RECENT RATES OF SHORELINE EROSION AT SARGENT BEACH, MATAGORDA COUNTY TEXAS

Robert A. Morton

Bureau of Economic Geology

The University of Texas at Austin

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EXECUTIVE SUMMARY

The Gulf shoreline at Sargent Beach, Texas is the most rapidly eroding open coast shoreline in the State and one of the most rapidly retreating beaches in the Gulf of Mexico. Because the Gulf Intracoastal Waterway (GIWW) is so close to the Gulf shoreline along this ten-mile coastal segment, continued erosion will breach the Waterway in the near future and preclude navigation through the GIWW unless preventive action is taken. Protecting the Waterway is of paramount importance considering the large negative economic impacts that would occur if the Waterway was even temporarily closed.

A study was conducted to determine the recent rates of erosion at Sargent Beach and to evaluate the factors that control erosion of this beach. Results of the study demonstrate that erosion at Sargent Beach accelerated after 1930 and recent rates of erosion generally are consistent with the higher rates recorded after 1930 (Figure). Erosion rates increase from northeast to southwest (Table 1) and highest erosion rates since 1965 consistently occur in the developed area east and west of State Road 457 (stations 37 to 42). Within this segment of rapid beach erosion, highest measured rates between 1987 and 1991 ranged from 51.6 to 67.3 ft/yr (Table 1) where the Gulf shoreline intercepted a dredged canal and encountered a former artificial inlet between the Gulf and the GIWW. Since 1974, the width of land between the high water line of the Gulf of Mexico and the south bank of the GIWW has rapidly decreased at some sites (Table 2) as a result of both beach erosion and bank erosion along the GIWW.

Recent rates of beach erosion along the Gulf shoreline have depended on storm frequency and intensity as well as on changes in the volume of sediment transported by waves and currents in the Gulf of Mexico. Future erosion rates will probably be similar to the most recent rates unless a major hurricane strikes the area causing a rapid increase in erosion or the sand supply is altered by human activities. Placing sand directly on the beach (beach nourishment) or bypassing sand around the San Bernard River would likely reduce erosion at Sargent Beach, whereas interception of the littoral material by dredging at the San Bernard River mouth or by placing structures perpendicular to the Gulf shoreline would prevent sand from reaching the downdrift coastal segment and would increase erosion at Sargent Beach.

Table 1. Recent average annual erosion rates (ft/yr) at Sargent Beach for selected periods.

	1965-1991 (25.3 yr)		1965-1987 (21.5 yr)		1974-1987 (12.7 yr)		1987-1991(3.9yr)	
Station	Dist.	Rate	Dist.	Rate	Dist.	Rate	Dist.	Rate
32	468	18.4	432	20.1	132	10.4	36	9.1*
33	441	17.4	363	16.9	138	10.9	78	19.7
34	580	22.9	520	24.2	220	17.3	60	15.2
35	618	24.4	554	25.8	254	20.0	64	16.1
36	711	28.1	642	29.9	292	23.0	69	17.3
37	868	34.3	805	37.4	430	33.9	63	15.8
38	907	35.8	844	39.3	444	35.0	109	27.5
39	935	36.9	780	36.2	505	39.8	155	39.2
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39.8							266	67.3
40	830	32.8	715	33.3	440	34.7	115	29.1
41	808	31.9	646	30.0	446	35.2	162	41.0
42	767	30.3	650	30.2	400	31.6	117	29.5*

*At edge of 1991 photograph and short of station location

Table 2. Decrease in land width at Sargent Beach between Intracoastal Waterway and Gulf high water line, 1974-1991.

	Measurement Stations									
Year	40	39.8	39.6	39.3	39	38	37	36	35	34
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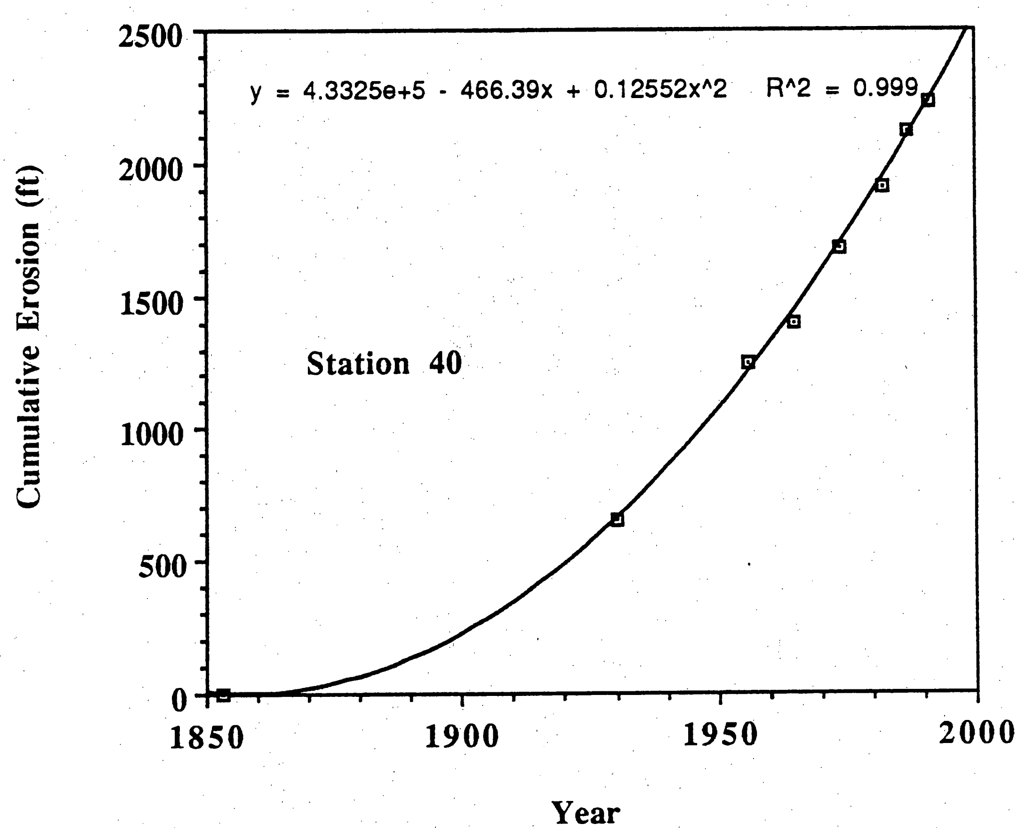

Figure. Typical plot showing accelerated erosion since 1930 at Sargent Beach Texas.

INTRODUCTION

The Gulf shoreline at Sargent Beach, Texas (fig. 1) is the most rapidly eroding open coast shoreline in the State and one of the most rapidly retreating beaches in the Gulf of Mexico. Because the Gulf Intracoastal Waterway (GIWW) is so close to the Gulf shoreline along this ten-mile coastal segment, continued erosion will breach the Waterway in the near future (Morton, 1989) and preclude navigation through the GIWW unless preventive action is taken. Protecting the Waterway is of paramount importance considering the large negative economic impacts that would occur if the Waterway was even temporarily closed.

The U.S. Army Corps of Engineers (1990) is preparing a plan to protect the Waterway and to prevent its destruction. The construction schedule for protecting the Waterway is partly determined by the projected date when the Waterway will be inoperable if no preventive action is taken. Despite its importance, the time when the Waterway would be inoperable is difficult to estimate because (1) erosion rates are not uniform in time or space, (2) future storm impacts and attendant rapid erosion are unpredictable, and (3) local erosion rates have been altered by changes in the sediment budget both within and adjacent to the coastal segment of interest.

Several previous studies of erosion rates at Sargent Beach can be used to evaluate past erosion trends and to assist in predicting the time when the Gulf shoreline will be at the GIWW. Erosion rates at Sargent Beach between 1853 and 1982 were summarized by Morton and Pieper (1975) and Paine and Morton (1989). However, only limited data are available for rates of erosion between 1982 and 1987 (Morton, 1989) and no published information is available regarding current (1991) erosion rates. An independent analysis of erosion rates at Sargent Beach is being conducted by the Coastal Engineering Research Center (Don Stauble, personal communication, 1991), but results of that study currently are unavailable.

