

Figure 1. AGRRA survey sites in Cahuita, Costa Rica (modified from Cortés, 1998).

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## A RAPID ASSESSMENT AT CAHUITA NATIONAL PARK, COSTA RICA, 1999 (PART 2: REEF FISHES)

BY

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### ABSTRACT

In Costa Rica's Cahuita National Park, fish density, diversity and size were greater in two shallow (<6 m) reefs, where topographic complexity and macroalgal abundance and height were higher and where density of *Diadema antillarum* and fishing pressures were lower than in a hardground at 7 m. Apparently there has been a slight improvement in the status of the lagoonal fish community since the implementation of fishing restrictions in 1978.

### INTRODUCTION

The fringing reef at Cahuita, 35 km south of the city of Limón, is the largest along Costa Rica's Caribbean coast. Nearshore currents in the area flow from northwest to southeast (Cortés, 1998). The outer reef (1 km from the coast) arcs around the northern tip of Punta Cahuita, runs southeast about 5 km, and bends inshore towards Puerto Vargas (Fig. 1). Several small patch reefs occur in the lagoon. There is also a small, 500-m long inner reef (100 m from the coast) in front of Puerto Vargas Beach and some carbonate hardgrounds occur to the south of the main reef.

Cahuita is a relatively protected national park; however, its coral reefs are not exempt from siltation stress arising in unprotected and deforested watersheds nearby. Deforestation, mainly for banana plantations, and consequent damage to reef organisms has greatly increased during the last 30 years (Cortés, 1994). The Caribbean coastal lowlands are very humid (annual rainfall near Cahuita is about 300 cm/year) leading to erosion of poorly covered soils. Currents are strong and wave energy is high (Cortés, 1998). Hence bottom sediments are easily resuspended, and suspended sediment levels are high (Cortés, 1994; Fonseca, 1999, Caribbean Coastal Marine Productivity unpublished report).

There have been few studies of fishes in Costa Rica's Caribbean coral reefs (e.g., Perry and Perry, 1974). In Cahuita, Phillips and Pérez-Cruet (1984) found that reefs with

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similar habitat complexity showed the highest fish composition similarity values, and an increase in fish size was observed as habitat complexity increased. Fish diversity currently is known to be low in Cahuita relative to other Caribbean reef areas, possibly due in part to the poor condition of its coral reefs. Fishing pressure overall is comparatively low because only hook-and-line fishing has been allowed inside the park since 1978.

Our purpose was to characterize the fish communities in Cahuita National Park at the end of the millennium using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol. Similar data were obtained a year later south of Cahuita in the fringing reef off Manzanillo, close to the Panamanian border. The results of the benthos surveys are described by Fonseca (this volume).

## METHODS

Three reefs (Fig. 1, Table 1) that are each considered representative of a habitat type in Cahuita National Park were strategically chosen for survey by an experienced observer (Gamboa) in October 1999.

- Meager Shoal, a circular, 7 m-deep hardground (10,000 m<sup>2</sup>) south of the southern end of the outer reef, seaward of Puerto Vargas beach, and about 1 km from the coast, was chosen for its higher coral diversity. The sediment that surrounds this bank is muddy and easily resuspended by currents.
- Eduardo Garden, a shallow lagoonal patch reef (6,060 m<sup>2</sup>) between the outer and inner reefs and about 500 m from the coast, was chosen because it is in better condition than other sites in the lagoon. Local guides take tourists snorkeling here, and its fish populations were surveyed in 1982 by Phillips and Pérez-Cruet (1984).
- Chance Mouth, a shallow, spur-and-groove fore reef at an average depth of 5.5 m and about 500 m from the coast, was chosen because it is adjacent to the mouth of the only natural boat channel crossing the outer reef. Off Manzanillo, the shallow fore reef at similar depths (4 m) is a low-relief platform.

The AGRRA Version 2.2 protocol (see Appendix One, this volume) was modified to include all relatively abundant damselfish (*Abudefduf*, *Microspathodon*, *Stegastes*) in the belt transects. The fish counts were all made between 10 a.m. and 4 p.m. Consistency training was undertaken with a graduated T-bar prior to beginning the surveys.

Fish diversity ( $H'$ ), equity ( $J$ ) and Morisita similarity ( $M_i$ ) indices, based on the entire dataset, were also estimated for each reef. Differences in fish diversity indices were tested with a Student t-test.

