Struisbaai, near Cape Agulhas

PART II
COASTAL SEDIMENT PROBLEMS

Wilderness Cape Province

ARTIFICIAL MANIPULATION OF BEACH PROFILES

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ABSTRACT

A field study was conducted at Myrtle Beach, South Carolina (U.S.A.), to determine the response of natural beaches to artificial manipulation by sand scraping. Between March 1981 and May 1982, a total of 100,000 m^3 of sand was shifted from the lower beach to the backbeach on three occasions over a 14-km length of shoreline. Fifty-four profile stations were surveyed to the -1.0 meter contour as many as ten times during the study to determine the effect of scraping and fill along a stable-to-slightly erosional beach. The purpose of the scraping and fill was to provide temporary erosion relief, protect existing dunes and structures, and provide a wider recreational beach at high tide. It was found that scraping and fill had little adverse effect on the beach cycle in the northern zone of the project area, which is fronted by a natural dune system. Fill placed at a gentle slope along the seaward margin of the dunes remained in place for up to ten months before eroding to the prefill surface. In contrast, similar quantities of fill along shore protection structures in the southern zone eroded in several weeks to four months. The study found significant differences in the response of armored versus unarmored shorelines with higher erosion rates and slower recovery of the beach at armored stations.

INTRODUCTION

A field study was conducted at Myrtle Beach, South Carolina (U.S.A.) to determine the response of a natural beach to artificial manipulation by sand scraping. One purpose of the study was to establish limiting criteria for the degree of berm or dune maintenance feasible on moderate energy sand beaches, without adverse impact to the natural beach cycle.

Several U.S. east coast beach communities including Ocean City, Maryland (Kerhin and Halka, 1981), and Hilton Head Island (South Carolina) have made a practice for a number of years of borrowing sand from the lower beach and backfilling the berm or dune area. In the case of Myrtle Beach, the purpose of the artificial beach manipulation has been to widen the recreational, high tide beach and reduce the erosion rate of dune scarps. This practice has been controversial

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since it does not add sediment to the littoral system but merely shifts it around. The simplistic view holds that scraping adversely steepens the beach profile, making subsequent erosion more likely and severe. To our knowledge, this notion has not been tested.

CEOMORPHIC SETTING AND DEVELOPMENT PRACTICES

Myrtle Beach, located along the northern coast of South Carolina on the U.S. east coast (Fig. 1), is a mainland, strand shoreline. It consists of a broad, 16-km arcuate section of coastline hacked by Pleistocene beach ridges. No major tidal inlets or marshes occur at that locality. In recent historic times, the shoreline has been slightly erosional experiencing dune recession rates averaging approximately one-third to one-half meter per year over the last century (Hubbard et al., 1977). Although erosion is slow, it has progressed to a point where the quality and character of the beach, on which much of the tourist economy depends, is becoming degraded. Rapid and sometimes haphazard development practices combined with steady recession of the shoreline have forced construction of retaining walls, bulkheads, and rock revetments to protect existing development.

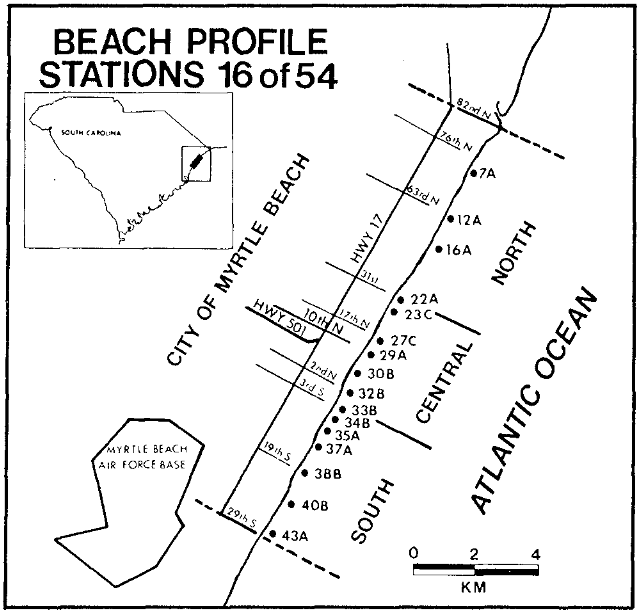

FIGURE 1. Location of Myrtle Beach (South Carolina) along the U.S. east coast. Selected beach profile stations along the northern-central and southern portion of the City are shown.

The shoreline along the City of Myrtle Beach is dominated by private residences in the northern half and hotels in the southern half (Fig. 2). Several piers and minor swashes (tidal channels emptying along the beach) interrupt an otherwise broad, arcuate shoreline. Isolated outcrops of Pleistocene-age mud or marsh clay deposits occur near the low watermark. Nearest navigable inlets are Little River (27 km to the northeast) and Murrells (21 km to the southwest). As Figure 2 shows, a narrow dune remains seaward of most residences in the northern portion of the city. The central area of the city shoreline has an increasing concentration of hotels. Natural dunes are rare; however, the shoreline edge is generally "soft" with landscaping or artificial fill along the seaward property boundaries. The southern third of the shoreline (Fig. 2c) is dominated by hard structures along the backbeach, with little or no setback of developed property.

