VIII. Region 1

Region 1 encompasses Brunswick County from the North Carolina/South Carolina Border to the Brunswick County/New Hanover County line. The Towns of Sunset Beach, Ocean Isle Beach, Holden Beach, Oak Island, Caswell Beach, and Bald Head Island all fall within this Region. Tubbs Inlet, Shallotte Inlet, Lockwoods Folly Inlet, and Cape Fear Inlet divide the barrier islands. Figure VIII-1 shows the boundaries of Region 1.

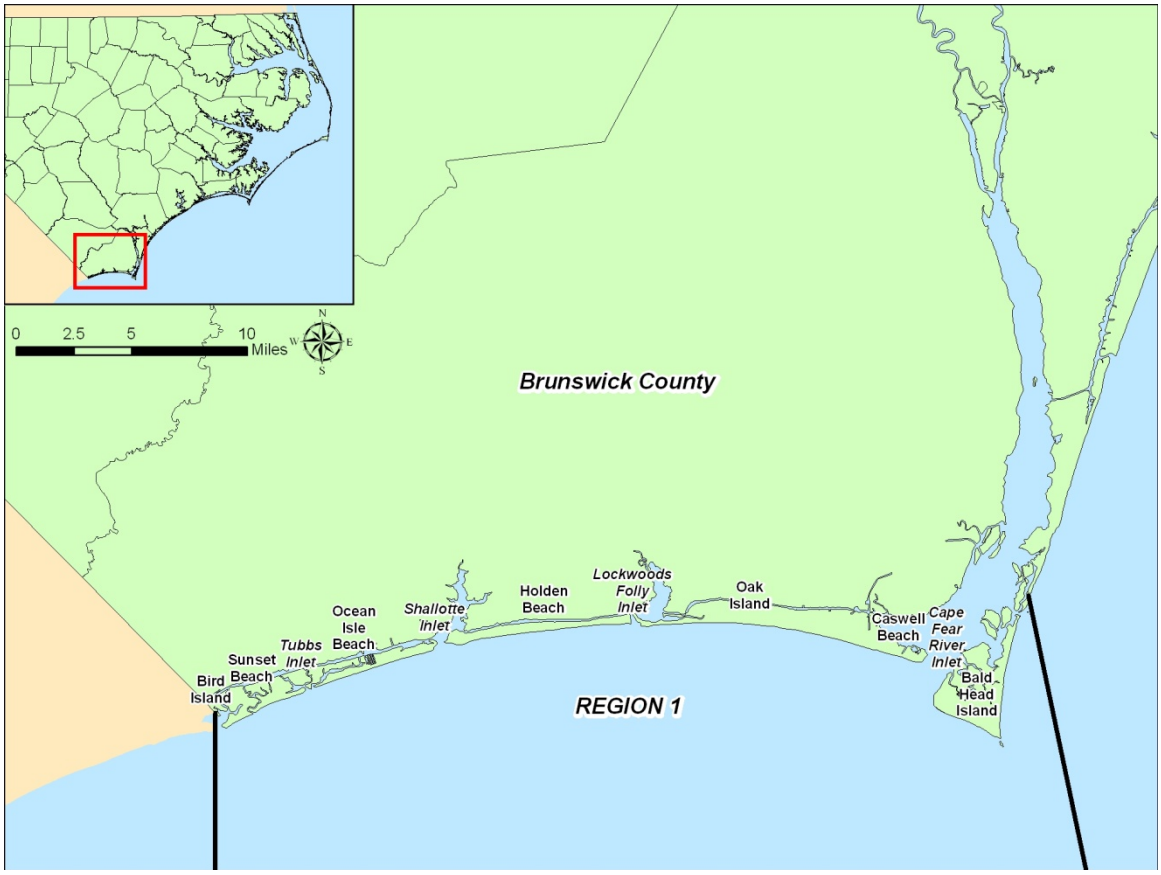

Figure VIII-1. Region 1 Boundaries

Region 1 is comprised primarily of developed shoreline, with the exception of Bird Island, which is state-owned and designated as "Not to be Developed." See Table VIII-1 for shoreline lengths.

Table VIII-1. Region 1 Shoreline Development Lengths

Shoreline Type	Shoreline Length (mi)
Not Developed	0
Developed	33
Not to be Developed	7
Total	40

Table VIII-2 provides an approximate breakdown of shoreline ownership. State-owned lands include portions of Bald Head Island and Bird Island.

Table VIII-2. Region 1 Shoreline Management

Shoreline Management	Shoreline Length (mi)
Municipal	**33**
State	**7**
Federal	**0**
Private	**0**
TOTAL	**40**

Table VIII-3 shows the approximate distance of shoreline that has been actively managed in the past. Approximately 31.2 miles of shoreline are managed in this region. Portions of Bald Head Island, Bird Island, and Sunset Beach have not been managed in the past.

Table VIII-3. Region 1 Managed Shoreline Lengths

Management	Shoreline Length (mi)
Managed	31.2
Not Managed	9.8
TOTAL	**40**

A. Current Available Pertinent Datasets

1. Waves and Water Levels

Beaches, as the transition zone between land and water, are susceptible to changes through waves, winds, and currents. Waves play a major role in the shaping and evolution of beaches and inlets. Moving water suspends and transports sediment, while the frequency and direction of incoming waves influence beach behavior and geometry. The Region 1 shoreline faces south, exposing it and making it susceptible to wave activity from the south. Waves can have short-term, seasonal, and long-term impacts on both the cross-shore and along-shore beach shape. Drastic changes in beach width and elevation can occur during a single hurricane, but it is the more frequent storms and wave events that generally drive the overall beach configuration. Winter storms and the associated higher wave activities typically pull sand offshore, and gentler summer waves move the sand from the offshore bar back onto the beach. The typical angle of wave approach transports sand along the shoreline, and inlets interrupt sand movement, forming deltas due to the currents generated in the inlets by the rising and falling tides. Wave data along the North Carolina coast is available from long term wave hindcast modeling and from measurements at various wave buoys operating at various locations.

Wave hindcasts are numerical models which use historic wind and meteorological data to calculate or hindcast what the waves would have been at a particular location. The United States Army Corps of Engineers Wave Information Study (WIS) is an extensive hindcast model that provides wave information (height, period, and direction) for the 20 year period of 1980-99 at more than 300 stations offshore of the North Carolina coast. This data is available from the U.S. Army Corps of Engineer's website at http://www.frf.usace.army.mil/cgi-bin/wis/atl/atl_main.html.Representative data available from USACE WIS Station 310 is depicted in Figure VIII-2. Figure VIII-3 shows the locations of WIS stations (locations where hindcast wave data is available) for Region 1. Note how the predominant offshore wave direction is from the southeast, while the local winds are more random.

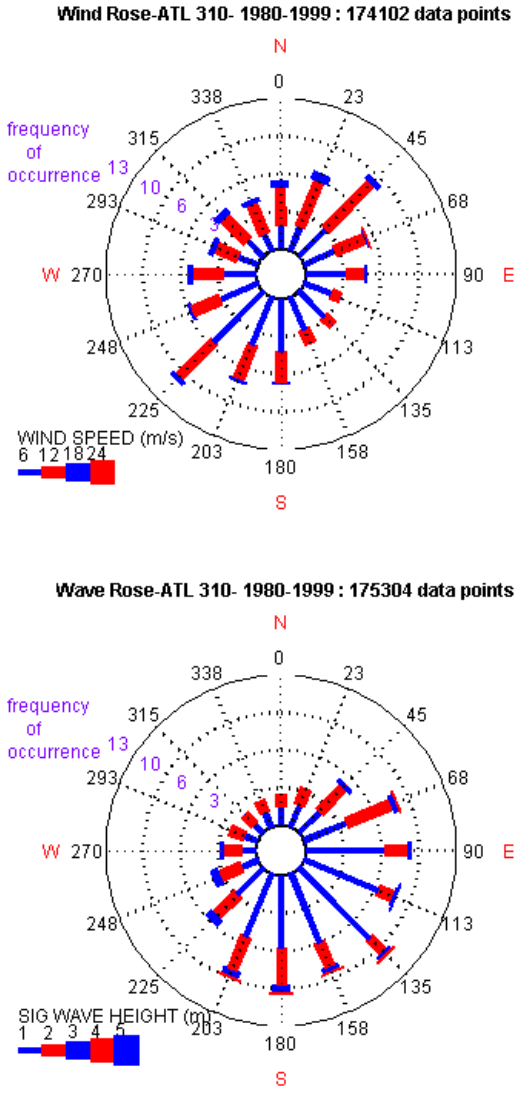

Figure VIII-2. Representative Wind and Wave Roses from WIS Station 310

Wave measurements can be obtained from wave buoys off the North Carolina coast and are available from the National Data Buoy Center (NDBC) website at http://www.ndbc.noaa.gov/. The wave buoys also collect climatological data. Both real time and historical data can be downloaded. Figure VIII-3 shows the locations of NDBC wave buoys for Region 1. This region also contains two Acoustic Doppler Current Profiler (ADCP) gauges monitored by the Field Research Facility (FRF) in Duck, NC under direction of the USACE Wilmington District. These gauges were placed to monitor waves as part of the dredging to deepen the channel through the Cape Fear River to the Port of Wilmington. As part of the navigation improvements, the ocean bar channel was deepened and realigned. The locations of these gauges are shown in Figure VIII-3.

In addition to wave activity, beaches and inlets are impacted by both temporal and spatial variations in the water level. Water level variations can be regular, such as the tides, or periodic, such as storm surge. Water level changes can also occur over long periods of time due to sea level rise (climate change or relative change due to land subsidence).

Along the North Carolina coast, tides are typically semidiurnal, having two high tides and two low tides of similar heights each day. Tides are currently measured at six locations along the North Carolina Coast by the National Oceanic and Atmospheric Administration (NOAA) and the USACE. There is one NOAA tide station located in Region 1, at Sunset Beach. Another station located just north of Cape Fear Inlet at Southport was decommissioned in January 2008. The tidal range for Region 1 is approximately 4.5 -5.5 feet. Table VIII-4 displays the tidal datums, in feet, with respect to Mean Lower Low Water (MLLW) for the two NOAA Tide Stations of record for Region 1. The NOAA tide stations data is available from the NOAA Tides and Currents website (http://tidesandcurrents.noaa.gov/). Figure VIII-3 shows the locations of NOAA tide stations for Region 1, including the former Southport station.

Table VIII-4. Tidal Datums (ft) for Region 1 Stations (past and present)

	Southport, NC	Sunset Beach, NC
Datum	Sta 8659084	Sta 8659897
Mean Higher High Water (MHHW)	4.73	5.51
Mean High Water (MHW)	4.40	5.12
Mean Tide Level (MTL)	2.28	2.65
Mean Sea Level (MSL)	2.32	2.66
Mean Low Water (MLW)	0.16	0.18
Mean Lower Low Water (MLLW)	0.00	0.00
North American Vertical Datum (NAVD)	2.78	No Data
National Geodetic Vertical Datum (NGVD)	1.68	No Data
Maximum Tide Level	6.88	7.56
Date Maximum Tide Level Recorded	12/2/1986	10/9/2006

Shorter term water level fluctuations caused by passing storms, both extratropical (northeasters) and tropical (tropical storms and hurricanes), can elevate water levels along the coast resulting in flooding and the reach of waves further up the beach face reshaping the shoreline. Storm driven water levels along the coast are available for events with a one percent annual chance of occurrence (100 year return period) from the Flood Insurance Rate Maps (FIRM) and Flood Insurance Studies (FIS) developed by the Federal Emergency Management Agency (FEMA). North Carolina is currently in the process of updating these along coastal regions, including extensive storm surge modeling. Information can be found at http://www.ncfloodmaps.com/.

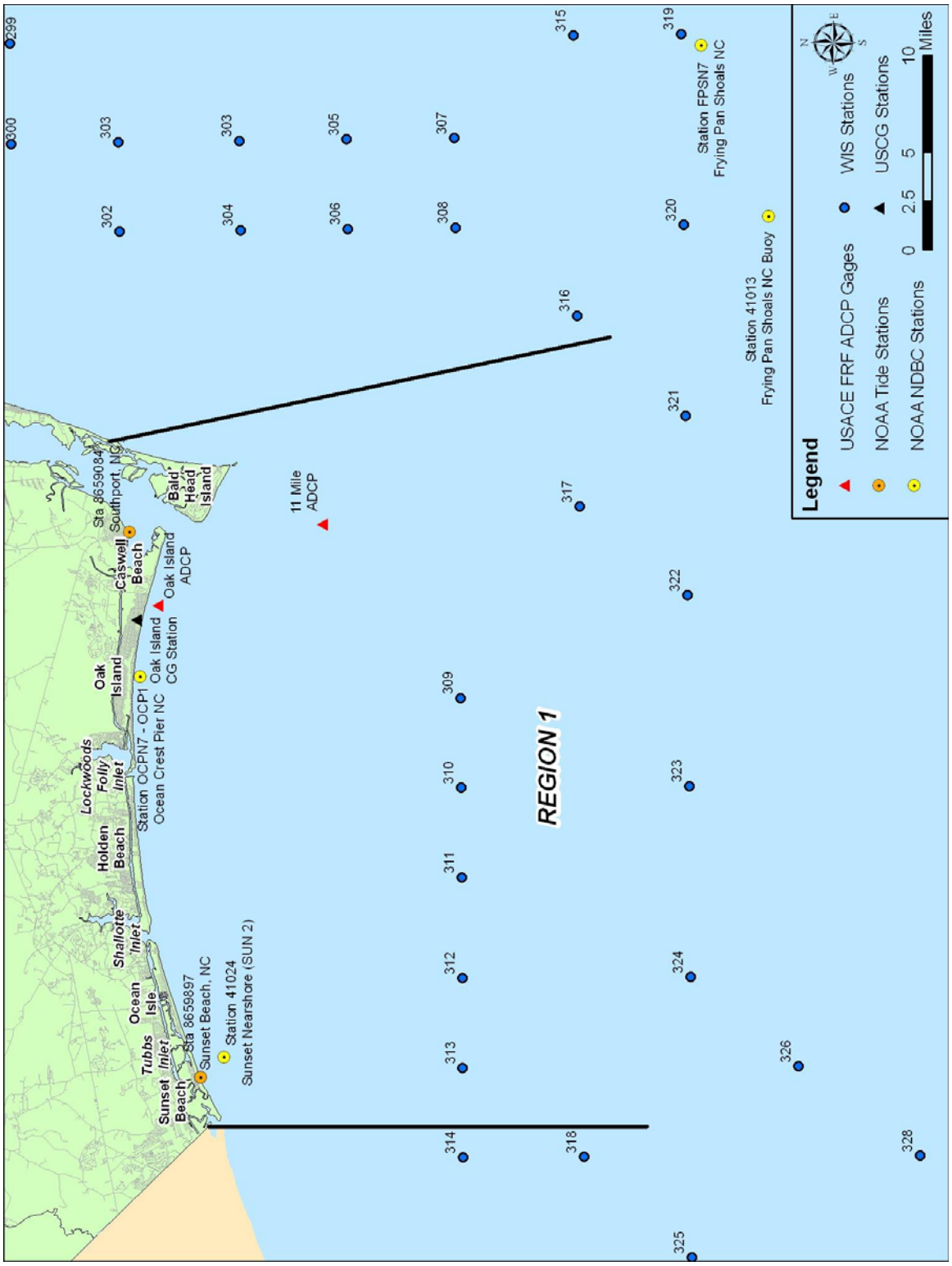

Figure VIII-3. Wave and Water Level Stations for Region 1

Due either to land subsidence, global climate changes or other factors, relative sea-level is rising along the North Carolina coast. The long-term tidal water level recording stations estimate the rate of this rise as approximately 1-1.5 feet over the last century along the N.C. coast. For the long-term NOAA tidal measurement station at Beaufort, the mean sea level trend is 3.71 mm/year (1.22 feet/century) with a standard error of 0.64 mm/year (0.21 feet/century) based on monthly mean sea level data from 1973 to 1999. Figure VIII-4 shows the sea level rise at a tide station at Beaufort, N.C. This is the only tide station along the North Carolina coast with an uninterrupted, long-duration measurement record for which this data has been developed.

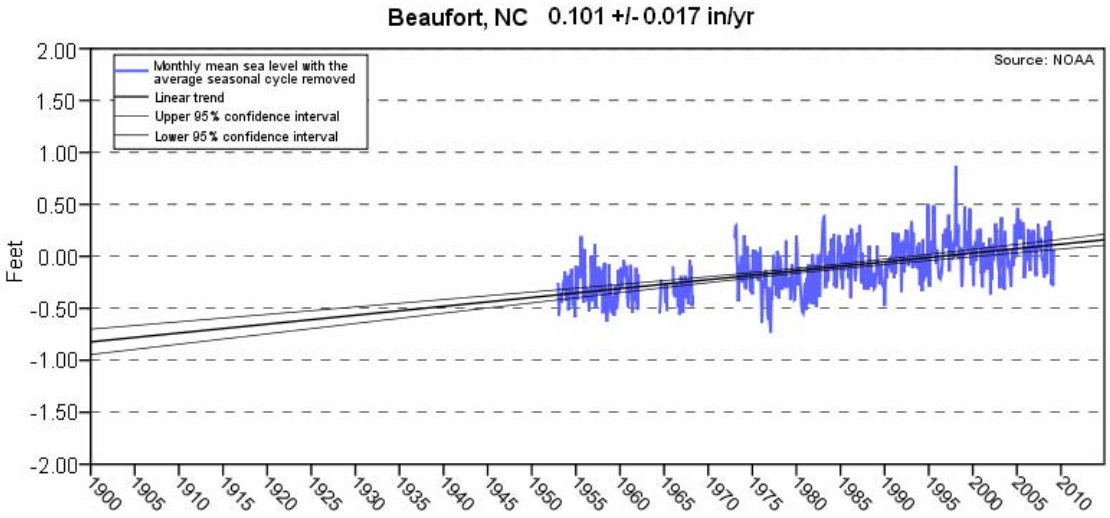

Figure VIII-4. Sea Level Rise at Beaufort, NC

Planning for long-term sea level rise is difficult since consensus on how much and how quickly it will rise is difficult to achieve. There are currently many researchers, government agencies and international organizations studying the topic with conflicting predictions and disputes over the causes of sea level rise. Short-term sea level rise from 1980 to 2000 at Duck, N.C. (Dare County), based on tide level readings, is estimated to be 1.5 feet/century (Riggs, 2008). Other studies show estimates of sea level rise for the Outer Banks of 10.5 inches/century (Pietrafesa *et al.*, 2005). Note that all of these estimates are based on extrapolation of measurements of less than 100 years. Nonetheless, the impact of rising sea levels, for which there is wide agreement, must be considered in long-term planning. It is possible to continue with strategies that are acceptable under current and shorter term historical changes, such as those predicted by the Beaufort gauge data, and then adapt as needed if conditions change in the coming years.

