SUMMARY OF

EXISTING COASTAL ENGINEERING DATA

FOR DAUPHIN ISLAND, ALABAMA

Scott L. Douglass
College of Engineering Report No. 91-1

Department of Civil Engineering
University of South Alabama
Mobile, Alabama 36688

prepared for
East End Management Task Force
Dr. George F. Crozier, Chairman
Marine Environmental Sciences Consortium
P.O. Box 369-370
Dauphin Island, Alabama 36528

and
Coastal Programs Office
Alabama Department of Economic and Community Affairs
3465 Norman Bridge Road
Montgomery, Alabama 36125-0347

January 1991

1. EXECUTIVE SUMMARY

The State of Alabama and the newly formed Town of Dauphin Island would like future development of the eastern end of the island to promote the economic, cultural and recreational resources of the site. A critical aspect of the long-term planning and management of the area is the beach erosion problem. The purpose of this report is to summarize the available data on the coastal engineering of the east end of Dauphin Island, provide recommendations for proceeding to stabilize the waterfront, and discuss what additional studies and analyses need to be accomplished to properly evaluate the alternative shoreline stabilization plans.

Our existing understanding of the coastal processes around Dauphin Island is rather poor. Specifically, the questions about why the beaches are eroding at the east end and the fishing pier cannot be conclusively answered because there is no documented evidence of where the sand is going or why. Fortunately, the existing database for coastal engineering analysis and design is not completely lacking. Data and analysis have been located in several dozen reports on various aspects of engineering, geology, oceanography, and meteorology of the Dauphin Island area. The data just have never been evaluated specifically for understanding the coastal processes related to the beach erosion problem.

Based on the present limited understanding of the coastal processes, the following alternatives are proposed and discussed below:

1) Do Nothing

2) Maintain Present Levels of shore protection effort

3) Beach Nourishment of the east end

4) Modifications to the Armoring of the east end

5) Manipulation of Sand Island shoals

6) Combinations of the above alternatives

However, the final decisions concerning which of the alternatives to pursue will have to be made by the politicians and, ultimately, the citizens of the area. It must be emphasized that there are no coastal engineering solutions that will work in all cases. The wrong approach can harm adjacent beaches and waste money. Therefore, understanding why the beaches are eroding and having a clear understanding of how a proposed solution should function is necessary.

The East End Management Task Force and the Town of Dauphin Island should consider the possible waterfront stabilization plans outlined above. Selection of the preferred alternative will require decisions about the desired use of the east end of the island. For example, if a beach is desired at the tip of the island then it will have to be put there and maintained there. Alternatively, a seawall, or revetment, may be acceptable along the east side of the fort but not around on the southern facing beaches.

In order to evaluate alternatives properly, a better understanding of the coastal processes of the area is needed. Specific areas of further study for this purpose include the collection of low-cost, visual wave climate data; investigation of historic shoreline change data through air photos and historic charts; and, documentation of recent and future beach erosion trends with air photos and beach surveying.

PREFACE

This report was prepared under contract with the Marine Environmental Sciences Consortium (MESC) for the East End Management Task Force. The Task Force was organized by MESC to address the management issues facing the eastern end of Dauphin Island, Alabama. The Task Force's study was funded by the Coastal Programs Office of the Alabama Department of Community and Economic Affairs (ADECA) with support from the National Oceanic and Atmospheric Administration's (NOAA) Coastal Zone Management (CZM) Office.

This report was written by Scott L. Douglass, Ph.D., P.E., Assistant Professor, Department of Civil Engineering, University of South Alabama, Mobile, Alabama.

Many people were contacted to locate existing data. In particular, Drs. George F. Crozier and William W. Schroeder, Dauphin Island Sea Lab; Dr. George M. Lamb, University of South Alabama; Edward B. Hands, U.S. Army Engineers Waterways Experiment Station; W. Everett Smith, Geological Survey of Alabama; Mike Henderson, Dauphin Island Park and Beach Board; Walter Burdin, Michael Peterson, Paul K. Bradley, and Dr. Susan Rees, U.S. Army Engineer District, Mobile provided data, discussions or reviews. The coordination with Drs. Bettye B. Burkhalter and Syd Spain, and William L. Lett of Auburn University is appreciated.

CONTENTS

SUMMARY OF EXISTING COASTAL ENGINEERING DATA FOR DAUPHIN ISLAND, ALABAMA

2. INTRODUCTION

The State of Alabama and the newly formed Town of Dauphin Island would like future development of the eastern end of the island to promote the economic, cultural and recreational resources of the site. The most critical aspects of the long-term planning and management of the area are the coastal sediment processes. The area is suffering from erosion of the beaches and shoaling in the boat launching and navigation areas. The beaches are critical to the overall planning process because of aesthetics, the danger to facilities, and the expense inherent in coastal engineering projects. Although shoreline variation is a natural process, it can cause significant problems when man builds structures such as the historic Fort Gaines and the boat ramps. Long-term management decisions concerning new fixed facilities or the protection of the Fort must be made within the context of an understanding of these natural processes so the Town and State can work with the natural processes or at least be prepared to pay the price of working against them.

The purpose of this report is to summarize the available data on the coastal engineering aspects of the east end of Dauphin Island. Data and analysis have been located in several dozen reports on various aspects of the engineering, geology, oceanography, and meteorology of Dauphin Island. This report describes the available database and discusses additional studies and analysis needed to properly evaluate alternative shoreline stabilization plans. This report provides recommendations for proceeding to stabilize the waterfront.

With funding from the Coastal Programs Office of the Alabama Department of Economic and Community Affairs, the East End Management Task Force for Dauphin Island commissioned this report.

3. THE BEACH EROSION PROBLEM

Previous reports on engineering and geology studies provide data on the historic shoreline changes and bathymetric changes in the vicinity of the east end of Dauphin Island. Several sources of air photos also document the shoreline changes in the past half century.

3.A. CHARTS

The National Oceanographic and Atmospheric Administration (NOAA) National Ocean Survey's and its predecessor, the U.S. Coast and Geodetic Survey's (USC&GS) navigation charts have been used by several investigators. US Army (1978) plots the shoreline locations of the area around the mouth of Mobile Bay. The area covered includes the east end of Dauphin Island, the Sand/Pelican Island complex, and the tip of Ft. Morgan Peninsula in 1847, 1868, 1892, 1908, 1916, and 1957. The plot shows the historic shoreline position traces plotted on top of each other. The figure is reproduced in Figure 1.

Hands and Bradley (1990) have plotted the shoreline location and bathymetry near the mouth of Mobile Bay including the east end of Dauphin Island for 1894, 1916, 1921, 1929, 1941, 1962, 1973, and 1986. Their plot is reproduced in Figure 2. They plot each chart separately but at the same scale. They show the 0, 6, 18, and 30 foot depth contours. Hands and Bradley point out that although the exposed Sand and Pelican Islands have moved around tremendously, the underlying shoals have always remained. Only the exposed portion, which is a small fraction of the total volume of sand in the shoals, has changed dramatically.

Hummell (1990) reproduces bathymetric charts of the mouth of Mobile Bay from 1772, 1849, 1929, 1941, 1961, 1973 and 1987. Hummell plots the changes in depth in Pelican Bay from 1973 to 1987. Figure 3 shows the 1849 chart (reproduced from Hummell 1990). Deposition of sand was much more common than scour. Hummell does not calculate volumetric changes nor postulate about what forces caused the bathymetric changes.

