PROGRESSION OF BIOEROSION AND ENCRUSTATION ON THE QUEEN CONCH SHELL (*STROMBUS GIGAS*) OF SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

Bioerosion is the process by which organisms directly excavate or penetrate hard substrates. Encrustation is the behavior by which organisms live on hard substrates. Encrusting and boring organisms represent a community that changes with the substrate that sustains them. In this study, the hard substrate is the shell of the queen conch, *Strombus gigas*. The purpose of this project is to determine the succession of bioerosion and encrustation on the queen conch shell as a function of the shells' age. As the conch ages, there are changes in the number and diversity of borings and encrusters on the conch shell.

LOCATION

Three collection sites were chosen from the coastal areas on San Salvador Island. At the first, Grahams Harbour, empty queen conch shells were found from along the beach shoreline. Both living queen conchs and empty shells were collected at the second location, Pigeon Creek. The Cockburn Town Fossil Coral Reef was the third collection site. Here Pleistocene conchs were taken from the loose rubble behind the main reef.

METHODS

Fifty empty *S. gigas* shells were collected from San Salvador Island, four-fifths from Grahams Harbour, and one-fifth from Pigeon Creek. The shells taken from Grahams Harbour were found scattered along the shoreline and the cliffbases. At Pigeon Creek the conchs were concentrated in a large pile located next to a fishing dock. All of the shells collected were found killed by the local fishermen. The fishermen take the conchs from their habitats, kill and remove the animals for food, and discard the shells into the disposal piles or along the beach. These shells never return to the ocean again, so it is presumed that the encrustering and boring of the shells occurred while the conch was alive. These borings and encrusters represent a living community on a living host.

A preliminary inspection of each conch shell was conducted on San Salvador Island. A worksheet was designed to aid in the description of the shells. This worksheet provided the initial information, height, width, condition of the periostracum, and shell thickness for each shell. Next, each shell was divided into a series of regions: the dorsal, ventral, left, and right portions of the spire, body whorl, and apertural edge, so that the descriptions of the encrusters and borings would not be duplicated. The identity and size of the borings and encrusters were recorded for each of the shells.

Because of the weight and bulk of the fifty *S. gigas* shells, only a portion of each shell could be transported to The College of Wooster. The spire and the spine most prominent on the dorsal body whorl were selected because of the relative ease in obtaining them and their representation of the encrustation and bioerosion of the rest of the shell.

In order to plot the succession of bioerosion and encrustation, the shells were arranged according to their relative ages. Because the actual ages of the conch shells are unknown, the shells were ordered by their shell thicknesses, which is the key in determining the relative ages of adult queen conchs. The conchs were then separated into groups in increments of 5mm shell thicknesses, producing eight groups total.

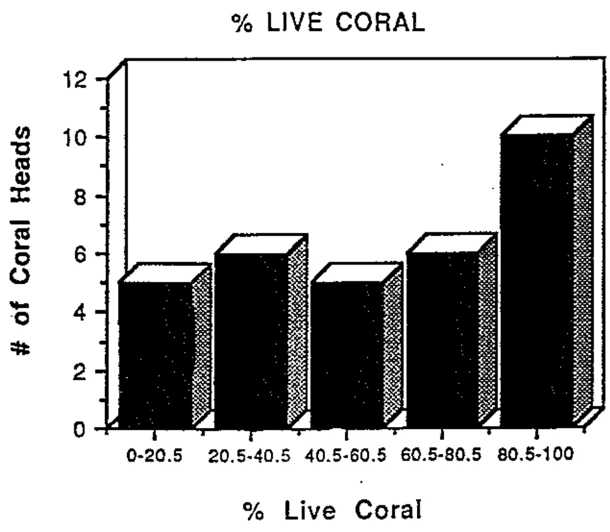

Figure 2
Distribution of percentage of
Live Coral Found on Each
M. annularis Coral Head

