Coastal Engineering Technical Note

SHORELINE RESPONSE TO THE REDINGTON SHORES, FL BREAKWATER

PURPOSE: To present a case study example of a detached breakwater project, and provide information on the functional application of a breakwater for shoreline stabilization purposes. This CETN summarizes information found in Chu, et al. (1991) and US Army Engineer District, Jacksonville (1990), and supplements the general material on detached breakwaters presented in CETN III-22 (1984).

INTRODUCTION: Detached breakwaters are structures situated offshore and generally parallel to the shore. Breakwaters protect the adjacent shoreline by attenuating incoming wave energy. Sand transported along the beach is then carried into the sheltered area behind the breakwater where it is deposited in the lower wave energy region. Dean and Pope (1987) suggest that if the breakwater attenuates too much wave energy, sediment may eventually fill in the lee of the breakwater and form a tombolo (Figure 1). The breakwater-tombolo system may then act as a groin, disrupting the longshore sediment transport processes in the area. A more desirable shoreline configuration may be a salient. A salient is also a seaward growth of the shoreline; however, it remains detached, allowing some sediment to continue to pass through the system. The effectiveness of a breakwater or breakwater system depends on the level of wave protection and the length of shoreline it protects; thus, the breakwater's height, length, wave transmission characteristics, and distance offshore are important design parameters.

Redington Shores is located on the west coast of Florida on the narrow arc-shaped barrier island, Sand Key, in Pinellas County (Figure 2). The Redington Shores breakwater is situated to the west of the Redington Shores beach approximately 340 ft from the existing seawall. The structure was designed to control beach erosion and reduce beach nourishment requirements. Since its construction in late 1985, the spit in the lee of the breakwater has grown several hundred feet, and is occasionally attached to the structure during low tide following extended periods of calm weather.

SITE CHARACTERISTICS: Indian Rocks Beach, the most westerly point on Sand Key, forms a headland for the barrier island. The shoreline orientation and the shoreface gradient at Indian Rocks Beach create a nodal point for littoral transport (Dean and Pope, 1987). Northerly littoral transport occurs to the north of Indian Rocks Beach, and southerly transport occurs to the south. Because of the lack of littoral sand in the Gulf of Mexico, the center portion of Sand Key has experienced severe beach erosion. Before breakwater construction, Redington Shores beach had a minimal width that varied from 0 ft to approximately 50 ft at its widest section (Terry and Howard, 1986).

The west central coast of Florida is characterized as a low energy coast. Average yearly waves range from 0.2 to 1.0 ft in height with a period of 2 to 4 seconds (Davis, Hine, and Belknap, 1985). The diurnal tidal range is 2.3 ft (National Oceanic and Atmospheric Administration, 1991).

