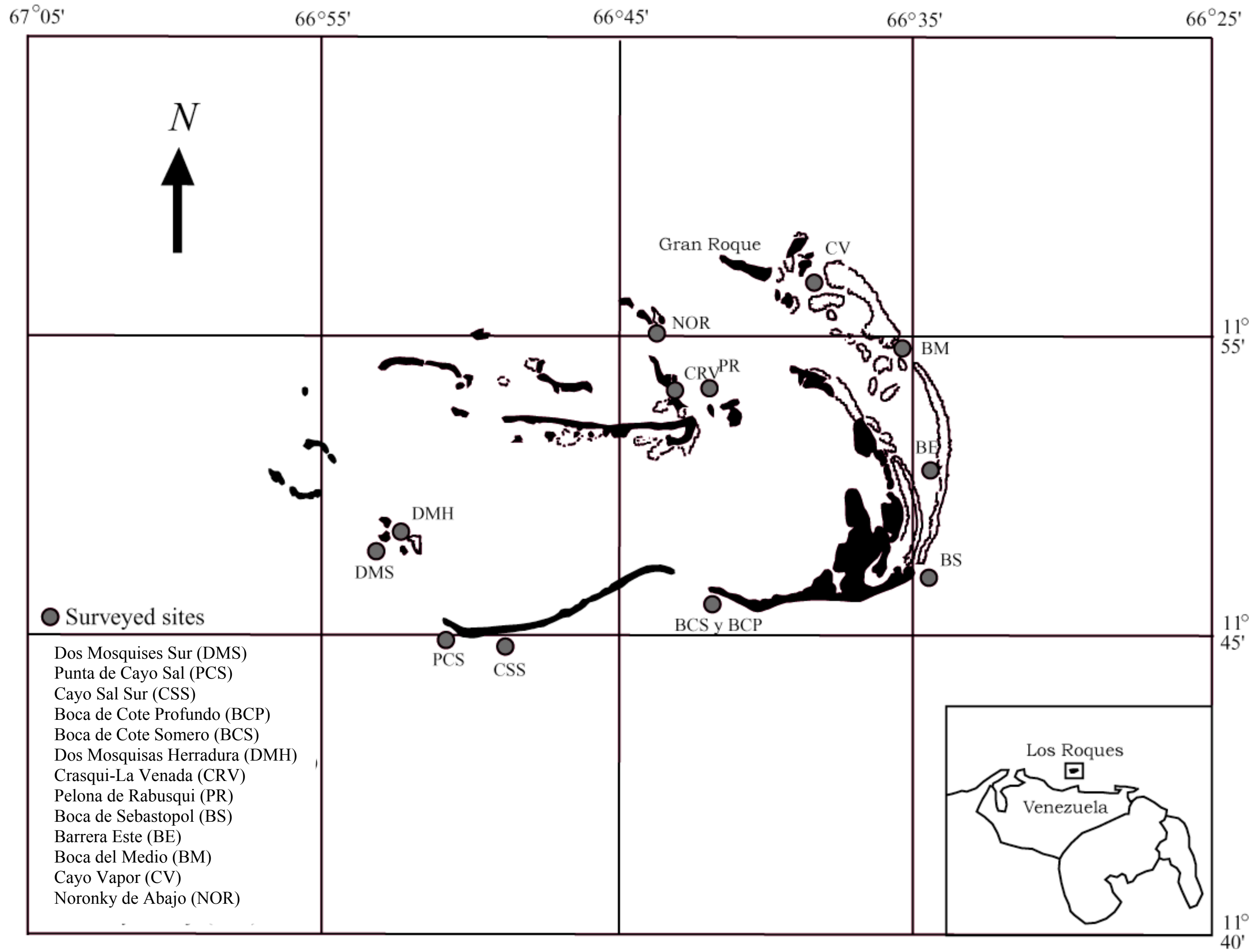

Figure 1. AGRRA survey sites in the Archipíelago de Los Roques National Park, Venezuela.

RAPID ASSESSMENT OF CORAL REEFS IN THE ARCHIPIÉLAGO DE LOS ROQUES NATIONAL PARK, VENEZUELA (PART 1: STONY CORALS AND ALGAE)

BY

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ABSTRACT

The status of the coral reefs in Archipiélago de Los Roques National Park, Venezuela was appraised in October, 1999 at 13 sites using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol. The reef complex appears to be in good condition overall. Live stony coral cover was especially high (30-60%) at four sites between 8-13 m in the southern and southwestern reefs. However, "standing dead" *Acropora* were particularly conspicuous in the eastern barrier reef and yellow-band disease was present in some colonies of *Montastraea annularis* and *M. faveolata*. Average values of recent partial-colony mortality were 8-10% in stony corals of ≥10 cm diameter in three reefs. Macroalgae were scarce (<10% relative abundance) in most (12/13) sites. The Los Roques reefs are likely to serve as important sources of coral larvae traveling through the southern Caribbean. Their protected status must be maintained.

INTRODUCTION

The Archipiélago de Los Roques National Park is Venezuela's major coral reef complex and one of the most important in the southern Caribbean region. Located 150 km north of the central Venezuelan coast, it is outside the geographic area routinely influenced by hurricanes. Land-based anthropogenic impacts are reduced in comparison to those in Venezuela's continental reef systems. The park, however, is subject to the impacts of commercial fishing pressures (mostly for spiny lobsters) and to increasing touristic activity (see Posada et al., this volume). Regional diseases, in particular white-

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band disease (WBD), have also impacted its stony coral populations, particularly the important framework builder *Acropora palmata* (Garcia, 2001; León, 2001).

The archipelago, which developed during the late Pleistocene around a metamorphic-igneous platform centered in Gran Roque Island, includes two main barrier reefs. The 24 km long eastern barrier, which runs from northeast to southeast, is fully exposed to the prevailing winds and seas. Strong currents characterize its seaward side. The southern barrier extends about 30 km from southeast to southwest and is progressively more protected from waves and currents as one moves from east to west. By protecting the interior of the archipelago from the direct influence of oceanic waves and currents, the barriers have facilitated the formation of numerous patch reefs, sand cays with fringing reefs, seagrass meadows and, in the southeastern part of the archipelago, mangrove forests (Méndez-Baamonde, 1978).

Annual surface seawater temperatures at Los Roques average 26° C (sd=2° C) with a minimum of about 23° C in February and a maximum of about 30° C in May although temperatures as high as the maximum can be found during October and November (Villamizar, 1993). Vertical water transparency is relatively high (15 to 25 m).

Méndez-Baamonde (1978) provided the first qualitative description of the major reef habitats in the archipelago. However, much of the research which has been undertaken in the Los Roques coral reefs is either unpublished or in undergraduate theses. Hung (1985) found that species distribution patterns, numbers of colonies and live stony coral cover varied with habitat in the southwestern Dos Mosquises Sur (DMS) fringing reef. Coral cover was greatest (7,200 cm^2/m^2) at "intermediate depths" (3-18 m) in the terrace and slope zones which were dominated by the *Montastraea annularis* complex. Hung (1985) also found numerous dead colonies of *Acropora palmata* in the reef crest at DMS and at another nearby fringing reef [Dos Mosquises Herradura (DMH)]. Sandía and Medina (1987), who studied the population dynamics of *A. cervicornis* off DMS, reported a maximum dominance (~18.0% of live coral cover and 9% of the colonies) of this species on the fore-reef terrace in depths of 3-6 m where numerous dead fragments of *A. cervicornis* were also found. *A. palmata* was the dominant species in shallower (<3 m) water while massive corals (particularly *M. annularis* and *Colpophyllia natans)* and gorgonians were most common below 6 m. Subsequently, Cróquer and Villamizar (1998) studied the effect of topographic variation on reef community structure in four sites at DMS finding the largest number of stony coral species (24) in the site with the least slope. Nevertheless the between-site similarity index of species composition was higher for the reef-slope zone than for the reef flat, reef crest and deep reef flat.

