CHAPTER 281

INFLUENCE OF NEARSHORE HARDBOTTOM ON REGIONAL SEDIMENT TRANSPORT

Paul C.-P. Lin, Ph.D., P.E.[1] and R. Harvey Sasso, P.E.[2]

ABSTRACT

The influence of nearshore hardbottom on longshore and cross-shore sand movement along a 21.2 km long southeast Florida coastline is evaluated. This study correlates a variation of longshore sediment transport rate within the region with the extent of nearshore hardbottom. The nearshore sand movement within this region was determined based on analysis of the hydrographic survey data over a 15-year period. The study area includes three major beach renourishment sites, which were renourished a combined total of seven (7) times with 5.5 million cubic meters of sand. The objectives of this study are to obtain a greater understanding of the causes of severe beach erosion and a more accurate estimate of nearshore sand movement in the region, thus providing a better design tool for future beach nourishment projects and inlet sand bypassing practices.

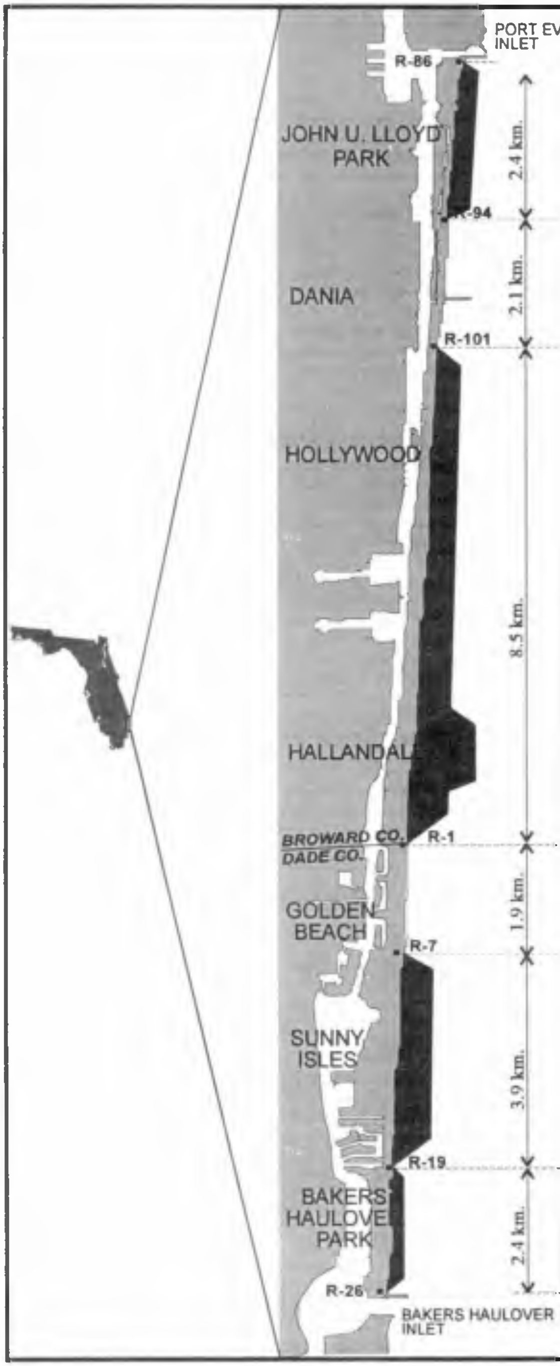
INTRODUCTION

The area of study extends from Port Everglades Inlet in Broward County to Bakers Haulover Inlet in Dade County. This region of coastline encompasses six (6) municipalities including, from north to south, John U. Lloyd, Dania, Hollywood/Hallandale, Golden Beach, Sunny Isles, and Bakers Haulover Park, with their major beach nourishment projects illustrated in Figure 1.

This study region is bounded by Port Everglades Inlet to the north and Bakers Haulover Inlet to the south. Port Everglades Inlet was opened in 1926 and stabilized by north and south jetties in 1931. Its 190-meter wide and 15 m deep inlet channel acted as a complete sand barrier and allowed no sediment bypassing

[1]Senior Engineer, Coastal Systems International, Inc., 464 South Dixie Highway, Coral Gables, Florida

[2]President, Coastal Systems International, Inc.



