1993

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PROCEEDINGS
of the
6th Symposium on the
GEOLOGY of the BAHAMAS

June 11 - 15, 1992

Edited by

Brian White

Bahamian Field Station

San Salvador, Bahamas

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REPRINTED FROM:

Brian White (ed.), 1993, *Proceedings of the 6th Symposium on the Geology of the Bahamas and Other Carbonate Regions*: San Salvador, Bahamian Field Station, p. 23-34.

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ABSTRACT

East Beach is a modern, medium-energy shoreline located on the northeast coast of San Salvador Island, Bahamas. Stake and horizon profiles were made at 9 sites along a 1-km section of the beach in June, 1990, and every six months thereafter through January, 1992. These observations appear to confirm that East Beach is a prograding shoreline, building onto the eastern shelf of the island. Seasonally corrected volume calculations indicate that between June, 1990 and January, 1992 approximately 14,000 m^3 of new sand per kilometer were added to the East Beach system, with most of the sand likely derived from the nearshore shelf area. Visual evidence for progradation could be seen in the formation of a heavily vegetated berm along the backshore, that by June, 1991 had reached a maximum height of 40 cm before its destruction by the powerful storm that hit San Salvador in late October, 1991. Seasonal topographic measurements and volume calculations indicate a minimum of 8,600 m^3/km of sediment moving offshore in response to higher average wave energies in the winter, and returning to build a wide foreshore and pronounced berm during the summer months. The late October storm battered East Beach with waves that entrained meter-sized blocks of coral, cut back the primary dune line by an average of 5.1 m, and washed over approximately 1,500 m^3 of sediment into the primary dune swale. Storm damage was measurably less severe at northern stations, possibly because of sheltering by Northeast Point and Man Head Cay, or by baffling action of the dense patch reefs offshore, or both.

INTRODUCTION

Although San Salvador is one of the geologically most thoroughly studied islands in the Bahamas, the island's extensive carbonate sand beaches have received relatively little attention from sedimentologists. Only the most general of surveys have been conducted; these have shown the beaches to be as varied as the island itself (Clark et al., 1989). Inattention to San Salvador's beaches is indicative of a larger pattern of ignorance worldwide concerning modern carbonate beach sediments and processes. Since strandline deposits are more likely to be preserved in the rock record than many other sedimentary facies (Inden and Moore, 1983) and since such deposits in the rock record can be useful as sea-level indicators, they deserve increased attention from geologists.

Previous work on San Salvador's beaches has been mostly of a reconnaissance nature. Hutto and Carew (1984) compared the composition of modern San Salvador beach sands to samples of Pleistocene and Holocene eolianites, and found increased proportions of skeletal material in the modern sediments. Lee et al. (1986) and Clark et al. (1989) presented general sedimentological reconnaissances of some of San Salvador's beaches and attempted to relate location on the island with grain size and sediment composition. Thesis research projects on East Beach (Brill, 1991) and on Sandy Point beach (Loizeaux, 1991), at the southwest corner of the island, represent the only detailed, longer-term, beach-processes studies that

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have been carried out on the island's beaches. This report and that of Loizeaux et al. (this volume) have resulted from these thesis projects and their continuation.

This study began in June, 1990 when a baseline was surveyed on the backshore along one kilometer of East Beach near the United Estates and Dixons settlements (Fig. 1); nine parallel transects were taken at 125-m intervals along this baseline.

of the beach thought likely to be preserved in the rock record were photographed and sketched. Stations were reoccupied and profiled in December, 1990, July, 1991, and January, 1992. At these times all visible changes were noted, and major characteristics of the beach were photographed and sketched.

In the lab, sand samples were sieved for ten minutes each using a Ro-Tap shaker, and sediment grain-size analysis was carried out with the help of the