García (2001) found that 6.87 % of the stony corals (n=3,344) examined during 2000 in seven Los Roques localities were affected by disease. Yellow-band (yellow-blotch) disease (YBD) and dark spots disease (DSD) were the most common (both 2.1%) with other diseases each occurring in fewer than 1% of the colonies.

León (2001) has assessed the effects of recreational diving activities by comparing one each experimental (frequently visited by divers) and control (low touristic activity) site in several of the Los Roques reefs. Live stony coral cover overall averaged 32.6 % (sd=16) and was higher in the control sites than in the experimental sites in three reefs [including Crasquí-La Venada (CRV) with 49% versus 11% and Pelona de Rabusquí (PR) with 53% versus 16%, respectively] and lower in the controls only in the

DMS reef. León (2001) also found that YBD and DSD were the most common stony coral diseases at these sites in 2000.

The purpose of the present study was to evaluate the condition in October 1999 of the Los Roques coral reefs through the application of the AGRRA protocols. Stony coral and algal components are considered in this paper; the fish assessment is given by Posada et al. (this volume). Our results provide a comprehensive overview of the archipelago's reefs, allowing comparisons with other areas in the Caribbean (Kramer, this volume), and creating a baseline against which future assessments can be compared.

METHODS

Thirteen sites which are considered by the two senior authors to be representative of the barrier, fringing, and patch-reef habitats at Los Roques were chosen for assessment. The majority of the sites were located along the axes of the two main barrier reefs in recognition of their size and ecological importance; only the northwest sector of the archipelago was not surveyed.

Three divers employed the AGRRA Version 2.2 benthos protocol (see Appendix One, this volume) with the following modifications. The minimum diameter of individually surveyed corals was 10 cm. Coral size was recorded to the nearest 5 cm. Species of stony corals that remain small as adults (e.g., *Favia fragum*) were omitted from the counts of coral recruits. Sediments were removed fairly vigorously from the algal quadrats before estimating the abundance of crustose coralline algae. Training in stony coral identifications and in designation of the percentage of partial mortality and algal abundance was conducted the day before the surveys officially began. Field identifications of corals were corroborated by reference to Humann (1994).

Correlation coefficients were calculated to examine relationships between the percentage of standing dead corals and both the abundance and partial mortality of *A. palmata*. Distributions were normalized by using the log N+1 transformation for abundances and the arcsine root transformation for proportions.

RESULTS

The 13 surveys were conducted at four sites each in the eastern and southern barrier reefs, at two sites each in the central-eastern and southwestern fringing reefs, and in one northeastern patch reef (Table 1, Fig. 1). Back-reef habitats were surveyed in the eastern barrier [Cayo Vapor (CV), Boca del Medio (BM), Barrera Este (BE) and Boca de Sebastopol (BS)] where our access to the fore reef was restricted by high waves. One outer reef crest [Boca Cote Somero (BCS)] and three fore reefs [Punta Cayo Sal (PCS), Cayo Sal Sur (CSS) and Boca del Cote Profundo (BCP)] were visited in the southern barrier, two of which (BCS, BCP) were located near a large mangrove forest. The reef at DMS has a maximum depth of 40 m, but the remaining fringing reefs (PR, CRV and DMH) extend no deeper than 6.5, 10, and 12 m, respectively, and the base of the Noronqui de Abajo (NOR) patch reef is at 2 m. Eight of the survey sites were considered shallow (≤6.5 m) and five as being in deeper water (7.5-13.5 m).

Pp. 512-529 in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496.

Stony Corals

The total cover of live stony corals (Table 1) varied from <10% in four shallow reefs (BS, CV, CRV, BCS) to >50% in three of the deeper southern reefs (PCS, BCP and DMS). Live coral cover in the remaining sites ranged between about 20 and 30%. The density of stony corals that were at least 10 cm in diameter was higher overall in the southern sites than along the eastern side of the archipelago (Table 1).

A total of 27 scleractinians (including *Eusmilia fastigiata, Favia fragum* and *Porites branneri* in addition to species on the original AGRRA coral list) and one hydrozoan (*Millepora complanata)* were large enough (≥10 cm in diameter) for individual survey. Seven to 13 of these species occurred in each of the shallow reefs where colonies of *Acropora palmata* that were mostly dead (see below) numerically dominated most (six/eight) of the reefs, along with *Porites astreoides* and *Diploria strigosa* (Fig. 2A). Live *A. cervicornis* was found in only two of the shallow reefs (NOR, where *A. palmata* was rare, and DMH). *M. annularis* occurred in six of the shallow reefs (BCS, DMH, CV, PR, CRV and NOR). Although *M. faveolata* was present in seven shallow reefs, it was relatively abundant only in the deepest (PR). *M. complanata* was abundant in one shallow reef on the southern barrier (BCS).

Eleven to 17 species of the individually surveyed corals were recorded in each of the deeper reefs. The most common species, *M. faveolat*a, *M. annularis, M. cavernosa*

