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CHANGES IN THE REEF-CORAL COMMUNITY OF CARYSFORT REEF, KEY LARGO, FLORIDA: 1975 - 1982-3

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NOTICE

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT
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Changes in the Reef-Coral Community of Carysfort Reef

Key Largo, Florida: 1975 - 1982-3

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Abstract

Data from 21 permanently marked line transects showed that significant changes occurred in the composition of the reef coral community on Carysfort Reef between 1975 and 1982-3. Coral populations between 0 and 9 meters show signs of change due primarily to physical disturbance while corals living between 10 and 22 meters have decreased in abundance as a result of sedimentation and disease. Some species show no signs of change while others appear to be undergoing shifts in their vertical distribution and/or significantly decreasing in mean colony size. Observed decreases in species diversity and eveness of the reef-building corals suggest that the vitality of Carysfort Reef declined between 1975 and 1982-3.

Key words: corals, coral reefs, community change, coral vitality
Key Largo

Introduction

The reefs of the northern Florida Keys are some of the most heavily visited in the world and are located close to major centers of human population. The coral reefs are utilized by tourists and sportsmen who marvel, and at the same time, exploit the rich, luxuriant fauna. The reef ecosystem of the Keys supports a variety of business endeavors including rich commercial fisheries and a multi-million dollar sport diving industry. In the last twenty years divers, fishermen, tourists, and scientists have noticed a decline in the general overall vitality of these reefs (Voss,1973, Dustan,1977). Fishermen talk of the large and numerous fish they used to catch (Shinn per. comm.). Experienced divers discuss the once luxuriant coral reefs and decreasing underwater visibility. And, fisheries statistics show that the commercial catch per unit effort of _Panularus argus_, spiny lobster, has declined significnatly since 1970 principally due to an exponential increase in traps and fishermen (Simmons, 1980; Fee,1986). While these observations are symptoms of ecosystem dysfunction suggesting that the internal dynamics of the ecosystem may be breaking down as a result of ecological stress (Rappaport et al, 1985), there is a paucity of quantitative data on the community structure of any of the above mentioned populations.

In 1974 we initiated a baseline study of the abundance and distribution of reef-building corals on Carysfort Reef off Key Largo in an attempt to quantify changes that might be occurring in the community structure of the coral reefs of the northern

Florida Keys (Dustan, 1985). This report summarizes the results of the study and describes changes that have occurred in the distribution and abundance of reef-building corals on Carysfort Reef between 1975 and 1982-83. The report is supplemented with underwater photographs taken in 1985 as part of our ongoing observations of the reef ecosystem.

Study Site

Carysfort Reef is situated at the northern fringe of luxuriant coral reef development along the eastern coast of North America (Figure 1). The reef, at position N. Latitude 25°13', W. Longitude 80°13', is buffered from harsh winters by the warm waters of the Gulf Stream which flow near the reef line and often wash over the outer reefs of the northern Florida Keys (Mayer, 1914). The geomorphology and species zonation of Carysfort Reef resembles descriptions for fringing reefs of the Caribbean (Goreau, 1959) ,the Bahamas (Storr, 1964),and other reefs of the Florida Keys (Jaap, 1984). Carysfort Reef is one of the most well-developed and diverse reefs within the entire Florida Reef Tract (Dustan, 1985). It lies near the northern boundary of the Key Largo National Marine Sanctuary. Molasses Reef, at the southern end of the Sanctuary at N. Lat 25° 1' is the center of recreational water sports for the region. Carysfort's remote northern position within the park reduces its contact with man.

In selecting a study site, we reasoned that detectable change in a slow growing, highly diverse community such as a coral reef might be most readily observed in regions of dense coral cover and high species diversity (Margalef, 1968). The study site on Carysfort Reef was chosen because reconnaissance suggested that it was the most well-developed reef community along the seaward face of the platform margin. The site is characterized by a wide reef flat that grades into a well-developed *A. palmata* zone on the seaward side. Seaward, a region termed the ridge/trough zone is dominated by *Millepora complanata*. A gently sloping plain inhabited mostly by gorgonians and small corals grades seaward of the trough/ridge zone to a depth of about 8-10m. The fore reef terrace community starts at 10m and continues to a depth 22m. Coral coverage and species diversity is highest on the fore reef terrace which ends with the reef grading into fine carbonate sand. For a more complete description of Carysfort Reef the reader is referred to Dustan (1985).

Materials and Methods

The determination of coral species coverage and abundance was carried out using a grid of line transects (Loya, 1972, 1978). The positions of the transects were established by stretching a taut line from the reef from the seaward base at 21 meters depth to the shoreward side of the reef flat, a horizontal distance of approximately 300 meters. The line was run on a compass heading of 110-290 degrees magnetic . This course was along the axis of surge channels in the *Acropora palmata* zone and normal to the direction of incoming swells as determined by the orientation of the seafan, *Gorgonia ventalina*, which orients perpendicularly to the swell direction (Wainright and Dillon, 1969). A second line was placed parallel and 25 meters to the north of the first. Numbered stainless steel pins (15 x .95 cm.) were driven into the reef along the two lines to create a series of transects on the reef that resembled the rungs of a ladder. Twenty-one 25 meter long "rungs" were positioned on the reef between its base and reef flat. Twenty-five meters was chosen as the optimal transect length as an asymptotic cumulative number of species had been reached in trials within 20 meters in accordance to the methods first described for reefs by Loya (1972). The careful alignment of the transects insured that we would survey the reef zones and coral abundance relative to their natural orientation as determined by the incoming wave surge and depth (Goreau, 1959). The horizontal spacing between the transects varied from 3 to 20 meters depending on the density of coral coverage and the degree to which the depth of the reef substrate was changing. Spacing was close at the base of the reef where coral coverage was high and the slope steep. Line spacing of 20 meters was used in the relatively homogeneous, gently sloping regions of the reef (see Figure 3 for reef profile and transect location).

Carysfort Reef was surveyed in 1975 (Dustan, 1985) and resurveyed in the summers of 1982 and 1983; it took two field sessions to find and resample all the transects. Transects 1-10 were surveyed in 1982 and 11-21 in 1983. The majority of the original pins marking the transects were located (33 of 42), which enabled us to remeasure the identical reef coral populations initially surveyed in 1975. We could not find transect pins for two transects on the reef flat, one transect in the Acropora palmata zone (the large coral colonies holding the pins had been physically destroyed), and the pins marking one end of transects 21 (back reef), transects 6 and 7 (fore reef). On the reef flat, and on transects 6 and 7, we found the tag lines we had used in 1975 to find the pins but the pins had been removed. Whenever we could not find the original pin we remeasured the distances from existing pins and reset the end positions of the transects. Thus the transects in these regions were not precisely on top of the previously surveyed corals but were less than a meter from their original positions.

The measurement of a transect began by securing the end of a length of floating polypropylene line to a transect pin. The line was then strung through the eye of the corresponding pin at the other end of the transect and pulled taut down onto the reef substrate. The line was inspected to be sure that it was strung straight between the two pins thus overlying the same portion of reef as in 1975. The length of line crossing over coral colonies and the space between them was measured to the nearest 0.5cm with a ruler and tallied on a plastic slate. Branching species were measured from the edges of a colony's branch tips. When branching colonies occurred in thickets, branches that could be traced to a common origin were considered to be part of a single colony. Colonies were inspected for algal infections, physically damaged areas, sediment covered tissue, or any other type of blemish. Regions of the reef that showed large scale destruction were examined for debris to ascertain the cause of the damage. The data were transferred to a notebook, then to computer file, and analyzed at the College of Charleston.

This report details the data dealing with the coral species distribution, colony size (mean intercepted distance), abundance, and species diversity and evenness on Carysfort Reef. The data are examined from two perspectives:

1. change that occurred at the individual coral species level
2. change that occurred at the community level

Calculations of species diversity ($H' = -\sum pi \log pi$) and evenness ($J' = H'/H'max$) were made using both centimeter coverage of colonies and the number of colonies (Pielou, 1975). These two measures are correlated but since corals are sessile benthic organisms their size as well as their numerical presence may have ecological significance (Hughes, 1984).

Results

Individual coral species

The data were first examined for changes in the coverage and mean colony size (mean intersected size) in each species on each transect (Appendix A.). These data were then used to generate a summary statistic for each species on the reef (Table 1). It is apparent from the data that different species of corals have undergone different types of changes in the time between surveys. Some species have increased in size and abundance while others have decreased. The t-test was applied to the data to test for significant change in mean colony size between years. Significant changes were observed in only a few species. Many species normally exhibit a wide range in colony size so that changes in average size may fall within the distributed range of sizes for that species. Only a few species were abundant enough in our data set to demonstrate significant changes in mean colony size.

Acropora palmata, one of the principal reef-building corals of the shallow reef, showed an overall increase in abundance of colonies and cover along the transects (94 to 201) but a decrease in mean colony size from 63 to 33 cm ($t=4.43$, $df=293$, $P<.001$). *Acropora cervicornis* decreased in abundance from 48 to 40 colonies while mean colony size did not change appreciably (51 to 50 cm). In 1983 we observed that the living tissue of *A. cervicornis* colonies did not extend as far down its branches as it had in 1975, so the same size colony in 1983 contained less biomass than in 1975 (Fig. 2). Montastrea annularis, a reef-building species abundant below 10m, declined in number of colonies (62 to 54) and showed a non-significant decrease in mean colony size (42 to 33 cm.). Agaricia agaricites changed from 93 to 82 colonies but increased in mean colony size from 4 to 6 cm.($t=2.15$, $df=173$, $p<.05$). Siderastrea siderea decreased in abundance from 77 to 65 colonies with no apparent change in mean colony size. Stephanocoenia michelinii, another massive coral species, exhibited little change in abundance (24 to 22 colonies) and a slight increase in colony size (19 to 20 cm, ns). Porites astreoides, the most abundant species on Carysfort Reef, increased in abundance (103 to 116 colonies) and showed no change in mean colony size (9 cm). The hydrozoan, Millepora complanata is abundant in the shallows of Carysfort and seems to have changed in a pattern similar to that of A. palmata. The species shows a complex pattern of changing abundance and colony size in the A. palmata zone. Colony size has decreased (37 to 26 cm) at the seaward edge of the zone while the number of colonies has increased (32 to 46 colonies). As in A. palmata, the increase in colonies has resulted from the fragmentation of large colonies with subsequent growth of the pieces. Other species, including the encrusting zooanthid Palythoa sp., exhibited a variety of changes but small sample size and patchy distribution made any patterns difficult to discern using line transect data.

A second level of analysis was carried out using the data in Appendix A. in which the appearance or loss of a species on a transect between the two surveys was recorded (Table 3). The data suggest that more species disappeared from transects in the deeper regions of the reef (Transects 1 - 9) and that there appears to be an increase in recruitment of new species in the shallower parts of the reef (Transects 10 - 21). A 3 x 2 Chi-square contingency test was carried out to test the null hypothesis that there was no significant difference in the frequency of occurrence of corals from the two regions of the reef between 1975 and 1982. The null hypothesis was rejected (Chi Sq.= 25.08, df=2, p<.01) suggesting that there were significant differences in the frequency of occurrence of coral species in the shallow and deep regions of Carysfort Reef.

The species that have notably increased their presence on shallow reef transects are primarily small corals with high reproductive potential (Dustan 1977; Bak and Engel, 1979; Rylaarsdam, 1983). Species such as Agaricia agaricites, Helioseris cucullata, Favia fragum, and Porites porites were all encountered as new recruits on three or more transects on the shallow reef. These species are rarely the dominant species on a reef and usually do not account for major reef framework construction on reefs in the Florida Keys. Their ecological role in the Keys seems to be one of colonizing the reef understory. In addition F.fragum ad P. porites may be found in harsh environments with high turbidity and extreme temperatures.

