The Biological and Geological Zonation of Seaview Reef, Grand Cayman, British West Indies

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Abstract

The coral reefs of the Caribbean island of Grand Cayman, British West Indies, are natural habitats to a variety of marine organisms, both invertebrate and vertebrate. Qualitative studies as well as measurements were made on one particular tropical reef in this region in an effort to create describe? a zonation of the reef by marine life and underlying sediment. Personal observation and literature research have determined the existence of five distinct zones. This consists of an inshore zone, a reef flat, a shallow terrace reef, a deep terrace reef, and a deep fore reef. The marine life forms characteristic to each zone as well as general interpretations of the geology of the region and sedimentary patterns on the reef are discussed.

Introduction

Coral reefs have only recently gained recognition for their beauty, in step with the development of the Self-Contained Underwater Breathing Apparatus (SCUBA) and extensive progress in the field of marine science. The underwater civilizations ? of reefs around the world are now acclaimed as valuable ecosystems, supporting the most fragile and remarkable organisms within their sheltered marine environments. The Cayman Islands, nestled in the Caribbean Sea between Cuba and the Central American mainland (See Figure # 1), are surrounded by these complex communities. Here, as in other coral reefs around the world, a systematic growth has occurred, based on the area's sediment, wave action, exposure to sunlight, depth, geological history, and stress imposed by increased tourism, SCUBA diving as sport, and beach

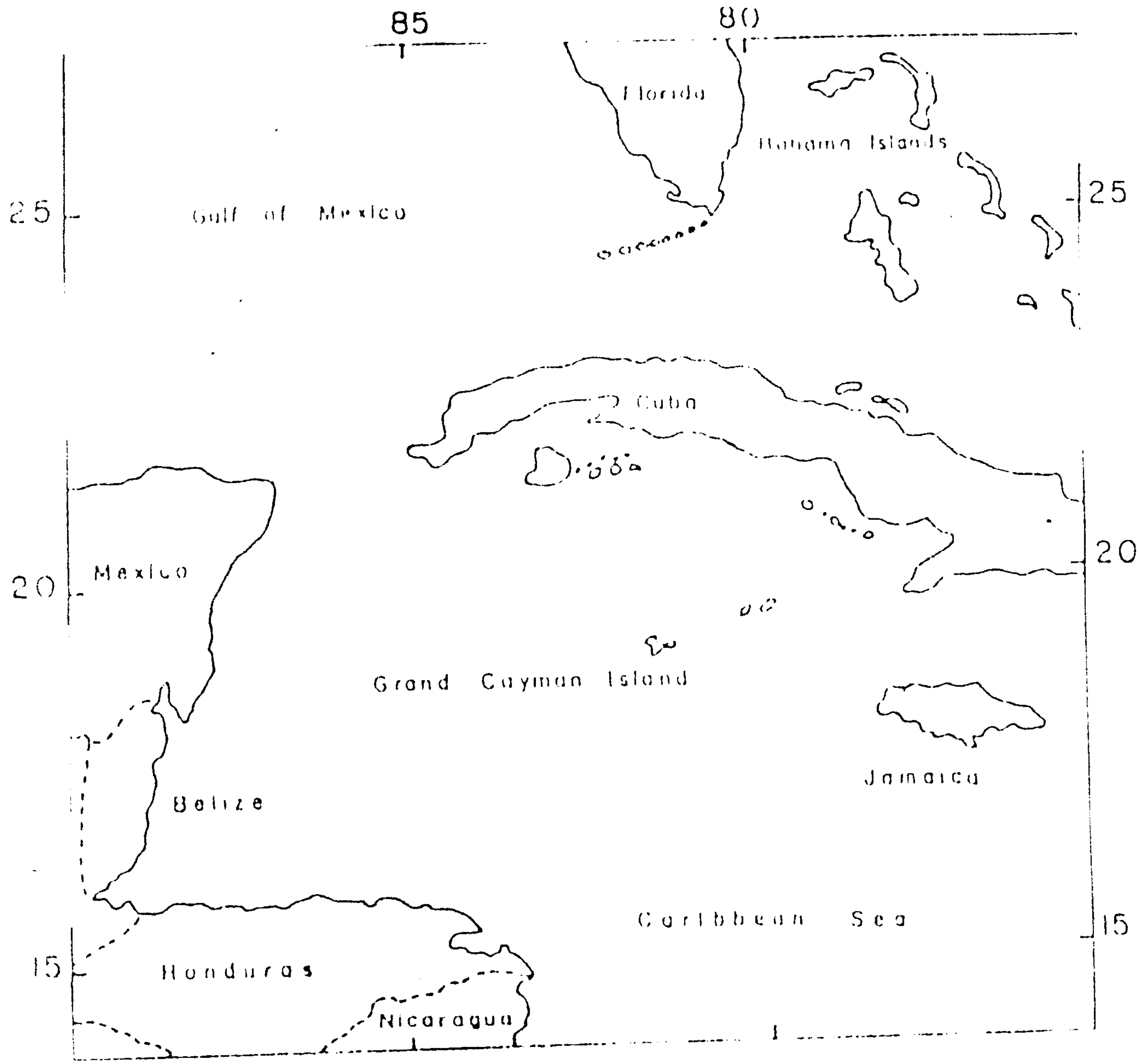


Figure #1. The Location of Grand Caymen Island going. This paper, in light of this, will discuss the zonation and species composition of a small fringing reef off the Grand Cayman shoreline.

The Cayman Islands consist of three islands: Grand Cayman, Cayman Brac, and Little Cayman. Grand Cayman, the largest of the three, has a population of approximately 19,000 and a total area of 27 square miles. It is located in the northwest Caribbean between 19º16' and 19º24' N latitude and 81º05' and 81º25' W longitude. This tropical location is most important to the strong development of the coral reefs.

On the days of 23, 25, and 27 March, 1989, the author had the opportunity to make six SCUBA dives on Seaview reef, the intended area of study (See Figure #2). Seaview reef itself is a well-formed and popular SCUBA diving site, roughly 1.5 km (.93 miles) south of Georgetown, the island's main town and port. Data and site observations were taken on all three days. Subsequent analysis and research occurred in order to verify the existence or lack of any type of reef zonation.

Methods

On each of the three days mentioned above, two dives were made. During the first dive, quantitative information was collected from the shore to a maximum depth of 36.6 m (120 feet). Roughly thirty minutes was spent on this dive. The second dive consisted mainly of descriptive observation and field sketching. An average depth of 18.3 m (60 feet) for approximately one hour provided a panoramic vantage point, from which almost the entire reef could be seen. In this particular manner, distinct zonations were

