Patterns of Carbonate Sediment Production and Distribution on Patch Reefs in San Salvador, Bahamas

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During June and July of 1989 calcareous sediments were collected from five locations of patch-reef growth in the near-shore shelf waters around the Bahamian island of San Salvador. From these samples a general pattern of sediment production and deposition by patch reefs has been constructed for both windward and leeward coasts. The sites were chosen to represent the variety in terms of wave-energy, ecology, and reef structure found on the patch reefs around San Salvador. The East Beach and French Bay sites represent high-energy, windward environments. Snapshot Reef, Bonefish Bay, and Dump Reef represent low-energy, leeward environments (Figure 1).

Ninety-seven samples were analyzed for size distribution using Ginsburg's (1956) sieving technique. The size catagories ranged from fine gravel to coarse silt (4mm - 1/16 mm). The fraction of silt and clay sized particles were minor and did not require close examination.

Forty-five of these samples were impregnated with epoxy, sectioned, and studied by making point counts so that major particle constituents could be determined. The major contributing skeletal components were coralline algae, Homotrema rubrum, Halimeda, mollusks, scleractinian corals, and pelagic foraminifera. The non-skeletal catagory included grapestone aggregates, pellets, ooids, and any other particles too highly altered to be identified as skeletal.

Clustering methods were used to analyze size distribution and particle constituent data. Resulting clusters were used to identify sediment patterns both within and among sites.

A high degree of variance for particle size distribution, mean, and standard deviation were evident for sediments in all five locations. The mean grain size ranged from coarse sands (-0.24 Phi size) to fine sands (2.16 Phi size). Overall, the samples were slightly finer in Bonefish Bay and East Beach locations. French Bay had slightly coarser samples. All five sites, however, consistently showed a range of mean grain size. Standard deviation values ranged from 1.9 to 0.6. All samples consistently showed good to medium sorting .

The variance of sedimentary size parameters among and within the five sites reflects the multiple variables involved in the creation of calcareous sediments. Jordan (1973) attributes compositional and textural trends in carbonate sediments to biological source, particle breakdown, and sediment transport. Carbonate sediments include skeletal remains from a wide assortment of organisms. The carbonate grains inherit the variety of stuctures and sizes of this biota and react to breakdown mechanisms in different ways. To complicate matters both biological and mechanical processes work to breakdown these grains. Numerous taxa including boring worms, sponges, and bivalves as well as parrot fish and echinoids significantly modify grains. Mechanical abraison and breakage also erode particles. Winnowing, sorting and dispersal of sediments by waves and tidal action further work carbonate grains and effect texture. All of these variables make a simple explanation of size distribution difficult. They also help explain why there is so much variety within and among sampling locations.

Despite this, several general conclusions can be made. In French Bay and Dump Reef where thick Thallasia and calcareous algae beds surrounded the reef patches, sediments taken on and immediately around the reef tended to be coarser that inter-reef areas. This difference is likely due to baffling processes by Thallasia which keeps the finer particles from being winnowed away (Ginsburg 1958). The expected difference in size distribution between the high-energy windward side and the lower-energy leeward side site was not evident. Differences in patch reef ecology and physiology complicate reef sedimentation systems. The size and texture of carbonate sediments cannot be evaluated only on the basis of mechanical transport and breakdown.

Analysis of constituent particle distribution shows a consistent difference between windward and leeward sediments. Windward sediments are primarily made of fragmented skeletal particles whereas leeward particles are predominately non-skeletal (Figure 1). Bonefish Bay, Snapshot Reef, and Dump Reef samples contain 70-75% non-skeletal particles that are primarily grapestones and unidentifiable, altered grains with some oolites and pellets. The windward sites contain only 23-27% non-skeletal particles. They are mostly made of fresh fragmented grains.

Calculation of particle ratios without the non-skeletal fraction shows that the sites have very similar

compositions of skeletal particles (Figure 2). Except for Snapshot Reef in which the average sample contains 50% scleractinian coral fragments and less than 10% Halimeda , all of the sites show that the major constituents are coral, Halimeda, and often pelagic foraminifera. These fragments occur in roughly equal amounts. There are some differences that are consistent between windward and leeward sediments. In the average East Beach and French Bay samples 12-13% of the skeletal portion is coralline algae compared to the leeward sites in which the average amounts range from 2-7%. Pelagic foraminifera are more common in leeward sites where the average amount is 20% of the skeletal fraction compared to 10% in windward sites.

