Historic Shoreline Changes in Southwest Florida

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1) This paper was published in Coastal Zone '89, the Proceedings of the Sixth Symposium on Coastal and Ocean Management, 1989, Vol. 5, pp. 4420-4433, published by the American Society of Civil Engineers, N.Y., USA. Permission to place this copy on the FDEP/BBCS WEB site was granted by ASCE in January 1997.

2) The agency name is now the Florida Department of Environmental Protection, Office of Beaches and Coastal Systems. The author's e-mail address is as follows : Emmett.Foster@dep.state.fl.us (as of jan. 2000).

3) The opinions expressed in this paper are those of the authors and do not necessarily reflect those of the FDEP.

4) The conditions in this area have not remained static. In particular, there have been major renourishment projects on

Anna Maria Key, Longboat Key, Venice, and possibly Lido Key. A smaller renourishment project occurred on Knight Island in Charlotte County, in the erosion pocket south of the Stump Pass ebb shoals. Several groinfields on Anna Maria Key and Longboat Key were removed prior to the filling. Erosion has spread southward in the pocket beach south of Point of Rocks, in Sarasota County.

4) The figures for the ASCII text version have been enclosed in the zipped total file as separate bitmap files, which can be viewed and printed via many software products, e.g., Wordperfect, Adobe, etc. The intent was to produce a document for general informational purposes which can be read independent of any particular software.

Abstract

An overview of the results of an analysis of historic shoreline changes in three adjacent southwest Florida coastal counties is presented. The data set includes historic coastal survey maps and Florida Department of Natural

Resources beach profile surveys. One of the more interesting findings is that the shoreline configuration in the central part of this region is strongly influenced by the nearshore and underlying limestone topography. The areas of concern from an erosion viewpoint are those locations where there is a deficit of sand supply in a wave climate of net southerly sand transport. In many areas, structures were simply built too close to the beach to allow for normal beach width fluctuations or gradual shoreline evolution. Effective beach management plans will depend upon a basic understanding of the coastal processes as developed in these studies.

Introduction

The subject area encompasses three adjacent southwest Florida counties bordering the Gulf of Mexico. Figure 1 shows the coast of Manatee County, consisting of Anna Maria Key and the north portion of Longboat Key. Figure 2 shows the coast of Sarasota County, which includes the southern part of Longboat Key, all of Lido Key, Siesta Key, Casey Key, the Venice area, and most of Manasota Key. Coastal Charlotte County is shown in Figure 3 and consists of the southern end of Manasota Key, Knight Island, and the northern portion of Gasparilla Island. The sands along this semi-tropical coast generally consist of

