Erosion Rate Update Study
Margery F. Overton
John S. Fisher
Department of Civil Engineering
North Carolina State University

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.

<table>
<thead>
<tr>
<th>Folder name</th>
<th>Dates of Shoreline</th>
<th>Approximate Spatial Coverage</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm7219</td>
<td>Jan 1973-Nov 1973</td>
<td>3 small areas around Bald Head Island, Carolina Beach, and Atlantic Beach</td>
<td>1:20K</td>
</tr>
<tr>
<td>cm7305</td>
<td>Apr 1974</td>
<td>most of Cape Hatteras to Cape Lookout (2 disjoint areas)</td>
<td>1:20K</td>
</tr>
<tr>
<td>idx126f</td>
<td>Jan 1933</td>
<td>South Carolina line through Bald Head Island</td>
<td>1:20K</td>
</tr>
<tr>
<td>idx134l</td>
<td>unknown</td>
<td>just south of Ocracoke through Cape Lookout</td>
<td>1:20K</td>
</tr>
<tr>
<td>ph45</td>
<td>Jan 1949-Mar 1951</td>
<td>Nags Head to 2 miles South of Oregon Inlet</td>
<td>1:20K</td>
</tr>
<tr>
<td>ph5</td>
<td>Jan 1946-Jul 1947</td>
<td>2 miles S of Oregon Inlet to Emerald Isle</td>
<td>1:10K</td>
</tr>
<tr>
<td>ph58</td>
<td>Nov 1949-Jul 1952</td>
<td>Emerald Isle to mid-Topsail</td>
<td>1:10K</td>
</tr>
<tr>
<td>idx134k</td>
<td>Jan 1933-Jan 1944</td>
<td>Bald Head Island to Emerald Isle</td>
<td>1:20K</td>
</tr>
<tr>
<td>ph20</td>
<td>Jan 1948-Mar 1949</td>
<td>Pamlico Sound (no ocean front coverage)</td>
<td>no ocean shoreline</td>
</tr>
<tr>
<td>cs275</td>
<td>Jan 1942-Jan 1944</td>
<td>South Carolina line through Bald Head Island</td>
<td>1:20K</td>
</tr>
</tbody>
</table>

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.**

<table>
<thead>
<tr>
<th>T-sheet group name</th>
<th>Approximate Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs275</td>
<td>Brunswick County through Kure Beach</td>
</tr>
<tr>
<td>idx134k</td>
<td>Carolina Beach through mid-Topsail Island</td>
</tr>
<tr>
<td>ph58</td>
<td>Topsail Island through mid-Bogue Banks</td>
</tr>
<tr>
<td>ph5</td>
<td>Mid-Bogue Banks through Oregon Inlet</td>
</tr>
<tr>
<td>ph45</td>
<td>Oregon Inlet to Kitty Hawk</td>
</tr>
</tbody>
</table>

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-term 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

<table>
<thead>
<tr>
<th>Photo Date</th>
<th>Photo Scale</th>
<th>Ground Pixel Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>June-August 1998</td>
<td>1:7200</td>
<td>0.5 ft</td>
</tr>
<tr>
<td>March 14, 1962</td>
<td>1:9600</td>
<td>0.667 feet</td>
</tr>
<tr>
<td>October 21, 1940</td>
<td>1:24,000</td>
<td>1.667 feet</td>
</tr>
</tbody>
</table>

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:

\[
\text{dist} = \sqrt{(x_{98} - x_{\text{early}})^2 + (y_{98} - y_{\text{early}})^2}
\]

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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Creator</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>polyint2pnt</td>
<td>Avenue Script</td>
<td>Dirk Vandervoort</td>
<td>Environmental Systems Research Institute (ESRI) ArcScripts website</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May 12, 1999</td>
<td><a href="http://arcscripts.esri.com/">http://arcscripts.esri.com/</a></td>
</tr>
<tr>
<td>AddXY</td>
<td>Avenue User</td>
<td>Zachary L. Stauber</td>
<td>Collection of ArcView Extensions</td>
</tr>
</tbody>
</table>

### 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.](image)

**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 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.

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

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

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

References


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

North Carolina Division of Coastal Management

This map is for general information only. The map outlines average rates of shoreline change over approximately 50 years. The map should not be used to determine the exact rate of erosion at any specific location. Use of this map may not be suitable for property-specific determination of shoreline displacement. For all specific determination contact your local CASA. Map prepared by the regional field office of the North Carolina Division of Coastal Management.

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Division of Emergency Management

For more information contact:
NC Division of Coastal Management
1820 Mail Service Center
Raleigh, NC 27699-1820
(919) 733-2260
Or visit:
www.ncostalmanagement.net

Legend

<table>
<thead>
<tr>
<th>1998 Erosion Factor</th>
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<td>0.5 - 2.0 PL / YR.</td>
<td>0.5 - 2.0 PL / YR.</td>
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<td>2.0 - 4.0 PL / YR.</td>
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<td>4.0 - 6.0 PL / YR.</td>
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<td>6.0 - 8.0 PL / YR.</td>
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<td>8.0 - 10.0 PL / YR.</td>
</tr>
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<td>&gt; 10.0 PL / YR.</td>
<td>&gt; 10.0 PL / YR.</td>
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</tbody>
</table>

