MODERN BEACH SEDIMENT DYNAMICS AND DEPOSITIONAL FEATURES, WITH HOLOCENE ANALOGS, AT SANDY POINT, SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

A complete understanding of sediment dynamics and the modern beach is essential in the investigation of the Holocene rock record. It is the purpose of this paper to investigate the modern dynamics of the Sandy Point beach on San Salvador Island, Bahamas and use some of these findings in recognizing different facies in a Holocene rock outcrop adjacent to Grotto Bay. Holocene analogs can often be found for many of the modern depositional features such as cuspate topography, animal burrows, and bubble porosity. In addition to researching the day-to-day changes in beach topography a comparison of the beach seasonally (Summer and Winter) has been conducted to look at longer term changes. The field research was conducted during the months of June and December, 1990, while staying at the CCFL Bahamian Field Station.

Sandy Point Beach stretches for nearly two kilometers along the most southerly tip of the island, beginning at a rock outcrop 250 m east of Sandy Point and continuing northward into Grotto Bay, ending at the Pleistocene fossil reef. Almost the entire length of beach is backed by eolian deposited dunes and the beach itself ranges in width from 20 m to 100 m. Offshore, the carbonate shelf is shallow (< 20 m) and less than .5 km in width. What makes the site particularly interesting is that the beach is "bent" around Sandy Point, receiving high energy forces on its southern exposure and calm, leeward forces on its western side during the predominant weather patterns. The Holocene stratigraphic sequence investigated was part of a 150 m rock outcrop lying along the most northerly bend in the beach.

FIELD AND LABORATORY METHODS

A number of methods were used in the investigation of the modern beach. A 1.85 km baseline was laid out using tape and compass measurements and ten regularly spaced stations were marked off with stakes. In both June and December each station was profiled from the rear of the backbeach to a water depth of 1.5 m using the stake and horizon method. Using the profile data, topographic maps were constructed for the beach during the summer and winter months (Figure 1). The profile data also facilitated a map showing net erosion and deposition of sediments (Figure 2).

During June, fifty modern, unconsolidated beach sediment samples were collected. Five samples were taken along each profile according to the following convention: one from the middle of the backbeach, one each from 1/6, 3/6, and 5/6 the distance from the berm to the plunge step, and a final sample taken at the end of the profile. The samples were sieved in the laboratory and characterized mathematically according to Folk and Ward (1957). These mathematical parameters define a sample by mean grain size, sorting, skewness, and kurtosis. The sediment data was analyzed and contoured for the four statistical parameters. Figure 3 illustrates sediment distribution according to mean grain size.

In the field, the Holocene rock stratigraphy was sketched, photographed, and sampled . Thin sections were made from what appeared to be different beach facies. The thin sections were made to examine relative grain sizes, an aid in pinpointing exact beach facies in the Holocene limestone stratigraphy.

DISCUSSION

The beach profile data were used to construct the topographic maps found in Figure I. A number of immediate observations can be made from these maps. First, there is an obvious change in the location of the sand lobe located off of station 3 in June. On the December map, the lobe is found off of station 2, suggesting a migration south. Another difference that can be noted is the apparent thinning of the beach on its northern half, most dramatically illustrated at stations 8 and 9. A common feature from both the summer and winter beach was the presence of storm runnels on the sand lobes. There were no observed changes to the eolian dunes that flanked the backbeach regions. Figure 2 shows net sediment erosion and deposition over the six month period. It is clear from this map that the northern 2/3 of the beach experienced significant erosion and the southern 1/3 similar deposition. The force behind the sediment movement was most surely water, as the universally dominant force in beach sediment movement is

