Distribution of Benthic Foraminifera in the Dump Reef Area, San Salvador Island, Bahamas

Elizabeth M. Haynes
Department of Geology
Smith College
Northampton, MA 01063

INTRODUCTION

Benthic foraminifera are sensitive indicators of bottom environments. Environmental zonations based on foraminiferal distributions have been related to the foram fossil record in many previous studies. The utility of benthic foraminifera as environmental indicators served as the catalyst for this study of modern benthic forams inhabiting the Dump Reef area along the North Shore of San Salvador Island, Bahamas. An examination of faunal distributions over a range of environments may delineate definite foraminiferal assemblages. If the influence of environmental factors such as substrate, salinity, and water depth can be determined, the factors controlling the distribution of distinguishable fossil foram biofacies may also be assessed. Knowledge of these biofacies may yield information pertinent for the reconstruction of ancient shallow water carbonate environments.

The study goals were: 1) to identify the species of foraminifera present in the Dump Reef area, 2) to correlate distribution abundances to particular environments, and 3) to map the area for future workers.

METHODS

Sediment samples were taken every 10 m along five 75 m transect lines oriented N020E. The transect lines were spaced 10 m apart (Fig. 1). Sediment was scooped with a small trowel; an attempt was made to collect the upper centimeter of sediment.

The species abundances for 34 samples containing a total of 40 species were analyzed using a cluster analysis program. This statistical method typically produces dendrograms, which display clusters of samples or species that are similar. The similarities are on the basis of composition (Q-mode) or on species distribution (R-mode).

RESULTS

Bottom environments within the Dump Reef study site were noted as field work was carried out. All sands and rocks in the area are carbonates. The sand zones include the sandy foreshore and sand channels around the reef. These areas have a firm bottom, mobile sand grains, and sparse vegetation. The extensive rocky substrate region is much more coarse than the sand, with cobbles and boulders. There also is a mix of marine grasses, algae, and soft corals. The patch reefs display the normal flora and fauna expected in wavy, parallel laminae (each lamina 3 or 4mm thick) and fills in karst depressions. There are small pockets or air vesicles found within the caliche cap that are approximately 1cm thick. This zone represents the lithification and development of paleosol within the unstratified swale-fill.

The second type of paleosol development if found at the crest of the ancient dune structures. The caliche cap is better developed in this setting and there is no soil development but rather two types of caliche pockets. Pisolite pockets are more infrequent and are characterized almost completely by vadose pisolites with a mean diameter of 1cm. Pockets average 30cm in depth and 1m in length, and show very little rhizomorph development. However, the second and more common type of caliche pocket contains heavy rhizomorph development and unstratified, fine-grained ooids. The size of these pockets range from 15cm to 50cm in depth and from 40cm to 1m in length. The significant differences between these paleosols and those developed on the swales, are the absence of shell fragments, particularly *Cerion* shells, and the lack of soil development below the caliche pockets.

SEA LEVEL DISCUSSION

The facies descriptions discussed above allow for interpretations to be made about the overall depositional history of the Gulf area. To begin with, all of these facies formed after the 125ka sea level maxima which stood at +6m and the lower portion of the section (0-4m mark) formed during the subsequent sea level fall. The coral rubble facies formed in the shallow, subtidal environment. During this deposition, there was significant development of ooid shoals on the narrow shelf.

As the sea level continued to fall, an intertidal, calcarenite, beach deposit formed, represented by the beach transition zone facies above the coral rubble facies. At this point, sea level was at a range of 0m to +.5m above present levels according to the stratigraphic position of the beach deposit. This ooid/peloid beach zone was subsequently cemented in the marine phreatic zone.

Sea level then dropped off significantly to expose the ooid shoals on the shelf, however the level did not drop below the shelf edge (Carew et al., 1984). The eolianites formed landward from the beach and slowly overtook the beach, migrating toward the shelf edge. As the sea level remained above the shelf edge, the aragonite ooids were incorporated into the eolian dunes and dune stabilization could not occur. However, the eolianite had time to lithify prior to the next sea level change.

The next sea level rise is recorded by the storm channel facies, which are found at heights ranging from 3-4m above present sea level, in places only 1m below the paleosol. The presence of coral in this facies indicates that sea level had to have been high enough to allow for the growth of reefs on the shelf. Also, and more importantly, the presence of marine aragonitic cements within these deposits indicates that sea level was at or above the levels that these channels were formed.

After this brief sea level high, the sea level dropped to allow for further eolianite deposition. Evidence for this stage of deposition is recorded by the sediments that are draped over the storm channel deposits.

The final sea level change for this Pleistocene study occurs when the level drops below the shelf edge. This causes the deposition of the eolian sands to halt and allows vegetation to stabilize the platform. The paleosol horizon then forms over the eolianite at this time.

NOTE: These sea level interpretations will be further evaluated after Uranium series dating has been completed on field samples taken from each facies.