PROJECT	YEAR	VOLUME (Cubic Meters)
JOHN U. LLOYD PARK NOURISHMENT	1977 1989	833,000 461,000
HOLLYWOOD/ HALLANDALE BEACH NOURISHMENT	1971 1979 1991	268,000 1,514,000 847,000
SUNNY ISLES BEACH NOURISHMENT	1988 1990	1,009,000 23,000
HAULOVER BEACH NOURISHMENT	1960 1978 1987	138,000 230,000 180,000

Figure 1. Study Area and Historic Beach Nourishment Projects

across the inlet (Coastal Tech, 1994). The Bakers Haulover Inlet is a man-made improved inlet measuring approximately 90 m wide and 5 m deep. This Inlet was opened in 1925 (CP&E, 1992a).

In the region, John U. Lloyd, Hollywood/Hallandale, and Sunny Isles have been periodically renourished. Some small-scale beach fill activities were also conducted in the Bakers Haulover Park. Meanwhile, Dania and Golden Beach have been accreting as a result of adjacent beach renourishment projects. The 2.4 km beach of John U. Lloyd Park was nourished in 1977 and 1989 with placement of approximately 0.83 million and 0.46 million cubic meters of sand, respectively. An estimated 0.27, 1.5, and 0.85 million cubic meters of sand were placed along the 8.5 km of Hollywood/Hallandale beach in 1971, 1979 and 1991, respectively. A major beach nourishment project took place along the 3.9 km of Sunny Isles beach in 1988 with placement of 1.0 million cubic meters of sand. Other small-scale beach fill projects within this region were detailed in the Sunny Isles report (Coastal Tech, 1993).

Extensive nearshore hardbottom was found within this study area, which aligned in a shore-parallel direction with an offshore distance between the hardbottom and shoreline increasing from north to south. Specifically, the nearshore hardbottom is located approximately 200 m offshore at the north end of the region and increases to 900 m offshore at the south end. The average width of the nearshore hardbottom area is 2,400 m.

REGIONAL SEDIMENT TRANSPORT

The overall sand movement within the study region is evaluated by examining volumetric changes at each DEP (formerly DNR) monument. The volumetric changes occurring above and below the -2 m National Geodetic Vertical Datum (NGVD) elevation are calculated. The depth of closure for sand movement in this region varies from approximately -4 m NGVD to -6 m NGVD, depending on the location of nearshore hardbottom. A detailed variation of volumetric changes along the region is illustrated in Figure 2.

Table 1 summarizes the average and total volumetric changes within each coastal municipality. In general, long-term hydrographic data for two consecutive beach nourishment projects were used to obtain an average volumetric change rate after a beach renourishment project. In the area of Sunny Isles and Bakers Haulover Park, relatively short-term data (approximately a three-year time period) was used due to the lack of accurate and extensive hydrographic survey data.