How to read Erosion Factors

"2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
"2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Inlet Hazard Area Boundary
Erosion Rate Boundary
Roads

This general area has been influenced by beach nourishment or other beach protection or shoreline changes. This action artificially lowers the erosion rate in this area.
Ocean Isle
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998
Holden Beach - West

Long-Term Average Annual Shoreline Study & Erosion Factors

Updated Through 1998

How to read Erosion Factors

- “2.0” indicates a 1990 Erosion Factor of 2.0 Feet / Year
- “2.0” indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend

1990 Erosion Factor
- 0.0 - 2.0 Ft / Yr
- 2.1 - 5.0 Ft / Yr
- 5.1 - 10.0 Ft / Yr
- 10.1 - 20.0 Ft / Yr
- > 20.0 Ft / Yr

1992 Erosion Factor
- 3.0 Ft / Yr
- 3.1 - 5.0 Ft / Yr
- 5.1 - 10.0 Ft / Yr
- 10.1 - 20.0 Ft / Yr
- > 20.0 Ft / Yr

This general area has been influenced by beach nourishment, either Nourishment Protection or Dredge disposal. This action artificially lowers the erosion rate in this area.
Holden Beach - East
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

1998 Long-term average annual shoreline change rate developed by:
NC State University’s Karen Natural Hazards Mapping Program and North Carolina Division of Coastal Management

For more information contact:
NC Division of Coastal Management
1030 West Executive Center
Raleigh, NC 27601-1638
(919) 733-7000
Or visit:
www.nccoastalmanagement.net

Legend

1982 Erosion Factor 1998 Erosion Factor
2.0 Ft./Yr. < 2.0 Ft./Yr.
2.5 - 3.0 Ft./Yr. 2.5 - 3.0 Ft./Yr.
3.0 - 4.0 Ft./Yr. 3.0 - 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.

This general area has been influenced by beach nourishment either for beach protection or erosion control. This action artificially lowers the erosion rate in this area.
Oak Island - West
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

How to read Erosion Factors
- "2.0" Indicates a 1990 Erosion Factor of 2.0 Feet / Year
- "3.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- 1998 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

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 affect 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.

Funding for this project was provided by:

For more information contact:
NC Division of Coastal Management
1818 Mail Service Center
Raleigh, NC 27699-1638
(919) 732-2200
Or visit:
www.nccoastalmanagement.net
Oak Island - Central
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina
Division of Coastal Management

How to read Erosion Factors

Legend
1998 Erosion Factor 1992 Erosion Factor

- 2.0 FL. / YR. - 2.0 FL. / YR.
- 2.5 - 3.0 FL. / YR. - 3.0 FL. / YR.
- 3.5 - 4.0 FL. / YR. - 4.0 FL. / YR.
- 4.5 - 5.0 FL. / YR. - 5.0 FL. / YR.
- 5.5 - 6.0 FL. / YR. - 6.0 FL. / YR.
- 6.0 - 7.0 FL. / YR. - 7.0 FL. / YR.
- 7.5 - 8.0 FL. / YR. - 8.0 FL. / YR.
- > 8.0 FL. / YR. - > 8.0 FL. / YR.

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.

For more information contact:
NC Division of Coastal Management
1538 Mail Service Center
Raleigh, NC 27699-1538
(919)733-2263
Or visit
www.nccoastalmanagement.net

Scale 1:25,000

Scale 1:250,000

Scale 1:2,000,000
Bald Head Island
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

How to read Erosion Factors
- "2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- 1998 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads
- *This general area has been influenced by beach nourishment either for beach protection or other dispositions. This action artificially lowers the erosion rate in these areas.*

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

For more Information contact:
NC Division of Coastal Management
1609 Mail Service Center
Raleigh, NC 27699-1838
919-733-2200
Or visit:
www.nccoastalmanagement.net

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

Scale 1:25,000

Atlantic Ocean

Regional Map

North Carolina Division of Coastal Management

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

For more Information contact:
NC Division of Coastal Management
1609 Mail Service Center
Raleigh, NC 27699-1838
919-733-2200
Or visit:
www.nccoastalmanagement.net

NC State University's Kenan Natural Hazards Mapping Program and North Carolina Division of Coastal Management
Cape Fear
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

How to read Erosion Factors
- "2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- 1998 Erosion Factor
  - 2.0 FL / Yr.
  - 2.5 - 3.0 FL / Yr.
  - 2.5 - 3.0 FL / Yr.
  - 3.5 - 4.0 FL / Yr.
  - 4.5 - 5.0 FL / Yr.
- 1992 Erosion Factor
  - 2.0 FL / Yr.
  - 3.0 FL / Yr.
  - 4.0 FL / Yr.
  - 5.0 FL / Yr.
  - 6.0 FL / Yr.

This general area has been influenced by beach nourishment, either for beach protection or shoreline recreation. This action artificially lowers the erosion rate in these areas.
Zeeks Island
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Legend

- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment, either for beach protection or shoreline advancement. This action artificially increases the erosion rate in these areas.
Carolina Beach - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
Division of Coastal Management

North Carolina Division of Coastal Management

This map is for general information only. The map illustrates average rates of shoreline change over approximately 60 years. The information presented here is not predictive but does reflect the short-term erosion that occurs due to storms. The map may not be suitable for property-specific determination of erosion rate factors due to its small scale. For site-specific determination contact your NOAA Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

Funding for this project was provided by: National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management.

