1-1-1993

A Survey of the Stony Coral Community Composition of Pompano Ledge, Broward County, Florida, with a Preliminary Evaluation of the Effectiveness of Mooring Buoys in Reducing Coral Damage

John D. Hocevar
Nova Southeastern University

A SURVEY OF THE STONY CORAL COMMUNITY COMPOSITION OF POMPANO LEDGE, BROWARD COUNTY, FLORIDA, WITH A PRELIMINARY EVALUATION OF THE EFFECTIVENESS OF MOORING BUOYS IN REDUCING CORAL DAMAGE

BY

JOHN D. HOCEVAR

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN
OCEAN SCIENCE

WITH SPECIALITY IN:

MARINE BIOLOGY

NOVA UNIVERSITY

1993

MASTER OF SCIENCE

THESIS

OF

JOHN D. HOCEVAR

WITH SPECIALITY IN:

MARINE BIOLOGY

Approved:

Thesis Committee

Major Professor ______________________

____

____

NOVA UNIVERSITY

1993

Table of Contents

Abstract

Stony corals of Pompano Ledge, First Reef, Broward County, Florida were sampled *in situ* using a new reef assessment method. The circular-radial method was used to assess the effectiveness of mooring buoys in reducing damage to reefs. Data will be part of a long-term monitoring study of buoy impacts. The parameter of recent injury was used to provide preliminary information on buoy effectiveness.

Results were as follows: approximately 6% of the study area was covered by stony corals, with an average of 3 colonies per square meter. Diversity based on abundance (H'n) was 1.7, and diversity based on relative coverage (H'c) was 1.1. Evenness based on abundance (J'n) was nearly .8, and evenness based on relative coverage (J'c) was .5. Approximately 6% of all colonies surveyed were observed under the shelter of ledges or overhangs. An average of 2% of colonies were observed to be recently injured in the Winter, compared with 6% in the Summer. Twenty-nine species of scleractinian corals were observed, 26 of which were present in sample areas. Montastrea cavernosa dominated stony coral coverage, and Siderastrea spp. and M. cavernosa were the most abundant.

Mooring buoys appear to be an effective management tool for minimizing damage to corals on Pompano Ledge. The percentage of corals that had been recently injured was lower in the buoyed site ($p = .082$) even though the buoyed site was

more heavily visited by both boats and divers. Future studies will be able to further assess buoy impacts by noting any changes in coral population parameters. The buoys have only been in place two years, so it will be interesting to see if the coral communities of the two sites begin to diverge in the future.

List of Tables

List of Figures Page

I. Statement of Purpose:

Mooring buoys are commonly used to reduce anchor damage to reefs. Boats visiting the reefs can tie up to mooring buoys rather than dropping anchor on fragile sponges, coral colonies, and other delicate reef organisms. A potential side effect is that by concentrating divers in smaller areas, deployment of mooring buoys may inadvertently increase physical damage caused by divers. Two distinct scenarios exist. Mooring buoys installed in areas that are already heavily used would have a different effect (greater overall relief) than buoys placed in areas that are not as well known. Buoys placed at lesser known sites would be more likely to attract more divers and possibly more damage. This study examined the hypothesis that mooring buoys are an effective tool for reducing overall physical damage to corals on Pompano Ledge, a heavily used site.

The primary objective of this study was to provide baseline information on the ecology of Southeast Florida reef corals off Pompano Beach in northern Broward County. As anthropogenic stresses increase in Florida and throughout the world, it is important to closely monitor their effects on the health of reef environments. Long-term monitoring projects are an essential part of mooring buoy plans (van Breda and Gjerde 1992). Providing a data base of conditions at specific repeatable sites as well as at haphazardly chosen sites will allow future researchers to make comparisons, identify changes, and investigate their causes. Additionally, observations were made of corals that had been recently injured in both buoyed and control sites to assess current impacts.

Ocean Watch Foundation applied to Florida Department of Natural Resources for a permit to install buoys on Broward County reefs. The D.N.R. allowed installation of 30 buoys on Pompano Ledge, but has required Ocean Watch Foundation to assess the usefulness of mooring buoys in reducing physical damage to reefs. The results from this study will be submitted to the D.N.R. This is the first such assessment requested by the D.N.R., and may therefore be important in future management decisions.

II. Introduction:

1. Definition of Coral Reef

Coral reefs are shallow water benthic habitats that support a high diversity of marine life. The framework of these calcareous structures are formed by accumulations of calcium carbonate secreted by colonial anthozoans of the order scleractinia. Scleractinians are known as the true or stony corals. Hermatypic corals refer primarily to corals that are reef-building and contain symbiotic algae, or zooxanthellae. The presence of zooxanthellae within coral tissue places physiological constraints on corals limiting distribution of reefs to clear, shallow waters in tropical and sub-tropical regions. Coral reefs are generally restricted to oligotrophic waters with an average temperature of 18° C or higher. Coral diversity tends to decrease at higher latitudes (Barnes 1987).

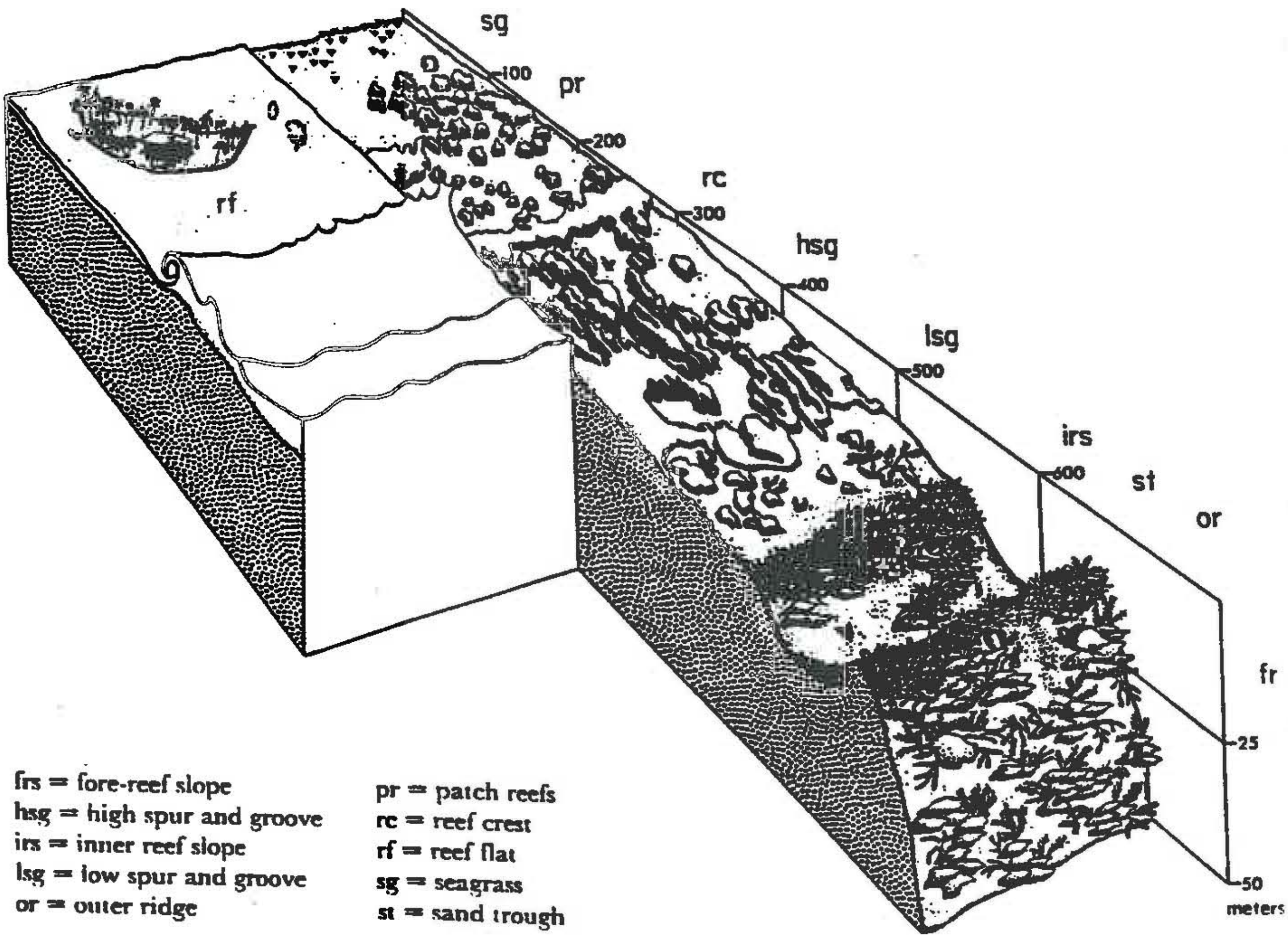
2. Types of Coral Reefs

There are several different reef types (Wells 1988). Fringing reefs are the most common form, projecting out away from shore. The ridges that parallel the southeastern coast of Florida are relict fringing reefs that were formed in the Holocene (Wells 1988). Barrier reefs tend to be larger and separated from land by a lagoon. The Great Barrier Reef of Australia is the oldest and largest biogenic structure on Earth. Patch reefs are common shallow water features forming submarine coral "islands" of relatively small size. Atolls are fringing reefs that surround the peaks of submerged volcanos. A common feature in the Indo-Pacific, atolls are typically round with a lagoon in the center.

3. Environmental Gradients

Environmental parameters such as light, temperature, wave action, turbidity, salinity, and depth are not uniform over the entire reef (Glynn *et al.* 1983). Numerous environmental gradients are present across the different habitats of a well-developed reef. Typical zonation for a Caribbean reef consists of some or all of the following: fore-reef slope, spur and groove formations, inner reef slope, outer ridge, patch reefs, reef crest, reef flat, seagrass bed, and sand trough (Rutzler and Macintyre 1982, Fig. 1). Coral species vary in their ability to tolerate ranges and extremes of sedimentation, light, turbulence, and temperature. Wave stress is an important factor in determining the distribution of corals on a reef (Geister 1977). Species such as *Porites astreoides* are more tolerant of exposed, shallow-water conditions than *Scolymia cubensis*, for example, which requires a more stable environment.

Figure 1. Block diagram of well-developed Caribbean reef zonation (from Rutzler and Macintyre 1982)



4. Stresses

a. Natural

Coral reefs face a barrage of stresses, both natural and man-made (Brown 1987,1988, Dustan and Halas 1987, Lessios *et al.* 1984). Disturbance, predation, competition, and disease are all processes known to be important factors determining coral community structure and diversity (Hughes 1989). Hurricanes can have devastating effects. For example, Live coral cover in the Virgin Islands declined by 40 to 73% after Hurricane Hugo (Rogers in press). Hurricane-associated storm surge can easily uproot and overturn corals of all sizes. Branching corals tend to be hit the hardest, due to their relative fragility. Acropora coverage declined over 90% on a shallow Jamaica reef following Hurricane Allen (Porter *et al.* 1981, Woodley *et al.* 1981).

Increased water temperature and increased exposure to solar radiation have been cited as causes for widescale bleaching and resulting mortality (Brown 1988, Williams *et al.* 1987, Lesser *et al.* 1990). The Southeast Florida reef tract, exclusive of the Florida Keys, is not subjected to temperatures as high as those associated with bleaching events in Caribbean reefs. However, corals of high-latitude reefs become stressed at temperatures that are within typical ranges of lower latitude corals (Cook *et al.* 1990). Bleaching was one source of mortality resulting in a loss of coral cover at five of six Florida reef sites over a seven year period

(Porter and Meier 1992).

b. Anthropogenic

Eutrophication, as defined to include sedimentation, nutrient enrichment, and toxification can have pronounced effects on the population structure of coral communities (Tomascik and Sander, 1987). In addition to spurring algal growth, high nutrient levels in reef waters can decrease coral calcification rates (Kinsey and Davis 1979). Reduction of nutrient inputs from rivers and sewage outfalls may be the most important step toward recovery of reefs near Negril, Jamaica (Goreau 1992). Dredging to acquire sand for beach renourishment projects may affect area reefs by increasing turbidity, a possibility that has been a source of controversy for the past twenty years (Goldberg 1989). The renourishment debate has been the impetus for the majority of reef assessment surveys conducted in Broward County (Dodge *et al.* 1992, Coastal Shelf Associates 1984, Britt and Associates 1979, Courtenay *et al.* 1974, Goldberg 1981, Marszalek 1981).

Oil spills can severely impact corals in some situations, particularly where oil becomes trapped in lagoonal areas (Vandermeulen and Gilfillan 1985). Mortality results from prolonged direct contact with whole oils, but in most cases wave and tidal action is sufficient to at least partially cleanse reefs. Corals also exhibit a variety of sublethal responses to toxic components of soluble fractions of oil, including expulsion of planular larvae, changes in feeding and growth rates, and increased production of mucus (Jackson *et al.* 1989, National Research Council 1985, Knap *et al.* 1985, Vandermeulen and Gilfillan 1985, Guzman *et al.* 1991).

Extensive damage due to ship groundings has been well documented (Wells and Hanna 1992, Dennis and Bright 1988, Rogers *et al.* 1988, Dustan and Halas 1987, Tilmant 1987, Smith 1985). Anchor damage is certainly a component of destruction caused by recreational activities (Halas 1985, UNESCO 1986, Tilmant 1987, Rogers *et al.* 1988, Sudara and Nateekarnchanalap 1988, Davis 1977). A study at Fort Jefferson National Monument in the Dry Tortugas found that twenty percent of a large Acropora cervicornis reef had been damaged by boat anchors (Davis 1977). A 1987 survey of 186 boats anchored in Virgin Islands National Park waters found 46% were damaging seagrass or coral (Rogers *et al.* 1988). Heavy anchors and anchor chains used by large cruise ships can be devastating. In one case on Grand Cayman Island, 3,150 m^2 of reef was destroyed by one ship in one day, with recovery periods estimated at over fifty years (Smith 1988).

Another source of recreationally caused damage may result from direct physical contact with snorkelers and divers. This type of damage is density dependent; destruction would be expected to increase with higher numbers of visitors to the reef. Damage caused by bumping into, grabbing, or standing on corals is widely recognized (Rogers *et al.* 1988, Jaap *et al.* 1988, Tilmant 1987, Sudara and Nateekarnchanalap 1988, UNESCO

1986). A study of diver-coral interactions at Looe Key National Marine Sanctuary indicated that 4-6% of corals within the sanctuary are touched by divers each week (Talge in press). However, damage of this nature is difficult to quantify, primarily due to problems with separating diver damage from other sources of physical damage (Tilmant *et al.* 1981). Recent findings question commonly held beliefs that corals are damaged or killed by human touch; of twelve species tested, no lethal or sub-lethal effects were observed as a result of touching (Talge in press). Additional density dependent sources of recreationally caused damage include illegal collection of living organisms, boat effluents, and suffocation and decay caused by deposits of plastics and other types of litter (UNESCO 1986). There has been concern that divers may significantly affect the water quality through release of untreated urine directly into the reef environment, thus raising nutrient levels and enhancing conditions for algal growth (Talge in press).

5. Long Term Monitoring

Long-term reef monitoring studies serve many purposes (Hughes 1992, Rogers 1988). Information gained through baseline ecology monitoring can be useful for impact assessment. It is important for managers to be able to document changes in reef health in order to assess the efficacy of current strategies in protecting reefs. Management plans may provide sufficient protection upon implementation. However, increased usage, episodic events such as hurricanes, species outbreaks or die-offs, or a reduction in water quality may cause additional stresses to reef organisms. Long-term demographic studies are useful to identify changes in species composition and size classes as well as overall changes in coverage. Monitoring studies of this type enable discovery of die-offs of specific types of corals and alerts managers to possible causes. For example, frequent observations of fragmentation in Acropora colonies in popular areas relative to less well known sections of Carysfort Reef led to the hypothesis that groundings and anchor damage were the most likely cause (Dustan and Halas 1987). A long-term monitoring plan is an essential part of any mooring buoy system (van Breda and Gjerde 1992).

There are several methods for assessing coral assemblages (Loya 1978, Maragos 1974, Pichon 1978, Scheer 1978, Brown 1988, Goldberg 1973, and Kenchington 1978). Popular assessment methodologies include the belt quadrat, line intercept, and point-centered quadrat methods. Commonly used techniques were reviewed by Chiappone and Sullivan (1991), Dodge *et al.* (1982), Ohlhorst *et al.* (1988) and Kinzie and Snider (1978). In general, the methods evaluated were found to be similar in accuracy. Differences occurred in the amount of time required in the field and in the laboratory, and in the type of information gathered. The circular-radial method designed for this study is similar to plot techniques such as the belt quadrat method, because a relatively large area is sampled, and all colonies within the area are recorded. Other types of circular sampling methodologies have been used by Gittings et al. (in press) and recommended by van Breda and Gjerde (1992).

6. Mooring Buoys

a. Purpose

Installation of mooring buoys is a technique designed to reduce damage to coral reefs, sea grass beds, or sensitive structures, such as wrecks. Where buoys are employed in sufficient numbers, anchor damage can be virtually eliminated. Buoys can also serve to guide users away from areas that have become overly stressed, or from shallow areas where groundings might occur. Buoys can be used to introduce divers to less known reefs. This has been done in the Key Largo National Marine Sanctuary (now part of the Florida Keys National Marine Sanctuary) to more evenly distribute diving pressure (Halas 1985). Buoy use has resulted in a 30% reduction in time required for enforcement officers to check for anchor-in-coral violations (Halas 1985). Commercial dive operations have reported that tying up to mooring buoys is both quicker than anchoring and requires less fuel (Dimartini pers. comm.).

b. Types

There are several types of mooring buoy designs, but the basic components are common to all designs. Mooring buoys consist of a float, a pick-up line that runs from the buoy to the boat, a down line that attaches the float to the anchor, and a means of anchoring the system to the substrate. Traditional systems rely on a heavy object such as a concrete block to anchor the buoy. While parts are inexpensive and readily available locally, traditional systems are generally not recommended, except for possibly in locations where they can be placed in sand or mud within swimming distance of a reef (van Breda and Gjerde 1992). Traditional "heavy object" anchors can be dragged across the substrate, potentially causing more damage than they prevent in fragile reef habitats. For example, an experiment by Halas (1985) demonstrated that a 318 kg railroad wheel was insufficient to prevent dragging.

The Halas mooring buoy system is a vast improvement on the traditional system, incorporating numerous key changes in design (Halas 1985, Fig. 2). A steel eyebolt is cemented into a hole drilled into the substrate, forming an immovable anchor. Because the hole is only 10 cm in diameter, the Halas system can be installed with virtually no damage to surrounding organisms. Additional modifications include replacement of heavy chain with a
floating line to prevent scouring damage, and a small (1/4 kg) weight near the top of the line to reduce scope during slack water. The entire system is designed with ease of maintenance in mind. Most parts can be replaced without dismantling the system. The Halas anchoring system works best in bedrock

substrates (van Breda and Gjerde 1992). Halas used a 1.75 m long screw anchor in soft substrates (Halas 1985). Other mooring systems, such as the Manta-Ray (Fig. 3) or Moorsecure designs, combine Halas-type rigging with anchors that can be used in a variety of substrates.

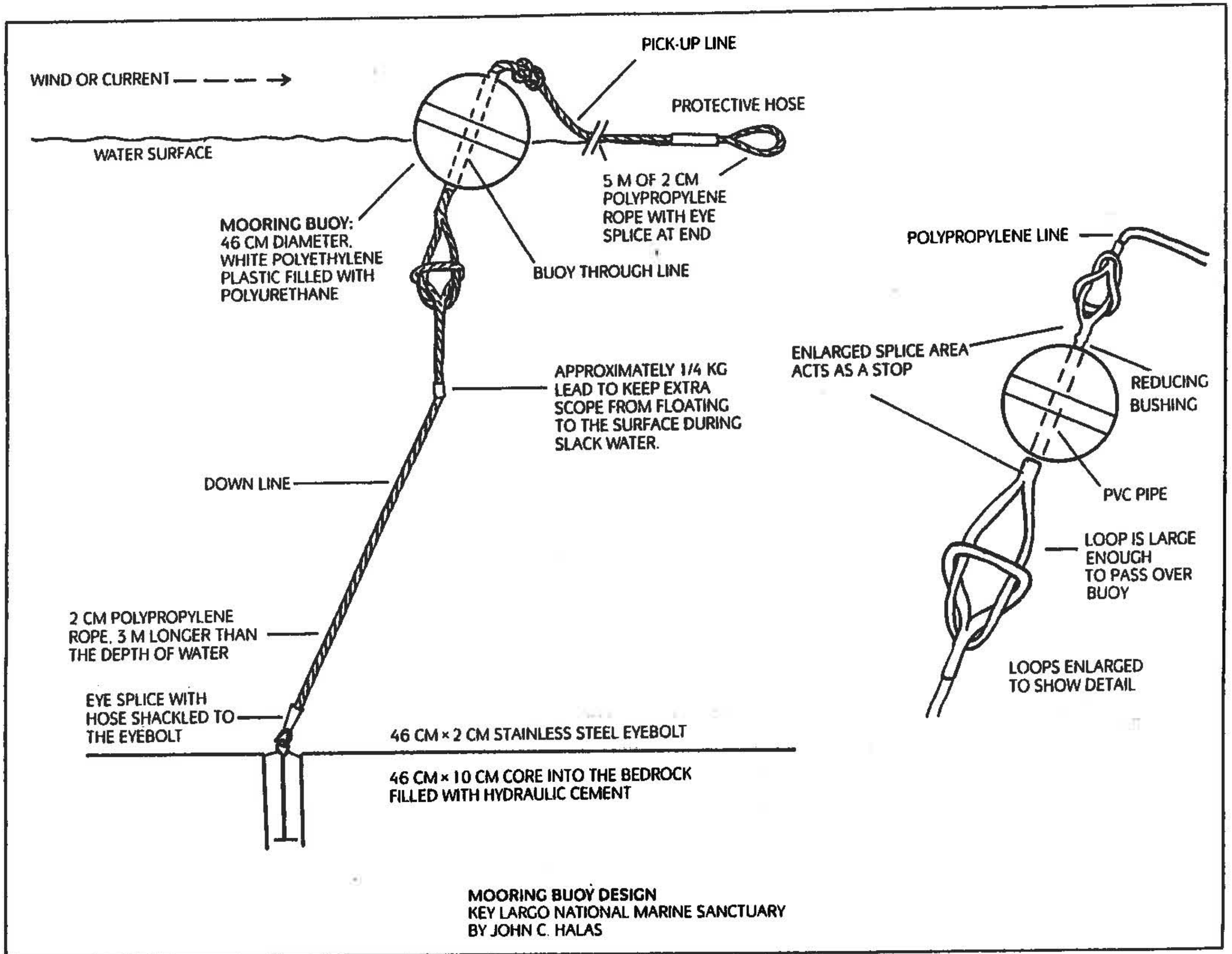
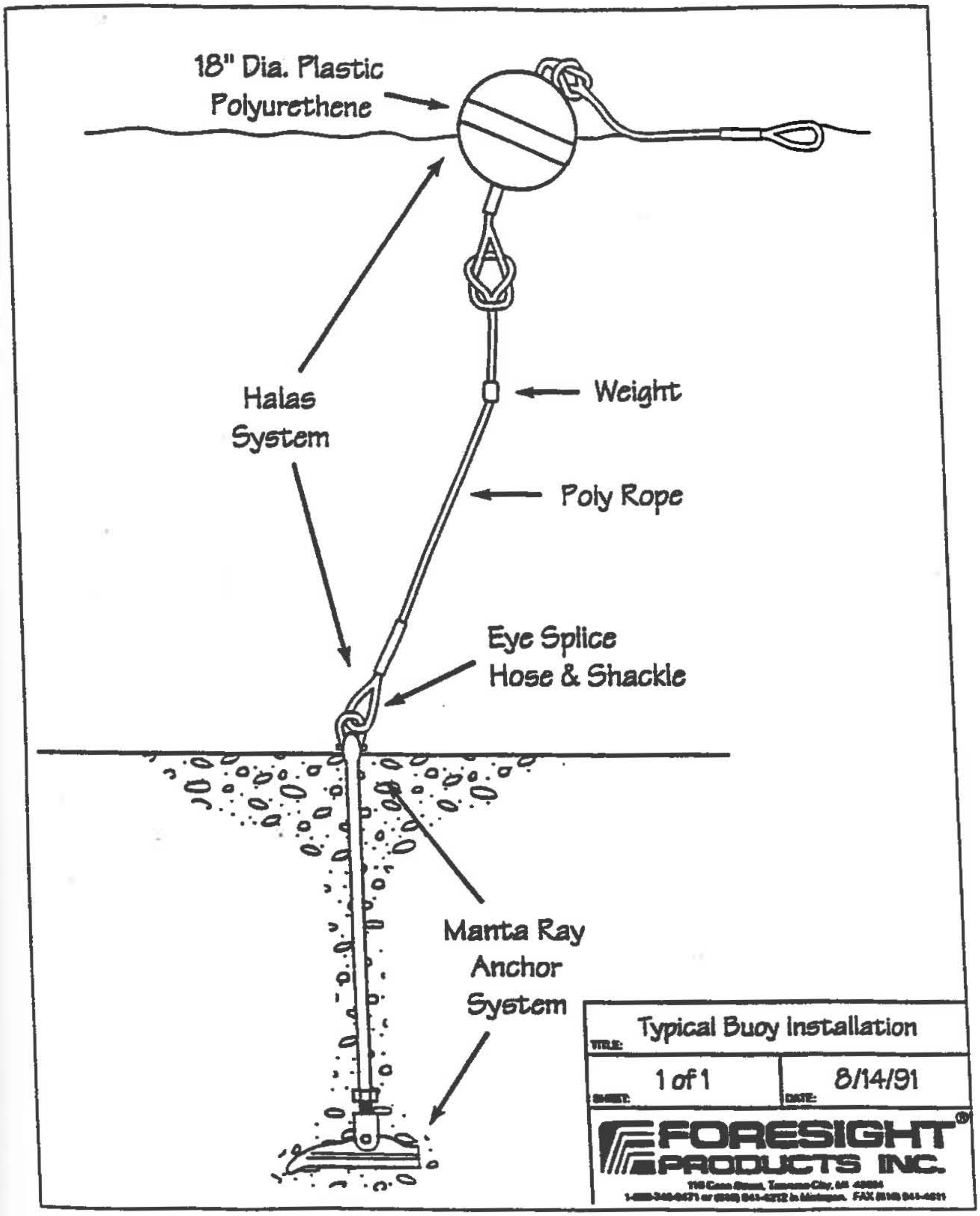


Figure 2. The Halas mooring system. Halas now uses a smaller diameter core and a stronger buoy through-line (adapted from van Breda and Gjerde 1992)

Figure 3. Figure 3. The Manta-Ray mooring system (from van Breda and Gjerde 1992)



c. Present Usage

Use of mooring buoys as a reef management tool is increasing. Several organizations have recently been involved with mooring buoy projects in South Florida, including Ocean Watch Foundation, Environmental Moorings International, Coral Reef Foundations, Reef Relief, and the Florida Keys National Marine Sanctuary. Over 1,800 Halas and Manta-Ray mooring buoys have been installed globally (Halas pers. comm.). Caribbean locations currently employing Halas-type buoys include the Bahamas, Curacao, Roatan, Cayman Islands, Puerto Rico, Belize, Turks and Caicos Islands, Anguila, Guadalupe, Saba, St. Vincent and the Grenadines, British Virgin Islands, U.S. Virgin Islands, and Jamaica (Halas pers. comm.). Moorsecure moorings have been used successfully in the British Virgin Islands for overnight use by large boats (Garrison pers. comm.), and Manta-Rays are used in soft or mixed substrates in the U.S. Virgin Islands and in the Florida Keys National Marine Sanctuary (van Breda and Gjerde 1992).

d. Do they Work?