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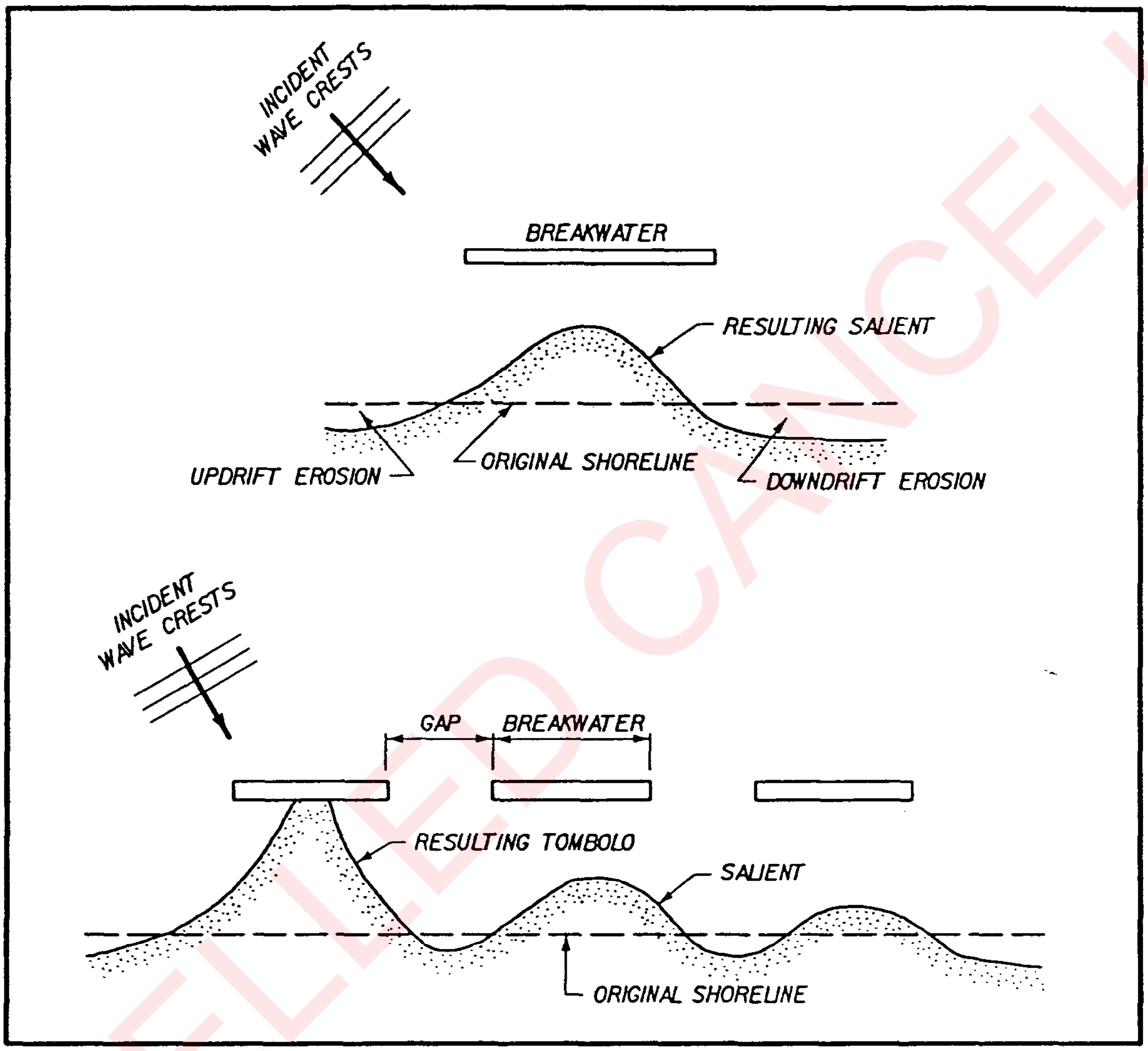

Figure 1. Types of shoreline changes associated with single and multiple breakwaters and definition of terminology.