Species that became absent on the largest number of transects were primarily deep water or massive corals: Mycetophyllia ferox, M. lamarckana, Solenastrea hyades, Scolymia cubensis, and Colpophyllia breviserialis. The encrusted, intact skeletons of these dead corals were found on the fore reef suggesting that they did not die from physically destructive forces. These colonies stand above the level of the substrate and mortality due to catastrophic innundation by sedimentation with subsequent uncovering seems unlikely. Living corals infected with black band disease, white plague and sediment-related tissue necrosis noted by Dustan (1977) are still prevalent in this region of the reef.

Community Analysis

Calculations of total coral coverage and abundance of the reef corals on transects provide estimates of the standing stock of living coral biomass. The Wilcoxon Matched-pair Sign Ranked Test was applied to the summarized transect data to test for significant changes in number of colonies, coral coverage, percent coverage, species diversity ,and evenness (Tables 1 & 4). The Wilcoxon Matched-pair Sign Ranked Test was used because small sample size and an unclear und erstanding of the normality of the data strongly pointed to using non parametric statistics as opposed to the traditional t-test (Sokal and Rohlf, 1969). Coral coverage and percent coral coverage increased sig nificantly, the number of coral colonies did not change significantly, while species diversity and evenness decreased (Table 5.) In general, the greatest amounts of change have occurred in the the *A. palmata* zone and deeper fore reef (Figs.3-6).

In the *A. palmata* zone coral coverage and number of colonies increased and mean colony size decreased (Figs. 2-4). Corals in the zone were smaller and more numerous in 1983 than in 1975. The shallows of Carysfort Reef are less diverse now and evenness has also decreased despite the addition of new species recruitment. The large decrease in evenness may be the result of changes in the coverage of a single species, *A. palmata*, which showed an increase in number of colonies (94 to 201) and a decrease in colony size (63 to 33 cm. diameter).

On the fore reef the number of colonies decreased in the region of greatest coral abundance (Table 1 and Fig.3) which resulted in a slight decrease in species diversity (Fig. 5). Mean colony size remained the same with the exception of a sharp decrease at the shallow edge of the fore reef terrace (Fig.4). This resulted from a decrease in size of the most abundant species at this depth. Acropora cervicornis decreased from a mean colony size of 62 to 49 cm, n= 25, and Montastrea annularis from 9 colonies to 1 with an average colony size changing from 29 to 22 cm. Most coral species on the fore reef decreased in number without changing size to a great extent.

Discussion

The matched-pair analyses of the transect data for the entire reef community suggest that the reef coral populations on Carysfort Reef have changed significantly between the two surveys. The data show consistant decreases in species diversity and evenness while an increase in the coverage of corals. Only the abundance of coral colonies did not show a significant change. However, Carysfort Reef is composed of two distinct coral communities: a shallow reef between the surface and 7 meters and a fore-reef community from about 10 to 23 meters (Dustan, 1985). These two communities have undergone different kinds of change during the years between the surveys. Corals increased in abundance in the shallows and decreased in abundance deeper on the fore reef. Some species, notably A. agaricities, H. cucullata, F. fragum, and P. porites seem to be colonizing shallower regions of Carysfort Reef. The changes that have occured on the shallow and deep regions of the same reef demonstrate that different regions of the same reef ecosystem may be subject to different selection pressures and that pooled, summarized statistics for the entire reef present an oversimplifed, possibly even distorted, picture of ecosystem change.

The shallow seaward edge of Carysfort Reef is characterized by large monotypic stands of Acropora palmata. In the years between the surveys this species has increased in abundance (94 to 201 colonies) and decreased in average colony size (63 to 33 cm). Physical fragmentation appears responsible for a significant portion of the observed change in this region of Carysfort Reef (Fig. 7). Many large colonies of A. palmata have been toppled and the broken pieces lay strewn about on the reef substrate. While searching for transect pins on the reef flat and in the A.palmata zone just seaward of the reef flat, we encountered broken bronze propellors, tangles of line, personal effects, and other debris suggesting numerous vessel groundings and boat wrecks have occurred between 1975 and 1982. The number of vessel groundings has been increasing within the Park and Sanctuary boundaries with 22 being reported in the two year period between August 1983 and August 1985 (Halas, unpublished field observations). Diver or anchor damage was also encountered on Carysfort Reef and was most noticeable in the vertical blades of Millepora complanata. Colonies of A. palmata and M. complanata that have been damaged often regenerate and the small pieces begin to grow into new colonies . Storms have also taken their toll of Carysfort Reef but our line transect data does not separate the effects of storm or boat groundings, only the magnitude of the disturbance and direction of change. Both types of damage would be greatest in the regions just seaward of the reef flat where the A. palmata is most luxuriant. Storm damage would be more of a reef-wide phenomenon while damage caused by vessel grounding would tend to occur more as isolated patches of intense destruction. South Carysfort Reef lies less than two kilometers south of our study site on Carysfort Reef. Fewer people visit South Carysfort as it is not well marked. If storms were the principal cause of breakage then South Carysfort should show the same degree of damage as Carysfort. South Carysfort Reef however still has large groves of undisturbed A. palmata and A. cervicornis on its shallow seaward face.

The once lush and densely covered A.palmata zone now has large areas of A. palmata rubble. This has transformed these once complex three dimensional groves of branching corals into less complex two dimensional beds of coral fragments. Fragmentation of A. palmata has resulted in the species becoming more abundant numerically but the mean colony size has dramatically decreased. In addition, the raw, unweighted line transect data tend to underestimate the coverage of vertically growing corals so the change in A. palmata biomass may be greater than estimated. Relatively few A. palmata fragments have survived and the vast majority of fragments have ended up as rubble. Some of the toppled colonies have sprouted new vertically growing branches which may regrow into large colonies. The toppling of these large palmate branching corals has opened new areas for recolonization, and the influx of new species may be similar to the successional process that happens in a forest after a large tree falls leaving a gaping hole in the canopy overhead. The most common new species, Agaricia agaricites, Helioseris cucullata, Favia fragum, and *Porites porites*, are characterized by high reproductive output (Bak and Engel ,1979, Rylaarsdam, 1983). Thus, it may be that the number of species has increased in the area as a result of the reduction of the dominance of *A. palmata*. Destruction, followed by recolonization, is thought by some to contribute to the long term maintenance of high species diversity on coral reefs (Connell 1978, Porter et al, 1981).

Small unbroken colonies of *A. palmata* were seldom encountered suggesting that the recruitment of planulae into the population is slow at best. *A. palmata* is also subject to white plague disease (Dustan, 1977; Peters, 1984) which further reduces its "governing" influence on the species diversity of the shallow seaward edge of Carysfort Reef. Thus, the change in species composition on the shallow reef may be an indication that the *A. palmata* zone is decreasing in size and luxuriance, and that possibly the role of *A. palmata* as a reef-builder is decreasing in importance on Carysfort Reef as the region becomes colonized by different species. Only time will tell if this change is an "intermediate disturbance" or a more permanent change in the reef coral community.

The zone of sparse coral cover that lies between the shallow and deep parts of Carysfort Reef is inhabited by many species of gorgonians. Most of the hard corals that inhabit this region are small colonies of *Dichocoenia stokesii*, *Porites porites*, and *P. asteroides* and significant change would be difficult to detect with such small sample sizes (see transects 8-10 Appendix A.) Two very large colonies of *Montastrea annularis* situated in this zone did show symptoms of either algal infection or disturbance by damsel fish gardening (Kaufman 1977). These spectacularly large colonies are important to the reef as they serve as cleaning stations for the local fish populations. While the line transects did not record a change in the size of these colonies, our field observations showed that they have blemished areas that are covered with algae and sediment pockets and are not as they were in 1975.

The coral community on the deeper regions of Carysfort Reef has significantly decreased in number of species, coral coverage, and the number of colonies present along most transects. The skeletons of dead corals are now covered with fleshy algae and fine carbonate sediments (Fig. 8). The tissues of many live corals are dying from a variety of bacterial and blue-green algal infections, and sedimentation. Coral diseases (see Peters, 1984) are becoming more prevalent in South Florida and elsewhere (Antonius, 1985) since first being described in the Florida Keys and Bermuda in the early 1970's (Antonius 1973; Garrett and Ducklow, 1975; Dustan 1977). In 1975 we established a site at 13m to monitor the recruitment of juvenile corals into the reef population (Dustan, 1975). In 1983 there were fewer small colonies at the site indicating that rates of successful recruitment may have decreased (Table 6.) Some species, however, are still present even though they apparently suffer heavy mortality. For instance, M. ferox is a species that was widely infected with white plague in 1975 and, it was predicted that M. ferox would soon disappear from Carysfort Reef (Dustan, 1977). The presence of healthy colonies in 1983 suggests that some colonies of this species are still able to survive and grow on Carysfort Reef. This suggests that some species of reef corals may be responding to changing selection pressures or may be resistant to this presumed disease.

The line transect study was designed to describe the species distribution and abundance on Carysfort Reef (Dustan 1985). Species area curves were used to establish the optimal transect length and the data generated are sufficient to numerically describe the reef coral community. Our line transect data shows that the community has changed significantly, but not to nearly the degree that seems apparent to an underwater observer. Overgrowth by fleshy algae and tissue necrosis due to fine sediment encroachment and disease has left the skeletons of many coral colonies only partially covered with living tissue (Dustan, 1977,and in prep). From observation, one gets a general impression that the Carysfort Reef ecosystem is suffering from general, overall environmental degradation akin to the impact of acid rain on forest ecosystems (Postel, 1984), or some other general stress resulting from a combination of these and other different selection pressures. The environmental degradation results in the ecosystem becoming simplified, in the most complex parts first (fore reef), and the system takes on the appearance of an individual organism that is chronically ill (Rappaport et al., 1985). Change detection in coral reef communities is becomming a topic of importance and newer methods have been developed since the inception of our study. Photographs and quadrats have been used to study small areas of reef communities (Shinn, 1976, Porter et al., 1981, 1982; Done, 1981; Jaap, 1984) while remote sensing techniques are being developed for large scale synoptic mapping (Dustan, 1985; Maniere and Jaubert, 1985). Our line transect study may not be as sensitive to changes in the reef community as our subjective observations and photographs, but this is because we have only estimated the abundance of corals, the structural elements of the ecosystem, and our impressions are based on observations and photographs (Figs. 2,7,8) which are more gestalt than numerical.

Clearly future studies of this type should be less myopic and include other elements of the reef community such as algae, fishes, sponges, and other invertebrates, including echinoids.

At this time it would be premature to implicate man in the degradation of Carysfort Reef, as it is difficult to quantitatively separate storm damage from boat groundings and the epidemiology of coral diseases is virtually unknown. But it would appear that vessel groundings are on the increase and do have a significant effect on the three dimensional geometry of A. palmata zone which, in turn, seems to increase the colonization of the region by r-selected species. The diseases observed on the deeper regions of the reef are caused by naturally occurring organisms (Peters, 1984). However, the role of slowly decreasing water quality may be contributory (Voss, 1973, Dustan, 1977). Corals on the fore reef are often covered with a thin verneer of fine sediment and mucous, presumably resulting from suspended sediments and organic snow. The organic material is a substrate for a resident bacterial population which may serve as both food and pathogen source for the corals. But, an increase in the sedimentation rate also increases the amount of energy a coral must expend to keep its tissues clean. The net result is that the coral tissue is slowly smothered by a combination of fine sediment, algal overgrowth, and disease (Dustan, 1977).

Studies and observations of other reefs are beginning to suggest that reefs are not the stable, equilibrium species assemblages that they were originally thought to be (Connell, 1978, Woodley et al., 1981, see Brown and Howard, 1985 for review). Coral reefs can change rapidly as a result of storms (Woodley et al., 1981), predation (Endean, 1976), urban impact (Dahl, 1981, Pastorok and Bilyard, 1985) and anchor damage (Davis, 1977). Our data suggest that the coral reef community of Carysfort Reef is undergoing relatively rapid change. The most diverse region of the reef, the fore reef, appears to be changing most with the ecosystem tending to become more simple due to the selective mortality of individuals. The transect data show that while the mean colony size is not decreasing on the fore reef, colonies are dying and not being replaced by recruitment. Simultaneously, the shallow reef is changing as the dominance of A. palmata is being reduced due to the physical destruction of large areas. Thus the overall character of Carysfort Reef is changing as a result of a variety of selection pressures.

