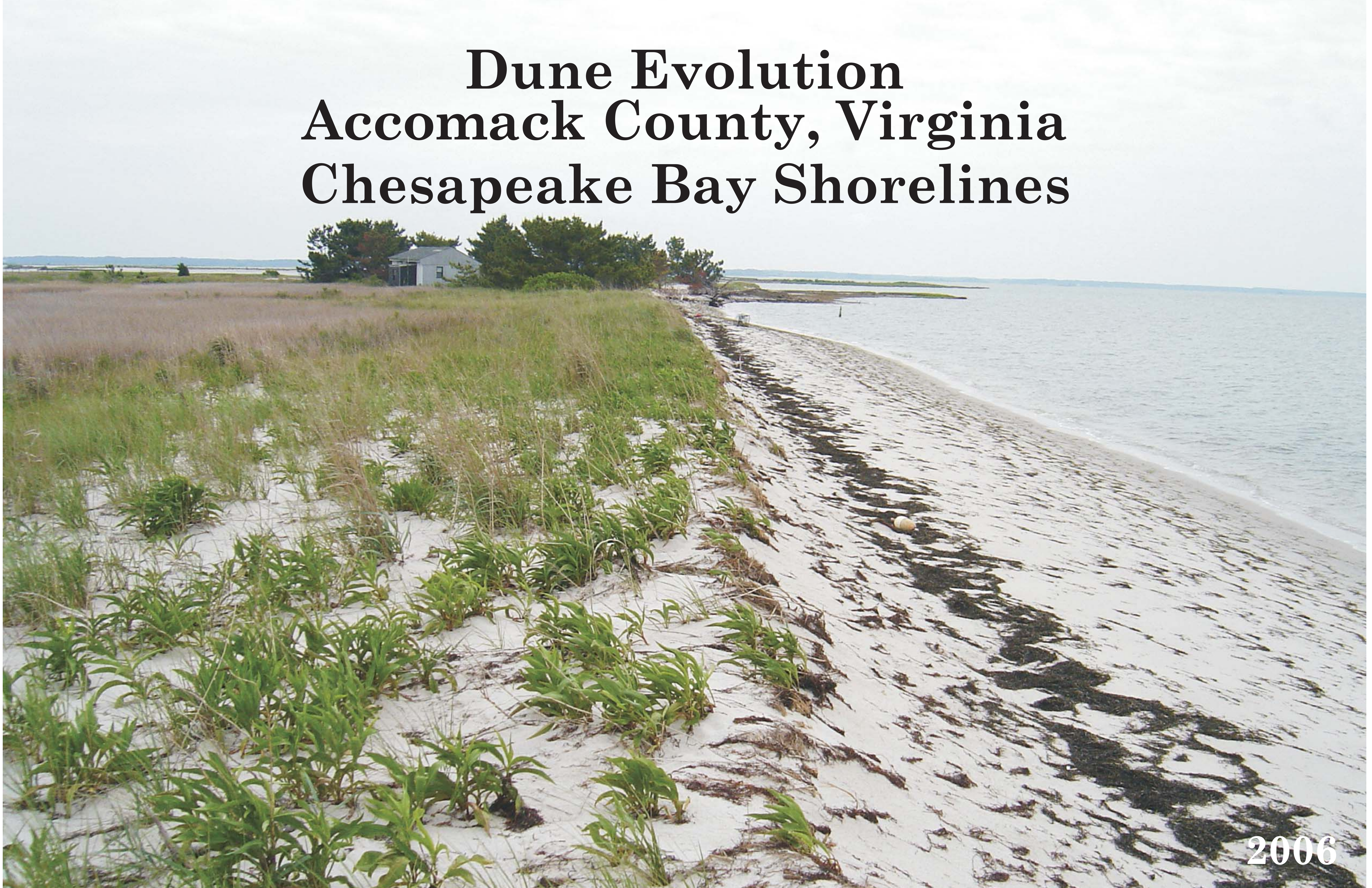
Dune Evolution
Accomack County, Virginia
Chesapeake Bay Shorelines



2006

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Chesapeake Bay Shorelines

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Cover Photo: Photograph of site AC28. Photo taken by Shoreline Studies Program on 27 May 2004.

I. INTRODUCTION

A. General Information

Shoreline evolution is the change in shore position through time. In fact, it is the material resistance of the coastal geologic underpinnings against the impinging hydrodynamic (and aerodynamic) forces. Along the shores of Chesapeake Bay, it is a process-response system. The processes at work include winds, waves, tides and currents, which shape and modify coastlines by eroding, transporting and depositing sediments. The shore line is commonly plotted and measured to provide a rate of change but it is as important to understand the geomorphic patterns of change. Shore analysis provides the basis to know how a particular coast has changed through time and how it might proceed in the future.

The purpose of this report is to document how the dunes on Chesapeake Bay shores of Accomack (Figure 1) have evolved since 1938. Aerial imagery was taken for most of the Bay region beginning that year, and it is this imagery that allows one to assess the geomorphic nature of shore change. Aerial imagery shows how the coast has changed, how beaches, dunes, bars, and spits have grown or decayed, how barriers have breached, how inlets have changed course, and how one shore type has displaced another or has not changed at all. Shore change is a natural process but, quite often, the impacts of man through shore hardening or inlet stabilization come to dominate a given shore reach. Most of the change in shore positions where dunes occur will be quantified in this report. Others, particularly very irregular coasts, around inlets, and other complicated areas will be subject to interpretation.

