

Figure 1. AGRRRA survey sites (Kalki, Jeremi, Lagun, Oostpunt) on the leeward coast of Curaçao.

CONDITION OF CORAL REEFS OFF LESS DEVELOPED COASTLINES OF CURAÇAO (PART 2: REEF FISHES)

BY

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ABSTRACT

Reef fish populations at 9-12 m depth in more remote eastern and western Curaçao were characterized by low abundance, size, and diversity of large-bodied species. Families often contained only a few of the species previously reported in Curaçao and many commercially important food species were absent. Grunts, parrotfishes, surgeonfishes and butterflyfishes were most abundant. The densities of most species averaged less than eight individuals/100 m² and their mean sizes were 15-25 cm. Most reefs contained one or two tiger grouper (*Mycteroperca tigris*) and barracuda of larger sizes (~25-35 cm) and several medium- to large-sized (20-28 cm) parrotfish. No major differences were apparent between an underwater park in Oostpunt and the western reefs. The cumulative impacts of heavy fishing pressure, lack of enforcement of a spearfishing ban, along with increased urbanization and degradation of coastal nursery areas, may have contributed to the decline of Curaçao's reef fishes.

INTRODUCTION

Curaçao, Netherlands Antilles is a small (61 km long; 443 km² area) oceanic island situated 60 km north of Venezuela (Fig. 1). The island is oriented on a northwest/southeast axis and has a narrow submarine shelf that slopes steeply into deep water. Fringing reefs surround the island but are best developed along the leeward (south) coast. The island is sparsely populated (155,000 people) with an economy based on an oil refinery and other industries, offshore banking, and tourism. There is a small commercial fishery that targets pelagic species with an estimated catch of 90-180 metric tons/year (Woodley et al., 1997). Most reef fishes for restaurant and grocery markets are imported from Venezuela although subsistence fishing is widespread along the leeward coast.

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Reef conditions and reef fish populations have degraded near population centers due to extensive coastal development, industrial activities, raw sewage discharge, sedimentation, and vessel impacts (Woodley et al., 1997). Reefs at the eastern and western ends of the island are thought to be in better condition as they are well removed from urban and industrial development. Two small fishing villages (Lagun and Westpunt) are found at the western end of Curaçao, but coastal development is minimal and population density is low. The Curaçao Underwater Park extends 21 km eastward from the outskirts of Willemstad (Princess Beach Hotel) to Oostpunt and includes a 12-km stretch of coastline that is undeveloped and uninhabited. The park also contains an extensive (436 hectares) partially enclosed bay (Spaanse Water) where most of the island's mangroves and *Thalassia testudinum* seagrass beds are found (Debrot et al., 1998).

Few quantitative data are available on the reef fish communities of Curaçao (Nagelkerken, 1974; 1977; 1980). However, they are reported to be overfished as a result of heavy artisanal fishing pressure and the use of spear guns, fish traps, and gill nets (Van't Hof et al., 1995). The purpose of this study was to collect baseline information on the status of fish populations in more remote locations of Curaçao at the time of initial enforcement of spearfishing prohibitions and to determine whether differences existed between the marine-park and open-access areas. The Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol was used to assess the diversity and population dynamics of reef fish with a focus on commercially and ecologically important large-bodied species.

METHODS

Limited estimates of the abundance and size of reef fish populations were made in four strategically chosen fringing reefs off the less populated, southeast (Oostpunt) and southwest (Jeremi, Lagun and Kalki) coasts of Curaçao by one diver (R. Bruckner) in August 1998. Belt transects were conducted as described in the AGRRA Version 2 fish protocol (Appendix One, this volume) except that temporal constraints restricted the number of transects to three-four at each reef. All transects (30 m long, 2m X 2m window) were run parallel to depth gradients at 9-12 m depth in the same general area as the benthic surveys (Bruckner and Bruckner, this volume). Counts of serranids (groupers) were restricted to species of *Epinephelus* and *Mycteroperca*. Scarids (parrotfishes) and haemulids (grunts) less than 5 cm in total length (TL) were not tallied and only one damselfish, *Microspathodon chrysurus*, was recorded. Previous training dives (July 1998; n=10 dives) were conducted in Puerto Rico using styrofoam fish models (for estimating sizes) and practice transects to obtain consistency in sampling area, swimming speed, and species identification. *Reef Fish Identification* by Humann (1997) was used to confirm species identities.

RESULTS

Most families of large-bodied reef fishes included in the AGRRA protocol were represented in the remote reefs of eastern and western Curaçao although the species richness and abundance of each were relatively low at all sites (Table 1; Fig. 2). Lagun and Oostpunt had the highest numbers of species (26), while Jeremi had the highest density (57 individuals/100 m²). Herbivores were prominent in all reefs. Overall, parrotfishes were more common than surgeonfishes (acanthurids), but there was a notable absence of schools containing more than 6-10 adult (≥ 10 cm TL) fish. *Sparisoma viride* and *Scarus taeniopterus* were the dominant parrotfishes; *S. rubripinne*, *S. aurofrenatum* and *S. croicensis* were also common and juveniles (<10 cm TL) of these and other species were abundant in all locations.

