1-1-2002

Marine Biological Monitoring in Broward County, Florida: Year 2 Annual Report

David S. Gilliam

Richard Dodge

Richard E. Spieler

Susan L. Thornton

Lance K. B. Jordan

TECHNICAL REPORT DPEP 02-01

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Prepared by:

David S. Gilliam, Ph.D., Richard E. Dodge, Ph.D., Richard E. Spieler, Ph.D.,
Susan L. Thornton, M.S. and Lance K. B. Jordan
Nova Southeastern University Oceanographic Center
8000 N. Ocean Dr., Dania, FL 33004

Prepared for:

BROWARD COUNTY
BOARD OF COUNTY COMMISSIONERS
Department of Planning and Environmental Protection
Biological Resources Division

ABSTRACT

A study has been undertaken to monitor Broward County, Florida (southeast Florida) coral communities, reef fish assemblages and sedimentation rates in relation to possible effects from a proposed extensive beach renourishment (restoration) project. Coral communities and reef fish assemblages will be monitored at a total of 23 stations distributed offshore Broward County. This monitoring effort will characterize and quantify populations of scleractinian (stony) corals, octocorallian (gorgonian) corals, sponges, and reef fishes. In addition, sediment traps located at each station will be sampled and analyzed.

This document reports the data collected during the second year of this project. Coral communities and fish assemblages were monitored at each of the 23 sites between September and October 2001. In addition, sedimentation analysis for the January, March, May, July and September 2001 collections were conducted.

For September/October 2001, mean ($\pm$ 1 S.D.) stony coral density for the 23 sites was 2.62 $\pm$ 1.85 colonies/m^2. Mean stony coral coverage was 2.39 $\pm$ 3.96%. Mean gorgonian density was 7.91 $\pm$ 8.01 colonies/m^2 and mean sponge density was 14.09 $\pm$ 6.93 colonies/m^2. First Reef sites had greater mean stony coral coverage but lower gorgonian and sponge density than Second and Third Reef sites. First Reef coral cover was much lower than the Third Reef when the First reef site, FTL4, was removed from the analysis. FTL4 had much greater stony coral cover than the mean cover for the remaining First Reef sites (19.95% compared to 1.45%). Shannon-Weaver Diversity Indices performed on the overall transect data resulted in values of 1.45 $\pm$ 0.53 and 1.72 $\pm$ 0.44 for cover and number of species respectively. Overall evenness was 0.77 $\pm$ 0.14 for number of species and 0.64 $\pm$ 0.21 for cover.

There was no significant difference determined between the January/February 2001 site visit data and the September/October 2001 site visit data for mean stony coral density and cover. Mean octocoral density also did not differ significantly between these site visits, but mean sponge density was significantly less in September/October 2001 than in January/February 2001.

Stony coral density, stony coral coverage, gorgonian density and sponge density data collected from the 18 monitoring sites established in 1997 and visited yearly from 1997 to 1999 were analyzed. No significant difference in yearly mean stony coral density, mean stony coral cover and mean gorgonian density was determined. Mean sponge density did show significant differences with 1998 sponge density greater than 1997.

Trends in fish density were similar to those trends identified within the coral community transects. The greatest density of fishes occurs on the Third Reef followed by the First and Second. A difference in richness was seen amongst the three Reefs with the First Reef having the lowest number of species. The differences noted in abundance, density, and richness between the data collected in January/February 2001 and in September/October 2001 confirm previous reports of temporal differences in the fish assemblage offshore Broward County (Spieler 1998).

The First Reef had a statistically higher rate of sedimentation than both the Second and Third Reefs when data from January-September 2001 were pooled. Pooled site data showed that January 2001 and May 2001 samples had the greatest sedimentation rates. The grain size for sites on the Third Reef was significantly smaller than both the First and Second Reefs. When site data were pooled, January 2001 had a significantly larger mean grain size than the other four sampling intervals in 2001.

Data collected and analyses completed during this monitoring project will be used to help evaluate effects from the proposed beach renourishment project.

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SECTION 1: INTRODUCTION

1.1 Shoreline Protection (Beach Renourishment) Project

1.1.1 History

In 1998, Nova Southeastern University (Consultant) was awarded a contract to provide biological monitoring services for the proposed Shoreline Protection Project. A notice to proceed for the initial biological monitoring (Pre-construction) was issued in December 2000. Year 1 Pre-construction field monitoring took place in January and February 2001. Year 2 Pre-construction field monitoring took place in September and October 2001. Renourishment is scheduled to begin in summer of 2002. The planned Project will involve dredging beach compatible sand from five borrow areas identified offshore Broward County. The sand will be placed on selected beaches between Hillsboro Inlet and Port Everglades and between Port Everglades and the Dade/Broward County line.

1.1.2 Rationale For Monitoring

Environmental regulations dealing with sedimentation and turbidity effects from beach renourishment may not be adequate to protect stony corals and coral reef communities (Telesnicki and Goldberg 1995). The objective of this project is to monitor, with respect to the effects of beach renourishment (e.g., turbidity and siltation), ecologically important scleractinian (stony) and octocorallian (gorgonian) coral, porifera (sponge) and reef fish species off Broward County. Southeastern Florida is a unique part of the Florida marine environment and deserves special attention. Coral communities here are at their northernmost limits on the North American continent, where, compared to more southern Caribbean and Atlantic reefs, they display reduced abundance, coverage, diversity, and growth due to naturally occurring decreases in light and water temperature (Goldberg 1973; Jaap 1984).

Since 1970 many beach restoration projects have been conducted in the Broward, Miami-Dade and Palm Beach County area employing offshore sand supplies. Concern exists that effects from future projects may create additional stress for coral communities and their associated organisms. It is important to document and quantify living marine communities over time to develop a proper database to assess the efficacy of the construction practices, possible renourishment effects and mitigation techniques currently in use.

1.2 Project Contracted Scope of Services

At the time this contract was awarded, biological monitoring was organized into five separate evaluation periods:

(a) One year prior to renourishment activities (= First pre-construction monitoring, completed in early winter 2001).
(b) Approximately one year after (a) (= Second pre-construction monitoring and first construction activity monitoring) (Note that this was completed in September-October 2001 and that construction did not begin in 2001).

(c) Approximately two years after (a) (= First during construction monitoring and second construction activity monitoring).
(d) Approximately three years after (a) (= Second during construction monitoring and third construction activity monitoring).
(e) Approximately fours years after (a) (= Post construction monitoring)

The 5-Year project scope of services consists of seven activities. Each activity has a separate timetable and may not be required during each of the five years of the contract. Below is a description of each activity taken directly from Exhibit A of the Agreement (Scope of Services and Timetable):

1. Upon receipt of the notice to proceed, the Consultant shall establish five (5) additional reef community monitoring sites at locations mutually agreed to by County and Consultant, at which Consultant shall install sediment collector ringstands and stainless steel transect pins, identical to those at the existing eighteen (18) locations. In addition a permanent belt quadrat transect shall be established as set forth to measure stony coral species density (colonies/m^2), diversity and evenness.

2. Annual Site Visits: These annual site visits shall be conducted upon receipt of a Notice from the Contract Administrator. During each site visit, the consultant shall perform the following:

   2.1 Coral Community Transects. At each of the twenty-three (23) reef monitoring sites (eighteen (18) ongoing, five (5) additional proposed) a permanent belt quadrat transect has been or will be established. Each transect consists of twenty-one (21), eighteen (18) inch-long, one half (0.5) inch diameter, stainless steel pins fixed in the bottom with marine, two-part epoxy or Portland Cement, exactly one (1) meter apart (± 1.0 cm) in a straight line. Transect analysis at each site will be consistent with methodology described by Dodge *et al.* (1982). A minimum of thirty (30) square meters of bottom will be analyzed at each site. After field data collection the following calculations and analysis will be conducted for each transect data set:

      2.1.1 Stony coral species density (colonies/m^2), diversity and evenness (Shannon-Weaver Index).
      2.1.2 Diversity and evenness for percent live polyp coverage.
      2.1.3 Density of octocorallia and porifera (colonies/m^2)

   2.2 Fish population analysis. At each of the twenty-three (23) reef monitoring sites, the Consultant shall conduct fish population assessments. Fish population assessments will be conducted as per methodology described in Bohnsack and Bannerot (1986) and Bortone *et al.* (1989). Two (2) thirty (30) meter long transects for fish counts and one fifteen (15) meter diameter cylinder (stationary counts) will be conducted. The thirty (30) meter transects will be established by adding

ten (10) meters to the existing coral transect lines (these are already twenty (20) meters long). A second transect for fish census will be conducted from one end of the first line and perpendicular to the first line in a direction along the reef that will provide maximum topographical change. Populations of fishes will be counted one meter on either side of the transect line and two meters above the line. The center for the stationary counts will be established seven and one-half (7.5) meters from the start point of the first line. Species counts will be to the lowest taxon that conditions allow and size (total length) estimates will be by class (0-2, 2-5, 5-10, 10-20, 20-50, >50cm). Statistical analysis of the data will be done using parametric and non-parametric analysis of variance (ANOVA) techniques as appropriate.

2.3 Survey of Infaunal Organisms. Should the dredge and fill permits issued by the State of Florida or the US Army Corps of Engineers require population analysis of infaunal organisms potentially affected by the beach construction activities, the Consultant shall collect fifteen (15) core samples (8.0 cm diameter x 12 cm deep) from each of eight (8) sites. The site locations shall be determined by the Contract Administrator in compliance with dredge and fill permit requirements. The number of replicate core samples (15) is based on the "leveling" of the cumulative species curve (in Southeast Florida this number is 15). Samples shall be sorted for all organisms larger than 0.5 mm (millimeters) and stained with Rose Bengal. Organisms shall be identified to the taxon as low as reasonably achievable.

3. Sedimentation Analysis: The Consultant shall change out each ringstand trap every sixty (60) days during the first four (4) years of the term of the agreement, for a minimum of six (6) change-outs per year. Analysis of trap contents will be conducted as per Standard Operating Procedures (SOPs) published and archived by Broward County. (SOP No. ERO-019, and SOP No. ERO-037). Site locations are positively established and are reoccupied using DGPS latitude and longitude and range triangulation photographs. These location numbers and pictures shall be supplied to the Consultant by the County with the Notice to proceed.

4. Pipeline Placement Survey: After receipt of written notice from the Contract Administrator, up to five (5) times during the term of Agreement, the Consultant shall examine and evaluate the anchor placement of the Offshore Pumpout Terminal and placement of the submerged discharge pipeline from the terminal to the beach each time the pipeline is moved and installed. The pipeline placement "corridor" across and reef community hard bottom shall be visually surveyed and photo/video documented to record the impact of the pipeline placement on the reef community habitat. After the pipeline has been removed from the reef the pipeline corridor shall be reexamined and further photo/video documented for any additional damage. The Consultant shall estimate the total square meters impacted by the placement of the pipeline on the bottom and submit this information in the Annual Report.

5. Reef Edge Surveys: During the course of construction of the Project, the Consultant shall perform weekly visual reef edge surveys at the edges of each reef community hard bottom areas adjacent to active sand borrow areas (using SCUBA). These surveys shall monitor for mechanical damage to the reef, the general condition of the reef and the amount of sediment accumulation on the reef. These surveys shall be conducted by a diver(s) with at least a Master of Science degree in Marine Biology, biological oceanography, and/or equivalent work experience necessary to identify and chart the southeast Florida reef community and document the extent of sediment or mechanical damage to those areas.

6. Reef Assessment Damage Survey: If during a Reef Edge Survey irreversible loss of the reef community resource is evident due to construction impacts, the Consultant shall immediately notify the Contract Administrator. Thereafter, upon receipt of written approval from the Contract Administrator, the Consultant shall immediately perform a reef Damage Assessment Survey to discover and reveal the full areal extent of the irreversible loss. The Reef Damage Assessment Survey shall be completed within three (3) calendar days of receipt of the Contract Administrator's written notification unless the Consultant receives prior written permission from the Contract Administrator. Performance of reef damage assessment activities prior to obtaining written approval from the Contract Administrator is at the Consultant's sole risk.

7. Reports:

    7.1 Annual Reports. Within ninety (90) days, or sooner as required by the dredge and fill permit issued by the United States Army Corps of Engineers and the State of Florida Department of Environmental Protection, of the Annual Site Visit, the Consultant shall submit its Annual Report which contains the Sedimentation analysis, Coral Transect Analysis, Fish Transect Analysis, Infaunal Analysis (as required), Reef Edge Surveys, and Pipeline Placement Surveys as applicable. Each subsequent Annual Report shall compare results of analysis with the previous reports where appropriate, and the final report will discuss the impact of the beach construction relative to any measured changes in the above parameters. These reports shall be submitted in Corel Word Perfect format or compatible as determined by the County on a compact disc.

The specific scope of work for Year 2 of the project includes:

1. Completing the Year 2 annual site visit including coral community and fish population analyses.

2. Continuing sediment collections and analyses.

SECTION 2: METHODS AND MATERIALS

2.1 Existing Sites Prior to the Start of this Project

Of the 23 transect sites, 18 sites existed prior to the start of this project and were used in prior Broward County surveys. Personnel from Broward County Department of Planning and Environmental Protection began monitoring these 18 sites in September 1997 and continued through September 1999.

2.2 New Site Selection for this Project

Prior to the first monitoring visit, four new coral community monitoring sites were selected on 12 December 2000. The County and the Consultant were both present when the sites were selected. Industrial Divers Corp, installed these four sites on 9 January 2001. A fifth new site is actually a previously established site north of Boca inlet that was used during an unrelated project but has now been incorporated into this project.

Table 1 shows the location and depth of all sites. Figure 1 shows the position of each site and the borrow areas off Broward County.

2.3 Site Installation

For all sites (existing and new), stainless steel pins were inserted and cemented/epoxied into the hard reef substrate at one-meter intervals establishing a permanent 20-meter transect.

2.4 Year 2 Annual Site Visits

The Year 2 annual visit to the 23 coral community monitoring sites occurred in September and October 2001. Table 2 includes the dates each site was visited for the Year 1 and Year 2 monitoring. Three dive teams each with specific tasks were present when visiting each site. The team completing the reef fish surveys would enter the water first, locate the coral community 20-meter transect, and complete the fish surveys. The second dive team would enter the water after the fish team had finished the fish transects. This team would take photographs of the 40, 0.75m^2 quadrats along the coral transect. The third team would enter the water last and complete the coral community monitoring along the 20-meter transect (details are provided in Section 2.4.1). During most field days, two or three monitoring sites were completed.

2.4.1 Coral Community Transects

2.4.1.1 Phototransects

Each transect was photographed (Figure 2) using a Nikonos V fitted with a 20mm lens attached to a 0.75m^2 quadrat framer. Each photograph was taken using Fuji® Sensia II 100 ASA 35mm slide film. Tags with the date, the site name and quadrat number (1-40) were attached to

the framer and included in each image for reference. It was necessary to use two divers to control the camera and framer positioning. The photographs were taken for archival purposes and were not used in quantitative data analysis.

2.4.1.2 Belt Quadrat Transects

At each site divers sampled a 20m x 1.5m belt transect with 21 permanent stainless steel pins delineating each meter. The pins were arranged linearly running generally in a north/south direction. Using SCUBA, divers assessed the transects sequentially along one side of the 20m transect and then along the other side with a $0.75m^2$ quadrat. A total of 30 square meters was monitored along each transect ($0.75m^2$ x 40 quadrats). The quadrat in the northeast corner of each transect was assigned quadrat #1 in order to keep the photo quadrats and survey data consistent. In one case (POMP1) a section of the substrate within the transect was previously moved by storm activity; measuring tape was stretched between the remaining pins to provide a guide for quadrats.

Field data collection was designed to permit the following calculations and analyses for each site:

a) stony coral species density (colonies/m^2) and percent live coral cover,
b) Shannon-Weaver indices for coral abundance and live polyp coverage and
c) density of Porifera and Octocorallia (colonies/m^2).

Scleractinian coral and hydrozoan, *Millepora alcicornis,* colonies were identified to genus and species. Each colony was measured to the nearest centimeter along its long and short axes. Corals with a diameter of less than 1 cm and unattached colonies were not surveyed. Branching gorgonians and fleshy sponges were counted. Because of the difficulty of discriminating individual colonies, encrusting gorgonians and sponges were not included in the survey.

Analysis of the stony coral data collected in the field was performed in several ways. To determine density, the number of corals in each transect was divided by $30m^2$. Surface area of each coral was obtained by applying the length and width measurements of corals to the equation A = l x w. The sum of all surface area values for each transect was divided by the surface area of the entire transect ($30m^2$) to generate a percent for live coral cover. Shannon-Weaver Diversity Indices for number of species (H'N) and cover (H'C) of corals were calculated for each transect using the following equation:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

where p_i is the relative abundance or cover of species i, and s is the number of species Evenness for number of species (J'N) and cover (J'C) at each transect were calculated using the equation $J' = H'/H'_{max} = H'/\ln S$, where H'_{max} is the maximum possible diversity or cover for any given s. While H'N and H'C indicate the index of diversity or cover, evenness indicates how close those values come to the maximum possible value for each transect.

Density of octocorals, as well as sponges, was calculated by dividing the numbers of colonies counted along each transect by $30m^2$.

The data recorded during the site visits were analyzed with SAS© (Statistical Analysis Systems) software (SAS Institute Inc., Cary, NC, USA). Microsoft Excel© was used to determine general descriptive statistics. The data entered into SAS was tested for normality (PROC UNIVARIATE NORMAL). The data was analyzed with parametric analysis of variance techniques (PROC GLM) or nonparametric analysis of variance techniques (PROC RANK then PROC GLM), and the Student-Newman-Kuels test between means (SNK).

2.4.2 Fish Population Analysis

Fish inventories were accomplished at, and adjacent to, all the coral community transects. Two counting methodologies were used at each site: a transect-count and a point-count (Figure 3).

Two transect-counts were done at each site. The first transect line (Fish Transect #1) included the established 20m coral community transect but extended it by 10m, in a straight line normally on the same compass heading, for a total of 30m. The second 30m transect (Fish Transect #2) began at the southern end of the Fish Transect #1 and was laid out, with a PVC tape, normally at a 90 degree angle, on an easterly heading (see Figure 3). In some instances (JUL1, FTL4, POMP1, POMP6, HB1, DB2: Table 3 and Figures 4-9) this angle and/or heading was altered to stay on hardbottom and avoid extensive areas of sandy substrate. Both ends of Fish Transect #2 were marked with a concrete block with a subsurface buoy attached to a 1m line. Using SCUBA, a diver swam directly over each transect recording all fish species, a total length size interval (<2, 2-5, 5-10, 10-20, 20-30, 30-50, 50+cm), and number within 1m either side or 2m above the transect. Thus each transect covered $60m^2$ and $120m^3$. In addition to a slate with a waterproof data sheet and pencil, the diver carried a PVC "T-Stick," 1m long and 1m wide with the topside of the "T" marked with 10cm increments, to aid in estimating fish length and distances from the transect line. It took approximately 3 minutes to swim a single transect depending on the number of times the diver paused to record data.

A single point-count (Bohnsack and Bannerot, 1986) (a.k.a. Reef Fish Visual Census Technique) was taken at each site. The center of this point-count was established 7.5m from the angle apex of the two transect lines (Figure 3). The point-count counts fish in an imaginary 15m-diameter cylinder from substrate to surface. Thus the point-count covered a surface area of $176.63m^2$ with varying volume depending on water depth. On initiating the count, the fish counter would pivot to scan the entire cylinder and record all species observed during a five-minute period. Following this initial five-minute count, the abundance, mean size, minimum size and maximum size were recorded for each species observed during the initial five minutes. Sample times outside of the 5- minute initial count were generally no longer than 30 minutes. The diver was equipped with a slate with a waterproof data sheet and pencil, an underwater watch, and a one-meter "fish-stick" (1m PVC pipe with perpendicularly attached 30 cm ruler) as an aid for estimating fish lengths. Fish counts were only completed when visibility was greater than eight meters.

The data recorded during the fish counts were entered into Microsoft Excel© and analyzed with SAS© (Statistical Analysis Systems) software. Microsoft Excel was used to

determine general descriptive statistics. The same data entered into SAS was analyzed with nonparametric analysis of variance techniques (PROC RANK then PROC GLM), and the Student-Newman-Keuls test between means (SNK).

2.4.3 Sedimentation Analysis

2.4.3.1 Sediment Trap Collection

Analysis of trap contents were conducted as per Standard Operating Procedures (SOPs) published and archived by Broward County, SOP No. ERO-019 and SOP No. ERO-037. Sediment trap collection and change-out, performed by divers from Industrial Divers Corporation, Ft. Lauderdale, Florida (Subcontractor), is scheduled to occurr approximately every sixty days (depending on sea conditions) starting 4 January 2001. Three sediment trap bottles on each sediment trap ring stand were changed-out during each collection. To ensure no sediment was lost during the change-out process, diver(s) collected the bottles by first removing PVC trap tops and replacing them with a standard bottle top. Diver(s) also noted any anomaly that could interfere with the sediment analysis, such as the presence of large living organisms (e.g., octopuses, eels, *etc.*) in a particular bottle or a missing trap bottle. Topside, the standard trap lids were labeled with site and date information. This report is comprised of data from January 2001 through September 2001.

2.4.3.2 Analysis of Sediment Trap Samples

Once samples arrived at Nova Southeastern University Oceanographic Center, they were fixed with enough 37% formaldehyde to make a 10% formalin/seawater solution. Samples remained undisturbed for the following 48 hours. After samples were fixed and allowed to settle, the preservative solution was removed by aspiration. The remaining sample was then washed (using freshwater) through a No. 230 (0.063mm) sieve positioned in the sieve ring stand assembly. Particles passing through the sieve, which constitute the silt/clay fraction (based on the Wentworth scale), were collected in a 4000mL beaker. The sand fraction sample was washed with freshwater until water flowed freely through the sand in the sieve. Additionally, all organisms (fish, crabs, worms, algae, *etc.*) were removed from the sand fraction. The sand fraction was then washed into an appropriately sized and labeled pre-weighed Nalgene® beaker. Water in those beakers was removed by aspiration after allowing settlement for 48 hours. The beakers were placed into a drying oven for a minimum of 24 hours, until dry. Silt/clay fractions were allowed to settle for 48 hours before aspiration of wash water. The silt/clay fraction was then washed into an appropriately sized and labeled pre-weighed Nalgene® beaker and allowed to settle for an additional 48 hours before aspirating off wash water. Following removal of wash water by aspiration, the sample was placed to dry in an oven (at 100-105° C) for at least 24 hours.

Once the sand and silt/clay samples were dry, they were removed from the oven and quickly placed into desiccators for cooling. After cooling, whole samples were weighed to the nearest 0.01g. These weights (minus the weight of the beaker, which was written in indelible ink on the beaker) were then recorded on a sediment trap analysis data sheet for the appropriate collection interval. No further analysis of the silt/clay samples was undertaken.

2.4.3.3 Grain Size Analysis of Sand Samples

To determine the average grain size of sand fractions, only the heaviest of the three samples from each site was analyzed. Depending on the weight of the sample, the sand fractions were split through a splitter device until reaching a 40-70g sub-sample. This sub-sample was then placed on the top (4.00mm) sieve of the stacked sieve series. The sieve series (U.S Standard Series) contained 13 sieves atop a pan used to collect grains less than 0.063mm. The 13 half-height sieves were: 4.00mm, 2.80mm, 2.00mm, 1.40mm, 1.00mm, 0.71mm, 0.50mm, 0.355mm, 0.250mm, 0.180mm, 0.125mm, 0.090mm, and 0.063mm. The sieve series topped by a lid was secured to the shaker. The shake period was 15 minutes. Fractions from each sieve were weighed in polystyrene weigh boats and the weights recorded on sieve analysis data sheets for the appropriate sample. Additionally, the weight of the silt/clay fraction was added to the weight of the 0.063mm fraction.

2.4.3.4 Data Analysis

Nonparametric univariate statistical analyses were performed on the data generated from the January 2001 to September 2001 sediment collections. Mean grain size was calculated using the Wentworth phi scale (Wentworth 1926). General trends in sedimentation are described in the results section through examination of bar graphs and statistical analyses of data collected since sediment collection began in 1997.

SECTION 3: RESULTS/DISCUSSION

3.1 Coral Community Transects

3.1.1 Phototransects

A photograph of every quadrat included on the 23 reef monitoring sites (920 images) was successfully produced. Although occasionally gorgonians and/or large sponges may have obscured some details in the quadrats, the images provide an accurate photographic representation of the coral community at each site. These images are archived with the Consultant, available for review upon request and will be supplied to the County at the completion of this project. Figure 10 is an example of a quadrat image.

3.1.2 Coral Community Transects

Table 4 provides summary data for stony coral, gorgonian and sponge density, percent live stony coral cover and Shannon-Weaver stony coral diversity and evenness indices for each site and reef for Year 2 (September-October 2001) monitoring.

3.1.2.1 General Analyses and Comparisons Among Reefs

a) Stony Corals: Species area curves were generated from the first annual site visit data (January-February 2001). The curves for each site showed apparent leveling (or reduced slope from initial sampling) before 30 m^2 were sampled, suggesting that a transect of 30 m^2 is sufficient to document species richness. Figures 11-17 show the species area curves for the sites by region.

Coral species abundances are listed in Table 5 for each site. A total of 1800 colonies and 31 species were observed on the reefs in this study. The most numerous species were *Siderastrea radians, Siderastrea siderea, Montastrea cavernosa, Millepora alcicornis, Porites astreoides*, and *Stephanocoenia michelinii.* See Figure 18 for percent species contribution.