After the field work for this research was completed there was a mass dieoff of the sea urchin Diadema antillarum throughout the Caribbean (Lessios et al. 1983, 1984; Bak et al., 1984; Hunt et al. 1986; Liddell and Ohlhorst , 1986). Mortality rates of 98 percent were reported for most area of the Caribbean and a water-born disease was suggested as the causal agent of the die off. Herbivorous urchins crop algal populations close to the reef substrate and their grazing has a demonstrated positive effect on the settlement and survivorship of juvenile corals (Sammarco, 1980, 1982). In subsequent visits to reefs in John Pennekamp Park and the Key Largo National Marine Sanctuary we have noticed an increase in the presence of macro algae on the reefs. Species of magroalgae now grow in great profusion around the borders of corals which may influence the growth and survival of adult as well as juvenile coral species (Dustan, in prep.). The die off of D. antillarum has added another dimension to the dynamics of long term change on Carysfort Reef and it will be most interesting to resuvey the reef once again in the near future.

Corals of the Florida Keys do have the ability to grow rapidly and recolonize large areas of destroyed reef in a relatively short period of time (Shinn, 1976), but this does not seem to be happening on Carysfort Reef. And whereas intermediate levels of disturbance may promote species diversity in some cases, the magnitude of disturbance on Carysfort Reef shows signs of promoting depauperacy. These observations must be taken into account when trying to assess the vitality of coral reefs and constructing management plans for their use and preservation. It is only through detailed, long term studies of the biology of these organisms that we will be able to fully understand the direction and cause of change in reef coral communities of the Florida Keys.

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Table 1. Descriptive statistics of transect data on Carysfort Reef, Key Largo, Fla. Transect ends are marked with stainless steel pins and are still in place on the reef. See Figures 2-5 for depth profile of the reef.

Transect Pin #	Meter #	Depth (M)	Total Colonies 75	82-3	Total Coverage cm. 75	82-3	Percent Coverage 75	82-3
151	0	21.0	19	23	224.5	303.0	8	12
252	3	19.0	44	31	510.0	411.0	22	16
353	6	17.6	35	27	499.0	422.0	20	17
454	10	15.8	59	59	656.5	787.2	25	29
555	20	15.3	53	32	1044.5	683.5	39	27
656	30	14.1	55	39	1730.0	1188.0	62	44
757	40	13.5	62	44	2052.0	1475.0	63	58
858	60	9.1	10	16	693.5	733.0	26	27
959	80	6.7	10	15	39.5	58.0	1	2
1060	100	4.7	24	19	157.0	113.2	6	5
1161	120	3.9	57	75	1391.0	1484.0	58	56
1262	140	1.9	43	42	687.0	684.5	28	27
1363	160	1.4	32	27	619.0	507.0	20	18
1464	180	1.2	46	53	600.0	1049.5	23	39
1565	200	0.6	46	33	964.0	1184.5	36	48
1666	210	0.3	38	50	885.0	1535.0	35	56
1767	220	0.3	15	42	921.0	1414.0	40	54
1868	240	0.3	60	75	1581.0	1431.5	56	55
1969	260	0.3	23	57	945.0	910.0	37	36
2070	280	0.3	19	67	1847.0	873.5	49	35
2171	300	0.3	6	15	63.0	191.5	3	8

Table 2. Summarized data showing change within species of reef corals on Carysfort Reef, Key Largo, Fla. Mean Colony size is the mean intercept distance of colonies. An "A" in the %Chng column denotes a species that was absent in 1975 and present in 1982-3. A "D" denotes a species that was present in 1975 and absent in 1982-3.

Species	# Colonies (n)			Species Coverage (cm)			Mean Clny Size (cm)		
	%Chng	75	82	%Chng	75	82	%Chng	75	82
Acropora palmata	114	94	201	12	5965.0	6665.5	-48	63	33**
Acropora cervicornis	-17	48	40	-18	2429.0	1983.0	-2	51	50
Mycetophyllia lamarckana	-57	7	3	-53	36.0	17.0	10	5	6
Mycetophyllia ferox	-64	11	4	-71	149.0	43.0	-21	14	11
Mycetophyllia aliciae	D	1	0	D	13.0	0.0	D	13	0
Solenastrea hyades	D	7	0	D	87.0	0.0	D	12	0
Agaricia agaricites	-12	93	82	12	404.5	455.0	28	4	6*
Agaricia lamarcki	0	1	1	14	21.0	24.0	14	21	24
Agaricia fragilis	-57	7	3	-40	30.0	18.0	40	4	6
Helioseris cucullata	25	8	10	175	32.0	88.0	120	4	9
Colpophyllia natans	0	9	9	31	159.0	209.0	31	18	23
Colpophyllia breviserialis	D	6	0	D	247.0	0.0	D	41	0
Scolymia cubensis	-25	4	3	38	6.5	9.0	85	2	3
Mussa angulosa	A	0	1	A	0.0	2.5	A	0	3
Montastrea annularis	-13	62	54	-31	2620.5	1808.7	-21	42	33
Montastrea cavernosa	-42	12	7	-6	123.5	116.0	61	10	17
Favia fragum	27	11	14	51	23.5	35.5	19	2	3
Siderastrea radians	50	2	3	175	4.0	11.0	83	2	4
Siderastrea siderea	-16	77	65	-12	1143.5	1002.7	4	15	15
Dichocoenia stokesi	-67	9	3	-52	39.5	19.0	44	4	6
Dichocoenia stellaris	A	0	1	A	0.0	6.5	A	0	7
Stephanocoenia michelini	-8	24	22	-1	445.0	439.5	8	19	20
Diploria clivosa	100	1	2	13	60.0	68.0	-43	60	34
Isophyllia sinuosa	D	1	0	D	8.0	0.0	D	8	0
Porites porites	89	9	17	92	71.5	137.0	1	8	8
Porites astreoides	13	103	116	9	951.0	1035.5	-3	9	9
Porites furcata	100	3	6	404	12.0	60.5	152	4	10
Madracis spp.	29	7	9	69	61.0	103.0	31	9	11
Madracis decactis	-50	4	2	-40	25.0	15.0	20	6	8
Millepora alcicornis	47	17	25	31	97.0	127.5	-11	6	5
Millepora complanata	19	113	135	4	2816.5	2925.5	-13	25	22
Eusmilia fastigiata	-40	5	3	-52	29.0	14.0	-20	6	5

(*=p<.05, **=p<.001)

Table 3. Chart showing the occurrence of reef coral species on transects in 1975 and 1982-3. A blank space means a species did not occur on a transect in either census. A period (.) depicts a species present in both surveys. An open circle (0) represents a species that was absent in 1975 and present in 1982-3 while an X represents a species that was present in 1975 and absent in 1982-3.

SPECIES	TRANSECT 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Acropora cervicornis						.	.						X			.		.	.		.
Acropora palmata												.	.	.	.	.	.	.	.	.	0
Mycetophyllia lamarckana	.	0		.		X	X			X											
Mycetophyllia ferox	0	X	.	X	.	X	X	0	X												
Mycetophyllia aliciae			X																		
Solenastrea hyades	X	X	X																		
Agaricia agaricites	0	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	0	.	0	.	.
Agaricia fragilis		X	X	.			.												0		
Agaricia lamarcki				.																	
Helioseris cucullata		.	.	.					0	0	X	0		X						0	
Colpophyllia natans	.			.	0	.	X			0											
Colpophyllia breviserialis			X	X	X																
Scolymia cubensis		.	0	X	X		X														
Mussa angulosa				0																	
Isophyllia sinuosa				X																	
Montastrea annularis	.	.	.	.	.	.	.	.		.											
Montastrea cavernosa	.	.	X	.	.		X				.										
Favia fragum							X			X	0		.	.	.	X	0	0	0	0	0
Siderastrea radians				X						X											0
Siderastrea siderea	.	.	.	.	.	.	.	0		.		X		0	X						
Dichocoenia stokesi								.	.	X											
Dichocoenia stellaris				0																	
Stephanocoenia michelini	0	.	.	.	.	.	.			X											
Diploria clivosa												.	0								
Porites porites		.		0	X	X	0	0		.	0							0	0	.	0
Porites astreoides		.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	X
Porites furcata				.	.	.													0		
Madracis spp.	0	.	0	.																	
Madracis decactis	.	X		0	X																
Millepora alcicornis		.	.	.	X	.	0	.	.	.	.			.							
Millepora complanata						0	0				.	.	.	.	.	.	.	.	.		
Eusmilia fastigiata	X			.	X	.															

PRESENT IN BOTH YEARS .
PRESENT ONLY IN 1982 0
PRESENT ONLY IN 1975 X

Table 4. Species diversity and evenness calculations for transects on Carysfort Reef, Key Largo, Fla. Calculations were made using both the abundance of coral colonies (n) and estimates of coral coverage (cm).

Tsect I.D.#	Diversity H´n 75	Diversity H´n 82-3	Evenness J´n 75	Evenness J´n 82-3	Diversity H´cm 75	Diversity H´cm 82-3	Evenness J´cm 75	Evenness J´cm 82-3
151	0.644	0.785	.713	.785	.506	.640	.561	.640
252	1.051	0.920	.894	.853	.905	.840	.769	.779
353	0.980	0.820	.880	.820	.788	.674	.708	.674
454	1.101	1.107	.846	.866	.919	.940	.706	.735
555	0.954	0.744	.833	.780	.570	.620	.497	.649
656	0.940	0.794	.844	.794	.660	.615	.592	.615
757	0.839	0.608	.754	.637	.413	.266	.371	.279
858	0.639	0.851	.914	.943	.160	.240	.229	.265
959	0.616	0.549	.881	.785	.599	.511	.857	.731
1060	0.894	0.722	.859	.855	.803	.691	.771	.817
1161	0.524	0.510	.673	.603	.272	.324	.350	.383
1262	0.588	0.639	.756	.821	.666	.601	.856	.772
1363	0.661	0.595	.850	.765	.521	.415	.669	.533
1464	0.691	0.668	.818	.790	.609	.509	.721	.602
1565	0.667	0.502	.858	.718	.360	.277	.462	.397
1666	0.689	0.448	.885	.641	.418	.264	.537	.378
1767	0.421	0.400	.883	.665	.284	.218	.595	.362
1868	0.600	0.523	.858	.619	.462	.311	.661	.368
1969	0.527	0.698	.875	.731	.355	.446	.589	.467
2070	0.439	0.560	.729	.720	.122	.382	.203	.492
2171	0.540	0.767	.896	.908	.479	.542	.795	.642

Table 5. Overall summary statistics of reef coral populations on Carysfort Reef for 1975 and 1982-3 surveys. Species diversity (H′) and equitability (J′) were computed using both number of colonies and centimeters coverage of coral as measures of coral abundance. Significance testing was carried out on data for each pair of transects (1975 and 1982-3) using a Wilcoxon Matched-pair Signed Rank Test with two-tailed test in which the alternate hypothesis states that the pairs could differ in either direction.

Parameter	1975	1982-3	Change	Probability of similarity
Colony abundance (n)	756	841	0	ns
Diversity (H′ colony)	1.1503	1.0534	-	<.005
Equitability (J′ colony)	0.7788	0.7279	-	<.005
Diversity (H′ cover)	0.9113	0.8730	-	<.005
Equitability (J′ cover)	0.6170	0.6032	-	<.01
Coverage (total cm.)	16109.5	17438.0	+	<.05
Coverage (percent)	31.6	32.2	+	<.01

Table 6. Abundance of juvenile corals (less than 15cm greatest diameter) at 13m on Carysfort Reef. The settlement site was established in 1975 and data first presented from March and October 1975 for 6.5,9 and 13m. In August 1983 only the deep (13m) site was censused. Data is summed for both original plots (see Dustan, 1977 for details).