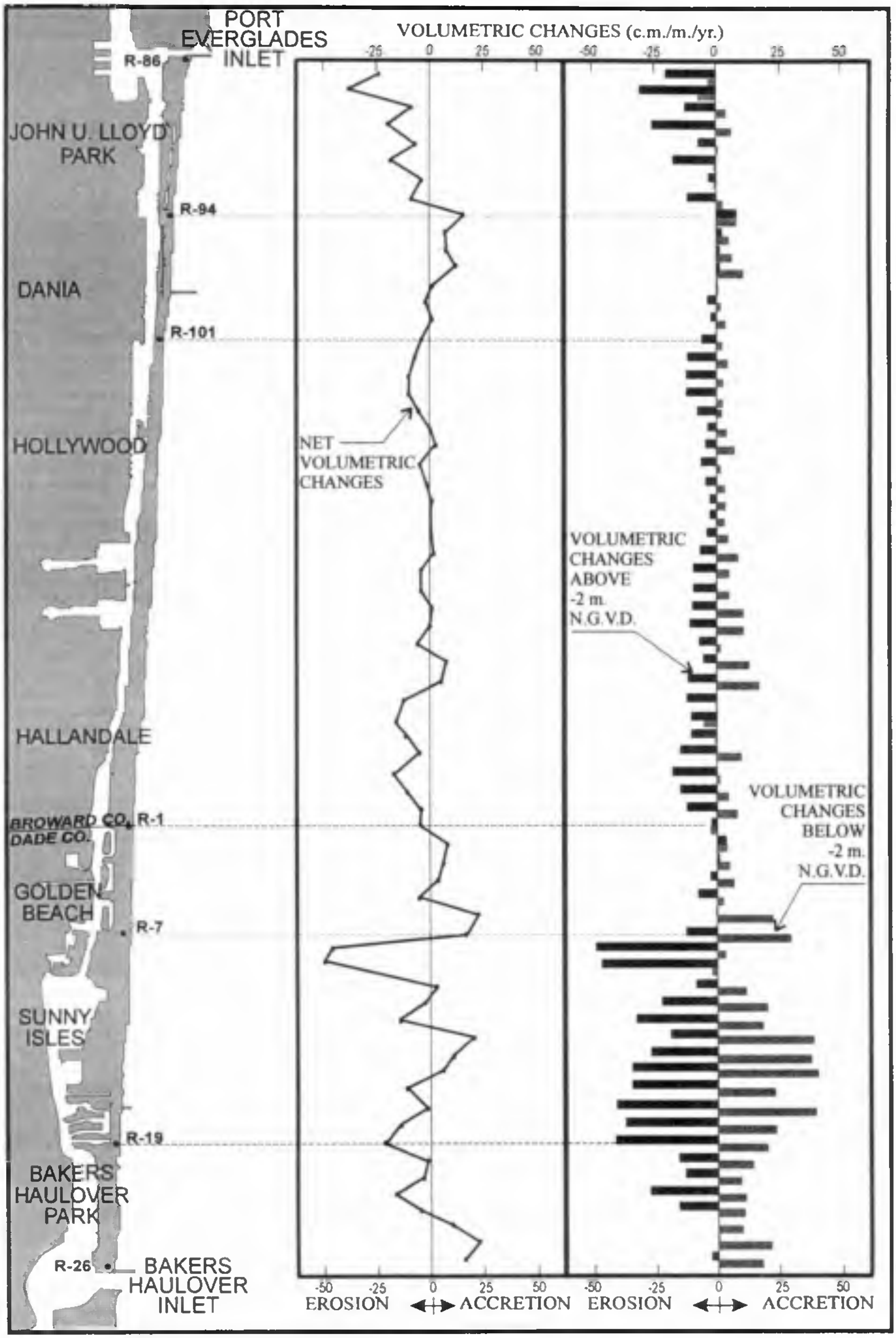


Figure 2. Net Volumetric Changes and Cross Shore Sand Movement

TABLE 1

VOLUMETRIC CHANGES WITHIN EACH COASTAL MUNICIPALITY

Coastal Municipality	Distance (km)	Survey Period	Volumetric Changes (c.m./m/yr)			Total Volumetric Changes (c.m./yr)
			Above -2 m NGVD	Below -2 m NGVD	Total	
John U. Lloyd State Park	2.4	1978-1989	-14.5	1.0	-13.5	-33,000
Dania	2.1	1978-1993	0.8	4.3	5.1	11,000
Hollywood/ Hallandale	8.5	1979-1991	-8.0	4.0	-4.0	-34,000
Golden Beach	1.9	1980-1991	-2.3	9.5	7.2	14,000
Sunny Isles	3.9	1989-1991	-30.6	22.1	-8.5	-34,000
Bakers Haulover Park	2.4	1989-1991	-8.8	14.0	5.2	13,000
Total	21.2	—	—	—	—	-63,000

The nourished beach at John U. Lloyd, Hollywood/Hallandale (CP&E, 1992b) and Sunny Isles was found to be eroding at similar rates of 33,000, 34,000 and 34,000 cubic meters per year, respectively. The erosion rate per meter of shoreline decreased with increasing length of the renourishment project. For instance, Hollywood/Hallandale, having the greatest project length of 8.5 km, was found to have the least erosion rate per linear meter of shoreline at 4.0 cubic meters per meter per year. The greatest erosion of 13.5 cubic meters per meter per year occurred at John U. Lloyd Park. This high erosion rate is mainly due to the downdrift impacts associated with Port Everglades Inlet.

