Results of a coral reef survey of Punta Cana, Dominican Republic, with comparisons to past studies and other Caribbean reefs

August 20th – 25th, 2003

By
Marilyn E. Brandt, Wade T. Cooper and Johanna F. Polsenberg

Field survey team:
Marilyn Brandt
Wade Cooper
Cara Dickman
Johnathan Kool

The National Center for Caribbean Coral Reef Research
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, Florida 33149
(http://ncore.rsmas.miami.edu)

1. Introduction

1.2 The Survey Team

This field survey was conducted by members of the National Center for Caribbean Coral Reef Research (NCORE), a center within the Rosenstiel School for Marine and Atmospheric Science at the University of Miami, FL, USA. NCORE, directed by Dr. John McManus, was founded in response to the need for critical information on how to best assess and manage coral reefs of the Caribbean, and focuses on the analysis and prediction of coral reef resilience in order to improve the scientific and socioeconomic basis of coral reef management.

1.3 Purpose of Survey

NCORE's purpose in performing an Atlantic and Gulf Rapid Reef Assessment (AGRRA; http://www.coral.noaa.gov/agrra/) of the Punta Cana reef was four-fold: 1) to provide scientific information to stakeholders of the Punta Cana reef; 2) to collect preliminary information on the Punta Cana reef tract for identification of potential future monitoring sites; 3) to compare the Punta Cana reef to other reefs across the Caribbean, using standardized AGRRA data; and 4) to obtain an initial survey for incorporation into a future AGRRA survey of the entire Dominican Republic.

1.4 Description of Punta Cana, Dominican Republic

Punta Cana is located on the southeast coast of the Dominican Republic (Map 1). The coast is characterized by a fringing reef system with spur and groove reef formations; the reef rises up to create "spurs" running perpendicular to shore that are separated by "grooves" of sand. The spur and groove formations often look from above like fingers of reef extending from the reef crest. Breakers marking the reef crest are located 1-2 kilometers offshore. Depth in the lagoon between the breakers and shore varies from 0.5-4 meters. The shoreline is primarily sandy beach with occasional areas of rocky shore.

2. Methods

2.2 Site Identification

Thirteen study sites within the Punta Cana reef (Table 1, Map 1) were located by visually assessing areas suggested by Mr. Manolo Despradal, a local person familiar with the region. In general, areas were suggested because they were thought to be typical of the region or, in the case of El Acuario, are a popular diving location. Three additional study sites, chosen for comparison purposes, were situated on reefs north of Punta Cana in the Babaro region (Table 1, Map 1). The Babaro region is significantly more developed than Punta Cana with several resorts occupying beachfront property. Two of the Babaro sites were located directly offshore from the developed area while a third was located up-current of any resorts.

Sites were surveyed in two depth ranges, 0.5 to 4 meters depth (shallow) and 5 to 10 meters depth (deep). At each site, we performed standard AGRRA fish and benthic surveys (available for download at http://www.coral.noaa.gov/agrra/), as described below. Shallow sites were located in the backreef, which is behind the reef crest, and deep sites were positioned in front of the reef crest, also known as the forereef.

2.3 Benthic Surveys

Five 10m-long benthic transect surveys were performed at each site to: 1) estimate the percent cover, size, and condition of total and individual coral species; 2) determine the density of the long-spined urchin *Diadema antillarum*; and 3) assess algal abundance and size.

2.3.1 Coral

To assess the coral at each transect, a diver first estimated live coral cover by recording the length of live coral on potential hard substrate underneath the 10m transect line (i.e., total length of living coral per total length of hard substrate, to the nearest 10cm). The diver then recorded information on each coral colony more than 10cm in diameter located directly beneath the transect line, including: species name; depth; size (diameter and height perpendicular to the axis of growth); substrate type; percent living, "recently dead" (corallite structure identifiable to genera), or "long dead" (corallite structure non-identifiable or covered thickly by organisms); disease type if infected (identification of diseases based on the Coral Disease Identification and Information webpage found in the NOAA Coral Health and Monitoring Program website (http://www.coral.noaa.gov/coral_disease); percent bleached if affected; and the total number of damselfish per coral head (for *Stegastes diencaeus, S. fuscus, S. planifrons,* and *S. variabilis*).

2.3.2 The long-spined urchin *Diadema antillarum*

To assess the density of the long-spined urchin *Diadema antillarum*, a diver counted the total number of individuals within 0.5m of each side of the transect line.

2.3.3 Algae

To assess algal abundance and size at each transect, a diver placed a 25x25cm quadrat every 2 meters along the transect line in a suitable area at 1, 3, 5, 7, and 9m marks. A suitable area was one that had greater than 80% absolute abundance by any algae type (macro-, turf, and/or coralline). If a suitable area was not present within a 1m radius of the 2m mark, a measurement was not recorded for that mark. Within each quadrat, the diver recorded substrate type (pavement, dead coral, or rubble); percent absolute abundance of living crustose coralline algae, fleshy macroalgae (>1cm in height), and calcareous macroalgae (>1cm in height); and average canopy height of fleshy and calcareous macroalgae.

2.4 Fish Surveys

The fish surveys consisted of two distinct methods: 1) a 30m belt transect survey to assess fish density and size; and 2) a roving diver census to assess fish presence/absence and relative abundances. Method 1 was used to gain a quantitative and standardized measurement of fish density, while Method 2 was used to gain a qualitative assessment of the species diversity and abundance. For Method 1, the divers conducted ten randomly-positioned belt transect counts, each 30x2m in size, and at least 5m laterally away from previous counts. For each transect, a diver swam the 30m distance within 6-8 minutes, counting all fish from a pre-determined list (Table 2) within an imaginary 2x2 meter box. The fish species counted (Table 2) represent common species likely affected by human impacts. Fish were assigned to one of six size categories (<5cm, 5-10, 10-20, 20-30, 30-40, and >40cm) using a 1m "T-bar" with 5cm increments to help in assessing sizes. Juvenile grunts and parrotfish were not counted if <5cm, since species identification can be difficult within this size category. For Method 2, a diver swam haphazardly for approximately 30minutes, recording all fish species observed and the relative abundance of each species as single (1 fish), few (2-10), many (11-100), or abundant (>100 fishes), following the methodology of the Reef Environmental Education Foundation (REEF, http://www.reef.org/).

3. Results

3.2 Forereef

The forereef community generally consisted of a well-developed, high-relief spur and groove system. The spurs rise steeply from a sandy sea floor perpendicular to the reef crest. Dominant scleractinian coral genera included *Montastrea*, *Diploria*, and *Siderastrea*. The tops of the spurs had large colonies of living *Acropora palmata*. Remnants of old *A. palmata* colonies were found as well however they were generally heavily eroded. Though species and abundance were not recorded in benthic transects, several gorgonians were also seen in varying amounts at forereef sites. Site DR0602, located in the forereef zone near the popular dive site El Acuario, was the only exception to the typical spur and groove formation. This site was a solid forereef structure, its edge at approximately 5 meters depth, dropping steeply down to a rippled sandy bottom at approximately 13 meters depth.

In addition to corals, other invertebrates found in the forereef environment included clumped distributions of the long-spined sea urchin *Diadema antillarum* (Table 4) as well as the smaller species *Echinometra viridis*, and *E. lucunter*. Two dominant invertebrates found at all sites were the White Encrusting Zoanthid, *Palythoa caribaeorum*, and the Coral Encrusting Sponge, *Cliona langae*, a species known to overgrow and bore into living coral. The most abundant algal species (Table 5), although variable from site to site, generally consisted of the following genera: *Turbinaria*, *Dictyota*, *Stypopodium*, *Sargassum*, *Halimeda*, and *Amphiroa.*

3.2.1 Coral

Twenty-three different coral species were found in the spur and groove forereef zone, and fourteen species were found at the solid forereef site (Table 3). Live coral cover at all deep forereef sites in the Punta Cana region ranged from 4.5 – 16.9% with an average cover of 9.7% (Table 4). On average, coral colonies exhibited 15% old mortality (i.e. no corallite structure identifiable) and 3% recent mortality (i.e. corallite structure still identifiable or covered by a thin layer of filamentous algae). Higher levels of live coral cover, 16.9% and 13.7%, were found at the two northern most sites in the Punta Cana region, DR0502 and the solid forereef site DR0602, respectively. With the exception of two Babaro deep sites (B), there is a decreasing trend in coral cover with decreasing latitude (Figure 1).

Live coral cover at two deep forereef sites in the Babaro region, DR0202 and DR0203, were 3% and 5% respectively. Compared with the Punta Cana forereef sites, these values are very low. Old mortality, however, was relatively low, 7% and 4%, while recent mortality was within average range, less than 1% and 3%, respectively.

3.2.2 Algae

Algal abundance was evaluated at each forereef site and then averaged over all forereef sites (Table 5) for the Punta Cana region. Crustose coralline algal abundance ranged from 25% to 51% at all sites with DR0602 exhibiting the greatest abundance. Fleshy macroalgal abundance ranged from 44% to 71% at all sites except DR0602, which was much lower at 11%. Lastly, calcareous macroalgal abundance at DR0602 was 32%, a value much higher than the 1% to 6% measured at all other sites. Results from DR0602 exerted a strong influence on the average values: 37% for crustose coralline algae, 51% for fleshy macroalgae, and 7% for calcareous macroalgae.

The Babaro region displayed similar algal abundance to the Punta Cana region, with the exception of DR0602. The two Babaro sites had high levels of fleshy macroalgal abundance, 43% and 71%, and low levels of calcareous macroalgal abundance, 1% and 5%. Crustose coralline algal abundance was 46% and 18%.

3.3 Backreef

The backreef zone examined in the Punta Cana region consisted of scattered coral colonies on a smooth pavement substrate. At one site, DR0501, small clusters of coral colonies were discovered and consisted of the massive species *Montastrea annularis* and *Agaricia spp*. These clusters were often dead and eroded on top with live coral on the surrounding edges, giving the patches a “donut” appearance. At all other shallow sites singular colonies of corals were dispersed across the pavement. Coral species were mainly *Diploria clivosa, D. strigosa, Millepora complanata, Acropora palmata,* and *Montastrea faveolata*. Occasionally, patches of this pavement were broken up by small fissures most likely due to the actions of the sea urchin *Echinometra lucunter* which was abundant throughout the surveyed areas. Other urchin species included clusters of *Diadema antillarum, Echinometra viridis, Eucidaris tribuloides,* and *Tripneustes ventricosus.* The White Encrusting Zoanthid,

P. caribaeorum, and the Coral Encrusting Sponge, *C. langae*, were often found covering rubble or standing dead coral colonies, mainly at the inshore patch reef sites described below.

The pavement substrate was generally covered with a fine layer of sediment and sparsely dispersed clusters of macroalgae. This macroalgae included the brown species *Turbinaria turbinata*, and other brown algae species belonging to the genera *Sargassum*, *Dictyota*, and *Stypopodium*. Other algae included red calcareous algae of the genera *Amphiroa*, and occasionally green algae belonging to the genera *Caulerpa*.

Two large inshore "patch" reefs were also examined, DR0102 and DR0301. These patch reefs were located approximately 200 meters off the sandy beach. Both inshore patch reefs sloped steeply up from the sea floor and were composed of mainly *Porites* spp rubble. Surrounding the patch reefs were areas of sand or seagrass beds of *Thalassia testudinum* and *Syringodium filiforme*. Coral species were dominated by *Millepora complanata, Porites porites,* and *P. astreoides*. Algae species were similar to those found at backreef sites.

3.3.1 Coral

Fifteen coral species were found in the shallow sites (Table 3), with live coral cover ranging from 4.2% - 13.1% with an average cover of 8.1% (Table 4). The inshore patch reef sites, DR0102 and DR0301, had coral cover values that were within the range of the other shallow sites surveyed, 5.0% and 9.0% respectively (Table 3, 4). On average, coral colonies exhibited 21% old mortality and 1% recent mortality at all backreef sites in Punta Cana.

One shallow backreef site was visited in the Babaro region. This site had less than average coral cover compared to Punta Cana shallow sites but was within the general range (Figure 2). The old and recent mortality values were also close to the Punta Cana average (Table 4).

3.3.2 Algae

Trends for algal abundance in shallow sites were similar to those for deep sites, where fleshy macroalgae was more abundant than both calcareous macroalgae and crustose coralline algae (Table 5). The ranges of abundance differed, however, between deep and shallow sites. Fleshy macroalgal abundance for shallow sites in the Punta Cana region ranged from 27% to 58% with an average abundance of 35%. With the exception of the deep site DR0602, this range is less than that for deep sites, which had an average abundance of 51%. Calcareous macroalgal abundance for shallow sites, ranging from 10% to 30% with an average abundance of 18%, was 11 percentage points higher than the deep sites. Similar to calcareous macroalgae, crustose coralline algal abundance, ranging from 4% to 34% with an average abundance of 15%, was higher than that of deeper sites. The shallow Babaro site had algal abundance values that compare to the shallow sites of the Punta Cana region.

3.4 Coral Recruits

Figure 3 shows that species within the genera *Porites* and *Agaricia* were the dominant recruits for all sites surveyed (colonies <5cm in size). These genera are fast growing corals

with high settlement rates (Rogers et al. 1984). Only a few recruits of massive corals were found, including those belonging to the genera *Diploria* and *Siderastrea*. No recruits of the major framework builder *Montastrea* were found. These results support other studies in the Caribbean (Chiappone and Sullivan 1996, Hughes et al. 2000, Miller et al. 2000) where brooding species (i.e., corals with internal fertilization and development; e.g., *Porites spp* and *Agaricia spp*) tend to recruit in greater densities than broadcast-spawning species (i.e., corals with external fertilization; e.g., *Montastrea spp* and *Diploria spp*).

The difference in reproductive modes, particularly the difference in where fertilization and larval-development occurs, has a strong influence on multiple aspects of recruitment for young corals. First, external fertilization by broadcast-spawners may be limiting to some populations, especially when adult densities are relatively low (Yund 2000), as in Punta Cana. With low adult densities, only a percentage of the viable eggs may be fertilized because of limited sperm availability in the water column (Oliver and Babcock 1992, Lasker et al. 1996). Second, larvae of brooding species are capable of settling on reef substrate as soon as released from the parent colony, while broadcast-spawners must develop for a period of 4-7 days after fertilization (Babcock and Heyward 1986), before being capable of settling on the substrate. Therefore, spawned gametes are more susceptible to factors causing mortality (e.g., pollutants, increased UV, etc.) while developing in the water column (Richmond 1997). Because of these factors and others, brooding species, such as *Porites spp* and *Agaricia spp*, are typically found in higher recruit densities than broadcast-spawning species. Although similar patterns have been found in multiple studies throughout the Caribbean and Pacific, questions still remain about the exact causal mechanisms of recruitment limitation in the framework-building, broadcast-spawning species.