2. Tropical Storms

Tropical storms, especially hurricanes, can be a major episodic force in reshaping beaches and inlets (including breaching new inlets through the barrier islands). NOAA maintains a GIS database of storm tracks for Atlantic and Pacific hurricanes and cyclones including approximate storm location, date, wind speed, pressure, and category that have

been recorded for storms since 1851. GIS shapefiles can be downloaded at NOAA's website. Region 1 has mainly been impacted by tropical storms but has been affected by Category 1, Category 2, and Category 3 hurricanes in the past. Due to its southern exposure Region 1 is susceptible to tropical storms. A map displaying the recorded Atlantic hurricane tracks in Region 1 since 1851 is presented in Figure VIII-6. Hurricanes Hazel (1954) and Fran (1996) have been the most significant for this region. The NOAA National Hurricane Center Risk Analysis Program has developed estimates for return periods of hurricanes of various intensities along the U.S. coast. Figure VIII-5 presents this data for the N.C. coast. The numbers indicate the expected return period (in years) on average that a hurricane can be expected within 75 nautical miles (86 statute miles) of the location. Region 1 generally experiences fewer hurricanes than other areas of the North Carolina coast with the exception of the northern reaches. For example, a Category 1 hurricane is expected in Region 1 once every 10 years whereas the same size storm is expected at Cape Hatteras once every five years (see upper left hand graphic of Figure VIII-5).

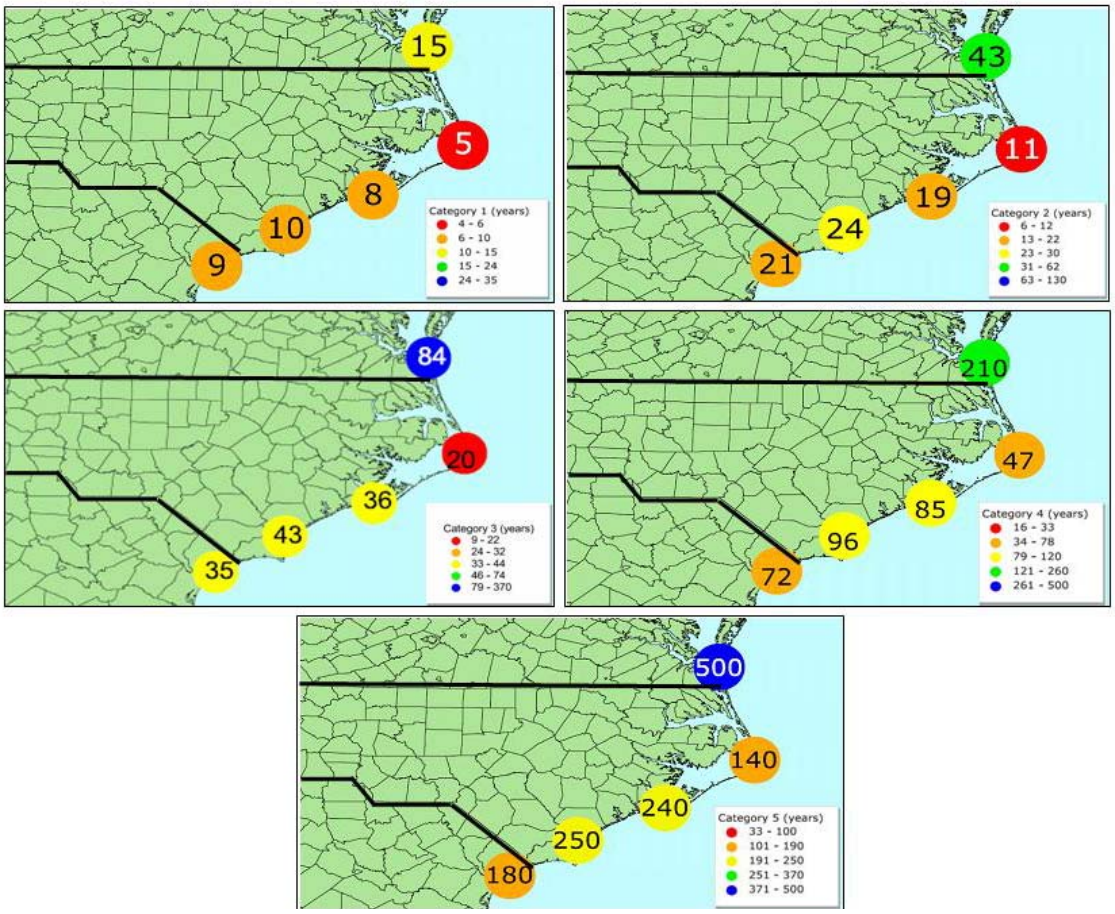

Figure VIII-5. Expected Return Period of Hurricanes

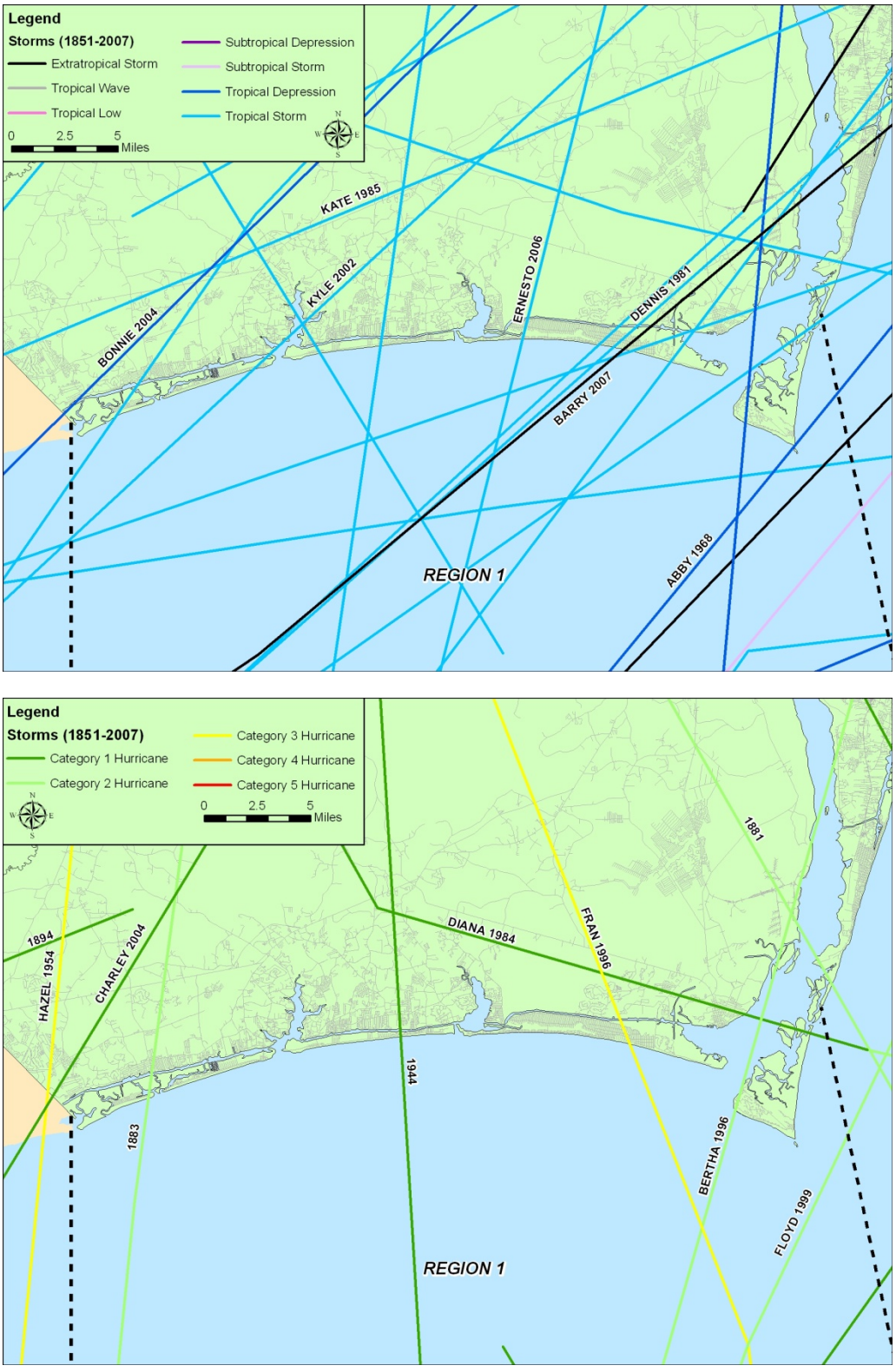

Figure VIII-6. Atlantic Storm and Hurricane Tracks for Region 1

3. Digital Orthophotography

Photography is available from various sources including the Division of Coastal Management (DCM), USGS, National Agriculture Imagery Program (NAIP), and individual county governments. Aerials of the entire oceanfront shoreline were taken in 1998 and 2004. In 2003, post-Isabel aerials were taken of the ocean shoreline by USGS, with the exception of Dare and Hyde counties. In 2006, the NAIP created mosaics for orthotiles for the entire coastline. Various counties also have oceanfront aerial photography for a variety of dates. Table VIII-5 identifies the specifics for the available digital orthophotography for Region 1.

Table VIII-5. Digital Orthophotography for Region 1

Inlet Photography (1938-2000)						
Date	**Coverage**	**Format**	**Mosaic/Tiles**	**Color**	**Source**	**Resolution**
1971, 1974, 1977, 1984, 1992	Bald Head Island, Cape Fear Inlet, Caswell Beach	Mr. SID	Mosaic	B&W	DCM	1'
1995, 2000	Bald Head Island, Cape Fear Inlet, Caswell Beach	Mr. SID	Mosaic	Color	DCM	1'
1938, 1958, 1971, 1978, 1988	Lockwoods Folly Inlet	TIFF	Mosaic	B&W	DCM	varies
1938, 1954, 1958, 1970, 1981, 1992	Shallotte Inlet	TIFF	Mosaic	B&W	DCM	varies
1938, 1949, 1954, 1961, 1970, 1981, 1992	Tubbs Inlet	TIFF	Mosaic	B&W	DCM	varies
1998	Tubbs Inlet	IMG	Mosaic	B&W	DCM	.5'
Oceanfront Photography (1998)						
Date	**Coverage**	**Format**	**Mosaic/Tiles**	**Color**	**Source**	**Resolution**
1998	Bald Head Island	Mr. SID	Tiles	B&W	DCM	.5'
1998	Holden Beach	Mr. SID	Tiles	B&W	DCM	.5'
1998	Oak Island & Caswell Beach	Mr. SID	Tiles	B&W	DCM	.5'
1998	Ocean Isle	Mr. SID	Tiles	B&W	DCM	.5'
1998	Sunset Beach	Mr. SID	Tiles	B&W	DCM	.5'
Post-Isabel Photography (2003)						
Date	**Coverage**	**Format**	**Mosaic/Tiles**	**Color**	**Source**	**Resolution**
2003	Brunswick County	Mr. SID	Mosaic	B&W	USGS	2'
Oceanfront Photography (2004)						
Date	**Coverage**	**Format**	**Mosaic/Tiles**	**Color**	**Source**	**Resolution**
2004	Bird Island to Bald Head Island (west)	Mr. SID	Mosaic	Color	DCM	.5'
2004	Bald Head Island, Zeke's Island, Fort Fisher	Mr. SID	Mosaic	Color	DCM	.5'
NAIP Photography (2006)						
Date	**Coverage**	**Format**	**Mosaic/Tiles**	**Color**	**Source**	**Resolution**
2006	Brunswick County	Mr. SID	Mosaic	Color	NAIP	1'

In addition, the USGS has Digital Orthophoto Quarter Quads (DOQQs) from 1998 for the entire coastline. These photos are Color Infrared MrSID images. MrSID, Multiresolution Seamless Image Database, is an image format developed for georeferenced raster graphics.

4. Historical Shorelines and Erosion Rates

In support of coastal planning efforts, DCM began developing a historical shoreline database starting in the 1970s. Shorelines were digitized for available years for the entire NC oceanfront using a variety of media dating back to 1933. The primary source of historical data is the geo-referenced T-Sheets, provided by NOAA Coastal Services Center (CSC). DCM has also collaborated with USGS and USACE to document the most recent shorelines based on delineation of the wet-dry line as interpreted from

orthophotography, as well as deriving the Mean High Water Level (MHWL) based on LiDAR survey data. In addition to the statewide oceanfront shoreline datasets, DCM has compiled a historical shoreline database in the vicinity of inlets, varying in length on either side of the inlet from approximately 10,000 feet to the entire stretch of shoreline leading to the next inlet. The available shoreline data and extents vary widely depending on the availability of historical photographs. Inlet shorelines were digitized and developed using multiple data sources including: North Carolina Department of Transportation rectified aerials, DCM orthophotos and NOAA CSC T-Sheets. Table VIII-6 presents the available shorelines which cover Region 1. GIS shapefiles of historical shorelines may be accessed via DCM's website at http://dcm2.enr.state.nc.us/Maps/chdownload.htm.

Table VIII-6. Digitized Shorelines for Region 1

Inlet Shorelines			
Date	**Coverage**	**Type**	**Source**
1938, 1943, 1944, 1949, 1954, 1961, 1970, 1981, 1992, 1998, 2003	Tubbs Inlet	Photo-Wet/Dry	DCM
1938, 1954, 1958, 1970, 1981, 1992, 1998, 2003	Shallotte Inlet	Photo-Wet/Dry	DCM
1944	Shallotte Inlet	NOS T-Sheet (MHW)	DCM
1938, 1958, 1971, 1978, 1988, 1998, 2003	Lockwoods Folly Inlet	Photo-Wet/Dry	DCM
1944	Lockwoods Folly Inlet	NOS T-Sheet (MHW)	DCM
1942, 1944, 1970	Cape Fear Inlet	NOS T-Sheet (MHW)	DCM
1971, 1974, 1977, 1984, 1995, 2000	Cape Fear Inlet	NC DOT Photography	DCM
1973	Cape Fear Inlet	-	NOAA/USGS
1997	Cape Fear Inlet	-	USGS
2004	Cape Fear Inlet	NC DCM Photography	DCM
Oceanfront Shorelines			
Date	**Coverage**	**Type**	**Source**
1933-1952	NC Shoreline (Bird Island to Kill Devil Hills)	NOS T-Sheet (MHW)	DCM
1998	Entire NC Shoreline	Photo-Wet/Dry	DCM
2003	NC Shoreline (Bird Island to Bear Island)	NOAA Photo-Wet/Dry	DCM
2004	Entire NC Shoreline	NCDCM Photo-Wet/Dry	DCM
1849-1873	Entire NC Shoreline	NOS T-Sheet (MHW), CERC map	USGS, Coastal Carolina
1925-1946	Entire NC Shoreline	CERC map, USACE Photos, NOS T-Sheet (MHW)	USGS, NOAA, DCM
1970-1988	Entire NC Shoreline	CERC map, NOS T-Sheet (MHW)	USGS, NOAA, Coastal Carolina
1997	Entire NC Shoreline	LIDAR MHW Shoreline	USGS

Using the digitized shorelines, the N.C. Coastal Resources Commission (CRC) has established oceanfront development setbacks based on long-term shoreline change rates. Setback factors determine the oceanfront setback distance that development can be sited measured from the first line of stable and natural vegetation. Shoreline change has been calculated by DCM using the end point method, based on the distance from the earliest shoreline archived by the state (varies for segments of shoreline but typically from the 1940s) to the most recent (1998) divided by the number of years between them. Erosion rates are calculated at transects spaced every 50 m (164 ft) along shore. These rates are then "smoothed" to account for local variance and influences of inlets. DCM then determines setbacks based on these "smoothed erosion rates." Details regarding the methods used to conduct the most recent update of setback rates (based on the 1998 shoreline location) are documented by Overton and Fisher (March 2004). Figure VIII-7 presents DCM's long-term erosion rates for Region 1.

Since inlets can interrupt and intercept the flow of sediments along the coast and migrate over time, they are typically areas of the greatest variation in erosion and accretion. This

can be seen in the erosion rates plotted in Figure VIII-7. It should be noted that Region 1 from the South Carolina border to Sunset Beach is one of the few longer term accretional zones along the North Carolina coast. The erosion rates point to relatively stable patterns with the exception of erosional hotspots along Bald Head Island, Caswell Beach, Holden Beach, and Ocean Isle Beach.

Figure VIII-7. NCDCM Erosion Rates for Region 1

5. Beach and Inlet Surveys

Beach profile data has been collected for several beaches along the North Carolina coast. This data is available in various file formats depending on the location. Available beach profile data locations for Region 1 are presented in Figure VIII-8.

As part of the Wilmington Harbor Monitoring Program, 58 stations along 2,200 feet of shoreline on Bald Head Island have been surveyed semi-annually since September 2000. As of February 2007, 15 beach profile data sets had been collected by the USACE Wilmington District and other consulting firms. Normally, onshore (dune to wading depth) profile conditions are surveyed at every transect, while offshore (wading depth to closure) conditions are surveyed at every other transect.

In addition to profiles collected at Bald Head Island, 62 monitoring profiles have also been established along 31,000 feet of Caswell Beach. Surveys have been taken semi-

annually since August 2000, with 14 data sets collected by February 2007. Until 2005, the spring surveys only covered onshore (dune to wading depth) at every transect, while fall surveys extended coverage offshore (wading depth to seaward distance of 15,000 feet or a depth of 25 feet) at every other transect. Since that time, both surveys cover the offshore area at every other transect. The remainder of Oak Island has limited survey data from 2001 and 2002 as part of beach nourishment projects.

As part of the Ocean Isle Beach and Shallotte Monitoring Program, 76 beach profiles are monitored semi-annually along Ocean Isle and the western 10,000 feet of Holden Beach. As of May 2007, 10 beach profile data sets were available with the earliest occurring in February 2001. Onshore (dune to wading depth) data is taken at every transect, while offshore (wading depth to depth of 30 ft) data is taken at every other transect for spring surveys.