Charts have been published with other dates by NOAA. These other charts might fill in some of the gaps in the existing database. However, updated charts often include portions of old

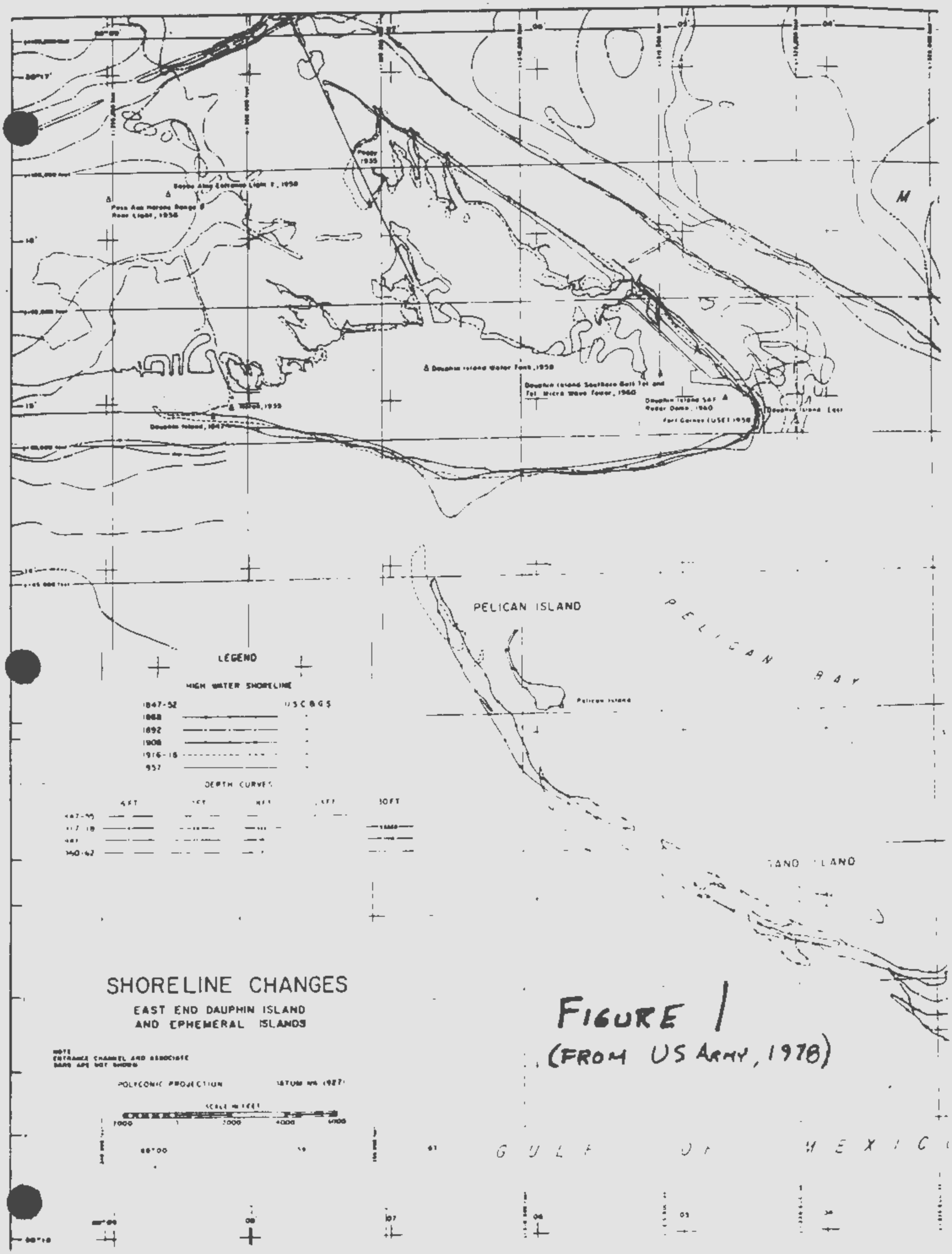


FIGURE 1
(FROM US ARMY, 1978)

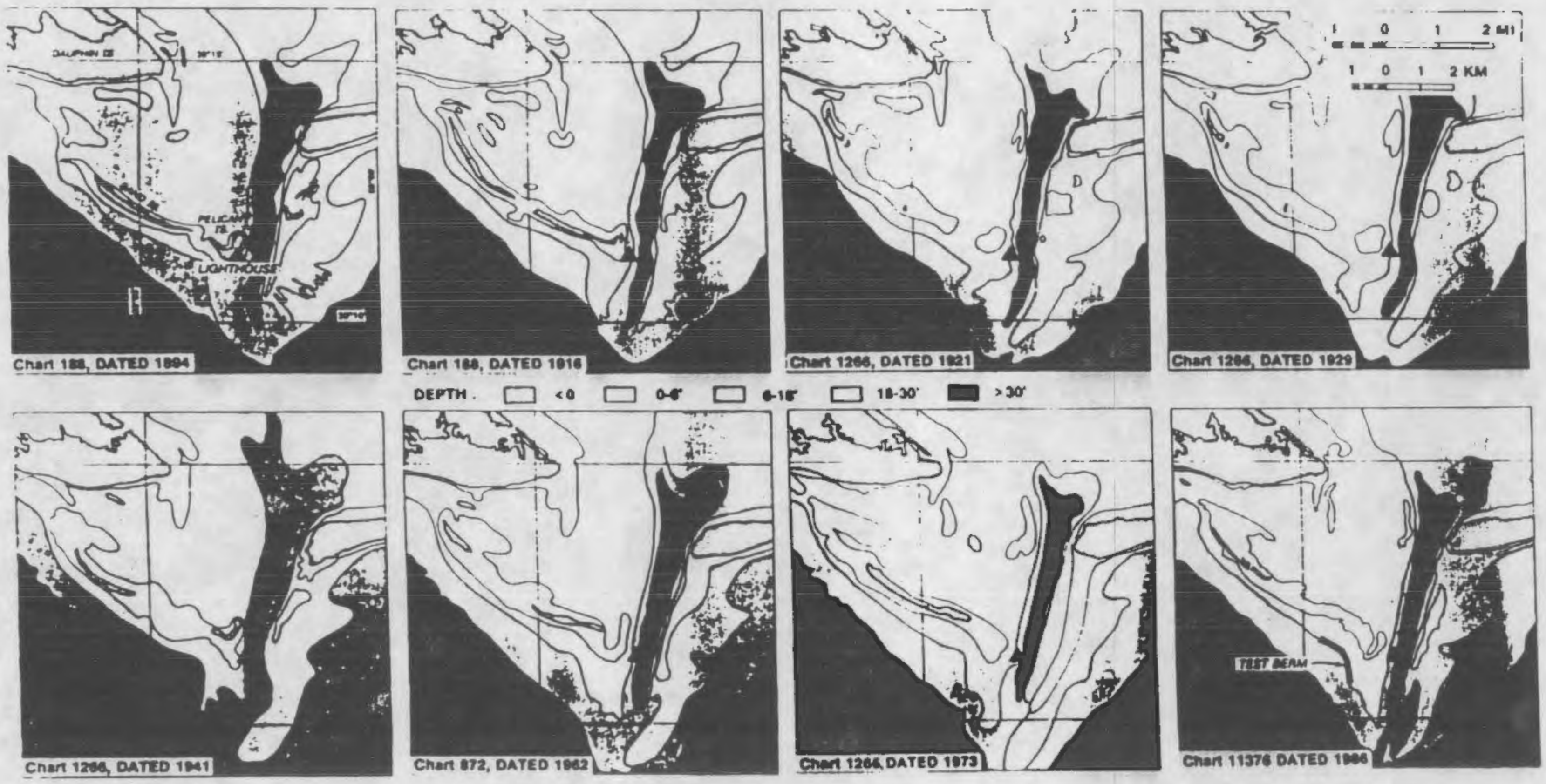
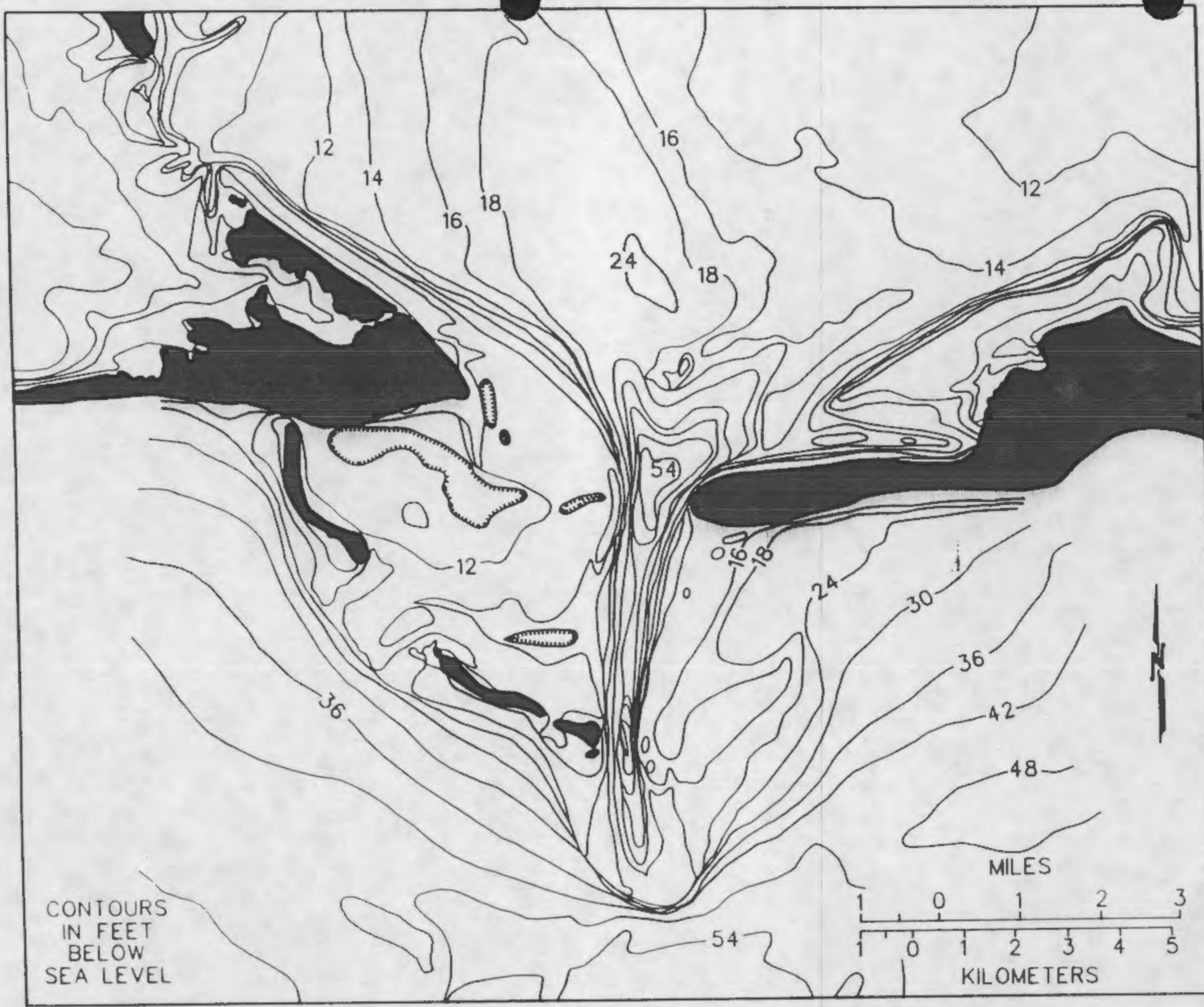