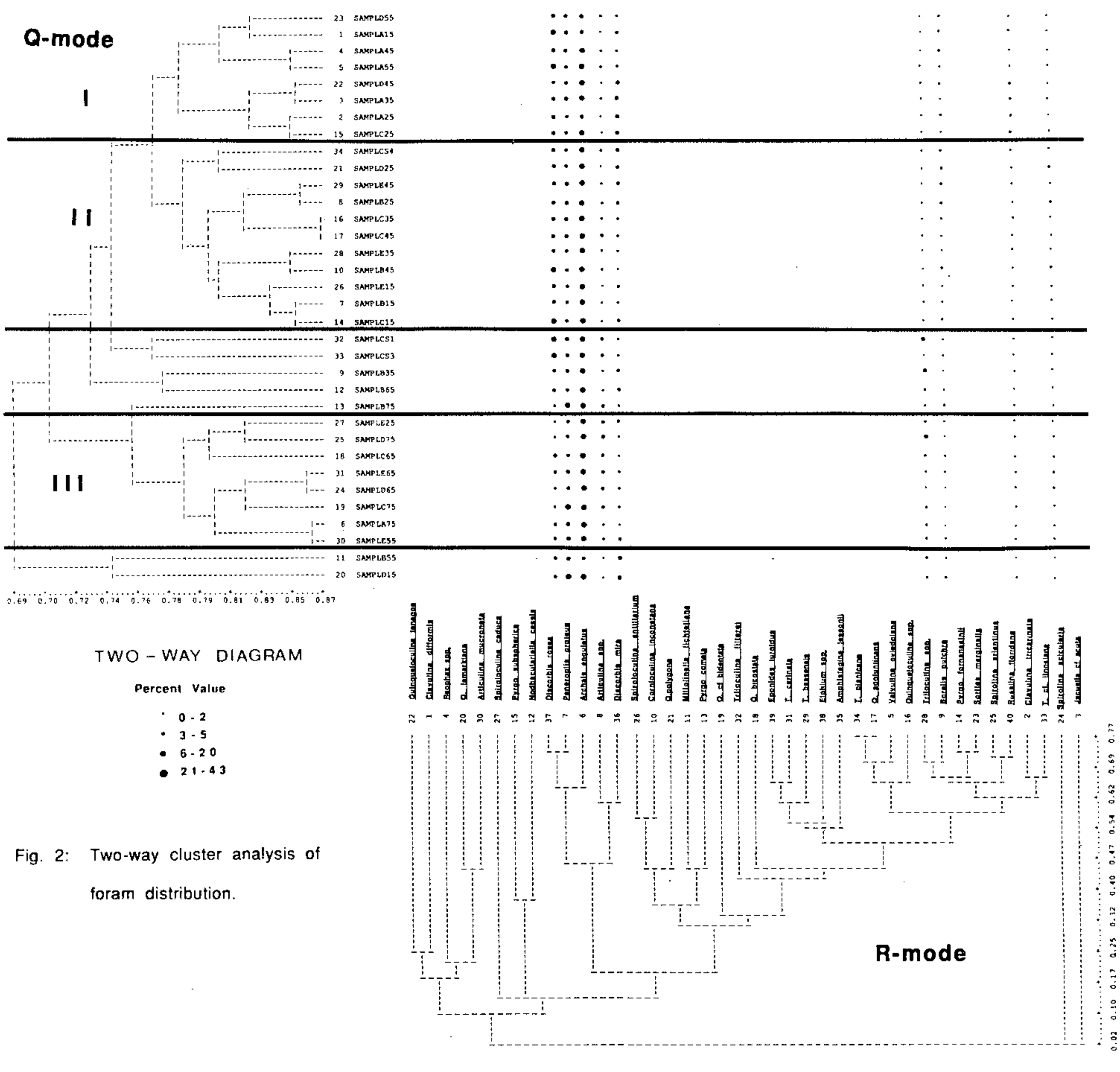

Fig. 2: Two-way cluster analysis of foram distribution.

