EVIDENCE OF QUATERNARY SEA LEVEL FLUCTUATION IN PLEISTOCENE LIMESTONES AT SUE POINT AREA, SAN SALVADOR ISLAND, BAHAMAS

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Introduction

A shoaling sequence of shallow subtidal to eolian carbonate rocks crops out along the modern shoreline at Sue Point, San Salvador Island, Bahamas. The tectonic stability of the Bahamian platform allows these Pleistocene outcrops to display significant evidence of Quaternary eustatic sea level change. In two parts, this project first revises and extends existing maps, and secondly focuses on a petrographic study which analyzes and confirms the post-depositional features left by the rise and fall of sea level.

Mapping

Sue Point (Figure 1) is a particularly useful field area for a study of sea level changes. Erosion of the modern beach at this locality has exposed a broad, relatively continuous outcrop of carbonate rock. Phase one of the project was to extend the existing maps of both northern and southern Sue Point where more recent erosion had exposed an additional portion of the older rock (Figures 2 and 3). The extensions were mapped using a meter tape, compass, meter sticks, and the horizon. Earlier maps and stratigraphic profile sections had already been created for northern Sue Point. The profile H-H' (Figure 2) is a new addition to these profiles and representative of the newly mapped section. The profile was also measured using a meter tape, and descriptions were recorded at intervals of every half meter. Taken together these stratigraphic profiles span an interval of shoreline approximately fifty meters wide with a vertical thickness of over five meters.

A more detailed inspection, together with a rock collection, was carried out in the area of northern Sue Point for use in a petrographic study. The overall reefal nature of the stratigraphy of this sequence had already been observed and described previously (White, 1989). Therefore, some time was spent judging, in greater detail, the character of each of the facies which comprise the shoaling sequence. Descriptions of macroscopic sedimentary structures such as cross beds, planar bedding, local zones of dissolution, and infaunal burrowing and boring were recorded so as to provide a more complete characterization of stratal history.

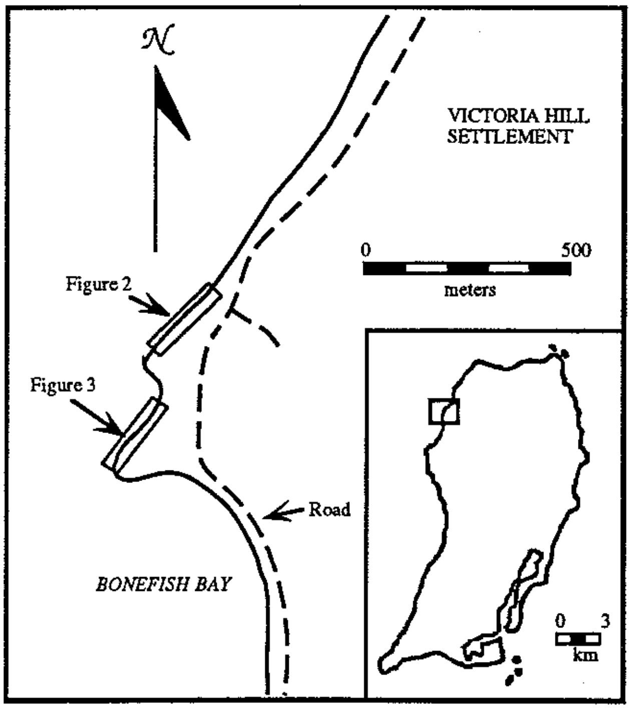


Figure 1: Location of Sue Point, San Salvador Island. Taken from White, 1989.

Petrology

The second phase of the field study was the collection of rock core samples for petrologic study. Using the previously described field profiles as position references, rock core plugs were obtained at regular intervals (Figure 2). Forty-one cylindrical core plugs were extracted using a hand-held rock drill. Each core is one inch in diameter and approximately five inches in length. Plugs were individually labeled by rock type, and location along a profile. They were then sliced into wafers and impregnated with a blue resin prior to thin-section preparation. These sections were usually cut in a longitudinal fashion in order to view variations in vertical extent over approximately one and a quarter inches in height. Absolute age dating by Chen, Mylroie and Cerew, using the Uranium-Thorium content of three corals taken from the rock outcrop at northern Sue Point, is approximately 120 to 135 thousand years (White, 1989). This gives an accurate time frame for the post-depositonal mineral alterations observed in the thin-sections. The maps of the outcrop, surveyed using an electronic total station.