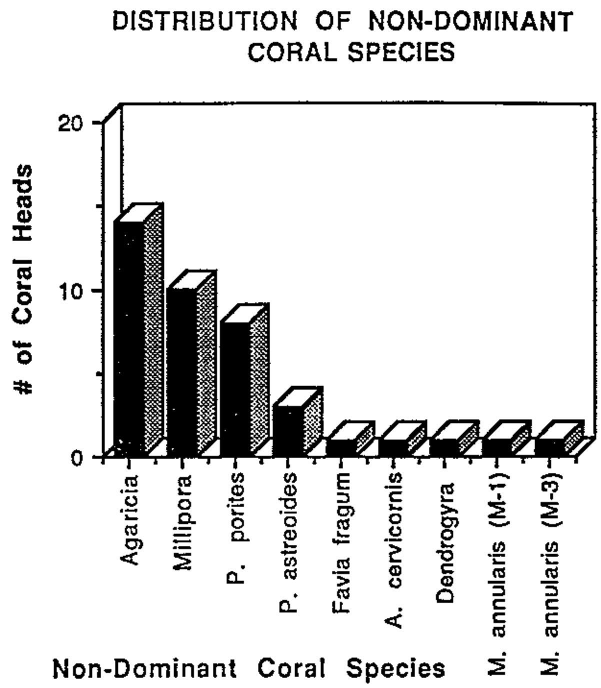

Figure 3
Distribution of All
Non-Dominant Coral Species
Present on Montastrea annularis
Coral Heads

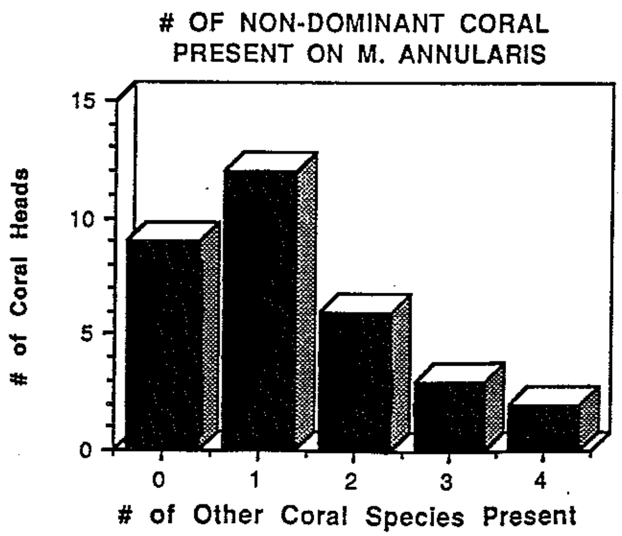

Figure 4
Relationship Between Number of
Coral Species Present, and
Number Of Montastrea annularis Coral
Heads Surveyed

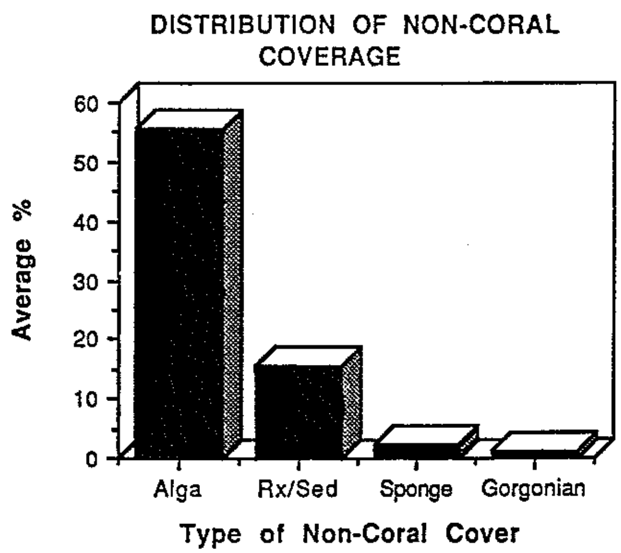

Figure 5
Distribution of Non-Coral Cover
on Montastrea annularis Coral Heads

These groups were used to compare and contrast the encrusters and borings on the shells as a function of the ages of the queen conchs.