In addition to beach monitoring through beach profile data, detailed surveys exist at Shallotte Inlet and Cape Fear Inlet, covering the morphological inlet features such as, the ebb and flood tidal shoals and the navigation channel. Also, the Navigation Branch of the USACE Wilmington District maintains a database of hydrographic surveys for federal navigation channels. Surveys for Lockwoods Folly Inlet and Wilmington Harbor (including Cape Fear River Inlet) can accessed via the USACE website at http://www.saw.usace.army.mil/nav/inlets.htm. These inlets, along with Shallotte Inlet, are part of federal dredge projects to maintain the navigation channels at authorized dimensions.

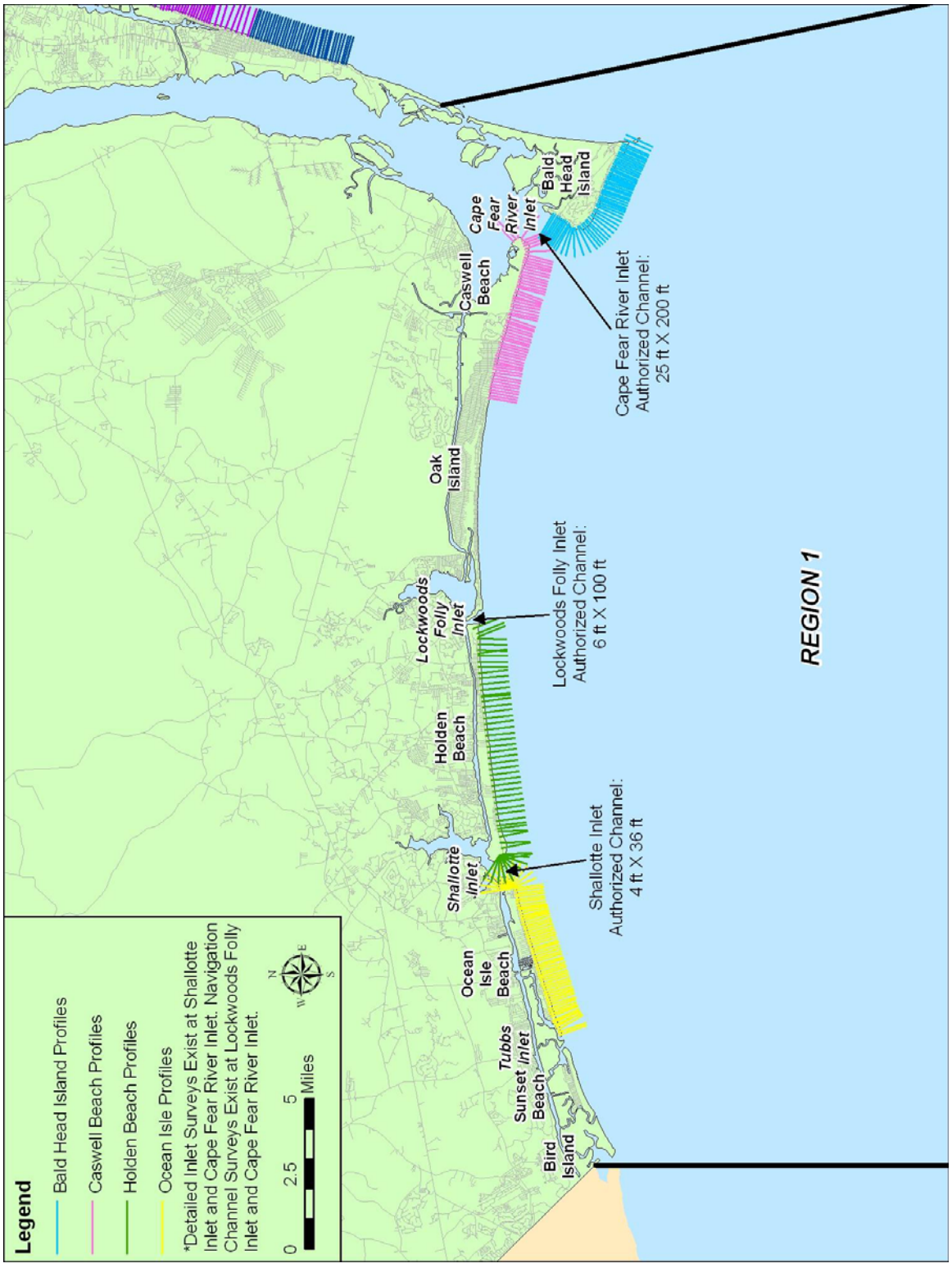

Figure VIII-8. Beach Profile Monitoring Locations for Region 1

6. Geologic Framework

The geological composition of the North Carolina coast and the dynamic nature of its inlets play a vital role in beach behavior and potential sources and availability of sand resources. Coastal geology the origin, structure, and characteristics of coastal sediments, combined with the geological formation of the coastline over thousands of years of physical and chemical processes dictates the properties of the sediments. The inlets can provide a natural disruption to longshore sediment transport and greatly impact sediment pathways. Coastal processes, of varying temporal and spatial scales, driven by water level changes, tides, waves, currents and winds interact with the local coastal geology and sediment supply to form and modify the configuration of the coastal region forming features such as beaches, dunes, and inlets. A detailed study of the coastal geology from Cape Lookout to the North Carolina/South Carolina border has been compiled by Dr. William Cleary, a coastal geologist and professor at the University of North Carolina Wilmington (UNC-W), and can be found in Appendix C. Figure VIII-9 illustrates the offshore geology for Region 1. The subsections following Figure VIII-9 present a detailed summary of the geologic framework for Region 1 beaches and inlets.

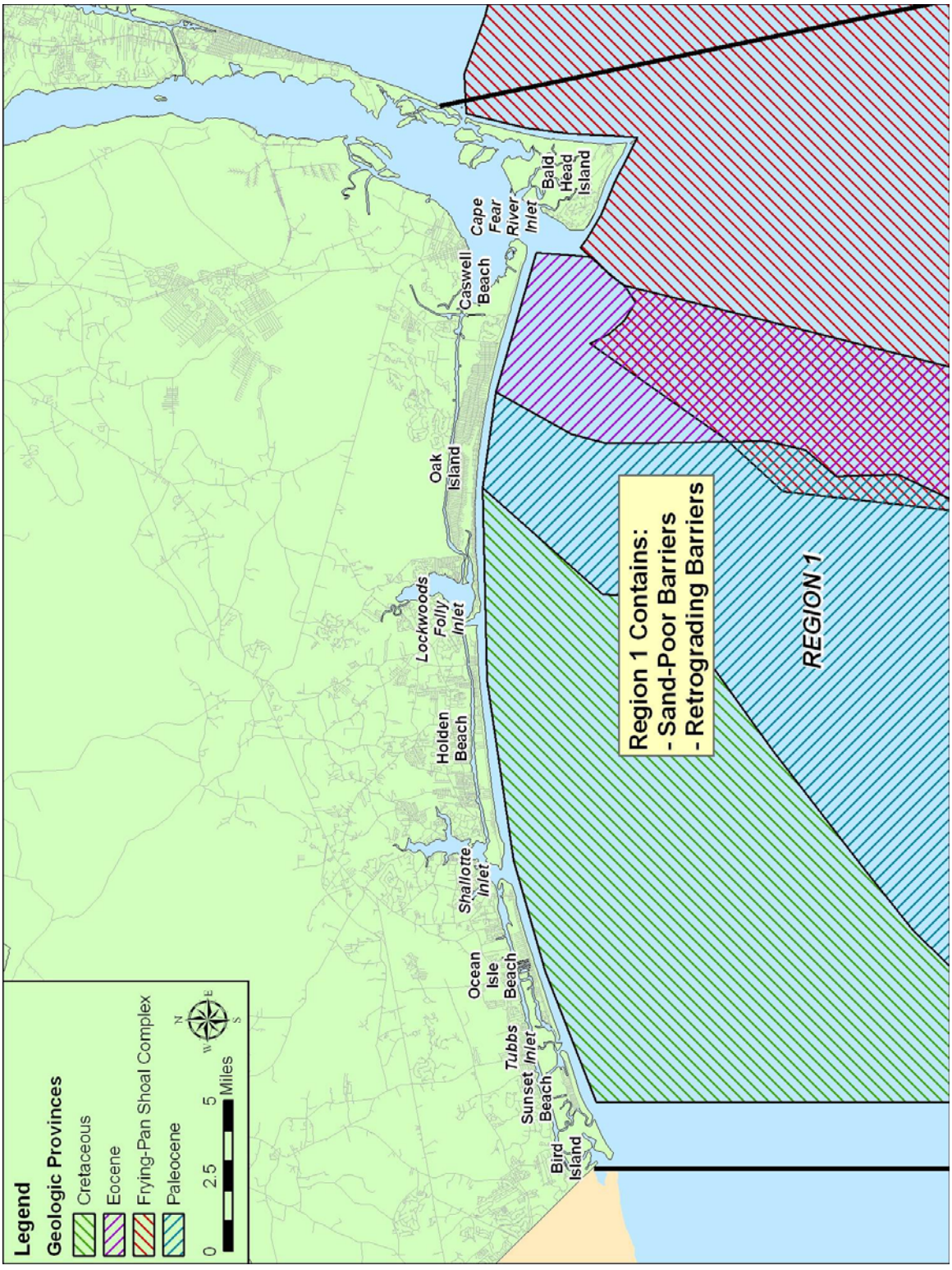

Figure VIII-9. Offshore Geology for Region 1

a) Region 1-Beaches and Inlets

1) Sunset Beach

Sunset Beach is located immediately east of Little River Inlet and the border of NC/SC. It is the westernmost developed barrier island in Long Bay. The island is 4.2 miles long and approximately 2,100 feet wide in the central portion near the pier. During the majority of the past three centuries, it has been comprised of a central core of dune ridges and, more recently, large parabolic dunes and two flanking spits. The physiography of Sunset Beach reflects the more sand rich nature of the western portion of the shoreface. The 2,100-foot wide central portion of the island is characterized by a sequence of 10 to 14-foot high dune ridges that front an extensive field of vegetated, 16 to 30-foot high parabolic dunes. Historically the length of the spits that extended from the island varied depending upon the position of both Mad (currently closed) and Tubbs Inlets. Figure VIII-10 shows the location of Sunset Beach with respect to Tubbs Inlet and the former location of Mad Inlet. Sunset Beach is the only community in Brunswick County that has not requested federal assistance for beach fill projects. In fact, it is the only barrier island in southeastern North Carolina that has prograded (accreted) naturally during the past 50 years (Budde and Cleary, 2006).

The nature of the shoreface in this area is unknown. It is likely that a number of paleo-channels associated with the Little River drainage basin are incised into the underlying Cretaceous units.

Figure VIII-10. Sunset Beach, Mad Inlet (closed), and Tubbs Inlet (Cleary, 2008)

2) Tubbs Inlet

Tubbs Inlet is a small, relatively shallow, unstable inlet that delineates the eastern boundary of Sunset Beach, separating the island from adjacent Ocean Isle. During the past century, the inlet has migrated westward along a 1.25-mile long pathway. Between 1856 and 1938 the average migration rate was approximately 66 feet per year (Cleary and Marden, 1999). The rate of migration increased to an average of 131 feet per year for the period between 1938 and 1970. In order to mitigate the rapid erosion of the eastern margin of Sunset Beach, the inlet was relocated in December 1969 to a position 3,280 feet eastward that approximated the inlet's 1938 location (Masterson *et al.,* 1973).

Subsequent to a period of adjustment to the new hydrodynamic conditions, Tubbs Inlet reversed its migration direction in the late 1970s and since then has been migrating eastward at variable rates (Marden and Cleary, 1999).

3) Ocean Isle

Ocean Isle is a 5.4-mile long transgressive barrier island situated between Holden Beach to the east and Sunset Beach to the west. Like the other barrier islands in Brunswick County, Ocean Isle is a composite feature with a 0.9-mile long and 1,000-foot wide barrier core composed of large parabolic dunes connected to the remainder of the island by low relief washover and breach prone areas (Figure VIII-11).

Figure VIII-11. Example of Parabolic Dune Core on Ocean Isle (Cleary, 2008)

Limited geological data are available for Ocean Isle but it is highly likely that the evolution of this barrier island is similar to that of nearby Holden Beach. All the islands in Brunswick County have one or two wide barrier core segments consisting of parabolic dunes. Historically the dune fields were mobile in the mid to late 19th and early 20th centuries. The available information suggests that prior to this period of time, the sand comprising the parabolic dune segments was contained in prograded dune ridges.

The shoreface off Ocean Isle is similar in nature to the area offshore Holden Beach. The upper 1.0 – 3.0 feet of sediment cover consists of fine quartz sand with minor amounts of shell material and mud. The average thickness of the surface unit is approximately 2.5 feet and typically the upper sediment sequence grades downward into muddy sand with minor amounts of shell material. This unit ranged in thickness between 0.5 -2.3 feet. The basal sediment unit is a gray mud to silt unit often containing pebble and cobble-sized lithoclasts (Sproat and Cleary, 1996). The sediment sequence is underlain by Cretaceous Age muddy sandstones and siltstones. Hardbottoms are not as frequent offshore Ocean Isle as they are farther eastward.

More detailed geophysical and geological surveys are needed to fully evaluate the sand resource potential of this segment of the Brunswick County shoreface. Isolated and irregularly shaped target areas containing thin sequences of beach compatible material are likely present, but only a very detailed exploratory effort is capable of mapping their extent and textural characteristics.

In the short-term, navigation improvement operations within Shallotte Inlet may provide small volumes of material for renourishment. One area yet unproven is located updrift of the eastern fillet of the Little River Jetties. This segment of the shoreface is certainly the most sand- rich area west of the entrance shoals of the Cape Fear Estuary. The prograded barriers in this area (Sunset Beach and Waites Island, S.C.) testify to the existence of an offshore sand source (buried channels or shoreface units).

4) Shallotte Inlet

Historical maps and coastal charts indicate that Shallotte Inlet has existed for a minimum of 300 years. Evidence gleaned from an 1858 map suggested that an inlet, possibly Shallotte Inlet, was located 1.5 miles to the west of its current position during the pre-Colonial period. Since the mid 19th century, Shallotte Inlet has been a relatively stable inlet with respect to its location. However in terms of a morphologic aspect, it has been a highly unstable inlet which has led to significant changes along the adjacent shoreline of Ocean Isle. These changes are directly related to the changing position and deflection/reorientation of the ebb channel that facilitates changes in the symmetry of the ebb delta. When the ebb channel was skewed toward Holden Beach (southeast alignment), the western shoreline Ocean Isle eroded. During the early 1960s when the channel alignment was approximately shore normal, accretion was common on both adjacent shorelines of the inlet. Deviation from this alignment promoted erosion on one or both shoulders as the ebb delta assumed an asymmetrical form and altered its breakwater effect (Marden and Cleary, 1999 and Marden, 1999). Between 1962 and 2001, the ebb channel's azimuth averaged approximately105°, which has promoted significant progradation along Holden Beach. Between 1970 and 2001, as much as 750 feet of progradation has occurred along the Holden Beach oceanfront. The presence of the accretionary wedge, characterized by vegetated parallel and recurved dune ridges, east of the inlet testifies to the important role the ebb channel alignment plays in adjacent shoreline changes. Figure VIII-12 illustrates the changes that have occurred in just five years (USACE).

Figure VIII-12. Shallotte Inlet: 2003 (left), 2008 (right)

In early 2001 the USACE realigned the ebb channel in a shore-normal fashion and in the course of dredging operations excavated approximately 1.9 million cubic yards of material that was placed along Ocean Isle. The realignment effort was expected to benefit both shorelines that border the inlet. Since realignment, the nature of the inlet and adjacent oceanfront shorelines has changed. The USACE are monitoring the changes on a periodic basis (USACE, 2002). It is likely that if the newly aligned channel maintains its original position, oceanfront progradation will continue along the Ocean Isle beaches while the former accretion zone will erode. If negative impacts result from the realigned ebb channel and the Holden Beach former accretion zone erodes to a critical point, it is unlikely that Shallotte Inlet could continually be used as a major source of beach fill on a regular cycle. If this occurs, the only long-term sand source for Ocean Isle will be the Cape Fear Inlet interior channel segments and possibly Jay Bird Shoals even though the source is some distance to the east.

5) Holden Beach

Holden Beach is an 8.1-mile long transgressive barrier bordered by Lockwood's Folly Inlet to the east and Shallotte Inlet to the west. The island is comprised of several zones where large parabolic dunes are present that reach elevations of approximately 32 feet. The intervening shoreline reaches connecting the topographically wider and higher segments are former inlet areas that are considered to be high hazard zones. Although the two inlets that border the barrier have been reasonably stable during the past 70 years, significant changes have occurred along the Holden Beach oceanfront due to the

changing position and alignment of the ebb channels of Lockwood's Folly Inlet to the east and Shallotte Inlet to the west (Cleary, 1999b) (Figure VIII-13).