Overall mean stony coral density for all sites was 2.62 ± 1.85 colonies/m^2. Mean density (±1 S.D.) was highest on the First Reef (2.90 ± 3.02 colonies/m^2) (Figure 19), but no significant difference between mean coral density on the three reef tracts was determined ($p = 0.3724$, nonparametric ANOVA). Figure 20 shows coral density by site. Overall mean coral cover was 2.39 ± 3.96%. Mean live polyp cover was highest on the First Reef (3.76 ± 6.67%) (Figure 21), but no significant difference in mean coral cover was determined ($p = 0.3157$, nonparametric ANOVA). One site (FTL4) had particularly high cover of 19.95% (Figure 22). FTL4 has much greater stony coral cover than the mean cover for the remaining First Reef sites (19.95% compared to 1.45%). The Third Reef showed higher coral cover than the First and Second Reefs when site FTL4 was removed from the data. However, removing FTL4 from stony coral coverage data did not change the statistical outcome which was no significant difference in mean coral cover determined among reefs ($p = 0.3864$, ANOVA on arcsin transformed data). The great difference between the coral cover at FTL4 and the other First Reef sites may indicate that more monitoring sites are needed to account

for the variability in the reef system off Broward County. Diversity indices H'C and H'N were lowest on the First Reef (0.91 ± 0.05 and 1.24 ± 0.39, respectively) and comparable on the Second (1.73 ± 0.20 and 1.93 ± 0.16) and Third Reefs (1.74 ± 0.28 and 2.01 ± 0.16) (Figures 23 and 24). Evenness values for numbers of species and coverage was similar on all reefs with the First Reef (0.46 ± 0.24 and 0.64 ± 0.15) having slightly smaller values than on the Second (0.74 ± 0.09 and 0.83 ± 0.07) and Third Reef (0.73 ± 0.13 and 0.84 ± 0.07) (Figures 25 and 26). Coral density, percent cover, H'C, H'N and evenness appeared to be more variable on the First Reef than on the Second and Third.

b) Gorgonians: The overall mean density (± 1 S.D.) on the 23 sites was 7.91 ± 8.01 gorgonians/m^2. Mean gorgonian density was significantly highest (11.02 ± 10.96 colonies/m^2) on the Third Reef and lowest on the First Reef (6.41 ± 5.48 colonies/m^2). The Third and Second Reefs did not differ significantly but both had significantly higher gorgonian density than the First Reef (p = 0.0297, ANOVA and SNK). See Figure 27 for gorgonian density by site for 2000-2001. Figure 28 shows gorgonian density by reef for 2000-2001.

c) Sponges: The overall mean density of sponges (± 1 S.D.) on the 23 sites was 14.08 ± 6.93 sponges/m^2. Mean density of sponges was lowest on the First Reef (9.80 ± 7.89 sponges/m^2) and similar on the Second (17.25 ± 5.64) and Third (15.36 ± 5.14) Reefs, but no significant difference in sponge density was determined (p = 0.3155, nonparametric ANOVA). See Figure 29 for sponge density by site and Figure 30 for sponge density by reef for 2000-2001.

3.1.2.2 Comparisons Between 2000 (January/February 2001) and 2001 (September/October 2001)

a) Stony Corals: Overall coral density increased from 2000 to 2001, but this increase was not significant (p = 0.7267, nonparametric ANOVA). The First Reef showed the greatest increase in coral density between 2000-2001. The large increase and high variability of coral density found at the First Reef can be attributed to site DB1, where many small *Siderastrea* spp. colonies were identified in 2001. Second Reef density values are very similar between 2000-2001, and Third Reef density values dropped slightly from 2000 to 2001. Percent live coral cover did not differ significantly between 2000 and 2001 (p = 0.9391, nonparametric ANOVA). See Figures 19 and 21 for coral density and percent cover from 2000 to 2001.

b) Gorgonians: Octocoral density decreased from 2000 to 2001, but this decrease was not significant (p = 0.7557, ANOVA on log transformed data). A large decrease in gorgonian density at site DB3, where the mean gorgonian density decreased from 51.43 colonies/m^2 in January 2001 to 30.97 colonies/m^2 in October 2001 was found. See Figures 27 and 28 for 2000-2001 gorgonian comparisons.

c) Sponges: Overall sponge density decreased significantly from 2000 to 2001 (p = 0.0340, ANOVA on square root transformed data). Figures 29 and 30 show sponge comparisons from 2000-2001.

3.1.2.3 Comparisons Between 1997, 1998, and 1999

a) Stony Corals: No significant difference between mean values for coral density ($p = 0.0503$, nonparametric ANOVA) or coral coverage ($p = 0.9626$, ANOVA on Arcsin transformed data) were determined. See Figure 31 for coral density and cover comparison from 1997 to 1999.

b) Gorgonians: No significant difference was determined between years for mean gorgonian density ($p = 0.8628$, ANOVA on log transformed data). See Figure 32 for gorgonian density comparison from 1997 to 1999.

c) Sponges: Significant differences were determined between years for mean sponge density ($p = 0.0134$, ANOVA) with 1997 sponge density less than 1998 sponge density. See Figure 33 for sponge density comparison, including multiple comparison (SNK) results, from 1997 to 1999.

3.2 Fish Population Analysis

A total of 6904 fishes of 117 species were counted in September/October 2001 (versus 5206 fishes and 110 species in January/February 2001) (see Table 6 which includes all 131 species identified during this project). There were statistically no significant differences in total fish abundance (Figure 34) or density (Figure 35) among the three Reefs when both point-and transect-counts were combined ($p > 0.05$, ANOVA). The Second and Third Reefs had more species than the First Reef ($p < 0.05$, ANOVA, SNK) but did not differ from each other (Figure 36). Haemulids were the predominant family on the First and Second Reefs; labroid fishes predominated (wrasses, damsels, and parrotfish) on the Third Reef (Table 7-9).

The point counts had higher numbers of both total fish ($p < 0.0001$, ANOVA) and species ($p < 0.0001$, ANOVA, $p < 0.05$, SNK) than either of the two transects (Fish transect #1 and #2). The two transects did not differ from each other ($p > 0.05$, SNK). However, when the abundance data was adjusted for density there was no longer a significant difference among the counts ($p > 0.05$) (Figure 35).

There was a significant difference ($p < 0.05$) for abundance, density and richness between Year 1 (January/February 2001) and Year 2 (September/October 2001) ($p < 0.0001$, ANOVA). The Year 2 data was larger in all cases (Figure 37-39).

3.3 Sedimentation Analysis

3.3.1 Comparison Among Reefs

To compare the general sedimentation rates among the three reef tracts, sites within a reef tract were pooled essentially standardizing the temporal variability in the data. Examination of Figure 40 shows that the First Reef had a statistically higher rate of sedimentation than both the Second and Third Reefs when data from October 2000 to September 2001 were pooled ($p < 0.05$, SNK). The Second and Third Reefs, however, did

not differ significantly from each other despite a five-fold difference between means ($p > 0.05$). Including past sediment data, Figure 41 suggests that the First Reef generally has a higher rate of sedimentation than the Second Reef, with the Third Reef averaging a lower rate than the Second Reef. Figure 42 indicates that the grain size for sites on the Third Reef was significantly smaller than both the First and Second Reefs ($p < 0.05$, SNK).

3.3.2 Temporal Comparisons

Analysis after pooling the data for all sites showed significant differences among sampling intervals (January-September 2001). The January 2001 and the May 2001 samples have the greatest sedimentation rates, and they did not differ from one another (Figure 43). When site data were pooled, January 2001 had a significantly larger mean grain size than the other four sampling intervals (Figure 44).

3.3.3 General Results

Since October 1997 it appears that the First Reef typically has the highest rate of sedimentation followed by the Second, then Third Reefs (Figure 45). Additionally, there appears to be a consistent seasonal trend in sedimentation rate in Broward County since October 1997, with the highest rates of sedimentation occurring in late fall/winter.

SECTION 4: SUMMARY

This document reports on the activities and data collected during the second year of this project. Five new monitoring sites were installed prior to the Year 1 site visit increasing the total number of sites from 18 to 23. Coral communities and fish assemblages were monitored at each of the 23 sites between September and October 2001. In addition, sedimentation analysis for the January, March, May, July and September 2001 collections are included.

Mean ($\pm$ 1 S.D.) stony coral density for the 23 sites was 2.62 $\pm$ 1.85 colonies/m^2. Mean live stony coral coverage was 2.39 $\pm$ 3.96%. Mean gorgonian density was 7.91 $\pm$ 8.01 colonies/m^2 and mean sponge density was 14.09 $\pm$ 6.93 colonies/m^2. The First Reef had the greatest stony coral cover when site FTL4, a First Reef site, is included in the analysis while the Third Reef had the greatest stony coral cover when site FTL4 is not included in the analysis. The Third Reef had higher gorgonian density than the First and Second Reefs (which were similar in gorgonian density). Sponge density was lowest on the First Reef and similar on the Second and Third Reefs. Shannon-Weaver Diversity Indices performed on the overall transect data resulted in values of 1.45 $\pm$ 0.53 and 1.72 $\pm$ 0.44 for cover (H'C) and number of species (H'N), respectively. Overall mean evenness was 0.77 $\pm$ 0.14 for number of species (J'N) and 0.64 $\pm$ 0.21 for cover (J'C).

The greatest density of fishes occurred on the Third Reef followed by the First and Second. A difference in richness was seen amongst the three Reefs with the First Reef having the lowest number of species. The differences noted in abundance, density, and richness between the data collected in January/February 2001 and in September/October 2001 confirm previous reports of temporal differences in the fish assemblage offshore Broward County (Spieler 1998). These temporal differences must be taken into account in establishing a sampling protocol and in data analysis. Extensive year-round inventories would establish the most reliable database with which to determine changes in the fish assemblages of Broward County. However, such an approach to environmental monitoring would be prohibitively expensive. In lieu of year-round monitoring, it is critical to make repeated fish counts, which are aimed at determining change, at the same time-of-year.

The First Reef had a statistically higher rate of sedimentation than both the Second and Third Reefs for the over all period from January-September 2001. The January 2001 and the May 2001 samples had the greatest sedimentation rates. Sedimentation analysis indicates that the average grain size was significantly highest on First Reef sites with Third Reef sites containing significantly smaller mean grain size compared to Second Reef sites. Average sediment rates for the three reefs since October 1997 indicate that the First Reef typically has the highest rate of sedimentation followed by the Second, then Third Reefs. Both sedimentation rate and average grain size from January 2001 to September 2001 appear to be consistent with data collected from previous years during these same sampling intervals.

The biological response of coral reefs and coral reef organisms to sedimentation and turbidity is complicated. These ecosystems have adapted, over long time periods, to certain low levels of natural sedimentation and turbidity. However, excessive or chronic

sedimentation causes documented adverse effects (Goldberg 1988). These can include reef species mortality and changes in growth (Bak 1978), as well as changes in benthic community composition, coverage, and density. These parameters, while linked, change at different rates and in different ways. The difficulty is that these changes are largely un-quantified for individual species, let alone the broad combinations of species and growth forms, which ultimately create ecosystems. Consequently, monitoring the effects of a particular event or events (e.g., a beach renourishment project) can be particularly difficult when effects are less than catastrophic (e.g., complete mortality).

As data is collected and analyses completed during this monitoring project, the results may be useful to evaluate effects from the proposed beach renourishment project on the coral reef communities off Broward County. Past studies (Dodge *et al* 1995) have not shown major detrimental effects on coral reef communities from beach renourishment activities. This does not suggest that future renourishment projects can be expected to have no impacts. It is also important to recognize the limitations of this monitoring project and possible confounding effects on the reefs from non-beach renourishment activities. Limitations include the natural variability of reef communities, which decreases the ability of statistical tests to detect differences related to the proposed beach renourishment project from non-beach renourishment activities and processes. Variability may be addressed more powerfully with the addition of more monitoring sites, which is limited by resources. Differences in depth, distance from shore and coral community composition within and among the three reef tracts all play a role in confounding the possible effects of beach renourishment activities. In addition, short-term disturbances (e.g., from storm activities) may add to or mask effects from beach renourishment activities. Long-term change to the coral communities from larger scale processes (e.g., global warming and chronic pollution from non-beach related activities) might also add to or mask effects. These examples of non-beach renourishment activities and processes that may affect the reef coral communities are not directly a part of this monitoring project.

SECTION 5: LITERATURE CITED

Bak, R.P.M. 1978. Lethal and sublethal effects of dredging on reef corals. Marine Pollution Bulletin 9:14-16.

Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. U.S. Dept. of Commerce, NOAA Technical Report NMFS 41:1-15.

Bortone, S.A., J.J. Kimmel, and C.M. Bundrick. 1989. A comparison of three methods for visually assessing reef fish communities: time and area compensated. Northeast Gulf Science 10:85-96.

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., W. Goldberg, C.G. Messing, and S. Hess. 1995. Final Report Biological Monitoring of the Hollywood - Hallandale Beach Renourishment. Prepared for the Broward County Board of County Commissioners, Broward County Department of Natural Resources Protection, Biological Resources Division. 103 pp.

Goldberg, W. 1973. The ecology of the coral-octocoral communities off the southeast Florida coast: geomorphology, species composition, and zonation. Bulletin of Marine Science 23:465-488.

Goldberg, W. 1988. Biological effects of beach restoration in South Florida. Gainesville. Beach Preservation Technology 88:19-27.

Jaap, W.C. 1984. The ecology of the south Florida coral reefs: a community profile. U.S. Fish and Wildlife Service FWS/OBS - 82/08. 138 pp.

Spieler, R.S. 1998. Recruitment of Juvenile Reef Fish to Inshore and Offshore Artificial Reefs: Final Report. Prepared for the Broward County Department of Natural Resource Protection, Biological Resources Division. 118 pp.

Telesnicki, G.L. and W.M. Goldberg. 1995a. Effects of turbidity on the photosynthesis and respiration of two South Florida reef coral species. Bulletin Marine Science 57:527-539.

Wentworth, C.K. 1926. Methods of computing mechanical composition types in sediments. Geological Society of America Bulletin. 40: 771-790.

SECTION 6: TABLES AND FIGURES

Table 1: Coordinates and depths for each of the 23 monitoring sites. Sites in bold are the five new sites established for this project.

SITE	REEF	DEPTH	LATITUDE	LONGITUDE
JUL2	Third	52	26 00.2593 N	80 05.3010 W
JUL1	Second	40	26 00.3014 N	80 05.8134 W
HH2	First	19	26 00.6946 N	80 06.7572 W
JUL8	Third	50	26 04.9957 N	80 05.0990 W
JUL7	Second	32	26 04.9635 N	80 05.7321 W
JUL6	First	12	26 04.9120 N	80 06.2226 W
FTL4	**First**	**20**	**26 08.2080 N**	**80 05.8440 W**
FTL3	Third	60	26 09.5183 N	80 04.6406 W
FTL2	Second	48	26 09.5971 N	80 04.9522 W
FTL1	First	19	26 09.5343 N	80 05.7475 W
POMP3	Third	51	26 11.2141 N	80 04.3650 W
POMP2	Second	48	26 11.3289 N	80 04.8039 W
POMP1	First	20	26 11.4356 N	80 05.2256 W
POMP4	**First**	**20**	**26 12.7320 N**	**80 05.2010 W**
POMP6	**Third**	**52**	**26 14.5660 N**	**80 04.3980 W**
POMP5	**Second**	**31**	**26 14.5660 N**	**80 04.7310 W**
HB3	Third	49	26 16.4255 N	80 03.8189 W
HB2	Second	35	26 16.5350 N	80 04.2620 W
HB1	First	21	26 16.8357 N	80 04.5390 W
DB3	Third	55	26 18.6828 N	80 03.5764 W
DB2	Second	37	26 18.6280 N	80 04.0262 W
DB1	First	18	26 18.5869 N	80 04.3928 W
BOCA1	**Second**	**30**	**26 20.8030 N**	**80 03.8830 W**

Table 2: Dates each of the sites have been visited during the project.

SITE	DATE COMPLETED YEAR 1	DATE COMPLETED YEAR 2
JUL2	17 Jan 2001	10 Sept 2001
JUL1	8 Jan 2001	10 Sept 2001
HH2	17 Jan 2001	10 Sept 2001
JUL8	15 Feb 2001	20 Sept 2001
JUL7	15 Feb 2001	21 Sept 2001
JUL6	15 Feb 2001	20 Sept 2001
FTL4	25Jan 2001	21 Sept 2001
FTL3	21 Feb 2001	11 Sept 2001
FTL2	22 Jan 2001	11 Sept 2001
FTL1	22 Jan 2001	17 Sept 2001
POMP3	21 Feb 2001	24 Sept 2001
POMP2	24 Jan 2001	17 Sept 2001
POMP1	23 Feb 2001	21 Sept 2001
POMP4	25 Jan 2001	24 Sept 2001
POMP6	7 Feb 2001	2 Oct 2001
POMP5	7 Feb 2001	24 Sept 2001
HB3	31 Jan 2001	3 Oct 2001
HB2	31 Jan 2001	2 Oct 2001
HB1	6 Feb 2001	3 Oct 2001
DB3	6 Feb 2001	15 Oct 2001
DB2	2 Feb 2001	27 Sept 2001
DB1	2 Feb 2001	27 Sept 2001
BOCA1	23 Feb 2001	15 Oct 2001

Table 3: Layout description of the fish transects and center of the point-counts for each site. The "Normal" layout is illustrated in Figure 3. The layouts that differ from the normal are illustrated in Figures 3-9.

SITE	DESCRIPTION
JUL2	Normal
JUL1	Transect #2 runs N at 60^0 from the southern end of Transect #1
HH2	Normal
JUL8	Normal
JUL7	Normal
JUL6	Normal
FTL4	Last 10m of Transect #1 runs at 330^0
FTL3	Normal
FTL2	Normal
FTL1	Normal
POMP3	Normal
POMP2	Normal
POMP1	Transect #2 runs to the W
POMP4	Normal
POMP6	Last 10m of Transect #1 runs at 230^0, Transect #2 runs NW, Point-count 280^0 off apex
POMP5	Normal
HB3	Normal
HB2	Normal
HB1	Transect #2 runs N at 300^0, Point count 210^0 off apex
DB3	Normal
DB2	Last 10m of Transect #1 runs at 180^0, Transect #2 runs to the W, Point count SSW off apex
DB1	Normal
BOCA1	Normal

Table 4: Summary of values measured for permanent transect sites in September/October 2001. New sites as of January 2001 are denoted by *.

	Depth	Stony Coral Density (colonies/m²)		Stony Coral % cover		H'C		H'N		J'C		J'N		# Coral Species	Sponge Density (per m²)		Octo-coral Density (per m²)	
		By site	By reef	By Site	By reef	By site	By reef	By site	By reef	By site	By Reef	By site	By reef		By site	By reef	By site	By reef
FIRST REEF																		
JUL6	12	1.73		4.35		1.16		1.12		0.53		0.51		7	6.43		1.53	
DB1	18	10.13		0.80		0.93		0.56		0.58		0.35		4	4.27		3.27	
HH2	19	1.13	2.90	1.36	3.76	0.19	0.91	0.87	1.24	0.17	0.46	0.79	0.64	7	4.93	9.80 ±	6.17	6.41
FTL1	19	1.37	±	0.85	±	1.43	±	1.64	±	0.62	±	0.71	±	9	10.83	7.89	8.80	±
FTL4*	20	2.17	3.02	19.95	6.67	0.37	0.51	1.54	0.39	0.16	0.24	0.64	0.15	9	26.17		4.73	5.48
POMP4*	20	1.37		0.17		1.68		1.47		0.86		0.75		6	5.80		2.47	
POMP1	18	1.13		2.10		0.86		1.63		0.39		0.74		9	3.47		5.57	
HB1	21	3.57		0.50		0.66		1.15		0.37		0.64		5	16.53		18.73	
SECOND REEF																		
BOCA1*	30	3.43		1.14		1.70		1.56		0.87		0.80		7	15.53		6.60	
JUL7	32	2.03		0.99		1.84		1.86		0.74		0.75		12	12.73		2.83	
HB2	35	1.67	2.26	3.71	1.41	1.39	1.73	1.97	1.93	0.56	0.74	0.79	0.83	9	25.43	17.25	2.30	6.70
DB2	37	3.37	±	1.16	±	1.92	±	1.96	±	0.80	±	0.82	±	15	26.73	±	0.47	±
JUL1	40	2.23	0.75	0.81	0.97	1.92	0.20	2.01	0.16	0.73	0.09	0.76	0.07	12	14.19	5.64	2.90	7.40
FTL2	48	1.53		0.79		1.66		1.94		0.76		0.88		12	13.40		9.73	
POMP5*	48	1.60		0.97		1.51		2.08		0.69		0.95		11	12.97		23.57	
POMP2	52	2.20		1.74		1.87		2.06		0.78		0.86		11	17.00		5.20	
THIRD REEF																		
HB3	49	4.13		2.04		2.04		2.10		0.82		0.84		15	33		4.23	
POMP3	51	3.77	2.72	2.77	1.94	1.93	1.74	1.95	2.01	0.75	0.73	0.76	0.84	11	25	15.36	2.63	11.02
JUL8	50	1.97	±	1.48	±	1.89	±	2.05	±	0.82	±	0.89	±	11	13	±	3.33	±
POMP6*	51	2.13	0.99	2.56	0.66	1.20	0.28	2.23	0.16	0.47	0.13	0.87	0.07	13	39	5.14	13.97	10.96
JUL2	52	1.87		1.46		1.74		2.12		0.79		0.96		11	15		2.70	
DB3	55	3.37		2.28		1.55		1.78		0.67		0.77		8	22		30.97	
FTL3	60	1.83		0.96		1.84		1.86		0.80		0.81		8	13		19.33	
MEAN (± 1 SD)		2.62 ± 1.85		2.39 ± 3.96		1.45 ± 0.53		1.72 ± 0.44		0.64 ± 0.21		0.77 ± 0.14		9.65	14.08± 6.93		7.91± 8.01	

Table 5: Coral species abundance at each transect site, September/October 2001. Species are arranged by relative abundance (from top to bottom).

SPECIES	JUL6	DB1	HH2	FTL1	FTL4	POMP 1	POMP 4	HB1	BOCA 1	JUL7	HB2	DB2	JUL1	FTL2	POMP 5	POMP 2	HB3	POMP 3	JUL8	POMP 6	JUL2	DB3	FTL3
	FIRST REEF SITES								SECOND REEF SITES								THIRD REEF SITES						
Siderastrea radians		254	22	4	6	13	16	12	22	18		1	1	1	1	6		2	2				
Siderastrea siderea	4	38	12	6		9	10	41	23	17	14	32	16	16	13	11	28	14	12	16	10	21	11
Montastrea cavernosa	1				37	1			6	2	10	26	5	4	7	7	30	31	10	12	8	14	6
Millepora alcicornis		10		1	1	3	1	2	39	1	4	8	9	8	6	19	10	20	8	6	12	24	12
Porites astreoides	35		2	20	2	3	8				5	11	5	2	2	2	24	21	10	1	7	8	
Stephanocoenia michelinii									2	12	6	10	18	7	6	9	9	3	10	11	7	26	14
Solenastrea bournoni		2	8			2		49	9	2		1	1	1	1				2		2		2
Meandrina meandrites					1	1				3	5	1	7	4	4	1	1	4		5	1	4	5
Dichocoenia stokesii	2			1	1	1			2	2	3	4	1	1	6	2	3	2			1		3
Madracis decactis												1	1				2	13	2	2	4	2	2
Montastrea faveolata					3	1					2					5	3	2	1	4	3		
Porites porites	3		6	4			5							1		3	1						
Agaricia agaricites				3	7					1		1		1			1						
Agaricia humilis																	5			1			
Colpophyllia natans				1								1	1		1	1				1			
Diploria clivosa	3				1					1							1						
Diploria strigosa												2			1					1		2	
Scolymia cubensis																	4			2			
Montastrea franksii					3												2						
Acropora cervicornis	4																						
Mycetophillia lamarkiana										1		1	2										
Cladocora arbuscula								3															
Solenastrea hyades			2				1																
Agaricia fragilis										1									1				
Manicina areolata																				2			
Diploria labyrinthiformis																		1					
Eusmilia fastigiata																					1		
Favia fragum																			1				
Isophyllia sinuosa				1																			
Isophyllia rigida												1											
Mycetophyllia aliciae											1												
Total species: 31																							
# species/ site	7	4	6	9	10	9	6	5	7	12	9	15	12	11	11	11	15	11	8	13	11	8	8

Table 6. Total species list of fishes identified at the 23 monitoring sites (transects and point-count data combined); includes Year 1 and Year 2 counts. Species in bold were not recorded in Year 1 (January-February 2001).