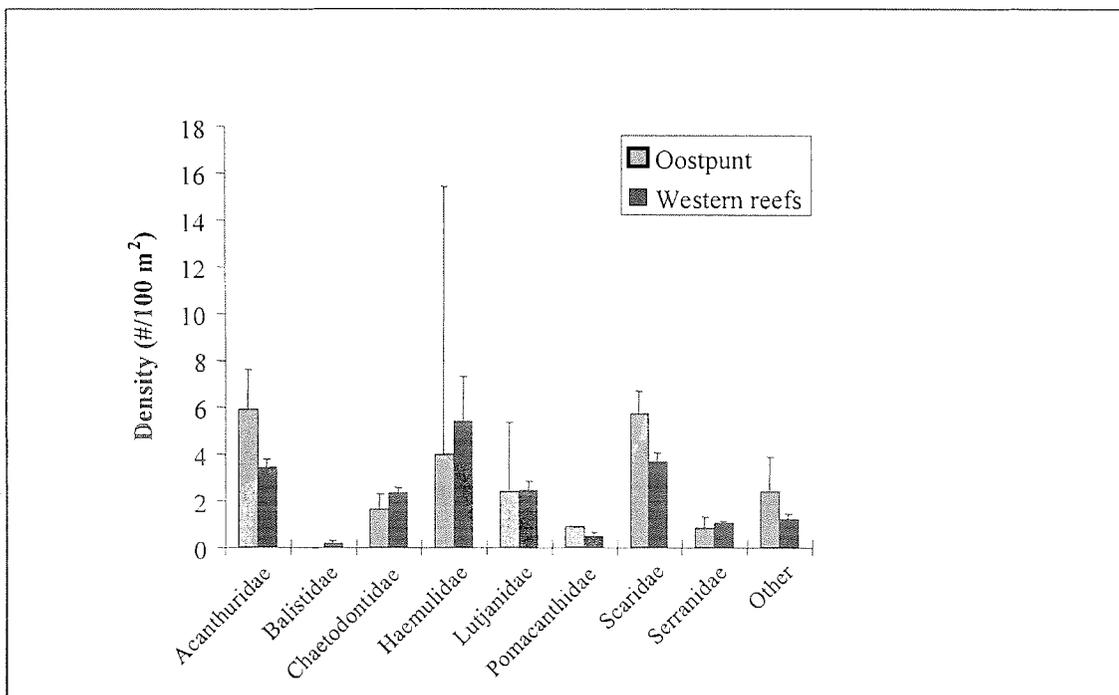


Figure 2. Mean fish abundance (no. individuals/100 m² ± sd) for AGRRA fishes in eastern and western Curaçao. Other = *Bodianus rufus*, *Microspathodon chrysurus*, *Sphyraena barracuda*.

There were no substantial differences between Oostpunt and western reefs in the overall abundance of reef fishes [pooled by family; two-factor Analysis of Variance (ANOVA); MS=0.8, F=0.95, p=0.36] although the abundance of individual families did vary (ANOVA; MS=6.6, F=8.1, p=0.004). Post-hoc analysis of major groups (pooled into herbivores, major predators, and other predators; Tukey HSD multiple comparison test) indicated that herbivores were significantly more abundant at Oostpunt with minor, non-significant differences among other groups (Fig. 2). The most abundant group of fish observed at Jeremi, Oostpunt and Lagun overall were grunts, which formed large resting

schools at the base of large coral heads, the dominant species being *Haemulon flavolineatum* and *H. aurolineatum*. Commercially important *H. plumieri* were encountered only at Oostpunt. Grunts were relatively uncommon at Kalki although three species (*Anisotremus surinamensis*, *H. sciurus* and *H. flavolineatum*) were observed. Oostpunt had a larger number and species of angelfishes (pomacanthids) and butterflyfishes (chaetodontids) than were recorded within transects on other reefs. No angelfish were recorded within transect areas at Jeremi whereas *Chaetodon capistratus* and *C. striatus* were present in all four locations. Among the leatherjackets (balistids), *Cantherines pullus* was recorded within a belt transect only on Jeremi. Filefish (*C. pullus*, *C. macrocerus*, *Aluterus scriptus*) were found in areas away from transects at the same depth on all reefs, and *Melichthys niger* commonly occurred in the water column at Oostpunt. *Balistes vetula* were also absent from transects in all locations but individuals were observed among gorgonians in shallow water (3-5 m depth) at Oostpunt. In addition, large schools of *Caranx ruber* and *C. crysos* were frequently sighted in the water column but not within transects. Important top predators were generally uncommon. Each reef had one-two individuals each of tiger grouper (*Mycteroperca tigris*) and barracuda (*Sphyraena barracuda*). The most abundant snapper was *Lutjanus apodus* which occurred on all reefs but was most common at Lagun. Other predators recorded on most reefs at a low abundance include *Epinephelus guttatus*, *E. cruentatus*, *Lutjanus apodus*, *L. griseus* and *L. mahogoni* and, at Oostpunt only, *Ocyurus chrysurus*.