3.5 Fish

Average fish density for all forereef sites in the Punta Cana region was 23.2/100m^2 (Table 6). The most common fish encountered were surgeonfish (Acanthuridae) which had a density of 12.9/100m^2 and averaged 12cm in size (Table 7, 8). Parrotfish (Scaridae) were the next most abundant at a density of 5.2/100m^2, averaging 17cm in length. Grunts (Haemilidae), Snapper (Lutjanidae), Grouper (Serranidae), Butterflyfish (Chaetodontidae), and Leatherjackets (Balistidae) were also found but at very low densities. Angelfish were not encountered in surveys of the forereef communities in either of the methods used.

The average density of fish for all shallow sites in the Punta Cana region was 37.5/100m^2 (Table 6). Like the deep forereef sites, Surgeonfish (Acanthuridae) were most abundant with a density of 17.7/100m^2 and an average length of 10cm. Grunt densities were much greater in the shallow sites (9.0/100m^2) compared to deeper sites (0.3/100m^2). These grunts were generally smaller than 10cm indicating that the population was mainly composed of juveniles (Table 6). Densities of other families surveyed were similar to deeper sites. Angelfish were encountered rarely and only in shallow sites at a density of 0.1/100m^2.

Previous studies have both affirmed and denied a relationship between the complexity of coral reef substrates and the abundance and diversity of reef fish assemblages (Lubchenco & Gaines 1981, Williams & Polunin 2001). Rugosity measurements, representing habitat

complexity, were taken during benthic transects (Table 4). As might be expected, shallow sites were less rugose than forereef sites though this did not appear to have an effect on fish abundance.

3.6 Coral Diseases

Black band disease, Dark Spots disease, White Plague disease and an unidentified syndrome were found on coral colonies in the Punta Cana region (Table 9). The prevalence values of the aforementioned syndromes in Punta Cana were low and the pattern was consistent with other areas surveyed in the Caribbean. White Plague disease was the most conspicuous syndrome, and Black band disease only somewhat less so. Similar to the rest of the Caribbean, prevalence of disease was higher for deep sites than for shallow sites (Table 10, Figures 4, 5).

3.6.1 Black Band Disease

Black Band disease is the best characterized syndrome affecting scleractinian corals in the Caribbean today (Green & Bruckner 2000). Cases of Black Band affecting corals have been reported from reefs all over the world. This disease is known to affect several species of corals, most commonly those belonging to the massive reef-building family Faviidae including the genera *Diploria, Montastrea,* and *Colpophyllia.* The disease is characterized by a thick black line that moves across the coral surface leaving in its wake dead white skeleton, which is then rapidly colonized by filamentous algae. The black line consists of a consortium of microbes including cyanobacterium, sulfate-reducing bacteria, and sulfide-oxidizing bacteria. It is thought that the anoxic environment created by the microbes at the base of the black band kills the coral tissue (Richardson et al. 1997).

Black Band disease was only seen in the shallow backreef environments of Punta Cana (Table 10). A total of two affected colonies were found (Table 9). There were no cases of black band recorded either in transects or qualitatively for forereef deep sites. At the popular dive and snorkel site El Acuario (DR0601) three active infections of Black Band disease were noted on colonies within one 200 meter^2 area but were not recorded in transects. Here, two *Diploria clivosa* and one *D. strigosa* colonies were affected. These colonies were all between 30 and 60 centimeters in diameter and had experienced approximately 10-50% mortality due to the Black Band infections. These diseased colonies were found located in the shallow pavement area in approximately 1-2 meters of water.

3.6.2 White Plague Disease

To date, there are three types of syndromes affecting hard corals in the Caribbean that are named White Plague. The first white plague syndrome identified was White Plague Type I in the Florida Keys (Dustan 1977). In 1995, a similar condition was noted to be affecting corals at a more rapid pace and was identified as White Plague Type II (Richardson et al. 1998). Most recently, in 1999, White Plague Type III was identified to have the fastest rate yet (Richardson et al. 2000). All three types of plague are characterized by the loss of coral tissue resulting in a distinct line between healthy tissue and dead white skeleton. Only White

Plague Type II has been characterized past the initial qualitative descriptions. This disease has been associated with the bacterial pathogen, *Aurantimonas coralicida* (http://www.coral.noaa.gov/coral_disease/). The defining characteristic of these different plague types is their rate of progression across the colony. Because of this, it is impossible to distinguish between types when performing a rapid survey because the individual corals must be examined over time. Therefore, all colonies exhibiting the signs of White plague are labeled as such and not further distinguished.

White Plague exhibited the highest prevalence of any disease identified in Punta Cana (Table 9). Affected colonies were noted in both shallow and deep environments though levels were higher for deeper sites (Table 10). Compared to the Caribbean at large, the levels of White Plague for Punta Cana were slightly elevated for both deep and shallow sites, and when sites at all depths were combined (Table 10). Twelve corals in the Punta Cana region and one coral in the Babaro region exhibited signs consistent with those described for the White Plague diseases (Table 9).

3.6.3 Dark Spots

This syndrome is not well characterized though it is widespread in the Caribbean. It is identified by areas of tissue on the coral colony which appear much darker than the surrounding tissue. The dark tissue itself is not lost and coral colonies have been documented to recover from this condition. No pathogen has been isolated for this syndrome.

Five cases of Dark Spots in the Punta Cana region and one case in the Babaro region was recorded in transects counts (Table 10). Although overall prevalence and average site prevalence values were both seemingly low they were higher than that recorded for the rest of the Caribbean region (Table 9 and 10).

3.6.4 *Acropora palmata* lesions

Of the thirteen sites surveyed, two backreef and two forereef sites (each site approximately 100m^2) had colonies of *A. palmata* that exhibited unusual signs similar to those described for calicoblastic epitheliomas by Peters et al. (1986). These signs included raised white irregular areas of skeleton that displayed no corallite structure and varied in size from approximately 1cm to 10cm. Similar small bumps of smooth white skeleton appeared on the underside of colony branches. Areas were also observed where algae had colonized the central portions and the raised white skeleton was found only on the edges. Regions such as this could be as large as 25cm and extend to the underside of the colony branch. Live tissue next to these raised areas exhibited normal corallite structure and color. In general, only 10-20% of the coral colony displayed these signs though in the most dramatic case, every branch of the colony exhibited signs (Photo 1). Personal communication with Esther Peters and others has indicated that this condition is most likely not the same condition as described in Peters et al. (1986); however, it is similar in that is appears to affect the normal structure and growth of the corallites (Photos 1-3). Examples of healthy colonies observed are in Photos 4 and 5.

The two northernmost sites surveyed in the Punta Cana area, DR0501 and DR0502, had the greatest number of colonies displaying these signs per site. Two other more southern and down-current sites, DR0302 and DR0401, one of the southernmost sites surveyed, had a lower number of *A. palmata* colonies in general and only one or two colonies exhibited the white bumps. DR0401 and DR0502 are separated by a distance of approximately 11.4 km.

4. Discussion

4.2 Comparison to past studies

Past studies to assess the condition of the Punta Cana coral reefs have had varying results. Silva and Battle (1994) reported between 4 and 19 coral species identified at each of ten different sites visited. Our survey reported 14 species in the solid forereef zone, 17 in the backreef zone, and 23 for the spur and groove zone. Similarly, Silva and Battle identified 19 to 43 different fish species at their sites while our survey found 17 to 30 species.

Burr in 2002 used a modified AGRRA methodology to assess four different sites in the Punta Cana region including El Acuario. He reported coral cover values of 4 – 29% with an average of 17% for sites within a comparable depth range to our own. Our results show a range of 4 – 17% and an average of 9% for shallow and deep sites (0.5 – 7.5m depth) in the Punta Cana region. Macroalgal abundance for Burr's sites ranged from 64-92% with an average of 79%. Macroalgal abundance recorded in the present study ranged from 11-71% with an average of 44%. These discrepancies in macroalgal abundance are probably due to differences in methodology. We divided our macroalgae into fleshy and calcareous and estimated using quadrats while Burr used transects and evaluated only "macroalgae." Even if the fleshy and calcareous categories are combined -- 37 -71% with an average of 55% -- our range for macroalgal abundance is still lower than Burr's results.

4.3 Comparison to Caribbean

4.3.1 Coral

Values of live coral cover from the Punta Cana region are low relative to values from other regions surveyed in the Caribbean. Live coral cover for deep sites ranged from 9.4% to 55.5% with an average of 22% (Figure 6). Only Cuba, surveyed in 2001, had a lower value than Punta Cana. Live coral cover for shallow sites ranged from 6.0% to 37.9% with an average of 18.3% (Figure 7). Again, only one country, Jamaica, had a lower value than Punta Cana.

Comparisons of coral recruitment across the Caribbean are shown in Figure 8. Although Punta Cana is positioned towards the middle, its value is less than average.

4.3.2 Fish

Figures 9, 11, 13, 15, 17, and 19 show herbivore, carnivore, and total fish densities for shallow and deep Punta Cana sites compared to other Caribbean values while Figures 10, 12,

14, 16, 18, and 20 compare biomass averages. Herbivores include species from the families Scaridae (Parrotfish) and Acanthuridae (Surgeonfish) as well as the *Microspathodon chrysurus* (Yellowtail damselfish). Carnivores include species from the families Haemilidae (Grunt), Lutjanidae (Snapper) and Serranidae (Grouper).

Punta Cana is among the lowest values for total average fish density in deep sites (Figure 9). Punta Cana's fish biomass is considerably lower than average and is the third lowest value in the Caribbean (Figure 10). A similar situation is seen with average herbivore densities and biomass (Figures 11 and 12) as well as average carnivore density and biomass (Figures 13 and 14).

The situation in the shallow environment was similar. Total fish density and biomass for Punta Cana were lower than average (Figures 15 and 16). Average herbivore density and biomass were lower than average and among the lowest values (Figures 17 and 18). Average carnivore density, however, was one of the highest values recorded for the Caribbean (Figure 19). Yet when the biomass average is examined it is also lower than average (Figure 20). This implies that, although carnivore densities were high in shallow sites, they consisted mostly of small individuals.

4.4 Fishing activities

Average values of fish density, biomass and size for the Punta Cana region were surprisingly low compared to other regions of the Caribbean. Fish densities and biomass values for Punta Cana are similar to Jamaica. Overfishing in Jamaica is widely documented (Koslow et al. 1988, Hughes 1994). Punta Cana's similarity to this country could be indicative of a similar situation. From discussions with local residents, spearfishing appears to be severe and widespread. A video taken by a local dive operator of a spearfisherman revealed that even the smallest members of almost all fish families are taken. Families we observed to be taken on the video included Haemulidae (Grunt), Lutjanidae (Snapper), Acanthuridae (Surgeonfish), Scaridae (Parrotfish), and Serranidae (Grouper), as well as Pomacanthidae (Angelfish), Carangidae (Jack), Balistidae (Leatherjacket), and even Ostraciidae (Boxfish). On the second day of surveying, we observed fishermen using hooka while spearfishing.

4.5 DR0602

This site was unusual in its algal composition and coral cover values. Live coral cover, calcareous algal abundance, and crustose coralline algal abundance were some of the highest values recorded. Meanwhile fleshy macroalgal abundance was much lower than any other site (Table 4). This is in contrast to the general trend of the other forereef sites where abundance and composition of algae were dominated by large canopy-forming brown algae (fleshy macroalgae) including species belonging to *Sargassum* and *Turbinaria.* Studies of algal succession have shown that these species are characteristic of a climax community where there is low herbivory by fish (McClanahan 1997). Other studies have described a strong positive correlation between crustose abundance and fish biomass and a strong negative correlation between fleshy macro algal abundance and fish biomass (Lubchenco & Gaines 1981, Williams & Polunin 2001). Also, in previous studies, calcareous algae have

shown resistance to herbivory through antipredatory defenses (Lubchenco & Gaines 1981, Littler et al. 1983).

Though the algal abundance and composition would suggest a higher level of herbivorous fish compared to all other sites, the results of the fish survey do not reveal a large difference between fish biomass levels for DR0602 and other deep sites (Table 6). However, it is noteworthy that the values for fish biomass are the second largest for deep sites and that it has the highest diversity of species for any site (Table 6). Qualitatively, we felt this site had a much more complex and abundant fish assemblage than any other site.

The significant differences in algae composition and abundance and the elevated fish biomass and diversity values may indicate that this site is less impacted by fishing activities. Our guides pointed out that the area was frequented by the resort diving operations and that fishermen tended to avoid it for this reason.

4.6 *Acropora palmata* populations

The last two decades of the 20th Century saw a drastic decline in populations of *Acropora palmata* and *A. cervicornis,* two important branching corals that once dominated the shallow and intermediately deep reefs of the Caribbean. During that time, these species were severely affected by White Band disease, a syndrome which has yet to be associated with a known pathogen. This disease appears as a white band that moves up the coral colony from the base leaving dead skeleton in its path. In some areas, nearly 95% of *Acropora* were lost (Precht et al. 2002). These species contribute to the development of the reef framework as well as provide habitat for a diversity of fish and other organisms. Our surveys in the Punta Cana region revealed a sparse, though, in general, healthy population of *A. palmata*. *A. cervicornis* was only noted at 3 sites surveyed and no colonies were recorded in transects. *A. palmata* individuals were noted at every site surveyed, often contributing substantially to the coral cover recorded. Individuals ranged in size from small recruits (2-3cm) to large colonies that spanned nearly 3 meters in diameter (Photos 4 and 5). There was no White Band disease identified at any of the sites surveyed. With the exception of the unidentified syndrome described previously affecting a small portion of the population, no other condition was observed.

4.7 *Diadema antillarum* populations

Between 1983 and 1984, *Diadema antillarum* populations in the Caribbean saw a reduction of over 97% because of mortality due to an unidentified pathogen (Lessios 1995). The effects of the loss of this important herbivore to coral reefs of the Caribbean have been drastic in some areas, especially those already facing problems associated with overfishing (Hughes 1994). Only recently have recoveries in populations been documented (Miller et al. 2003). The results of our survey indicate that there is a small population of *D. antillarum* in Punta Cana. Densities of *D. antillarum* varied from 0 – 5.4% (Table 4). The average density was higher for the forereef zone than the backreef zone, 1.6% versus 0.5% respectively. Individuals were noted at all but five sites.

