CHAPTER 179

SHORELINE CHANGE AT OREGON INLET TERMINAL GROIN

M. F. Overton (M)[1], J. S. Fisher (M)[2]
W. A. Dennis (M)[3], and H. C. Miller (AM)[4]

Abstract

The Oregon Inlet Terminal Groin was completed in 1991. The groin was built to provide protection to the bridge crossing the inlet. A detailed monitoring program has analyzed shoreline position with the use of aerial photographs collected every two months. To date, no adverse impacts of the groin have been found on the shoreline within a 6 mile distance downdrift of the groin.

Introduction

Oregon Inlet is located between Bodie Island and Pea Island on the North Carolina coast, Figure 1. These islands form a part of the barrier island system generally referred to as the Outer Banks. This inlet formed in 1846 during a major storm, and has remained open to the present. During this 146 year interval the inlet has gone through many changes in width and position, with a net migration to the south of approximately 2 miles. The inlet width has varied from a minimum of about 2,000 ft to a maximum of just over 5,000 ft. While there have been numerous discussions and plans to stabilize it with jetties, Oregon Inlet remains one of the largest unimproved inlets along the east coast of the United States.

The inlet is spanned by the 2.4 mile long Bonner Bridge constructed in 1962, Figure 2. This bridge is located along the

[1]Dept. Civil Engineering, NCSU, Raleigh, NC 27695-7908
[2]Dept. Civil Engineering, NCSU, Raleigh, NC 27695-7908
[3]US Army COE, Wilmington District, P.O. Box 1890, Wilmington, NC 28502
[4]US Army COE, FRF, 1261 Duck Rd., Kitty Hawk, NC 27949

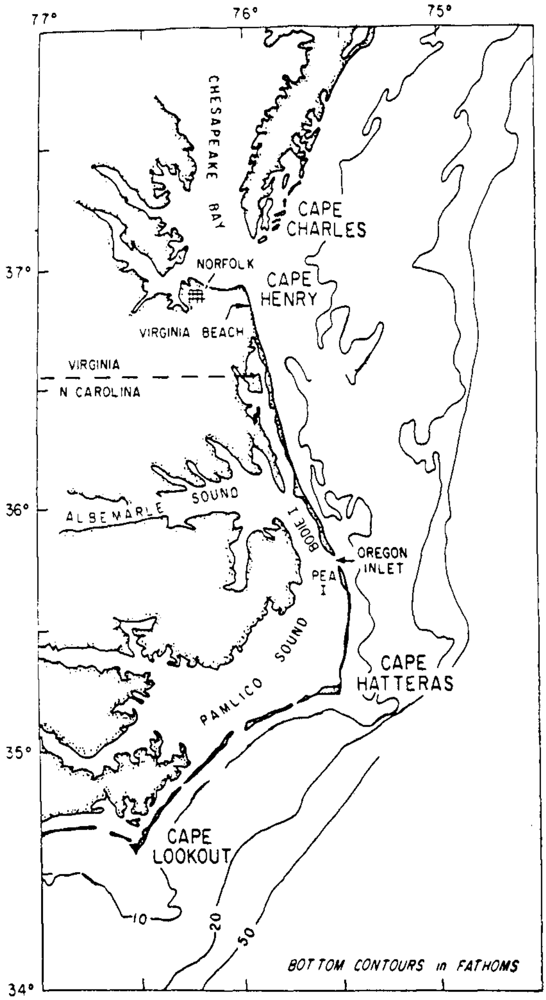

Figure 1. Location of Study Area
(from Inman and Dolan, 1989)