FIGURE 2

(FROM HANDS & BRADLEY, 1990)



--Bathymetry circa 1849 (1847-51) for the study area. Contours in feet below sea level (modified from Ryan, 1969).

FIGURE 3
(FROM HUMMELL, 1990)

data and the actual changes from chart to chart must be carefully investigated.

Mobile Pass is, in essence, a very large tidal inlet on a sandy coast. It is one of the largest inlets on the continent and Dauphin Island is part of the total inlet system. Mobile Pass has the shoals and inlet system associated with smaller inlets. Specifically, its width is probably controlled by the dynamic interplay between the forces of the tidal currents trying to widen the mouth and the littoral drift trying to close it off.

The shoals extend nine miles to the south of Dauphin Island. Walton and Adams (1976) have calculated the total volume of sand in the shoals at the mouth of Mobile Bay to be 1.2 billion cubic yards of sand. They calculate this by estimating the bathymetric contours which would exist without the presence of the inlet, and computing the difference.

Across most of the shoals, the main ebb tidal channel is 50 feet deep and 3000 feet wide naturally. The seaward section of the channel has been dredged to maintain depths for navigation. Before dredging, its natural depth was only about 20 feet.

Hands and Bradley (1990) state that the historical dredging rate on this outer 1.5 miles of ship channel shoals is 325,000 cubic yards of sand per year. This material has historically been removed to deeper water beyond the ebb shoal complex. In essence, this sand has been permanently removed from the coast of Alabama. This material is probably very good quality beach sand which has moved naturally from the Fort Morgan Peninsula, Dixie Shoals and the Sand/Pelican Island shoals. Hands and Bradley do not state the length of time from which this average was calculated. Since dredging started about 1932 (US Army 1978), a rough estimate of the total amount dredged is over 15 million cubic yards of sand.[1] This 15 million cubic yards of sand has been removed from the littoral system directly in front of Dauphin Island. It would have been in the Sand/Pelican Island shoals and maybe on Dauphin Island if it had not been removed to deeper water by the dredging.[2]

3.B. BEACH PROFILE SURVEYS

Surveying the elevation of the sand along a line perpendicular to the shoreline (a profile) is a common method for quantifying beach changes.

Profiles were surveyed in 1989 by the Alabama Geological Survey at 18 locations along the east end of Dauphin Island (Smith, 1989). The profiles have not been surveyed again and thus, there is nothing to compare with. Unfortunately, the actual elevation of the monument at the landward end of each profile was not surveyed. However, the locations of the monuments have been described in detail. The elevations of these monuments should be surveyed and then the 1989 data could be referenced to NGVD (National Geodetic

---

[1]Note: 15 million cubic yards of sand would cover the entire inhabited eastern portion of Dauphin Island 4 to 5 feet deep

[2]During the most recent deepening of the ship channel, some dredged sands were placed just offshore of the Sand/Pelican Island shoals in 20 feet of water instead of the usual deepwater, 40-50 feet, disposal site.

Vertical Datum of 1929). Unfortunately, relatively few elevations were actually shot on each profile (3 to 8) and the profiles only went down to a convenient wading depth. Thus, the precision of volume change calculations from this survey to the next would be limited. More importantly, changes beyond the seaward limit of the survey would be missed.

It is recommended that these profile lines be reoccupied and used to measure volumetric beach changes. For example, reoccupying these lines now would give a measure of beach erosion during the past year. Since such quantitative information is so valuable, the lines should be surveyed periodically - perhaps annually or as frequently as quarterly. The number of lines could be reduced or increased in the future.

The Corps of Engineers conducted an extremely intensive survey of the elevation of the island after Hurricane Frederic. Elevations were surveyed across the entire island width at at least six locations. The elevations surveyed after the hurricane are compared to pre-hurricane elevations from four years earlier obtained from air photo analysis in US Army Engineer District, Mobile (1981). In addition to the published profiles at the six locations, the Mobile District of the Corps surveyed many beach profiles at 200 foot spacing down the beach between the six cross-island profiles. These data are in blueprint plotted form. The beach profiles extend to a wading depth of several feet. Thus, although the data are obviously influenced by the hurricane, a historic beach profile can be obtained for most locations on the island. It would be very interesting if these profiles were resurveyed to provide detailed data on how the island has recovered from Frederic during the past 12 years.