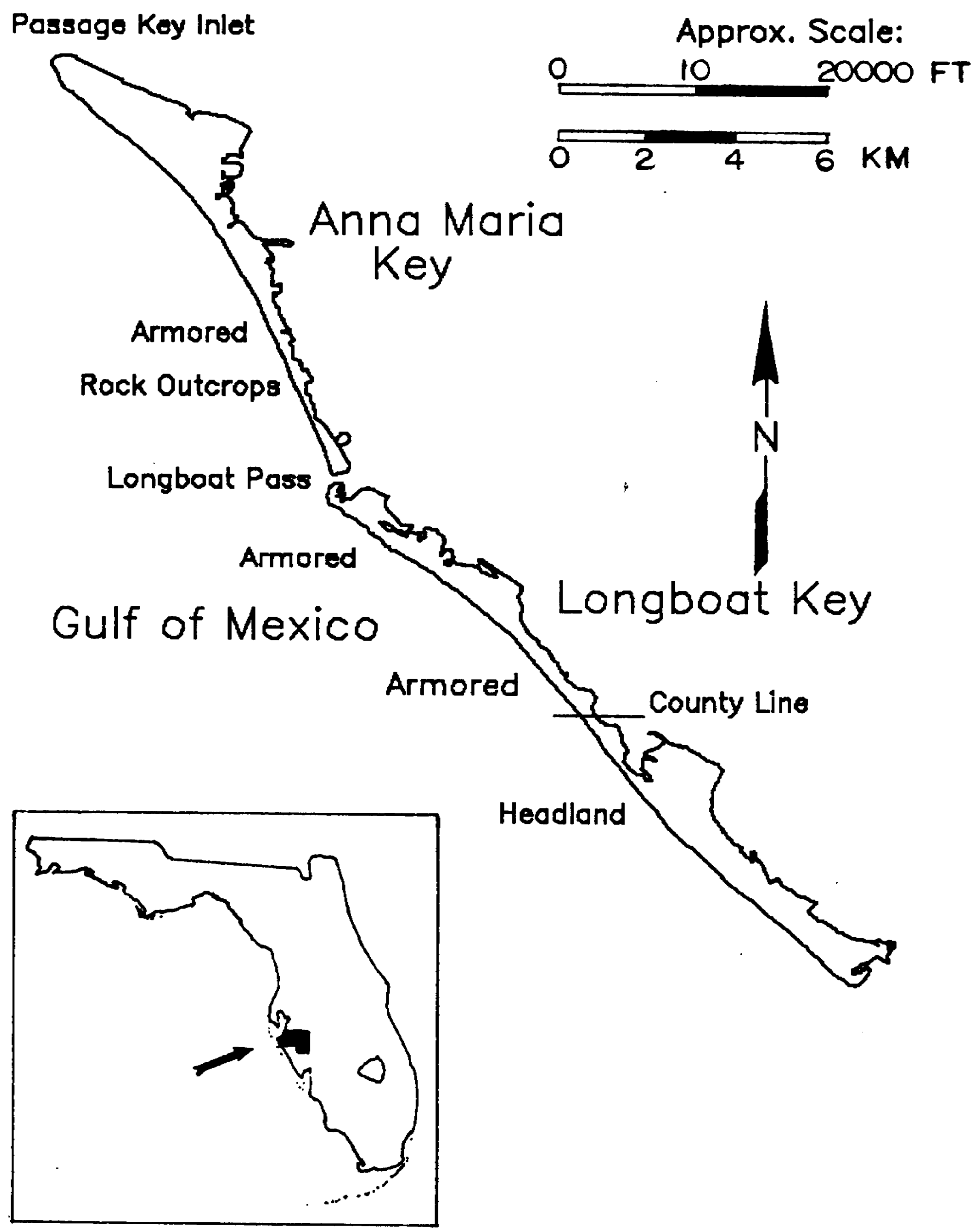

Figure 1. Coastal Manatee County

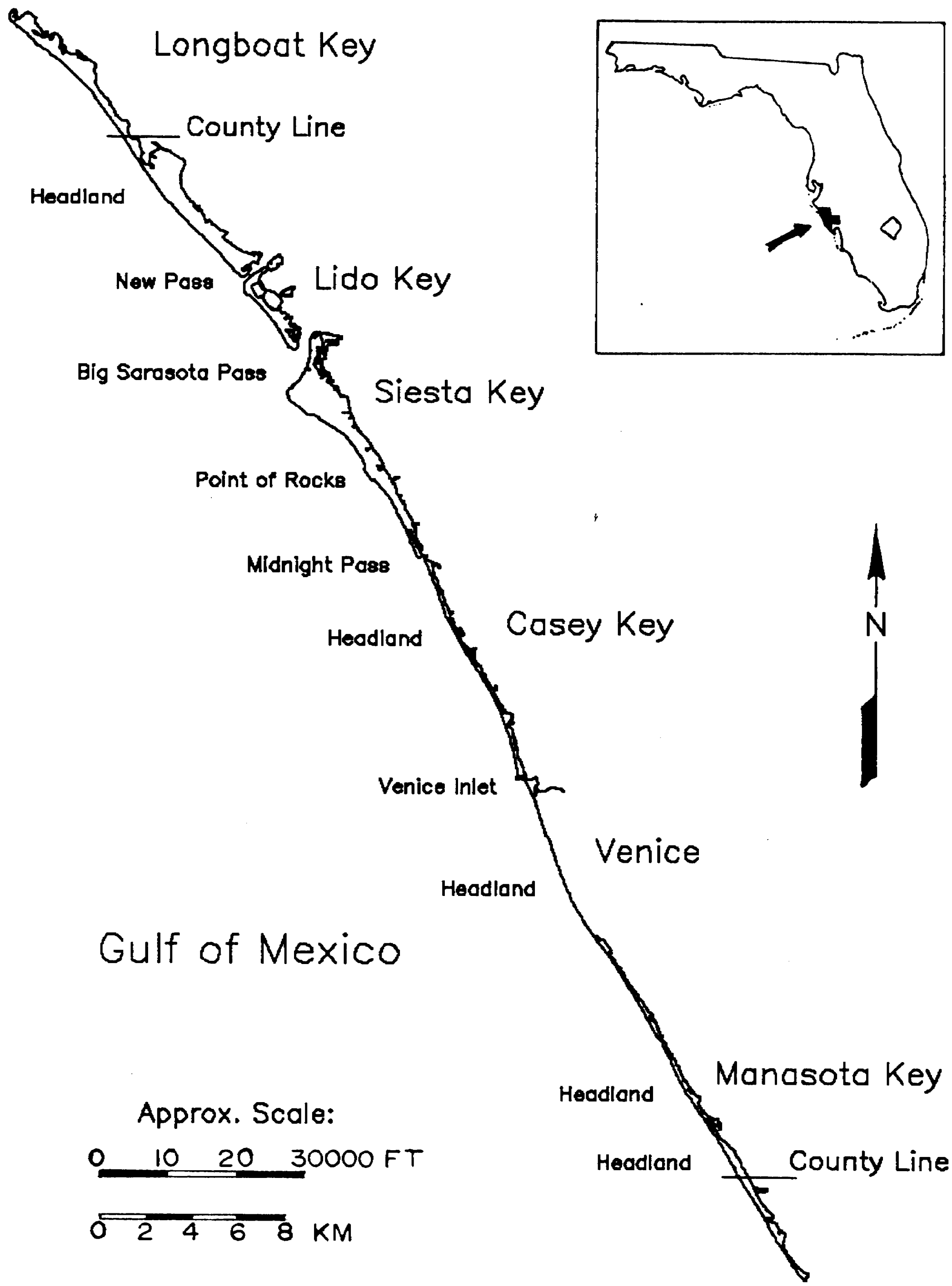

Figure 2. Coastal Sarasota County

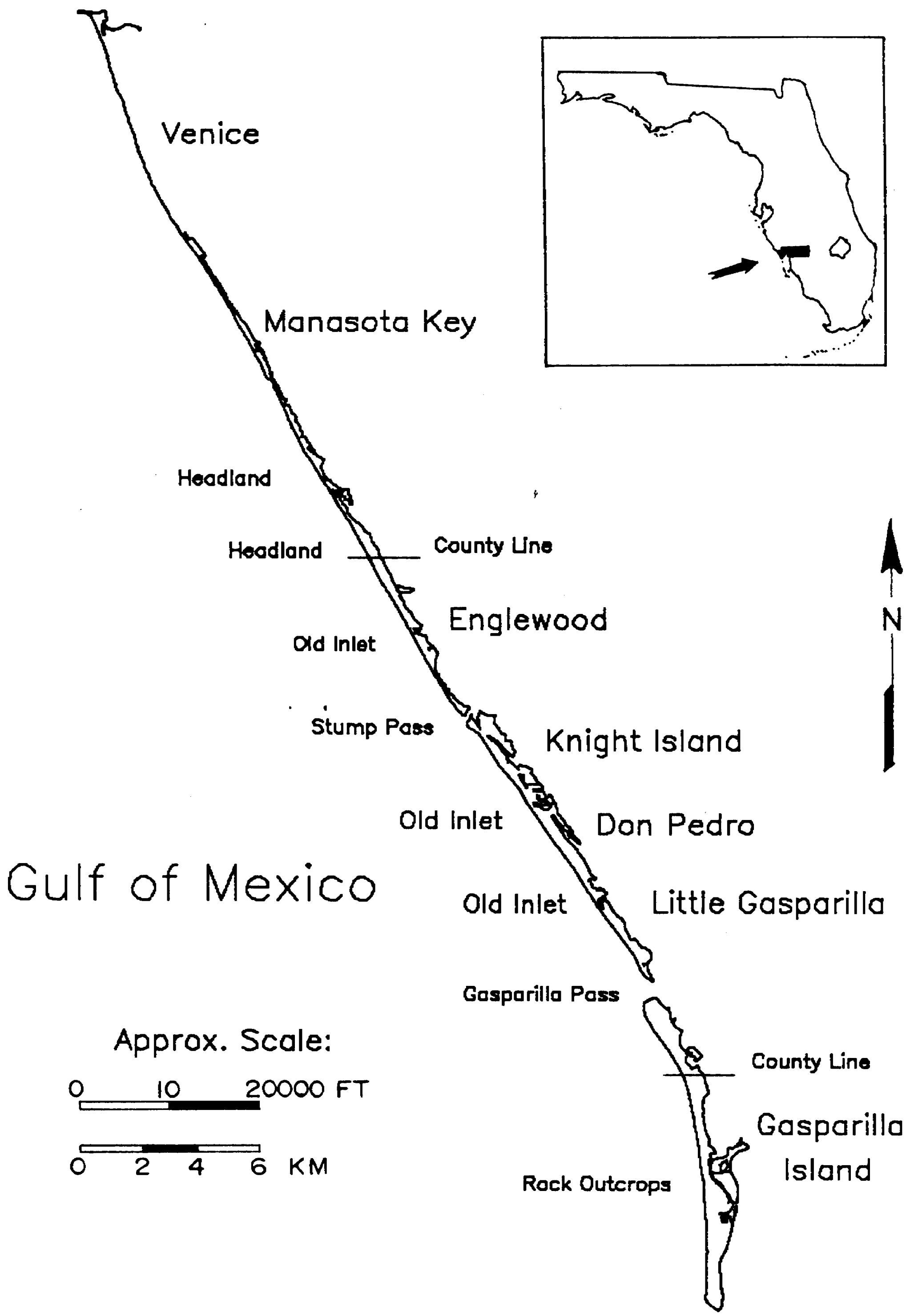

Figure 3. Coastal Charlotte County

varying mixtures of quartz and shell.

In an analysis of historic shoreline changes, it is generally useful to have a large reliable data base, and to examine both the wave climate and geology of the subject area. An understanding of the coastal features which are characteristic of the area can then be developed and applied both in an overall and site by site review.

Data Set and Methods of Analysis

These items are discussed in detail in an accompanying article in this publication: Foster and Savage (1989). However, a brief review is warranted to help visualize how the results were obtained.

In essence, all the historic coastal topographic survey maps of the area by the U.S. Coast & Geodetic Survey (USC&GS), National Ocean Survey (NOS), and U.S. Geologic Survey (USGS), have been carefully digitized and compared on standardized scale and coordinate systems. This work was done by researchers at Florida State University under contract with the Florida Department of Natural Resources

(DNR). The DNR coastal survey monument and beach profile set was used as a shoreline sampling pattern with approximate 1000 feet (300 meter) spacing. DNR beach profile survey data from 1972 to 1988 were added to the data sets. The result is a set of computer-generated composite maps showing all the digitized shorelines, and tabulated data sets of quantitative changes along profile bearings from the 1850's to 1988. The shoreline changes are all relative to the location of the approximate Mean High Water (MHW) contour.