Coral species	Number of coral colonies 3/75	10/75	8/83
Agaricia agaricites	61	36	7
Agaricia fragilis	14	11	3
Helioseris cucullata	10	8	3
Porites porites	10	3	1
Porites astreoides	13	12	5
Siderastrea siderea	8	6	4
Siderastrea radians	0	0	1
Mycetophyllia lamarckiana	6	8	1
Mycetophyllia ferox	0	1	0
Scolymia lacera	0	1	1
Eusmilia fastigiata	3	3	2
Montastrea cavernosa	2	1	0
Montastrea annularis	0	0	2
Colpophyllia natans	1	0	0
Madracis spp.	8	2	7
Total colonies	136	92	37

Figure Legends

Figure 1. Location of Carysfort Reef, Key Largo, Florida.

Figure 2. The *Acropora cervicornis* zone on Carysfort Reef near transect 7 (Meter 40 at 12m depth): The picture labelled 1974 was taken in December 1974 and shows rich growth of *A.cervicornis*. In July 1985 the *A. cervicornis* had decreased in colony size, coverage, and the extend to which its branches are covered with living tissue.

Figure 3. Distribution of reef-coral abundance (number of colonies) and coral coverage (centimeters of intercepted transect line) on Carysfort Reef, Key Largo, Florida. The location of transects are marked with asterisks and numbered along the reef profile which is provided for perspective (see Table 1). (dashed line = 1975 , solid line = from 1982-3)

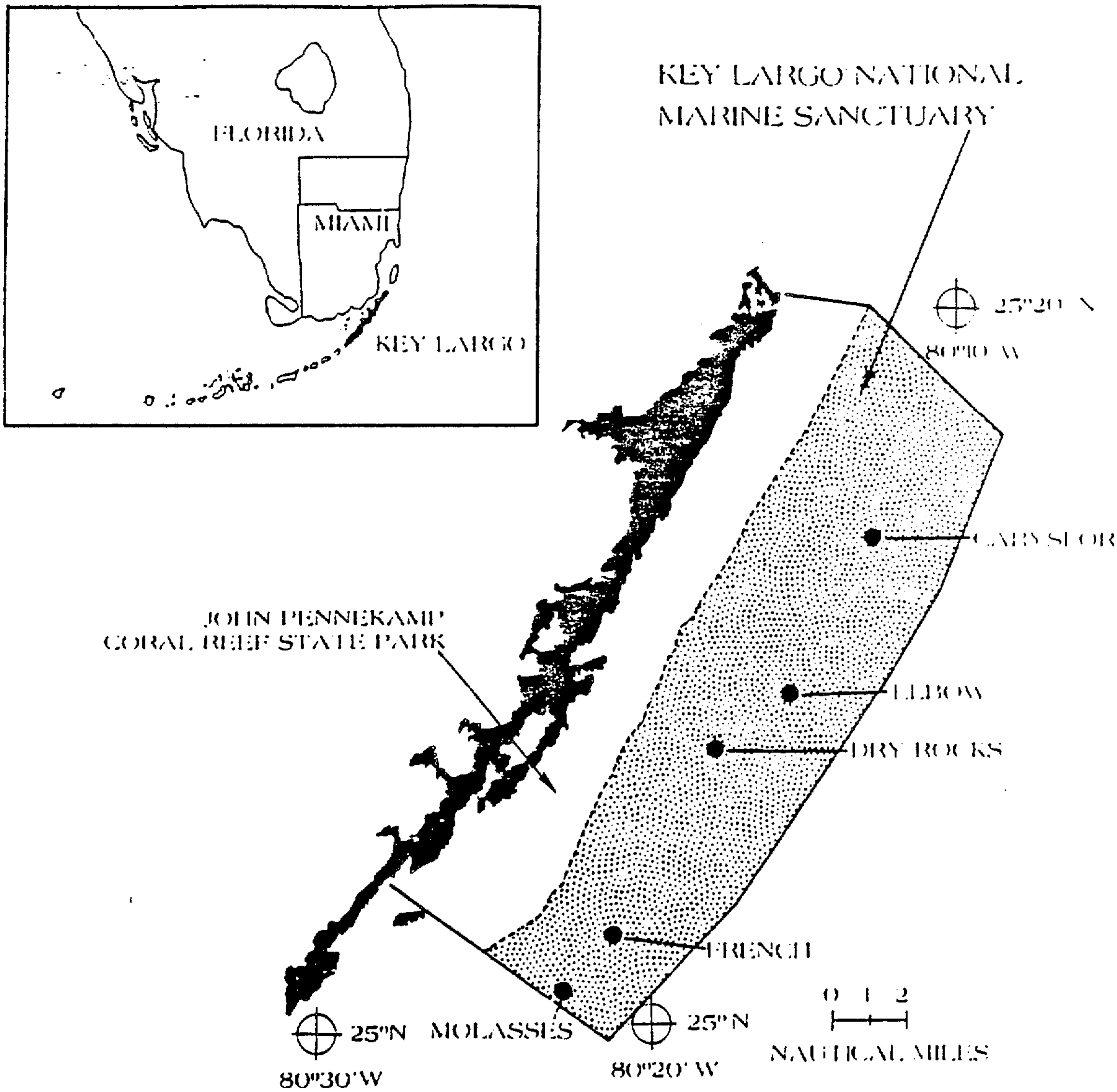
Figure 4. Distribution of reef coral mean colony size (mean intercept distance) and percent coral coverage on Carysfort Reef, Key Largo, Florida. The location of transects are marked with asterisks and numbered along the reef profile which is provided for perspective. (dashed line = 1975, solid line = 1982-3).

Figure 5. Distribution of reef coral species diversity (H′) on Carysfort Reef, Key Largo, Fla. Colony diversity computed using the number of colonies as a measure of abundance. Cover diversity computed using the centimeters of intercepted line transect as a measure of abundance of species. Transect locations are marked with asterisks and numbered along the reef profile. (dashed line = 1975, solid = 1982-3, see Table 1).

Figure 6. Distribution of Evenness on Carysfort Reef. Colony evenness computed using the number of colonies as a measure of abundance while cover evenness was computed using the number of intercepted centimeters of transect line as a measure of abundance. Transect locations are marked with asterisks and numbered along the reef profile. (dashed line = 1975, solid line = 1982-3, see Table 1).

Figure 7. The Acropora palmata zone on Carysfort Reef: The lower photograph (labelled 1975) was taken in August 1975 and looks northeast across rich coral growth of A. palmata in the region of transects 16 and 17 (Meters 180-210 in Figure 3.) The reef flat is just to the left of the frame. The upper picture (labelled 1985) was taken in July 1985 in the same region of the reef. The photograph was taken at the outer edge of the reef flat looking seaward towards transects 16 and 17. The v-shaped cut in the reef visible just left of center is typically the type of scar left by a vessel grounding. Most of the large colonies of A. palmata have been reduced to rubble. The destruction of these coral colonies explains the decrease in mean colony size on this species, while the spread of small fractured pieces results in an increase in coverage and number of colonies.

Figure 8. The fore reef terrace of Carysfort Reef in 1975 and 1985. Pictures are of similar coral colonies of Montastrea annularis at 14-16m along the edge of the escarpment in the region of transect 4 (Meter10 in Fig. 2). Colonies of M. annularis in 1975 showed little signs of tissue necrosis while in 1985 many colonies were showing signs of white plague, sediment damage, and subsequent overgrowth by fleshy algae.



Location of Carysfort Reef, Key Largo, Florida.

Figure 1.

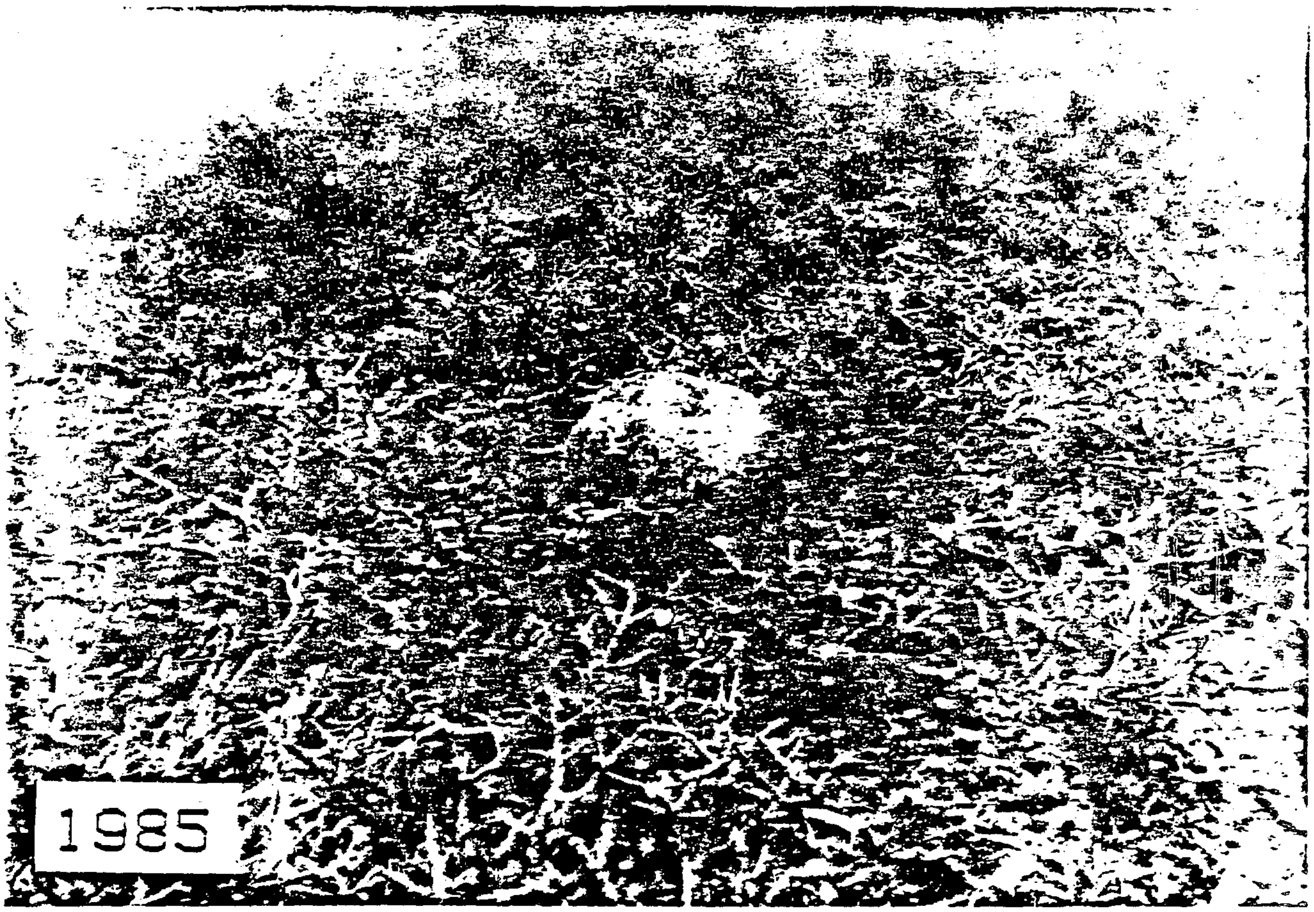
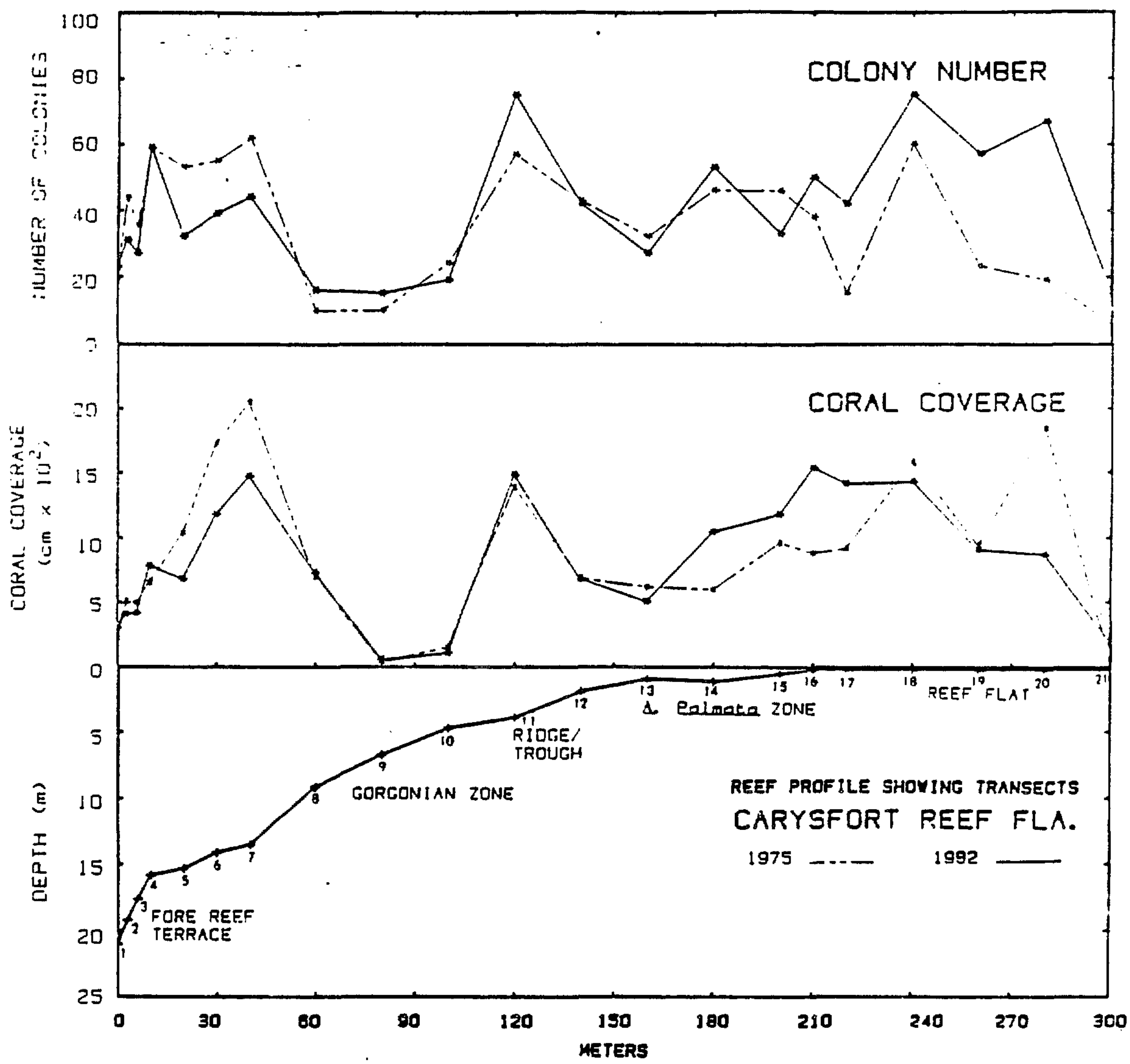