Reports of mooring buoy effectiveness have been enthusiastic. Billy Causey, then Sanctuary Manager of the Looe Key National Marine Sanctuary, stated that "the installation of mooring buoys has been the most beneficial effort that we could have undertaken to protect our reefs" (Rogers *et al.* 1988). Surprisingly, however, there have been no published reports quantitatively demonstrating the effects of mooring buoy usage. Mooring buoys may cause significant increases in density of visitors to areas of reefs where buoys are present. It is possible that, in some cases, density dependent sources of damage from increased visitation may increase or even outweigh damage prevented by mooring buoys. Additionally, damage may occur as a direct result of buoy use, such as "halo" damage caused by down-lines or chains dragging across reef formations, or by moorings that pull out of the substrate (Garrison pers. comm.). Halo damage results when down-lines lie on or near the bottom, as occurs when the buoy sinks or is destroyed. It would be useful to determine the magnitude of these effects to evaluate the efficiency of mooring buoys in reducing damage to reefs. The effectiveness of mooring buoys may be evaluated by monitoring reef communities over time and assessing changes.

III. Methods

1. Description of Sampling Sites

a. Site Locations

The area surveyed in this study is located at 26° 15′ N x 80° 5′ W, and is known locally as the Pompano Drop-off or Pompano Ledge (Fig. 4). Reefs of Southeast Florida in general are not considered to be actively accreting (Marszalek et al. 1977, Lighty *et al.* 1978). On this basis the ridge is referred to as a coral community rather than a coral reef (Wainwright 1965). Pompano Ledge is part of the shallowest of three ridges in the area, and ranges in depth from 4 to 7 m. Large branching corals are rarely found in the study area, although much of the underlying ridge was originally formed by Acropora palmata. The region is characterized as an octocoral-dominated hardground community, with low stony coral abundance relative to more southerly Florida waters (Goldberg 1973). However, the ridge is populated with a diversity of hard corals, gorgonians, and sponges, as well as numerous other invertebrates and fishes. Stony corals of the first reef in northern Broward County have not been well described. A recent study in southern Broward County identified Siderastrea siderea, Montastrea cavernosa, Stephanocoenia michelinii, and Dichocoenia stokesi as the most abundant species (Dodge *et al.* 1992). Coral population parameters were calculated for the first reef: % cover = 1.35%, abundance = 2.2 col m^2, diversity indices H′n (based on abundance) and H′c (based on relative coverage) = 1.35 and 1.1, and evenness indices J'n (based on abundance) and J'c (based on relative coverage) = 0.7 and 0.58 (Dodge *et al.* 1992).

Thirty Halas-type buoys were installed along Pompano Ledge in July 1990 by Ocean Watch Foundation. The buoys are spaced about 58 m apart, forming one line covering a total distance of 1.68 km. Depth at the base of the buoys is approximately 4 m. The substrate is consolidated reef (Anastasia formation) and is well suited for Halas-type moorings.

b. Kinds of Sampling Areas

Two different categories of sites were established: those potentially affected by mooring buoys usage and unbuoyed control sites. Buoyed sites were positioned at mooring buoys along the length of the line of mooring buoys. Control sites were located along the same First Reef ridge as the buoyed sites, in increments of 50 m, located 50 to 300 m north of the buoys. The general locations of control sites were identified by approximate distance from the northernmost buoy as visually estimated by the boat captain. Each site consisted of at least a 20 m^2 circular area.

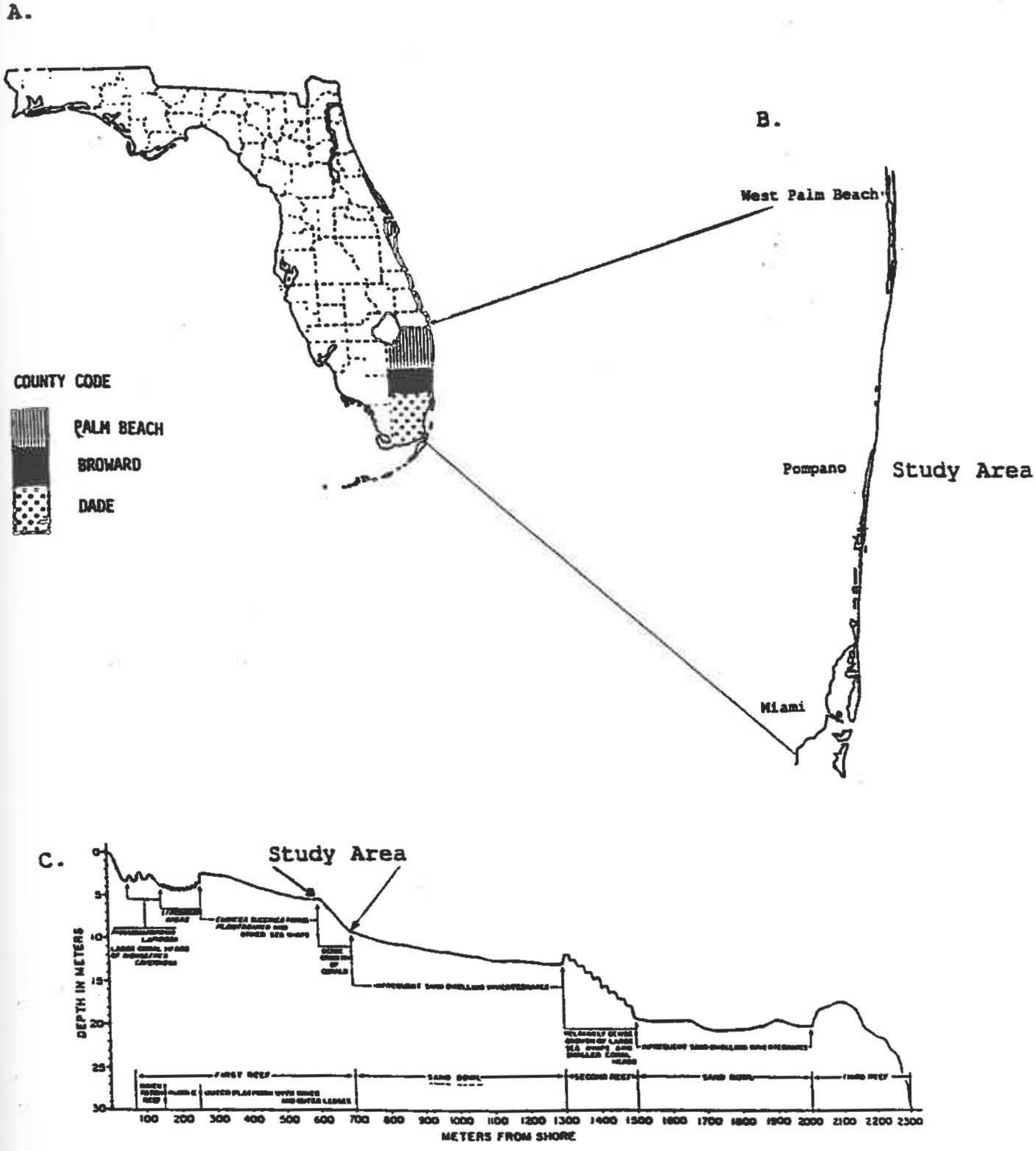


Figure 4. Study site location: A) Florida; B) coastline of Palm Beach, Broward and Dade Counties; C) shelf morphology profile off Pompano Beach (adapted from Courtenay et *al.* 1974).

c. Assessment Periods

Sampling was performed in Winter 1991-92 and repeated in Summer 1992 in order to study seasonal effects. Fifteen buoyed sites and twelve control sites were sampled from February 15 to March 27, 1992. Fourteen buoyed sites were reoccupied for resampling and twelve control sites were sampled from July 16 to September 15, 1992. Buoyed sites could be reoccupied precisely due to the presence of the buoy. However, control sites were established anew at each monitoring. Additional replicates of buoyed sites were conducted to provide an estimate of error and short-term population fluctuations. Ten buoyed sites were reoccupied in September 1992 to assess impacts of Hurricane Andrew. Of the twelve control sites sampled in Summer 1992, six were sampled before the hurricane, and six were sampled afterwards.

d. Monitoring of Visitor Frequency

Visitor frequency was monitored by counting commercial and private boats visiting both the buoyed sites and non-buoyed control sites by using binoculars from the shore. Distinctions were made between boats utilizing the mooring buoys and those that anchored. Boats were observed at thirty minute intervals for six hour periods, twice during February 1992 and twice during August 1992. All observations of visitor frequency were made on weekends. Commercial dive boat operators were interviewed to provide further visitation information.

2. Assessment Methodologies

a. Measurement Method

A marked line was attached to the eyebolt at the base of the mooring buoy line, and to a twelve pound weight for control sites. Weights were placed haphazardly and in a manner consistent with buoy placement (ie. not in the middle of a coral colony). The line was stretched taut to ensure consistency of area sampled. The line was divided into two parts to reduce the area the observer had to survey at one time. On the first revolution all colonies from the eyebolt to the 1.26-m mark were surveyed. On the second revolution all colonies between the 1.26-m mark and the 2.523-m mark were surveyed. For colonies that were on the outer boundary of the sample area, diameter or length and width data were recorded for the portion of the colony located within the sample area. Colonies on the boundary of the first revolution were measured for the full dimensions, because this boundary was simply an arbitrary procedural division.

At some sites where sufficient time remained after completing sampling of one 20 m^2 sample area (two revolutions), a third and additional revolution was made, during which all colonies were measured and identified between the 2.523-m mark and the 3.568-m mark. This additional revolution contained an area of 20-m^2 and was treated as an additional sample area. Colonies on the boundary between two sample areas were treated as two separate colonies for the purpose of frequency data, and the area of each portion was measured separately. In addition to serving as additional 20-m^2 sample areas, two concentric circles of 20-m^2 each allows the full 40-m^2 area also to be analyzed as a unit.

All stony corals were identified to the lowest taxonomic level possible. Humann (1983, 1992), Smith (1971), Cairns (1982), and Wood (1983) were used for identification. When *in situ* identification was not possible, a colony of the same species was removed from outside the sample area to allow classification based on skeletal characteristics. The hydrozoan Millepora alcicornis was treated as a stony coral for the purpose of this study. All data was recorded *in situ* on mylar sheets taped to a PVC tube worn on the wrist of the observer. Colonies were measured to the nearest 0.5 cm using a transparent ruler. Diameter was measured for rounded corals and length and width were recorded for rectangular colonies. Recently injured corals were noted by circling the size measurement of the affected colony. For the purpose of this study, colonies were only considered recently injured if a portion of the bare skeleton was visible at the time of observation, in a manner similar to Guzman *et al.* (1991). Corals with wounds that were overgrown with algae were not considered recently injured. "Sheltered" colonies, defined as those that were located entirely underneath overhangs or ledges, were noted by underlining the size entry of the colony.

b. Sample size validity

A species-area curve was plotted (Fig. 5), in which the mean cumulative number of species encountered was plotted versus area sampled to verify that 20 m^2 was a sufficient sample size (Loya 1972). The assumption is that because diversity is a function of abundance, the point at which the number of cumulative species levels off represents a sample size that is sufficient to characterize the coral population of that reef. A line was pre-marked at radii that represent circles of from 1 m^2 to 30 m^2 in increments of $1m^2$. One end was attached to a buoy anchor, and corals were identified in a similar manner to the methodology for this study. Five replicate buoy sites were assessed in this manner to obtain data for Fig. 5.

c. Parameters Calculated

Colony abundance and relative percent coral coverage were calculated for each species. Percent recent injury was computed for each site, calculated as the number of recently injured colonies of a given site divided by the total number of colonies in that site (times 100). The percentage of corals of each species that were observed to be "sheltered" was also calculated in this way.

Stony Coral Species-Area Curve

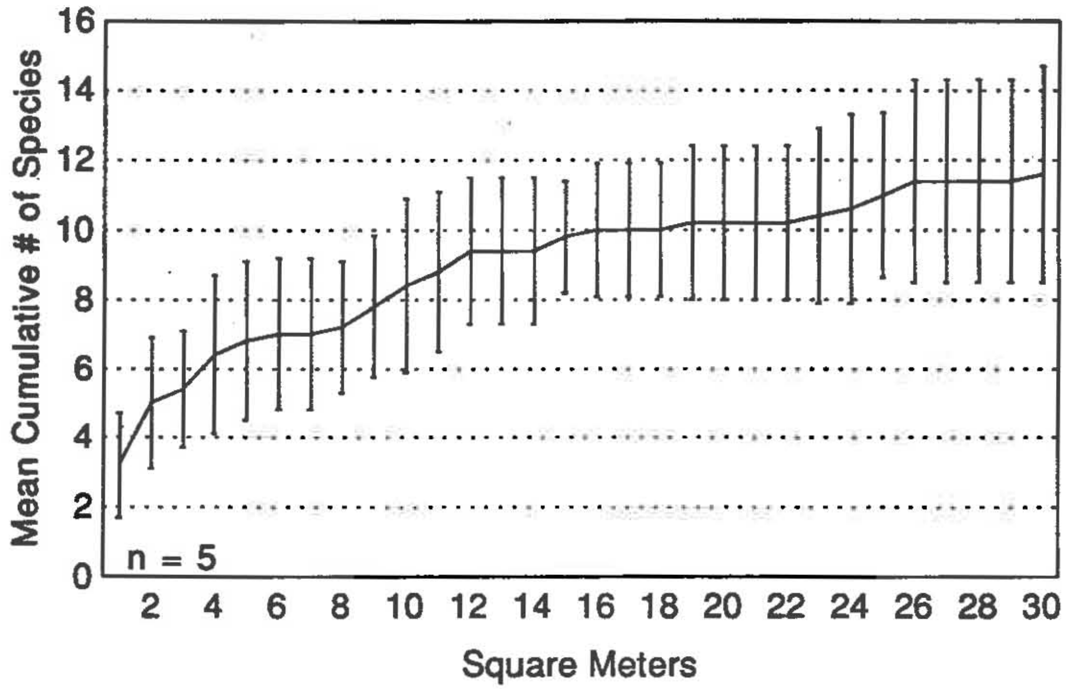


Figure 5: Stony coral species-area curve for Pompano Ledge. Error bars represent +/- 1 standard deviation.

d. Diversity Indices

Diversity was described by the Shannon-Weaver index: $H'n= -\Sigma\ p_i \ln p_i$, where $p_i= N_i/N$ is the proportion of colonies of a given species to total number of colonies. Relative Coverage was also used to describe diversity, such that $H'c= -\Sigma\ p_i \ln p_i$, where $p_i= C_i/C$ is the proportion of coverage by a given species to the total coral coverage. Pielou evenness components were calculated for both frequency (J'n) and coverage (J'c) as well, where $J' = H'/\ln S$ and S = number of species observed. Millepora alcicornis was included in diversity and evenness calculations. For colonies that were only identified to the genus level, ie. Agaricia, Siderastrea, Solenastrea, and Mycetophyllia, genus was substituted for species in diversity and evenness indices. In cases where more than one colony occupied the same space in the horizontal plane, as occurs when corals are found both on top of and underneath ledges, only the top colony was considered for cover calculations, after Loya (1972, 1978). Both colonies were included in all abundance calculations.

e. Statistical Tests Used

Correlation coefficients were computed for relevant parameters. Two-way ANOVAs were used to test for differences in parameters between seasons, between buoyed and control sites, and to test for interaction between seasons and sites. Chi-square analysis was used to compare size class relative frequency histograms.

IV. Results

A listing of data and statistical parameters for 20 m^2 station within each site is provided in Appendix A. Data and statistical parameters for each 40 m^2 station are provided in Appendix B. The following presents the results for the parameters of stony coral abundance, cover, diversity, evenness, recent injury, and protection for each season.

1. Abundance

a. Winter

Mean 20 m^2 data for buoyed and control sites are presented in Table 1, and Figure 6 depicts stony coral abundance. The mean stony coral abundance for buoyed sites surveyed during the winter sampling period was 56.9/20 m^2, and 60.3/20 m^2 for control sites (Table 1, Fig. 6). A species data summary is presented in Table 2, and species abundance pie graphs for the Winter sampling period are provided in Figures 7 and 8. Siderastrea was the most abundant genus, followed by Montastrea, particularly M. cavernosa (Table 2, Figs. 7 and 8). Other abundant species included Dichocoenia stokesi, Millepora alcicornis, and Porites astreoides. Agaricia spp., Stephanocoenia michelinii, and Solenastrea spp. were common but less abundant, and remaining species were infrequently encountered. Diploria strigosa was the rarest species, with only one colony observed in 5,400 m^2. Buoyed and control sites were similar in species relative abundance. Diploria strigosa was present only in the control site, while Acropora cervicornis and Oculina diffusa were only present in the buoyed site. Porites astreoides and Stephanocoenia were more abundant in the control site, and Millepora alcicornis and Montastrea annularis were more abundant in the buoyed site. A summary of 20 m^2 station data is provided in Table 3. Stony coral density was highly variable, ranging from 12.0 colonies/20 m^2 at Station 350.5 to 110 colonies/20 m^2 at buoy three (Table 3).

Table 1: Mean 20 sq. m data for buoyed and control sites for each season

	Winter					Summer				
	N	Abundance	SD	%Cover	SD	N	Abundance	SD	%Cover	SD
Buoy	15	56.933	27.683	7.993	7.367	20	59.867	28.437	5.835	4.672
Control	12	60.250	28.547	4.671	3.491	12	60.250	20.942	4.199	2.971
		H'n	SD	H'c	SD		H'n	SD	H'c	SD
Buoy	15	1.704	0.275	1.039	0.527	20	1.766	0.263	1.088	0.473
Control	12	1.775	0.256	1.222	0.426	12	1.608	0.261	1.117	0.321
		J'n	SD	J'c	SD		J'n	SD	J'c	SD
Buoy	15	0.777	0.093	0.467	0.212	20	0.772	0.128	0.461	0.175
Control	12	0.821	0.087	0.556	0.157	12	0.731	0.120	0.503	0.126
		%Prot	SD	% Inj	SD		%Prot	SD	% Inj	SD
Buoy	15	8.09	12.11	1.05	1.78	20	5.84	7.72	5.29	4.58
Control	12	9.38	9.88	3.82	3.58	12	4.18	4.10	6.78	7.00

Note: Abundance units are colonies/ 20 sq. m

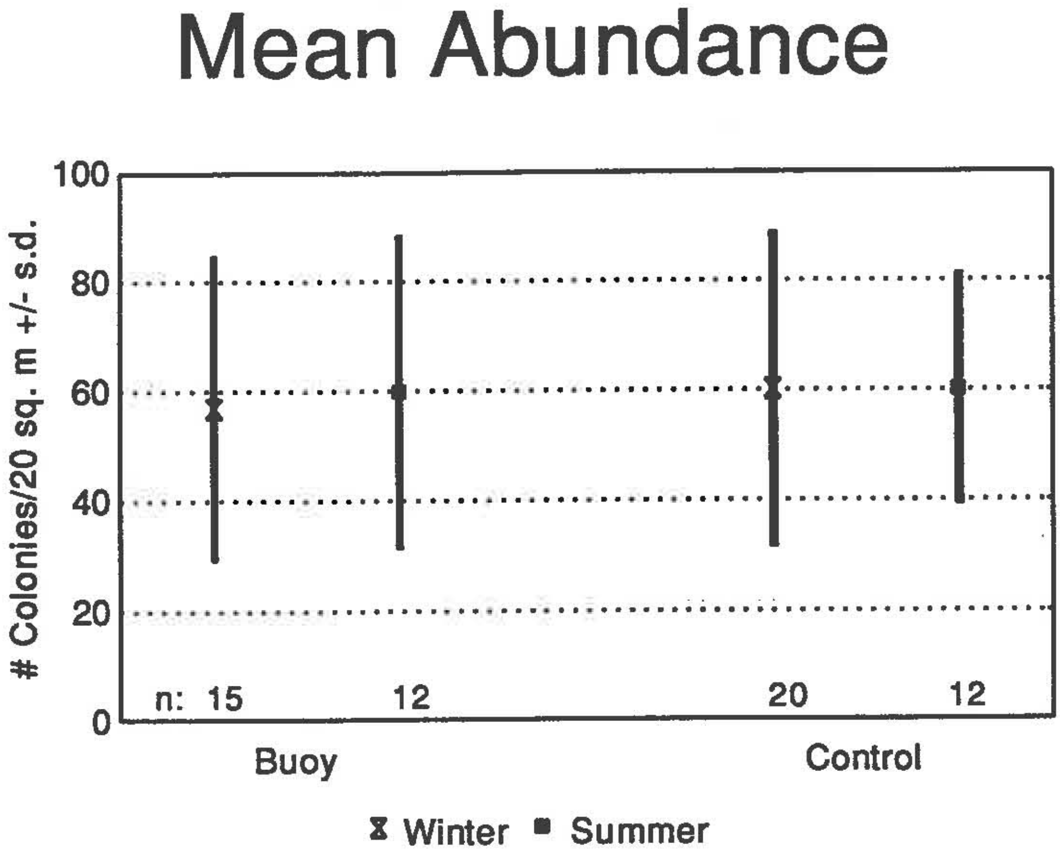


Figure 6: Mean coral abundance at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

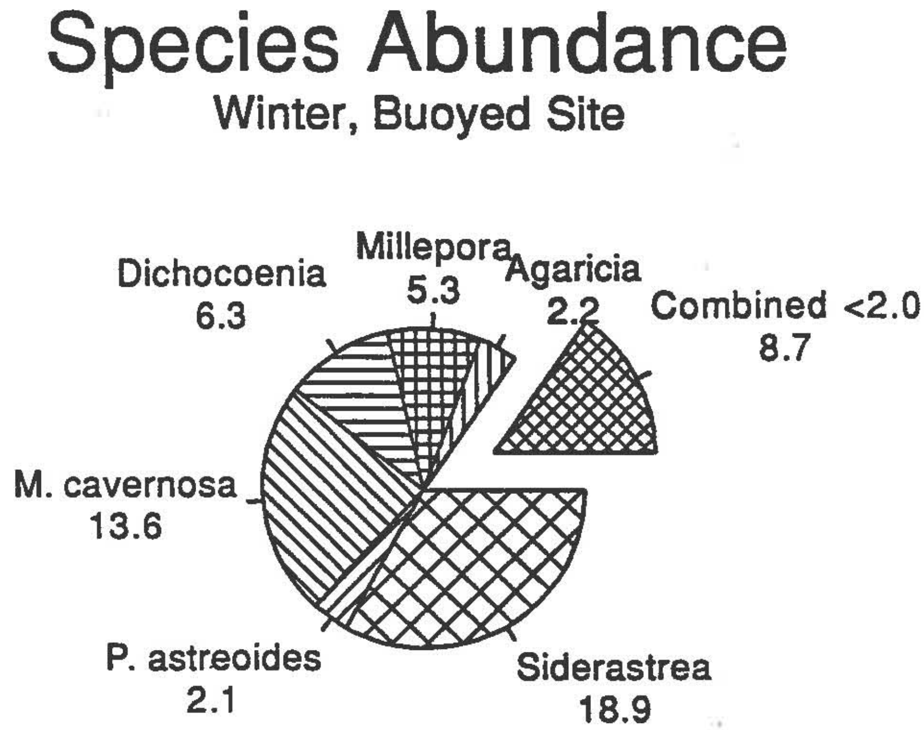


Figure 7: Mean species abundance at buoyed site during Winter sampling period.

