

TYPES AND CAUSES OF BEACH EROSION ANOMALY AREAS IN THE U.S. EAST COAST BARRIER ISLAND SYSTEM: STABILIZED TIDAL INLETS

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ABSTRACT: *Contemporary research suggests that most U.S. beaches are eroding, and this has become an important political and economic issue because beachfront development is increasingly at risk. In fact, the Heinz Center and Federal Emergency Management Agency (FEMA) estimate that over the next 60 years, beach erosion may claim one out of four homes within 150 meters of the U.S. shoreline. This is significant because approximately 350,000 structures are located within 150 meters of the shoreline in the lower 48 states, not including densely populated coastal cities such as New York and Miami. Along the East Coast, most beaches are eroding at 1 to 1.5 meters per year. However, beach erosion is especially problematic along so-called beach erosion anomaly areas (EAAs) where erosion rates can be as much as five times the rate along adjacent beaches. Identifying and understanding these places is important because property values along U.S. East Coast barrier islands are estimated to be in the trillions of dollars, and the resultant beach erosion may also destroy irreplaceable habitat. There are a number of factors—natural and anthropogenic—that cause beaches to erode at anomalous rates. This paper will focus on the barrier island system of the U.S. East Coast, classify beach EAAs, and examine beach erosion down drift from stabilized tidal inlets because they are perhaps the most spatially extensive and destructive EAAs.*

Keywords: *Beach erosion, Beach erosion anomaly areas, Hot spot erosion, Tidal inlets*

INTRODUCTION

Beach erosion is a pervasive problem within the U.S. coastal zone, and most of the barrier islands along the U.S. East Coast are experiencing significant levels of erosion (Williams et al., 1994; Dean, 1999; Heinz Center, 2000; NOAA, 2007). Beach erosion is problematical along discrete geomorphic units where recession rates are typically more than double that of adjacent segments of shoreline. These erosion anomaly areas (EAAs), or so-called “hot-spots,” magnify the problem and cause significant loss of property and coastal habitat. Identifying and understanding EAAs is important because property values along the barrier islands of the U.S. East Coast are estimated to be in the trillions of dollars and development and population growth in the coastal zone is higher than other areas of the country (Department of Commerce, 1990; Heinz Center, 2000). There are a number of factors—natural and anthropogenic—that cause beaches to erode at anomalous rates. This paper proposes a classification of beach EAAs and will focus on EAAs associated

with stabilized tidal inlets. Beach erosion down drift from stabilized tidal inlets is perhaps the most spatially extensive and destructive EAA (Galgano, 1998; Kraus and Galgano, 2001; Hanson and Kraus, 2001).

Beach erosion is a complex physical process encompassing a number of natural and anthropogenic factors. Natural conditions include sea-level rise, as well as tidal variations, sediment supply, antecedent geology, seasonal variations in wave energy, the frequency and intensity of coastal storms, and naturally existing tidal inlets (National Research Council, 1990; Brunn, 1995; Galgano, 1998; Leatherman et al., 2000; Leatherman et al., 2001). Humans also influence the spatial and temporal variability of beach erosion by building shoreline structures, dredging inlets, damming rivers, and undertaking beach nourishment projects (Heinz Center, 2000). Quantifying and understanding the types and causes of beach EAAs are important because beach erosion, compounded by large coastal storms, has devastated many coastal communities causing the loss of property measured in the billions of dollars (Dean, 1999; Raloff, 2005). In fact, beach

erosion was the salient issue in at least 25 federal disaster declarations between 1980 and 2000. Furthermore, 76 storm-related federal disaster declarations contained provisions for mitigating the effects of beach erosion during the decade of the '90s (Dean, 1999; Loughheed, 2006). The Heinz Center (2000) and Federal Emergency Management Agency (FEMA) estimate that over the next 60 years, beach erosion may claim one out of four homes within 150 meters of the U.S. shoreline. This equates to approximately 350,000 structures in the lower 48 states, not including densely populated coastal cities such as New York and Miami. Nevertheless, beachfront property remains some of the most desirable and costly real estate in the U.S. With property values estimated at over \$3 trillion for the East Coast, a number of investigations have been conducted to study coastal evolution and the magnitude of beach erosion in order to formulate land-use policies, because public financial support of beach restoration is approaching economically and politically insupportable levels (Dean, 1999; Leatherman et al., 2001; Raloff, 2005). Avoiding larger losses in the future demands more effective coastal zone management policies and a better understanding of how EAAs operate in time and space.