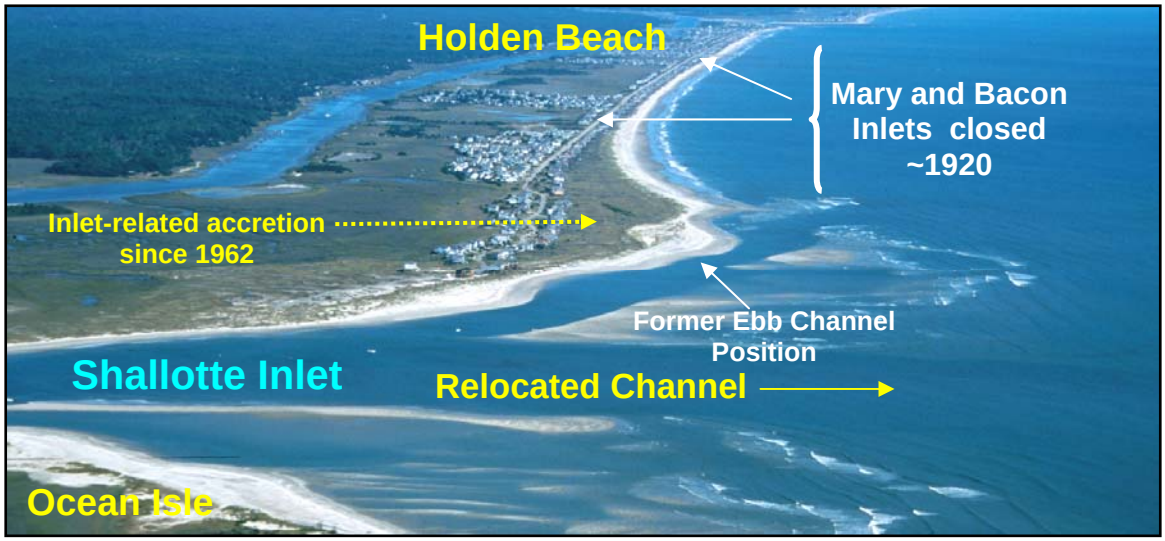

Figure VIII-13. Former Inlet Zones and Changing Alignment of Ebb Channel (Cleary, 2008)

The shoreface off Holden Beach is similar in nature to the area offshore of Oak Island. Much of the shoreface is underlain by Cretaceous Age sandstones and sandy limestones. Many of the units are exposed forming extensive areas of hardbottom (Marden *et al.*, 1999). Limited vibracore date indicated that the sediment veneer is generally thin (<1.0 foot). More detailed geophysical and geological surveys are needed to fully evaluate the sand resource potential of the shoreface. It is likely that the potential will be low and if that proves to the case, the only long-term large sand source for Holden Beach will be the Cape Fear Inlet interior channel segments and possibly Jay Bird Shoals.

6) Lockwoods Folly Inlet

Lockwoods Folly Inlet is morphologically similar to Shallotte Inlet. Historical maps indicate that the inlet existed as early as 1672. The Oak Island inlet shoreline and oceanfront near Lockwoods Folly Inlet have undergone significant periodic changes associated with the realignment of the ebb channel. From 1938 to the mid-1970s the channel orientation was favorable for accretion on the updrift Holden Beach side while erosion along the downdrift Oak Island was the norm. During this period of time, the western end of Oak Island eroded significantly. During the mid 1970s until late 1984 the ebb channel deflected toward the updrift side of Holden Beach reversing the erosion trend along Holden Beach (Cleary and Marden, 1999 and Cleary *et al.*, 2000). In the mid-1980s the ebb channel again deflected toward Oak Island renewing accretion along the western end of the spit (Figure VIII-14). The ebb channel maintained a southeastern alignment until May 2001 when an ebb delta breaching event reoriented the ebb channel in a shore-normal fashion. Since 2002 the western Oak Island oceanfront immediately adjacent to the inlet eroded and will continue to erode until the seaward portion of the outer bar channel deflects toward Oak Island.

Figure VIII-14. Lockwoods Folly Inlet with Holden Beach Erosion and Oak Island Accretion (Cleary, 2008)

7) Oak Island

Oak Island is located in Long Bay immediately west of the Cape Fear River and Bald Head Island. The term "Oak Island" refers to a segment of the mainland isolated by the construction of the Atlantic Intracoastal Waterway in 1930. With the exception of Yaupon Beach, a 1.6-mile long, subaerial headland segment, Oak Island consists of two transgressive barrier spits (Caswell and Long Beaches) comprised of a variably thick layer of sand that is perched on top of Holocene and Pleistocene units. The headland dominated shoreline segment at Yaupon Beach is underlain by a Quaternary sequence consisting of a Pleistocene humate sandstone and Coquina limestone. This sequence extends beneath Oak Island, the nearby mainland. Caswell Beach is a narrow 2.5-mile long spit that extends eastward from the headland toward the Cape Fear River estuary. The remaining portion of Oak Island is composed of the "Long Beach" spit that extends 8.7 miles westward towards bordering Lockwood's Folly Inlet. This morphologically complex spit fronts a narrow marsh filled lagoon (Figure VIII-15).

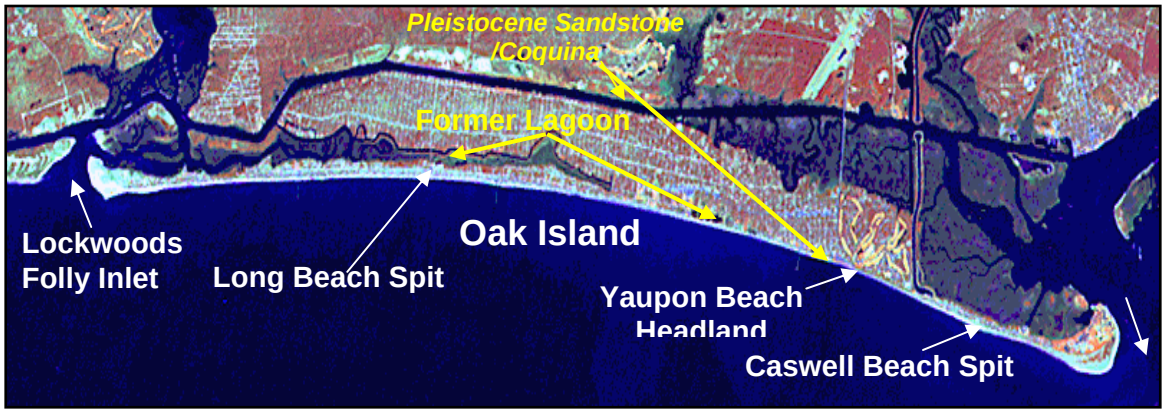

Figure VIII-15. Oak Island, Comprised of Long Beach Spit and Caswell Beach Spit (Cleary, 2008)

Several shoreline reaches along the spit are characterized by low-relief parabolic dunes that likely represent small barrier island segments that were connected by an ancestral transgressive spit that extended westward from the headland. The relatively young peat units exposed along much of eastern portion of the spit indicate that recent inlet activity has been lacking along the area. Radiocarbon dating indicated the peat units range in age from 1.0 ka (kiloannum, or 1,000 years) along Long Beach to approximately 1.8 ka near the headland at Yaupon Beach. The stump forest along the headland segment that underlies the peat by contrast is thousands of years older and dates to 3.8 ka (Griffin *et al.*, 1977).

The shoreface within this region is underlain by truncated Cretaceous to Eocene Age units that are mantled by a patchy mosaic of sediments of variable thickness, texture, and composition (Meisburger, 1977 and 1979; Cleary, 1999a and Cleary *et al.*, 2000). The shoreface off Lockwoods Folly Inlet is dominated by low relief to moderate relief (1.0 - 5.0 feet) hardbottom areas. The units in the area offshore Lockwoods Folly Inlet are Cretaceous well-indurated limestone and silica-cemented sandstone. The majority of the eastern half of the shoreface is dominated by irregularly shaped, linear depressions that are floored by coarse muddy sand and muddy shell hash.

The complex surface sediment mosaic originates from the reworking of the underlying strata and sediments. Muddy sediment is also being added by the nearby Cape Fear River, particularly during flood stage conditions (Cleary, 1999). The veneer is easily reworked during storms, exposing rock units in areas where the sediment cover is thin. Vibracore data indicate that the shoreface consists of variably thick sequences of gravelly, muddy sands and muddy, sandy gravels intercalated with muds and muddy sands (Cleary, 1999a and Cleary *et al.*, 2000). Thickness of the modern sediment package ranges from less than one inch in hardbottom areas to more than 11 feet in intervening regions. Seaward of the active beach (>30 feet) thicker deposits appear to be confined to topographic lows that formed between the topographically higher portions of the more indurated units or within dissolution/collapse features.

Generally the sediment thickness increases in an easterly direction. With the exception of the areas marginal to the ebb-tidal delta, the sediment sequence is usually thin landward of the 30-foot contour. Ponding of sediments against some of the hardbottom scarps and in depressions between ridges may produce small localized areas of deposits that approach 10 feet in thickness. Granulometric analyses of cores indicated that the majority of the samples analyzed were muddy, sandy gravels and gravelly, muddy sands. The majority of sand units are generally muddy although some units are relatively clean.

One of the focal points of the requested USACE's General Reevaluation Report (GRR) for a separate storm reduction project along Oak Island was the availability of sufficient quantities of beach quality fill material for future re-nourishment cycles. Several studies had identified a variety of potential sources. One potential source included the western segment of the Cape Fear Estuary entrance shoals, locally known as Jay Bird Shoals (Meisburger, 1977 and 1979). This western segment of the ebb-tidal delta contains as much as 20 million cubic yards of material. The USCAE vibracoring operations across the western entrance shoal recovered hundreds of cores that generally contained a mixture of clean sand interbedded with muddy sand and shell hash. On the basis of this vibracore data the USACE concluded that while the shoals contained some beach compatible fill material, the majority of the sediment sequences cored were muddy and therefore incompatible with the local beach material.

An additional potential borrow area for Oak Island that was reevaluated was the shoreface off Oak Island (Cleary, 1999a and Cleary *et al.*, 2000). This new borrow area provided a means of reevaluating the information contained in the USACE 1973 General Design Memorandum for Oak Island and for planning future exploitation efforts. Interpretation of the data indicated that beach fill quality sand resources of significant volume (>1.9 million cubic yards) were limited in the area. The broad belt of hardbottoms off the western portion of Oak Island precluded the use of this area of the shoreface as a potential source. Data compiled from available vibracores indicated that sand units when present were thin and mud-rich. The muddy units were usually interbedded with thin units of cleaner sands and shell gravels. Paleo-channels that were identified on the limited seismic lines, proved to be filled with estuarine mud and muddy sand.

Some regions on the shoreface, however, may contain beach fill quality sand but the volume and quality of material was difficult to determine due to the lack of detailed vibracore and seismic data (Cleary, 1999). One marginally attractive borrow area is located off the western portion of Oak Island where the surface sediment is generally rippled fine quartz sand. The 0.78-mi^2 target area straddles the outer margin of the active beach at –30 feet and extends to depths of –35 feet. The site is located in a region of the shoreface between the mud-rich deposits of the upper shoreface and an area where the sediments are often thin and bordered by an area of limestone hardbottoms. Vibracores recovered from adjacent areas contain sequences of clean fine quartz sand with minor amounts of fine material. Thickness of the sand units ranged from approximately 5.0 – 7.0 feet. These thicker deposits of sediment probably occupy a collapse feature or a

topographic depression between limestone units that comprise the underlying framework of the shoreface. Whether or not this area is proven to contain compatible material, it is highly unlikely that the shoreface will be a long-term borrow source.

8) Cape Fear River Inlet

The Cape Fear River Inlet is approximately 6,650 feet wide and is the largest inlet system in southeastern North Carolina (Figure VIII-16). The western segment of the estuary entrance shoals (ebb-tidal delta) contains as much as 85 million cubic yards of material in water depths of 18 feet. The ebb channel (ship channel) serves as the entry to the Wilmington Harbor, North Carolina's primary commercial port, located 19 miles inland from the coast. Dredging of the Cape Fear River estuary and throat began in 1829. Additional major improvements of the ebb channel occurred in 1871 when the ebb channel dimensions were increased to approximately 12 x 100 feet. Between 1890 and 1985, the entrance channel was progressively widened and deepened to approximately 40 x 400 feet (Cleary and Hosier, 1988 and Cleary *et al.*, 1989). In 2001 the ship channel was realigned to a south-southwest orientation, deepened an additional four feet and widened to as much as 900 feet (USACE, 2008).

Previous investigations (Cleary *et al.*, 1989 and USACE, 1989) of historical shoreline and shoal configuration changes indicated the reorientation and subsequent stabilization of the ship channel in the 1880s led to significant changes in the morphology and volume of the ebb-tidal delta (outer bar). Since major modifications began in the late 1880s, approximately 70 million cubic yards of material have been dredged from the entrance channel and its landward extension (USACE, 1989). The ship channel was deepened an additional four feet when it was realigned to a more southeasterly direction during 2001. Since major dredging operations began in the 1880s, the cross-sectional area of the entrance channel has increased from 99,405 ft^2 to 120,825 ft^2 (USACE, 1989). Although data suggest the ebb-tidal delta volume should increase due to an increase in channel cross sectional area and tidal prism, calculations show that the entire ebb-tidal delta (to -18 feet) has lost approximately 17.8 million cubic yards (Cleary *et al.*, 1989).

The realignment of the Ship Channel in 2001 was the subject of controversy. Opponents' concerns focused on the potential impact the newly aligned channel might have on the immediate shoreline due to the existing chronic erosion along both South and West Beaches of Bald Head Island. In February to July 2001, approximately 1.85 million cubic yards of material derived from local dredging operations was placed along South Beach. Since 2001 an additional 1.62 million cubic yards of has been placed on Bald Head Island as part of the USACE's Sand Management Plan. Since the ship channel was relocated, approximately 4.05 million cubic yards have been used to nourish the island (USACE, 2008).

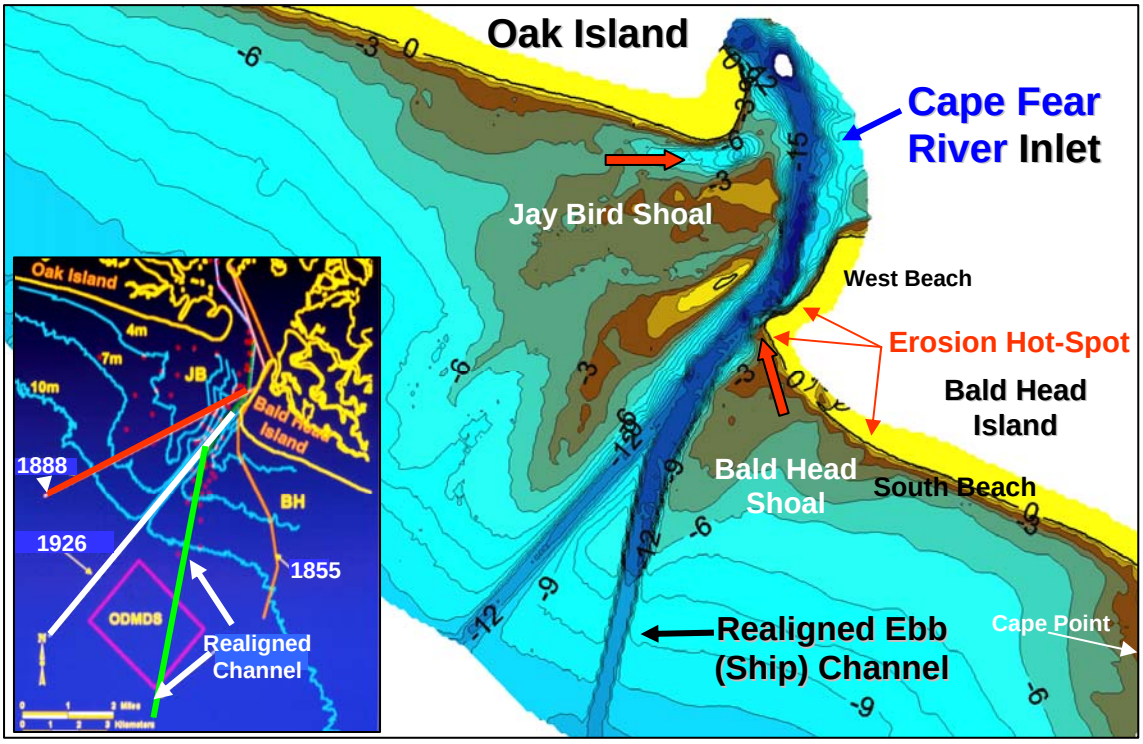

Figure VIII-16. Cape Fear River Inlet Channel Realignment (Cleary, 2008)

9) Bald Head Island

Bald Head Island is a barrier island located at the mouth of the Cape Fear River Estuary. Bald Head Island, a 5.6-mile long barrier segment, represents the largest segment of the Cape Fear Foreland. Bald Head, and three smaller "islands" separated from it by tidal marsh, are part of a once more-extensive Holocene regressive sequence that has since been drowned by rising sea level. The origins of the Cape Fear Foreland as well as the other two Capes in North Carolina (Capes Hatteras and Lookout) are conjectural and have been related to a variety of mechanisms including ocean current eddies (Dolan and Ferm, 1968) and erosion of remnant Pleistocene river deltas (Hoyt and Henry, 1971). Data from the extensive shoals suggest the Capes may be relatively old and related to subtle structural features (Blackwelder *et al*, 1982). Unpublished information supports the contention that the present Cape is one of a number of such features that have shifted southward since the mid-Pleistocene.

Regardless of their origin, the present day morphology of the three islands that form the foreland complex date from approximately 4.5 ka when sea-level rise is thought to have decelerated. The progradational phase during this period of sea level rise may have lasted 2,500 years or longer; the exact length is speculative because it is difficult to determine without detailed stratigraphic data and dates on the age of the stranded dune ridges. Since the last progradational episode, rising sea level has drowned the low swale areas between the ridges, all of which are now filled with tidal marsh and crossed by large tidal creeks. The geometric arrangements of the historical multiple dune sets reflect

the change in the pattern of the shoals immediately offshore both at the eastern and western end of the island. The eastern end (Figure VIII-17) is characterized by truncated forested beach ridges with sets of smaller multiple dunes oriented perpendicular to the ridge complex. During major storms the majority of the eastern shoreline (East Beach) is overtopped resulting in the formation of large overwash terraces which extend into the marsh.