COMMON NAME	SCIENTIFIC NAME
FAMILY: STINGRAY	DASYATIDAE
Yellow Stingray	*Urolophus jamaicensis*
FAMILY: RHINOBATIDAE	GUITARFISH
Guitarfish	*Rhinobatos lentiginosus*
FAMILY: MORAY EELS	MURAENIDAE
Purplemouth Moray	***Gymnothorax vicinus***
FAMILY: LIZARDFISHES	SYNODONTIDAE
Sand Diver	*Synodus intermedius*
FAMILY: BIGEYE	PRIACANTHIDAE
Glasseye Snapper	*Heteropriacanthus cretatus*
FAMILY: SQUIRRELFISHES	HOLOCENTRIDAE
Longspine Squirrelfish	*Holocentrus rufus*
Squirrelfish	*Holocentrus adsensionis*
Blackbar soldierfish	*Myripristis jacobus*
Reef Squirrelfish	*Holocentrus coruscum*
FAMILY: TRUMPETFISHES	AULOSTOMIDAE
Trumpetfish	*Aulostomus maculatus*
FAMILY:CORNETFISH	FISTULARIIDAE
Bluespotted Cornetfish	*Fistularia tabacaria*
FAMILY: SEA BASSES	SERRANIDAE
Red Grouper	*Epinephelus morio*
Sand Perch	*Diplectum formosum*
Harlequin Bass	*Serranus tigrinus*
Tobaccofish	*Serranus tabacarius*
Graysby	*Cephalopholis cruentata*
Butter Hamlet	*Hypoplectrus unicolor*
Hamlet	*Hypoplectrus spp.*
Blue Hamlet	*Hypoplectrus gemma*
Chalk Bass	*Serranus tortugaum*
Lantern Bass	*Serranus baldwini*
Red Hind	*Epinephelus guttatus*
Greater Soapfish	***Rypticus saponaceus***
FAMILY: CARDINALFISHES	**APOGONIDAE**
Barred Cardinalfish	***Apogon binotatus***
Belted Cardinalfish	***Apogon townsendi***

Table 6: Continued

COMMON NAME	SCIENTIFIC NAME
FAMILY: TILEFISHES	**MALACANTHIDAE**
Sand Tilefish	***Malacanthus plumieri***
FAMILY: JACKS	CARANGIDAE
Almaco Jack	*Seriola rivoliana*
Blue Runner	*Caranx crysos*
Bar Jack	*Caranx ruber*
Yellow Jack	*Caranx bartholomaei*
FAMILY: SNAPPERS	LUTJANIDAE
Yellowtail Snapper	*Ocyurus chrysurus*
Mahogany Snapper	***Lutjanus mahogani***
Gray Snapper	*Lutjanus griseus*
Mutton Snapper	*Lutjanus analis*
Schoolmaster	***Lutjanus apodus***
FAMILY: MOJARRAS	**GERREIDAE**
Yellowfin Mojarra	***Gerres cinereus***
FAMILY: GRUNTS	HAEMULIDAE
Cottonwick	***Haemulon melanurum***
White Grunt	*Haemulon plumieri*
Tomtates	*Haemulon aurolineatum*
Juvenile Grunts	*Haemulon* juveniles
French Grunt	*Haemulon flavolineatum*
Spanish Grunt	*Haemulon macrostomum*
Bluestripe Grunt	*Haemulon sciurus*
Sailors Choice	*Haemulon parrai*
Black Margate	***Anisotremus surinamensis***
Porkfish	*Anisotremus virginicus*
Smallmouth Grunt	*Haemulon chrysargyreum*
Striped Grunt	*Haemulon striatum*
Ceasar Grunt	*Haemulon carbonarium*
FAMILY: PORGIES	SPARIDAE
Spottail Pinfish	*Diplodos holbrooki*
Sheepshead Porgy	*Calamus penna*
Silver Porgy	***Diplodus argenteus***
Jolthead Porgy	***Calamus bajonado***

Table 6: Continued

COMMON NAME	SCIENTIFIC NAME
FAMILY: DRUMS	SCIAENIDAE
Highhat	*Equetus acuminatus*
FAMILY: GOATFISHES	MULLIDAE
Spotted Goatfish	*Pseudupeneus maculatus*
Yellow Goatfish	*Mulloidichthys martinicus*
FAMILY: SEA CHUBS	KYPHOSIDAE
Bermuda Chub	*Kyphosus sectatrix*
FAMILY: SPADEFISHES	**EPHIPPIDAE**
Spadefish	***Chaetodipterus faber***
FAMILY: Butterflyfishes	CHAETODONTIDAE
Reef Butterflyfish	*Chaetodon sedentarius*
Spotfin Butterflyfish	*Chaetodon ocellatus*
4-eye Butterfly	*Chaetodon capistratus*
Banded Butterfly	*Cheatodon striatus*
FAMILY: ANGELFISHES	POMACANTHIDAE
Queen Angelfish	*Holocanthus cilaris*
Blue Angelfish	*Holocanthus bermudensis*
French Angelfish	*Pomacanthus paru*
Grey Angelfish	*Pomacanthus arcuatus*
Rock Beauty	*Holocanthus tricolor*
FAMILY: DAMSELFISHES	POMACENTRIDAE
Sergeant Major	*Abudefduf saxatilis*
Dusky Damselfish	*Stegastes fuscus*
Threespot Damselfish	*Stegastes planifrons*
Cocoa Damselfish	*Stegastes variabilis*
Beaugregory	*Stegastes leucostictus*
Bicolor Damselfish	*Stegates partitus*
Brown Chromis	*Chromis multilineata*
Blue Chromis	*Chromis cyaneus*
Purple Reeffish	*Chromis scotti*
Sunshinefish	*Chromis insolata*
Yellowtail Damsel	*Microspathodon chrysurus*

Table 6: Continued

COMMON NAME	SCIENTIFIC NAME
FAMILY: WRASSES	LABRIDAE
Hogfish	*Lachnolaimus maximus*
Spanish Hogfish	*Bodianus rufus*
Creole wrasse	*Clepticus parrai*
Clown wrasse	*Halichoeres maculipinna*
Slippery Dick	*Halichoeres bivittatus*
Yellowcheek wrasse	*Halichoeres cyanocephalus*
Yellowhead wrasse	*Halichoeres garnoti*
Puddingwife	***Halichoeres radiatus***
Rainbow wrasse	***Halichoeres pictus***
Blackear wrasse	*Halichoeres poeyi*
Bluehead Wrasse	*Thalassoma bifasciatum*
FAMILY: PARROTFISHES	SCARIDAE
Parrotfish	*Sparisoma* sp.
Red tail Parrotfish	*Sparisoma chrysopterum*
Redfin Parrot	***Sparisoma rubripinne***
Stoplight Parrotfish	*Sparisoma virride*
Redband Parrot	*Sparisoma aurofrenatum*
Striped Parrot	*Scarus croicensis*
Bucktooth Parrot	*Sparisoma radians*
Greenblotch Parrot	*Sparisoma atomarium*
Princess Parrot	*Scarus taeniopterus*
Queen Parrot	*Scarus vetula*
Bluelip Parrot	*Cryptotomus roseus*
FAMILY: CLINIDS	CLINIDAE
Roughhead Blenny	*Acantheblemaria aspera*
FAMILY: COMBTOOTH BLENNIES	BLENNIDAE
Saddled Blenny	***Malcoctenus triangulatus***
Seaweed Blenny	*Parablennius marmoreus*
Rosey Blenny	***Malcoctenus macropus***

Table 6: Continued

COMMON NAME	SCIENTIFIC NAME
FAMILY: GOBIES	GOBIIDAE
Neon Goby	***Gobiosoma oceanops***
Bridled Goby	*Coryphopterus glaucofraenum*
Masked Goby	*Coryphopterus personatus*
Colon Goby	***Coryphopterus dicrus***
Blue Goby	***Ioglossus calliurus***
Goldspot Goby	*Gnatholepis thomsoni*
FAMILY: JAWFISH	OPISTOGNATHIDAE
Dusky Jawfish	*Opistognthus whitehursti*
Yellowhead Jawfish	***Opistognathus aurifrons***
FAMILY: SURGEONFISHES	ACANTHURIDAE
Ocean Surgeon	*Acanthurus bahianus*
Doctorfish	*Acanthurus chirurgus*
Blue tang	*Acanthurus coeruleus*
FAMILY: MACKERALS	SCOMBIDAE
Cero	*Scomberomorus regalis*
FAMILY: SCORPIONFISH	SCORPAENIDAE
Spotted Scorpionfish	*Scorpaena plumieri*
FAMILY: LEFTEYE FLOUNDERS	BOTHIDAE
Flounder	Bothidae
FAMILY: LEATHERJACKETS	MONOCANTHIDAE
Scrawled Filefish	*Aluterus scriptus*
Orangespotted Filefish	*Cantherhines pullus*
Whitespotted Filefish	*Cantherhines macrocerus*
Planehead Filefish	*Monocanthus hispidus*
FAMILY:TRIGGERFISH	BALISTIDAE
Grey Trigger	*Balistes capriscus*
Queen Trigger	*Balistes vetula*
FAMILY: BOXFISHES	OSTRACIIDAE
Scrawled cowfish	*Lactrophrys quadricornis*
Smooth trunkfish	*Lactrophrys triqueter*
Honeycomb Cowfish	*Lactophrys polygonia*
FAMILY: PUFFERS	TETRAODONTIDAE
Sharpnose Puffer	*Canthigaster rostrata*
Bandtail Puffer	*Sphoeroides spengleri*
FAMILY: SPINY PUFFERS	DIODONTIDAE
Porcupinefish	*Diodon hystrix*
Balloonfish	*Diodon holocanthus*
131	**# Species Year 1 and Year 2**

Table 7: Fish abundance on each of the First Reef sites. The species are listed in order of total abundance.

COMMON NAME	SCIENTIFIC NAME	HH2	JUL6	FTL4	FTL1	POMP1	POMP4	HB1	DB1	TOTAL
Tomtates	*Haemulon aurolineatum*	0	14	322	0	31	0	0	0	367
French Grunt	*Haemulon flavolineatum*	0	2	276	0	37	0	0	2	317
Bluehead Wrasse	*Thalassoma bifasciatum*	0	17	68	6	41	0	50	27	209
Juvenile Grunts	*Haemulon juveniles*	60	3	0	0	0	25	90	0	178
Ocean Surgeon	*Acanthurus bahianus*	2	33	16	6	17	45	14	12	145
Slippery Dick	*Halichores bivittatus*	3	17	9	11	2	28	7	42	119
Blue Runner	*Caranx crysos*	0	0	0	0	95	0	2	0	97
White Grunt	*Haemulon plumieri*	0	8	6	17	4	4	37	4	80
Striped Parrot	*Scarus croicensis*	0	0	60	10	1	0	0	0	71
Grey Trigger	*Balistes capriscus*	0	0	1	1	0	0	55	2	59
Doctorfish	*Acanthurus chirurgus*	0	4	1	11	0	0	35	0	51
Cocoa Damselfish	*Stegastes variabilis*	0	9	10	6	1	6	2	10	44
Blue tang	*Acanthurus coeruleus*	0	25	9	0	6	0	0	0	40
Redband Parrot	*Sparisoma aurofrenatum*	1	9	8	1	5	9	1	4	38
Bar Jack	*Caranx ruber*	0	0	0	0	30	0	0	0	30
Yellow Jack	*Caranx bartholomaei*	0	0	0	0	0	0	0	30	30
Clown wrasse	*Halichores maculipinna*	0	7	7	1	3	8	0	4	30
Bicolor Damselfish	*Stegates partitus*	0	8	6	0	3	1	0	1	19
Yellowhead wrasse	*Halichores garnoti*	0	0	16	0	0	2	0	0	18
Bridled Goby	*Coryphopterus glaucofraenum*	7	0	0	4	0	5	0	1	17
Sergeant Major	*Abudefduf saxatilis*	0	4	7	2	2	0	0	0	15

Table 7: Continued.

COMMON NAME	SCIENTIFIC NAME	HH2	JUL6	FTL4	FTL1	POMP1	POMP4	HB1	DB1	TOTAL
Seaweed Blenny	*Parablennius marmoreus*	0	1	0	1	0	7	0	5	14
Rosey Blenny	*Malcoctenus macropus*	7	1	0	0	0	4	0	0	12
Yellowtail Snapper	*Ocyurus chrysurus*	0	0	3	2	1	5	0	0	11
Smallmouth Grunt	*Haemulon chrysargyreum*	0	0	11	0	0	0	0	0	11
Silver Porgy	*Diplodus argenteus*	0	0	0	0	8	0	0	3	11
Dusky Damselfish	*Stegastes fuscus*	0	1	7	0	3	0	0	0	11
Threespot Damselfish	*Stegastes planifrons*	0	0	10	0	0	0	0	0	10
Stoplight Parrotfish	*Sparisoma virride*	0	2	6	0	1	0	0	0	9
Bucktooth Parrot	*Sparisoma radians*	2	0	0	1	0	6	0	0	9
Striped Grunt	*Haemulon striatum*	0	0	8	0	0	0	0	0	8
Bluestripe Grunt	*Haemulon sciurus*	0	2	0	0	3	1	0	1	7
Beaugregory	*Stegastes leucostictus*	0	3	0	1	0	0	0	3	7
Blackear wrasse	*Halichoeres poeyi*	0	0	0	1	0	5	0	0	6
Squirrelfish	*Holocentrus adsensionis*	0	0	5	0	0	0	0	0	5
Butter Hamlet	*Hypoplectrus unicolor*	0	0	4	0	1	0	0	0	5
Cottonwick	*Haemulon melanurum*	0	0	0	0	0	0	0	5	5
Ceasar Grunt	*Haemulon carbonarium*	0	0	3	0	2	0	0	0	5
Spottail Pinfish	*Diplodos holbrooki*	0	0	0	0	4	0	0	1	5
Grey Angelfish	*Pomacanthus arcuatus*	0	0	2	3	0	0	0	0	5
Red Grouper	*Epinephelus morio*	0	0	2	1	0	0	1	0	4

Table 7: Continued.

COMMON NAME	SCIENTIFIC NAME	HH2	JUL6	FTL4	FTL1	POMP1	POMP4	HB1	DB1	TOTAL
Highhat	*Equetus acuminatus*	2	0	1	0	0	0	1	0	4
Greenblotch Parrot	*Sparisoma atomarium*	0	4	0	0	0	0	0	0	4
Princess Parrot	*Scarus taeniopterus*	0	0	0	0	4	0	0	0	4
Saddled Blenny	*Malcoctenus triangulatus*	0	2	0	2	0	0	0	0	4
Goldspot Goby	*Gnatholepis thomsoni*	0	0	0	0	0	3	0	1	4
Dusky Jawfish	*Opistognthus whitehursti*	4	0	0	0	0	0	0	0	4
Porkfish	*Anisotremus virginicus*	0	0	3	0	0	0	0	0	3
Sailfin Blenny	*Emblemaria pandionis*	3	0	0	0	0	0	0	0	3
Neon Goby	*Gobiosoma oceanops*	0	3	0	0	0	0	0	0	3
Scrawled Filefish	*Aluterus scriptus*	0	0	0	0	0	0	3	0	3
Sharpnose Puffer	*Canthigaster rostrata*	0	0	0	0	2	0	0	1	3
Bandtail Puffer	*Sphoeroides spengleri*	1	0	0	0	0	0	1	1	3
Saucereye Porgy	*Calamus calamus*	0	0	0	0	0	0	0	2	2
Red tail Parrotfish	*Sparisoma chrysopterum*	0	0	1	0	0	0	0	1	2
Masked Goby	*Coryphopterus personatus*	0	0	0	2	0	0	0	0	2
Cero	*Scomberomorus regalis*	0	0	1	0	0	0	0	1	2
Purplemouth Moray	*Gymnothorax vicinus*	0	0	0	0	0	0	0	1	1
Sand Perch	*Diplectum formosum*	0	0	0	0	0	0	0	1	1
Greater Soapfish	*Rypticus saponaceus*	0	0	0	0	0	0	1	0	1
Grey Snapper	*Lutjanus griseus*	0	0	0	0	1	0	0	0	1
Yellowfin Mojarra	*Gerres cinereus*	0	0	0	0	0	0	0	1	1
Black Margate	*Anisotremus surinamensis*	0	0	1	0	0	0	0	0	1
Spotted Goatfish	*Pseudupeneus maculatus*	0	0	1	0	0	0	0	0	1

Table 7: Continued.

COMMON NAME	SCIENTIFIC NAME	HH2	JUL6	FTL4	FTL1	POMP1	POMP4	HB1	DB1	TOTAL
Bermuda Chub	*Kyphosus sectatrix*	0	0	0	0	0	0	0	1	1
Foureye Butterfly	*Chaetodon capistratus*	0	0	0	0	1	0	0	0	1
French Angelfish	*Pomacanthus paru*	0	0	0	0	0	0	1	0	1
Hogfish	*Lachnolaimus maximus*	0	0	1	0	0	0	0	0	1
Spanish Hogfish	*Bodianus rufus*	0	0	1	0	0	0	0	0	1
Puddingwife	*Halichores radiatus*	0	0	0	0	1	0	0	0	1
Bluelip Parrot	*Cryptotomus roseus*	0	0	1	0	0	0	0	0	1
Orangespotted Filefish	*Cantherhines pullus*	0	0	0	0	0	0	0	1	1
Planehead Filefish	*Monocanthus hispidus*	0	0	0	0	0	0	1	0	1
Smooth trunkfish	*Lactrophrys triqueter*	0	0	0	0	0	1	0	0	1
Balloonfish	*Diodon holocanthus*	0	0	0	0	0	0	1	0	1
	# FISH per SITE	92	179	894	90	310	165	303	169	
	# SPECIES per SITE	209	209	209	209	209	209	209	209	
	# FISH per REEF									2202
	# SPECIES per REEF									75

Table 8. Fish abundance on each of the Second Reef sites. The species are listed in order of total abundance.

COMMON NAME	SCIENTIFIC NAME	JUL1	JUL7	FTL2	POMP5	HB2	DB2	POMP2	BOCA1	TOTAL
Bluehead Wrasse	*Thalassoma bifasciatum*	78	125	44	8	128	147	27	28	585
Bicolor Damselfish	*Stegates partitus*	67	46	15	0	164	133	23	15	463
Yellowhead wrasse	*Halichores garnoti*	19	18	23	1	13	25	20	18	137
Redband Parrot	*Sparisoma aurofrenatum*	18	28	11	5	23	10	13	14	122
Creole wrasse	*Clepticus parrai*	0	0	0	0	35	75	0	0	110
Yellowtail Snapper	*Ocyurus chrysurus*	0	2	0	0	49	50	0	2	103
Sergeant Major	*Abudefduf saxatilis*	0	1	0	0	61	28	0	0	90
Ocean Surgeon	*Acanthurus bahianus*	4	17	13	2	5	4	2	10	57
Slippery Dick	*Halichores bivittatus*	16	16	4	4	0	0	0	16	56
French Grunt	*Haemulon flavolineatum*	0	3	0	0	25	25	0	1	54
Striped Parrot	*Scarus croicensis*	0	26	10	1	7	0	10	0	54
Brown Chromis	*Chromis multilineata*	0	0	0	0	50	2	0	0	52
Blue tang	*Acanthurus coeruleus*	0	6	22	0	9	5	2	3	47
Grey Trigger	*Balistes capriscus*	8	0	10	7	0	0	1	12	38
White Grunt	*Haemulon plumieri*	3	10	0	0	1	20	1	2	37
Cocoa Damselfish	*Stegastes variabilis*	0	2	0	4	4	6	2	11	29
Sharpnose Puffer	*Canthigaster rostrata*	1	5	10	1	1	7	1	3	29
Clown wrasse	*Halichores maculipinna*	0	12	0	0	3	0	3	5	23
Bridled Goby	*Coryphopterus glaucofraenum*	13	1	3	1	2	2	0	1	23
Masked Goby	*Coryphopterus personatus*	0	0	0	0	12	10	0	0	22

Table 8: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL1	JUL7	FTL2	POMP5	HB2	DB2	POMP2	BOCA1	TOTAL
Reef Butterflyfish	*Chaetodon sedentarius*	8	5	0	0	0	0	2	1	16
Stoplight Parrotfish	*Sparisoma virride*	0	7	1	0	3	5	0	0	16
Harlequin Bass	*Serranus tigrinus*	2	1	6	1	1	1	1	2	15
Juvenile Grunts	*Haemulon juveniles*	0	0	0	12	0	0	0	0	12
Graysby	*Cephalopholis cruentata*	0	0	0	0	3	7	0	1	11
Bluelip Parrot	*Cryptotomus roseus*	1	0	4	0	0	2	4	0	11
Princess Parrot	*Scarus taeniopterus*	2	0	0	0	6	0	2	0	10
Grey Angelfish	*Pomacanthus arcuatus*	3	0	2	4	0	0	0	0	9
Threespot Damselfish	*Stegastes planifrons*	0	0	0	0	5	4	0	0	9
Blackear wrasse	*Halichoeres poeyi*	0	0	9	0	0	0	0	0	9
Seaweed Blenny	*Parablennius marmoreus*	0	0	0	6	0	3	0	0	9
Spotfin Butterflyfish	*Chaetodon ocellatus*	4	0	2	0	0	2	0	0	8
Beaugregory	*Stegastes leucostictus*	1	3	0	0	0	2	0	2	8
Blue Chromis	*Chromis cyaneus*	0	0	0	0	0	7	1	0	8
Goldspot Goby	*Gnatholepis thomsoni*	2	0	1	0	0	4	0	1	8
Doctorfish	*Acanthurus chirurgus*	0	0	5	0	0	1	1	1	8
Tobaccofish	*Serranus tabacarius*	2	0	5	0	0	0	0	0	7
Greenblotch Parrot	*Sparisoma atomarium*	4	0	2	0	0	0	1	0	7
Butter Hamlet	*Hypoplectrus unicolor*	1	2	0	0	2	1	0	0	6
Mutton Snapper	*Lutjanus analis*	0	1	0	5	0	0	0	0	6
Bluestripe Grunt	*Haemulon sciurus*	0	0	0	0	0	6	0	0	6

Table 8: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL1	JUL7	FTL2	POMP5	HB2	DB2	POMP2	BOCA1	TOTAL
Spotted Goatfish	*Pseudupeneus maculatus*	0	2	0	0	0	2	1	1	6
Foureye Butterfly	*Chaetodon capistratus*	0	2	0	0	0	2	2	0	6
Red tail Parrotfish	*Sparisoma chrysopterum*	1	2	2	0	1	0	0	0	6
Hogfish	*Lachnolaimus maximus*	3	0	2	0	0	0	0	0	5
Yellowhead Jawfish	*Opistognthus aurifrons*	0	0	5	0	0	0	0	0	5
Squirrelfish	*Holocentrus adsensionis*	0	0	0	0	3	1	0	0	4
Porkfish	*Anisotremus virginicus*	1	0	0	0	1	1	0	1	4
Spottail Pinfish	*Diplodos holbrooki*	0	0	0	0	0	0	0	4	4
French Angelfish	*Pomacanthus paru*	2	0	0	2	0	0	0	0	4
Puddingwife	*Halichores radiatus*	0	0	0	0	0	0	0	4	4
Bar Jack	*Caranx ruber*	0	0	0	2	1	0	0	0	3
Yellow Jack	*Caranx bartholomaei*	0	0	0	3	0	0	0	0	3
Purple Reeffish	*Chromis scotti*	0	2	0	0	1	0	0	0	3
Spanish Hogfish	*Bodianus rufus*	0	0	0	0	0	2	1	0	3
Barracuda	*Sphyraena barracuda*	0	0	0	0	0	0	0	3	3
Orangespotted Filefish	*Cantherhines pullus*	1	0	0	0	2	0	0	0	3
Scrawled cowfish	*Lactrophrys quadricornis*	0	0	0	0	0	1	0	2	3
Red Grouper	*Epinephelus morio*	0	0	1	0	0	0	0	1	2
Grey Snapper	*Lutjanus griseus*	0	0	2	0	0	0	0	0	2
Rock Beauty	*Holocanthus tricolor*	2	0	0	0	0	0	0	0	2
Yellowcheek wrasse	*Halichores cyanocephalus*	2	0	0	0	0	0	0	0	2
Bandtail Puffer	*Sphoeroides spengleri*	0	0	0	1	0	0	1	0	2
Trumpetfish	*Aulostomus maculatus*	0	0	0	0	1	0	0	0	1

Table 8: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL1	JUL7	FTL2	POMP5	HB2	DB2	POMP2	BOCA1	TOTAL
Hamlet	*Hypoplectrus spp.*	0	0	0	0	0	0	1	0	1
Blue Hamlet	*Hypoplectrus gemma*	0	0	0	0	0	0	1	0	1
Barred Cardinalfish	*Apogon binotatus*	1	0	0	0	0	0	0	0	1
Tomtates	*Haemulon aurolineatum*	0	0	0	0	1	0	0	0	1
Sailors Choice	*Haemulon parrai*	0	0	0	0	0	1	0	0	1
Black Margate	*Anisotremus surinamensis*	0	0	0	0	0	0	0	1	1
Silver Porgy	*Diplodus argenteus*	0	0	0	0	0	1	0	0	1
Redspotted Hawkfish	*Amblycirrhitus pinos*	0	0	0	0	1	0	0	0	1
Saddled Blenny	*Malcoctenus triangulatus*	0	0	0	1	0	0	0	0	1
Colon Goby	*Coryphopterus dicrus*	0	0	0	1	0	0	0	0	1
Blue Goby	*Ioglossus calliurus*	1	0	0	0	0	0	0	0	1
Planehead Filefish	*Monocanthus hispidus*	0	0	0	0	0	0	0	1	1
Queen Trigger	*Balistes vetula*	0	0	0	0	0	0	1	0	1
Smooth trunkfish	*Lactrophrys triqueter*	0	0	0	0	0	1	0	0	1
Honeycomb Cowfish	*Lactophrys polygonia*	0	0	0	0	0	1	0	0	1
Balloonfish	*Diodon holocanthus*	1	0	0	0	0	0	0	0	1
	# FISH per SITE	272	345	214	72	624	607	125	167	
	# SPECIES per SITE	209	209	209	209	209	209	209	209	
	# FISH per REEF									2426
	# SPECIES per REEF									80

Table 9. Fish abundance on each of the Third Reef sites. The species are listed in order of total abundance.