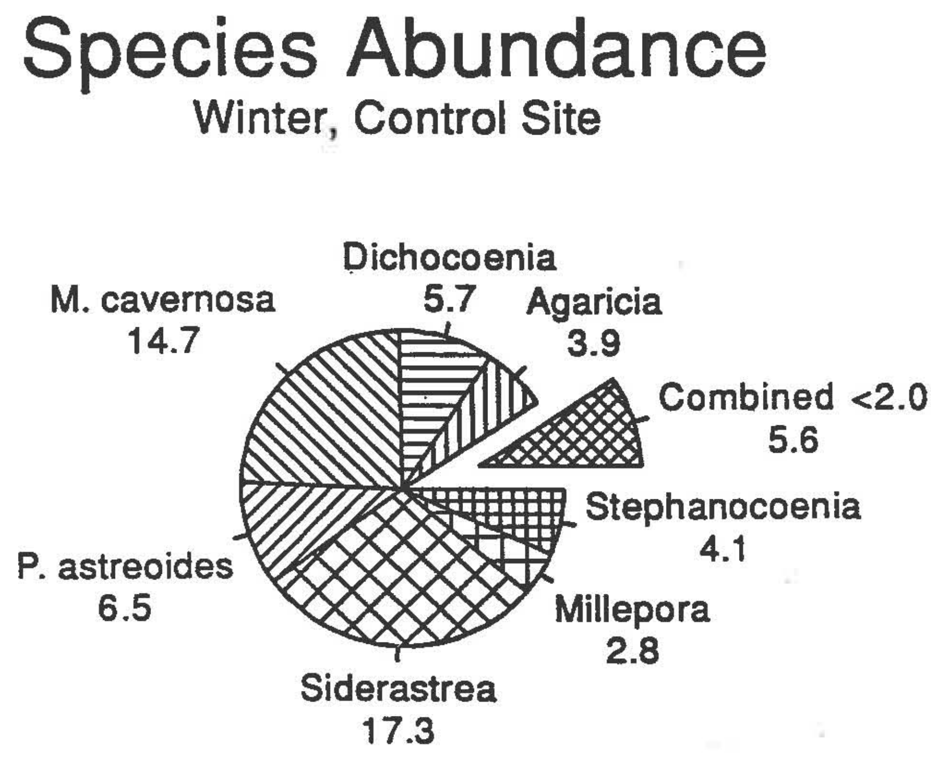


Figure 8: Mean species abundance at control site during Winter sampling period.

Table 2: Species data summary for buoyed and control sites

Winter 1992

	Buoyed Site (n=15)						Control Site (n=12)					
Species	Abund.	SD	RelCov	SD	% Inj	%Prot	Abund.	SD	RelCov	SD	% Inj	%Prot
Acropora cervicornis	0.200	0.775	0.142	0.541	0.00	0.00						
Agaricia spp.	2.200	4.491	1.309	3.787	0.00	87.88	3.917	5.583	4.707	7.859	0.00	59.57
Colpophyllia natans	1.333	1.718	0.561	1.214	0.00	15.00	0.500	0.522	0.153	0.237	0.00	16.67
Dichocoenia stokesi	6.267	4.166	4.664	4.457	5.32	3.19	5.667	3.085	6.058	5.387	8.96	2.99
Diploria clivosa	0.733	0.704	2.037	2.981	0.00	0.00	0.417	0.669	0.206	0.448	0.00	0.00
Diploria labyrinthiformis	0.333	0.617	1.139	3.088	0.00	0.00	0.083	0.289	0.108	0.375	0.00	100.0
Diploria strigosa							0.083	0.289	0.667	2.310	0.00	0.00
Eusmillia fastigiata	0.133	0.352	0.008	0.025	0.00	0.00	0.083	0.289	0.083	0.287	0.00	0.00
Madracis decactis	1.000	1.732	0.969	2.062	5.00	65.00	1.000	1.809	1.775	4.038	0.00	100.0
Meandrina meandrites	1.067	1.580	2.646	4.412	0.00	0.00	0.167	0.389	0.103	0.349	0.00	0.00
Millepora alcicornis	5.267	3.305	3.902	5.536	6.33	2.53	2.750	1.913	1.346	1.343	0.00	0.00
Montastrea annularis	1.467	1.685	10.557	21.50	4.55	18.18	0.083	0.289	0.039	0.134	0.00	0.00
Montastrea cavernosa	13.60	7.089	59.047	31.79	0.98	2.94	14.67	10.23	59.280	17.11	2.84	6.25
Oculina diffusa	0.133	0.516	0.020	0.076	0.00	100.0						
Porites astreoides	2.133	1.807	1.453	2.506	0.00	0.00	6.500	4.359	4.843	3.523	3.85	3.85
Porites porites	0.600	1.549	0.345	0.849	0.00	0.00	1.000	1.279	0.656	1.211	0.00	0.00
Scolymia cubensis	0.333	0.617	0.115	0.237	0.00	60.00	0.583	2.021	0.062	0.215	0.00	100.0
Siderastrea spp.	18.867	17.89	7.409	8.880	0.00	3.53	17.25	9.827	16.432	8.420	2.43	3.43
Solenastrea spp.	1.067	2.631	2.635	6.989	0.00	0.00	1.500	2.939	1.603	3.530	0.00	11.11
Stephanocoenia michelinii	0.267	0.594	1.087	3.890	0.00	0.00	4.083	4.562	2.580	3.008	4.17	16.67

Summer 1992

	Buoyed Site (n=20)						Control Site (n=12)					
Species	Abund.	SD	RelCov	SD	% Inj	%Prot	Abund.	SD	RelCov	SD	% Inj	%Prot
Acropora cervicornis	0.350	1.182	0.262	0.828	0.00	28.57						
Agaricia spp.	1.775	2.262	1.014	1.577	3.13	31.25	1.750	1.545	2.651	3.740	0.00	14.29
Colpophyllia natans	0.792	1.570	0.696	1.956	6.67	13.33	0.417	0.669	0.158	0.469	0.00	0.00
Dichocoenia stokesi	8.600	6.003	4.913	5.808	6.79	0.62	6.000	3.593	7.535	11.04	15.28	2.78
Diploria clivosa	0.808	0.963	1.411	3.884	0.00	0.00	0.750	1.485	0.471	0.808	0.00	0.00
Diploria labyrinthiformis	0.183	0.346	0.052	0.198	0.00	0.00	0.167	0.389	0.081	0.191	0.00	0.00
Eusmillia fastigiata	0.125	0.393	0.010	0.034	0.00	0.00	0.083	0.289	0.060	0.208	0.00	0.00
Madracis decactis	1.050	2.395	1.836	4.228	0.00	95.24	0.250	0.622	1.718	5.506	0.00	100.0
Manicina areolata	0.050	0.224	0.018	0.082	0.00	0.00						
Meandrina meandrites	0.792	1.294	3.306	7.339	0.00	5.88	0.417	0.669	7.942	19.96	40.00	20.00
Millepora alcicornis	5.392	4.104	2.247	1.917	6.60	0.00	2.667	2.060	0.654	0.683	1.52	0.00
Montastrea annularis	0.725	1.491	8.289	16.50	7.14	0.00	0.333	0.888	0.602	1.644	0.00	0.00
Montastrea cavernosa	12.33	7.549	58.219	27.98	12.05	1.61	17.17	10.30	59.403	17.70	7.77	1.94
Mussa angulosa	0.100	0.447	0.025	0.110	0.00	0.00	0.083	0.289	0.019	0.064	0.00	0.00
Mycetophyllia spp.	0.100	0.308	0.097	0.304	0.00	50.00						
Oculina diffusa	0.067	0.298	0.016	0.069	0.00	100.0	0.417	1.165	0.230	0.642	0.00	40.00
Phyllangea americana	0.100	0.447	0.001	0.005	0.00	0.00						
Porites astreoides	3.250	1.811	2.714	4.034	1.61	3.23	4.500	3.205	3.148	3.174	3.70	1.85
Porites porites	0.950	1.605	1.437	3.060	16.67	0.00	0.750	1.055	0.462	0.627	0.00	0.00
Scolymia cubensis	0.125	0.393	0.047	0.178	0.00	100.0						
Siderastrea spp.	18.786	16.82	10.438	13.76	1.37	2.47	21.50	15.84	11.908	10.75	2.33	2.33
Solenastrea spp.	1.100	1.721	2.176	4.054	0.00	6.90	0.833	1.267	1.364	2.368	0.00	30.00
Stephanocoenia michelinii	2.314	2.375	1.739	2.961	0.00	13.16	2.167	1.899	1.591	2.174	3.85	3.85

Note: Abundance units are colonies/sq. m

Table 3: 20 sq. m station data summary

Site	#Reps	Abund	%Cover	H'n	H'c	J'n	J'c	%Prot	%Inj
Winter 1992, Buoyed Site									
3	1	110	4.178	1.868	1.482	0.752	0.597	0.91	3.63
4	1	81	0.585	2.107	2.296	0.821	0.895	27.16	0.00
5	1	32	5.295	1.585	1.373	0.763	0.661	9.38	0.00
7	1	64	9.816	2.139	1.218	0.861	0.490	28.13	0.00
12	1	74	27.341	1.989	0.970	0.801	0.390	0.00	2.70
15	1	105	13.819	1.430	1.013	0.575	0.408	6.67	0.95
18	1	52	9.094	1.819	0.379	0.875	0.182	34.62	0.00
18.5	1	40	17.097	1.697	0.209	0.773	0.095	13.16	0.00
19	1	42	2.724	1.527	1.086	0.852	0.606	0.00	0.00
20	1	29	5.791	1.374	0.625	0.767	0.349	0.00	0.00
20.5	1	79	13.108	1.174	0.682	0.603	0.350	1.27	0.00
24	1	55	6.465	1.482	0.864	0.675	0.393	0.00	0.00
25	1	21	0.961	1.790	0.568	0.861	0.273	0.00	0.00
25.5	1	34	1.321	1.847	1.475	0.841	0.672	0.00	2.94
26	1	36	2.301	1.734	1.344	0.834	0.647	0.00	5.56
Mean	15	56.93	7.993	1.704	1.039	0.777	0.467	8.085	1.052
Winter 1992, Control Site									
50	1	54	1.734	2.005	1.761	0.871	0.765	22.22	1.85
100	1	72	1.935	2.148	1.869	0.896	0.780	23.61	1.39
101	1	37	3.095	1.585	0.932	0.762	0.448	2.70	0.00
101.5	1	56	7.756	1.271	0.734	0.611	0.353	0.00	5.36
150	1	53	3.057	1.530	0.766	0.786	0.393	7.55	1.89
200	1	102	5.709	1.903	1.524	0.826	0.662	25.49	0.98
250	1	103	6.478	2.136	1.492	0.809	0.566	8.74	1.94
300	1	49	2.502	1.846	1.486	0.840	0.676	16.33	6.12
301	1	88	8.248	1.736	1.434	0.790	0.653	4.55	4.55
350	1	25	1.641	1.776	1.141	0.854	0.548	0.00	12.00
350.5	1	12	1.384	1.748	0.930	0.976	0.519	0.00	8.33
400	1	72	12.516	1.622	0.598	0.834	0.307	1.39	1.39
Mean	12	60.25	4.671	1.775	1.222	0.821	0.556	9.381	3.816

Note: Abundance units are colonies/ 20 sq. m

Table 3: 20 sq. m station data summary (cont.)

Summer 1992, Buoyed Site

Site	#Reps	Abund	%Cover	H'n	H'c	J'n	J'c	%Prot	%Inj
2	1	85	5.006	2.007	1.664	0.872	0.712	10.59	2.35
3	2	105	3.767	1.978	1.476	0.810	0.605	1.29	3.02
4	2	96.5	0.790	2.034	1.996	0.806	0.790	12.37	2.71
7	1	64	7.701	2.168	1.263	0.845	0.492	32.81	17.19
12	1	91	11.591	1.990	1.312	0.801	0.528	3.30	4.40
13	1	48	3.649	2.131	1.292	0.889	0.539	3.70	3.70
14	1	33	4.183	1.538	1.052	0.522	0.357	0.00	6.06
15	1	124	21.018	1.400	0.944	0.563	0.380	3.23	3.23
16	1	55	3.304	2.092	1.437	0.873	0.599	1.82	9.09
17	1	44	8.545	1.906	0.365	0.828	0.159	9.09	2.27
18	3	35.67	4.397	1.517	0.395	0.847	0.220	0.00	3.49
18.5	3	47.67	8.686	1.799	0.347	0.783	0.152	14.72	9.07
19	1	45	3.224	1.401	1.024	0.782	0.572	6.67	0.00
20	2	31	5.927	1.709	0.873	0.878	0.448	4.17	8.11
20.5	2	65.5	6.142	1.381	0.774	0.673	0.375	0.00	3.06
24	2	65	8.127	1.712	0.810	0.714	0.338	4.40	6.90
24.5	1	61	7.394	1.724	0.996	0.785	0.454	1.64	6.56
25	2	8	0.506	1.665	0.512	0.980	0.301	0.00	14.55
25.5	1	36	0.200	1.426	1.687	0.484	0.573	0.00	0.00
26	1	57	2.535	1.750	1.546	0.704	0.622	7.02	0.00
Mean	20	59.87	5.835	1.766	1.088	0.772	0.461	5.84	5.288

Summer 1992, Control Site

Site	#Reps	Abund	%Cover	H'n	H'c	J'n	J'c	%Prot	%Inj
50.10	1	93	5.559	1.458	0.988	0.749	0.508	0.00	3.23
100.10	1	54	11.561	1.902	0.911	0.915	0.438	2.08	8.33
100.15	1	56	1.532	1.480	1.630	0.643	0.708	7.14	0.00
101.10	1	63	1.418	1.047	1.563	0.476	0.711	11.11	4.76
101.15	1	41	1.714	1.305	0.993	0.594	0.452	0.00	4.88
150.10	1	74	4.054	1.510	1.075	0.687	0.489	1.35	6.76
150.15	1	72	6.793	1.778	1.069	0.772	0.464	1.39	4.17
200.10	1	94	1.965	1.801	1.377	0.725	0.554	2.13	0.00
250.10	1	48	4.475	1.811	0.696	0.824	0.317	4.17	6.25
300.10	1	65	2.512	1.855	1.493	0.774	0.622	1.54	1.54
301.10	1	35	2.780	1.547	0.714	0.744	0.343	8.57	20.00
400.10	1	28	6.026	1.797	0.901	0.864	0.433	10.71	21.43
Mean	12	60.25	4.199	1.608	1.117	0.731	0.503	4.183	6.778

Note: Abundance units are colonies/ 20 sq. m

b. Summer

Stony coral abundance averaged 59.9 colonies/20 m^2 in the buoyed site and 60.3 colonies/20 m^2 in the control site (Table 1, Fig. 6). Abundance ranged from 8.0 col./20m^2 at buoy twenty-five to 124.0 col./20m^2 at buoy fifteen (Table 3). Figures 9 and 10 depict pie graphs of mean species abundance during the Summer sampling period. Siderastrea spp. was the most abundant, followed by Montastrea cavernosa, and Dichocoenia stokesi (Table 2, Figs. 9 and 10). Species identified in the summer that were not observed in the winter were Mycetophyllia spp., Manicina areolata, Phyllangea americana, and Mussa angulosa (see discussion). These four corals, along with Scolymia cubensis, were the least abundant in the summer sampling period. Diploria strigosa was the only species observed in the winter but not in the summer. Results of two-way ANOVA for treatments and seasons are provided in Table 4. Abundance data showed no significant effects of season (p = .839), treatment (p = .797), or interaction of seasons and treatments (p = .839) (Table 4).

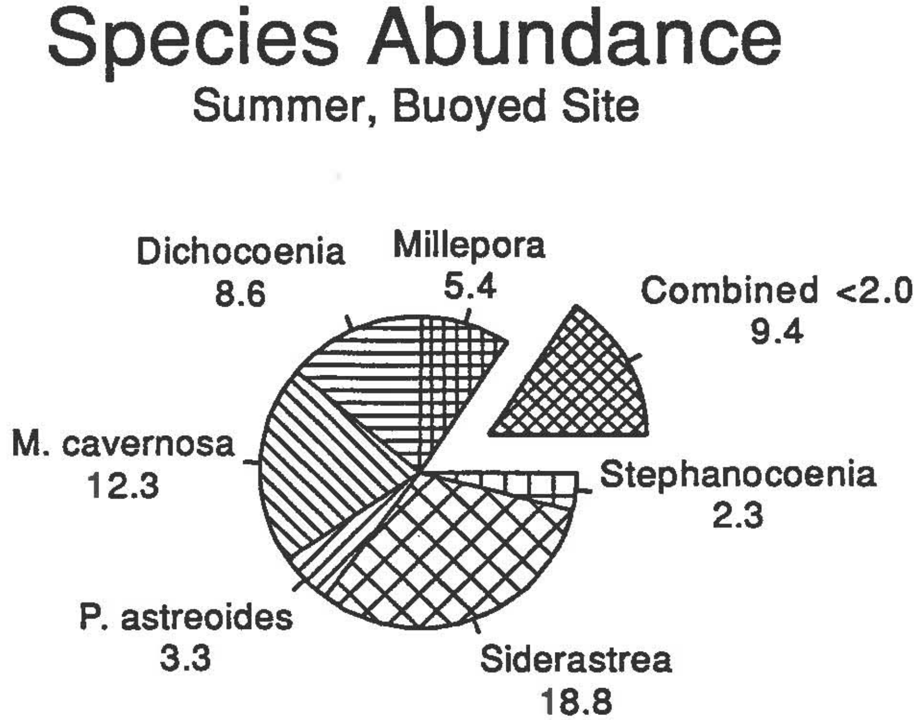


Figure 9: Mean species abundance at buoyed site during Summer sampling period.

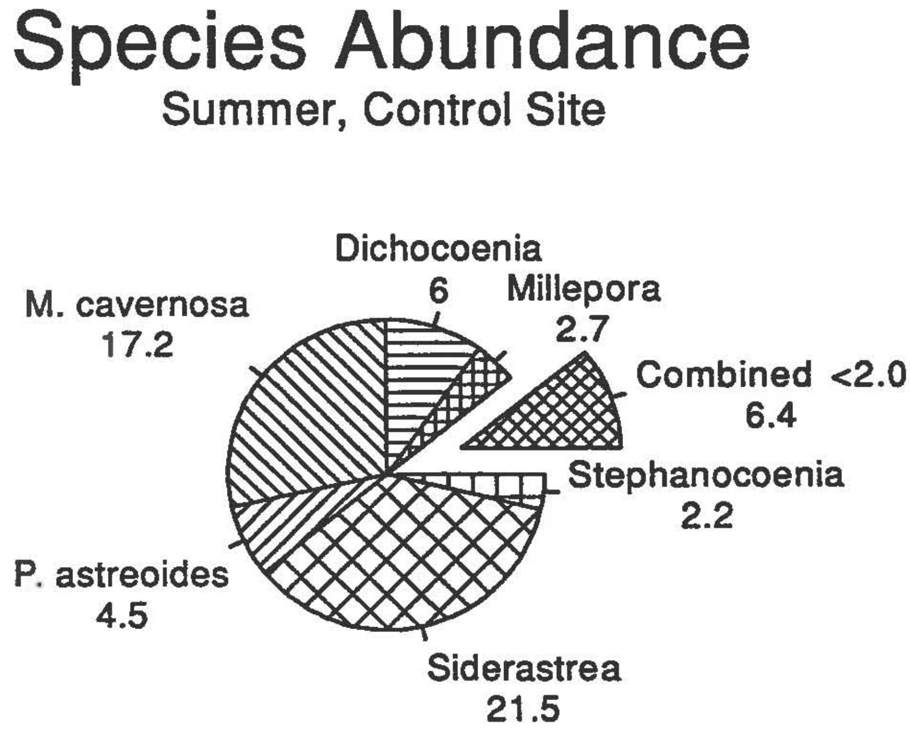


Figure 10: Mean species abundance at control site during Summer sampling period.

Table 4: Two-way ANOVA results for seasons and treatments for $p < .05$

Abundance	Significance	p value
Treatment (buoy, control)	not significant	0.797
Season (Winter, Summer)	not significant	0.839
Interaction (Treatment x Season)	not significant	0.839

% Cover	Significance	p value
Treatment (buoy, control)	not significant	0.071
Season (Winter, Summer)	not significant	0.333
Interaction (Treatment x Season)	not significant	0.534

H'n Diversity	Significance	p value
Treatment (buoy, control)	not significant	0.537
Season (Winter, Summer)	not significant	0.456
Interaction (Treatment x Season)	not significant	0.108

H'c Diversity	Significance	p value
Treatment (buoy, control)	not significant	0.382
Season (Winter, Summer)	not significant	0.818
Interaction (Treatment x Season)	not significant	0.525

J'n Evenness	Significance	p value
Treatment (buoy, control)	not significant	0.957
Season (Winter, Summer)	not significant	0.111
Interaction (Treatment x Season)	not significant	0.152

J'c Evenness	Significance	p value
Treatment (buoy, control)	not significant	0.102
Season (Winter, Summer)	not significant	0.289
Interaction (Treatment x Season)	not significant	0.837

% Recently Injured Colonies	Significance	p value
Treatment (buoy, control)	not significant	0.082
Season (Winter, Summer)	significant - greater in Summer	0.004
Interaction (Treatment x Season)	not significant	0.598

% Protected Colonies	Significance	p value
Treatment (buoy, control)	not significant	0.940
Season (Winter, Summer)	not significant	0.126
Interaction (Treatment x Season)	not significant	0.540

2. Cover

a. Winter

A graph of mean % coral cover is provided in Figure 11. Mean % cover for buoyed sites during the winter sampling period was 8.0%, and 4.7% in the control sites (Table 1, Fig. 11). Stony coral coverage was variable, ranging from 0.6% at buoy four to 27.3% at buoy 12 (Table 3). Pie charts depicting species relative coverage are presented in Figures 12 and 13. Coverage was less evenly distributed among species than abundance; Montastrea cavernosa dominated coral coverage (Table 2, Figs. 12 and 13). Siderastrea spp. was also prominent, followed by Montastrea annularis and Dichocoenia stokesi. Species relative coverage varied considerably between buoyed and control sites, as well as within sites. M. annularis relative % cover (r.c.) was second highest in the buoyed site (r.c. = 10.56%), but ranked last in coverage in species present in the control site (r.c. = 0.04%). Relative frequency histograms of colony size classes for all species shows the predominance of small colonies in both sites (Figs. 14 and 15).

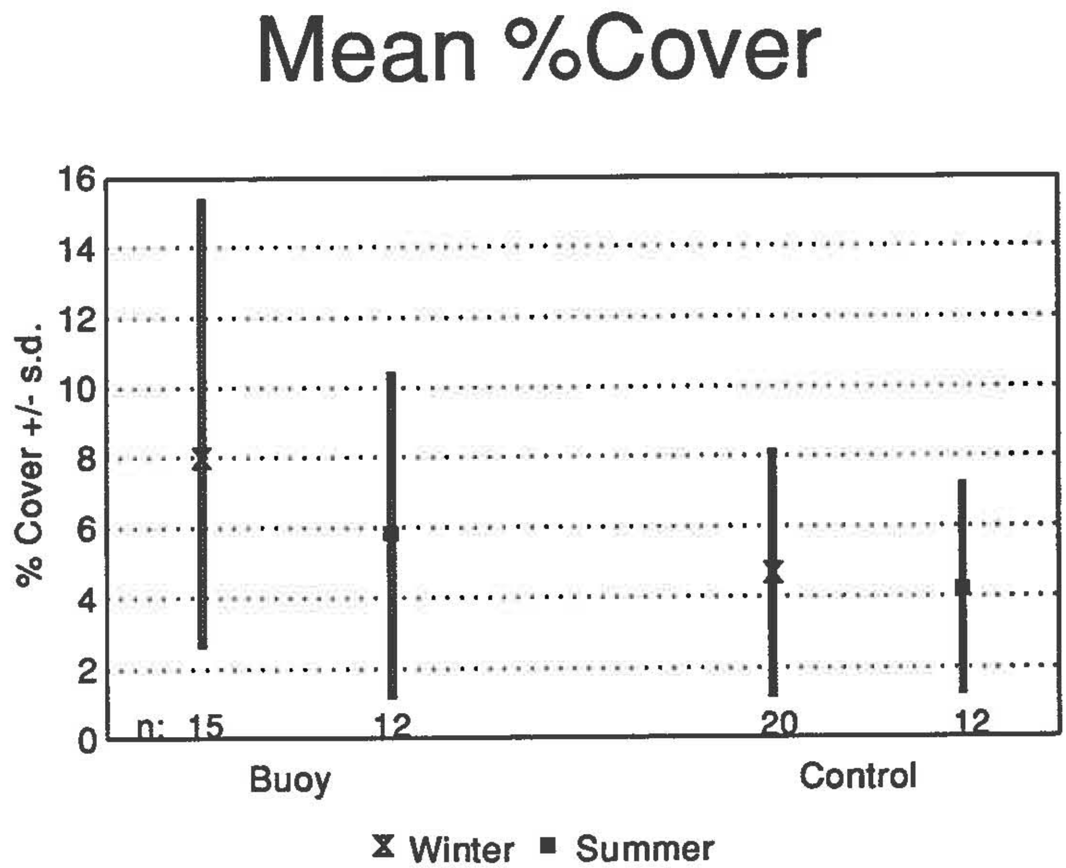


Figure 11: Mean % coral cover at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

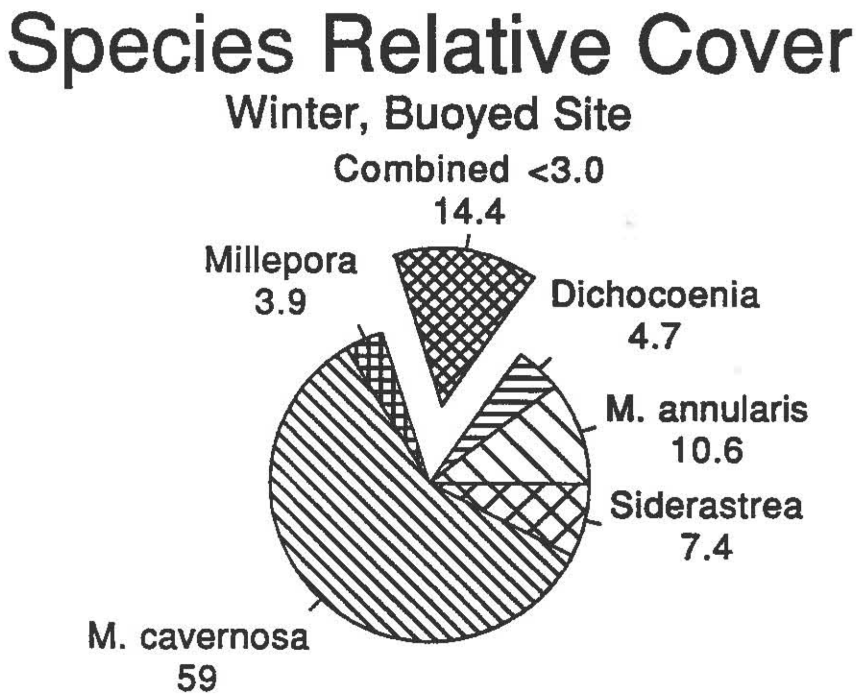


Figure 12: Mean species relative cover at buoyed site during Winter sampling period.