In the subject area, the data were divided into geographic reaches according to the location of inlets or other significant littoral boundaries. It was readily observed in longshore sequences of distance/time plots that shoreline changes were not at all constant over time in many areas. With the large amount of data, it became possible to identify basic long-term coastal processes at work within the pattern of shoreline changes. Historic and recent aerial photography sets were used for qualitative verification of the timing and conditions shown in the survey maps, for studying the vegetation, dune ridge, overwash, and wave refraction patterns, as well as for locating coastal structures and nearshore rock features. Field observations were made of present beach conditions and processes. Historic bathymetric surveys were also digitized, but have been used only for qualitative comparison at this time. Soundings from DNR offshore profile surveys were used to investigate profile shapes and bottom features within 3000 feet (900 meters) of the beach. A literature review of previous studies of the areas was also conducted in order to compare the results and conclusions. Previous studies include those by the U.S. Army Corps of Engineers (1977, 1979, and 1984).

Weather and Wave Climate

The shoreline changes and evolving shoreline orientations in the subject area over the last 100 years are extremely consistent with net southerly littoral transport. Hindcast wave data from the U.S. Army Corps of Engineers Waterway Experiment Station (1988) for the period 1956-1975, as well as the personal observations of one of the authors (Foster) since 1972, confirm that higher energy waves generally approach from the northwest during the winter season. The NW waves result from the southeasterly passage of a series of cold fronts across the southern states. A discussion of the cold front pattern has been given by Rosendal (1965). Summer waves are typically lower energy, high frequency, wind waves and lower frequency swell from the southwest. This is a low wave energy coast in general, with a mean significant wave height of 0.8 meters, and there is a very wide and shallow coastal shelf. Nevertheless, in this area the prevailing higher energy NW wave pattern, as modified by the local geology and the occasional tropical storm, was found to be the primary force controlling shoreline changes over the last 100 years.

It is noted that there are indications in the data that net littoral drift reversals other than seasonal have probably occurred, but the surveys and aerial photography are too randomly and unevenly spaced to prove this point. In the future, more frequent monitoring of beach conditions should help to verify how and when this process occurs.

The tropical storm season extends from June to November. These storms can affect the shoreline in many ways depending on the path, speed, intensity, and frequency of occurrence. Lists of historic tropical storms have been generated from Neumann, et.al (1981), the Mariner's Weather Log of the U.S. Dept. of Commerce (1981-1988), as well as from previous studies. The effects of any storm of set of storms in the past are difficult to determine with accuracy. However, there is occasionally a strong correspondence of major shoreline change with a storm or set of storms, and this should be noted. There are also occasional written and photographic records linking major changes such as inlet break-throughs or washouts to certain storms. It is noted that a tropical storm following a northward path along the lower Florida Gulf coast could theoretically cause a net transport of sand to the north, due to the more organized wind field in the northeast quadrant.

Discussion of Geology

It is well known that the Florida peninsula is largely founded on limestone, including the coastal shelf on the Gulf, as discussed by White (1970) and Hine, et.al. (1985). It is perhaps not so well known that the subject coastal island group is strongly influenced and possibly founded in part on limestone and beachrock outcroppings.

This coast contains a sequence of inlets, headlands, and pocket beaches, as can be seen in Figures 1 thru 3. The coastal islands extend northwest and southeast of a mainland area which directly fronts the Gulf. This is the Venice area of Sarasota County, which is a geologically complex headland feature having several readily observable sand and peat stratifications, limestone outcrops, extremely irregular offshore bathymetry, and dark colored beach sand containing quartz, shell, heavy minerals, and fossils (e.g. shark teeth).

