ANALYSIS OF A MODERN PATCH REEF, SNAPSHOT REEF, SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

Existing studies of coral reefs have focused primarily on barrier and fringing reefs. There have been few studies devoted to patch reefs, and there is surprisingly little known about the ecologic "health" of modern patch reefs in terms of community structure, diversity, and short-term change. Coral-dominated patch reefs are well documented from the fossil record of tropical, shallow marine environments (Scoffin, 1978), and patch reefs are prominent in modern reefal settings (Brown and Dunne, 1980). The few studies that have focused on organism distribution and diversity on patch reefs have used line transects to sample the reefs (Chiappone and Sullivan, 1991), even though patch reefs generally exhibit only minor zonation.

This study focuses on Snapshot Reef, a small *Montastrea annularis*-dominated patch reef located off the west coast of San Salvador Island, Bahamas. A different mapping approach was used in this analysis of the reef. A plan map of the reef was made in a previous study of Snapshot Reef in 1984 (Fig. 1), and this map was used instead of line transects to document the distribution and abundance of organisms on the reef. Descriptive and statistical analyses were then performed on the data to provide a view of the present state of Snapshot Reef.

Similar data from the 1984 study of Snapshot Reef provided an opportunity for comparison of the state of the reef then and now. Through analyses of data gathered from the two studies, short-term changes on the reef can be determined, and these may serve to indicate the present "health" of this patch reef. Such studies provide baseline data concerning the "health" of modern patch reefs and are much needed in light of present-day concerns about the global well-being of reefs and possible detrimental effects of human activity.

FIELD METHODS

The original plan map (Chambers, 1984) was used to define the reef area for this study. Buoys were placed in the four corners of the 50 m by 50 m reef area and coral heads were numbered using the map as a reference. Sixty-four heads were identified, numbered, and studied in detail.

Data concerning the abundance and distribution of organisms was collected for each coral head. The following protocol was created to provide systematic observation at each coral head: 1. The approximate percentage of live coral coverage (1= 0-20%, 2= 20-40%, 3= 40-60%, 4= 60-80%, 5= 80-100%); 2. The dominant coral found on the head; 3. The total number of coral species present; 4. *Montastrea annularis* morphotypes present, as described by Knowlton et al. (1992); 5. The relative abundance of non-coral components, i.e. algae, sponges, octocorals, and bare rock (1 = rare, 2 = minor, 3 = common, 4 = dominant); 6. Depth of water; and 7. Height of the coral head.

DATA ANALYSIS METHODS

Frequency histograms were created using the 1992 data to illustrate general trends found throughout the reef and to create a descriptive definition of the present state of the reef. The program SYSTAT was used to perform statistical analyses of the data. General descriptive statistics including the mean, median, standard deviation, and variance of the data were calculated. Pearson and Spearman correlation matrices were used to determine correlations between pairs of variables. Multiple regressions were used to determine relationships between groups of variables to see if any of the measured variables were predictors of height or percent living coral on a head.

T-tests were used to compare the 1984 data with the 1992 data to see if there were any significant short-term changes on the reef. Multiple regressions were plotted to determine if any variables from the 1984 study were predictors of the height or percent living coral for a given head in 1992.

Height and percent living coral were chosen as the dependant variables for the multiple regressions because these variables appear to be the best indicators of the "health" of the reef. To be able to predict either of these variables may prove to be a powerful step in predicting the "health" of a reef.

RESULTS

Present State of Snapshot Reef

Frequency histograms of height (Fig. 2), percent living coral (Fig. 3), number of coral species (Fig. 4), presence of *Montastrea annularis* morphotypes, presence of *Agaricia agaricities*, and abundance of non-coral components were created. The average coral head height is 1.36 m, the average percent living coral is 37%, the