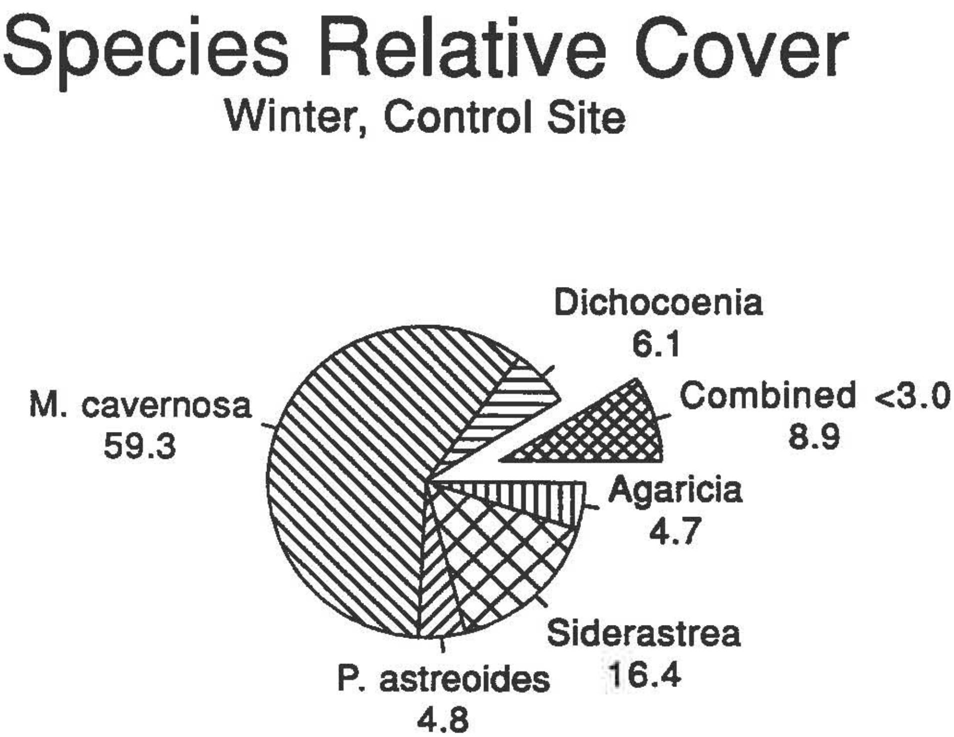


Figure 13: Mean species relative cover at control site during Winter sampling period.

Colony Size Class Relative Frequency
Buoyed Site

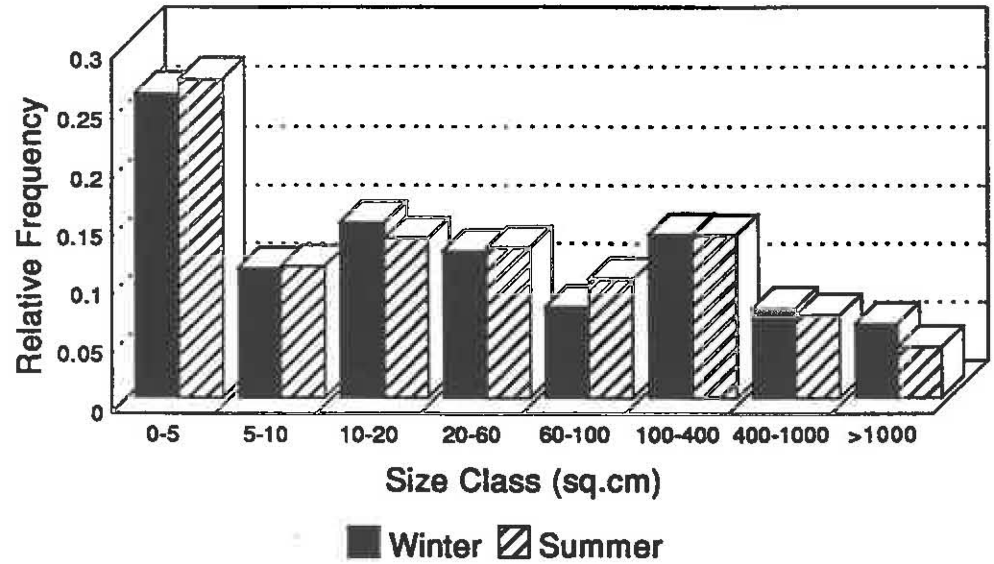


Figure 14: Colony size class relative frequency histogram for buoyed site during Winter and Summer sampling periods.

Colony Size Class Relative Frequency
Control Site

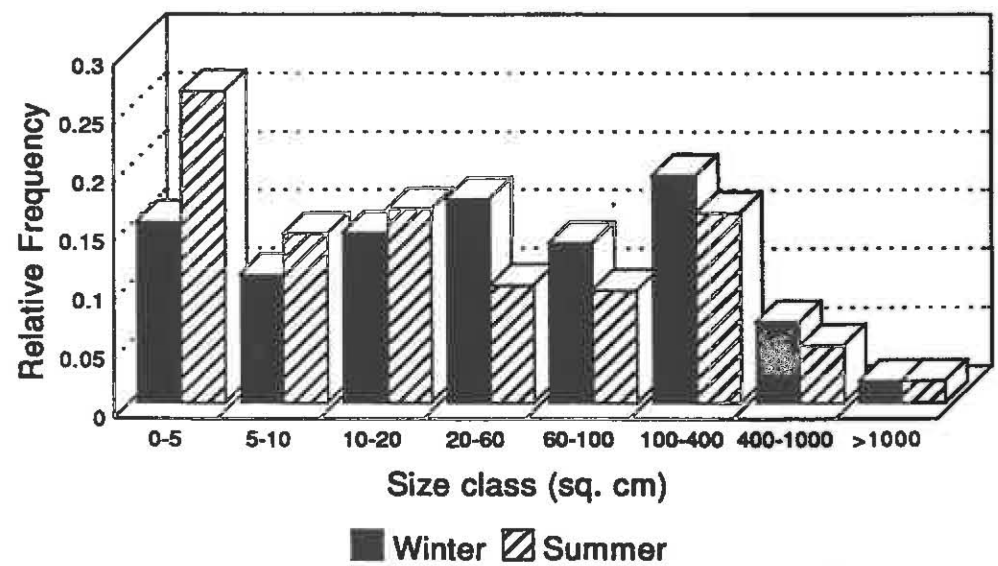


Figure 15: Colony size class relative frequency histogram for control site during Winter and Summer sampling periods.

b. Summer

Mean coral cover in the summer sampling period was 5.8% in the buoyed site and 4.2% in the control site (Table 1, Fig. 7). Mean % cover ranged from 0.2% at buoy twenty-five to 21.0% at buoy 15 (Table 3). Species relative cover pie charts for the Summer sampling period are provided in Figures 16 and 17. Montastrea cavernosa was the dominant species in terms of cover at both sites, followed by Siderastrea spp. (Table 2, Figs. 16 and 17). Summer species relative cover proportions were very similar to winter species relative cover figures. Notable differences between sampling periods include an increase in Meandrina meandrites relative cover, and the aforementioned changes in species present. Over half of all colonies observed in both sites were smaller than 20 cm^2 (Figs. 14 and 15). Distribution of colony size was not significantly different between sites in either season ($p > .10$, chi-square).

Results of two-way ANOVA for % cover data showed no significant effects of season ($p = .333$), treatment ($p = .071$), or interaction of seasons and treatments (.534) (Table 4).

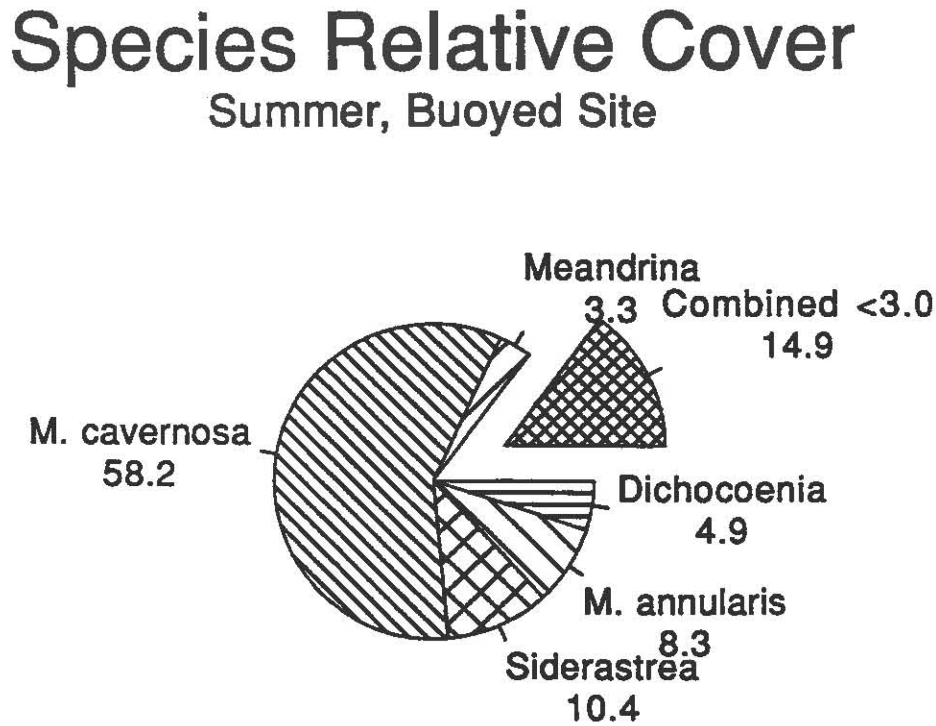


Figure 16: Mean species relative cover at buoyed site during Summer sampling period.

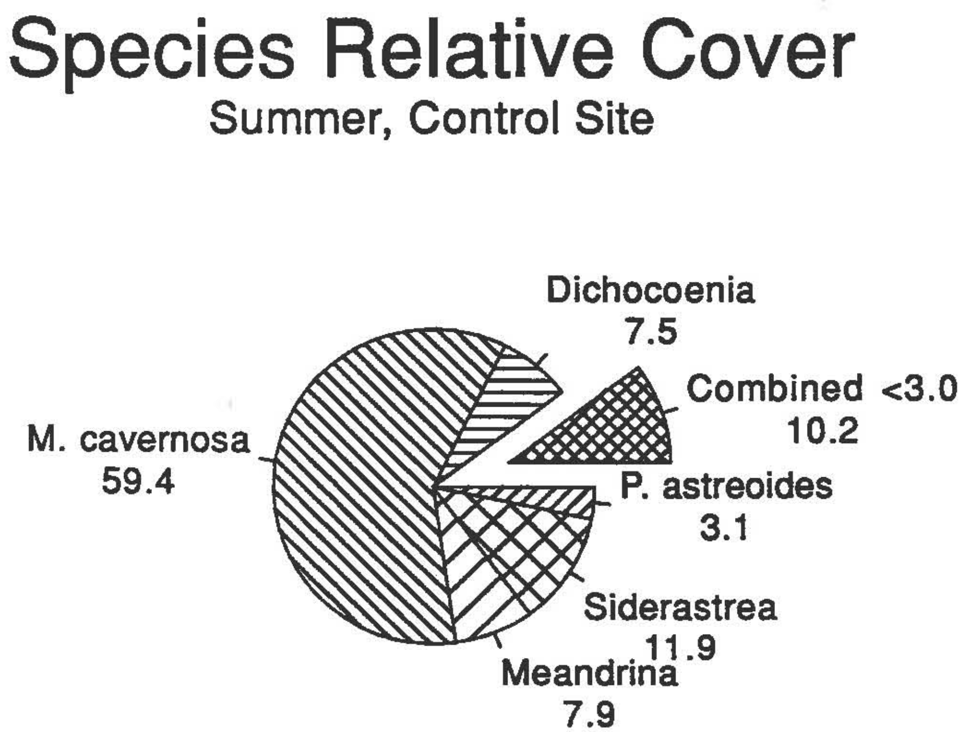


Figure 17: Mean species relative cover at control site during Summer sampling period.

3. Diversity and Evenness

a. Winter

Figures 18 - 21 depict graphs of H'n and H'c diversity and J'n and J'c evenness for buoyed and control sites in Winter and Summer sampling periods. Mean diversity based on abundance (H'n) was 1.70 in buoyed sites for the winter sampling period and 1.78 in the control site (Table 1, Fig. 18). Mean diversity based on relative coverage (H'c) was 1.04 in the buoyed site and 1.22 in the control site (Fig. 19). Mean evenness based on abundance (J'n) was 0.67 in the buoyed site and 0.82 in the control site (Fig. 20). Mean evenness based on relative coverage (J'c) was 0.35 in the buoyed site and 0.56 in the control site (Fig. 21). Indices ranged from 0.999 to 2.329 for H'n, from 0.209 to 2.296 for H'c, from 0.513 to 0.896 for J'n, and from 0.095 to 0.895 for J'c (Table 3).

b. Summer

Mean H'n was greater than mean H'c and mean J'n was higher than mean J'c. Mean diversity and evenness data for the buoyed site were H'n = 1.77 (Fig. 18), H'c = 1.09 (Fig. 19), J'n = .69 (Fig. 20), and J'c = .39 (Fig. 21). For the control site, mean H'n = 1.61, H'c = 1.12, J'n = .73, and J'c = .50.

Results of two-way ANOVA for diversity and evenness data showed no significant effects of season, treatment, or interaction of seasons and treatments (Table 4).

H'n Diversity (Based on Abundance)

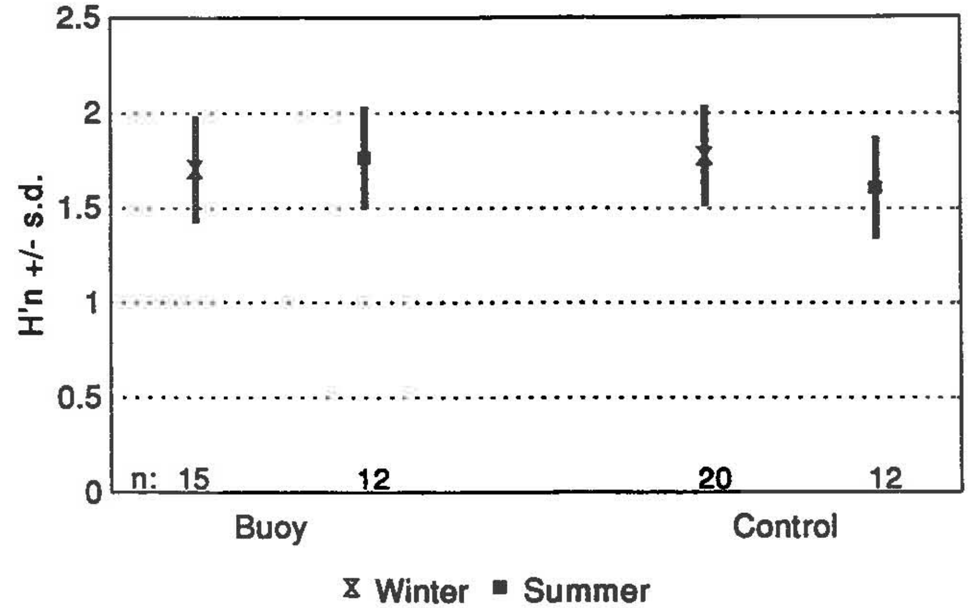


Figure 18: Mean H'n diversity (based on abundance) at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

H'c Diversity (Based on Coverage)

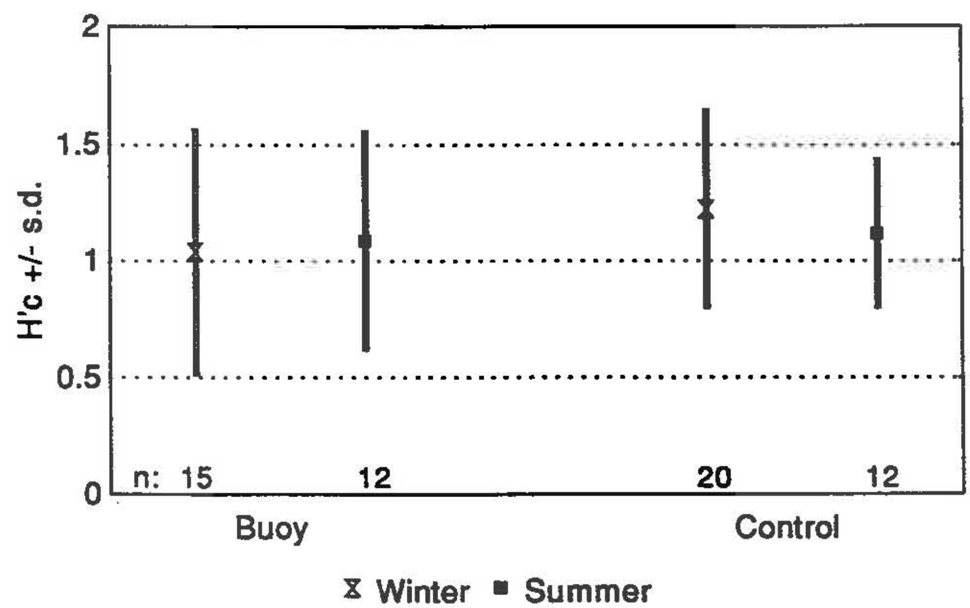


Figure 19: Mean H'c diversity (based on coverage) at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

J'n Evenness (Based on Abundance)

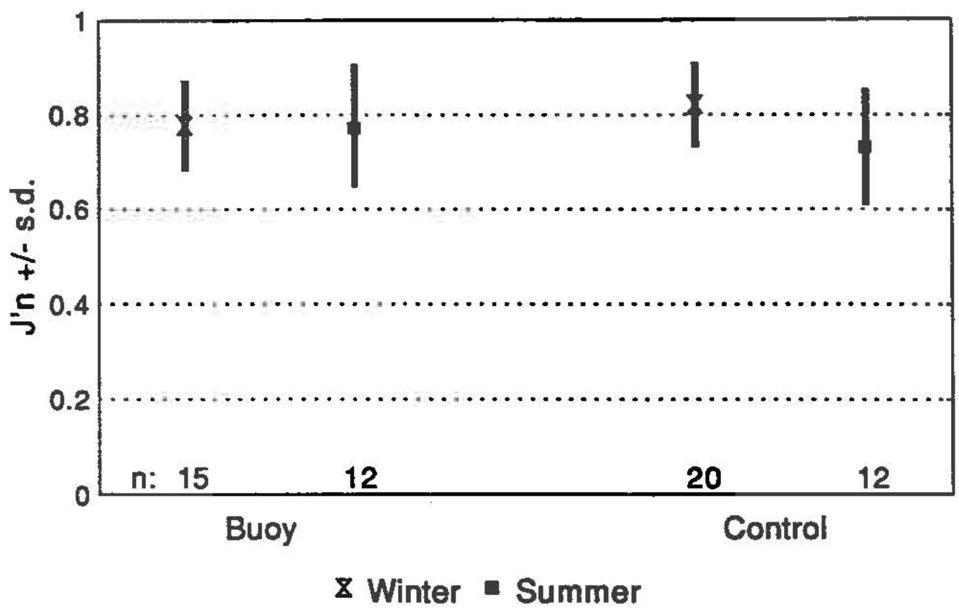


Figure 20: Mean J'n evenness (based on abundance) at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

J'c Evenness (Based on Coverage)

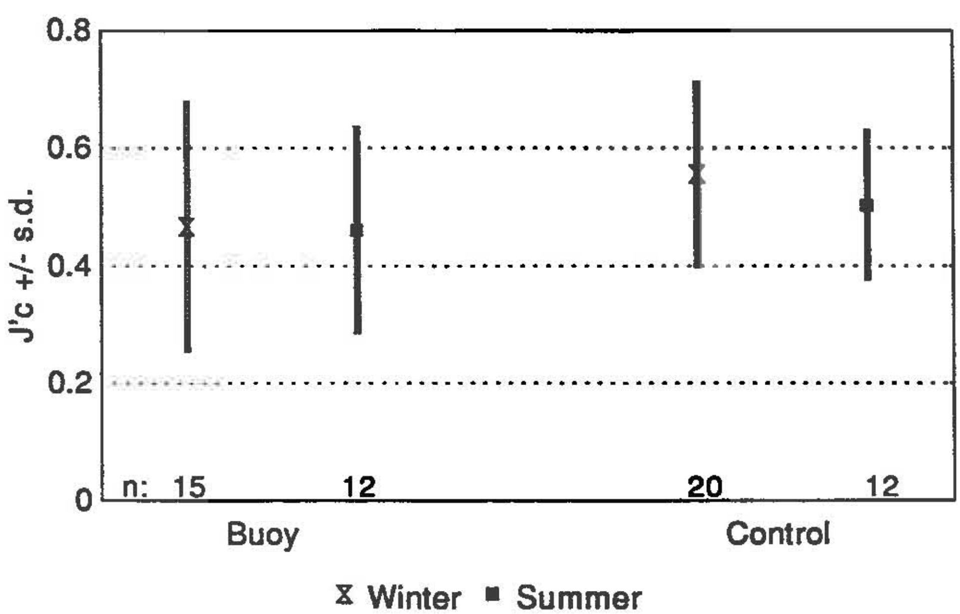


Figure 21: Mean J'c evenness (based on coverage) at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

4. Recent Injury

a. Winter

Figure 22 depicts a graph of percentage of recent injury. Mean percentage of colonies that were observed to be recently injured during the winter sampling period was 1.1% and 3.8% in the buoyed and control sites respectively (Table 1, Fig. 22). Mean percent recent injury per sample ranged from 0.0 to 12.0% (Table 3).

b. Summer

A summary of recent injury data is provided in Table 5. Mean percent recent injury increased significantly in the summer sampling period (Table 5, Fig. 22). The control site had a higher mean percentage (6.8%) than the buoyed site (5.3%), but this was not statistically significant.

Two-way ANOVA identified a significant seasonal effect on % of colonies that were observed recently injured ($p = .004$) (Table 4). Treatment effects were nearly significant ($p = .082$), and treatment x season interaction was not significant ($p = .60$).