NEARSHORE PROCESSES

The study area lies in a broad, wave-dominated embayment that forms an arc between Cape Fear (North Carolina) and Winyah Bay (South Carolina). A mean tidal range of 1.6 m (5.1 ft) and a spring tidal range of 1.8 m (6.0 ft) places Myrtle Beach in the high end of the microtidal (<2.0 m) class.

Nearshore bathymetry from the shoreline to 400 m offshore is characteristically concave upward and steep, with an average slope of 14 m/km. From 400 m to 4 km offshore, the rate is only 0.8 m/km and from 4 km to 12 km, the rate is 0.4 m/km (Brown, 1977).

Without the influence of inlet-associated tidal currents, the major mechanism affecting sediment transport is wave action. At Myrtle Beach, both longshore and onshore/offshore transport are significant in the surf zone. The observed cyclic changes of the beach profile are largely a result of the onshore/offshore component. Short-period storm waves erode beach sediment and transport it offshore where it commonly deposits as a bar. During fair-weather conditions, lower-energy waves move sediment back onshore. The longshore component is highly correlated with the prevailing seasonal winds that determine the direction and angle of wave approach and the resulting longshore current direction. On an annual basis, the net longshore sediment transport in South Carolina is to the south (Hubbard et al., 1977).

PREVIOUS WORK

There have been few studies dealing with beach scraping as a soft approach to beach restoration. Among the nonstructural means of restoring shorelines, artificial nourishment from offshore, inlet, and inland sources (Strock and Noble, 1975; Walton and Purpura, 1977; CERC, 1977) has been widely preferred and employed over the cannibalization of sand from portions of the beach. Beach scraping has generally been performed on a small scale, mainly to protect one or a few properties from wave attack.

FIGURE 2A) Northern Zone: Predominantly residential with existing low, natural foredune. Few shore protection structures.

FIGURE 2B) Central Zone: Transition from residential to predominantly hotels. Note encroachment of development up to dune line. Shore protection structures are generally fronted by landscaped, soft edges along the backbeach.

FIGURE 2C) Southern Zone: Dominated by hotels and hard structures along the backbeach. Natural dunes essentially nonexistent.

FIGURE 2. Representative oblique aerial photographs of the northern (2A), central (2B), and southern (2C) portions of the project area at Myrtle Beach, South Carolina. All photos taken at low tide on 3 February 1981.

Documentation on the effects of beach scraping projects have dealt with the comparison of beach volumes and morphologic changes along the manipulated profile; however, statistical applications for significance testing have not been performed. In a study of beach scraping conducted at Ocean City (Maryland), Kerhin and Halka (1981) report accelerated erosion in the backshore due to artificial disruption of the natural beach profile. Their project, however, preceded a winter season that proved to be one of the stormiest in recent history. Conclusions made from sweep-zone profile plots indicated that bulldozing of the lower foreshore oversteepened an already steep beach slope and interfered with the seasonal readjustment to an equilibrium profile, allowing erosion at a greater rate.

Tye (in press) presents a comparison of morphologic changes between scraped and nonscraped profile stations at Folly Beach (South Carolina) shortly after the passage of Hurricane DAVID (1979). Analyses of sequential profile plots had indicated an interrupted natural recovery cycle along scraped portions of the beach due to mechanical steepening of the lower foreshore, allowing a transformation in breaker type from spilling to plunging and inducing a net offshore movement of sediment. His emphasis from this study was placed on the importance of a quantitative assessment of the initial erosion and subsequent recovery as a baseline for implementing a more prudent beach scraping program.

Another concept of placing sand on the beach, practiced during the 1960s at Jupiter Island (Florida), is that of the Sauerman drag scraper (Department of Coastal and Oceanographic Engineering, University of Florida, 1969). In this project, borrow zones were located offshore, seaward of the normal surf zone, ranging frem 50 to 240 m from the shoreline. Approximately one year after scraping, a survey revealed a much steeper backshore and beach face, largely attributed to a coarser grain size transported from the offshore borrow area. The total volume of sand comprising the supratidal beach, however, was greater at the end of the study than before scraping. The beach fill had a positive effect in preventing any large-scale erosion, although it probably did not stop overall erosion along the profile.

Foredune construction through various sand-fencing materials and methods has been practiced at Cape Cod (Massachusetts), Core Banks (North Carolina), and Padre Island (Texas) (CERC, 1977). Recently, the townships of Ortley Beach and Lavalette (New Jersey) have experimented with erecting closely spaced sand fencing along the backshore, angled normal to the predominant northeast winds (S. Halsey, N.J. Environmental Protection Agency, pers. comm.). During fall and winter, sand is trapped by the fence, building up the backshore. Prior to the summer season, the fence is removed and the accumulated sand is mechanically redistributed both landward and seaward, creating an artificial berm and simultaneously decreasing the beach slope. These beach scraping and nourishment programs have all been conducted along highly developed, critically eroding barrier islands on the Atlantic coast, often in sediment-starved beaches. At Myrtle Beach, the erosion rate is considerably lower, and sediment supply is apparently more readily available from the eroding Pleistocene ridges and updrift sources.

