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FIELD STUDIES OF BEACH CONES AS COASTAL EROSION CONTROL/REVERSAL DEVICES FOR AREAS WITH SIGNIFICANT OIL AND GAS ACTIVITIES

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ANNUAL REPORT

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ABSTRACT

The primary objective of this project was to evaluate the utility of a device called the "beach cone" in combating coastal erosion. Seven initial sites were selected for testing beach cones in a variety of geometric configurations, and six sites were actually used. Six hundred beach cones were installed at the six sites in late July and early August, 1992. An additional 109 cones were installed at an eighth site in December of 1992. Findings indicate that beach cones accreted significant amounts of materials along the beach of a barrier island. At the eighth installation the amount of accreted material was measured by surveys to be 2200 cubic meters (2900 cubic yards) in February of 1993, when the cones were found to have been completely covered by the material. The average increase in elevation was about 7 inches (0.18 m) with a maximum buildup of 3 ft. (1 m). At other test sites, accretion rates have been less dramatic but importantly, no significant additional erosion has occurred, which is a positive result. The cost of sediment accretion using beach cones was found to be about \$13.72 per cubic yard of sand or approximately \$500,000 per mile of beach, which would be much lower if the cones were mass produced. The survival of the cones through the fringes of Hurricane Andrew indicates that they can be anchored sufficiently to survive significant storms. The measurements of the cones settling rates indicate that this effect is negligible, does not hinder their effectiveness. We do not yet have sufficient data to state the categorical success of the beach cones, but results to date are encouraging.

INTRODUCTION

Coastal Louisiana has become the focus of an intense national debate concerning the control of coastal erosion. Although there are many causes of erosion in this area, the rate of beach and marsh retrogradation has been accelerated by man's activities. The goals of the current project are to test and evaluate the effectiveness of a particular device call the "beach cone" with regard to arresting erosion and possibly reversing the process by accreting sediments. A description of a beach cone appears in Figure 1.

Most often, beach cones are deployed in pyramids of two or three layers. An example of such a configuration is shown in Figure 2. In that figure, the pyramid is three-high with the bottom layer consisting of fifteen cones with interstitial "wave blocks" that interlock adjacent cones. The second layer has eight cones and the top layer consists of three cones and two wave blocks, so the entire pyramid contains twenty six cones. Although not shown in the figure, each wave block is cast with a nominal two-inch vertical hole through which PVC pipe is driven. The geometry of the pyramid is such that the holes in the wave blocks align vertically so that the PVC pipe can be driven directly through the pyramid and into the sediment beneath. This gives the pyramid great stability but does not render it entirely rigid.

Approximately 600 beach cones, with the associated wave blocks, have been installed at six locations within a typical barrier island/marsh ecosystem located south of Empire, LA in Plaquemines Parish. The map of Figure 3 identifies the approximate locations of the test sites. Note that there is no Site 5 since it was abandoned, having been judged not suitable for this study. The installed beach cones were monitored for a six month period.

Weight: 40 kg (88 lb) Weight in water: 20 kg (44 lb)
 Material of construction: lightweight concrete

Figure 1. Beach cone geometry and characteristics.

Figure 2. A 3-high pyramid of 26 cones with wave blocks.

SITE DESCRIPTION AND INITIAL TOPOLOGY FOR STUDY ONE

For the first study, seven sites in and around the Bayou Cook area of South Louisiana were selected initially. These sites were chosen based on their varied topology, sediment size, and incident wave characteristics, and are indicated in Figure 3. Site 5 is not listed because it was abandoned due to its lack of a sloped shoreline which made cone placement very difficult. The dates of cone placement and configuration of cones at each site is given chronologically in Table 1. As shown in this table the cones were deployed over a two and one-half week period in late July and early August of 1992. All these sites were monitored for changes every two to four weeks as weather permitted. Lack of funds prevented taking instrument measurements of elevations at the six sites in study one. All changes recorded were based on comparisons of visual inspection of the sites with nearby areas without cones. All of the areas without cones showed continued erosion.

Table 1. Cone Placement Date and Configuration - Study One.

Date	Site #	# of cones	Configuration
July 20	1	38	2 - double high
July 21	7	38	2 - double high
July 24	2	133	7 - double high
July 25			
July 28	2	30	single file around eroding marsh area
July 30	3	19	1 - double high
July 30	7	10	zig-zag between islands started
July 31	7	84	zig-zag completed
August 4	7	76	1 - triple high 2 - double high
August 5	6	38	2 - double high
August 6	4	20	single file
August 7	2	118	single file
Total #		of cones	600

Figure 3. Map of the Empire to Shell Island estuary.