Table 5: Mean % recently injured colony summary

Winter

Total n	Buoy n	Control n	Total % inj	SD	Buoy % inj	SD	Control % inj	SD
27	15	12	2.281	2.892	1.052	1.416	3.816	3.611

Summer (pre-Hurricane Andrew)

Total n	Buoy n	Control n	Total % inj	SD	Buoy % inj	SD	Control % inj	SD
22	16	6	5.157	4.771	5.603	5.421	3.965	2.261

Summer (Post-Hurricane Andrew)

Total n	Buoy n	Control n	Total % inj	SD	Buoy % inj	SD	Control % inj	SD
20	14	6	6.864	6.655	5.695	5.260	9.592	9.144

Total Summer

Total n	Buoy n	Control n	Total % inj	SD	Buoy % inj	SD	Control % inj	SD
42	30	12	5.970	5.739	5.646	5.254	6.778	6.997

Combined

Total n	Buoy n	Control n	Total % inj	SD	Buoy % inj	SD	Control % inj	SD
69	45	24	4.391	5.195	4.021	4.923	5.086	5.713

Mean % Recently Injured Colonies

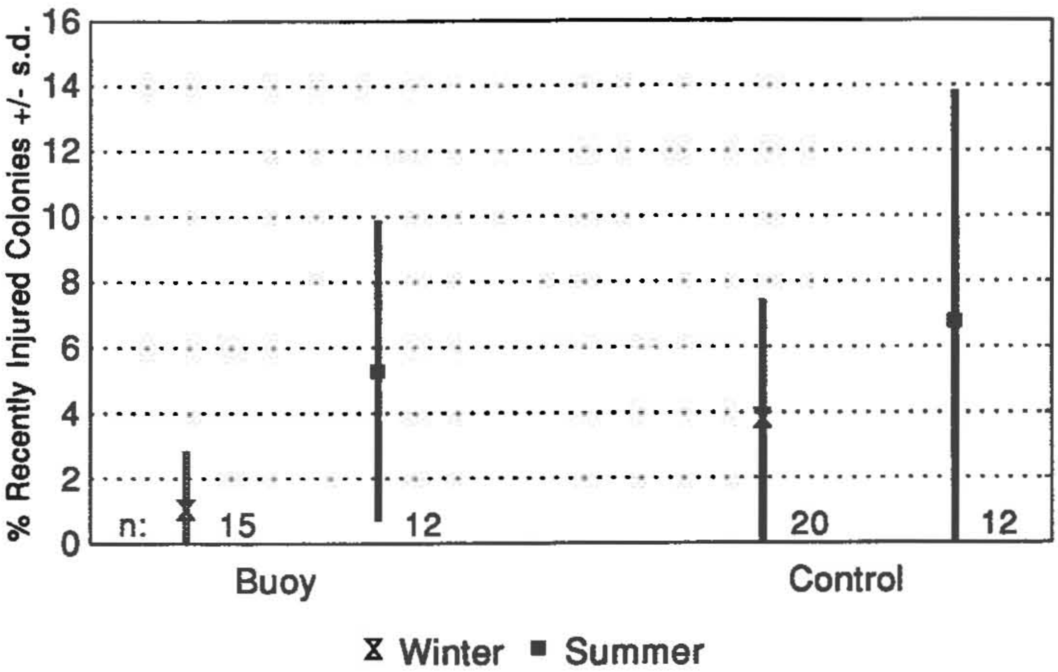


Figure 22: Mean % recently injured colonies at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

5. Shelter

a. Winter

A graph of % protected colonies is presented in Figure 23. Mean percentage of colonies that were observed to be sheltered during the winter sampling period was 8.1% in the buoyed site, and 9.4% in the control site (Table 1, Fig. 23). Mean % sheltered per station ranged from 0.0 to 34.6% (Table 3). Species that were most likely to be observed in a sheltered location were Oculina diffusa, Madracis decactis, Scolymia cubensis, and Agaricia spp. (Table 2).

b. Summer

Mean percent of corals found in sheltered locations was 5.8% in the buoyed site and 4.2% in the control site (Table 1, Fig. 23). All colonies of Scolymia cubensis encountered in the summer sampling period were sheltered (Table 2). Other corals frequently observed in sheltered locations were Madracis decactis, Mycetophyllia spp., Acropora cervicornis, Oculina diffusa, and Agaricia spp..

Results of two-way ANOVA for % protected data showed no significant effects of season ($p = .126$), treatment ($p = .940$), or interaction of seasons and treatments (.540) (Table 4).

Mean % Protected Colonies

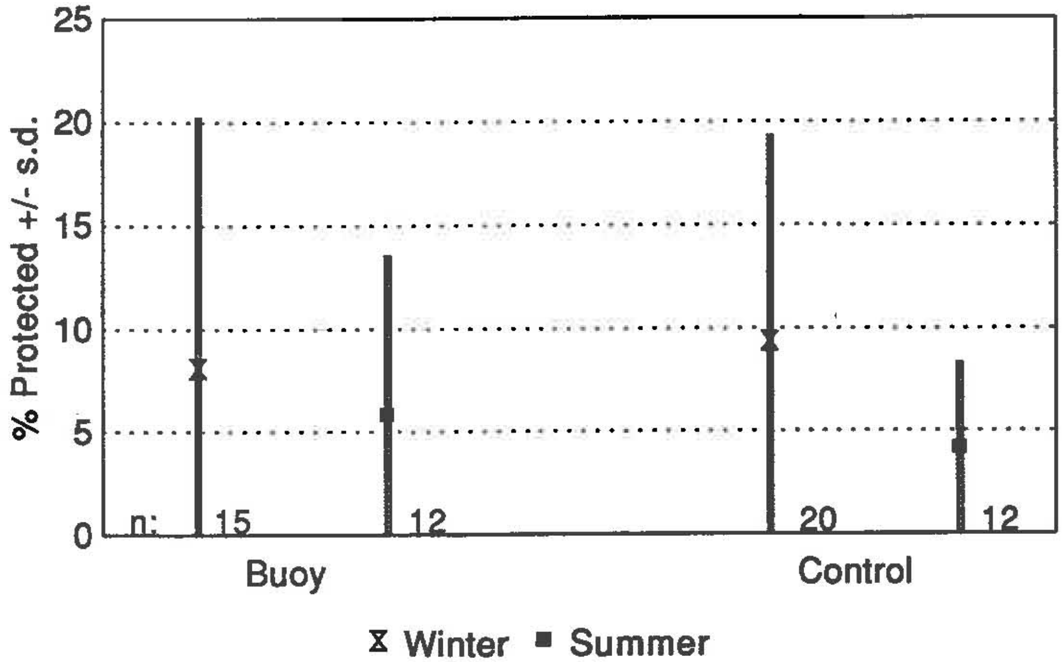


Figure 23: Mean % protected colonies at buoyed and control sites during Winter and Summer sampling periods. Error bars represent +/- 1 standard deviation.

6. Visitation

a. Winter

A summary of visitation data is provided in Table 6 and Figure 24. During the winter sampling period, an average of 6.7 boats were observed using the buoyed site at 30 minute observation intervals for the two day data collection (Table 6, Fig. 24). Of these, 22.4% were anchored and 77.6% were tied up to mooring buoys. All commercial dive boats observed visiting the buoyed site utilized mooring buoys; only private boats were witnessed anchoring at the buoyed site. The control site was characterized by a lower rate of visitation, with an average of 5.5 boats using the site at a time. All boats using the control site were privately owned; none were commercial dive charters.

b. Summer

Mean visitation increased from 12.2 boats using the study area at a time in the winter to 18.9 in the summer (Table 6, Fig. 24). Use was more intensive at the buoyed site (12.9) than the control site (6.0). Only 7.5% of boats visiting the buoyed site anchored in that area, in contrast with 22.4% in the winter. No commercial dive charters were observed anchoring in either site.

Table 6: Visitation summary

	BUOYED SITE								CONTROL	
	# Private Boats				# Charters		Total #		# Priv.	
Date	Moored		Anchored		Moored		Boats at Site		Moored	
Avg. Winter	4.039		1.500		1.154		6.693		5.500	
Avg. Summer	10.654		0.962		1.270		12.886		5.962	
		S.D.		S.D.		S.D.		S.D.		S.D.
2/2/92	6.000	1.581	2.462	0.967	1.538	0.967	10.000	1.826	8.615	2.022
2/23/92	2.308	1.494	0.538	0.660	0.769	0.725	3.615	1.502	2.385	1.502
8/16/92	13.000	2.582	1.154	0.689	1.231	0.599	15.385	2.599	6.769	1.691
8/28/92	8.308	1.316	0.769	0.725	1.308	0.751	10.385	1.850	5.154	1.345

Note: Units are # boats observed at a given time.
Observations were made at 30 minute intervals for six hour periods.
No charter boats were observed anchoring or using the control site.

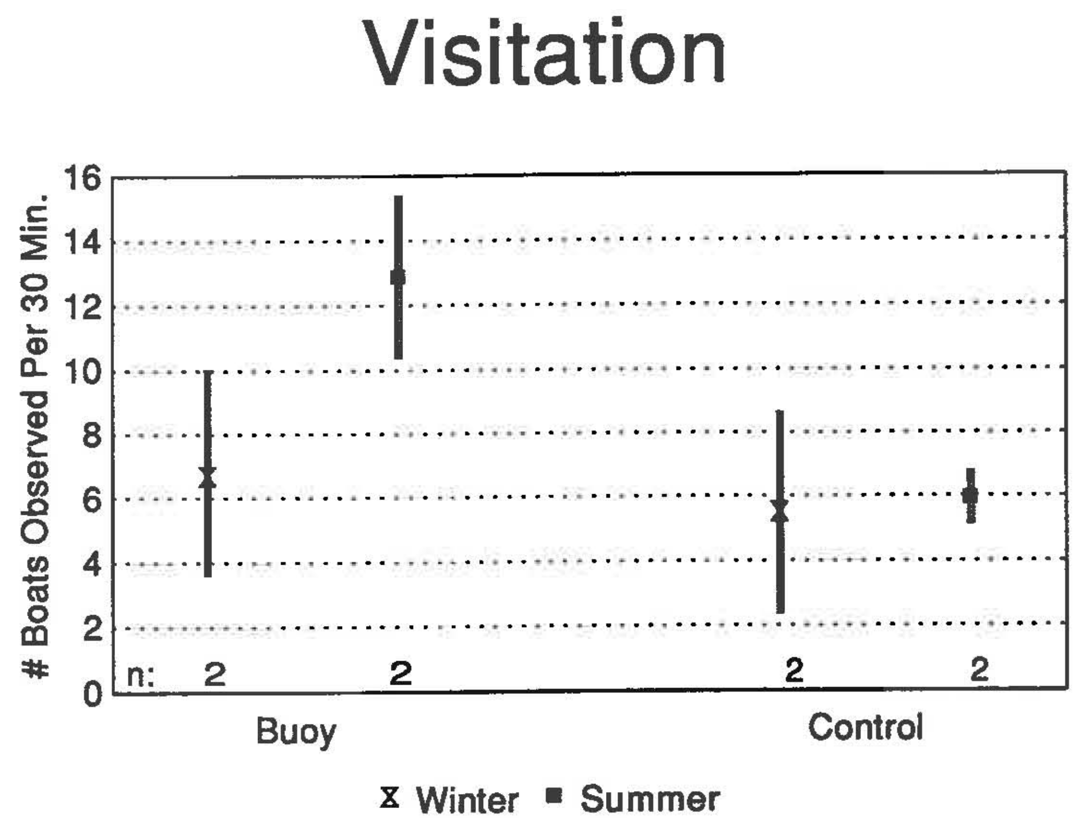


Figure 24: Mean boat visitation at buoyed and control sites (based on observations made at 30 minute intervals) during Winter and Summer sampling periods. Error bars represent the range of means from two days of observations.

c. Qualitative Results

Interviews were conducted with several local commercial dive charter captains, including Walt DiMartini, former president of Broward Association of Safe Dive Operators to obtain an estimation of typical rates of visitation to the study area. All local charter boats use the buoyed site exclusively when visiting the study area; none anchor in the control site instead of tying up to buoys. Charters make about 2,000 visits to the buoyed site annually. Both boat visitation and number of divers increases in the summer. All available buoys are frequently in use by commercial and private boats on summer weekends.

7. Correlation of Parameters

A matrix of correlation coefficients for stony coral population parameters is provided in Table 7. Abundance was positively correlated with % cover, H'c diversity, and J'c evenness, and negatively correlated with % recent injury (Table 7). Percent cover was negatively correlated with H'c diversity and J'c evenness. Positive correlations were identified between H'n and H'c, J'n, and % protected. H'c was positively correlated with J'c and % protected, and negatively correlated with % recent injury. J'c was positively correlated with % protected.

Table 7: Correlation coefficients (r values), n = 45

	% Cover	H'n	H'c	J'n	J'c	% Inj	% Prot
Abundance	0.369	0.164	0.396	-0.200	0.305	-0.442	0.184
% Cover		-0.024	-0.396	-0.095	-0.456	-0.071	-0.100
H'n			0.366	0.732	0.259	0.032	0.400
H'c				-0.014	0.963	-0.302	0.366
J'n					0.045	0.197	0.224
J'c						-0.276	0.332
% Injured							-0.032

For p < .05, r > .294 or r < -.294
Significant values boxed.

8. 40 m^2 Data

A summary of mean population parameters for 40 m^2 stations is presented in Table 8. A summary of two-way ANOVA results comparing 20 m^2 and 40 m^2 stations is provided in Table 9. There were no significant differences in stony coral data between 40 m^2 and 20 ^{2} stations for any parameters (Table 9).

Table 8: Mean 40 sq. m data for buoyed and control sites for each season

	Winter					Summer				
	N	Abund	SD	%Cover	SD	N	Abund	SD	%Cover	SD
Buoy	3	42.50	27.18	8.260	5.482	4	43.813	35.34	5.110	3.122
Control	2	65.00	39.60	3.469	2.767	3	60.00	22.72	4.512	2.612
		H'n	SD	H'c	SD		H'n	SD	H'c	SD
Buoy	3	1.776	0.428	0.899	0.707	4	1.361	0.622	0.681	0.314
Control	2	1.168	0.305	0.682	0.192	3	1.558	0.319	1.216	0.163
		J'n	SD	J'c	SD		J'n	SD	J'c	SD
Buoy	3	0.772	0.159	0.394	0.308	4	0.665	0.219	0.327	0.101
Control	2	0.599	0.095	0.349	0.063	3	0.660	0.144	0.513	0.061
		%Prot	SD	% Inj	SD		%Prot	SD	% Inj	SD
Buoy	3	8.64	14.17	0.64	1.11	4	3.64	3.98	4.98	2.19
Control	2	0.54	0.76	7.02	5.35	3	4.52	2.80	4.64	0.93

Note: Abundance units are colonies/ 20 sq. m

Table 9: One-way ANOVA results for 20 sq. m and 40 sq. m sample areas for $p < .05$

Abundance	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.920

% Cover	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.574

H'n Diversity	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.264

H'c Diversity	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.673

J'n Evenness	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.074

J'c Evenness	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.343

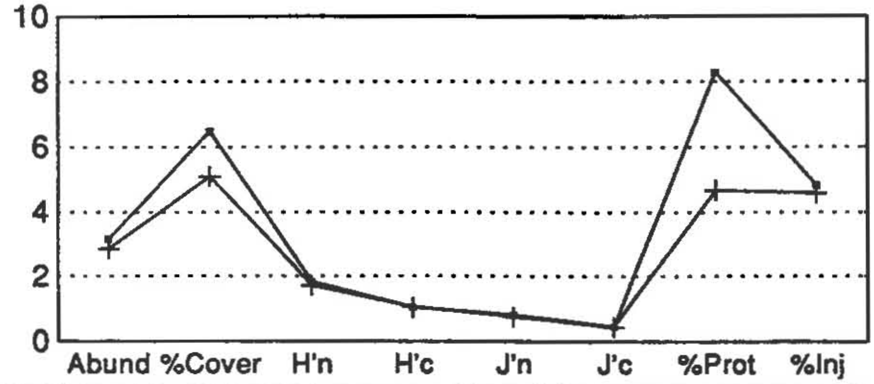
% Recently Injured Colonies	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.882

% Protected Colonies	Significance	p value
Sample Area (20 sq. m, 40 sq. m)	not significant	0.615

9. Hurricane Impacts

Table 10 and Figures 25 and 26 depict mean data for periods before and after Hurricane Andrew in Summer 1992. A summary of p values calculated by two-way ANOVA for all parameters is presented in Table 11. Hurricane Andrew had no significant impact on any coral parameter (Table 11).

Hurricane Andrew Impact Assessment
Buoyed Site

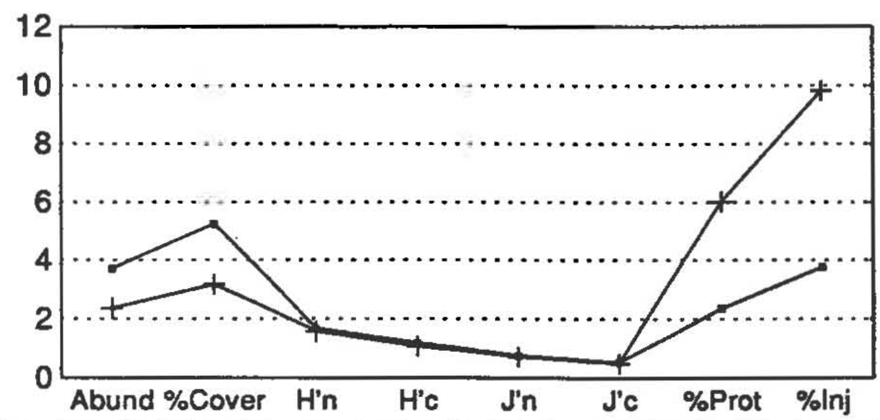


	Abund	%Cover	H'n	H'c	J'n	J'c	%Prot	%Inj
Pre-Hurricane	3.15	6.47	1.821	1.037	0.805	0.453	8.28	4.83
Post-Hurricane	2.85	5.1	1.702	1.044	0.754	0.437	4.68	4.59

—•— Pre-Hurricane —+— Post-Hurricane

Figure 25:Buoyed site coral parameter means for periods before and after Hurricane Andrew in Summer 1992. Abundance units are colonies/ sq. m. N=13 stations for each period, 6 of which were resurveyed.

Hurricane Andrew Impact Assessment
Control Site



	Abund	%Cover	H'n	H'c	J'n	J'c	%Prot	%Inj
Pre-Hurricane	3.7	5.24	1.655	1.175	0.748	0.527	2.35	3.75
Post-Hurricane	2.35	3.15	1.56	1.06	0.713	0.48	6.02	9.81

—•— Pre-Hurricane —+— Post-Hurricane

Figure 26: Control Site coral parameter means for periods before and after Hurricane Andrew in Summer 1992. Abundance units are colonies/sq. m, n=6 for each period.

Table 10: Mean 20 sq. m data for periods before and after Hurricane Andrew

	Pre-Hurricane					Post-Hurricane				
	N	Abund	SD	%Cover	SD	N	Abund	SD	%Cover	SD
Buoy	13	62.92	23.07	6.474	3.307	13	56.692	35.16	5.104	5.363
Control	6	73.83	17.26	5.244	3.697	6	46.667	14.98	3.154	1.768
		H'n	SD	H'c	SD		H'n	SD	H'c	SD
Buoy	13	1.821	0.286	1.037	0.511	13	1.702	0.214	1.044	0.516
Control	6	1.655	0.194	1.175	0.273	6	1.560	0.327	1.060	0.380
		J'n	SD	J'c	SD		J'n	SD	J'c	SD
Buoy	13	0.805	0.095	0.453	0.206	13	0.754	0.147	0.437	0.176
Control	6	0.748	0.093	0.527	0.097	6	0.713	0.148	0.480	0.156
		%Prot	SD	% Inj	SD		%Prot	SD	% Inj	SD
Buoy	13	8.28	9.82	4.83	4.25	13	4.68	6.64	4.59	3.41
Control	6	2.35	2.47	3.75	3.42	6	6.02	4.78	9.81	8.60

Note: Abundance units are colonies/ 20 sq. m

Table 11: Two-way ANOVA results for pre and post-Hurricane periods and treatment for p < .05

Abundance	Significance	p value
Treatment (buoy, control)	not significant	0.962
Hurricane Effects (pre, post)	not significant	0.080
Interaction (Treatment x Hurricane Effects)	not significant	0.265

% Cover	Significance	p value
Treatment (buoy, control)	not significant	0.270
Hurricane Effects (pre, post)	not significant	0.231
Interaction (Treatment x Hurricane Effects)	not significant	0.801

H'n Diversity	Significance	p value
Treatment (buoy, control)	not significant	0.095
Hurricane Effects (pre, post)	not significant	0.243
Interaction (Treatment x Hurricane Effects)	not significant	0.893

H'c Diversity	Significance	p value
Treatment (buoy, control)	not significant	0.638
Hurricane Effects (pre, post)	not significant	0.742
Interaction (Treatment x Hurricane Effects)	not significant	0.711

J'n Evenness	Significance	p value
Treatment (buoy, control)	not significant	0.266
Hurricane Effects (pre, post)	not significant	0.326
Interaction (Treatment x Hurricane Effects)	not significant	0.866

J'c Evenness	Significance	p value
Treatment (buoy, control)	not significant	0.346
Hurricane Effects (pre, post)	not significant	0.610
Interaction (Treatment x Hurricane Effects)	not significant	0.804

% Recently Injured Colonies	Significance	p value
Treatment (buoy, control)	not significant	0.226
Hurricane Effects (pre, post)	not significant	0.091
Interaction (Treatment x Hurricane Effects)	not significant	0.069

% Protected Colonies	Significance	p value
Treatment (buoy, control)	not significant	0.376
Hurricane Effects (pre, post)	significant	0.990
Interaction (Treatment x Hurricane Effects)	not significant	0.165

10. Summary of Results

Stony coral coverage was nearly 6% and was dominated by Montastrea cavernosa. There were an average of approximately 60 colonies/20 m^2 station, with Siderastrea spp. and Montastrea cavernosa dominating abundance. H'n diversity was about 1.7, and H'c diversity was 1.1. J'n and J'c evenness indices were nearly .8 and .5 respectively. Approximately 6% of all colonies observed were in a protected or sheltered location. Some species, such as Madracis decactis, Scolymia cubensis, and Agaricia spp., were more likely to be protected than others. About 2% of all corals observed had been recently injured during the Winter sampling period, and 6% had been recently injured during the Summer. There was a higher percentage of corals observed to be recently injured in the period following Hurricane Andrew than in the preceding period. Visitation to both sites increased in the Summer, and usage was greater at the buoyed site in both seasons. There were no significant differences between coral populations at buoyed and control sites for any parameter. There was no significant seasonal difference in any parameter at the .05 level with the exception of % recent injury, which was greater in the Summer for both sites ($p = .004$). There were no significant differences between 20 m^2 and 40 m^2 stations for any parameter. Hurricane Andrew had no significant effect on any coral parameter.

V. Discussion

1. Justification and Evaluation of Methodology

a. Site Selection

Buoyed sites were centered around the permanently fixed eyebolts at the base of the buoy anchors to ensure site repeatability in this study and in future annual reports. By selecting sample areas directly under the buoy, it follows that these areas would presumably be free from anchor damage, as well as being likely high use areas by divers using the buoys. Divers entering the water from boats that are tied up to mooring buoys would usually descend next to the boat. Dive masters often instruct groups of students to follow the buoy line to the bottom, and regroup at the base. A common source of diver-coral contact
occurs at the bottom after the initial descent, while divers work to attain neutral buoyancy and get their bearings.

The consistency with which the buoys are situated on the reef with regards to depth, position on the ledge, and distance apart, made it easy to relocate eyebolts even when buoys were lost or removed. Some confusion occurred when replacement buoys were installed with incorrect labels, but this was later avoided by reliance on land sightings rather than buoy labels. Data for all buoyed sites have been verified except for buoy number five, which was originally labeled as buoy three. Buoyed sites were not evenly distributed along the line of buoys, largely because several buoys were missing for the majority of the study. Up to fifteen of the thirty buoys were noted to be missing at one time.

Control sites were not precisely repeatable in the manner that buoyed sites were. The general locations of control sites were noted and repeated. Early phases of the project experimented with rebar stakes to mark fixed control sites, but stakes could not be relocated in most instances. This is probably due to a combination of factors. The sites were in very shallow water and were therefore vulnerable to wave and tidal action. Additionally, the area was heavily visited by recreational divers who may have removed some stakes as well.

b. Circular Sample Area Shape

A new assessment method was designed for this study. Circular sampling areas were used to take advantage of the permanent nature of the buoy eyebolts. Use of circular areas resulted in a smaller perimeter length than square or rectangular quadrats of the same area (15.85 m vs. 17.89 m), reducing possible sampling error due to surveying corals on or near the area perimeter. Circular sampling employed only one internal perimeter of length = 7.917 m. Due to the nature of this method, at no time were colonies covered or hidden by sampling apparatus, a problem which is inherent to quadrat use. Use of quadrats would have involved internal perimeters of at least 8.944 m, assuming that a minimum of four quadrats would be required, with a common corner point at the buoy eyebolt. An additional benefit of the circular method is that there is no contact with coral; the line is held just above the substrate. A drawback is that the line must be carefully attached to the eyebolt and be kept taut at all times to provide a precise and consistent sampling area.

c. Sample Area Size

A 20 m^2 sample area appeared to be more than sufficient to assess stony corals on Pompano Ledge. The species-area curve presented in Figure 5 demonstrates that as little as 10 m^2 may have been adequate to properly survey the coral community. A relatively large area was used in this study to provide a more reliable evaluation of recent injury. A comparison of 20 m^2 and 40 m^2 stations demonstrated that doubling the sample area size had no effect on any parameters.

d. *In Situ* vs. Photographic Data Collection

Measurements were taken manually in lieu of photographic means, thus sacrificing some degree of precision in favor of overall accuracy in describing the complete stony coral community. The *in situ* method enabled this observer to identify corals as small as 0.5 cm in diameter and allows inclusion of numerous cryptic, hidden, and "protected" colonies or even species that would be missed by most photographic methods. Photographic data collection requires better visibility and less turbulent conditions than manual methods. This was a factor in this study, particularly in the winter when high winds and rough seas were common. *In situ* coral identification is often easier than identification from still or video photography. However, in cases where corals are believed to have been misidentified, a photographic record enables the analyst to make comparisons and corrections that are not possible with manually recorded data.

Ideally, *in situ* measurements should be taken in conjunction with photography to maximize accuracy and quantity of information. Photography provides a permanent record that allows for multiple analyses. Whereas this study focused exclusively on stony corals, a photographic record would include additional information on sponges, gorgonians, algae, and other sessile organisms. Photographic data would be useful in monitoring the health of selected rare or spectacular features of the reef, such as large colonies of Dendrogyra cylindrus or Acropora palmata.

e. Impact Assessment

The two primary goals of this study were to:

1. collect baseline data for a long term monitoring project; and
2. evaluate current effectiveness of mooring buoys in reducing incidence of injury to nearby corals.

Baseline data can be compared with future surveys to identify changes in coral population parameters which may be related to buoy impacts or other natural or unnatural perturbations. Observations of recent injury made in this study quantify specific injuries to specific corals. The other parameters, such as community structure, diversity, and abundance may not be as sensitive as recent injury. This is because these parameters do not respond to changes within the individual components, only to changes involving presence or absence. Coverage parameters can respond to changes within individuals, but are still less sensitive than the parameter of recent injury. Not all injuries will result in the death of the colony; some colonies would be expected to recover. Mortality, reduction of living coral coverage, and loss of diversity can certainly result from anchor damage, but this would take place over a longer period of time.