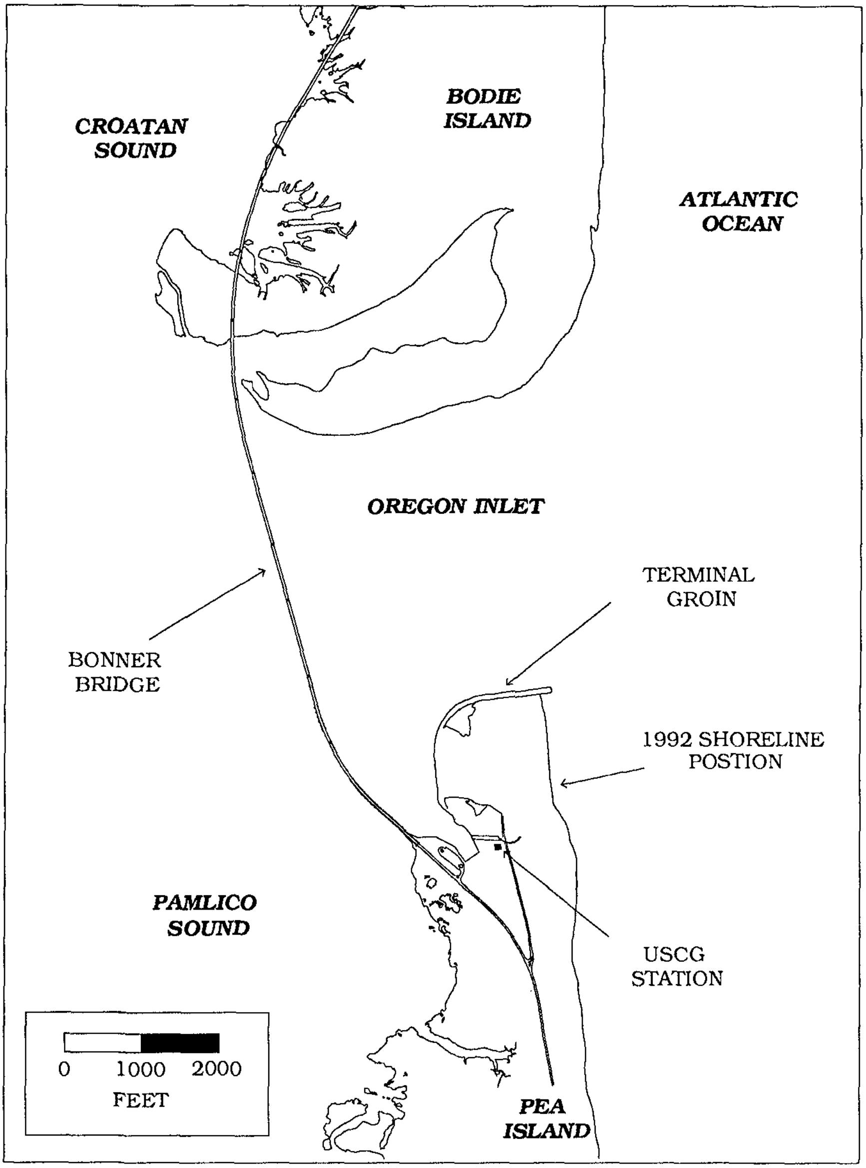

Figure 2. Detail of the Oregon Inlet Area.

principal highway serving the Cape Hatteras National Seashore. Peak summertime traffic is in excess of 10,000 cars per day.

The navigation channel spanned by the Bonner Bridge provides an important marine connection between Croatan and Pamlico Sounds and the Atlantic Ocean. This channel is used by both commercial and sport fishing interests. The channel is maintained by the U. S. Army Corps of Engineers. Maintenance dredging is done annually, with combined dredge volumes for the inner and outer channels in excess of 750,000 yd. The difficulty in dredging this channel has led to the consideration of an inlet stabilization project at this site. Preliminary designs by the Army Corps of Engineers call for a pair of jetties approximately 10,000 ft long.

The persistent migration of the inlet to the south has created an extreme erosion problem on the north end of Pea Island. By 1988 the portion of this island facing the inlet was eroding at an annual rate of about 80 ft/yr (NCDOT, 1988). This high erosion rate created a threat to the future safety of the Bonner Bridge. The North Carolina Department of Transportation (NCDOT) was concerned that the erosion, if left unchecked, would eventually allow storm waves to impact directly on the bridge deck at the southern end where it connects with Pea Island.

Several alternatives were considered to protect the bridge. These alternatives included beach nourishment, a series of short groins, and the selected choice of the single terminal groin (NCDOT, 1988). This latter choice was based upon the assumption that there was substantial local longshore transport to the inlet on the north end of Pea Island for the groin to trap. Thus, the groin would artificially reverse the erosion locally, and the resulting accretion would provide the needed protection to the bridge. The potential for this accretion was documented by a number of sediment budget studies undertaken as part of the evaluation of the proposed jetty project (Inman and Dolan, 1989).