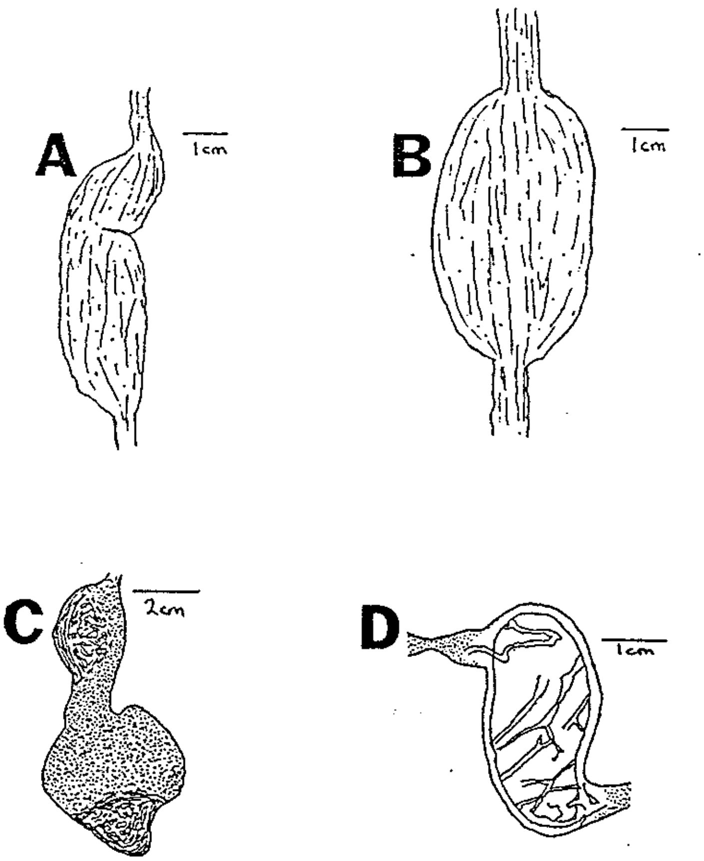

Figure 2. A-B) Living bulbous roots. C) Pleistocene bulbous root structure with areas eroded away. D) Cross-section of Pleistocene bulbous root structure.

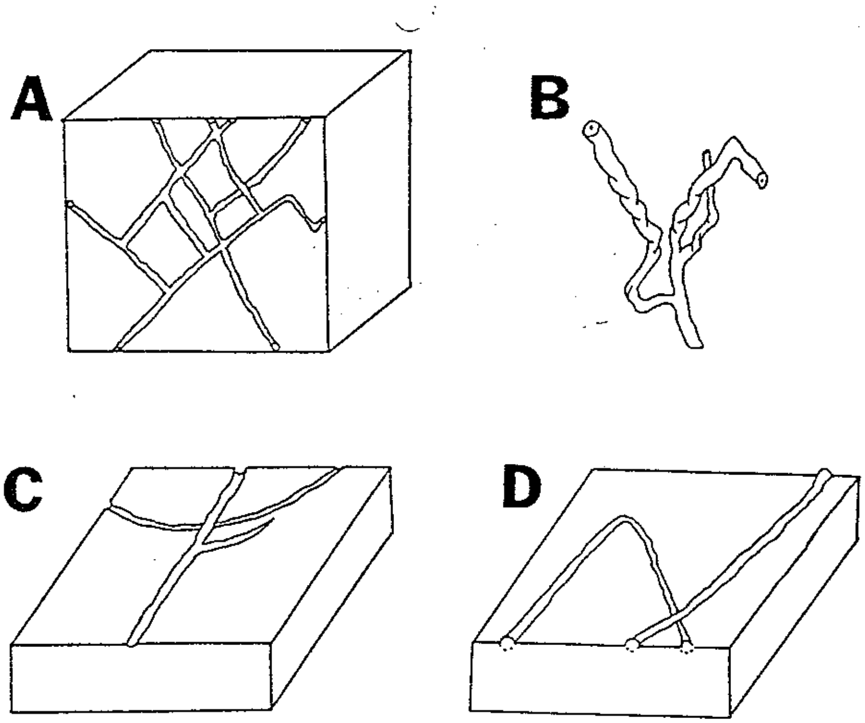

Figure 3. A) Vertical, freestanding rhizoliths. B) Y-branching rhizoliths. C) Bedding parallel root mold. D) Raised straight trailer.