ENCRUSTERS ON LIVING *S. gigas*

CHLOROPHYTA (green algae)
- *Dasycladus vermicularus*
- *Batophora oerstedii*
- *Acetabularia calyculus*

PHAEOPHYTA (brown algae)
- *Dictyota cervicornis*
- *Lobophora*

RHODOPHYTA (red algae)
- *Champia purvula*

OTHERS
- various low growing brown or green algae
- several fleshy polychaete worm tubes

BORINGS ON DEAD *S. gigas*

PORIFERA (sponges)
- *Entobia* (the boring of *Cliona*): at least two species

BIVALVIA (clams)
- *Gastrochaenolites*

OTHERS
- worm borings: various shapes and sizes

ENCRUSTERS ON DEAD *S. gigas*

FORAMINIFERA
- *Planorbulinoides*
- *Homotrema*

CNIDARIA (corals)
- *Montastrea annumlaris*

MOLLUSCA (clams, snails)
- *Echinochama areinella*
- *Spiroglyphus*

OTHERS
- coralline algae
- various polychaete worm tubes

Table 1. Taxonomic list of encrusters and borings on both the living queen conch shells and the fifty shells collected from San Salvador Island, Bahamas.

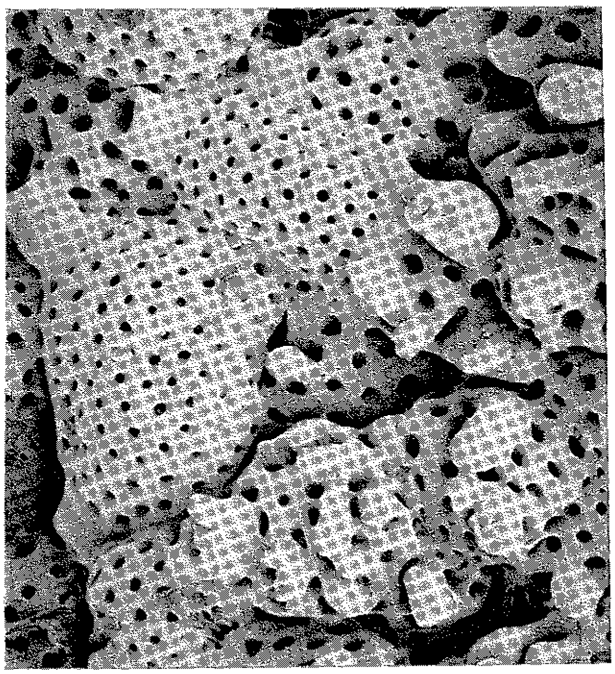


Figure 1. Fresh *Planorbulinoides* sample taken from young queen conch shell San Salvador Island, Bahamas; (x 140).