Non-nourished areas adjacent to the renourished beaches were accreting, as illustrated in Table 1. Dania, Golden Beach and Bakers Haulover Park were accreting at a rate of 11,000, 14,000 and 13,000 cubic meters per year, respectively. The accretion rates in these areas were relatively uniform, ranging from 5.1 to 7.2 cubic meters per meter per year.

A sediment budget, as illustrated in Figure 3, is developed for the region based on a known boundary condition and the results of the above volumetric changes. This sediment budget encompasses a region that extends beyond the area that is conventionally studied under inlet management plans and beach renourishment projects. The well-defined northern boundary condition of Port Everglades Inlet has improved the accuracy in the derivation of this regional sediment budget. A number of studies have reported that Port Everglades Inlet has interrupted 100 percent of longshore sediment transport and resulted in no sediment being naturally bypassed from north of the inlet to John U. Lloyd Park (COE, 1990; Coastal Tech, 1988 and 1994).

The regional sediment budget indicates that the longshore sediment transport rate at the north end of the region is less than the rate at the south end. This is contradictory to the trend experienced along the east coast of Florida, where longshore sediment transport rates usually decrease toward the south. The wave-induced longshore transport rate is found to be 33,000 cubic meters per year at John U. Lloyd/Dania, as compared to 76,000 cubic meters per year at Sunny Isles/Bakers Haulover Park. A net southern longshore transport rate of 77,000 cubic meters per year at Bakers Haulover Park was predicted by COE (1995) using the GENESIS numerical model.

The results of volumetric changes show that beach erosion generally occurred above the -2 m NGVD elevation and accretion occurred below the -2 m NGVD. Among all the beach renourishment projects, the amount of erosion that occurred above -2 m NGVD elevation was greater than the accretion in the area below -2 m NGVD.

Substantial beach erosion occurred above -2 m NGVD elevation in Sunny Isles, where a great amount of sand that was placed on the beach moved offshore. More substantial cross-shore sand movement occurred in Sunny Isles than that in other areas, as illustrated in Figure 2. This is due to the nearshore hardbottom in these other areas that have restricted sand movement in a cross-shore direction.

IMPACTS OF HARDBOTTOM ON SAND MOVEMENT

The relationship between the net longshore sediment transport rate and offshore location of hardbottom is presented in Figure 4. In general, the longshore sediment transport rate increases from north to south, as does the offshore