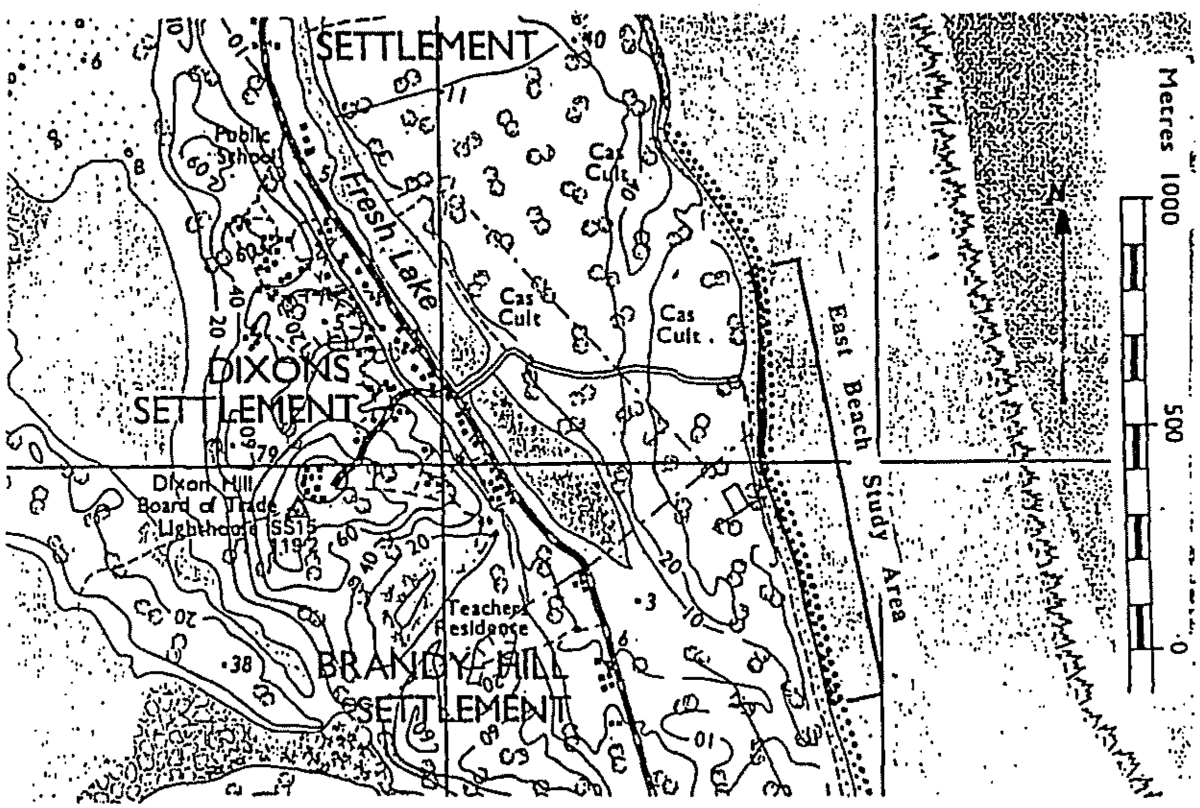

Fig. 1. Topographic map showing the location of East Beach in relation to Fresh Lake, Dixons settlement, and the Dixon Hill Lighthouse on San Salvador Island. East Beach faces the Atlantic Ocean and a wide shelf studded with coral patch reefs. Though not fully defined on this map, the one-kilometer long study area encompasses two full cycles of the rhythmic topography that characterizes this strandline.

Transect stations were numbered one through nine, north to south. Stake and horizon profiles were made along each transect from the slope of the secondary dune to 1.5 m water depth. Six sediment samples were taken along each transect, and ten large trenches were dug in foreshore and primary dune areas to investigate the erosional or depositional nature of the beachface at each site. To assess sediment transport potential, nearshore currents were measured with a flowmeter once at each station and at one station through a full tidal cycle. Burrows and other features

IBM PC programs PROBSPL.5 and SIEVE (Fox, 1991). Profile data were corrected for mean sea level and matched with previous profiles from the same station. Elevation data were then entered into a database and gridded using the MacGridzo contouring package on a Macintosh II computer. These grids then can be used to create topographic maps and or subtracted from one another to obtain isopach surface-elevation change maps. Grids are also easily subtracted from one another to obtain total erosion and deposition volumes between data sets.

Titus (1987) supported this interpretation of a progradational East Beach dune field system.

Conspicuously absent from the East Beach strandline is any evidence of the early lithification that produces beachrock so common to many Bahamian beaches (Bain, 1989). Instead of this penecontemporaneous cementation, sand beneath the beach is soft to a depth of several meters, perhaps indicating rapid progradation. It displays the sedimentary structures of foreshore lamination and keystone vugs, backshore reverse slope beds, and primary dune climbing ripples. Landward of the primary dune, the sediment surface becomes well-vegetated, and thick root systems hinder viewing of sedimentary structures in trenches.

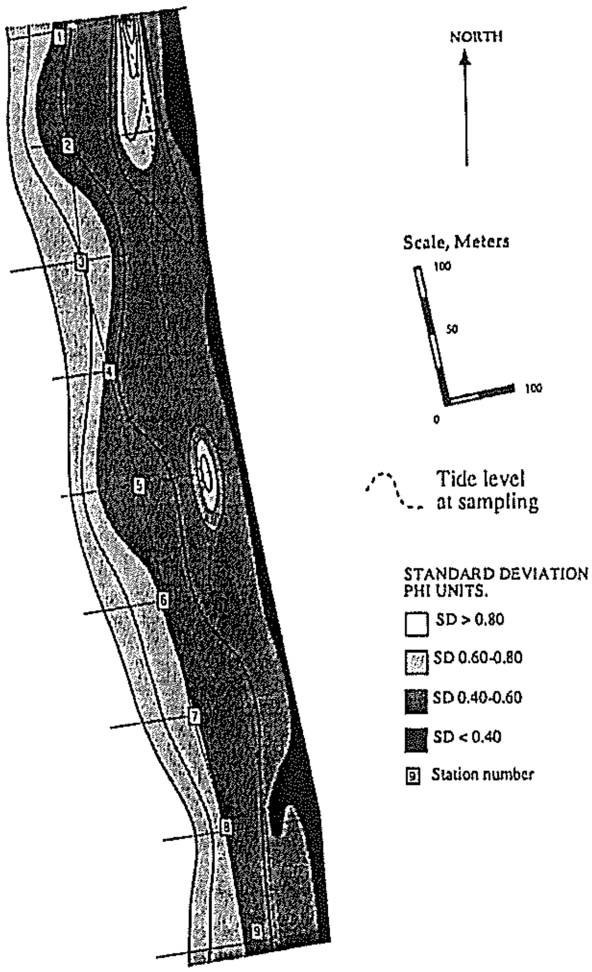

Fig. 3. Contour map for graphic standard deviation on East Beach in June, 1990. Contour interval is 0.10 phi. Sediments are moderately to very well sorted with values ranging from 0.91 to 0.33 phi. Sorting increases with proximity to the water. Poor sorting at the waterline and on beach protuberances is due to increased local energy and the presence of a shell lag population.

Onshore winds also carry the refuse of the open ocean to the beach. As a result, the white sand of the backshore is thickly covered with wrackline deposits. These heavy lines of *Sargassum, Thalassia,* and other flotsam are distinctive of east-facing beaches on San Salvador and other Bahamian islands. This dense mat traps the sand of the beach, creating erosion scarps. The mats also can become buried in the shifting sediment and subsequently may be preserved in the rock record (White and Curran, 1987).