B. Chesapeake Bay Dunes

The primary reason for developing this Shoreline Evolution report is to be able to determine how dunes and beaches along the Bay coast of Accomack have and will evolve through time. The premise is that, in order to determine future trends of these important shore features, one must understand how they got to their present state. Beaches and dunes are protected by the Coastal Primary Sand Dune Protection Act of 1980 (Act)[1]. Research by Hardaway *et al.* (2001) located, classified and enumerated jurisdictional dunes and dune fields within the eight localities listed in the Act. These include the counties of Accomack, Lancaster, Mathews, Northampton and Northumberland and the cities of Hampton, Norfolk and Virginia Beach (Figure 2). Only Chesapeake Bay and river sites were considered in that study.

In 2004, Hardaway *et al*. created the Accomack County Dune Inventory. That report detailed the location and nature of the jurisdictional primary dunes along the Bay shore of Accomack, and those results appear in Appendix B. For this study, the positions of the dune sites are presented using the latest imagery in order to see how the sites sit in the context of past shoreline positions. The dune location information has not been field verified since the original visits in 1999, 2000 and 2004, depending on the site. This information is not intended to be used for jurisdictional determinations regarding dunes.

II. SHORE SETTING

A. Physical Setting

The Chesapeake Bay shoreline of Accomack County extends from the boundary with Northampton County at Occohannock Creek to the Maryland state line through Pocomoke Sound on the Eastern Shore. At least 50 miles of tidal shoreline occurs along Pocomoke Sound and Chesapeake Bay not inclusive of the many creeks, coves, and guts along this meandering coast. The Bay shorelines along Accomack are, in large part, low marsh with intermittent sand beaches. Historic erosion rates vary from 0 ft/yr to over 5 ft/yr with a very few areas of shore accretion along the Bay coast (Byrne and Anderson, 1978).

The coastal geomorphology of Accomack is a function of the underlying geology and the hydrodynamic forces operating across the land/water interface, the shoreline. The necks of land between the many creeks that dissect the coast are made up of Holocene sands and muds (Figure 3). These sharply contrast with the sandy upper Pleistocene Kent Island Formation that backs these low marshy areas. The Atlantic Ocean has come and gone numerous times over the Virginia coastal plain over the past million years or so. The effect has been to rework older deposits into beach and lagoonal deposits at time of the transgressions.

The last low stand found the ocean coast about 60 miles to the east when sea level about 300 feet lower than today and the coastal plain was broad and low. The current estuarine system was a meandering series of rivers working their way to the coast. About 15,000 years ago, sea level began to rise and the coastal plain watersheds began to flood. Shorelines began to recede. The slow rise in sea level is one of two primary long-term processes which cause the shoreline to recede; the other is wave action, particularly during storms. As shorelines recede or erode the bank material provides the sands for the offshore bars, beaches and dunes. Accomack's littoral system is sand rich from erosion over time of the sandy upland banks and nearshore substrate as evidenced by mostly sand beaches along the coast and a very extensive and complex system of offshore sand bars. These sand bars greatly influenced and are themselves influenced by the impinging wave climate.

Sea level is continuing to rise in the Tidewater Region. Tide data collected at Sewells Point in Norfolk show that sea level has risen 4.42 mm/yr (0.17 inches/yr) or 1.45 ft/century (http://www.co-ops.nos.noaa.gov/). On the Eastern Shore of Virginia at Kiptopeke, sea level has risen 3.59 mm/yr or 1.18 ft/century. This directly effects the reach of storms and their impact on shorelines. Anecdotal evidence of storm surge during Hurricane Isabel, which impacted North Carolina and Virginia on September 18, 2003, put it on par with the storm surge from the "storm of the century" which impacted the lower Chesapeake Bay in August 1933. Boon (2003) showed that even though the tides during the storms were very similar, the difference being only 4 cm or about an inch and a half, the amount of surge was different. The 1933 storm produced a storm surge that was greater than Isabel's by slightly more than a foot. However, analysis of the mean water levels for the months of both August 1933 and September 2003 showed that sea level has risen by 41 cm (1.35 ft) at Hampton Roads in the seventy years between these two storms (Boon, 2003). This is the approximate time span between our earliest aerial imagery (1938) and our most recent (2002), which means the impact of sea level rise to shore change is significant. The beaches, dunes, and nearshore sand bars try to keep pace with the rising sea levels.

Three shore reaches are considered in this report along the shoreline of Accomack (Figure 4). Reach I extends from Beasley Bay south to Big Marsh. Reach II extends from Big Marsh south to Onancock Creek. Reach III starts at Pungoteague Creek and extends south to Occohannock Creek.

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[1] The General Assembly of Virginia enacted the Coastal Primary Sand Dune Protection Act (the Dune Act) in 1980. The Dune Act was originally codified in § 62.1-13.21 to -13.28. The Dune Act is now recodified as Coastal Primary Sand Dunes and Beaches in § 28.2-1400 to -1420.