5. Summary and Recommendations

5.2 Coral Cover

Summary: Recent reports have indicated a Caribbean-wide decline in coral cover due to human activities (Gardner et al. 2003). It is noteworthy that when compared to 19 other shallow surveys and 29 other deep surveys across the Caribbean both deep and shallow values for Punta Cana are second to lowest. Though it is impossible to say based on this brief survey, the well developed structure of the reef suggests that this has not always been the case.

Recommendation: Reef building corals are susceptible to many human activities including eutrophication (i.e. excess nutrients due to runoff), sedimentation (e.g. from land development), and direct impacts (e.g. damage from anchors, contact with divers and fishermen). Limiting or avoiding these activities when possible could have a positive influence on coral cover. Installation and maintenance of a system of moorings and briefing of divers before allowing them in the water are two methods that have been effective for mitigating diver and fishing impacts.

5.3 Fishing activities

Summary: When compared with 15 other countries/regions in the AGRRA database, Punta Cana has some of the lowest recorded fish density and biomass values. Overfishing is likely responsible. Algae abundance and composition indicate a lack of herbivores. Coral cover values were second to lowest in the Caribbean, also a significant find, and it indicates that the Punta Cana reef ecosystem may be in serious trouble.

Recommendation: It is recommended that action be taken to limit fishing through effective management and enforcement.

5.4 Juanillo (DR0401, 0402, and 0403)

Summary: Development at this area has just begun within the past year. It will result in the extensive alteration of the coastline and increased recreational use of the offshore natural resources through diving, boating, waterskiing, etc.

Recommendation: Long term monitoring sites should be established to track changes in the benthic and fish communities both in the shallow backreef and deep forereef zones. Sites surveyed in the present study could be used for these sites and provide baseline data for future studies.

5.5 El Acuario (DR0602)

Summary: Coral cover at this site was among the highest in the sites surveyed, with a more complex assemblage of fish species present.

Recommendation: The placement of regularly maintained moorings could be used to protect against anchor damages from diving operations. In addition, long term monitoring of fish densities and coral cover that could be used to compare to more degraded areas.

5.6 *Diadema antillarum* population

Summary: Although we cannot determine whether the population of *D. antillarum* in Punta Cana is a new phenomenon or if it has existed for some time, the species was present at nearly every site.

Recommendation: Investigation of the impacts of this population on the reef environment of Punta Cana, specifically concerning algal/coral grazing, should be undertaken.

NCORE would like to thank Mr. Ted Kheel for his generosity in providing for the team's housing and boat support. Mr. Manolo Despradel was a significant source of excellent local information on the distribution of coral reefs throughout the area. This information was vital to our work.

NCORE Survey Team:
Marilyn Brandt
Wade Cooper
Cara Dickman
Johnathan Kool
Johanna Polsenberg, Ph.D.

References

Babcock R.C., and A.J. Heyward. 1986. Larval development of certain gamete-spawning scleractinian corals. Coral Reefs 5:111-116.

Burr, S.A. 2002. A baseline survey of scleractinian coral cover and species abundance on Punta Cana Reef, Dominican Republic. A report of Cornell University.

Chiappone, M., and K. M. Sullivan. 1996. Distribution, abundance and species composition of juvenile scleractinian corals in the Florida Reef Tract. Bulletin of Marine Science 58:555-569.

Dustan, P. 1977. Vitality of reef coral populations off Key Largo, Florida: Recruitment and mortality. Env. Geol. 2: 51-58.

Gardner, T.A., Cote, I.M., Gill, J.A., Grant, A., and A.R. Watkinson. 2003. Long-term region-wide declines in Caribbean corals. Science 301: 958-960.

Green, E.P. and A.W. Bruckner. 2000. The significance of coral disease epizootiology for coral reef conservation. Biological Conservation 96(3): 347-361.

Hughes, T.P. 1994. Catastrophes, Phase Shifts, and Large-Scale Degradation of a Caribbean Coral Reef. Science 265 (5178): 1547-1551.

Hughes, T. P., and J. E. Tanner. 2000. Recruitment failure, life histories, and long-term decline of Caribbean corals. Ecology 81:2250-2263.

Koslow, J.A., Hanley, F. and R. Wicklund. 1988. Effects of fishing on reef fish communities at Pedro Bank and Port Royal Cays, Jamaica. Mar. Eco. Prog. Ser. 43 (3): 201-212.

Lasker, H. R., D. A. Brazeau, J. Calderon, M. A. Coffroth, R. Coma, and K. Kim. 1996. In situ rates of fertilization among broadcast spawning gorgonian corals. Biological Bulletin 190:45-55.

Little, M.M., Taylor, P.R., and D.S. Littler. 1983. Algal resistance to herbivory on a Caribbean Barrier Reef. Coral Reefs 2: 111-118.

Lubchenco, J. and S.D. Gaines. 1981. A unified approach to marine plant-herbivore interactions. I. Populations and communities. Ann. Rev. Ecol. Syst 12: 405-437.

McClanahan, T.R. 1997. Primary succession of coral-reef algae: Differing pattern on fished versus unfished reefs. J. Exp. Mar. Bio. Eco. 218: 77-102.

Miller, M. W., E. Weil, and A. M. Szmant. 2000. Coral recruitment and juvenile mortality as structuring factors for reef benthic communities in Biscayne National Park, USA. Coral Reefs 19:115-123.

Oliver, J., and R. Babcock. 1992. Aspects of the Fertilization Ecology of Broadcast Spawning Corals - Sperm Dilution Effects and Insitu Measurements of Fertilization. Biological Bulletin 183:409-417.

Peters, E.C., Halas, J.C., and H.B. McCarty. 1986. Calicoblastic neoplasms in *Acropora palmata*, with a review of reports on anomalies of growth and form in corals. J Natl Cancer Inst 76 (5): 895-912.

Richardson, L.L., Kuta, K.G., Schnell, S., and R.G. Carlton. 1997. Ecology of the black band disease microbial consortium. Proc. 8th Int. Coral Reef Symp. 1: 597-600.

Richardson. L.L., Goldberg, W.M., Carlton, R.G. and J.C. Halas. 1998. Coral disease outbreak in the Florida Keys: Plague Type II. Rev. Bio. Trop. 46: 187-198.

Richardson, L.L. 2000. Coral Epidemiology. Opportunities for Environmental Applications of Marine Biotechnology; Proceedings of the October 5-6, 1999 Workshop: 85.

Richmond, R.H. 1997. Reproduction and recruitment in corals: critical links in the persistence of reefs. Pp. 175-197 in (C. Birkland, ed.) Life and death of coral reefs. Chapman and Hall, New York, USA

Rogers, C.S., Fitz, H.C. III, Gilnack, M., Beets, J., and J. Hardin. 1984. Scleractinian coral recruitment patterns at Salt River Submarine Canyon, St. Croix, U.S. Virgin Islands. Coral Reefs 3: 69-76.

Silva, R. and O. Batlle. 1994. Rapid ecological assessment and reef characterization; Punta Cana, Dominican Republic. A report of La Fundacion Ecologica de Punta Cana.

Williams, I.D. and N.V.C. Polunin. 2001. Large-scale associations between macroalgal cover and grazer biomass on mid-depth reefs in the Caribbean. Coral Reefs 19: 358-366.

Table 1 – Site Descriptions

Region	Date	Site	Depth	Latitude / Longitude	Reef Type
Punta Cana	8/20/2003	DR0101	S	N18°32.018, W68°21.066	Shallow backreef
Punta Cana	8/20/2003	DR0102	S	N18°31.780, W68°21.514	Inshore patch reef
Punta Cana	8/20/2003	DR0103	D	N18°31.980, W68°20.863	Offshore spur and groove
Babaro	8/21/2003	DR0201	S	N18°40.642, W68°23.909	Shallow backreef
Babaro	8/21/2003	DR0202	D	N18°40.928, W68°23.668	Offshore spur and groove
Babaro	8/21/2003	DR0203	D	N18°39.549, W68°20.749	Offshore spur and groove
Punta Cana	8/22/2003	DR0301	S	N18°30.865, W68°22.029	Inshore patch reef
Punta Cana	8/22/2003	DR0302	D	N18°31.305, W68°21.272	Offshore spur and groove
Punta Cana	8/22/2003	DR0303	D	N18°30.367, W68°21.779	Offshore spur and groove
Punta Cana	8/23/2003	DR0401	S	N18°28.571, W68°23.220	Shallow backreef
Punta Cana	8/23/2003	DR0402	D	N18°28.257, W68°23.192	Offshore spur and groove
Punta Cana	8/23/2003	DR0403	D	N18°27.783, W68°23.440	Offshore spur and groove
Punta Cana	8/24/2003	DR0501	S	N18°33.330, W68°20.565	Shallow backreef
Punta Cana	8/24/2003	DR0502	D	N18°32.995, W68°20.567	Offshore spur and groove
Punta Cana	8/25/2003	DR0601	S	N18°32.349, W68°20.888	Shallow backreef
Punta Cana	8/25/2003	DR0602	D	N18°32.256, W68°20.747	Offshore solid forereef
Additional points of reference					
Punta Cana		Dive Shop	-	N18°30.595, W68°22.244	--
Punta Cana		Marina	-	N18°30.224, W68°22.549	--

Table 2 – Common and scientific names for all fish species counted using Method I of the AGRRA fish surveys.

Common Name	Scientific Name	Common Name	Scientific Name
Angelfishes		***Groupers***	
Queen	*Holacanthus ciliaris*	Rock Hind	*Epinephelus adscensionis*
Rock Beauty	*Holacanthus tricolor*	Graysby	*Epinephelus cruentatus*
Gray	*Pomacanthus arcuatus*	Coney	*Epinephelus fulvus*
French	*Pomacanthus paru*	Red hind	*Epinephelus guttatus*
Butterflyfishes		Nassau	*Epinephelus striatus*
Longsnout	*Chaetodon aculeatus*	Black	*Mycteroperca bonaci*
Foureye	*Chaetodon capistratus*	Yellowmouth	*Mycteroperca interstitialis*
Spotfin	*Chaetodon ocellatus*	Tiger	*Mycteroperca tigris*
Reef	*Chaetodon sedentarius*	Yellowfin	*Mycteroperca venenosa*
Banded	*Chaetodon striatus*	***Snappers***	
Grunts		Mutton	*Lutjanus analis*
Black Margate	*Anisotremus surinamensis*	Schoolmaster	*Lutjanus apodus*
Porkfish	*Anisotremus virginicus*	Cubera	*Lutjanus cyanopterus*
White Margate	*Haemulon album*	Gray	*Lutjanus griseus*
Tomtate	*Haemulon aurolineatum*	Dog	*Lutjanus jocu*
Caesar	*Haemulon carbonarium*	Mahogany	*Lutjanus mahogoni*
Smallmouth	*Haemulon chrysargyreum*	Lane	*Lutjanus synagris*
French	*Haemulon flavolineatum*	Yellowtail	*Ocyurus chrysurus*
Spanish	*Haemulon macrostomum*	***Surgeonfishes***	
Sailors choice	*Haemulon parra*	Ocean	*Acanthurus bahianus*
White	*Haemulon plumieri*	Doctorfish	*Acanthurus chirurgus*
Bluestriped	*Haemulon sciurus*	Blue Tang	*Acanthurus coeruleus*
Parrotfishes		***Leatherjacket***	
Midnight	*Scarus coelestinus*	Scrawled Filefish	*Aluterus scriptus*
Blue	*Scarus coeruleus*	Queen triggerfish	*Balistes vetula*
Striped	*Scarus croicensis*	Whitespotted filefish	*Cantherhines macroceros*
Rainbow	*Scarus guacamaia*	Orangespotted filefish	*Cantherhines pullus*
Princess	*Scarus taeniopterus*	Ocean triggerfish	*Canthidermis sufflamen*
Queen	*Scarus vetula*	Black Durgon	*Melichthys niger*
Greenblotch	*Sparisoma atomarium*	Sargassum triggerfish	*Xanthichthys ringens*
Redband	*Sparisoma aurofrenatum*	***Other fishes***	
Redtail	*Sparisoma chrysopterum*	Spanish Hogfish	*Bodianus rufus*
Redfin	*Sparisoma rubripinne*	Bar Jack	*Caranx ruber*
Stoplight	*Sparisoma viride*	Hogfish	*Lachnolaimus maximus*
		Yellowtail Damselfish	*Microspathodon chrysurus*
		Great Barracuda	*Sphyraena barracuda*