DESIGN

Low cost attracted the City of Myrtle Beach to implement a beach-scraping maintenance program to enhance the backshore and provide temporary protection from shoreline recession, at least until longer-term solutions could be financed and implemented. This soft-engineering approach, though temporary, was considered cost-effective and aesthetically preferable to hard structures in 1981.

The plan for backbeach restoration followed the design shown in Figure 3 (Kana and Dinnel, 1981). Borrow areas were generally located along broad, low-relief intertidal ridges with higher volumes removed at localized accretion fillets around piers. Fill zones were graded to a gentle slope (approximately 1:10) as illustrated in Figure 4. Typical unit width volumes of borrow and fill were 6-8 m^3/linear meter of beach. Construction was by means of pan earth movers and bulldozers. The design of borrow zones attempted to distribute any adverse effects of scraping by identifying broad sections of the low-tide beach where relatively more sand was available, and by limiting the depth of scraping to within 0.3 to 0.5 m. This was determined by comparison of the total unit width volumes from 54 reference cross-sections.

DATA BASE

NETWORK OF STATIONS

The data base for design and evaluation of the Myrtle Beach scraping program consists of 54 beach profile stations (Fig. 1) measured up to ten times each between February 1981 and May 1982 (300 data sets total). Stations were spaced approximately 250 m apart and surveyed from the backshore to the -1.0 m mean sea level (MSL) contour.

The stations represent a variety of beach conditions and backbeach configurations ranging from natural dune/beach areas to armored shorelines. Erosional scarps of semilithified Pleistocene mud are also common along the central third of the project area. The most common armoring of the backbeach is by means of vertical concrete bulkheads; timber and sheetpile bulkheads are next common; riprap of 50-500 pound stone (typical) occurs at several stations.

These data offer a detailed comparison of short-term beach response due to artificial manipulation as well as natural changes along armored and unarmored beaches.

STANDARDIZED BEACH SEGMENTS

The basis for spatial and temporal comparison of profiles were standard unit width cross-sections of the intertidal beach from the base of scarps or armoring to the -1.0 m MSL contour (Fig. 5). These sections included backbeach, mid-beach, and low-tide ridge areas for evaluating the effect of scraping and fill on particular parts of the profile. Segments were normalized against mean beach section for statistical comparison and significance testing.

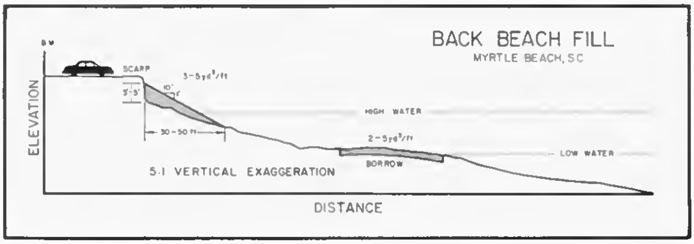

FIGURE 3. (Above) General design for beach scraping and backbeach fill at Mrytle Beach.

FIGURE 4. (A-C) Construction sequence showing pan earthmovers scraping near the low watermark on an intertidal ridge (4A); grading to a gentle 1:10 slope along the backbeach (4B); and the final condition after raking (4C). In general, mean high water was shifted seaward 10-15 m to the base of the fill zone.

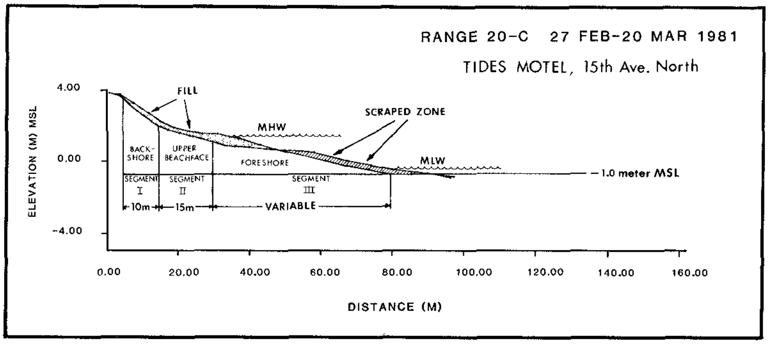

FIGURE 5. Representative reference beach cross-section in the central zone of Myrtle Beach. Principal borrow zones were along Segment III (foreshore) on intertidal ridges. Fill zones were located along Segment I (backshore) at or above the high watermark up to existing dune scarps or shore protection structures.

The backshore (Segment I) consists of a 10-m-wide section of the beach from the base of dunes or shore-protection structures and coincides with the zone of fill near high water. The upper beach face (Segment II) is designated as an arbitrary 15-m-wide zone which generally was undisturbed by scraping or fill. The lowermost segment (III) included the entire low-tide terrace and ridge system extending to the -1.0 m MSL contour. Width of Segment III varied from approximately 60 to 100 m, becoming narrower in the southern portion of the city, and incorporated all borrow zones. Table 1 is a summary of backshore station types over the project area. Note that the northern portion of the shoreline is dominated by dunes or sand fill, whereas the southern district is more commonly armored.