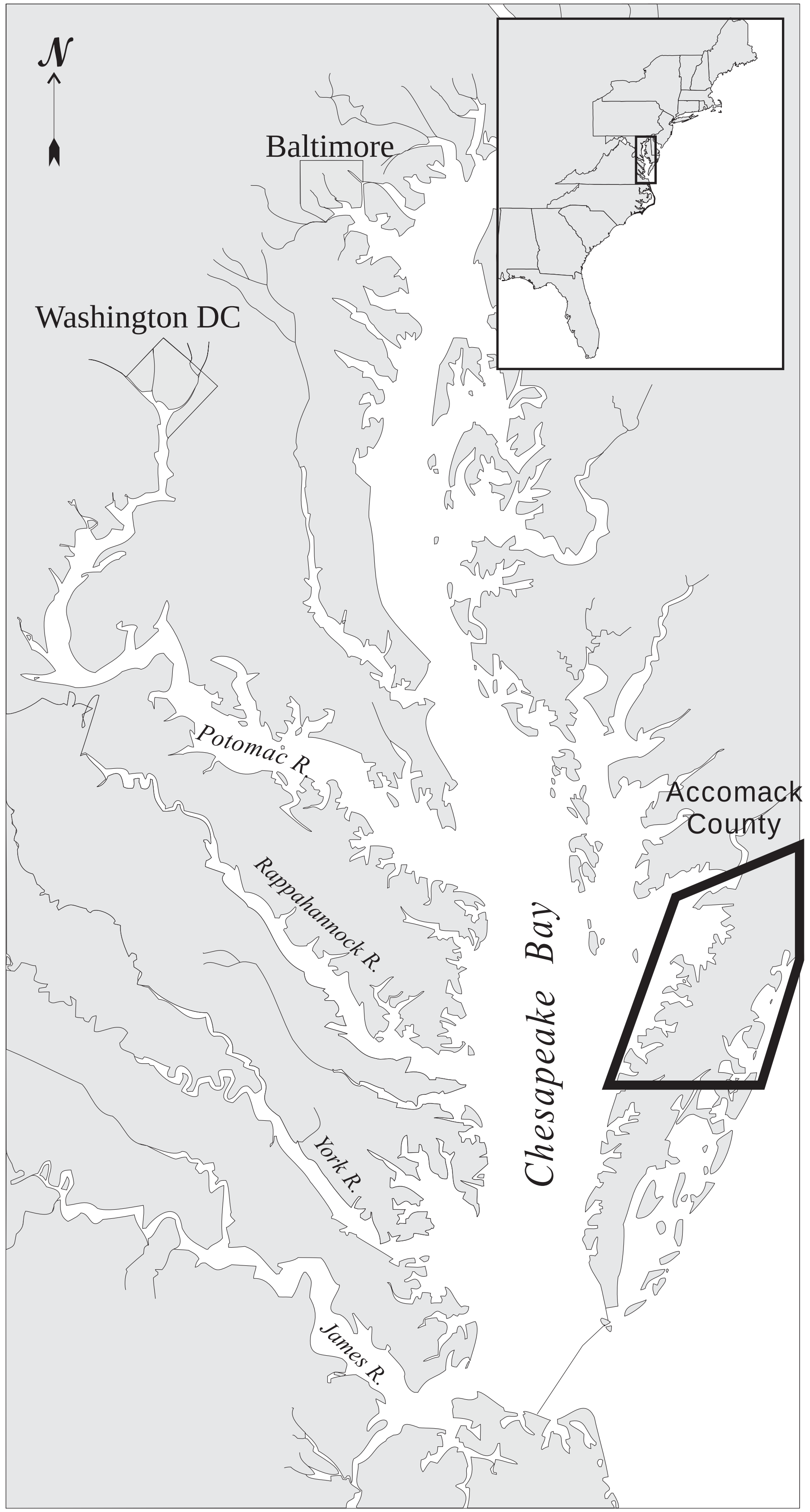

Figure 1. Location of Accomack County within the Chesapeake Bay estuarine system.