Table 3 – Coral Species Lists

Species	Spur and Groove	Solid Forereef	Backreef	Inshore Patch Reef
Acropora cervicornis	rare		rare	
Acropora palmata	many	rare	many	rare
Agaricia agaracites	few	rare	few	rare
Agaricia humilis	rare			
Agaricia lamarcki				
Agaricia tenuifolia	many	many	rare	
Colpophyllia natans	rare	rare		
Dichocoenia stokesii	many			
Diploria clivosa	few		many	
Diploria labrynthiformis	rare			
Diploria strigosa	abundant	rare	abundant	rare
Eusmilia fastigiata	rare			
Favia fragum	rare	rare		
Isophyllastrea rigida	rare			
Isophyllia sinuosa				
Leptoseris cucullata	rare	rare		
Madracis decactis				
Madracis mirabilis				
Madracis pharensis				
Manicina areolata				
Meandrina meandrites				
Millepora alcicornis				
Millepora complanata	many	rare	many	few
Montastraea annularis			rare	
Montastraea cavernosa	few	rare	few	few
Montastraea faveolata	many	few	rare	
Montastraea franksi				
Mussa angulosa				
Mycetophyllia danae				
Mycetophyllia ferox				
Mycetophyllia lamarckiana	rare	rare	rare	
Porites astreoides	many	rare	abundant	many
Porites branneri	rare			
Porites porites	rare	rare	many	many
Porites divariacata			few	
Porites furcata			rare	
Siderastrea radians	few		rare	
Siderastrea siderea	many	rare	rare	
Solenastrea bournoni				
Stephanocoenia intersepta				
Unknown species				
TOTAL	23	14	17	7

rare	<=5
few	5< <=15
many	15< <=30
abundant	>30

Table 4 – Coral Summary

Region	Site	S/D	% Live Coral Cover	±	Avg. Diameter (cm)	±	Avg. Height (cm)	±	% Old mortality	±	% Recent mortality	±	Diadema (#/10m2)	Rugosity (cm)	Recruits (#/m2)
PuntaCana	DR0103	D	8.2	6.9	36.9	27.4	21.6	17.4	11	19	2	4	1.3	62	1.60
PuntaCana	DR0302	D	6.7	4.1	63.0	64.7	47.8	53.4	30	41	2	9	5.4	47	0.00
PuntaCana	DR0303	D	7.2	3.8	44.7	64.9	26.4	41.4	12	23	6	23	1.0	49	0.60
PuntaCana	DR0402	D	7.3	5.4	33.9	37.5	21.5	25.5	16	25	6	21	0.2	46	1.28
PuntaCana	DR0403	D	7.7	3.3	30.1	32.2	19.0	18.4	10	21	2	9	0.2	28	1.28
PuntaCana	DR0502	D	16.9	4.4	68.1	55.5	34.6	28.8	11	18	2	5	0.0	49	1.92
PuntaCana	DR0602	D	13.7	8.2	43.0	52.4	23.3	28.9	18	28	2	7	2.8	44	1.28
PuntaCana	DR0101	S	8.5	5.0	33.1	60.0	16.6	20.7	14	23	0	0	0.0	27	3.84
PuntaCana	DR0102	S	5.0	2.1	47.8	51.7	28.5	26.2	28	36	0	0	0.0	31	4.80
PuntaCana	DR0301	S	9.0	5.3	28.3	24.3	15.5	7.1	30	29	0	0	0.0	14	0.00
PuntaCana	DR0401	S	4.2	1.1	37.0	43.1	18.1	24.6	22	33	2	10	1.6	22	3.20
PuntaCana	DR0501	S	9.0	0.9	40.1	31.3	20.6	15.1	18	25	1	3	0.4	14	0.00
PuntaCana	DR0601	S	13.1	7.8	58.4	53.3	23.5	20.1	15	26	1	3	0.8	16	3.20
Babaro	DR0201	S	5.6	3.2	34.5	29.4	25.6	22.4	29	30	0	0	0.6	34	0.64
Babaro	DR0202	D	4.5	1.7	23.9	22.4	13.5	15.2	7	19	3	18	0.2	68	1.28
Babaro	DR0203	D	3.3	1.7	20.3	17.1	9.6	9.9	4	10	0	0	0.0	18	0.00
Average all			8.1	3.7	40.2	13.6	22.8	9.0	17	8	2	2	0.9	36	1.56
Average Deep			8.4	4.3	40.4	16.3	24.1	11.4	13	8	3	2	1.2	46	1.03
Average Deep (Punta Cana only)			9.7	4.0	45.7	14.5	27.7	10.2	15	7	3	2	1.6	46	1.14
Average Shallow			7.8	3.1	39.9	10.2	21.2	4.9	22	7	1	1	0.5	23	2.24
Average Shallow (Punta Cana only)			8.1	3.2	40.8	10.8	20.5	4.9	21	6	1	1	0.5	21	2.51
Average Punta Cana			9.0	3.6	43.4	12.7	24.4	8.7	18	7	2	2	1.0	35	1.77
Average Babaro			4.5	1.2	26.2	7.3	16.2	8.4	13	14	1	2	0.3	40	0.64
Pooled															
Deep			8.4	6.0	40.8	47.9	24.3	31.1	14	25	3	13	5.0	1	1.02
Shallow			7.7	4.7	37.5	41.8	20.1	19.3	23	29	1	4	3.2	0	2.13
All			8.1	5.4	39.4	45.5	22.6	27.0	17	27	2	11	4.1	1	1.50
Deep - Punta Cana			9.7	6.2	44.9	51.2	27.0	33.2	15	26	3	13	4.4	2	1.10
Shallow - Punta Cana			8.0	4.8	38.0	43.6	19.2	18.6	22	29	1	4	3.4	0	2.40
All - Punta Cana			9.0	5.6	42.0	48.2	23.7	28.2	18	28	2	11	3.9	1	1.90

Table 5 – Algae Summary

Region	Site	S/D	% Crustose	±	% Fleshy Macro	±	% Calc Macro	±	Fleshy Macro Hgt (cm)	±	Calc Macro Hgt (cm)	±
PuntaCana	DR0103	D	33	38	62	37	1	3	5.2	3.2	2.8	1.5
PuntaCana	DR0302	D	24	31	68	34	3	6	4.7	1.7	2.4	1.2
PuntaCana	DR0303	D	25	34	71	33	0	1	4.9	1.9	1.7	0.6
PuntaCana	DR0402	D	44	38	48	34	5	12	7.7	5.4	3.8	1.0
PuntaCana	DR0403	D	49	37	44	33	1	2	7.8	4.2	1.7	0.5
PuntaCana	DR0502	D	31	35	53	35	6	20	4.6	1.8	2.3	0.8
PuntaCana	DR0602	D	51	33	11	14	32	29	3.6	2.2	3.7	2.2
PuntaCana	DR0101	S	4	10	31	24	18	24	8.4	3.9	3.5	1.6
PuntaCana	DR0102	S	17	23	33	30	30	26	1.8	1.5	2.2	0.7
PuntaCana	DR0301	S	34	29	27	23	24	22	5.6	2.0	3.1	3.0
PuntaCana	DR0401	S	22	30	35	27	12	18	8.2	2.3	4.1	1.7
PuntaCana	DR0501	S	5	8	58	19	12	9	8.6	2.0	4.7	0.8
PuntaCana	DR0601	S	10	22	27	17	10	8	5.6	1.9	3.6	1.1
Babaro	DR0201	S	12	20	56	28	9	9	5.8	2.2	4.7	2.8
Babaro	DR0202	D	46	38	43	36	5	9	4.6	2.4	2.3	0.8
Babaro	DR0203	D	18	16	71	18	1	2	9.9	3.4	3.0	0.7
Average all			26	15	46	18	11	10	6.1	2.2	3.1	1.0
Average Deep			36	12	52	19	6	10	5.9	2.1	2.6	0.8
Average Deep (Punta Cana only)			37	11	51	20	7	11	5.5	1.6	2.6	0.8
Average Shallow			15	11	38	13	16	8	6.3	2.4	3.7	0.9
Average Shallow (Punta Cana only)			15	11	35	12	18	8	6.4	3	3.5	1
Average Punta Cana			27	15	44	18	12	11	5.9	2	3.0	1
Average Babaro			25	18	57	14	5	4	6.8	3	3.3	1
Pooled												
Deep			36	35	52	36	6	16	6.1	3.7	2.7	1.5
Shallow			15	23	38	27	16	19	6.5	3.2	3.7	2.0
All			27	32	46	33	10	18	6.2	3.5	3.3	1.9
Deep - Punta Cana			37	36	51	37	7	18	5.6	3.5	2.8	1.6
Shallow - Punta Cana			16	24	35	26	17	20	6.6	3.3	3.5	1.9
All - Punta Cana			27	33	44	33	12	19	6.1	3.5	3.3	1.8

Table 6 – Fish Summary

Region	Site	S/D	# Species	# Individuals	Density (#/100m2)	Average Biomass (g/100m2)
PuntaCana	DR0103	D	18	80	13.3	1254
PuntaCana	DR0302	D	23	139	23.2	1948
PuntaCana	DR0303	D	18	144	24.0	1652
PuntaCana	DR0402	D	20	130	21.7	1604
PuntaCana	DR0403	D	19	235	39.2	3262
PuntaCana	DR0502	D	23	100	16.7	1549
PuntaCana	DR0602	D	30	145	24.2	2378
PuntaCana	DR0101	S	22	159	26.5	1524
PuntaCana	DR0102	S	29	347	57.8	4461
PuntaCana	DR0301	S	19	425	70.8	3359
PuntaCana	DR0401	S	21	131	21.8	1300
PuntaCana	DR0501	S	23	83	13.8	530
PuntaCana	DR0601	S	22	164	34.2	2136
Babaro	DR0201	S	22	131	21.8	1166
Babaro	DR0202	D	27	178	29.7	3319
Babaro	DR0203	D	17	166	27.7	1344
Average			22	172	29.1	2049
Average Deep			22	146	24.4	2034
Average Deep Punta Cana			22	139	23.2	1950
Average Shallow			23	206	35.3	2068
Average Shallow Punta Cana			23	218	37.5	2218

Table 7 – Fish densities by family and trophic group

Density (#/100m2)													
Region	**Site**	**S/D**	***Surgeon***	***Parrot***	***Grunt***	***Snapper***	***Grouper***	***Angel***	***Butterfly***	***Leather-jacket***	***Other***	***Herbivore***	***Carnivores***
PuntaCana	DR0103	D	8.3	2.5	0.5	0.0	0.5	0.0	0.0	0.0	1.5	11.2	1.0
PuntaCana	DR0302	D	9.7	8.0	0.2	0.3	0.3	0.0	0.0	0.3	4.3	19.3	0.8
PuntaCana	DR0303	D	9.5	9.8	0.3	0.0	0.3	0.0	0.0	0.2	3.8	20.5	0.7
PuntaCana	DR0402	D	11.5	7.0	0.3	0.0	0.0	0.0	0.0	0.2	2.7	19.3	0.3
PuntaCana	DR0403	D	27.5	4.5	0.3	0.0	0.2	0.0	0.2	2.2	4.3	37.0	0.5
PuntaCana	DR0502	D	10.8	1.2	0.5	0.0	0.3	0.0	0.0	1.0	2.8	13.0	0.8
PuntaCana	DR0602	D	13.0	3.7	0.0	0.0	0.5	0.0	0.3	0.7	6.0	18.0	0.5
PuntaCana	DR0101	S	12.7	12.3	0.5	0.7	0.0	0.0	0.0	0.0	0.3	29.0	1.2
PuntaCana	DR0102	S	16.8	14.5	16.8	6.2	0.0	0.5	1.3	0.0	1.7	34.7	23.0
PuntaCana	DR0301	S	22.2	17.0	27.7	1.3	0.0	0.0	0.7	0.0	2.0	40.0	29.0
PuntaCana	DR0401	S	20.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.8	23.2	0.0
PuntaCana	DR0501	S	12.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	17.5	0.0
PuntaCana	DR0601	S	21.0	2.3	8.8	0.6	0.6	0.0	0.0	0.2	0.6	23.5	10.0
Babaro	DR0201	S	15.5	4.2	0.5	0.0	0.2	0.0	0.7	0.0	0.8	25.5	0.7
Babaro	DR0202	D	6.5	14.2	3.2	0.0	0.2	0.0	0.0	0.0	5.7	23.0	3.3
Babaro	DR0203	D	24.3	1.3	0.2	0.0	0.3	0.0	0.3	0.0	1.2	26.1	0.5
Average			15.2	6.5	3.7	0.6	0.2	0.0	0.2	0.3	2.4	23.8	4.5
Average Deep			13.5	5.8	0.6	0.0	0.3	0.0	0.1	0.5	3.6	20.8	0.9
Average Deep (Punta Cana only)			12.9	5.2	0.3	0.0	0.3	0.0	0.1	0.6	3.6	19.8	0.7
Average Shallow			17.4	7.4	7.8	1.3	0.1	0.1	0.4	0.0	0.9	27.6	9.1
Average Shallow (Punta Cana only)			17.7	7.9	9.0	1.5	0.1	0.1	0.3	0.0	1.0	28.0	10.5

Table 8 – Average fish size by family and trophic group

Average Size (cm)													
Region	**Site**	**S/D**	***Surgeon***	***Parrot***	***Grunt***	***Snapper***	***Grouper***	***Angel***	***Butterfly***	***Leather-jacket***	***Other***	***Herbivore***	***Carnivores***
PuntaCana	DR0103	D	12	16	26	0	16	0	0	0	16	40	41
PuntaCana	DR0302	D	12	15	26	26	26	0	0	17	15	43	77
PuntaCana	DR0303	D	12	14	21	0	16	0	0	8	14	40	36
PuntaCana	DR0402	D	9	19	26	0	0	0	0	16	15	42	26
PuntaCana	DR0403	D	11	17	21	0	26	0	8	18	13	42	46
PuntaCana	DR0502	D	14	20	19	0	26	0	0	16	16	46	44
PuntaCana	DR0602	D	13	18	0	0	19	0	16	12	13	42	19
PuntaCana	DR0101	S	11	12	16	16	0	0	0	0	12	39	31
PuntaCana	DR0102	S	8	12	18	14	0	26	4	0	15	35	31
PuntaCana	DR0301	S	7	12	10	15	0	0	5	0	13	34	24
PuntaCana	DR0401	S	12	17	0	0	0	0	0	0	15	43	0
PuntaCana	DR0501	S	9	9	0	0	0	0	0	0	17	31	0
PuntaCana	DR0601	S	11	16	16	16	16	0	0	8	16	35	47
Babaro	DR0201	S	7	14	16	0	16	0	8	0	15	34	31
Babaro	DR0202	D	10	18	19	0	16	0	0	0	15	43	34
Babaro	DR0203	D	8	17	16	0	21	0	8	0	13	37	36
Average			10	15	15	5	12	2	3	6	14	39	33
Average Deep			11	17	19	3	18	0	4	10	14	42	40
Average Deep Punta Cana			12	17	19	4	18	0	3	12	15	42	41
Average Shallow			9	13	11	8	4	4	2	1	15	36	23
Average Shallow Punta Cana			10	13	10	10	3	4	2	1	14	36	22

Table 9 – Coral disease prevalence overall

Syndrome	# Colonies Affected	Overall Prevalence	Prevalence for Caribbean
Black Band	2	0.5%	0.5%
Dark Spots	5	1.2%	0.2%
White Plague	12	2.8%	1.1%
Unkown	1	0.2%	0.7%
All - Deep	15	6.1%	4.0%
All - Shallow	5	2.8%	2.8%
Total	20	4.7%	3.2%
Prevalence = (# colonies with disease / total # colonies)*100			

Table 10 – Average coral disease prevalence per site by depth

Average Prevalence	%BB	%DS	%WP	%UK	%Total Disease
Punta Cana - deep	0.0	1.1	4.2	0.4	5.8
Caribbean - deep	0.6	0.3	1.6	1.2	4.6
Punta Cana - shallow	1.4	0.0	2.4	0.0	3.8
Caribbean - shallow	0.2	0.1	0.6	0.6	2.5
Punta Cana - all sites	0.6	0.6	3.4	0.2	4.9
Caribbean - all sites	0.4	0.2	1.0	0.8	3.3