TABLE 1. Distribution of stations (%).

Region	Shoreline Length	No.	Armored	Natural Erosional Scarps	Dunes/ Old Fill
North	6.6 km	17	6%	12%	82%
Central	3.9 km	22	9	37	54
South	4.2 km	15	68	13	19
Overall	14.7 km	54	26%	21%	53%

Mean unit width beach volume from the dune line to the approximate -1.0 m MSL contour is given in Figure 6 for each zone of the project area. Also indicated are the proportion of armored versus natural stations and number of stations for each zone. Note the general decrease in unit beach volume from north to south. There was an average of 20 percent less sand in the reference sections along the more heavily armored southern zone than along the northern zone. All profiles were ohtained over a 3-day period in November 1981.

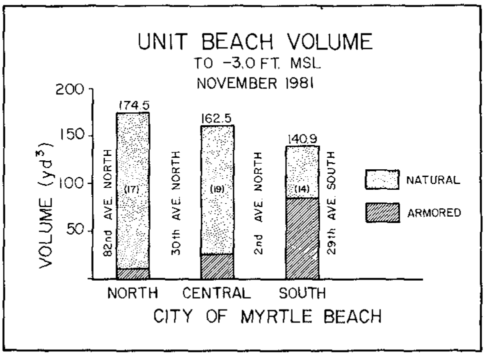

FIGURE 6. Mean unit-width beach volume for reference sections between the base of the dunes or the shoreline structures to the -3.0 ft (approx. -1.0 m) MSL contour. Relative proportion of armored versus unarmored stations and number of stations are indicated on each bar. Note the 20 percent decrease in unit volume from north to south correlating with increase in proportion of armored stations.

ARTIFICIAL BEACH CHANGES

Between March 1981 and May 1982, portions of Myrtle Beach were scraped along the lower beach and backfilled along the upper beach on three occasions. Approximately 25-50 percent of the project shoreline was directly affected by scraping or filling on the first two occasions. In some cases, borrow sections did not correspond to fill sections. This allowed evaluation of stations which were borrowed but not filled and vice versa. Total volume moved was approximately 29,000 m^3 during operations in March and June 1981. During a second-phase plan beginning January 1981, over 80 percent of the shoreline was scraped and filled (estimated volume 75,000 m^3).

PERFORMANCE EVALUATION

PHASE I CHANGES

Soon after the first sections of shoreline were scraped and backfilled, a minor northeast storm on 22 March impacted the Myrtle Beach area. The storm was sufficiently large enough to destroy a section of an ocean pier in the central zone of the project area. Beach measurements before and after the storm allowed evaluation of the effect of scraping and backbeach fill on selected portions of the shoreline. Figure 7 shows pre- and poststorm changes to the reference beach section (Segments I, II, and III, combined) for eight representative stations. All profiles were obtained between 21 and 24 March 1981. Figure 7 shows a trend of increasing erosion from north to south and somewhat higher erosion at armored stations (on average).

During the ensuing months, considerable natural recovery occurred. To illustrate how several representative stations responded, backbeach (Segment I) unit volume changes are given in Figure 8 for the period February-November 1981. The data represent short-term

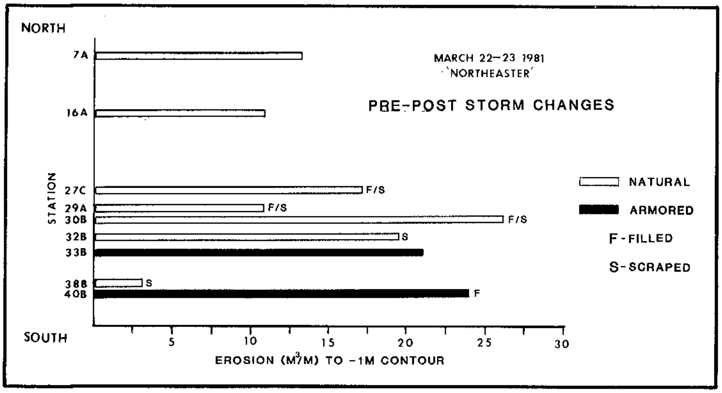

FIGURE 7. Pre- and poststorm beach changes at Myrtle Beach for 8 representative stations. Erosion is measured as the unit-width volume change (m^3/m) for a reference cross-section from the base of dunes or armor walls to the -1.0 m MSL contour.

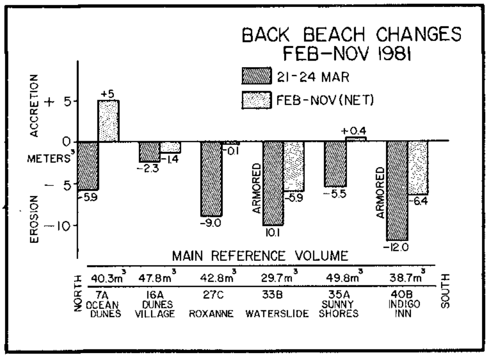

FIGURE 8. Representative poststorm (21-24 March) and six-month (February-November) backbeach volumetric changes for six variously armored, scraped, or filled stations along the project area. See Table 2 for status of each station.

erosion after the minor NE storm on 22 March 1981, and the net back-beach volumetric change along the landwardmost 15 m of beach. Profile data indicated were obtained on 27 February, 21 March, 24 March, and 8 November 1981. Table 2 gives the status of each station.