The living queen conchs were found while snorkling in the grassbeds at Pigeon Creek. Because there was no need to kill the organisms in order to examine their shells, they were taken ashore, photographed, measured, sampled, and then returned to the grassbeds.

Pleistocene *Strombus gigas* shells were collected at the Cockburn Town Fossil Reef. Although several shells were found in the loose rubble behind the main reef, a few were semi-buried in the coralstone of the reef but were too fragile and eroded to excavate or study.

THE QUEEN CONCH

Strombus gigas is a mesogastropod characterized by a thick, flaring lip, bright pink interior, and thick, horny periostracum (Randall, 1986). Charles D'Asaro (1965) observed the development of the juvenile queen conch in the Bahamas. Within fifteen hours of the spawning of the eggs, the young conchs develop their first shells, the protoconchs. Four days after hatching, the first whorl of the shell is complete. Five days later the second whorl is formed, and so forth. After 46 days, the queen conch already has a heavy accumulation of microorganisms, such as diatoms and bacteria, growing on the shell (D'Asaro, 1965). Shortly afterward, the juvenile conchs bury themselves into the loose sediments of the ocean floor in order to escape predation and perhaps to rid themselves of their encrusting growth. They grow rapidly in substrate and resurface at the age of 1 to 1.5 years or a length of approximately 5cm (Iverson, Jory, and Bannerot, 1986). Queen conchs reach their sexual maturity at the age of 2.5 to 3 years at which point they stop adding whorls to their shells and start flaring their outer lip and adding new layers to their shells. If the conchs are allowed to die naturally, they will live only about 6 years (Davis, Mitchell, and Brown, 1984).

RESULTS AND DISCUSSION

There are differences between the collections found at the two location sites. The Pigeon Creek samples were found in a single disposal pile beside the dock where the local fishermen husk their harvests. Because of the over-harvesting of the area, younger and smaller conchs are now collected and the shells of these individuals are found at the top of the disposal pile. The shells taken from Grahams Harbour, however, are older than the ones from Pigeon Creek. These conch shells were not found in a single pile but along the shoreline. They appeared to have been in this location for a longer period of time than those at Pigeon Creek as indicated by the deterioration of the periostracum. These conchs were probably discarded earlier than those at Pigeon Creek at a time when the queen conch harvests were more abundant and profitable, causing the ages of the collected conchs to be older.

The preservation of the periostracum decreases with the age of the conch. That is, the frequency of shells with the periostracum still intact decreases with the age of the conch shell. The majority of the younger specimens had a complete or deteriorating periostracum while the older conch shells had little or no periostracum remaining.

Many different encrusters and borers live on the queen conch shell during the life of the conch (Table 1). There seems to be a pattern in the types of organisms encrusting on the different aged conchs. The younger conchs have the foraminiferan *Planorbulinoides* as the dominant encruster, with only small percentages of small serpulid polychaete worm tubes, *Homotrema*, and *Montastrea annularis*. As the queen conchs age, the amount of *Planorbulinoides* decreases and the amount of coralline algae increases. Also, the amount and size of the serpulid worm tubes, *Homotrema*, and *Montastrea annularis* increased as well. *Echinochama areinella* also begins to appear on the older conch shells and becomes more frequent in the oldest conchs.

The diversity of encrusters seems to increase through the lifetime of a queen conch. While the youngest specimens appear to have primarily foraminiferans, a few worm tubes, and coral underneath a fair amount of fleshy algae, the older conchs have the same foraminifera and coral as the younger shells as well as bivalves, coralline algae, and a greater variety of worm tubes. The sizes, shapes, colors, and amounts of encrustation increase in proportion to the conchs' ages.