3.C. AIR PHOTOS

Air photos can provide information on beach recession and accretion along the entire beach. Air photo analysis can be used to "fill in the gaps" between surveyed profile lines.

The Cartography Section of the Mobile District of the Corps of Engineers has an archive of historical air photos dating back to 1940. The east end of Dauphin Island has been covered by vertical air photos over two dozen times. The flight paths have not always included the rest of the island. The photos are of varying quality and scale. The more recent sets of air photos have been shot at a scale of 1:12,000 (1 inch on the photo equals 1000 feet on the ground) with very good quality equipment. A list of available coverage is given in Table 1. The list is partial in that the Corps may have other historical photos which are not indexed for retrieval.

This photo archive is a very valuable data set for understanding the coastal processes of the area. Most of the existing historical air photos of Dauphin Island have been shot at a smaller scale than is usually used to measure beach width changes. However, this small scale (high altitude) photography allows for viewing the entire shoals at one time. Also, with some loss of clarity, the print can be enlarged.

Unfortunately, the Corps' photography is not in a readily useable form. Most of the photography is on large rolls of negative or positive film. In order to use the data in a study, prints must be made. The Corps will arrange for the film to be sent off for prints if the requestor will pay for the costs. A ballpark estimate of the cost is $100 per flight for the photos at the east end of the island. It is recommended that some of these prints be obtained.

Lamb (1987) uses air photos from 1940, 1960, and 1984 to show that the erosion in the vicinity of the groin field at the east end has been ephemeral. In 1940 the beaches were eroded to the point that the westernmost few groins are completely surrounded by water during all tides. The coastal engineering term for such a condition is "flanked": the beach has receded to the point where the groin is flanked. In 1960, the groin field is full of sand and not flanked. But in 1984, the groin field is beginning to be flanked again by shoreline recession of the beaches to the immediate west. The flanking has continued since 1984. Eight of the groins in the groin field are flanked now in 1990.

Lamb (1987) postulates that the erosion patterns of the east end of Dauphin Island are controlled by the changes in the position of Sand Island. Hands and Bradley (1990) carry this speculation further to include the shoals around Sand Island. They believe that since the shoals upon which these offshore islands (Sand and Pelican) sit have been rather constant, only the exposed portions

Table 1. Summary of existing vertical air photos of Dauphin Island

date	owner	scale	notes
10/40	USA	1:72,000	east half island & Sand I, 1 B&W print
45	CE		
3/53	USA	1:36,000	east end, 1 B&W print
60			in Lamb (1987)
70	CE		
72	CE		
9/72	USA	1:48,000	east end & Sand I, 1 B&W print
4/73	DISL	1:12,000	entire island, not Sand I, B&W
76	CE		
2/79	CE	1:24,000	east end (4 mi.) & Sand I, IR pos.
5/79	CE	1:24,000	east end (4 mi.) & Sand I, IR pos.
9/79	USA	1:6000	entire island, not Sand I, blueprints
10/80	CE	1:24,000	east end (4 mi.) & Sand I, CIR pos.
2/81	CE	1:24,000	east end (3 mi.) & Sand I, CIR pos.
2/82	CE	1:24,000	entire island & most of Sand I, CIR pos.
9/82	CE	1:24,000	entire island & Sand I, CIR pos.
3/83	CE	1:24,000	entire island & Sand I, CIR pos.
9/83	CE	1:24,000	entire island & Sand I, CIR pos.
1/84	CE	1:24,000	entire island & Sand I, CIR neg.
3/84	USA	1:2400	blown up to this scale on blueprints
3/85	CE	1:24,000	entire island & Sand I, CIR pos.
3/86	CE	1:24,000	east end (6 mi.) & Sand I, CIR pos.
10/86	CE	1:24,000	east end (8 mi.) & Sand I, CIR pos.
[illegible]	CE		
[illegible]	CE		
1/89	CE	1:12,000	entire island, not Sand I., color pos.
8/89	CE	1:12,000	island, not Sand I, CIR neg.
9/89	CE	1:12,000	island, not Sand I, color pos.

have shown dramatic changes, they have provided constant sheltering effects on Dauphin Island. They conclude that the changes in position of Sand Island has a "more apparent than real effect on the stability of Dauphin Island." Neither Lamb nor Hands and Bradley provide an in-depth correlation between beach changes on Dauphin Island and the position of Sand Island.

4. THE COASTAL FORCES

4.A. WINDS

The Dauphin Island Sea Lab has operated a meteorological station since 1974. Schroeder and Wiseman (1985) provide some summary analyses of the data from 1974 to 1984. Wind roses (a graphical way to present the wind speed and direction frequencies) for each month in the 11 year period are presented along with composite wind roses for all Januarys, Februarys, etc.; yearly summary roses; and a total composite rose. The frequency of occurrence information used to plot the roses is also given in tabular form.

The composite wind rose for the entire data set (Plate 52 of Schroeder and Wiseman) shows that the most common direction for wind is from the north. The north also is the most common direction for very strong winds (over 21 knots). North winds generate waves which are moving away from the southward facing beaches of Dauphin Island. Of the winds generating waves along or towards these beaches (W, SW, S, SE, E), the winds from the east of south are much more common than the winds from the west of south. Thus, the portion of longshore sand transport due to locally generated sea waves moves more sand to the west than to the east. Besides locally generated sea, the total wave climate and resulting littoral drift includes swell waves which have been generated elsewhere in the Gulf and have propagated to the beaches.

Schroeder and Wiseman (1985) do not specifically analyze the extreme values of the wind data. They do not present frequency of occurrence of the highest windspeeds. Thus, engineering estimation of extreme value return period is not possible. In other words, we cannot attempt to answer the question of "what is the 10-year wind speed," the maximum expected wind speed during a ten year period? Apparently some of the original data could be obtained and analyzed for extreme value statistics. Wind data covering longer time spans could be obtained from Brookley Field or Bates Field airports in Mobile.

4.B. WAVES

Hands and Bradley (1990) describe the use of electronic wave gages several miles south of Dauphin Island since 1987. The gages were operated as part of the monitoring program for the dredged material disposal sites for the deepening of the Mobile Ship channel. The disposal sites are on the south side of the

Sand/Pelican Island shoals. Two different types of wave gages have been used for disposal site monitoring. First, a bottom-mounted wave gage has been operating in about 26 feet of water about 4.5 miles south of Fort Gaines. Second, two wave measuring buoys have been operating in about 50 feet of water about 2 miles southwest of the bottom-mounted gage. The Corps of Engineers Coastal Engineering Research Center in Vicksburg, Mississippi has been operating the bottom-mounted gage and the NOAA National Data Buoy Center has been operating the buoy gage. Both types of wave gages measure wave heights and periods and direction. The techniques and the gages are the state-of-the-art of coastal engineering and provide relatively accurate and reliable data. Unfortunately, such gages are also expensive to maintain and operate. All three gages are supported by the Corps of Engineers monitoring programs and are scheduled to be removed in September 1990 (Hands, personal communication).

Hands, et al (1990) discuss some very interesting wave gage results from two hurricanes in 1988. The gages measured long period swell waves from Hurricane Gilbert. Gilbert passed across the Yucatan Peninsula and the eye of the storm remained over 500 miles away from the Alabama coast. However, the wave periods approached 12 seconds and the significant wave heights exceeded 10 feet. This very long-period swell generated typical water current velocities of over 6 feet per second in a depth of 20 feet of water. Such velocities are clearly capable of moving sand, silt or clay from the dredge disposal sites. Hurricane Florence, which made landfall in Louisiana, generated similar wave heights and periods.