## RESULTS

The number of species (AGRRA list/total) in the belt transects varied between 15/18 in Meager Shoal and 31/34 in Eduardo Garden (Table 1, Appendix A, this paper). Eduardo Garden also had the highest values for the diversity and equity indices, whereas

the lowest of both were found in Meager Shoal. Diversity indices varied significantly among sites (t-test,  $p < 0.0001$ ). The fish faunas in Eduardo Garden and Chance Mouth were the most similar in composition ( $M_i = 0.90$ ), those in Chance Mouth and Meager Shoal were somewhat less similar ( $M_i = 0.69$ ), while the least similar were the faunas of Eduardo Garden and Meager Shoal ( $M_i = 0.54$ ). Damselfishes (mainly *Stegastes fuscus* and, except in Meager Shoal, *Abudefduf saxatilis*) were numerical dominants in all three sites. At Manzanillo in 2000 the number of AGRRA/total species were 13/14, of which the dominant were grunts (haemulids) and surgeonfishes (acanthurids; Tables 1 and 2).

In 1999, AGRRA-listed fishes were over four times more abundant in Eduardo Garden than in Meager Shoal and about a third more plentiful in Meager Shoal than in Chance Mouth (Table 1). The two most common fishes in Meager Shoal were the parrotfish (scarid), *Sparisoma viride*, and the damselfish, *Microspathodon chrysurus* (Appendix A, this paper). In addition, three of the four most abundant AGRRA fishes in Eduardo Garden (two parrotfishes, *Scarus croicensis* and *Sparisoma rubipinne*, and one surgeonfish, *Acanthurus bahianus*) and five of the seven AGRRA fishes that were most common in Chance Mouth (*S. rubipinne*, *M. chrysurus*, and the surgeonfishes, *Acanthurus coeruleus*, *A. bahianus* and *A. chirurgus*) were herbivores.

The snapper (lutjanid), *Lutjanus apodus*, and grunts, particularly *Haemulon aurolineatum*, were also conspicuous in Eduardo Garden, while a grunt (*H. macrostomum*) and a jack (carangid), *Caranx ruber*, were fairly common in Chance Mouth. Three species of small-sized groupers (serranids) were seen in Eduardo Garden, two of which were also present in Meager Shoal (Appendix A, this paper). The overall densities of parrotfishes, snappers and grunts were highest in Eduardo Garden, while surgeonfishes were most abundant in Chance Mouth. Groupers, particularly *Epinephelus cruentatus*, were most common in Meager Shoal. The average density of the AGRRA-listed species off Manzanillo in 2000 was about half of that which had been found in Chance Mouth the previous year (Table 1). The most common species in Manzanillo were the surgeonfish, *A. coeruleus* ( $\sim 2 \pm 3$  individuals/100 m<sup>2</sup>), the grunts, *Haemulon carbonarium* and *H. parra* ( $\sim 1.5 \pm 5$  and  $\sim 2 \pm 6$  individuals/100 m<sup>2</sup>, respectively), and the parrotfish, *S. viride* ( $\sim 1.5 \pm 1.5$  individuals/100 m<sup>2</sup>).

The mean lengths of surgeonfishes in all three of the Cahuita reefs, and of parrotfishes, groupers and snappers in Meager Shoal, were each less than 20 cm (Table 3). Grunts in all reefs, as well as parrotfishes and snappers in Eduardo Garden and Chance Mouth, each had mean lengths in the 20-30 cm interval. Overall, however, many individual fishes were in the 11-20 cm size range. In Manzanillo all the surveyed fishes were less than 20 cm in length, except for snappers which averaged 30 cm, and a single grouper, *Mycteroperca bonaci*, that was 50 cm long.

## DISCUSSION

The density, size and diversity of the AGRRA fishes at Cahuita were higher in the two shallower reefs than in the deeper hardground (Tables 1-3; Appendix A, this paper). Relative to Meager Shoal, these reefs also had larger-sized corals, somewhat more macroalgae and crustose coralline algae (Fonseca, this volume), and fishing pressures

were lower (personal observations). Topographic complexity was also higher in Chance Mouth, due to its spur-and-groove topography, and in Eduardo Garden with its large colonies of mostly-dead *Acropora palmata* than in Meager Shoal. The macroalgal index (macroalgal relative abundance x macroalgal height, a proxy for macroalgal biomass) was highest in Chance Mouth (Table 2), where herbivore feeding may be inhibited by the comparatively high surge and wave action (Hay, 1981). Herbivorous fishes in these two reefs apparently are less capable of removing macroalgae from the substrata than the *Diadema antillarum* that currently are more common in Meager Shoal.