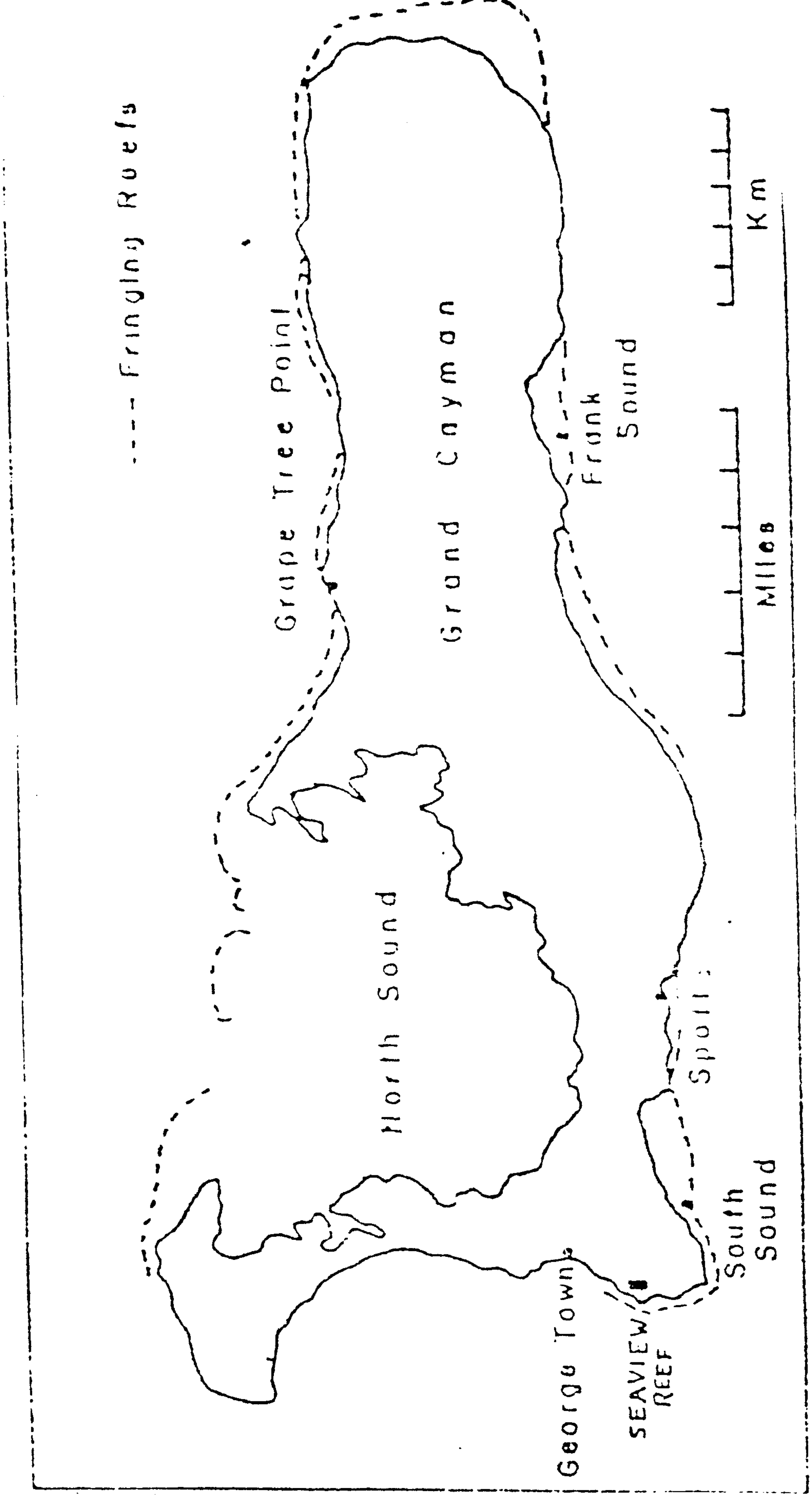


Figure #2 The Study Site and Fringing Reef Formation determined visually. Both quantitative and qualitative observations will be presented and interpreted in this study.

Quantitative measurements of the reef were made with a simple tape measure. Difficulties in measuring underwater (currents, uneven terrain), however, made it necessary to only approximate total length and width of the reef, using the tape measure as a guide. Temperature was read with a submersible dive thermometer made by Scubapro[tm]. Temperature readings were taken to a depth of 36.6 m (120 feet). Nautical bearings and underwater navigation were performed using a Dacor[tm] dive compass. Overall, any type of measurement, observation, or sketch was recorded on an underwater slate and later transposed into a field notebook.

The majority of the measurements, nonetheless, were made along the reef in order to assess the distribution of invertebrate species which would indicate distinct regional zonation. This information was gathered with the use of a modification on the "line intercept" method, which is intended to measure the percent of ground covered by species. The starting point of a transect was established at the beginning of the shallow terrace reef. Due to this primary reef's distance from shore, however, the inshore zone and reef flat zone could not be surveyed. From the beginning of the shallow terrace reef, the tape measure was extended horizontally along the reef at a bearing of 265^{o}, perpendicular to the shore, and parallel with the extension of the reef. The transect continued along the deep terrace reef and the deep fore reef toward the near vertical drop of the seawall. At a depth of 36.6 m (120 feet), the transect end was anchored. Then, from the starting point of each visible zonation, every foot of transect line was examined for a dominant species. Observed species were identified, both underwater and back on land, and the number of sightings within a zone was divided by the zone's

Technique is ok but how do you distinguish between different sized individuals total length. For simplification, species were grouped by family and general characteristics. The percentage cover of each group, then, was calculated within each respective zone. This type of analysis was performed twice, with two parallel transects being laid on the same reef approximately 50 m (152 ft) apart. **Note**: Seaview reef is, in fact, only one reef in a series of fringing reefs off Grand Cayman Island. Please refer to Figure #2. It was difficult, therefore to determine the width of the reef itself, as it was bordered on both sides by similar reefs. For ease of measurements, the area observed was a 75 m (230 feet) wide zone along the coast, stretching 732 m (2400 feet) seaward in length.

Observations

Conditions on Grand Cayman on the 23rd, 25th, and 27th of March were typical of tropical environments in the late winter and early spring. The first of the tree days, Thursday, was clear and sunny with a slight offshore breeze from the northeast. Air temperature, then, was 85.4 ^{o}Farenheit (29.7 ^{o}Celcius), slightly warmer than the other two days. Saturday and Monday, with temperatures of 82.9 ^{o}F (28.3 ^{o}C) and 83.1 ^{o}F (28.4 ^{o}C) respectively, were overcast with a chance of rain. Nevertheless, the sun appeared frequently to improve underwater visibility.

In the water, temperatures remained around 80 ^{o}F, a climate necessary for the strong development of coral reef ecosystems (See Table #1). A slight thermocline of -1.4 ^{o}F did occur at the depth of 95 feet (A thermocline is a layer in a thermally stratified body of water that separates an upper, warmer, lighter oxygen-rich zone from a lower, colder, heavier

not much of one at that — Where is bottom of Euphotic zone?

Temperature Readings
Off Seaview Reef

Depth	3/23/89	3/25/89	3/27/89
Air	85.4 °F	82.9 °F	83.1 °F
Surface	83.5	83.4	83.5
10 Ft.	80.0	80.0	80.0
20 Ft.	80.0	80.0	80.0
30 Ft.	80.0	80.0	80.0
40 Ft.	80.0	80.0	80.0
50 Ft.	80.0	80.0	80.0
60 Ft.	80.0	80.0	80.0
70 Ft.	80.0	80.0	80.0
80 Ft.	80.0	80.0	80.0
90 Ft.	80.0	80.0	80.0
100 Ft.	78.6	78.7	78.6
110 Ft.	78.6	78.7	78.6
120 Ft.	78.6	78.7	78.6

Table #1. Water Temperatures on Seaview Reef oxygen-poor zone). Underwater visibility exceeded 100 feet, making it easy to view the entire reef. Water currents were not encountered. Near the shore, however, slight seaward tows existed due to the surge and wave action at shallow depths.

Initial observations surveyed the reef area as a whole. The shoreline region in front of Seaview reef is mainly "iron shore". This term refers to the characteristics of the rugged, rocky limestone coast which has a relatively low projection. Underwater limestone formations continue down the slope, with periodic sandy and silty areas. Major sediment in the area includes exposed rock and coarse beach talus. The bottom is mostly sand and silt, for approximately 363 m (1290 feet). Due to the lack of coral development, the general sedimentary makeup, and in keeping with established reef zonation (Goreau (1973), Sefton and Webster (1986), Zeiller (1974)), this zone was termed the "inshore" zone. Moving further from the shore, algal flats, small coral beds, and grass beds are found scattered in the region. Sands, silts, and muds make up the bottom, along with any rubble that may have been transported from the reef crests. This second visible division was characterized as the "reef flat". Proceeding to a depth of approximately 9.15 m (30 feet), coral heads and spurs begin to develop more significantly on the flat, often rising within ten feet of the surface. This zone covers approximately 177 m (580 feet). Sandy plains with some coral developments extend to the major reef formations, beginning with a "shallow terrace reef" at approximately 13.7 m (45 feet). At this point, divisions become much smaller, as the shallow terrace reef extends for only 49 m (160 feet). The flats continue to the "deep terrace reefs" and "deep fore reefs" at approximately 36.6 m (120 feet). The deeper terrace reefs found in this region are about 79 m (260 feet) in length and are characterized by a