The purposes of this investigation are (1) to determine the most recent rates of erosion along Sargent Beach, (2) to estimate the average annual volume of sediment eroded from the ten-mile beach segment, (3) to analyze the temporal and spatial variability of the shoreline changes, and (4) to evaluate the influence of recent beach alterations on rates of erosion. The last objective is particularly important because short-term variability in erosion rates can either signal a change in the long-term trend or they may be only a temporary aberration in the long-term trend.

ANALYSIS OF EROSION RATES

The analysis of recent erosion rates at Sargent Beach involved three different efforts: (1) comparison of shorelines mapped on aerial photographs, (2) comparison of beach profiles, and (3) calculation of volumetric losses.

Aerial Photographs

Methods- Shorelines for 1987 and 1991 were mapped and compared in order to complete the shoreline change analysis between 1982 and 1991. Low-altitude black and white vertical aerial photographs taken in March 1987 (scale 1"=1,000') were obtained from the Texas General Land Office and comparable photographs taken in February 1991 (scale 1"=500') were provided by Lanmon Aerial Photography Inc.

Criteria used to map shorelines on aerial photographs depended on beach composition. Outcrops of mud on the beach, which occur between stations 37 and 41 (fig. 1), are highly crenulated in plan view. They appear as dark, irregular patches in contrast to the surrounding white sand and shell. Washover deposits of sand and shell, which lie above and landward of the mud outcrops, may also appear as sandy beach deposits on aerial photographs. The landward expression of the mud outcrops was mapped as the shoreline because the erosional escarpment typically coincides with the landward limit of wave runup and therefore it approximates the position of the berm on sandy beaches.

The boundary between the wet beach and dry beach was mapped as the shoreline on sandy beaches. This boundary is consistent with shorelines mapped for previous studies (Morton and Pieper, 1975; Paine and Morton, 1989; Morton, 1989). Low-altitude oblique color photographs taken in March 1991 were used to confirm the position of the shoreline mapped on the February 1991 vertical aerial photographs.

The 1987 and 1991 shorelines were optically transfered to base maps that also portray shorelines previously mapped by Morton and Pieper (1975), Paine and Morton (1989), and Morton (1989). A microrule was used to measure distances between the 1982, 1987, and 1991 shorelines at reference stations 32 through 42 (fig. 1). Rates of erosion at each station were calculated by dividing the distance between the 1982, 1987, and 1991 shorelines by the elapsed time. The data were stored in tables and used to plot cumulative erosion versus time at each reference station (figs. 2-6).

The monitoring techniques used in this study and their potential sources of error as well as past rates of erosion at the same reference stations are described in more detail by Morton and Pieper (1975) and Paine and Morton (1989). The 1987 and 1991 shorelines were also digitized and stored in ARC/INFO, a geographic information system that is used for shoreline change analysis and construction of map displays.

To maximize the accuracy of the shoreline comparison for the most recent time period, the 1987 shoreline was also transferred directly onto the 1991 photographs using a Zoom Transfer Scope.

Ample geomorphic and cultural control exists on both sides of the GIWW to insure proper registry of the two images. Measuring stations 32-42 located on the topographic maps were also projected onto the 1991 photographs to facilitate data reduction and to maintain consistency between the 1982-1987 and 1987-1991 data sets.

Results- The magnitude and rates of beach erosion between 1982, 1987, and 1991 are incorporated in figures 2-6. Rates of erosion generally increase from east to west and maximum erosion equal to or greater than 30 ft/yr is concentrated in the developed area between stations 38 and 42 (Table 1). The plot of alongshore erosion rates (fig. 7) illustrates the spatial and temporal variability in erosion of the Gulf shoreline. The plot also shows that the highest measured rates of erosion generally occurred between 1965 and 1974 except west of station 40 where maximum rates of erosion occurred between 1982 and 1987. Between 1987 and 1991, erosion rates generally decreased compared to the preceding time period. Because erosion rates are neither uniform nor constant, the most recent accelerations and decelerations in erosion are best interpreted in comparison with past rates of erosion (figs. 2-6) and in the context of any known or suspected changes to the littoral system. Considering the sequential rates of erosion for individual time periods, the most recent trends do not depart dramatically from the overall accelerated trends established after 1930 (figs. 2-6).

Average annual erosion rates were calculated for four recent time periods to evaluate the unsteady nature of beach erosion. The periods were selected to approximate 5, 15, 20, and 25 year intervals as closely as the data would allow (Table 1). The calculations show that at stations 32-38 erosion rates were highest between 1965 and 1987 but at stations 39-42 erosion rates were highest between 1974 and 1987. Maximum average erosion rates recorded for the four periods occurred at either station 38 or 39 (39.3 ft/yr and 39.8 ft/yr respectively). Average erosion rates were consistently equal to or greater than 30 ft/yr at stations 37-42 for all three periods investigated.

Local observers have reported exceptionally high erosion rates at Sargent Beach between stations 39 and 40 based primarily on ground measurements made near FM 457 and McCabe's Cut. To investigate the maximum short-term erosion rates for the ten-mile segment, supplementary measurements of shoreline changes between 1987 and 1991 were made at FM 457 and one each on the east and west side of McCabe's Cut (Table 1). Those measurements show rates of erosion ranging from 51.6 ft/yr to 67.3 ft/yr. Together, accelerated erosion at these sites caused a substantial but local embayment of the Gulf shoreline.

The anomalously high rates of erosion between stations 39 and 40 are attributed (1) to recession of the banks of McCabe's Cut before it was closed and (2) to interception of a dredged canal immediately west of FM 457. The hydrostatic head differential between the Gulf and the Intracoastal Waterway periodically created strong flood and ebb currents through McCabe's Cut that scoured the banks and channel bed and transported large volumes of littoral drift into the GIWW. Together erosion of the channel banks and associated increased erosion of the adjacent Gulf shoreline created a large funnel at the Gulf entrance of McCabe's Cut. Erosion on the east side of the Cut was also enhanced by a finger canal dredged parallel to the Gulf shoreline when the Sargent Beach community was being developed. The dredged canal was partly filled by sand and shell transported from the Gulf and deposited in the canal by storm waves. Gulf shoreline erosion locally accelerated when the beach intersected the canal because the washover deposits that filled the canal were more easily eroded than the surrounding stiff mud.

The magnitude of erosion at Sargent Beach was also examined by measuring the width of land between the GIWW and the Gulf high water line in 1974, 1982, 1987, and 1991 (Table 2). Each measurement was made directly from aerial photographs and converted to distance according to the scale of the photograph. This procedure is much faster but less accurate than transferring all the data to a single base map and making measurements at the same scale and exact location. An evaluation of errors in measurement indicates that the reported distances (Table 2) are probably within 50' of true distances. Errors are attribute to different scales of photographs ranging from 1"=2,000' to 1"=500', using uncontrolled photographs that contain slight distortions and scale variances, and minor differences in locating the reference stations on each photograph. Because land width measurements also include some bank erosion of the GIWW and because the high water line was used as the mapping boundary, the decreases in land width are not the same as magnitudes of erosion measured for the Gulf shoreline for the same time periods.

The measurements show that the land width has substantially decreased between 1974 and 1991 (Table 2). The area of greatest narrowing is located between stations 39 and 40, especially in the vicinity of McCabe's Cut (supplementary station 39.6). This same locale exhibits the greatest risk of land breaching either due to continued erosion or during a storm because (1) long-term and short-term erosion rates are the highest for the entire ten-mile segment, (2) elevations are near sea level between the Gulf and the GIWW, (3) the land between the Gulf and the GIWW is narrow, (4) the presence of another shore-parallel canal will accelerate erosion rates in the near future. and (5) the material filling McCabe's Cut is more easily eroded than the cohesive mud along adjacent beaches.

Beach Profiles

Methods- Average annual erosion rates for the same area and similar time period can also be estimated using the five beach profiles surveyed by the Galveston District Corps of Engineers in January 1989 and January 1991. Approximate positions of the beach profiles were located on the 1991 aerial photographs using a small-scale map provided by the Corps of Engineers. Erosion rates between 1987 and 1991 were also determined from the aerial photographs at the estimated positions of the beach profiles and are reported for comparison (Table 3).