BEACH EROSION ANOMALY AREAS

Beaches are dynamic geomorphic features and changes in planform are typically equilibrium responses to geomorphic processes. Therefore, accretion at one beach is often balanced by erosion at another. Thus, beach erosion is a naturally occurring process, which is typically viewed as a problem when human development in the coastal zone is at risk. In the Continental United States, this risk is extensive and growing as population and development along the coast increases (Smith, 1998; Dean, 1999). A number of studies have attempted to delineate this risk. The National Shoreline Study (U.S. Army Corps of Engineers, 1971) found that 42% of the U.S. coast (less Alaska) is experiencing significant erosion. Williams et al. (1994) indicate that nearly 75% of U.S. beaches are "severely" or "moderately" eroding. Galgano (1998) demonstrated that along the barrier islands of the East Coast, 86% of the beaches are eroding; and that 70% of that erosion was caused by tidal inlets.

Coastal erosion is not typically considered an imminent threat to public safety, except when associated with a major storm. Nonetheless,

eventually beach erosion threatens and ultimately damages infrastructure and habitat. Erosion-related damage in the coastal zone characteristically results from a combination of long-term beach erosion (e.g., background rate), punctuated by episodic, high-energy events such as a hurricane or nor'easter. Damage from erosion is exacerbated when beaches erode at anomalous rates. Consequently, an understanding of causes and types is essential to recognize and mitigate their effects (Stauble and Gravens, 2004).

Since the early 1990s, a number of researchers have studied the existence of EAAs, and more than a dozen possible causes have been identified (Kraus and Galgano, 2001). In most cases, existing classification systems tend to focus on EAAs that result from beach nourishment projects (Stauble and Gravens, 2004; NOAA, 2007). However, the most spatially extensive, temporally persistent, and destructive EAAs are those result from natural causes, especially the downdrift effects of tidal inlets (Galgano, 1998; Smith, 1998; Hanson and Kraus, 2001). Regardless of the cause, insight to underlying coastal processes and their relationship to human activity are essential to understanding EAAs (Komar, 1998).

What are Erosion Anomaly Areas?

Beach EAAs are essentially segments of a beach that erode at substantially higher rates than adjacent areas (Figure 1). The proliferation of beach nourishment projects in the early 1990s generated the first broad appreciation and systematic examination of EAAs (Stauble and Kraus, 1993; Smith, 1998; Kraus and Galgano, 2001). These engineering studies, along with the examination of large-scale coastal behavior (e.g., Terwindt and Wijnberg, 1991; Leatherman, 1993), demonstrated consistently that some areas along the U.S. East Coast are especially prone to elevated rates of erosion. The term "hot spot" was first adopted in the literature in an engineering context to describe discrete segments of beach nourishment projects that were not performing to design specifications. For example Stauble (1993), Stauble and Kraus (1993), and Stauble et al. (1993) employ the term "hot spot" in conjunction with their examination of the performance of the Ocean City, Maryland Beach Nourishment Project. Other examples include Ulrich et al. (1993) who used the term "hot spot" to describe anomalous beach erosion in Pensacola, Florida and Bridges (1995) to describe beach nourishment projects in Florida.

Thus, early definitions of EAAs or so-called "hot spots" (e.g., Bridges, 1995; Dean et al., 1999) were intended to delineate erosional phenomena that