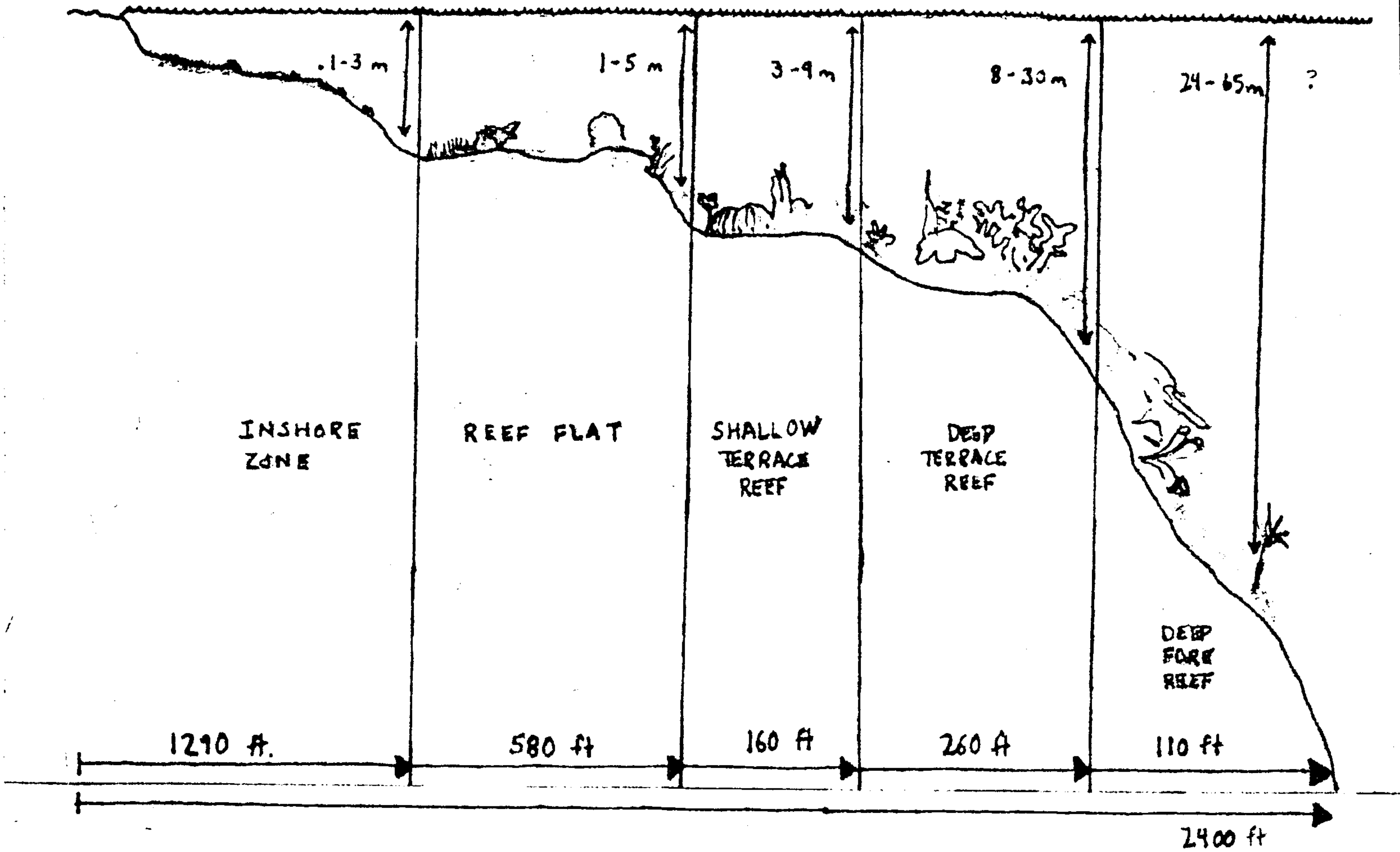


Figure #3. Observed Reef Zonations on Seaviw Reef

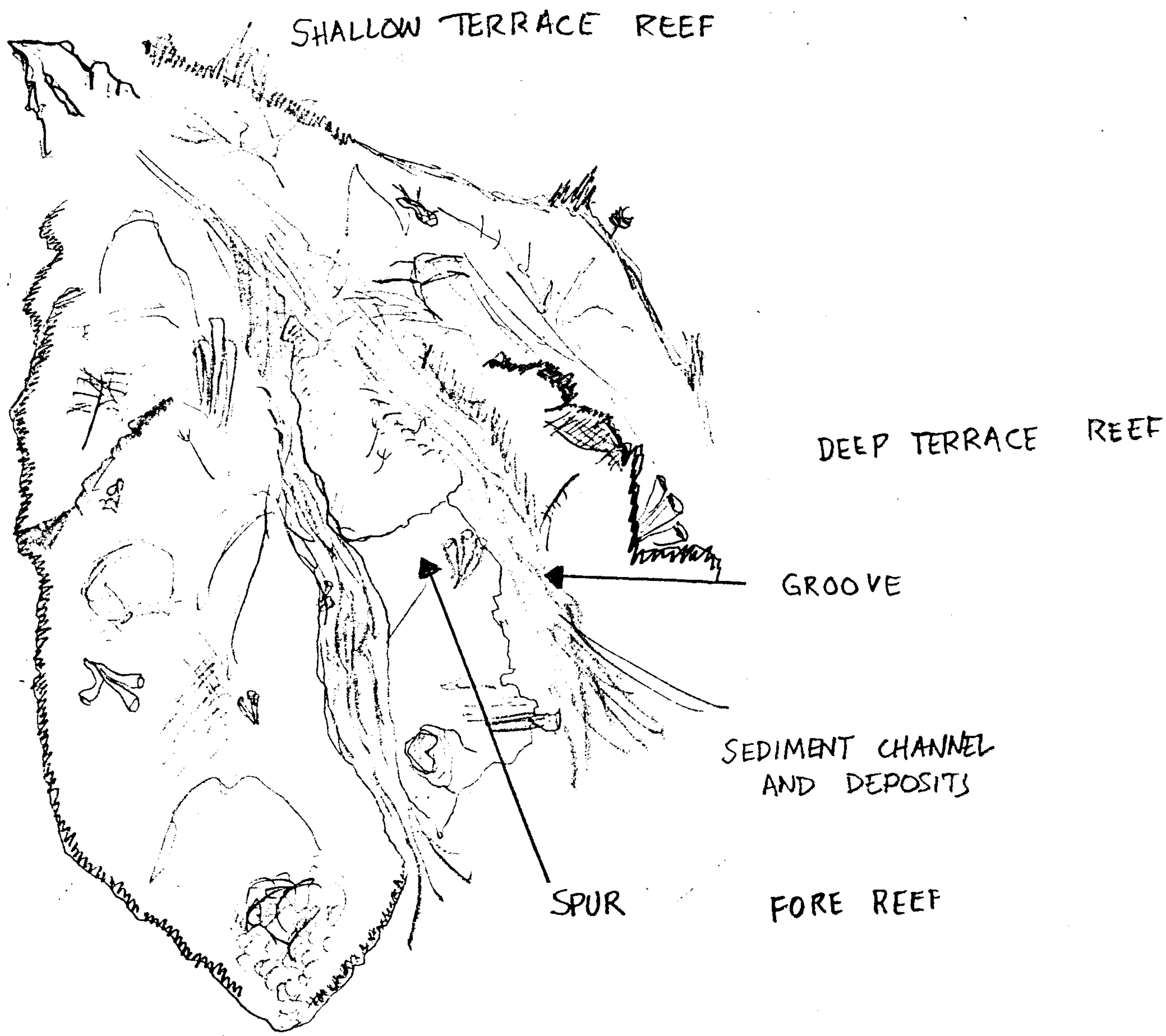


Figure #3A. A Spur and Groove Formation in the Deep Terrace Zone typical spur and groove environment. Judging from the amount of trapped sediment, it seems that these grooves, nearly 1 to 2 m wide (3.05 to 6.10 ft), channel reef rubble and debris down the reef slope toward the wall. The length of fore reef which was measured was only 34 m (110 feet) due to depth restrictions. Nevertheless, reef development continues downward eventually reaching the dropoff, with slopes varying from 45º to 90º. A sectional sketch of the visible reef zonation, as seen at Seaview is shown in Figure #3. A scenic sketch of the spur and groove formations on the deep terrace reef is shown in Figure #3A.

Lists of all marine life sighted on and around Seaview reef appear in Table #2. The distribution groupings within the reefs and their constituents are also defined in Table #3.

The line intercept method was utilized in three particular areas, each corresponding with a visibly distinct reef division. The flats and more shallow terrace reefs (see Figure #4,5 and Table #4,5) are predominantly algae, as the data reveals, [non-calcareous, (1) 34.6% (2) 37.0%; calcareous, (1) 8.85% (2) 8.17%], and sand and sediment [(1) 11.9%; (2) 12.53%]. Corals which have developed in the region cover less than 50% of the region. The stony corals, referring to the main reef builders and cementers, collectively represent 31.6% of the reef area on transect #1 and 27.5% on transect #2. Included in this group are brain corals, staghorn corals, elkhorn corals, star corals, and finger corals. Gorgonians, softer corals without a rigid calcified structure, cover another 13.05% of the area along transect #1, and 14.90% of that along transect #2. Other notable marine life at these shallow depths include a number of parrotfish, grunts, sergeant majors, damselfish, and chromis. These seem to be the smaller of the reef fishes which feed on organisms and the large algae populations in the area.

