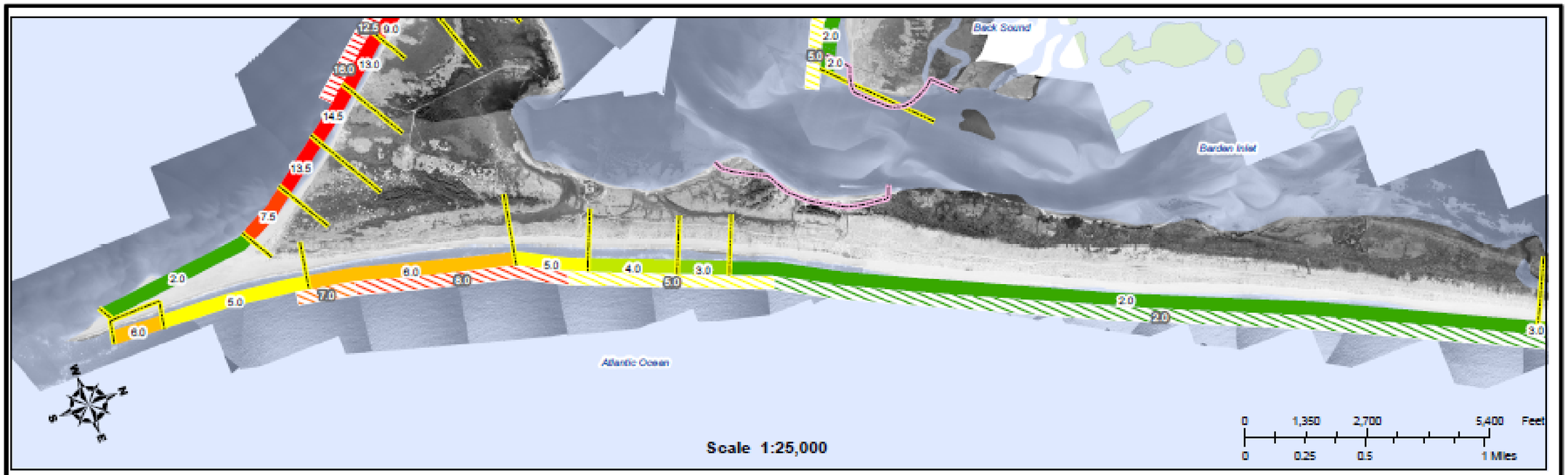
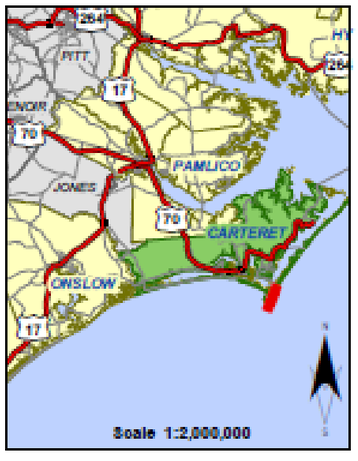


Cape Lookout

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
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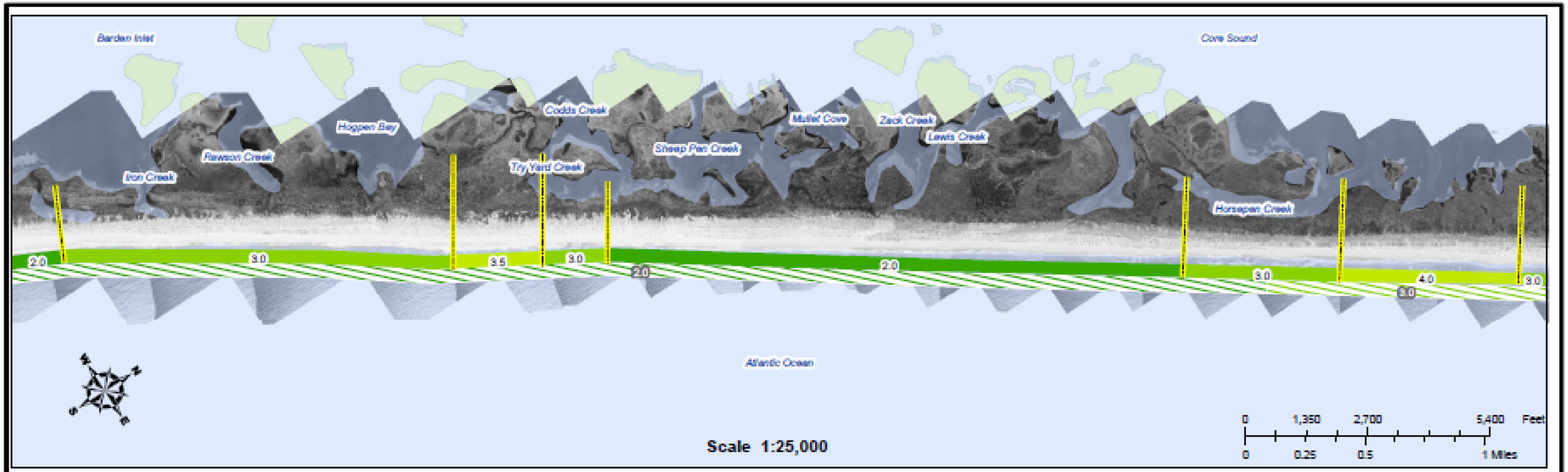
NC Division of Coastal Management GIS - Printed: April 2008

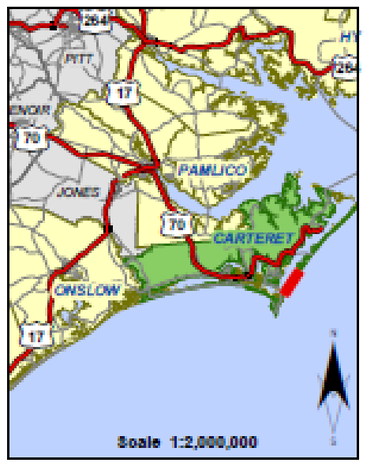


Core Banks - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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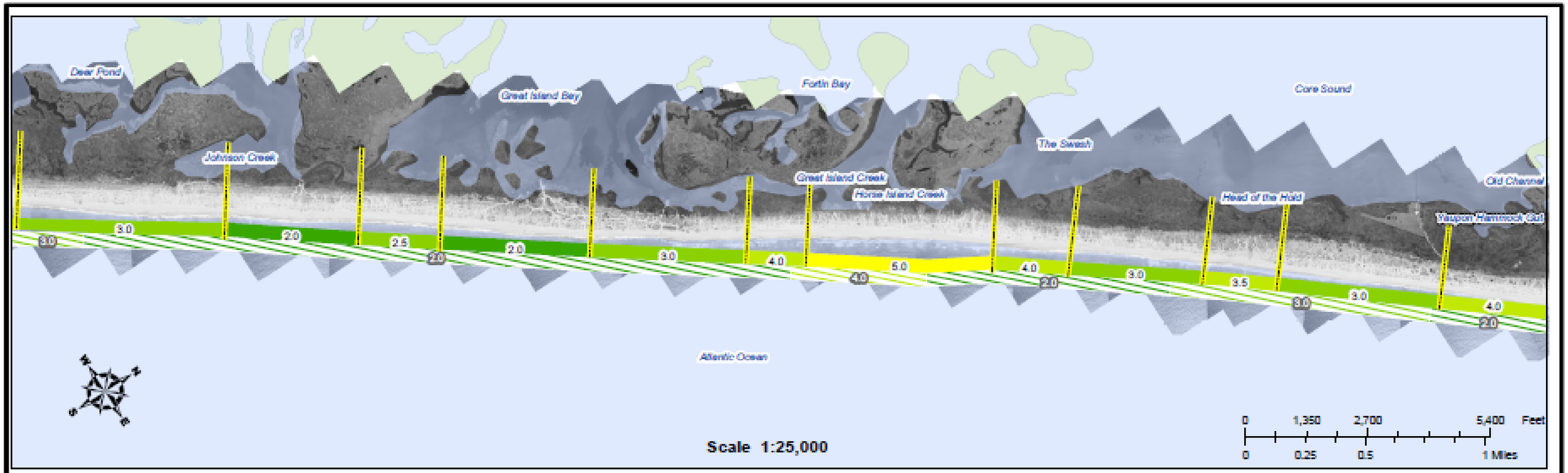
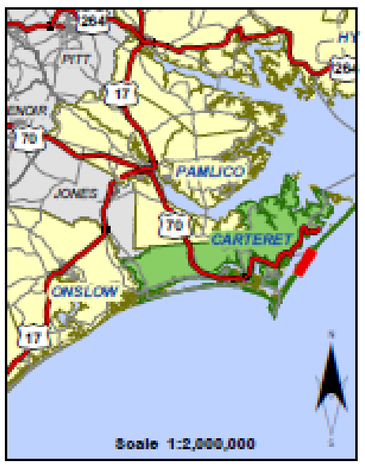


Core Banks - Central

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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Roads
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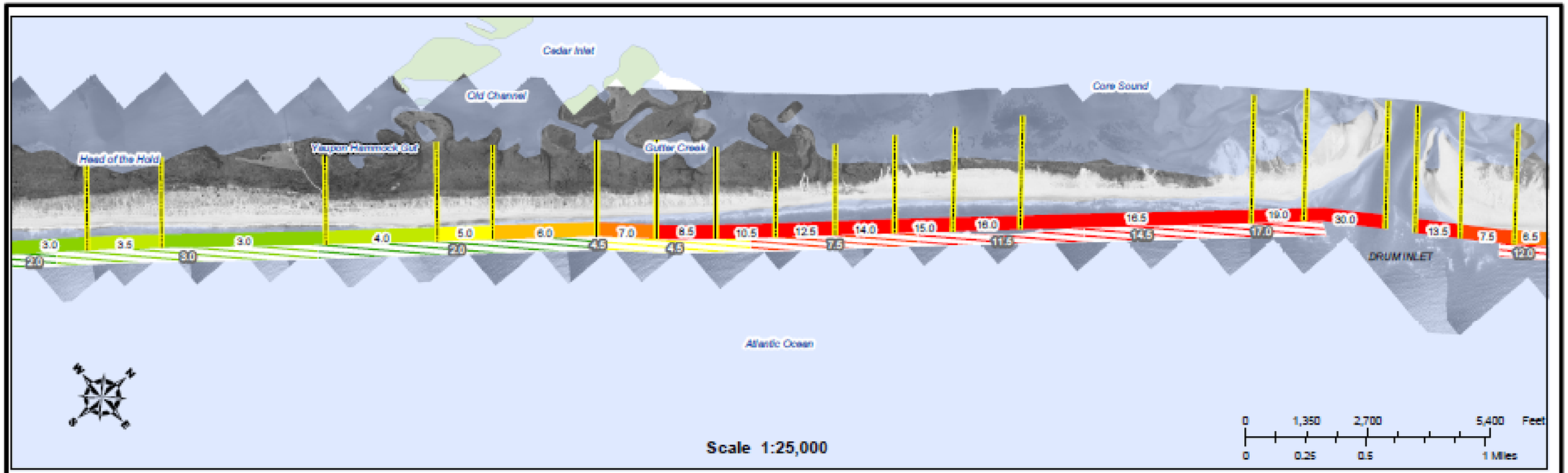
NC Division of Coastal Management GIS Section, April 2002