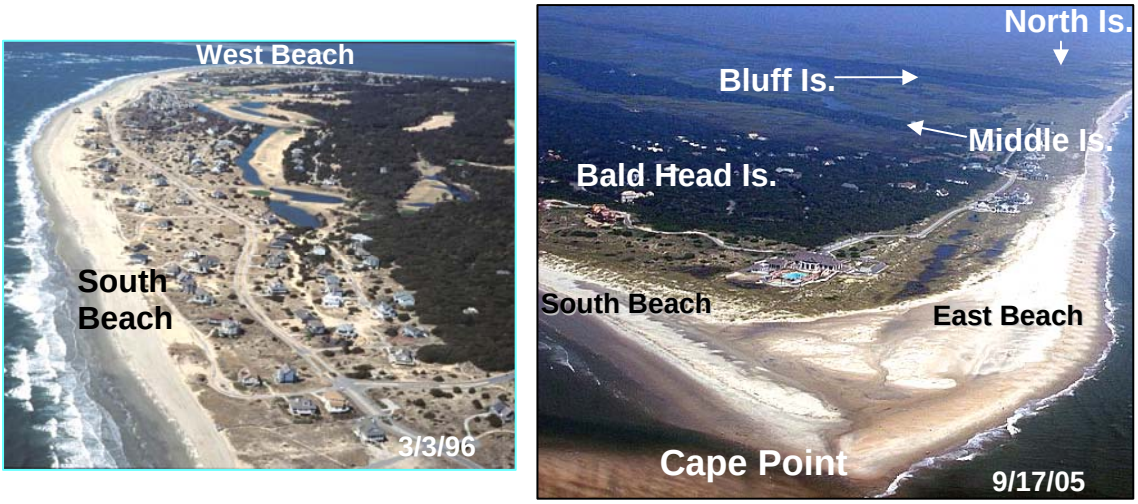

Figure VIII-17. Bald Head Island Beaches (Cleary, 2008)

7. Sediment Budgets

Region 1 is the only area of the North Carolina coast with an extensive, recent sediment budget. Previous sediment budget analyses on Cape Fear River and Lockwoods Folly Inlets were performed in the 1970s by the USACE. However, the USACE completed a detailed sediment budget analysis from Bald Head Island to Tubbs Inlet in 2008 (USACE and OCTI, 2008).

The results of the 2008 study indicate that the net longshore transport rate is approximately 200,000 cubic yards per year directed to the west. Large volumes of sand enter the Cape Fear River Inlet region from Bald Head Island and also to a lesser degree eastwardly from Caswell Beach. While there are small areas of reversal, the dominant net transport is to the west.

The detailed sediment budget was also used in further study by the USACE (2008) to determine how to effectively manage sand resources throughout Brunswick County. This included using the Cascade model to examine how much material could be dredged from various inlets and placed on the beaches on a yearly basis without altering the long term sediment transport processes, shoreline and inlet behavior, or specifically not causing deflation of the inlet tidal shoal complexes. The Cascade model showed that the ebb shoals of Shallotte, Lockwoods Folly, and Tubbs inlets could not withstand the original USACE Wilmington sand management plan of placing approximately 50 million cubic yards over the next 50 years on Oak Island/Caswell Beach, Holden Beach, and Ocean Isle with approximately 8 million cubic yards for initial construction from Jay Bird Shoals.

Further Cascade modeling indicated that the initial estimate of 50 million cubic yards over 50 years was not necessary due to longshore transport of material and eventual storage in the ebb shoals of inlets, allowing for recovery and recycling of material. Based on model results, the proposed overall plan includes initial nourishment on Holden Beach (3.2 million cubic yards) and Oak Island/Caswell Beach (4.9 million cubic yards) using material from Jay Bird Shoals and future renourishment of Ocean Isle, Oak Island/Caswell Beach, and Holden Beach, totaling 21 million cubic yards over the next 50 years, using material from Cape Fear River Inlet, Lockwoods Folly Inlet, Shallotte Inlet, and Yellow Banks.

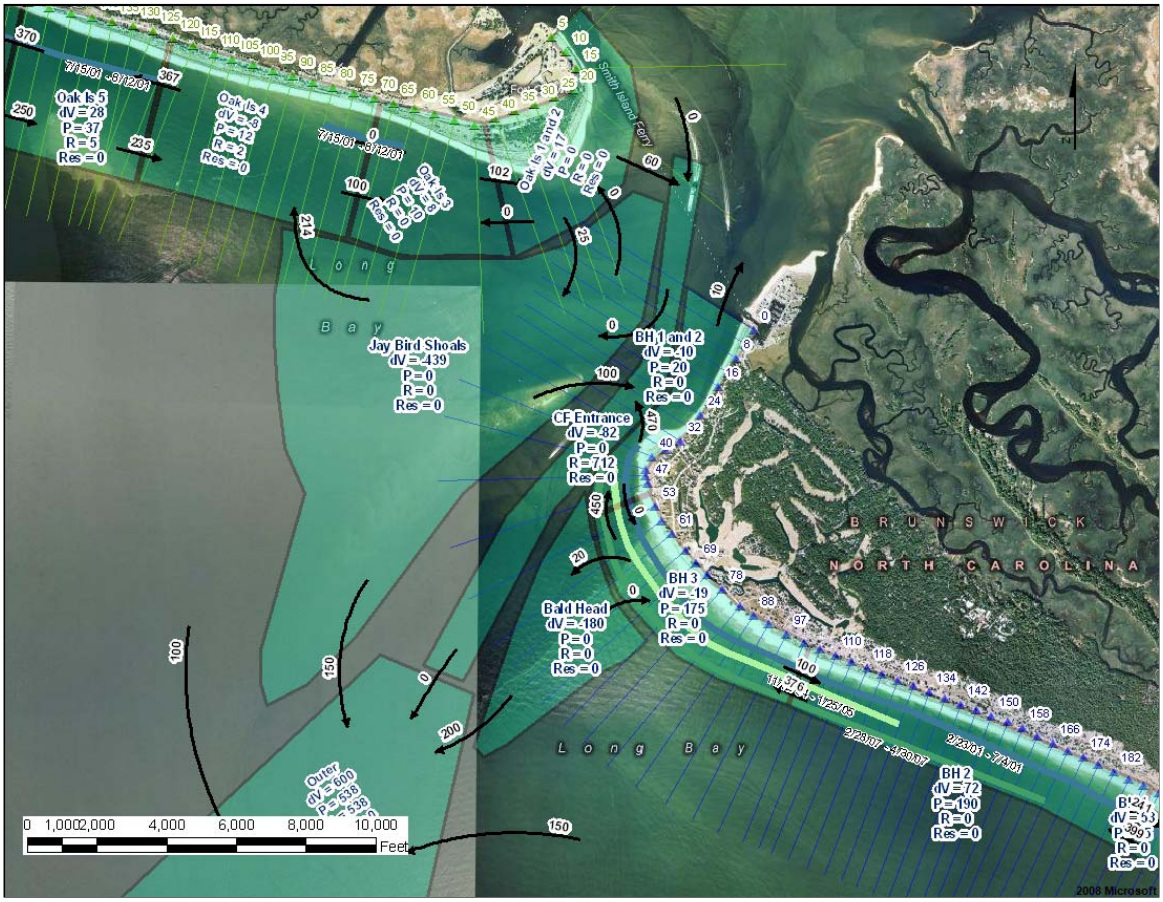

Figure VIII-18. Cape Fear River Inlet Detailed Sediment Budget Cells

8. Potential Sand Resources

Sand resources for beach nourishment projects can come from inlet dredging, upland sources, offshore material deemed compatible with the beach, and offshore disposal sites containing previously dredged material. Potential sand sources are identified in various NCGS Open File Reports, USACE findings, USGS databases, and consulting firm investigations.

Region 1 contains three inlets (Cape Fear River, Lockwoods Folly, and Shallotte) which have been used as sediment sources for nearby beaches through channel realignment and regular maintenance projects. The USACE Wilmington Harbor navigation project (Cape Fear River Inlet) has also provided material through direct disposal of dredge material onto Bald Head Island, Oak Island/Caswell Beach, and Holden Beach as well as material from the Wilmington Harbor Ocean Dredged Material Disposal Site (ODMDS). It is estimated that the ODMDS has a capacity of 166 million cubic yards and approximately one to two million cubic yards of material gets deposited in the ODMDS each year (USACE 2007). It should be noted that the USACE and local towns have all expressed concern with utilizing the ODMDS as a reliable, suitable borrow source. It is commonly believed that the area has too many mixed pockets of fine grained sediments or "fines" from the inner reaches of the river to make it a long-term viable source. Jay Bird Shoals, west of the Cape Fear River Entrance Channel with an estimated volume of up to 20 million cubic yards of material (Cleary, 2008), and Frying Pan Shoals, east of the Cape Fear River Entrance Channel extending almost 20 miles south of Cape Fear, are also considered possible sediment sources for Region 1, especially for Bald Head Island given their proximity. A 2007 study by Olsen Associates, Inc. included a sand search investigation for the Village of Bald Head Island which concluded that material within Jay Bird Shoals met the state standards for borrow site compatibility with the native material of Bald Head Island and would thus be a good offshore source of sediment. According the USGS SEABED database, there is a potential area offshore of Holden Beach which contains material with an acceptable grain size for many North Carolina Beaches [phi size=1.0-2.0 or 0.25 mm-0.5 mm (0.01 - 0.02 inches)]. This area off Holden Beach should be examined further to determine suitability. Holden Beach has also trucked sand from upland sources and placed it on the beach. The material for the Oak Island Sea Turtle Habitat Restoration came from Yellow Banks, a USACE dredge disposal site adjacent to the AIWW. Figure VIII-19 shows the potential sediment resources for Region 1.

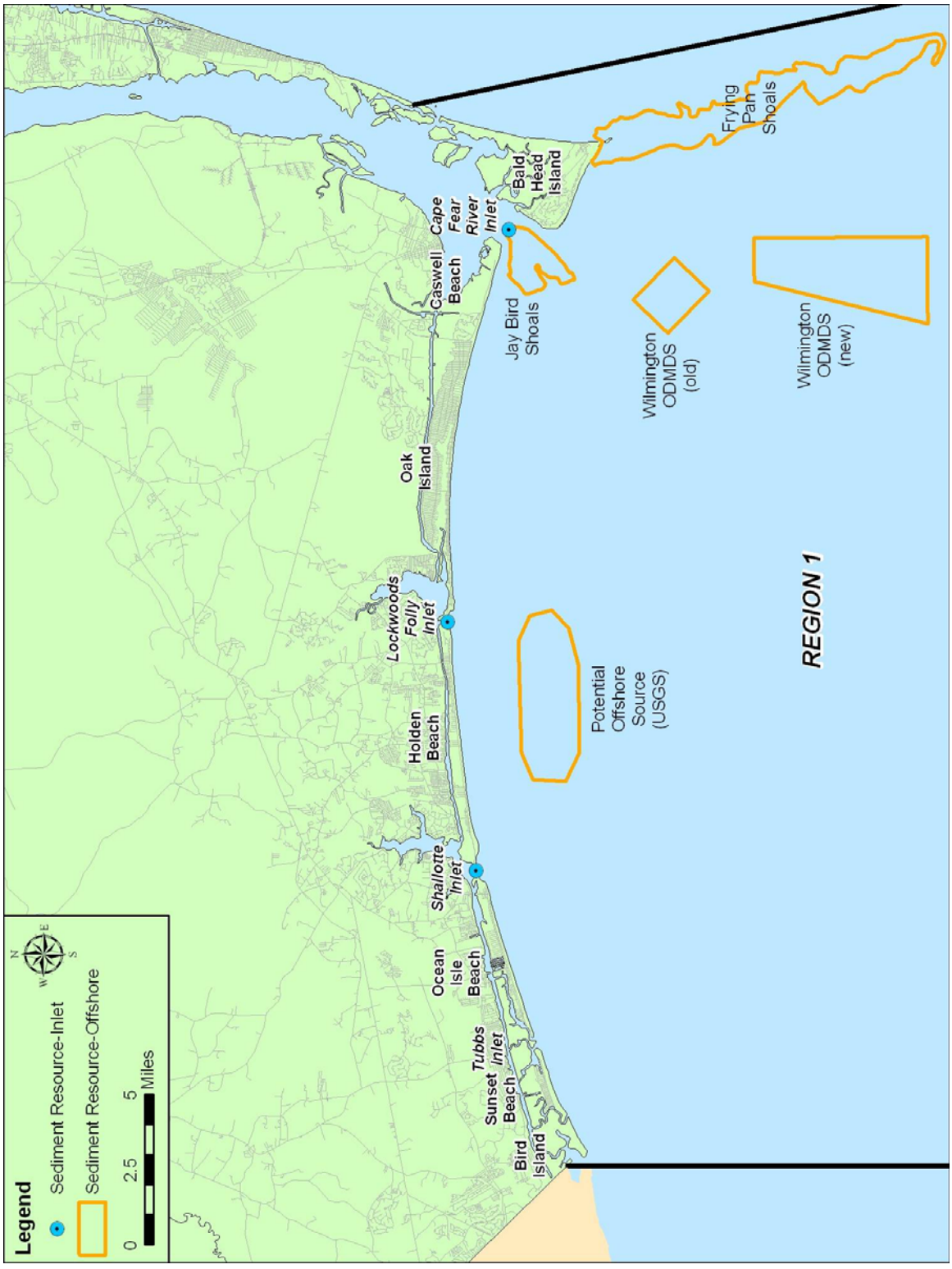

Figure VIII-19. Potential Sediment Resources for Region 1

9. Environmental Considerations

The BIMP recognizes environmental concerns as a vital part of holistic beach and inlet management strategies. Environmental considerations can be constraints on strategy choices, projects, or timing of projects, but management strategies can also represent opportunities to preserve, restore, or create habitat. The Coastal Habitat Protection Plan (CHPP) identifies six primary habitats along coastal North Carolina that are vital to the health and function of North Carolina's coastal ecosystems and fisheries. This section identifies the federally protected species, Natural Heritage Program (NHP) Element Occurrences, Critical Habitats, and Significant Natural Heritage Areas. Site specific concerns for each beach and inlet in Region 1 are also identified. Appendix F contains maps of the primary coastal habitats as well as protected species and critical wildlife habitat mapping.

a) Region 1 - Federal Protected Species, NHP Element Occurrences, Critical Habitats, and Significant Natural Heritage Areas

- NHP identifies element occurrences for plant and animal species within Region 1 including the following species that could potentially occur within the identified project study area: seabeach amaranth, shortnose sturgeon, loggerhead sea turtle, green sea turtle, leatherback sea turtle, Kemp's Ridley sea turtle, piping plover, wood stork, and West Indian manatee. A site specific assessment and U.S. fish and Wildlife Service (USFWS) coordination should be conducted during project planning to avoid impacts to protected species.

- USFWS identifies May 1 – November 15 as the moratoria period for sea turtle nesting areas.

- Site specific sea turtle nesting data can be obtained from the N.C. Wildlife Resources Commission (http://www.seaturtle.org/nestdb/index.shtml?view=1).

- USFWS has identified critical habitat areas within Region 1 for the piping plover near Mad Inlet, Shallotte Inlet and Lockwoods Folly Inlet. Site specific information regarding these critical habitat areas can be obtained through USFWS at http://criticalhabitat.fws.gov/. Activities within critical habitat areas will require consultation with USFWS. USFWS identifies April 1 – July 15 as the moratoria period for piping plover nesting areas.

- Region 1 contains significant habitat for colonial water birds, wading birds and shore birds. The beachfront of the lower Cape Fear basin is considered an important area used by shorebirds within the southeastern coastal plain. All applicable USFWS and WRC moratoria should be observed.

- Site specific colonial water bird and shorebird data can be obtained from WRC.

- Site specific seabeach amaranth data can be obtained from the USFWS and USACE as well as the NHP.

- Significant natural heritage areas occur within Region 1. Some of these areas are located near the mouth of the Cape Fear River and include Bald Head Island, Battery Island, Fort Caswell Dunes and marsh, Bluff Island and East Beach, the Lower Cape Fear River Aquatic Habitat, Zeke's Island Estuarine Sanctuary, and Middle Island. Coastal edge sites of significant importance include Brantley Island, Sunset Beach Wood Stork Ponds, and Bird Island. Tidal wetland sites of significance include Town Creek Marshes, Town Creek Aquatic Habitat, Brunswick River/Cape Fear River Marshes, and Lockwoods Folly River Tidal Wetlands.

b) Shipwrecks

An assessment was made for the potential of the inlets and surrounding areas to contain underwater shipwrecks. Time periods assessed included the sixteenth and seventeenth centuries, the eighteenth and early nineteenth centuries, the Civil War, and the late nineteenth and twentieth centuries. Four categories of potential for underwater shipwrecks are given: low, moderate, high, and general:

- Low potential means that the area around the inlet has little potential to contain shipwrecks from that time period.

- Moderate potential means it is known the inlet was used by shipping during that time period and that wrecks from that time period are present in the area.

- High potential means that the inlet witnessed high volumes of ship traffic during that time period and that wrecks from that time period are present in the area.

- General potential means that shipping traffic used the inlet during that time period, but the volume and presence of wrecks in the area cannot be categorized.

Note that shipwrecks are only listed in the following sections if there is a high probability of encountering them based on available data. Mapping of shipwrecks and other cultural resources is currently not as complete as required for detailed assessments.

c) Region 1 - Site Specific Concerns

The following details the environmental considerations specific to each beach/shoreline segment and inlet under the general headings of CHPP elements, protected species and wildlife elements, and any other notable considerations. The first section identifies elements related to the beach or inlet with respect to the CHPP. The second lists key protected species and wildlife issues and time of year restrictions on construction related

activities. The third group lists the potential for shipwrecks at the inlets where applicable. The fourth, entitled "Other," lists any other environmental considerations, such as designated heritage or significant areas.