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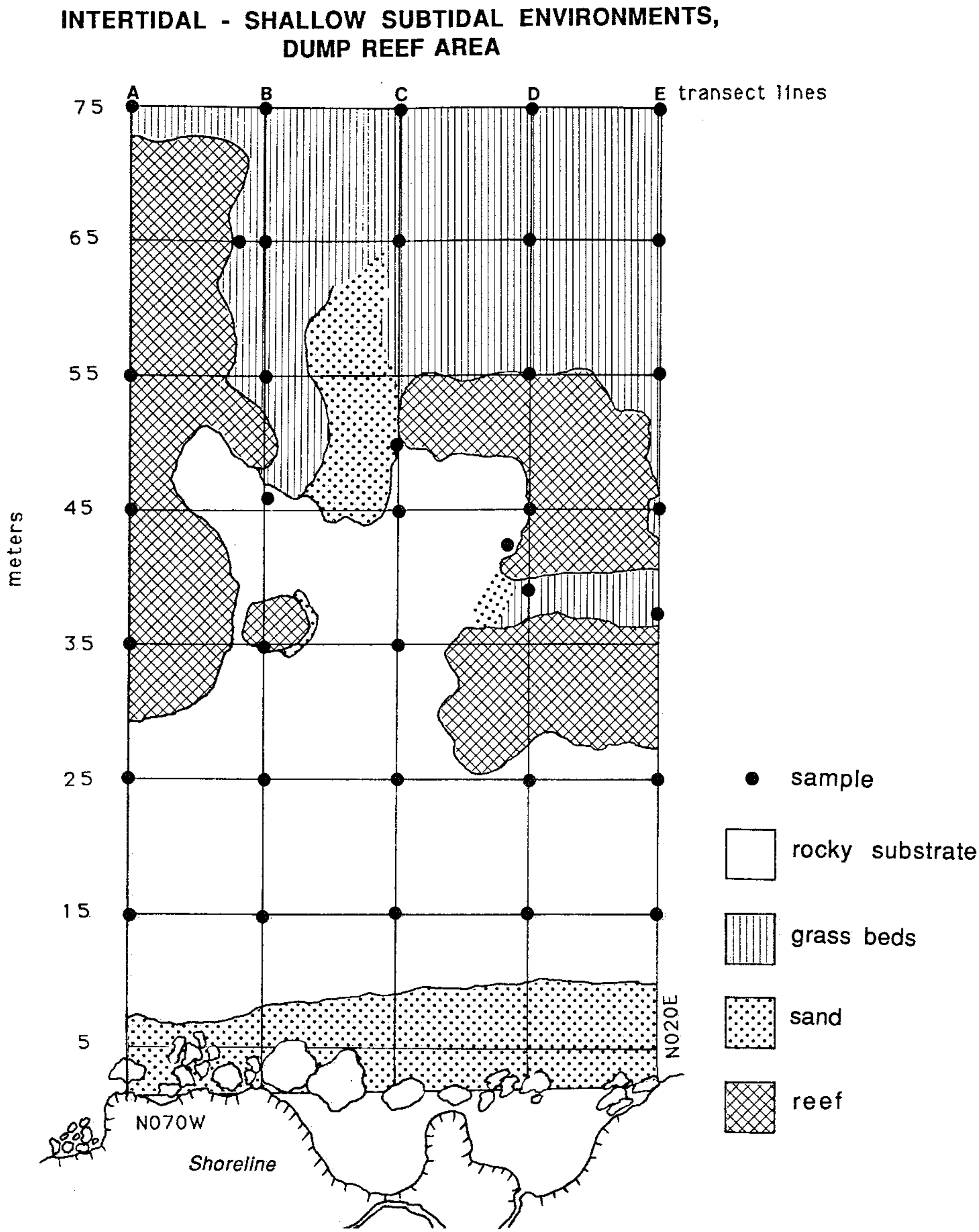

Fig. 1: Sample sites, shoreline sketch, and distribution of bottom environments.

such a system. *Thalassia* grass interspersed with manatee grass dominates the sea-grass beds. There are few rocks in this region.

In the statistical analysis, the Q-mode dendrogram showed three major clusters labelled I, II, and III (Fig. 2). Cluster I has eight samples taken directly from or quite near the reef areas of the study site. The eleven samples in Cluster II concentrate in the rocky substrate region. Cluster III contains eight samples focused in the sea-grass beds. In each cluster there are a few samples that do not match the overall environment. The R-mode clusters showed taxa grouped together on the basis of similarity. This in of itself is not useful in describing the distribution of taxa. The R-mode dendrogram was helpful in developing the two-way diagram, which illustrates the interrelationships between species and samples.

CONCLUSION

Statistical analysis of foraminiferal data illustrates that certain species prefer particular substrates along the study site transects. Two species, *Archais angulatus* and *Peneroplis proteus* range over the entire Dump Reef area in large numbers. Because these two species dominate the entire sampling site, it can be termed the *Archais/Peneroplis* biofacies. Within this framework, three microbiofacies have been recognized.