Core Banks - North

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map

North Carolina
Division of Coastal Management

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Erosion Factor Boundary
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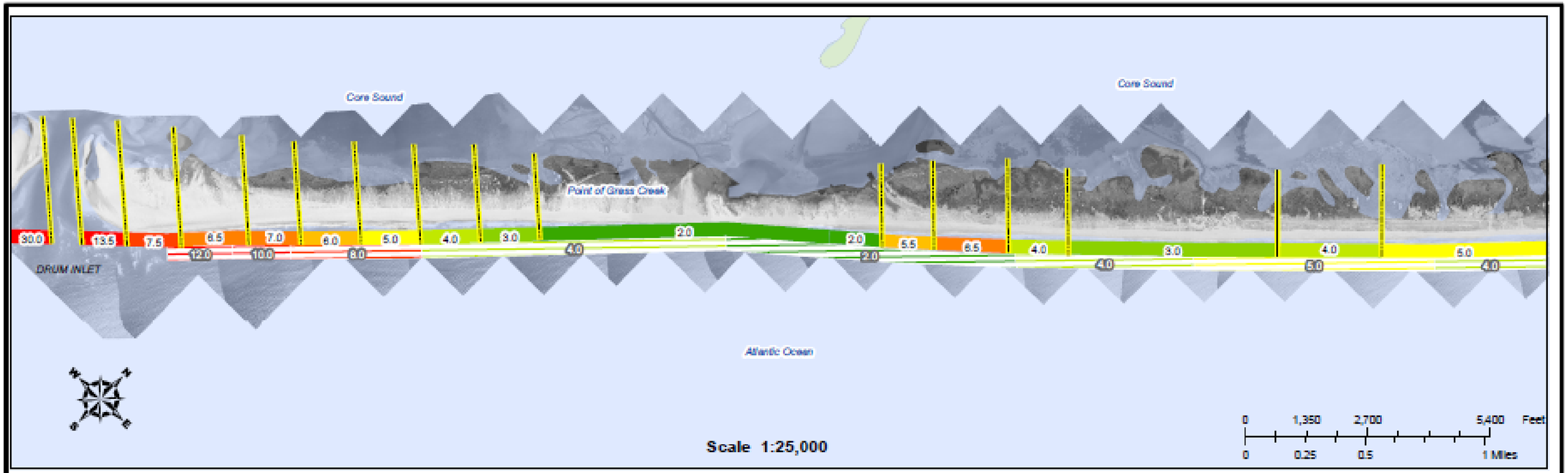
NC Division of Coastal Management GIS, Printed: April, 2000

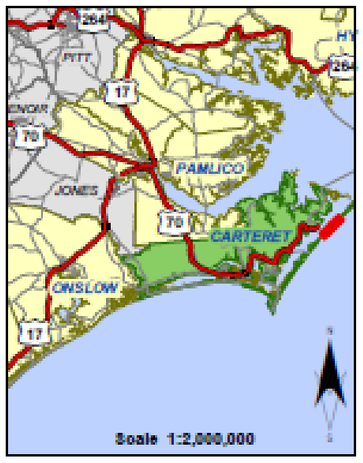


Portsmouth Island - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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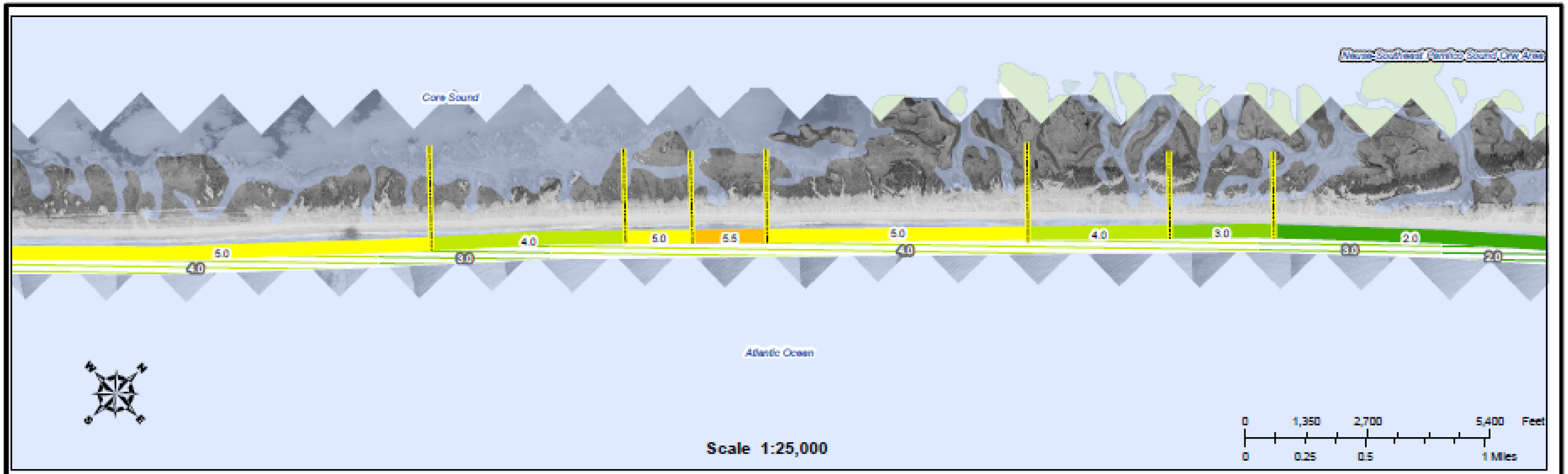
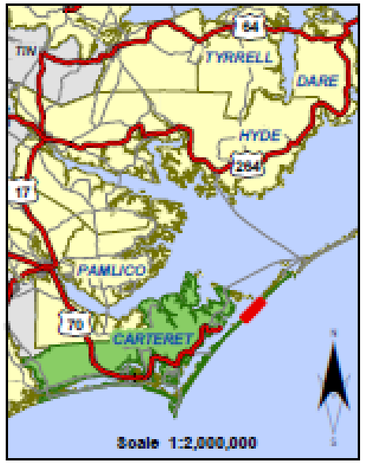


Portsmouth Island - Central (1of 2)

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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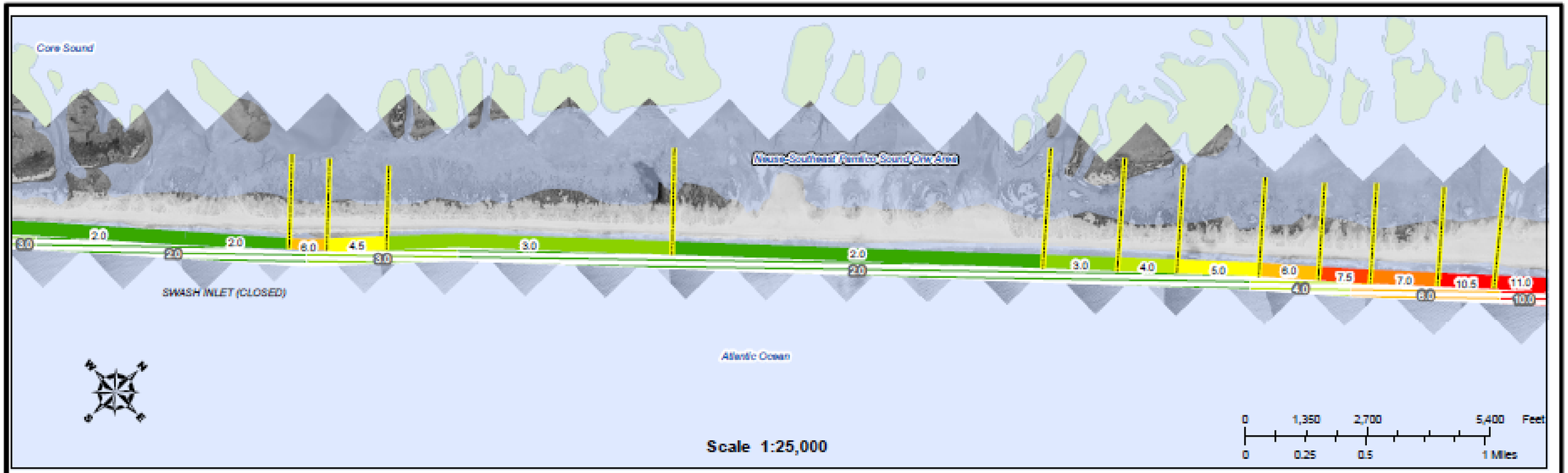

Portsmouth Island - Central (2 of 2)