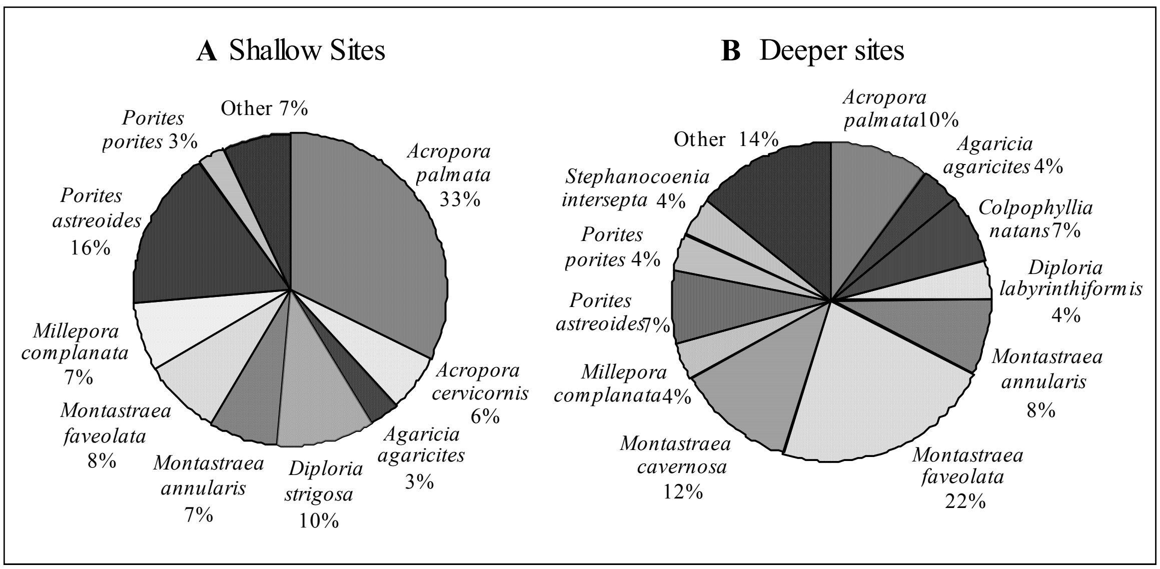

Figure 2. Species composition and mean relative abundance of the most abundant stony corals (≥10 cm diameter) in **(A)** shallow (n=672) and **(B)** deeper (n=415) sites in Los Roques, Venezuela.
Other: **(A) =** *Agaricia tenuifolia, Colpophyllia natans, Diploria clivosa, D. labyrinthiformis, Favia fragum, Porites branneri, Siderastrea radians, S. siderea;* **(B) =** *A. tenuifolia, Dendrogyra cylindrus, Dichocoenia stokesi, D. clivosa, D. labyrinthiformis, Eusmilia fastigiata, F. fragum, Madracis decactis, M. mirabilis, Meandrina meandrites, Montastraea franksi, P. branneri, S. radians, S. siderea.*

(especially at CSS) and *C. natans* (in particular at DMS), all had massive morphologies (Fig. 2B) except in the eastern barrier reef (at BM) where *A. palmata, P. astreoides and Agaricia agaricites* were predominant.

Average values in excess of 100 cm (Table 2) were found for the maximum diameters of individually surveyed stony corals in the five eastern reefs that were numerically dominated by *A. palmata* (BE, BS, CV, CRV and BM). The smallest (38 cm) was in one of the deeper, southern barrier reefs (CSS) where *M. cavernosa* was the most abundant species and the largest colonies of *M. faveolata* were less than 120 cm in maximum diameter. Average height was closely correlated with maximum diameter in most sites (Fig. 3).

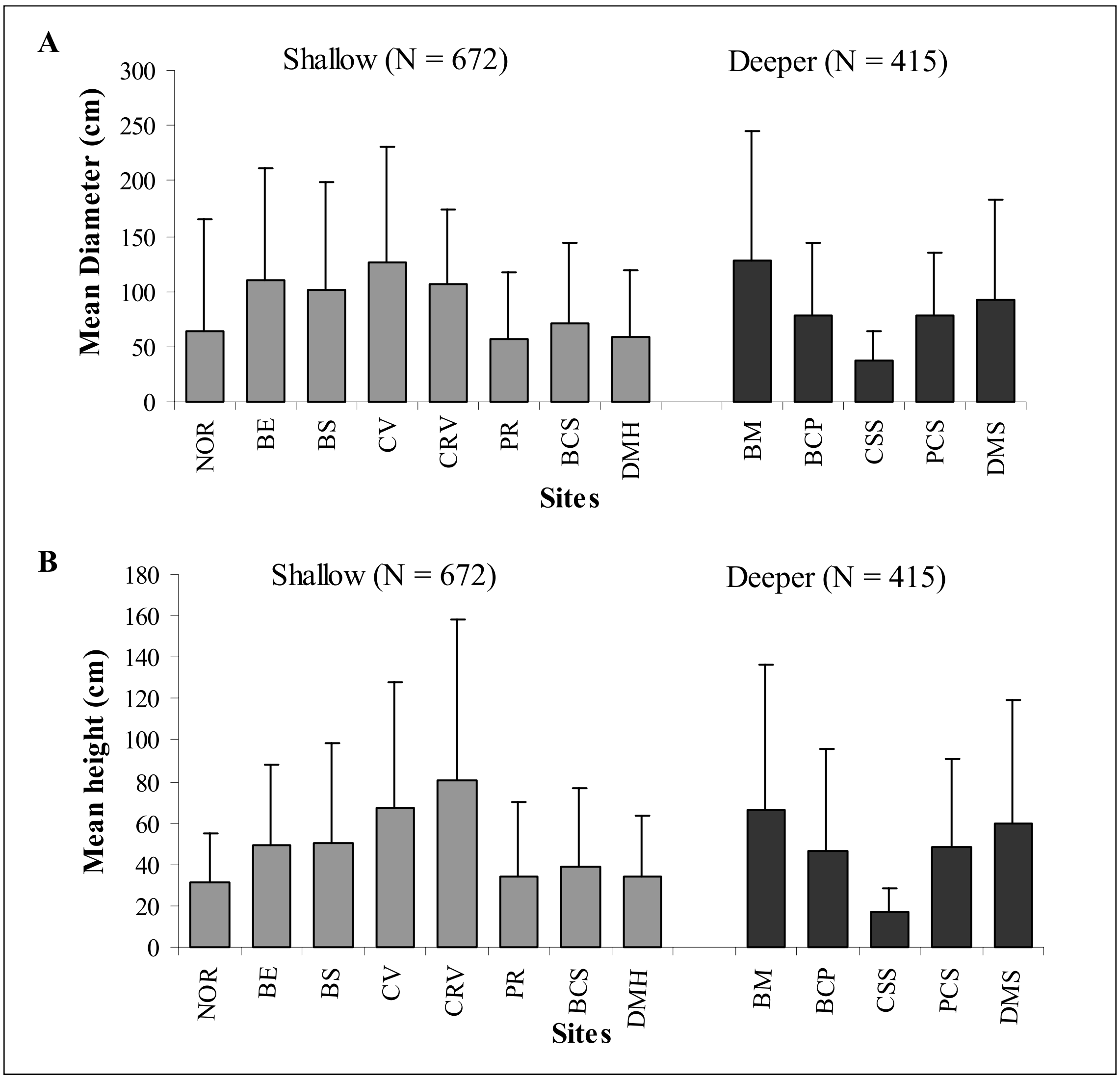

Figure 3. (A) Diameter and **(B)** height (mean ± sd) of all stony corals (≥10 cm diameter) by site in Los Roques, Venezuela. See Table 1 for site codes.

Many colonies of *A. palmata* in the shallow reefs were >100 cm in maximum diameter and the largest exceeded 400 cm (Fig. 4). A majority of the *D. strigosa* were <100 cm although some were larger (to 210 cm). *P. astreoides* was almost exclusively represented by colonies with diameters of <20 cm. *M. faveolata* in the deeper reefs resembled the shallow *A. palmata* in having a wide range of maximum diameters with the largest colonies being ~300 cm in maximum diameter (Fig. 5). Most colonies of the smaller-sized *M. cavernosa* were in the 20-70 cm size intervals.