In addition to the somewhat centralized Venice headland, there are sequences of major and minor headlands along the coastal islands to either side which are apparently based on high spots in the topography of the underlying limestone and superficial beachrock formations. Beachrock is defined here as a composite of cemented layers of sand and/or shell. The limestone varies in composition but is generally a hardened mixture of mud, sand, and shell, at least in nearshore grab samples obtained by the authors and as described by Gould and Stewart (1956). The thickness and true extent of the formations is unknown. However, the report of the U.S. Army Corps of Engineers for Sarasota County (1984) contains a map of minimum sediment depth contours in the offshore county area (Plate 1 of that report). These contours, when extrapolated landward, intersect with the Longboat, Casey, and Manasota Key major headlands. This suggests the formations may be related as a group and that there is considerable regional extent. In Manatee County to the north, there are also three known nearshore rock exposures of significant size along the southern half of Anna Maria Key. Further north, there is a massive offshore limestone formation in roughly the same alignment off the central Pinellas County coast, related to the Indian Rocks headland, as discussed by Evans, et.al. (1985), and Winston, et.al. (1968).

The few available geologic opinions appear to be divided between Miocene and Pleistocene as the age(s) of origin for the limestone, e.g. Gould and Stewart (1956), Bland (1985), and Campbell (1985). The Pinellas County feature is reported to be Miocene per Evans, et.al. (1985). The beachrock, which appears to cover the limestone in some areas, is probably Pleistocene, particularly at Point of Rocks on Siesta Key, per Puri and Vernon (1964).

It is observed that several known past and present inlets are located in close proximity to natural headlands. It is suggested that the inlets may have formed in weak or low areas of the limestone topography. Such inlets could be more hydraulically stable as a result of less resistance and/or natural jetty effects.

These findings suggest the need for more geologic research. A systematic seismic and core sampling program along the beach, islands, and offshore is suggested to accurately map the underlying formations.

Characteristic Coastal Features

It is important to understand that the upland areas on the headlands are subject to severe erosion during high water level storm events, and most have consequently been heavily armored by property owners with seawalls, revetments, and/or groinfields to protect the upland property. The amount of protection offered by the underlying rock depends primarily on the elevation of the rock layer and the longshore/offshore extent of the formation. The post-storm recovery of the beach in these areas depends a great deal on the availability of sand to resupply that moved off the site. Very little sand may be available from offshore due to a hard bottom, and the longshore sand supply may or may not be available or sufficient, depending on site specific conditions. The heavily armored limestone associated headlands in the subject area are the following, from north to south: three locations along central and southern Anna Maria Key; the Longboat Key headland; Point of Rocks; the Casey Key headland; the Venice headland; the Manasota Key major headland; and the Charlotte County Line minor headland. The headlands are labeled in Figures 1 thru 3.

It has also been observed that sand often moves in large masses or "slugs", up to 10000 feet (3000 meters) in length, within the larger pocket beaches between headlands, and between headlands and inlets. The movement is slow but apparently in response to directional wave energy. The aerial photographs suggest similarity to a highly viscous fluid traveling back and forth in a bowl. The sand masses also occasionally move across the headlands. This phenomena in general can result in significant short-term variability in beach width, on the order of 150 feet (50 meters). The large pockets which exhibit this phenomena are the following: between the Casey Key headland and Venice inlet; between the Venice headland and the Manasota Key headland; between the latter and the Charlotte County Line minor headland; and from the latter to Stump Pass.

The remaining major features to be discussed are the bulbous-shaped accretion/fluctuation areas located on the south sides of the unstabilized inlets. These areas developed for several reasons: the large ebb tidal shoals on the south side of the inlets shelter the areas from high energy wave activity except during high water level storms; the shoals occasionally merge onto the shoreline; and the shoals can refract or bend waves such that sand transport is generally directed into the area from the south during all seasons. Frequent and random shoal re-orientations result in extremely unstable beaches in these areas. The north ends of Anna Maria Key, Longboat Key, Lido Key, Siesta Key, Knight Island, and Gasparilla Island are all typical cases. The north sides of the inlets are equally or more unstable since they are protected by lesser shoals.

A Brief Tour

Some of the more interesting site specific beach conditions will now be described, working from north to south through the area.