Figure 1

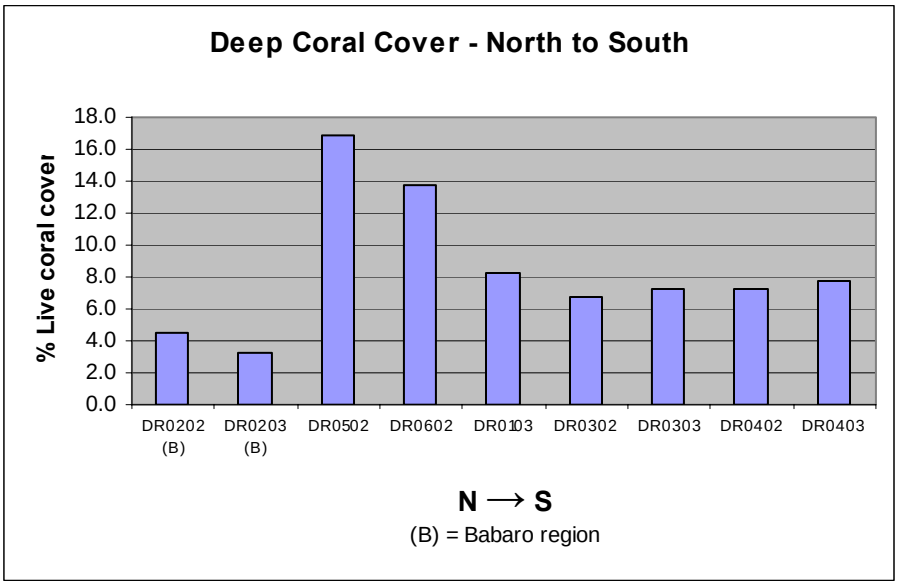


Figure 2

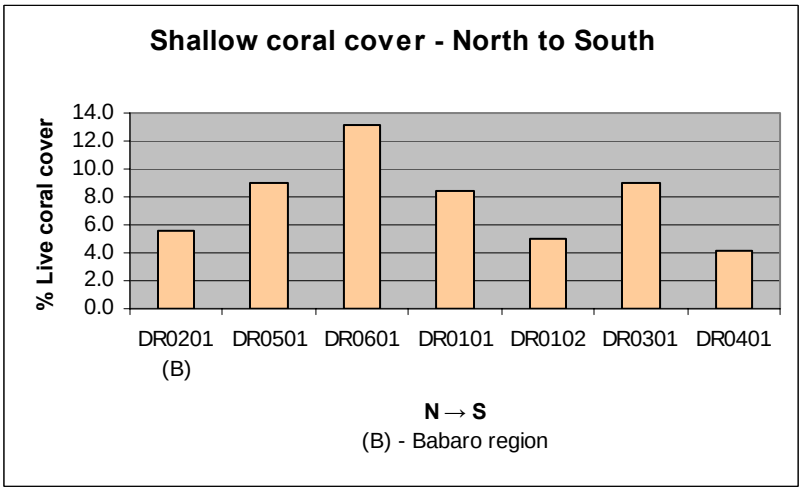


Figure 3

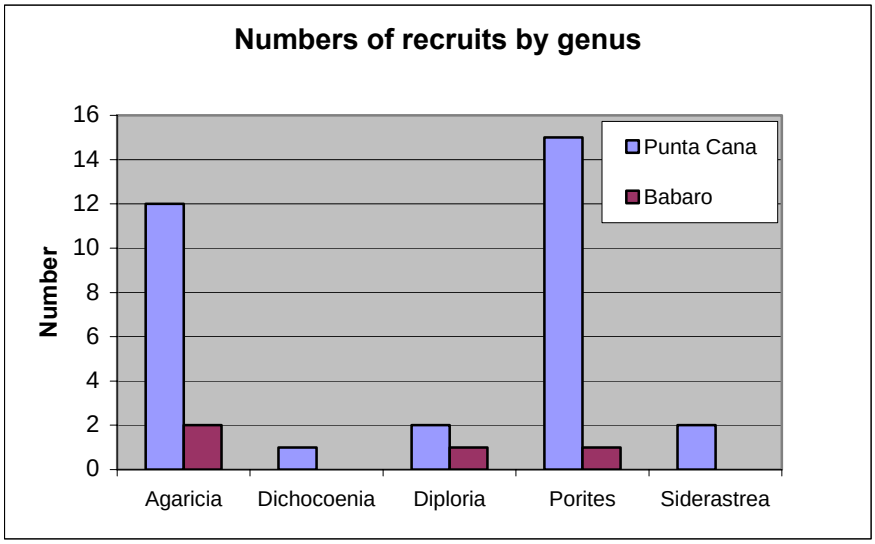


Figure 4

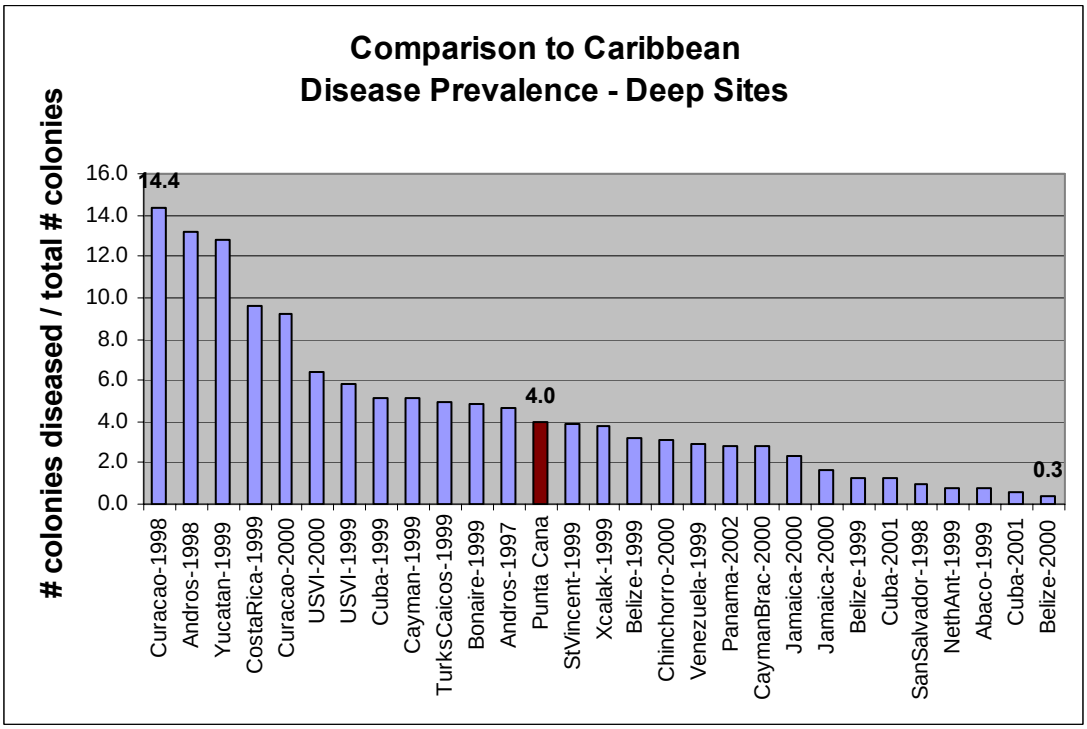


Figure 5

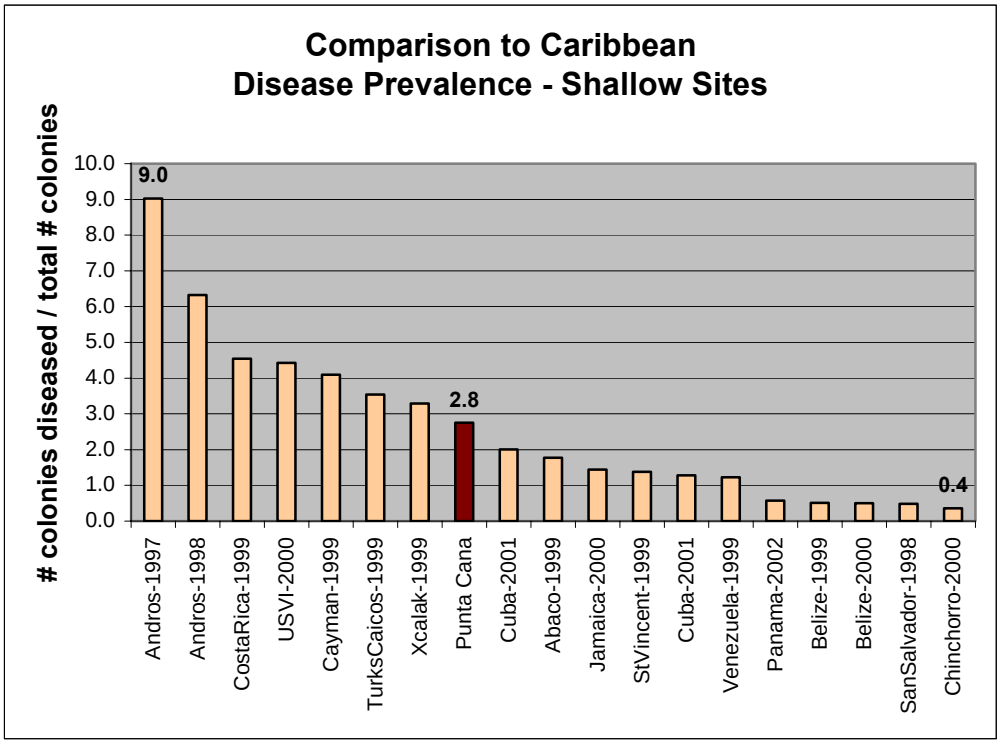


Figure 6

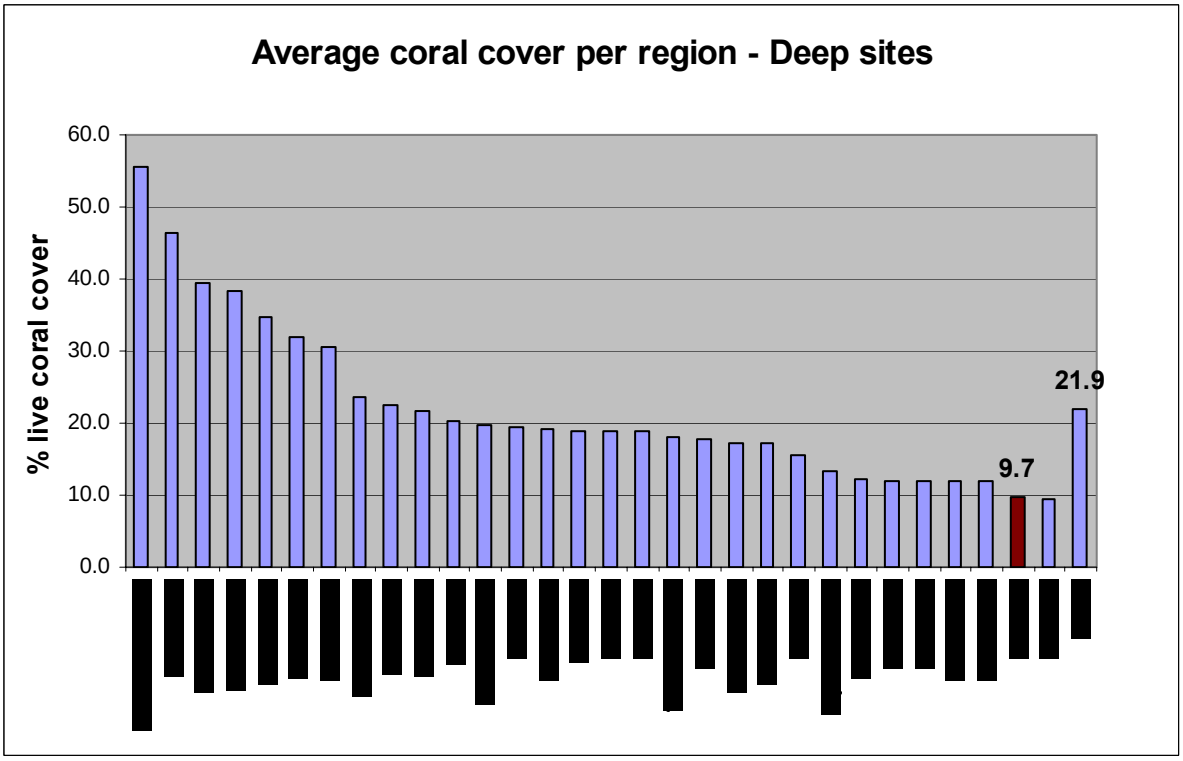


Figure 7

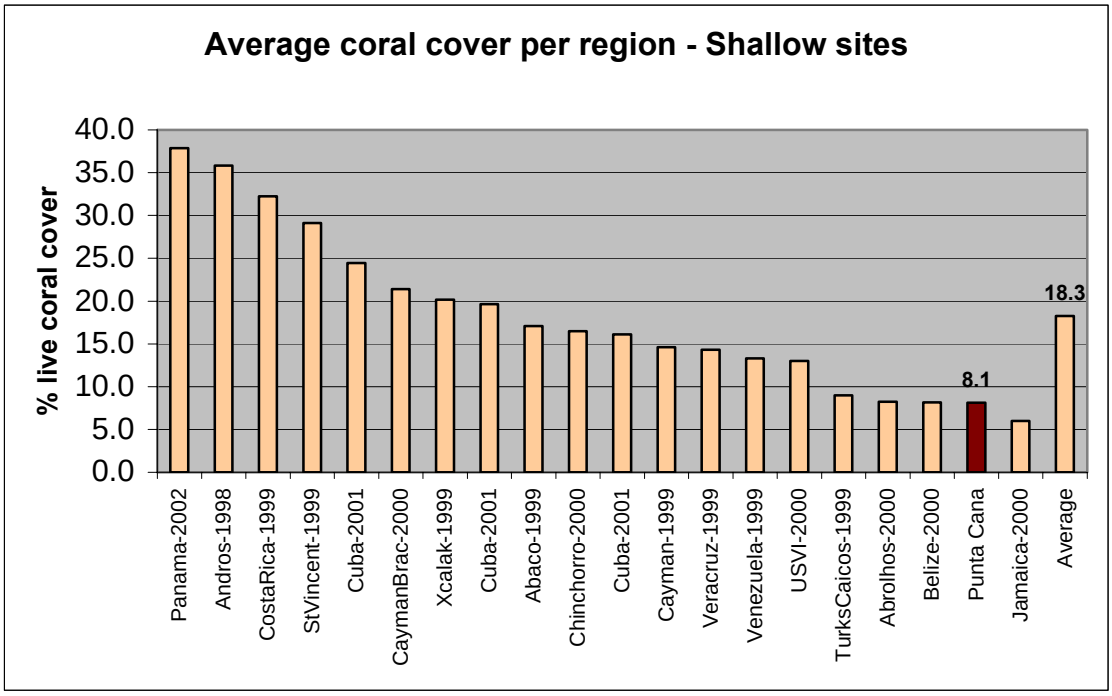


Figure 8

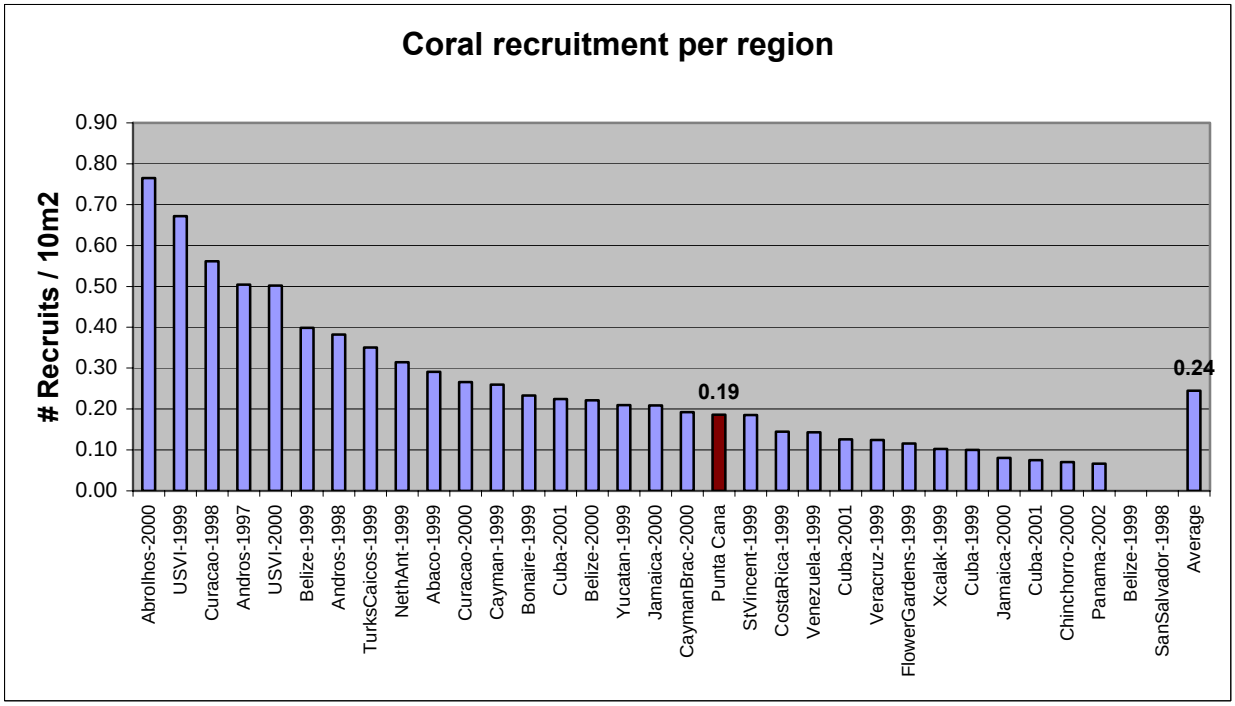


Figure 9

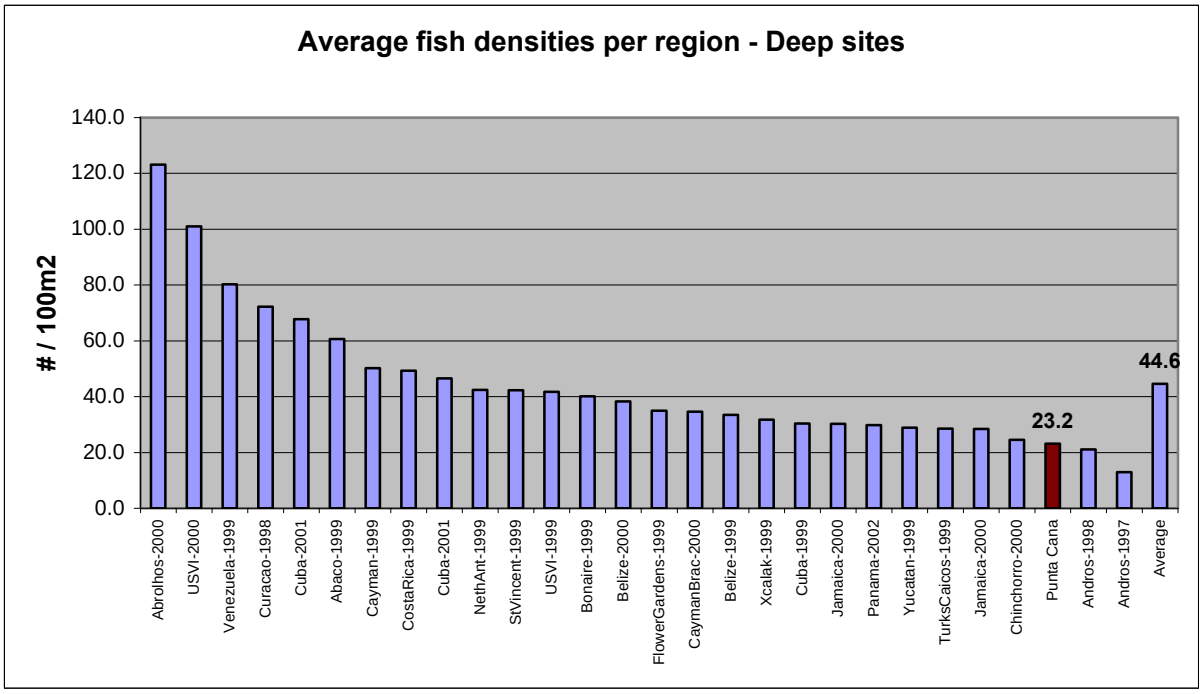


Figure 10

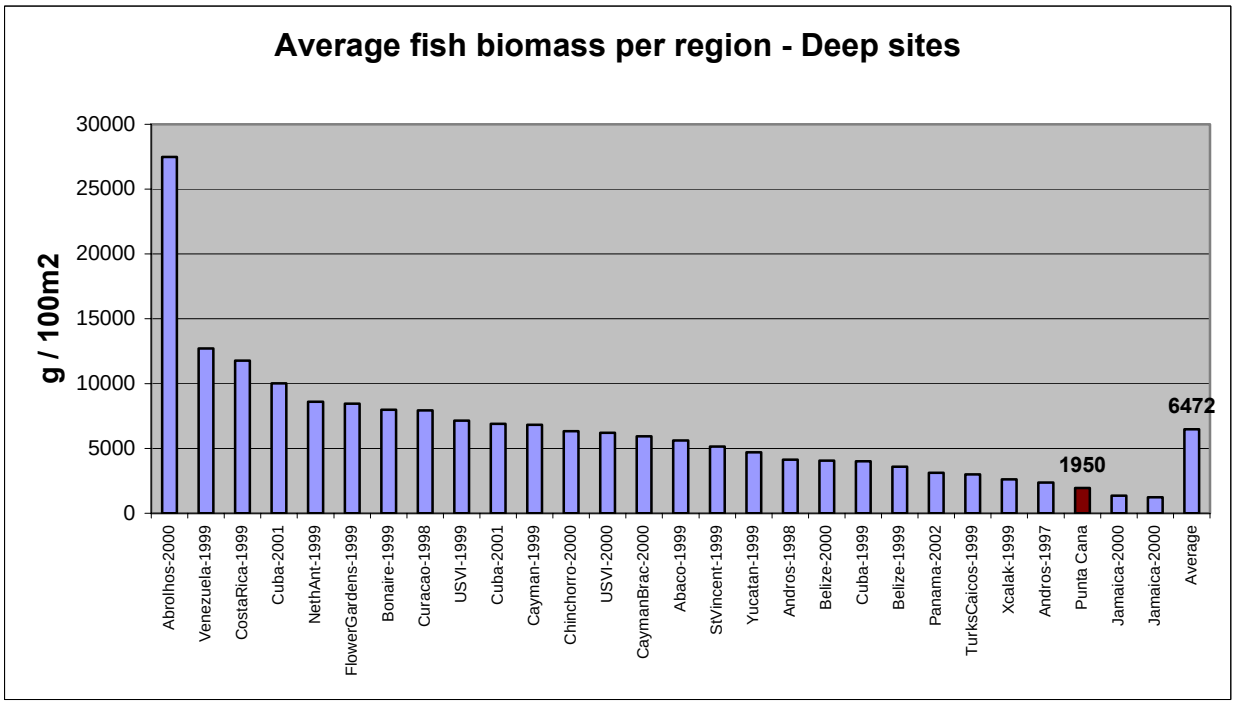


Figure 11

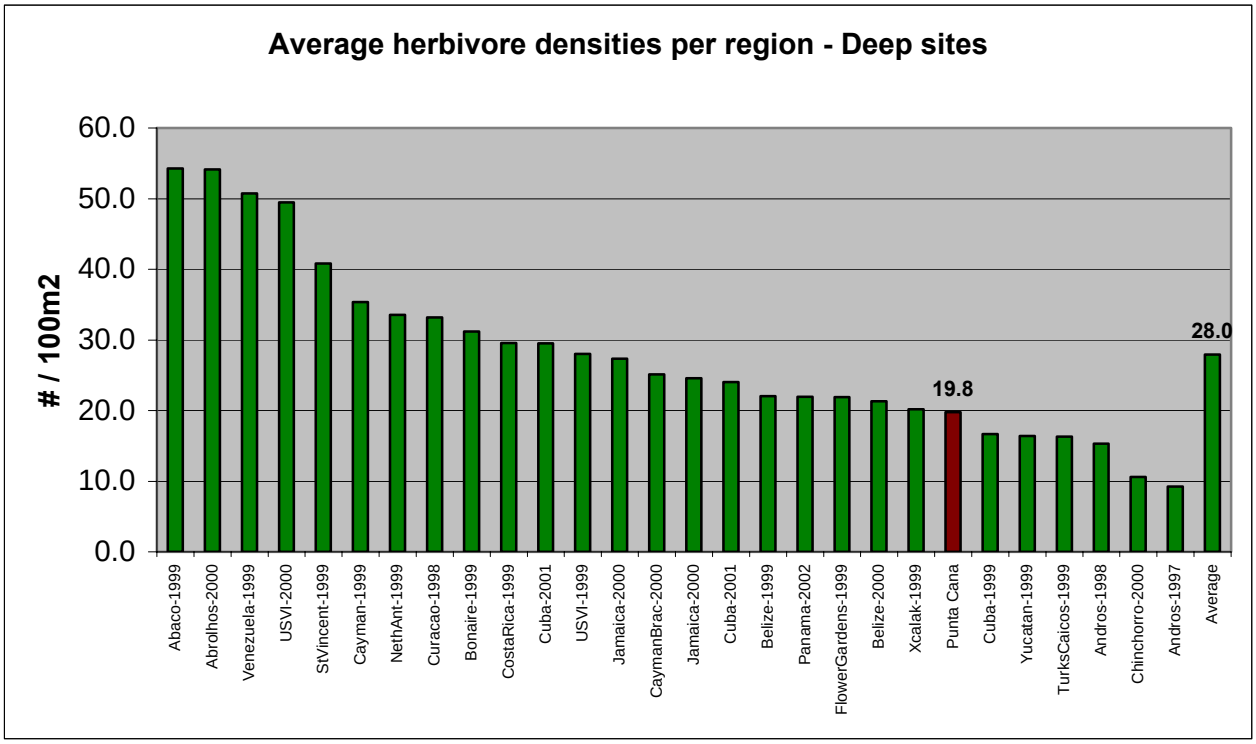