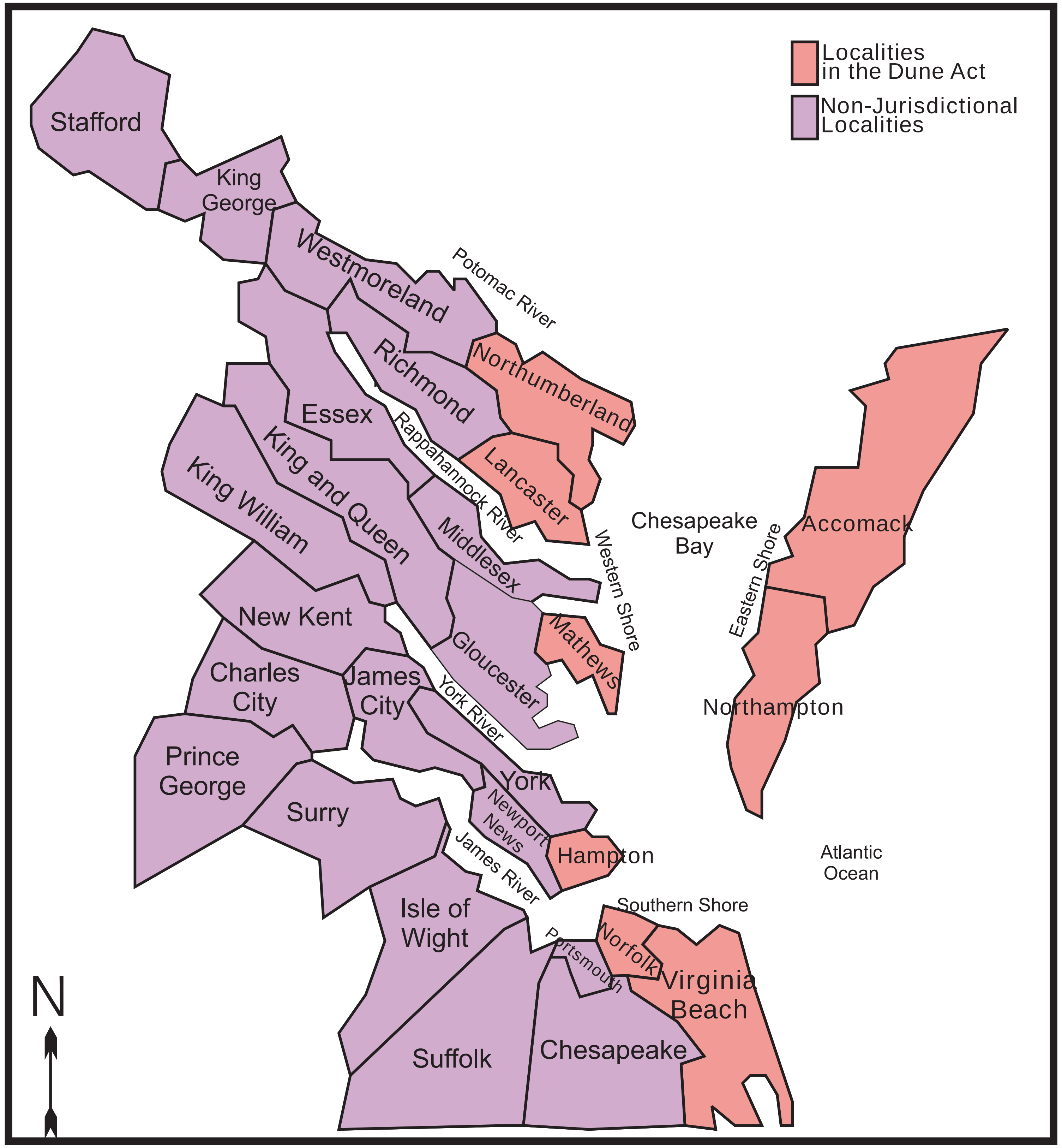

Figure 2. Location of localities in the Dune Act with jurisdictional and non-jurisdictional localities noted.

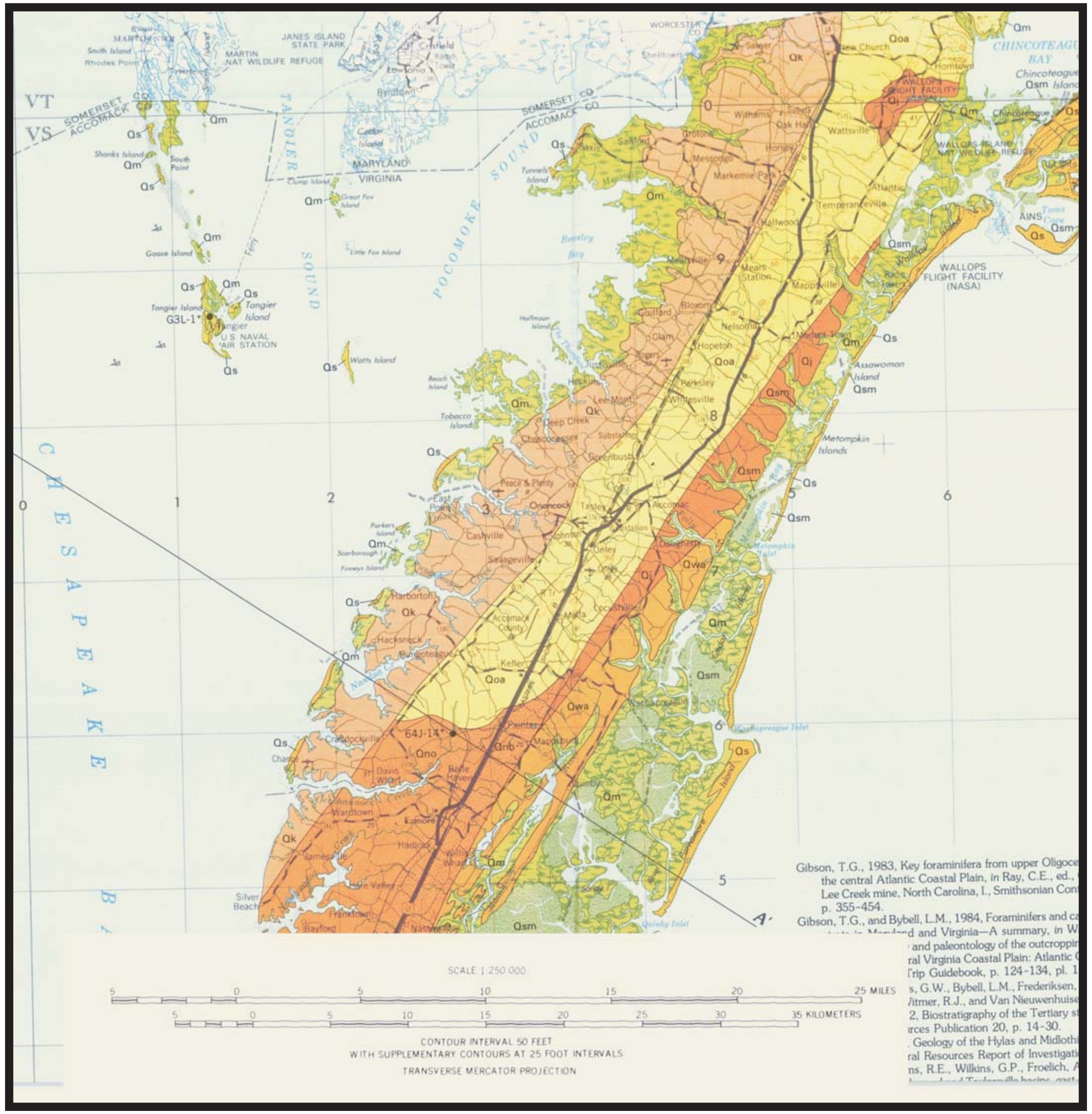

Figure 3. Geologic map of Accomack County (from Mixon *et al*., 1989).