Figure 2.



COLONY NUMBER
NUMBER OF COLONIES
CORAL COVERAGE
CORAL COVERAGE (cm x 10²)
DEPTH (m)
FORE REEF TERRACE
GORGONIAN ZONE
RIDGE/ TROUGH
A. Palmata ZONE
REEF FLAT
REEF PROFILE SHOWING TRANSECTS
CARYSFORT REEF FLA.
1975
1982
METERS

Figure 3.

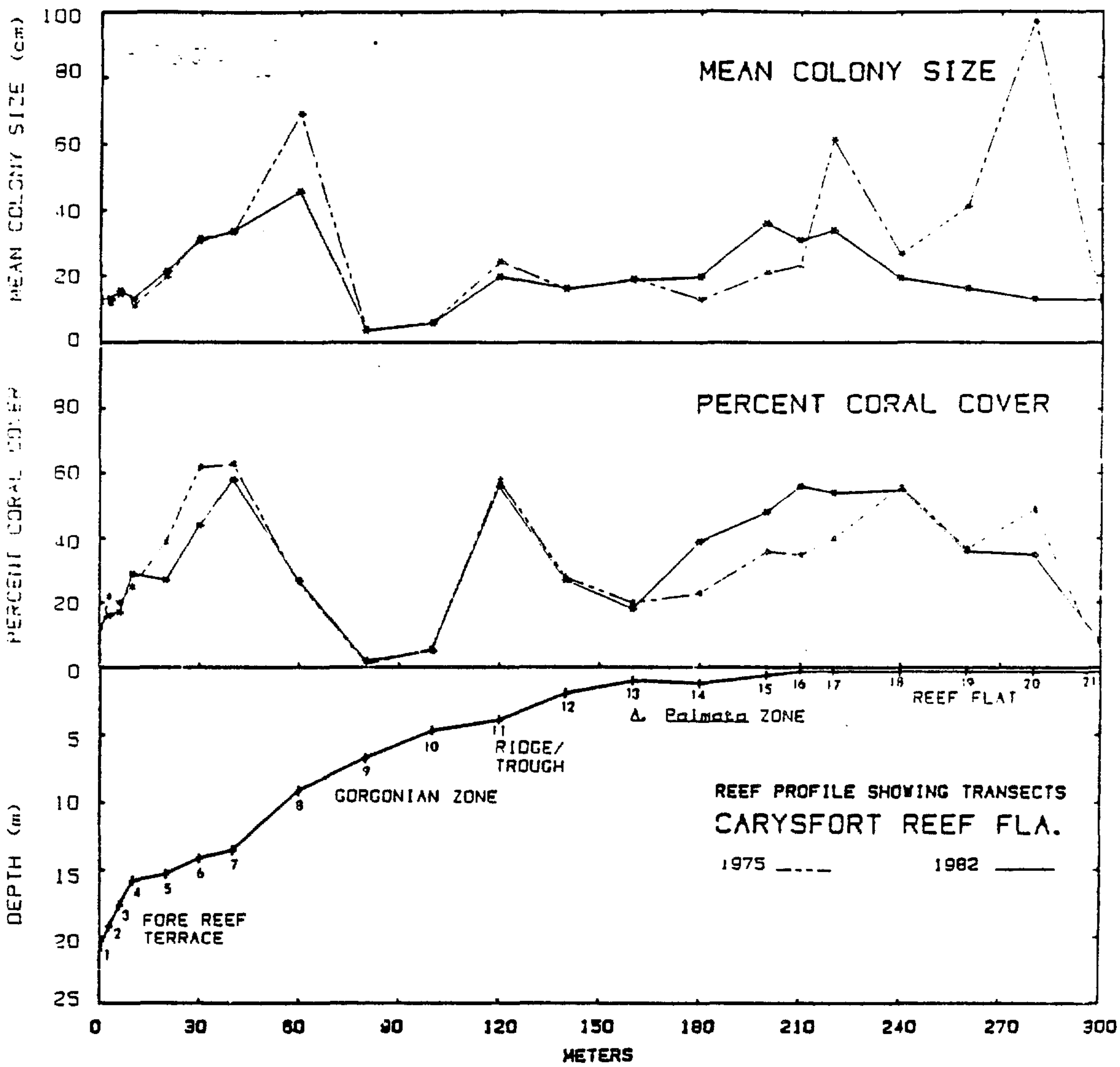
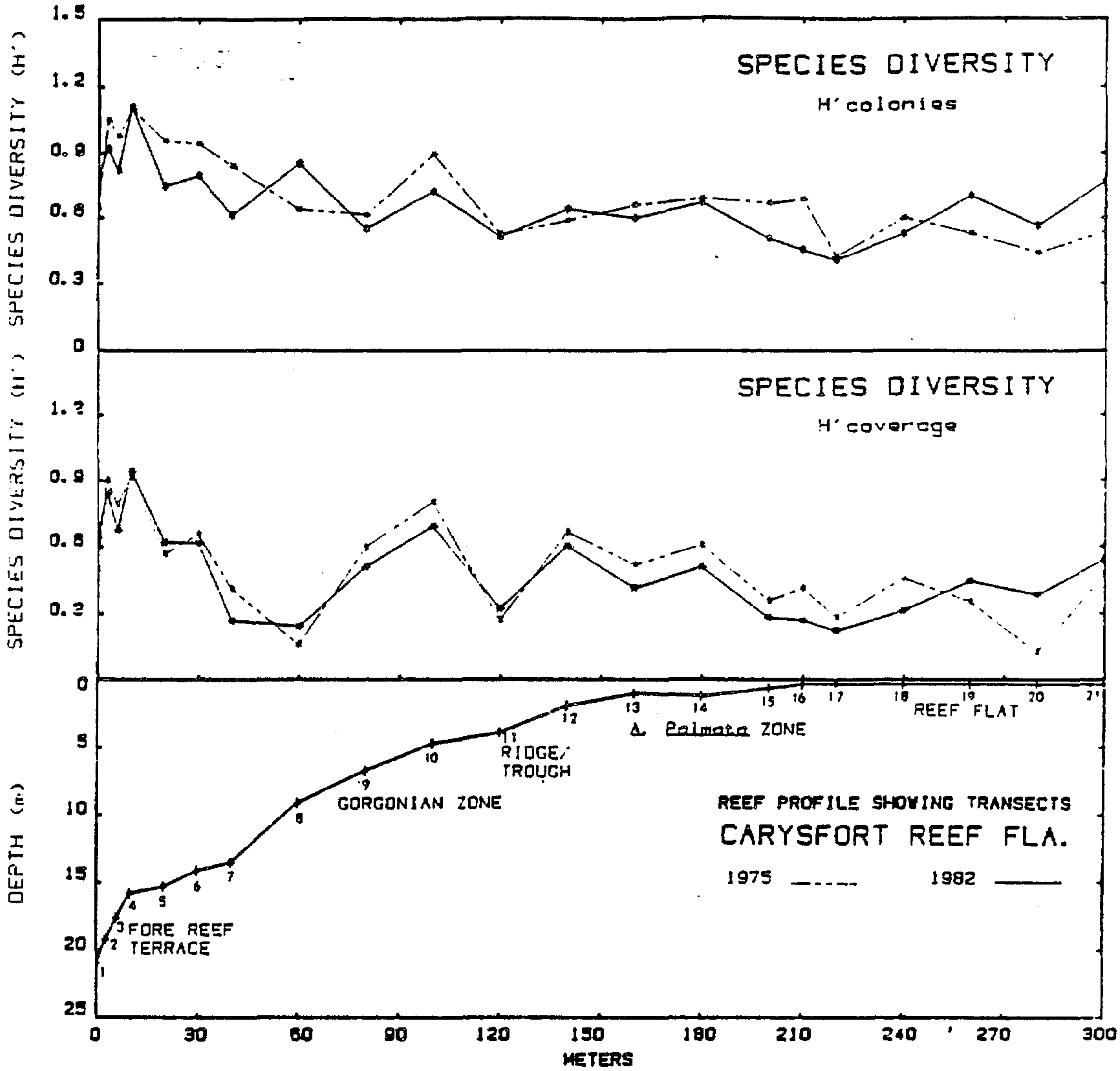

MEAN COLONY SIZE
PERCENT CORAL COVER
MEAN COLONY SIZE (cm)
PERCENT CORAL COVER
DEPTH (m)
METERS
FORE REEF
TERRACE
GORGONIAN ZONE
RIDGE/
TROUGH
A. Palmata ZONE
REEF FLAT
REEF PROFILE SHOWING TRANSECTS
CARYSFORT REEF FLA.
1975
1982

Figure 4.



SPECIES DIVERSITY
H' colonies
SPECIES DIVERSITY (H')
SPECIES DIVERSITY
H' coverage
SPECIES DIVERSITY (H')
DEPTH (m)
REEF FLAT
A. Palmata ZONE
RIDGE/
TROUGH
GORGONIAN ZONE
FORE REEF
TERRACE
REEF PROFILE SHOWING TRANSECTS
CARYSFORT REEF FLA.
1975
1982
METERS

Figure 5.