Figure 4. Site 1.

Site 1 is located at a pass between Halfmoon Bay and Bay Adams that has been widening due to erosion. This site was selected because it provided medium size sediment particles combined with waves of moderate to high energy caused by the long fetch distance available in Bay Adams. In addition, the site provided for competing waves from the Halfmoon Bay side. These waves were smaller due to the shorter fetch of Halfmoon Bay. At this site, two pyramids of nineteen cones each were placed directly on the eroding end of the pass between the remaining point of land and pilings, (see Figure 4), which mark the former extent of the land. The pyramids were placed end to end with about a twenty five foot (7.62 m) gap between them.

Figure 5. Site 2.

Site 2 was selected to determine the viability of using beach cones to reduce erosion along the shoreline of a bayou. The bayou runs from left to right along the bottom of Figure 5. This site, located at a point in Bayou Cook, is subject to waves caused by the short fetch across the bayou (approximately 600 ft., 183 m.), by an occasionally passing boat, and by strong tidal currents. The primary sediment at this site is small. Five sets of two high pyramids consisting of nineteen cones each were placed at the mouth of a lagoon which opens to the Bayou. Two sets of identical pyramids were placed at an opening in the marsh that has been receding rapidly over the past few years. Finally, a string of cones was laid single file around a camp to test the viability of cones forming a sediment trap.

Site 3 is on the eastern shore of Bastian Bay several hundred yards from the opening of Bayou Cook. There is a small erosion zone at this site creating a dimple in the shore line, (see Figure 6). This site has the same sediment size as Site 2 but the wave energy is higher owing to the larger fetch distance in Bastian Bay. Due to the proximity to the Bayou Cook opening, there is a significant current along the shore during tidal changes. A single two high pyramid of nineteen cones was placed at this site parallel to the former shoreline.

Figure 6. Site 3.

Figure 7. Site 4.

Site 4 is located at the opening of an oil/gas pipeline canal on the western side of Bastian Bay. It was selected to test the utility of using beach cones in a single file manner to repair small erosion damaged spots.

Figure 8. Site 6.

Site 6 is located on the north side of Shell Island Bay. It differs from Site 3 in two important ways. First, the location is far from the entrance to any canals or bayous which constrict the flow area available to the tidal waters and thereby increase the water velocity in the immediate area. Second, the site is close to several "overwash fans" (sediment from a barrier island that has been washed into the back bays by large waves) resulting from the overtopping of Shell Island, by large

waves. The overwash fans provide a larger sediment size, without requiring the placement of the cones in a high wave energy situation. Two pyramids consisting of nineteen cones each were placed at this site in a V shaped pattern.

Figure 9. Site 7.

Site seven is located at a point along Shell Island where a shallow pass, six to twelve inches (15 to 30 cm) in depth at low tide, has developed. This site has a large sediment size, consisting of many shells and some sand. The waves impacting the area come from the Gulf without any obstruction resulting in a high wave energy relative to all other areas in the study. There are also waves impacting this site from the north from Bastian Bay. Over a period of two weeks, four two-high pyramids, one three-high pyramid and one long single-file were placed at this site. It is important to note that this includes two 19 cone pyramids placed west of the gap on the Gulf side of the island. These are shown in the upper right of Figure 9. The single file of cones extended from the end of the island on the west side of the pass to the island on the east end of the pass in a zig-zag like pattern. At low tide, the tops of many of these cones were out of the water. Two nineteen cone pyramids were placed on the Gulf side of this row and still further out the three high pyramid consisting of thirty-six cones was placed.

DESCRIPTION OF STUDY TWO

There is only one test site in study two, which is located on Fourchon beach in South Louisiana. Fourchon is a sandy beach on the Gulf of Mexico, that has medium grain size combined with moderately high wave energy. An initial topological survey was taken during the two day period of beach cone deployment in December of 1992. The results of this survey together with the cone placement is shown in Figure 14. Four two high pyramids and two three high pyramids were deployed in the area. The pyramids were placed at different angles to the shore line with varying distances between them and the shore line and between each other. In

February a second survey was conducted and in June of 1993 a third survey was performed. The changes in the topology of the beach, the amount of sediment gained or lost, and the degree to which the cones shifted and settled during the study were determined from these surveys. Although surveys were conducted at the site where cones were placed, lack of funds precluded the possibility of surveying a remote section of the beach without cones as a control.

DISCUSSION OF FIELD RESULTS

Study One:

The monitoring of the sites in Study One have shown a wide range of effectiveness. The morphological changes in the sites has ranged from small islands becoming evident to no change except the cessation of erosion. There is no evidence at any site in the study of the cones having an adverse effect on the ecosystem or on the site morphology.