COMMON NAME	SCIENTIFIC NAME	JUL2	JUL8	FLT3	POMP3	POMP6	HB3	DB3	TOTAL
Bluehead Wrasse	*Thalassoma bifasciatum*	154	69	51	121	20	83	2	500
Bicolor Damselfish	*Stegates partitus*	143	67	6	49	27	39	5	336
Tomtates	*Haemulon aurolineatum*	0	0	0	61	0	125	0	186
Yellowhead wrasse	*Halichores garnoti*	13	49	30	13	26	11	13	155
Creole wrasse	*Clepticus parrai*	80	0	0	8	0	52	0	140
Redband Parrot	*Sparisoma aurofrenatum*	11	37	7	23	14	17	11	120
Princess Parrot	*Scarus taeniopterus*	31	23	6	13	0	14	2	89
French Grunt	*Haemulon flavolineatum*	0	0	0	22	0	44	0	66
Smallmouth Grunt	*Haemulon chrysargyreum*	0	0	0	30	0	34	0	64
Ocean Surgeon	*Acanthurus bahianus*	3	11	4	8	16	5	6	53
Masked Goby	*Coryphopterus personatus*	0	0	0	0	0	25	25	50
Blue tang	*Acanthurus coeruleus*	1	15	5	8	0	5	4	38
Sharpnose Puffer	*Canthigaster rostrata*	1	7	10	2	3	6	3	32
Reef Butterflyfish	*Chaetodon sedentarius*	6	1	0	11	1	1	2	22
Spotfin Butterflyfish	*Chaetodon ocellatus*	0	2	4	0	1	12	1	20
Bluelip Parrot	*Cryptotomus roseus*	0	12	0	0	8	0	0	20
Striped Parrot	*Scarus croicensis*	7	0	0	5	3	3	0	18
Harlequin Bass	*Serranus tigrinus*	3	2	8	0	2	1	1	17

Table 9: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL2	JUL8	FLT3	POMP3	POMP6	HB3	DB3	TOTAL
Tobaccofish	*Serranus tabacarius*	1	7	5	0	3	0	0	16
Foureye Butterfly	*Chaetodon capistratus*	0	0	0	9	0	5	1	15
Doctorfish	*Acanthurus chirurgus*	0	0	12	0	1	0	1	14
Schoolmaster	*Lutjanus apodus*	0	0	0	12	0	0	0	12
Colon Goby	*Coryphopterus dicrus*	0	0	0	0	12	0	0	12
Blackbar soldierfish	*Myripristis jacobus*	0	0	0	2	0	9	0	11
Butter Hamlet	*Hypoplectrus unicolor*	3	2	0	3	2	1	0	11
Yellowtail Snapper	*Ocyurus chrysurus*	0	2	0	0	1	8	0	11
Bermuda Chub	*Kyphosus sectatrix*	0	0	0	11	0	0	0	11
Goldspot Goby	*Gnatholepis thomsoni*	2	3	4	0	2	0	0	11
Porkfish	*Anisotremus virginicus*	1	2	0	4	0	2	1	10
Red tail Parrotfish	*Sparisoma chrysopterum*	0	0	10	0	0	0	0	10
Bridled Goby	*Coryphopterus glaucofraenum*	2	4	1	0	2	1	0	10
Grey Angelfish	*Pomacanthus arcuatus*	1	1	4	1	0	2	0	9
Greenblotch Parrot	*Sparisoma atomarium*	1	2	3	0	3	0	0	9
Yellowhead Jawfish	*Opistognthus aurifrons*	0	0	2	0	7	0	0	9
Blue Hamlet	*Hypoplectrus gemma*	2	0	0	3	0	2	0	7
White Grunt	*Haemulon plumieri*	0	2	0	1	0	4	0	7

Table 9: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL2	JUL8	FLT3	POMP3	POMP6	HB3	DB3	TOTAL
Clown wrasse	*Halichores maculipinna*	1	0	0	0	6	0	0	7
Stoplight Parrotfish	*Sparisoma virride*	0	1	3	2	0	1	0	7
Spotted Goatfish	*Pseudupeneus maculatus*	0	1	1	1	0	3	0	6
Scrawled Filefish	*Aluterus scriptus*	0	0	0	1	1	0	4	6
Trumpetfish	*Aulostomus maculatus*	0	0	0	1	0	3	1	5
Hamlet	*Hypoplectrus spp.*	1	0	0	1	0	1	2	5
Bar Jack	*Caranx ruber*	0	0	0	1	1	0	3	5
Spadefish	*Chaetodipterus faber*	0	0	0	5	0	0	0	5
Sergeant Major	*Abudefduf saxatilis*	0	0	0	2	0	3	0	5
Cocoa Damselfish	*Stegastes variabilis*	1	0	0	2	0	2	0	5
Blue Chromis	*Chromis cyaneus*	0	0	0	0	0	5	0	5
Slippery Dick	*Halichores bivittatus*	0	0	0	0	5	0	0	5
Blue Goby	*Ioglossus calliurus*	0	5	0	0	0	0	0	5
Squirrelfish	*Holocentrus adsensionis*	0	0	0	4	0	0	0	4
Lantern Bass	*Serranus baldwini*	0	1	1	0	2	0	0	4
Banded Butterfly	*Cheatodon striatus*	0	0	0	2	0	2	0	4
Queen Angelfish	*Holocanthus cilaris*	0	4	0	0	0	0	0	4
Blue Angelfish	*Holocanthus bermudensis*	1	1	0	0	1	0	1	4
Beaugregory	*Stegastes leucostictus*	0	3	0	1	0	0	0	4
Spanish Hogfish	*Bodianus rufus*	1	0	0	2	0	1	0	4

Table 9: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL2	JUL8	FLT3	POMP3	POMP6	HB3	DB3	TOTAL
Grey Trigger	*Balistes capriscus*	0	3	0	0	1	0	0	4
Graysby	*Cephalopholis cruentata*	2	0	0	1	0	0	0	3
Mahogany Snapper	*Lutjanus mahogani*	3	0	0	0	0	0	0	3
Bluestripe Grunt	*Haemulon sciurus*	0	0	0	0	0	3	0	3
Striped Grunt	*Haemulon striatum*	0	0	0	0	0	3	0	3
Rainbow wrasse	*Halichores pictus*	0	0	0	0	3	0	0	3
Orangespotted Filefish	*Cantherhines pullus*	0	0	1	1	0	1	0	3
Yellow Stingray	*Urolophus jamaicensis*	1	0	0	0	1	0	0	2
Sand Tilefish	*Malacanthus plumieri*	0	1	0	0	1	0	0	2
Black Margate	*Anisotremus surinamensis*	0	1	0	0	0	0	1	2
Ceasar Grunt	*Haemulon carbonarium*	0	0	0	1	0	1	0	2
Threespot Damselfish	*Stegastes planifrons*	0	0	0	1	0	1	0	2
Purple Reeffish	*Chromis scotti*	0	0	0	0	0	2	0	2
Smooth trunkfish	*Lactrophrys triqueter*	1	0	1	0	0	0	0	2
Balloonfish	*Diodon holocanthus*	0	2	0	0	0	0	0	2
Spotted Moray	*Gymnothorax moringa*	0	1	0	0	0	0	0	1
Belted Cardinalfish	*Apogon townsendi*	0	1	0	0	0	0	0	1
Yellow Jack	*Caranx bartholomaei*	0	0	0	0	0	1	0	1
Grey Snapper	*Lutjanus griseus*	0	0	0	1	0	0	0	1

Table 9: Continued.

COMMON NAME	SCIENTIFIC NAME	JUL2	JUL8	FLT3	POMP3	POMP6	HB3	DB3	TOTAL
Mutton Snapper	*Lutjanus analis*	0	0	0	0	1	0	0	1
Spanish Grunt	*Haemulon macrostomum*	0	0	0	0	0	1	0	1
Saucereye Porgy	*Calamus calamus*	0	0	1	0	0	0	0	1
Jolthead Porgy	*Calamus bajonado*	1	0	0	0	0	0	0	1
French Angelfish	*Pomacanthus paru*	0	0	0	0	0	1	0	1
Rock Beauty	*Holocanthus tricolor*	0	0	0	1	0	0	0	1
Hogfish	*Lachnolaimus maximus*	1	0	0	0	0	0	0	1
Redfin Parrot	*Sparisoma rubripinne*	1	0	0	0	0	0	0	1
Saddled Blenny	*Malcoctenus triangulatus*	1	0	0	0	0	0	0	1
Seaweed Blenny	*Parablennius marmoreus*	0	0	0	0	0	1	0	1
Neon Goby	*Gobiosoma oceanops*	1	0	0	0	0	0	0	1
Spotted Scorpionfish	*Scorpaena plumieri*	0	0	0	0	1	0	0	1
Planehead Filefish	*Monocanthus hispidus*	0	0	1	0	0	0	0	1
Honeycomb Cowfish	*Lactophrys polygonia*	0	1	0	0	0	0	0	1
	# FISH per SITE	483	346	181	451	178	547	90	
	# SPECIES per SITE	209	209	209	209	209	209	209	
	# FISH per REEF								2276
	# SPECIES per REEF								89

Figure 1: LADS bathymetry data of Broward County showing the locations of the 23 monitoring sites. Site locations are shown as dots; borrow areas are outlined; the three County reef lines are noted as are prominent shore locations.

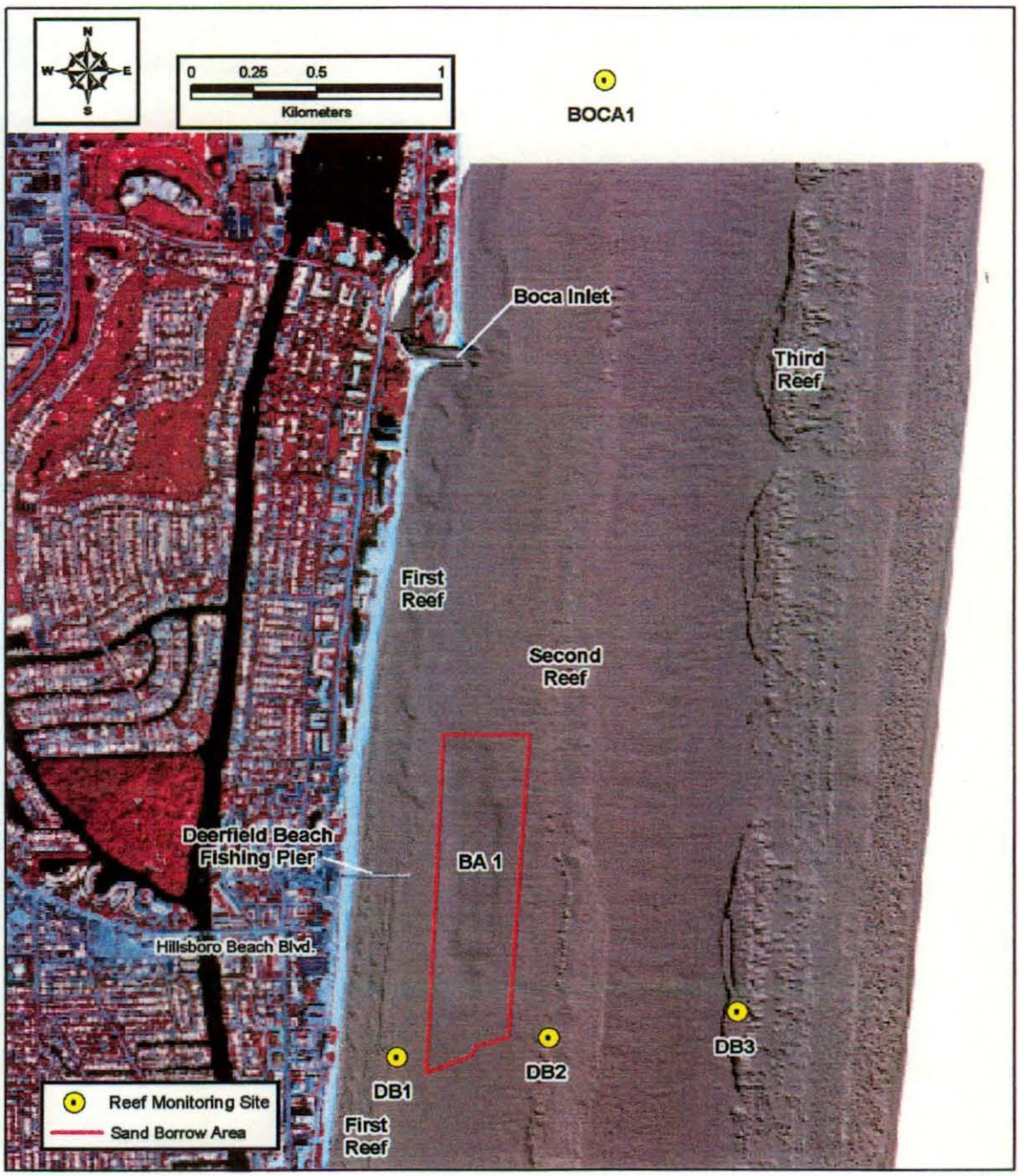

Figure 1: Continued.

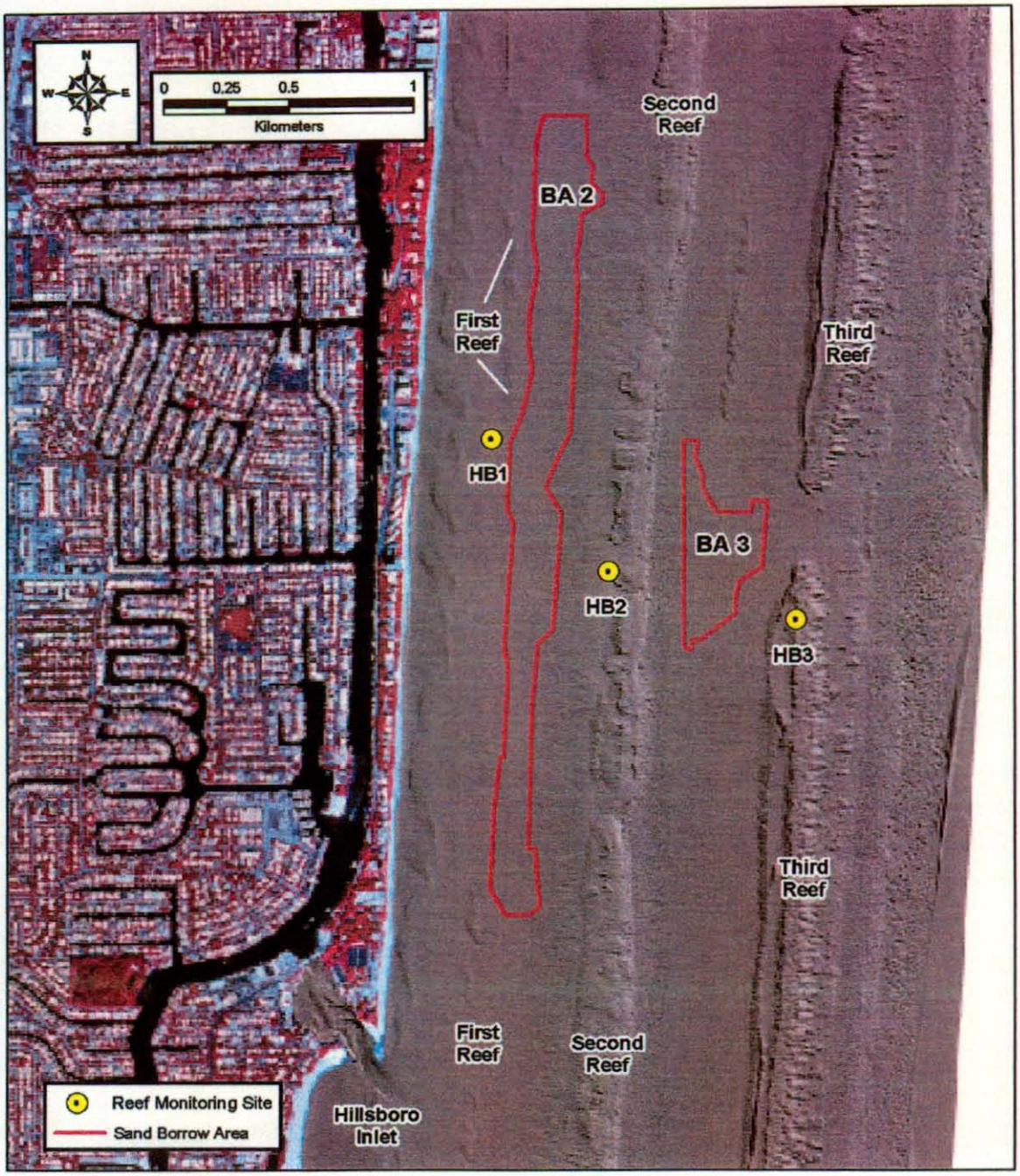

Figure 1: Continued.

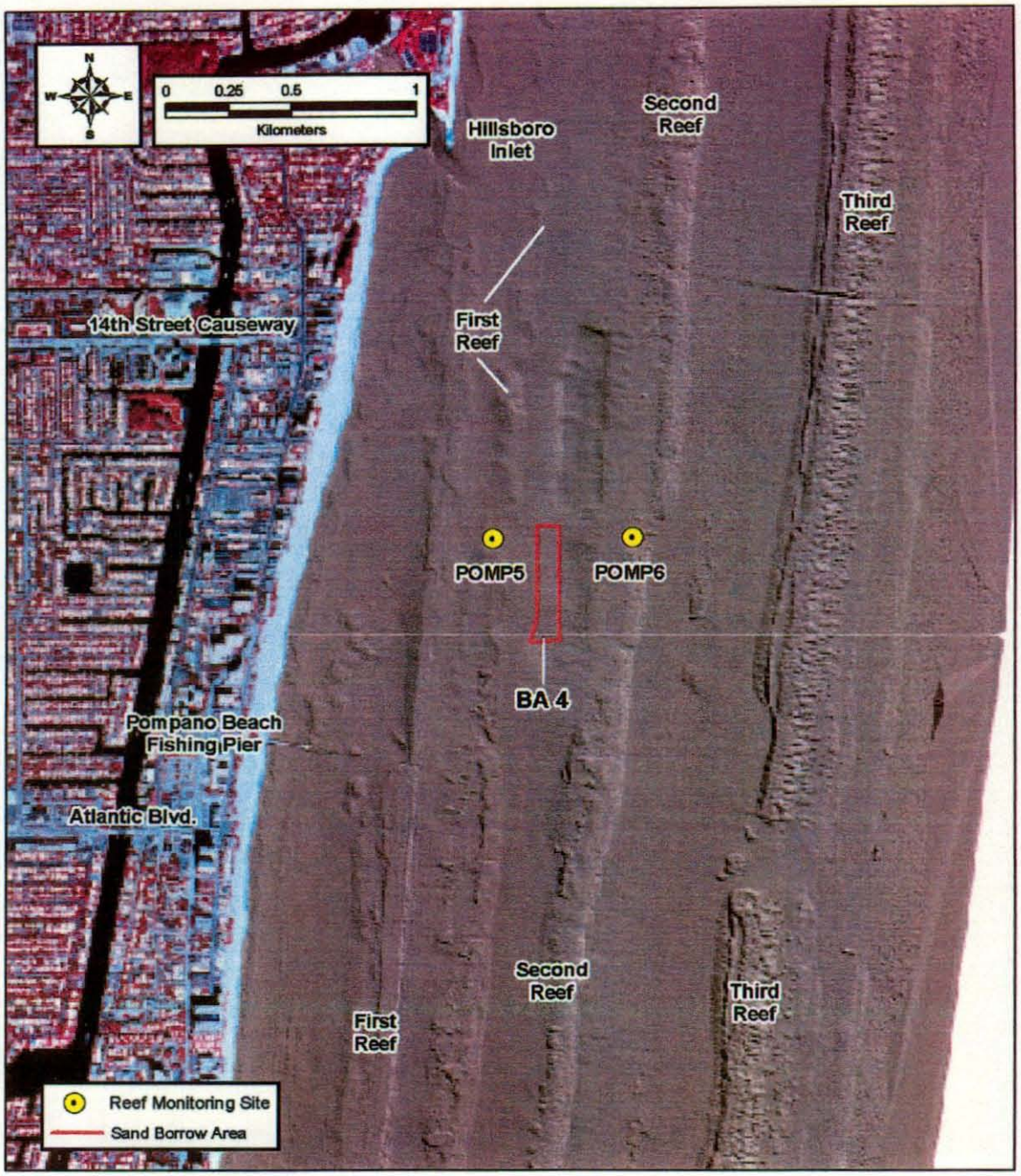

Figure 1: Continued.

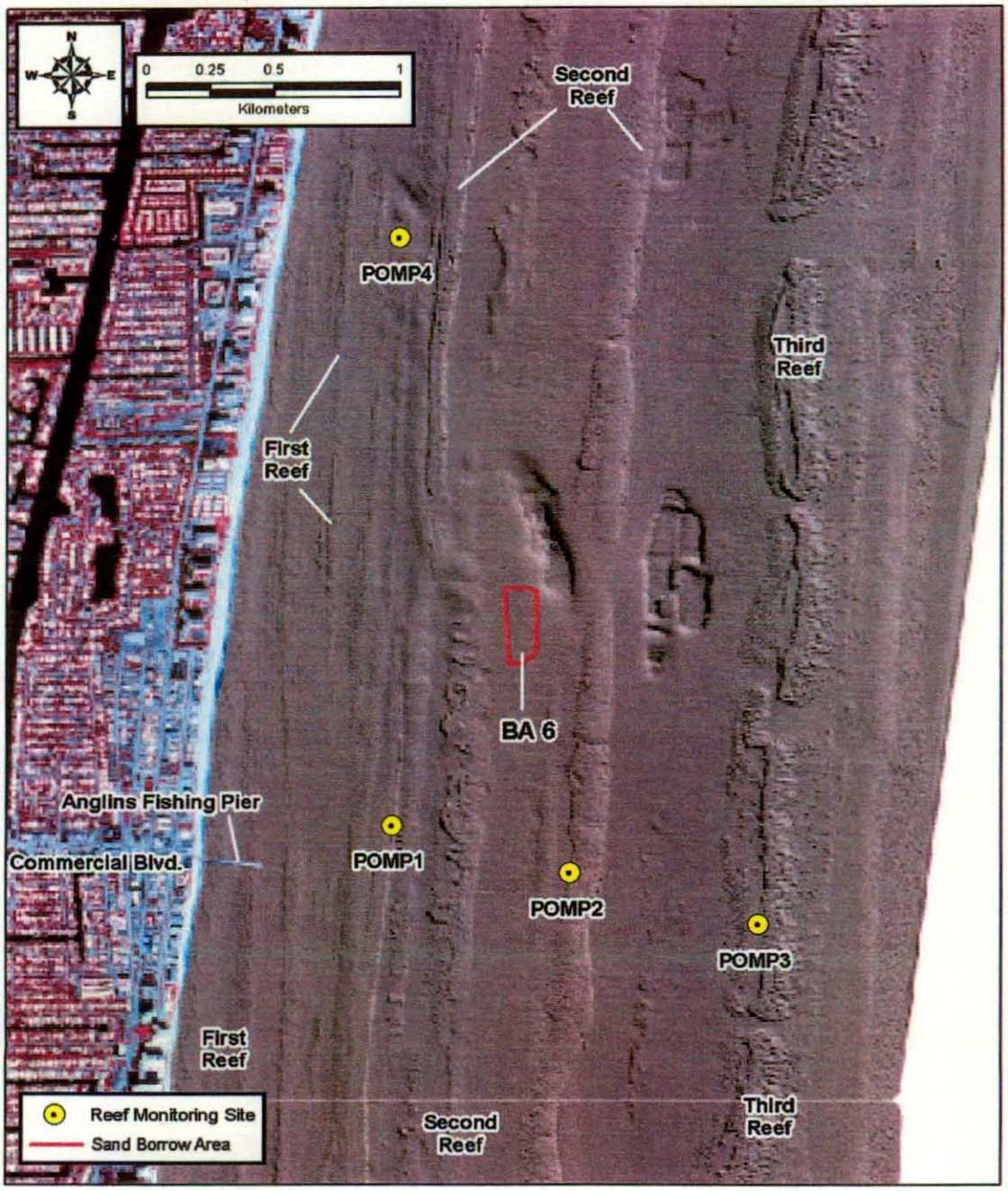

Figure 1: Continued.

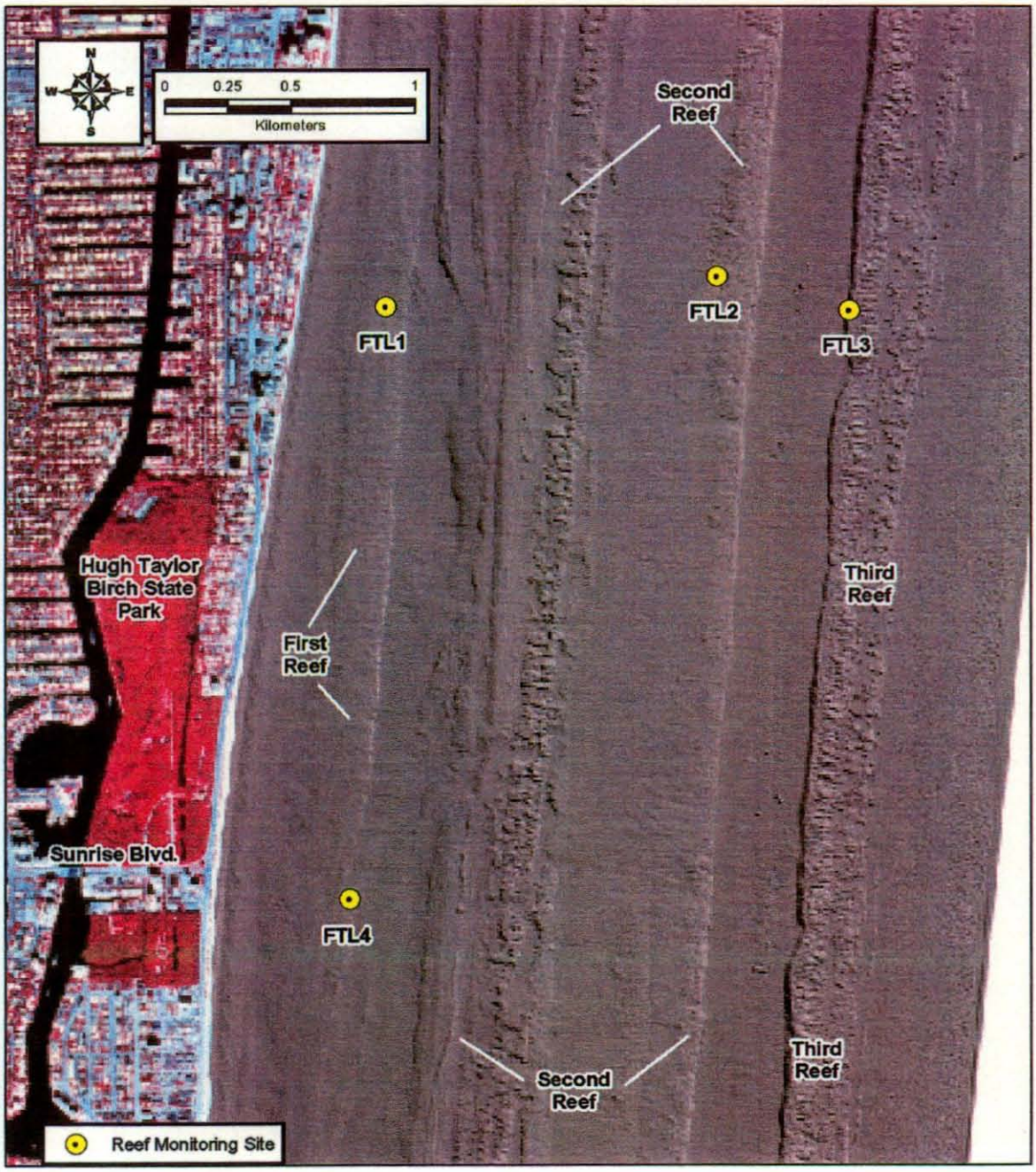

Figure 1: Continued.