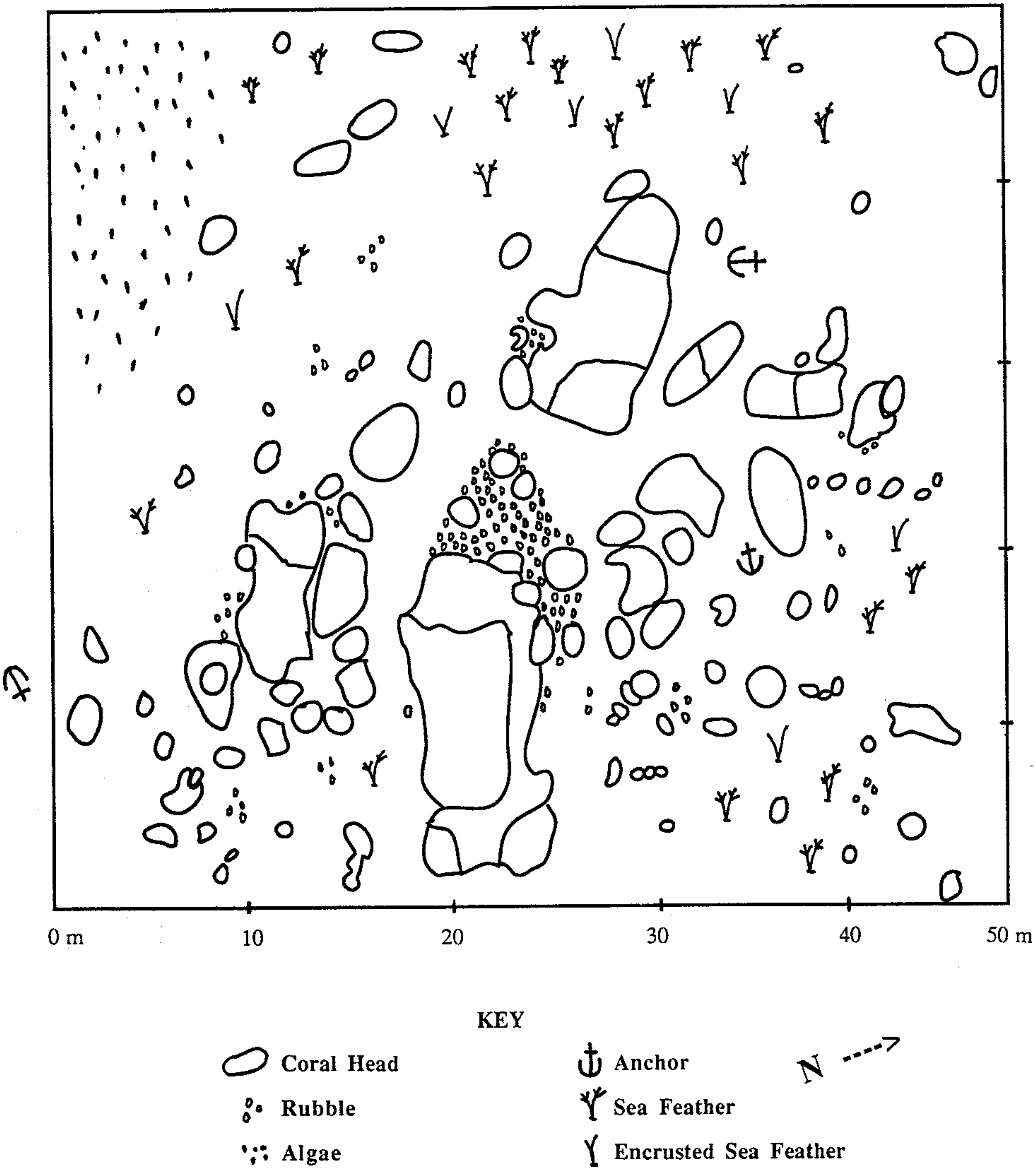

Figure 1. Plan map of Snapshot Reef illustrating coral heads that were identified, numbered, and studied.

average number of coral species per head is 7, *M. annularis* morphotype 1 is the most dominant morphotype, morphotype 3 is abundant, and algae and bare rock are the most dominant non-coral components.

Using a Pearson correlation matrix, the highest correlation found was between height and number of coral species (= 0.703, a strong correlation). A negative correlation between relative abundance of algae and sediment (= -0.527, a fairly strong correlation), and a correlation between coral species and relative abundance of octocoral (= 0.488, a fairly strong correlation) were also seen. The multiple regression analysis illustrated a correlation between percent living coral and number of coral species when height was used as the dependant variable ($R = 0.732$, $R^2 = 0.535$; a strong correlation indicating that 54% of the variability of the height of a coral head can be predicted if the percent living coral and number of coral species on a given head are known).

Short-Term Changes on Snapshot Reef

T-tests showed that there has been significant average growth of the coral heads of 13 cm ($P < .0001$, a very significant value) from 1984 to 1992. There are significantly more numbers of coral species ($P < .010$, a significant value), less algae ($P < .012$), and less sponges ($P < .0001$) on each head now compared to 1984. The t-tests also showed that there was not a significant change in the percentage of live coral on each head. The multiple regression analysis also showed a correlation between the number of coral species and the relative abundance of algae when height was used as the dependant variable ($R = 0.928$, $R^2 = 0.860$; a very strong correlation indicating that 86% of the variability of the present height of a coral head can be predicted if the number of coral species and relative abundance of algae on a given head are known from a previous study).