For more information contact:
North Carolina Division of Coastal Management
1638 Mail Service Center
Raleigh, NC 27699-1638
(919) 753-2200
Or visit:
www.nccostalmanagement.net

Legend
1998 Erosion Factor  1992 Erosion Factor

- 0.0 FL / Yr.  - 0.0 FL / Yr.
- 2.0 - 3.0 FL / Yr.  - 2.0 - 3.0 FL / Yr.
- 3.5 - 4.0 FL / Yr.  - 3.5 - 4.0 FL / Yr.
- 4.5 - 5.0 FL / Yr.  - 4.5 - 5.0 FL / Yr.
- 5.5 - 6.0 FL / Yr.  - 5.5 - 6.0 FL / Yr.
- 6.6 - 7.0 FL / Yr.  - 6.6 - 7.0 FL / Yr.
- 7.5 - 8.0 FL / Yr.  - 7.5 - 8.0 FL / Yr.
- 8.0 FL / Yr.  - 8.0 FL / Yr.

- Erosion Factor Boundary
- Inundation Area Boundary
- Roads

This general area has been influenced by beach nourishment either for beach protection or erosion control. This action artificially lowers the erosion rate in these areas.
Masonboro Island - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998
Figure Eight Island
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina
Division of Coastal Management

1998 Long-term average annual shoreline change rate development by:
NC State University’s Keno Natural Hazards Mapping Program and North Carolina Division of Coastal Management.

How to read Erosion Factors:
- "2.0" Indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend:
- 1998 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment, erosion by beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.
Hutaf's Island
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

How to read Erosion Factors
- “2.0” indicates a 1998 Erosion Factor of 2.0 Feet / Year
- “6.0” indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads
- This general area has been influenced by beach nourishment, either for beach protection or dune disposal. This action artificially lowers the erosion rate in these areas.
Topsail Island at Topsail Beach
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

How to read Erosion Factors

- "2.0" Indicates a 1996 Erosion Factor of 2.0 Feet / Year
- "2.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend

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<td>&gt; 8.0 PL / Yr.</td>
<td>&gt; 8.0 PL / Yr.</td>
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</tbody>
</table>

This general area has been influenced by beach nourishment, seawall construction or other modifications to the natural shoreline. These actions may have altered the erosion rates in these areas.

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. For a site-specific determination of erosion rates, contact your CAMA Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

For more information contact:
NC Division of Coastal Management:
1638 West Office Center
Raleigh, NC 27608-1638
(919) 789-2593
Visit www.nccoastalmanagement.net
Topsail Island at Surf City
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
1998 Erosion Factor
2.0 FL. / YR.
3.0 FL. / YR.
4.0 FL. / YR.
5.0 FL. / YR.
6.0 FL. / YR.
7.0 FL. / YR.
8.0 FL. / YR.
12.0 FL. / YR.
16.0 FL. / YR.
20.0 FL. / YR.
1992 Erosion Factor
2.0 FL. / YR.
3.0 FL. / YR.
4.0 FL. / YR.
5.0 FL. / YR.
6.0 FL. / YR.
7.0 FL. / YR.
8.0 FL. / YR.
12.0 FL. / YR.
16.0 FL. / YR.
20.0 FL. / YR.

How to read Erosion Factors
2.0 FL. / YR. indicates a 1998 Erosion Factor of 2.0 Feet / Year
12.0 FL. / YR. indicates a 1992 Erosion Factor of 12.0 Feet / Year

Erosion Factor boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment shore for beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.
Topsail Island at North Topsail Beach
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Regional Map

Legend

Erosion Factor Boundary
Inlet Hazard Area Boundary
Rivers

This general area has been influenced by beach nourishment and for beach protection or dredge disposal. This action artificially changes the erosion rate in these areas.
Topsail Island - NorthEast
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

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 actual erosion that occurs during storms. This map may not be suitable for property-specific determination of erosion rate factors due to its scale. For a site-specific determination, contact your CMAA Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

For more information contact:
NC Division of Coastal Management
1000 Mail Service Center
Raleigh, NC 27699-1388
(919) 733-2203

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

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

Scale 1:25,000

How to read Erosion Factors

20" Indicates a 1998 Erosion Factor of 2.0 Feet / Year
80" Indicates a 1992 Erosion Factor of 1.0 Feet / Year

Legend

1998 Erosion Factor 1992 Erosion Factor
2.0 FL / YR 2.0 FL / YR
2.5 - 3.0 FL / YR 3.0 FL / YR
3.5 - 4.0 FL / YR 3.5 - 4.0 FL / YR
4.5 - 5.0 FL / YR 4.5 - 5.0 FL / YR
5.5 - 6.0 FL / YR 5.5 - 6.0 FL / YR
6.5 - 7.0 FL / YR 6.5 - 7.0 FL / YR
7.5 - 8.0 FL / YR 7.5 - 8.0 FL / YR
8.0 FL / YR 8.0 FL / 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 these areas.
Onslow Beach
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
- Erosion Factor Boundary
- Inundation Area Boundary
- Floods

1998 Erosion Factor
- 2.0 ft. / yr.
- 2.5 - 3.0 ft. / yr.
- 3.0 - 4.0 ft. / yr.
- 4.0 - 5.0 ft. / yr.
- 5.0 - 6.0 ft. / yr.
- 6.0 - 7.0 ft. / yr.
- 7.0 - 8.0 ft. / yr.
- > 8.0 ft. / yr.