Thick Halimeda and Thallasia beds grow within 1.0 m or less to the edges of the patch reefs at French Bay and Dump Reef. These beds contribute large amounts of Halimeda flakes to the sediments of the area. Some portion of the Halimeda found in sediments at the reef edge must contain a portion of that from the Thallasia beds. However because the skeletal compositions of French Bay and Dump Reef are similar to the other three sites where inter-reef beds are negligible, it is clear that the patch reefs themselves are sites of Halimeda growth. Coral fragments are not the only grains being contributed. Indeed, examination of the living reef shows Halimeda commonly growing on reef flats and hanging in reef crevices. The low amount of Halimeda in the Snapshot samples may reflect the high amount of live coral growing there.

Differences in amounts of coralline algae and pelagic foraminifera between windward and leeward sites most likely indicates the preference of these organisms to different energy environments.

The high percent of non-skeletal particles found in leeward sediments reflects the lower amount of energy in these systems compared to the windward reefs. Reefs which thrive in aggitated waters (James 1983) are probably more productive. The higher rate of production would translate into a higher rate of sedimentation. It is logical to conclude that in areas with more rapid production and sedimentation, grains would be much less altered or rounded. This difference is clearly represented on San Salvador.

It is unclear if the grapestone and oolite portions of the non-skeletal fraction are autochthons or allochthons. The oolites are probably allochthons. It is doubtful oolites would form in such near-shore environment (Gebelein 1974). Those conditions of steady but mild circulation of water necessary for the development of grapestones do seem present however in the leeward sites (Gebelein 1974). Grapestones could be forming autochthonously.

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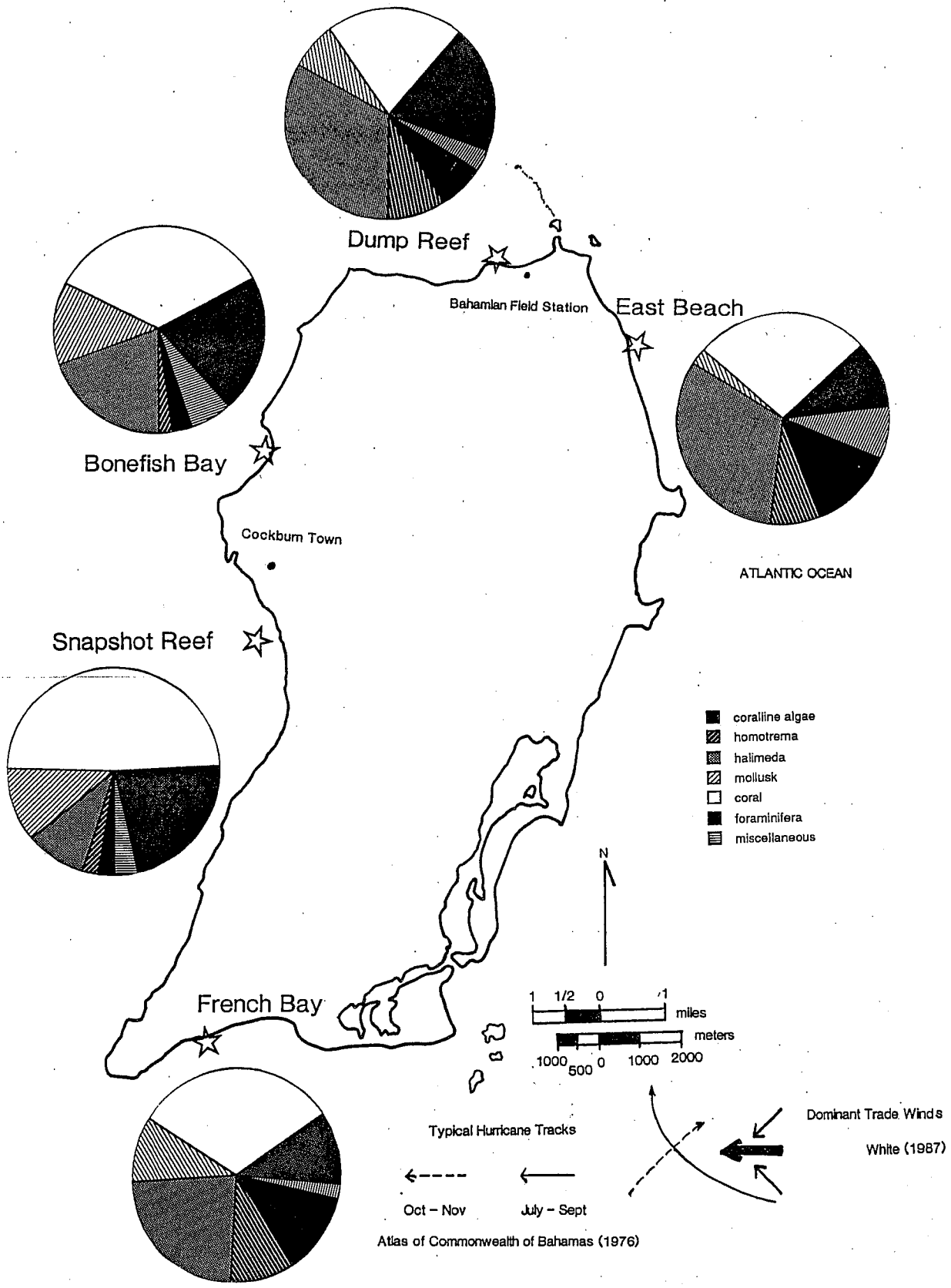