DISCUSSION

The data from the frequency histograms creates a picture of Snapshot Reef in 1992. Most of the 64 coral heads are between 0.5 and 2.0 m tall and have less than 60% living coral, 4-11 coral species are found on each head, and *M. annularis* morphotypes 1 and 3, *Agaricia agaricities*, algae, and bare rock are very abundant.

Several short-term changes have occurred on the reef in the past 8 years. There has been an average growth of 16 mm per year; a very optimistic growth rate for *M. annularis*, the major reef-building coral of Snapshot Reef. This growth rate is higher than previously proposed *M. annularis* growth rates, 10.7 mm per year (Hoffmeister and Multer, 1964) and 7.8 mm per year (Knowlton et al., 1992), possibly due to operator error, but is within reason of the previously proposed rates and does show that there has been some significant growth on Snapshot Reef. There is also a higher diversity of coral species found on each head, there is less algae and sponges, and there is not a significant change in the percent living coral found on each head.

The equation to predict the variability of the present height of the heads using variables from 1984 indicated that 86% of the variability of the present height in 1992 can be predicted from the number of coral species and the relative abundance of algae found on each head in 1984. In other words; if the number of coral species and relative abundance of algae is known on a given coral head, 86% of the variability of the height of that coral head can be predicted in the future. This equation creates a powerful means of predicting the "health" of the reef into the future. It allows the prediction of short-term changes that will occur on the reef from data gathered at the time of study.

Through the synthesis of field observations and statistical analyses of the data gathered both in 1984 and 1992, the ecologic "health" of Snapshot Reef was determined concerning short-term changes in community structure and diversity. Snapshot Reef does not show signs of deterioration over the past eight years with respect to growth rates, percent living coral, or species diversity. Based on the growth rate of 16 mm per year, along with no significant decrease in the percent living coral, it appears that the reef currently is in a steady state.

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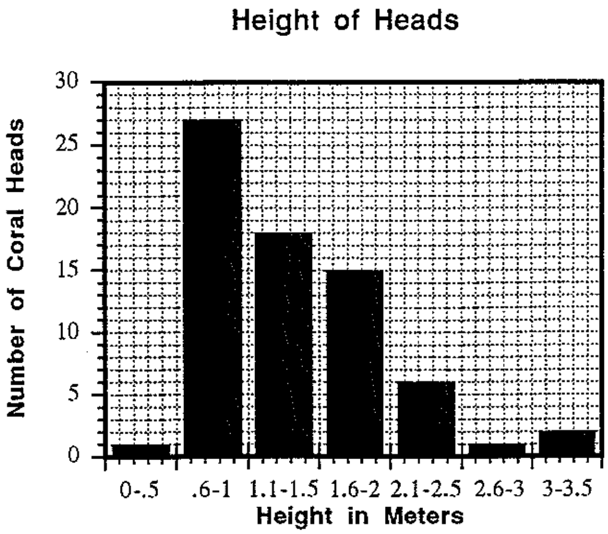

FIGURE 2. Frequency histogram showing heights of coral heads.

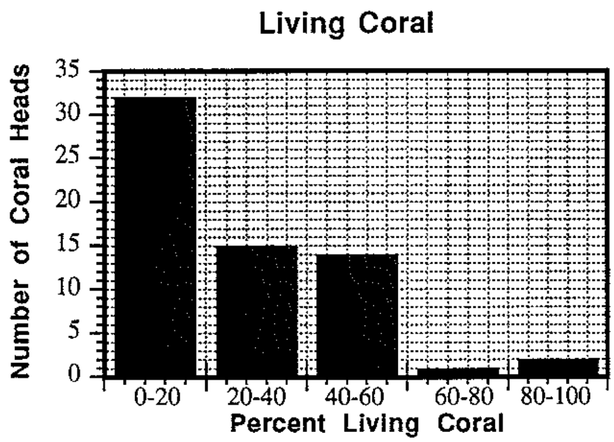

FIGURE 3. Frequency histogram showing percent living coral on coral heads.