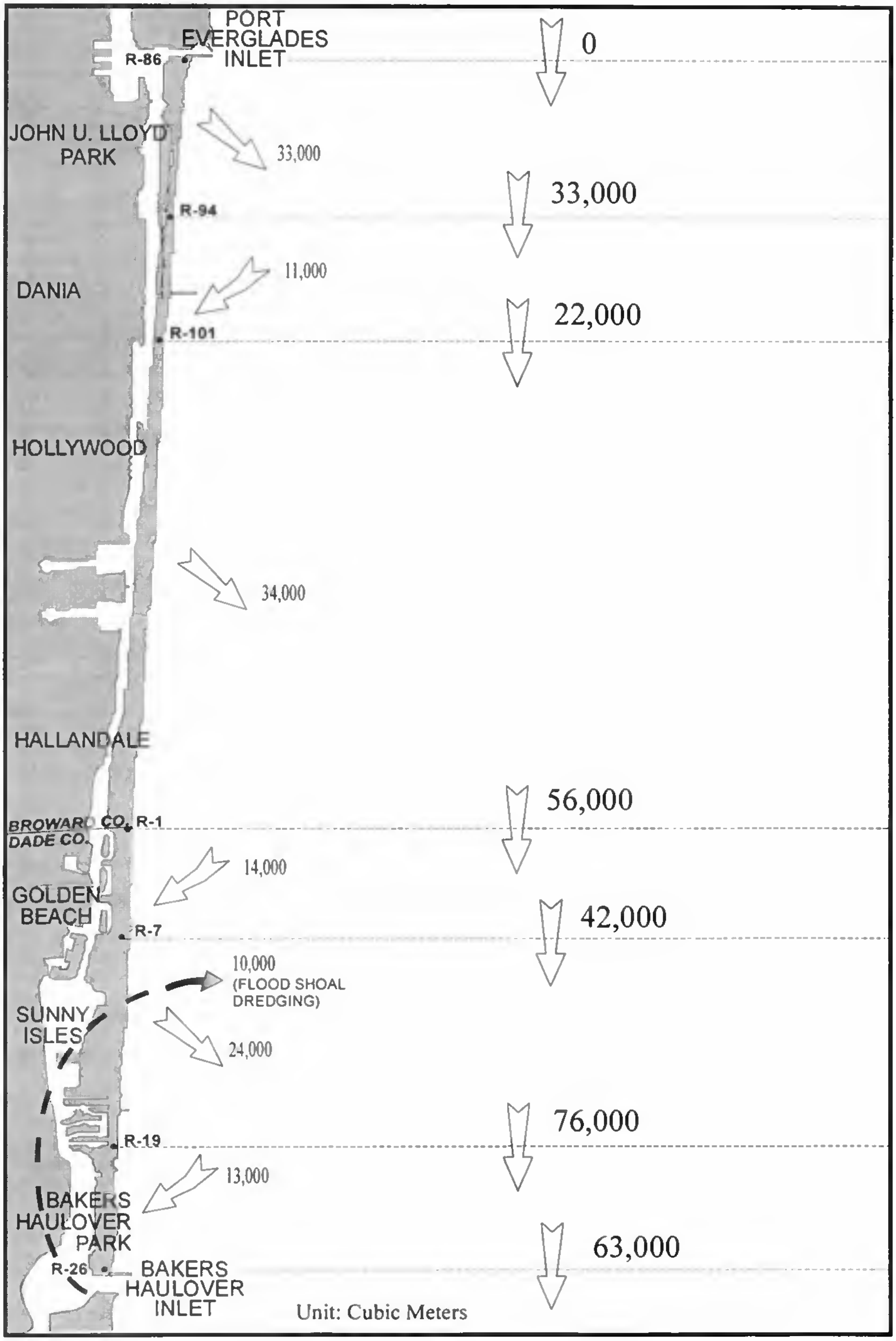


Figure 3. Regional Sediment Budget

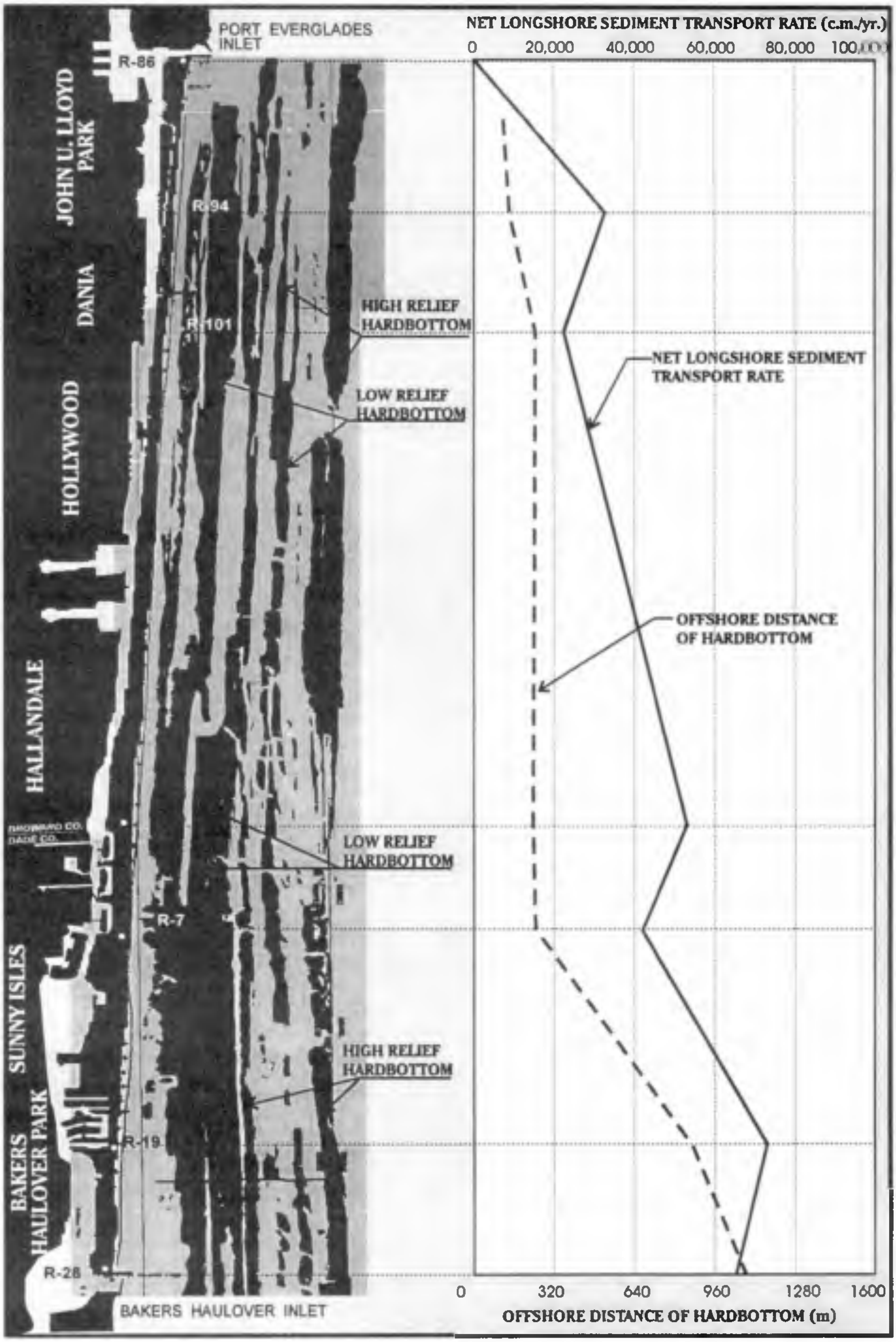


Figure 4. Longshore Sediment Transport Rate vs. Offshore distance of Hardbottom

distance of hardbottom.

Offshore wave climates along this study area are generally similar (Stauble, 1993). Along the north end, nearshore hardbottom has reduced wave energy and resulted in less longshore sand movement. In the northern half of the region, the hardbottom is located between 120 m and 300 m offshore, while the net longshore sediment transport rate ranged from 22,000 to 33,000 cubic meters per year. However, the hardbottom was located further offshore along the southern half of the area with the offshore distance between 300 m to 1,000 m, while the annual net longshore sediment transport rate ranged from 42,000 to 76,000 cubic meters.

Due to the differential sediment transport rate, there is an inherent sediment supply deficit within the region that would result in beach erosion. This may explain historically the need for beach renourishment projects for a combined total of 14.8 km of shoreline within the region.

CONCLUSIONS

The results of this study indicate that the existence of nearshore hardbottom has a significant impact on longshore and cross-shore sand movement within the region between Port Everglades and Bakers Haulover Inlet. Specifically, the net longshore sediment transport rate within the study area increased from north to south as the nearshore hardbottom aligned further offshore at the southern part of the area. The annual net longshore sediment transport rate increased from 33,000 cubic meters at John U. Lloyd State Park to 63,000 cubic meters at Bakers Haulover Inlet with a maximum of 76,000 cubic meters at the area between Sunny Isles and Bakers Haulover Park.