Meager Shoal, with the highest relative abundance of turf algae (Fonseca, this volume), also had the fewest and smallest fishes (excepting groupers). Species targeted by hook-and-line fishers are primarily grunts and snappers (Mug, unpublished report) and one of the most popular, *Haemulon macrostomum*, was extremely rare in this hardground (yet it was the only grunt present in the belt transects; Appendix A, this paper). The fishing pressure in Manzanillo is greater still since it is not a national park. Its fore-reef platform also has lower topographic relief than the spurs and grooves off Cahuita, and macroalgae were about twice as abundant here in 2000 as had been found the previous year at similar depths in Chance Mouth.

Damselfishes and wrasses (labrids) dominated Phillips and Pérez-Cruet's (1984) surveys of Caribbean fishes. Damselfishes are still very abundant in Cahuita (Appendix A, this paper). In Eduardo Garden (their transect 7), Phillips and Pérez-Cruet (1984) found a mean density of 113.3 individuals/100 m<sup>2</sup> and a diversity index of 2.71 ( $J = 0.80$ ;  $S = 30$ ). Our values for fish density and diversity (including all damselfishes but lacking wrasses) were both higher in Eduardo Garden in 1999 (Appendix A, this paper).

Presumably the protection against most forms of fishing in Cahuita National Park is allowing some recovery of its reef fish populations. Nevertheless, fish diversity in the park is low relative to other areas of the Caribbean (Perry and Perry, 1974; Phillips and Pérez-Cruet, 1984) and probably related to the poor condition of its coral reefs (Fonseca, this volume). Hence stronger management actions must be implemented in the park, particularly in the southern hardgrounds.

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Table 1. Site information for AGRRA fish surveys in Cahuita and Manzanillo, Costa Rica.

Site name	Site code	Reef type	Latitude (°' " N)	Longitude (°' " W)	Survey date	Depth (m)	% live stony coral cover (mean ± sd) <sup>1</sup>	30 m fish transects (#)	AGRRA fishes		<i>Diadema</i> (#/10 m <sup>2</sup> ) <sup>1</sup>
									Density (#/100 m <sup>2</sup> ) (mean ± sd)	Species (#)	
<b>Cahuita</b>											
Meager Shoal	A	Carbonate bank	9 43 50	82 48 32	Oct 7 1999	7.0	2.0 ± 1.0	10	20.0 ± 13.08	15	6.1 ± 3.2
Eduardo Garden	B	Lagoonal patch reef	9 44 30	82 48 30	Oct 22 1999	2.0	3.0 ± 1.0	10	92.2 ± 66.13	31	0.1 ± 3
Chance Mouth	C	Fore-reef spur & groove	9 45 00	82 48 35	Oct 22 1999	5.5	3.0 ± 1.0	10	62.0 ± 50.62	17	0.7 ± 7
<b>Manzanillo</b>	D	Fore-reef platform	9 38 22	82 39 13	Oct 4 2000, Oct 11 200	4	1.5 ± 0.5	11	10.1 ± 8.37	13	1.0 ± 22

<sup>1</sup> Data from Fonseca (this volume).

Table 2. Density (mean ± standard deviation) of AGRRA fishes and macroalgal index, by sites in Costa Rica.

Site name	Herbivores (#/100 m <sup>2</sup> )			Carnivores (#/100 m <sup>2</sup> )			Chaetodontidae (#/100 m <sup>2</sup> )	Pomacanthidae (#/100 m <sup>2</sup> )	Macroalgal index <sup>2</sup>
	Acanthuridae	Scaridae (≥5 cm)	<i>Microspathodon chrysurus</i>	Haemulidae (≥5 cm)	Lutjanidae	Serranidae <sup>1</sup>			
<b>Cahuita</b>									
Meager Shoal	2.5 ± 2.5	6.5 ± 6.5	4.5 ± 5.0	0.2	2.5 ± 4.5	3.5 ± 2.0	0.8 ± 1.2	0	48
Eduardo Garden	20.0 ± 18.5	28.5 ± 17.5	5.0 ± 3.5	23.5 ± 25.0	11.0 ± 16.5	2.0 ± 4.0	2.0 ± 1.3	0	78
Chance Mouth	25.0 ± 27.0	13.5 ± 11.5	7.0 ± 7.0	10.0 ± 8.5	5.0 ± 4.5	0	0.8 ± 1.4	0.2	134
<b>Manzanillo</b>	3.2 ± 5.0	1.7 ± 1.5	0.3	3.3 ± 11.1	0.8 ± 2.0	0.2	0	0.4 ± 0.8	416

<sup>1</sup> *Epinephelus* spp. and *Mycteroperca* spp.