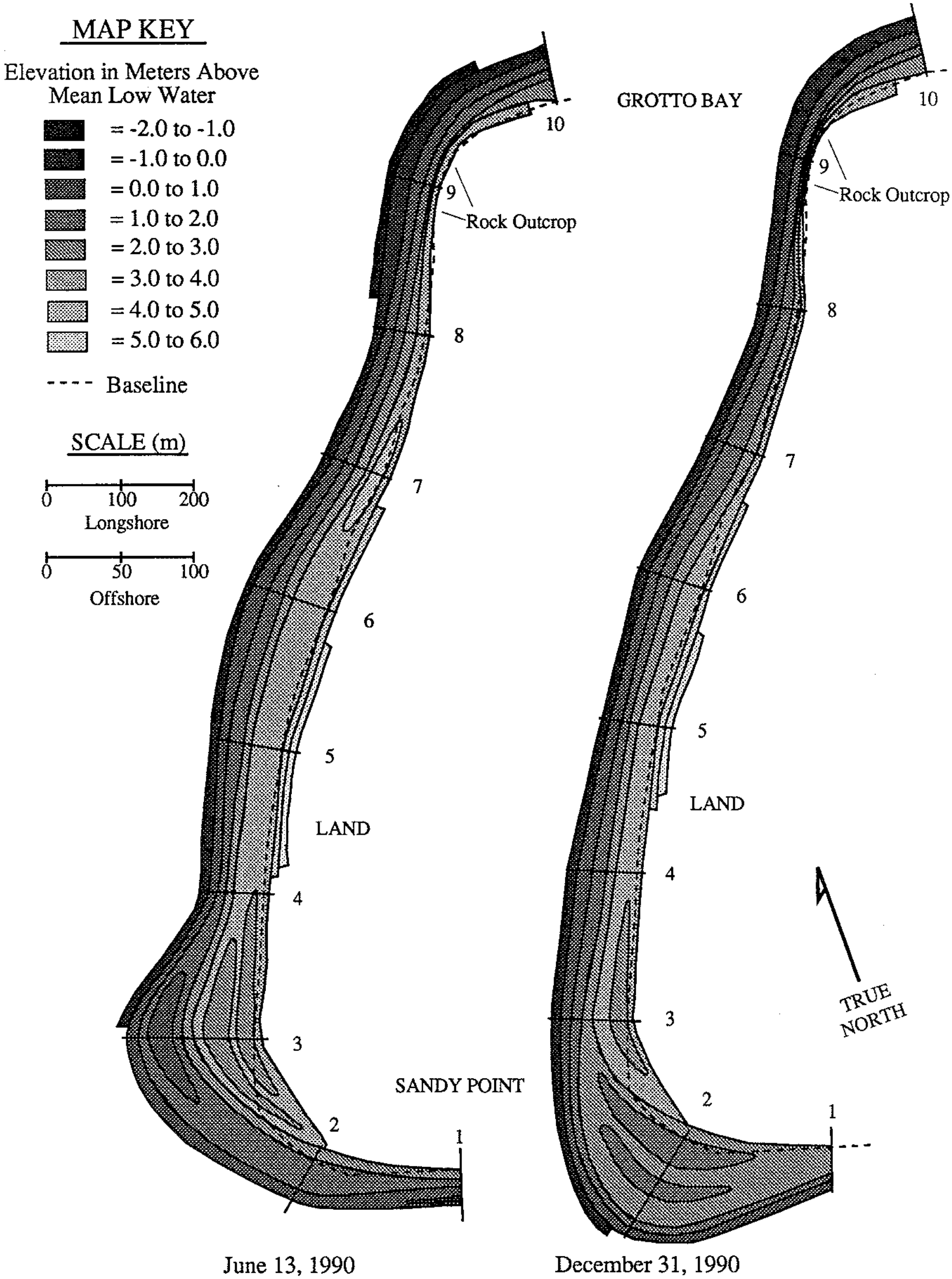

FIGURE 1. Topography of Sandy Point Beach in June and December, 1990. Note the change in the location of the sand lobe and storm runnels, as well as the dramatic narrowing of the beach at the northern stations. Contour interval 1.0 meters.