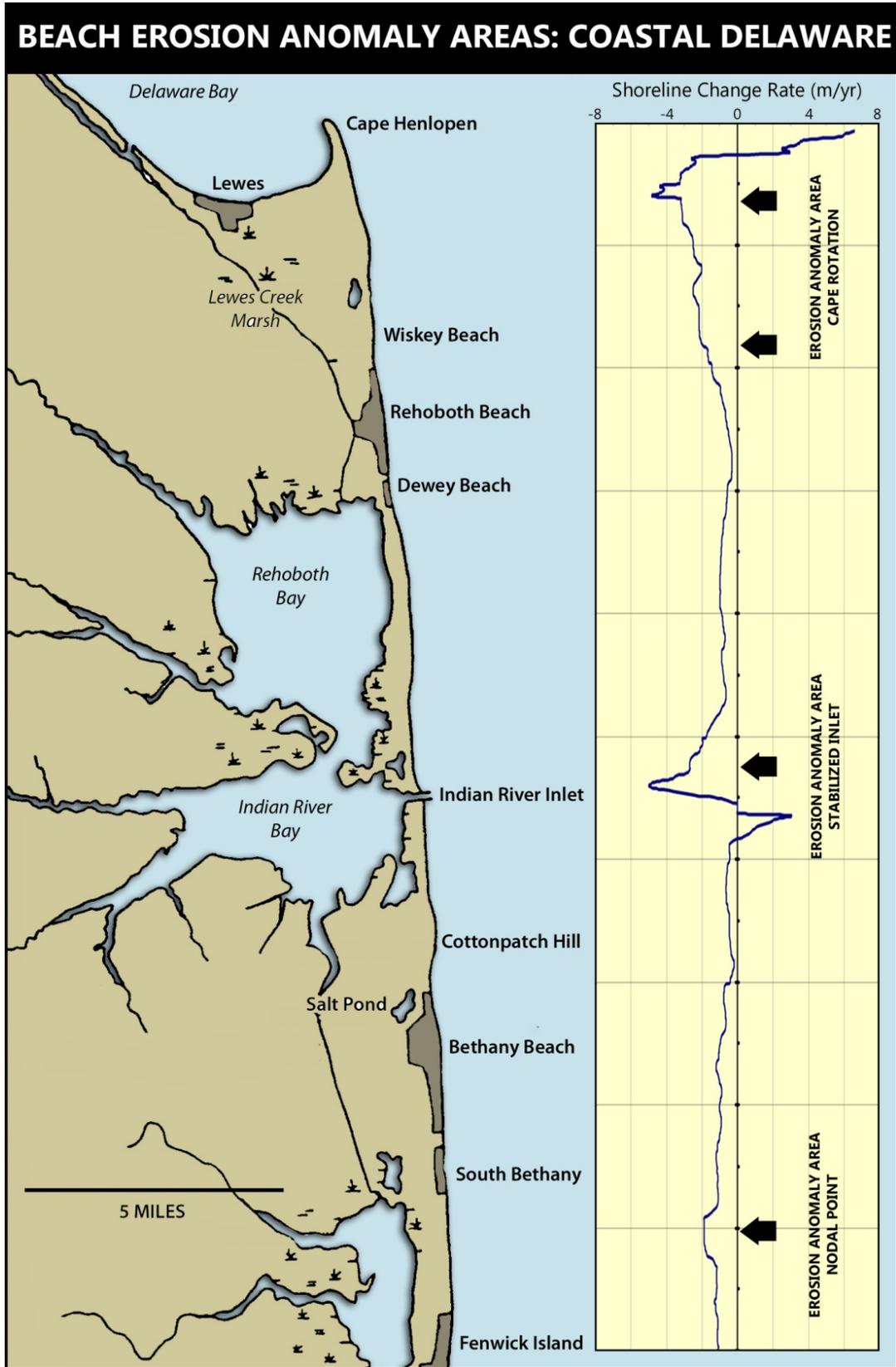


Figure 1. Beach erosion anomaly areas in Delaware. The data indicate that there are three types along this shoreline: cape rotation, stabilized inlet arc of erosion, and a nodal point. (After Galgano, 1998).

were unexpected and predominantly local (e.g., a well-defined and spatially limited area of a beach nourishment project) and the definitions are all similar: that is they address elevated rates of erosion above what was predicted as part of the project design. Similar definitions are given in Stauble (1993), Stauble and Kraus (1993), Ulrich et al. (1993), Bridges (1995), Dean et al. (1999), Bodge et al. (1999), Hanson and Kraus (2001), and Stauble and Gravens (2004). However, these definitions seldom quantify the term “higher erosion rates,” and they focus on small spatial areas of erosion that persist for short temporal spans (Smith, 1998).

During the past several years, the study of EAAs has begun to focus on larger areas of persistent anomalous erosion (as opposed to localized, isolated areas of short duration) and they include a geomorphic context to define natural mechanisms or causes. Kraus and Galgano (2001) examined traditional “hot spots” but expanded their classification scheme to include many geomorphic process-response models. Smith (1998) recognized the inadequacy of the term “hot spot” and coined the term “beach erosion anomaly areas.” Additionally, Smith (1998) attempted to quantify EAAs by stating that they are segments of beach greater than 1,000 meters in length that erode at a rate exceeding 1.3 m/yr. Smith’s (1998) definition is based on a presumed mean rate of erosion of 0.63 m/yr for the East Coast barrier island system published by Galgano (1998). The drawback to this definition is that it assumes consistent behavior between geomorphic units within coastal compartments. Although Galgano (1998) published an “average erosion rate” for the East Coast, his research also demonstrated that the long-term behavior of discrete geomorphic units have to be studied separately and warned against consolidating erosion data for large geographic areas. Thus, for this paper, EAAs are defined as discrete segments of the beach (>250 meters) that are eroding at a rate at least twice that of the long-term average for adjacent beaches within the same geomorphic unit.