Results- Comparing beach profiles illustrates that different rates of erosion can be measured at the same profile location depending on the datum selected (Table 3). The zero intercept and berm were selected for the erosion analysis because the former is a fixed datum and the latter is a geological feature that more closely corresponds to the wet beach-dry beach boundary mapped on aerial photographs.

Erosion rates determined for the zero intercept (Table 3) show a trend of increased rates of erosion to the west that range from no change (S-1) to 41 ft/yr (S-4). Rates of berm erosion determined from the same beach profiles range from 19 ft/yr to 45 ft/yr and they are generally higher and more variable than those determined for the zero intercept.

Discrepancies between erosion rates determined from aerial photographs and those calculated from beach profiles (Table 3) are related (1) to imprecision in locating beach profiles relative to measurements made on photographs, (2) to the use of different datums or morphological features to represent the shoreline, and (3) to averaging erosion rates over different short periods of time. In general, the rates of erosion determined from aerial photographs agree more closely with the berm recession rates documented on beach profiles rather than to recession rates of the zero intercept.

VOLUMETRIC ANALYSIS

Methods- The average annual volumes of sediment eroded from the beach and nearshore zone between 1982, 1987, and 1991 were estimated using (1) the surface area eroded for each station segment and (2) an average sediment thickness of 12 ft. This thickness was based on average surface elevations and depths of upper shoreface erosion illustrated on beach profiles at Sargent Beach (U.S. Army Corps of Engineers, 1980). The same thickness was used in previous estimates of volumetric losses from the beach (Morton, 1989).

Results- The volumetric calculations reveal that between 1982 and 1987 the minimum loss of beach and nearshore sediment averaged 532,172 yd^3/yr and between 1987 and 1991 the minimum loss averaged 525,738 yd^3/yr. These remarkably similar rates of volumetric loss for the entire ten-mile segment, which were calculated from independent data sets, agree closely with past rates of loss (fig. 8) estimated by Morton (1989).

DISCUSSION

The rapid erosion recorded at Sargent Beach is a product of natural coastal processes and human activities. The human activities tend to alter the sediment budget whereas the natural processes primarily establish the wave and current energy; however, the erosive forces can also be altered by human activities.

Wave and Current Energy

The physical energy dissipated on Sargent Beach is controlled by meteorological events and is intensified by tropical cyclones and winter storms. Although no hurricanes or tropical storms made landfall at Sargent Beach during the study period, several storms caused abnormally high water levels and waves that contributed to the observed erosion.

1982-1987- During this five-year period, no tropical cyclones had a direct impact on Sargent Beach. Hurricane Alicia (1983) was a minor, small-diameter storm (class 3) that crossed the Texas coast on the west end of Galveston Island. The location and fast forward speed of Alicia prevented any significant shoreline changes at Sargent Beach. Considering the entire time period, the lack of exceptionally high waves, lack of prolonged high tides, and absence of strong storm-generated currents are plausible explanations for the minor decrease in measured erosion rates between 1982 and 1987.

1987-1991- Although hurricanes Gilbert (1988) and Jerry (1989) did not make landfall near Sargent Beach, they both influenced beach changes. Gilbert was a large, class 5 storm that followed a westerly track crossing Jamaica, the Grand Caymen Islands, and Cozumel before making landfall in Mexico. The westerly track of Gilbert raised water levels all along the northern Gulf of Mexico and flooded the beach at Sargent. The abnormally high water at Sargent Beach (approximately 2 ft) redistributed the nourishment sand placed on the beach two months prior to the storm.

In contrast to Gilbert, Hurricane Jerry was a small storm of minimum strength (class 1) that crossed the Texas coast near High Island; therefore, Sargent Beach was on the left side of the eye where storm impact is typically minor. Although Jerry was a small weak storm, the associated elevated water redistributed the beach nourishment material.

Increased water levels associated with both low-pressure systems flooded the beaches at Sargent, reworked washover and beach nourishment deposits, and reconstructed the washover terraces farther inland. The greatest landward transport of washover sediment occurred west of Charpiot's Cut, which coincides with the area of highest erosion. Although these storms redistributed most of the beach and washover deposits, none of these storms caused as much beach erosion as Hurricane Allen in 1980.

Between 1987 and 1991, wave refraction patterns and current patterns between stations 37 and 40 were also modified as a result of the 1989 closing of both McCabe's Cut and Charpiot's Cut. Charpiot's Cut formed about 1975, when beach erosion intercepted a residential development canal, and closed in September 1989 when Hurricane Jerry relocated much of the beach nourishment material placed on the beach earlier that month. In September 1983, McCabe's Cut was dredged between the GIWW and the Gulf in a relict channel segment of Caney Creek. This cut was deliberately plugged in March 1989 with material dredged from the GIWW.

While these artificial inlets were open, longshore currents regularly flowed into the GIWW removing large volumes of sand that were being transported along the beach. Regardless of direction of sediment transport (northeast or southwest) an opening was available to intercept the littoral drift and to deprive the adjacent beach of some of the sand moving along the coast. Now the pathway of sediment transport is unimpeded and sand is freely transferred directly across the former entrances of the inlets. The new Caney Fork Cut, opened in May 1990, is downdrift far enough from Sargent Beach that it probably will not dramatically effect erosion rates like Charpiot's Cut and McCabe's Cut.

Sediment Budget

Between 1982 and 1991, the sediment budget of the study area was dramatically altered by (1) the placement of dredged material directly on the beach, (2) by elimination of two sediment sinks, and probably by (3) introduction of new sediment from updrift sources. All of these conditions would have a positive impact on the sediment budget of Sargent Beach and are undoubtedly responsible for the most recent reduced rates of erosion.

Beach Nourishment- According to records provided by a dredge operator and the Galveston District Corps of Engineers, a total of approximately 696,000 yd^3 of sediment dredged from the GIWW was hydraulically placed on Sargent Beach in 1988 and 1989. This large volume of material, which was placed in a limited area, represents more than one year of the average annual volume of sediment eroded from the entire ten-mile segment (see fig. 8). Consequently, erosion rates probably would have been higher between 1987 and 1991 if the dredged material had not been placed on the beach.

More specifically, between June and July 1988, 430,000 yd^3 of dredged material was pumped onto the beach between GIWW mile markers 414 and 417 (fig. 9). The composition and textures of this material were not quantified, but ground photographs by local residents show that beach-quality sand widened the beach at least 100 ft seaward of the former Gulf shoreline. Most of this material was reworked by Hurricane Gilbert in September 1988. The 22,360 yd^3 of sand placed on the seaward side of McCabe's Cut in October 1988, was used to reinforce the mud plug and therefore is not included in the total volume available for beach nourishment and erosion reduction.

In September 1989, 133,000 yd^3 of sand and mud dredged from the GIWW was placed on the Gulf beach at GIWW mile marker 414 (fig. 9). Most of this fill was reworked almost immediately by Hurricane Jerry in September 1989. In January 1990, an equal volume (133,000 yd^3) was placed on the beach at mile marker 416. The beach nourishment locations correspond to stations 35-38 (fig. 9), which explains the minor reductions in erosion rates between 1987 and 1991 at these same stations.

Elimination of Sediment Sinks- Closing of artificial inlets at McCabe's Cut and at Charpiot's Cut altered the sediment transport patterns and therefore the sediment budget of the local coastal compartment. The large volume of beach quality sand dredged from the GIWW between McCabe's Cut and Charpiot's Cut in 1988 is clear evidence that the inlets acted as a sediment sink that removed sand from the littoral system. Closing the artificial inlets now prevents the loss of sand into the GIWW and promotes the exchange of sand along the beach when currents reverse as a result of a change in wind direction. Maintaining this sand in the littoral system also increases the sediment supply and reduces the rates of erosion, especially between stations 37 and 40.

Updrift Supply- Formation of a shallow shoal at the mouth of the San Bernard River and prominent southwesterly accretion of the updrift spit are both indications that sand transported along the western flank of the new Brazos delta is currently bypassing the San Bernard River. This sand is probably feeding beaches between the river and Cedar Lakes and may explain the lower rates of erosion between 1987 and 1991 observed at stations 32-37 (figs. 2-4) and on beach profile S-1 in the same area (Table 3).