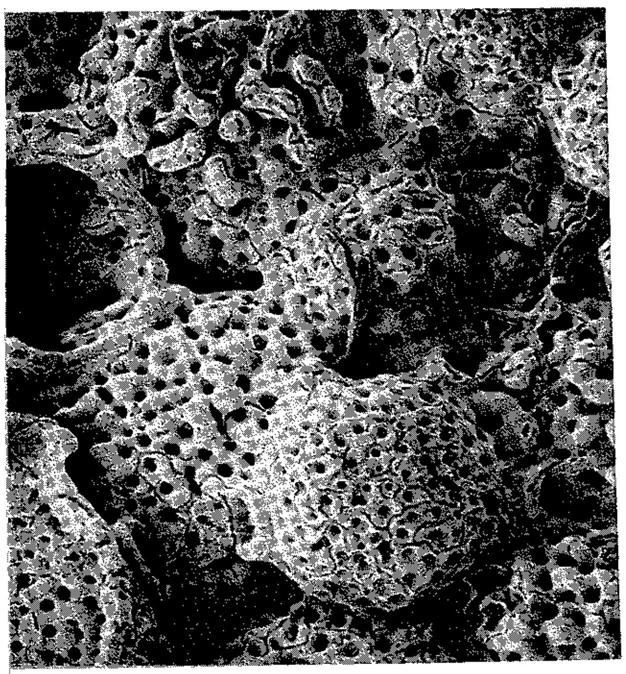
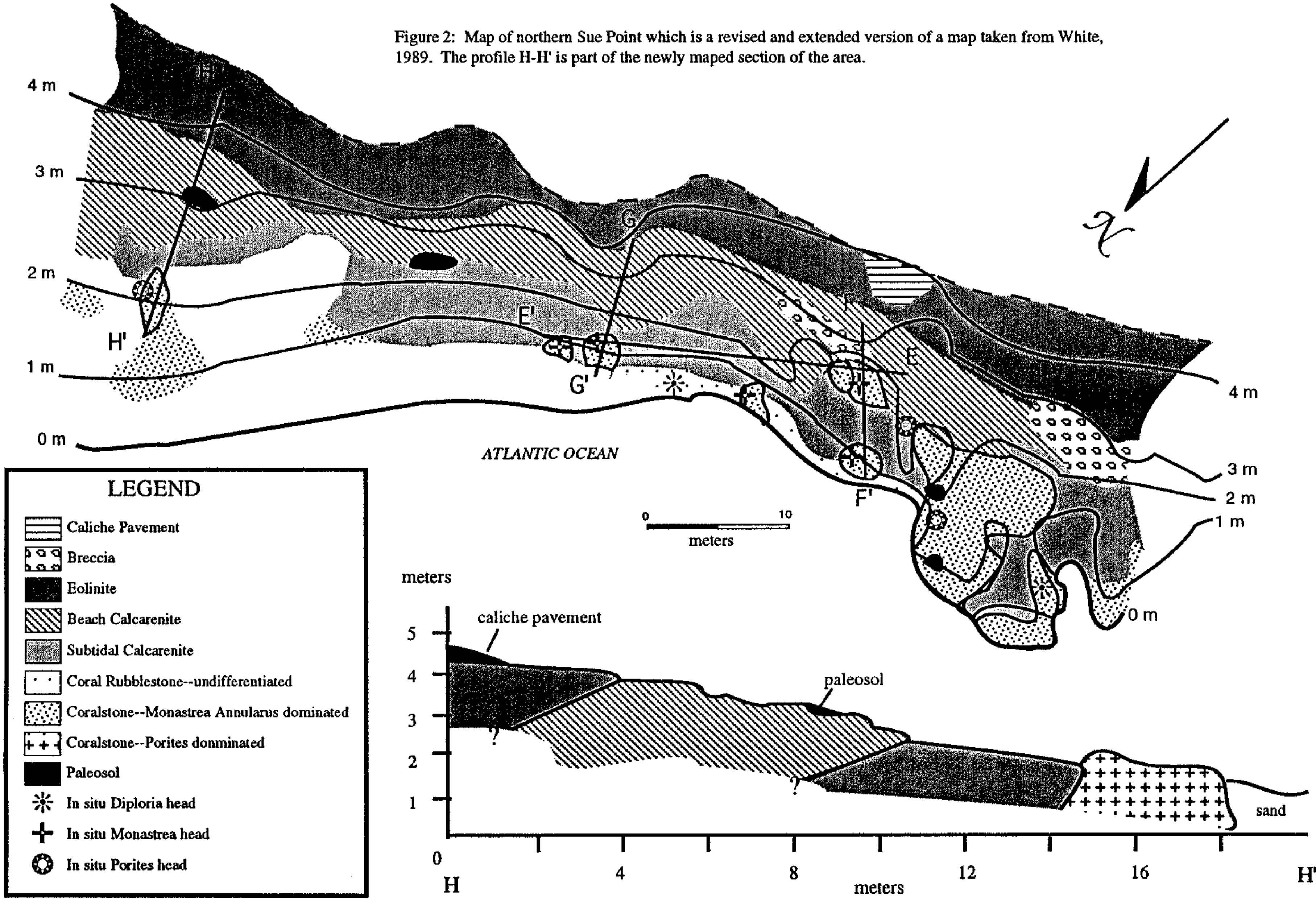