(1) Bird Island

CHPP Elements
- Class SA waters
- Salt marsh wetlands behind island
- Hard bottom habitat located just offshore
- Closed shellfish waters

Protected Species & Wildlife Elements
- Seabeach amaranth occurrences (will require surveys)
- Loggerhead sea turtle nest sites (May 1-November 15 moratoria)
- Piping plover nest sites (April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nest site (April 1-August 31 moratoria in nesting areas)
- Little River Inlet EFH for 26 species; 70 species for Atlantic Ocean

Other
- Primary Nursery Area behind island
- Island considered Area of Regional Significance

(2) Sunset Beach

CHPP Elements
- Class SA waters
- Salt marsh along rear of island
- Some sporadic freshwater marsh behind dunes
- Hard bottom habitat located southeast of Sunset beach
- Open shellfish waters near Tubbs Inlet; closed waters elsewhere

Protected Species & Wildlife Elements
- Seabeach amaranth occurrences (will require surveys)
- Piping plover nest sites (April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nest site (April 1-August 31 moratoria in nesting areas)
- Loggerhead and green sea turtle nest sites (May 1-November 15 moratoria)
- West Indian manatee occurrence (June –October moratoria; observers possibly required)
- Essential fish habitat (EFH) present for 70 species (Atlantic Ocean)

Other
- Primary Nursery Area behind island

(3) Ocean Isle

CHPP Elements
- Class SA waters
- Open shellfish waters near Tubbs and Shallotte Inlets; closed waters behind most of the island
- Salt marsh on back side of island
- Hard bottom located approximately three miles southeast of the island

Protected Species & Wildlife Elements
- Seabeach amaranth occurrences; 20 plants observed in 2007 (will require surveys)
- Piping plover nest sites (April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nest site (April 1-August 31 moratoria in nesting areas)
- Loggerhead and green sea turtle nest sites (May 1-November 15 moratoria)
- West Indian manatee occurrence (June –October moratoria; observers possibly required)
- EFH present for 70 species (Atlantic Ocean)

Other
- Primary nursery area behind island

(4) Shallotte Inlet

CHPP Elements
- Class SA waters
- Open shellfish waters surrounding inlet
- Salt marsh to the north, east and west of inlet
- Hard bottom located approximately three miles south and two miles east of inlet
- Soft bottom habitat associated with ebb-shoal delta
- SAV mapping needed

Protected Species & Wildlife Elements
- Green sea turtle habitat (limit takes during dredging)
- West Indian manatee occurrence (June –October moratoria; observers possibly required)
- Piping plover nesting (shoal habitat; April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nesting (shoal habitat; April 1-August 31 moratoria in nesting areas)
- EFH present for 25 species

Shipwrecks
- Moderate potential for eighteenth and early nineteenth century shipwrecks
- Moderate potential for Civil War shipwrecks
- Moderate potential for late nineteenth and twentieth century shipwrecks
- Potential for areas to have been subjected to underwater archaeological survey

Other
- Primary nursery areas to north and west of inlet

(5) Holden Beach

CHPP Elements
- Class SA waters
- Open shellfish waters surrounding island except for canals
- Salt marsh along AIWW; some interior wetlands on island
- Hard bottom locations less than one mile from beach

Protected Species & Wildlife Elements
- Seabeach amaranth occurrences; 281 plants observed in 2007 (will require surveys). West end of Holden Beach has highest concentration of plants
- Piping plover nest sites (April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nest site (April 1-August 31 moratoria in nesting areas)
- Loggerhead and green sea turtle nest sites (May 1-November 15 moratoria)
- West Indian manatee occurrence (June – October moratoria; observers possibly required)
- EFH present for 70 species (Atlantic Ocean)

(6) Lockwoods Folly Inlet

CHPP Elements
- Class SA waters
- Open shellfish waters surrounding inlet
- Salt marsh inside of inlet near AIWW
- Hard bottom approx. two miles southeast and 2.5 miles southwest of inlet
- Soft bottom habitat associated with ebb-shoal delta
- SAV mapping needed

Protected Species & Wildlife Elements
- West Indian manatee occurrence (June –October moratoria; observers possibly required)
- Green sea turtle and Atlantic Ridley sea turtle habitat (limit takes during dredging)
- Colonial waterbird nesting (shoal habitat; April 1-August 31 moratoria in nesting areas)
- EFH present for 25 species

Shipwrecks
- Moderate potential for eighteenth- and early nineteenth-century shipwrecks
- Moderate potential for Civil War shipwrecks
- Moderate potential for late nineteenth and twentieth century shipwrecks
- Potential for areas to have been subjected to underwater archaeological survey
- Section of Cape Fear Civil War Shipwreck National Register District to south of inlet

Other

- Primary nursery areas beginning at the mouth of Lockwoods Folly River, opposite the AIWW

(7) Oak Island

CHPP Elements
- Class SA waters
- Closed shellfish waters behind island
- Salt marsh behind island; some interior wetlands on island
- Hard bottom less than 1.5 miles from beach

Protected Species & Wildlife Elements
- Loggerhead, Atlantic Ridley and leatherback sea turtle nest sites (May 1-November 15 moratoria)
- Piping plover nest sites (April 1-July 15 moratoria in nesting areas)
- Colonial waterbird nest site (April 1-August 31 moratoria in nesting areas)
- West Indian manatee occurrence (June – October moratoria; observers possibly required)
- Seabeach amaranth occurrences; 116 plants observed in 2007 (will require surveys)

Other
- Primary nursery area behind island and along AIWW
- Artificial reef located approximately two miles offshore
- Fort Caswell property
- EFH present for 70 species (Atlantic Ocean)

(8) Cape Fear River Inlet

CHPP Elements
- Class SA waters
- Salt marsh behind Bald Head Island and Oak Island; marsh islands inside inlet in the river
- Open shellfish waters in the inlet
- Hard bottom approx. four miles southwest of inlet
- SAV mapping needed

Protected Species & Wildlife Elements
- Shortnose sturgeon occurrence (February 1 – June 15 moratoria)
- Colonial waterbird nest site on shoals and islands in river channel (April 1 – August 31 moratoria in nesting areas)
- Sea turtle habitat (limit takes during dredging)
- EFH present for 25 species

Shipwrecks
- Potential for sixteenth and seventeenth century shipwrecks
- High potential for eighteenth and early nineteenth century shipwrecks

- High potential for Civil War shipwrecks
- High potential for late nineteenth and twentieth century shipwrecks
- Many locations around this inlet have been subjected to underwater archaeological surveys
- Southport National Register Historic District nearby

Other
- Cape Fear Inlet is Area of State Significance

(9) Bald Head Island

CHPP Elements
- Class SA waters
- Salt marsh adjacent to Cape Fear River and Inlet
- Closed shellfish waters along Bald Head Creek; open waters elsewhere
- Hard bottom approximately one mile offshore at north end of island

Protected Species & Wildlife Elements
- Loggerhead and green sea turtle nest sites (May 1-November 15 moratoria)
- Seabeach amaranth occurrences; 0 plants observed in 2007 (will require surveys) Shortnose sturgeon occurrence (February 1 – June 15 moratoria)
- Colonial waterbird nest site (April 1 - August 31 moratoria in nesting areas)
- EFH present for 70 species (Atlantic Ocean)

Other
- Bald Head Island is an Area of State and National Significance

(10) North of Cape Fear

CHPP Elements
- Class SA waters except along the shoreline from Southport to Price Creek Lighthouse
- Salt marsh islands in the river channel
- Closed shellfish waters along northwest shoreline of river; open elsewhere
- SAV mapping needed

Protected Species & Wildlife Elements
- Loggerhead and green sea turtle habitat (limit takes during dredging)
- Colonial waterbird nest site on shoals and islands in river channel (April 1-August 31 moratoria in nesting areas)
- EFH present for 25 species

Other
- WRC Islands including Pelican Islands, Ferry Slip Island, and UNI Cape Fear River 3

(11) Zeke's Island

CHPP Elements
- Class SA waters
- Salt marsh present around island
- Open shellfish waters
- SAV mapping needed

Protected Species & Wildlife Elements
- Green sea turtle occurrences (May 1-Nov. 15 moratoria)
- Shortnose sturgeon occurrence (February 1-June 15 moratoria)

Other
- Primary nursery area between Zeke's Island and Federal Point
- Area of State Significance-Zeke's Island National Estuarine Research Reserve

A sample figure displaying some environmentally sensitive areas in Region 1 is presented in Figure VIII-20. Appendix F contains mapping by region of all important environmental concerns.

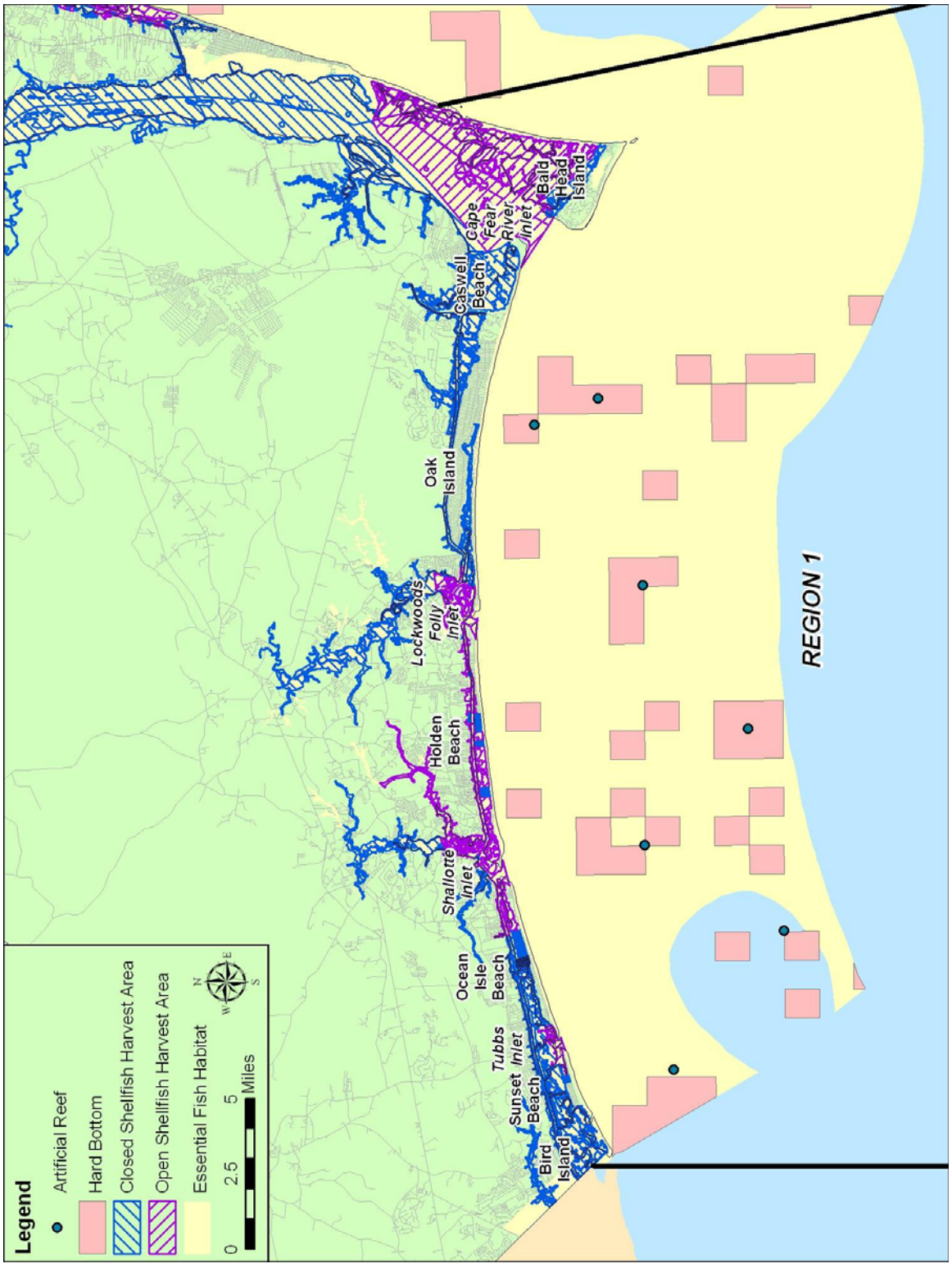

Figure VIII-20. Sample Environmental Considerations for Region 1

10. Economic Valuation

a) Property Value at Risk

Table VIII-7 provides the value of property at risk from sea level rise for Region 1. Unfortunately, Region 1 was not included within the estimates based on the Bin *et al.* study (2007). This region should be included in future studies. As outlined in Chapter IV, the CRC Science Panel on Coastal Hazards released a report with a likely range of rise that should be adopted for policy development and planning purposes. The Science Panel found the most likely scenario for 2100 AD is a rise of 0.4 meter to 1.4 meters (15 inches to 55 inches) above present. In comparison to the BIMP scenarios presented in Table IV-1, the Science Panel ranges represent a rise in sea level between 0.29 and 1.02 feet by 2030 and between 1.02 and 3.57 feet by 2080. In addition, the North Carolina Sea Level Rise Risk Management Study being carried out by the N.C. Division of Emergency Management is ongoing with final scenarios expected in mid-2011.

Table VIII-7. Property Value At Risk From Sea Level Rise – Region 1

Coastal Region	County	Beach	Value of Residential Coastal Property at Risk 2004	Value of Commercial Coastal Property at Risk 2004	Value of Residential Coastal Property at Risk 2008	Value of Commercial Coastal Property at Risk 2008
1	Brunswick	All	N/A	N/A	N/A	N/A

b) Beach Recreation

The direct annual expenditures and the associated employment and estimated total economic impact including multiplier effects are presented in Table VIII-8 along with the consumer surplus value of beach recreation. The data has been aggregated to a beach segment level for the region.

Table VIII-8. Beach Recreation Values – Region 1

Coastal Region	County	Beach	Beach Recreation 2005-2006 Total Impact Employment (jobs)	Beach Recreation 2008 Annual Direct Expenditures	Beach Recreation 2008 Annual Total Impact Output/ Sales/ Business Activity	Beach Recreation 2008 Annual Consumer Surplus
1	Brunswick	Bird Island	N/A	N/A	N/A	N/A
1	Brunswick	Sunset Beach	815	$33,945,467	$58,267,660	$2,530,369
1	Brunswick	Ocean Isle Beach	1290	$53,741,814	$92,248,245	$4,036,936
1	Brunswick	Holden Beach	1299	$54,097,121	$92,858,134	$4,558,441
1	Brunswick	Oak Island	898	$37,424,734	$64,239,849	$3,317,360
1	Brunswick	Bald Head Island	419	$17,453,742	$29,959,486	$897,687
REGION 1 TOTALS=			4,721	$196,662,878	$337,573,374	$15,340,794

c) Shore and Pier Fishing

In addition to beach recreation value, people attach value to fishing from the shore and from pier structures. This value defined here as consumer surplus is presented in Table VIII-9 for the Region 1 beaches.

Table VIII-9. Shore and Pier Fishing – Region 1

Coastal Region	County	Beach	Annual Pier/Bridge/Jetty Fishing Consumer Surplus (2008)	Annual Shore/Bank Fishing Consumer Surplus (2008)
1	Brunswick	Bird Island	$0	$0
1	Brunswick	Sunset Beach	$391,463	$83,537
1	Brunswick	Ocean Isle Beach	$70,592	$234,346
1	Brunswick	Holden Beach	$410,716	$301,619
1	Brunswick	Oak Island	$603,238	$476,825
1	Brunswick	Bald Head Island	$0	$0
REGION 1 TOTALS=			$1,476,009	$1,096,327

d) Marine Recreation Services

Marine recreational services are businesses that can be dependent on water access but are not direct beach recreation or fishing related. Some examples include ecotourism, canoe, kayak, and surf board rentals. Table VIII-10 provides the economic values associated with marine recreation services on a per county basis.

Table VIII-10. Marine Recreation Services – Region 1

Coastal Region	County	Number Businesses (2007)	Annual Direct Sales (2007)	Direct Employment (jobs) (2007)	Annual Total Impact Output/ Sales/ Business Activity (2007)	Total Impact Employment (jobs) (2007)	Annual Direct Sales (2008)	Annual Total Impact Output/ Sales/ Business Activity (2008)
1	Brunswick	14	$949,795	159	$1,995,001	166	$970,398	$2,038,276

e) Commercial Fishing

The employment value of fish landings and associated seafood processing industry economic values are presented in Table VIII-11.

Table VIII-11 Commercial Fishing – Region 1

Coastal Region	Waterway/Inlet	County	Estimated Direct Seafood Processing and Packing Output/Sales/Yr Supported by NC Seafood Landings 2007	Estimated Seafood Processing and Packing Jobs Supported by NC Seafood Landings 2007	Commercial Fishery Landings Direct Output/Sales (Dockside Value)/Yr 2007	Number of Commercial Fishing Jobs Supported 2007	Total Impacts on Business Activity/Sales 2008 (incl mult effects)	Total Jobs Supported 2008 (incl mult effects)
1	AIWW	Brunswick	N/A	N/A	N/A		N/A	
1	Cape Fear Inlet	Brunswick	$5,102,745	25	$1,479,796		$8,589,261.57	
1	Lockwoods Folly Inlet	Brunswick	$534,769	3	$155,083	443	$900,156.81	581
1	Shallotte Inlet	Brunswick	$7,606,224	37	$2,205,805		$12,803,275.66	
1	Tubbs Inlet	Brunswick	N/A	N/A	N/A		N/A	
REGION 1 TOTALS=			$13,243,738	65	$3,840,684	443	$22,292,694	581

f) For Hire Fisheries

For hire fisheries include charter boats and head boats where people pay a fee to go fishing. Table VIII-12 outlines the various spending, employment and economic impact of this industry segment.

Table VIII-12. For Hire Fisheries – Region 1

Coastal Region	Waterway/Inlet	County	2008 For-Hire Fishery Passenger Direct Spending On Fishing Fees	2008 For-Hire Fishery Passenger Direct Spending On Other	2008 For-Hire Fishery Direct Captain & Crew Jobs Supported	2008 For-Hire Fishery Total Impact (incl mult effects) Business Activity	2008 For-Hire Fishery Total Impact (incl mult effects) Jobs Supported	2008 For-Hire Fishery Passenger Consumer Surplus
1	AIWW	Brunswick						
1	Cape Fear Inlet	Brunswick						
1	Lockwoods Folly Inlet	Brunswick	$7,962,846	$20,213,565	201	$56,619,233	852	$15,319,636
1	Shallotte Inlet	Brunswick						
1	Tubbs Inlet	Brunswick						
REGION 1 TOTALS=			$7,962,846	$20,213,565	201	$56,619,233	852	$15,319,636

g) Private Boating

The direct expenditures of private recreational boaters as well as the multiplier effects and associated jobs are present in Table VIII-13 together with the consumer surplus value.

Table VIII-13. Private Boating – Region 1

Coastal Region	Waterway/Inlet	County	2008 Direct Private Boater Spending per Yr	2008 Total Impact Business Activity/Sales per Yr	2008 Total Impact Jobs	2008 Consumer Surplus
1	AIWW	Brunswick				
1	Cape Fear Inlet	Brunswick				
1	Lockwoods Folly Inlet	Brunswick	$6,550,955	$13,399,681	217	$1,977,423
1	Shallotte Inlet	Brunswick				
1	Tubbs Inlet	Brunswick				
REGION 1 TOTALS=			$6,550,955	$13,399,681	217	$1,977,423

h) Boat Building

The boat building industry employs people at various locations along the State's waterways. Boat builders rely on the maintenance of the waterways to create interest in the boating industry and subsequent sales of boats. Table VIII-14 presents the direct sales and economic impact of the boat building industry.