Marine Life Observed

Off Seaview Reef

Sources for Identification: Sefton and Webster, Greenberg, Romashko

Common Name	Scientific Name
Green moray	*Gymnothorax funebris*
Spotted moray	*G. morigna*
Tarpon	*Megalops atlantica*
Barracuda	*Sphyraena barracuda*
Sand Diver	*Synodus intermedius*
Trumpetfish	*Aulostomus maculatus*
Squirrelfish	*Holocentros ascensionis*
Reef squirrelfish	*H. coruscus*
Jewfish	*Epinephelus Itajara*
Nassau grouper	*Ep. striatus*
Red grouper	*Ep. morio*
Rock Hind	*Ep. adscensionis*
Red Hind	*Ep. guttatus*
Yellowtail snapper	*Ocyurus chrysurus*
White grunt	*Haemulon plumieri*
Blue striped grunt	*H. sciurus*
Black grunt	*H. bonariense*
Yellow goatfish	*Multidichthys martinicus*
Jackknife fish	*Equetus lanceolatus*
Spotted Drum	*Eq. punctatus*
Bermuda Chub	*Kyphosus sectarix*
Reef Butterfly fish	*Chaetodon sedentarius*

Table #2. Marine Life Observed on Seaview Reef

Four-eye Butterfly fish	*C. capistratus*
Banded Butterfly fish	*C. striatus*
French Angelfish	*Pomacanthus paru*
Queen Angelfish	*Holacanthus ciliaris*
Rock Beauty	*H. Tricolor*
Sargeant Major	*Abudefduf saxatilis*
Yellowtail damselfish	*Microspathodon Chrysurus*
Blue chromis	*Chromus cyaneus*
Honey damselfish	*Pomacentrius mellis*
Neon goby	*Gobiosoma oceanops*
Bridled goby	*Coryphopterus glaucofraenum*
Yellow wrasse	*Halichoeres garnoti*
Hogfish	*Lachnolaimus maximus*
Spanish Hogfish	*Bodianus rufus*
Stoplight parrotfish	*Sparisoma viride*
Rainbow parrotfish	*Scarus guacamaia*
Blue parrotfish	*S. coeruleus*
Black durgeon	*Melichthys niger*
Gray triggerfish	*Balistes capriscus*
Blue tang	*Acanthurus coeruleus*
Doctorfish	*A. chirurgus*
Ocean surgeon	*A. batiianus*
Whitespotted filefish	*Cantherhines macrocerus*
Scrawled filefish	*Aluterus scriptus*
Scrawled cowfish	*Lactophrys quadricornis*
Spotted trunkfish	*L. bicaudalis*
Porcupinefish	*Diodon hystrix*

Table #2. Marine Life Observed on Seaview Reef

Saucereye porgy	*Calamus calamus*
Indigo hamlet	*Hypoplectrus indigo*
Barjack	*Caranx ruber*
Serpulid Worm	*Filograna implexa*
Arrow Crab	*Stenorhynchus seticornis*
Crinoids	*Nemaster*
Brittle Starfish	unidentified
Banded Coral Shrimp	*Stenopus hispidia*
Sabellid Worm	unidentified
Giant Feather Duster	*Sabellastarte magnifica*
Spotted Feather Duster	*Branchioma nigramaculata*
Bryzoan	unidentified
Christmas Tree Worm	*Spirobranchus grandis*
Yellow Tube Sponge	*Alpysina fistularis*
Black Ball Sponge	*Ircinia strobilina*
Pink Vase Sponge	*Dasychalina cyanthina*
Lavender Finger Sponge	*Haliclona hogarthi*
Red Finger Sponge	*H. rubens*
Bowl Sponge	*Cribrochalina vasculum*
Branching Vase Sponge	*Callyspongia vaginalis*
Brown Tube Sponge	*Agelas*

Table #2. Marine Life Observed on Seaview Reef

Corals and Algae Observed

Off Seaview Reef

Sources for Identification: Sefton and Webster, Greenberg, Romashko

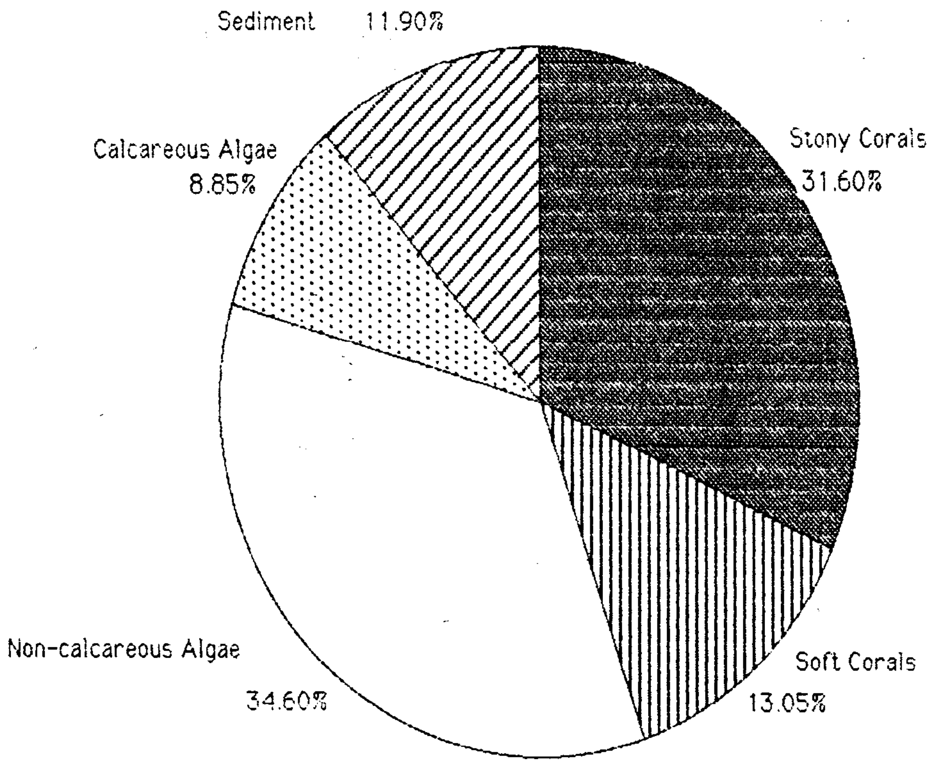
Grouping	Common Name	Scientific Name
Stony Corals	Elkhorn Coral	*Acropora palmata*
	Staghorn Coral	*A. cervicornis*
	Large Star Coral	*Montastrea annularis*
	Small Star Coral	*M. cavernosa*
	Starlet Coral	*Siderastrea*
	Lettuce Coral	*Agaricia agaricites*
	Finger Coral	*Porites porites*
	Giant Brain Coral	*Diploria labyrinthiformis*
	Smooth Brain Coral	*D. strigosa*
Soft Corals	Venus sea fan	*Gorgonia flabellum*
	Common sea fan	*G. ventalina*
	Deepwater gorgonian	*Iciligorgia schrammi*
	Sea Whip	*Muricea muricata*
	Bushy Sea Whip	*Plexaurella*
	Sea Plume	*Pseudopterogorgia*
Fire Corals	Encrusting Fire Coral	*Millepora alcicornis*
	Leafy Stinging Coral	*M. complanta*
Non-calc Algae	Brown Algae	*Lobophora variegata*

Table #3. Coral Populations and Other Reef Organisms on Seaview Reef

Calcar. Algae	Green Algae	*Avrainvilla*
	Atriculated Algae	*Halimedia copiosa*
	Cactus Algae	*H. copuntia*
	Silver Ball Algae	*Valonia ventricosa*

Table #3. Coral Populations and Other Reef Organisms on Seaview Reef

Shallow Terrace Reef Distribution #1



Transect Data

Shallow Terrace Reef Transect# 1

Group	Percentage of Total Area
Stony Corals	31.6%
Soft Corals	13.05
Fire Corals	0
Sponges	0
Non-calc. Algae	34.60
Calcareous Algae	8.85
Sand and Sediment	11.9