<sup>2</sup> Macroalgal index = % relative abundance of macroalgae x canopy height; data from Fonseca (this volume).

Table 3. Total length in cm (mean  $\pm$  standard deviation) of AGRRA fishes, by sites in Costa Rica.

Site name	Herbivores			Carnivores			Chaetodontidae	Pomacanthidae
	Acanthuridae	Scaridae ( $\geq 5$ cm)	<i>Microspathodon chrysurus</i>	Haemulidae ( $\geq 5$ cm)	Lutjanidae	Serranidae <sup>2</sup>		
<b><i>Cahuita</i></b>								
Meager Shoal	18.5 $\pm$ 6.0 n <sup>1</sup> =6	14.5 $\pm$ 5.0 n=10 <sup>1</sup>	11.0 $\pm$ 2.5 n=10	25.5 n=1	17.5 $\pm$ 4.5 n=5	18.0 $\pm$ 3.5 n=9	8.5 $\pm$ 5.5 n=4	0
Eduardo Garden	18.5 $\pm$ 6.0 n=6	20.5 $\pm$ 5.5 n=10	13.5 $\pm$ 3.0 n=10	24.0 $\pm$ 4.5 n=10	24.0 $\pm$ 7.5 n=9	22.0 $\pm$ 5.0 n=4	14.5 $\pm$ 2.5 n=8	0
Chance Mouth	17.0 $\pm$ 7.0 n=9	23.5 $\pm$ 8.0 n=10	12.0 $\pm$ 2.0 n=10	23.0 $\pm$ 6.0 n=9	20.0 $\pm$ 8.5 n=8	0	13.0 $\pm$ 4.5 n=3	25.5 n=1
<b><i>Manzanillo</i></b>	10.6 $\pm$ 12.6 n=21	13.7 $\pm$ 6.7 n=11	11.8 n=2	12.1 $\pm$ 1.41 n=22	30.5 $\pm$ 7.1 n=5	50.0 n=1	0	18.8 $\pm$ 5.8 n=3
<b>All Cahuita sites</b>	<b>17.5 <math>\pm</math> 6.0 n=23</b>	<b>19.5 <math>\pm</math> 7.0 n=30</b>	<b>12.5 <math>\pm</math> 2.5 n=30</b>	<b>23.7 <math>\pm</math> 5.0 n=20</b>	<b>21.0 <math>\pm</math> 7.5 n=22</b>	<b>19.0 <math>\pm</math> 4.0 n=13</b>	<b>12.5 <math>\pm</math> 4.5 n=15</b>	<b>25.5 n=1</b>

<sup>1</sup>n = number of individuals

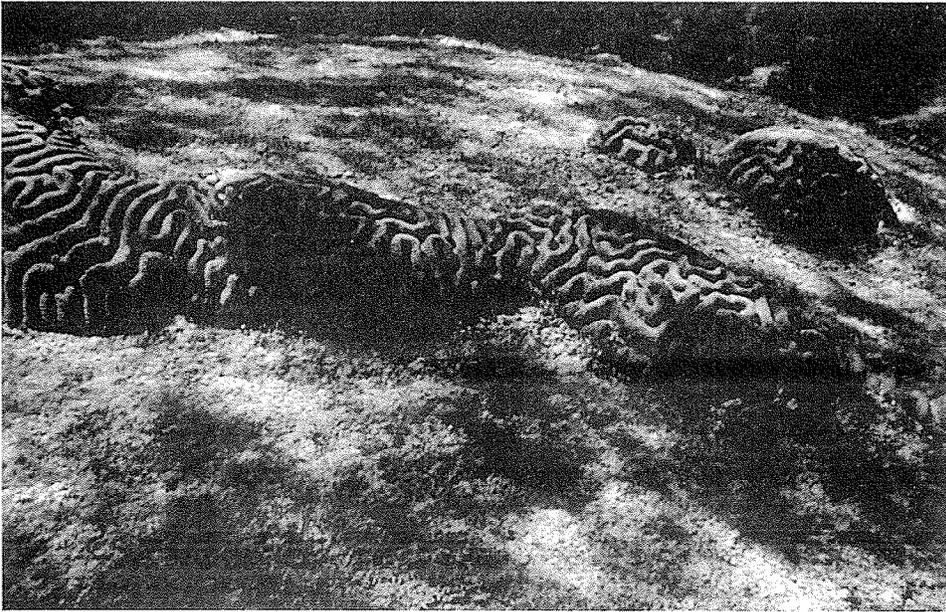
<sup>2</sup>*Epinephelus* spp. and *Mycteroperca* spp.