Table VIII-14. Boat Building – Region 1

Coastal Region	Waterway/Inlet	County	2008 Number of Firms	2008 Direct Sales	2008 Direct Employment	2008 Total Impact Output	2008 Total Impact Employment
1	AIWW	Brunswick	No Data	No Data	No Data	No Data	No Data
1	Cape Fear Inlet	Brunswick	1	$120,136,736	550	$163,634,546	981
1	Lockwoods Folly Inlet	Brunswick	No Data	No Data	No Data	No Data	No Data
1	Shallotte Inlet	Brunswick	No Data	No Data	No Data	No Data	No Data
1	Tubbs Inlet	Brunswick	No Data	No Data	No Data	No Data	No Data
REGION 1 TOTALS=			1	$120,136,736	550	$163,634,546	981

i) Marinas

Coastal marinas support both private boating and for hire fishing charters. The data presented for marinas has some overlap with the private boating and for hire fishing data. Table VIII-15 provides the economic marina data for Region 1.

Table VIII-15. Marina Sales and Employment – Region 1

Coastal Region	Waterway/Inlet	County	2008 Number of Marinas	2008 Estimated Direct Marina Sales/Year	2008 Estimated Direct Marina Employment
1	AIWW	Brunswick	19	$5,665,320	141
1	Cape Fear Inlet	Brunswick	No Data	No Data	No Data
1	Lockwoods Folly Inlet	Brunswick	No Data	No Data	No Data
1	Shallotte Inlet	Brunswick	No Data	No Data	No Data
1	Tubbs Inlet	Brunswick	No Data	No Data	No Data
REGION 1 TOTALS=			19	$5,665,320	141

B. Potential Beach and Inlet Management Strategies

Development of draft management strategies for coastal North Carolina must take into account a variety of measures including current management practices, associated costs, environmental considerations, economic valuation of beaches and inlets, and potential funding options. This section will discuss the current and potential strategies applicable to Region 1.

1. Historical Strategies

Historical strategies in North Carolina have included beach nourishment, coastal zone management practices (*i.e.*, setbacks, retreat), storm recovery (*i.e.*, dune reconstruction, planting, beach bulldozing, breach fill), dredging, sand bypassing, inlet relocation, and hard structures. Current methods applicable to Region 1 are presented in the following sections. Costs associated with each of the strategies have been updated to reflect 2008 values.

a) Beach Nourishment

A beach nourishment database has been compiled from several sources to provide a comprehensive summary of the state's nourishment activities. Sources include the U.S. Army Corps of Engineers, Western Carolina's Center for Developed Shorelines, the Carteret County Shore Protection Office, Spencer Rogers of North Carolina Sea Grant, and Tom Jarrett with Coastal Planning & Engineering, Inc. The database extends over a time period from 1939 through 2007. A summary of the beach nourishment data for Region 1 is presented in Table VIII-16. The relative size of the projects listed in Table VIII-16 can be found in Figure VIII-21. As can be seen from the figure, there is a wide range of project sizes with many large hopper projects as well as smaller ones completed with the USACE special purpose dredge. Beach nourishment project locations for Region 1 can be seen in Figure VIII-25. The complete beach nourishment database is in Appendix D.

Table VIII-16. Summary of Beach Nourishment Data – Region 1

Location	First Year of Record	Number of Times Nourished	Total Amount Nourished (cy)	Average Unit Cost ($ / cy)	Cost per Project ($ / proj)
BALD HEAD ISLAND	1991	7	6,613,818	5.71	4,632,173
CASWELL BEACH	2001	1	133,200	No Data	No Data
HOLDEN BEACH	1971	38	3,253,676	5.66	337,742
MONK ISLAND	1981	3	197,955	13.49	890,408
OAK ISLAND	2001	6	5,363,294	4.96	7,287,127
OCEAN ISLE BEACH	1974	15	5,659,766	5.34	4,328,634
WILMINGTON HARBOR ODMDS*	1997	11	17,082,712	2.45	3,800,975
TOTAL REGION	**N/A**	**81**	**38,304,421**	**N/A**	**N/A**

*While placed offshore, the location of these historical dredging operations were in areas where beach compatible materials have been found

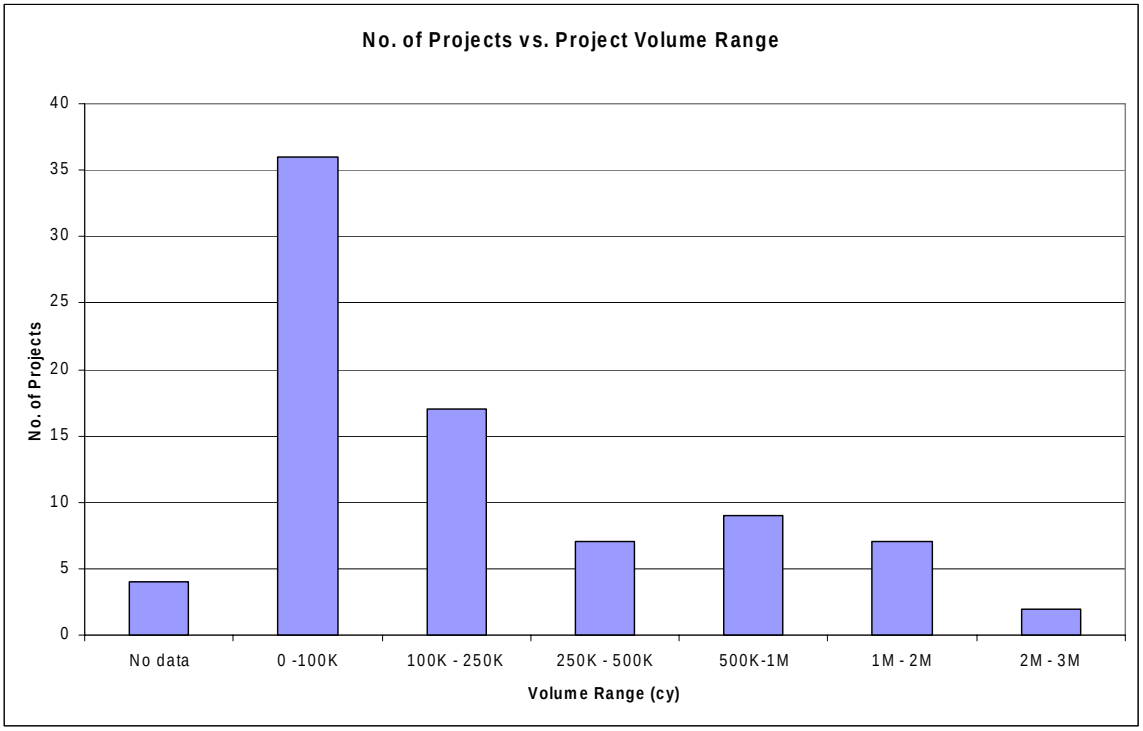

Figure VIII-21. Number of Nourishment Projects – Region 1 by Project Size

Nourishment material comes from nearby inlets and channels. Table VIII-17 shows the known historical borrow sources for each of the Region 1 beaches.

Table VIII-17. Historical Borrow Sources – Region 1 Beaches

Beach	Historical Borrow Sources
Ocean Isle Beach	Shallotte Inlet, Ocean Isle Waterways, Tubbs Inlet
Monks Island	Shoals of Lockwoods Folly Inlet
Holden Beach	Shoals of Lockwoods Folly Inlet, Holden Beach Waterways, Wilmington Harbor Entrance Channel
Long Beach	Shoals of Lockwoods Folly Inlet
Oak Island	Wilmington Harbor Entrance Channel, Yellow Banks
Caswell Beach	Wilmington Harbor Entrance Channel
Bald Head Island	Wilmington Harbor Entrance Channel, Smith Island Channel Reach

In Region 1, the Towns of Sunset Beach, Ocean Isle Beach, and Holden Beach have used beach bulldozing to help mitigate storm damage along the oceanfront. Beach bulldozing is a common method of erosion management that moves sand, usually to repair storm damage to an existing dune or to create a protective berm if the dune system has been completely washed away.

b) Coastal Zone Management

As mentioned previously, DCM has estimated long-term shoreline change rates based on the distance from the earliest digitized shoreline archived by the state (typically the 1940s) to the 1998 shoreline. Using these shoreline change rates, the CRC has established oceanfront setback factors that determine the minimum allowable distance between a structure and the first line of stable and natural vegetation during development. Currently, the minimum setback is 30 times the long-term average annual erosion rate (minimum of 60 feet) for all structures less than 5,000 square feet. Above 5,000 square feet, and every 5,000 square feet thereafter, the setback factor increases from 60 to 90 in increments of five. The maximum setback factor becomes 90 times the erosion rate for structures greater than or equal to 100,000 square feet. Setback factors for the entire coast can be seen on the DCM website (http://dcm2.enr.state.nc.us/Maps/SB_Factor.htm).

In Region 1, Sunset Beach has an average annual erosion rate of 2.0 feet per year. This is the default rate for any area of shoreline that has a calculated erosion rate of 2.0 feet per year or less, including stable and accretional shorelines. Ocean Isle Beach has an average annual erosion rate of 2.0 feet per year along a majority of its shoreline with the exception of the area nearest Shallotte Inlet where it increases to 4.5 feet per year. The western portion of Holden Beach has an average annual erosion rate of 2.0 feet per year. The rate along the eastern portion of the shoreline steadily increases to 7.5 feet per year at Lockwoods Folly Inlet. The western portion of Oak Island has an average annual erosion rate of 2.0 feet per year while the erosion rate in the middle portion increase to 5.5 feet per year. The rate decreases to 2.0 feet per year on the eastern portion of the island. The average annual erosion rate on Bald Head Island ranges from 2.0 feet per year in the middle of the southern facing shoreline to 8.0 feet per year near Cape Fear Inlet and 15.0 feet per year on the eastern tip of the island (Cape Fear).

c) Dredging

A dredging database has been compiled from 1975 to 2007 of dredging performed or contracted by the USACE. Corps of Engineers dredge data was obtained for 1995-2007 as well as contract dredging data for 1990-2007. Projects occurring prior to these dates were obtained from the North Carolina Historic Dredging Data book from the Wilmington district of the USACE. In a previous study by Moffatt & Nichol on shallow draft navigation (November 2005), a database was created of all shallow draft projects from 1975 through 2004. Deep draft projects and projects from 2005 to 2007 were added to this database.

A summary of the dredge data from the database applicable to Region 1 is presented in Table VIII-19. Figure VIII-22 shows the relative size of projects as well. Analysis was also performed for projects within the last 10 years to get an idea of more recent dredging activities and requirements. A summary of data from just these recent years is depicted in Tables VIII-18, VIII-19 and VIII-20. Dredge project locations can are also shown in Figure VIII-25. The complete dredge database is available in Appendix E.

Table VIII-18. Summary of Dredge Volume Data – Region 1 (1975-2007)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Volume
	(cy)	(cy)	(cy)	(cy)	(cy / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	2,902,865	1,338,875	169,670
CAPE FEAR INLET	0	16,999,452	0	0	566,648
OVERALL TOTAL (Potential Nourishment)	**0**	**16,999,452**	**2,902,865**	**1,338,875**	**736,318**
LOCKWOODS FOLLY RIVER	305,389	0	1,066,562	636,283	66,941
CAPE FEAR RIVER	723,995	0	56,389	0	26,013
SHALLOTTE RIVER	203,786	0	0	13,375	7,239
WILMINGTON HARBOR	31,836,513	0	0	0	1,061,217
OVERALL TOTAL	**33,069,683**	**16,999,452**	**4,025,816**	**1,988,533**	**1,897,728**

Table VIII-19. Summary of Dredge Volume Data – Region 1 (1997-2007)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Volume
	(cy)	(cy)	(cy)	(cy)	(cy / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	1,823,261	205,160	202,842
CAPE FEAR INLET	0	4,099,671	0	0	409,967
OVERALL TOTAL (Potential Nourishment)	**0**	**4,099,671**	**1,823,261**	**205,160**	**612,809**
LOCKWOODS FOLLY RIVER	69,570	0	652,766	81,515	80,385
CAPE FEAR RIVER	0	0	44,970	0	4,497
SHALLOTTE RIVER	0	0	0	13,375	1,338
WILMINGTON HARBOR	11,001,640	0	0	0	1,100,164
OVERALL TOTAL	**11,071,210**	**4,099,671**	**2,520,997**	**300,050**	**1,799,193**

Table VIII-20. Summary of Dredge Volume Data – Region 1 (2002-2007)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Volume
	(cy)	(cy)	(cy)	(cy)	(cy / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	1,584,035	42,735	325,354
CAPE FEAR INLET	0	3,367,950	0	0	673,590
OVERALL TOTAL (Potential Nourishment)	**0**	**3,367,950**	**1,584,035**	**42,735**	**998,944**
LOCKWOODS FOLLY RIVER	69,570	0	296,596	37,180	80,669
CAPE FEAR RIVER	0	0	6,800	0	1,360
SHALLOTTE RIVER	0	0	0	13,375	2,675
WILMINGTON HARBOR	9,356,486	0	0	0	1,871,297
OVERALL TOTAL	**9,426,056**	**3,367,950**	**1,887,431**	**93,290**	**2,954,945**

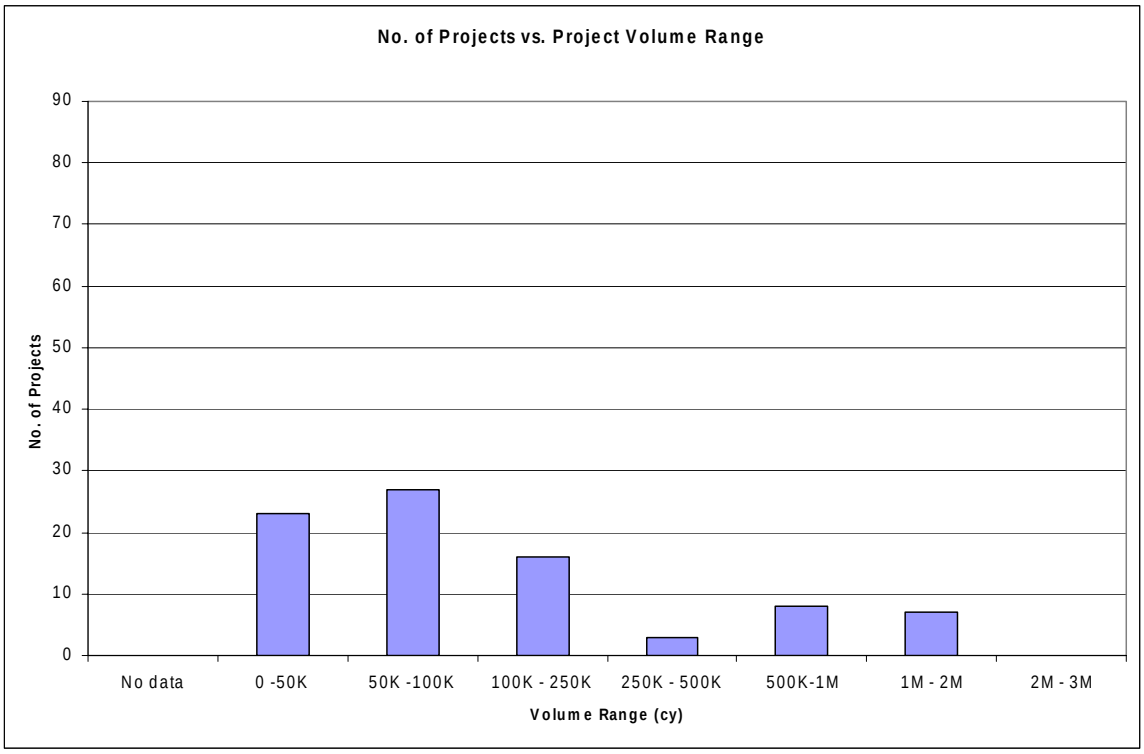

Figure VIII-22. Number of Dredge Projects – Region 1 by Project Size

d) Structures

The state has prohibited the use of permanent erosion control structures since 1985, leaving the coast of North Carolina relatively free of engineered structures used to influence beach or inlet behavior. The ban on the use of permanent structures has been both through the CRC's rules and more recently (2003) by state law.

Permanent erosion control structures exist on Bald Head Island (groin field) near Cape Fear Inlet and a seawall and two bulkheads on Oak Island. Permanent erosion control structures in Region 1, including sandbags, are shown in Figure VIII-23.

e) Channel Realignment and Inlet Relocation

(1) Wilmington Harbor Navigation Channel

The Wilmington Harbor navigation channel has recently undergone improvements to alleviate navigation constraints that required larger vessels entering through Cape Fear Inlet to travel light-loaded or wait for high tide. The solution to this was to widen and deepen the channel. The new alignment reduced deepening costs and environmental impacts and made beach compatible sand available for use on nearby Brunswick County beaches. Continued maintenance of the new channel will provide additional sediment for use on Region 1 beaches from direct placement.

(2) Tubbs Inlet

Tubbs Inlet (Brunswick County) was relocated in December 1969 to mitigate erosion of the eastern portion of Sunset Beach due to inlet migration of approximately 131 feet per year to the west. The inlet was relocated 3,280 feet eastward that approximated the inlet's 1938 location (Masterson *et al.*, 1973).