Qs	Holocene Sand - Pale gray to light-yellowish gray, fine to coarse, poorly sorted to well sorted, shelly in part; contains angular to rounded fragments and whole valves of mollusks. Comprises deposits of coastal barrier islands and narrow beach-dune ridges bordering brackish-water marshes of Chesapeake Bay. As much as 40 ft in thickness.
Qm	Holocene Soft Mud - Medium to dark-gray, and peat, grayish brown. Comprises sediment of marshes in coastal areas and Chesapeake Bay. Thickness is 0-10 ft.
Qsm	Holocene sandy mud and muddy fine sand - Light- to dark-gray. Locally, Contains abundant shell material characterized by *Crassostrea virginica* and *Mercenaria mer*cenaria. Comprises sediments of shallow bays and tidal flats in area of coastal lagoons. Unit not mapped in Chesapeake Bay and Back Bay areas. Thickness is 0-30ft.
Qno	Occohannock Member - Light-yellowish-gray, fine to medium sand underlying southwest sloping terrace (alt. 30 - 18ft) on west side of upland. Sand is dominantly massive to horizontally bedded but shows some-scale crossbedding; locally, contains clay and silt as matrix and thin beds. Unit was deposited in a low-engery, open-bay environment. Thickness ranges from a featheredge near bay-facing scrap along western margin of upland to 20 ft in downdip areas. Near present bay.
Qnb	Bulter Bluff Member - Pale-gray to light-yellowish-gray, fine to coarse, crossbedded, pebbly sand and sandy Gravel comprising surficial deposits of upland (alt. 35-40 ft). Diverse molluscan assemblage in lower part Of the unit, including *Marginenlla, Mulinia, Nassarius, Spisula, Pleuromeris,* and *Olivella,* indicates a shallow, nearshore-shelf depositional environment. Unit was deposited as a southward-buliding complex if spit-platform sands and shallow shoals and is as much as 60 ft in thickness. In subsurface, unit overlies 140 ft, or more, of pebbly to cobbly sand, clay-silt, and muddy fine-grained sand of the Stumptown Member of the Nassawadox Formation, which fills a late Pleistocene paleochennel of the Susquehanna River system.
Qoa	Accomack Member of Omar Formation (middle Pleistocene) - Light- to dark-gray, light- yellowish -gray, Brownish-gray, and yellowish-orange sand gravel, silt, clay, and peat of southwest-tending central upland (alt. 38 - 50ft) in Accomack County. Upper part of unit is bounded on east and west by ocean- and bay-facing scraps; lower part present in subsurface of adjacent lowland areas where it is overlain unconformably by upper Pleistocene and Holocene deposits. In northern part of county, unit is barrier-backbarrier sequence of clean, crossbedded, gravelly sand (above) and peat, clayey silt, and muddy sand (below); mollusks include *Crassostrea, Merenaria,* and *Noetia.* In southern part of county, fine to coarse, trough-crossbedded sands of barrier-spit origin overlie fine to very fine, muddy, nearshore-shelf sand containing *Spisula, Ensis, Anomia,* and *Mulinia.* At base of unit, pebbly to bouldery, medium to very coarse sand and thick, compact clay-slits constitute the fluvial-estuarine fill of a paleochannel of the Susquehanna River system. Accomack Member and underlying channel fill are as
Qwa	Wachapreague Formation (upper Pleistocene) - Coarsening-upward sequence includes a lower member of clayey and silty, fine to very fine, gray sand interbedded with clay-silt and an upper member of medium to coarse, gravelly sand. Mollusks, including *Mesodesma arctatum and Siliqua costata,* and ostracode assemblages dominated by *Elofsonella concinna* and *Muellerina canadensis* indicate cooling ocean temperatures during deposition of the unit. Pollen assemblage dominated by pine, spruce, birch, and alder suggests cool- to cold-temperate conditions in near land areas. Unit is surficial deposit of narrow, accurate coastal lowland ranging in altitude from sea level, at eastern border with Holocene barrier-lagoon complex, to about 15 ft at toe of ocean-facing scrap forming western boundary. Thickness is 0 - 40 ft.
	Nassawadox Formation (upper Pleistocene) - Surficial sandy and gravelly deposits of narrow, flat upland and adjacent bay-side terrace in Northampton and southernmost Accomack Counties.
Qk	Kent Island Formation (upper Pleistocene) - Play gray to yellowish-gray, medium to coarse sand and sandy gravel grading upwards into poorly to well-sorted, fine to medium sand, in part clayey and silty. Unit is surficial deposit of broad, bayward-sloping lowland (altitude ranges from sea level to about 20 ft) bordering east side of Chesapeake Bay. Thickness ranges from a featheredge at scrap along eastern edge of lowland to about 40 ft in downdip areas.
Qj	Joynes Neck Sand (upper Pleistocene) - Yellowish-gray, fine to coarse sand coarsening downward to gravelly sand and sandy gravel. Cross- lamination in finer-grained sands accentuated by black, heavy minerals. Unit was deposited in nearshore- shelf depositional environment; constitutes surficial deposit of coast-parallel terrace (alt. 23-26 ft) on eastern side of upland in Accomack County. Thickness ranges from 0-30 ft.

B. Hydrodynamic Setting

Mean tide range along the Bay coast of Accomack is about 1.7 ft on the southern end of the county and increases to 2.3 ft on the northern end of the county. The wind/wave climate impacting the Accomack Bay coast is defined by large fetch exposures to the northwest and west across Chesapeake Bay. Wind data from Norfolk International Airport reflect the frequency and speeds of wind occurrences from 1960 to 1990 (Table 1) which characterize the locally-generated Bay waves.

Northeasters are particularly significant in terms of the impacts of storm surge and waves on beach and dune erosion. Often during the course of a storm, the wind shifts to the northwest greatly impacting the Eastern Shore. Hurricanes, depending on their proximity and path can also have an impact to the Accomack's coast. Hurricane Floyd in 1999, greatly impacted the Eastern Shore because winds came from the northwest for a significant period of time. Hurricane Isabel, which passed through Virginia on 18 September 2003, had little impact on the Eastern Shore because the main damaging winds began from the north and shifted to the east then south. Beach erosion and dune scarping were significant in other areas of the Bay, but, generally, areas with wide beaches offered more protection to the adjacent dunes.

Table 1. Summary wind conditions at Norfolk International Airport from 1960-1990.