Appendix A. Density (mean  $\pm$  standard deviation) and diversity indices for AGRRA fishes and other damselfishes, by site in Cahuita, Costa Rica.

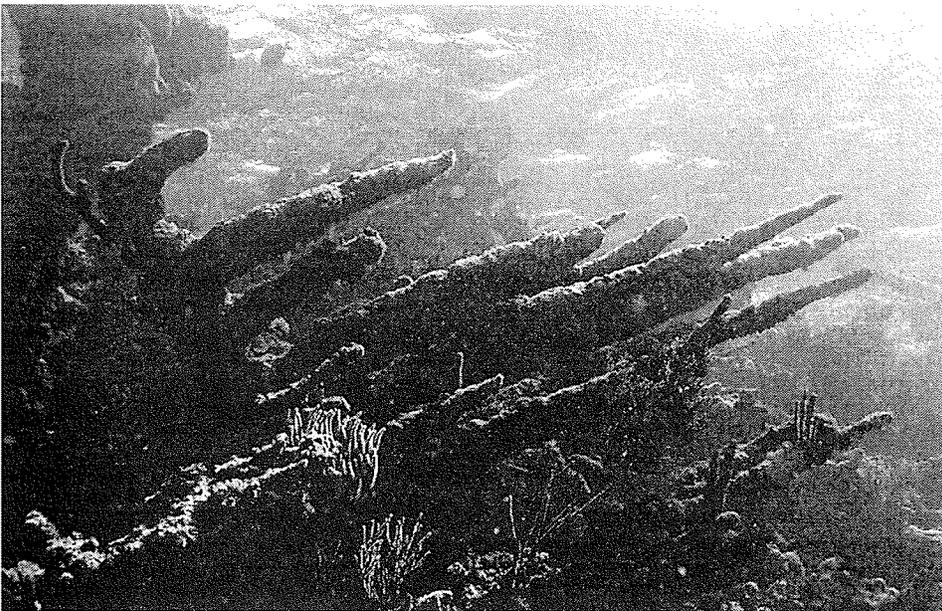
Fish species	Density (#/100 m <sup>2</sup> )		
	Meager Shoal	Eduardo Garden	Chance Mouth
<i>Pomacanthus paru</i>	0.0 $\pm$ 0.0	0	0.2 $\pm$ 0.5
<i>Chaetodon capistratus</i>	0.2 $\pm$ 0.5	0.2 $\pm$ 0.5	0
<i>Chaetodon striatus</i>	0.0 $\pm$ 0.0	0.5 $\pm$ 0.8	0
<i>Chaetodon ocellatus</i>	0.7 $\pm$ 1.2	1.3 $\pm$ 1.7	0.8 $\pm$ 1.4
<i>Anisotremus virginicus</i>	0	1.0 $\pm$ 1.4	0.5 $\pm$ 0.8
<i>Anisotremus surinamensis</i>	0	0.2 $\pm$ 0.5	0
<i>Haemulon plumieri</i>	0	0.8 $\pm$ 1.6	0
<i>Haemulon sciurus</i>	0	1.2 $\pm$ 2.1	0
<i>Haemulon flavolineatum</i>	0	4.5 $\pm$ 3.5	0
<i>Haemulon aurolineatum</i>	0	7.5 $\pm$ 15.6	0
<i>Haemulon carbonarium</i>	0	4.8 $\pm$ 15.2	0
<i>Haemulon macrostomum</i> <sup>1</sup>	0.2 $\pm$ 0.5	3.7 $\pm$ 4.4	9.5 $\pm$ 8.4
<i>Sparisoma viride</i>	4.8 $\pm$ 5.6	2.8 $\pm$ 4.0	1.2 $\pm$ 1.4
<i>Sparisoma rubripinne</i>	1.2 $\pm$ 1.8	7.8 $\pm$ 3.7	7.8 $\pm$ 4.4
<i>Sparisoma aurofrenatum</i>	0.3 $\pm$ 0.7	1.7 $\pm$ 3.8	3.3 $\pm$ 10.5
<i>Scarus taeniopterus</i>	0	0.2 $\pm$ 0.5	0
<i>Scarus croicensis</i>	0	14.2 $\pm$ 12.2	1.2 $\pm$ 3.7
<i>Sparisoma chrysopterum</i>	0	1.5 $\pm$ 4.7	0
<i>Scarus coelestinus</i>	0	0.2 $\pm$ 0.5	0.2 $\pm$ 0.5
<i>Epinephelus guttatus</i>	0.3 $\pm$ 0.7	0.3 $\pm$ 0.7	0
<i>Epinephelus cruentatus</i>	3.0 $\pm$ 2.1	1.5 $\pm$ 3.6	0
<i>Epinephelus fulvus</i>	0	0.2 $\pm$ 0.5	0
<i>Lutjanus analis</i> <sup>1</sup>	0	0.2 $\pm$ 0.5	0
<i>Lutjanus apodus</i> <sup>1</sup>	0	7.8 $\pm$ 16.9	0
<i>Lutjanus griseus</i> <sup>1</sup>	0	0	0.2 $\pm$ 0.5
<i>Lutjanus mahogoni</i> <sup>1</sup>	2.2 $\pm$ 4.6	2.2 $\pm$ 3.9	3.7 $\pm$ 3.8