The hardbottom remains relatively close to the shore at approximately 120 m offshore at John U. Lloyd, then increases to 300 m offshore at Dania, Hollywood, Hallandale and Golden Beach, 600 m offshore at Sunny Isles, and 1,000 m offshore at Bakers Haulover Park. It is evident that the longshore sediment transport rate increases as the protection of nearshore hardbottom is diminished. At the southern end of the region, the net longshore sediment rate is consistent with that predicted by the COE using the GENESIS numerical model without consideration of hardbottom effect. Hence, the offshore hardbottom at Sunny Isles and Bakers Haulover Park has little or no effect on reducing wave energy and subsequently on the sand movement.

The effect of nearshore hardbottom on cross-shore sand movement is also evident. By examining the volumetric changes above and below -2.0 m NGVD as illustrated in Figure 2, less active offshore sand movement was observed in the area from John U. Lloyd to Hallandale. It suggests that the nearshore hardbottom may act as a perch structure preventing sand from moving offshore.

The use of the GENESIS numerical model to predict shoreline changes and sediment transport, may not provide reasonable results in regions with extensive nearshore hardbottom, such as occurs in southeast Florida. The effects of these nearshore hardbottom areas on longshore and cross-shore sand movement should be considered in developing a sediment budget for inlet or beach management plans.

ACKNOWLEDGEMENT

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