CONCLUSIONS

Rates of coastal erosion at Sargent Beach, Texas were determined using aerial photographs, an aerial overflight, ground observations, and ground surveys. Results of the study show that between 1982 and 1987 and between 1987 and 1991 the range of erosion rates was similar (3.6 ft/yr to 43.1 ft/yr and 9.1 ft/yr to 41.0 ft/yr, respectively), but erosion at most measurement stations was slower than during the preceding time period (1974-1982).

The recent decrease in erosion rates is a minor departure from the accelerated erosion previously reported (figs. 2-6). This general decrease in erosion is attributed to low storm incidence and an increase in sediment supply. Analysis of the volume and location of dredged material placed on the beach indicates that erosion rates between 1987 and 1991 would have been higher without the beach nourishment projects.

Future rates of erosion at Sargent Beach will depend largely on storm history and whether or not the most recent increase in sediment supply is sustained. For example, erosion rates could rapidly accelerate along the entire ten-mile segment and specifically between stations 38 and 42 if the area is near landfall of a major hurricane. Although closing the artificial inlets did not add new sediment to the littoral system, it did reestablish the sand exchange system along the beach and stopped chronic sediment losses. However, the processes probably have attained equilibrium so that future erosion mitigation associated with inlet closing will be minimal. Assuming that no additional material is

added directly to the beach in the future, then the only long-term source of new sediment supply to Sargent Beach is sand transported from the southwest flank of the Brazos delta. This source of beach sand can be maintained unless disrupted; for example, by dredging a channel across the bar at the San Bernard River.

REFERENCES

Morton, R. A., and Pieper, M. J., 1975, Shoreline changes in the vicinity of the Brazos River delta (San Luis Pass to Brown Cedar Cut): The University of Texas at Austin, Bureau of Economic Geology, Geological Circular 75-4, 47 p.

Morton, R. A., 1989, Analysis of shoreline erosion at Sargent Beach, Texas and projection of shoreline positions in the years 2000 and 2050: The University of Texas at Austin, Bureau of Economic Geology, contract report prepared for the Galveston District U.S. Army Corps of Engineers, 15 p. Attachment 1 <u>in</u> Gulf Intracoastal Waterway, Texas, Section 216 Reconnaissance Report, Galveston District U.S. Army Corps of Engineers, Galveston, Texas.

Paine, J. G., and Morton, 1989, Shoreline and vegetation-line movement, Texas Gulf Coast, 1974-1982: The University of Texas at Austin, Bureau of Economic Geology, Geological Circular 89-1, 50 p.

U.S. Army corps of Engineers, 1966, Maps of Gulf Intracoastal Waterway, Texas, Sabine River to the Rio Grande: Galveston District, U. S. Army Corps of Engineers.

U.S. Army corps of Engineers, 1980, Texas cost inlet studies-beach profiles, jetty condition surveys, and mid-point surveys, 1979-1980: Galveston District, U. S. Army Corps of Engineers, 130 p.

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* McCabe's Cut open, disposal levee constructed

** McCabe's Cut open, measuring station transects open water

† High water line coincides with levee on fill material

Table 3. Erosion rates based on 1989-1991 beach profiles (COE) and 1987-1991 aerial photographs (Lanmon).

Profile	Erosion Rates (ft/yr)		
Station	Zero Elev.	Berm	Photo
S-1	0.0	37.5	17.1
S-2	5.5	19.0	21.9
S-3	22.5	45.0	37.3
S-4	41.0	26.0	41.0
S-5	25.0	30.0	32.5

Figure 1. Ten-mile segment of the Texas Gulf shoreline referred to as Sargent Beach. Station numbers referenced in the Texas and in figures are the same as those used by Morton and Pieper (1975).

Figure 2. Cumulative erosion at stations 32 and 34 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

Figure 3. Cumulative erosion at stations 36 and 37 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

Figure 4. Cumulative erosion at stations 38 and 39 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

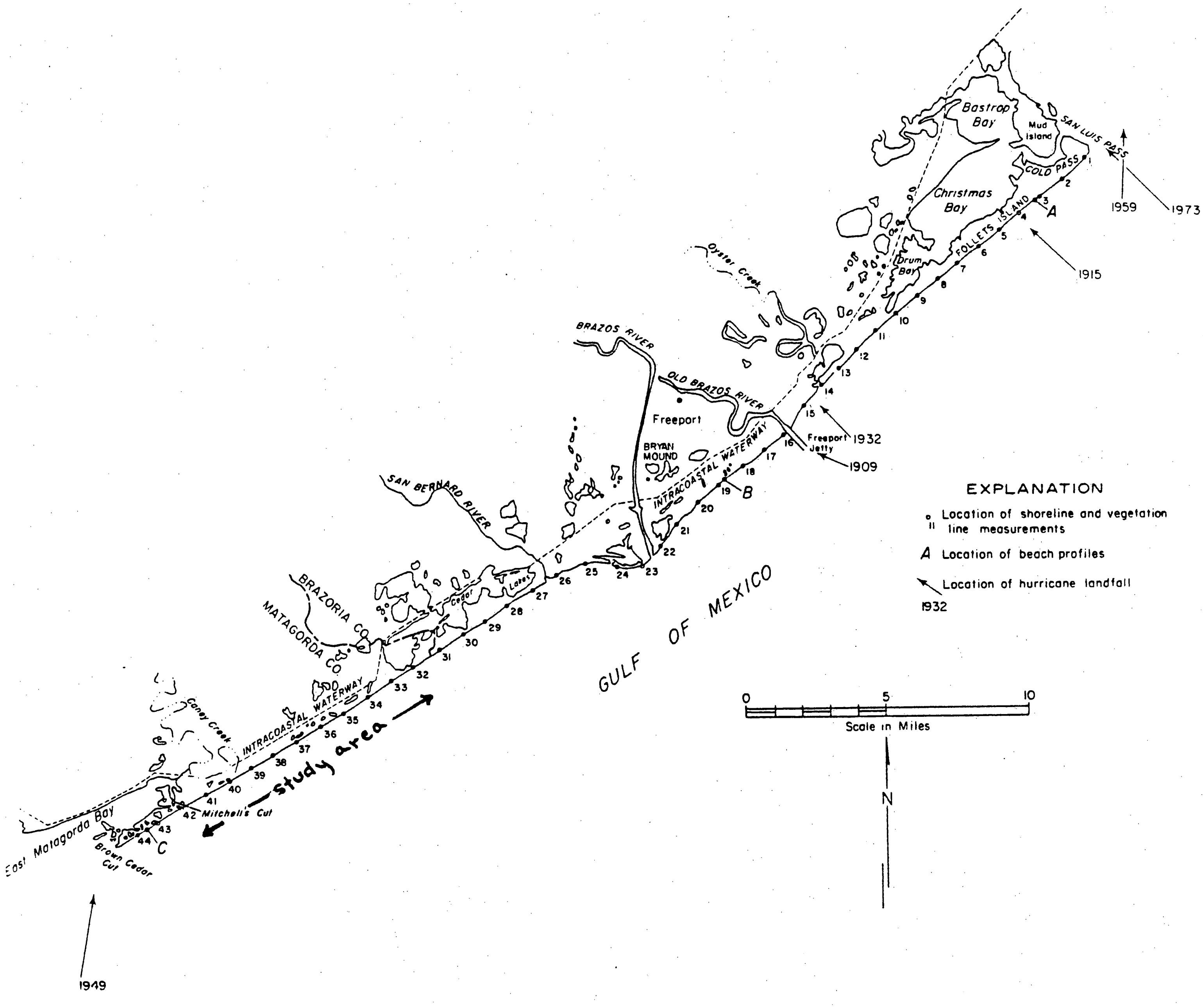
Figure 5. Cumulative erosion at stations 40 and 41 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

Figure 6. Cumulative erosion at station 42 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

Figure 7. Alongshore rates of erosion at stations 32-42 between 1930 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), Morton, 1989, and this study. Only values at even numbered stations were used to reduce data clutter.