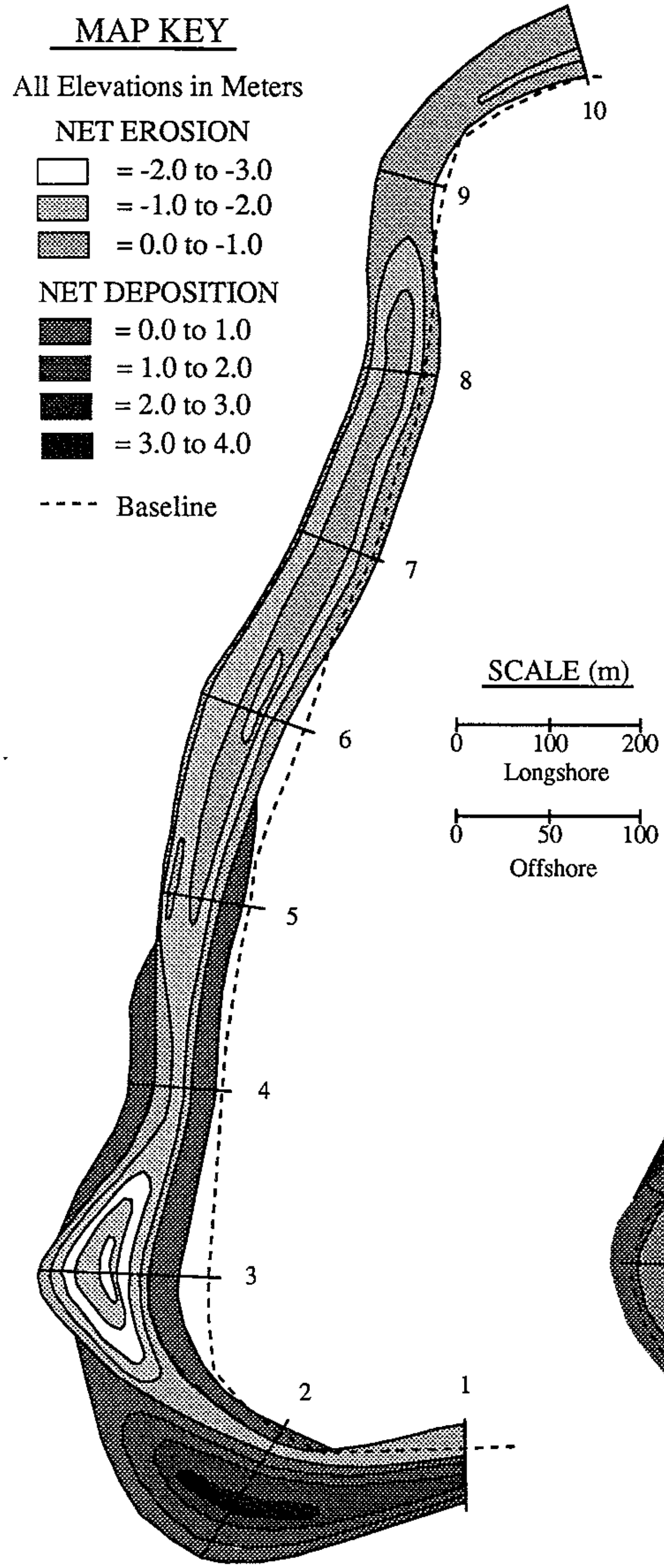

FIGURE 2. Net erosion and deposition on Sandy Point Beach from June 13 to December 31, 1990. Contour interval is 1.0 meters.