Once NCDOT selected the terminal groin as the preferred solution to protect the bridge, it was necessary to obtain both state and federal permits for construction. The site for the groin is located on a National Wildlife Refuge managed by the U. S. Fish and Wildlife Serviee. In addition, the inlet is located along the Cape Hatteras National Seashore, managed by the National Park Service. These federal interests, as well as those of the North Carolina Division of Coastal Management necessitated unusual restrictions on the construction permit for the groin. Specifically, NCDOT is required to insure that the groin does not result in an accelerated erosion of the downdrift shoreline. This requirement led to the initiation of a detailed monitoring program to evaluate shoreline change near the groin. The current results of this ongoing monitoring are presented in this paper.

Description of Groin

The terminal groin was designed for NCDOT by the Wilmington District of the U. S. Army Corps of Engineers. The total length of the groin section is approximately 3,100 ft. At its seaward end the water depth is about 6 ft (mlw). The top width increases from 25 ft at the landward end to 39 ft at the seaward head. Crest elevation is +9.5 ft (msl) at the head. Side slopes are 2 on 1, except at the head where they are 3 on 1. The core material is covered by a layer of rubble ranging in weight from 4 to 2500 lb, with an armor layer of rock with weights from 0.75 to 11 tons. Toe protection on the inlet side of the groin is provided by a 43 ft wide single layer of the armor stone on top of a layer of core material (NCDOT Project 6051020 plans).

Monitoring

It was expected that a natural sand fillet would begin to form as soon as the groin construction to extended beyond the natural shoreline, and that eventually this fillet would extend to the seaward end of the groin. Thus, this accretion caused by the presence of the groin would result in a northern migration of Pea Island and would serve as the needed protection for the bridge.

While the development of the sand fillet adjacent to the groin was the desired outcome of the project, the construction permit required monitoring to insure that this accretion at the groin did not come at the expense of the downdrift shoreline. Specifically, the permit required that the six miles of shoreline just south of the groin be monitored (Overton and Fisher, 1992).

The monitoring program includes the analysis of aerial photographs taken every two months as well as immediately after severe storms, and field surveys collected twice each year. In a separate effort the Corps of Engineers is also collecting data to monitor the performance of the terminal groin. These data include beach and bathymetric surveys in the project area and wave height and direction in the inlet.

The bimonthly aerial photographs are the principal data used to monitor shoreline change. The photographs are made as close to spring high tide as possible, with the shoreline defined as the position of the wet sand line.

The analysis of the shoreline change follows a modification of a procedure developed by Dolan, et al., 1978. For each set of aerial photographs, the position of the shoreline is measured relative to a fixed baseline offshore. The distance from the baseline to the shoreline is determined every 150 ft over the 6 mile length of monitored shoreline. The shoreline position is digitized from the aerial photographs by NCDOT using an Intergraph Intermap Analytic Stereoplotter Workstation. The distance from the baseline to these digitized shorelines is then determined on a computer.

Historical Erosion Rates

In order to determine if the terminal groin is causing accelerated shoreline erosion, a comparison is made of the measured shoreline position with the position predicted from historical rates. If the analysis indicates that current rate of erosion exceeds the historical rate, then NCDOT has agreed to correct the excess erosion by beach nourishment. Thresholds for action have been established based upon the assumption that 1 sq ft of erosion determined from the aerial photographs is equivalent to 1 cu yd of volume loss from the beach. Two thresholds are being used; 250,000 cu yd over a 1 mile shoreline segment, and 500,000 cu yd over a 3 mile segment. The threshold must be exceeded for several successive bimonthly survey intervals before remedial action is required (Overton and Fisher, 1992).

The dates selected to establish the project historical erosion rates are September 19, 1984, and October 9, 1988. The 1984 date was chosen because it is the earliest record available after the Corps of Engineers initiated large scale hopper dredging in Oregon Inlet. Since this hopper dredging may have accelerated the erosion of the north end of Pea Island, earlier photographs would potentially bias the calculation to lower erosion rates. The more recent date, October 1988, was chosen because it is the most recent date prior to a severe storm (March 1989) which caused major erosion, and therefore might bias the erosion rates to higher values.

Figure 3 shows the annual historical erosion rate based upon the September 1984 to October 1988 interval. Mile zero in this figure is the location of a United State Coast Guard (USCG) Station, Figure 2. This station is approximately 2,000 ft south of the terminal groin. In general the erosion rate along this portion of Pea Island is relatively high, with a mean value of about 27 ft/yr. The portion of the shoreline nearest the inlet is clearly the area of highest erosion, as one would expect near the inlet. In this area the erosion rate has a maximum value on the order of 100 ft/yr. These relatively high erosion rates near the inlet clearly document the need for the construction of the terminal groin.