Classifying Erosion Anomaly Areas

The literature contains no studies that address universal causes for EAAs. Most publications address types and causes gathered empirically, addressing examples on a case-by-case basis. Many researchers have examined beaches with exceedingly high erosion rates (e.g., Belknap and Kraft, 1985; Riggs et al., 1995; Basco et al., 1998; Demarest and Leatherman, 1985; Kana, 1995), but, situations are examined without an overarching framework. Perhaps the first attempt to classify

EAAs was published by Bridges (1995), which suggested that there are eight types. Bridges’ (1995) classification focused on beach nourishment projects and the characteristics of beach fill and profile adjustments. Dean et al. (1999) expanded Bridges’ (1995) classification to 12 types, by adding effects of offshore bathymetry and wave characteristics. The principal shortcomings of both classifications are that the effects discussed are highly localized, they lack a discussion of the duration and spatial scale, they offer very little discussion of geomorphic process-response, and they are essentially focused only on beach fill projects. Bridges (1995) and Dean et al. (1999) were expanded to 18 types by Kraus and Galgano (2001), but their classification added explanations for temporal and spatial scales and addressed geomorphic process-response models, not just beach fill anomalies. Nonetheless, Kraus and Galgano (2001), like previous attempts, addressed numerous discrete types, and failed to provide an overarching framework. Smith (1998) recognized the need to add a framework to classification of EAAs rather than expand the classification to accommodate each discrete example observed. Hence, Smith (1998) suggested a classification system with four major categories: coastal framework, sediment supply, wave energy, and subsidence.

The classification system offered in this paper proposes a more generic taxonomy, based on the general characteristics of East Coast barrier island EAAs and their genetic properties (e.g., origin and development rather than empirical observation). This classification system is summarized in Table 1. General characteristics of EAAs include duration and spatial scale, as well as natural or anthropogenic origin. Genetic properties are focused on three generic modes applicable to the East Coast and a limited number of sub-classifications (Smith, 1998; Kraus and Galgano, 2001). While this classification system includes discrete sub-types, it is important to comment that a location may be influenced by two or more factors: for example, an EAA may be caused by wave refraction and the influence of a tidal inlet.

Coastal configuration is the large-scale geomorphic arrangement of landforms initiated by geomorphic conditions. This factor includes the area’s antecedent geology, compartmentalization of the coast, and cape evolution. It is generally accepted that there is regional geographic diversity in coastal landforms, and this variety is a result of the differences and combined effects of coastal processes: shoreline change and coastal configuration are the integrative result (Leatherman, 1993). A “mode” of shoreline behavior is defined as a discrete pattern of shoreline movement identified through a

Table 1. Proposed Erosion Anomaly Area Classification¹

Genetic Type	Example Location	Duration	Spatial Scale	Source
Coastal Configuration				
Antecedent Geology	S. Bethany, Delaware	Millennia	Small ² -Medium ³	Natural
Coastal Compartments	Virginia Barrier Islands	Millennia	Large ⁴	Natural
Cape Evolution	Henlopen, Delaware	Centuries	Small-Medium	Natural
Sediment Supply				
Shoreline Structures	N. Assateague Island	Decadal	Small	Anthropogenic
Stabilized Tidal Inlets	Moriches Inlet, N.Y.	Decadal	Small	Anthropogenic
Natural Tidal Inlets	Oak Beach, N.Y.	Centuries	Small	Natural
Nodal Points	S. Bethany, Delaware	Millennia	Small-Medium	Natural
Sand Waves	Long Island	Decadal	Small	Natural
Wave Refraction				
Offshore Shoals	S. Bethany, Delaware	Centuries	Small	Natural
Mesotidal Barriers	VA Barrier Islands	Decadal	Medium	Natural
Shoreface Slope	Sandbridge, Virginia	Centuries	Small	Natural

¹ After Smith (1998) and Kraus and Galgano (2001)

² Small: smaller than the geomorphic unit (e.g., 250m -2 km)

³ Medium: incorporates nearly all of the geomorphic unit (2-25 km)

⁴ Large: larger than the geomorphic unit, may include coastal compartment (25-100+ km)

recognition of a unique change in shape, a rate of movement, or a cycle of change: in this case EAAs.