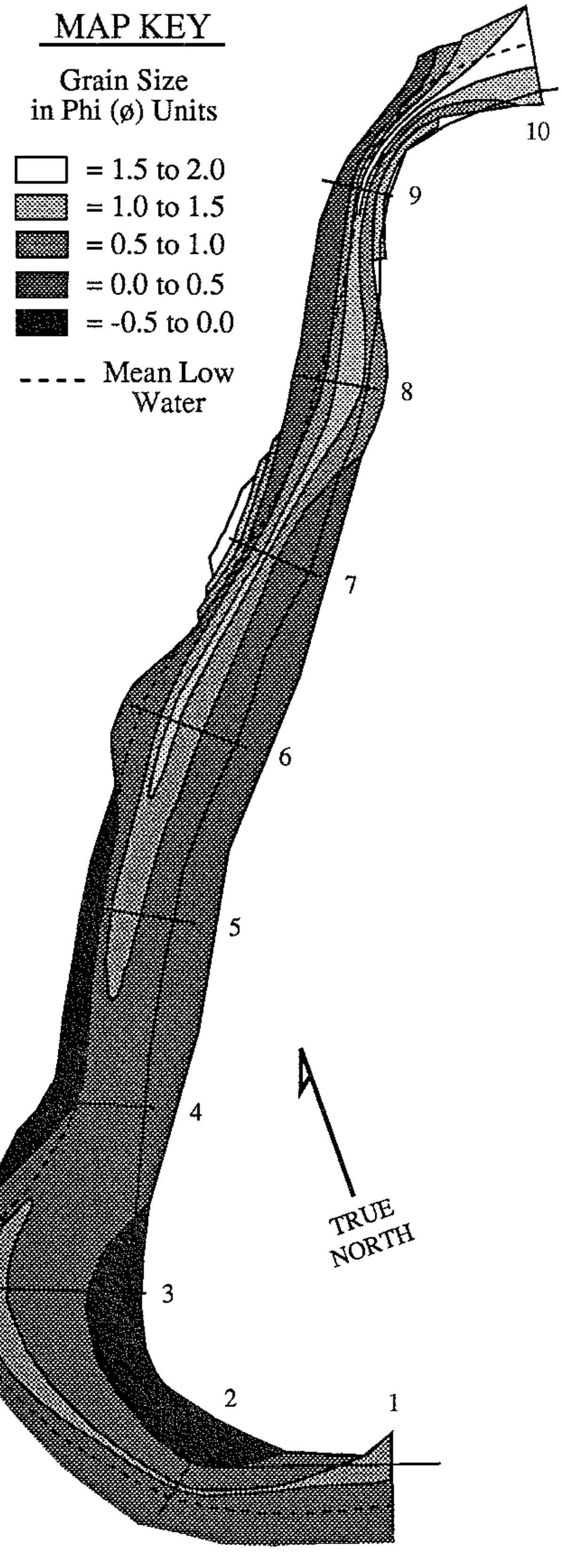

FIGURE 3. Mean grain size distribution on Sandy Point Beach on June 13 and 14, 1990. Contour interval is 0.5 phi (ø) units.

longshore current generated by waves (Davis, 1985). For such a southerly migration of sediment to have occurred on the lee side of the island, the dominant easterly winds and weather patterns could not have played a major role. Most likely, the forces that moved the sediment were those accompanying the northwesterly storms that periodically hit the island.

The sediment samples displayed a high degree of variance for all four statistical parameters, but only mean grain size and sorting will be considered here. The mean grain sizes ranged from 1.88 ø to -.12 ø (.24 mm to 1.1 mm). Using the Wentworth size classification scheme, these values range from fine sand to very coarse sand, with the vast majority of them falling into the coarse and medium sand classes. The second important statistical measurement is sorting, which is based on standard deviation. Of the fifty samples sieved, standard deviation values ranged from .88 ø to .29 ø. The corresponding verbal terms for these values are moderately to very well sorted. The majority of samples were well sorted. The mean grain sizes were plotted on a map and contoured (Figure 3). The map shows that the finer sediments are located in the northern half of the beach and the coarsest sediments are located south, both high up on the beach and below mean low water. The mean grain size distribution grades towards coarser as one moves south on the beach. Although not shown graphically here, the sorting of sediments also differed significantly by region. The poorest sorted samples were located on the northern half of the beach and the best sorting was found to the south. The presence of the largest and best sorted sediments on the southern half of the beach suggests that this is an area of highest wave energy, responsible for winnowing out the finer sediments. Conversely, the finer and more poorly sorted sediments found on the northern half would suggest low wave energies. These laboratory conclusions are compatible with observations made in the field.

In addition to the work done on the modern beach, some investigative work was done on the nearby Holocene cliffs to identify lithified beach facies. The rock face was searched for trace fossils which are often good indicators of paleoenvironments (Curran and White, 1986). Using the preferred burrow location of the modern day ghost crab for comparison, it is likely that fossilized ghost crab burrows would also have been located in a region extending from behind the swash zone to the rear of the backbeach. The rock stratigraphy also had regions with high spherical porosity, which is interpreted as fossilized bubble porosity. Previously documented in the the carbonate rock record, bubble porosity in the modern beach is found in the uppermost laminations of the accretion beds, near the berm (Inden and Moore, 1983). A third, mega-scale, facies indicator are large lithified cusps and horns, a topographic feature commonly found midway up the modern day beach. Finally, it is hypothesized that the upward fining stratigraphy of this outcrop is indicative of a sea level regression. The uppermost beds appear to be eolian, underlain by upper beach and berm deposits and the lowermost beds appear to be marine deposits. The sea level regression proposal is supported by the presence of fossilized clasts of beach rock in the outcrop, a feature that Inden and Moore (1983) argue to be a typical indicator of sea level regressions in rock stratigraphy.