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Updated Through 1998

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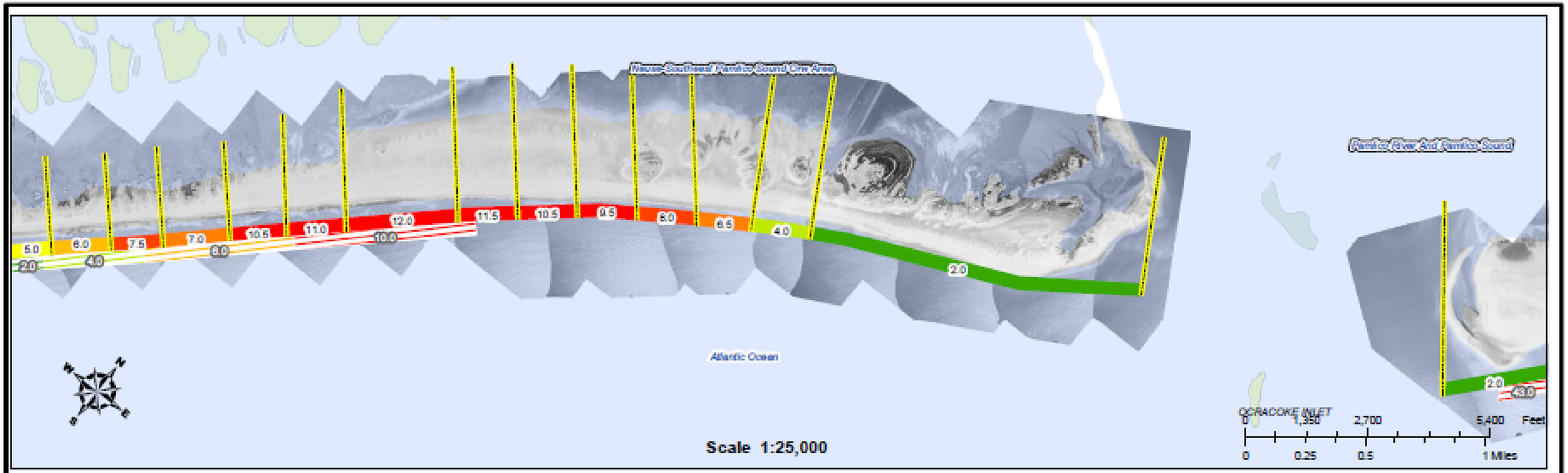

Portsmouth Island - North

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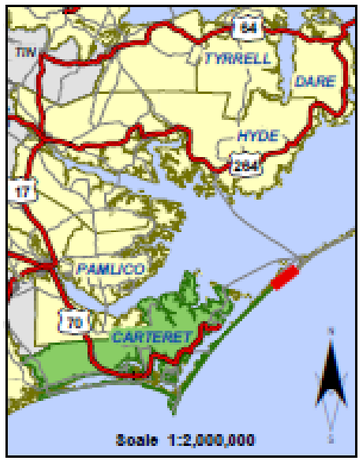

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How to read Erosion Factors

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Legend

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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
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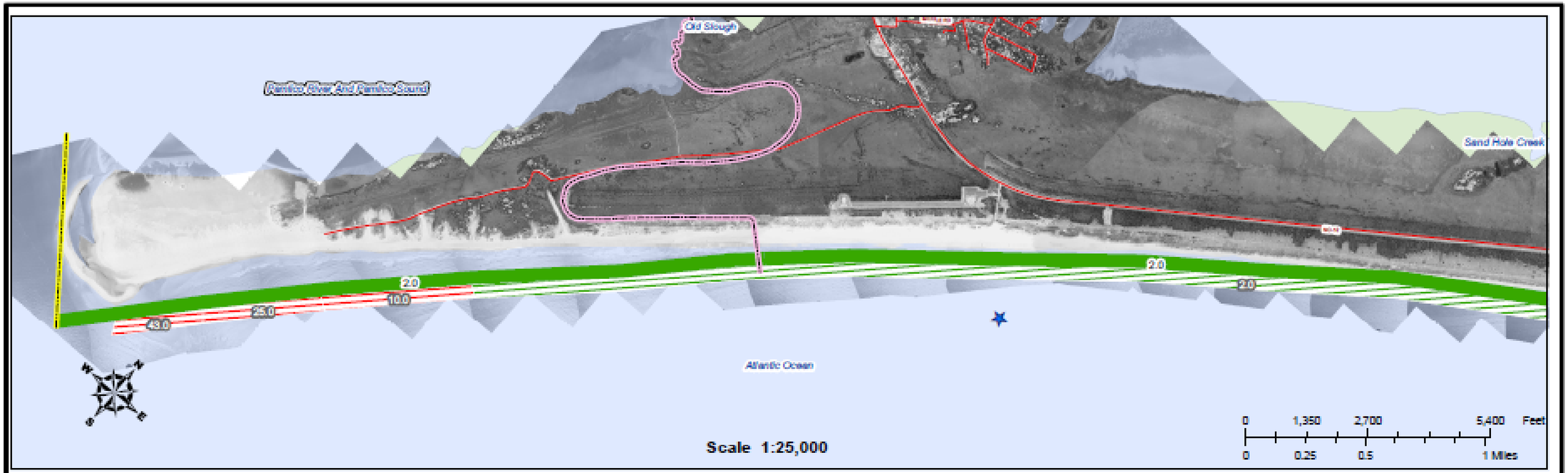

Ocracoke - SouthWest

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map

North Carolina
Division of Coastal Management

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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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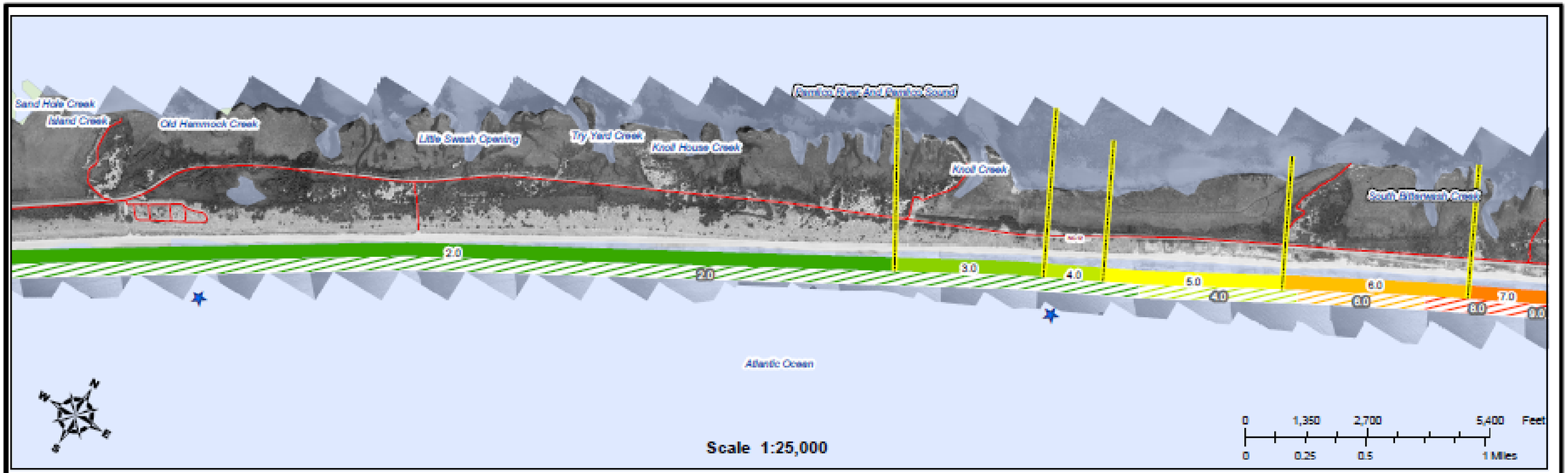
NC Division of Coastal Management GIS - Printed: April 2000



Ocracoke - Central

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map

North Carolina
Division of Coastal Management

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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
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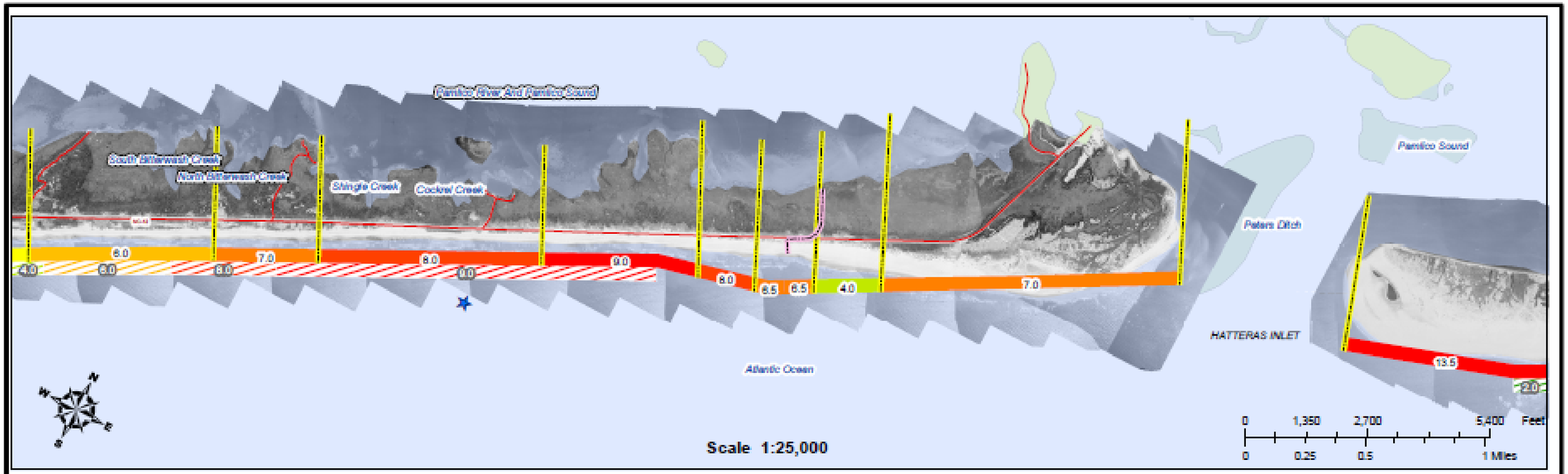
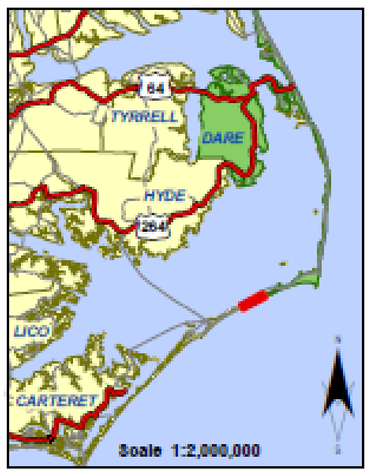