Figure #4 and Table #4. Seaview Reef Zonation Breakdown

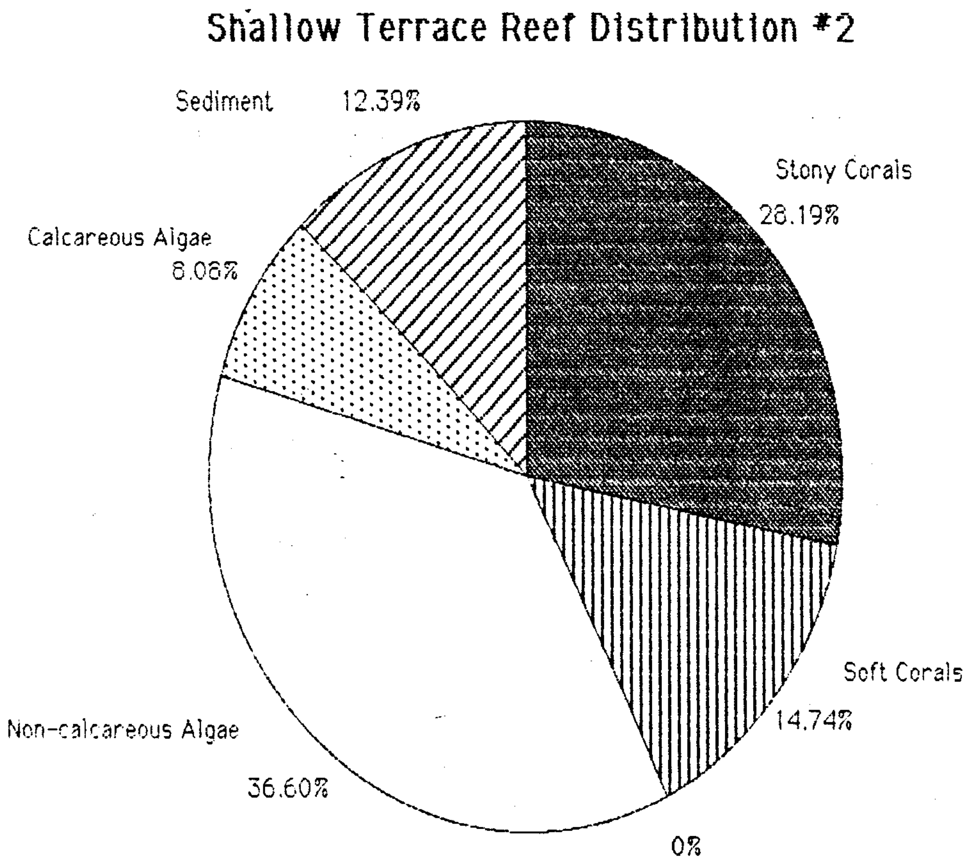


Figure #5 and Table #5. Seaview Reef Zonation Breakdown

Transect Data

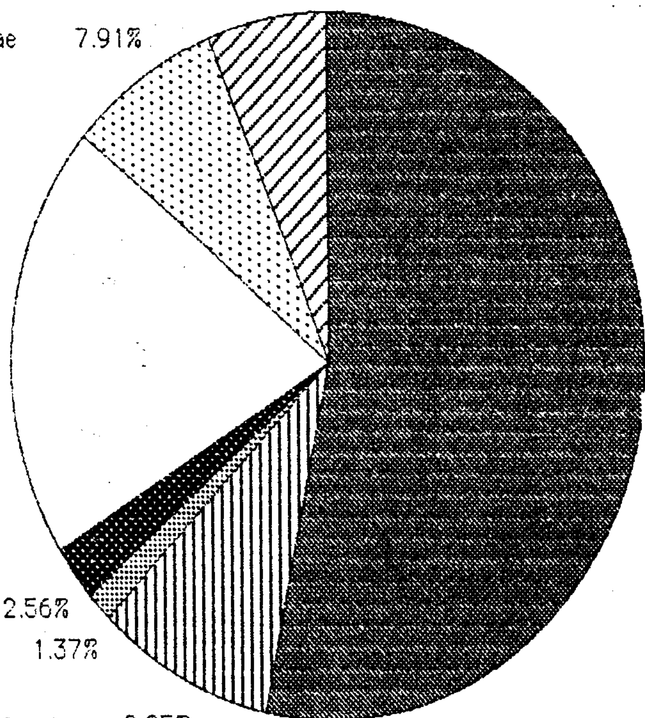
Shallow Terrace Reef Transect#2

Group	Percentage of Total Area
Stony Corals	27.5%
Soft Corals	14.9
Fire Corals	0
Sponges	0
Non-calc. Algae	37.0
Calcareous Algae	8.17
Sand and Sediment	12.53

Stony reef building corals, however, dominate the deeper reef terrace, covering 53.5%/54.9% of the reef (See Figures #6/7 and Tables #6/7). The overall number of soft corals, compared to the more shallow reef, is slightly smaller, amounting to 8.95%/12.7% of the reef's area. At this point, a variety of sponges [(1) 2.56% (2) 5.14%] as well as encrusting fire corals [(1) 1.37% (2) 0.82%] appear. Algae, although present, covers only half of the area which it does in the more shallow reef zone [NC (1) 19.97% (2) 16.93%; C (1) 7.91% (2) 8.0%]. A small percentage of sand and sediment, in the groove formations, can be seen as well. The larger corals in general are interlocked and cemented within the reef, offering few places for sediment accumulation. In terms of general marine life, it appears that at this location, the reef is most active. Larger predators, such as barracudas and morays, appear on occasion. Average-sized reef fish, including parrotfish, snappers, porgies, and squirrelfish, circle the reef in schools. Even spectacular smaller fish, such as blue chromis, butterfly fish, trumpetfish, and damselfish, are noticed, taking shelter in the massive coral and sponge formations.

Moving on to the deep fore reef and wall, the depth plunges sharply from 30 m (98.4 feet) to a seemingly infinite depth. While fewer stony corals appear here, now representing 42.25% and 35.40% of the area, the distribution of soft corals virtually doubles, accounting for 17.86% and 12.65% of the reef surface along the two transects (See Figures #8/9 and Tables #8/9). Sponges (1.58%/5.10%) and fire corals (2.67%/1.20%) appear with the same frequency as before. It is also noticed that sediments that are directed through the grooves eventually find their way to this part of the reef. Sand, silt, and mud deposits make up 1.74% and 2.14% of the deep fore reef zone. It is at this point on the reef that the larger of the reef fish,

Deep Terrace Reef Distribution #1

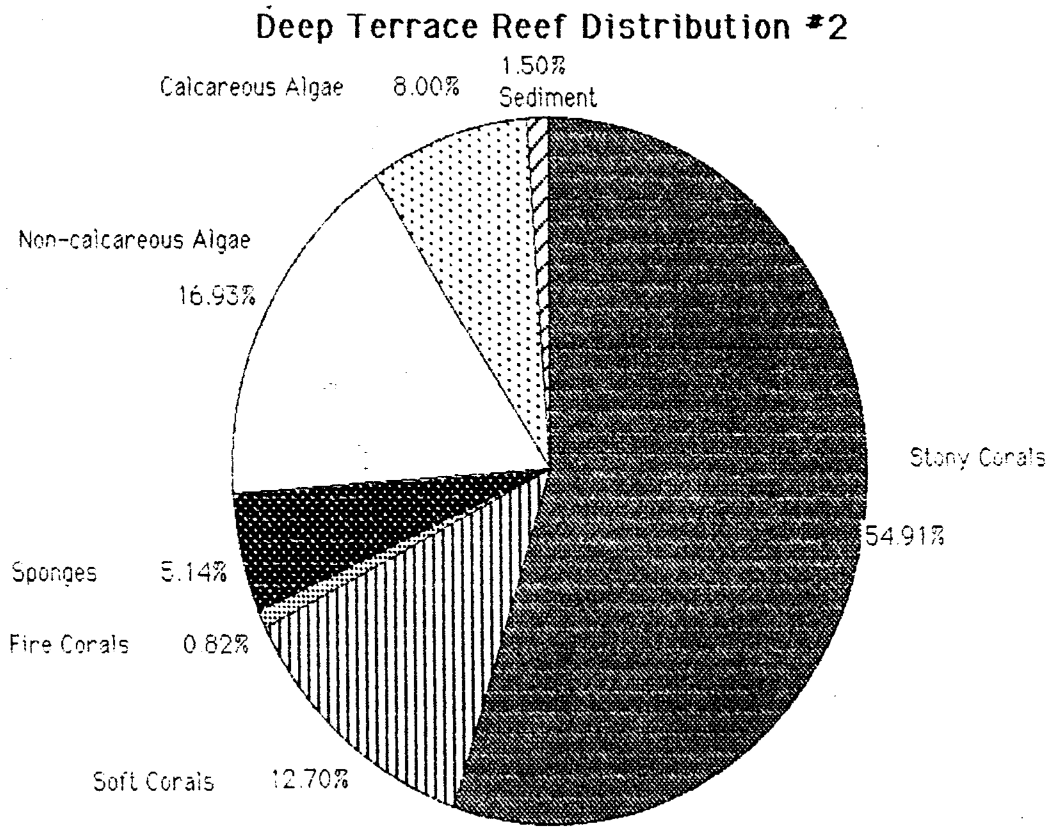


Transect Data

Deep Terrace Reef Transect #1

Group	Percentage of Total Area
Stony Corals	53.3%
Soft Corals	8.95
Fire Corals	1.37
Sponges	2.56
Non-calc. Algae	19.97
Calcareous Algae	7.91
Sand and Sediment	5.94

Figure #6 and Table #6. Seaview Reef Zonation Breakdown



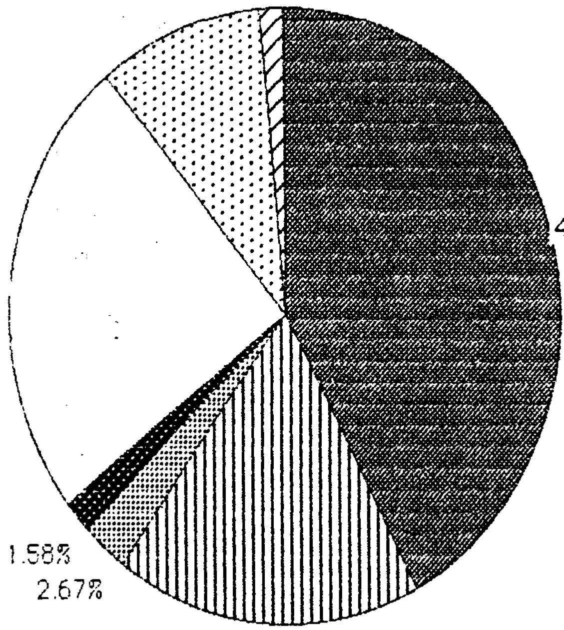
Transect Data

Deep Terrace Reef Transect#2

Group	Percentage of Total Area
Stony Corals	54.9%
Soft Corals	12.7
Fire Corals	.82
Sponges	5.14
Non-calc. Algae	16.93
Calcareous Algae	8.0
Sand and Sediment	1.5