The largest amount of change has occurred at Site 7. In late August of 1992, Hurricane Andrew destroyed the island to the east of the pass. The island to the west of the pass showed little damage from the storm. There was no indication that the storm altered the configuration of the cones. The condition of Site 7 after the hurricane is shown in Figure 10. The survival of the beach cones through Hurricane Andrew is a good indication of the stability of the structures under very high energy waves.

A few weeks after Andrew passed, a significant buildup of sediment at the eastern end of the zig-zag pattern was noted. On November 27, 1992 a visit to the site revealed a significant buildup of shell size sediment just to the north of the cone installations. By December 4, 1992 this area had grown to a size of 25 by 40 feet (7.62 by 12.19 meters) at a height of sixteen inches (40.6 cm).

Continued observations revealed that this sediment was moving northward. The island at the west end of the zig-zag was also extending to the north. By the middle of May 1992, a new island north of the cones and a new island east of the cones had appeared. The island to the east is most likely a result of the first noted buildup moving to the northeast and growing. This growing island was not seen during the February examination due to very high tides. The island to the west had detached from the cones and was continuing to move north. The changes seen in the site are summarized in Figures 11 to 13.

The fact that the original pass between the islands was not repaired is not considered a failure. To the contrary, the significant amount of accretion that has occurred since the passing of Andrew is a positive indication but it is not possible to attribute this to the cones.

Figure 10. Site 7 after Hurricane Andrew.

Figure 11. Site 7 December 4, 1992.

Figure 12. Site 7 February 1993.

Figure 13. Site 7 mid May 1993.

The only other sites to show accretion in Study One were Sites 1 and Site 2. Site 1 had a slight build up of sediment (about 7 inches, 0.18 m) on the south side of the cones on November 27, 1992 and this elevation has remained the same. Site 2 was observed to have a buildup on the marsh side of the two pyramids to the north on November 27, 1992. This site has shown a continuous accretion rate and is now on

the order of 10 inches (0.25 m). Furthermore, the single file ring of cones around the camp has a large number of oysters growing on and within the cones, which has produced a significant buildup of material. The other sites in Study One have shown no accumulation to date, but importantly there has been no further erosion.

Table 2 ranks the sites, including the one in Study Two, according to amount of sediment accumulated. The current referred to is one other than those resulting from obliquely incident waves, which are present at all the sites. It appears that the best conditions for beach cones are moderate to high wave energies combined with a sandy beach. The area of least impact occurred with small or medium energy waves combined with small or medium grain size. However, as noted earlier, even some of these sites showed slight accretion, and none of them showed continued erosion. Table 2 indicates that the incident wave energy is the predominant factor in determining success or failure. The effect of currents in the area is not apparent and needs further study.

Table 2. Sites Ranked by Overall Effectiveness of Cones.

Site	Wave Energy	Particle Size	Current
Fourchon	High	Medium	none
Seven	High	Large	none
Two	Small	Oyster Shell	yes
One	Medium	Medium	yes
Three	Medium	Small	yes
Four	Medium	Small	yes
Six	Small	Medium	none

Study Two:

The initial survey of the Fourchon beach is shown in Figure 14. The cone pyramids are shown as dark ovals. It can be seen that the contour lines are all roughly straight and parallel to the shoreline, which is at the 3.0 ft. (0.9 m) contour during mid tide, except for around the -1.5 ft. (-0.45 m) contour. The variance of the -1.5 ft. (-0.45 m) contour is explained by the presence of a large pipe running across the contour lines in the point at which the -1.5 ft. (-0.45 m) contour abruptly changes.

The second survey is shown in Figure 15 from which it can be seen that the general shape of the contours is the same but those less than 3.0 ft. (0.9 m) have shifted south east by about 25 ft (7.6 m). Also, the contours around 0 ft. have moved further apart. This is an indication that the overall slope of the beach is decreasing. Those contours higher than 3.0 ft. (0.9 m), the shore line at mid tide, only moved slightly. The fact that all of the contour lines remained generally straight and parallel without abrupt changes in direction indicates that the cones were functioning in a manner that allowed each pyramid's effect on the topology to overlap with its neighbors.

Figure 14. Fourchon Beach December 1992.

Figure 15. Fourchon Beach February 1993.

In an effort to better assess the effectiveness of the cones, a *difference* map of the December and February data was generated as shown in Figure 16. This map indicates that the accretion was greatest in the northeast section of the study area, in which up to 2.3 feet (0.7 m) of sediment was accreted. This is as expected because two of the three pyramids in this area were three cones high, and took longer to become completely covered. Figure 16 also shows a net loss of sediment in the southern most corner of the study area. However, the region between the two zero accretion contours is also the location of the pipe mentioned previously, which is believed to have affected the accretion in this area.