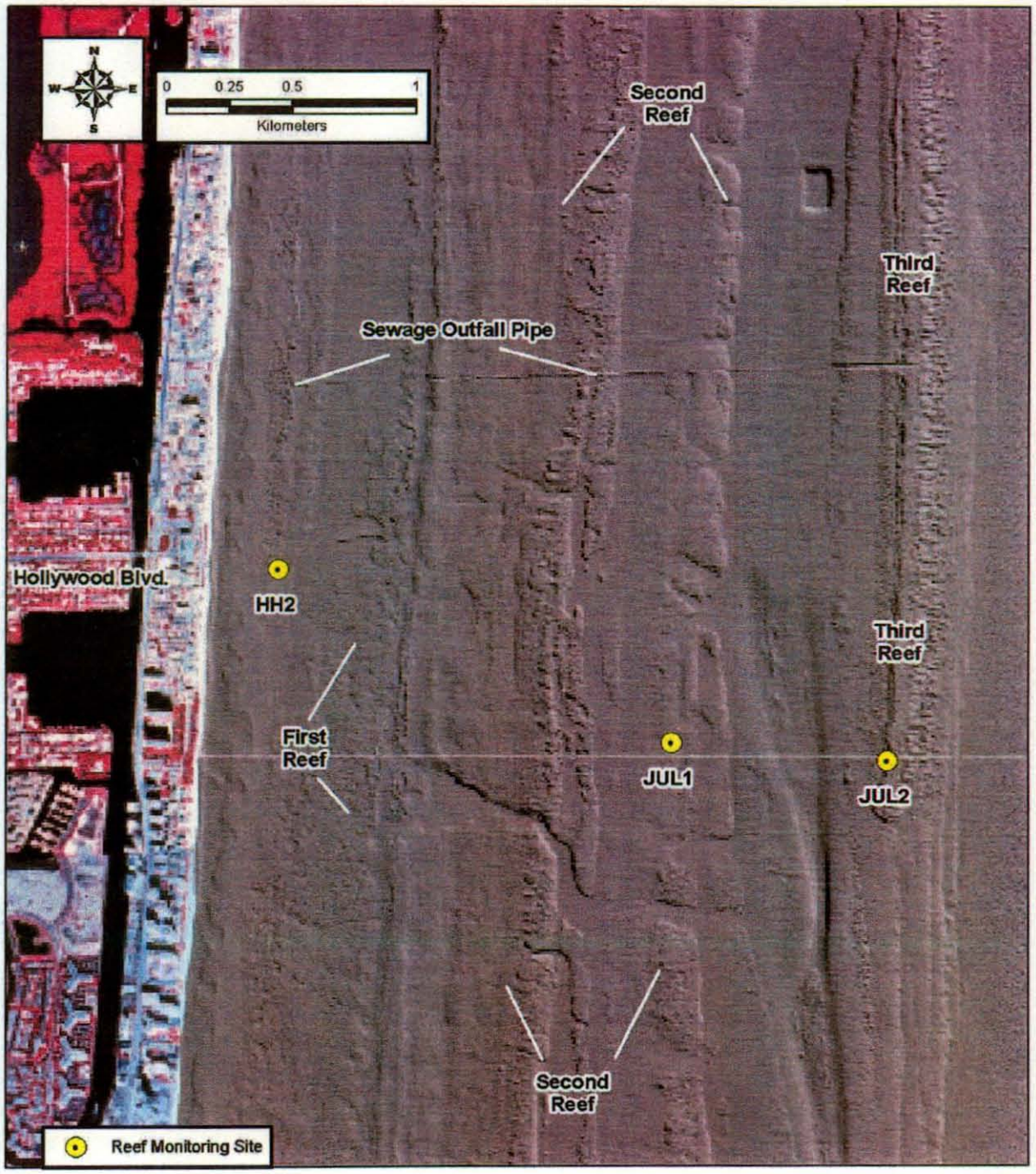

Figure 2. Diver photographing $0.75m^2$ quadrats along a $30m^2$ transect.

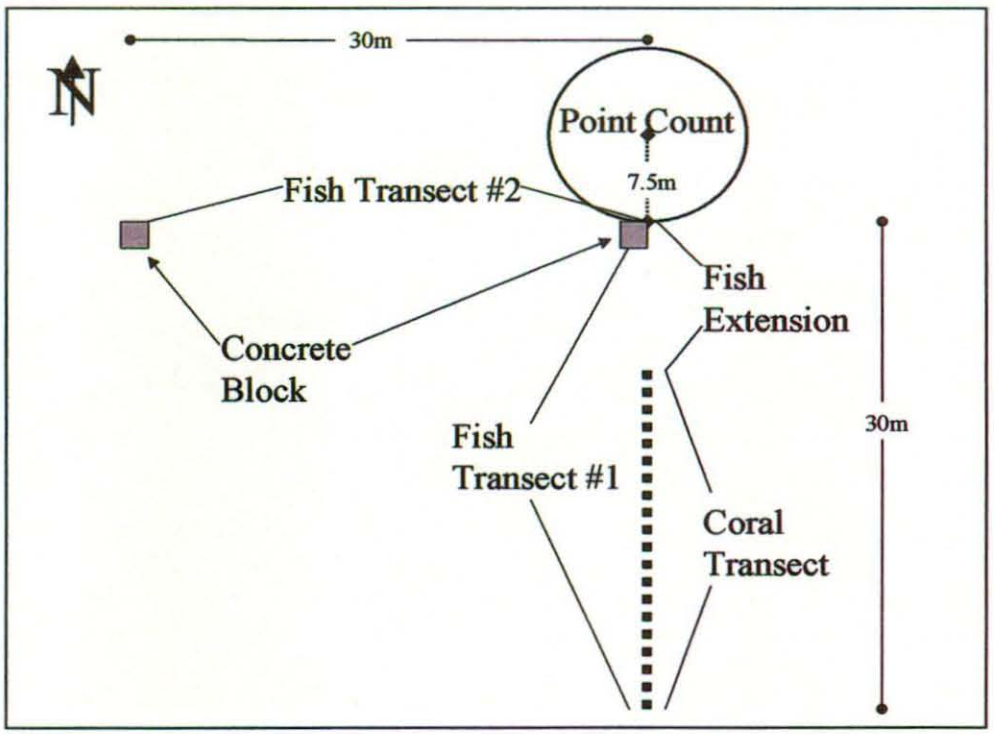

Figure 3. Schematic illustrating a "Normal" site lay-out. Not drawn to scale.

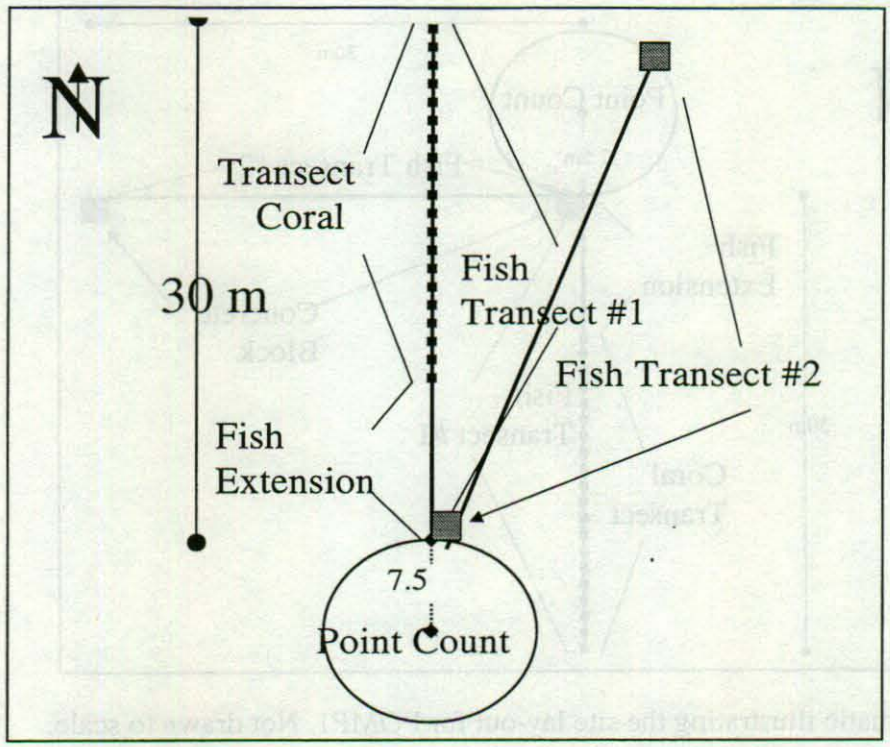

Figure 4: Schematic illustrating the site lay-out for JUL1. Not drawn to scale.

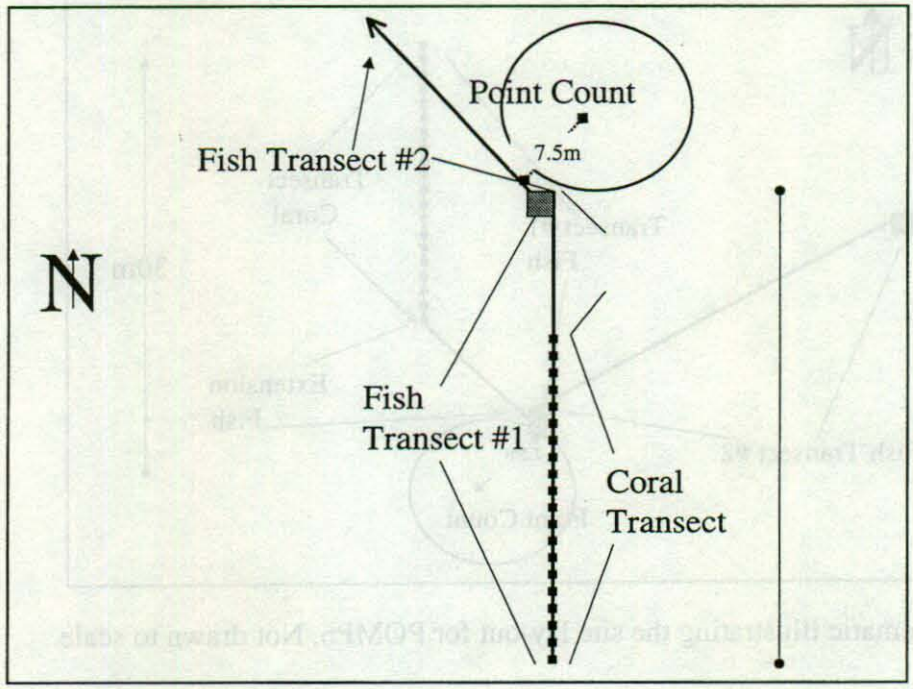

Figure 5: Schematic illustrating the site lay-out for FTL4. Not drawn to scale.

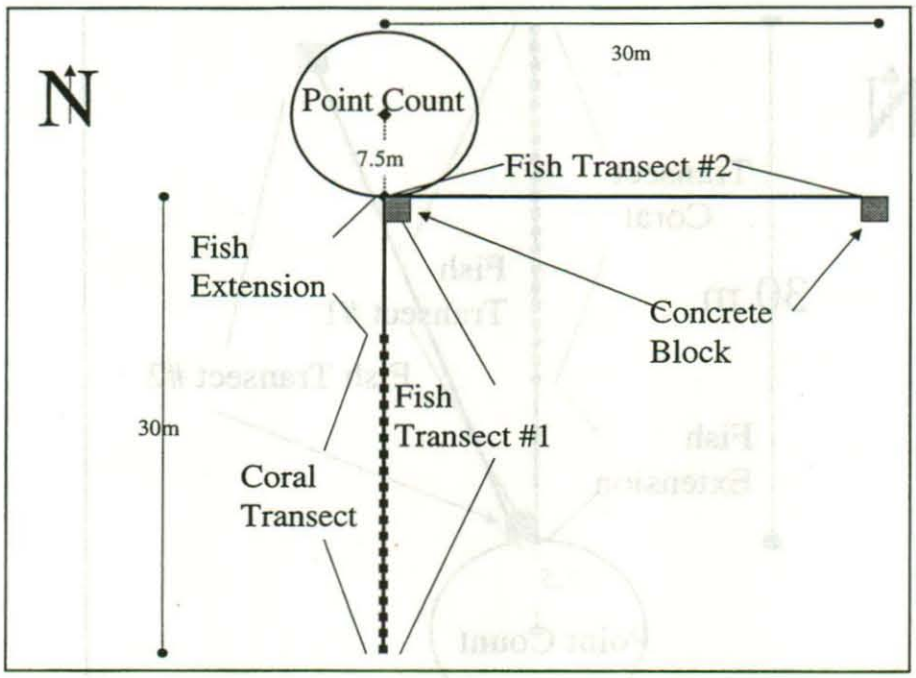

Figure 6: Schematic illustrating the site lay-out for POMP1. Not drawn to scale.

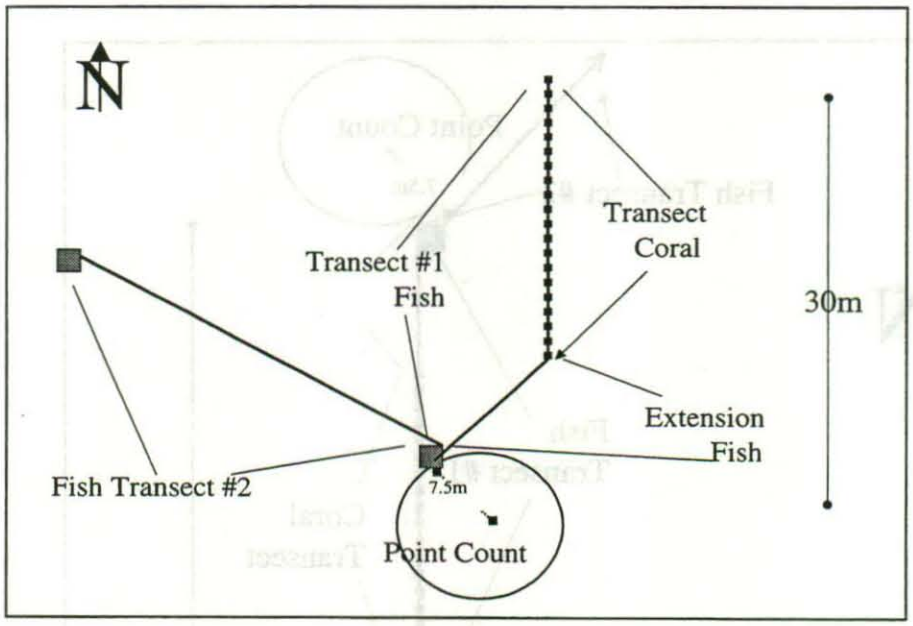

Figure 7: Schematic illustrating the site lay-out for POMP6. Not drawn to scale.

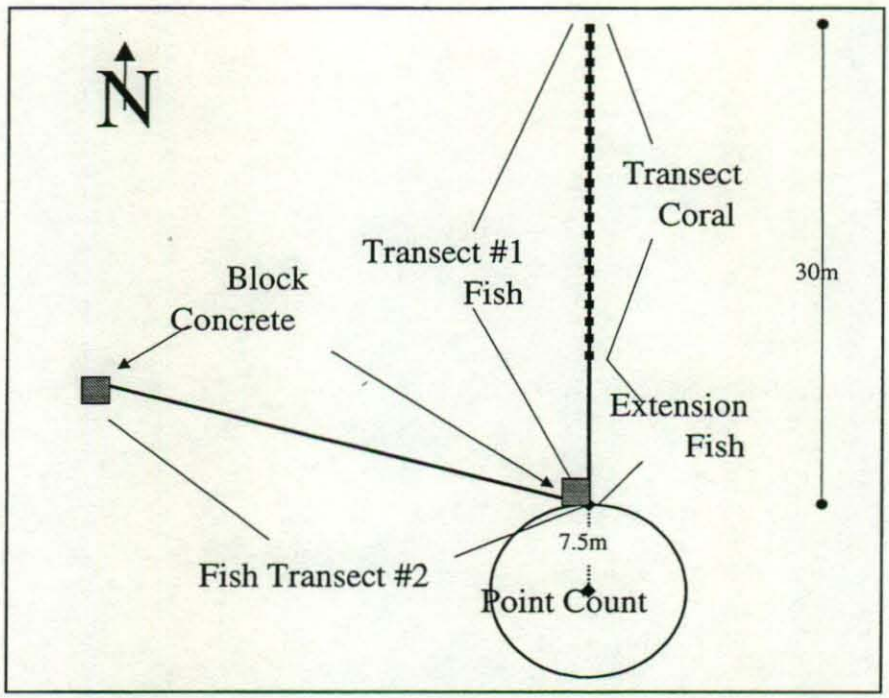

Figure 8: Schematic illustrating the site lay-out for HB1. Not drawn to scale.

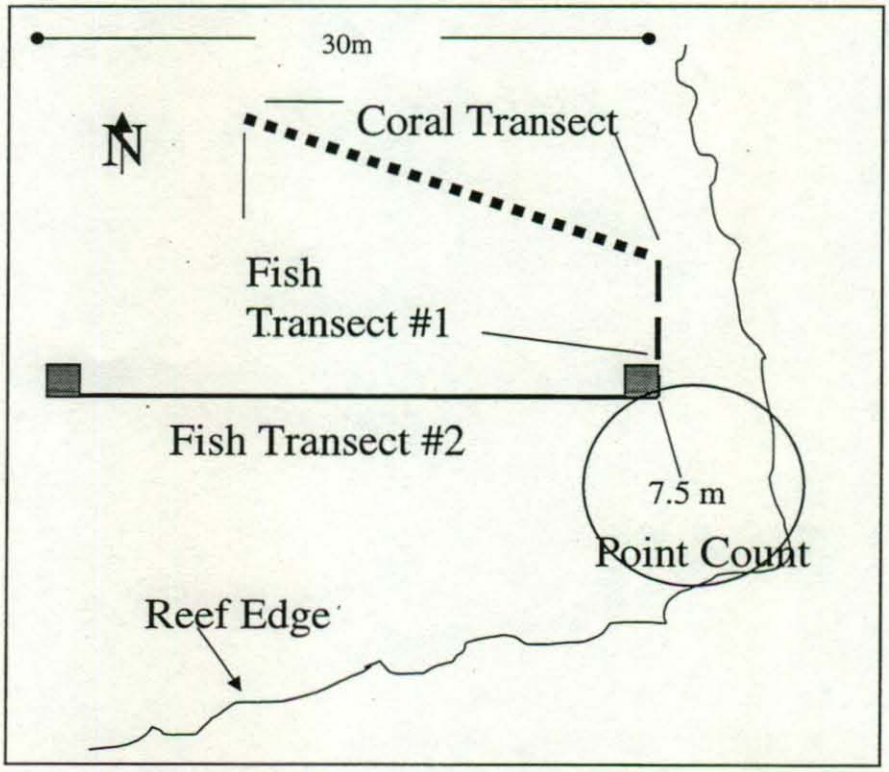

Figure 9: Schematic illustrating the site lay-out for DB2. Not drawn to scale.

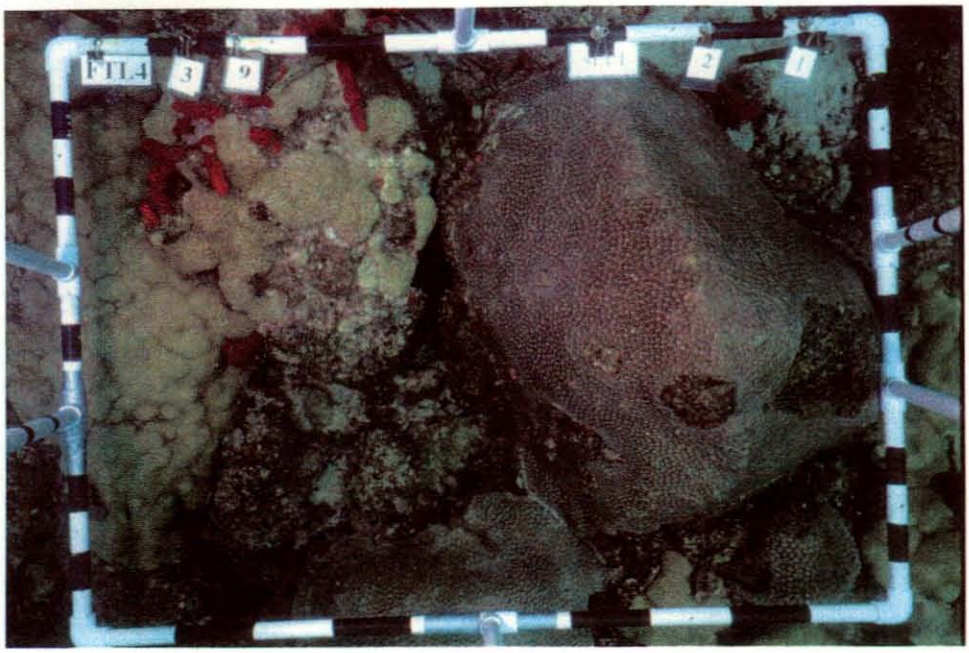

Figure 10: Example of a phototransect quadrat image. Note quadrat number (#39), site code (FTL4), and date (Sept 21).

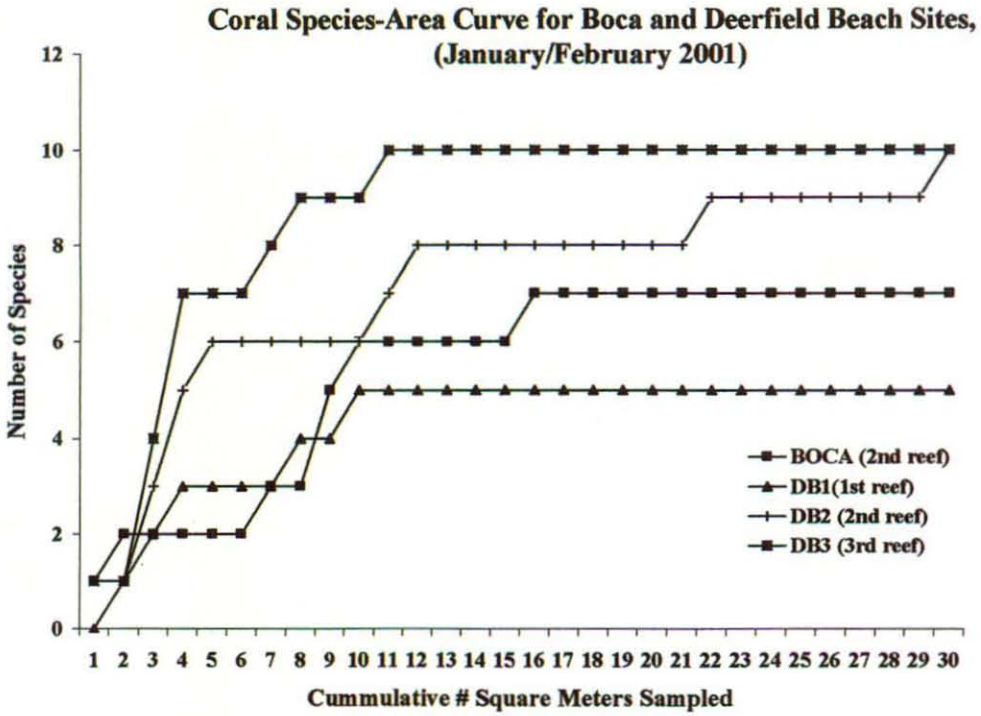

Figure 11: Coral species-area curve for transects at Boca and Deerfield Beach sites. Data represents the January/February 2001 monitoring.