Figure 2. Bored *Planorbulinoides* sample taken from older queen conch San Salvador Island, Bahamas; (x 140).

Figure 2: Map of northern Sue Point which is a revised and extended version of a map taken from White, 1989. The profile H-H' is part of the newly maped section of the area.



The new data are tied to bench marks of mean sea level that are located on the dock in Cockburntown (White 1989). These data and field methods permitted the present results obtained from core samples to be judged against an accurate modern sea level.

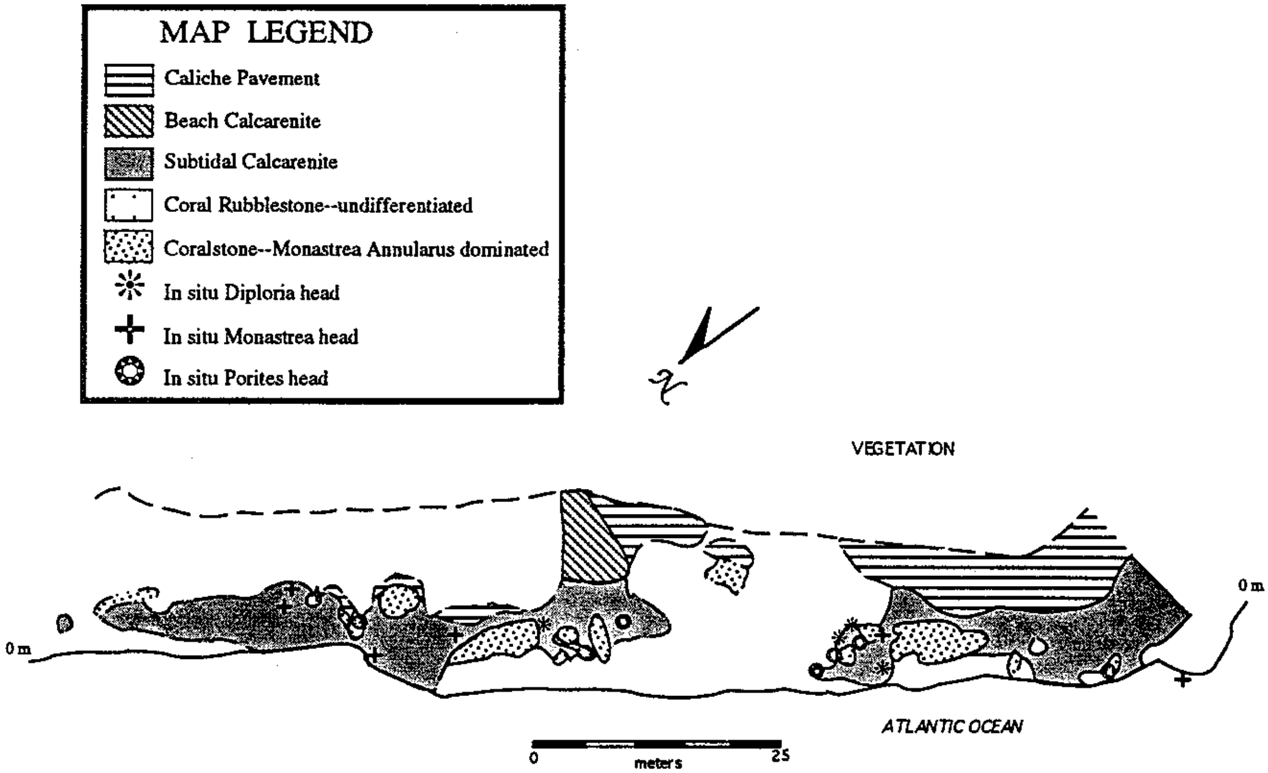


Figure 3: South Sue Point. The total vertical variation in this view is approximately 1.5 meters. The map is a revised and extended map from White, 1989.