Figure #7 and Table #7. Seaview Reef Zonation Breakdown

Deep Fore Reef Distribution #1

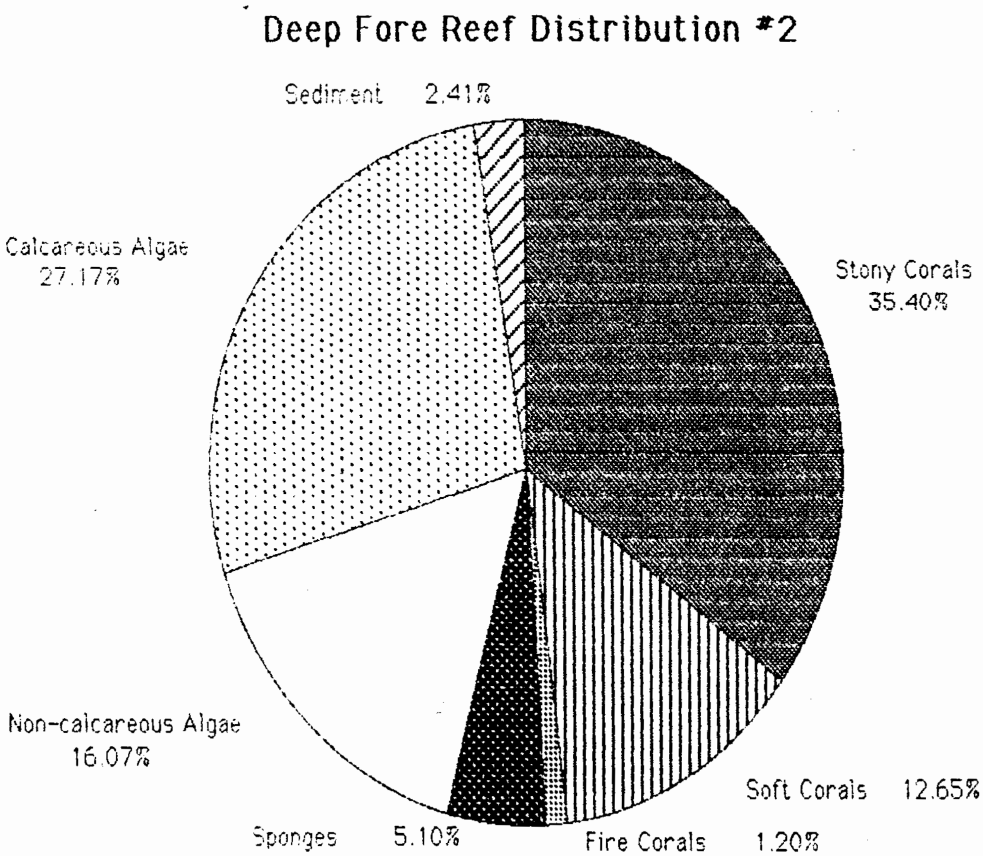


Transect Data

Deep Fore Reef Transect# 1

Group	Percentage of Total Area
Stony Corals	42.25%
Soft Corals	17.86
Fire Corals	2.67
Sponges	1.58
Non-calc. Algae	24.32
Calcareous Algae	9.60
Sand and Sediment	1.72

Figure #8 and Table #8. Seaview Reef Zonation Breakdown



Transect Data

Deep Fore Reef Transect#2

Group	Percentage of Total Area
Stony Corals	35.40%
Soft Corals	12.65
Fire Corals	1.20
Sponges	5.10
Non-calc. Algae	16.07
Calcareous Algae	27.17
Sand and Sediment	2.41

Figure #9 and Table #9. Seaview Reef Zonation Breakdown

including the jewfish, groupers, hinds, tarpons, and angelfish become more prominent.

Discussion

As coral reefs are found mainly in high energy littoral areas, interaction with the rest of the marine environment is an essential source of sustenance. Thus, tropical coral reef zonations and their biological constituents are largely a function of the characteristics of the particular marine ecosystem. A variety of literature on the subject supports this statement, and many of the observations of Seaview reef are confirmed.

Romashko (1975) declares that the species composition and growth forms within reef zones are determined by area depth, wave action, light, geological history, and the amount of freshwater and sediment runoff from land. Goreau (1973) similarly lists important factors which contribute to reef growth as illumination, the geomorphology of the antecedent rock, the abundance and texture of reef sediment, the area's turbulence, and finally the degree of water salinity.

Uniquely essential to a coral reef environment, more so than any other factor, is a regional water temperature that does not fall below 21 $^{\circ}$C (69.8 $^{\circ}$F) (Goreau, 1973). Even off Grand Cayman, during the month of March, water temperatures to 36.6 m (120 feet), came within 7 degrees of the warm air temperatures, remaining constant for approximately 26.2 m (80 feet). In discussing diving off of Grand Cayman, Roessler (1986) explains that even cold waves have little or no effects on undersea conditions. Year round, water temperatures range from 25 °C (77 °F) to 27.8 °C (82 °F). These thermostatic conditions are believed to have an important effect on a reef's rate of growth. This link serves as a possible explanation for the lack of major reef developments north of the Georgia and South Carolina coasts. The colder temperatures found in the Middle and North Atlantic waters cannot sustain such fragile ecosystems as coral reefs. Similarly, down the Cayman reef slope, a significant decrease in the overall coral population corresponds with the decrease in temperature over depth. The first of many thermoclines occurs at approximately 29.0 m (95 feet) and drops only from 26.7 °C (80 °F) to 25.8 °C (78.5 °F), not large enough to severely effect coral growth. At depths lower than 98.4 m (300 feet), however, temperatures are much lower because of the lack of solar heat. The *Kirk Pride* is a freighter which went down off the Cayman wall during a storm in 1976. Photos at its resting depth of 262.4 m (800 ft) show no coral growth on the ship's massive hulk, even after twelve years (Clark, 1988). It seems, then, that whereas corals can survive in waters from 16.1 °C (61 °F) to 36.1 °C (97 °F), the optimum reef building temperatures are range from 22.8 °C (73 °F) to 25 °C (77 °F) (Romashko, 1975).

Along with temperature, sunlight illumination is also crucial to reef growth. First of all, coral reefs differ from other marine depositional environments in that their calcification processes are interlinked with photosynthesis (Goreau, 1973). For example, the predominant reef building corals contain *zooanthellae*, simple celled symbiotic algae groups which live in the tissues of corals and promote photosynthesis (Sefton and Webster, 1986). Through their photosynthetic processes and calcium deposition, the action of these *zooanthellae* aid in coral nutrition, deriving most of the energy within a coral zone from photosynthetic activity alone. Thus, most reef developments are restricted to shallow waters which are constantly sunlit. Scientists have concluded that daily productivity rates are twice on a sunny day what they are on a cloudy day (Sefton and Webster ,1986). As the surveys of Seaview reef by transect show (Figures #4-9 and Tables #4-9), the populations of the larger stony corals, the major builders, dominate all three major reef regions (shallow terrace reef, deep terrace reef, and deep fore reef). Between the deep terrace reef and the deep fore reef, however, there is a significant drop in the percentage of these corals, indicating that their presence is possibly a function of the amount of sunlight at certain depths. Farther down the wall, deeper than 98.4 m (300 feet), such corals do not grow [probably because of] due to the reduced temperature and above all the absence of light. In a National Geographic article on the Cayman wall, these deeper depths, although they cannot support coral life, are home to an immense variety of sponges and other marine life.

heterotrophs deriving their energy from dead o.m. filtering down?

As mentioned above, several authors emphasize the effect which turbulence and wave action have on reef growth. Goreau (1973) states that the optimum conditions for mineral accretion (the sum of all biological processes of calcification) are when mechanical erosion is at a maximum. Sefton and Webster (1986) conclude that this factor contributes to the spur and groove systems frequently observed in high energy reefs. Any sediment which is the result of mechanical erosion finds itself channeled down the reef by the groove system. Reef erosion and proper sediment drainage enhances coral growth by providing areas into which corals can spread. In general, coral reef sediment ranges from .2 mm to 5 mm. In areas where large amounts of sediments accumulate through transport,

Greater delivery of nutrients with high wave & tidal energy corals can literally be choked to death (by fine sediments) or crushed (by larger sediment) if the light supply is cut off or the feeding mechanisms are clogged by thick layers of sand and silt (Smith, 1988). Because of its proximity to the iron shore and shallow depths, the inshore region receives the largest amount of wave action, transporting large amounts of sediment. The percentage of sediment observed in this area was more than two times that in deeper zones. For the most part, the large sandy plains and silty grass and algal beds allowed for minimal coral adhesion.