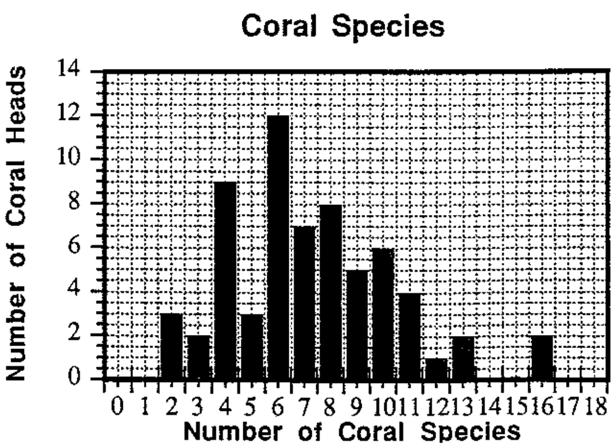

FIGURE 4. Frequency histogram showing number of coral species on coral heads.

Molluscan Taphonomy of Pigeon Creek Lagoon
San Salvador Island, Bahamas

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Introduction

Pigeon Creek Lagoon is a shallow, tidally-dominated basin which terminates in a tidal delta in Snow Bay, on San Salvador Island's southeastern coast. Pigeon Creek branches west and north from its tidal inlet, with both arms lined by dense stands of red mangrove. Each arm contains a tidal channel, ranging in depth from 3 to 10 feet (1 to 3 m), which is bordered by often lush subtidal grassbeds. In these grassbeds *Thalassia* is abundant, along with *Syringodium* and *Halodule*. Calcareous green algae is commonly found in the subtidal flats as well. In many areas, the grassbeds shallow to tidal flats, which contain the same marine grasses as well as extensive *Callianassa* shrimp mound development.

Taphonomy is the study of the processes of preservation. The various environments in Pigeon Creek result in an abundant and diverse molluscan fauna. In addition, these environs possess unique physical, biological and chemical attributes that can potentially affect the degree and style of post-mortem degradation. Thus, Pigeon Creek naturally lends itself to taphonomic study.

The overriding objective of the taphonomic study of Pigeon Creek Lagoon lies in establishing distinct "taphofacies" between the four basic depositional environments: tidal flat, subtidal grassbeds, tidal channel and tidal delta. To achieve this objective, various aspects of shell degradation will be analyzed for shell samples taken from Pigeon Creek's different environments. In theory, the different physical environments of the Pigeon Creek Lagoon subject shells to different modes of physical wear, each creating its own distinctive taphonomic signature. Analyses of the data obtained will determine whether or not this is the case.

Field Methods

The sampling undertaken for this taphonomic study occurred in the southern arm of Pigeon Creek Lagoon. A transect line was established in the Creek's tidal flats, eventually extending 850 meters through the various environments and terminating in the tidal delta in Snow Bay. The natural bend of the channel,

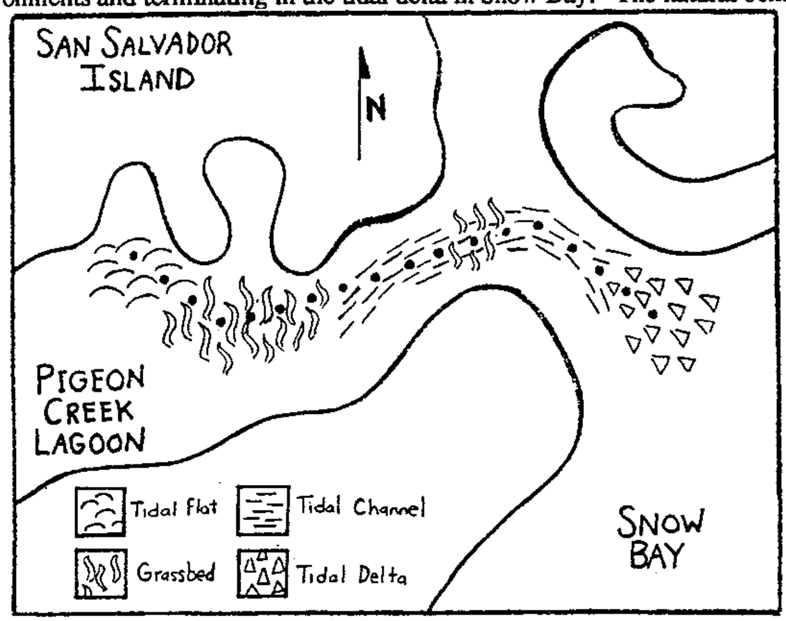

Figure One: Local map of Pigeon Creek Lagoon. Dots represent the 50-meter interval sample sites along the transect, from its origin in the tidal flats to point 850 on the tidal delta.