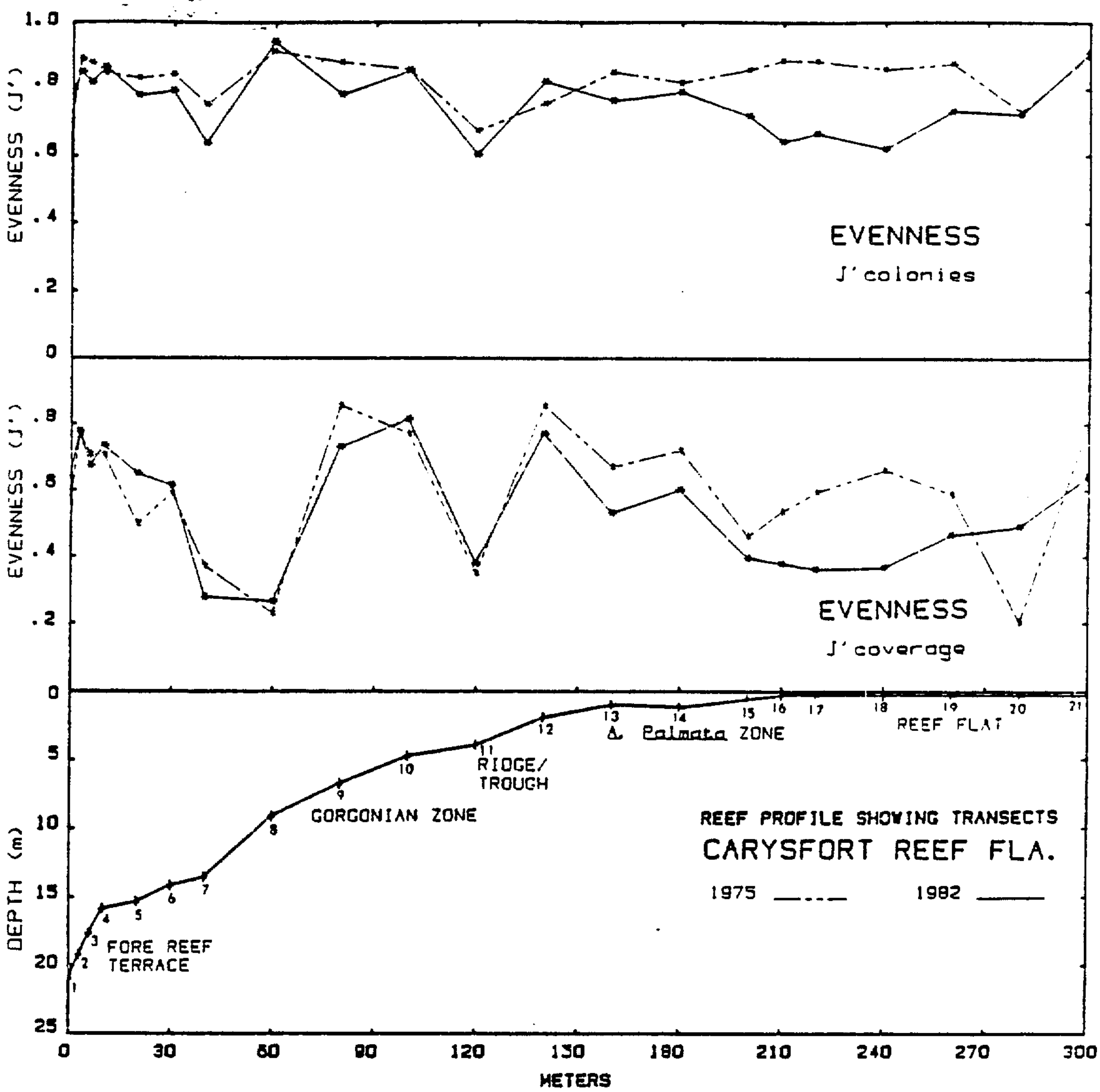

EVENNESS (J')
EVENNESS
J'colonies
EVENNESS (J')
EVENNESS
J'coverage
DEPTH (m)
A. Palmata ZONE
REEF FLAT
RIDGE/
TROUGH
GORGONIAN ZONE
FORE REEF
TERRACE
REEF PROFILE SHOWING TRANSECTS
CARYSFORT REEF FLA.
1975
1982
METERS

Figure 6.

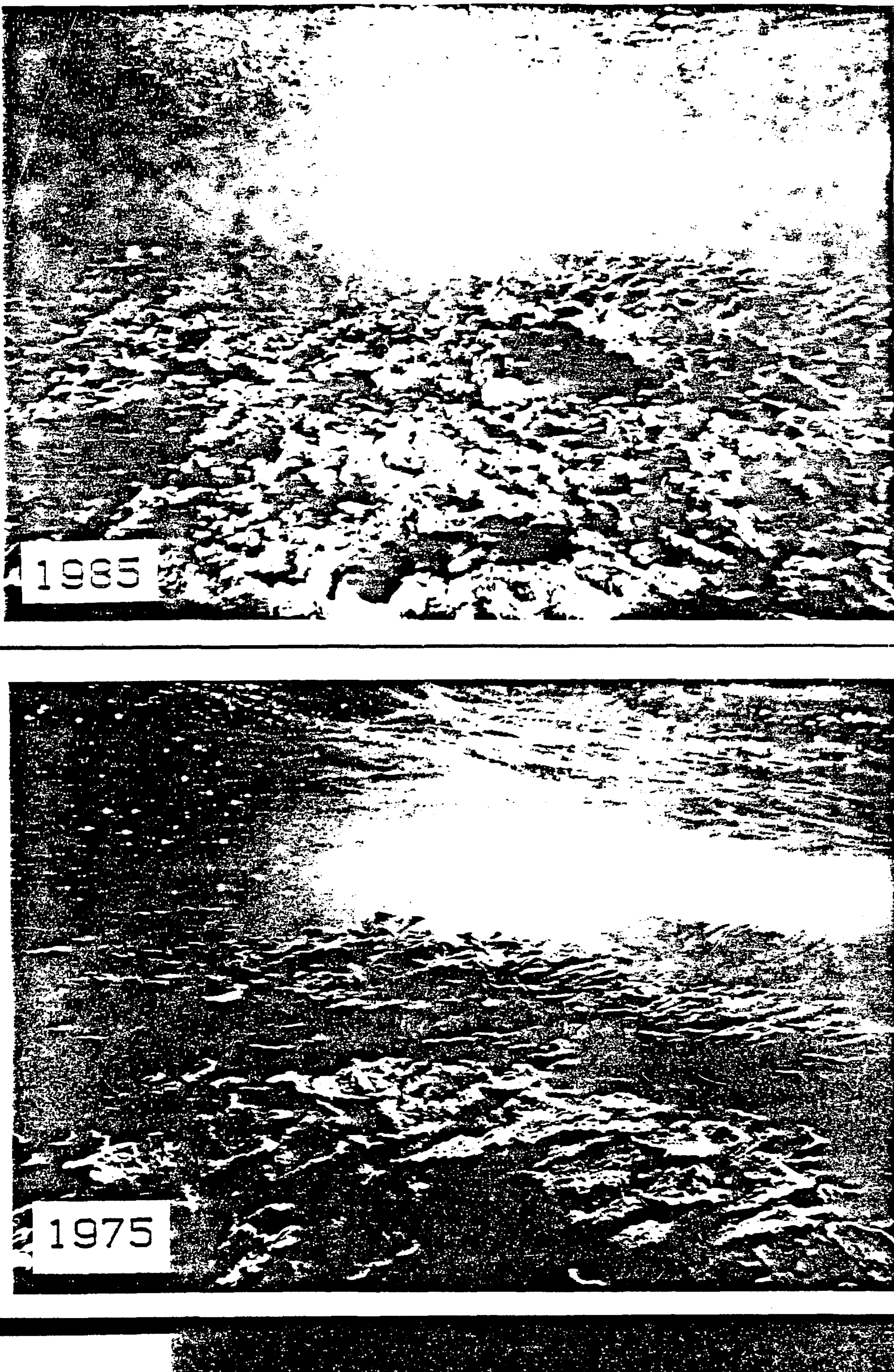


Figura 7.

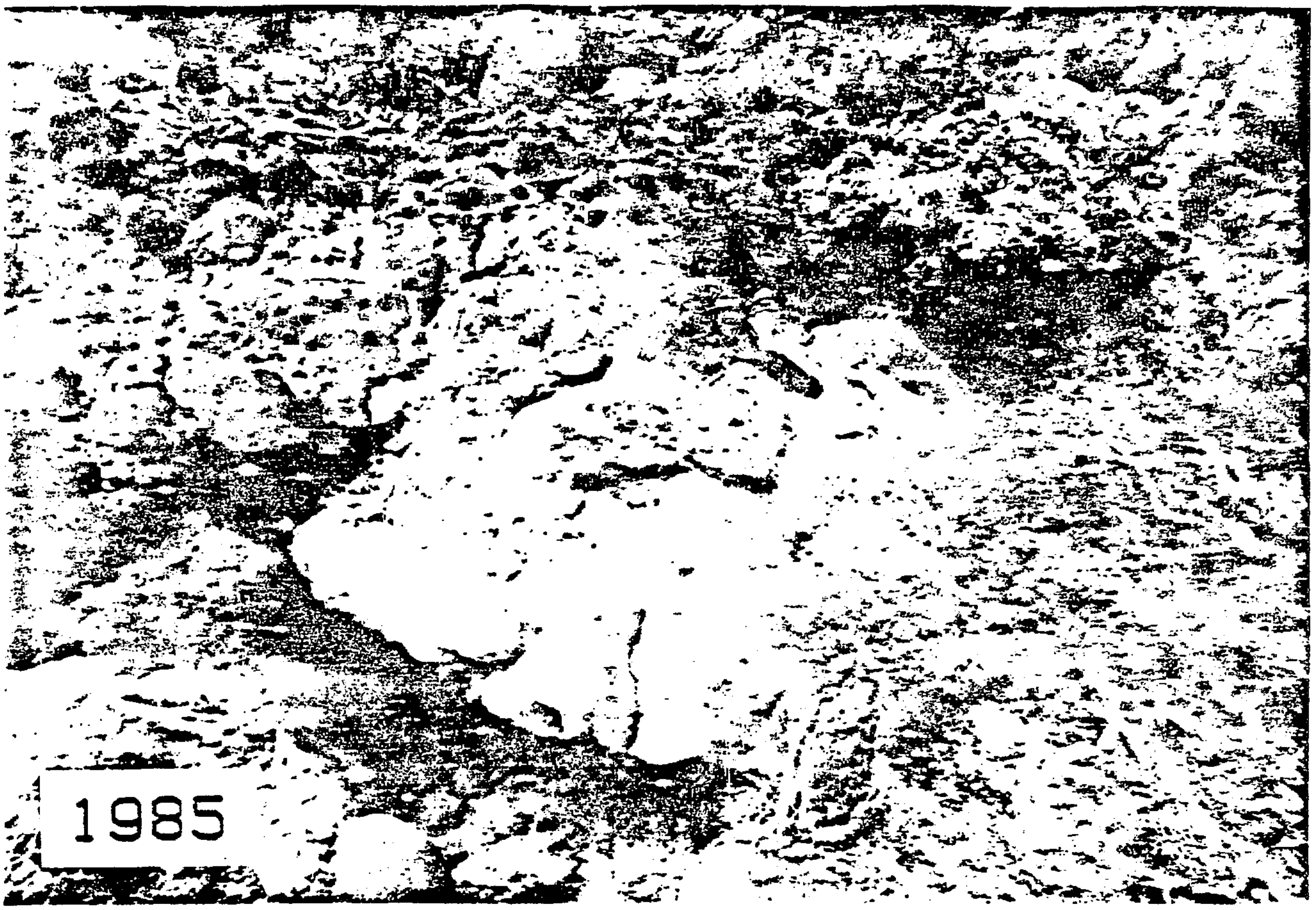


Figura 8.