Antecedent geology (Table 1) plays a key role in controlling coastal configuration, modes of shoreline behavior, and thus EAAs. In this situation sea-level rise and shoreline transgression intersects the pre-Holocene geology. Thus, antecedent geology may influence many aspect of coastal morphology, but it typically manifests EAAs by two means: (1) dissected, pre-Holocene drainage valleys that are intersected by sea-level rise (e.g., Belknap and Kraft, 1985); and (2) the exposure of erodible fine-grained material on the shoreface (e.g., Demarest and Leatherman, 1985). Coastal compartmentalization

contributes to the formation of EAAs in a number of ways, but particularly by the absence of a suitable sediment supply (e.g., headland), which subsequently causes sediment starvation downdrift. Finally, capes are large complex features (tens of kilometers) that extend into the ocean (Figure 1), and exhibit a distinct behavior that includes considerable erosion on one flank and accretion and migration of the beach on the opposite side—the result is a distinctive rotation of the landform through time (Galgano, 1998).

Beaches erode and accrete based on the balance between sea level rise, wave energy, geological structure, and sediment supply (Table 1). Excluding human intervention, sediment supply is the

key variable because the others remain unchanged, or change at a steady rate over long periods. Consequently, short-term (e.g., decadal time frames) deficits in sediment supply along a segment of beach can generate elevated rates of erosion and perhaps cause an EAA. Possibly the most pervasive alteration of the sediment supply along the East Coast is the presence of shoreline structures. When humans emplace groins, jetties and breakwaters, they typically adversely affect the downdrift characteristics of the littoral system and the beach responds to the sediment deficit with higher rates of erosion (National Research Council, 1990). A classic example is the eastern segment of Westhampton Beach, New York, which was nearly destroyed by sediment starvation from a groin field that was emplaced updrift during the 1960s (Black, 1989). By 1993, the barrier lost much of its elevation and the combination of erosion and storm waves destroyed the community and caused a breach in the barrier island.

Perhaps the most dramatic examples of EAAs generated by shoreline structures are tidal inlets stabilized by jetties. Current research suggests that tidal inlets in general, but stabilized inlets specifically, are responsible for much of the beach erosion along the U.S. East Coast (Walton, 1978; Dean, 1996; Galgano, 1998; Hanson and Kraus, 2001). The literature indicates that beaches located directly downdrift experience significant erosion and can be termed broadly as EAAs (e.g., Leatherman et al., 1987; Dean and Work, 1993; Douglas and Walther, 1994; Bruun, 1995; Fenster and Dolan, 1994; Mehta, 1996). These regional EAAs, which typically measure 10-20 km in length, are not limited to stabilized inlets (Galgano, 1998). Unstabilized tidal inlets have a demonstrated capacity to generate persistent EAAs as well because littoral processes there are the most dynamic and complex element of the barrier island system. The tidal jet produced by an unstabilized inlet can disrupt the flow of littoral sand and modify the coastal configuration for tens of kilometers. Consequently, unstabilized inlets can cause EAAs that extend some 30-40 km downdrift. Chincoteague Inlet at the southern terminus of Assateague Island is one such example. Shoreline recession rates of more than 10 m/yr are observed for tens of kilometers to the south. The net result is a highly concave shoreline extending 35 km south of the inlet (Finkelstein, 1983; Galgano, 1998).

Nodal points are areas of divergent longshore sediment transport caused by wave refraction patterns. Consequently net longshore sediment transport at a nodal point is essentially non-existent, and the location erodes at substantially higher rates than adjacent beaches (Oertel and Kraft,

1994). There is a persistent nodal point opposite South Bethany, Delaware (Figure 1) and this location has been an area of persistent erosion (Dalrymple and Mann, 1985). Similarly, the nodal point at Sandbridge, Virginia contributes to erosion in the range of 1.5-2.5 m/yr higher than adjacent beaches (Galgano, 1998).