The zone that is compared in Figure 8 is the recreational back-beach area (Segment I). The response at each station varied, but several trends were obvious. All stations eroded along the backbeach between 21-24 March; losses being greatest at the two armored stations (33B and 40B). At Station 7A, the fill placed in June accounts for much of the observed recovery after the storm. But at the other

TABLE 2. Status of each station given in Figure 8.

STATION) LOCALITY:	NOTES
7A) Ocean Dunes Hotel:	Scraped and backfilled with 8.5 m^3/m in June 1981; natural beach and dune system.
16A) Dunes Village:	Not scraped or filled; natural beach and dune.
27C) Roxanne Motel:	Filled with 8.5 m^3/m on 13 March before storm, but not scraped; Pleistocene scarp.
33B) Waterslide:	Not scraped or filled; vertical concrete bulkhead.
35A) Sunnyshores Motel:	Scraped and filled on 12 March before storm; natural scarp, no armoring.
40B) Indigo Inn:	Filled with 10 m^3/m on 20 March, but not scraped; vertical concrete bulkhead.

five stations, no fill was placed after the storm of 22 March. The response of these stations varied in large part as a function of the backshore armoring. Armored stations, 33B and 40B, eroded more during the storm (21-24 March volume change) and recovered less between March and November. On the other hand, unarmored stations generally eroded less and recovered to approximately their prestorm volumes. These trends were generally consistent for the entire data set of 54 profiles.

CHANGES THROUGH MAY 1982

Beach surveys were completed on ten occasions between February 1981 and May 1982 before, during, and after the three scraping and beach fill projects. Figure 9 summarizes the results, giving mean unit volume changes by zone (north, south, and entire shoreline); by beach segment (backbeach, upper beach face, and foreshore as defined in Figure 5); and by shoreline type (armored vs unarmored). Mean unit volumes were computed for each category for a particular survey and compared with the preceding survey to give the average change. Major trends of this data set include:

1) Erosion from February to April 1981 (pre- and poststorm of 22 March).

2) Accretion for the period May through October 1981.

3) Erosion between October 1981 and February 1982.

4) Net erosion for the entire period for armored stations.

5) Little net change for the period along unarmored stations.

6) Greater net change in the southern zone compared with the northern zone.

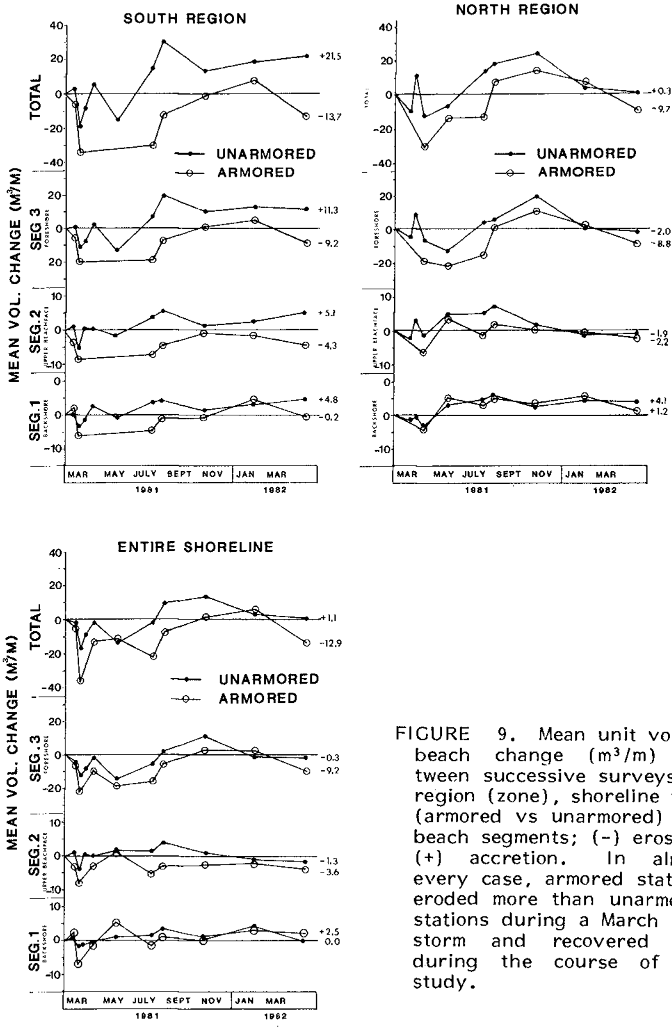

FIGURE 9. Mean unit volume beach change (m^3/m) between successive surveys by region (zone), shoreline type (armored vs unarmored) and beach segments; (-) erosion; (+) accretion. In almost every case, armored stations eroded more than unarmored stations during a March 1981 storm and recovered less during the course of the study.

Note that in almost every division of the data, armored shorelines showed greater losses, although erosion/deposition patterns were similar in form between successive time periods.