Figure 12

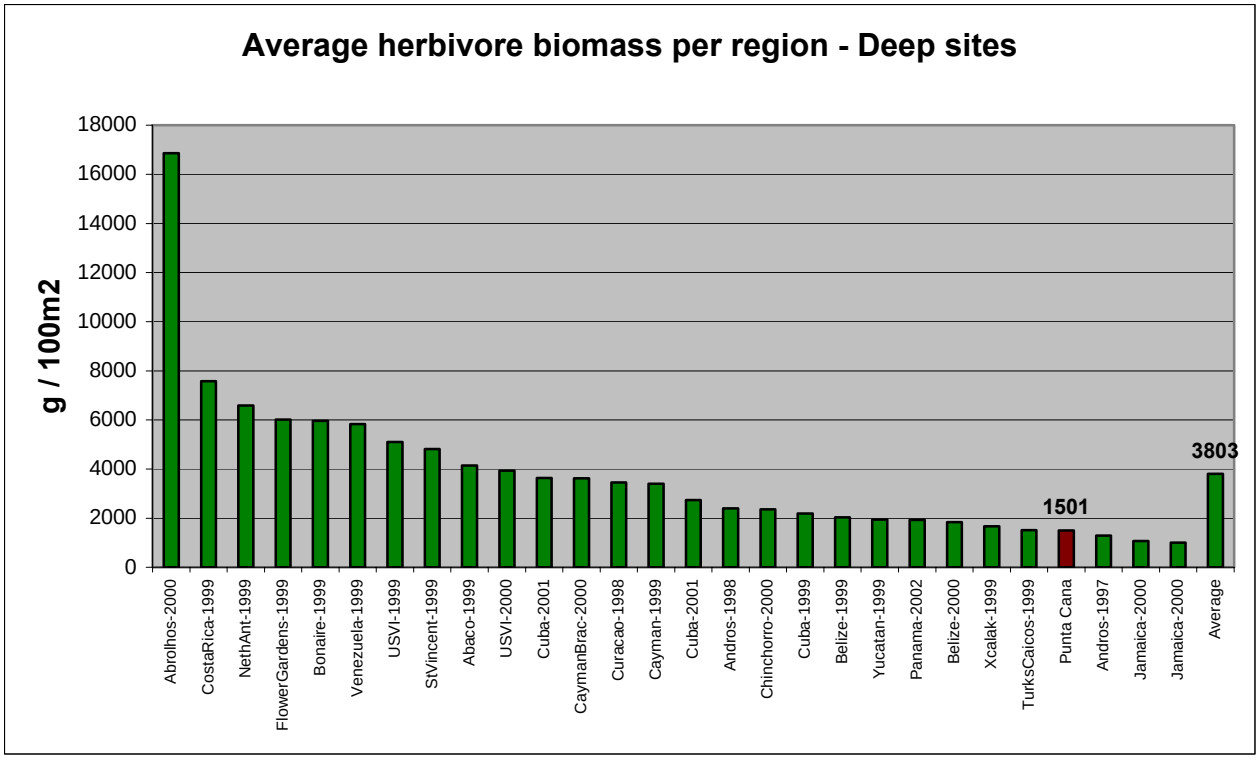

Average herbivore biomass per region - Deep sites
g / 100m2
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
3803
1501
Abrolhos-2000
CostaRica-1999
NethAnt-1999
FlowerGardens-1999
Bonaire-1999
Venezuela-1999
USVI-1999
StVincent-1999
Abaco-1999
USVI-2000
Cuba-2001
CaymanBrac-2000
Curacao-1998
Cayman-1999
Cuba-2001
Andros-1998
Chinchorro-2000
Cuba-1999
Belize-1999
Yucatan-1999
Panama-2002
Belize-2000
Xcalak-1999
TurksCaicos-1999
Punta Cana
Andros-1997
Jamaica-2000
Jamaica-2000
Average