Thevenot and Kraus (1995) demonstrated the existence and longevity of longshore sand waves at Southampton Beach, New York as well as other locations along the East Coast. These are large morphologic features (e.g., 750 x 40 meters) created by the episodic opening and closing of inlets. These sand waves maintain their morphologic integrity through time while moving along the shore; however, as they pass a location, there are high rates of erosion that persist for a period of years. This is an example of a geomorphic process-response model that generates an EAA that persists for a short temporal span (e.g., 5-10 years) as the feature migrates downdrift.

Wave refraction or the focusing of wave energy on a discrete segment of the shoreline is a process-response mechanism that can produce an EAA, which can persist for a period of decades or longer. Wave refraction from offshore finger shoals produce zones of concentrated wave energy and contribute to the formation of an EAA. Moody (1964) demonstrated how finger shoals off the Delaware coast focused energy and created higher rates of erosion. Galgano (1998) demonstrated how these locations not only eroded at higher rates, but were clearly more susceptible to inlet breaching. Mesotidal inlets generate EAAs downdrift because of wave refraction around their large ebb-tidal deltas. The delta "shadows" the shoreline opposite causing rapid accretion and a distinctly bulbous shape, however, concentration of wave energy downdrift from the inlet generates an EAA with significant rates of erosion, thus forming the slender distal end of the island (Hayes, 1979; Smith, 1998). Finally, very steep shoreface slopes contribute to the generation of EAAs because onshore wave energy is increased (Roy et al., 1994). On steeper slopes, higher energy conditions cause the offshore movement of sand-sized sediment, which is typically lost to the littoral system. The net result is a reduction of the shore profile and accelerated rates of erosion as is exhibited in Sandbridge, Virginia and Nags Head, North Carolina (Smith, 1998). Each of these examples illustrates natural process-response models that generate EAAs that persist over diverse spatial and temporal scales.

EROSION ANOMALY CASE STUDY: OCEAN CITY INLET, MARYLAND

Stabilized tidal inlets are responsible for much of the beach erosion along the U.S. East Coast and have generated some of the most problematic and damaging EAAs (Walton, 1978; Dean, 1996; Galgano, 1998; Hanson and Kraus, 2001). Dean and Walton (1975) indicated that tidal inlets represented the largest sediment sink of beach sand along the coast, and are believed to be responsible for much of the beach erosion in Florida. Dean (1991) has shown that inlets are responsible for 80-85% of the beach erosion in Florida due to the modification of longshore transport and sand storage in flood and ebb shoals. Galgano (1998) demonstrated that nearly 70% of the erosion along the barrier islands of the East Coast is caused by tidal inlets.

The Ocean City Inlet jetties impact on the evolution of northern Assateague Island is one of the most significant examples of the modification of adjacent shorelines by a stabilized tidal inlet (Figure 2). Since the stabilization of Ocean City Inlet in 1934, the northern segment of Assateague Island has been offset by three island widths driven by erosion rates that approach 10 m/yr within the arc of erosion (Galgano, 1998). This portion of the island is subject to frequent overwash and is vulnerable to being breached by a major storm event. If left unchecked, the erosion of northern Assateague Island may cause it to merge with the mainland shoreline within the next 10-15 years (Leatherman et al., 1987). The rapid erosion and possible dissolution of northern Assateague Island represents an important problem for coastal managers typical of EAAs.

Long-term shoreline change rates were obtained from the analysis of shoreline change maps and transect measurements developed by Galgano (1998). Ocean City Inlet opened by bay-side breaching during a large hurricane in August 1933. The inlet was stabilized by the Corps of Engineers with two stone rubble and concrete jetties in 1934 and 1935). Net longshore sediment transport is to the south and the sediment volume is estimated at 153,000 m³/yr (Leatherman, et al., 1987). A shoreline change map of Ocean City Inlet is given in Figure 3. The map clearly illustrates the inlet-induced modification of the adjacent shorelines since inlet stabilization. Downtide erosion has been severe south of the inlet. Prior to the existence of the inlet, the historic background trend was -0.60 m/yr. After the inlet was stabilized, rates of erosion accelerated to -9.30 m/yr along the beach just south of the inlet causing the northern segment of Assateague Island to

displace landward by nearly three barrier island widths.

This type of EAA demonstrates their dramatic influence on the long-term evolution of a barrier island. In a natural system, it is generally accepted that the long-term evolution of a barrier island will follow a general model of landward migration through time. In this scenario, the entire system (e.g., barrier island, bay, and mainland shoreline) will migrate as a geomorphic unit and retain the same general configuration. Ocean City Inlet provides an example where the system has been altered to the extent that large-scale evolution of a coastal unit is fundamentally changed. The jetties clearly had a rapid and pronounced influence on the morphology of northern Assateague Island. They interrupted a longshore sediment flow of 153,000 m³/yr, and the ebb-tidal delta captured an estimated 6,000,000 m³ of sediment, thus completely depriving the downdrift beaches of sand, creating an arc of erosion that extends some 16 km downdrift (Galgano, 1998).