1992 Erosion Factor
- 2.0 ft. / yr.
- 3.0 ft. / yr.
- 3.5 - 4.0 ft. / yr.
- 4.0 - 5.0 ft. / yr.
- 4.5 - 6.0 ft. / yr.
- 5.0 - 6.0 ft. / yr.
- 6.0 - 7.0 ft. / yr.
- 7.0 - 8.0 ft. / yr.
- > 8.0 ft. / yr.

How to read Erosion Factors
- "2.0" indicates a 1998 Erosion Factor of 2.0 ft. / yr.
- "2.0" indicates a 1992 Erosion Factor of 2.0 ft. / yr.

This general area has been influenced by beach management actions, either for beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.
Bear Island
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Legend

1988 Erosion Factor  1992 Erosion Factor

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<th>1992</th>
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<td>2.0 F.L./Yr.</td>
</tr>
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<td>2.0 F.L./Yr.</td>
<td>2.0 F.L./Yr.</td>
</tr>
<tr>
<td>4.5-5.0 F.L./Yr.</td>
<td>2.0 F.L./Yr.</td>
<td>2.0 F.L./Yr.</td>
</tr>
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<td>5.5-6.0 F.L./Yr.</td>
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</tr>
</tbody>
</table>

How to read Erosion Factors

- 2.0" indicates a 1988 Erosion Factor of 2.0 F.L./Yr.
- 2.0" indicates a 1992 Erosion Factor of 2.0 F.L./Yr.

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

For more information contact:
NC Division of Coastal Management
1538 Mall Service Center
Raleigh, NC 27699-1038
P.O. Box 733 - 2268
Or visit:
www.nccoastalmanagement.net

This area has been influenced by beach nourishment or dredge disposal. This action artificially lowers the erosion rates in these areas.
Bogue Banks at Emerald Isle
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina
Division of Coastal Management

Legend
1994 Erosion Factor
20 FT/YR
30 - 40 FT/YR
45 - 50 FT/YR
55 - 60 FT/YR
65 - 70 FT/YR
75 - 80 FT/YR
> 90 FT/YR

1992 Erosion Factor
2.0 FT/YR
3.0 FT/YR
3.5 - 4.0 FT/YR
4.5 - 5.0 FT/YR
5.5 - 6.0 FT/YR
6.5 - 7.0 FT/YR
7.5 - 8.0 FT/YR
> 9.0 FT/YR

How to read Erosion Factors
“2.0” indicates a 1992 Erosion Factor of 2.0 Feet / Year
“3.0” indicates a 1994 Erosion Factor of 3.0 Feet / Year

This general area has been influenced by beach nourishment and other beach protection and dune disposal. This action may have altered the erosion rate in these areas.

Scale 1:25,000

Legend:
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

For more information contact:
NC Division of Coastal Management:
1501 Mail Service Center
Raleigh, NC 27699-1501
(919) 733-2203

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment and other beach protection and dune disposal. This action may have altered the erosion rate in these areas.
Bogue Banks at Atlantic Beach - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

How to read Erosion Factors:
- "2.0" Indicates a 1996 Erosion Factor of 2.0 Feet / Year
- "1.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- 1996 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment, either by beach protection or dune nourishment. This action artificially lowers the erosion rate in these areas.
Shackleford Banks - West
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

How to read Erosion Factors

2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year

2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend

<table>
<thead>
<tr>
<th>1998 Erosion Factor</th>
<th>1992 Erosion Factor</th>
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<tbody>
<tr>
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<tr>
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<td>6.5 - 7.0 PL / Yr.</td>
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<td>7.5 - 8.0 PL / Yr.</td>
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</tr>
<tr>
<td>&gt; 8.0 PL / Yr.</td>
<td>&gt; 8.0 PL / Yr.</td>
</tr>
</tbody>
</table>

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 eases the erosion rate in these areas.
Shackleford Banks - East
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
- 20: "2.0" indicates a 1990 Erosion Factor of 2.0 Ft./Yr.
- 20: "2.0" indicates a 1992 Erosion Factor of 2.0 Ft./Yr.

For more information contact:
NC Division of Coastal Management, 1505 Wall Street, Raleigh, NC 27601, 919-735-2280

Funding for this project was provided:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management
Cape Lookout - West
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1994

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 40 years. The information presented here is not predictive nor does it reflect the shorelines eroding at any given time. This may not be suitable for propertyspecific determination of erosion rates due to its small scale. For a site-specific determination contact your CAMP Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

How to read Erosion Factors

Erosion Factor

Legend

1998 Erosion Factor

1952 Erosion Factor

- 20 FT/ YR

- 20 FT/ YR

- 25 - 30 FT/ YR

- 30 FT/ YR

- 35 - 40 FT/ YR

- 40 FT/ YR

- 45 - 50 FT/ YR

- 50 FT/ YR

- 55 - 60 FT/ YR

- 60 FT/ YR

- 65 - 70 FT/ YR

- 70 FT/ YR

- 75 - 80 FT/ YR

- 80 FT/ YR

- >8.0 FT/ YR

- >8.0 FT/ YR

Erosion Factor Boundary

Inlet Hazard Area Boundary

Roads

This general area has been influenced to beach nourishment either for beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.
Cape Lookout
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Regional Map

Legend

- 20 Ft./Yr.
- 25-30 Ft./Yr.
- 35-40 Ft./Yr.
- 45-50 Ft./Yr.
- 55-60 Ft./Yr.
- 65-70 Ft./Yr.
- 75-80 Ft./Yr.
- >80 Ft./Yr.

- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet/Year
- "<2.0" indicates a 1996 Erosion Factor of less than 2.0 Feet/Year

Erosion Factor Boundary
Flood Hazard Area Boundary
Roads

This general area has been identified as vulnerable to erosion, either for beach protection or utility placement. This action may increase the erosion rate in these areas.

For more information contact:
NC Division of Coastal Management
1958 State Service Center
Raleigh, NC 27699-1938
Phone: 919-733-2259
Visit: www.nccoastalmanagement.net
Core Banks - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Regional Map

How to read Erosion Factors
- "2.0" indicates a 1996 Erosion Factor of 2.0 Feet / Year
- "4.0" indicates a 1992 Erosion Factor of 4.0 Feet / Year

Legend
- 1996 Erosion Factor
  - 2.0 Ft. / Yr.
  - 1.5 - 2.0 Ft. / Yr.
  - 1.0 - 1.5 Ft. / Yr.
  - 0.5 - 1.0 Ft. / Yr.
  - 0.25 - 0.5 Ft. / Yr.
  - 0.025 - 0.25 Ft. / Yr.
- 1992 Erosion Factor
  - 2.0 Ft. / Yr.
  - 1.5 - 2.0 Ft. / Yr.
  - 1.0 - 1.5 Ft. / Yr.
  - 0.5 - 1.0 Ft. / Yr.
  - 0.25 - 0.5 Ft. / Yr.
  - 0.025 - 0.25 Ft. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment efforts or coastal protection or erosion control. This action artificially reduces the erosion rate in these areas.
Core Banks - Central
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
Division of Coastal Management

North Carolina

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 definitive nor does it reflect the shoreline loss that occurs during storms. This map may not be suitable for project-specific determination of erosion rate factors due to its small scale. For a more-specific determination contact your Coastal Land Permissions Officer in the regional field office of the North Carolina Division of Coastal Management.

1990 Long-term average annual shoreline change rate developed by:
NC State University's Karen Natural Hazards Mitigation Program and North Carolina Division of Coastal Management

For more information contact:
NC Division of Coastal Management:
1821 Mail Services Center
Raleigh, NC 27699-8383
Phone: 919-733-2290
Or visit:
www.nccoastalmanagement.net

Legend

<table>
<thead>
<tr>
<th>1998 Erosion Factor</th>
<th>1992 Erosion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 PL / Yr</td>
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<tr>
<td>2.5 - 3.0 PL / Yr</td>
<td>3.0 PL / Yr</td>
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<tr>
<td>3.5 - 4.0 PL / Yr</td>
<td>4.0 PL / Yr</td>
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<tr>
<td>4.5 - 5.0 PL / Yr</td>
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<tr>
<td>5.5 - 6.0 PL / Yr</td>
<td>6.0 PL / Yr</td>
</tr>
<tr>
<td>6.5 - 7.0 PL / Yr</td>
<td>7.0 PL / Yr</td>
</tr>
<tr>
<td>7.5 - 8.0 PL / Yr</td>
<td>8.0 PL / Yr</td>
</tr>
</tbody>
</table>

Erosion Factor Boundary
Inundation Area Boundary
Roads

How to read Erosion Factors
1.0 PL / Yr indicates a 1998 Erosion Factor of 1.0 PL / Yr
1.5 PL / Yr indicates a 1992 Erosion Factor of 1.5 PL / Yr

This general area has been influenced by beach nourishment and is at risk of shoreline erosion. This action artificially lowers the erosion rate in these areas.

Page 34 of 69
Core Banks - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Legend

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

Erosion Factor Boundary
Hazard Area Boundary

This general area has been influenced by beach nourishment or erosion.

How to read Erosion Factors
- "2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

For more information contact:
NC Division of Coastal Management:
1638 Mail Service Center
Raleigh, NC 27695-1038
704-733-2505
Or visit:
www.nccoastalmanagement.gov
Portsmouth Island - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend

1998 Erosion Factor
2.0 - 3.0 ft./yr.
3.1 - 4.0 ft./yr.
4.1 - 5.0 ft./yr.
5.1 - 6.0 ft./yr.
6.1 - 7.0 ft./yr.
7.1 - 8.0 ft./yr.
> 8.0 ft./yr.

1992 Erosion Factor
2.0 - 3.0 ft./yr.
3.1 - 4.0 ft./yr.
4.1 - 5.0 ft./yr.
5.1 - 6.0 ft./yr.
6.1 - 7.0 ft./yr.
7.1 - 8.0 ft./yr.
> 8.0 ft./yr.