		WIND DIRECTION								
Wind Speed (mph)	**Mid Range (mph)**	**South**	**South west**	**West**	**North west**	**North**	**North east**	**East**	**South east**	**Total**
< 5	3	5497* 2.12+	3316 1.28	2156 0.83	1221 0.47	35748 13.78	2050 0.79	3611 1.39	2995 1.15	56594 21.81
5-11	8	21083 8.13	15229 5.87	9260 3.57	6432 2.48	11019 4.25	13139 5.06	9957 3.84	9195 3.54	95314 36.74
11-21	16	14790 5.70	17834 6.87	10966 4.23	8404 3.24	21816 8.41	16736 6.45	5720 2.20	4306 1.66	100572 38.77
21-31	26	594 0.23	994 0.38	896 0.35	751 0.29	1941 0.75	1103 0.43	148 0.06	60 0.02	6487 2.5
31-41	36	25 0.01	73 0.03	46 0.02	25 0.01	162 0.06	101 0.04	10 0.00	8 0.00	450 0.17
41-51	46	0 0.00	0 0.00	0 0.00	1 0.00	4 0.00	4 0.00	1 0.00	0 0.00	10 0.00
Total		41989 16.19	37446 14.43	23324 8.99	16834 6.49	70690 27.25	33133 12.77	19447 7.50	16564 6.38	259427 100.00

*Number of occurrences +Percent

III. METHODS

A. Photo Rectification and Shoreline Digitizing

Recent and historic aerial photography was used to estimate, observe, and analyze past shoreline positions and trends involving shore evolution for Accomack. Some of the photographs were available in fully geographically referenced (georeferenced) digital form, but most were scanned and orthorectified for this project.

Aerial photos from VIMS Shoreline Studies and Submerged Aquatic Vegetation (SAV) Programs, as well as from United States Geological Survey (USGS) archives were acquired. The years used for the shoreline change analysis included 1938, 1955, 1979, 1994, and 2002. Color aerials were obtained for 1994 and 2002. The 1994 imagery was processed and mosaicked by USGS, while the imagery from 2002 was mosaicked by VIMS's SAV Program. The aerial photography for the remaining years were mosaicked by the VIMS Shoreline Study Program.

The images were scanned as tiffs at 600 dpi and converted to ERDAS IMAGINE (.img) format. They were orthorectified to a reference mosaic, the 1994 Digital Orthophoto Quarterquadrangles (DOQQ) from USGS. The original DOQQs were in MrSid format but were converted into .img format as well. ERDAS Orthobase image processing software was used to orthographically correct the individual flightlines using a bundle block solution. Camera lens calibration data was matched to the image location of fiducial points to define the interior camera model. Control points from 1994 USGS DOQQ images provide the exterior control, which is enhanced by a large number of image-matching tie points produced automatically by the software. A minimum of four ground control points were used per image, allowing two points per overlap area. The exterior and interior models were combined with a 30-meter resolution digital elevation model (DEM) from the USGS National Elevation Dataset (NED) to produce an orthophoto for each aerial photograph. The orthophotographs that cover each USGS 7.5 minute quadrangle area were adjusted to approximately uniform brightness and contrast and were mosaicked together using the ERDAS Imagine mosaic tool to produce a one-meter resolution mosaic also in an .img format.

To maintain an accurate match with the reference images, it was necessary to distribute the control points evenly. This can be challenging in areas with little development. Good examples of control points are permanent features such as manmade features and stable natural landmarks. The maximum root mean square (RMS) error allowed is 3 for each block.

Once the aerial photos were orthorectified and mosaicked, the shorelines were digitized in ArcMap with the mosaics in the background to help delineate and locate the shoreline. For Accomack's coast, an approximation to mean low water (MLW) was digitized. This is approximately the edge of the marsh or the "toe" of the beach. In areas where the shoreline was not clearly delineated on the aerial photography, the location was estimated based on the experience of the digitizer. Digitizing the shoreline brings in, perhaps, the greatest amount of potential error because of the problems of image clarity and definition of shore features. A series of Accomack dune site profiles are displayed in Figure 5 which shows beach/dune variability. Figure 6 shows the relationship of MHW, MLW and beach/dune system components.

B. Rate of Change Analysis

A custom Arcview extension called "shoreline" was used to analyze shoreline rate of change. A straight, approximately shore parallel baseline is drawn landward of the shoreline. The extension creates equally-spaced transects along the baseline and calculates distance from the baseline at that location to each year's shoreline. The output from the extension are perpendicular transects of a length and interval specified by the user. The extension provides the transect number, the distance from beginning baseline to each transect, and the distance from the baseline to each digitized shoreline in an attribute table. The attribute table is exported to a spreadsheet, and the distances of the digitized shoreline from the baseline are used to determine the rates of change. The rates of change are summarized as mean or average rates and standard deviations for each Plate.

It is very important to note that this extension is only useful on relatively straight shorelines. In areas that have unique shoreline morphology, such as creek mouths and spits, the data collected by this extension may not provide an accurate representation of true shoreline change. The shore change data was manually checked for accuracy. However, where the shoreline and baseline are not parallel, the rates may not give a true indication of the rate of shoreline change.

Figure 5. Variability of dune and beach profiles in Accomack

Figure 6. Typical profile of a Chesapeake Bay dune system

IV. RESULTS

The Plates referenced in the following sections are in Appendix A. Dune locations are shown on all photo dates for reference only. Dune sites and lengths are positioned accurately on the 2002 photo. Because of changes in coastal morphology, the actual dune site might not have existed earlier. Site information tables are in Appendix B. More detailed information about Chesapeake Bay dunes and individual dune sites in Accomack can be found in Hardaway *et al.* (2001) and Hardaway *et al.* (2004). Since much of the dune data were collected several years ago and the beach and dune systems may have changed, this report is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits. Only those areas that have dune sites are shown in Appendix A.