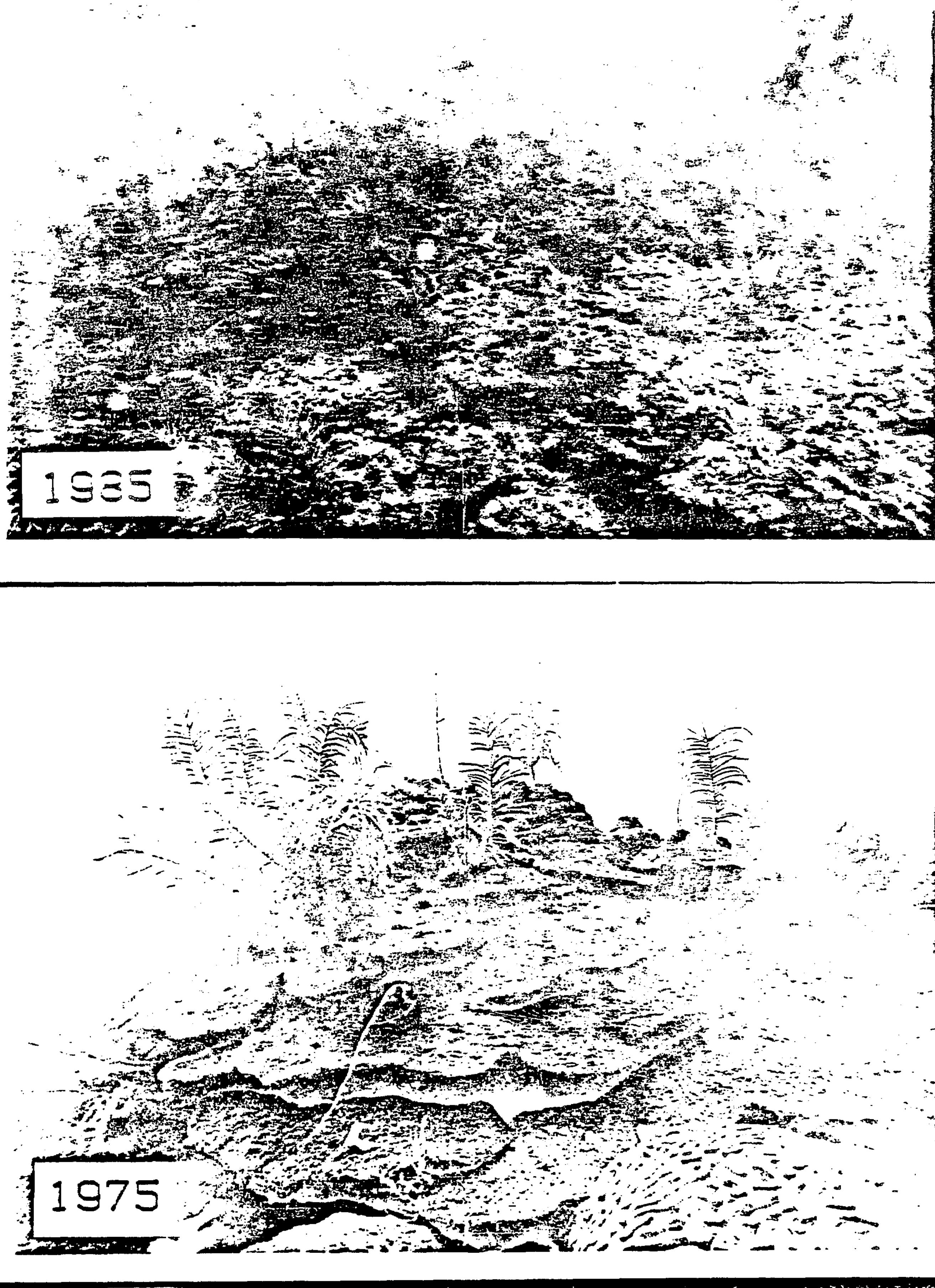


Figure 8.

Appendix A: Listing of change that occurred in each species of reef coral on each transect between 1975 and 1982-3 on Carysfort Reef. The %Chng column denotes the percentage change between the parameter for the two survey periods. An "A" appears in the %Chng column if the species was absent in 1975 and present in 1982-3. The disappearance of a species from 1975 to 1982-3 is denoted by "D".

Transect Number	Species	Number of Colonies (n)			Species Coverage (cm)			Mean Colony Size (cm)		
		%Chng	75	82	%Chng	75	82	%Chng	75	82
151	Mycetophyllia lamarckana	0	1	1	67	3.0	5.0	67	3	5
151	Mycetophyllia ferox	A	0	1	A	0.0	22.0	A	0	22
151	Solenastrea hyades	D	1	0	D	39.0	0.0	D	39	0
151	Agaricia agaricites	A	0	1	A	0.0	7.0	A	0	7
151	Colpophyllia natans	0	1	1	20	5.0	6.0	20	5	6
151	Montastrea annularis	0	1	1	0	5.0	5.0	0	5	5
151	Montastrea cavernosa	100	1	2	140	7.5	18.0	20	8	9
151	Siderastrea siderea	0	11	11	21	148.0	179.0	21	13	16
151	Stephanocoenia michelini	A	0	2	A	0.0	22.0	A	0	11
151	Madracis spp.	A	0	2	A	0.0	34.0	A	0	17
151	Madracis decactis	-50	2	1	-50	10.0	5.0	0	5	5
151	Eusmilia fastigiata	D	1	0	D	7.0	0.0	D	7	0
252	Mycetophyllia lamarckana	A	0	1	A	0.0	4.0	A	0	4
252	Mycetophyllia ferox	D	1	0	D	3.0	0.0	D	3	0
252	Solenastrea hyades	D	4	0	D	35.0	0.0	D	9	0
252	Agaricia agaricites	-33	3	2	8	12.0	13.0	63	4	7
252	Agaricia fragilis	D	3	0	D	15.0	0.0	D	5	0
252	Helioseris cucullata	-50	2	1	140	10.0	24.0	380	5	24
252	Scolymia cubensis	0	1	1	50	2.0	3.0	50	2	3
252	Montastrea annularis	0	1	1	65	20.0	33.0	65	20	33
252	Montastrea cavernosa	-33	3	2	13	38.0	43.0	70	13	22
252	Siderastrea siderea	-9	11	10	-4	158.0	151.0	5	14	15
252	Stephanocoenia michelini	-17	6	5	-53	117.0	55.0	-44	20	11
252	Porites porites	0	1	1	-29	7.0	5.0	-29	7	5
252	Porites astreoides	33	3	4	4	53.0	55.0	-22	18	14
252	Madracis spp.	0	2	2	-14	28.0	24.0	-14	14	12
252	Madracis decactis	D	1	0	D	5.0	0.0	D	5	0
252	Millepora alcicornis	-50	2	1	-86	7.0	1.0	-71	4	1
353	Mycetophyllia ferox	0	1	1	220	5.0	16.0	220	5	16
353	Mycetophyllia aliciae	D	1	0	D	13.0	0.0	D	13	0
353	Solenastrea hyades	D	2	0	D	13.0	0.0	D	7	0
353	Agaricia agaricites	-75	4	1	-89	19.0	2.0	-58	5	2
353	Agaricia fragilis	D	1	0	D	1.0	0.0	D	1	0
353	Helioseris cucullata	100	1	2	105	11.0	22.5	2	11	11
353	Colpophyllia breviserialis	D	1	0	D	25.0	0.0	D	25	0
353	Scolymia cubensis	A	0	2	A	0.0	6.0	A	0	3
353	Montastrea annularis	-40	5	3	-73	86.0	23.0	-55	17	8
353	Montastrea cavernosa	D	2	0	D	16.0	0.0	D	8	0
353	Siderastrea siderea	10	10	11	4	221.0	229.0	-6	22	21
353	Stephanocoenia michelini	-50	2	1	-15	68.0	58.0	71	34	58
353	Porites astreoides	33	3	4	246	12.0	41.5	159	4	10
353	Madracis spp.	A	0	1	A	0.0	18.0	A	0	18
353	Millepora alcicornis	-50	2	1	-33	9.0	6.0	33	5	6
454	Mycetophyllia lamarckana	0	1	1	33	6.0	8.0	33	6	8
454	Mycetophyllia ferox	D	3	0	D	44.0	0.0	D	15	0
454	Agaricia agaricites	-25	4	3	-32	17.0	11.5	-10	4	4
454	Agaricia lamarcki	0	1	1	14	21.0	24.0	14	21	24
454	Agaricia fragilis	-50	2	1	-50	12.0	6.0	0	6	6
454	Helioseris cucullata	50	2	3	488	4.0	23.5	292	2	8
454	Colpophyllia natans	100	1	2	2225	2.0	46.5	1063	2	23
454	Colpophyllia breviserialis	D	1	0	D	21.0	0.0	D	21	0
454	Scolymia cubensis	D	1	0	D	1.0	0.0	D	1	0
454	Mussa angulosa	A	0	1	A	0.0	2.5	A	0	3
454	Montastrea annularis	60	5	8	94	93.0	180.0	21	19	23
454	Montastrea cavernosa	-67	3	1	-41	29.0	17.0	76	10	17
454	Siderastrea radians	D	1	0	D	3.0	0.0	D	3	0
454	Siderastrea siderea	-33	18	12	-35	268.0	174.2	-2	15	15
454	Dichocoenia stellaris	A	0	1	A	0.0	6.5	A	0	7
454	Stephanocoenia michelini	300	2	8	175	61.0	168.0	-31	31	21
454	Isophyllia sinuosa	D	1	0	D	8.0	0.0	D	8	0