Anna Maria Key has a highly fluctuating, north bulbous shaped area. Due to the potentially tremendous hurricane surge volume which can pass to and from Tampa Bay, the north end of

Anna Maria Key is particularly vulnerable to being washed away, as happened during a hurricane in 1921. The north central zone appears to be somewhat protected and supplied by the massive offshore shoals, and the beach width has fluctuated depending on the shoal and storm conditions.

There are three nearshore limestone features along central and southern Anna Maria Key. This section of the island is south of a refraction nodal zone and has historically been retreating since the 1920's at an approximate rate of 1-3 ft/yr (less than 1 m/yr). An estimate of just how fast has been obscured by the construction of a near continuous mixture of seawalls, revetments, and groinfields starting in the 1950's with major development of the island. At about the same time the southernmost end of the island was stabilized with a terminal groin and a groinfield. If left alone, the shoreline would have been expected to continue to evolve in a curved orientation to face the northwest waves, with some anchoring by the rock outcrops.

Ground level photographs from the 1950's and 1960's show essentially the same conditions as the present in that area: a mix of coastal structures with no beach except in minor pockets. It appears that buildings and roads were simply built on lots too close to and perhaps even out into the water from the very beginning. The costs of the construction remain: continuing storm damage, perpetual structural repairs, and no recreational beach.

At Longboat Pass, dredging for navigation purposes has rearranged the shoals and added sand to the north and south shores. This pass was also washed out by storms in the early 1960's. The inlet has migrated northward over time, leaving structures built on the previous bulbous area exposed to major erosion and storm damage.

Continuing with Longboat Key, there is a small, high erosion pocket immediately south of the armored area, followed by a longer, relatively stable to mildly eroding pocket beach. The Longboat Key major headland appears to begin approximately at the Manatee/Sarasota County Line. This shoreline contains many groinfields and seawalls constructed during and since the 1960's. However, it does not appear the area was heavily eroding before or after the armoring. Erosion rates have been on the order of 0-1 ft/yr (0-0.5 m). South of the headland there is a continuing shoreline retreat towards New Pass, at approximately 2-3 ft/yr (0.5-1 m), indicating a sand deficit exists across the headland. It is noted that Longboat Key is actually composed of two previous islands which were once separated by an inlet (prior to the 1883 survey) adjacent to the most prominent rock outcroppings on the headland.

Lido Key is unique in that it has an entirely man-made shoreline which was constructed in the 1920's by filling in between a set of small islands. There have been six renourishment projects to maintain the beaches on the heavily developed island from 1964 to 1987, totaling approximately 1.4 M cubic yards (1.1 M cubic meters). The shoals have been building at both ends over time, modifying the wave refraction pattern and resulting in accretion at both ends of the shoreline. There is a historic erosion "hot spot" just south of the northern shoals. Aerial photography shows that the refracted wave pattern tends to remove sand from this area without replacement.

Continuing southward, it is of interest to note that pre-development 1948 aerial photographs of Siesta Key show a pattern of seaward tending accretionary dune ridges, typical on this coast of the south side of an extremely large pass system. Big Sarasota Pass has been pressured against Siesta Key by wave action on the shoals, and the shoal-protected north point is not a stable landform. Armoring is heavy and continuous along the channel and northernmost point. The large pocket beach between the armored north point and Point of Rocks has historically been accreting, and relatively stable in recent years. The only obvious source of present supply is the ebb shoal system. The beach within this pocket tends to align itself to face directional wave energy, seasonal or otherwise.

From Point of Rocks southward to Stump Pass in Charlotte County, there is essentially a repetitive series of very similar and relatively stable pocket beaches and armored headlands. The same basic processes occur along and within each cell. The problem of structures built too far seaward is generally true all along the major and minor headlands. For example, the road along the Casey Key headland has repeatedly washed out since the 1930's.