Ocracoke - NorthEast

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

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4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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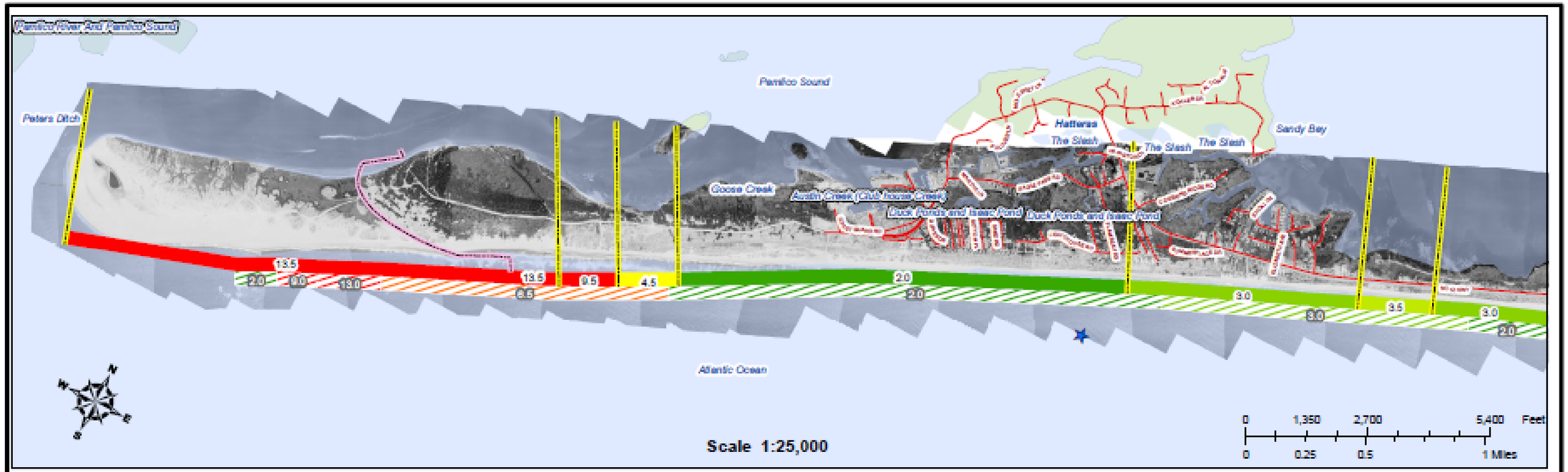
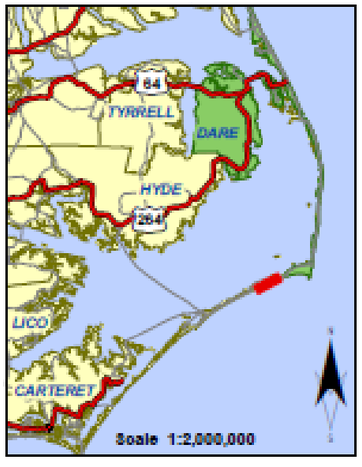


Hatteras Island - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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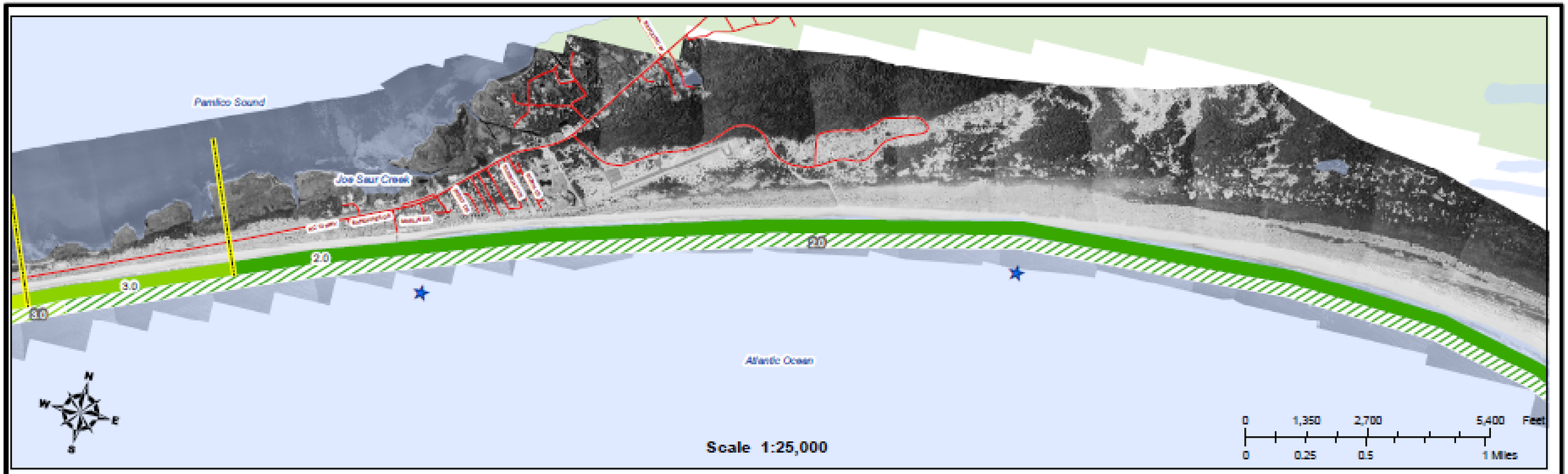
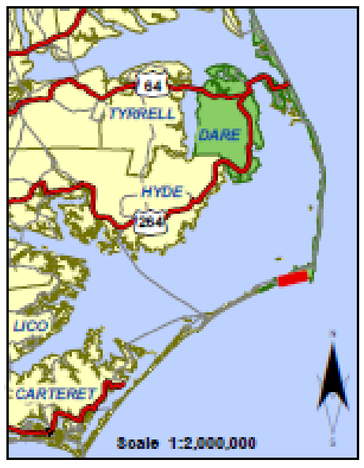


Cape Hatteras

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
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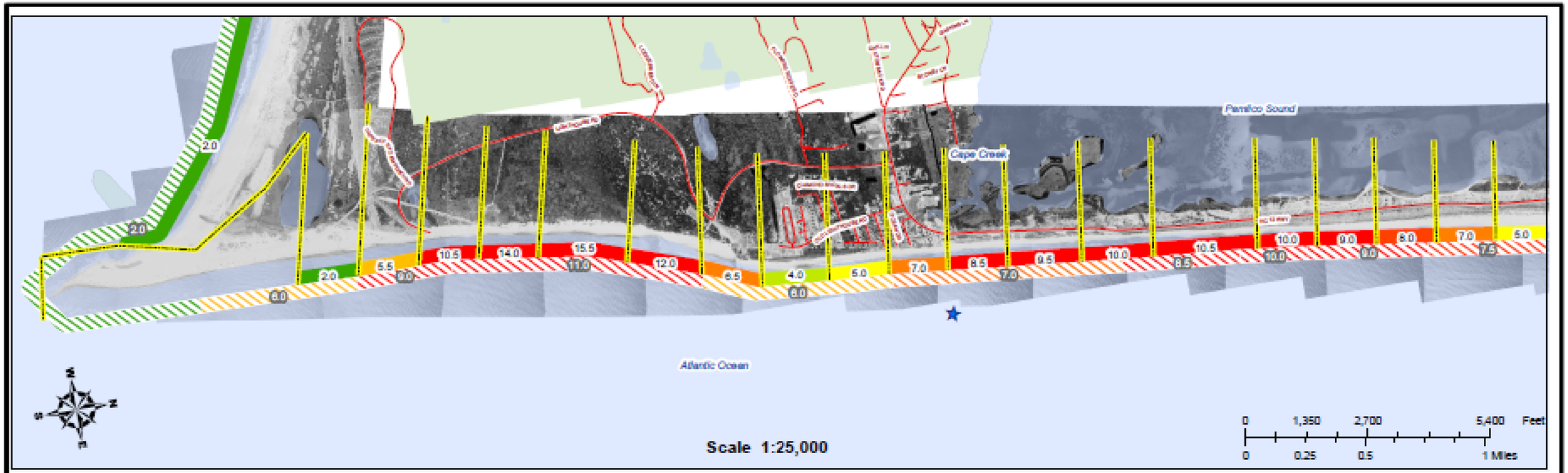
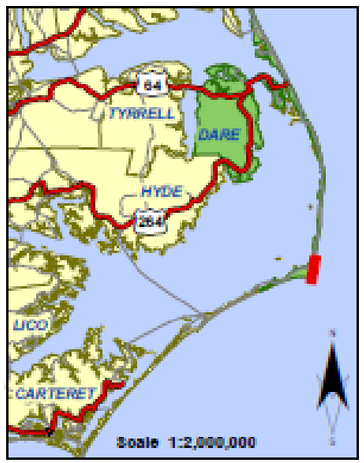


Cape Hatteras at Buxton

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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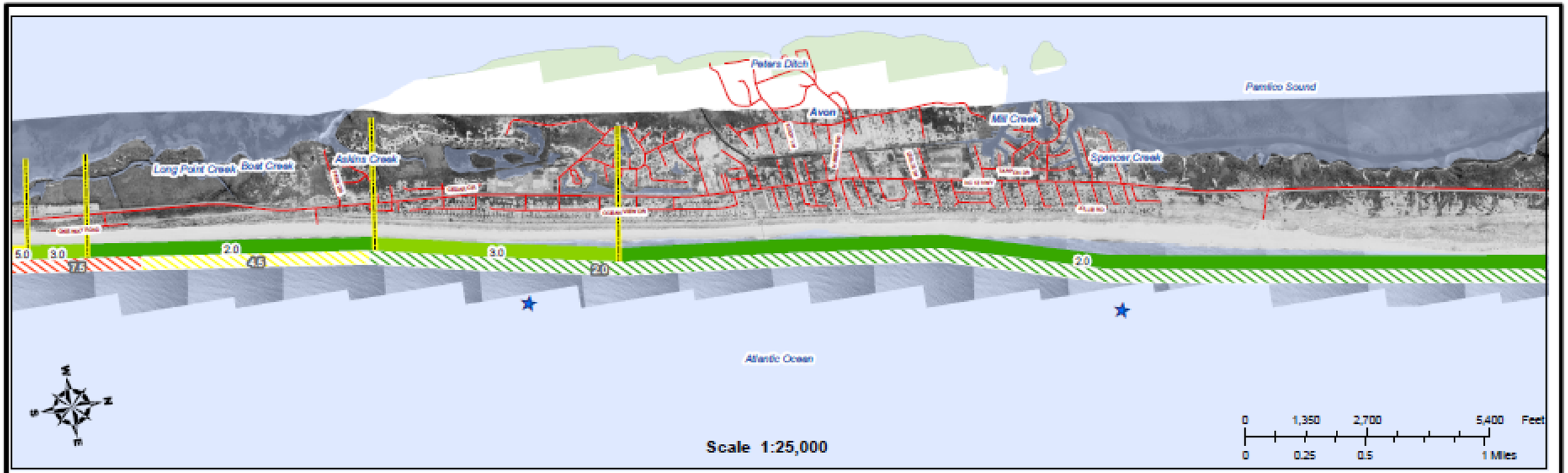
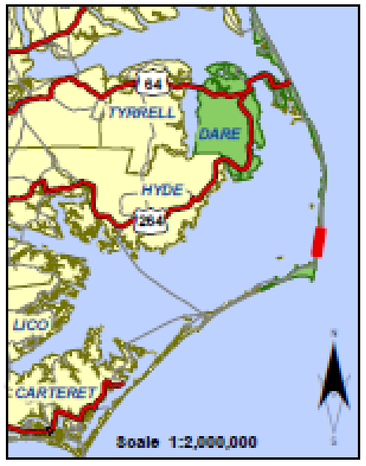