Figure 8. Volumetric rates of erosion between 1930 and 1991 along the ten-mile segment of Sargent Beach. Modified from Morton (1989).

Figure 9. Locations of Gulf Intracoastal Waterway mile markers and shoreline monitoring stations. Modified from U.S. Army Corps of Engineers (1966).



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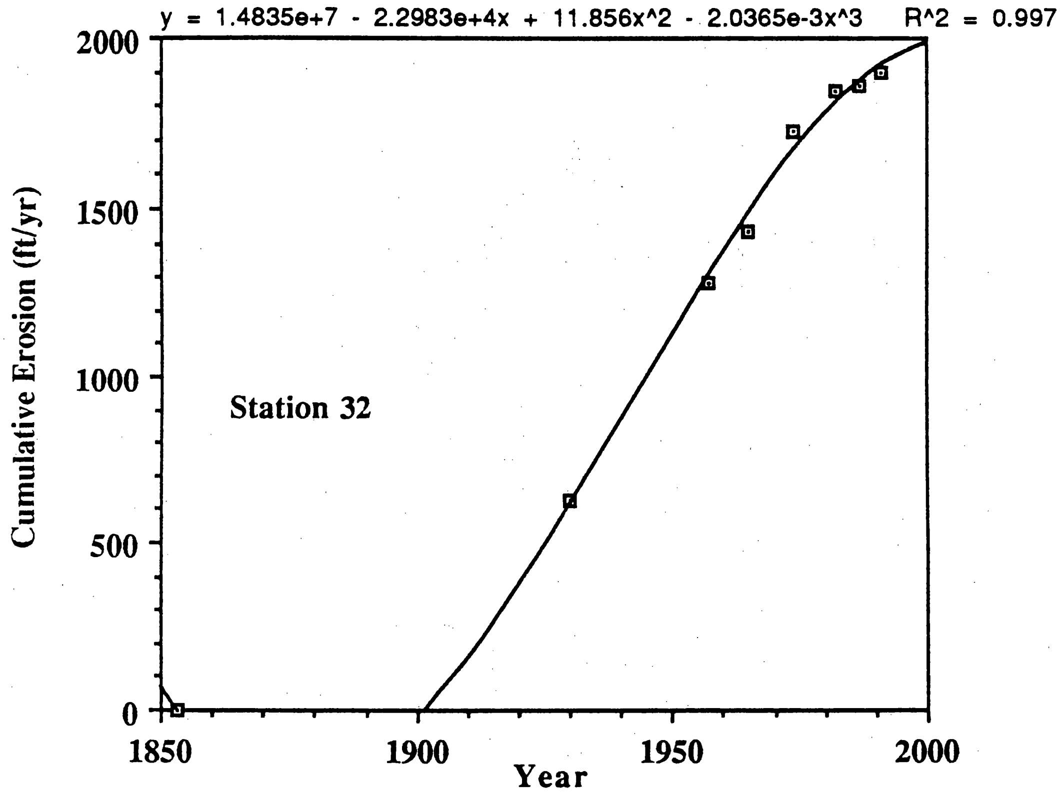


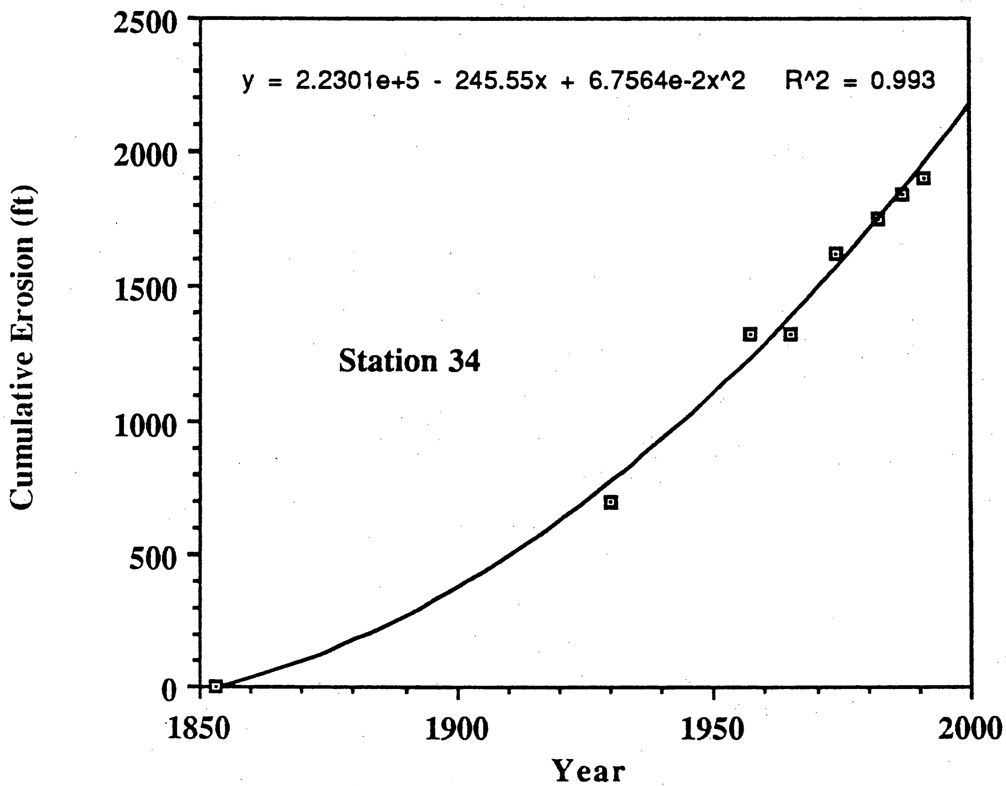
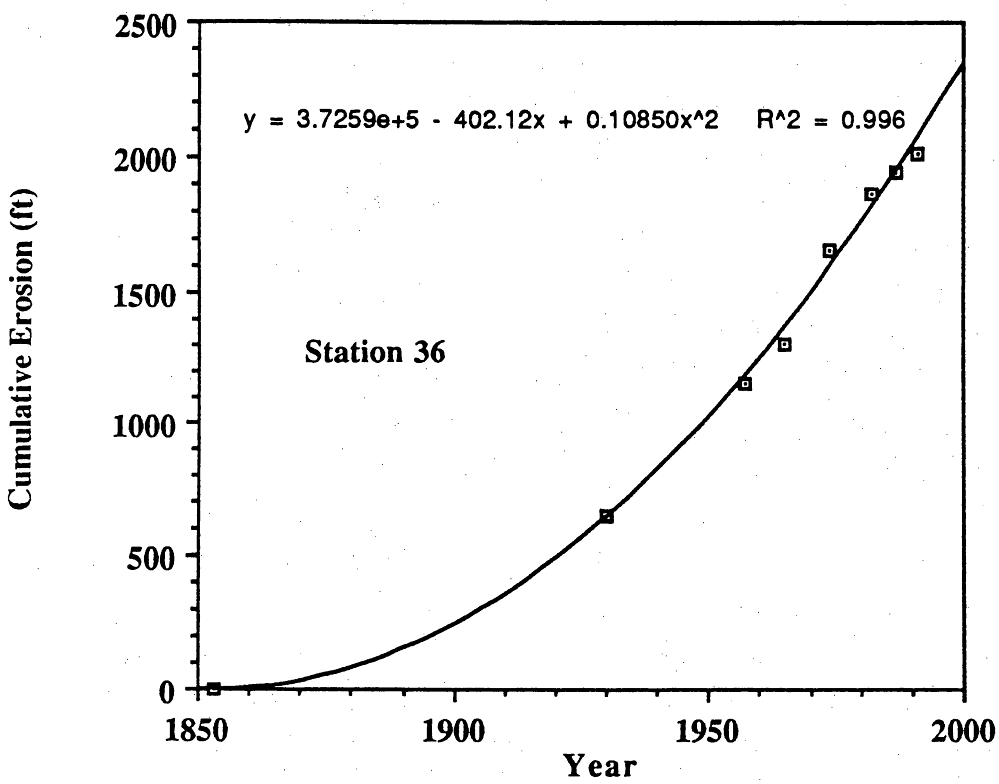


Figure 2. Cumulative erosion at stations 32 and 34 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.