It is noted that Midnight Pass has existed within the pocket between Point of Rocks and the Casey Key headland, and has caused highly fluctuating beach widths in areas adjacent to the inlet. The channel extended as far northward as Point of Rocks in 1883. The inlet closed in 1983 during an attempt to relocate the unstable channel away from some threatened residential structures.

A more complex headland and a significant erosion problem exists at Venice, with rates generally in the 1-3 ft/yr (0.5-1 m) range. At Venice Inlet on the north side, the jetties have been in place and repaired since 1937-8, and have acted as effective littoral barriers. There has been very little maintenance dredging, a net sand deficit has developed to the south along the Venice headland, and sand has accreted against the north jetty.

The previously described moving sand mass phenomena appears to be the dominant cause of major beach width changes in the sequence of three large pocket beaches extending southward from Venice into Charlotte County.

It is noted that an inlet known as Old Blind Pass once existed prior to 1883 immediately south of the Manasota Key major headland.

In the southern end of our subject area, in Charlotte County south of Stump Pass, there is an unusual island which will be referred to here as Knight Island. It is actually a composite of three recent islands : Knight, Don Pedro, and

Little Gasparilla Islands. This island and the area immediately north of and including Stump Pass are distinctly different from the coastal islands to the north in that there are no apparent stabilizing rock features. There have been many major shoreline changes in this vicinity, including multiple inlets and rearrangements by storms, such as occurred in the 1950's. This area is located at the end of a long southward littoral transport system. There are portions of more landward, older islands. It is also in a transitional zone between two distinct shoreline alignments. To the south, Gasparilla and a successive chain of islands in Lee County have a significantly closer to north-south orientation. Gasparilla Island also has extensive nearshore beachrock outcroppings along its' central and southern half, in apparent alignment with the new general island chain orientation.

Knight Island has a bulbous-shaped, highly fluctuating north end adjacent to Stump Pass, followed by a refraction- caused erosion pocket. The remainder of the island is slowly retreating toward the south and the Gasparilla Pass shoals. Bulges in the shoreline due to prior inlets are gradually being smoothed out. There are fluctuating, shoal-influenced beaches on both sides of Gasparilla Pass. A large, bulbous-shaped beach exists on the north tip of Gasparilla Island, followed by a relatively stable, shoal- supplied zone extending into Lee County. The processes and conditions on Gasparilla Island, although the analysis for that island is presently incomplete, appear very similar to those of Anna Maria Key at the very opposite end of the subject area.

It can be said that, in the entire subject area, significant erosion occurs in general at any location where there is a net sand supply deficit either due to a natural or man-made littoral barrier or a wave refraction pattern. The worst cases are the following: the southern half of Anna Maria Key; the armored area just south of Longboat Pass; the south half of Longboat Key; the middle of Lido Key; the area immediately south of Point of Rocks; and the Venice area south of Venice Inlet.

Conclusions

The Gulf coast of Manatee, Sarasota, and Charlotte Counties in southwest Florida contains a series of inlets, pocket beaches, and headlands. Historic shoreline changes appear to be a direct result of long-term net southerly transport, as modified by geologic features and tropical storms. There are erosion problems in areas lacking adequate sand supply due to littoral barriers (man-made or natural) and/or wave refraction effects around shoal systems. In many problem areas, residential structures were simply built too close to the active beach to allow for natural beach width fluctuations or the gradual pattern of shoreline evolution. The armored natural headlands will continue to be very vulnerable to storm damage, although the mean high water line tends to recover in the long term if there is available sand supply. Areas adjacent to unstabilized inlets will continue to experience large scale beach width fluctuations due to random changes in the offshore shoals and storm attack. The larger pocket beaches can experience significant short-term beach width variability due to the movement of large sand masses within the bowl-shaped pockets and occasionally across the boundary headlands.

With the large and growing amount of coastal data available for this area, it is now possible to recognize the major coastal processes occurring at a local and regional level, and to use this information for making better management and regulatory decisions.

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