The Bay coast of Accomack County was divided into three reaches. Reach I includes the shoreline from Saxis southward to Island Bay and borders on Pocomoke Sound. Reach II extends from Big Marsh to Onanock Creek along Chesapeake Bay. A short break in shore discussion occurs between Onancock and Pungoteague Creek, and then Reach III goes from Pungoteague Creek to Occohannock Creek. The entire Bay coast is not discussed, just those areas with dune sites. Shore change analysis also is limited to those relatively straight shoreline segments beginning with Plate 9. Plates 1 through 8 are mostly broad marsh coasts which tend to be more resistant to wind/wave erosion than their upland counterparts and often exist as headland features.

A. Reach I

Reach I includes Plates 1 through 6. Dune site AC6 is found on Plate 1. The site evolved as a sand spit from Long Point which crossed a small bay and attached to the AC6 shore segment. It appeared more prominent in the 1994 imagery than the 2002 where it has become a more isolated feature. Dune site AC7 is the only dune of Plate 2. It developed in a small marsh embayment and may have been a dune as early as 1955.

Plate 3 has three dune sites, AC11, AC13, and AC14. Site AC11 is on Guilford Creek and has evolved between marsh headlands adjacent to Jobes Island. Sites AC13 and AC14 both lie in embayed coasts on the open bay. Plate 4 overlaps Plate 3 has three additional dune sites. Sites AC15 and AC16 occur on either side of a L-shaped spit in Bagwell Cove, did not appear until the 1994 imagery and currently seem to be in a state of decay. The long curvilinear embayed coast the provides a stable geomorphic foundation for AC17 which can be seen through time beginning in 1938.

Plate 5 has three dune sites between Jack’s Island and Sandy Point. Site AC18 appears to have existed in 1955 and may have even been longer. In 2002, it is reduced in length but relatively stable. Sites AC19 and AC20 are isolated remnants of a once more extensive spit feature that extends eastward from Sandy Point. Only one dune site occurs on Plate 6. Site AC22 did not exist in 1938, but by 1955, the spit from Halfmoon Island had connected to Webb Island, and sand moved into the AC22 bay where it developed into a dune field.

B. Reach II

Plate 7 begins the Reach II results with one small isolated dune site, AC25, which developed in a small cove on the Bay side of Big Marsh. Two dune sites are shown on Plate 8; both reside on Beach Island. Beach Island is a boomerang-shaped sand spit that has developed over time. Site AC27 lies on the northward facing prong and AC28 on the westward facing prong. Both sites are linear dune fields.

Four dune sites occur on Plate 9 where the broad marsh coast along Pocomoke Sound is beginning to narrow and the upland has a close proximity to the Bay. Dune sites AC32 and AC33 are basically one site divided by a small established housing development. Site AC35 is a small vegetated washover along the marshy coast while AC37 is an erosional remnent of a large spit feature seen in the earlier aerial imagery. The net average erosion rate along the coast from Chesconessex Creek and Back Creek is -1.4 ft/yr.

Dune site AC39 and AC41 occur on Plate 10. Site AC39 came into existence in 1979 and now resides as a small isolated pocket beach feature. Dune site AC41 is a dune field on the “lee” side of Ware Point along the Onancock Creek shore. The bay shoreline in Plate 10 has a net erosion rate of -5.3 ft/yr.

C. Reach III

Reach III is represented by the last five plates, 11, 12, 13, 14 and 15. Plate 11 has three dune sites along its coast. Sites AC49 and AC50 are isolated linear dunes on the coast between Bluff Point and Butcher Creek. Dune site AC51 is a dune field that has been in existence since 1938. Plate 12 shows two dune sites, AC57 and AC59 that have developed as isolated erosional remnants near Milby’s Point on the North end of Hyslop Marsh. The net shoreline recession rate along the reach is about -3.2 ft/yr.

The shoreline along the Bay side of Hyslop Marsh, Plate 13, is a long, relatively straight coast with extensive sandy washovers. Site AC61 is a long dune field that has been in existence since 1938 and has maintained itself as the shore has receded at about -2.3 ft/yr. Site AC62 has been part of Sandy Point as it has evolved over time and now is a curvilinear dune field. Plate 14 shows the northern half of Scarborough Neck with four dune sites. Site AC65 can be seen at the mouth of Bull Cove in 1955. As that inlet was closed by a migrating spit, a new inlet opened and AC66 came into being while AC65 now resides along the closed inlet. Dune sites AC67A and AC67B are two sections of a long dune field along the Bay coast of Scarborough Neck separated by a short reach non-dune shore. The net long-term erosion rate is about -2.0 ft/yr with some areas of significant recession particularly at Bull Cove and between stations 0 to 2500.

Plate 15 rounds out Reach III and the Accomack County Bay coast and shows the southern end of Scarborough Neck where three dune sites exist. Their present day positions were all well landward of the coast in 1938. A large spit covered the southern end of Scarborough Neck up through 1955. By 1979, AC68 was part of the retreating dune barrier which has decayed through time. In 2002, it was an small erosional remnant. After the spit breached, dune sites AC69A and AC69B formed in an embayment between a small creek and marsh headlands. What was originally one dune was divided in 2002 by a short area of no dune. Significant shore change has occurred over the years, but due to the complex trend, no baseline analyses were performed.

V. DISCUSSION: NEAR FUTURE TRENDS OF DUNE SITES

The following discussion is a delineation of shoreline trends based on past performance. Ongoing shore development, shore stabilization and/or beach fill, and storms will have local impacts on the near term. “Near Future” is quite subjective and only implies a reasonable expectation for a given shore reach to continue on its historic course for the next 10 to 20 years. In addition, the basis for the predictions are the shorelines digitized on geo-rectified aerial photography which have an error associated with them (see Methods, Section III). Each site’s long-term and recent stability as well as a near future prediction are shown in a table in Appendix B. **This data is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.**

A. Reach I

Site AC6 lies along a slowly moving coastal subreach and should be relatively stable in the near term. Dune site AC7 is in a small stable embayment. Site AC11 is on a mobile but relatively stable beach (Figure 7). AC13 is slightly erosional while AC14 resides in long-term stable pocket bay. Site AC15 is on a migrating (erosional) overwash while AC16 and AC17 will migrate landward but keep their overall morphology (Figure 7).