How to read Erosion Factors
2.0 indicates a 1998 Erosion Factor of 2.0 Foot/Year
2.0 indicates a 1992 Erosion Factor of 2.0 Foot/Year

Erosion Factor Boundary
Initial Hazard Area Boundary
Rocks

This general area has been influenced by beach nourishment, either for beach protection or dredge disposal. This action artificially reduces the erosion rate in these areas.
Portsmouth Island - Central (2 of 2)
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
- 1998 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roats

This general area has been influenced by beach nourishment or other local conditions that may have altered the erosion rate in these areas.
Portsmouth Island - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Legend

- 0.0 - 2.0 ft./yr.
- 2.1 - 4.0 ft./yr.
- 4.1 - 6.0 ft./yr.
- 6.1 - 8.0 ft./yr.
- 8.1 - 10.0 ft./yr.
- 10.1 - 12.0 ft./yr.
- 12.1 - 14.0 ft./yr.
- 14.1 - 16.0 ft./yr.
- 16.1 - 18.0 ft./yr.
- 18.1 - 20.0 ft./yr.
- 20.1 - 22.0 ft./yr.
- 22.1 - 24.0 ft./yr.
- 24.1 - 26.0 ft./yr.
- 26.1 - 28.0 ft./yr.
- 28.1 - 30.0 ft./yr.
- 30.1 - 32.0 ft./yr.
- 32.1 - 34.0 ft./yr.
- 34.1 - 36.0 ft./yr.
- 36.1 - 38.0 ft./yr.
- 38.1 - 40.0 ft./yr.
- 40.1 - 42.0 ft./yr.
- 42.1 - 44.0 ft./yr.
- 44.1 - 46.0 ft./yr.
- 46.1 - 48.0 ft./yr.
- 48.1 - 50.0 ft./yr.
- 50.1 - 52.0 ft./yr.
- 52.1 - 54.0 ft./yr.
- 54.1 - 56.0 ft./yr.
- 56.1 - 58.0 ft./yr.
- 58.1 - 60.0 ft./yr.
- 60.1 - 62.0 ft./yr.
- 62.1 - 64.0 ft./yr.
- 64.1 - 66.0 ft./yr.
- 66.1 - 68.0 ft./yr.
- 68.1 - 70.0 ft./yr.
- 70.1 - 72.0 ft./yr.
- 72.1 - 74.0 ft./yr.
- 74.1 - 76.0 ft./yr.
- 76.1 - 78.0 ft./yr.
- 78.1 - 80.0 ft./yr.
- 80.1 - 82.0 ft./yr.
- 82.1 - 84.0 ft./yr.
- 84.1 - 86.0 ft./yr.
- 86.1 - 88.0 ft./yr.
- 88.1 - 90.0 ft./yr.
- 90.1 - 92.0 ft./yr.
- 92.1 - 94.0 ft./yr.
- 94.1 - 96.0 ft./yr.
- 96.1 - 98.0 ft./yr.
- 98.1 - 100.0 ft./yr.

- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment, fees, or beach protection, or other repairs. This action often results in the erosion rate in these areas.
Ocracoke - SouthWest
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend

1998 Erosion Factor 1992 Erosion Factor
2.0 PL./YR. 2.0 PL./YR.
3.0 - 3.9 PL./YR. 3.0 PL./YR.
4.0 - 4.9 PL./YR. 4.5 - 5.9 PL./YR.
5.0 - 5.9 PL./YR. 5.5 - 6.9 PL./YR.
6.0 - 6.9 PL./YR. 6.5 - 7.9 PL./YR.
7.0 - 7.9 PL./YR. 7.5 - 8.9 PL./YR.
> 8.0 PL./YR. > 8.0 PL./YR.

How to read Erosion Factors
"2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
"2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year
Ocracoke - Central
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1993

Regional Map
North Carolina Division of Coastal Management

How to read Erosion Factors
- "2.0" indicates a 1995 Erosion Factor of 2.0 Feet / Year
- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- 1995 Erosion Factor
- 1992 Erosion Factor
- Inlet Hazard Area Boundary
- Erosion Factor Boundary
- Roads

For more information contact:
NC 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 herein is not definitive nor does it reflect the short-term erosion that occurs during storms. This map may not be suitable for property-specific determination of erosion rates by due to its scale. For a site-specific determination contact your CAM Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

Funding for this project was provided by:

Scale 1:25,000

Atlantic Ocean

Scale 1:2,000,000
Ocracoke - NorthEast
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1988

Legend
- 2.0 ft / yr
- 2.5 - 3.0 ft / yr
- 3.5 - 4.0 ft / yr
- 4.0 - 5.0 ft / yr
- 5.5 - 6.0 ft / yr
- 6.5 - 7.0 ft / yr
- 7.5 - 8.0 ft / yr
- > 8.0 ft / yr

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

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 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.