Leatherman (1984) indicates that the implications of this dramatic increase in erosion will have important consequences on the long-term evolution of northern Assateague Island. The northern segment of the island will not migrate landward as an entity as some predict in accordance with accepted models of shoreline behavior. If sea level alone were the driving influence behind this migration, this assumption would be essentially correct, but sea-level rise represents only a small portion of the erosional potential and the bay is shrinking in width over time. The accelerated movement of northern Assateague Island has resulted in a washover flat at the expense of dunes and other coastal environments. Leatherman (1984) theorized that the result will be a loss of a section of the barrier island with the opening of the mainland to ocean waves in the near future, similar to what occurred at Nauset Beach, Chatham, Massachusetts. Galgano (1998) modeled the erosion of northern Assateague Island to quantitatively determine its future movement, and demonstrated that the arc of erosion will continue to migrate southward through time (Figure 3). The northernmost 16 kilometers of the island currently represents the arc of erosion, however, there is no terminal end to this arc in a temporal sense. In other words the arc of erosion will continue to migrate southward through time. Further, the area of maximum erosion will migrate downdrift so that the erosion rate will represent a non-steady-state condition. Galgano (1998) and Leatherman et al. (1987) propose that, because of the island's low elevation and narrow width, a future storm event would cause inlet breaching by the year 2020 with



Figure 2. Image of Ocean City Inlet, Maryland illustrating the influence of an EAA on the coastal configuration of Assateague Island. The inlet and jetties have caused a clear offset of the two islands, which before 1934, were one. The elevated rates of erosion south of the inlet caused the development of a 16 km-long arc of erosion and have displaced the northern end of Assateague Island landward by three island widths (After Galgano, 1998).