Seaweed, tar, and refuse form an excellent habitat for many of the beaches' animal inhabitants. The foreshore and berm are riddled with habitations of the ghost crab, *Ocypode quadrata.* Ghost crab burrows are only found on the unvegetated beach and their distinctive Y-shaped burrows can be an ideal marker of the upper foreshore - berm crest - backshore facies transitions in ancient deposits (Curran and White, 1987, 1991). Above the foreshore, large numbers of burrowing rove beetles of the Family Staphylinidae commonly can be found. These beetles, first described on San Salvador by Adams (1989), lace the finer-sand beaches on the island with irregular, raised tunnels 1-3 mm in width. Beyond the backshore, the Bahamian land crab, *Gecarcinus lateralis*, burrows in the thickly vegetated dunes (Curran and White, 1987, 1991). Also present in the primary dune and backdune areas is a variety of bees, ants, spiders, and other burrowers whose excavations may be preserved in the fossil record (Curran and White, 1987, 1991).

The backshore and berm areas at East Beach are colonized by species of *Ernodea* and *Sesurbium*, salt-tolerant succulents that appear to play an important role in holding the shifting sands of the beach and thus promoting progradation. Behind these colonizers in the primary dune appear grasses such as *Uniola paniculata* and *Cencvus incertus*. Farther inland in the primary dune swale, reclining groundcovers of *Ambrosia hispida* and *Ipomoea pes caprae* weave a dense mat of foliage over the shifting sands, further stabilizing the accreting dunes. The most stable inland dune ridges are vegetated by members of the coppice-thicket community, such as the sea grape, *Coccoloba uvifera.*

The purpose of this study is to document the characteristics of East Beach, a typical carbonate island windward strandline, and then to illustrate the dynamics of and long-term changes to the beach-dune system. Titus' (1987) hypothesis that East Beach is a prograding shoreline system was tested through the observation of sedimentary structures in the beach and primary dune and by analysis of the eighteen months of stake and horizon profile data. Once the depositional nature of the beach was determined, the rates and processes of long term change as well as seasonal patterns of sediment movement could be investigated and clarified. Differences between the July, 1991 and January, 1992 data sets appear to be mainly a result of the strong storm that hit the island in late October, 1991. These differences give insight as to how the beach responds to "unusual" storm events that play an important part in the cycle of progradation, erosion, and washover that makes this beach such a dynamic environment. For at least the near-term future, East Beach will be the site of ongoing study, with stations reoccupied every June and late December/January by visiting Williams College and Smith College geology groups. It is hoped that from this large body of topographic data will come further clarification of the responses of this beach system to the passage of weather-related and other events through time.

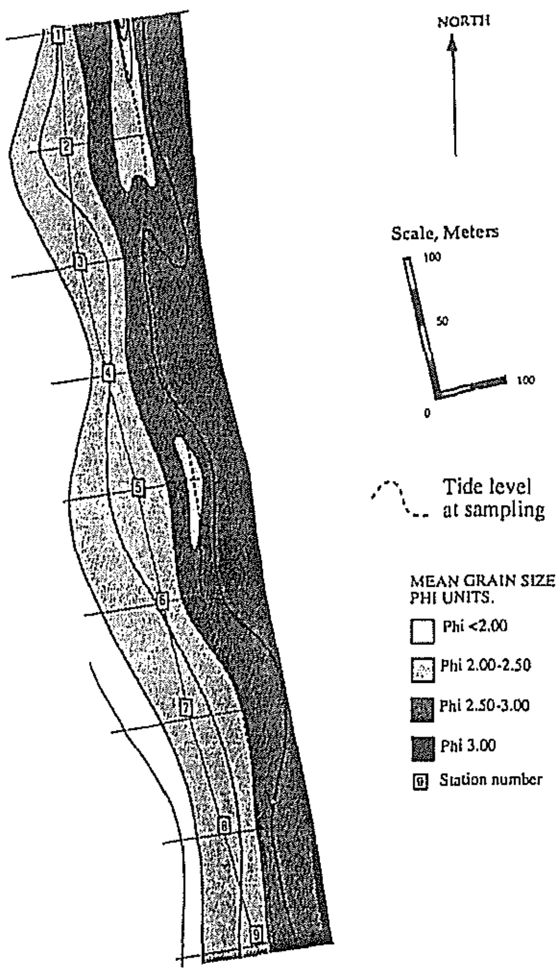

Fig. 2. Contour map showing graphic mean grain size observed on East Beach in June, 1990. Contour interval is 0.25 phi. Values range from 2.04 to 2.80 phi, fine to very fine carbonate sand. Grain sizes generally decrease toward the water, except where a coarse, plunge-zone shell hash is present. Sediment on beach protuberances is coarser than at corresponding locations in the small bays.

THE GEOLOGIC SETTING

East Beach is a modern, medium-energy shoreline located on the northeast corner of San Salvador Island. The beach is typical of many windward strandlines in the Bahamas, exposed to steady onshore winds averaging ten knots from the east (U.S. Naval Weather Service Command, 1974). Because of the usual wind direction, offshore wave energy is theoretically higher on the eastern margin of San Salvador, although wave height along the beach is limited by a kilometer-wide shelf and dense offshore patch reefs (Fig. 1; Clark et al., 1989). Winter storms blow strongly out of the northwest quarter, resulting in a degree of shelter from these events for the island's east-facing beaches. The tidal classification for the island's coastline is microtidal, ranging from approximately 0.5 to 1.5 m. One might, therefore, expect primary sediment movement patterns along East Beach to relate not to tidal influences or frequent storm waves, but, instead, to the E and SE trade winds and the resultant northward-flowing longshore current.