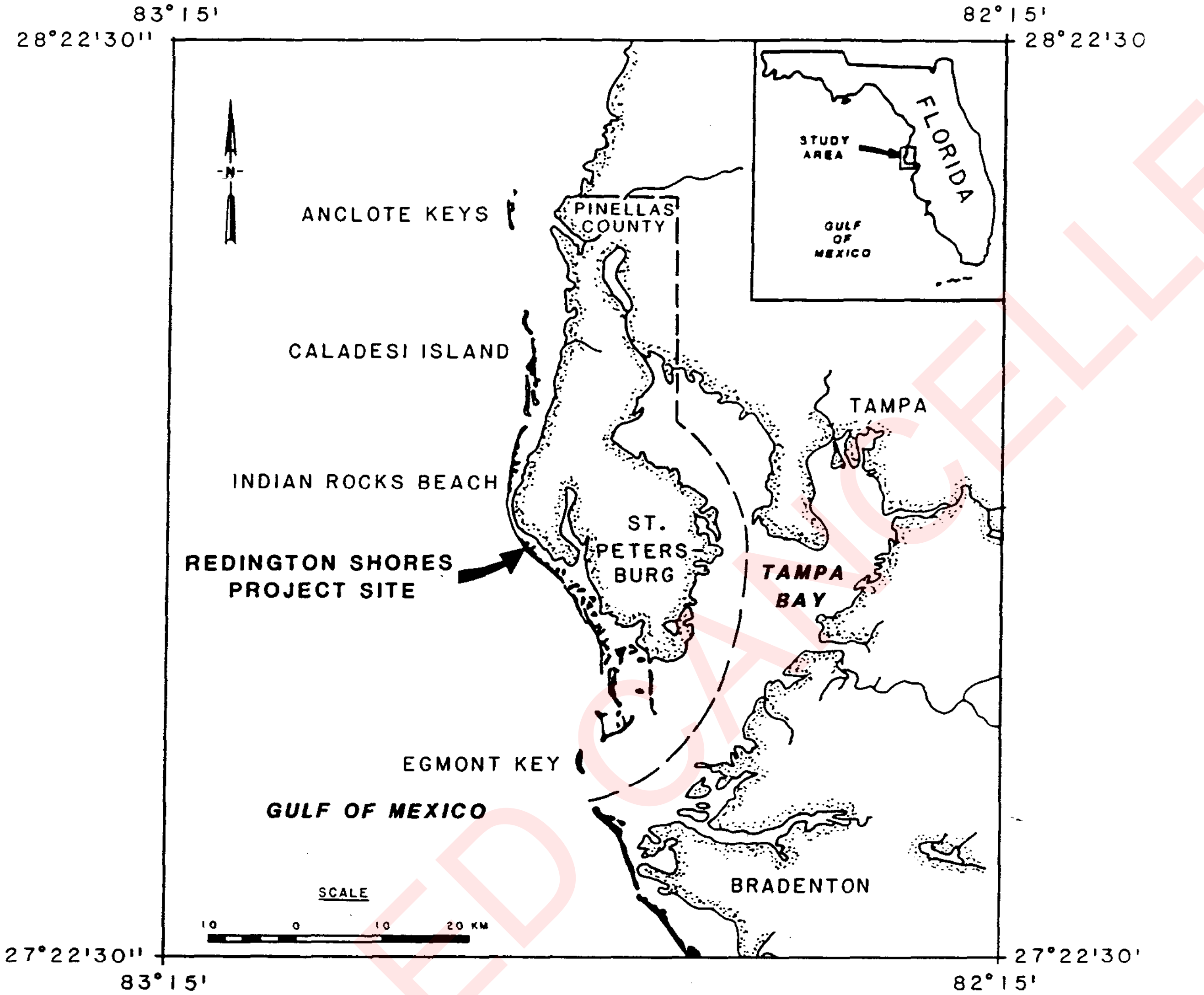

Figure 2. Project location map.

PROJECT DESCRIPTION: The Redington Shores breakwater was constructed between December 1985 and January 1986. The first 260 ft of the breakwater is parallel to the face of the seawall. The southern 90 ft is a dogleg to the south at 45 degrees to the axis of the main trunk. A low-crested design of 1.5 ft above Mean Low Water (MLW) was intended to facilitate longshore sediment transport during higher tide levels and storm events. Immediately following completion of the structure, approximately 30,000 cubic yards of sand was placed along a 1000 foot length of shoreline in front of the existing seawall. This material was native to the region and of similar characteristics to the native beach sediment.

In August 1988, Redington Shores beach was renourished with approximately 380,000 cubic yards of sand. At that time, 38 armor stones were removed from the breakwater to lower the crest elevation from 1.5 ft to 0.5 ft MLW. The objective was to allow more wave energy to enter the structure's lee and spread the salient over a wider reach of shoreline.

MONITORING PROGRAM: The U.S. Army Engineer District, Jacksonville performed a number of surveys prior and subsequent to project construction. Following completion of the structure, a shoreline response monitoring program was initiated to assess the breakwater's effectiveness for beach erosion control. This program was planned for a minimum of 5 years. The survey area originally covered 2,000 ft northwest and southeast of the breakwater and was extended to 4,200 ft northwest and 4,000 ft southeast of the structure after the second survey. Each survey consisted of 37 profile lines extending from the existing seawall seaward approximately 750 ft. Profile line spacing varied from 50 ft in the vicinity of the breakwater to 500 ft on the extreme northwestern and southeastern ends of the study area.

SHORELINE RESPONSE: Figure 3 is an aerial photograph of the project area just 4 months after breakwater completion. This photograph demonstrates the rapid tombolo formation which occurred in the lee of the breakwater and the effectiveness of the structure in attenuating wave energy.

For the total 22-month period from April 1986 to February 1988, the net increase in sediment volume within the study area was 57,400 cubic yards. Since the Redington Shores beach is a naturally eroding coastline, this increase in sediment volume during the post-construction period is most likely attributed to the presence of the offshore breakwater and placement of 30,000 cubic yards of sand. The monthly changes from August 1987 to February 1988 in the erosion/accretion processes are very scattered, apparently reflecting the weather and littoral conditions of those relatively short durations. Figure 4 shows an aerial photograph of the breakwater and tombolo in October 1987. Between April 1986 and February 1988, the nearshore region northwest of STA 06+00 (located 600 ft to the southeast of the breakwater) accreted at an average rate of 26.6 cu yd/ft/yr. However, the area southeast of STA 06+00 was experiencing erosion at a rate of 14.4 cu yd/ft/yr. The interruption of littoral transport by the tombolo may be responsible for the erosion that occurred downdrift of the structure.