How to read Erosion Factors
- "2.0" indicates a 1996 Erosion Factor of 2.0 feet/yr,
- "3.0" indicates a 1992 Erosion Factor of 3.0 feet/yr,

For more information contact:
NC Division of Coastal Management
1838 Mail Service Center
Raleigh, NC 27699-1838
(919) 793 - 2504
Or visit: www.nccoastalmanagement.net

Funding for this project was provided by:
Cape Hatteras
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
- 20 = "20" indicates a 1998 Erosion Factor of 2.0 Feet / Year
- 20 = "20" indicates a 1992 Erosion Factor of 2.0 Feet / Year

How to read Erosion Factors
1998 Long-term average annual shoreline change rate developed by:
NC State University's Karen Natural Hazards Mapping Program and North Carolina Division of Coastal Management

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

This general area has been influenced by beach nourishment, either for beach protection or shoreline stabilization. This action artificially lowers the erosion rate in these areas.
Cape Hatteras at Buxton
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend
- 2.0: Indicates a 1990 Erosion Factor of 2.0 Feet/Year
- *2.0: Indicates a 1992 Erosion Factor of 2.0 Feet/Year

Legend
- 1990 Erosion Factor
- 1992 Erosion Factor
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment or beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.

North Carolina Division of Coastal Management

For more information contact:
NC Division of Coastal Management:
ICBM Mail Services Center
Raleigh, NC 27610-1036
(919) 733-3004
www.nccoastalmanagement.net
Hatteras Island at Avon
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 or the same as reflect the shoreline changes that occur during storms. This map may not be suitable for property-specific determination of shoreline change. Contact your NCMA Local Permit Office or the regional field office of the North Carolina Division of Coastal Management for more information.

Funding for this project was provided by:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management

Legend
1984 Erosion Factor
1992 Erosion Factor
Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads
This version area has been influenced by beach nourishment efforts for beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.

How to read Erosion Factors

*2.0* indicates a 1998 Erosion Factor of 2.0 feet per year
*2.0* indicates a 1992 Erosion Factor of 2.0 feet per year
Hatteras Island at Avon - North
Long-Term Average Annual Shoreline Change & Erosion Factors
Updated Through 1998

North Carolina
Division of Coastal Management

Regional Map

Legend

Erosion Factor
- 2.0 PL. YR.
- 2.5 - 30 PL. YR.
- 3.5 - 40 PL. YR.
- 4.5 - 50 PL. YR.
- 5.5 - 60 PL. YR.
- 6.5 - 70 PL. YR.
- 7.5 - 80 PL. YR.
~ 8.0 PL. YR.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Floods
This general area has been influenced by beach nourishment, either for beach protection or shoreline disposal. This action artificially lowers the erosion rate in these areas.

How to read Erosion Factors
'2.0' indicates a 1998 Erosion Factor of 2.0 Feet / Year
'2.0' indicates a 1992 Erosion Factor of 2.0 Feet / Year

For more information contact:
NC Division of Coastal Management:
1938 N 4th Street, South, NC 27807-1938
(919) 733-5172
www.nccoastalmanagement.net
Hatteras Island at Salvo
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 instantaneous rate of shoreline change. The map is not suitable for property-specific determination of shoreline change rates. For a shore-specific determination contact your NCMA Local Permit Office or the regional Permit Office of the North Carolina Division of Coastal Management.

Funding for this project was provided by:
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 & Karen Natural Hazards Mapping Program and North Carolina Division of Coastal Management

For more information contact:
NC Division of Coastal Management
1608 Mall Service Center
Raleigh, NC 27609-1608
(919) 733 – 2263
Or visit:
www.nccoastalmanagement.net

Legend

1998 Erosion Factor

2.0 PL/yr

3.0 PL/yr

4.5 - 6.0 PL/yr

5.5 - 7.0 PL/yr

7.5 - 8.0 PL/yr

9.0 PL/yr

1992 Erosion Factor

2.0 PL/yr

3.0 PL/yr

4.5 - 6.0 PL/yr

5.5 - 7.0 PL/yr

7.5 - 8.0 PL/yr

9.0 PL/yr

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been
influenced by beach nourishment.
This action artificially lowers the erosion rate in these areas.

How to read Erosion Factors

"2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year

"2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

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Hatteras Island at Rodanthe
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1992

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 small scale. For a specific determination contact your CEM Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

Funding for this project was provided by:

1992 Erosion Factor 1993 Erosion Factor
2.0 PL/yr. 2.0 PL/yr.
2.5 - 3.0 PL/yr. 3.0 PL/yr.
3.5 - 4.0 PL/yr. 3.5 - 4.0 PL/yr.
4.5 - 5.0 PL/yr. 4.5 - 5.0 PL/yr.
5.5 - 6.0 PL/yr. 5.5 - 6.0 PL/yr.
6.0 - 7.0 PL/yr. 6.0 - 7.0 PL/yr.
7.0 - 8.0 PL/yr. 7.0 - 8.0 PL/yr.
>8.0 PL/yr. >8.0 PL/yr.

Legend
- Erosion Factor Boundary
- Inlet Hazard Area Boundary
- Roads

This general area has been influenced by beach nourishment, erosion, or beach incision or dredge disposal. This action artificially lowers the erosion rate in these areas.
Pea Island - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

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 shoreface 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 streamlined determination contact your DMA Local Permit Officer or the regional field office of the North Carolina Division of Coastal Management.

For more information contact:
NC Division of Coastal Management:
1901 Mail Service Center
Raleigh, NC 27606-1901
(919) 733 – 2263
Or visit:
www.nccoastalmanagement.net

Legend
1990 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.
- 6.0 - 7.0 ft. / Yr. - 5.0 - 7.0 ft. / Yr.
- 7.0 - 8.0 ft. / Yr. - 7.0 - 8.0 ft. / Yr.
- > 8.0 ft. / Yr. - > 8.0 ft. / Yr.