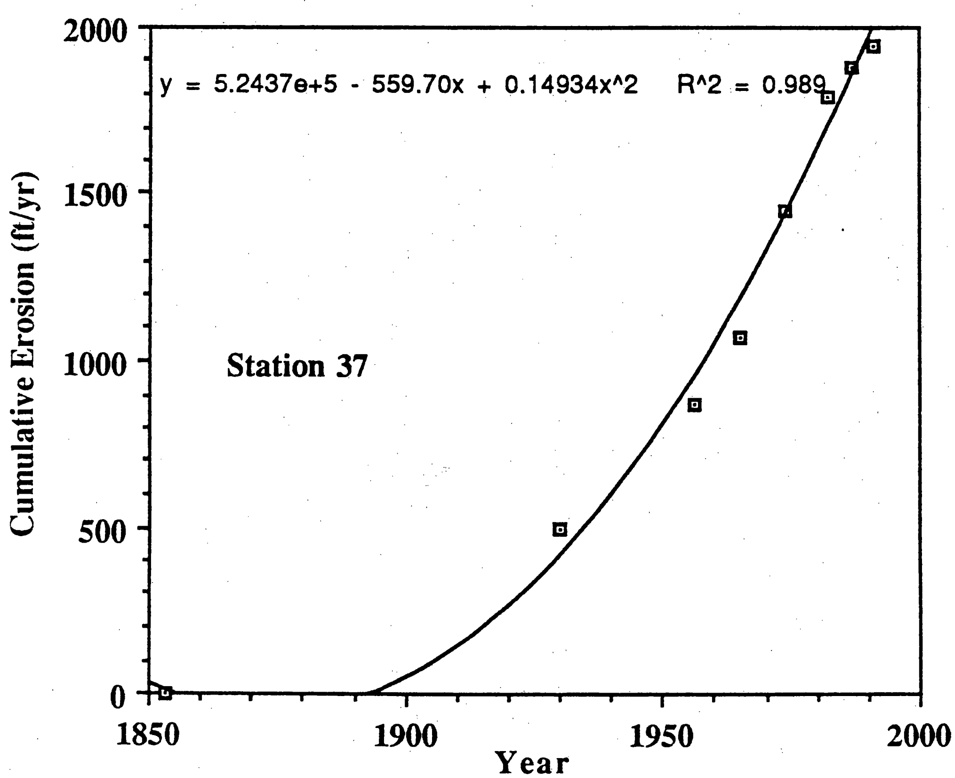
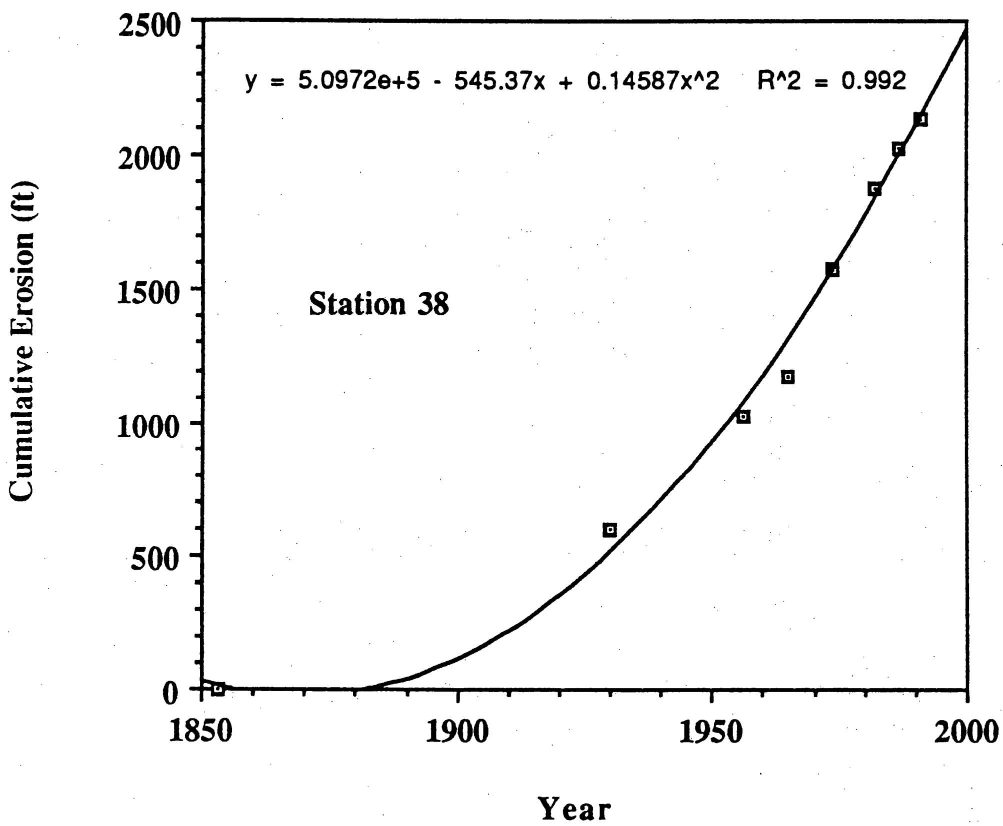


Figure 3. Cumulative erosion at stations 36 and 37 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.



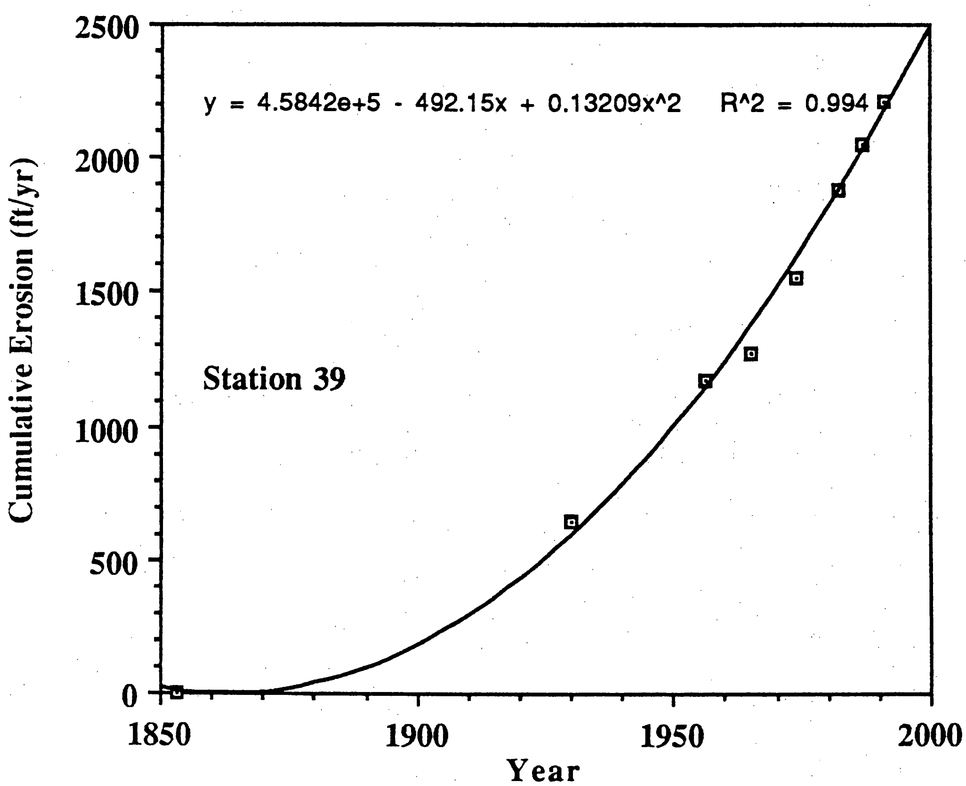


Figure 4. Cumulative erosion at stations 38 and 39 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