Since the gages are located on the Gulf side of Sand Island, they provide estimates of the wave climate along Sand Island and along the western end of Dauphin Island. These wave data could be used to estimate longshore sand transport rate along these beaches for the three year period. The complex transformations of the wave field across the ebb shoal complex with the tidal currents preclude using the data from the gages to estimate wave climate on the east end of the island.

The Corps has developed a methodology to predict historical wave climates from historical atmospheric pressure maps. The technique is called wave hindcasting instead of wave forecasting, which uses the same equations. The Corps' Coastal Engineering Research Center has applied the technique to 20 years of data for the Gulf of Mexico and has an estimate of the wave height, period and direction every three hours from 1956 to 1975 at a location about 16 miles south of Dauphin Island. The depth is about 90 feet. Hubertz and Brooks (1989) present summary and extreme value statistics for the wave climate excluding tropical storms. The average significant wave height is 3.6 feet and the most common wave period is 5.3 seconds. The largest waves during the 20 year period were 13 feet. Abel, et al (1989) provides the wave hindcast statistics for hurricanes. The average return period for waves with a significant height of 18 feet is once every five years. The corresponding 10-, 20- and 50-year wave heights are 24, 30, and 46 feet, respectively. For example, hurricane conditions generating 46 foot waves in this location can be expected twice per century. This twice per century concept is over the long term, i.e. if we were able to measured waves for several centuries.

Visual wave observations have been made from the beaches at the east end of Dauphin Island occasionally as part of classes at the Marine Environmental Science Consortium at the Dauphin Island Sea Lab. Visual wave observations provide a very inexpensive measurement of the wave climate. Another major advantage of such data is that the data is collected at the exact location on the beach where it is needed, i.e. not offshore where the wave climate is different. The obvious disadvantage of visual data is the accuracy is subject to observer bias. However, conscientious, consistent, trained volunteer observers have provided valuable data on the shore processes at many locations around the country during the past several decades. The most successful visual observation programs pay a small, daily "expense" fee to observers who live in the area and are concerned about the beaches and make the effort to collect the highest quality data. Such a program is strongly recommended for Dauphin Island. With the complexities of littoral drift along the east end of the island due to the tidal currents and the offshore shoals, long-term (at least one year) visual observations at several locations would be very valuable.

4.C. WATER LEVELS

The astronomical tides at Dauphin Island are diurnal (one high and low per day). The mean range (low to high) of the tide is 1.2 feet with a mean tide level of 0.6 feet above MLLW (Mean Lower Low Water) (NOAA 1989). The nearest long-term NOAA tide station is at Mobile.

The Dauphin Island Sea Lab (DISL) has operated a NOAA tide gage at the east end of the island since 1973. The data has been analyzed for general summary statistics by Schroeder and Wiseman (1985). Schroeder and Wiseman point out that the actual water level at any time is not only a function of the astronomical tide but also winter "cold front" storms, tropical cyclones, strong easterly winds and river flooding. Dinnel and Schroeder (1990) investigated the wind effect and compared the data with a gage on the coast at Gulf Shores, Alabama. They concluded that the DISL gage is reasonably representative of the open Gulf coast water levels.

The DISL tide gage data have not been analyzed for extreme value statistics. High water level marks at the east end of the island after Hurricane Frederick were found at 9 feet above NGVD (National Geodetic Vertical Datum of 1929; which is about 0.3 feet above MLLW). Water marks as high as 13 feet above NGVD were found two to three miles west of Fort Gaines.

Long-term sea level rise has been estimated by plotting the average water level at Biloxi (Plate II, US Army 1978). There is a clear upward trend which is on the order of 5 or 6 inches from 1900 to 1970.

4.D. SEDIMENTS

Hummell (1990) has mapped the type of bottom surface sediments in the main pass area. Around Dauphin Island, the only non-sand on the surface is clay in the deepest part of the natural channel by Fort Morgan. No detailed mapping of the sand sizes has been located. A typical median diameter for the sand being dredged during the deepening of the ship channel is 0.2 mm (Hands and Bradley 1990). On the beach face, samples as coarse as 0.56 mm median diameter have been found (Otvos 1982). Apparently, several investigators have considered the sand size distribution in detail but literature references have not been located.

4.E. LITTORAL DRIFT

US Army (1978) references a contracted study by Walton (1974) that estimates that the net littoral drift, or longshore sand transport rate, along Dauphin Island is 460,000 cubic yards per year to the west. This consists of 140,000 cubic yards per year to the east and 600,000 cubic yards per year to the west. The method used by Walton is very crude and should probably only be used for determining the general direction of littoral drift. Walton's method uses visual estimates of wave height, period and direction from ships (SSMO data) in the general vicinity on the Gulf of Mexico. The wave data is transformed into shallow water where an empirical longshore sand transport equation is applied (Walton 1973). Walton's method clearly applies only to the open Gulf beaches on the west end of the island away from the sheltering effects of the ebb-tidal delta complex (Sand Island).

It was noted in the section on winds that the winds from the east of south are much more common than the winds from the west of south. Thus, the portion of longshore sand transport due to locally generated sea waves moves more sand to the west than the east. Some portion of sand movement along the beach is due to waves which have been generated elsewhere in the Gulf and have propagated to the beaches as swell.

No quantitative or even qualitative estimates of longshore sand transport rate for the east end of Dauphin Island have been made. The changes in the direction and rate of sand movement along the beaches, both in time and in location, are probably a very critical influence on the beach erosion problem. Visual wave observations would be a low-cost way to collect such data.

4.F. STORMS

Individual hurricanes have had obvious, dramatic effects on the beaches of Dauphin Island. US Army Corps of Engineers, Mobile District (1981); Schramm, et al (1980); and Nummedal, et al (1980) describe the impacts of Hurricane Frederic on Dauphin Island.

These references contain air photos taken after the storm that clearly show that sand was transported across the island from the beaches into the Mississippi Sound. This overwash process occurred west of the high dune fields. Schroeder and Wiseman (1985) present some of the water level and wind data from Frederic.

4.G. OTHER LITERATURE

Bradley and Hands (1989), Hands and Bradley (1990), and McLellan and Imsand (1989) describe what the Corps of Engineers is currently doing with the dredged material from the Mobile ship channel deepening project. The material is being dumped in two large, underwater mounds. Most of the silts and clays dredged from within the Bay are being dumped in about 40 feet of water. Some of the sandy material from the outer reaches of the channel across the ebb-tidal shoals is being dumped in about 20 feet of water directly south of Fort Gaines, adjacent to the Sand Island shoals. The intent is for the fine-grained silts and clays to stay in the deeper water away from the beaches and for the sand to eventually move up onto the Sand Island shoals and onto the Dauphin Island beaches. The above cited references focus on the Corps' programs to determine how these mounds are behaving.

US Army (1990) describes a proposed project to dredge the channel behind Little Dauphin Island to a depth of 8 feet. The dredged sand will be placed on the Mobile Bay side of Little Dauphin Island. Although some mention is made of using the East end of Dauphin Island as an alternative disposal site, this alternative is not clearly specified nor used in the cost analysis. Presumably, none of the sand will be placed on Dauphin Island unless local or state governments pay for the difference in cost to put it there. The sand is probably of beach quality and would make a good beachfill.

5. COASTAL ENGINEERING HISTORY OF DAUPHIN ISLAND

There is no comprehensive history of the coastal engineering efforts along Dauphin Island. The dredging records related to the Mobile Ship Channel are probably available from the Corps of Engineers although they are not in the literature. Complete records would include how much material was removed, where it was removed from, when it was dredged, and where it was disposed of. The small boat area at the northeast corner of the island is visible on 1940 air photos. The date of its construction and the entrance groins should be documented. The groins around the fort and the groin field of ten groins south of the fort are also visible on the 1940 air photo. Dates when these groins were installed should be established in order to understand the historic changes in shoreline location.