Comparative profile plots in Figures 10 and 11 illustrate two extremes between a northern station (16A) backed by a natural dune field and a southern station (40B) backed by a vertical bulkhead. In the case of Station 16A, fill placed along the backbeach was aided by buildup of a low-tide ridge (June-November 1981) which provided additional sand to the profile and reduced the threat of erosion at high tide. This station had a higher-than-average beach cross-section. Station 40B, however, had a lower-than-average beach cross-section to begin with and a poorly developed, low-tide ridge. Despite the addition of fill on two occasions from an updrift source (i.e., the lower beach at that station was not scraped), the station continued to erode at a high rate. Empirical evidence suggests the higher erosion rate was at least partly due to the presence of a vertical wall at the station which was exposed to wave action at high tide.

There was considerable deviation from the mean in net volumetric beach change from one station to another for the period. Figure 12 gives the variation in unit beach volume change proportioned about the mean by zone for the entire data set. Banded areas indicate stations which were armored or responded like armor stations [such as cohesive mud scarps (Station 12A)]. In general, there is a correlation between net erosion and the presence of vertical walls or scarps. The greatest variation occurs between Stations 32A and 35A which are affected by a minor swash inlet and an exposed rock outcrop along the lower beach.

SIGNIFICANCE TESTING AND DISCUSSION

Numerous comparisons were made between portions of the data set by Svetlichny (1982) to determine the significance of the observed changes in profile volume. Various combinations of station types and scrape/fill status were tested using standard statistical procedures to evaluate difference of the means (Ostle and Mensing, 1975). Figures 13 and 14 give two results.

Figure 13 shows overall means by beach segment for armored versus unarmored stations. For the indicated time period, the backshore and foreshore segments were significantly different at the 90 percent confidence level applied to a t-test supporting the notion that erosion was greater along armored stations.

Figure 14 provides a comparison between scraped, filled, and unaltered stations for the generally accretional period, March-November 1981. Combining means for armored and unarmored stations by each division of the data, it was found that there was no significant difference (at the 90 percent confidence level) between scraped and filled stations compared with unaltered stations. However, stations scraped but not filled eroded significantly more than unaltered stations or stations which were scraped and filled. The data of Figure 14 compare changes during an overall accretionary period and indicate the backbeach (Segment I) changes were dwarfed by natural changes along the

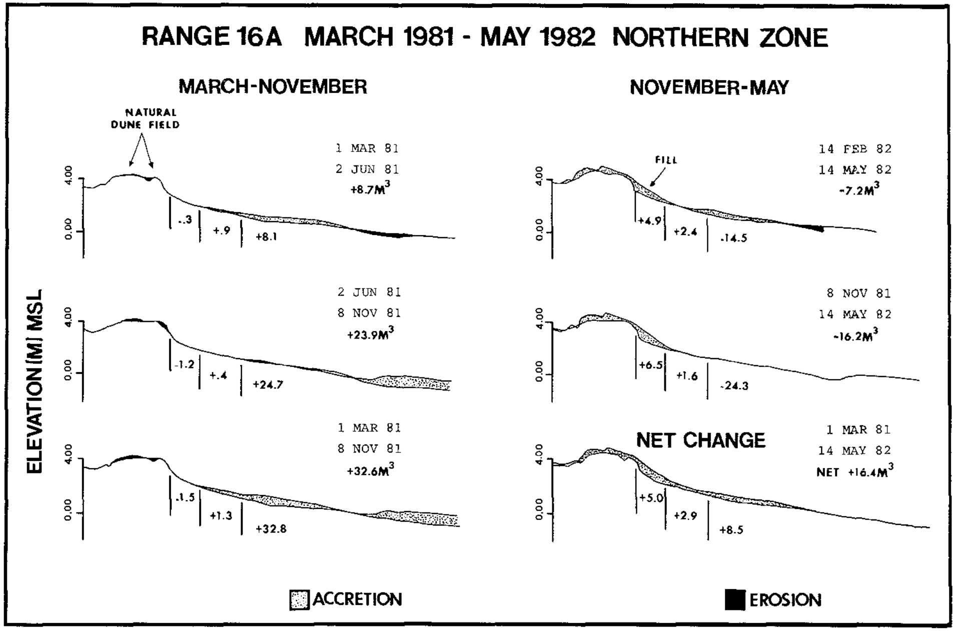

FIGURE 10. Comparative profiles for station 16A in the northern zone between 1 March 1981 and 14 May 1982. This station was backed by a natural dune field and developed a sizable, low-tide ridge during summer and early fall 1981. The lower beach was scraped and the backbeach filled with approximately 8 m^3/m in March 1981. Net accretion for the study period was double this amount.