East Beach is characterized by a shallow dipping (3-7°) broad expanse of fine- to very fine-grained skeletal sand. The steady trade winds and waves have shaped East Beach into a series of giant cusps and beach protuberances. Wavelength of this rhythmic topography is about 500 m, but higher order harmonics also produce an intermittent cusp and horn system with a wavelength of approximately 13 m. The beach lies at the seaward edge of a large dune field that may represent past strandline locations, following the theory of Bahamian island growth by accreting dune ridges described by Sealy (1985).

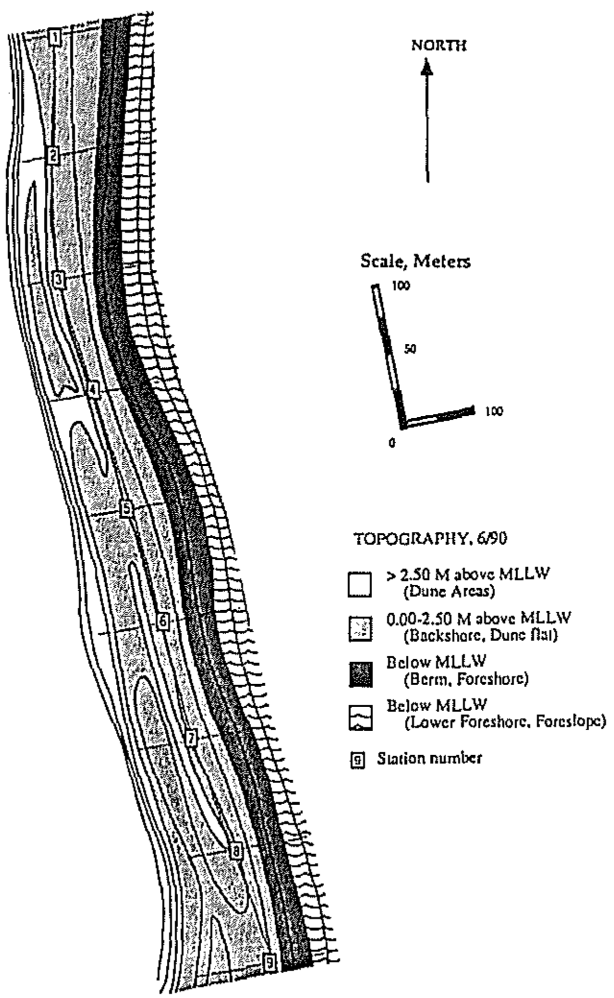

Fig. 4. Hand-contoured topographic map of the study area in June, 1990. Contour interval is 0.5 m. The map is shaded to enhance the contrast of dune and beach areas. Note the low, broken primary dune, flat backshore, and broad, gently sloping foreshore.

THE SEDIMENTS OF EAST BEACH

Results of sieve analysis showed mean grain sizes on the beach in the fine to very fine range, decreasing from 2.04 phi in dune areas to 2.80 phi at the bottom of the foreshore (Fig. 2; water lies to the right of the diagram). This is consistent with previous, more cursory samplings of East Beach sediment carried out by Lee et al. (1986) and Clark et al. (1989). Unusually high energy levels in the swash zone and on beach protuberances add a coarse mollusc-benthic foram shell lag population to the sediments. Mean grain sizes in these areas are up to one phi unit greater than those found on the rest of the beach at the same elevation.

Sorting, skewness, and kurtosis in the sediment populations on the beach also vary with spatial position and degree of local energy. Values for standard deviation range from 0.91 phi to 0.33 phi, in the moderate to very-well sorted range (Fig. 3). This is a result of gentle winnowing action by a steady wave state. Winnowing has produced near-symmetrical values for sorting and a mesokurtic distribution in most of the 60 sediment samples obtained from the beach. Sediments near the water and on beach protuberances tend to be better sorted and more leptokurtic than those farther up the beach except in the swash zone, where the addition of the mollusc-foraminiferal shell hash creates a measurable coarse sub-population.

BEACH MORPHOLOGY AND MORPHOLOGIC CHANGE

Beach Morphology - June, 1990

Several distinctive environments of the East Beach system are visible in a hand-contoured topographic map of the summer beach in June, 1990 (Fig. 4). The ocean lies to the right of the figure. The broad foreshore is evidenced by wide and even spacing of contours near and just below mean low water and shows well the gently undulating, rhythmic topography of the beach. Embayments and prominences on the foreshore do not necessarily correspond to the two larger cove-point cycles on which the baseline was surveyed, although there are protuberances at stations one (at the extreme north end of the study area) and five (in the middle). Farther up the beach lie more closely spaced contour lines indicating the rise of the berm. Between the berm and baseline lies the flat area of the backshore, evidenced by a wide space between the 1.5 and 2 m contour lines. It is here that thick mats of drifted *Sargassum* wash up and are entombed within the mobile sand, and where colonizing succulent plants hold the sand until the more permanently rooted grasses from the dunes can fully take hold. Beyond the baseline lies the low, broken primary dune crest and the swale behind it. Inland of the primary dune and swale lie the straight, closely spaced contours of the secondary dune ridge, heavily vegetated with many species of woody plants.