CONCLUSION

A number of conclusions can be made from this study. (1) There was a net change in sediment distribution over the six month period from June to December, 1990. Figure 2 illustrates net erosion between stations 3 and 10 and deposition between stations 1 and 5. (2) Both mean grain size data and sediment sorting data indicate higher wave energy to the south and lower wave energy to the north. (3) The rock stratigraphy of the northern cliffs displays an upward fining sequence and many lithified features that are good indicators of specific beach facies. The addition of forthcoming thin section data, will aid in further delineating these facies.

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PALEOENVIRONMENTAL AND PALEOECOLOGICAL ANALYSES OF A PLEISTOCENE LAGOONAL, MOLLUSK-RICH FACIES, SAN SALVADOR ISLAND, BAHAMAS

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Numerous exposures of a Pleistocene mollusk-rich, lagoonal facies occur just south of the Bahamian Field Station on San Salvador Island. These outcrops surround a network of tidally-influenced saline lakes and blueholes (fig. 1). The facies is exposed as discontinuous lenses of poorly indurated, shelly rock. Twenty-four species of fossil mollusks have been identified. This facies contains two distinct molluscan associations. The most common association is dominated by two species of the burrowing bivalve *Codakia*. The other association is characterized by the carnivorous gastropods *Cerithium* and *Bulla* and the bivalve *Trigoniocardia* (Sterrer, 1986).

This Pleistocene facies represents a tidally-influenced lagoon of undetermined size similar to the modern south arm of Pigeon Creek Lagoon on San Salvador, which was studied for comparison. The shell assemblages found in this modern environment, which occur most commonly in current scour pits and in the main channel of the creek, contain many species identical to those identified in the fossil assemblages (Table 1). The fossil deposits resemble the thick, discontinuous deposits of shells found today in Pigeon Creek. Rocks of the Pleistocene deposits provide further evidence of an intertidal lagoon paleoenvironment. The *Codakia* association is found in a clean shelly marine sand of subtidal origin. This is equivalent to the subtidal channel in Pigeon Creek Lagoon. The *Cerithium-Bulla* assemblage, however, is present in a burrowed, muddy sand that contains a newly discovered trace fossil produced by *Upogebia* shrimp, that today burrow in the intertidal flats of Pigeon Creek Lagoon (fig. 2) (Noble et. al., 1991).

Direct correlations between the modern Pigeon Creek and the fossil assemblages reveal distinct relationships which provide valuable information for the paleoecologic and paleoenvironmental reconstruction of the Pleistocene facies, and also further develop the parameters which may strongly bias the interpretations of all paleoenvironments. There are striking similarities between the two study areas. The most abundant species found in the fossil assemblages, including the *Codakia* species, *Cerith*, and *Bulla*, are some of the most common species found in Pigeon Creek. The highly fossiliferous, discontinuous, lensoidal deposits in the Pleistocene facies are nearly identical in size, shape and density of shells to the modern molluscan accumulations in the scour pits and main channel of Pigeon Creek. Finally, the trace fossil in the Pleistocene facies, produced by burrowing activity of the shrimp *Upogebia*, is a significant paleoenvironmental indicator of the intertidal zone.

However, further comparisons between the modern and Pleistocene lagoonal facies reveal that there is a significant amount of difference. *Periglypta listeri*, which seems particularly susceptible to boring sponges, is underrepresented in the fossil record. *Divaricella quadrisulcata* and *Lucina pensylvanica* are entirely absent from the fossil record whereas they are common to abundant in the modern deposits of Pigeon Creek. In addition, several of the ark shells, *Noetia ponderosa* and *Anadara lienosa floridana*, are common in the fossil remains yet appear to be missing in the Pigeon Creek deposits.

The similarities between the modern and ancient study areas indicate that the Pleistocene molluscan assemblages were indeed deposited in a lagoonal facies. The differences between the two facies are equally as significant, but they do not dispute this interpretation. Rather, the differences illustrated by this study provide some parameters on the reliability of paleoenvironmental and paleoecologic reconstructions.