Transect Number	Species	Number of Colonies (n) %Chng	75	82	Species Coverage (cm) %Chng	75	82	Mean Colony Size (cm) %Chng	75	82
454	Porites porites	A	0	1	A	0.0	2.0	A	0	2
454	Porites astreoides	100	3	6	388	12.5	61.0	144	4	10
454	Porites furcata	0	1	1	175	2.0	5.5	175	2	6
454	Madracis spp.	-20	5	4	-18	33.0	27.0	2	7	7
454	Madracis decactis	A	0	1	A	0.0	10.0	A	0	10
454	Millepora alcicornis	-33	3	2	-70	10.0	3.0	-55	3	2
454	Eusmilia fastigiata	100	1	2	22	9.0	11.0	-39	9	6
555	Mycetophyllia ferox	0	1	1	-73	11.0	3.0	-73	11	3
555	Agaricia agaricites	-40	5	3	14	14.0	16.0	90	3	5
555	Colpophyllia natans	A	0	2	A	0.0	59.0	A	0	30
555	Colpophyllia breviserialis	D	4	0	D	201.0	0.0	D	50	0
555	Scolymia cubensis	D	1	0	D	2.5	0.0	D	3	0
555	Montastrea annularis	-19	16	13	-40	632.0	379.0	-26	40	29
555	Montastrea cavernosa	0	1	1	467	3.0	17.0	467	3	17
555	Siderastrea siderea	-20	10	8	20	92.0	110.0	49	9	14
555	Stephanocoenia michelini	-50	4	2	50	46.0	69.0	200	12	35
555	Porites porites	D	2	0	D	6.0	0.0	D	3	0
555	Porites astreoides	-50	2	1	50	4.0	6.0	200	2	6
555	Porites furcata	0	1	1	380	5.0	24.0	380	5	24
555	Madracis decactis	D	1	0	D	10.0	0.0	D	10	0
555	Millepora alcicornis	D	3	0	D	8.0	0.0	D	3	0
555	Eusmilia fastigiata	D	2	0	D	10.0	0.0	D	5	0
656	Acropora cervicornis	-14	7	6	3	490.0	504.0	20	70	84
656	Mycetophyllia lamarckana	D	1	0	D	4.0	0.0	D	4	0
656	Mycetophyllia ferox	D	2	0	D	60.0	0.0	D	30	0
656	Agaricia agaricites	D	6	0	D	21.5	0.0	D	4	0
656	Colpophyllia natans	-50	6	3	-21	122.0	96.0	57	20	32
656	Montastrea annularis	0	17	17	-48	811.0	424.0	-48	48	25
656	Siderastrea siderea	-25	4	3	-50	102.0	50.5	-34	26	17
656	Stephanocoenia michelini	-25	4	3	-1	58.0	57.5	32	15	19
656	Porites porites	D	1	0	D	8.0	0.0	D	8	0
656	Porites astreoides	-50	4	2	-54	43.5	20.0	-8	11	10
656	Porites furcata	100	1	2	440	5.0	27.0	170	5	14
656	Millepora alcicornis	0	1	1	50	2.0	3.0	50	2	3
656	Millepora complanata	A	0	1	A	0.0	3.0	A	0	3
656	Eusmilia fastigiata	0	1	1	0	3.0	3.0	0	3	3
757	Acropora cervicornis	4	25	26	-17	1547.0	1278.0	-21	62	49
757	Mycetophyllia lamarckana	D	3	0	D	17.0	0.0	D	6	0
757	Mycetophyllia ferox	D	2	0	D	19.0	0.0	D	10	0
757	Agaricia agaricites	67	3	5	92	26.0	50.0	15	9	10
757	Agaricia fragilis	0	1	1	0	2.0	2.0	0	2	2
757	Colpophyllia natans	D	1	0	D	30.0	0.0	D	30	0
757	Scolymia cubensis	D	1	0	D	1.0	0.0	D	1	0
757	Montastrea annularis	-89	9	1	-91	257.5	22.0	-23	29	22
757	Montastrea cavernosa	D	1	0	D	4.0	0.0	D	4	0
757	Favia fragum	D	1	0	D	1.0	0.0	D	1	0
757	Siderastrea siderea	-33	9	6	-17	86.5	72.0	25	10	12
757	Stephanocoenia michelini	-80	5	1	-80	51.0	10.0	-2	10	10
757	Porites porites	A	0	2	A	0.0	26.0	A	0	13
757	Porites astreoides	D	1	0	D	10.0	0.0	D	10	0
757	Millepora alcicornis	A	0	1	A	0.0	1.0	A	0	1
757	Millepora complanata	A	0	1	A	0.0	14.0	A	0	14
858	Mycetophyllia ferox	A	0	1	A	0.0	2.0	A	0	2
858	Agaricia agaricites	0	2	2	22	20.5	25.0	22	10	13
858	Montastrea annularis	0	1	1	2	640.0	650.0	2	640	650
858	Siderastrea siderea	A	0	1	A	0.0	6.0	A	0	6
858	Dichocoenia stokesi	-50	4	2	-16	19.0	16.0	68	5	8
858	Porites porites	A	0	2	A	0.0	16.0	A	0	8
858	Porites astreoides	100	2	4	120	5.0	11.0	10	3	3
858	Millepora alcicornis	200	1	3	-22	9.0	7.0	-74	9	2
959	Mycetophyllia ferox	D	1	0	D	7.0	0.0	D	7	0
959	Agaricia agaricites	25	4	5	24	16.5	20.5	-1	4	4
959	Helioseris cucullata	A	0	1	A	0.0	3.0	A	0	3
959	Dichocoenia stokesi	-67	3	1	-71	10.5	3.0	-14	4	3
959	Porites astreoides	0	1	1	100	1.5	3.0	100	2	3
959	Millepora alcicornis	600	1	7	613	4.0	28.5	2	4	4
1060	Mycetophyllia lamarckana	D	1	0	D	6.0	0.0	D	6	0
1060	Agaricia agaricites	-25	8	6	-27	22.0	16.0	-3	3	3
1060	Helioseris cucullata	A	0	1	A	0.0	5.5	A	0	6

Transect Number	Species	Number of Colonies (n) %Chng	75	82	Species Coverage (cm) %Chng	75	82	Mean Colony Size (cm) %Chng	75	82
1060	Colpophyllia natans	A	0	1	A	0.0	1.5	A	0	2
1060	Montastrea annularis	0	4	4	0	48.0	48.2	0	12	12
1060	Favia fragum	D	1	0	D	1.5	0.0	D	2	0
1060	Siderastrea radians	D	1	0	D	1.0	0.0	D	1	0
1060	Siderastrea siderea	0	1	1	114	7.0	15.0	114	7	15
1060	Dichocoenia stokesi	D	2	0	D	10.0	0.0	D	5	0
1060	Stephanocoenia michelini	D	1	0	D	44.0	0.0	D	44	0
1060	Porites porites	-67	3	1	8	6.5	7.0	223	2	7
1060	Porites astreoides	D	1	0	D	1.0	0.0	D	1	0
1060	Millepora alcicornis	400	1	5	100	10.0	20.0	-60	10	4
1161	Agaricia agaricites	18	11	13	78	69.0	123.0	51	6	9
1161	Helioseris cucullata	D	1	0	D	3.0	0.0	D	3	0
1161	Montastrea cavernosa	0	1	1	-19	26.0	21.0	-19	26	21
1161	Favia fragum	A	0	1	A	0.0	1.5	A	0	2
1161	Porites porites	A	0	1	A	0.0	18.0	A	0	18
1161	Porites astreoides	0	10	10	-11	101.0	90.0	-11	10	9
1161	Millepora alcicornis	50	2	3	61	18.0	29.0	7	9	10
1161	Millepora complanata	44	32	46	2	1174.0	1201.5	-29	37	26
1161	Zoanthid (Palythoa)	D	3	0	D	29.0	0.0	D	10	0
1262	Acropora palmata	600	1	7	53	141.0	216.0	-78	141	31
1262	Agaricia agaricites	-18	11	9	-26	57.0	42.0	-10	5	5
1262	Helioseris cucullata	A	0	1	A	0.0	6.5	A	0	7
1262	Siderastrea siderea	D	2	0	D	38.0	0.0	D	19	0
1262	Diploria clivosa	0	1	1	2	60.0	61.0	2	60	61
1262	Porites astreoides	-22	9	7	-27	91.0	66.0	-7	10	9
1262	Millepora complanata	-11	19	17	-2	300.0	293.0	9	16	17
1262	Zoanthid (Palythoa)	0	5	5	35	104.0	140.0	35	21	28
1363	Acropora palmata	60	5	8	-49	270.0	138.0	-68	54	17
1363	Acropora cervicornis	D	2	0	D	37.0	0.0	D	19	0
1363	Agaricia agaricites	-50	2	1	0	4.0	4.0	100	2	4
1363	Favia fragum	-50	2	1	-79	7.0	1.5	-57	4	2
1363	Diploria clivosa	A	0	1	A	0.0	7.0	A	0	7
1363	Porites astreoides	-50	8	4	-33	56.5	38.0	35	7	10
1363	Millepora complanata	-8	13	12	30	244.5	319.0	41	19	27
1363	Zoanthid (Palythoa)	400	5	25	387	203.0	989.0	-3	41	40
1464	Acropora palmata	300	2	8	338	125.0	548.0	10	63	69
1464	Agaricia agaricites	-50	12	6	-65	51.0	18.0	-29	4	3
1464	Helioseris cucullata	D	2	0	D	4.0	0.0	D	2	0
1464	Favia fragum	-67	3	1	-70	5.0	1.5	-10	2	2
1464	Siderastrea siderea	A	0	2	A	0.0	16.0	A	0	8
1464	Porites astreoides	55	11	17	-15	120.0	102.0	-45	11	6
1464	Millepora alcicornis	0	1	1	45	20.0	29.0	45	20	29
1464	Millepora complanata	20	15	18	22	275.0	335.0	2	18	19
1464	Zoanthid (Palythoa)	A	0	4	A	0.0	107.0	A	0	27
1565	Acropora palmata	19	16	19	22	748.0	913.0	3	47	48
1565	Agaricia agaricites	-90	10	1	-87	27.0	3.5	30	3	4
1565	Favia fragum	0	2	2	40	5.0	7.0	40	3	4
1565	Siderastrea siderea	D	1	0	D	23.0	0.0	D	23	0
1565	Porites astreoides	-70	10	3	-77	81.0	19.0	-22	8	6
1565	Millepora complanata	14	7	8	203	80.0	242.0	165	11	30
1565	Zoanthid (Palythoa)	500	1	6	323	66.0	279.0	-30	66	47
1666	Acropora palmata	154	13	33	115	592.0	1273.0	-15	46	39
1666	Acropora cervicornis	-33	3	2	-53	59.0	28.0	-29	20	14
1666	Agaricia agaricites	-67	3	1	-44	9.0	5.0	67	3	5
1666	Favia fragum	D	2	0	D	4.0	0.0	D	2	0
1666	Porites astreoides	0	7	7	79	28.0	50.0	79	4	7
1666	Millepora complanata	-30	10	7	-7	193.0	179.0	32	19	26
1666	Zoanthid (Palythoa)	-67	6	2	-51	335.0	164.0	47	56	82
1767	Acropora palmata	200	8	24	80	645.0	1158.0	-40	81	48
1767	Agaricia agaricites	A	0	1	A	0.0	4.0	A	0	4
1767	Favia fragum	A	0	2	A	0.0	4.0	A	0	2
1767	Porites astreoides	D	2	0	D	9.0	0.0	D	5	0
1767	Millepora complanata	200	5	15	-7	267.0	248.0	-69	53	17
1767	Zoanthid (Palythoa)	113	8	17	19	600.0	713.0	-44	75	42
1868	Acropora palmata	57	28	44	14	1006.0	1143.0	-28	36	26
1868	Acropora cervicornis	-88	8	1	-95	203.0	11.0	-57	25	11
1868	Agaricia agaricites	-67	3	1	-33	9.0	6.0	100	3	6
1868	Favia fragum	A	0	2	A	0.0	6.5	A	0	3
1868	Porites porites	A	0	2	A	0.0	8.0	A	0	4

Transect Number	Species	Number of Colonies (n) %Chng	75	82	Species Coverage (cm) %Chng	75	82	Mean Colony Size (cm) %Chng	75	82
1868	Porites astreoides	33	12	16	44	119.0	171.0	8	10	11
1868	Millepora complanata	0	9	9	-65	244.0	86.0	-65	27	10
1868	Zoanthid (Palythoa)	-50	4	2	7	57.0	61.0	114	14	31
1969	Acropora palmata	144	9	22	-10	704.0	633.0	-63	78	29
1969	Acropora cervicornis	100	2	4	-24	67.0	51.0	-62	34	13
1969	Agaricia agaricites	A	0	3	A	0.0	21.0	A	0	7
1969	Agaricia fragilis	A	0	1	A	0.0	10.0	A	0	10
1969	Favia fragum	A	0	2	A	0.0	5.0	A	0	3
1969	Porites porites	A	0	3	A	0.0	22.0	A	0	7
1969	Porites astreoides	111	9	19	18	135.0	159.0	-44	15	8
1969	Porites furcata	A	0	2	A	0.0	4.0	A	0	2
1969	Millepora complanata	-67	3	1	-87	39.0	5.0	-62	13	5
1969	Zoanthid (Palythoa)	100	3	6	13	419.0	472.0	-44	140	79
2070	Acropora palmata	183	12	34	-64	1734.0	632.0	-87	145	19
2070	Agaricia agaricites	1500	1	16	1120	5.0	61.0	-24	5	4
2070	Helioseris cucullata	A	0	1	A	0.0	3.0	A	0	3
2070	Favia fragum	A	0	2	A	0.0	5.5	A	0	3
2070	Porites porites	50	2	3	-34	44.0	29.0	-56	22	10
2070	Porites astreoides	175	4	11	123	64.0	143.0	-19	16	13
2070	Zoanthid (Palythoa)	0	1	1	-55	84.0	38.0	-55	84	38
2171	Acropora palmata	A	0	2	A	0.0	11.5	A	0	6
2171	Acropora cervicornis	0	1	1	327	26.0	111.0	327	26	111
2171	Agaricia agaricites	100	1	2	30	5.0	6.5	-35	5	3
2171	Montastrea annularis	67	3	5	59	28.0	44.5	-5	9	9
2171	Favia fragum	A	0	1	A	0.0	3.0	A	0	3
2171	Siderastrea radians	A	0	3	A	0.0	11.0	A	0	4
2171	Porites porites	A	0	1	A	0.0	4.0	A	0	4
2171	Porites astreoides	D	1	0	D	4.0	0.0	D	4	0