Hatteras Island at Avon

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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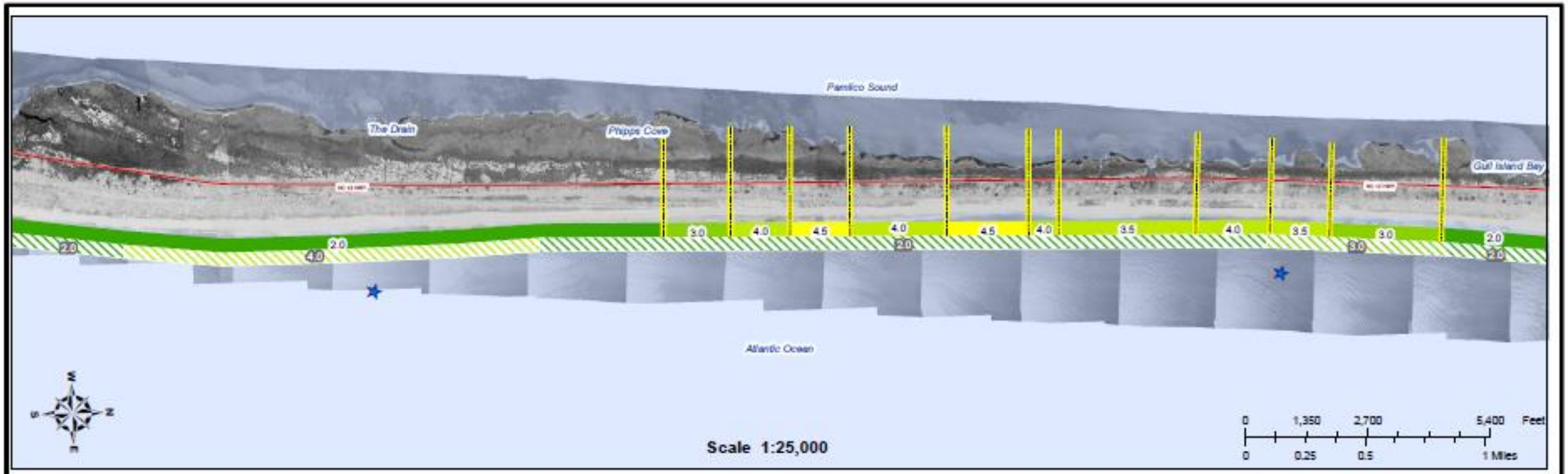

Hatteras Island at Avon - North

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

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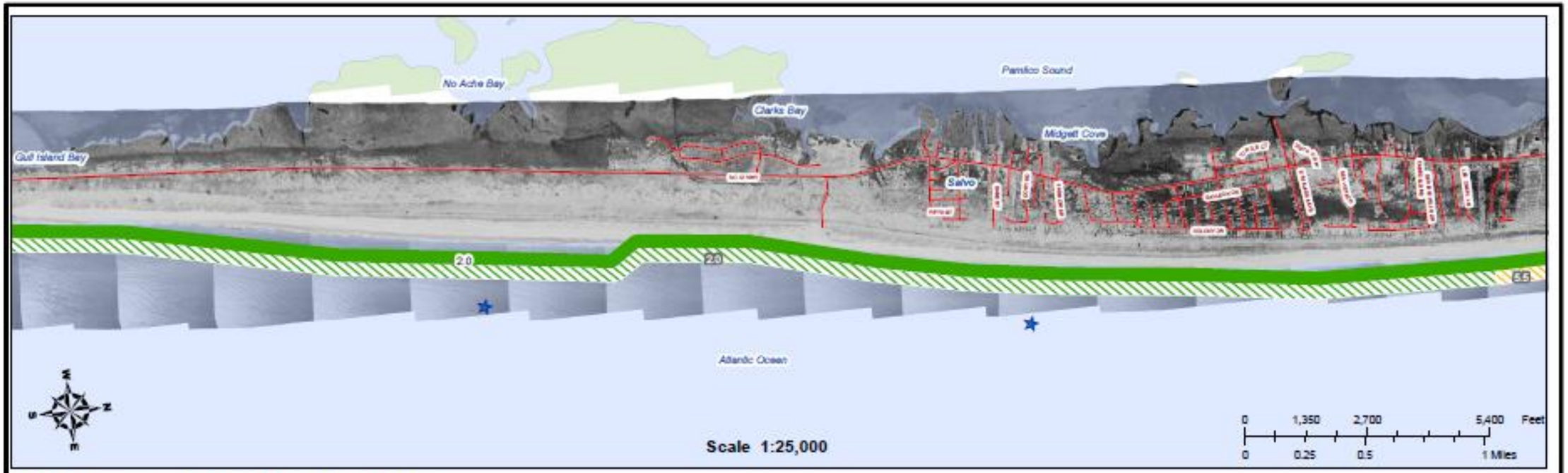

Hatteras Island at Salvo

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6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
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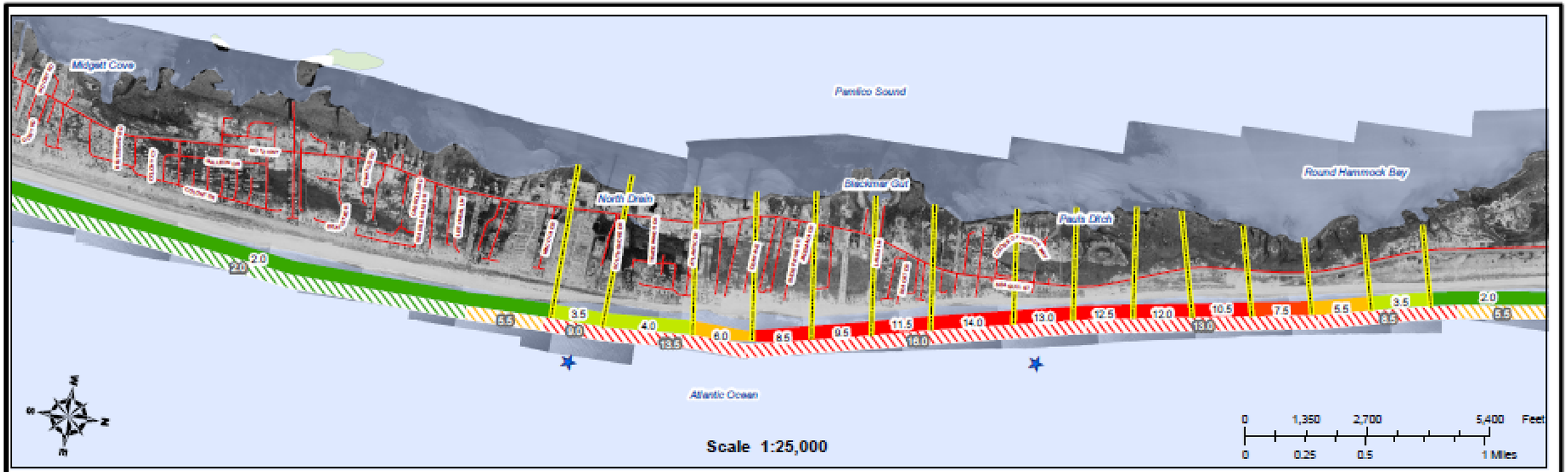
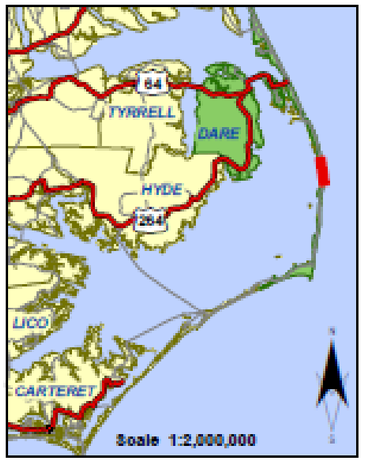


Hatteras Island at Rodanthe

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
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3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
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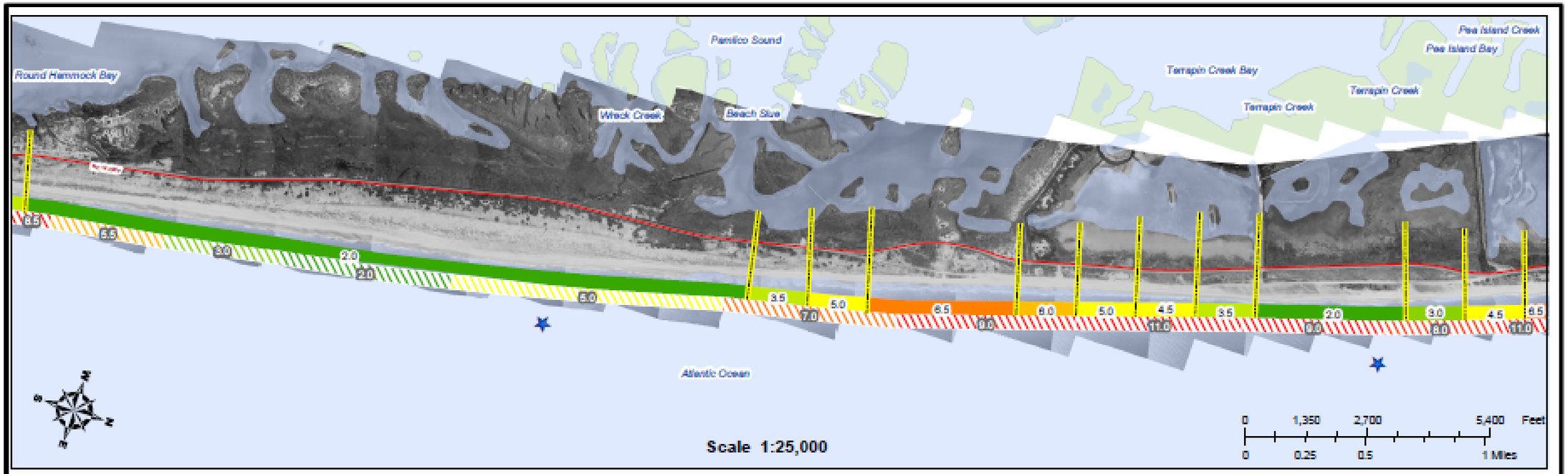
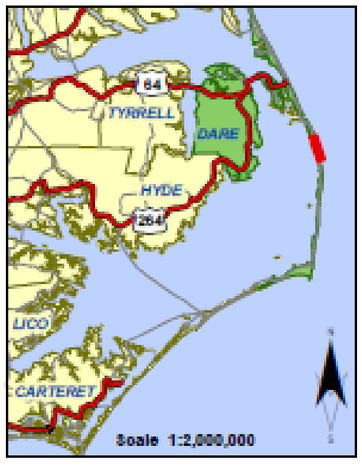