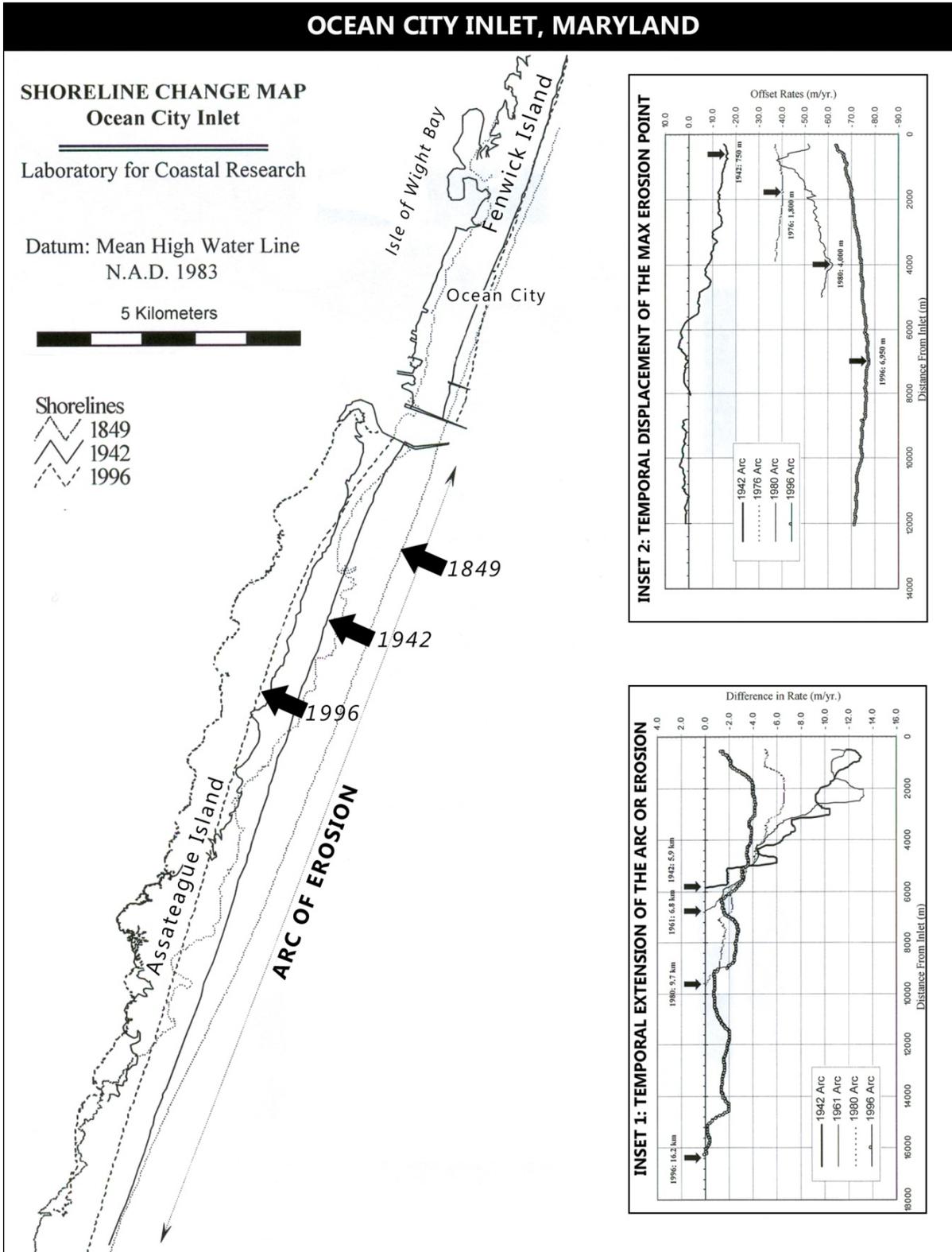


Figure 3. Shoreline change map of Fenwick and Assateague Islands. The map demonstrates that the northern segment of Assateague Island has migrated landward by three island widths. Inset 1 illustrates the temporal expansion of the arc of erosion, which was 16 km long by 1996. Inset 2 demonstrates how the point of maximum erosion moves down drift over time.

loss of the northern portion of the island as the sand is welded onto the mainland.

SUMMARY AND CONCLUSION

Research into the dynamics and long term behavior of coastal environments has demonstrated that selected areas along U.S. beaches are more prone to erosion. Many of these places are eroding at rates that exceed recession on adjacent beaches by at least a factor of two. These EAAs are problematical because they threaten coastal development and habitat. Many areas are eroding at extremely high rates and extend for many kilometers along the shoreline. Assuming that accelerated sea-level rise and global warming scenarios prove correct, beach erosion problems will be exacerbated.

The Ocean City Inlet case study demonstrates just how problematical an erosion anomaly area can become. Since the emplacement of the jetties in 1934, the northern segment of Assateague Island has migrated landward about three island widths. A relatively stable landform that was eroding at background rate of -0.62 m/yr before the opening of the inlet was transformed by erosion rates that approached -10 m/yr, and the integrity of the island is now threatened. The dune fields in the northern segment of the island are gone along with irreplaceable habitat, and the dissolution of the island will threaten the mainland beach across the bay. Ocean City Inlet is a good case study because it is so dramatic, however, other stabilized inlets—there are 22 in the mid-Atlantic region alone—are experiencing anomalous erosion as well.

There are many types of EAAs that threaten coastal communities and habitat, and it would be difficult to examine each one in a single paper. The cause and effect relationships between inlets and anomalous beach erosion are relatively well understood. However, there is a paucity of adequate process-response modeling for other, equally problematical anomaly areas, and these too, need to be defined. Nevertheless, a classification system that provides a broad geomorphic framework is an important first step. Early attempts at classification were focused almost exclusively on “hot spot” erosion along beach nourishment projects. This research was important to solving problems where nourishment projects did not perform as designed. However, the areas studied were relatively small in size and persisted for only short periods of time. Furthermore, the classification schemes were

essentially empirically determined as opposed to ones that were based on a universal framework.

This paper proposed a classification scheme for the barrier island coastline of the Eastern U.S., and defined an erosion anomaly area as a segment of beach that is eroding at least two times the rate of adjacent beaches within the same geomorphic unit. Rather than apply a “magic number” to quantify an erosion anomaly area, I instead referenced the rate relative to the long term behavior of the geomorphic unit. Classifying and understanding EAAs is important because it is not economically or politically feasible that we will abandon coastal development. Hence, we need a practical understanding of what causes anomalous erosion so that we can put into place reasonable development and re-development practices. Clearly more research is required with respect to this proposed classification scheme. Additionally, it should be developed to encompass all of the U.S. coast.

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