Seasonal Changes - June, 1990 to December, 1990

Topography measured in December, 1990

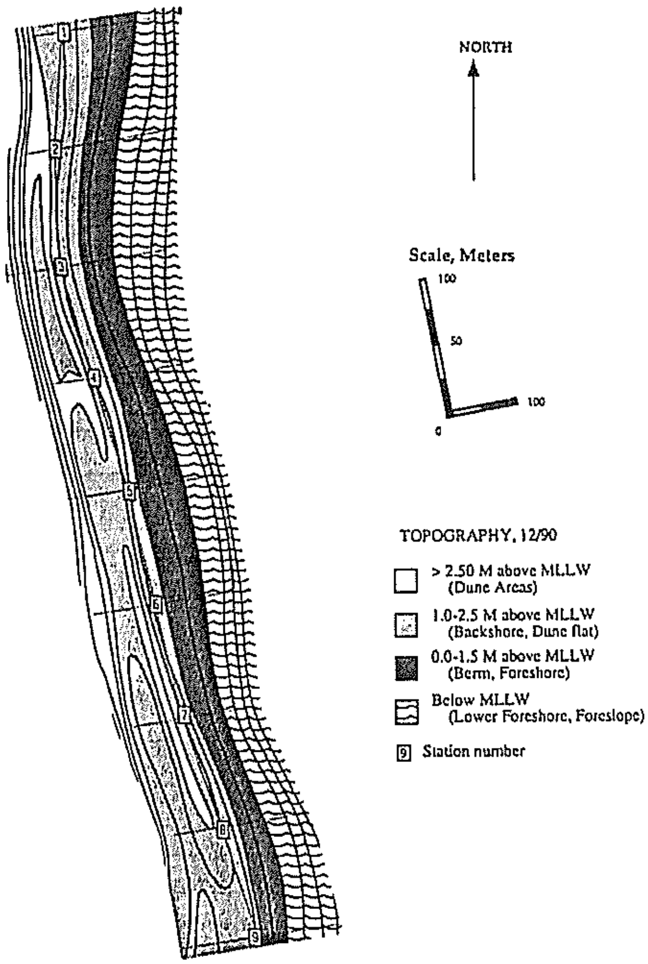

Fig. 5. Hand-contoured topographic map of East Beach, December, 1990. Contour interval is 0.5 m. Changes from the summer beach shown in Fig. 4 include berm retreat, a steeper foreshore, and enhanced protuberances and minor bays. These changes are characteristic of East Beach during the winter season, and likely are the result of increased average wave energy.

(Fig. 5) was noticeably different from that observed six months earlier. Rhythmicity of the beach was more pronounced, with large prominences evident at stations one, five, and nine. The contour lines are clearly more closely spaced in the foreshore and berm areas, indicating a steeper, narrower winter beach.

When June topography is subtracted from the December elevations the patterns truly begin to emerge. The major feature of the hand-contoured isopach map for the period (Fig. 6) is a wide band of erosion along the foreshore, where up to 0.5 vertical meters of sediment have been removed. Trenches dug on the beachface in December showed truncation of beach laminations, a method of spot checking for a retreating foreshore. Foreshore and berm retreat are most likely a response to increased average winter wave energy eroding sand from the lower regions of the beach. Backshore areas, as one would expect, changed little over the period. It is interesting to note the narrow but continuous bands of minor deposition (thickness less than 25 cm) recorded at the base of the primary dune and on the foreslope.

These two bands of deposition are actually quite important in clarifying seasonal and longer term trends of sediment movement on the beach. The seaward zone, found at the base of the foreshore, most likely represents the shoremost edge of a seasonal sand body. This sand sheet or bar acts as a sort of "holding tank" for sediment eroded from East Beach during the winter months, later to be pushed back onshore and become part of the depositional summer beachface.

Though sediment amounts are minor, in the hundreds of m^3/km, the depositional nature of backbeach areas was supported by observation. Between June and December, an elongate, vegetated sand mound formed on the backshore near station two. The mound had reached about 20 cm in height by December, 1990, and had the appearance of a healthy, enlarging sand dune. Growth of this mound over the six-month period indicated that East Beach was undergoing steady net deposition superimposed upon a background pattern of seasonal onshore-offshore sediment movement.

Calculations indicate a net loss of approximately 8,600 m^3 of sediment from the measured beach area over the period June to December, 1990. This erosion was largely concentrated on the south sides of beach protuberances, indicating the influence of a northward littoral drift. Sediment eroded from the berm likely moves during winter to nearshore sand bodies, to be restored to the beach during the calmer summer months. The zone of deposition along the base of the foredune indicates the progradational character of the backbeach and the tendency for growth of a new, seaward primary dune.

Long-term Changes

In order to assess long-term topographic change without seasonal "noise", it is best to compare earlier data sets with those gathered a year later. The East Beach profiles, taken in June 1990 then can be compared with those from July, 1991 without having to correct for seasonal erosion. The resulting machine-contoured isopach map (Fig. 7) shows that the beach was uniformly depositional over this period. Especially obvious in this format is a long band of deposition at approximately 1.5 m above mean low water. This corresponds to the band of deposition found on the June-December, 1990 erosion map, and represents continued accretion of sand at the base of the primary dune. By July, 1991, this nascent dune ridge had grown in places up to 40 cm high.

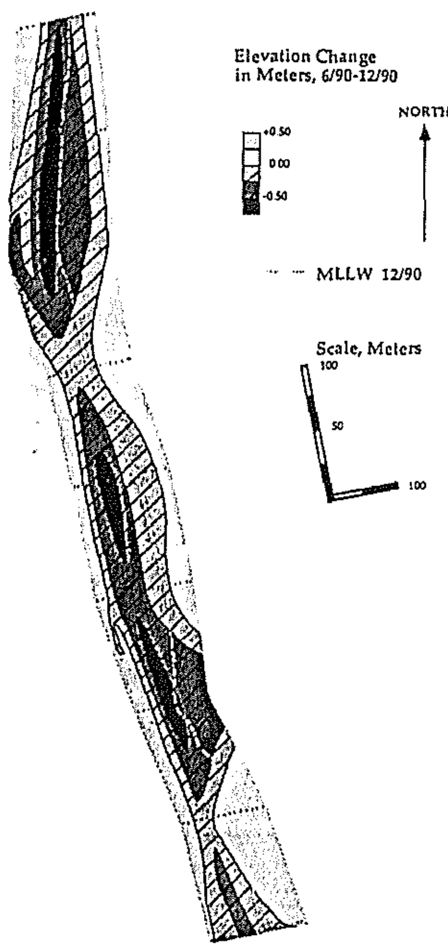

Fig. 6. Hand-contoured isopach erosion map for the period June, 1990 to December, 1990. Contour interval 0.25 m; points along transect lines indicate the actual 12/90 data locations. The beach suffered net erosion of 8,600 m^3 of sediment over this period, mainly from foreshore areas and the updrift sides of beach protuberances. Zones of minor deposition indicate a progradational backbeach and nearshore seasonal sand storage.