Some coastal engineering history of importance is the history of the 1980 beachfill at the east end of the island. The best way to predict the behavior of a proposed beachfill is to look at how a previous beachfill behaved. The Corps' air photos described above include semi-annual photos since 1980 and would be an excellent database to use to determine the performance of the 1980 beachfill. Photos taken from the ground by DISL personnel would supplement the air photos. Apparently (Crozier 1990, personal communication), much of the beachfill sand moved south and west around the tip of the island into and through the groin field during the next several years.

The history of the dredging immediately adjacent to the island should be compiled. This should include the dredging of Billy Goat Hole and the waterway to Dauphin Bay. The dredging requirements in the small boat basin directly north of the fort have been a recurring problem. From personal discussions (Mike Henderson, George Crozier and others), it appears that dredging was required across the entrance on an annual basis during the 1980's. The rate of shoaling and, therefore, the frequency of required dredging have decreased in recent years. A logical explanation of the dredging requirements is that some of the sand placed on the 1980 beachfill was moving along the beach and nearshore around the end of the island into the entrance to the boat basin. As the beachfill eroded to the point where the jetty and groins became more exposed, the longshore transport of sand decreased and the shoaling rate decreased. These dredging records should be located and summarized. These data would help explain the fate of the 1980 beachfill behavior.

6. COASTAL PROCESSES OF DAUPHIN ISLAND

The ebb-tidal delta, including Sand Island and all the shoals, provides partial protection from waves to the east end. The shoals also have probably provided sediment to the beaches of Sand Island. How the sand gets from the Sand Island area to the Dauphin Island beaches is a question of major importance. Although the evidence is sketchy, the dominant direction of longshore sand transport along the Alabama coast is westward from Florida to Mississippi. Sand moves westward some days and eastward some days but the westward rate is probably higher as Walton's estimates show. Sand moving westward from the Fort Morgan Peninsula doesn't directly cross the Mobile Pass onto Dauphin Island. Historically, this sand moved into the western slopes of the Pass and was swept out to the ebb-tidal shoal (Dixie Shoals). From there it slowly moved along the outer bar of the ebb shoal until it reached the Sand Island shoals. The movement of sand from the eastern shoals (Dixie Shoals) to the western shoals (Sand Island) may have been accomplished by an eastward realignment of the outer portion of the ebb shoal during storm events. Since dredging began, man has removed this sand from the western edges of the channel across the outer bar and has removed it from the littoral system by dumping it in deep water several miles to the west.

Because of the alignment of Sand Island, longshore sand transport moves towards Dauphin Island. The depths of the tidal channel (Pelican Passage) between the fishing pier and the northwestern tip of Sand Island have been greater than ten feet at the time of each historical bathymetric survey. The mechanism of sand transport across this gap is unclear. Two possible mechanisms are small, steady, tide-influenced transport and episodic transport of large amounts due to island and shoal breaching. In the first instance, waves would gradually move sand off the tip of Sand Island into Pelican Passage where the tidal currents would move it east and west. Some of the sand would eventually reach the Dauphin Island beachface. In the second instance, a more episodic movement of sand would occur after breaching of the tip of Sand Island. In other words, if Sand Island were to break in half during a hurricane, like it may have in the past, Pelican Passage might relocate through the resulting gap. Sand in the shoal closest to Dauphin Island would be free to move onto the Dauphin Island beaches. Such a scenario is typical of inlets with large, distinct ebb shoals like Sand Island. Thus, a large volume of sand is added to the beaches at one time. It would then be free to move both east and west along the shoreline.

The evidence for episodic breaching at Mobile Pass is not strong. However, inspection of the historical shoreline change map (Figure 1) shows that in 1850 Sand Island extended farther to the north than it does even today. The shoreline of Dauphin Island was located much farther to the north in 1850 than today. The bathymetry from this USC&GS chart (Figure 3) shows that Sand Island was split in two and there were depths through the split of 2 fathoms (12 feet). The shoreline twenty years later, 1869, shows a very large bulge in the Dauphin Island shoreline (up to 2000 feet of shoreline accretion) and the exposed portion of Sand Island located about 3000 feet south of where it was in 1850.

Apparently, as Sand Island lengthens to the north, Pelican Passage is pushed north into Dauphin Island. This may be what is occurring today that is causing the shoreline recession near the pier.[3]

The historical location of the eastern tip of Dauphin Island has almost definitely been effected by man's presence. The groins and seawall protecting the fort have successfully prevented the island tip from migrating to the west. Inspection of air photos shows this "armored" tip of the island extending farther to the east and southeast than the adjacent beaches. The adjacent beaches include the south side of the east end of Dauphin Island and the shoreline along Little Dauphin Island.

Another impact of man on the shoreline of Dauphin Island is the channel cut to Billy Goat Hole on the north side of the east end. Before this cut sand was able to move along the beaches from Little Dauphin Island to the east end of Dauphin Island during times when waves and winds were from the north. Dredging this channel removed a path of sand transport onto the east end. There is a build-up of sand on the north side of the jetty on the north side of the channel. This build-up indicates that sand may be moving towards the channel from the beaches of Little Dauphin

---

[3]The position of the tip of Sand Island appears to be more to the west today than in 1850.

Island. Thus, instead of reaching the east end of Dauphin Island, the sand remains trapped against the jetty.[4]

7. EVALUATION OF EXISTING DATA

Our existing understanding of the coastal processes around Dauphin Island is rather poor. Specifically, the questions about why the beaches are eroding at the east end and the fishing pier cannot be conclusively answered because there is no documented evidence of where the sand is going or why. Several hypothetical explanations of parts of the sand transport paths around the east end can be made and have been mentioned in some of the literature. Unfortunately, the quantifiable evidence and the correlations are weak.

Fortunately, the existing database for coastal engineering analysis and design is not completely lacking. The data sets described above have been gathered for different purposes. They just have never been gathered and analyzed from a coherent coastal processes perspective. These data should be gathered and supplemented so the whole coastal processes picture can be evaluated.

---

[4]The recent history of the Corps dredging disposal in this area must be investigated. This build-up of sand north of the entrance channel jetty may have been placed there during dredging.

8. WATERFRONT STABILIZATION PLAN

Possible alternatives for stabilizing the waterfront are outlined below. However, the final decisions concerning which of the alternatives to pursue should be based on a focussed analysis of the coastal processes data and will have to be made by the politicians and, ultimately, the citizens of the area. It must be emphasized that there are no cost efficient coastal engineering solutions that will work in all cases. The wrong approach can harm adjacent beaches and waste money. Therefore, understanding why the beaches are eroding and having a clear understanding of how a proposed solution will function is necessary. Based on the present understanding of the coastal processes, the following alternatives are proposed and discussed below:

1) Do Nothing
1) Maintain Present Levels of shore protection effort
2) Beach Nourishment of the east end
3) Modifications to the Armoring of the east end
4) Manipulation of Sand Island shoals
5) Combinations of the above alternatives

1) Do Nothing

The do nothing alternative means abandoning the shoreline and spending no further money to maintain the location of the road, beach, or fort. Without previous coastal engineering (including the dumping of sand, rubble and other material to protect the road), the fort would presently be exposed daily to waves and currents and perhaps be destroyed by now. Maintaining the fort's present location will therefore require some form of continuing manipulation of the coastal processes by man. Abandonment of the fort and retreat will cost money for removal! The material dumped along the road, the roadway itself, the stones in the groins and rubble wall, and the fort would need to be removed. Cost estimates are not placed on this alternative. The remainder of this report is based on the policy assumption that moving, removing, or abandoning Fort Gaines is not an acceptable alternative.