Thin section analysis

Both marine and nonmarine features were noted in the petrologic study carried out on the rocks at northern Sue Point. Several diagnostic cements are commonly present in marine rocks which provide evidence of part of the depositonal fluid history that is directly related to sea level fluctuations. Other cements and diagenetic features are diagnostic of a non-marine environment. Some of the most diagnostic post-depositonal cements included, acicular aragonite, micritic calcite, and high or low magnesium calcite. Shape and sequence of cementation were additional diagnostic traits as well as the presence of dissolution.

Initially, marine limestones such as those at Sue Point are commonly cemented diagenetically by aragonite. The aragonite is acicular, a lath-like cement. It is the first cement to form from salt water solution. Aragonite bioclastic sediment and the diagenetic aragonite crystals are also the first to be effected by dissolution. The blue resin used in thin section preparation causes aragonite needles to appear as tiny light-blue radiating spikes under polarized light. Other forms of carbonate cement that are stable in salt water are micritic calcite and sparry calcite.

Micritic calcite is a very fine muddy cement. It is primarily composed of bioclastic aragonite, and at 1 to 5 microns is visible as a clayish layer or infilling. Sparry calcite is a very common coarsely crystalline cement that is translucent. It is precipitated from a supersaturated interstitial solution filling the pores of the rock. The texture of sparry calcite is predominately isopachous and fills earlier pore spaces between grains. Marine saturated sparry calcite is usually high in magnesium. However, sparry calcite can also fill interiors of grains and be a result of recrystallization of lime muds, calcite grains, or even previous cements. Laterally continuous bands of sparry cement, which are usually seen as approximately 2 millimeters in thickness are characteristic of an event called a still stand. Sea level commonly stays at a particular height for an extended time. This provides the opportunity for layers of sparry cement to be precipitated just below a stratigraphic level of super-saturation. Many of the still stands observed do not seem to be related to the original diagenesis of their host rocks facies.

The vadose zone is a region of periodic infiltration of fresh water percolating through rocks whose pore spaces are not fluid saturated. The zone has a different cementation chemistry than those supersaturated with salt water. A characteristic morphology of these crystals is a meniscus shape.

Meniscus shapes appear when the cement precipitates within the waters surrounding air bubbles trapped in the pore spaces. Pendant-shaped cement "dripping" off crystals can also often be observed. The cement collects between grains and forms hourglass-shaped pillars. The calcites of the fresh water environment are low magnesium calcite and, several staining techniques can help distinguish between high and low magnesium calcite.

Exposing the calcite grains of the saturated zone to fresh water and partial saturation may cause a dissolution of the grains as well as the cements. Dissolution is often seen in the thin sections as progressively destroying the intergranular cement as well as the original calcite grains and leaving behind a muddy micritic residue. Dissolution can be further intensified with the adjunct of micro-bacteria and plant root activities. Rhizomorphs were found in field evidence, and suggest that this form of dissolution seems likely.

Marine and non-marine cements can be seen to overlap one another within the thin-sections of thin-sections taken from northern Sue Point. In most cases, specific types of diagnostic features overlapped each other and were thus non sequential. However, the overlapping sequences of cementation were pervasive throughout the samples studied. Additional examination is in progress in an attempt to identify correlations of cementation history that may be held in common by sections which are parallel laterally in the rock outcrop.