Pea Island - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
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Erosion Factor Boundary
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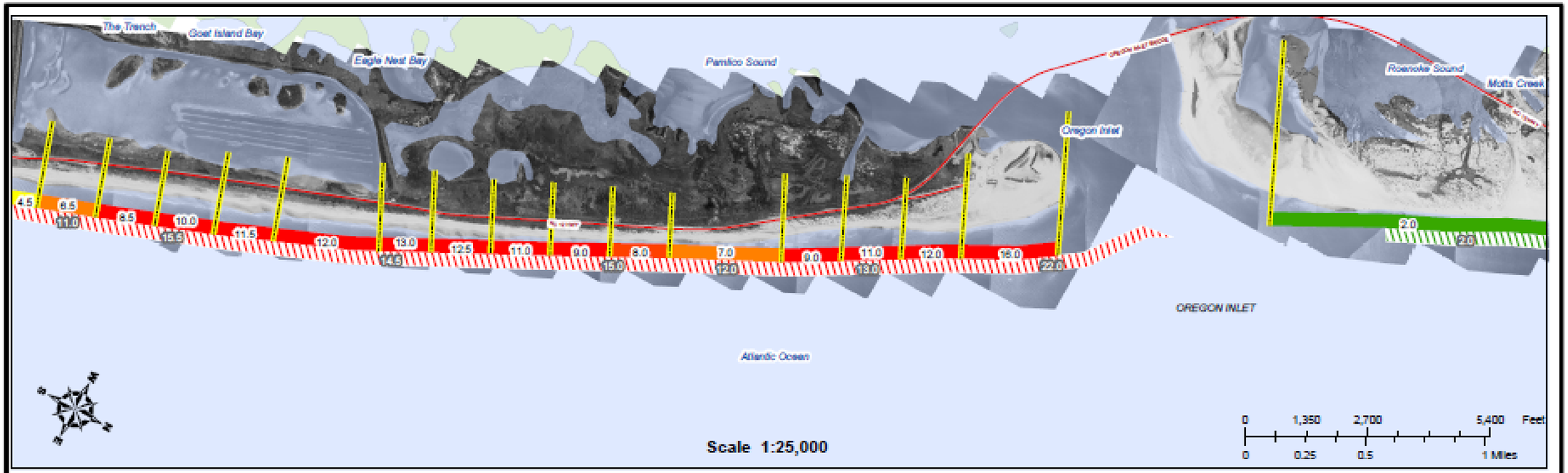
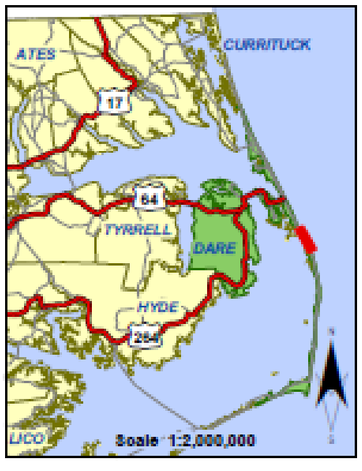


Pea Island - North

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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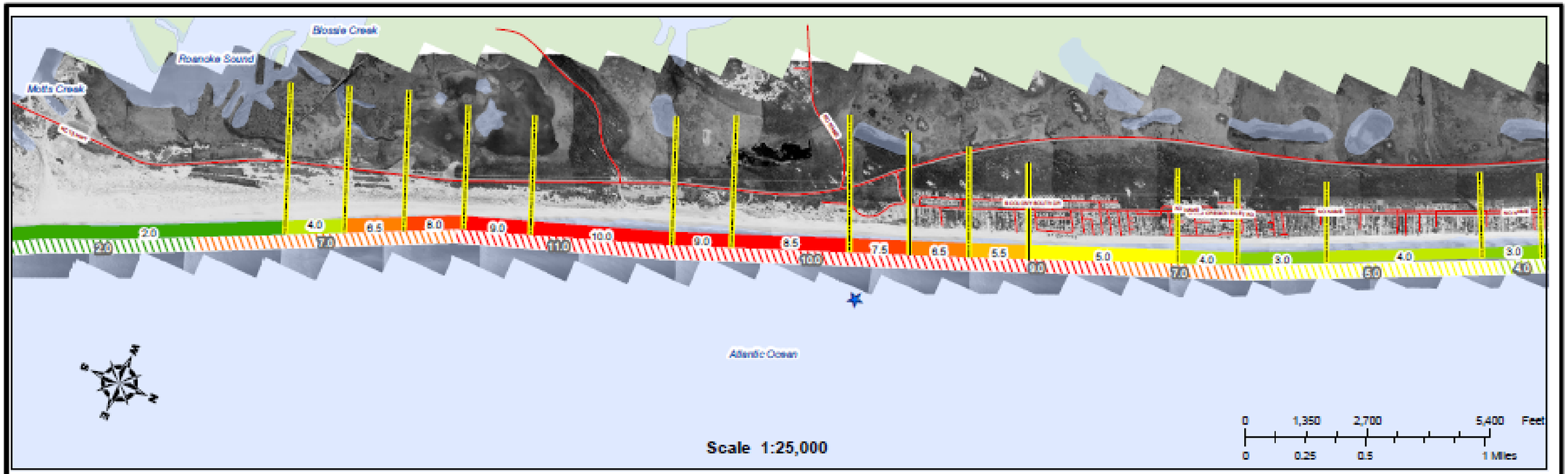
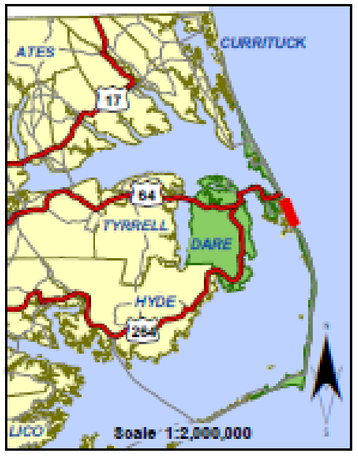


Bodie Island - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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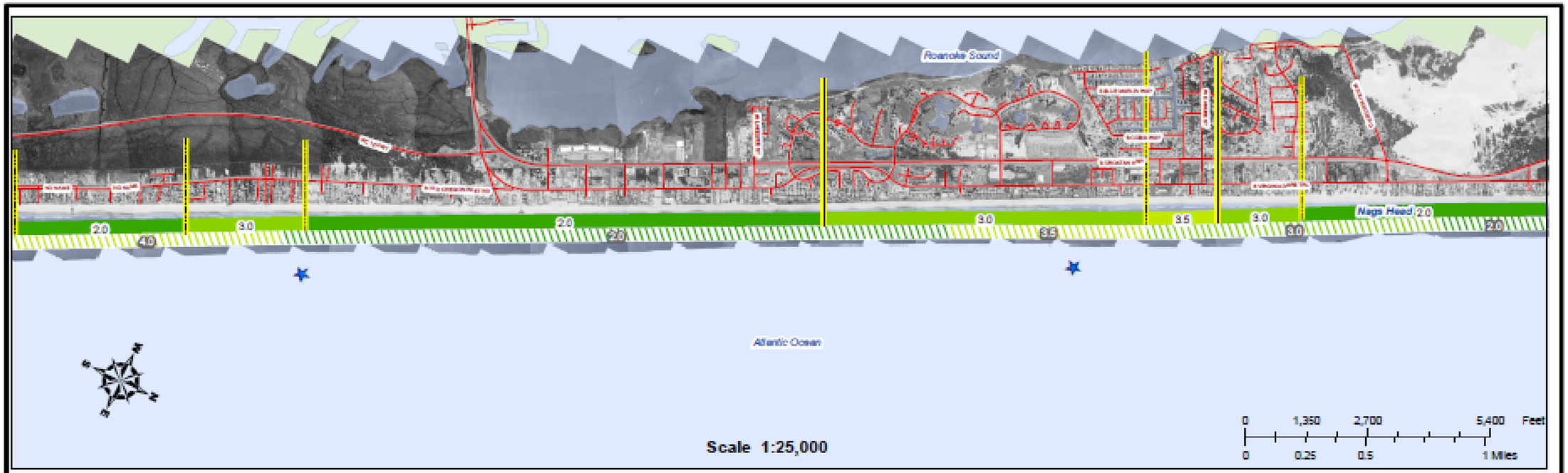
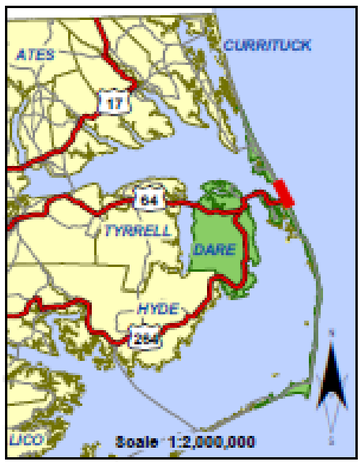