2) Maintain Present Levels of shore protection effort.

The present level of shore protection effort includes the dumping of material along the roadway after large storms to protect the roadway. It also includes the periodic dredging of the boat basin and the Billy Goat Hole area. The risk of this alternative is that the present shoreline recession along the south side of the east end will continue. The historical shoreline changes discussed above show some long-term (50-150 year) cyclical phenomenon might restore the shoreline to its old location. However, the mechanisms that would cause this shoreline accretion are very unclear at this time and they may not repeat themselves again. For instance, the long-term removal of sand from the system by the Corps of Engineers during the past 50 years of dredging of the ship channel bar may be changing the natural processes. Even without the influence of man, the natural system is changing over the long-term. For instance, sea level has clearly risen and the natural migration of the east end of the island is to the west. The costs of maintaining the present levels of shore protection will not be constant, but will continue to escalate. The commissioning of this study indicates that the present level of shore protection effort is not acceptable.

3) Beach Nourishment of the east end

Beach nourishment, or beachfill or replenishment, is the mechanical placement of sand on the beach. Usually, sand from nearby shoals is dredged and hydraulically pumped onto the beach. Placing sand on a beach is obviously not a "permanent" or "one-time solution." Sand will wash away and need to be replaced. The philosophy of beach nourishment is that the benefits realized while the sand is in place outweigh the costs of periodic maintenance. The analogy of the homeowner painting his house is appropriate. The homeowner knows that the paint job will only last a few years but the protection and the aesthetics the paint provides are worth the effort. Although a homeowner has a pretty good idea how long his paint job will last, the duration of a beachfill is not as well understood.

The east end of Dauphin Island should have relatively low initial dredging and pumping costs since nearby sand shoals are plentiful. However, the length of duration of an individual beachfill will be relatively short because the tip of the island is so exposed to waves from the north, east, and south. A beachfill on the southern shoreline of the east end will last longer than a beachfill on the immediate eastern tip.

An engineering estimate of the costs and duration of a beachfill will require more study of the local coastal processes. However, a quick-and-dirty estimate of the cost can be made as follows. Beachfills typically cost $1-$5 per cubic yard of sand depending on the size of the fill, the type of dredge used, the distance to the sand source, present dredging market conditions, etc. A 100,000 cubic yard beachfill would initially widen the beach by 100 feet along roughly 3000 feet of beach front. Assuming $5 per cubic yard, since it is a small beachfill, it could cost $500,000. By contrast, the beachfill presently being placed on the eastern end of Perdido Key has 6 million cubic yards of sand widening the beach about 400 feet along about 6 miles of shoreline.

An estimate of the expected replacement or maintenance interval requires further study of the behavior of the 1980 beachfill. A educated guess is replacement of fill could be required as often as annually along the eastern facing shoreline and up to once every 5 to 10 years along the southern facing shoreline. Remember that a beachfill will probably increase the future dredging costs in the small boat basin and the entrance to Billy Goat Hole.

The beachfill costs could be paid by the federal government in a number of ways. Although the cause and effect would be hard to prove, the federal government could be held responsible for historical shoreline erosion due to the dredging of the Mobile ship channel and the entrance channel to Billy Goat Hole. The mechanism exists within the law whereby erosion of adjacent beaches caused in part by federal navigation projects must be fixed by the federal government. A logical and cost effective fix would be the direct pumping of sand onto Dauphin Island beaches.

4) Modifications to the Armoring of the east end

The armoring of the east end could be modified to better protect the roadway and fort while making the area more attractive aesthetically. For instance, the dumped rubble could be replaced with an engineered, rubble-mound revetment. The result would require some maintenance after large storms but not the level required at present. Although the armoring of shorelines is not the alternative of choice for most of the nation's coastlines, this stretch at Dauphin Island could be an exception. If a nice swimming beach is not required here, modifications to the armoring should be investigated further. The waters are immediately adjacent to the ebb tidal currents in Mobile Pass and drownings are not uncommon.

The costs of revetments varies from $100-$2000 per linear foot depending on the type of construction, the severity of wave climate, availability of quarrystone, etc. A quick-dirty-estimate of the cost of the appropriate protection assuming $300 to $500/foot for 2000 feet (around the front of the fort) is $600,000 to $1,000,000. A better estimate of the cost would require preliminary engineering analysis of the required size of the armor units and an investigation onto typical local costs. Some stones are available on site from the existing structures. Armoring will only protect the area directly behind the revetment or seawall. It will not protect the rest of the beaches to the west.

5) Manipulation of Sand Island shoals

Man-induced changes to the natural coastal processes have been used elsewhere to solve beach erosion problems. The most common, successful manipulations are attempts to copy or speed up the shifting of shoals that naturally bypass sand across inlets. Man has already influenced the coastal processes in several dramatic, and unnatural ways at the east end of Dauphin Island. The removal of sand from the ebb-tidal delta for the ship channel, the armoring of the east end, and the dredging of the entrance channel to Billy Goat Hole have already been discussed.

The natural process of Sand Island feeding the beaches of Dauphin Island could be encouraged by creating a man-made breach in the Sand Island. A dredge could be used to create the breach and attempt to relocate Pelican Pass channel to the north of its present location. Sand in the northern portion of Sand Island would then be driven onshore by waves. If the breach were wide enough, the exposure to waves from the west of south would move some of the sand eastward towards the east end of Dauphin Island. The cost of this alternative would depend on the width and depth of the breach needed. It has some possible cost advantages in that the bulk of the eventual sand movement would be natural and a side-casting dredge could create the breach. Further study of the historical charts and photos to understand whether such breaching has actually occurred is absolutely necessary. It is included here as a possibility for further consideration.

6) Combinations of the above alternatives

The optimal solution for effectiveness at the least cost is probably a combination of the above alternatives. Structures are commonly used in conjunction with beachfill projects to extend the life of the beachfill. If the cost of the structure is less than the savings realized by increasing the renourishment period, the structure should be considered. Specifically, extending and/or realigning the jetty adjacent to the boat basin should be considered to keep beachfill sand on the beach and out of the channel. Another possible combination is the use of offshore segmented breakwaters to extend the life of the beachfill. The present "flanked" groin field south of the fort is functioning like offshore breakwaters. However, breakwaters are aligned parallel to the shoreline. The stones in the groins could be realigned to function better as offshore breakwaters.

A possible combination is to armor the shoreline around the fort and nourish the beaches on the southern facing shore to the west (DISL, Coast Guard, campground, and Audubon land). Thus, fixed facilities could be developed around the fort while providing a softer solution to the beach erosion problem of the southward facing landowners. For this alternative, the groin field could be modified to function as offshore segmented breakwaters to extend the life of the beachfill.

9. RECOMMENDATIONS

The East End Management Task Force and the Town of Dauphin Island should consider the possible waterfront stabilization plans outlined above. Selection of the preferred alternative will require decisions about the desired use of the east end of the island. For example, if a beach is desired at the tip of the island than it will have to be put there and maintained there with the increased dredging costs. Perhaps, a seawall may be acceptable along the east side of the fort but not around on the southern facing beaches. A combination of strategies will probably be adopted. For example, the seawall can be modified to protect the road and a possible boardwalk or sidewalk and the groin field can rebuilt to function as offshore segmented breakwaters protecting a beachfill along the southern facing beaches.

In order to evaluate these alternatives in more detail, better cost estimates require a better understanding of the coastal processes of the area. Specific areas of study outlined above include the collection of low-cost, visual wave climate data; investigation of historic shoreline change data through air photos and historic charts; and, documentation of recent and future beach erosion trends with air photos and beach surveying.