What minor erosion did occur between June, 1990 and July, 1991 was concentrated at station two, on the south side of a beach protuberance. This and a similar result from the June-December, 1990 isopach map (Fig. 6) indicates that the beach protuberance system is suffering long-term erosion on its updrift side. Reduced erosion is evident on the northward (downdrift) side of beach protuberances in Figure 6. These observations can be combined with the knowledge of a northward longshore drift and field measurements of foreshore scarp formation taken in June, 1990 to show that these beach protuberances are slowly moving northward within the study area.

Subtraction of data sets indicates that over the eighteen months between June, 1990 and January, 1992, approximately 5,200 m^3 of new sediment were deposited within the study area. Because a summer beach is being compared with a winter one, however, this sediment volume number must be corrected for seasonal sediment movement. The seasonal offshore flux was measured between June and December, 1990 as at least 8,600 m^3/km/season; this number must then be added to the January, 1992 figure to obtain a true volume of deposition over the period. The calculated volume for total addition of sediment to the East Beach system over the 18 months of the study period is then 5,200 + 8,600 (minimum value) = 13,800 m^3/km.

Short-term Morphologic Change - The October Storm

In late October, 1991, a major storm hit the island of San Salvador with winds and waves from the northeast. These unusually large, deep-water waves are thought to have been generated from Hurricane Grace, which later combined with a low pressure system from the mainland to produce a major northeaster storm. Now referred to as the "All Hallows' Eve" storm, this northeaster was one of the most severe Atlantic storms of the past 50 years and caused considerable damage and strandline modification along much of the U.S. Atlantic coast (Davis and Dolan, 1992).

During the storm, East Beach was severely battered by waves that entrained objects such as a ten meter-long palm tree trunk and blocks of coral boundstone weighing at least 100 kg, throwing them high onto the beach. Sand was mobilized through dune retreat (an average of 5.1 m) and backshore erosion, and washed, along with floating trash and mats of *Sargassum*, over the crest of the primary dune and deposited as washover lobes in the dune swale area. The primary dune was breached in several places and the growing, vegetated "proto-primary dune" on the backshore was totally destroyed. When the beach was reprofiled in January, 1992, it quickly was realized that this data set could be helpful in showing how East Beach responds to northeasterly storm events.

Several patterns in the destruction were immediately apparent. Areas of severe backshore and dune erosion were more concentrated at the southern end of

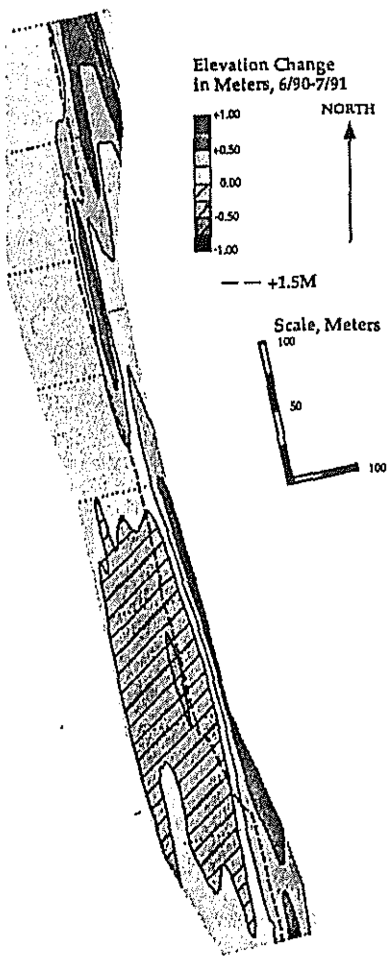

Fig. 7. Machine drawn isopach map of erosion over the period June 1990 to July 1991. Contour interval 0.25 m; points along transect lines indicate the actual 7/91 data locations. One year of change revealed the beach to be uniformly depositional, except for a region of minor erosion on the updrift (south) side of a beach protuberance. Deposition is concentrated on the backshore in an area of dune formation and heavy succulent plant cover.

the study area. Blowouts were generally oriented toward the northeast, and commonly represented complete destruction of the primary dune ridge. Stakes that had marked the two southernmost transect stations, eight and nine, were either buried under washovers or had been washed away; these sites had to be relocated through measurement from adjacent, still-intact station markers.

Beach profiles later quantified the pattern of increasing damage at more southerly stations. Figure 8 compares a beach profile at station nine from December, 1990 with one taken in January, 1992 and shows the total destruction of the 1.3 m high primary dune at this, the southernmost site. Washover extends from what had been the swale behind the primary dune nearly to the top of the secondary dune, 46 m from the former vegetation line. For comparison, Figure 9 shows profiles at the northernmost site taken from the same two data sets. Here, damage is confined to erosion at the base of the primary dune and the deposition of a fresh washover atop the old dune flat.

Erosion averages are telling in north-south erosion inequalities. Cutback of the primary dune line at the northern four sites averaged 0.9 m; at the southern five, this figure jumped to 9.2 m. Maximum vertical erosion encountered at each site was also averaged, with the northern sites experiencing a mean of only 0.36 m of erosion, versus 0.71 m at the southern five sites.