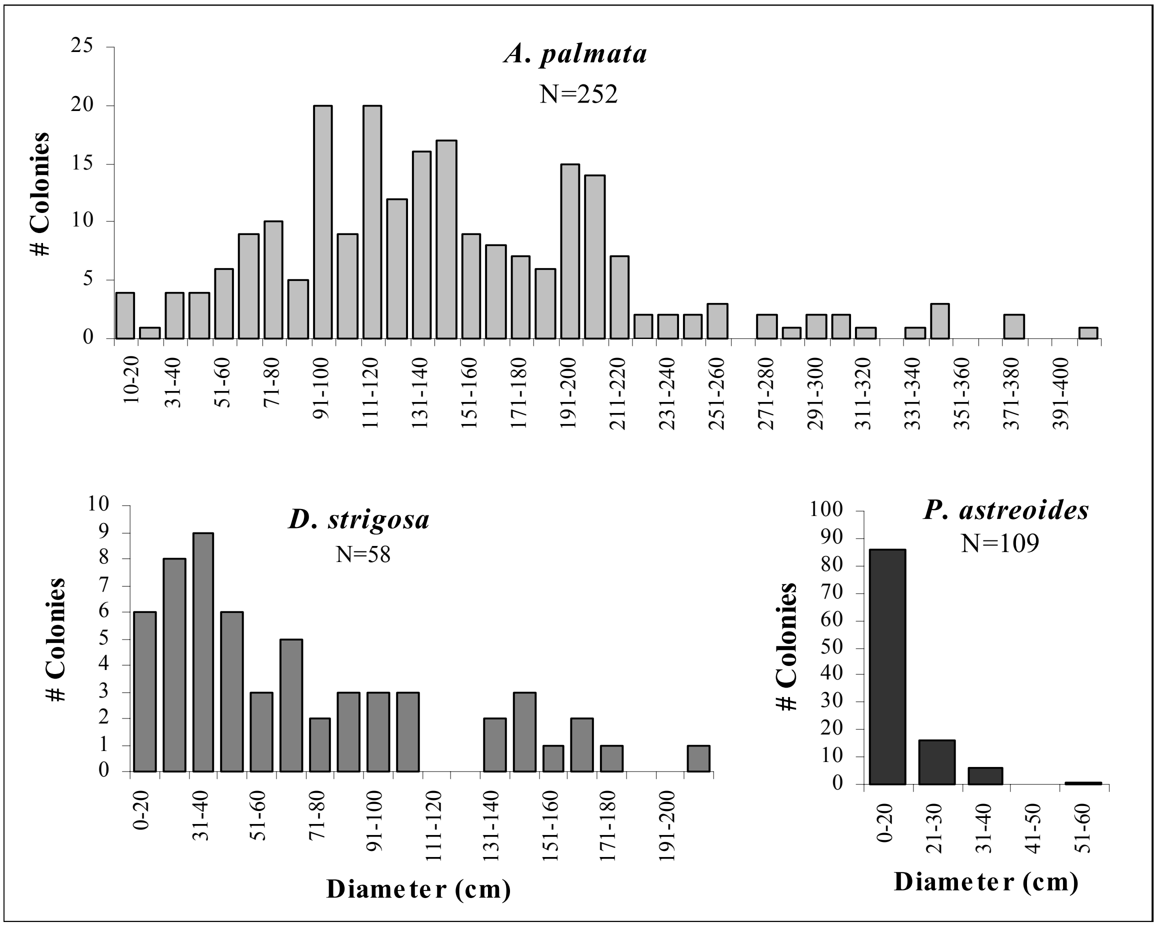

Figure 4. Size-frequency distributions of ≥10 cm diameter colonies of *Acropora palmata, Diploria strigosa and Porites astreoides* at shallow sites in Los Roques, Venezuela.

No stony coral "recruits" (≤2 cm diameter) were recorded in seven (three shallow, four deeper) of the survey sites (Table 3). Their densities in the remainder were less than five corals/m^2 (~0.3/.0625 m^2) at all but two of the shallower sites (BS, PR). *Agaricia* and *Porites* were the most common genera. *Agaricia* recruits appeared to preferentially colonize dead *A. palmata* branches (particularly in BM). Although no recruits of *Acropora, Montastraea* or other large massive corals were found in the quadrats, some small established *A. cervicornis* recruits were noted outside the AGRRA survey site in the crest of the patch reef (NOR).

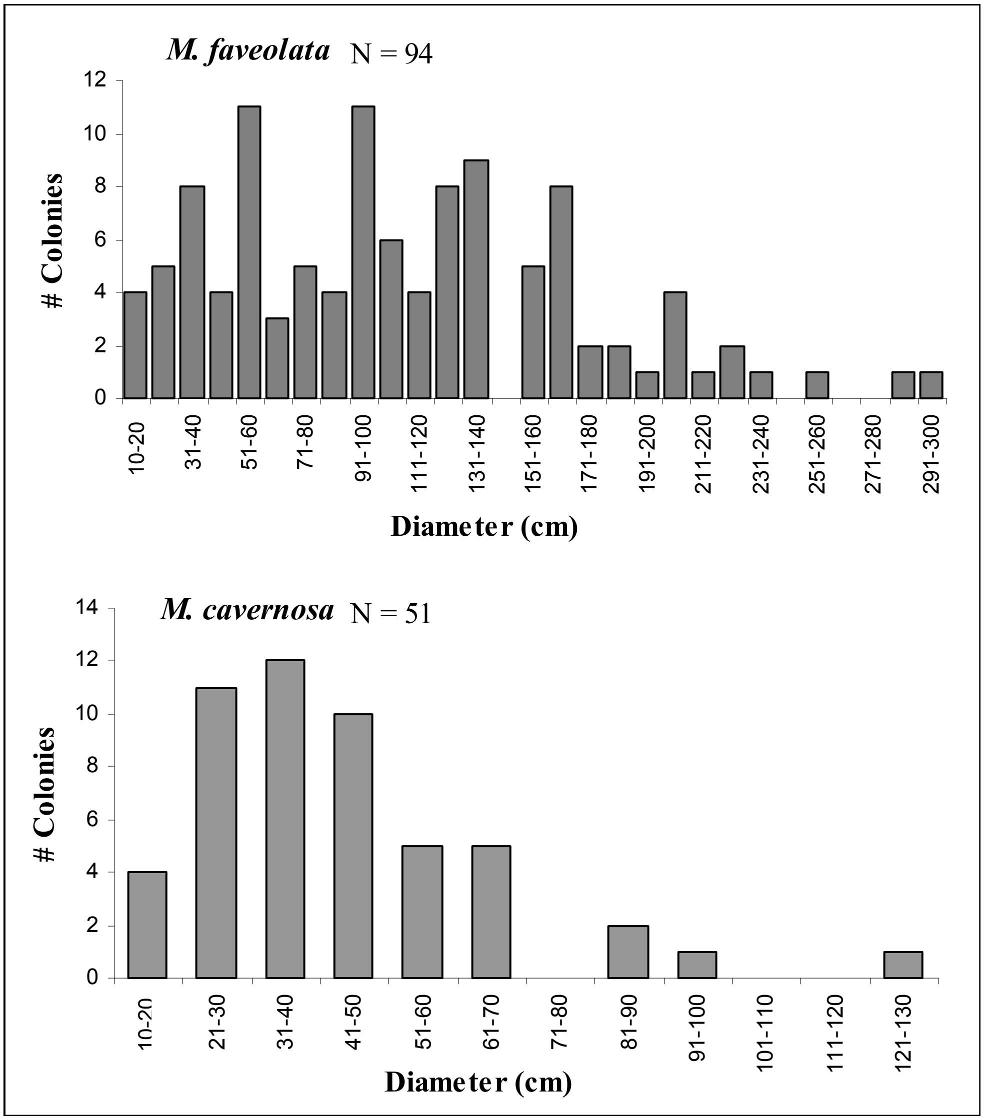

Figure 5. Size-frequency distributions of ≥10 cm diameter colonies of *Montastraea faveolata* and *M. cavernosa* at deeper sites in Los Roques, Venezuela.