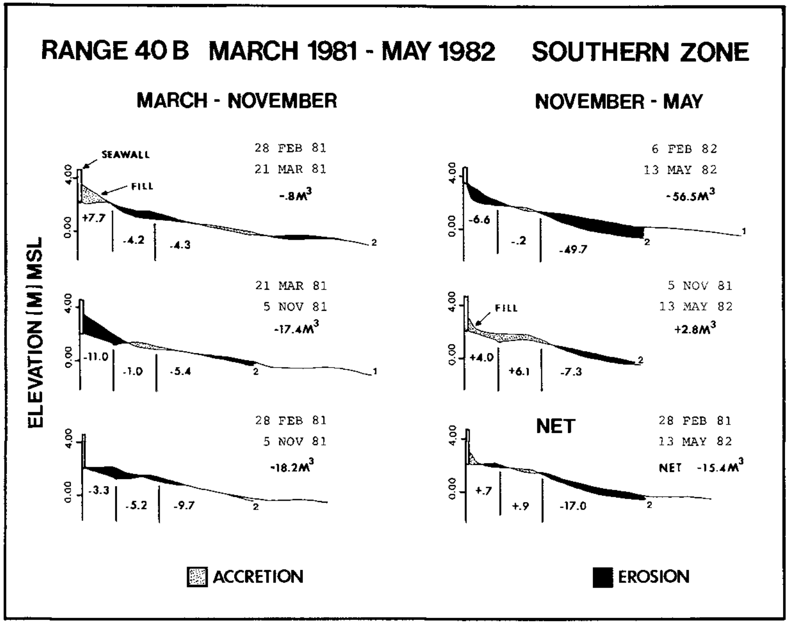

FIGURE 11. Comparative profiles for an armored station (40B) in the southern zone. This station was filled, but not scraped on two occasions, in March 1981 and February 1982. Note erosion of fill as well as the lower beach. Despite the addition of over 10 m^3/m from updrift sources, the station lost 15 m^3/m during the study period.

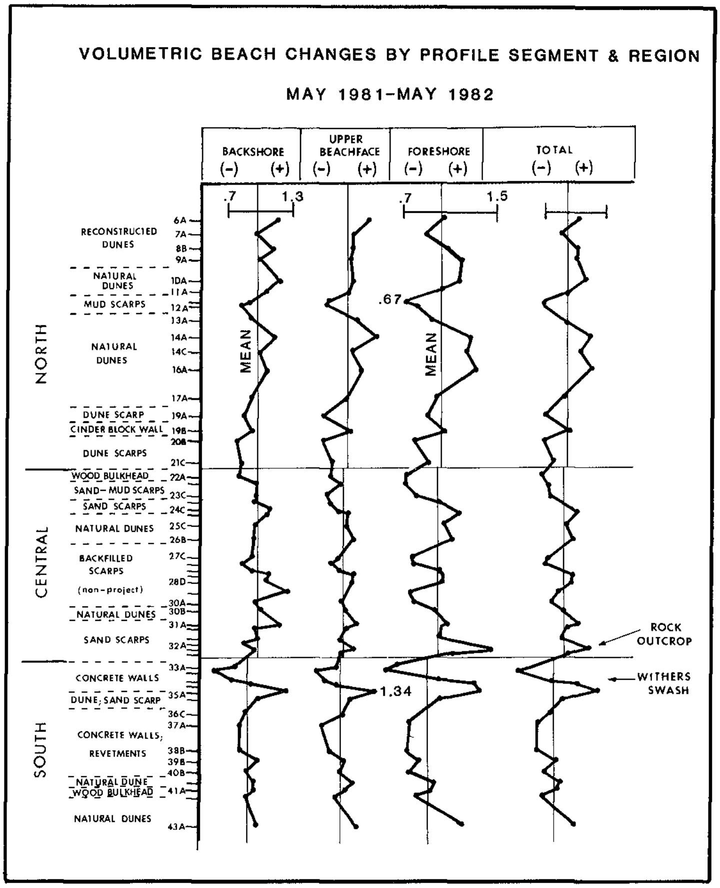

FIGURE 12. Mean unit volumes for 54 stations plotted as a ratio about the mean regional volumes for the northern, central, and southern zone. The left column describes the backshore configuration. Note that positive values generally occur where dune systems exist. Negative values generally correspond to shore protection structures or cohesive mud scarps.

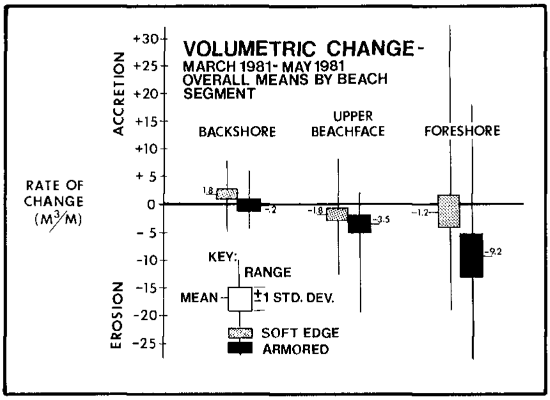

FIGURE 13. Bar graphs depicting the average rate of unit volume beach change between armored and unarmored stations for the study period. The differences are significant at the 90 percent confidence level for backshore (Segment I) and foreshore (Segment III).