Figure 13

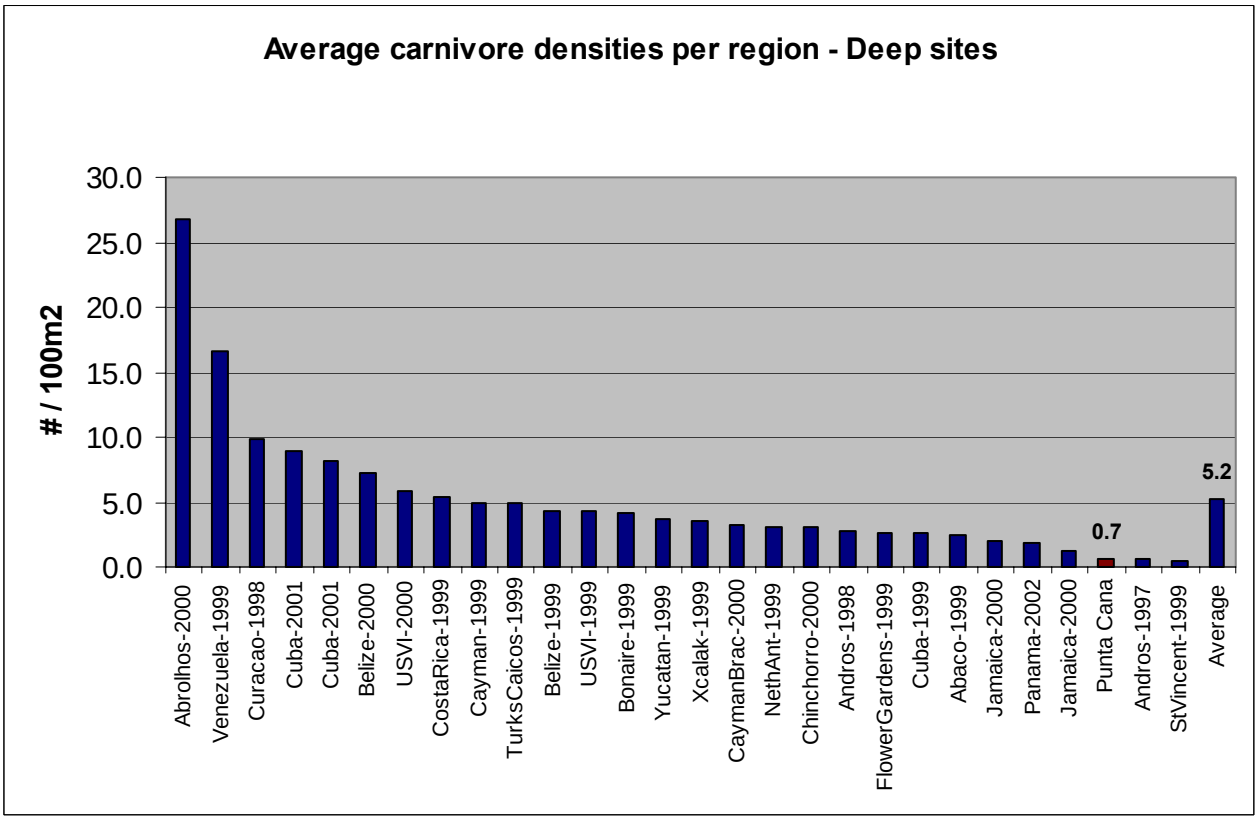

Average carnivore densities per region - Deep sites
/ 100m2
30.0
25.0
20.0
15.0
10.0
5.0
0.0
5.2
0.7
Abrolhos-2000
Venezuela-1999
Curacao-1998
Cuba-2001
Cuba-2001
Belize-2000
USVI-2000
CostaRica-1999
Cayman-1999
TurksCaicos-1999
Belize-1999
USVI-1999
Bonaire-1999
Yucatan-1999
Xcalak-1999
CaymanBrac-2000
NethAnt-1999
Chinchorro-2000
Andros-1998
FlowerGardens-1999
Cuba-1999
Abaco-1999
Jamaica-2000
Panama-2002
Jamaica-2000
Punta Cana
Andros-1997
StVincent-1999
Average

Figure 14

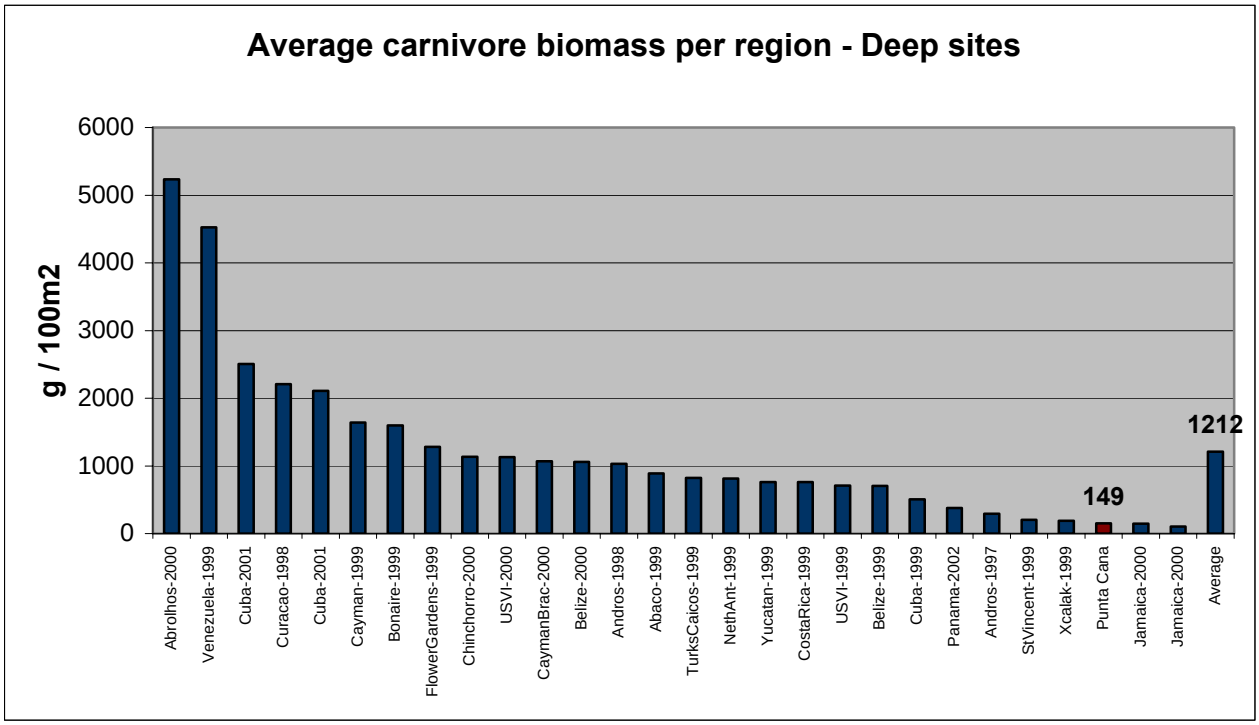


Figure 15

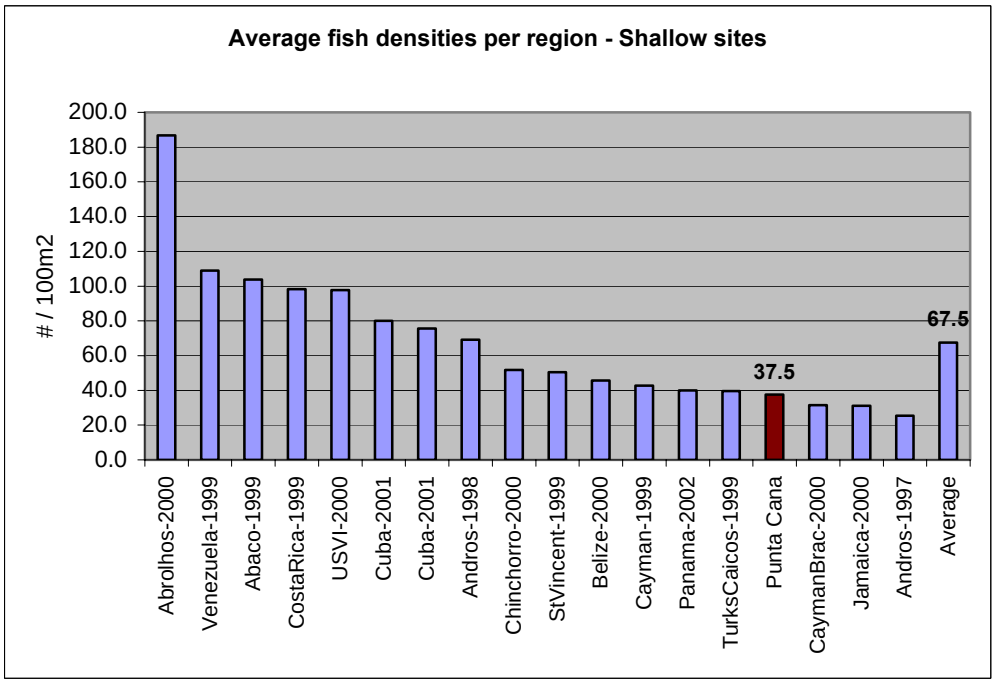


Figure 16

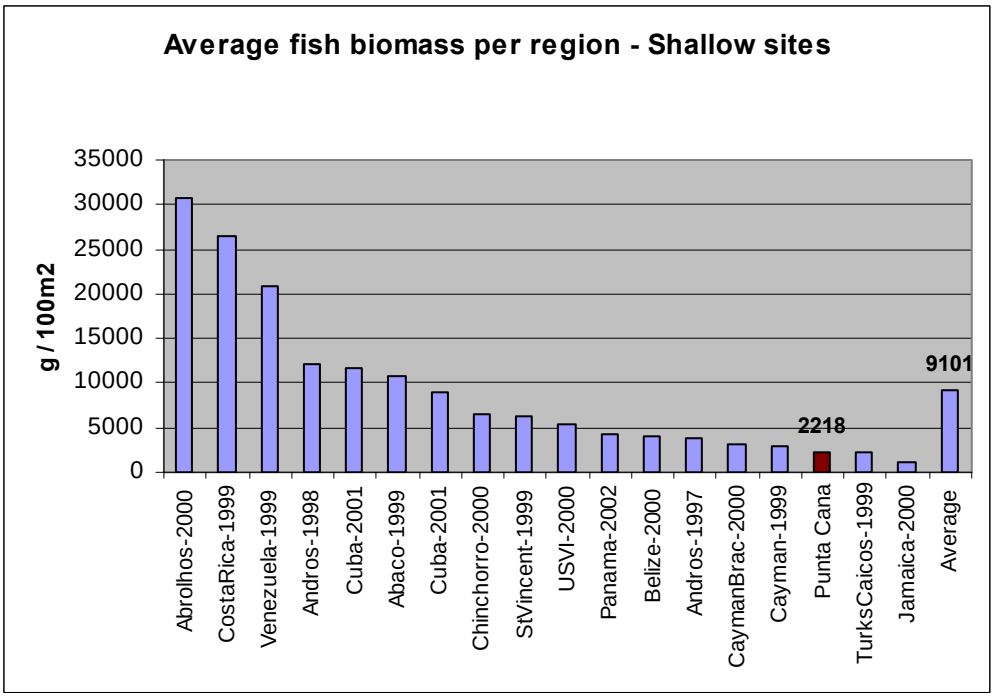

Average fish biomass per region - Shallow sites
g / 100m2
35000
30000
25000
20000
15000
10000
5000
0
9101
2218
Abrolhos-2000
CostaRica-1999
Venezuela-1999
Andros-1998
Cuba-2001
Abaco-1999
Cuba-2001
Chinchorro-2000
StVincent-1999
USVI-2000
Panama-2002
Belize-2000
Andros-1997
CaymanBrac-2000
Cayman-1999
Punta Cana
TurksCaicos-1999
Jamaica-2000
Average