The state of North Carolina uses a long term shoreline change rate for shoreline management purposes. This rate is determined from aerial photographs with a method similar to that used to monitor the terminal groin (McCullough, 1988). In this case the long term rate is based upon the interval from 1945 to 1986. This Long Term Rate for the project area is also shown on Figure 3. The higher erosion rates

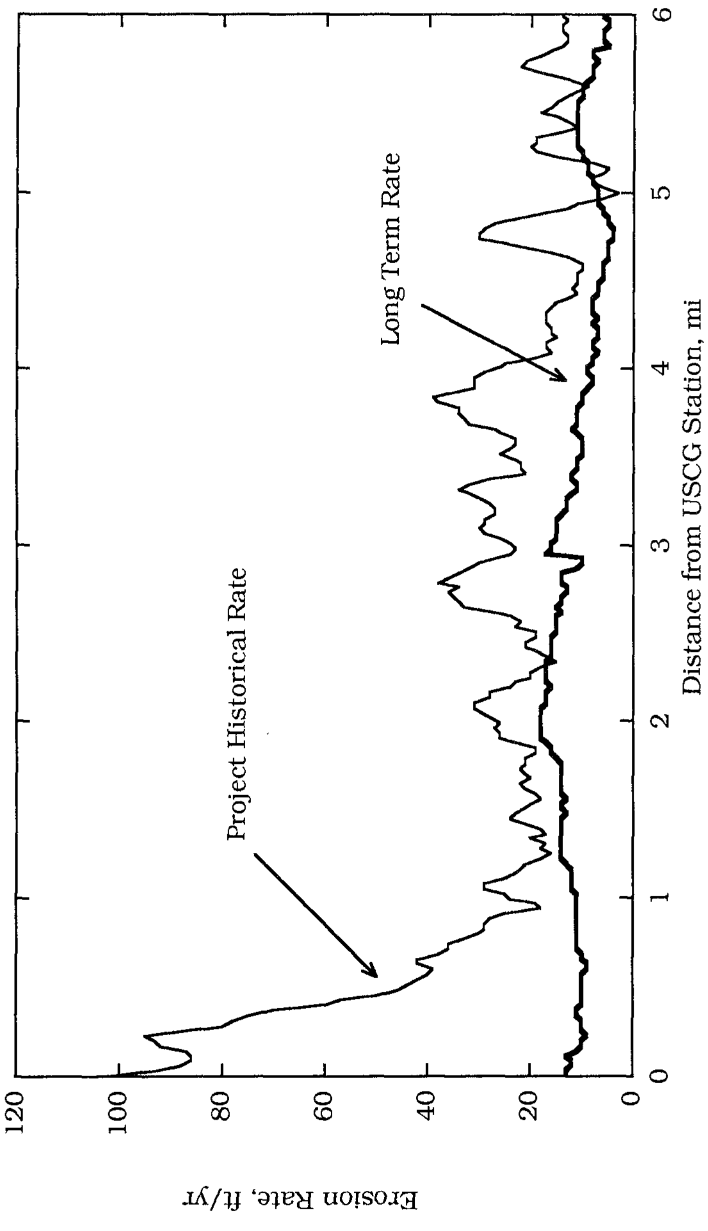

Figure 3. Comparison of the Long Term Rate, based on 1945 - 1986 shoreline position data, and the Project Historical Rate, based on 1984 - 1988 shoreline position data.

near the groin (between mile 0.0 and 1.0) are further indication of the increase in erosion in recent years. Further south the two erosion rates appear to converge. The greater variability in the Project Historical Rate relative to the Long Term Rate is a typical difference between short and long records of shoreline change.

Beach Nourishment

The initial plans for the terminal groin did not include beach nourishment. However, the project area has benefited from the continued maintenance dredging of Oregon Inlet for navigation purposes. The spoil from this dredging is currently being placed on the beach with the terminal groin project area. Since the groin was completed in March 1991 there have been three separate Corps projects where the beach near the groin was used as a disposal site for the dredging operations. Table 1 summarizes these nourishment events.