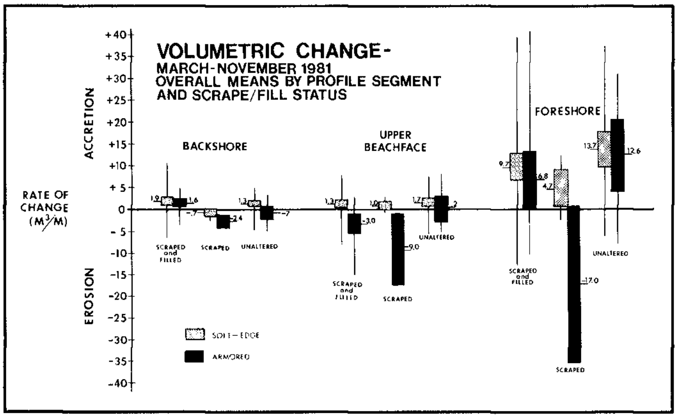

FIGURE 14. The average rate of changed by scrape-and-fill status. See text for explanation.

lower beach. (Note: There was an insufficient number of unaltered control stations for testing after November 1981.)

These results suggest that there were conditions under which beach scraping had no adverse effect on the profile, namely, along unarmored stations which had average or greater unit-width beach volumes; or during time periods when the shoreline tended to be naturally accretional. The data also indicate that scraping without concomitant beach fill adversely affected the profile [although areas where this was practiced generally had more sand at the time of the redistribution as per design (Kana and Svetlichny, 1981)].

In general, unarmored stations readjusted more rapidly to scraping than armored stations. It was found that the lower beach (Segment III) along natural profiles accreted twice as much as the lower beach fronting armored stations (10.7 m^3/m vs 4.9 m^3/m) between March and November 1981.

Tests for the 15-month study period revealed a distinct contrast in the response of armored and unarmored beaches to beach scraping. The foreshore at armored sections did not recover following the February 1981 scraping and yielded a net erosion of 9.2 m^3/m over the 15-month study. During the winter and spring, the foreshore at unarmored beaches eroded by 11.9 m^3/m, but recovered sufficiently so that the net change between March 1981 and May 1982 was only -1.2 m^3/m. The upper beach face (Segment II) eroded at an approximately uniform rate along the entire shoreline. Fill at armored backshores (Segment I) was completely eroded (net change was -0.2 m^3/m). Fill at soft-edge backshores was only partially eroded and had resulted in an average of 1.8 m^3/m more sediment than the initial (March 1981) prefill unit volume.

SEDIMENT BUDGET

A sediment budget was estimated for the study period March 1981 to May 1982 extrapolating from the reference profile cross-sections. As shown in Table 3 in units of m^3/km, the positive effect of beach scraping and backbeach fill was greatest in the northern zone where the backbeach had a net gain of over 2.2 m^3/m. The northern zone gained more recreational, high-tide beach as a result of scraping with virtually no overall loss of volume in the overall beach section. In addition, the fill in this area tended to remain in place for an entire year, protecting previously erosional dune scarps. Fill in the central and southern zones added little volume overall to the recreational backbeach due to the continuous erosion of the lower beach. Fill lasted several weeks to four months at most locations along the southern zone before erosional scarps or seawalls were reexposed. While it certainly provided some temporary recreational benefit (more high-tide beach) and some protection to the existing edge, it may have created a somewhat false sense of security, judging from the sediment losses along the lower beach (3-6 m^3/m). Although the backbeach fill held the shoreline stable near the high watermark in the central and southern zones, the potential remains for accelerated erosion due to losses along the lower beach.

TABLE 3. Sediment budget. Annualized by zones (March 1981-May 1982).

ZONE	VOLUMES (m^3/km)			
	Backshore	Upper Beach	Foreshore	Net Change
North	+2240	-1840	- 430	- 80
Central	+ 160	-2240	-5600	-7680
South	+ 480	- 400	-2960	-2880

CONCLUSIONS

There are a number of perspectives from which to judge the success or benefit of sand scraping and backbeach fill at Myrtle Beach. From the recreational standpoint, it provided a wider high-tide beach for a period of several weeks to almost one year at different localities. The benefit decreased from north to south and was least where most needed, in front of vertical walls. From a dune protection standpoint, the project delayed the time before reactivation of erosional scarps and further retreat of the strandline. Similarly, the buffer of gently sloping fill in front of shore protection structures reduced wave impact forces and potential damage to seawalls for the limited time it remained in place.

From a geological standpoint, the degree of profile manipulation by man was generally dwarfed by the natural cycle of beach changes, although there is some evidence that scraping in the northern zone promoted onshore movement of sand. In this latter case, the borrow zones tended to be narrower than existing low-tide ridges, leaving intact an effective breakpoint bar.

Finally, from a cost standpoint, the project was a relatively inexpensive experiment. Unit costs were approximately US$1.50-2.00 per linear foot of shoreline fill during each project. This compares with US$200 per foot for a typical bulkhead along the South Carolina coast.

Along stable or accretional shorelines, small-scale beach scraping should be highly preferred over armoring. Along slightly erosional shorelines such as the southern portion of Myrtle Beach, the scheme is at best temporary, but may be a suitable interim measure until long-term beach restoration can be implemented. In our opinion, this is preferable from an aesthetic as well as cost standpoint and should be considered as another shore protection option. Along highly erosional shorelines, scraping will obviously produce little benefit and may, in fact, accelerate erosion of the backbeach much like armoring appears to do.

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