Stony Coral Condition

No totally bleached corals were observed at the time of our surveys. At seven sites, however, fewer than 4% of the colonies were either pale or partially bleached (Table 2). There was no evidence of infection with WBD in any of the live colonies of *Acropora*. YBD was found in three sites (Table 2), occurring in *Montastraea annularis* (seven colonies), *M. faveolata* (three colonies), and *M. franksi* (one colony). A total of one colony each of *Porites porites, P. astreoides* and *A. palmata* also showed signs of a disease resembling YBD in overall appearance. One colony of *M. faveolata* had signs resembling those of red-band disease and a *Diploria strigosa* had white plague.

Pp. 512-529 in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496.

Average values of recent partial-colony mortality (hereafter recent mortality) varied from <1% in two of the deeper reefs in the southern barrier to >8% in three shallow reefs (CRV, PR and BCS) (Table 2). In addition to the above-mentioned diseases, mortality agents identified in the shallow localities included predation by scarids and the snail *Coralliophila* plus overgrowth by gorgonians and algae. However, a large number of the shallow colonies with recent mortality were associated with territories of *Stegastes planifrons* (see below). Recent mortality was somewhat lower overall in the deeper sites (Table 2, Figs. 6, 7). We observed no predation by *Diadema antillarum* on live stony corals, although such behavior had been previously observed (Villamizar, personal observations during 1995 in DMH).

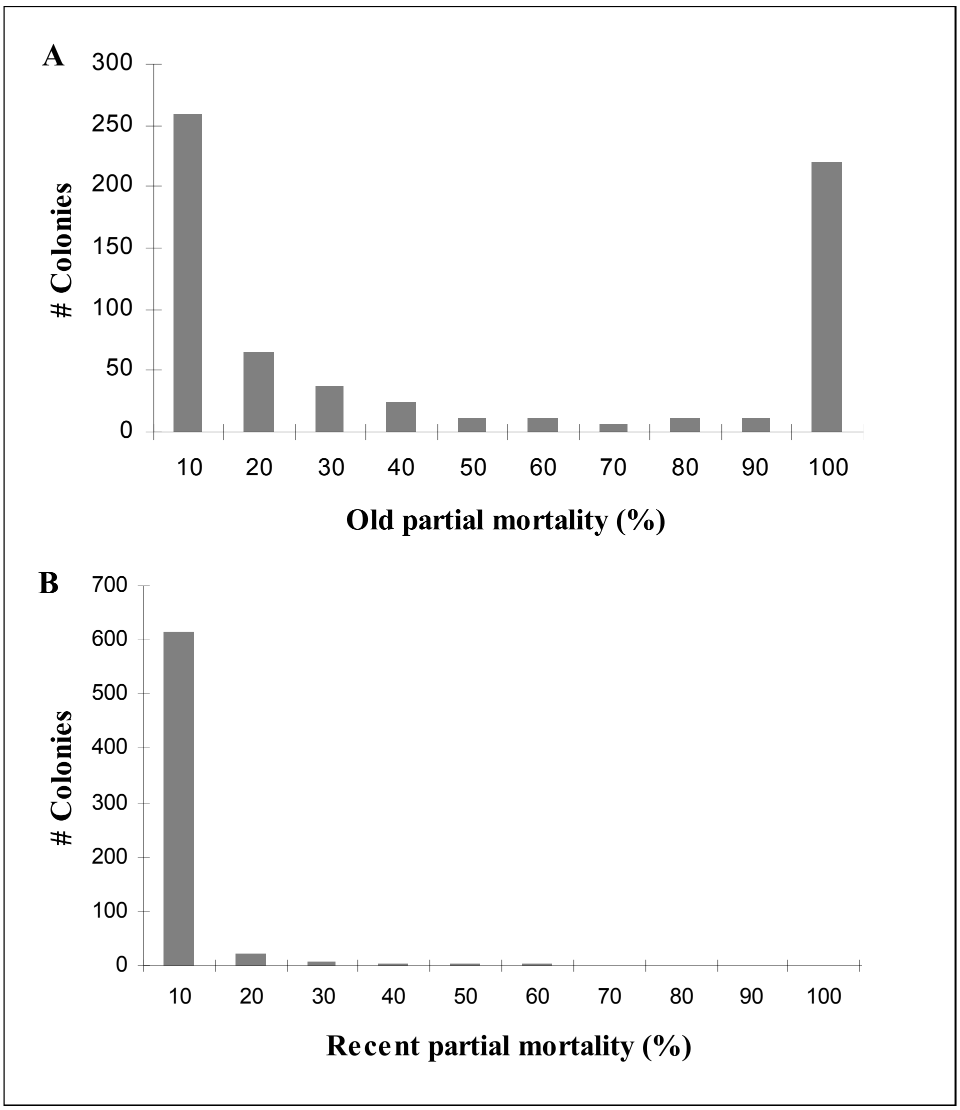

Figure 6. Frequency distributions of (**A**) old partial-colony mortality and (**B**) recent partial-colony mortality of all stony corals (≥10 cm diameter) at shallow sites in Los Roques, Venezuela.