Nags Head - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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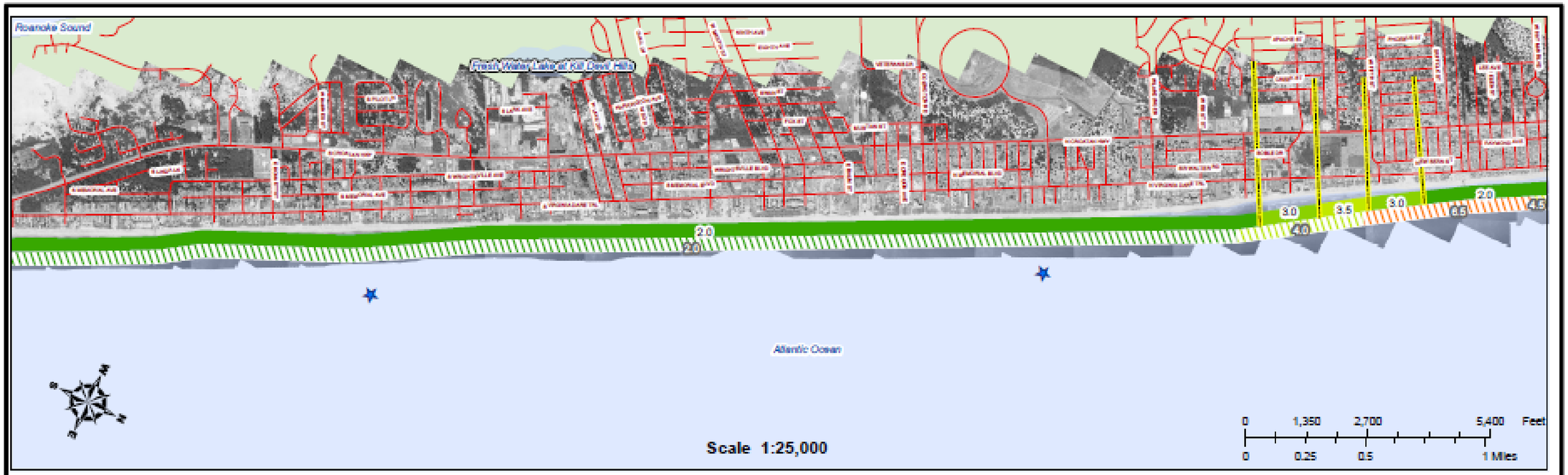
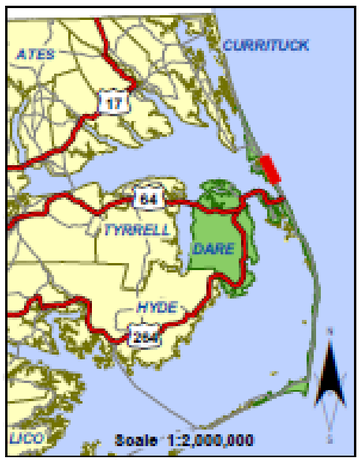


Nags Head - North to Kill Devil Hills - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
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Erosion Factor Boundary
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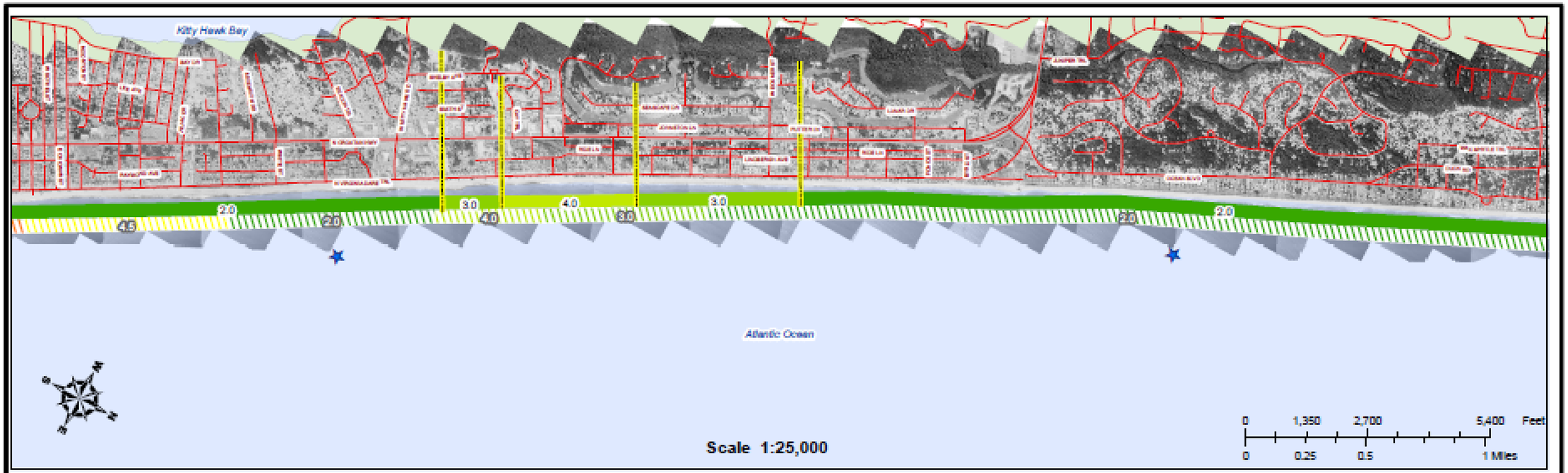
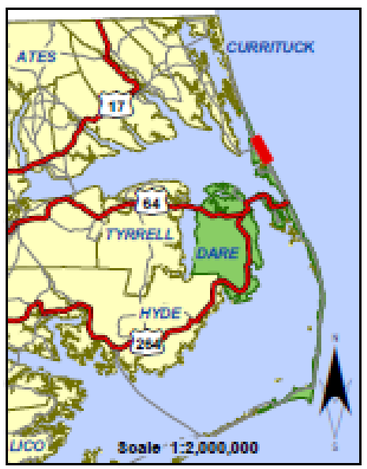


Kill Devil Hills - North to Duck - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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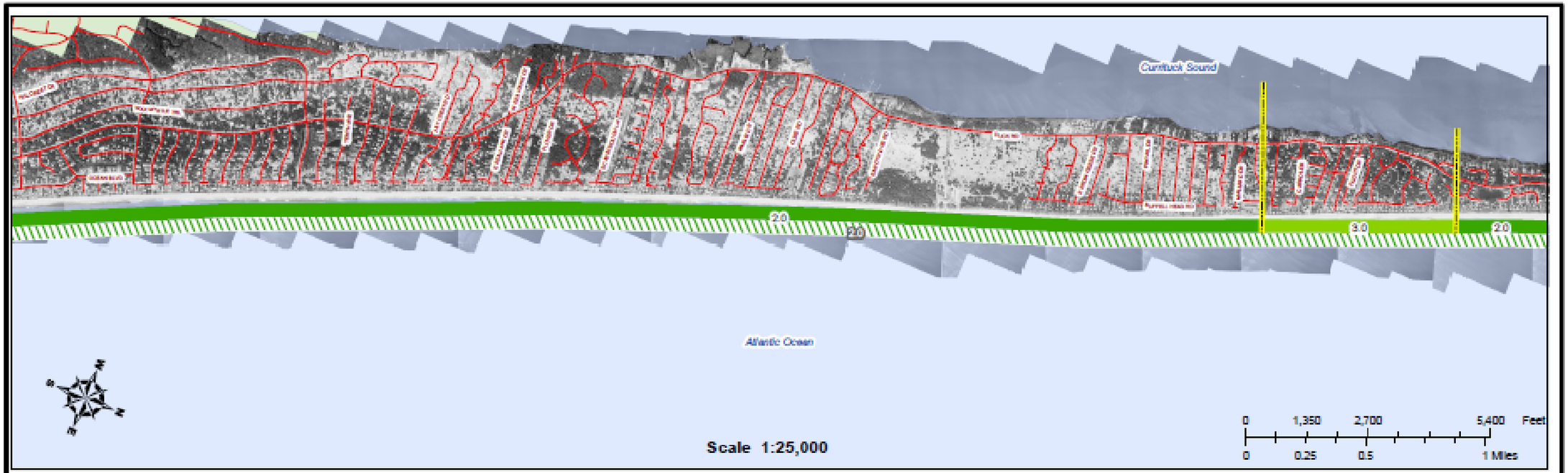
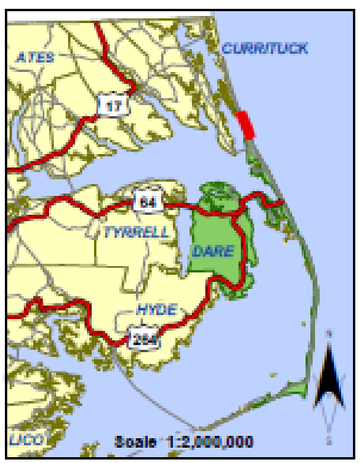


Duck to Sanderling - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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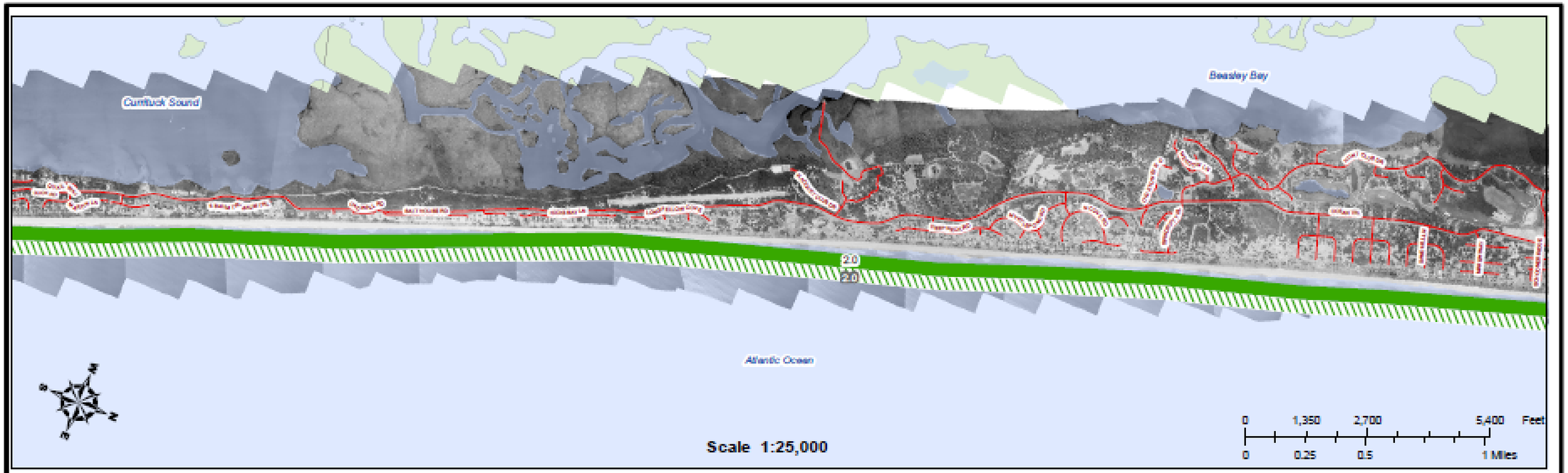
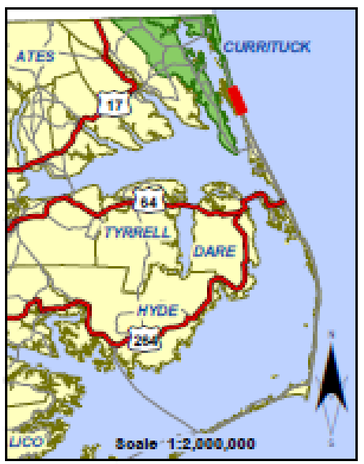