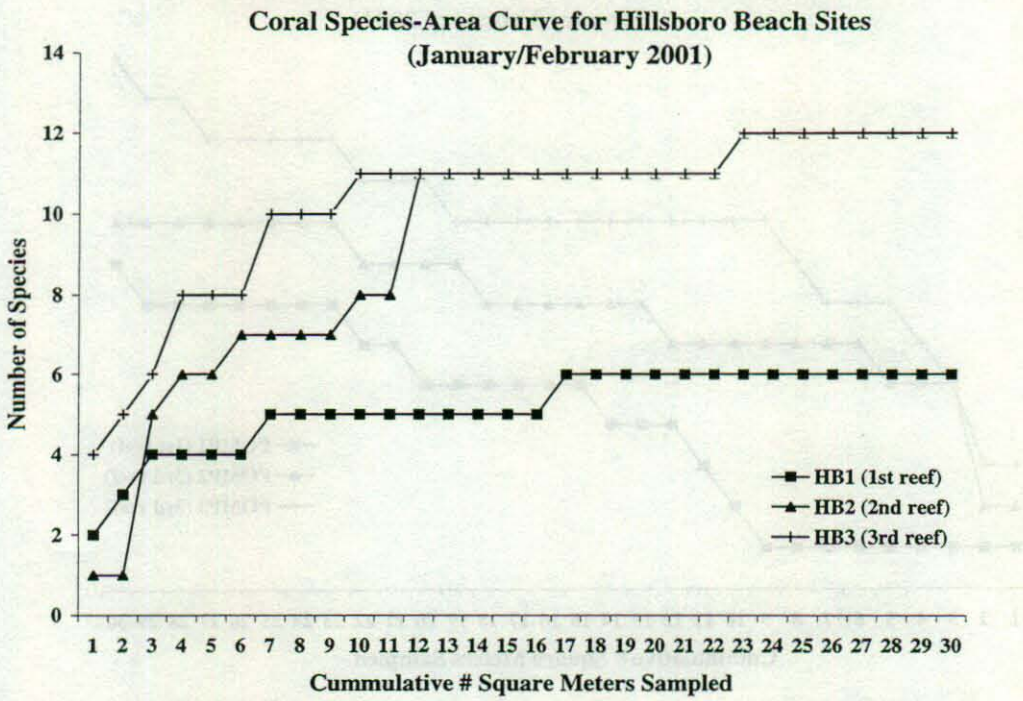

Figure 12: Coral species-area curve for transects at Hillsboro Beach sites. Data represents the January/February 2001 monitoring.

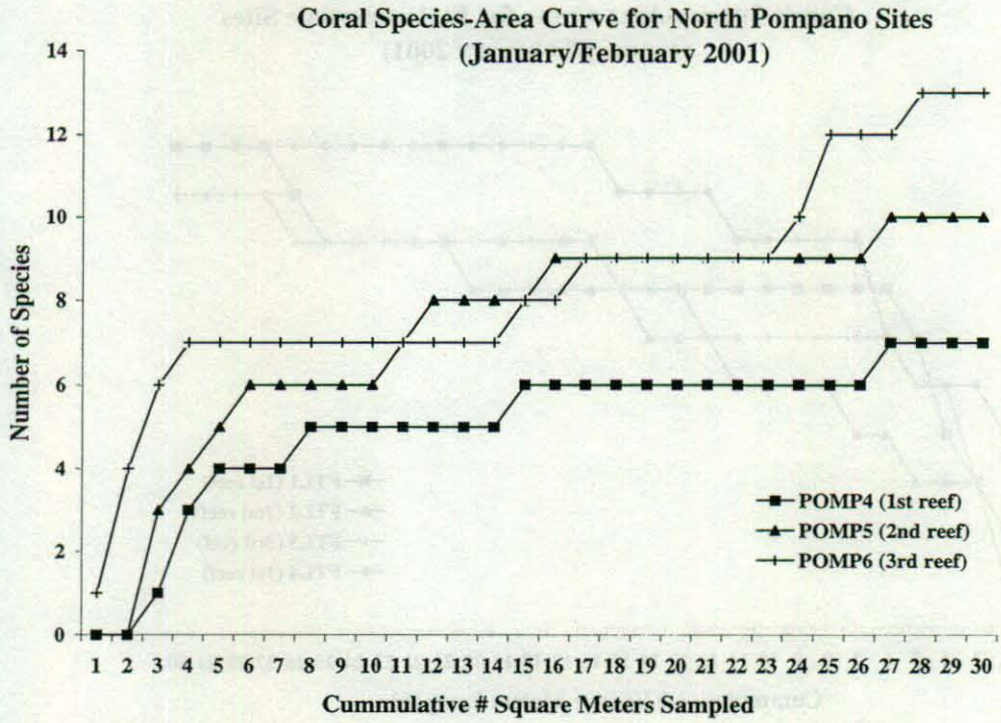

Figure 13: Coral species-area curve for transects at North Pompano Beach sites. Data represents the January/February 2001 monitoring.

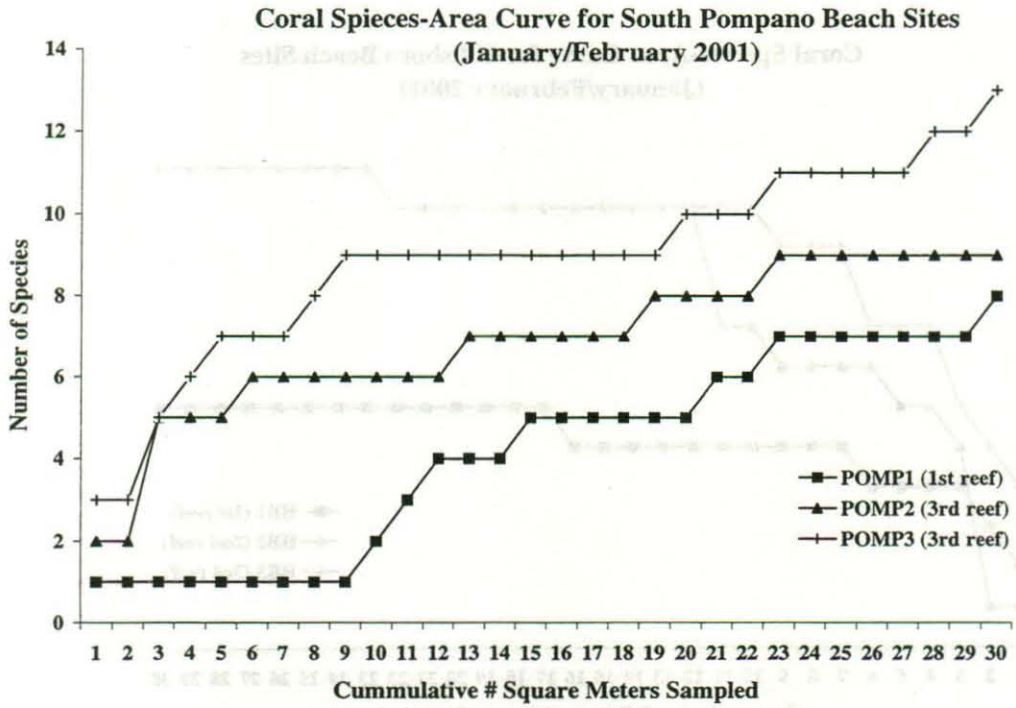

Figure 14: Coral species-area curve for transects at South Pompano Beach sites. Data represents the January/February 2001 monitoring.

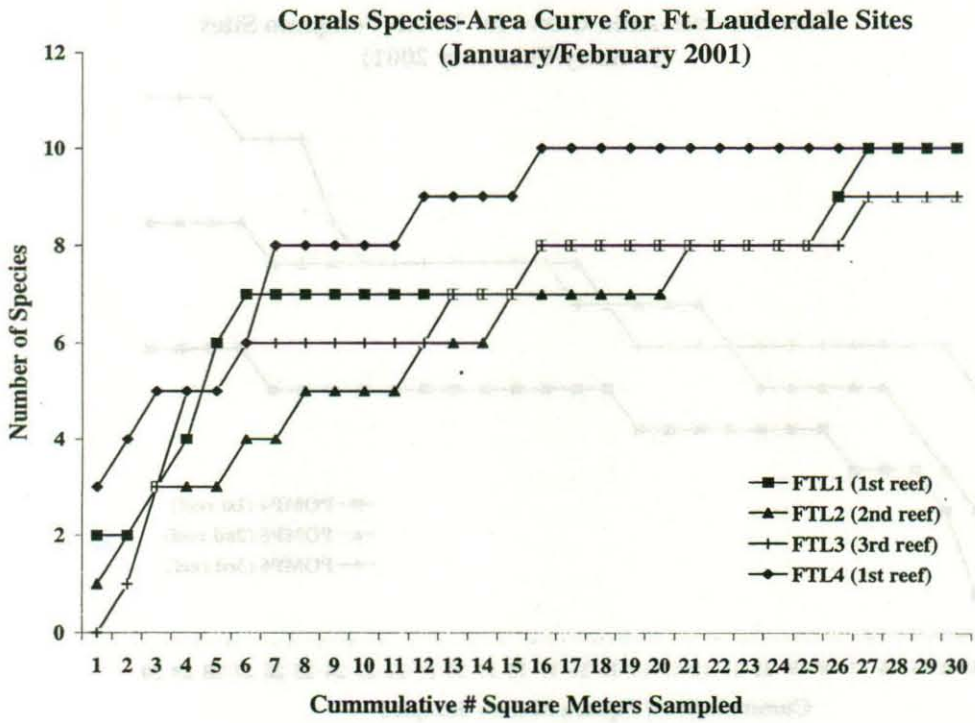

Figure 15: Coral species-area curve for transects at Ft. Lauderdale Beach sites. Data represents the January/February 2001 monitoring.

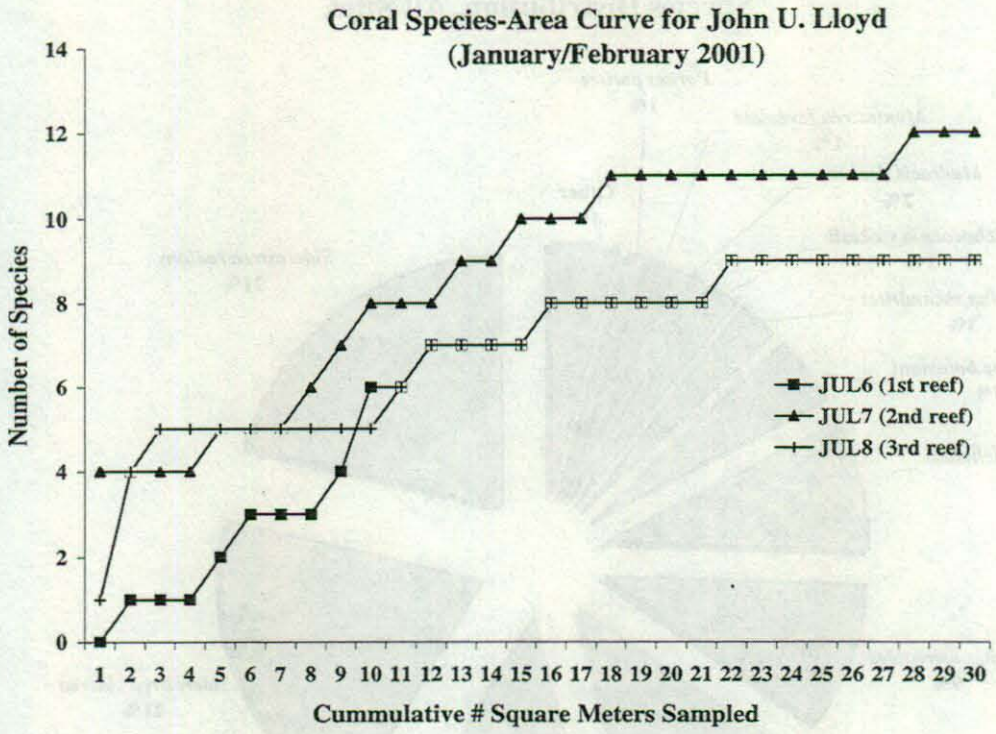

Figure 16. Coral species-area curve for transects at north John U. Lloyd sites. Data represents the January/February 2001 monitoring.

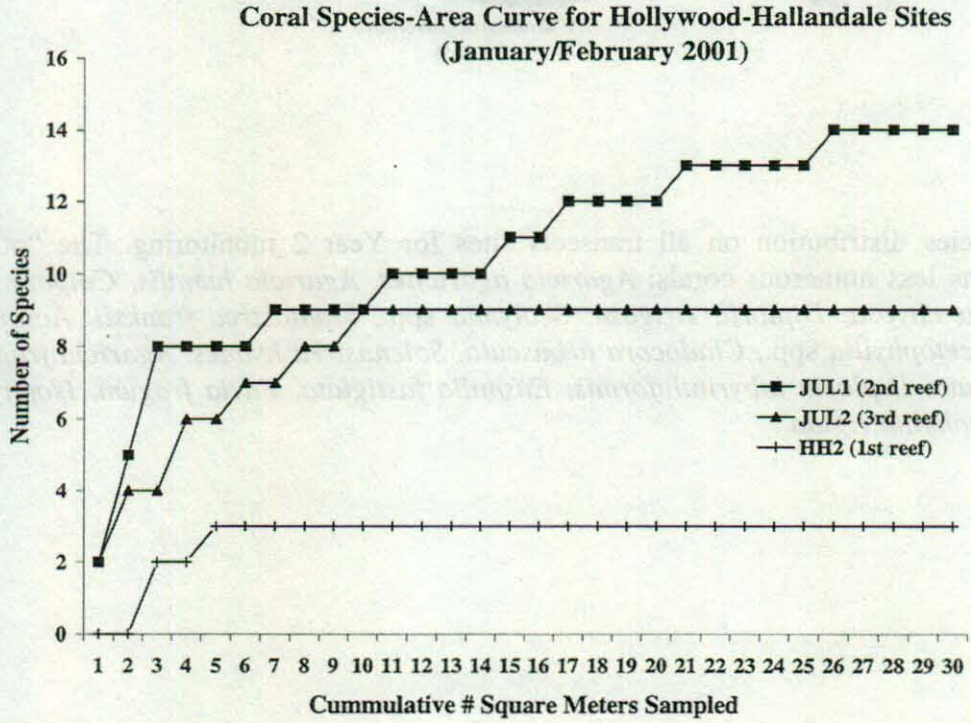

Figure 17. Coral species-area curve for transects at south John U. Lloyd sites. Data represents the January/February 2001 monitoring.

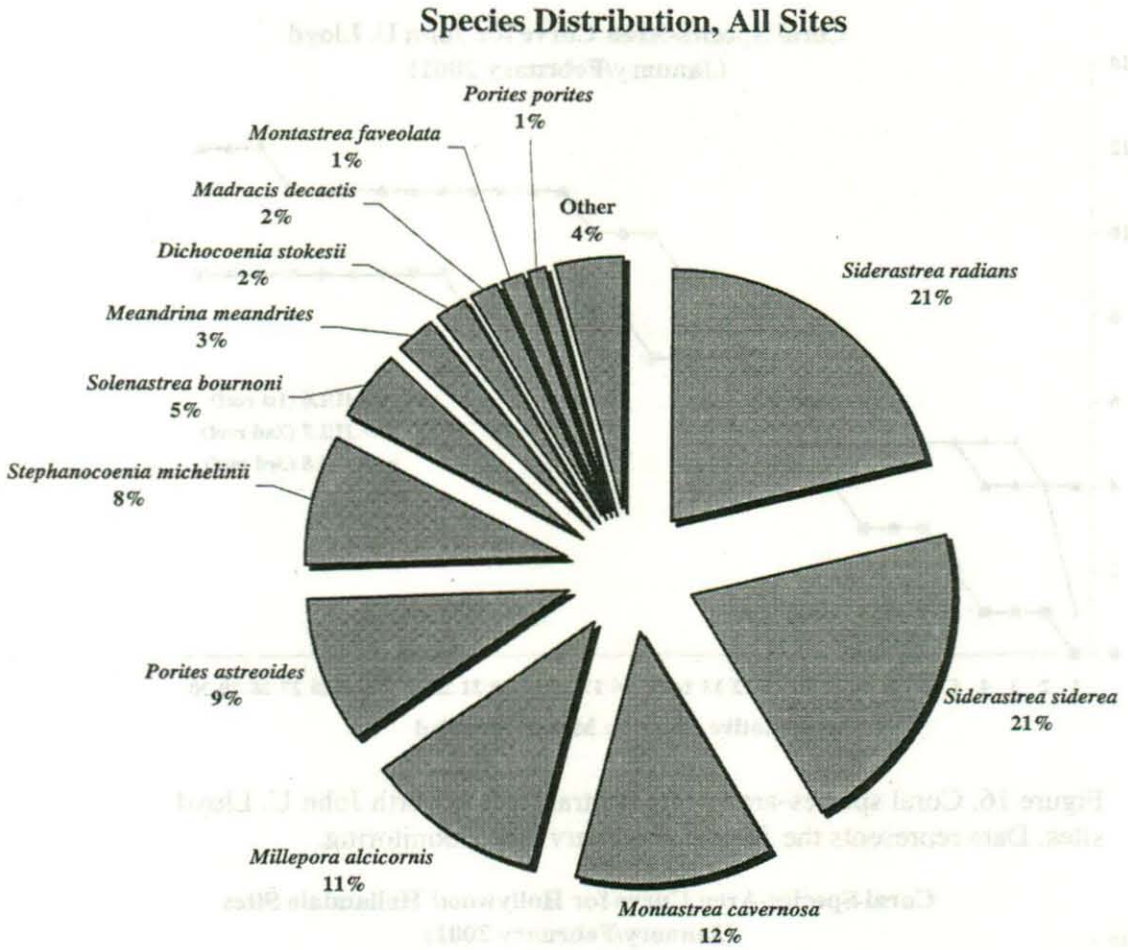

Figure 18: Species distribution on all transects sites for Year 2 monitoring. The "other" category contains less numerous corals: *Agaricia agaricites, Agaricia humilis, Colpophyllia natans, Diploria clivosa, Diploria strigosa, Scolymia* spp., *Montastrea franksii, Acropora cervicornis, Mycetophyllia* spp., *Cladocora arbuscula, Solenastrea hyades, Agaricia fragilis, Manicina areolata, Diploria labyrinthiformis, Eusmilia fastigiata, Favia fragum, Isophyllia sinuosa,* and *Isophyllia rigida.*

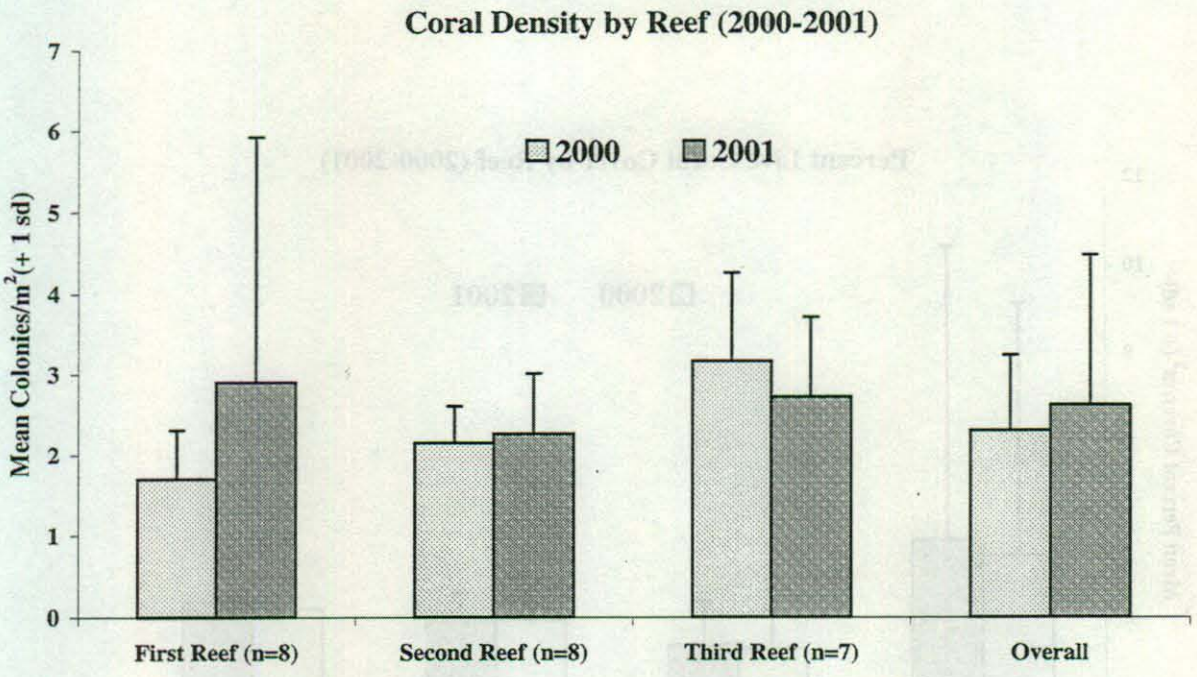

Figure 19. Density of coral by reef, 2000-2001. Error bars reflect one standard deviation.

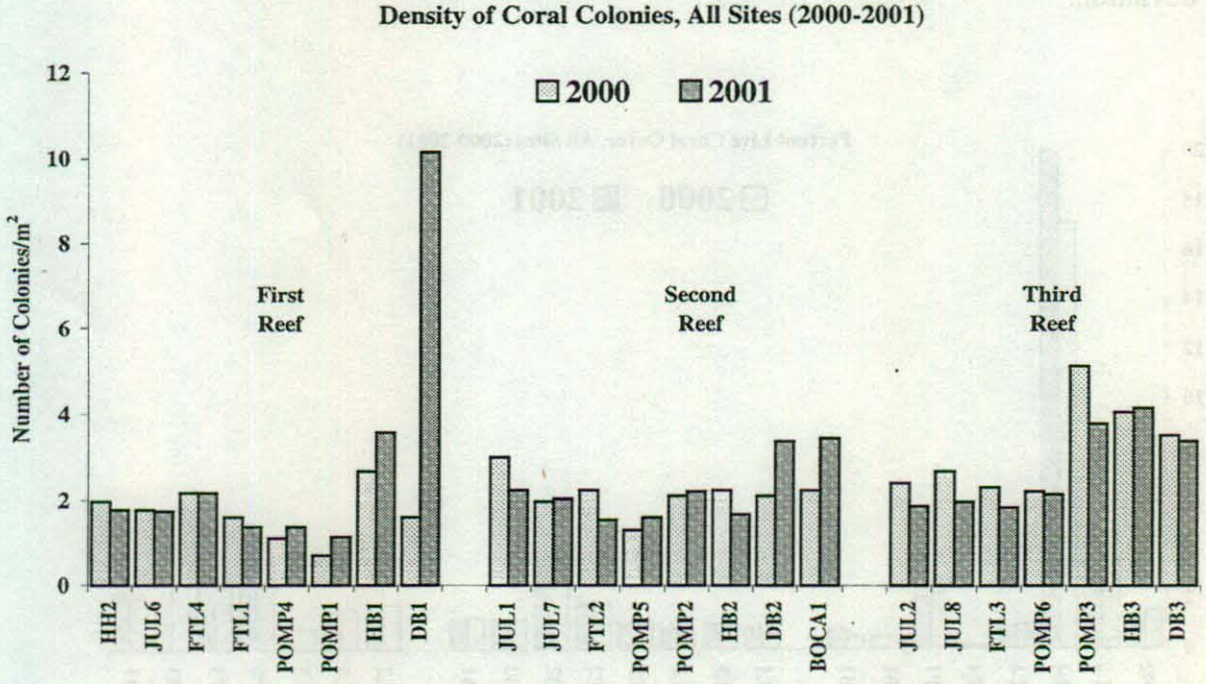

Figure 20. Density of corals at each transect site, 2000-2001. Sites are arranged by First, Second and Third Reefs. Note the large increase in colony density in site DB1 was due to many *Siderastrea* spp. recruits that were large enough to be included in 2001 but were not included in 2000.

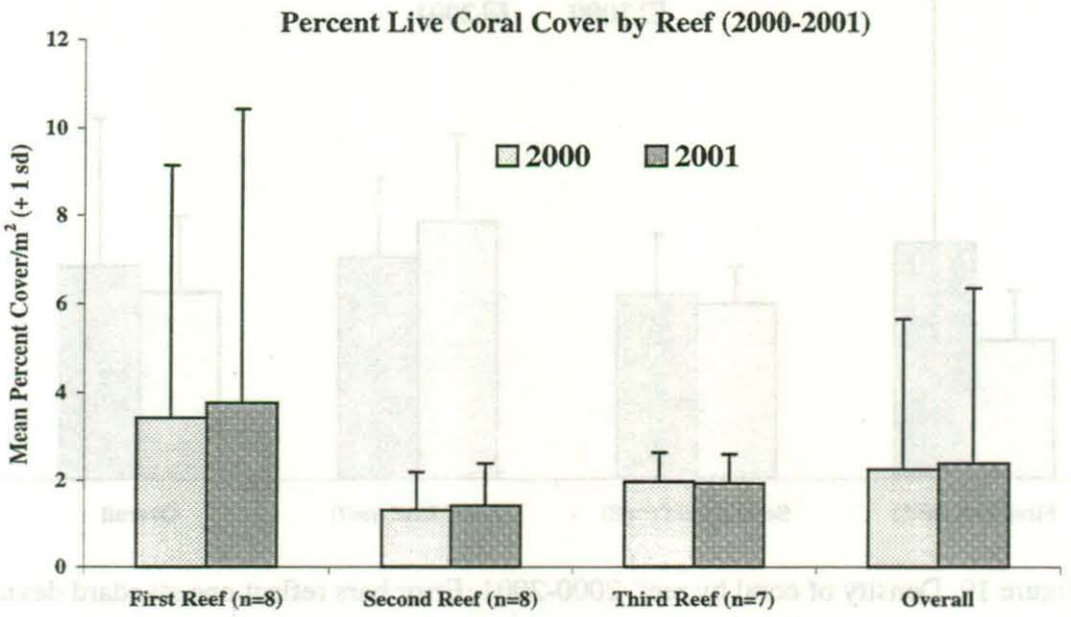

Figure 21. Percent live coral cover by reef, 2000-2001. Error bars reflect one standard deviation.