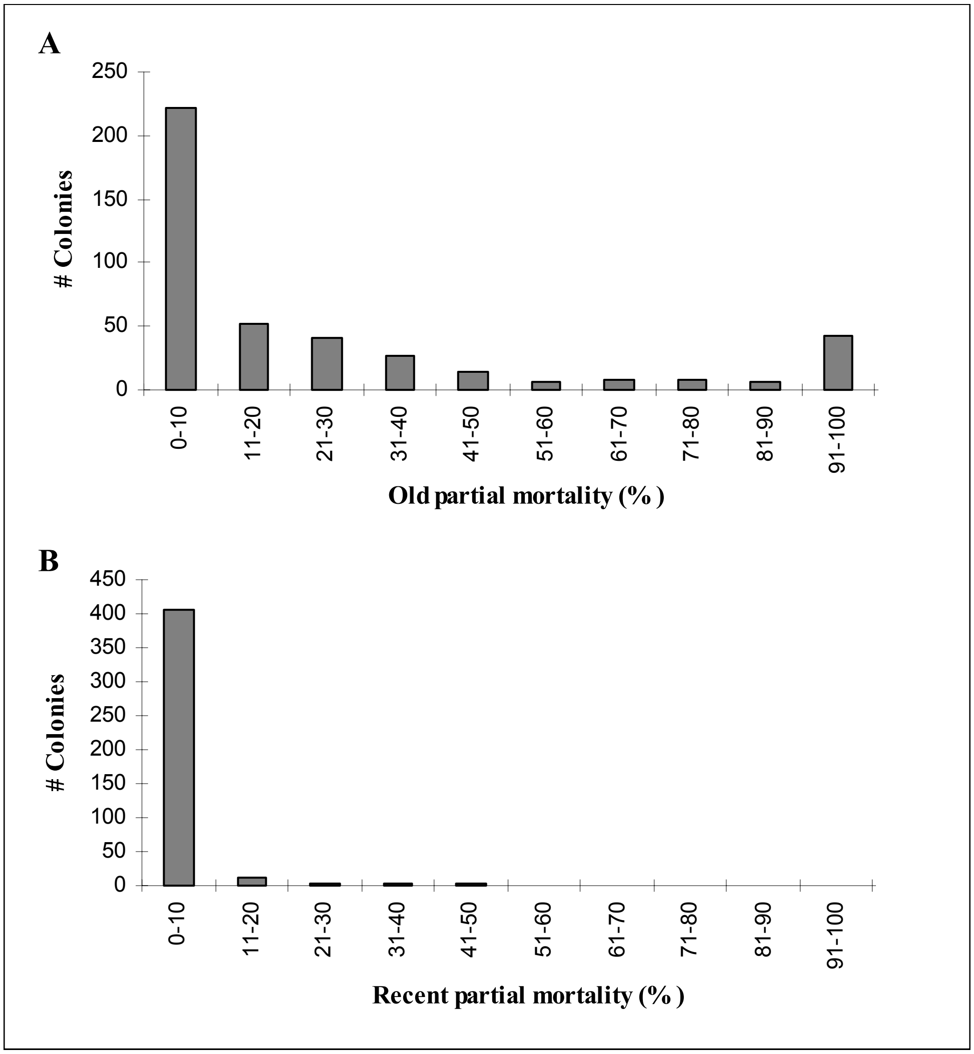

Figure 7. Frequency distributions of (**A**) old partial-colony mortality and (**B**) recent partial-colony mortality of all stony corals ($\geq$10 cm diameter) at deep sites in Los Roques, Venezuela.

Old partial-colony mortality (hereafter old mortality) ranged from <30% in six sites (two shallow, four deeper) to >60% in three of the shallow sites (Table 2). Total (recent + old) partial mortality was <25% in three of the four deeper southern-to-southwestern sites, ~43-75% in the four reefs along the eastern barrier, and over 80% in one of the central-eastern fringing reefs (CRV).

Of the colonies with some remaining live tissues (i.e., for which total mortality was <100%), recent mortality values for the dominant species varied from about 1% for *M. cavernosa* and *C. natans* in the deeper sites to approximately 18% for *A. palmata* in shallow sites (Fig. 8). The corresponding averages for old mortality were lowest in shallow *A. cervicornis* (~13%) and highest in *D. strigosa* (38%). The ratio of recent mortality to old mortality was lowest in the deeper *M. cavernosa* (0.04) and highest in the shallow *Acropora* spp. (0.62 in *A. palmata*; 0.64 in *A. cervicornis*).

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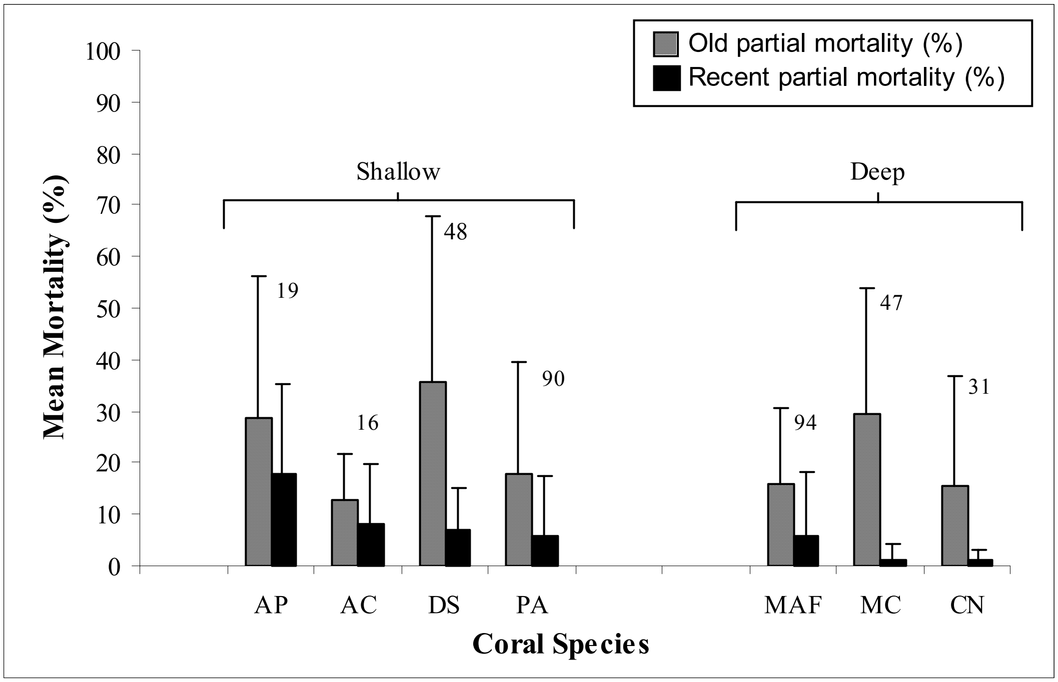

Figure 8. Percent old partial-colony mortality and percent recent partial colony mortality of ≥10 cm diameter stony corals with at least some live tissues (i.e., for which mortality is <100%) at shallow and deep sites in Los Roques, Venezuela. AP = *Acropora palmata*, AC =*.A. cervicornis*, DS = *Diploria strigosa*, PA = *Porites astreoides*, MAF = *Montastraea faveolata,* MC = *M. cavernosa*, CN = *Colpophyllia natans.*

Over 25% of the colonies were "standing dead" (completely dead but still attached to the substratum) in six survey sites. All but one of these, BM, were shallow and five sites were located in (BS, CV, BE, BM) or near (CRV) the eastern barrier. *Acropora palmata* accounted for most of these standing dead with <7% (17/252) of all surveyed colonies having any live tissues. Statistically significant correlations were found between the percentage of standing dead corals in each site and both the abundance of *A. palmata* (r=0.93, p<0.05, n=13) and the percentage of its total mortality (r=0.87, p<0.05, n=13). Only one reef (DMH) had a high proportion (11/14) of colonies of *A. palmata* still having some living tissues. Elsewhere, with the exception of one or two colonies in each site that were partially alive, the remainder were standing dead.

Algal groups, *Diadema* and Damselfishes

Overall, turf algae clearly dominated the algal functional groups in seven shallow and three deeper sites (Table 3). Crustose coralline algae (especially *Lithophyllum*) and *Peyssonnelia* were dominant in two deeper reefs (CSS, DMS) and one shallow (BCS) reef and both were essentially codominant with turfs in one shallow fringing reef (CRV). Macroalgae were completely absent from quadrats in three sites (one shallow, two deeper) and conspicuous only at Boca de Cote shallow (BCS) where their relative abundance was 29% at 2.5 m. Commonly observed macroalgae were *Halimeda opuntia, H. monile*, *Bryopsis pennata*, *Cladophoropsis* sp., *Ventricaria* sp., *Wrangelia penicillata*, *Ceramium rubrum*, *Amphiroa fragilissima,* and *Dyctyopteris delicatula*. The cyanobacterium, *Blennothrix lyngbyacea*, was included in the macroalgal group. Macroalgal indices (macroalgal relative abundance x macroalgal height) were 0-1 at nine sites, 2-10 at three sites, but 70 in one shallow site (BCS, where macroalgae also grew somewhat taller than the average elsewhere).

The sea urchin, *Diadema antillarum,* was present in five shallow sites (Table 3). Maximum densities of about 36 individuals/100 m^2 were found in a shallow fringing reef (DMH). Damselfish, particularly *Stegastes planifrons,* exhibiting algal-gardening behavior in individually surveyed stony corals were recorded in all but one site (CSS), with the highest percentages found in shallow water (Table 2). Algal gardens were primarily found in live colonies of *M. faveolata* and were also present in *M. annularis, M. franksi* and *Millepora complanata;* in one site (CRV), the damselfish showed a high preference for standing dead colonies of *A. palmata*.