Description of the stony coral community of the First Reef was more easily accomplished than evaluation of the extent to which buoys reduce injury to corals at the site. Methodology suitable for describing coral species composition is not necessarily ideal for monitoring damage. A 20 m^2 sample area is more than sufficient to study population structure, but may not be large enough to optimize tests for statistical significance of impact. Recent injury data from 40 m^2 stations was consistent with data from 20 m^2 stations, however, which is evidence that 20 m^2 may have been sufficient. Future attempts to survey recent injury may wish to sample areas of the reef between buoys in an attempt to identify whether a gradient of increasing or decreasing injury exists in relation to distance from a buoy.

Corals were surveyed biannually to incorporate seasonal effects. However, in order to identify all instances of coral injury, it is necessary to sample at least once a month due to rapid algal overgrowth of damaged corals (Rogers *et al.* 1988). Monthly surveys were beyond the scope of this study, therefore injury assessments were taken as representative of typical conditions for the season rather than reports of the totality of coral injury for the year. Coral community structure is not likely to change greatly in the course of a year; therefore it may be prudent to assay population changes less frequently than injury assessments. As injury assessments are less time consuming than species composition studies, it may then be possible to survey more frequently as well as increasing the amount of area surveyed.

f. Visitation

Evaluation of buoy effectiveness requires an understanding of quantity and type of use of buoyed and control sites. Results of informal surveys of area divers and boaters suggested that use at both sites is greater in the summer, that the buoyed site is more heavily visited than the control site, and that commercial dive boats only use the buoyed site. These findings were supported by the quantitative visitation study. The visitation study demonstrated that all classifications of usage were greater at the buoyed site than in the control site. However, observations were made on only two days for each season, and it is possible that results were not representative. The results were sufficient to confirm the trends suggested by the qualitative study, but should not be used to represent actual numbers of visitors. More reliable quantitative estimates of visitation would be useful for future evaluations.

g. Problems in Coral Taxonomy

Reef monitoring studies typically focus primarily on stony corals due to their longevity and role as the cornerstone of the reef habitat. However, *in situ* identification of stony corals is often difficult. Coral taxonomy is based almost exclusively on skeletal characteristics, many of which are obscured by living tissue or are simply too small to be visible without magnification. Corals are taken from outside the sample area to allow laboratory classification of difficult species. However, at times this is not sufficient, particularly in the case of small colonies. For this reason, several taxa were only identified to the genus level. Scleractinians frequently exhibit great variability in skeletal characteristics important for classification, such as calice diameter and septal structure (Best *et al.* 1984, Lang 1984). Species boundaries may overlap, e.g. Acropora, or even form continuous morphologic series, e.g. Agaricia, Mycetophyllia, and Porites (Foster 1984, 1985, Lang 1984). This variability arises from both genetic differences (Dustan 1975) and response to environmental factors (Foster 1979).

As a result of the high potential for intraspecific variability within scleractinians, it is possible that taxonomic keys based on corals observed in the southern Caribbean may not always apply precisely to corals observed at the northern limit of their distribution. In practice, this was only a problem in one instance. Small colonies of Dichocoenia stokesi were difficult to distinguish from Favia fragum. Based on a variety of characteristics, all colonies were determined to be Dichocoenia; Favia was not present in the study area. Costae were present but reduced, and septal margins were primarily smooth, which is characteristic of Dichocoenia (Smith 1971, Wood 1983, Cairns 1982). Columella appeared less spongy than an archive sample of Favia. Septa did not form the three to four complete cycles characteristic of Favia (Smith 1976).

Occasionally, observed differences in species composition at replicated buoy sites were certainly due to errors in identification rather than representing actual changes. This appeared to occur most frequently in small colonies of brain corals of the genera Diploria and Colpophyllia and to a lesser degree in small colonies of star corals of the genera Solenastrea and Stephanocoenia. It was not possible to separate classification errors from actual changes with complete certainty, so observations were not adjusted for the purpose of analysis.

2. Species Composition

The stony coral coverage of the first reef of northern

Broward County is dominated by M. cavernosa and Siderastrea spp. (Table 2, Figs. 12, 13, 16, and 17). This is consistent with the findings of Dodge *et al.* (1992) for shallow southern Broward sites. However, the southern Broward study observed Stephanocoenia michelinii as the third most abundant species, while in this study Stephanocoenia was only moderately abundant. Courtenay *et al.* (1974) noted the presence of numerous large colonies of M. cavernosa in the vicinity of this study area. Isophyllia multiflora, described as one of the most frequently encountered scleractinian species in the area (Courtenay *et al.* 1974), was not present at any stations and was very rarely observed during the course of this study. Dichocoenia stokesi, the third most abundant stony coral in this study, has been frequently cited as abundant in Broward County (Dodge *et al.* 1992, Continental Shelf Associates 1980, Coral Reef Associates 1984). Millepora alcicornis was moderately abundant. Coverage estimates for Millepora may be somewhat misleading due to the fact that colonies tended to be taller than they were wide. Classification of Montastrea annularis has recently been divided into three species (Knowlton *et al.* 1991). Only one species, morphotype 2, is believed to be present in the study area.

Species richness is a term used to describe the total number of species in an area. Scleractinian coral species richness (excluding Millepora) on Pompano Ledge was 29, 26 of which were present in the sample areas. This is reasonably high for a shallow Caribbean reef. Total stony coral species richness for Broward County can be expected to be higher still when corals from the deeper second and third reefs are included. A summary of species richness reports for the greater Florida area were compiled by Blair and Flynn (1989). Estimates of Florida species richness range from a low of 21 for Broward (Dodge *et al.* 1992) to 36 for southern Dade (Burns 1985). Other area reports include 45 species in the Dry Tortugas (Jaap *et al.* 1989), 31 in Looe Key (Wheaton and Jaap 1988), 24 for Carysfort Reef (Dustan and Halas 1987), and 24 for Boca Raton (Coastal Planning and Engineering 1991).

Stony coral diversity based on abundance (H'n) was higher than reported by Dodge *et al.* (1992) for offshore of John U. Lloyd State Recreation Area, but diversity based on coverage was very similar. Both evenness indices were very similar at the two sites. Percent coral cover was greater than 5% on Pompano Ledge (Table 1), compared with 1.25% for the first reef off John U. Lloyd State Recreational Area. An earlier study (Ocean Research and Survey, Inc. 1980) reported stony coral cover on the first reef in southern Broward County as 7.5%, but this included large colonies that were deliberately selected for analysis, and was therefore not representative. Stony coral abundance was approximately 3 colonies/m^2 on Pompano Ledge, and 2.2 col./m^2 for John U. Lloyd State Recreational Area. It is possible that differences between results of the two studies are a result of methodological artifacts, but it seems likely that they represent actual differences between the two sites.

The coral communities of Broward County are subjected to a variety of stressful environmental conditions, including relatively low temperatures, poor clarity, sedimentation, eutrophication, and pollution. Formed in the Holocene, Broward reefs have not been actively accreting in the last 8,000 years (Marszalek *et al.* 1977). Present coral growth rates in the region are approximately one half that of corals in more ideal habitats (Dodge and Vaisnys 1974). Diversity, density, and percent coverage of stony corals is significantly lower than reefs in the Florida Keys or most other Caribbean sites (Jaap and Hallock 1990).

The sub-optimal conditions are further evidenced by coral community structure. Acropora palmata, which dominates shallow zones in almost all Caribbean reefs (Porter 1987), was not found in any stations. A few colonies were observed to the west of the sample area at a depth of approximately 3 m. The slightly deeper zone of Acropora cervicornis and Montastrea annularis common to Caribbean reefs is also absent. Both species are present, but not in large numbers (Table 2). A. palmata has been described as "extremely rare" in the area (Coral Reef Associates 1984).

M. cavernosa and Siderastrea siderea are highly efficient sediment rejectors (Tomascik and Sander 1987). M. cavernosa dominates coral coverage on turbid Puerto Rican reefs (Loya

1976). Conversely, M. annularis is not as well adapted for areas of high sedimentation (Hubbard and Pocock 1972). The growth rate of M. annularis has been observed to be low in areas of high turbidity (Dodge *et al.* 1974). Acropora palmata is generally an indicator of clear water. It seems likely that the near absence of acroporid species and the replacement of M. annularis by M. cavernosa on shallow northern Broward reefs is due at least in part to high turbidity. However, sub-optimal temperatures are also likely to be important, particularly in Acroporids. A cold water intrusion in the Dry Tortugas in 1977 resulted in the subsequent mortality of 96% of Acropora colonies in depths of less than 2 m (Porter *et al.* 1982).

3. Correlation of Population Parameters

Mean percent recent injury was inversely correlated with abundance ($r = -.442$) (Table 4). This was primarily an artifact of the methodology used. Corals were classified either as injured or not injured, no quantification was made of extent of area damaged. Injury to a large colony was therefore treated the same as injury to a small colony. Injury was rarely detected in small colonies. Some injuries to large colonies were larger than the entire surface area of many small colonies. Injury to small colonies would often have been fatal, because small colonies would be susceptible to crushing or burying. Therefore, sample areas with numerous small corals would be likely to have a lower percentage of surviving injured corals than an area with fewer, larger colonies.

Abundance was positively correlated with diversity based on coverage, H'c (r = .396). This is logical, because stations with low coral abundance generally had a low species richness, and a high abundance would encompass a corresponding high species richness. This is in marked contrast to % cover, with which H'c was inversely correlated (r = -.396). Stations with high coral coverage were often dominated by one or more large colonies of Montastrea. H'c was strongly positively correlated with J'c (r =.963), which was also inversely correlated with % cover (r = -.456). The two parameters are mathematically related; J'c is a function of H'c. H'n and J'n were similarly positively correlated (r = .732).

Diversity based on coverage, H'n, was positively correlated with mean percentage of corals that were observed in protected or sheltered areas (r = .400). An area with a high % protected value would have a greater structural heterogeneity than an area with a low % protected value. This structural heterogeneity provides a greater number of microhabitats, therefore supporting a higher diversity of corals. Corals such as Madracis decactis, Agaricia spp. or Scolymia cubensis which were primarily observed under ledges were not typically found in stations that did not have a strong three-dimensional component.

4. Hurricane Impacts

Hurricane Andrew had no significant effect on any population parameters. However, the hurricane overturned numerous coral heads, some of which were removed from or deposited into sample areas. Corals were occasionally encountered that appeared to have been damaged by impact from corals that were picked up and moved. The lack of significant impact may be due to the location of the majority of sites on the reef crest. Most evidence of hurricane damage appeared to be found on the seaward edge of Pompano Ledge. On many other area reefs, the hurricane deposited large quantities of sediments that suffocated or impacted corals, but that did not appear to be a problem on Pompano Ledge.

5. Seasonal Differences

There was no detectable difference between seasons in any population parameters at the 0.05 level of significance, except for an increase in % recent injury in the summer (p =.004) (Table 4). Visitation increased 92.5% from winter to summer in the buoyed site, and only 8.4% in the control site. This site-specific increase in visitation may explain why there was a greater increase in % recent injury at the buoyed site than in the control site. Although increased visitation was probably important, several other factors contributed to the increase in % recent injury for the summer sampling period as well. Hurricane Andrew may have had an impact on recent injury results despite a lack of statistical significance.

Lobster "mini-season" is recognized locally as a source of damage caused by careless or inexperienced divers colliding with or overturning coral heads. Algal growth also increases during summer months, growing over damaged or highly stressed corals. Algae may also obscure some small healthy corals, which may or may not recover when algal cover is later reduced.

Twenty-three stony coral and Millepora taxa were surveyed in the summer, compared with twenty in the winter. Mycetophyllia spp., Manicina areolata, Phyllangea americana, and Mussa angulosa were surveyed only in the summer, and Diploria strigosa was surveyed only in the winter. Differences in species presence or absence are not due to colonization or local extinctions. Mussa, Phyllangea, and Manicina were observed in stations that were only surveyed in the summer. Mycetophyllia colonies were observed under ledges and were difficult to see, and were probably missed during the initial survey. Diploria strigosa was observed at a control station, and was therefore not resurveyed.

6. Buoy Effectiveness

Boats that tie up to mooring buoys are not anchoring, and anchoring in coral causes damage. Therefore, use of mooring buoys will reduce that type of damage to reefs. This is the basic premise behind mooring buoy use. As long as damage prevented by anchors is greater than possible diver damage caused by a resulting increased usage of the site, buoys are extremely useful management tools. Anchor damage can be minimized or even prevented from occurring by use of mooring buoys. The total amount of overall diver damage, however, is not likely to be reduced or increased by buoy usage; divers not using the buoyed site would probably be diving somewhere else. A potential scenario where mooring buoy usage would be detrimental includes the following. 1. Diver damage was more significant than anchor damage. 2. Diver damage was concentrated in the area of the buoys as a result of the buoys being there. 3. The concentrated diver damage was elevated to a level beyond that of the reef to repair itself by recruitment and regrowth.

There is no evidence to indicate that buoys are causing concentrated diver induced reef damage on Pompano Ledge. In fact, the mooring buoys on Pompano Ledge seem to be a useful tool to reduce human impacts to fragile reef organisms. The buoyed site was visited 22% more than the control site during the winter sampling period, and 116% more in the summer (Table 6). Dive charters full of inexperienced student divers frequently use the buoyed site. In spite of these factors, % recent injury was lower in the buoyed site than in the control site (p = .082) (Table 4, Fig. 22). The value of the mooring buoys is demonstrated even if injury is equal in both sites, because visitation is much higher at the buoyed site.

Pompano Ledge is an example of an area where buoys were installed on a popular reef with a pre-existing condition of heavy dive pressure. Before installation of mooring buoys, it is likely that dive pressure was uniformly distributed along Pompano Ledge. Buoyed and control sites are very similar in coverage and composition of the stony coral community as well as in overall appeal to divers. A notable exception is the wreck of the Copenhagen at the southern end of the buoyed site. The spectacular pillar coral Dendrogyra cylindrus is also unique to the buoyed site, but this is not likely to greatly influence dive pressure to the site. Buoy installation appears to have concentrated dive pressure to some degree. However, there is no evidence to indicate that diver-caused damage is greater in magnitude than anchor damage. Concentration of diver effects is minimized by use of a large number of buoys spread out over a large area. Drift diving is popular in the area, particularly among dive charters, and this would further contribute to minimizing concentration of divers.

7. Management Considerations

Mooring buoys are an excellent tool to reduce anchor damage to heavily used reefs, and can be an important part of a comprehensive reef management plan (see van Breda and Gjerde 1992). Introducing buoys to popular reefs will reduce anchor damage with maximum efficiency. Greater care needs to be taken in locations where dive pressure is relatively low. In these situations, mooring buoys may serve to attract divers to the sites. This may be useful to managers attempting to more evenly distribute dive pressure. In general, however, it is probably more desirable to retain some areas in relatively pristine conditions where possible. These areas can serve as sources of larval recruitment and provide "natural" comparisons that will be useful for assessing impacted reefs.

Education is a vital component of a successful mooring buoy plan. Installation of mooring buoys is a waste of time and money if the public is unaware of what to do with them. Education is an ongoing process, as new divers are constantly moving to or visiting the area. Ocean Watch Foundation educates the dive community through pamphlets available at area dive shops, booths at topical expositions and fairs, a quarterly newsletter, and numerous activities such as parties, meetings, and beach clean-ups. Dive charter operators can and do play an important leadership role in educating divers on their boats. During the course of this study, several dive boat captains were witnessed using loudspeakers or radios to lecture private boat operators that had anchored near mooring buoys.

A good maintenance program is another essential part of a mooring buoy plan. A good mooring buoy system, such as the Halas-type system, must be designed for simple and inexpensive maintenance. Buoys, lines, shackles, eyebolts, and pins must be regularly inspected, cleaned and/or replaced as necessary. Reef Relief (1992) outlines a thorough maintenance and inspection plan patterned after the National

Marine Sanctuaries Program. Reef Relief and Ocean Watch Foundation both utilize area dive captains to assist in this task. However, it is important to have one individual or committee to oversee maintenance and inspection to make sure parts are available and that missing buoys are promptly replaced. Numerous buoys are frequently missing from Pompano Ledge for long periods of time, during which buoyless downlines are allowed to lie on the bottom. This can result in injury to gorgonians, sponges, and other high relief organisms, which can be uprooted by the line when it is swept around by the current.

V. Summary and Conclusions

The stony coral community structure of Pompano Ledge, part of the first reef of Broward County, Florida, was described using a new reef assessment method developed for this study. Organisms within a circular sample area were identified and measured *in situ*. This was well-suited for monitoring buoy effectiveness because stations could be centered around buoy eyebolts. Use of a weighted line allowed the method to be adapted to use in the non-buoyed control site as well. This method may be useful for future monitoring studies because it allows for precise reoccupation of sites while requiring only one permanent marker. An additional advantage is that a circular sample area has the smallest boundary distance for a given area.

Coral abundance, % cover, and diversity were higher than reports for the First Reef in other parts of Broward County. A total of 29 species of scleractinian corals were observed, 26 of which were present in sample areas. Siderastrea was the most abundant genus, while Montastrea cavernosa dominated coverage. The dominance of these species and relative paucity of acroporids and Montastrea annularis that are common to shallow Caribbean reefs suggests that Pompano Ledge coral species composition may be affected by low temperatures and high turbidity.

Mooring buoys were demonstrated to be an effective management tool for minimizing injury to corals on Pompano Ledge. In general, the percentage of recently injured colonies was greater in the control site, even though the buoyed site was more heavily visited. Future studies will be able to further assess buoy impacts by comparing any changes in coral population parameters. The buoys have only been in place for two years, so it will be interesting to see if the coral communities of the two sites begin to diverge in the future.

Acknowledgements

I wish to thank Ocean Watch Foundation for the financial and logistical support that made this study possible. Dr. Richard Dodge provided invaluable assistance in designing this study and editing this manuscript. I would also like to thank John Halas and Dr. Curtis Burney for advice and guidance. Sea Horse Charters, Orbit Marine Sports, Reef Cruiser, and Underseas Sports donated thousands of dollars worth of services for this project. Barry Steinlage, Larry Rubin, and the Good Time Diver II were very helpful in the early stages of this study. Thanks are further extended to Ghislaine Llewellyn, Kevin Carter, David Stout, John Braker, Brant Touchette, Bob Miller, Chris Marshall, Stephanie Morris, James Sulikowski, and Dan Anderegg for assisting with data collection. Finally, I need to thank D.J. Meeks for her invaluable support throughout the project.

Literature Cited

Barnes, R.D. 1987. Invertebrate Zoology. Saunders College Publishing. Philadelphia. pp. 149-163.

Best, M.B. *et al*. 1984. Species concept and ecomorph variation in living and fossil scleractinia. Paleontographica 54:70.

Blair, S.M. and B.S. Flynn. 1989. Biological monitoring of hard bottom reef communities off Dade county Florida:community description. In M. Lang and W. Jaap (eds). Diving For Science. Proc. of the American Academy of Underwater Sciences Ninth Annual Scientific Diving Symposium. Woods Hole, Mass. pp. 9-24.

Britt, D.E. & Associates. 1979. Final report, reef damage survey for the Broward County Erosion Prevention Division. Broward County, Fl. pp. 1-64.

Brown, B.E. 1987. Worldwide death of corals- natural cyclical events or man-made pollution. Mar. Pollut. Bull. 18:9-13.

Brown, B.E. 1988. Assessing environmental impacts on coral reefs. Proc. 6th Int Coral Reef Symp. 1:71-79.

Brusca, R.C. and G.J. Brusca. 1990. Marine Invertebrates. Sinnauer Associates, Inc. Massachusetts. pp. 211-261.

Burns, T.P. 1985. Hard-coral distribution and cold-water disturbances in South Florida: variation with depth and location. Coral Reefs 4:117-124.

Cairns, S.D. 1982. Stony corals of Carrie Bow Cay, Belize. In K. Rutzler and I. Macintyre (eds). The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize. 1:271-302.

Chiappone, M and K.M.Sullivan. 1990. A comparison of line transect versus linear percentage sampling for evaluating stony coral (Scleractinia and Milleporina) community similarity and area coverage on reefs of the central Bahamas. Coral Reefs 10:139-154.

Continental Shelf Associates, Inc. 1980. Biological survey of proposed offshore borrow areas north of Haulover Beach Park, Dade County, Florida. Report to U.S. Army Corps of Engineers, Jacksonville, FL. 21 pp.

Continental Shelf Associates, Inc. 1984. Biological analysis of macro-epibiotal and macro-infaunal assemblages following beach nourishment north Broward County, Florida. Report to Broward County Environmental Quality Control Board. 56 pp.

Cook, C.B. *et al*. 1990. Elevated temperatures and bleaching on a high latitude coral reef: the 1988 Bermuda event. Coral Reefs 9:45-49.

Coral Reef Associates. 1984. An inventory of macrobenthic flora and fauna on the reefs off northern Broward County, Florida for the Broward County Environmental Quality Control Board.

Courtenay, W.R. *et al*. 1974. Ecological monitoring of beach erosion control projects, Broward County and adjacent areas. U.S Army Corps of Engineers Coastal Engineering

Research Center. Tech. Memo. 41. pp. 1-88.
Davis, G.E. 1977. Anchor damage to a coral reef on the coast of Florida. Biological Conservation 11:29-34.
Dennis, G.D. and T.J. Bright. 1988. The impact of a ship grounding on the reef fish assemblage at molasses reef, Key Largo National Marine Sanctuary, Florida. Proc. 6th Int. Coral Reef Symp. 2:213-218.
Dodge, R.E., R.C. Aller, and J. Thomson. 1974. Coral growth related to re-suspension of bottom sediments. Nature (Lond.) 247:574-577.
Dodge, R.E. and J.R. Vaisnys. 1977. Coral populations and growth pattern responses to sedimentation and turbidity associated with dredging. J. Mar. Res. 35:715-730.
Dodge, R.E., A. Logan, and A. Antonius. 1982. Quantitative reef assessment studies in Bermuda: a comparison of methods and preliminary results. Bulletin of Marine Science 32:745-760.
Dodge, R.E., S. Hess, C. Messing. 1991. Final report: biological monitoring of the John U. Lloyd beach renourishment: 1989. Prepared for Broward County Board of County Commissioners. 62 pp.
Dustan. 1975. Growth and form in the reef-building coral Montastrea annularis. Marine Biology 33:101-107.
Dustan, P. and J.C. Halas. 1987. Changes in the reef-coral community of Carysfort Reef, Key Largo, Florida:1974 to 1982. Coral Reefs 6:91-106.
Foster, A.B. 1984. The species concept in fossil hermatypic corals: a statistical approach. Paleontographica 54:58.
Foster, A.B. 1979. Phenotypic plasticity in the reef corals Montastrea cavernosa and Siderastrea siderea. J. Exp. Mar. Biol. Ecol. 39:25-54.
Foster, A.B. 1985. Variation within coral colonies and its importance for interpreting fossil species. Journal of Paleontology 59:1359-1381.
Geister, J. 1977. The influence of wave exposure on the ecological zonation of Caribbean coral reefs. Proc. 3rd Int Coral Reef Symp.
Gittings, S.R. *et al.* 1988. The recovery process in a mechanically damaged coral reef community: recruitment and growth. Proc. 6th Int Coral Reef Symp. 2:225-231.
Glynn, P. *et al.* 1983. Corals and Coral Reefs of the Galapagos Islands. California Press. Berkeley, CA.
Goldberg, W.M. 1973. The ecology of coral-octocoral communities off the southeast Florida coast: geomorphology, species composition, and zonation. Bull. Mar. Sci. 23:465-488.
Goldberg, W.M. 1981. A re-survey of coral communities adjacent to a beach restoration area in south Broward County, Florida. Unpublished rept. to Broward County Environmental Quality Control Board and Erosion Prevention District. pp. 1-23.
Goldberg, W.M. 1985. Long term effects of beach restoration in

Broward County, Florida, a three year overview. Unpublished rept. to Broward County Environmental Quality Control Board and Erosion Prevention District. pp. 1-51.
Goldberg, W.M. 1989. Biological effects of beach restoration in South Florida: the good, the bad and the ugly. Proc. Fla. Shore and Beach Presev. Assn. 1988. Gainseville, FL.
Goreau, T.J. 1992. Coral reef health in the Negril area. In Reef Relief (eds.) Protecting Jamaica's Coral Reefs: Final Report of the Negril Reef Mooring Buoy Workshop and Installation Project. Reef Relief, FL. pp. 32-70.
Guilcher, A. 1986. Coral reef environment: Damage through man action, efforts for better management. Thalassas 4:57-61.
Guzman, H.M., J.B. Jackson, and E. Weil. 1991. Short-term ecological consequences of a major oil spill on Panamanian subtidal reef corals. Coral Reefs 10:1-12.
Halas, J.C. 1985. A unique mooring system for reef management in the Key Largo National Marine Sanctuary. Proc. 5th Int Coral Reef Cong. 2:237-242.
Hubbard and Y. Pocock. 1972. Sediment rejection by recent scleractinian corals: a key to palaeo-environmental reconstruction. Geol. Rundsch. 61:598-626.
Hughes, T.P. 1992. Monitoring of coral reefs: a bandwagon? Reef Encounter 11:9-12.
Hughes, T.P., D. Ayre and J.H. Connell. 1992. The evolutionary ecology of corals. Trends in Ecology and Evolution 7:292-295.
Hughes, T.P. 1989. Community structure and diversity of coral reefs: the role of history. Ecology 70:275-279.
Humann, P. 1992. Reef Coral Identification. New World Publications. Jacksonville, FL. 239 pp.
Humann, P. 1983. Ocean Realm Guide to Corals. Ocean Realm Publishing. Miami, FL. pp. 1-80.
Jaap, W.C., J.C. Halas, and R.G. Muller. 1988. Community dynamics of stony corals (Milleporina and Scleractinia) at Key Largo National Marine Sanctuary, Florida, during 1981-1986. Proc. 6th Int. Coral Reef Symp. 2:237-243.
Jaap, W.C. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (south Florida). Reef -building corals. Biol. Rep. U.S. Fish Wildl. Serv. pp.1-32.
Jaap, W.C. *et al.* 1989. Stony corals (Scleractinia and Milleporina) community at Bird Key Reef, Ft. Jefferson National Monument, Dry Tortugas, Florida. Florida Marine Research Publication No. 463. 31 pp.
Jaap, W.C. and P. Hallock. 1990. Coastal and nearshore communities: coral reefs. In N.W. Phillips and K.S. Larson (eds). Synthesis of Available Biological, Geological, Chemical, Socioeconomic, and Cultural Resource Information for the South Florida Area. U.S. Dept. of the Interior. 97-116.
Jackson, J.B. *et al.* 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science