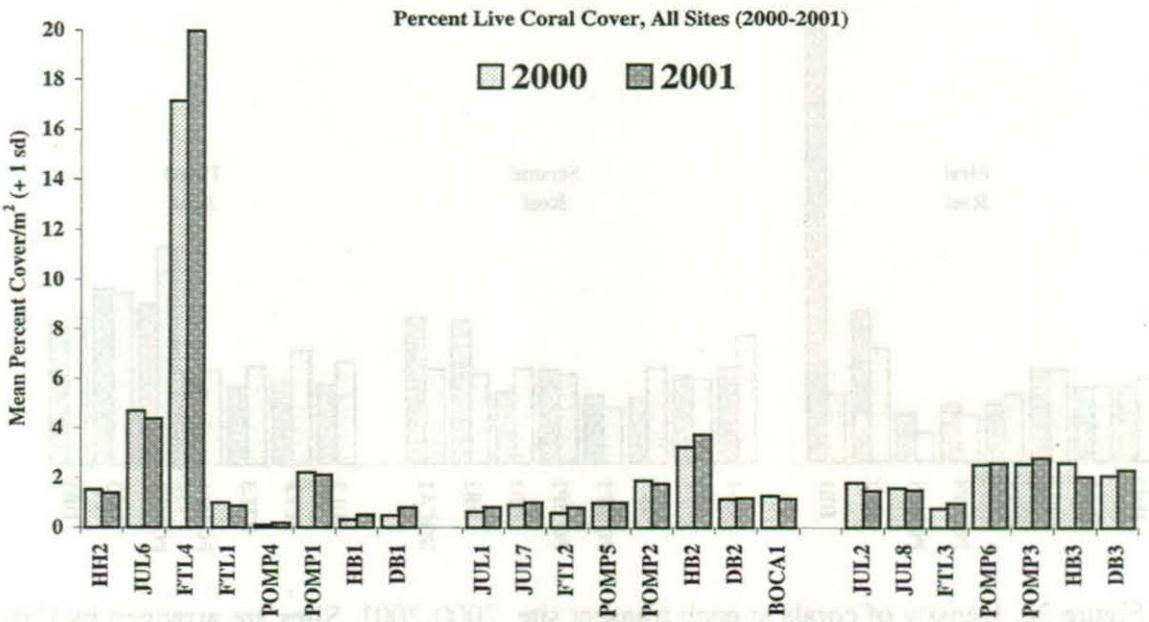

Figure 22. Percent live coral cover at each transect site, 2000-2001. Sites are arranged by First, Second and Third Reefs.

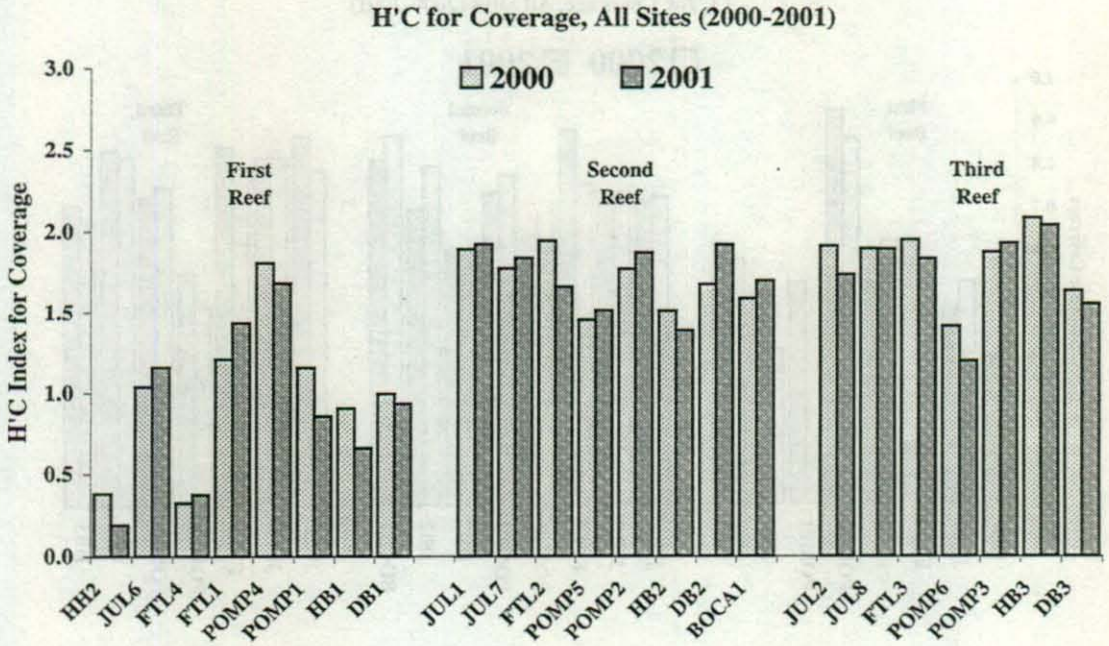

Figure 23. Shannon-Weaver Coverage Diversity of corals at transect sites, 2000-2001. Sites are arranged by First, Second and Third Reefs.

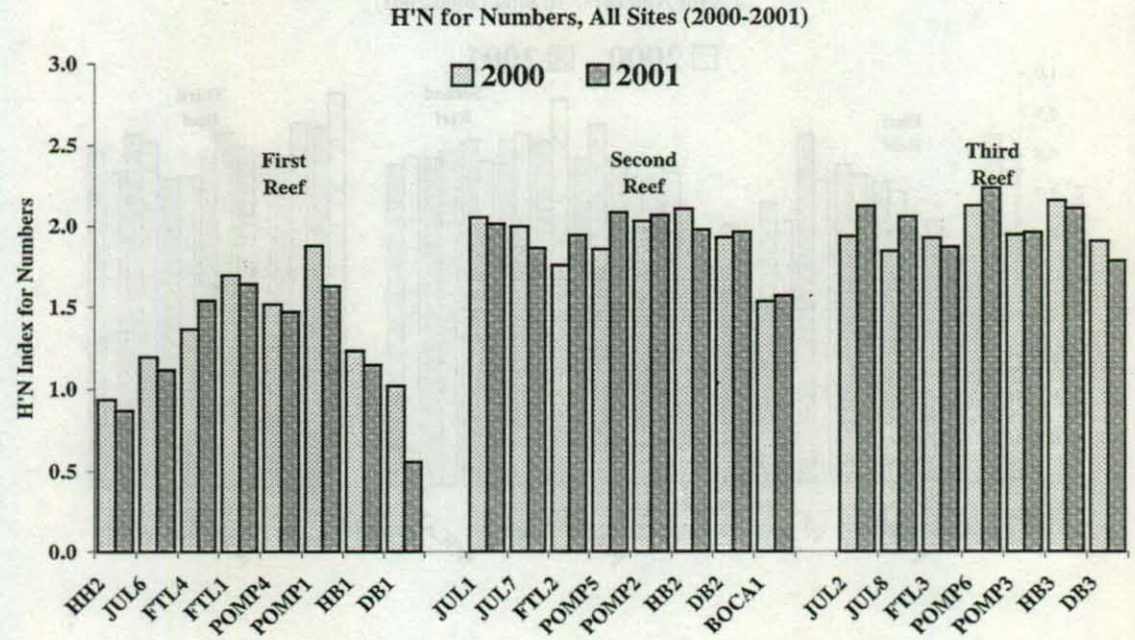

Figure 24. Shannon-Weaver Abundance Diversity of corals at transect sites, 2000-2001. Sites are arranged by First, Second and Third Reefs.

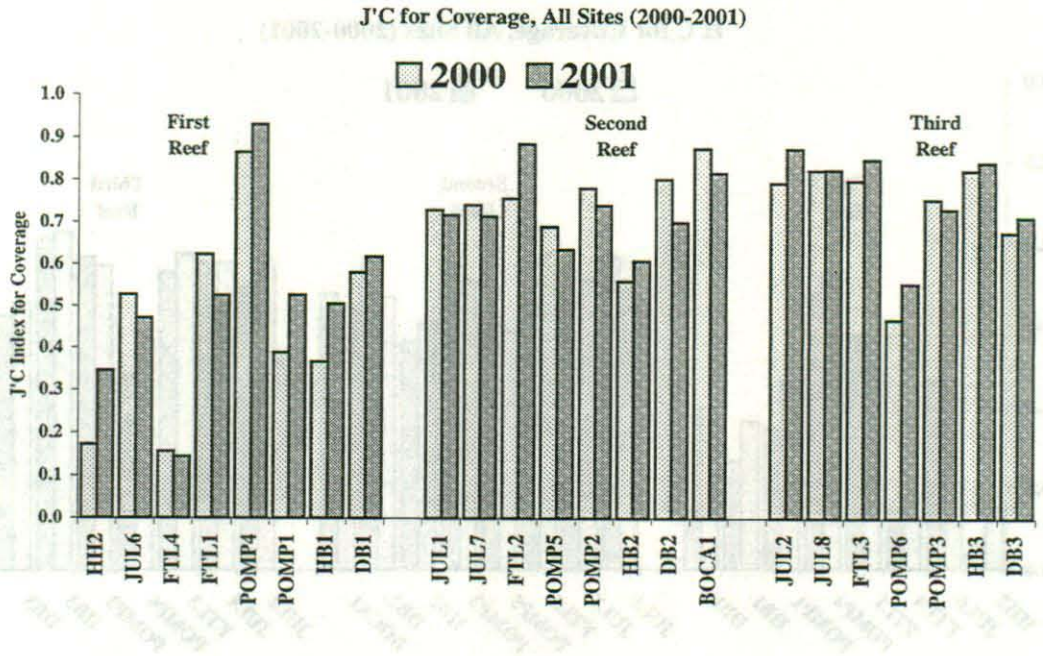

Figure 25. Evenness for coverage of corals at transect sites, 2000-2001. Sites are arranged by First, Second and Third Reefs.

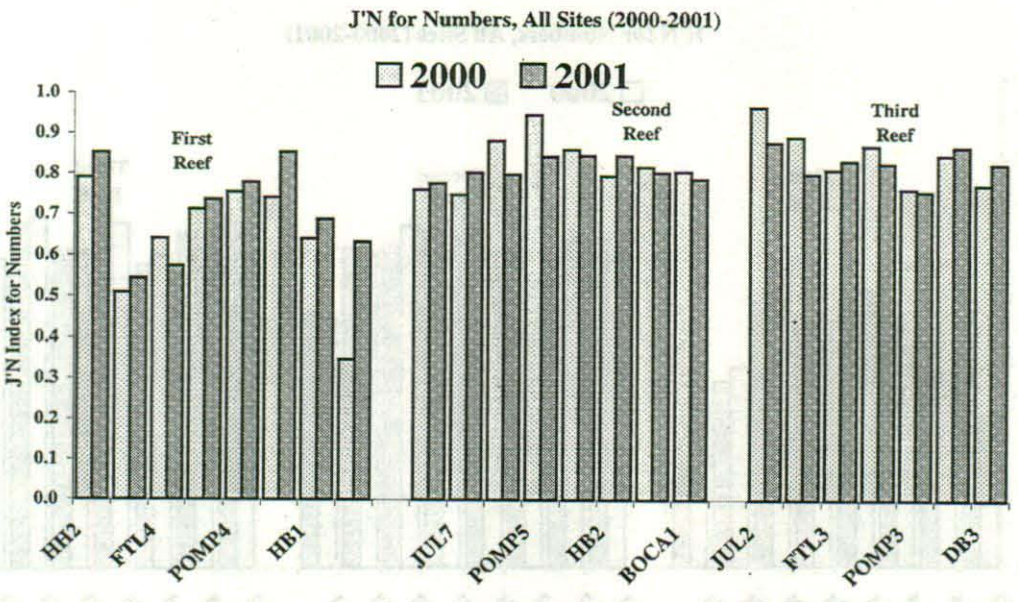

Figure 26. Evenness of numbers of species of corals at transect sites, 2000-2001. Sites are arranged by First, Second and Third Reefs.

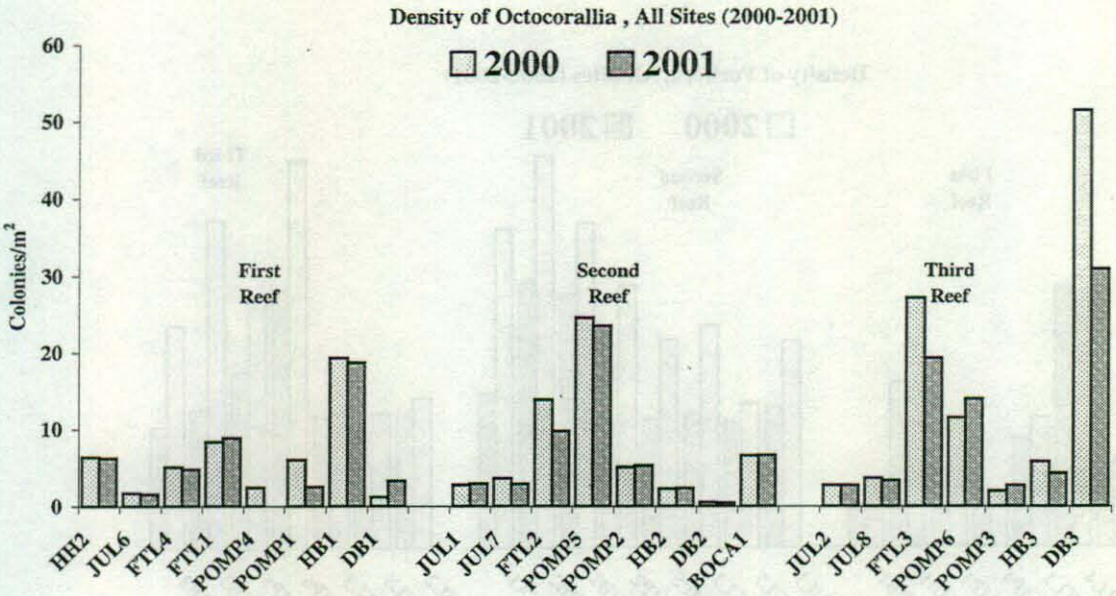

Figure 27. Density of Octocorallia (gorgonians) at transect sites, 2000-2001. Sites are arranged by First, Second, and Third Reefs.

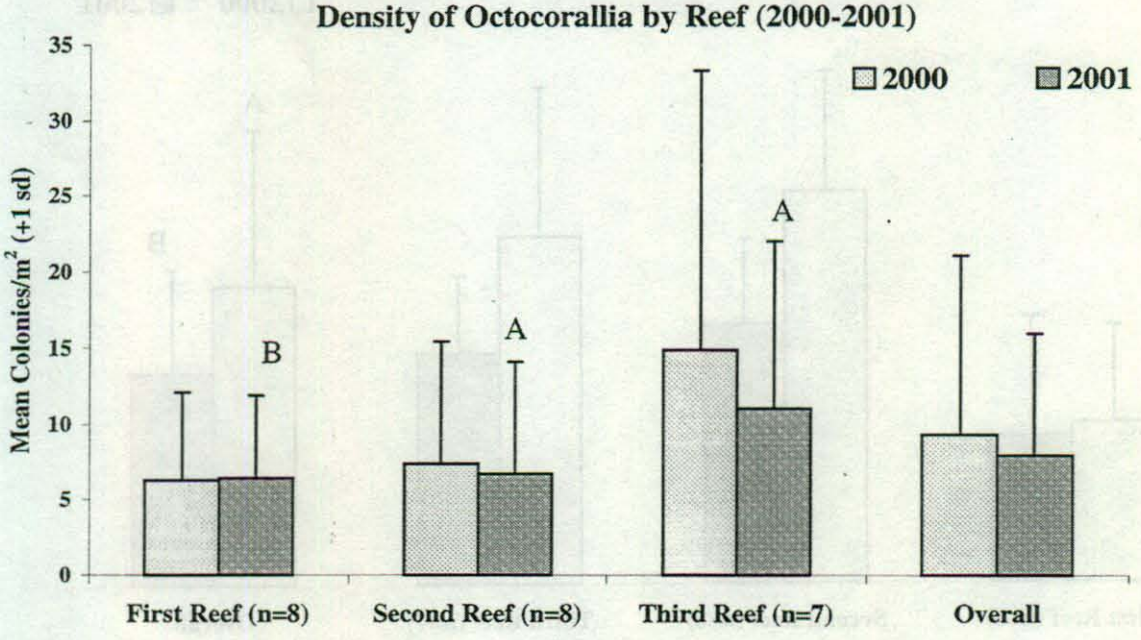

Figure 28. Density of Octocorallia (gorgonians) by reef. Error bars reflect one standard deviation. Multiple comparison (SNK) results are included for the overall mean values. Means with different letters (A, B) are significantly different.

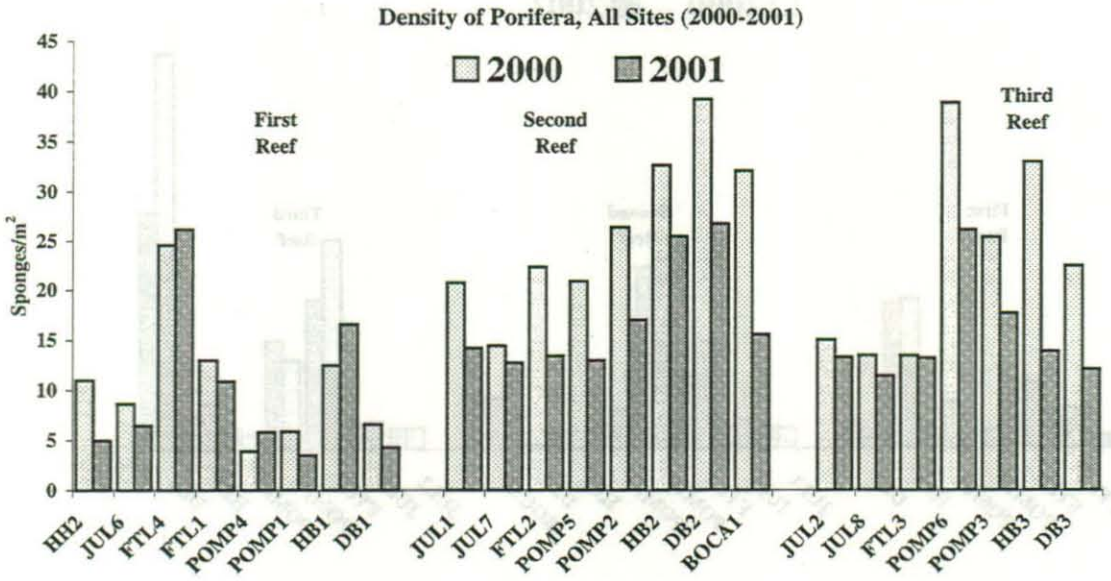

Figure 29. Density of Porifera (sponges) at transect sites, 2000-2001. Sites are arranged by First, Second and Third Reefs.

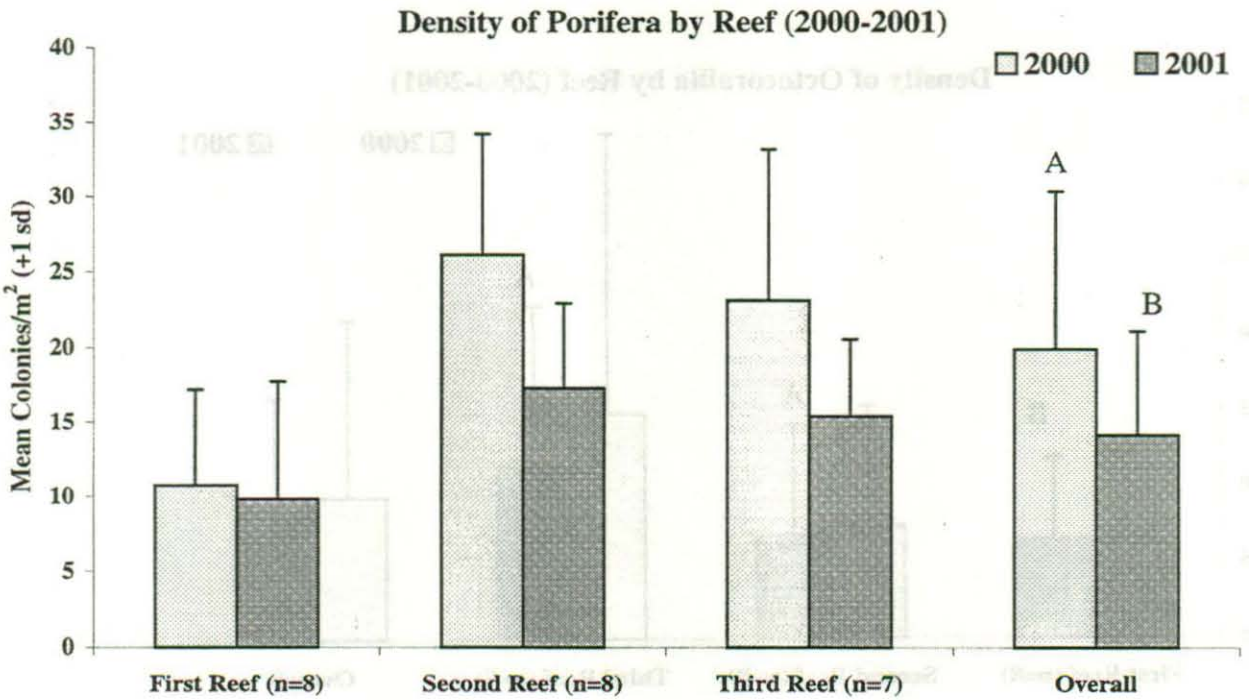

Figure 30. Density of Porifera (sponges) by reef. Error bars reflect one standard deviation. Multiple comparison (SNK) results are included for the overall mean values. Means with different letters (A, B) are significantly different.

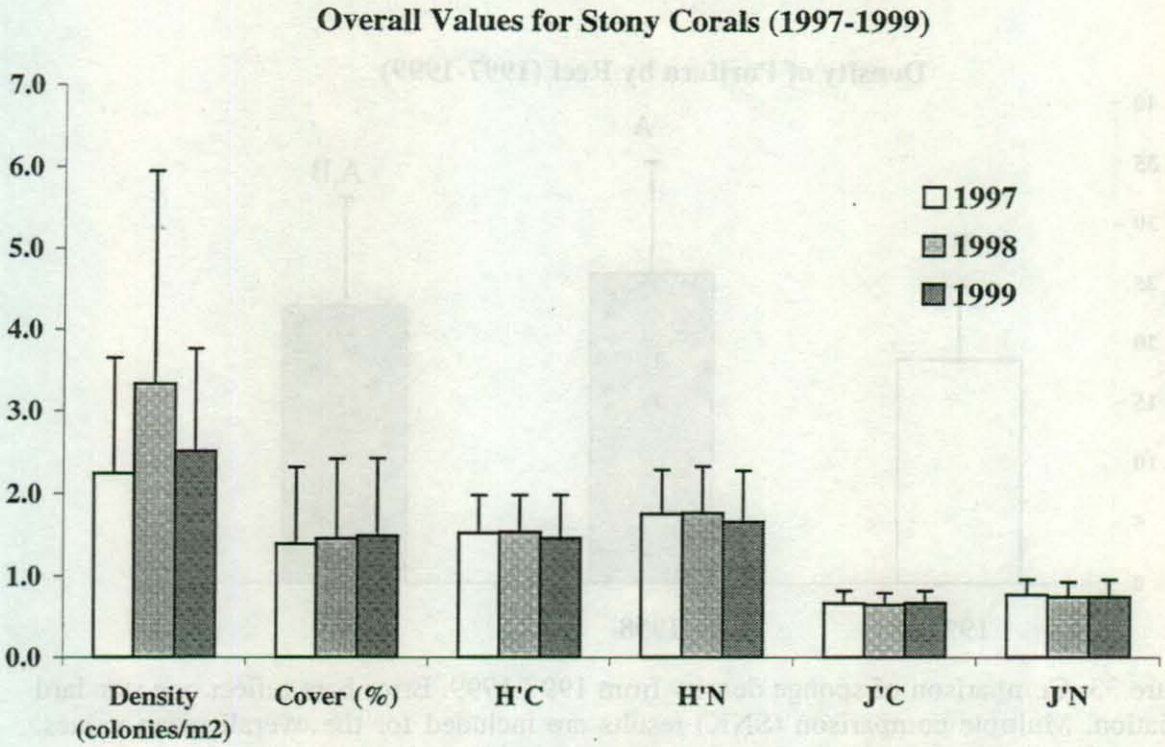

Figure 31. Comparison of overall coral density, percent cover, diversity and evenness for 1997-1999. Error bars reflect one standard deviation.

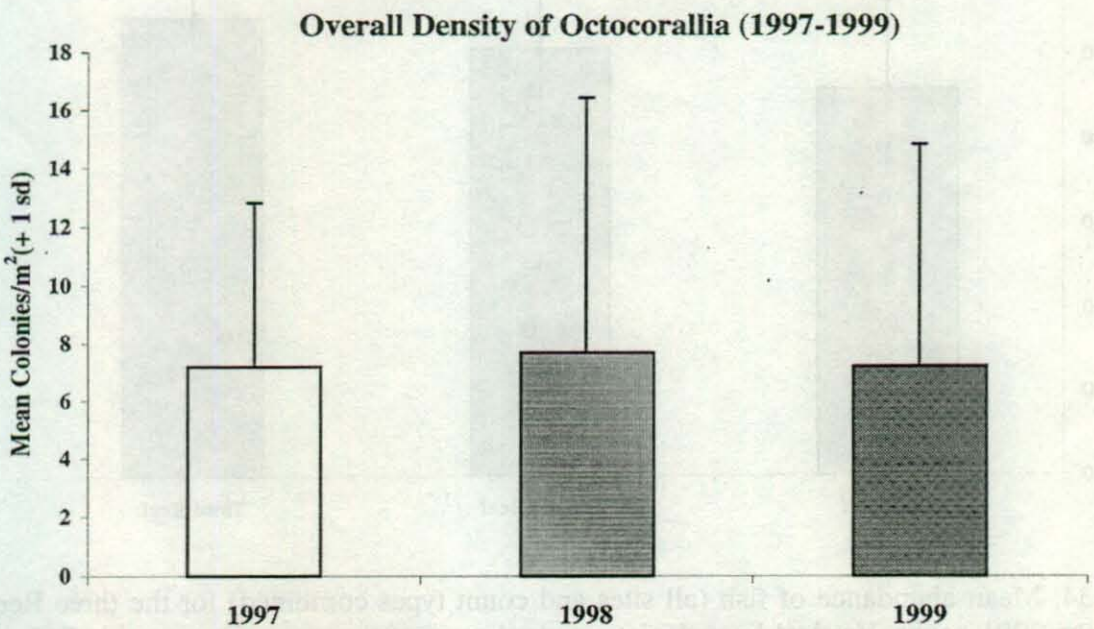

Figure 32. Comparison of gorgonian density from 1997-1999. Error bars reflect one standard deviation.