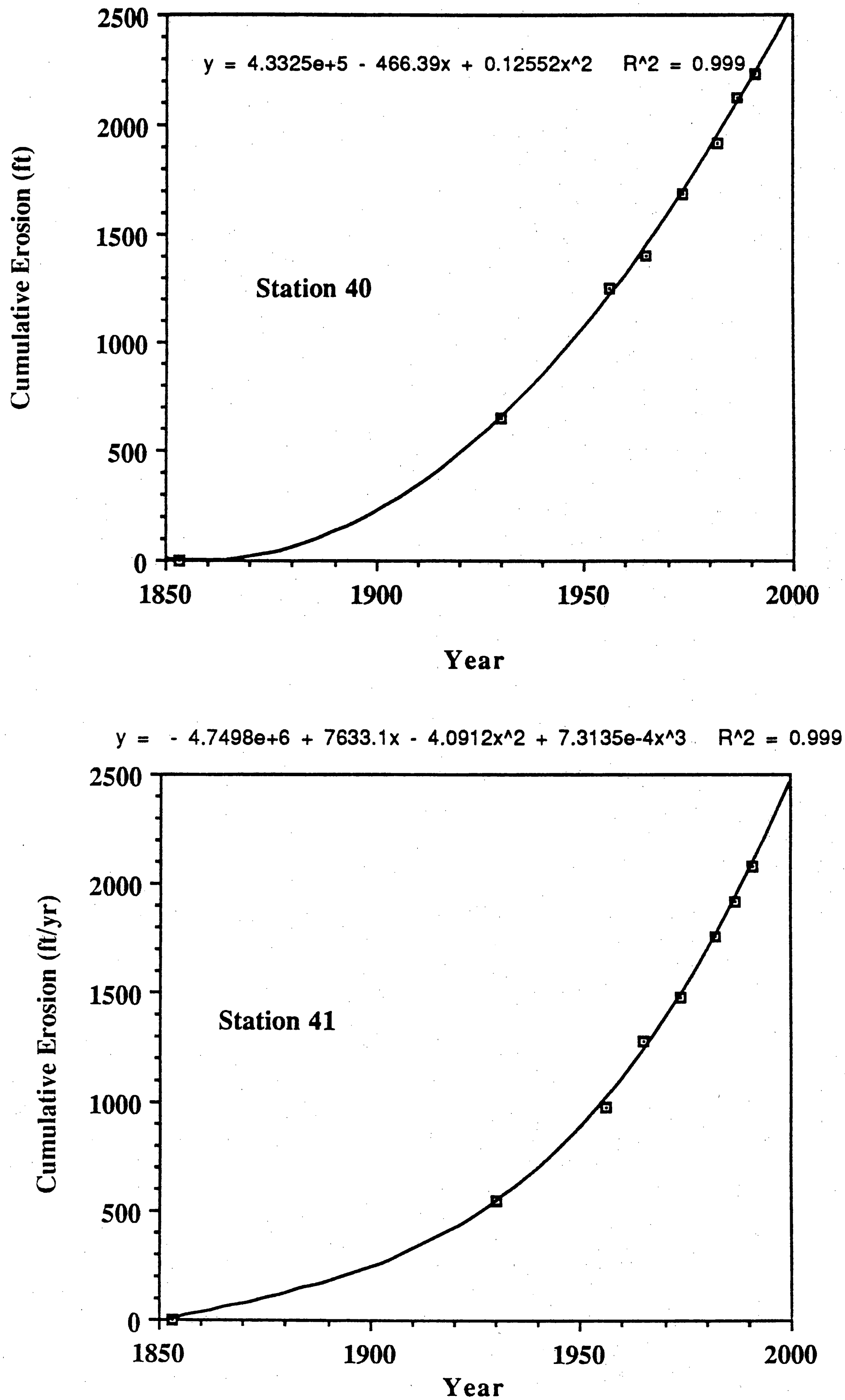


Figure 5. Cumulative erosion at stations 40 and 41 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

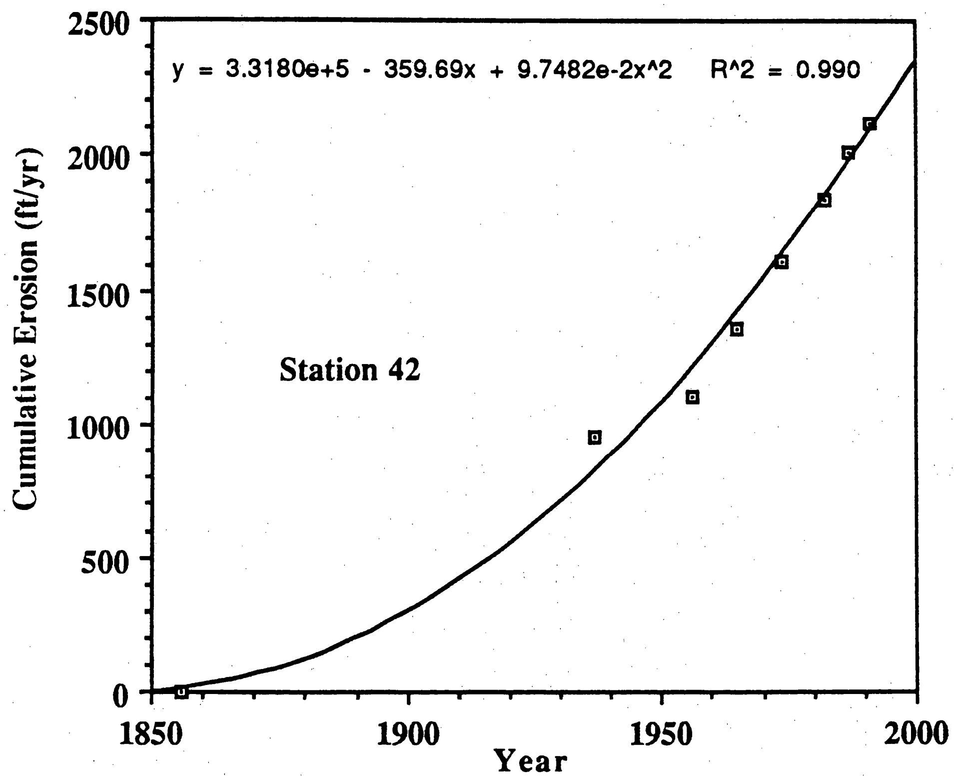


Figure 6. Cumulative erosion at station 42 between 1853 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), and this study.