Figure 17

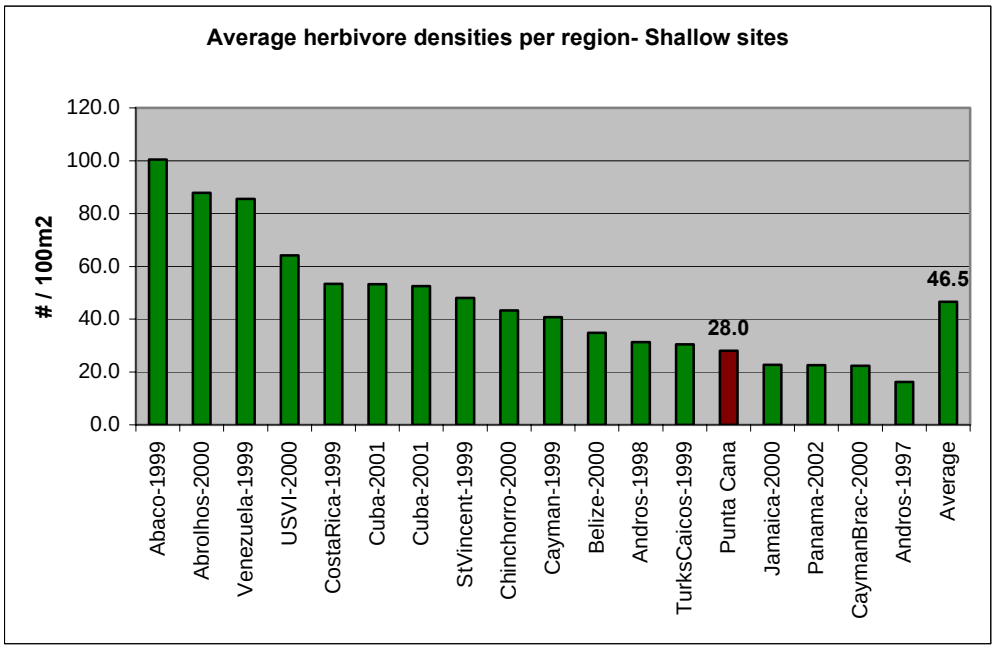


Figure 18

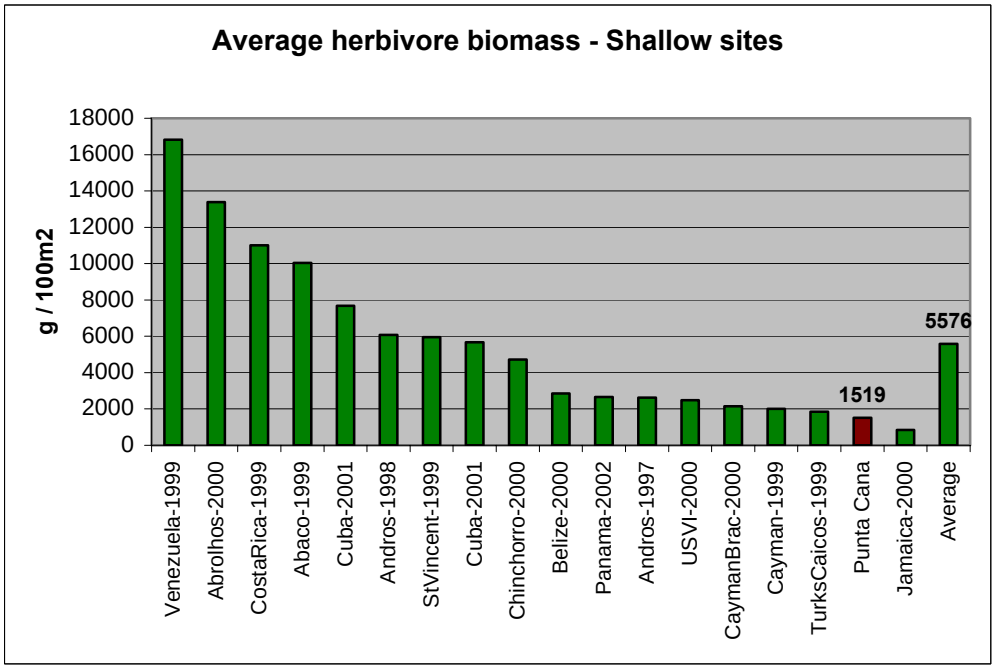


Figure 19

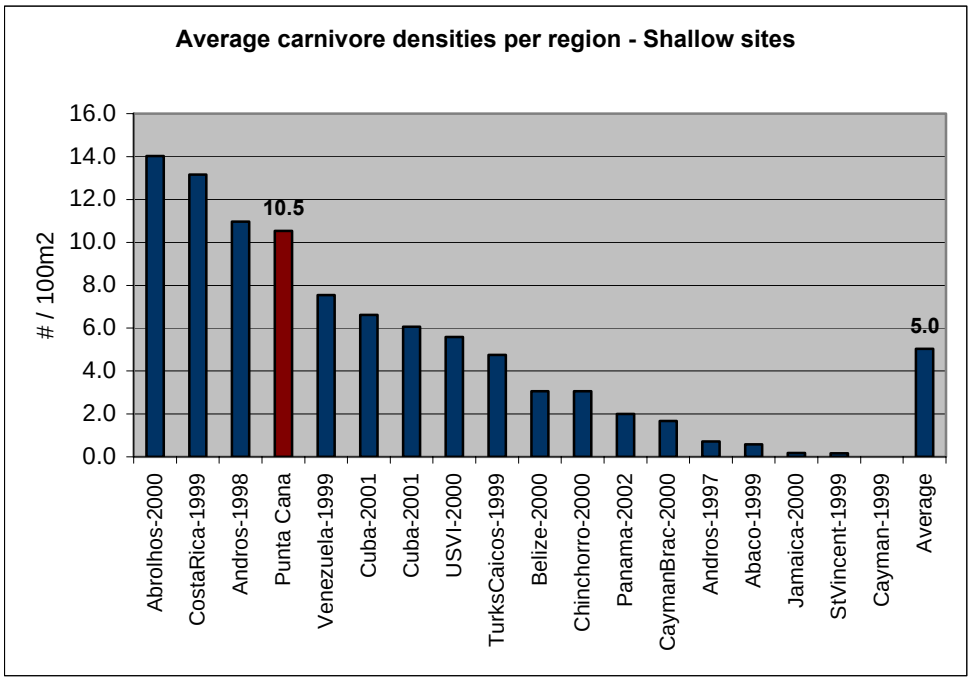
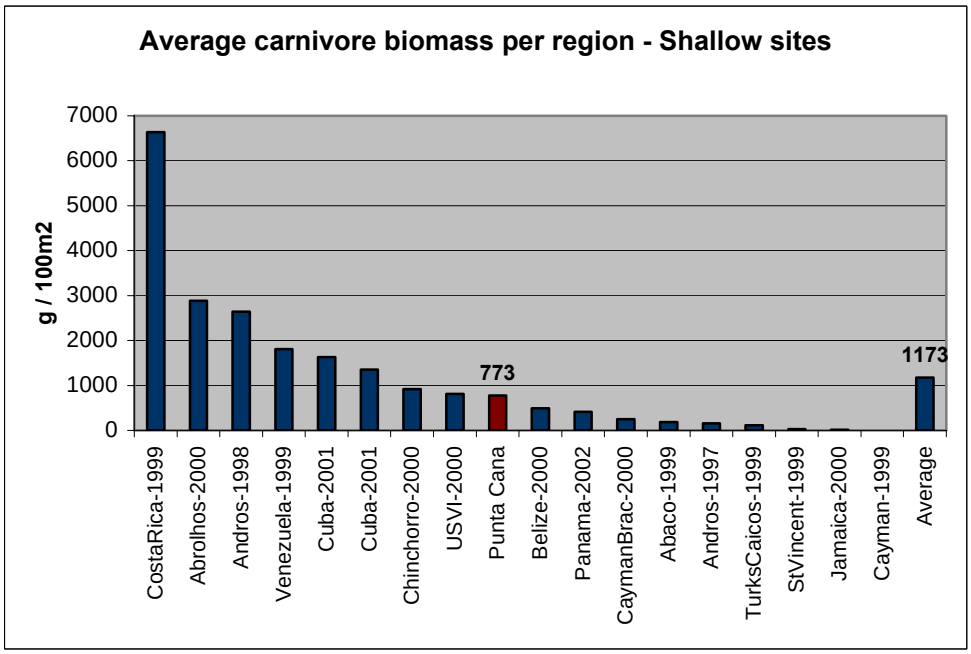


Figure 20



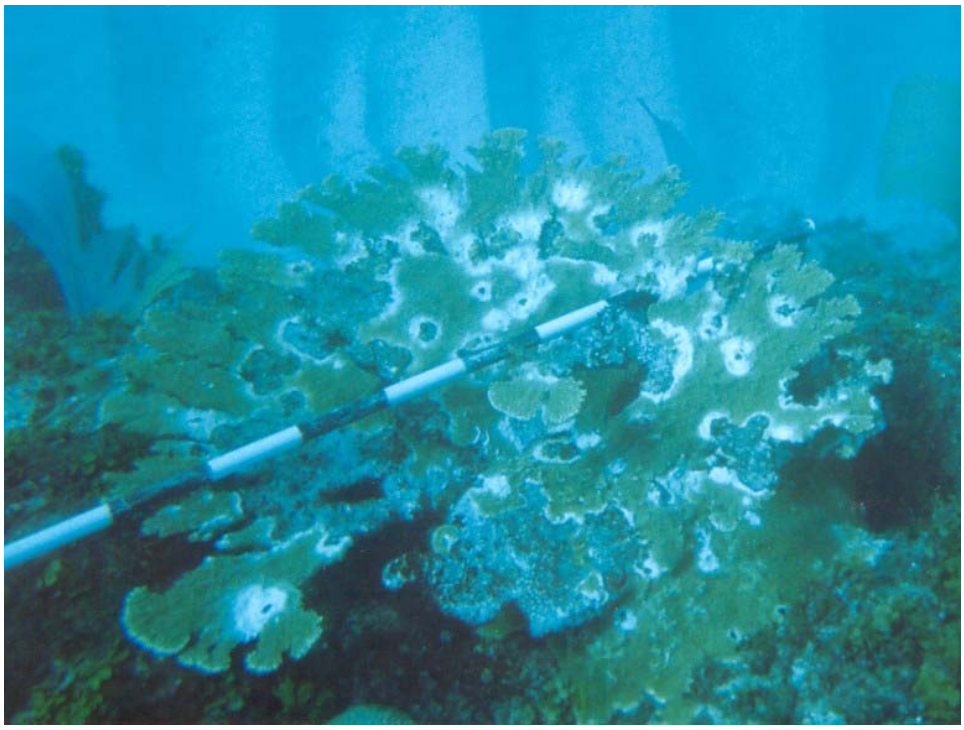


Photo 1 - This colony was approximately 90cm in diameter and was one of the most extensively affected corals seen.

Photo 2 - A close up of the colony in Photo 1. White regions had no corallite structure, were raised above surrounding tissue and were generally smooth.

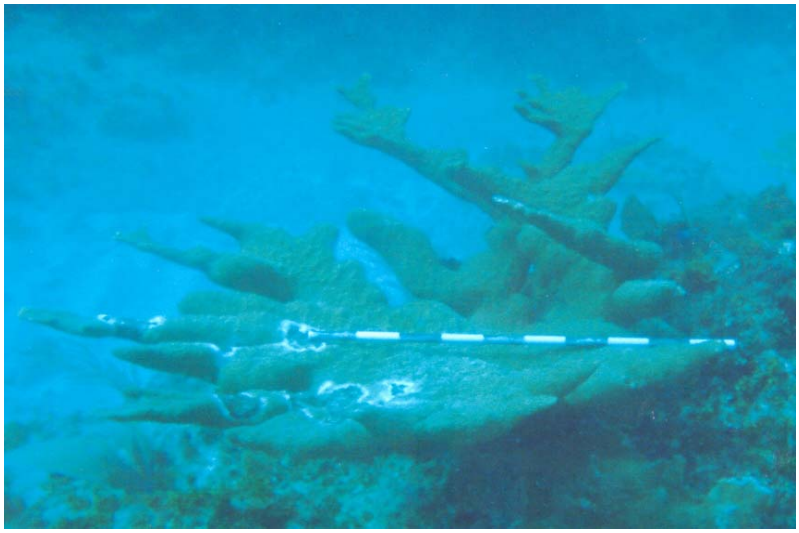


Photo 3 – Colony approximately 175cm in diameter. This colony was one of the larger colonies exhibiting lesions and was more characteristic of the extent to which coral colonies were affected.

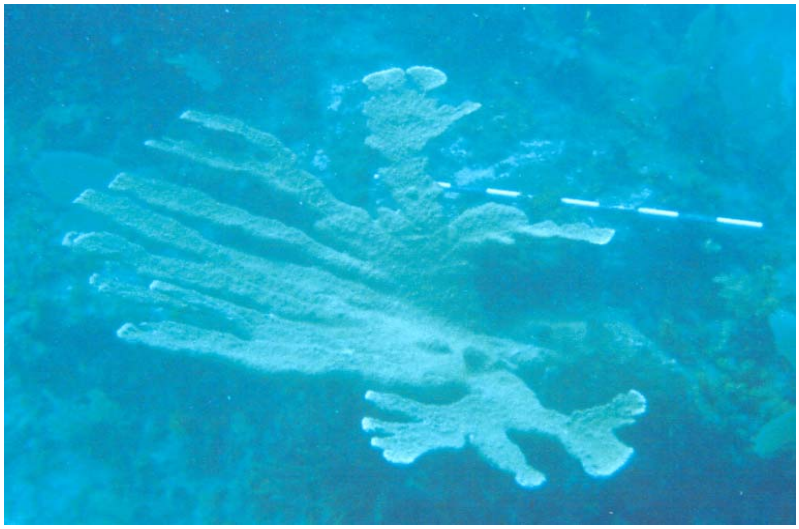


Photo 4 - Large healthy colony

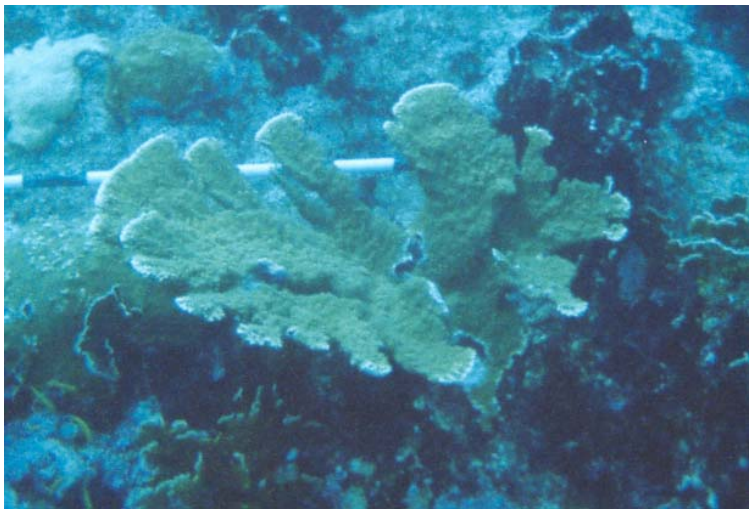


Photo 5 - Small healthy colony