<i>Ocyurus chrysurus</i> <sup>1</sup>	0.2 $\pm$ 0.5	0.7 $\pm$ 0.9	1.3 $\pm$ 3.1
<i>Lutjanus jocu</i> <sup>1</sup>	0	0.3 $\pm$ 0.7	0
<i>Acanthurus bahianus</i>	1.7 $\pm$ 2.1	13.8 $\pm$ 20.0	8.0 $\pm$ 11.1
<i>Acanthurus chirurgus</i>	0.3 $\pm$ 1.1	0.8 $\pm$ 2.1	6.0 $\pm$ 12.5
<i>Acanthurus coeruleus</i>	0	5.2 $\pm$ 5.8	11.2 $\pm$ 19.4
<i>Bodianus rufus</i>	2.8 $\pm$ 4.8	4.0 $\pm$ 3.2	4.5 $\pm$ 8.1
<i>Microspathodon chrysurus</i>	4.3 $\pm$ 5.2	5.2 $\pm$ 3.5	7.0 $\pm$ 7.1
<i>Stegastes fuscus</i> <sup>2</sup>	31.5 $\pm$ 16.0	37.5 $\pm$ 56.4	71.3 $\pm$ 31.6
<i>Stegastes partitus</i> <sup>2</sup>	3.0 $\pm$ 5.1	0	0
<i>Abudefduf saxatilis</i> <sup>2</sup>	0.3 $\pm$ 1.1	47.2 $\pm$ 76.3	69.5 $\pm$ 108.1
<i>Caranx ruber</i>	0	2.0 $\pm$ 3.3	9.3 $\pm$ 12.6
<b>Total fish species (S)</b>	<b>18</b>	<b>34</b>	<b>20</b>
<b>Total fishes (N)</b>	<b>350</b>	<b>1096</b>	<b>1297</b>
<b>Total fish species diversity (H)'</b>	<b>2.5</b>	<b>3.7</b>	<b>2.8</b>
<b>Total fish species equity (J)</b>	<b>0.6</b>	<b>0.7</b>	<b>0.6</b>

<sup>1</sup>Fishes targeted by line fishers (Mug 2000, unpublished report)

<sup>2</sup>Not included in the calculations of AGRRA fish density in Table 1.



**Plate 7A.** “Old mortality,” as in this *Diploria strigosa*, is defined as any non-living parts of a stony coral in which the corallite structures have either been lost or are covered by organisms that are not easily removed (certain algae, invertebrates and colonial foraminifera). (Photo Kenneth W. Marks)



**Plate 7B.** Colonies that are completely, or 100% dead, known as “standing dead,” are also assessed as long as they can be identified to generic level based on colony morphology, as shown for this *Acropora palmata*, or by residual corallite characters (e.g., *Diploria* spp., *Montastraea cavernosa*). (Photo Robert S. Stenenck)