Figure 16. Fourchon Beach February '93 - December '92 Difference Map

The accretion region map shown in Figure 17 shows regions where sediment accumulation occurred in white and regions where losses occurred in black. This figure indicates that the area in which the cones would be expected to have an effect, elevations below the mid tide line, showed only accretion. The one exception was the area in which the pipe was located. This indicates that the cones had a positive effect on the accretion in the area.

Figure 17. Fourchon Beach February '93 - December '92 Accretion Region Map

Figure 18. Fourchon Beach June 1993

A third survey was done in June of 1993 and is shown in Figure 18. The contour lines taken during this survey vary little from those taken in the February survey. The *difference* map shown in Figure 19 indicates that there was little accretion during this time. These results indicate that the overall changes in the area were small during the February to June period. The measured volume change for the February to June period of 450 cubic meters (600 cubic yards) compared to that of the December to February period of 2200 cubic meters (2900 cubic yards) is further indication that the change during this period was small compared to the previous period. Figure 20 is an accretion map for the February - June period where again accumulation areas appear in white while areas of loss are shown in black.

Figure 19. Fourchon Beach June '93 - February '93 Difference Map.

The difference map and accretion region map for the over all December to June period are shown in Figures 21 and 22. They appear to be very similar to the December to February data but different from the February to June data. This is taken as strong evidence that the changes in the area from December to June occurred almost entirely during the December to February time frame. Since the cones were found to be completely covered during the February survey, they would be expected to have effected the accretion rates only during this period. The rate of accretion was roughly 1450 cubic yards per month between December and February, when the cones would have had an effect, and 200 cubic yards per month between February and June when the cones had no effect. If the accretion rates during the second time frame are assumed to be due to some natural background accretion the cones have demonstrated the ability to increase the accretion rate significantly.

Note that from Figure 21 the maximum elevation gain is in the order of 3 ft. (1 m) in the neighborhood of the triple high pyramids. This suggests that it is not optimum to place pyramids with only two layers of beach cones and that triples or even quad-high arrangements should be used.

Figure 20. Fourchon Beach June '93 - February '93 Accretion Region Map.

Figure 21. Fourchon Beach June '93 - December '92 Difference Map

Figure 22. Fourchon Beach June '93 - December '92 Accretion Region Map.

The cost of beach restoration using beach cones can be crudely estimated from the data taken from Fourchon. The cost for the six beach cone installations located at this area was \$40,000 for 460 feet, which is equivalent to about \$500,000 per mile of beach. The amount of accreted material was 2900 cubic yards (2200 cubic meters), which translates to \$13.79 per cubic yard (\$17.95 per cubic meter) for the December to February time frame. Importantly, the cost of the cones will decrease if they are produced in larger quantities.

In addition to sand elevations, the elevation of the tops of the pyramids was taken in the surveys at Fourchon beach. This information is summarized in Figure 23. There were two sets of measurements taken on pyramids one and six. The numbering of the pyramids is from lower left to upper right in Figures 14 to 22. The average change in these eight points is a loss of one fifth of a foot (0.06 m) in

elevation. The maximum loss was three fifths of a foot (0.18 m) at one point on pyramid one while no change was found at pyramids three and six. This indicates that while the cones may settle in soft sand, these effects are small compared to the height of accreted sediment. Furthermore, most of the settlement was during a "seating" period of just a few hours of installation.

Figure 23. Top of Pyramid Elevations.

CONCLUSIONS

Based on this study the following conclusions can be drawn.

1. Beach cones can have a noticeable effect on erosion rates. The ideal conditions for their use would be medium to high wave energies with sandy beaches.
2. The cost beach of cones is favorable when compared to that of conventional beach restoration methods. A conservative estimate from Study Two indicate that the cost per cubic yard is \$13.72 (\$17.95 per cubic meter). The cost of the entire installation was equivalent to about \$500,000 per mile of beach.
3. The structure of the cones is strong enough and they can be anchored sufficiently to survive significant storms.
4. The average accretion in Study Two was 0.6 ft. (0.18 m) while the maximum gain in elevation was about 3 ft. (1 m) in the vicinity of the triple high pyramids. This suggests that double high pyramids should not be used.
5. While the cones settle in soft sand, it has been demonstrated that this effect is small and it occurs almost entirely within a few hours of installation.
6. Based on visual inspections, there have been no detrimental effects to flora or fauna from beach cone use.

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