Dune site AC18 is on a long, linear stable coast while AC19 and AC20 are on mobile point and spit features. Dune AC22 presently lies in a stable embayed setting but will migrate as the adjacent marsh headlands erode.

B. Reach II

Dune site AC25 appears relatively stable while AC27 and AC28 are on a highly mobile Beach Island (Figure 8). Dunes sites AC32 and AC33 appear to be slightly erosional while AC35 is relatively stable (Figure 8). Site AC37 is in a transgressive/erosional setting as is AC39. Dune site AC41 appears to be in a slightly accretionary mode.

C. Reach III

Dunes sites AC49 and AC50 occur along erosional reaches while AC50 appears relatively stable for the near term (Figure 9). Dune sites AC57 and AC59 are on an erosion reach of marshy coast (Figure 9). Dune site AC61 is currently stable, and AC62 is experiencing an accretionary trend. Site AC65 has evolved into a relatively stable planform, and AC66 appears mobile and erosional at the mouth of a small creek. Dunes sites AC67A and AC67B exist as a long dune field that is intermittently erosional and stable. Dune site AC68 is slightly erosional. Sites AC69A and AC69B have developed into relatively stable pocket beaches (Figure 9).

Figure 7. Photos Reach I dune sites.

Figure 8 &8 photos

VI. SUMMARY

Shoreline change rates are based on aerial imagery taken at a particular point in time. We have attempted to portray the same shoreline feature for each date along the coast of Accomack County. Many plates did not have baselines, and therefore, shore change rates, because their marsh shoreline was too irregular. For those plates that did have baselines, the rate of change was calculated every 500 ft. The mean or average rate for each plate is shown in Table 2 for five time periods with the long-term rate determined between 1937 and 2002. The total average and standard deviation (Std Dev) for the entire data set of individual rates is also given. The standard deviation shows the relative spread of values about the mean or average. Larger standard deviation values relative to the mean indicates a wider scatter of erosion rates about the mean while lower standard deviation values indicates erosion rates are concentrated near the mean (*i.e.* all the rates calculated for the entire plate were similar).

Overall, the standard deviations are close to the average rate of change indicating that the shore change rates were relatively consistent for that time period. Plate 10 had the highest overall rate of change at -5.3 ft/yr. This section of shore has been highly erosive since 1955. Plates 9 and 11A had the lowest overall rates of change. However, for Plate 9 between 1979 and 1994, the standard deviation is much larger than the average rate of change indicating that the overall rate is probably not indicative of the change which occurred on this section of shore. When short time frames are used to determine rates of shoreline change, shore alterations may seem amplified. The rates based on short-time frames can modify the overall net rates of change.

The shore change patterns shown in this report along with the aerial imagery will indicate how the coast will evolve based on past trends and can be used to provide the basis for appropriate shoreline management plans and strategies. Dunes and beaches are a valuable resource that should be either maintained, enhanced or created in order to abate shoreline erosion and provide sandy habitat.

Table 2. Summary shoreline rates of change and their standard deviation for Accomack County.

	Plate 9		Plate 10		Plate 11A		Plate 11B		Plate 12		Plate 13		Plate 14	
Imagery Dates	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**	**Rate of Change (ft/yr)**	**Std. Dev.**
1938-1955	-2.0	1.8	-2.8	2.7	0.5	1.2	-4.8	7.5	-0.9	1.1	0.3	2.6	-3.1	3.5
1955-1979	-1.4	0.8	-6.5	2.4	-1.8	1.2	-5.4	5.5	-4.9	0.8	-5.1	4.2	-2.9	2.9
1979-1994	-0.1	1.0	-5.1	3.3	-2.5	1.2	-3.1	3.5	-4.3	7.2	-0.2	2.7	-1.8	3.3
1994-2002	-2.9	1.6	-6.5	4.7	-2.4	4.8	-2.1	3.5	-1.3	1.9	-3.3	4.5	-3.9	4.1
1938-2002	**-1.4**	**0.7**	**-5.3**	**1.1**	**-1.4**	**1.0**	**-4.3**	**4.1**	**-3.2**	**1.9**	**-2.3**	**1.5**	**-2.0**	**1.6**

VII. REFERENCES

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APPENDIX A

For each Plate shown on Figure 4, Appendix A contains orthorectified aerial photography flown in 1938, 1955, 1979, 1994, and 2002.
Also shown are the digitized shorelines, identified dune sites, and an arbitrarily created baseline.
A plot shows only the relative locations of the shorelines while another one depicts the rate of shore change between dates.
A summary of the average Plate rate of change in ft/yr as well as the standard deviation for each rate is also shown.

This data is intended as a resource for coastal zone managers and homeowners;
it is not intended for use in determining legal jurisdictional limits.

Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Plate 6
Plate 7
Plate 8
Plate 9
Plate 10
Plate 11
Plate 12
Plate 13
Plate 14
Plate 15

APPENDIX B

The data shown in the following tables were primarily collected as part of the Chesapeake Bay Dune: Evolution and Status report and presented in Hardaway *et al.* (2001) and Hardaway *et al.* (2004). Individual site characteristics may now be different due to natural or man-induced shoreline change.

An additional table presents the results of this analysis and describes each dune site's relative long-term, recent, and near-future predicted stability. This data results from the position of the digitized shorelines which have an error associated with them (see Methods, Section III).

Since much of the dune data were collected several years ago and the beach and dune systems may have changed, this report is intended as a resource for coastal zone managers and homeowners; it is not intended for use in determining legal jurisdictional limits.