An area's geomorphology and geological history also determines the reef's growth intensity. Grand Cayman in particular, as well as other Caribbean islands, sits on an ancient coral reef, a conclusion drawn by shore and seabed drilling and core sampling (Bush, P. , 1989, Pers. Comm.). Most modern Caribbean reefs, however, are young in a geological perspective, being formed within the past 5,000 years (Sefton and Webster ,1986). They were built, nevertheless, on top of older limestone reefs dating from the Miocene, Pliocene, and most importantly the Pleistocene (2 million to 10,000 years ago) epochs (Goreau,. 1973). It is thought that the glaciations during the Pleistocene epoch lowered sea levels, thus exposing the reefs for extended periods, until the sea level stabilization approximately 5,000 years ago promote new reef life.

Coral reefs themselves are dominated by calcium carbonate, secreted by coral organisms and forming a rigid framework. Most of the sediment on the reef, then, is produced by certain corals and calcareous algae. It is expected, as the transects of Seaview reef show, that the percentages of sediment is greater where algal flats are more extensive, namely in the inshore, reef flat, and shallow terrace reef zone. Transportation also occurs

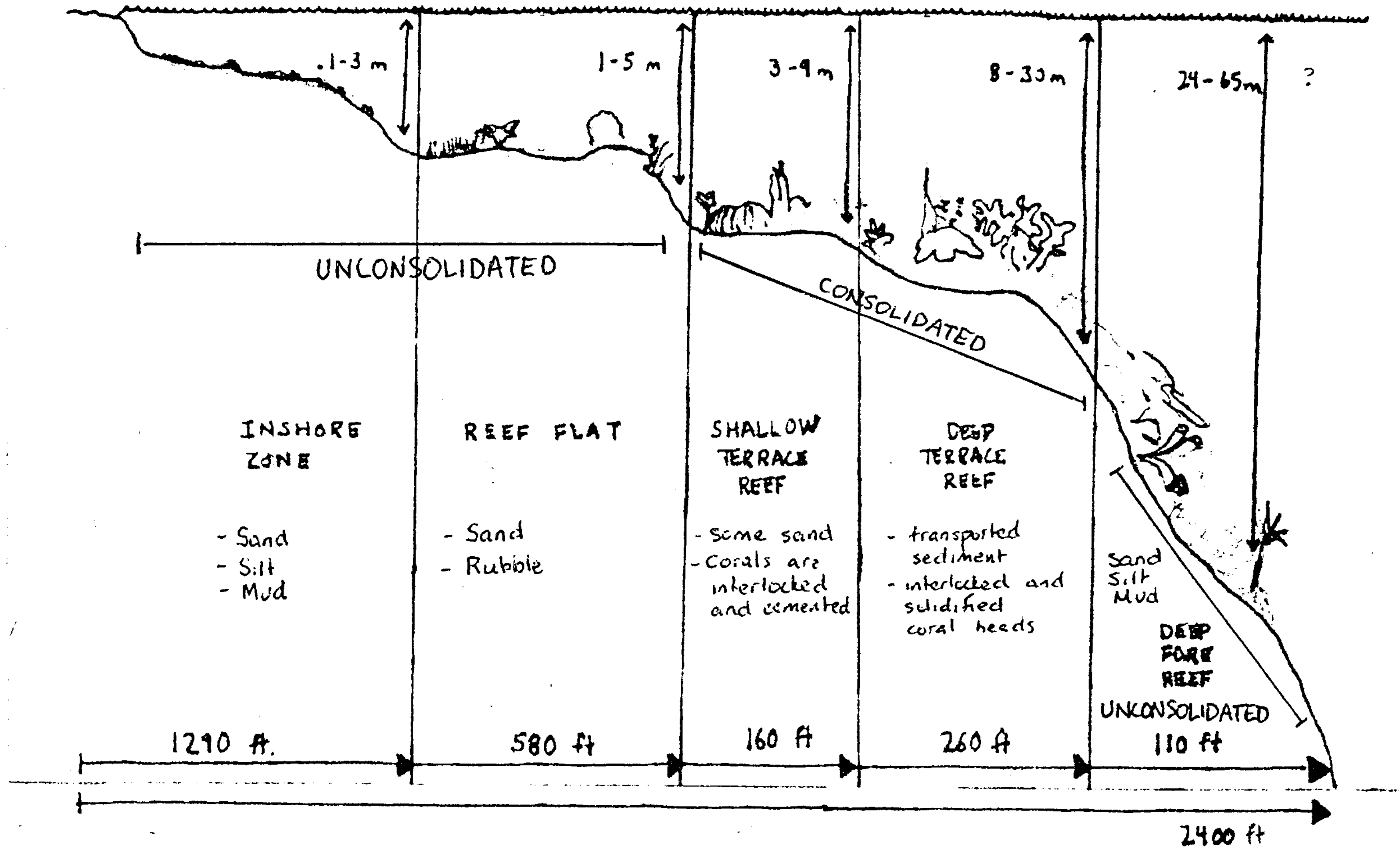


Figure #10. The Sedimentary Makeup of Seaview Reef from the reef crest, areas where coral heads rise close to the surface, and areas of increased turbulence. Physical damage to reefs by boats, divers, and natural catastrophes also increases the percentage of sediment. Some reefs around Cayman have been pulverized entirely due to these occurrences. Heavy marine traffic is increasingly becoming a problem to Cayman's reefs (Smith, 1988). In some areas on the Seaview reef, this can be seen, although it is extremely difficult to determine the source of observed sediment.

On Seaview, sedimentary processes are quite defined (refer to Figure #10). Mostly unconsolidated material appears along the inshore and reef flat zones because of mechanical erosion. The terrace reefs and the spur and groove system, however, are consolidated. The major reef building corals anchor themselves, and use sediment as a means of growth. The ventilation of the inshore and reef flat sediments through the grooves finally deposits unconsolidated materials on the lower fore reef. These observations of sediment and reef layout are supported by Goreau's findings on the reefs of Jamaica, a nearby island possessing similar characteristics.

In general, marine life on the coral reef seems to take preference to certain characteristics of the environment. Several variables, such as those mentioned above, must be taken into account. Small fish might take to the warmer shallow waters. Herbivores might inhabit the algal and grass flats. And larger fish and predators might take advantage of the abundance and variety of life (and possible prey) on the reef itself. Similarly, corals grow at certain depths, sponges at others, and different sediments are present at each point on the reef, no matter whether it be on different zone or within the same one. See Figures #11-13 for a comparison of grouping percentages