There are two plausible explanations for this north-south inequality of erosion. It is possible that for the northern beach area, Northeast Point and Man Head Cay offered some shelter; waves refracted around these features might have been concentrated on the more southerly parts of East Beach, resulting in higher wave action and increased erosion. Another cause could relate to denser patch reef distribution off the northern part of the study area. These reefs, though not actually forming a barrier to wave action, may have baffled and broken the storm waves farther offshore, resulting in lower energy levels on the beach at northern stations. Probably a combination of these two sheltering influences protected the north end of East Beach from the most severe storm erosion.

In addition to this major pattern of increasing storm damage in a southerly direction, one might expect erosion to be more severe on beach protuberances than at stations located in the minor bays. This is supported by measurements taken after the storm; sheltered stations suffered an average of 1.3 m of horizontal cutback in the primary dune line, while the

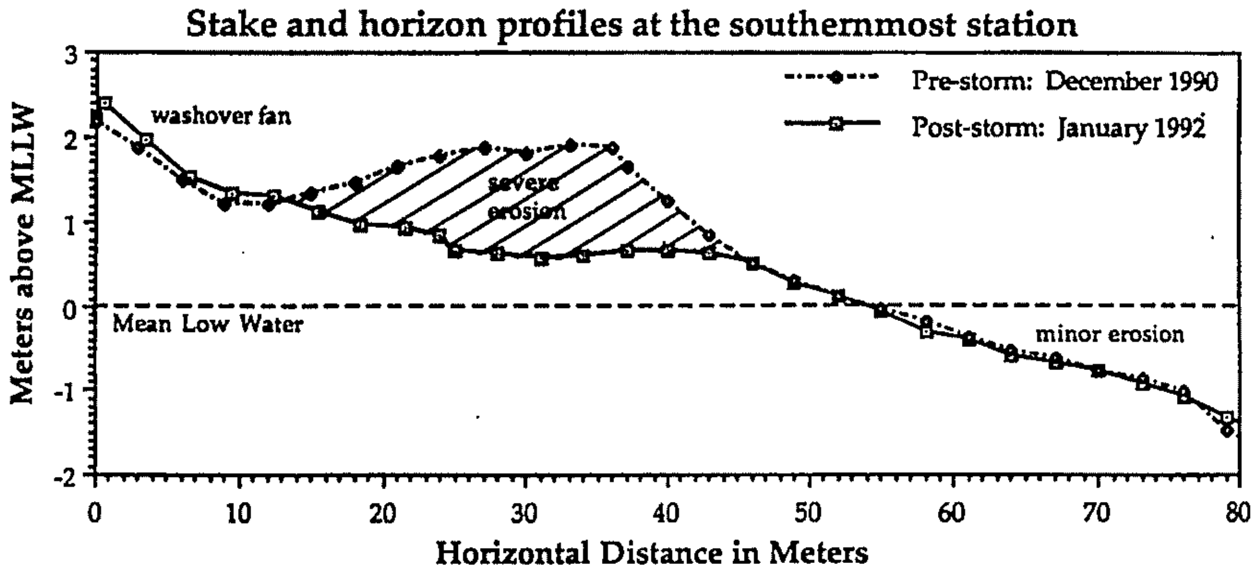

Fig. 8. Plots of beach profiles at station 9, in the southernmost and least sheltered part of the study area. The late October, 1991 storm waves destroyed the established primary dune at this site, a cutback of 23.5 m. Maximum vertical erosion at the site reached 1.3 m, and washovers were deposited nearly to the top of the secondary dune, a distance of 46 m inland from the pre-storm vegetation line.

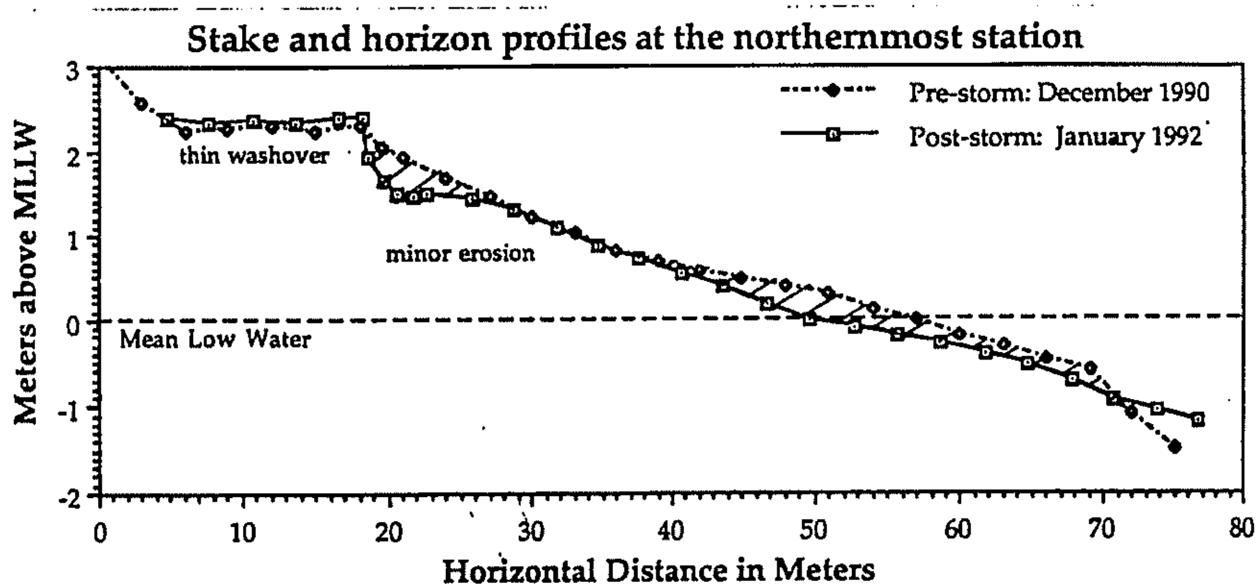

Fig. 9. Pre- and post-storm winter beach profiles at station 1, on the northern end of the study area. The beach was affected by storm waves, suffering vertical erosion of up to 0.5 m. Average cutback at the northern four sites was 0.36 meters, one half the figure for the southern five. This could be due to the sheltering effects of Man Head Cay and Northeast Point, or because of dense coral patch reef distribution on the northern shelf.