BIBLIOGRAPHY

Abel, C.E., Tracy, B.A., Vincent, C.L., and Jensen, R.E., 1989. "Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956-1975". WIS Report No. 19, US Army Engineer Waterways Experiment Station, Vickburg, Mississippi.

Abston, J.R., Dinnel, S.P., Schroeder, W.W., Schultz, A.W., and Wiseman, Wm J. Jr., 1987. "Coastal Sediment Plume Morphology And Its Relationship To Environmental Forcing: Main Pass, Mobile Bay, Alabama". Proceedings of the Coastal Sedinments '87 Conference, American Society of Civil Engineers, pp. 1989-2005.

Bearden, B.L., Hummell, R.L., and Mink, R.M., 1989. "Geomorphology Of Coastal Sand Dunes, Baldwin County, Alabama" Proceedings of Coastal Zone '89 Conference, American Society of Civil Engineers, pp. 1038-1050.

Bradley, K.P., and Hands, E.B., 1989. "Dredged Material Underwater Berms." Proceedings of Coastal Zone '89 Conference, American Society of Civil Engineers, pp. 2947-2954.

Crozier, G.F., 1987. "Beach Trends In Coastal Alabama". Dauphin Island Sea Lab Technical Report No. 88-001, Dauphin Island Sea Lab, Al.

Dinnel, S.P., and Schroeder, W.W., 1989. "Coastal Water Level Measurements, Northeast Gulf of Mexico". Journal of Coastal Research, Vol. 5, No. 3, 553-561, Charlottesville, VA.

Hands, E.B., Allison, M.C., and McKinney, J.P., 1990. "Dispersion of Waves From Hurricane Gilbert and Their Intermittent Reception on the Alabama Coast". Offshore Technology Conference, Houston, Texas.

Hands, E.B. and Bradley, K.P., 1990. "Construction of the Sand Island Nearshore Berm and Assessment of the First Year's Monitoring Results". US Army Corps of Engineers, Waterways Experiment Station Technical Report CERC- (draft), Vicksburg, MS.

Hubertz, J.M. and Brooks, R.M., 1989. "Gulf of Mexico Hindcast Wave Information". WIS Report No. 18, US Army Engineer Waterways Experiment Station, Vickburg, Mississippi.

Hummell, R.L., 1990. "Main Pass and the Ebb-Tidal Delta of Mobile Bay, Alabama". Geological Survey of Alabama, Energy and Coastal Geology Division, Circular 146.

Kent, H.C., 1976 "Modern Coastal Sedimentary Environments Alabama and Northwest Florida". unpublished report, Geological Exploration Associates, Ltd., Golden, CO.

Lamb, G.M., 1987a. "Erosion Downdrift from Tidal Passes in Alabama and the Florida Panhandle". Bulletin of the Association of Engineering Geologists, Vol. XXIV, No. 3, pp 359-362.

Lamb, G.M. 1987b. "Coastline Development and Change in Alabama and the Florida Panhandle" Gulf Coast Association of Geological Societies Transactions, v. 37, p. 393-398.

McLellan, T.N. and Imsand, F.D., 1989. "Berm Construction Utilizing Dredged Material". Proceedings of WODCON XII, Western Dredging Association, Fairfax, VA.

McLellan, T.N., Pope, M.K., and Burke, C.E., 1989. "Benefits of Nearshore Placement". US Army Engineers, Coastal Engineering Research Center, Waterways Experiment Station, Vicksburg, MS.

McLellan, T.N., Truitt, C.L., and Flax, P.D., 1989. "Nearshore Placement Techniques for Dredged Material". US Army Corps of Engineers Waterways Experiment Station.

NOAA, 1989. "Tide Tables 1990, East Coast of North and South America," US Dept. of Commerce, 290 pp.

Nummedal, D., Penland, S., Gerdes, R., Schramm, W., Kahn, J., and Roberts, H., 1979. "Geologic Response To Hurricane Impact On Low-Profile Gulf Coast Barriers". Transactions - Gulf Coast Association of Geological Societies, v. 30, pp. 183-195.

Otvos, E.G., 1982. "Coastal Geology of Mississippi, Alabama and Adjacent Louisiana Areas". Guidebook, Gulf Coast Research Laboratory, Ocean Springs, MS, Field Trip June 5-6, 1982, The New Orleans Geological Society, New Orleans, LA.

Otvos, W.G., 1976. "Mississippi Offshore Inventory and Geological Mapping Project". US Army Engineer District, Technical Library, Mobile, AL., No. 002032.

Sapp, C.D., Emplaincourt, J.G., and Hardin, J.D., 1975. "Remote Sensing of Shoreline Dynamics, Mobile Bay Area". Transactions- Gulf Coast Association of Geological Societies, vo. 25, pp. 153-166.

Schramm, W.E., Penland, S., Gerdes, R.G., Nummedal, D., 1979. "Effects of Hurricane Frederic On Dauphin Island, Alabama". Shore & Beach, vol. 48, no. 4.

Schroeder, W. W., 1976. "Physical Environment Atlas of Coastal Alabama". Mississippi-Alabama Sea Grant Program Report 76-034.

Schroeder, W.W., Huh, O.K., Rouse, L.J., and Wiseman, Wm.J., 1985. "Satellite Observations of the Circulation East of the Mississippi Delta: Cold-Air Outbreak Conditions". Remote Sensing of Environment, 18:49-58, Elsevier Science Publishing Co., Inc., NY.

Schroeder, W.W. and Lysinger, W.R., 1979. "Hydrography and Circulation of Mobile Bay". Symposium on the Natural Resources of the Mobile Bay Estuary, Alabama, pp. 75-94.

Schroeder, W.W., and Wiseman, W., Jr. 1985. "An Analysis of the Winds (1974-1984) and Sea Level Elevations (1973-1983) In Coastal Alabama". Mississippi-Alabama Sea Grant Consortium Publication No. MASGP-84-024.

Sears, R.D.,1983. "Coastal Alabama Shoreline Erosion". Alabama Department of Economic and Community Affairs, State Planning Division, Research and Graphics.

Shirley, T., 1984. "The Perdido Pass Area: A Geomorphological And Historical Report". undergraduate dissertation. University of South Alabama, Geology Dept.

Smith, W.E., 1989a. "Mississippi Sound North Shoreline Changes in Alabama, 1955-1985". Geological Survey of Alabama, Information Series 67.

Smith, W.E., 1989b. unpublished plots of the beach profiles along Dauphin Island and the descriptions of the monument locations.

US Army Engineer District, Mobile. "Mississippi Sound and Adjacent Areas - Final Report," v. III, App. E, Resource Inventory.

US Army Engineer District, Mobile. 1978. "Mobile County, Alabama, Feasibility Report for Beach Erosion Control and Hurricane Protection". Mobile, AL.

US Army Corps of Engineers, Mobile District. 1981. "Hurricane Frederic Post Disaster Report," Mobile, AL.

US Army Engineer District, Mobile. 1990 "Detailed Project Report, Fort Gaines Channel, at Dauphin Island, Alabama."

Walton, T.L. 1973. "Littoral Drift Computations Along the Coast of Florida By Means of Ship Wave Observations," Technical Report No. 15, Coastal and Oceanographic Engineering Laboratory, University of Florida, Gainesville, Florida,

Walton T.L., and Adams, W.D. 1976. "Capacity of Inlet Outer Bars to Store Sand," Proceedings of the 16th International Conference on Coastal Engineering, Honolulu, Hawaii, American Society of Civil Engineers, New York, pp. 1919-1937.

Wiseman, Jr., Wm.J., Schroeder, Wm.W., and Dinnel, S.P., 1988. "Shelf-Estuarine Water Exchanges Between the Gulf of Mexico and Mobile Bay, Alabama". American Fisheries Society Symposium 3:1-8.