Figure 2

Skeletal Constituents of Sediments on San Salvador

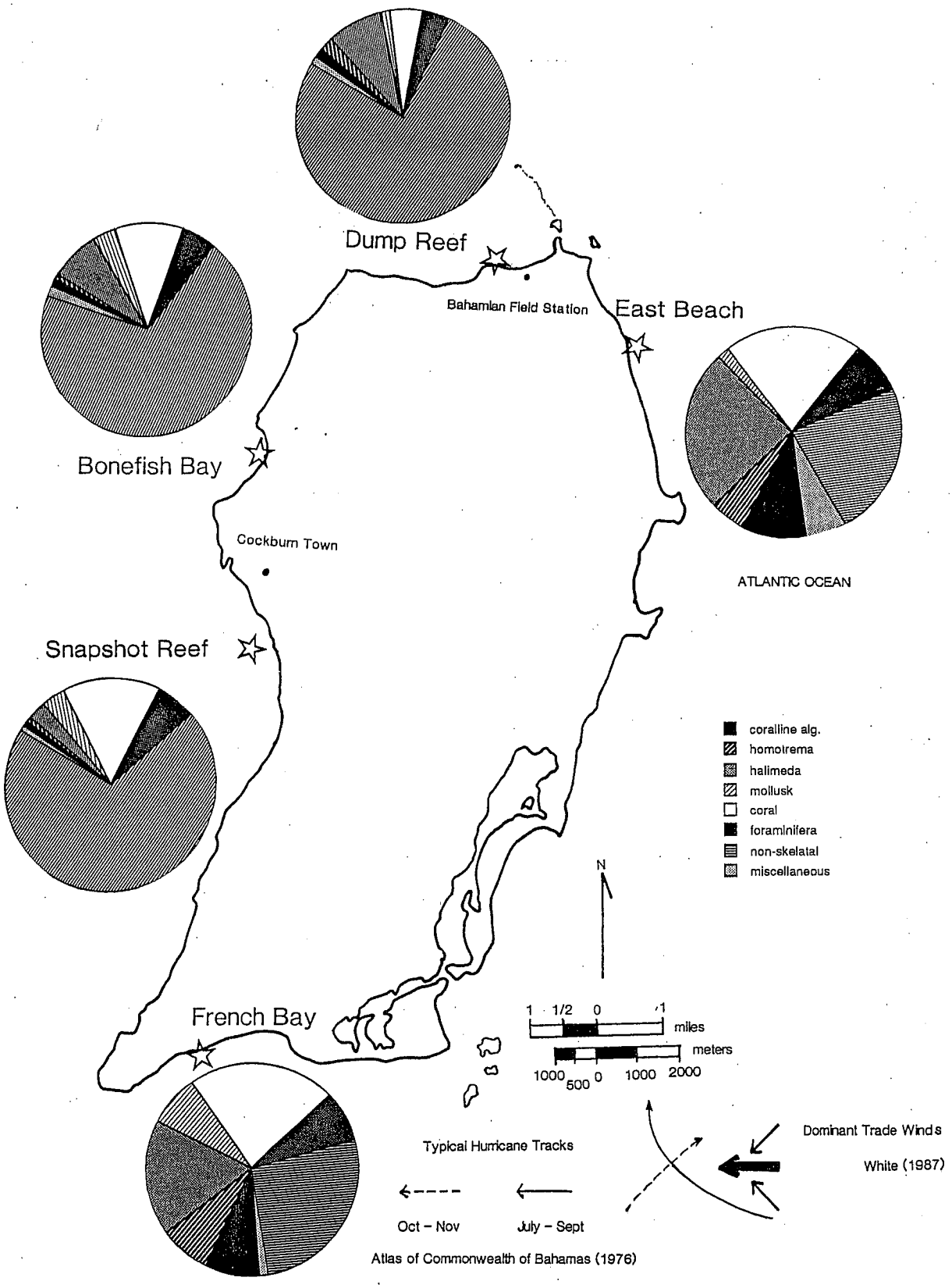

Figure 1 Particle Constituents of Sediments on San Salvador