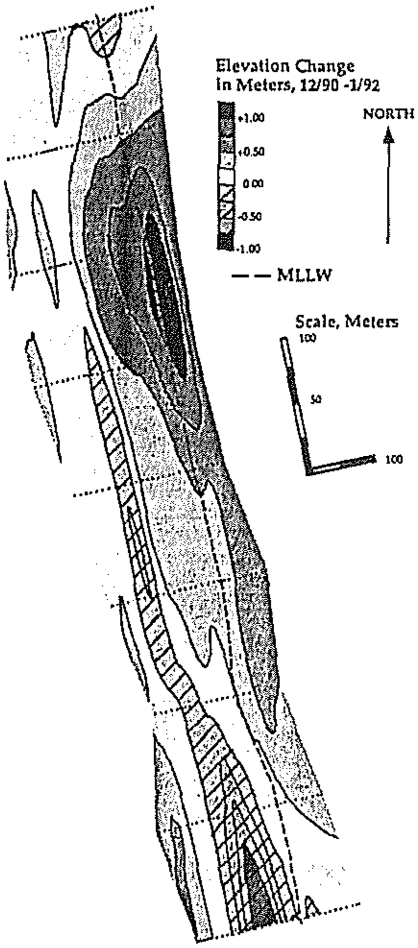

Fig. 10. Map showing erosion and deposition on East Beach between December, 1990 and January, 1992. Contour interval is 0.25 m; points along transect lines indicate actual 1/92 data locations. Most changes can be directly attributed to the October,1991 storm; maximum erosion was recorded at backshore and dune areas, at southern stations, and on beach protuberances. The large area of deposition between stations 2 and 3 represents over 20,000 m^3 of deposition, mostly of storm-mobilized sand.

average for stations located on beach protuberances was 9.6 m. The average for maximum vertical erosion at protuberances was 0.76 m, over five times the mean for bay stations, which was 0.15 m.

Profile data discussed above are summarized in Figure 10, a MacGridzo isopach map for the period of December, 1990 to January, 1992. Though much of the map shows deposition over this period, reflecting the prograding beach setting, there is a zone of severe erosion located at the southern end of the study area in the vicinity of the primary dune line. Erosion extended north along the backshore, increasing in severity at the middle of the study area where a beach protuberance is located, subsided, and then reappeared on the northernmost beach protuberance. The large region of deposition on the foreshore, greater than one meter thick in places, contains 20,000+ m^3 of sediment. This sand body probably consists largely of sediment eroded from more southerly areas of the beach; littoral drift is pushing it slowly north through the study area. Also shown on the map are washovers amounting to a total of approximately 1,500 m^3, building the level of the swale behind the primary dune.

CONCLUSIONS

Data collected between June, 1990 and January, 1992 have resulted in the documentation of many dynamic aspects of a typical windward Bahamian beach. While eighteen months of data do not yet a truly long-term study make, and large margins of error could be expected in long-term projections of erosion or deposition along the beach, several meaningful conclusions can be drawn from our sedimentological, biological, and topographic observations of the East Beach system:

1. East Beach bears all the characteristics typical of a windward Bahamian carbonate sand strandline, composed of fine to very fine, moderately to very well sorted skeletal sand. Sediments on the beach respond to local variations in energy and elevation.

2. East Beach appears to be prograding, with new sand being added to the beach at an average rate of slightly less than 10,000 m^3 of sediment per km of beach per year. This sediment likely is derived primarily from the wide, shallow shelf area to the east of the strandline. Once on the beach, sediment packages are stabilized first by salt tolerant succulent plants and then by rooted grasses; they eventually become home for a wide variety of animals and woody plants. A variety of physical and biogenic structures can be preserved in the prograding primary dune and backshore sediments.

3. The rhythmic topography found along East Beach responds to the influences of a northerly littoral drift. Over the period June, 1990 to July, 1991, beach protuberances moved measurably to the north before being altered by storm waves in late October, 1991.

4. The beach undergoes major seasonal changes, with at least 8,600 m^3 of sediment per km eroded from foreshore and berm areas each winter in

response to increased wave action. Sand eroded from the beach probably resides in nearshore sand bodies, and it is returned during the summer months to build a wide, gently sloping foreshore.

5. Despite the normally placid appearance of East Beach, storms can and do make severe changes in the standard patterns of sediment movement. Northerly storm waves can entrain very large objects and tend to do most damage to beach protuberances and southern parts of East Beach. Reduced storm damage at northern sites may be due to sheltering by Northeast Point and Man Head Cay, or the baffling effects of closely spaced offshore patch reefs, or both.

ACKNOWLEGMENTS

We are indebted to Don and Kathy Gerace and the entire staff of the Bahamian Field Station for the logistical support of our field work and their continued encouragement for completion of this project. This research was supported by the W. M. Keck Foundation through a grant to the Keck Geology Consortium. The senior author thanks Paul Godfrey of the University of Massachusetts for sharing his botanical expertise; Nick Loizeaux for his extensive help in the field and lab; Megan Bresnehan, Cathy Curran, Tim Donahue, Liz Haynes, David White, and Kathy White for their assistance with the field work.

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