243:37-43.
Jordan-Dahlgren, E. 1992. Recolonization patterns of Acropora palmata in a marginal environment. Bulletin of Marine Science 51:104-117.
Kenchington, R.A. 1978. Visual surveys of large areas of coral reefs. In D.R. Stoddart and R.E. Johannes (eds). Coral Reefs: Research Methods. UNESCO, Paris. 149-162.
Kinzie, D.W. and P.J. Davies. 1979. Effects of elevated nitrogen and phosphorus on coral reef growth. Limnology and Oceanography 24:935-940.
Kinzie, R.A. and R.H. Snider. 1978. A simulation study of coral reef survey methods. In D.R. Stoddart and R.E. Johannes (eds). Coral Reefs: Research Methods. UNESCO, Paris, 231-250.
Knap, A.H. *et al.* 1985. The effects of chemically and physically dispersed oil on the brain coral Diploria strigosa (Dana)- a summary review. Proc. 1985 Oil Spill Conference:547-552.
Knowlton, N. *et al.* 1991. Sibling species in Montastrea annularis, coral bleaching, and the coral climate record. Science 255:330-332.
Lang, J.C. 1984. Whatever works: the variable importance of skeletal and of non-skeletal characters in scleractinian taxonomy. Paleontographica 54:18.
Lesser, M.P. *et al.* 1990. Bleaching in coral reef anthozoans: Effects of irradiance, ultraviolet radiation, and temperature an the activities of protective enzymes against active oxygen. Coral Reefs 8:225-232.
Lessios, H.A., D.R. Robertson and J.D. Cubit. 1984. Spread of Diadema mass mortality through the Caribbean. Science 226:335-337.
Lighty, R.G., I.G. MacIntyre, and R. Stuckenrath. 1978. Submerged early Holocene barrier reef south-east Florida. Nature 276: 59-60.
Loya, Y. 1972. Community structure and species diversity of hermatypic corals at Eilat, Red Sea. Marine Biology 13:100-123.
Loya, Y. 1976. Sedimentation effects on the community structure of Puerto Rican corals. Bull. Mar. Sci. 26:450-466.
Loya, Y. 1978. Plotless and transect methods. In D.R. Stoddart and R.E. Johannes (eds). Coral Reefs: Research Methods. UNESCO, Paris. 197-218.
Maragos, J.E. 1974. Coral communities on a seaward reef slope, Fanning Island. Pac. Sci. 28:257-258.
Marsh, G.A. and D.B. Turbeville. 1981. The environmental impact of beach renourishment. Two studies on southeastern Florida. Shore and Beach 49:40-44.
Marszalek, D.S. *et al.* 1977. Reef distribution in South Florida. Proc. 3rd Int. Coral Reef Symp. 2:224-229.
Marszalek, D.S. 1981. Impact of dredging on a subtropical reef community, southeast Florida. Proc. 4th Int. Coral Reef

Symp. 1:147-153.
National Research Council 1985. Oil in the Sea. National Academy Press. Washington, D.C. 449-457.
Ocean Research and Survey, Inc. 1980. Final Report, Hollywood-Hallandale Dredge Monitoring Study to Erosion Prevention Division of Environmental Quality Control Board, Broward County Board of Commissioners.
Ohlhorst, S.L. 1984. The use of polyacrylamide gel electrophoresis in coral taxonomy.
Ohlhorst, S.L. *et al.* 1988. Evaluation of reef census techniques. Proc. 6th Int. Coral Reef Symp. 2:319-324.
Pichon, M. 1978. Problems of measuring and mapping coral colonies. In D.R. Stoddart and R.E. Johannes (eds). Coral Reefs: Research Methods. UNESCO, Paris. 219-230.
Porter, J.W., J. Battey, and G. Smith. 1982. Perturbation and change in coral reef communities. Proc. Natl. Acad. Sci. 79:1678-1681.
Porter, J.W. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (south Florida)-reef-building corals. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.73) U.S. Army Corps of Engineers. 23 pp.
Porter, J.W. *et al.* 1981. Population trends among Jamaican reef corals. Nature 294:249-250.
Porter, J.W. and O.W. Meier. 1992. Quantification of loss and change in Floridian reef coral populations. Unpublished draft of paper presented at Symposium on Long-Term Dynamics of Coral Reefs. 34 pp.
Reef Relief. 1992. Protecting Jamaica's Coral Reefs: Final Report of the Negril Reef Mooring Buoy Workshop and Installation Project. Reef Relief, Key West, FL. 87 pp.
Rogers, C.S. 1988. Recommendations for long-term assessment of coral reefs: U.S. National Park Service initiates regional program. Proc. 6th Int Coral Reef Symp. 2:399-403.
Rogers, C.S., L. Mclain and E. Zullo. 1988. Damage to coral reefs in Virgin Islands National Park and Biosphere Reserve from recreational activities. Proc. 6th Int Coral Reef Symp. 2:405-410.
Rutzler, K. and I.G Macintyre. 1982. The habitat distribution and community structure of the barrier reef complex at Carrie Bow Cay, Belize. In K. Rutzler and I.G. Macintyre (eds). The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize. 1:9-46.
Scheer. G. 1978. Application of phytosociologic methods. In D.R. Stoddart and R.E. Johannes (eds). Coral Reefs:Research Methods. UNESCO, Paris. 175-196.
Smith, F.G. 1971. Atlantic Reef Corals. University of Miami Press. 164 pp.
Smith, S.H. 1985. Reef damage and recovery after ship groundings on Bermuda. Proc. 5th Int. Coral Reef Cong. 6:497-502.

Smith, S.H. 1988. Cruise ships: a serious threat to coral reefs and associated organisms. Ocean and Shoreline Management 11:231-248.

Sudara, S. and S. Nateekarnchanalap. 1988. Impact of tourism on the reef in Thailand. Proc. 6th Int. Coral Reef Symp. 2:273-275.

Talge, H. In press. Impact of recreational divers on scleractinian corals at Looe Key, Florida.

Talge, H. In press. Impact of recreational divers on coral reefs in the Florida Keys.

Tilmant, J.T. 1987. Impacts of recreational activities on coral reefs. In: Salvat, B. (ed). Human Impacts on Coral Reefs; Facts and Recommendations. Antenne Museum, EPHE, French Polynesia. pp. 195-214.

Tomascik, T. and F. Sander. 1987. Effects of eutrophication on reef-building corals. Marine Biology 94:53-75.

UNESCO. 1986. Human induced damage to coral reefs. UNESCO Reports in Marine Science 40. Paris. 180 pp.

Vandermeulen, J.H. and E.S. Gilfillan. 1985. Petroleum pollution, corals and mangroves. MTS Journal 18:62-72.

Van Breda, A. and K. Gjerde. 1992. The Use of Mooring Buoys as a Management Tool. Center for Marine Conservation, Washington, DC. 56 pp.

Wainwright, S.A. 1965. Reef communities visited by the Israel South Red Sea Expedition, 1962. Israel South Sea Expedition, 1962, Rep., No. 9, Bull. Sea Fish. Res. Sta. Haifa, 38:40-53.

Wells, S.M. and N. Hanna. 1992. The Greenpeace Book of Coral Reefs. Sterling Publishing Co. New York. 160 pp.

Wells, S.M. 1988. Coral Reefs of the World. UNEP, Nairobi. pp. 311-345.

Wheaton, J.L. and W.C. Jaap. 1988. Corals and other prominent benthic cnidaria of Looe Key National Marine Sanctuary, Florida. Fla. Mar. Res. Pub. no. 43. 25 pp.

Williams, E.H., C. Goenaga, and V. Vicente. 1987. Mass bleachings on Caribbean coral reefs. Science 238:877-878.

Wood, E.M. 1983. Corals of the World. T.F.H. Publications. Neptune City, NJ. pp. 9-113.

Woodley, J.D. *et al.* 1981. Hurricane Allen's impact on Jamaican coral reefs. Science 214:749-755.

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Two
Surveyed 7/23, Summer 1992 (n=1)

Species	Abund	RelCov
Acropora cervicornis	2	2.048
Dichocoenia stokesi	21	7.538
Madracis decactis	4	8.657
Montastrea cavernosa	14	48.630
Millepora alcicornis	15	1.997
Porites astreoides	2	0.643
Porites porites	1	1.498
Siderastrea spp.	12	11.608
Solenastrea spp.	6	12.896
Stephanocoenia michelinii	8	4.495

	Abund	%Cover
Mean	85	5.01
	H'n	H'c
Mean	2.007	1.664
	J'n	J'c
Mean	0.872	0.712
	%Prot	% Inj
Mean	10.59	2.35

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Three

	Winter (n=1) Surveyed 2/13/92				Summer (n=2) Surveyed 7/16, 8/7/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Agaricia spp.	1		0.957		7.5	6.364	4.191	1.311
Diploria clivosa	2		0.235		1.5	0.707	0.171	0.028
Dichocoenia stokesi	14		7.269		16	2.828	6.204	1.056
Eusmilia fastigiata	1		0.096		1.5	0.707	0.142	0.042
Montastrea cavernosa	20		46.906		22	4.243	52.86	0.897
Millepora alcicornis	13		6.739		10	0	3.858	2.237
Meandina meandrites	1		0.151		1	0	0.172	0.040
Porites astreoides	3		1.214		2.5	0.707	1.192	1.256
Porites porites	6		1.799		4	1.414	2.750	0.014
Siderastrea spp.	39		7.964		30	5.657	8.807	1.752
Solenastrea spp.	10		26.660		4.5	6.364	11.22	15.868
Stephanocoenia michelinii					4.5	4.95	8.443	11.827

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Agaricia spp.	5.333	5.859	3.113	2.084
Diploria clivosa	1.667	0.577	0.193	0.042
Dichocoenia stokesi	15.33	2.309	6.559	0.968
Eusmilia fastigiata	1.667	0.577	0.127	0.04
Montastrea cavernosa	21.33	3.215	50.874	3.494
Millepora alcicornis	11	1.732	4.818	2.295
Meandina meandrites	1	0	0.165	0.031
Porites astreoides	2.667	0.577	1.199	0.888
Porites porites	4.667	1.528	2.433	0.549
Siderastrea spp.	33	6.557	8.526	1.331
Solenastrea spp.	6.333	0.707	24.550	2.983
Stephanocoenia michelinii	3	4.95	8.443	11.83

	Abund	SD	%Cover	SD
Comb.	106.7	11.37	3.90	0.669
Winter	110		4.18	
Summer	105	15.56	3.77	0.885

	H'n	SD	H'c	SD
Comb.	1.952	0.071	1.478	0.025
Winter	1.901		1.483	
Summer	1.978	0.079	1.476	0.034

	J'n	SD	J'c	SD
Comb.	0.795	0.027	0.602	0.021
Winter	0.765		0.597	
Summer	0.81	0.012	0.605	0.029

	%Prot	SD	% Inj	SD
Comb.	1.17	1.314	3.22	3.036
Winter	0.91		3.64	
Summer	1.30	1.831	3.02	4.264

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Four

Species	Winter (n=1) Surveyed 3/9/92 Abund	SD	RelCov	SD	Summer (n=2) Surveyed 7/31, 9/15/92 Abund	SD	RelCov	SD
Agaricia spp.	10		14.757		6	2.828	5.520	0.731
Colpophyllia natans	6		4.531		6	0	6.700	4.736
Diploria clivosa	1		4.299		4	5.657	4.134	5.846
Dichocoenia stokesi	14		8.794		23.5	3.536	17.462	9.332
Diploria labyrinthiformis	2		2.282		0.5	0.707	0.891	1.260
Madracis decactis	2		7.116		3	0	26.979	1.599
Montastrea annularis	1		2.419					
Montastrea cavernosa	4		2.215		6.5	4.95	23.646	30.058
Millepora alcicornis	7		18.998		3	0	7.024	4.183
Meandrina meandrites	6		9.616		5.5	0.707	11.636	5.497
Porites astreoides					3.5	2.121	1.637	1.979
Porites porites					0.5	0.707	0.654	0.925
Scolymia cubensis	2		0.537		1.5	0.707	0.792	0.213
Siderastrea spp.	25		9.297		30.5	24.75	8.114	2.541
Stephanocoenia michelinii	1		15.103		2.5	0.707	0.822	0.011

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Agaricia spp.	7.333	3.055	5.349	0.595
Colpophyllia natans	6	0	4.979	4.483
Diploria clivosa	4.5	4.95	4.863	4.815
Dichocoenia stokesi	20.33	6.028	14.572	8.281
Diploria labyrinthiformis	1.5	0.707	1.278	0.712
Madracis decactis	2.667	0.577	20.358	11.52
Montastrea annularis	0.333	0.58	0.274	0.474
Montastrea cavernosa	5.667	3.786	16.015	25.03
Millepora alcicornis	4.333	2.309	6.832	2.976
Meandrina meandrites	5.667	0.577	8.845	6.203
Porites astreoides	2.333	2.517	1.091	1.689
Porites porites	0.333	0.577	0.436	0.756
Scolymia cubensis	1.667	0.577	0.589	0.383
Siderastrea spp.	28.67	17.79	6.461	3.381
Stephanocoenia michelinii	2	1	2.256	2.484

	Abund	SD	%Cover	SD
Comb.	91.33	32.747	0.722	0.125
Winter	81		0.585	
Summer	96.5	44.548	0.790	0.057

	H'n	SD	H'c	SD
Comb.	2.154	0.066	2.187	0.143
Winter	2.107		2.296	
Summer	2.034	0.047	1.996	0.122

	J'n	SD	J'c	SD
Comb.	0.824	0.029	0.836	0.043
Winter	0.821		0.895	
Summer	0.806	0.037	0.791	0.030

	%Prot	SD	% Inj	SD
Comb.	17.30	9.680	1.81	1.608
Winter	27.16		0.00	
Summer	12.37	6.442	2.71	0.523

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Five
Surveyed 2/12, Winter 1992 (n=1)

Species	Abund	RelCov
Dichocoenia stokesi	3	0.686
Diploria clivosa	1	9.612
Diploria labyrinthiformis	1	11.866
Meandrina meandrites	1	13.082
Millepora alcicornis	8	0.667
Montastrea annularis	3	9.411
Montastrea cavernosa	14	54.560
Siderastrea spp.	1	0.142

Note: Abundance units are colonies/20 sq. m

	Abund	%Cover
Mean	32	5.30
	H'n	H'c
Mean	1.585	1.373
	J'n	J'c
Mean	0.763	0.661
	%Prot	% Inj
Mean	9.38	0.00

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Seven

Species	Winter (n=1) Surveyed 2/17/92 Abund	SD	RelCov	SD	Summer (n=1) Surveyed 8/4/92 Abund	SD	RelCov	SD
Agaricia spp.	5		1.192		5		2.176	
Colpophyllia natans	1		0.196		1		0.078	
Diploria clivosa	1		4.625		1		3.447	
Dichocoenia stokesi	9		2.681		7		0.817	
Madracis decactis	5		4.514		10		7.348	
Montastrea annularis	4		7.839					
Montastrea cavernosa	19		68.691		18		67.059	
Millepora alcicornis	7		0.767		8		1.772	
Meandrina meandrites	2		8.117		1		8.609	
Porites astreoides	3		0.200		3		0.367	
Scolymia cubensis	1		0.049					
Siderastrea spp.	7		1.387		6		1.413	
Solenastrea spp.					3		6.836	
Stephanocoenia michelinii					1		0.082	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Agaricia spp.	5	0	1.684	0.695
Colpophyllia natans	1	0	0.137	0.084
Diploria clivosa	1	0	4.036	0.833
Dichocoenia stokesi	8.0	1.41	1.749	1.318
Madracis decactis	7.5	3.54	5.931	2.004
Montastrea annularis	2	2.83	3.920	5.543
Montastrea cavernosa	18.5	0.71	67.875	1.154
Millepora alcicornis	7.5	0.71	1.270	0.711
Meandrina meandrites	1.5	0.71	8.363	0.348
Porites astreoides	3.0	0	0.283	0.118
Scolymia cubensis	0.5	0.71	0.025	0.035
Siderastrea spp.	6.5	0.71	1.400	0.018
Solenastrea spp.	2	2.12	3.418	4.834
Stephanocoenia michelinii	1	0.71	0.041	0.058

	Abund	SD	%Cover	SD
Comb.	64	0	8.76	1.496
Winter	64		9.82	
Summer	64		7.70	

	H'n	SD	H'c	SD
Comb.	2.155	0.021	1.241	0.032
Winter	2.139		1.218	
Summer	2.168		1.263	

	J'n	SD	J'c	SD
Comb.	0.853	0.011	0.491	0.001
Winter	0.861		0.490	
Summer	0.845		0.492	

	%Prot	SD	% Inj	SD
Comb.	30.47	3.309	8.60	12.16
Winter	28.13		0.00	
Summer	32.81		17.19	

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Twelve

Species	Winter (n=1) Surveyed 2/28/92 Abund	SD	RelCov	SD	Summer (n=1) Surveyed 8/17/92 Abund	SD	RelCov	SD
Acropora cervicornis	3		2.097		5		3.194	
Agaricia spp.	2		0.088		3		0.495	
Colpophyllia natans	1		0.023					
Dichocoenia stokesi	9		0.580		9		0.685	
Diploria labyrinthiformis					1		0.054	
Madracis decactis	1		0.691		1		1.626	
Montastrea annularis	3		69.603		3		52.278	
Montastrea cavernosa	23		20.282		23		30.582	
Millepora alcicornis	5		0.359		6		0.725	
Porites astreoides	5		0.531		6		0.986	
Porites porites					1		0.216	
Siderastrea spp.	18		4.625		28		6.489	
Solenastrea spp.	3		1.121					
Stephanocoenia michelinii	1		0.006		5		2.682	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Acropora cervicornis	4.0	1.414	2.645	0.775
Agaricia spp.	2.5	0.707	0.291	0.288
Colpophyllia natans	0.5	0.71	0.012	0.016
Dichocoenia stokesi	9.0	0	0.632	0.074
Diploria labyrinthiformis	0.5	0.71	0.027	0.038
Madracis decactis	1.0	0	1.159	0.661
Montastrea annularis	3.0	0	60.941	12.25
Montastrea cavernosa	23.0	0	25.432	7.283
Millepora alcicornis	5.5	0.707	0.542	0.259
Porites astreoides	5.5	0.707	0.759	0.321
Porites porites	0.5	0.71	0.108	0.153
Siderastrea spp.	23.0	7.071	5.557	1.318
Solenastrea spp.	1.5	2.12	0.560	0.792
Stephanocoenia michelinii	3.0	2.828	1.344	1.893

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	82.5	12.021	19.47	11.14
Winter	74		27.34	
Summer	91		11.59	

	H'n	SD	H'c	SD
Comb.	1.990	0.001	1.141	0.242
Winter	1.989		0.970	
Summer	1.990		1.312	

	J'n	SD	J'c	SD
Comb.	0.801	0.000	0.459	0.097
Winter	0.801		0.391	
Summer	0.801		0.528	

	%Prot	SD	% Inj	SD
Comb.	1.65	2.333	3.55	1.202
Winter	0.00		2.70	
Summer	3.30		4.40	

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Thirteen
Surveyed 8/12, Summer 1992 (n=1)

Species	Abund	RelCov
Agaricia spp.	2	2.238
Dichocoenia stokesi	9	5.180
Diploria clivosa	1	0.011
Madracis decactis	1	0.872
Millepora alcicornis	6	0.699
Montastrea annularis	2	25.255
Montastrea cavernosa	11	57.252
Mussa angulosa	2	0.493
Porites astreoides	7	2.828
Siderastrea spp.	4	3.779
Stephanocoenia michelinii	3	1.380

	Abund	%Cover
Mean	48	3.65
	H'n	H'c
Mean	2.131	1.292
	J'n	J'c
Mean	0.889	0.539
	%Prot	% Inj
Mean	3.70	3.70

Buoy # Fourteen
Surveyed 9/13, Summer 1992 (n=1)

Species	Abund	RelCov
Dichocoenia stokesi	6	4.771
Diploria clivosa	1	0.143
Meandrina meandrites	1	31.234
Millepora alcicornis	14	4.209
Montastrea cavernosa	7	57.510
Porites astreoides	3	2.119
Siderastrea spp.	1	0.009

	Abund	%Cover
Mean	33	4.18
	H'n	H'c
Mean	1.538	1.052
	J'n	J'c
Mean	0.522	0.357
	%Prot	% Inj
Mean	0.00	6.06

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Fifteen

	Winter (n=1) Surveyed 2/27/92				Summer (n=1) Surveyed 8/31/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Colpophyllia natans	2		0.037		2		0.021	
Diploria clivosa	1		4.546		1		1.884	
Dichocoenia stokesi	6		0.975		9		0.510	
Diploria labyrinthiformis	1		0.182		1		0.030	
Madracis decactis	1		0.543		2		1.757	
Montastrea annularis	1		10.923					
Montastrea cavernosa	22		72.595		21		40.214	
Millepora alcicornis	3		0.210		2		0.036	
Meandrina meandrites					1		0.674	
Porites astreoides	5		0.993		4		0.307	
Porites porites	1		0.076		2		0.083	
Siderastrea spp.	60		7.945		75		54.346	
Stephanocoenia michelinii	2		0.966		4		0.129	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	2	0	0.029	0.011
Diploria clivosa	1	0	3.215	1.883
Dichocoenia stokesi	7.5	2.12	0.743	0.329
Diploria labyrinthiformis	1	0	0.106	0.108
Madracis decactis	1.5	0.71	1.150	0.858
Montastrea annularis	0.5	0.71	5.460	7.722
Montastrea cavernosa	21.5	0.707	56.404	22.9
Millepora alcicornis	2.5	0.707	0.123	0.123
Meandrina meandrites	0.5	0.71	0.337	0.477
Porites astreoides	4.5	0.707	0.650	0.485
Porites porites	1.5	0.71	0.080	0.005
Siderastrea spp.	67.5	10.61	31.146	32.81
Stephanocoenia michelinii	3	1.414	0.548	0.592

	Abund	SD	%Cover	SD
Comb.	114.5	13.435	17.42	5.091
Winter	105		13.82	
Summer	124		21.02	

	H'n	SD	H'c	SD
Comb.	1.417	0.024	0.978	0.049
Winter	1.434		1.013	
Summer	1.400		0.9435	

	J'n	SD	J'c	SD
Comb.	0.570	0.010	0.394	0.02
Winter	0.577		0.408	
Summer	0.563		0.38	

Note: Abundance units are colonies/20 sq. m

	%Prot	SD	% Inj	SD
Comb.	4.95	2.430	2.09	1.611
Winter	6.67		0.95	
Summer	3.23		3.23	

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Sixteen
Surveyed 9/13, Summer 1992 (n=1)

Species	Abund	RelCov		Abund	%Cover
Agaricia spp.	2	2.591	Mean	55	3.30
Dichocoenia stokesi	5	1.878			
Diploria clivosa	1	0.146		H'n	H'c
Millepora alcicornis	2	0.199	Mean	2.092	1.437
Montastrea annularis	6	48.879			
Montastrea cavernosa	4	7.671		J'n	J'c
Phyllangea americana	2	0.024	Mean	0.873	0.599
Porites astreoides	3	5.206			
Porites porites	6	4.036		%Prot	% Inj
Siderastrea spp.	18	28.061	Mean	1.82	9.09
Stephanocoenia michelinii	6	1.319			

Buoy # Seventeen
Surveyed 7/31, Summer 1992 (n=1)

Species	Abund	RelCov		Abund	%Cover
Agaricia spp.	2	0.340	Mean	44	8.55
Dichocoenia stokesi	14	2.056			
Manicina areolata	1	0.369		H'n	H'c
Millepora alcicornis	7	0.878	Mean	1.906	0.365
Montastrea cavernosa	8	93.297			
Porites astreoides	6	1.575		J'n	J'c
Porites porites	1	1.094	Mean	0.828	0.159
Siderastrea spp.	3	0.095			
Solenastrea spp.	1	0.294		%Prot	% Inj
Stephanocoenia michelinii	1	0.005	Mean	9.09	2.27