Table 1
Summary of Beach Nourishment Activities

Date	Volume (cu yd)	Location (miles south of USCG)
April 1991	282,600	0.4-1.2
Sept. 1991	157,600	0.2-0.4
Aug. 1992	1,078,000	0.8-1.8

Severe Storms

In addition to the bimonthly aerial photographs, the monitoring program includes the analysis of any severe storms that might have significant impact along the project. There have been a number of large storms since the construction of the groin. One of these, October 1991 (The Halloween Storm) is estimated to have been larger than the 1962 Ash Wednesday Storm (Dolan and Davis, 1992). The average immediate post-storm erosion along the project was about 75 ft for this storm. In general, the storm history since the construction of the groin has been one of the most severe on record. However, while there is usually considerable erosion caused by the high waves and surge, the beach appears to be able to recover most of the short-term loss during the post-storm periods (Overton and Fisher, 1992).

Shoreline Change Near the Groin

The shoreline change within the first 3,750 ft south of the groin is shown in Figure 4. October 5, 1989, represents the shoreline position just prior to groin construction. Groin construction began in

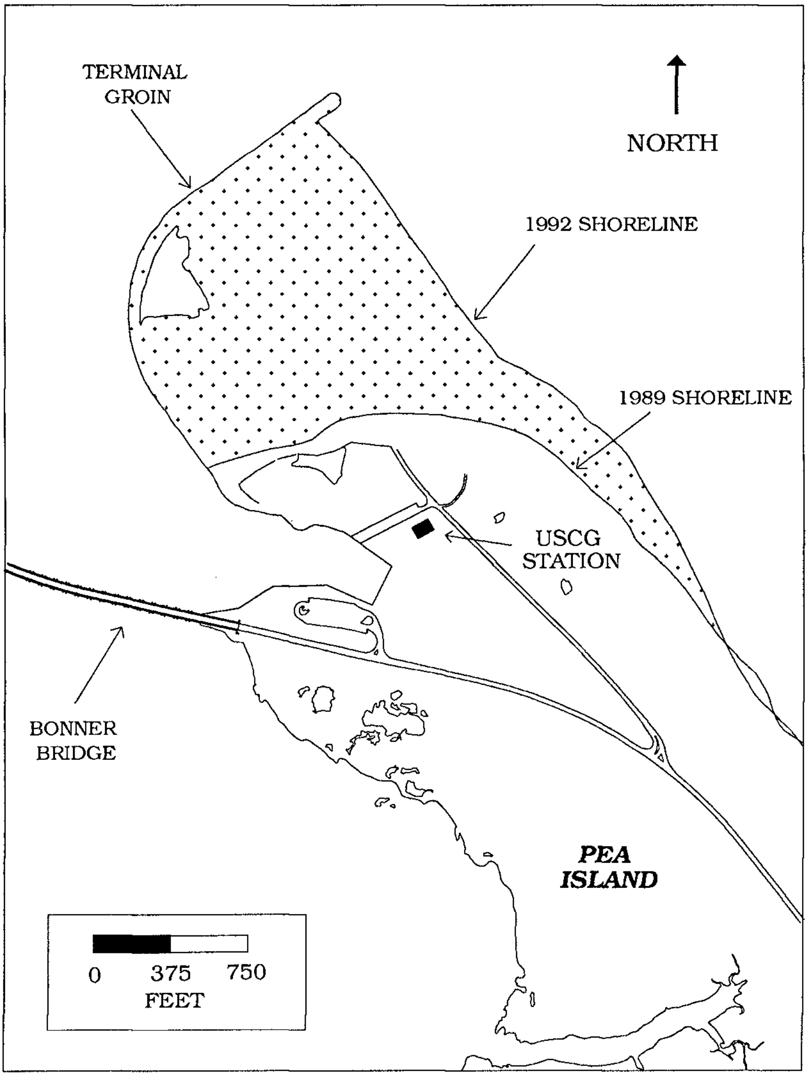

Figure 4. Detail of the groin fillet.

October 1989, and thus the most recent date, October 1992 spans a period of three years. As expected, during this interval there has been substantial accretion at the groin itself. The area of accretion above the mean high water line is estimated to be approximately 2 million sq ft. This figure clearly illustrates the effectiveness of the groin in causing the northern end of Pea Island to accrete to the inlet, thus providing the needed protection for the bridge.