DISCUSSION

The application of the AGRRA protocol, in concert with the recent studies of García (2001) and León (2001), has given us a general overview of the present condition of the barrier, fringing, and patch reefs in Los Roques National Park. The earlier descriptions of Méndez-Baamonde (1978) can now be updated and our results will allow comparisons of this important oceanic marine system with other reefs in the wider Caribbean (Kramer, this volume).

Hung's (1985) *area-based* estimate of percent live stony coral cover in a shallow SW fringing reef (DMH) in 1984 was highest at 2-3 m (mean=59, sd=17.5) which is about double that of our *linear* cover estimate in the same habitat in 1999 (Table 1). Numerous taxa (*Acropora prolifera, Agaricia* sp., *Dendrogyra cylindrus, Madracis* spp., *Meandrina meandrite*s, *Agaricia lamarcki*) that routinely achieve diameters in excess of 10 cm were listed by Hung (1985) but absent from the AGRRA surveys. Although the *A. prolifera* may well have disappeared as a result of WBD, we are unsure if the apparent loss of the other taxa is real or an artifact of different sampling intensity. Although we found no diseased corals in this site, García (2001) reported that 5.8% of the 605 stony corals (all size classes) examined here in 2000 showed signs of disease.

In 1984, the percent of live stony coral cover in the DMS fringing reef was highest (mean=72, sd=22.5, areal estimate) at 3-18 m (Hung, 1985). Relative to that baseline, our linear-based percentage data at 12 m in 1999 (mean=60, sd=18.5) and León's (2001) areal estimate at 1-11 m in the experimental diving area (mean=52.8, sd=25.2) are somewhat reduced, but in León's (2001) control area live stony coral coverage was substantially lower (mean=33.5, sd=3.2). Of the seven sites studied in 2000 by García (2001), the frequency of diseased corals (11.6%, n=335 corals) was greatest in the DMS fringing reef and an order of magnitude larger than what we had found the previous year (Table 2).

García (2001) also noted proportionately higher incidences of disease in 2000 in two other sites that were visited by the AGRRA team (6.7% at CRV; n=492 corals, and 5.8% at Boca de Cote; n=542 corals). However, the two datasets are not strictly comparable since García (2001) examined all size classes and surveyed in slightly different depths (1.5-5 m and 4-9 m).

Overall, during the quarter century since Méndez-Baamond's (1978) pioneering observations, the most striking change in shallow-intermediate depths at Los Roques has been the near disappearance of species of *Acropora*. Many colonies died during the early 1980's (Hung, 1985; Medina and Sandía, 1987), presumably from the effects of WBD as happened in so many areas of the wider Caribbean (Gladfelter, 1982; Aronson and Precht, 2001). Live *A. palmata* were still very rare in 1999 at the AGRRA survey sites with over half of the surviving colonies (11/17) occurring in a single shallow reef (DMH). Live colonies of *A. cervicornis* in the shallow sites were somewhat more abundant (e.g., 19 at DMH, 11 at NOR), more widespread (also occurring outside the belt transects in CRV, PR and BCS) and had a higher ratio of live/dead colonies (35/42). As we saw no recruits of *A. palmata* and those of *A. cervicornis* were only present in one site (NOR), it is very unlikely that their populations can recover any time in the near future to levels comparable to those observed in the archipelago during the 1970s.

In contrast to the reduced coverage in many shallow reef habitats, live stony coral cover values of ~30-60% at 8-13.5 m in the southern and southwestern reefs are high relative to recent reports from comparable habitats throughout much of the wider Caribbean (Kjerve, 1998; Kramer, this volume).

The high proportion of large colonies of *A. palmata* and *D. strigosa* in shallow sites (Fig. 4) and of *M. faveolata* in deeper sites (Fig.5) is evidence that, prior to the arrival of WBD, conditions for the growth and survival of stony corals at Los Roques must have been excellent for many decades or even centuries. Smaller colonies of these species may reflect past recruitment (although recruits of these species were absent in the AGRRA surveys) or subdivision of colonies from physical breakage or partial mortality of the live tissues.

The most common and widespread disease recorded in the 1999 AGRRA assessment was YBD (Table 2), which primarily occurs in *Montastraea*, and it was tied for first place with DSD in García's (2001) surveys during 2000. Given the seminal importance of *Montastraea* spp. (Figs. 2, 5) in these habitats, it would be of great concern should this trend continue.

In all but two shallow localities (BM, DMH), the key herbivore, *Diadema antillarum*, was either very rare or absent. Macroalgae were extremely sparse (<10% relative abundance) in all reefs except Boca de Cote, where the abundance of herbivorous fishes was somewhat reduced in the deeper (BCP) site (Posada et al., this volume) and where macroalgal indices (a proxy for biomass) were only elevated in the shallow (BCS) site. Hence, we suspect that nutrients are naturally exported from the large mangrove forests nearby in Sebastopol and stimulate benthic macroalgal production at Boca de Cote, particularly in shallow water where proportionately more sunlight is available for photosynthesis.

From the results obtained in this study, it is possible to conclude that the Archipiélago de Los Roques as a whole is still a "healthy" coral reef system, even allowing for the drastic declines that have occurred in its populations of *A. palmata* and *A. cervicornis.* However, the deeper sites in the southern barrier and a southwestern fringing reef were in better condition than the shallow sites. We suggest that major efforts must be made to continue to protect this reef system, which is of great importance for Venezuela and the Caribbean region.

ACKNOWLEDGMENTS

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Table 1. Site information for AGRRA stony coral and algal surveys in the Archipiélago de Los Roques National Park, Venezuela.

Site name	Site code	Reef type	Latitude (° ' N)	Longitude (° ' W)	Survey date	Depth (m)	Benthic transects (#)	≥10 cm stony corals species (#)	≥10 cm stony corals colonies (#/10 m)	% live stony coral cover (mean ± sd)
Shallow sites										
Noronqui de Abajo	NOR	Patches(NE)	11 55.805	66 44.629	Oct 10 99	1.5	7	7	8	21.5 ± 9.5
Barrera Este	BE	Barrier (East)	11 47.540	66 53.714	Oct 8 99	1.5	7	8	12	18.5 ± 8.0
Boca de Sebastopol	BS	Barrier (East)	11 46.711	66 34.827	Oct 8 99	4	11	9	8	7.5 ± 6.5
Cayo Vapor	CV	Barrier (East)	11 57.257	66 37.360	Oct 9 99	4	6	9	9	9.0 ± 7.0
Crasqui - La Venada	CRV	Fringing (CE)	11 52.868	66 53.714	Oct 7 99	5.5	11	12	11	8.0 ± 9.0
Pelona de Rabusqui	PR	Fringing (CE)	11 52.934	66 41.342	Oct 7 99	6.5	9	13	12	25.5 ± 12.0
Boca Cote Somero	BCS	Barrier (South)	11 48.014	66 42.346	Oct 6 99	2.5	8	12	11	7.5 ± 5.0
Dos Mosquises Herradura	DMH	Fringing (SW)	11 48.014	66 53.051	Oct 6 99	2	8	10	15	27.5 ± 14.0
All shallow sites (mean ± se)						**3.5 ± 2.0**	**8.5 ± 2..0**	**10**	**11 ± 2.5**	**15.5 ± 8.5**
Deep sites										
Boca del Medio	BM	Barrier (East)	11 54.638	66 35.547	Oct 9 99	7.5	9	11	7	19.0 ± 6.5
Boca de Cote Profundo	BCP	Barrier (South)	11 45.982	66 42.346	Oct 6 99	12	6	16	18	57.0 ± 21.5
Cayo Sal Sur	CSS	Barrier (South)	11 44.134	66 50.858	Oct 5 99	9.5	8	17	17	30.5 ± 17.0
Punta Cayo Sal	PCS	Barrier (South)	11 44.529	66 51.463	Oct 5 99	13.5	5	11	13	54.0 ± 9.5
Dos Mosquises Sur	DMS	Fringing (SW)	11 47.540	66 53.714	Oct 5 99	12	7	13	15	60.0 ± 18.5
All deep sites (mean ± se)						**10 ± 3.0**	**7 ± 2.0**	**13.5**	**13 ± 3.0**	**44.0 ± 18.0**