Most of the encrusting activity is found on the ventral surface of the shell, specifically at the junction of the flare and the spire. This area is probably the most protected region on the entire shell because the conch moves in the opposite direction and the water currents are not as strong. Also, as the ventral body whorl scrapes across the ocean floor, it would have little or no encrusting growth in this area. However, by the shape and symmetry of the shell, the spire is raised above the ocean floor and more growth can occur.

Cliona sponge borings are the most dominant borings on all of the shells. In the youngest queen conchs, *Cliona* is the only borer of the shells. The intermediate aged conch shells begin to show small circular and tubular worm and bivalve borings. These circular and tubular borings tend to increase in size, abundance, and frequency as the conchs grow older.

The location and distribution of the borings is the only other pattern associated with the bioerosion of the conch shell. While the circular and tubular borings seem to have no particular region of dominance, *Cliona* borings seem to be concentrated at the spines of both the body whorl and spire as well as the apex of the shell. Also, there are more *Cliona* borings on the spire than on the body whorl of the shell. The spire is the oldest section of the shell and thus allows for more boring activity. The body whorl and apertural edge of the shell are younger with respect to the spire and covered with the thick periostracum in life. *Cliona* boring could not penetrate this periostracum, but as the spire has none, *Cliona* has a better chance of boring if it can get past the heavy layers of fleshy algae.

Several Scanning Electron Microscopic (SEM) photographs were taken of the foraminiferan *Planorbulinoides*. The specimens were chosen from different aged conchs and show the foraminiferan in various stages of coloration and deterioration. The fresh specimen was taken from one of the youngest queen conchs (Figure 1). *Planorbulinoides* consists of calcareous chambers or bulbs which are coarsely perforate. The darker chambers have numerous apertures at the ends of short necks extending from the main chambers. Here, the chambers and necked apertures are complete and unbored. In Figure 2, the chambers and necked apertures are both broken and bored, possibly by a boring algae. This sample and others similar to it were taken from the older conchs. As the abundance of *Planorbulinoides* decreases as the conchs grow older, a coralline algae replaces the foraminiferan as the dominant encruster in the older conchs.

CONCLUSIONS

There is a succession of bioerosion and encrustation as a function of the age of the queen conch. As the queen conch ages, the number and diversity of encrusters and borers on the shell increases.

Although *Planorbulinoides* is the dominant encruster on the younger queen conchs, its abundance and frequency decreases as the coralline algae increase until coralline algae is the primary encruster on the oldest conch shells.

There are other factors, such as the collecting location and the condition of the periostracum, attributing to the differences between bioerosion and encrustation on the conch shells.

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ENCRUSTERS ON LIVING *S. gigas*	ENCRUSTERS ON DEAD *S. gigas*
CHLOROPHYTA (green algae)	FORAMINIFERA
Dasycladus vermicularus	*Planorbulinoides*
Batophora oerstedii	*Homotrema*
Acetabularia calyculus	CNIDARIA (corals)
PHAEOPHYTA (brown algae)	*Montastrea annumlaris*
Dictyota cervicornis	MOLLUSCA (clams, snails)
Lobophora	*Echinochama areinella*
RHODOPHYTA (red algae)	*Spiroglyphus*
Champia purvula	OTHERS
OTHERS	coralline algae
various low growing brown or green algae	various polychaete worm tubes
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	

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.