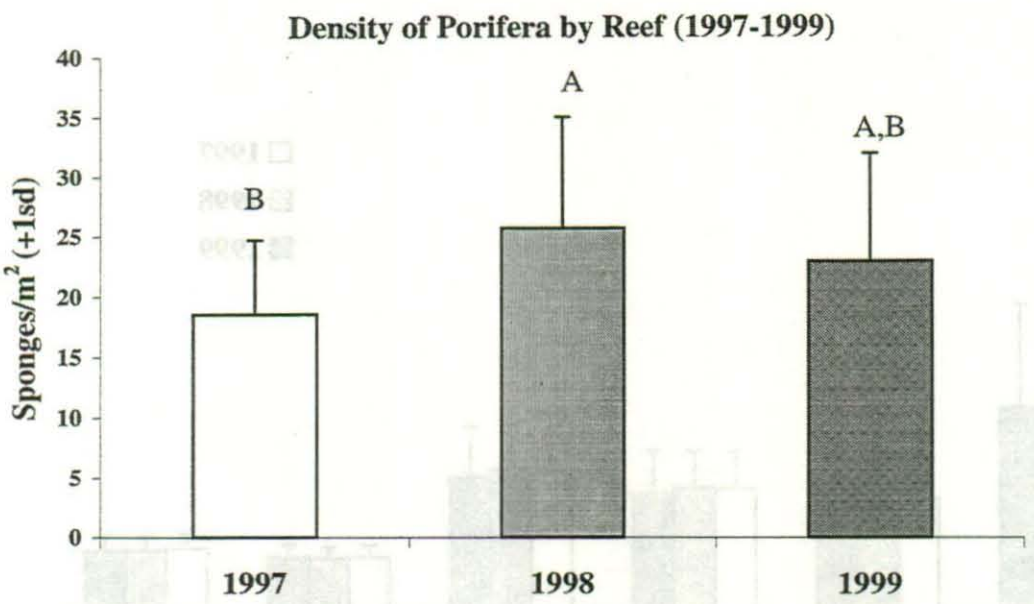

Figure 33. Comparison of sponge density from 1997-1999. Error bars reflect one standard deviation. Multiple comparison (SNK) results are included for the overall mean values. Means with different letters (A, B) are significantly different.

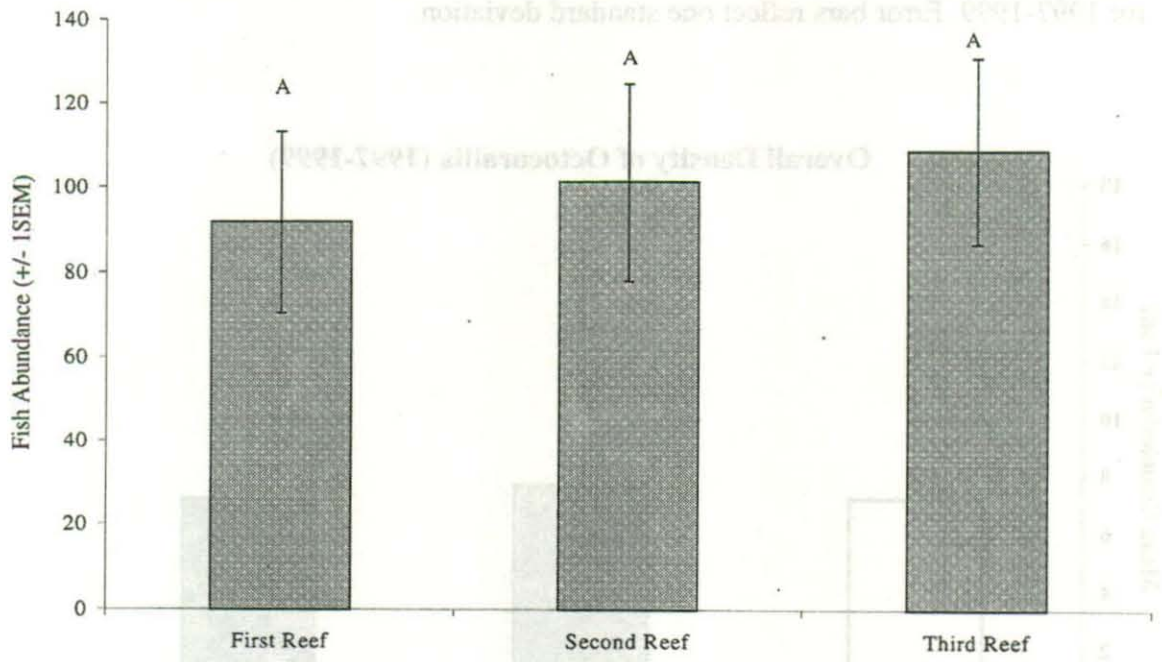

Figure 34. Mean abundance of fish (all sites and count types combined) for the three Reefs during the 2001 count. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

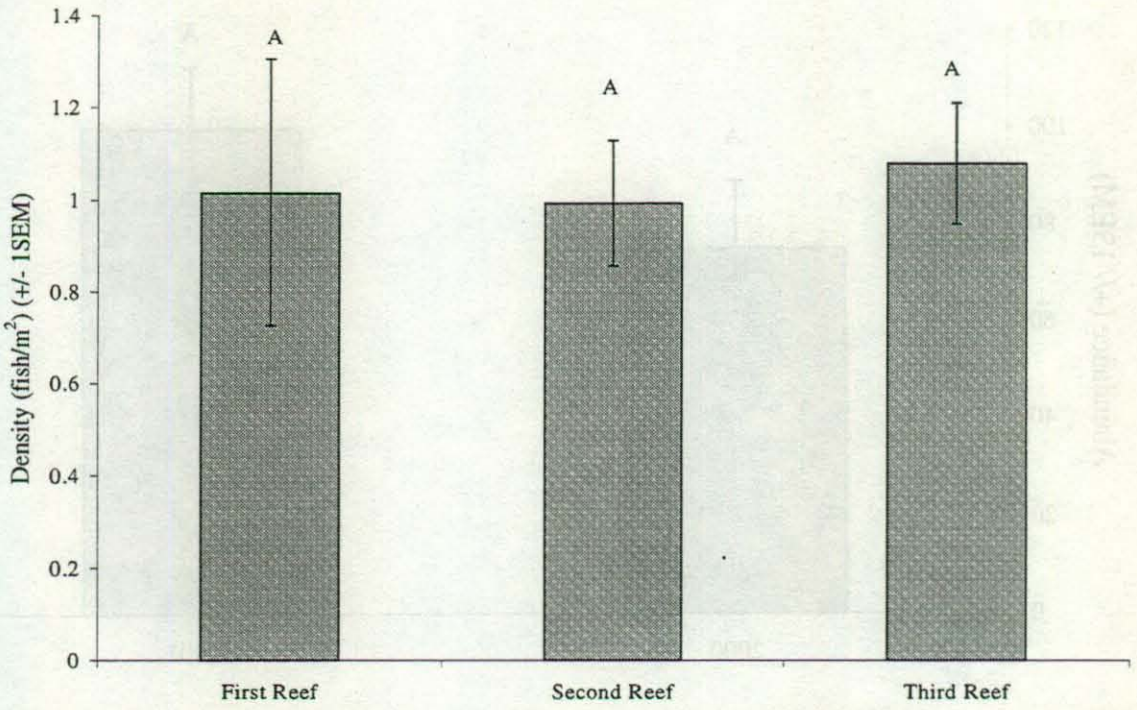

Figure 35. Mean density of fish (all sites and count types combined) for the three Reefs during the 2001 count. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

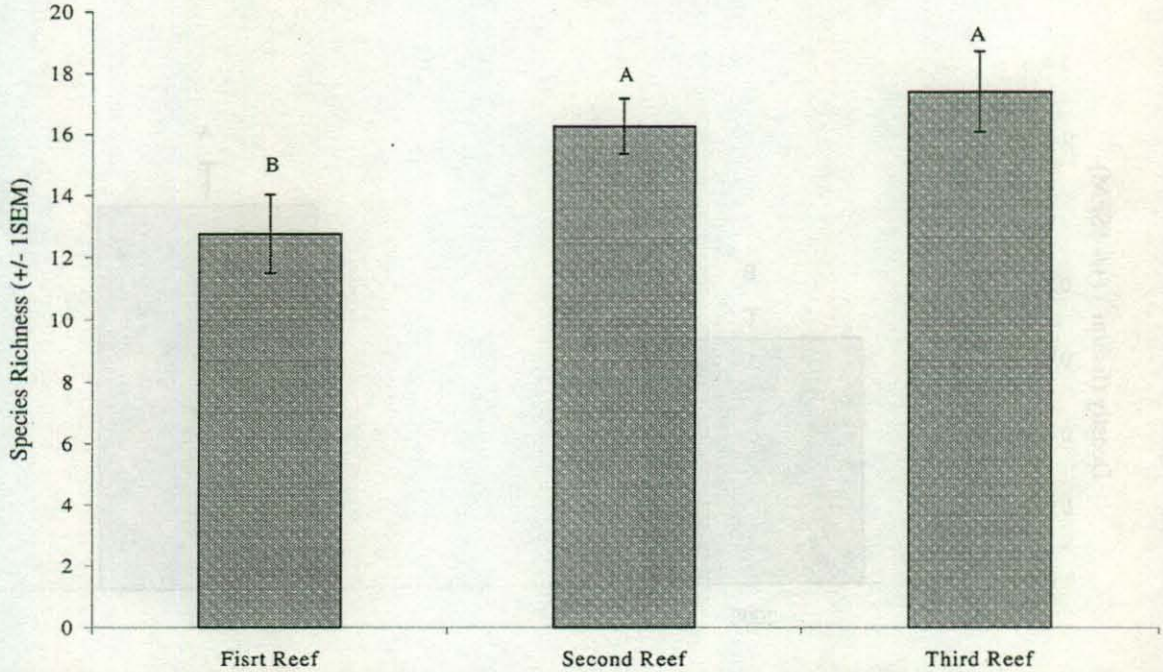

Figure 36. Mean fish richness (all sites and count types combined) for the three Reefs during the 2001 count. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

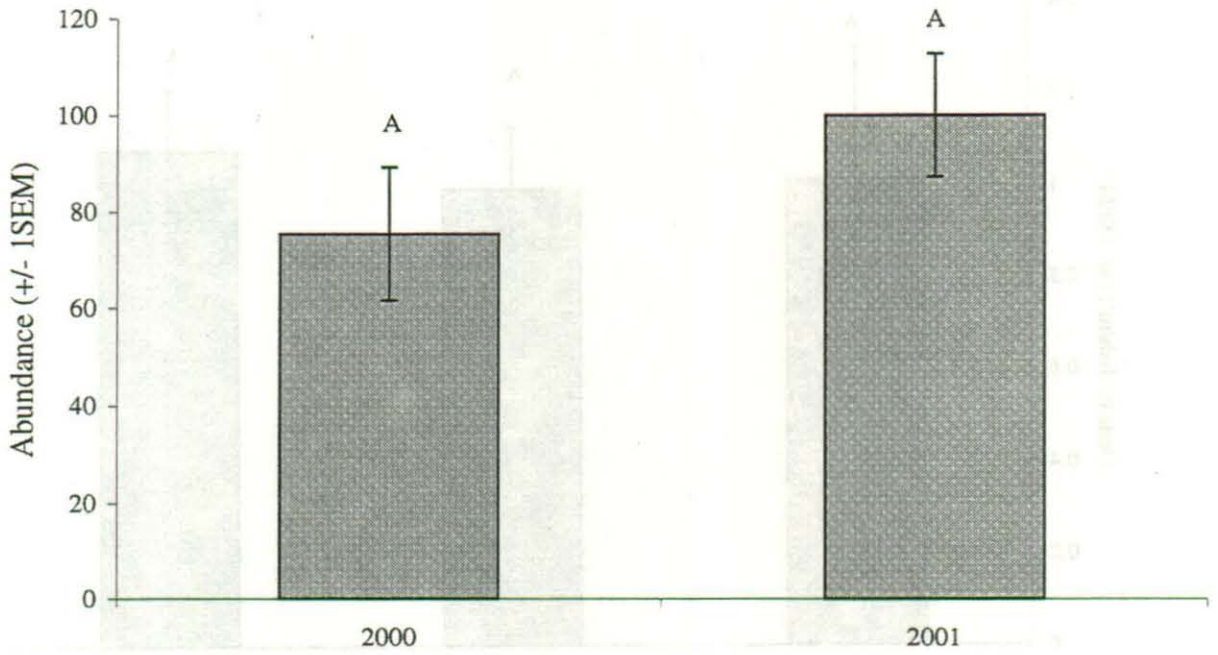

Figure 37. Mean abundance of fish (all species, sizes, reef tracts, and count types combined) for 2000 and 2001. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

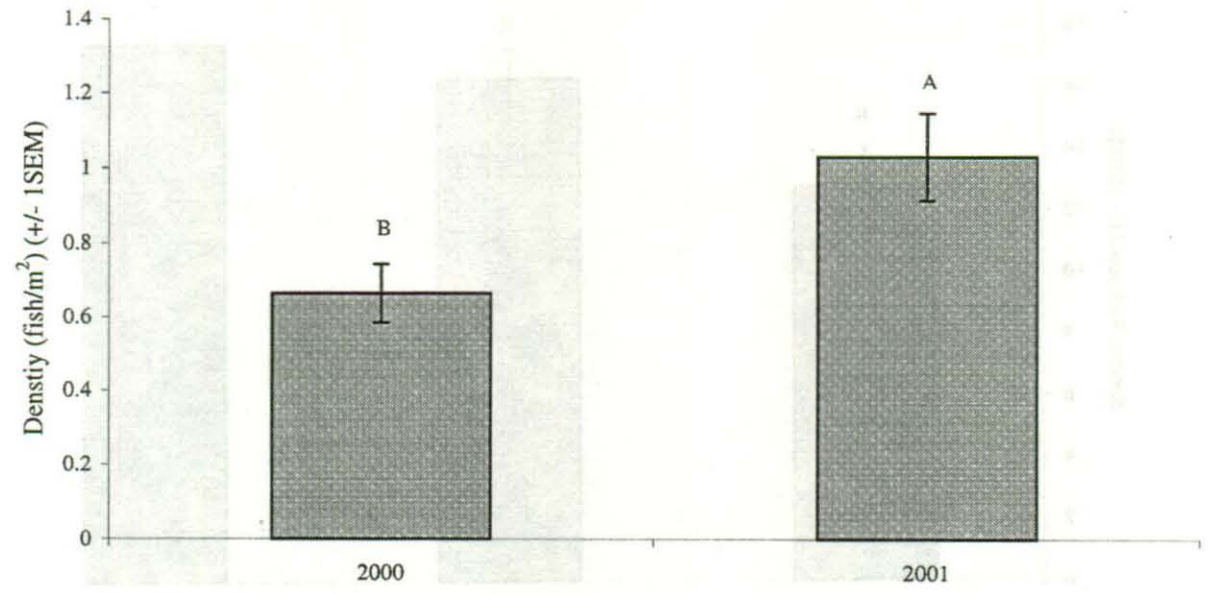

Figure 38. Mean site density of fish (all sites and count types combined) for two sampling dates. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

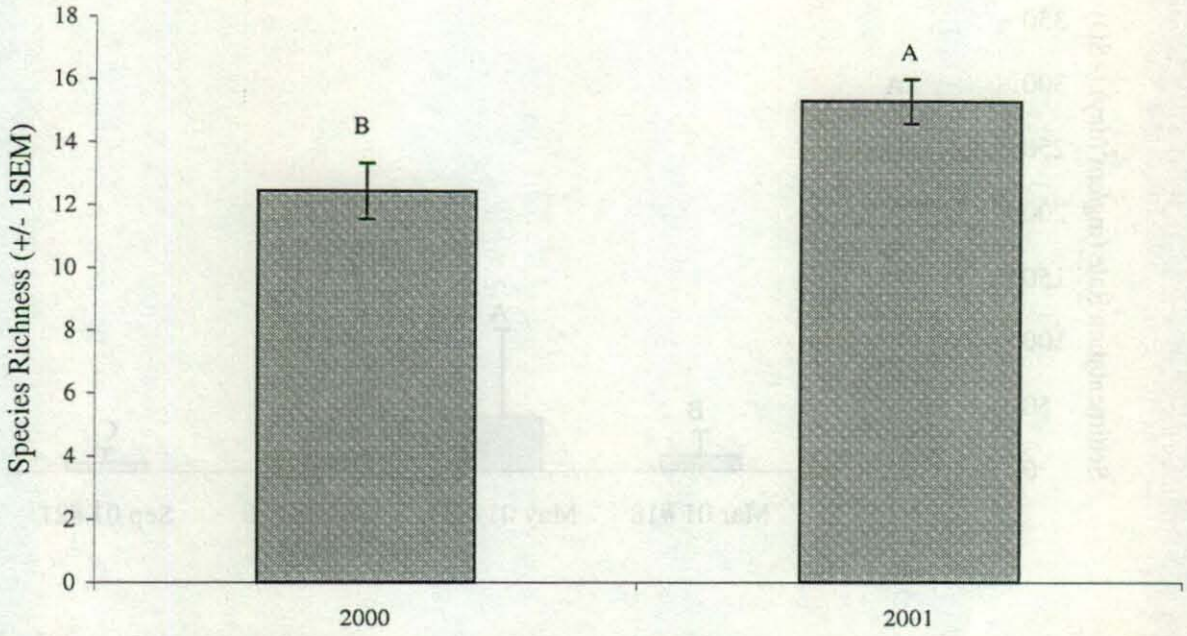

Figure 39. Mean site fish species richness (reef tracts and count types combined) for two sampling dates. Vertical lines depict standard error of the mean, means with differing letters (A, B) are significantly different ($p < 0.05$, SNK).

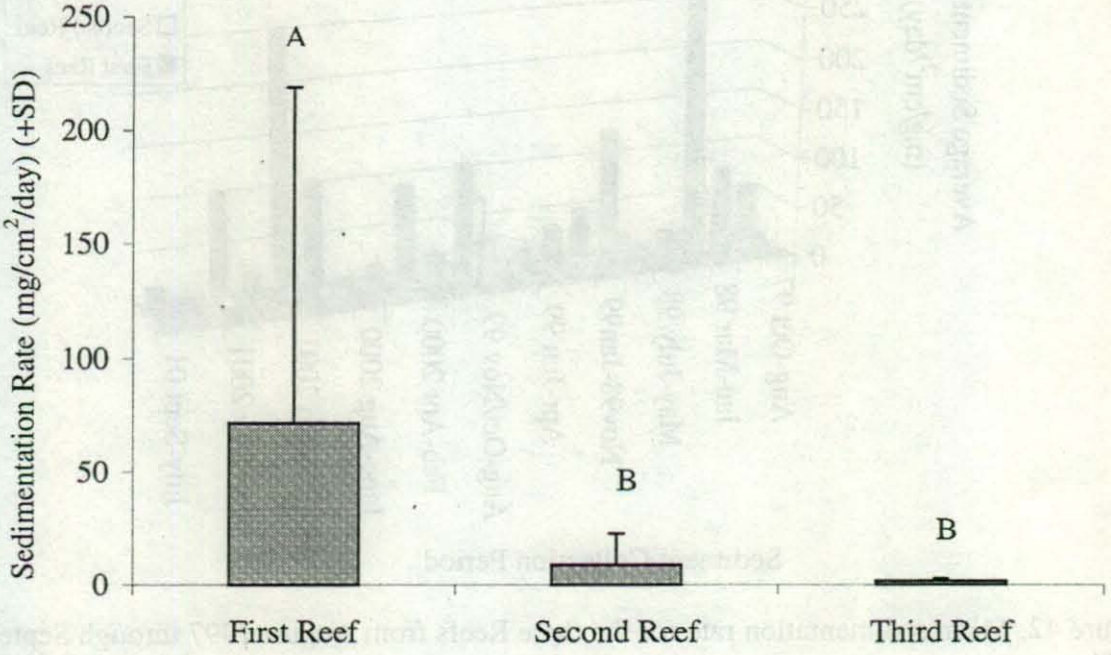

Figure 40. Sedimentation rate for the three Reefs from October 2000 - September 2001. Means with same letters are not significantly different ($p > 0.05$, SNK).

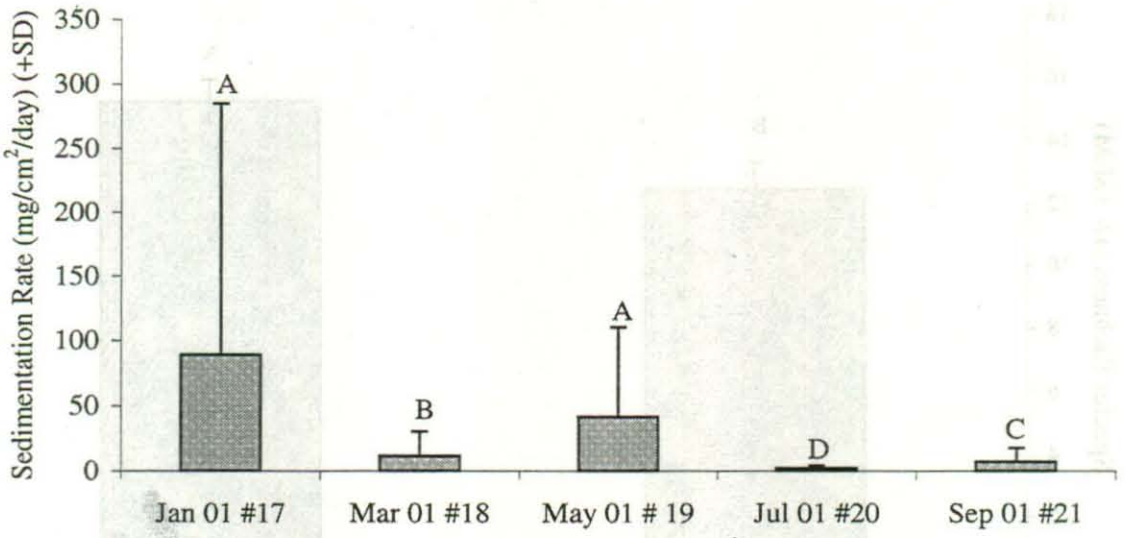

Figure 41. Sedimentation rate for sampling intervals January 2001 – September 2001 (data pooled for all sites). Means with same letters are not significantly different ($p > 0.05$, SNK).

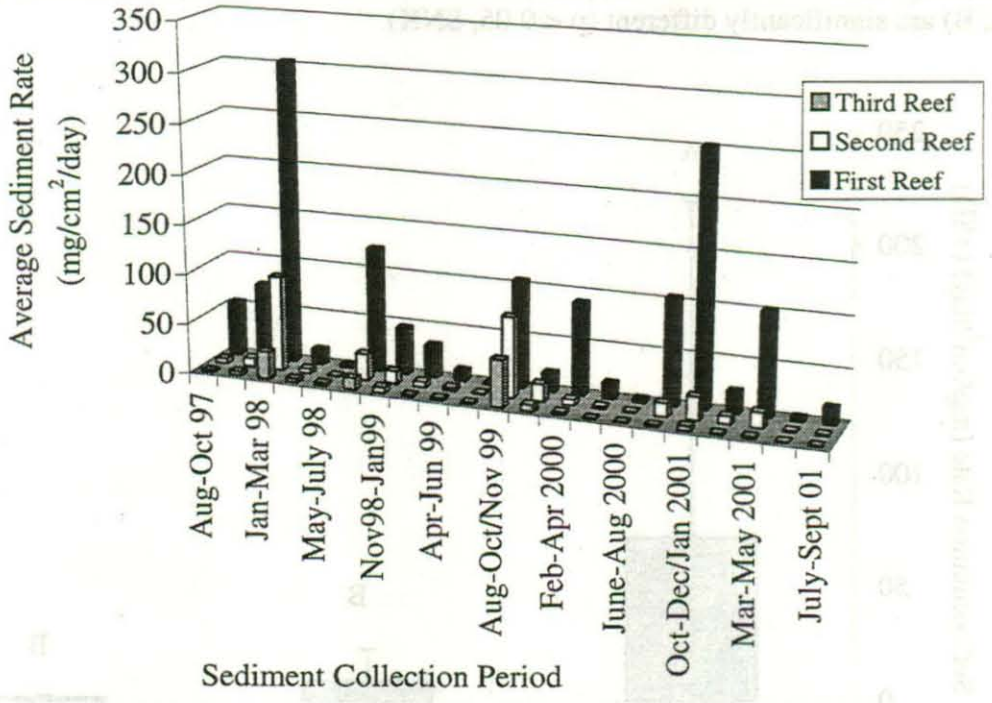

Figure 42. Mean sedimentation rate for the three Reefs from August 1997 through September 2001.