Sanderling - North to Corolla - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Roads
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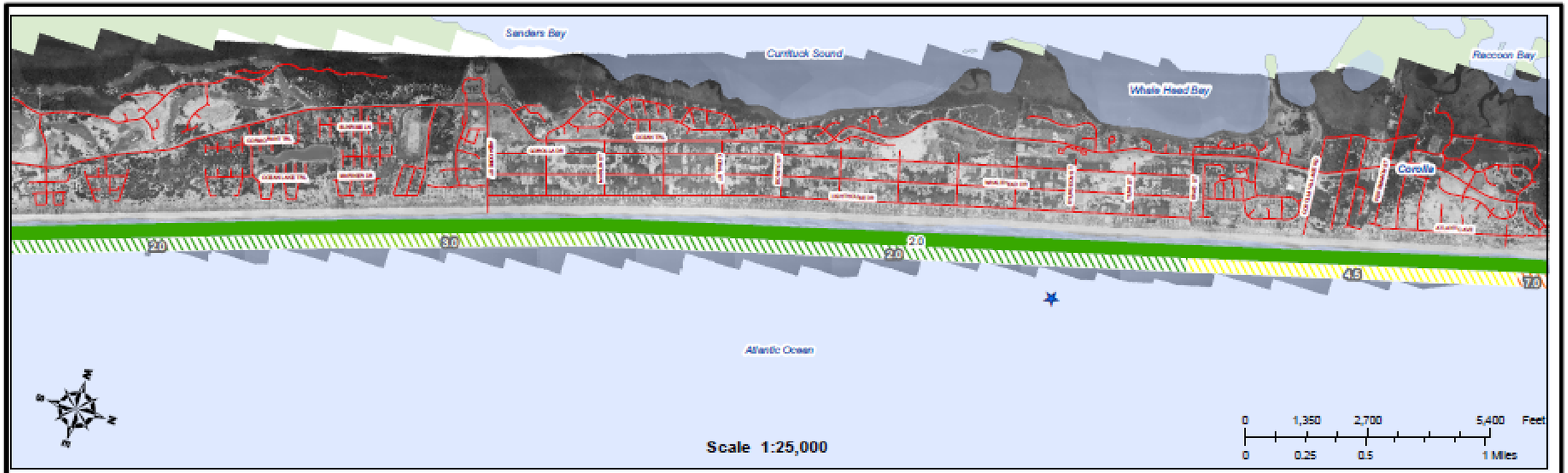
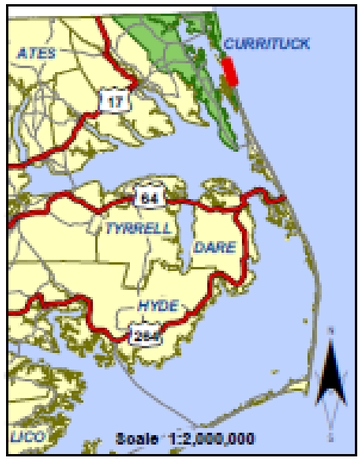


Corolla - South

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



North Carolina
Division of Coastal Management

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National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

1998 Long-term average annual shoreline change rate developed by:

NC State University's Kenan Natural Hazards Mapping Program and North Carolina Division of Coastal Management

For more information contact:

NC Division of Coastal Management:

1638 Mail Service Center
Raleigh, NC 27699-1638
(919) 733 – 2293

Or visit:

www.nccoastalmanagement.net

How to read Erosion Factors

2.0 → "2.0" Indicates a 1998 Erosion Factor of 2.0 Feet / Year

2.0 → "2.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend

1998 Erosion Factor	1992 Erosion Factor
2.0 Ft. / Yr.	2.0 Ft. / Yr.
2.5 - 3.0 Ft. / Yr.	3.0 Ft. / Yr.
3.5 - 4.0 Ft. / Yr.	3.5 - 4.0 Ft. / Yr.
4.5 - 5.0 Ft. / Yr.	4.5 - 5.0 Ft. / Yr.
5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
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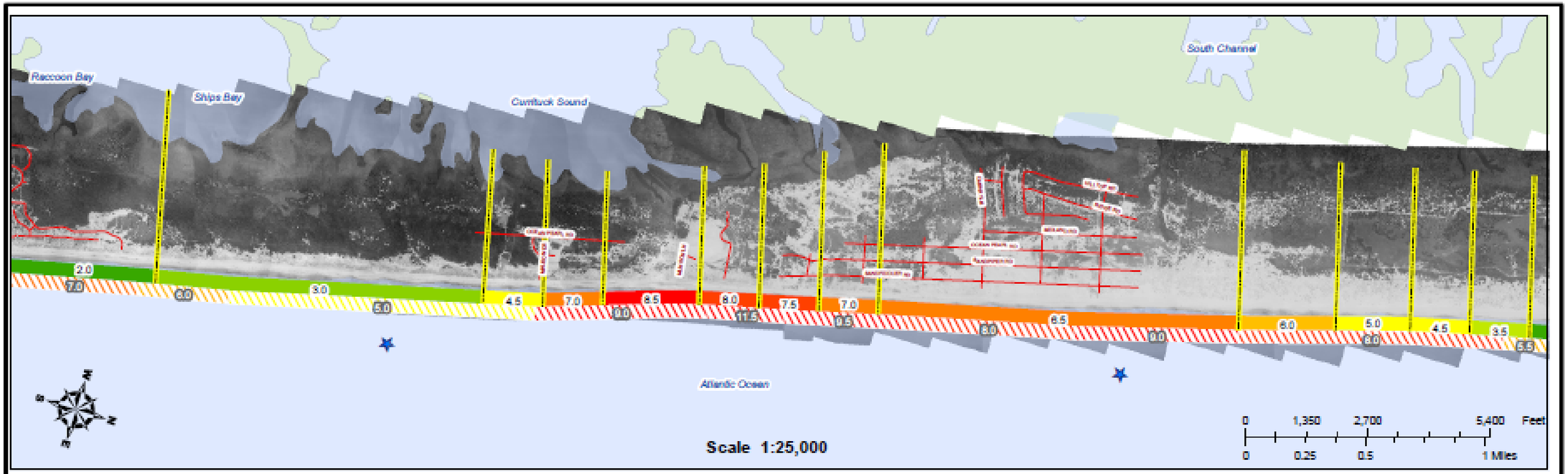
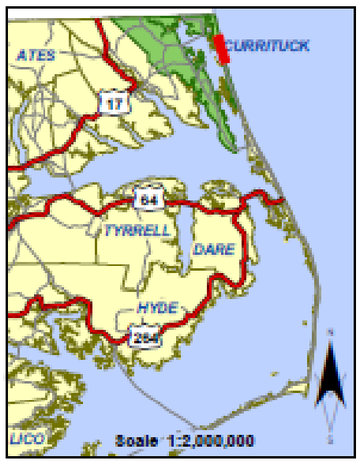


Corolla - North

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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5.5 - 6.0 Ft. / Yr.	5.5 - 6.0 Ft. / Yr.
6.5 - 7.0 Ft. / Yr.	6.5 - 7.0 Ft. / Yr.
7.5 - 8.0 Ft. / Yr.	7.5 - 8.0 Ft. / Yr.
> 8.0 Ft. / Yr.	> 8.0 Ft. / Yr.

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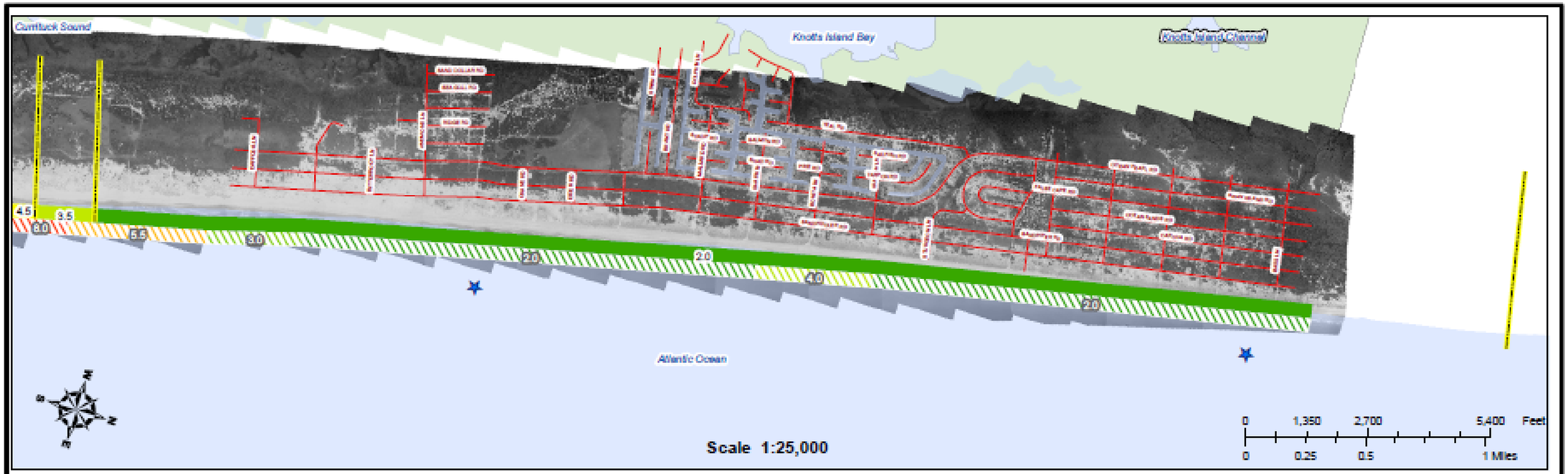
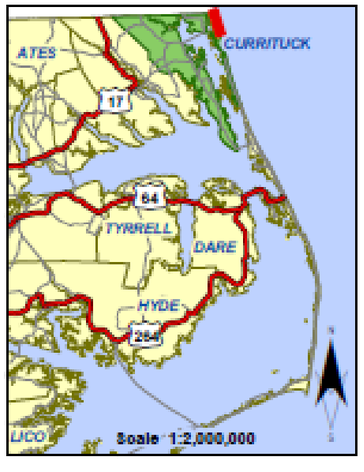


North of Corolla to Virginia

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

Regional Map



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Erosion Factor Boundary
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