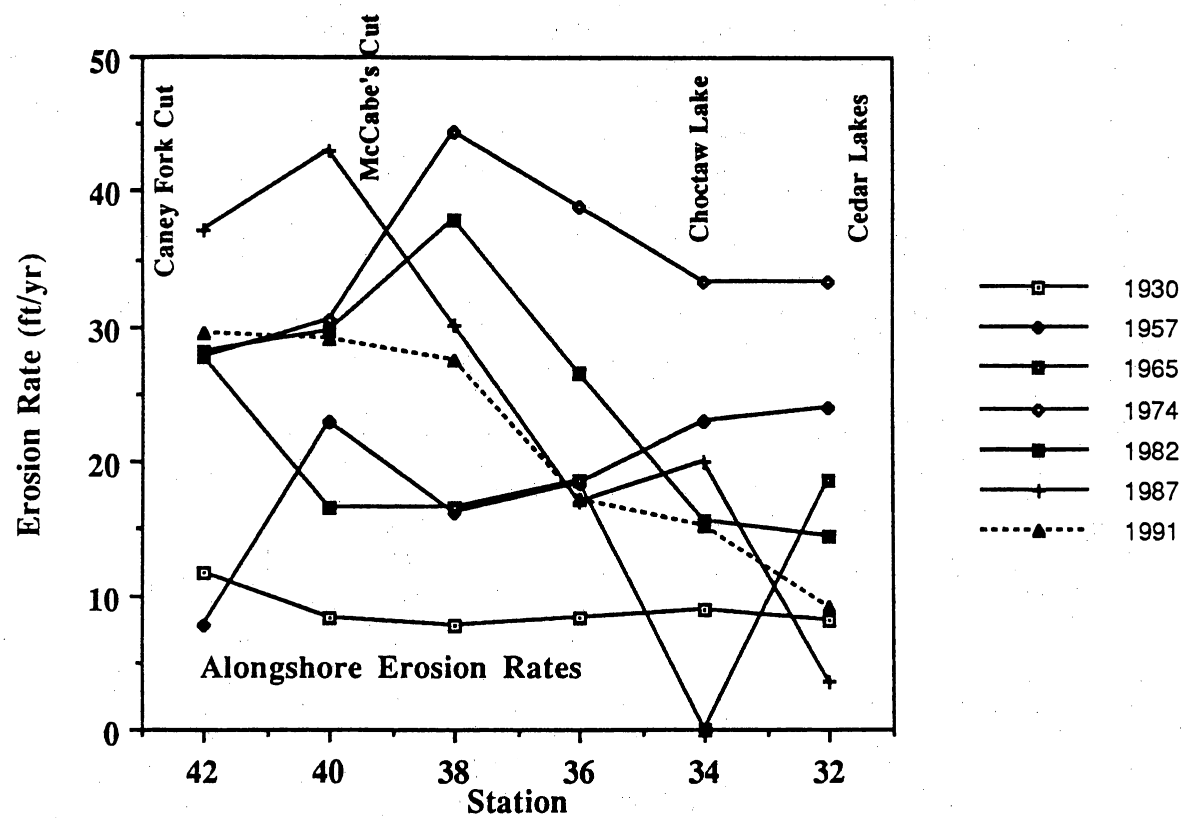


Figure 7. Alongshore rates of erosion at stations 32-42 between 1930 and 1991. Data from Morton and Pieper (1975), Paine and Morton (1989), Morton, 1989, and this study. Only values at even numbered stations were used to reduce data clutter.

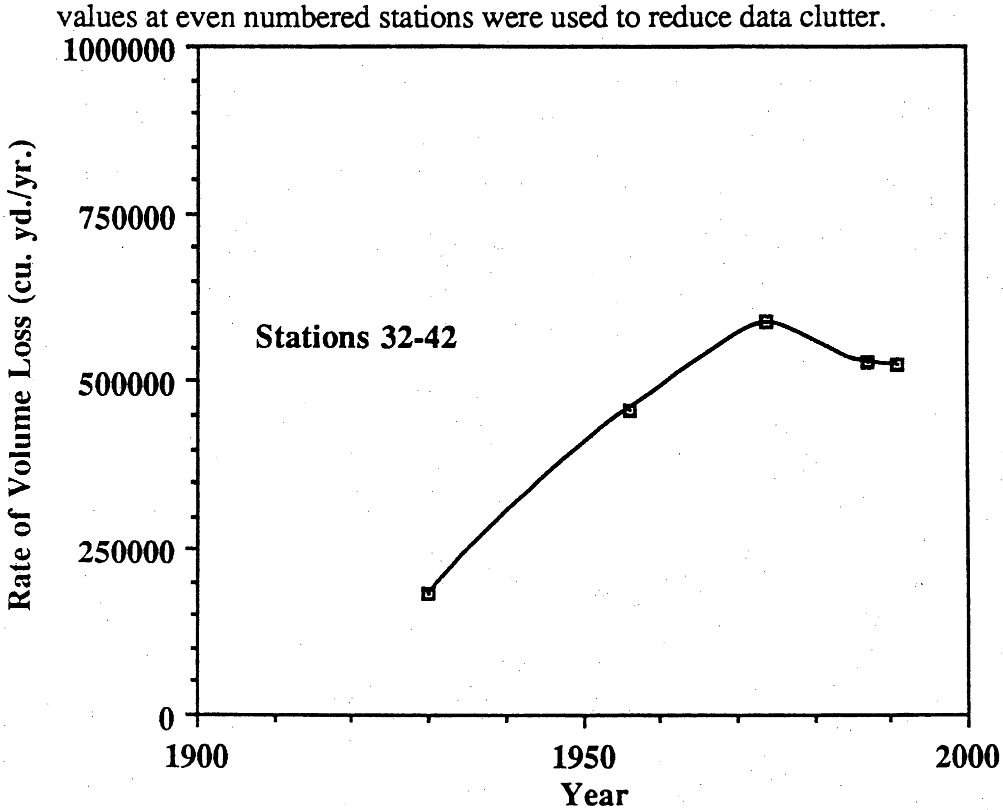


Figure 8. Volumetric rates of erosion between 1930 and 1991 along the ten-mile segment of Sargent Beach. Modified from Morton (1989).

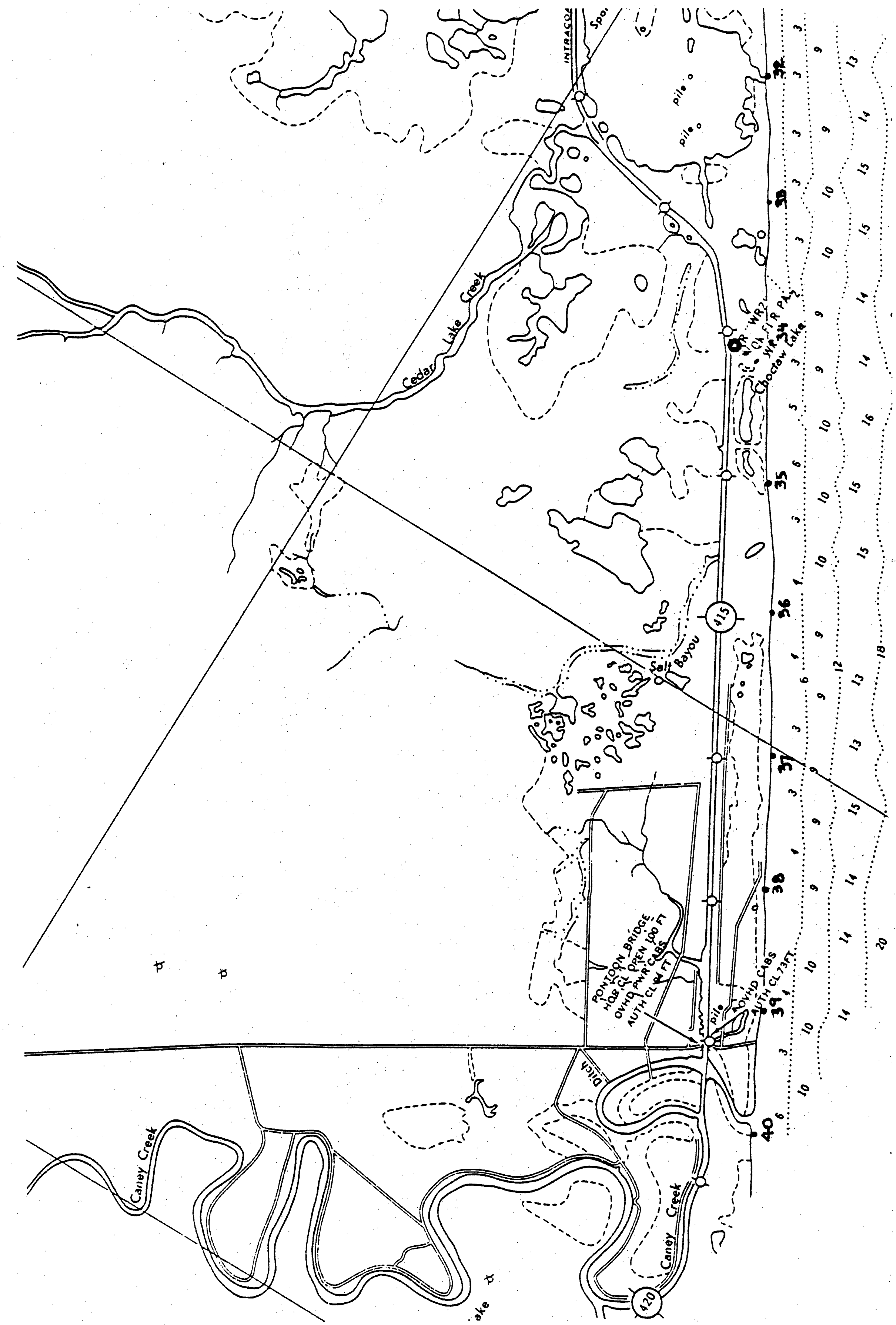


Figure 9. Locations of Gulf Intracoastal Waterway mile markers and shoreline monitoring stations. Modified from U.S. Army Corps of Engineers (1966).