Conclusions

The petrologic evidence supports the idea that the rocks at northern Sue Point have been effected by more than one fluctuation in sea level. Besides the obvious fact that the outcrop itself is made up of marine sediments which are now sitting above water, sequences of alternating marine to non marine cements are seen in thin-section analysis. Other post depositonal evidence, for example aragonite cementation on dissolution surfaces, also suggest alternating environments. This petrologic data complies with San Salvador field evidence that sea level has risen and fallen several times in the last hundred thousand years (see various articles in Mylroie, 1989). This conclusion is also concordant with worldwide data which validates several sea level fluctuations in the Quaternary. Research for further petrologic evidence is still in progress at this time.

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A TAPHONOMIC COMPARISON OF PLEISTOCENE AND MODERN CORALS, SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

The Cockburn Town Fossil Reef, located just northwest of the center of Cockburn Town, on San Salvador Island, displays a shallowing upward sequence reflecting a post-Sangamon lowering of sea level (White et al, 1984). The sequence includes a coral rubblestone, which is largely composed of *Acropora cervicornis* , and a coralstone facies, which is abundant in in situ *Acropora palmata*. These two facies were interpreted by White, et al. (1984) as back reef and reef tract facies respectively. Although the reef has been dated radiometrically to have flourished between 131-119 ky before present (Carew, 1983; Chen et al, 1990), data concerning the rate at which sea level fell has remained elusive.

The Cockburn Town reef provides an exceptional opportunity for a variety of comparative studies because of the exceptional preservation exhibited and its proximity to analogous modern depositional environments. For example, Telephone Pole Reef and Lindsey Reef, located in Fernandez Bay and Long Bay respectively (see Curran, this volume), are generally accepted as modern examples of the coral rubblestone and coralstone described by White et al (1984) from the fossil reef. The purpose of this study is to compare processes of preservation (taphonomy) currently affecting subfossil corals, collected from Telephone Pole Reef and Lindsey Reef, to that preserved in Pleistocene corals collected from the Cockburn Town reef. Parsons and Brett (1991) have pointed out that there is much anecdotal evidence that fossil assemblages are commonly better-preserved than would be predicted from examination of subfossil counterparts (p. 23). This is the first study to quantify this general observation. Moreover, the degree of degradation suffered by carbonate material as a result of biologic processes is related to the time spent in the taphonomically active zone (TAZ, Davies et al, 1989). This zone is roughly equivalent to the sea floor surface. Thus taphonomic comparisons may be used to assess the relative rapidity with which coral material was removed from exposure on the sediment surface by burial: for the Cockburn Town Reef this is related to the rate at which sea level fell during post-Sangamon time. Measurement of a variety of taphonomic attributes (e.g. borer and encruster activity) reveals significant differences in the amount of degradation suffered by modern and ancient material: the Pleistocene is better preserved than the Recent. This suggests that processes of deposition observable in the modern environments studied are not sufficient to explain the preservation in the Cockburn Town Fossil Reef. Associated field experiments have thus far remained inconclusive on determining an actual time between death and burial.

FIELD METHODS

Along the Cockburn Town Fossil Reef, ten *Acropora* samples were collected from within five 9 m^2 sites. A total of 50 specimens was gathered from the fossil reef, resulting in a 4:1 ratio of *Acropora cervicornis* to *Acropora palmata*.

In the modern environment, fifty specimens were obtained from various sites (defined by a 9 m^2 grid). Modern samples were collected in the following quantities: (a) at Telephone Pole Reef, ten pieces of *A. cervicornis* were gathered from four separate sites, totaling forty specimens; and (b) at Lindsey Reef, ten pieces of in situ *A. palmata* were broken off within one site. This ratio comes to that observed in the Cockburn Town reef collection.

Two cages containing pristine specimens of both species of coral were placed at Dump Reef in Graham's Harbor (see Curran, this volume) in January, 1992. They were retrieved and examined for development of potentially preservable encrustation and/or borer activity after intervals of six and twelve months.

LABORATORY METHODS

The 100 samples were categorized using a qualitative scale of abrasion (1=pristine with pristine corallites to 5= heavily abraded with no visible corallites). The amount and types of coverage by preservable encrusters on modern corals were recorded and compared to the degree and types of encrustation