Table 2. Size and condition (mean ± standard deviation) of all stony corals (≥10 cm diameter) by site in Los Roques National Park, Venezuela.

Site code[1]	Stony corals		Partial colony mortality (%)			Stony corals (%)			
	#	Diameter (cm)	Recent	Old	Total	Standing dead	Bleached[2]	Diseased[3]	with Damselfish
Shallow sites									
NOR	54	64.5 ± 101.5	6.0 ± 7.0	24.5 ± 33.5	30.5 ± 34.0	5.5	3.5 PB	0	26.0
BE	72	109.5 ± 102.0	2.0 ± 5.0	52.0 ± 45.5	53.5 ± 45.0	34.5	0	1.5 WP,1.5RB	9.0
BS	87	100.5 ± 98.0	2.0 ± 3.5	74.0 ± 43.0	74.5 ± 42.0	49.5	0	0	89.0
CV	55	127.0 ± 104.5	1.5 ± 3.0	55.5 ± 44.5	56.5 ± 44.5	43.5	0	2 YBD-like	1.5
CRV	118	106.0 ± 67.0	10.0 ± 16.0	80.0 ± 36.5	82.5 ± 33.5	64.5	1P, 1.7 PB	1.5 YBD	38.5
PR	101	57.0 ± 60.5	8.0 ± 15.0	28.5 ± 32.5	35.5 ± 34.0	11	2 PB	6 YBD	31.5
BCS	86	71.0 ± 73.0	8.0 ± 13.5	66.5 ± 40.5	70.0 ± 39.0	32.5	1 P, 3.5 PB	3.5 YBD-like	31.5
DMH	99	58.5 ± 60.5	4.5 ± 10.0	34.0 ± 37.0	37.0 ± 36.0	14.0	0	0	37.5
All shallow sites (mean ± se)	**84 ± 23**	**87.0 ± 27.0**	**5.5 ± 3.5**	**52.0 ± 21.0**	**55.0 ±19.5**	**32.0 ± 20.5**			**36.0 ± 27.5**
Deep sites									
BM	65	128.0 ± 117.5	2.0 ± 5.0	39.5 ± 42.5	43.0 ± 42.5	16.5	3 P, 3 PB	0	29.0
BCP	101	78.0 ± 65.5	4.5 ±11.0	17..0 ± 16.0	22.0 ± 20.0	0	1 P, 3 PB	3 YBD	20.0
CSS	101	38.0 ± 26.5	1.0 ± 2.5	28.0 ± 28.5	28.5 ± 28.5	4	0	0	0
PCS	61	78.5 ± 57.0	1.0 ± 2.0	23.0 ± 20.5	24.0 ± 20.5	0	3.5 P	3.5 UK	16.5
DMS	87	92.5 ± 89.5	4.5 ± 8.5	18.5 ± 17.5	23.5 ± 20.0	0	0	1 UK	20.5
All deep sites (mean ± se)	**78.5 ± 19**	**83.0 ± 32.5**	**2.5 ± 2.0**	**25.0 ± 9.0**	**28.0 ± 8.5**	**10.0 ± 12.5**			**17.0 ± 10.5**

[1]Site names corresponding to the site codes are given in Table 1.
[2]P = pale; PB = partly bleached
[3]WP = white plague; RB = red-band disease; YBP like = unknown disease resembling YBD; YBP = yellow-blotch disease; UK = cause of recent mortality unknown but disease suspected.

Table 3. Algal characteristics (mean ± standard deviation), density of stony coral recruits and *Diadema antillarum* by site in the Archipiélago de Los Roques, National Park, Venezuela.

Site code[1]	Quadrats (#)	Relative abundance (%)			Macroalgal		Recruits (# /.0625m²)	*Diadema* (# /100m²)
		Macroalgae	Turf algae	Crustose coralline algae	Height	Index[3]		
Shallow sites								
NOR	30	6.0 ± 10.5	76.0 ± 16.5	18.0 ± 13.5	1.5 ± 2.0	10	0	0
BE	38	0	84.0 ± 15.5	16.0 ± 15.5	N[2]	N	0	17
BS	45	1.0 ± 2.5	62.5 ± 24.5	36.5 ± 25.0	0.5 ± 1.0	<0.5	.33	0
CV	20	3.5 ± 5.4	60.0 ± 25.5	36.5 ± 27.0	1.5 ± 1.5	5	0	0
CRV	40	0.5 ± 1.0	53.5 ± 22.5	46.5 ± 22.0	<0.5 ± 0.5	<0.5	.1	2
PR	30	0.5 ± 0.5	67.5 ± 25.0	32.5 ± 24.5	<0.5 ± 0.5	<0.5	.57	7
BCS	15	29.0 ± 32.0	26.5 ± 25.5	44.5 ± 21.0	2.5 ± 1.0	70	.13	1
DMH	30	1.5 ± 4.5	72.0 ± 30.0	26.5 ± 30.0	0.5 ± 1.5	1	.1	36
All shallow sites (mean ± se)	**31 ± 10**	**5.5 ± 9.8**	**63.0 ± 17.5**	**32.0 ± 11.3**	**~1.0 ± 1.0**	**~12 ± 26**	**.2 ± .2**	**8 ± 13**
Deep sites								
BM	24	<0.05 ± 0.1	63.5 ± 26.5	36.0 ± 26.5	<0.5 ± 0.5	<0.5	0	0
BCP	34	2.5 ± 5.5	76.0 ± 13.5	21.0 ± 13.5	1.0 ± 1.5	2.5	0	0
CSS	19	0	37.5 ± 9.0	62.5 ± 9.0	N	N	0	0
PCS	23	<0.05 ± <0.5	67.5 ± 8.0	32.5 ± 8.0	0.5 ± 0.5	<0.5	.22	0
DMS	27	0	38.0 ± 6.5	62.0 ± 6.5	N	N	0	0
All deep sites (mean ± se)	**25 ± 5.5**	**0.5 ± 1.0**	**56.5 ± 17.5**	**43.0 ± 18.5**	**~0.5 ± 0.5**	**~1 ± 1**	**.04 ± .1**	**0**

[1]Site names corresponding to the site codes are given in Table 1.
[2] N = not present.
[3] Data from Villamizar et al. (this volume).