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Eighteen

	Winter (n=1) Surveyed 2/19/92				Summer (n=3) Surveyed 8/4, 8/17, 8/27/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Agaricia spp.	15		2.371					
Colpophyllia natans	2		0.225					
Diploria clivosa					1	0	0.085	0.071
Dichocoenia stokesi	3		0.363		4.333	0.577	1.033	0.215
Montastrea cavernosa	13		92.656		3.667	1.155	91.400	3.047
Millepora alcicornis	9		1.910		9	1	4.444	2.543
Oculina diffusa	2		0.294					
Porites astreoides	4		1.835		3.333	0.577	1.297	0.188
Siderastrea spp.	4		0.347		14.333	4.041	1.746	0.341

Combined Winter and Summer (n=4)

Species	Abund	SD	RelCov	SD
Agaricia spp.	3.75	7.50	0.593	1.186
Colpophyllia natans	0.5	1.00	0.056	0.113
Diploria clivosa	1	0	0.085	0.071
Dichocoenia stokesi	2.5	1	0.815	0.399
Montastrea cavernosa	1.5	0.577	0.051	0.024
Millepora alcicornis	6	4.761	91.715	2.563
Oculina diffusa	9	0.816	3.811	2.432
Porites astreoides	0.5	1.00	0.060	0.120
Siderastrea spp.	3.5	0.577	1.432	0.310

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	39.75	8.655	5.57	2.382
Winter	52		9.09	
Summer	35.67	3.512	4.40	0.489

	H'n	SD	H'c	SD
Comb.	1.593	0.169	0.391	0.078
Winter	1.819		0.379	
Summer	1.517	0.093	0.395	0.095

	J'n	SD	J'c	SD
Comb.	0.854	0.045	0.211	0.047
Winter	0.875		0.182	
Summer	0.847	0.052	0.220	0.053

	%Prot	SD	% Inj	SD
Comb.	8.66	17.310	2.62	3.627
Winter	34.62		0.00	
Summer	0.00	0.000	3.49	3.894

Appendix A: Station data and statistical parameters

Buoy # 18.5

	Winter (n=1) Surveyed 2/19/92				Summer (n=3) Surveyed 8/4, 8/17, 8/27/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Agaricia spp.					3.000	5.196	0.439	0.760
Colpophyllia natans	1		0.021		0.333	0.577	0.008	0.013
Diploria clivosa					0.667	0.577	0.025	0.041
Dichocoenia stokesi	3		0.811		2.667	0.577	1.066	0.240
Diploria labyrinthiformis					0.667	0.577	0.009	0.012
Madracis decactis	5		1.551		6.000	5.29	1.827	1.736
Montastrea annularis	1		1.012					
Montastrea cavernosa	18		96.453		17.000	6.245	93.364	2.762
Millepora alcicornis	4		0.118		2.000	1	0.085	0.030
Meandrina meandrites	1		0.113		0.333	0.577	0.053	0.093
Oculina diffusa					1.333	0.577	0.311	0.056
Porites astreoides	1		0.147		3.667	0.577	1.077	0.384
Siderastrea spp.	6		0.152		9.000	0	0.282	0.327
Solenastrea spp.					1.000	0	1.302	0.333

Combined Winter and Summer (n=4)

Species	Abund	SD	RelCov	SD
Agaricia spp.	2	4.50	0.329	0.659
Colpophyllia natans	1	0	0.022	0.002
Diploria clivosa	1	0	0.038	0.048
Dichocoenia stokesi	2.75	0.5	1.002	0.234
Diploria labyrinthiformis	1	0	0.014	0.013
Madracis decactis	5.75	4.349	1.659	1.456
Montastrea annularis	0.25	0.50	0.253	0.506
Montastrea cavernosa	17.25	5.123	94.136	2.733
Millepora alcicornis	2.5	1.291	0.093	0.03
Meandrina meandrites	1	0	0.136	0.034
Oculina diffusa	1.333	0.577	0.311	0.056
Porites astreoides	3	1.414	0.845	0.561
Siderastrea spp.	8.25	1.5	0.250	0.275
Solenastrea spp.	0.75	0.5	0.982	0.696

	Abund	SD	%Cover	SD
Comb.	40.25	2.363	10.79	4.495
Winter	40		17.10	
Summer	40.33	2.887	8.69	1.944

	H'n	SD	H'c	SD
Comb.	1.880	0.381	0.310	0.115
Winter	1.697		0.209	
Summer	1.944	0.442	0.347	0.113

	J'n	SD	J'c	SD
Comb.	0.826	0.143	0.138	0.053
Winter	0.773		0.095	
Summer	0.843	0.170	0.152	0.054

	%Prot	SD	% Inj	SD
Comb.	14.44	10.79	6.85	8.384
Winter	12.50		0.00	
Summer	15.08	13.11	9.13	8.614

Note: Abundance units are colinies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Nineteen

Species	Winter (n=1) Surveyed 2/19/92 Abund	SD	RelCov	SD	Summer (n=1) Surveyed 7/22/92 Abund	SD	RelCov	SD
Colpophyllia natans					1		0.093	
Diploria clivosa	1		0.057					
Dichocoenia stokesi	9		13.727		9		13.150	
Montastrea cavernosa	10		64.431		10		65.168	
Millepora alcicornis	5		11.043		4		2.920	
Meandrina meandrites	2		1.468		1		1.628	
Siderastrea spp.	15		9.284		20		17.051	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	0.5	0.71	0.047	0.066
Diploria clivosa	1	0.71	0.029	0.04
Dichocoenia stokesi	9	0	13.439	0.408
Montastrea cavernosa	10	0	64.800	0.521
Millepora alcicornis	4.5	0.707	6.981	5.744
Meandrina meandrites	1.5	0.707	1.548	0.113
Siderastrea spp.	17.5	3.536	13.167	5.491

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	43.5	2.121	2.97	0.354
Winter	42		2.72	
Summer	45		3.22	

	H'n	SD	H'c	SD
Comb.	1.464	0.089	1.055	0.044
Winter	1.527		1.086	
Summer	1.401		1.024	

	J'n	SD	J'c	SD
Comb.	0.817	0.049	0.589	0.024
Winter	0.852		0.606	
Summer	0.782		0.572	

	%Prot	SD	% Inj	SD
Comb.	3.33	4.714	0.00	0
Winter	0.00		0.00	
Summer	6.67		0.00	

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Twenty

Species	Winter (n=1) Surveyed 2/14/92 Abund	SD	RelCov	SD	Summer (n=2) Surveyed 7/23, 9/10/92 Abund	SD	RelCov	SD
Colpophyllia natans					0.5	0.707	0.117	0.165
Dichocoenia stokesi	2		5.302		2	0	4.854	1.636
Montastrea annularis					0.5	0.707	7.003	9.904
Montastrea cavernosa	9		82.656		8	4.243	75.846	5.951
Millepora alcicornis	3		0.149		5	1.414	0.665	0.183
Porites astreoides	1		0.932		3	1.414	1.374	0.319
Scolymia cubensis	1		0.382					
Siderastrea spp.	13		10.581		9	0	7.806	2.985
Solenastrea spp.					3	2.828	2.338	1.335

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	0.33	0.577	0.078	0.135
Dichocoenia stokesi	2.00	0.000	5.003	1.185
Montastrea annularis	0.33	0.577	4.670	8.089
Montastrea cavernosa	8.33	3.055	78.116	5.759
Millepora alcicornis	4.33	1.528	0.493	0.324
Porites astreoides	2.33	1.528	1.227	0.340
Scolymia cubensis	0.33	0.577	0.127	0.221
Siderastrea spp.	10.3	2.309	8.731	2.650
Solenastrea spp.	3.00	2.828	2.338	1.335

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	30.33	7.095	5.88	1.732
Winter	29		5.79	
Summer	31	9.899	5.93	2.447

	H'n	SD	H'c	SD
Comb.	1.597	0.197	0.790	0.185
Winter	1.374		0.625	
Summer	1.709	0.052	0.873	0.167

	J'n	SD	J'c	SD
Comb.	0.841	0.067	0.415	0.084
Winter	0.767		0.349	
Summer	0.878	0.027	0.558	0.086

	%Prot	SD	% Inj	SD
Comb.	0.67	1.155	5.41	4.687
Winter	0.00		0.00	
Summer	1.00	1.414	8.11	0.311

Appendix A: 20 sq. m station data and statistical parameters

Buoy # 20.5

	Winter (n=1) Surveyed 2/14/92				Summer (n=2) Surveyed 7/23, 9/10/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Dichocoenia stokesi	2		3.731		4.5	2.121	0.570	0.596
Diploria labyrinthiformis	1		2.520		0.5	0.707	0.055	0.077
Montastrea annularis	5		2.397		0.5	0.707	4.400	6.223
Montastrea cavernosa	14		83.42		13	2.828	80.83	0.077
Millepora alcicornis	4		2.220		5	1.414	1.617	0.856
Meandrina meandrites	1		0.048		1	0	2.267	0.349
Porites astreoides	1		1.427		0.5	0.707	0.978	1.383
Siderastrea spp.	51		4.243		35.5	10.61	5.287	3.411
Solenastrea spp.					1.5	0.707	0.710	0.158
Stephanocoenia michelinii					3.5	4.95	3.286	4.647

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Dichocoenia stokesi	3.667	2.082	1.633	1.89
Diploria labyrinthiformis	0.667	0.577	0.876	1.424
Montastrea annularis	3	2.828	2.397	4.55
Montastrea cavernosa	13.33	2.082	81.69	1.494
Millepora alcicornis	4.667	1.155	1.818	0.698
Meandrina meandrites	1	0	1.527	1.305
Porites astreoides	1	0	1.128	1.012
Siderastrea spp.	40.67	11.68	4.939	2.486
Solenastrea spp.	1.5	0.707	0.473	0.425
Stephanocoenia michelini	2	4.04	2.191	3.794

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	70	7.937	8.46	4.933
Winter	79		13.11	
Summer	65.5	2.121	6.14	4.040

	H'n	SD	H'c	SD
Comb.	1.312	0.182	0.743	0.056
Winter	1.174		0.682	
Summer	1.595	0.109	0.757	0.002

	J'n	SD	J'c	SD
Comb.	0.650	0.114	0.367	0.021
Winter	0.603		0.350	
Summer	0.820	0.056	0.389	0.001

	%Prot	SD	% Inj	SD
Comb.	0.42	0.733	2.04	1.768
Winter	1.27		0.00	
Summer	0.00		3.06	0.099

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Twenty-four

	Winter (n=1) Surveyed 2/13/92				Summer (n=2) Surveyed 7/16, 8/30/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Agaricia spp.					3	2.828	1.510	0.916
Dichocoenia stokesi	4		8.768		7	2.828	3.965	2.497
Diploria clivosa	1		0.735		1	0	0.488	0.067
Meandrina meandrites	2		6.550		2	0	4.705	1.483
Millepora alcicornis	2		0.194		2.5	0.707	0.342	0.047
Montastrea annularis	1		0.389					
Montastrea cavernosa	23		77.138		26	4.243	81.37	6.759
Mycetophyllia spp.					1	0	1.166	0.369
Porites astreoides	1		0.152		3	2.828	0.732	0.940
Scolymia cubensis	1		0.735					
Siderastrea spp.	19		5.338		17	2.828	4.7856	0.223
Solenastrea spp.					1	0	0.165	0.165
Stephanocoenia michelinii					1.5	0.707	0.769	1.063

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Agaricia spp.	3	2.828	1.510	0.916
Dichocoenia stokesi	6.333	2.309	5.566	3.490
Diploria clivosa	1	0	0.570	0.150
Meandrina meandrites	2	0	5.320	1.495
Millepora alcicornis	2.333	0.577	0.293	0.091
Montastrea annularis	0.333	0.58	0.130	0.225
Montastrea cavernosa	25	3.464	79.960	5.368
Mycetophyllia spp.	1	0	1.166	0.369
Porites astreoides	2.333	2.309	0.539	0.745
Scolymia cubensis	0.333	0.58	0.245	0.424
Siderastrea spp.	17.67	2.309	4.970	0.356
Solenastrea spp.	1	0	0.165	0.165
Stephanocoenia michelinii	1.5	0.707	0.769	1.063

	Abund	SD	%Cover	SD
Comb.	61.67	7.638	7.57	1.245
Winter	55		6.47	
Summer	65	7.071	8.13	1.122

	H'n	SD	H'c	SD
Comb.	1.666	0.198	0.831	0.176
Winter	1.482		0.864	
Summer	1.712	0.191	0.810	0.243

	J'n	SD	J'c	SD
Comb.	0.694	0.058	0.347	0.070
Winter	0.675		0.393	
Summer	0.714	0.079	0.338	0.102

	%Prot	SD	% Inj	SD
Comb.	2.94	3.735	4.60	3.994
Winter	0.00		0.00	
Summer	4.41	3.868	6.91	0.332

Note: Abundance units are colonies/20 sq. m

Appendix A: 20 sq. m station data and statistical parameters

Buoy # 24.5
Surveyed 8/30, Summer 1992 (n=1)

Species	Abund	RelCov
Agaricia spp.	2	0.834
Dichocoenia stokesi	8	3.347
Meandrina meandrites	2	5.146
Millepora alcicornis	3	2.461
Montastrea cavernosa	21	74.890
Mycetophyllia spp.	1	0.765
Porites astreoides	4	2.047
Siderastrea spp.	18	9.704
Stephanocoenia michelinii	2	0.813

Note: Abundance units are colonies/20 sq. m

	Abund	%Cover
Mean	61	7.39
	H'n	H'c
Mean	1.724	0.996
	J'n	J'c
Mean	0.785	0.454
	%Prot	% Inj
Mean	1.64	6.56

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Twenty-five

	Winter (n=1) Surveyed 3/7/92				Summer (n=2) Surveyed 8/31, 9/10/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Colpophyllia natans	2		0.531					
Dichocoenia stokesi	1		0.042		1.5	0.707	0.088	0.015
Montastrea cavernosa	5		86.909		1.5	0.707	87.089	2.026
Millepora alcicornis	7		4.908		2	1.414	2.780	1.180
Porites astreoides	3		3.875		1.5	0.707	2.295	0.546
Porites porites	1		0.312					
Siderastrea spp.	1		0.161		0.5	0.707	0.040	0.056
Solenastrea spp.	1		3.309		1	0	7.763	0.174

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	0.5	1.15	0.177	0.307
Dichocoenia stokesi	1.333	0.577	0.072	0.029
Montastrea cavernosa	2.667	2.082	87.029	1.436
Millepora alcicornis	3.667	3.055	3.489	1.485
Porites astreoides	2	1	2.822	0.99
Porites porites	0.33	0.58	0.104	0.18
Siderastrea spp.	1	0	0.120	0.058
Solenastrea spp.	1	0	6.278	2.574

Note: Abundance units are colonies/20 sq. m

	Abund	SD	%Cover	SD
Comb.	12.33	8.083	0.66	0.263
Winter	21		0.96	
Summer	8	4.243	0.51	0.012

	H'n	SD	H'c	SD
Comb.	1.645	0.193	0.939	0.648
Winter	1.79		0.568	
Summer	1.573	0.208	1.125	0.795

	J'n	SD	J'c	SD
Comb.	0.768	0.251	0.387	0.163
Winter	0.861		0.273	
Summer	0.772	0.337	0.444	0.183

	%Prot	SD	% Inj	SD
Comb.	0.00	0.000	9.70	10.01
Winter	0.00		0.00	
Summer	0.00	0.000	14.55	7.715

Appendix A: 20 sq. m station data and statistical parameters

Buoy # Twenty-six

Species	Winter (n=1) Surveyed 3/27/92 Abund	SD	RelCov	SD	Summer (n=1) Surveyed 9/10/92 Abund	SD	RelCov	SD
Colpophyllia natans	1		0.837		1		0.828	
Diploria clivosa	1		0.426		1		0.552	
Dichocoenia stokesi	8		3.636		7		2.153	
Eusmilia fastigiata	1		0.017		1		0.062	
Montastrea annularis					1		1.255	
Montastrea cavernosa	8		41.896		10		35.668	
Millepora alcicornis					1		3.550	
Porites astreoides	4		9.716		5		10.334	
Scolymia cubensis					1		0.139	
Siderastrea spp.	11		35.588		25		34.873	
Solenastrea spp.	2		7.876					
Stephanocoenia michelinii					4		10.588	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	1	0	0.832	0.006
Diploria clivosa	1	0	0.489	0.089
Dichocoenia stokesi	7.5	0.707	2.895	1.048
Eusmilia fastigiata	1	0	0.040	0.032
Montastrea annularis	1	0.710	0.628	0.887
Montastrea cavernosa	9	1.414	38.782	4.404
Millepora alcicornis	1	0.710	1.775	2.510
Porites astreoides	4.5	0.707	10.025	0.437
Scolymia cubensis	1	0.707	0.070	0.098
Siderastrea spp.	18	9.899	35.231	0.506
Solenastrea spp.	1	1.414	3.938	5.569
Stephanocoenia michelini	2	2.828	5.295	7.488

	Abund	SD	%Cover	SD
Comb.	46.5	14.849	2.42	0.166
Winter	36		2.30	
Summer	57		2.54	

	H'n	SD	H'c	SD
Comb.	1.742	0.011	1.445	0.142
Winter	1.734		1.344	
Summer	1.750		1.546	

	J'n	SD	J'c	SD
Comb.	0.769	0.092	0.634	0.017
Winter	0.834		0.647	
Summer	0.704		0.622	

Note: Abundance units are colonies/20 sq. m

	%Prot	SD	% Inj	SD
Comb.	3.51	4.964	2.78	3.932
Winter	0.00		5.56	
Summer	7.02		0.00	

Appendix B: 40 sq. m station data and statistical parameters

Buoy # Eighteen

	Winter (n=1) Surveyed 2/19/92				Summer (n=3) Surveyed 8/4, 8/17, 8/27/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Agaricia spp.	15		0.826		3	5.196	0.313	0.542
Colpophyllia natans	3		0.092		0.333	0.577	0.004	0.008
Dichocoenia stokesi	6		0.658		7	1	1.044	0.184
Diploria clivosa					1.667	0.577	0.049	0.018
Diploria labyrinthiformis					0.667	0.577	0.007	0.009
Madracis decactis	5		0.757		6	5.292	1.146	1.030
Meandrina meandrites	13		0.743		0.333	0.577	0.037	0.064
Millepora alcicornis	1		0.074		11	1	1.492	0.704
Montastrea annularis	1		0.663					
Montastrea cavernosa	31		95.51		19	6	84.116	15.117
Oculina diffusa	2		0.102		1.333	0.577	0.202	0.012
Porites astreoides	5		0.736		7	1	1.126	0.193
Siderastrea spp.	10		0.220		22.667	2.887	0.874	0.291
Solenastrea spp.					1	0	0.843	0.130

Combined Winter and Summer (n=4)

Species	Abund	SD	RelCov	SD
Agaricia spp.	6	7.348	0.441	0.512
Colpophyllia natans	1	1.414	0.026	0.044
Dichocoenia stokesi	6.75	0.957	0.947	0.245
Diploria clivosa	1.25	0.957	0.037	0.028
Diploria labyrinthiformis	0.5	0.577	0.005	0.008
Madracis decactis	5.75	4.349	1.049	0.863
Meandrina meandrites	11.5	1.291	1.305	0.686
Millepora alcicornis	0.5	0.577	0.046	0.055
Montastrea annularis	0.25	0.500	0.166	0.332
Montastrea cavernosa	22	7.746	86.963	13.59
Oculina diffusa	1.5	0.577	0.177	0.051
Porites astreoides	6.5	1.291	1.029	0.251
Siderastrea spp.	19.5	6.758	0.711	0.404
Solenastrea spp.	0.75	0.500	0.632	0.435

	Abund	SD	%Cover	SD
Comb.	80	8.756	8.17	3.322
Winter	92		13.05	
Summer	76	4.359	6.54	0.827
	H'n	SD	H'c	SD
Comb.	1.962	0.250	0.416	0.128
Winter	1.968		0.292	
Summer	1.96	0.307	0.458	0.12
	J'n	SD	J'c	SD
Comb.	0.834	0.092	0.177	0.053
Winter	0.821		0.122	
Summer	0.838	0.112	0.195	0.046
	%Prot	SD	% Inj	SD
Comb.	12.89	10.22	4.89	5.968
Winter	25.00		0.00	
Summer	8.85	7.670	6.52	6.125

Note: Abundance units are colonies/40 sq. m

Appendix B: 40 sq. m station data and statistical parameters

Buoy # Twenty

Species	Winter (n=1) Surveyed 2/14/92 Abund	SD	RelCov	SD	Summer (n=2) Surveyed 7/23, 9/10/92 Abund	SD	RelCov	SD
Colpophyllia natans					0.5	0.707	0.066	0.093
Dichocoenia stokesi	4		4.212		6.5	2.121	2.794	1.433
Diploria labyrinthiformis	1		1.748		0.5	0.707	0.030	0.042
Meandrina meandrites	1		0.033		1	0	1.123	0.333
Millepora alcicornis	7		1.586		10	0	1.169	0.394
Montastrea annularis	5		1.663		1	1.414	5.597	7.915
Montastrea cavernosa	23		83.188		21	1.414	78.498	2.717
Porites astreoides	2		1.275		3.5	2.121	1.241	0.486
Scolymia cubensis	1		0.117					
Siderastrea spp.	64		6.185		44.5	10.61	6.558	3.374
Solenastrea spp.					4.5	3.536	1.488	0.487
Stephanocoenia michelinii					3.5	4.95	1.443	2.041

Combined Winter and Summer (n=3)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	0.33	0.58	0.044	0.076
Dichocoenia stokesi	5.67	2.082	3.266	1.303
Diploria labyrinthiformis	0.67	0.58	0.602	0.993
Meandrina meandrites	1	0	0.759	0.672
Millepora alcicornis	9.00	3.142	1.308	0.368
Montastrea annularis	2.33	2.517	4.286	6.040
Montastrea cavernosa	21.7	1.528	80.061	3.32
Porites astreoides	3	1.732	1.252	0.345
Scolymia cubensis	0.3	0.578	0.039	0.068
Siderastrea spp.	51.0	13.53	6.433	2.395
Solenastrea spp.	3	3.606	0.992	0.925
Stephanocoenia michelini	2.33	4.041	0.962	1.666

	Abund	SD	%Cover	SD
Comb.	100.3	10.786	7.173	3.024
Winter	108		9.449	
Summer	96.5	12.021	6.035	3.243

	H'n	SD	H'c	SD
Comb.	1.487	0.183	0.817	0.095
Winter	1.285		0.729	
Summer	0.665	0.103	0.370	0.045

	J'n	SD	J'c	SD
Comb.	0.677	0.083	0.372	0.043
Winter	0.585		0.332	
Summer	0.723	0.105	0.392	0.064

Note: Abundance units are colonies/40 sq. m

	%Prot	SD	% Inj	SD
Comb.	1.07	1.143	2.931	2.539
Winter	0.93		0.000	
Summer	1.14	1.607	4.397	0.069

Appendix B: 40 sq. m station data and statistical parameters

Buoy # Twenty-four
Surveyed 8/30, Summer 1992 (n=1)

Species	Abund	RelCov
Agaricia spp.	7	1.493
Diploria clivosa	1	0.267
Dichocoenia stokesi	17	4.710
Montastrea cavernosa	44	75.737
Millepora alcicornis	5	1.426
Meandrina meandrites	4	5.449
Mycetophyllia spp.	2	0.835
Porites astreoides	9	1.723
Siderastrea spp.	37	7.176
Solenastrea spp.	1	0.024
Stephanocoenia michelinii	4	1.165

	Abund	%Cover
Mean	131	7.36
	H'n	H'c
Mean	1.805	1.005
	J'n	J'c
Mean	0.753	0.419
	%Prot	% Inj
Mean	4.58	6.87

Note: Abundance units are colonies/40 sq. m

Appendix B: 40 sq. m station data and statistical parameters

Buoy # Twenty-five

	Winter (n=1) Surveyed 3/7/92				Summer (n=1) Surveyed 8/31/92			
Species	Abund	SD	RelCov	SD	Abund	SD	RelCov	SD
Colpophyllia natans	6		1.325		4		2.931	
Dichocoenia stokesi	7		6.737		7		7.159	
Diploria clivosa	2		3.234		2		8.214	
Millepora alcicornis	9		7.523		3		2.579	
Montastrea annularis	3		31.572					
Montastrea cavernosa	7		37.192		4		61.56	
Porites astreoides	4		1.908		3		2.987	
Porites porites	2		1.819		2		5.914	
Siderastrea spp.	14		7.316		21		3.052	
Solenastrea spp.	1		1.394		1		5.626	

Combined Winter and Summer (n=2)

Species	Abund	SD	RelCov	SD
Colpophyllia natans	5	1.41	2.128	1.136
Dichocoenia stokesi	7	0	6.948	0.298
Diploria clivosa	2	0	5.724	3.521
Millepora alcicornis	6	4.24	5.051	3.496
Montastrea annularis	1.5	2.121	15.786	22.32
Montastrea cavernosa	5.5	2.121	49.378	17.23
Porites astreoides	3.5	0.707	2.448	0.763
Porites porites	2	0	3.867	2.896
Siderastrea spp.	17.5	4.95	5.184	3.015
Solenastrea spp.	1	0	3.510	2.993

Note: Abundance units are colonies/40 sq. m

	Abund	SD	%Cover	SD
Comb.	51	5.657	1.391	1.26
Winter	55		2.282	
Summer	47		0.5	

	H'n	SD	H'c	SD
Comb.	1.544	0.750	1.284	0.555
Winter	2.074		1.676	
Summer	1.013		0.891	

	J'n	SD	J'c	SD
Comb.	0.623	0.394	0.515	0.301
Winter	0.901		0.728	
Summer	0.344		0.302	

	%Prot	SD	% Inj	SD
Comb.	0	0.000	1.973	0.219
Winter	0		1.82	
Summer	0		2.13	