Shoreline Change Over the Six Mile Study Area

Figure 5 compares the Project Historical Erosion rate with the Current Project Erosion Rate (defined as the erosion rate computed from October 1989 to the present date) along the six mile study area starting at the Coast Guard Station. For the two miles closest to the groin there has been almost a complete reversal from erosion to accretion. Mile zero on this figure is approximately 2,000 ft of the groin, and thus this accretion is south of the fillet area shown in Figure 4. However, the most recent dredging operation spoiled over 1,000,000 cu yd of sand within the first two mile stretch shown on Figure 5. Therefore, much of the accretion shown in this area can be assumed to be due to this nourishment activity. For the remaining 4 miles of the monitoring area there is essentially no difference between the erosion rates prior to and after groin construction based on thc October 1992 shoreline position.

Conclusion

On the basis of the record of shoreline change since the construction of the Oregon Inlet terminal groin, there has been no adverse impact of the groin on the downdrift shoreline, Figure 5. The combination of the sand trapping of the groin and the three beach nourishment projects has resulted in substantial accretion near the groin. Further south the erosion rates before and after groin construction are essentially the same. During the three years of monitoring the "excess erosion thresholds" have been reached three times, but the beach has recovered naturally by the date of the succeeding bimonthly surveys. Thus, NCDOT has not had to take any remedial actions to mitigate the impact of the groin.

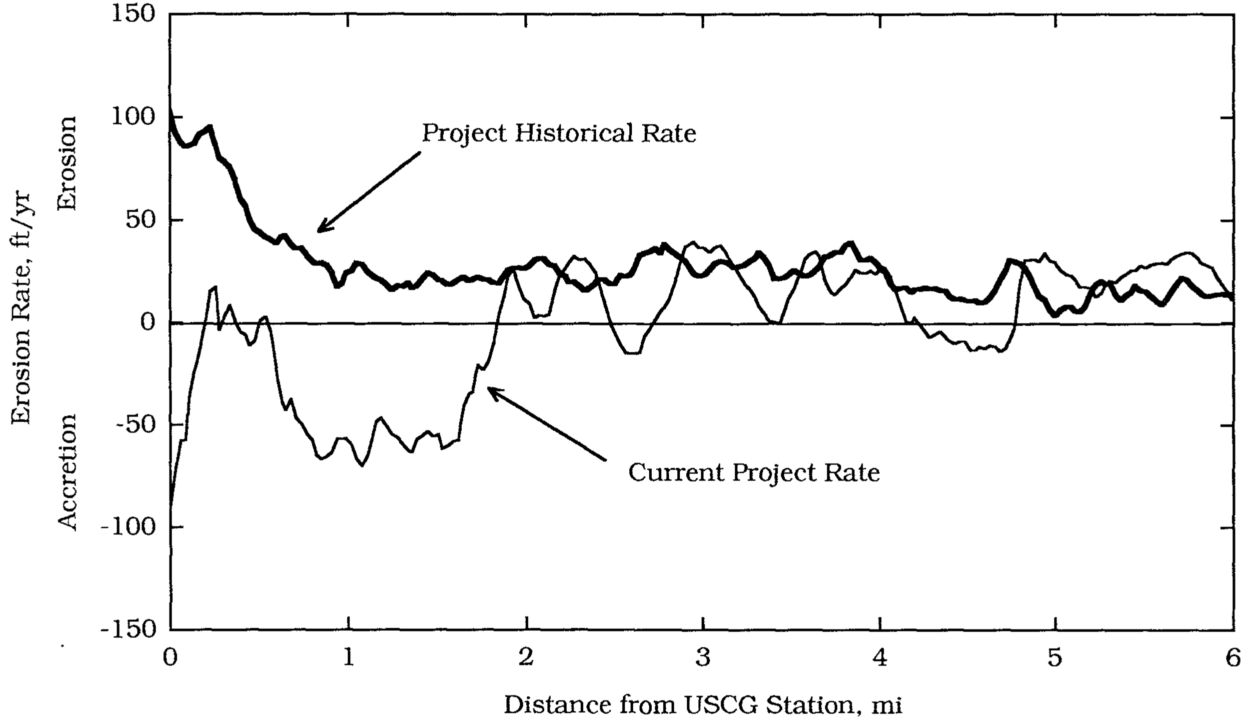

Figure 5. Comparison of the Project Historical Rate and the Current Project Rate which is based on the October1989 - October1992 shoreline position data.

Acknowledgments

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