SUMMARY: The Redington Shores breakwater has accomplished its design function of stabilizing the eroding beach immediately behind the structure. However, the ability of bypassing the longshore sediment transport is occasionally hampered by the formation of a tombolo in the lee of the structure. The initial shoreline response to the presence of the breakwater was relatively rapid and resulted in substantial growth of a tombolo in the three months following completion of breakwater construction. Variations in the erosion/accretion patterns during different survey periods are likely due to seasonal events.

From April 1986 to February 1988, a total of 57,000 cubic yards of sand accumulated in the study area but was not evenly distributed along the 8,000 ft of shoreline. Erosion continued about 600 ft southeast of the breakwater, and was generally larger than that northwest of the structure. The occasional interruption in the net southerly longshore transport by the low-water tombolo (groin effect) was apparently responsible for the erosion southeast of the structure, prior to the lowering of the breakwater crest elevation in 1988. The dogleg segment of the breakwater did not alleviate the downdrift erosion.

ADDITIONAL INFORMATION: For further information on the Redington Shores project or on general breakwater design guidance, contact Ms. Monica Chasten or Dr. Yen-hsi Chu, CERC, Coastal Structures and Evaluation Branch, (601) 634-2072 or (601) 634-2067.

Figure 3. Aerial photograph of Redington Shores breakwater: April 1986 (four months after construction).

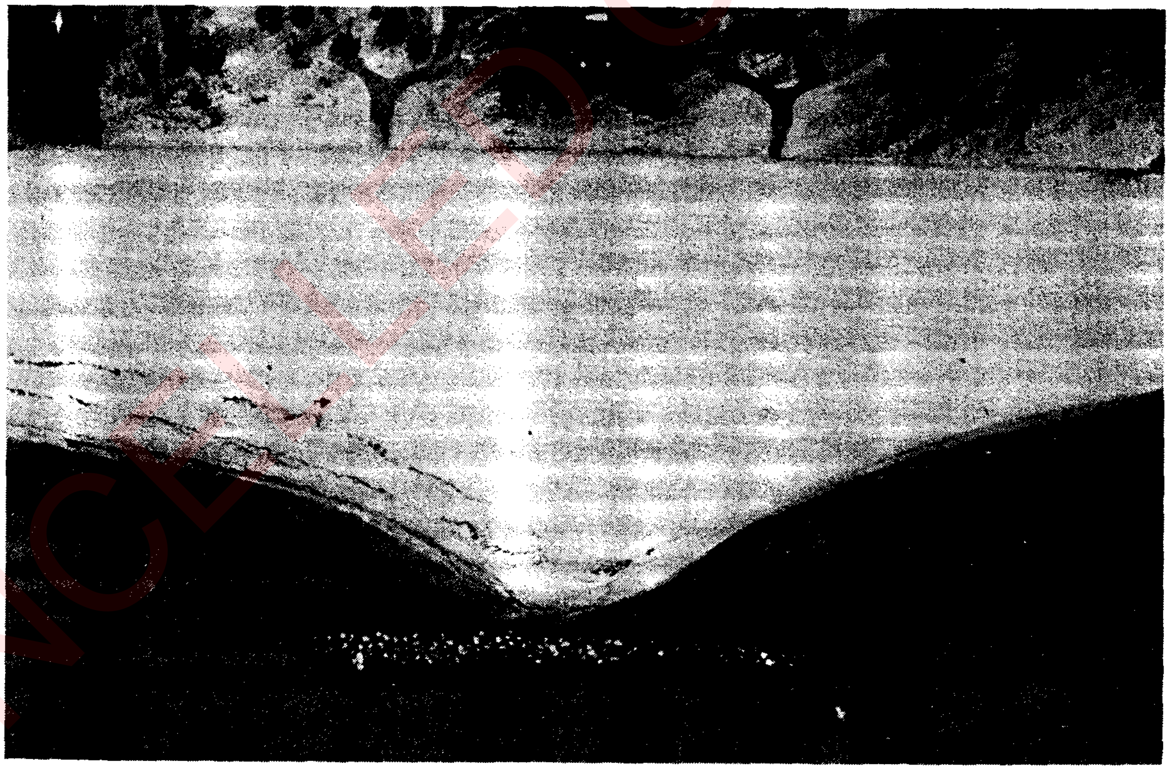

Figure 4. Aerial photograph of Redington Shores breakwater: October 1987.

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