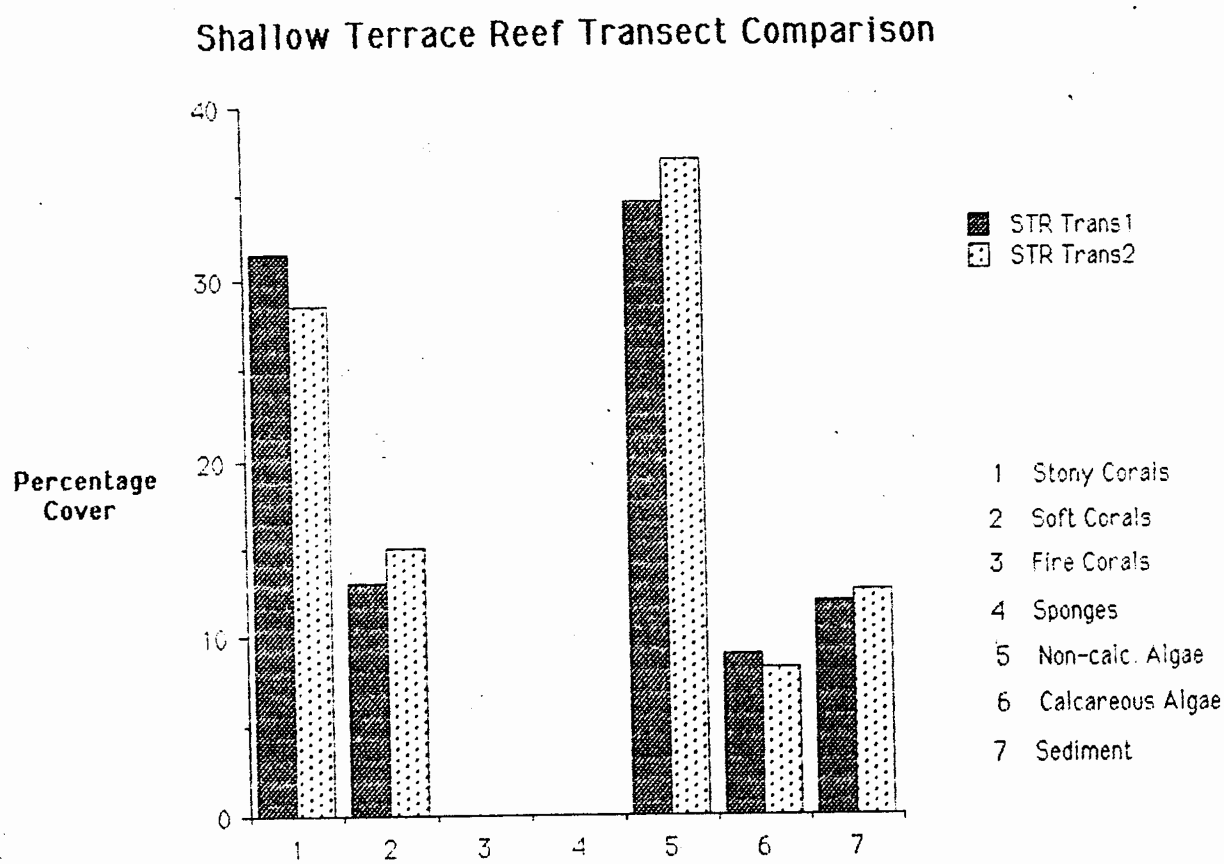


Figure #11. Seaview Reef Transect Comparison

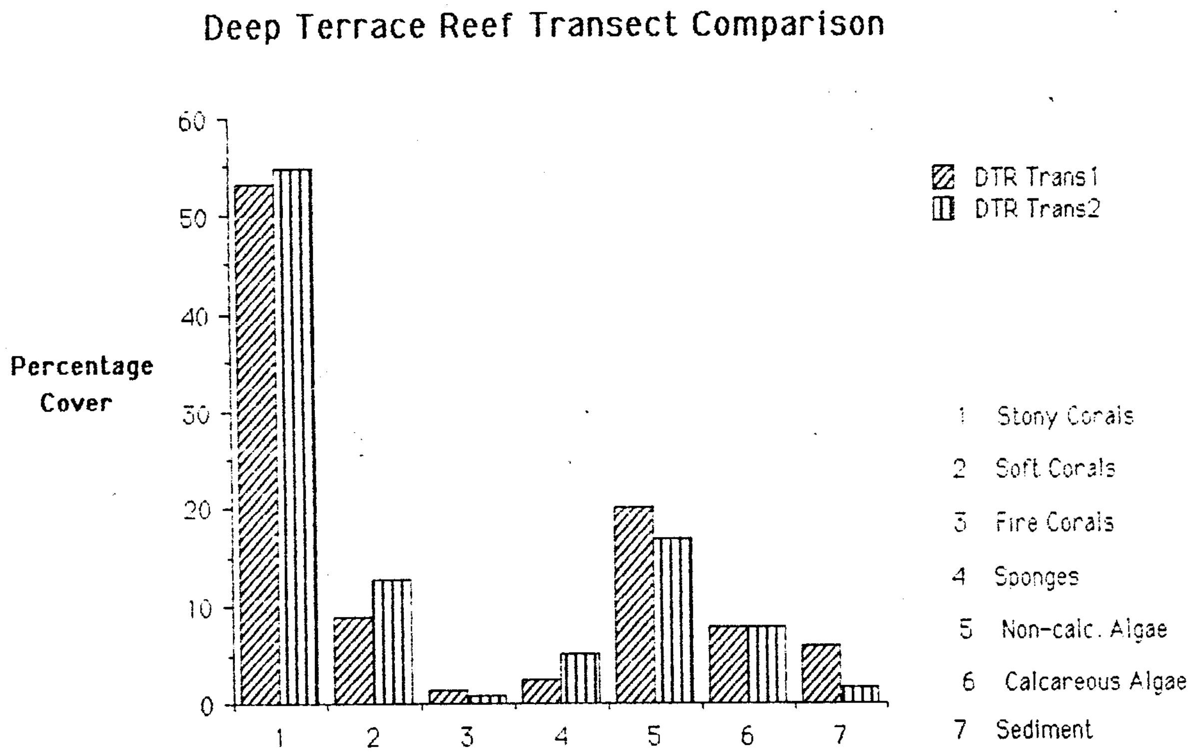


Figure #12. Seaview Reef Transect Comparison

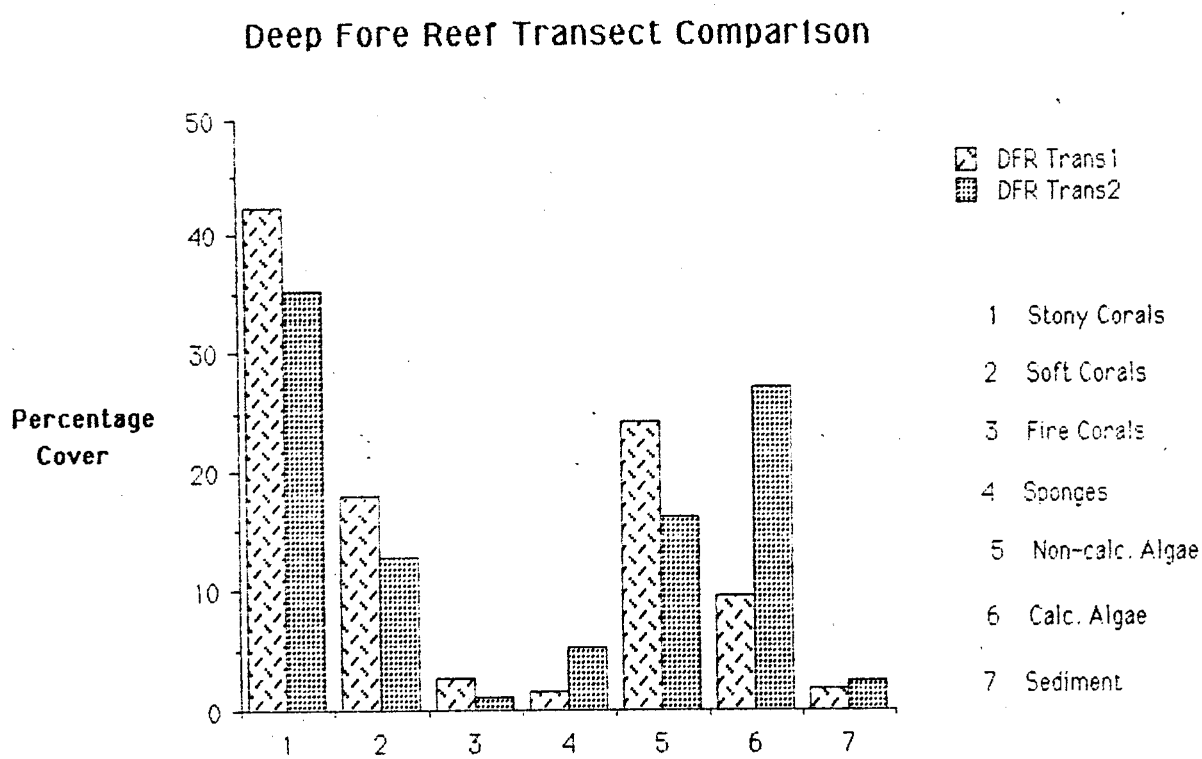


Figure #13. Seaview Reef Transect Comparison

within each zone. As the transects were placed 50 m apart, one would expect that similar characteristics might be observed. In few cases do the percentages differ by more than 5%. This is not to say that reef growth and marine life was exactly the same over such a distance, but it does indicate that overall, occurrence and percentage distribution is the same within certain parameters.

Conclusion

Overall, this research project explores geological, chemical, and biological characteristics of the tropical coral reef ecosystem. Outside literature was extremely helpful in organism identification and the formation of a general reef zonation. It has been determined that each zone possesses its own unique characteristics in terms of marine life distribution and environmental characteristics. The author only regrets that more time could not have been spent in the observation and data collection stages. What results, in any case, is the proposed reef profile and marine life observation. Based on marine conditions, research, and general observations, the Seaview reef has been divided into a sandy inshore zone, a reef flat dominated by algae, a shallow terrace reef with some development, the major growth of a deep terrace reef, and the transitional fore reef zone. Although the entire reef consists of all of these zones, observation and data have proven that each one can be identified by its own unique characteristics. Operating under a variety of very restricted conditions, the Seaview reef has revealed the complexities of the tropical marine ecosystem of the coral reef.

Marshall - An excellent piece of work combining observation, field data, outside literature, etc. — (A)