This general area has been influenced by beach nourishment, barrier elongation or beach protection or dune stabilization. This action artificially lowers the erosion rate in these areas.
Nags Head - North to Kill Devil Hills - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map

North Carolina Division of Coastal Management

Legend

1988 Erosion Factor
2.0 PL / Yr.
2.5 - 3.0 PL / Yr.
3.5 - 4.0 PL / Yr.
4.5 - 5.0 PL / Yr.
5.5 - 6.0 PL / Yr.
6.5 - 7.0 PL / Yr.
7.5 - 8.0 PL / Yr.
> 8.0 PL / Yr.

1992 Erosion Factor
2.0 PL / Yr.
3.0 PL / Yr.
3.5 - 4.0 PL / Yr.
4.5 - 5.0 PL / Yr.
5.5 - 6.0 PL / Yr.
6.5 - 7.0 PL / Yr.
7.5 - 8.0 PL / Yr.
> 8.0 PL / 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 these areas.

How to read Erosion Factors

"2.0" indicates a 1988 Erosion Factor of 2.0 Feet / Year

"2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year
Duck to Sanderling - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map

North Carolina Division of Coastal Management

How to read Erosion Factors
- "2.0" indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
- Erosion Factor Boundary
- Initial Hazard Area Boundary
- Roads
- This general area has been influenced by beach nourishment and/or beach protection or dredge disposal. This action artificially lowers the erosion rate in these areas.
Sanderling - North to Corolla - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

Regional Map
North Carolina Division of Coastal Management

Legend

1998 Erosion Factor 1992 Erosion Factor

- 0.0 Fl. / Yr. 0.0 Fl. / Yr.
- 1.0 Fl. / Yr. 1.0 Fl. / Yr.
- 3.0 Fl. / Yr. 3.0 Fl. / Yr.
- 5.0 Fl. / Yr. 5.0 Fl. / Yr.
- 7.0 Fl. / Yr. 7.0 Fl. / Yr.
- 9.0 Fl. / Yr. 9.0 Fl. / Yr.
- 10.0 Fl. / Yr. 10.0 Fl. / Yr.


This general area has been impacted by beach nourishment, either for beach protection or shoreline maintenance. This action artificially lowers the erosion rate in these areas.

How to read Erosion Factors

"2.0" indicates a 1991 Erosion Factor of 2.0 Fl. / Year
"3.0" indicates a 1992 Erosion Factor of 3.0 Fl. / Year
Corolla - South
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina
Division of Coastal Management

Regional Map

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 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.

Funding for this project was provided by:
National Oceanic and Atmospheric Administration; Federal Emergency Management Administration; and North Carolina Division of Emergency Management.

Legend
1998 Erosion Factor
1992 Erosion Factor
Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment or dredge disposal. This action artificially lowers the erosion rate in these areas.

How to read Erosion Factors
"2.0" indicates a 1998 Erosion Factor of 2.0 Feet/Year
"2.0" indicates a 1992 Erosion Factor of 2.0 Feet/Year

Scale 1:25,000
Corolla - North
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina
Division of Coastal Management

Regional Map

How to read Erosion Factors
- "2.0" Indicates a 1998 Erosion Factor of 2.0 Feet / Year
- "2.0" Indicates a 1992 Erosion Factor of 2.0 Feet / Year

Legend
1998 Erosion Factor 1992 Erosion Factor
0.0 - 2.0 FL. / Yr. 0.0 - 2.0 FL. / Yr.
2.5 - 3.0 FL. / Yr. 2.5 - 3.0 FL. / Yr.
3.5 - 4.0 FL. / Yr. 3.5 - 4.0 FL. / Yr.
4.5 - 5.0 FL. / Yr. 4.5 - 5.0 FL. / Yr.
5.5 - 6.0 FL. / Yr. 5.5 - 6.0 FL. / Yr.
6.0 - 7.0 FL. / Yr. 6.0 - 7.0 FL. / Yr.
7.0 - 8.0 FL. / Yr. 7.0 - 8.0 FL. / Yr.
8.0 + FL. / Yr. 8.0 + FL. / Yr.

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment.
Erosion rates may exceed those shown on this map due to beach
protection of beach restorations and actions artificial
cover or fill.
North of Corolla to Virginia
Long-Term Average Annual Shoreline Study & Erosion Factors
Updated Through 1998

North Carolina Division of Coastal Management

Regional Map

Legend
- 2.0 FL / YR
- 2.1 - 3.0 FL / YR
- 3.1 - 4.0 FL / YR
- 4.1 - 5.0 FL / YR
- 5.1 - 6.0 FL / YR
- 6.1 - 7.0 FL / YR
- 7.1 - 8.0 FL / YR
- > 8.0 FL / YR

Erosion Factor Boundary
Inlet Hazard Area Boundary
Roads

This general area has been influenced by beach nourishment either for beach protection or dune/ridge stabilization. For more information contact:
National Oceanic and Atmospheric Administration, Federal Emergency Management Administration, and North Carolina Division of Emergency Management