These foram microbiofacies appear to be substrate controlled. On the basis of statistical analysis of the samples, three regions (substrates) have been identified with characteristic forams (Fig. 2). The first is the patch reef environment. The foraminiferal assemblage consists of large numbers of *Rosalina floridana*. Also common and abundant are *Borelis pulchra, Discorbis rosea,* and *Discorbis mira.*

The rocky substrate, with its variations in vegetation and bottom topography, is the preferred substrate of *Triloculina cf. linneana*. Also present in large numbers are *Borelis pulchra, Discorbis rosea,* and *Discorbis mira.*

The sea-grass beds, found in deeper water and with a regular, firm bottom attract large concentrations of *Articulina spp.* In addition, *Triloculina spp.* is abundant. The sea-grass showed lower abundances of *Borelis pulchra, Discorbis rosea,* and *Discorbis mira* relative to the reef and rocky areas.

These patterns illustrate the importance of bottom environments in controlling foram distributions. Foraminiferal assemblages have been identified and related directly to particular environments. This study suggests that fossil foram microbiofacies could be useful as tools for paleoenvironmental reconstruction in similar ancient tropical, shallow-water carbonate settings.

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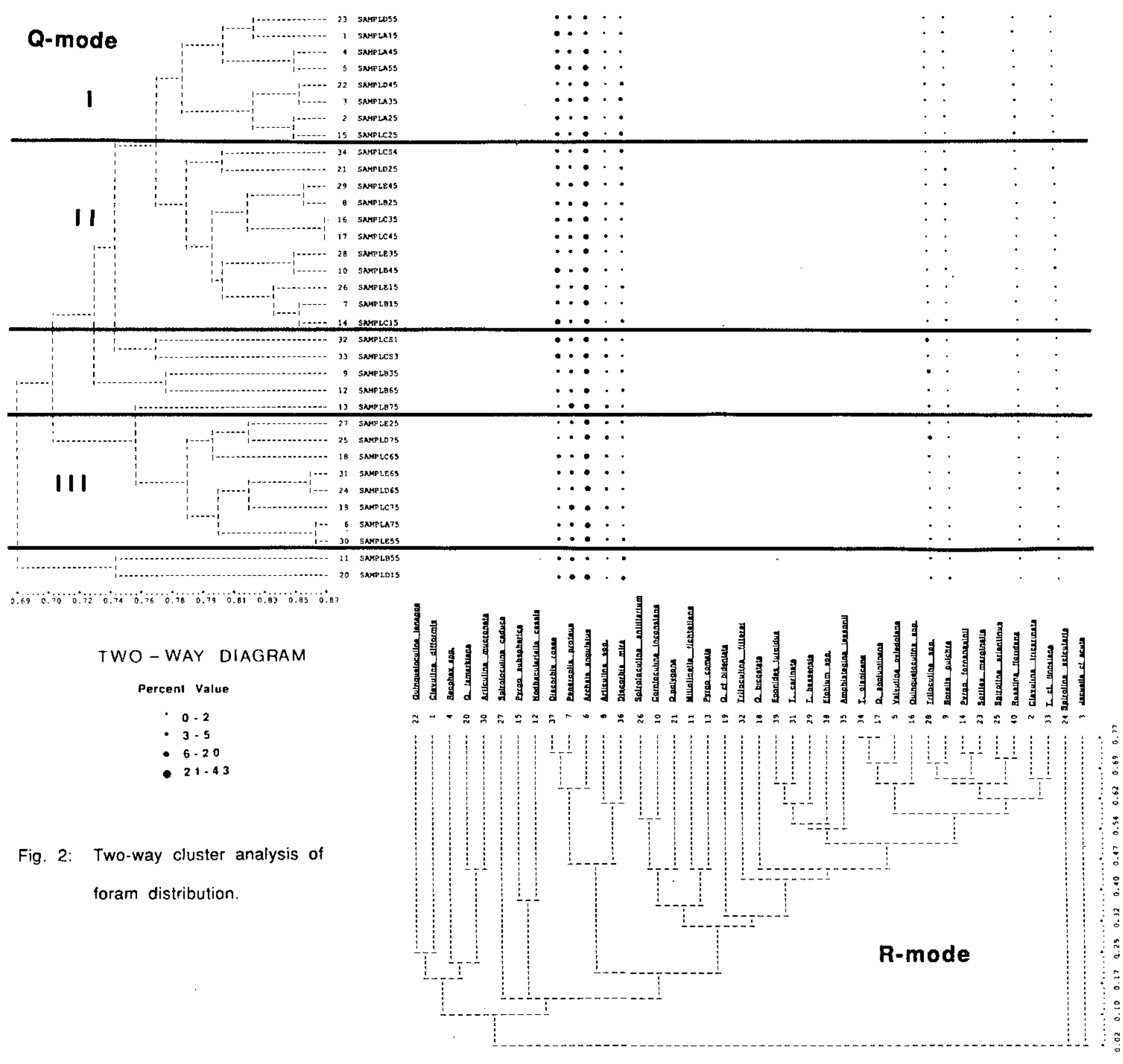

Fig. 2: Two-way cluster analysis of foram distribution.

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

Nicholas T. Loizeaux
Williams College
Williamstown, MA 01267

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