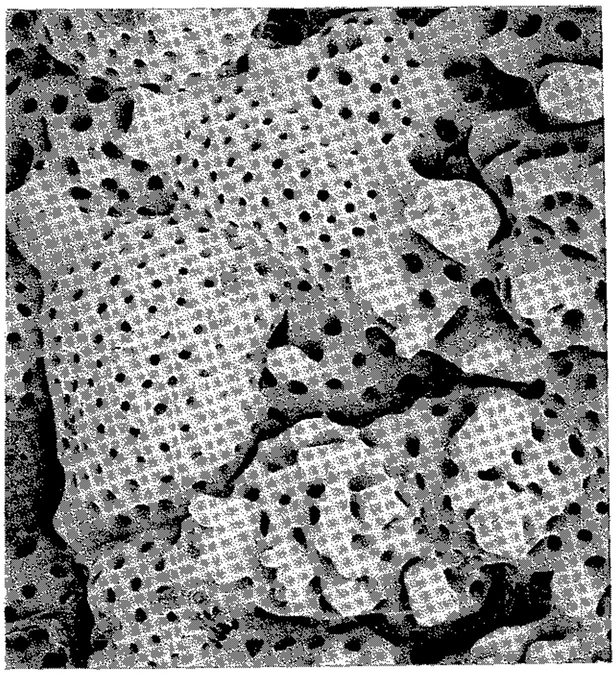

Figure 1. Fresh *Planorbulinoides* sample taken from young queen conch shell San Salvador Island, Bahamas; (x 140).

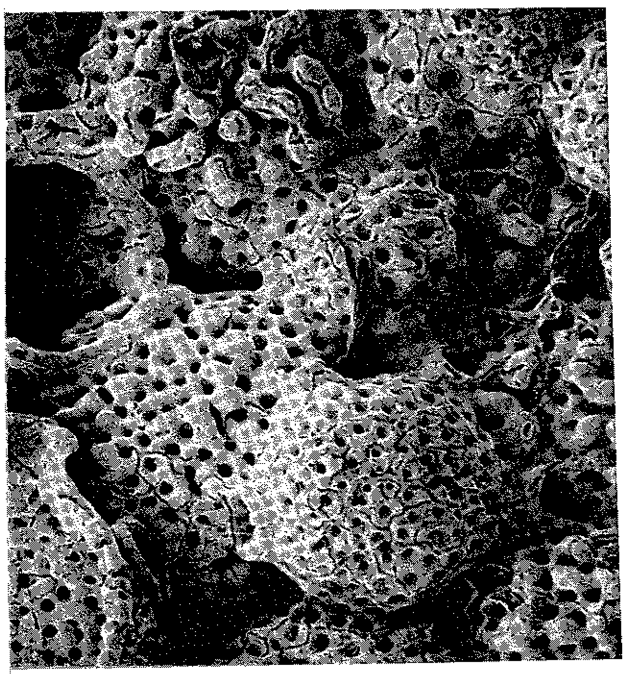

Figure 2. Bored *Planorbulinoides* sample taken from older queen conch San Salvador Island, Bahamas; (x 140).

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.

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.

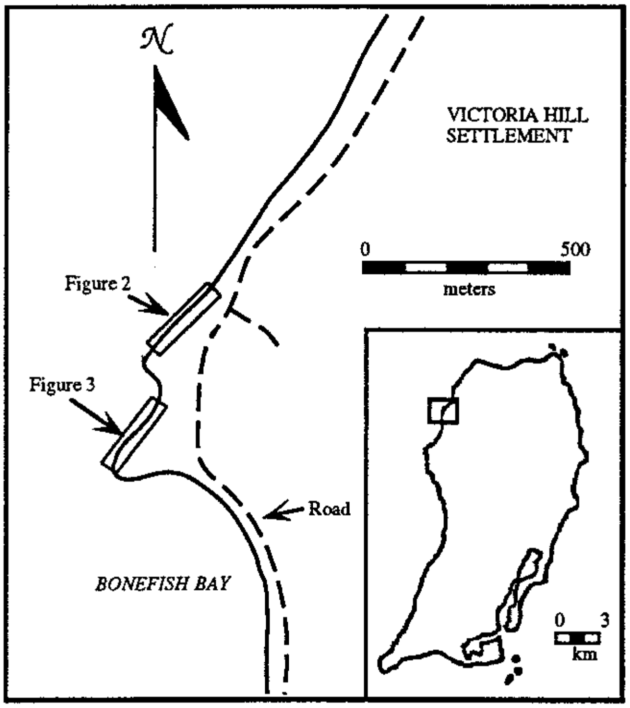

Figure 1: Location of Sue Point, San Salvador Island. Taken from White, 1989.