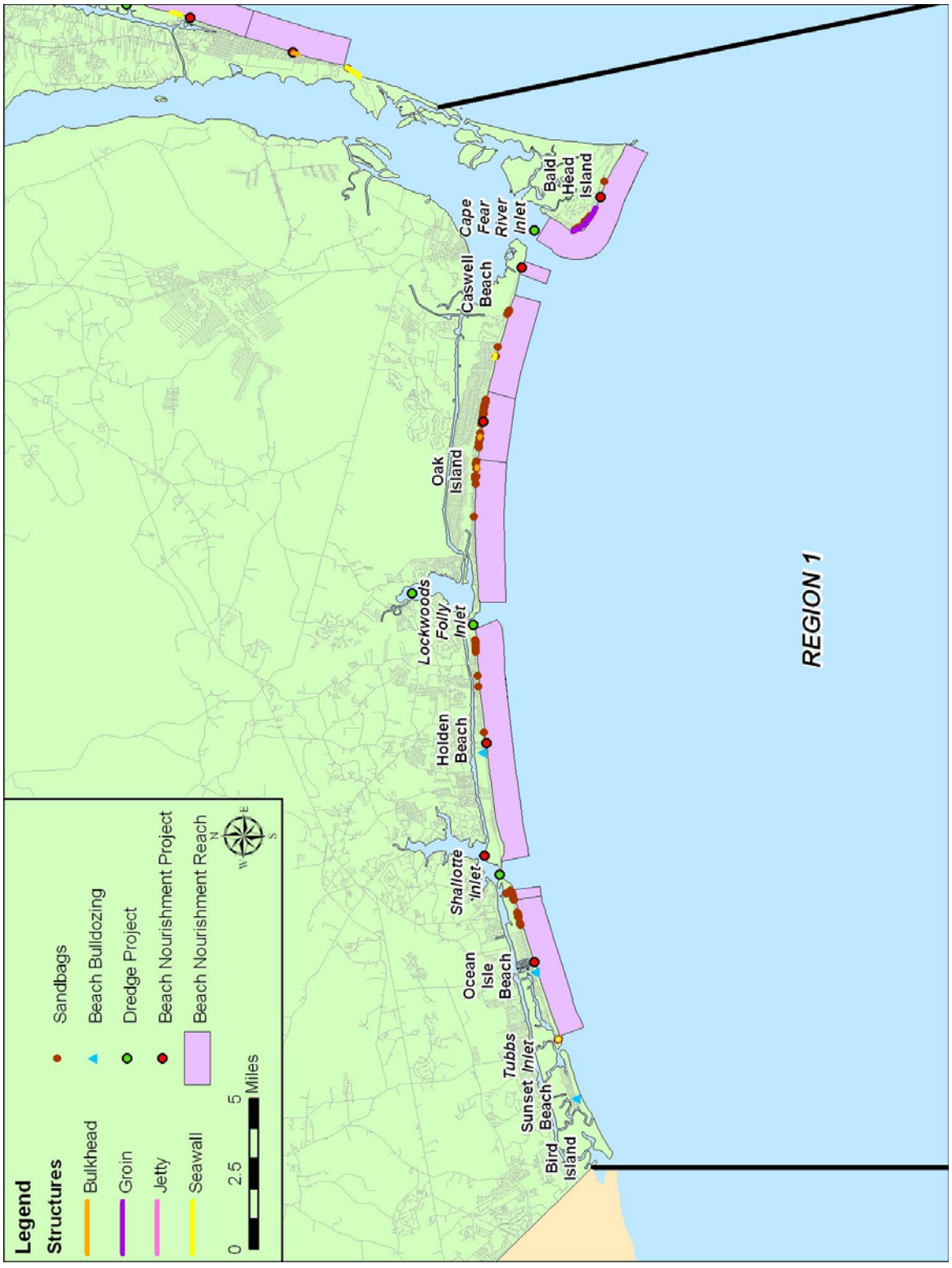

Figure VIII-23. Historical Management Strategies for Region 1

2. Potential Management Strategies

Current North Carolina policy relies on beach nourishment and dredging due to the prohibition on permanent erosion control structures. Continuation of these methods is expected with improvements in efficiency through the establishment of plans for location, frequency, quantity, and cost of nourishment projects on a cyclic basis. The adoption of a regional approach would also serve to ensure sure that all beach compatible sand from dredging projects is placed on the beach or back into the nearshore system. For example, coordinating dredging to maintain an inlet with beach nourishment or habitat creation would be an effective and efficient use of resources.

To begin this regionalized approach, sand sources within each region have been identified and tentatively assigned to various stretches of beach based on distance to the source. As discussed in Section VI - strategy development, using offshore borrow areas or sediment from inlets is only cost effective up to a certain distance from the beach. Table VIII-21 shows the nearest inlet and offshore sources of sediment for Region 1 beaches.

Table VIII-22 shows the most likely sediment borrow areas to be used for each beach based on distances and sediment quality. The Wilmington Harbor ODMDS was not considered a viable source of beach sediment given USACE and stakeholder concerns that it contains too many fines to be reliable as a source of beach compatible sand. Figure VIII-24 shows the locations and distances of the most likely sediment resources. Section VI also contains a general discussion on the development of potential strategies and costs for the entire coast.

Table VIII-21. Nearest Sediment Sources – Region 1 Beaches

Location	Nearest Inlet Source		Nearest Offshore Source	
	Name	Distance (mi)	Name	Distance (mi)
Bird Island	Shallotte Inlet	9.5	Wilmington Harbor ODMDS (USACE)	30.0
Sunset Beach	Shallotte Inlet	7.6	Wilmington Harbor ODMDS (USACE)	29.0
Ocean Isle	Shallotte Inlet	3.0	Wilmington Harbor ODMDS (USACE)	25.5
Holden Beach	Shallotte Inlet/Lockwoods Folly Inlet	4.2	Wilmington Harbor ODMDS (USACE)	20.2
Oak Island	Lockwoods Folly Inlet/Cape Fear Inlet	6.3	Jay Bird Shoals	6.2
Caswell Beach	Cape Fear Inlet	2.5	Jay Bird Shoals	2.4
Bald Head Island	Cape Fear Inlet	2.5	Jay Bird Shoals	2.6
North of Cape Fear (along Bald Head)	Cape Fear Inlet	7.2	Jay Bird Shoals	7.5

Table VIII-22. Most Likely Sediment Sources – Region 1 Beaches

Location	Most Likely Sand Source		Likely Dredge Type	Annual Need (CY)	Developed
	Name	Distance (mi)			
Bird Island	Shallotte Inlet	9.5	Pipeline/Hopper	0	N
Sunset Beach	Shallotte Inlet	7.6	Pipeline/Hopper	0	Y
Ocean Isle	Shallotte Inlet	3.0	Pipeline/Hopper	45,972	Y
Holden Beach	Shallotte Inlet/Lockwoods Folly Inlet	4.2	Pipeline/Hopper	189,747	Y
Oak Island	Lockwoods Folly Inlet/ Cape Fear Inlet	6.3	Pipeline/Hopper	74,573	Y
Caswell Beach	Cape Fear Inlet	2.5	Pipeline/Hopper	44,099	Y
Bald Head Island	Cape Fear Inlet	2.5	Pipeline/Hopper	209,730	Y

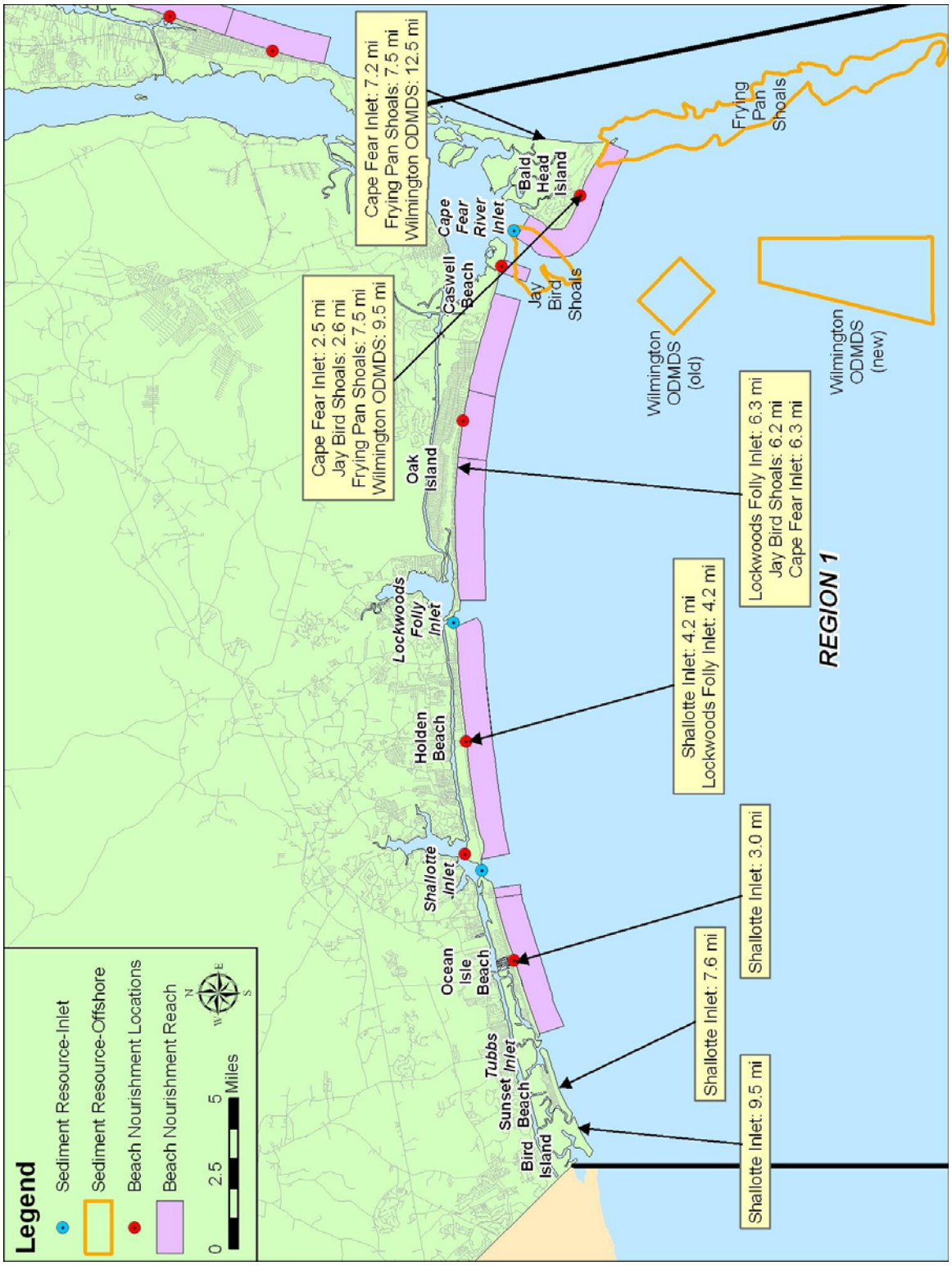

Figure VIII-24. Potential Sediment Resources for Region 1

C. Costs and Effectiveness of Strategies

1. Historical Costs

The beach nourishment and dredge databases were used to analyze historical costs for projects. Not all projects in the two databases contained cost information; therefore analysis was done in each case for the whole dataset, the past 10 years, and the past five years. Attention was paid to projects which were particularly costly or inexpensive so as not to bias the average costs that were calculated in the end. Costs associated with each of the strategies have been updated to reflect 2008 values.

a) Beach Nourishment

Tables VIII-23 through VIII-25 show the costs over various time periods for beach nourishment projects which have taken place in Region 1. The region as a whole has averaged approximately $8 million per year in beach nourishment activities.

Table VIII-23. Beach Nourishment Costs – Region 1 (Whole Dataset)

Location	First Year of Record	Number of Times Nourished	Average Unit Cost ($ / cy)	Avg Volume (cy/YR)	Avg Cost ($/YR)
BALD HEAD ISLAND	1991	7	5.71	413,364	2,361,663
CASWELL BEACH	2001	1	No Data	22,200	No Data
HOLDEN BEACH	1971	38	5.66	90,380	511,814
MONK ISLAND	1981	3	13.49	7,614	102,739
OAK ISLAND	2001	6	4.96	893,882	4,431,042
OCEAN ISLE BEACH	1974	15	5.34	171,508	916,326
WILMINGTON HARBOR ODMDS	1997	11	2.45	1,708,271	4,181,072
TOTAL REGION	**N/A**	**81**	**N/A**	**3,307,219**	**12,504,657**
TOTAL WITHOUT ODMDS	**N/A**	**70**	**N/A**	**1,598,948**	**8,323,585**

Table VIII-24. Beach Nourishment Costs – Region 1 (1997-2007)

Location	Number of Times Nourished	Average Unit Cost ($ / cy)	Avg Volume (cy/YR)	Avg Cost ($/YR)
BALD HEAD ISLAND	4	7.56	469,882	3,554,072
CASWELL BEACH	1	No Data	13,320	No Data
HOLDEN BEACH	14	5.94	132,322	786,294
MONK ISLAND	0	No Data	0	No Data
OAK ISLAND	3	4.47	496,840	2,219,264
OCEAN ISLE BEACH	8	5.34	533,566	2,850,710
WILMINGTON HARBOR ODMDS	11	2.45	1,708,271	4,181,072
TOTAL REGION	**41**	**N/A**	**3,354,201**	**13,591,413**
TOTAL WITHOUT ODMDS	**30**	**N/A**	**1,645,929**	**9,410,341**

Table VIII-25. Beach Nourishment Costs – Region 1 (2002-2007)

Location	Number of Times Nourished	Average Unit Cost ($ / cy)	Avg Volume (cy/YR)	Avg Cost ($/YR)
BALD HEAD ISLAND	2	7.45	478,806	3,569,400
CASWELL BEACH	0	No Data	0	No Data
HOLDEN BEACH	6	10.24	84,146	861,470
MONK ISLAND	0	No Data	0	No Data
OAK ISLAND	0	No Data	0	No Data
OCEAN ISLE BEACH	6	6.07	303,379	1,841,329
WILMINGTON HARBOR ODMDS	4	3.07	840,755	2,584,870
TOTAL REGION	**18**	**N/A**	**1,707,086**	**8,857,069**
TOTAL WITHOUT ODMDS	**14**	**N/A**	**866,331**	**6,272,199**

b) Dredging

Tables VIII-26 through VIII-28 show the costs over various time periods for dredging projects which have taken place in Region 1. The region as a whole has averaged approximately $7 million per year dredging activities.

Table VIII-26. Dredging Costs – Region 1 (Whole Dataset)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Cost
	($)	($)	($)	($)	($ / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	10,648,877	4,849,662	619,942
CAPE FEAR INLET	0	45,855,641	0	0	1,528,521
OVERALL TOTAL (Potential Nourishment)	**0**	**45,855,641**	**10,648,877**	**4,849,662**	**2,148,463**
LOCKWOODS FOLLY RIVER	3,997,401	0	5,874,695	2,535,355	413,582
CAPE FEAR RIVER	4,807,767	0	494,616	0	176,746
SHALLOTTE RIVER	1,314,655	0	0	52,965	45,587
WILMINGTON HARBOR	111,322,999	0	0	0	3,710,767
OVERALL TOTAL	**121,442,821**	**45,855,641**	**17,018,188**	**7,437,982**	**6,495,145**

Table VIII-27. Dredging Costs – Region 1 (1997-2007)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Cost
	($)	($)	($)	($)	($ / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	4,809,355	1,080,101	588,946
CAPE FEAR INLET	0	11,058,771	0	0	1,105,877
OVERALL TOTAL (Potential Nourishment)	**0**	**11,058,771**	**4,809,355**	**1,080,101**	**1,694,823**
LOCKWOODS FOLLY RIVER	830,556	0	1,958,147	192,375	298,108
CAPE FEAR RIVER	0	0	394,454	0	39,445
SHALLOTTE RIVER	0	0	0	73,161	7,316
WILMINGTON HARBOR	39,891,963	0	0	0	3,989,196
OVERALL TOTAL	**40,722,518**	**11,058,771**	**7,161,956**	**1,345,637**	**6,028,888**

Table VIII-28. Dredging Costs – Region 1 (2002-2007)

Location	Pipeline	Hopper	Sidecast	Currituck	Avg Cost
	($)	($)	($)	($)	($ / YR)
TUBBS INLET	0	0	0	0	0
SHALLOTE INLET	0	0	0	0	0
LOCKWOODS FOLLY INLET	0	0	4,178,330	162,820	868,230
CAPE FEAR INLET	0	5,166,488	0	0	1,033,298
OVERALL TOTAL (Potential Nourishment)	**0**	**5,166,488**	**4,178,330**	**162,820**	**1,901,528**
LOCKWOODS FOLLY RIVER	830,556	0	889,719	87,745	361,604
CAPE FEAR RIVER	0	0	59,646	0	11,929
SHALLOTTE RIVER	0	0	0	73,161	14,632
WILMINGTON HARBOR	34,172,488	0	0	0	6,834,498
OVERALL TOTAL	**35,003,043**	**5,166,488**	**5,127,696**	**323,726**	**9,124,191**

2. Potential Costs

In addition to historical quantity and cost data for beach nourishment and dredging projects, unit costs were developed for each stretch of beach for various beach nourishment scenarios encompassing different types of dredges and distances from sediment sources. For each stretch of beach in Region 1, the historical DCM erosion rates were used to estimate future volumetric needs. Unit costs were then applied to these needs to estimate potential costs for each region, on a yearly basis, which could then be summed to predict the cost for the entire coast. Tables VIII-29 presents the predicted annual costs for each beach in Region 1. Section VI also contains a general discussion on the methodology employed for the development of potential strategies and costs for the entire state. Based on the findings outlined in Section VI, the predicted annual costs for the beach strategies below should be factored up by 1.3 to 1.7 (assumed to be 1.5 for this report) to account for cubic yards lost per foot of shoreline due to storm impacts. Note that the costs for the inlet maintenance (dredging) strategies are assumed to be equivalent to historical trends.

Table VIII-29. Predicted Annual Costs – Region 1 Beaches

Location	Shoreline Length	Total Volume Needed	Total Volume Cost
	MI	CY	$
Ocean Isle	5.6	45,972	444,547
Holden Beach	8.2	189,747	1,863,312
Oak Island	9.3	74,573	1,082,052
Caswell Beach	3.6	44,099	361,615
Bald Head Island	4.5	209,730	1,719,787
TOTAL DEVELOPED	**31.2**	**564,121**	**5,471,313**

D. Data Gaps

During the data collection efforts several data gaps were identified that would greatly aid future updates to the BIMP and beach and inlet management projects. The following lists some of these key data gaps by general topic:

Geology

- Inlet bathymetry – Detailed inlet surveys covering morphological features of Lockwoods Folly Inlet and Tubbs Inlet were not located (Navigation channel surveys for Lockwoods Folly Inlet can be located through USACE website - http://www.saw.usace.army.mil/nav/).

- Sand source investigations – Offshore borrow sources for Region 1 need to be investigated, including compatibility of the Wilmington Harbor ODMDS. In addition, Jay Bird Shoals and Frying Pan Shoals should be investigated further.

Physical Processes

- Sediment budget – Sediment budget information is lacking west of Ocean Isle (Tubbs Inlet and Sunset Beach).

Economics

- Extend property at risk study to include all coastal counties – Brunswick County values were estimated based on Carteret County and New Hanover County.

- Extend and refine beach recreation value surveys/study to include all coastal counties – Brunswick County values were based on Wrightsville Beach.