The mean total length of all fishes recorded within the belt transects was generally 15-25 cm (Table 2). The largest predators were *M. tigris*, *S. barracuda* and *L. apodus* (25.5-35.5 cm). Large stoplight parrotfish (*S. viride*) were identified at Jeremi (28 cm), Oostpunt (24 cm) and Kalki (21.5 cm), but this species was smaller at Lagun (18 cm) and

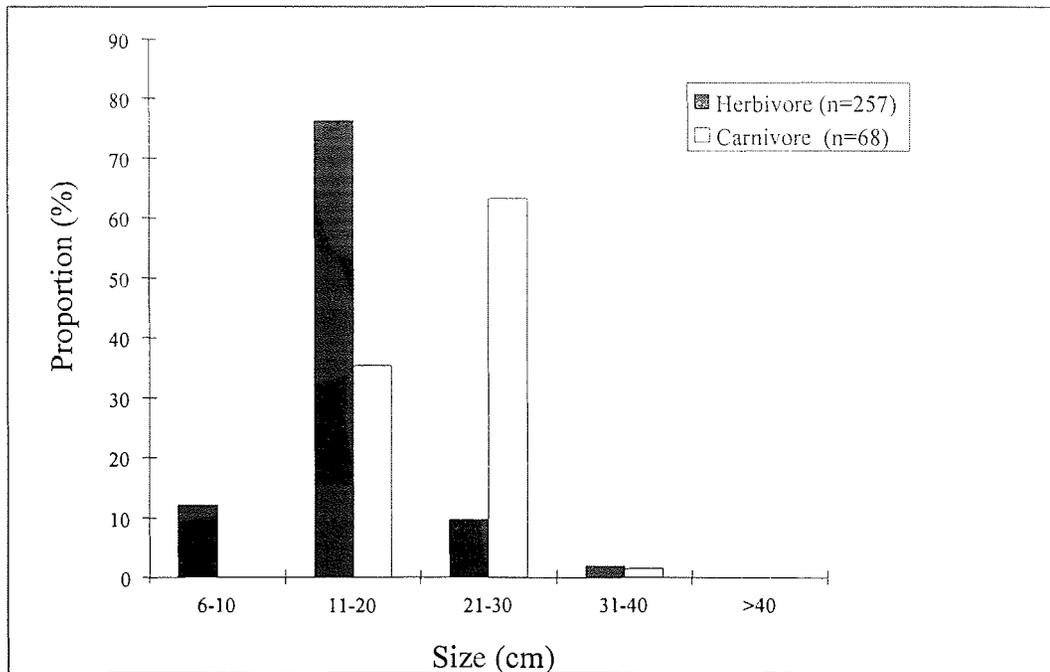


Figure 3. Size frequency distribution of herbivores (acanthurids, scarids ≥ 5 cm, *Microspathodon chrysurus*) and carnivores (all lutjanids, select serranids) in eastern and western Curaçao.

other species of parrotfish were mostly small (12-20.5 cm). Most grunts were small (8-15.5 cm) with the exception of a single *Haemulon macrostomum* at Oostpunt (25.5 cm) and one *A. surinamensis* (25.5 cm) at Kalki (Table 2). The size frequency distribution of commercially important carnivores (snappers and select groupers) and key herbivores (parrotfish, surgeonfish and yellowtail damselfish) are presented in Figure 3.

DISCUSSION

The ecologically and commercially important species of reef fishes included in the AGRRA species list exhibited a low diversity, abundance and size in the four locations examined in Curaçao. The dominant families seen during these surveys were Haemulidae, Scaridae and Acanthuridae, although one snapper (*Lutjanus apodus*) was abundant at a single location in western Curaçao. Typically, each family was represented by one-four species with the exception of parrotfishes, for which three-six species occurred in each reef. In each reef the top predators consisted of one-two tiger groupers and one-two barracudas, although these were fairly small in total length (25-35 cm). Other medium-sized fishes that were often equally or more abundant than the AGRRA-listed species included goatfish (Mullidae), squirrelfish and soldierfish (Holocentridae), and wrasses (Labridae) (R. Bruckner, unpub. obs.). From the historical data available for Curaçao, it is apparent that many commercially important groupers, snappers, grunts, hogfish (*Lachnolaimus maximus*) and other species that were formerly common on these reefs (Nagelkerken, 1974, 1977, 1980, 1981) were absent or occurred at very low numbers during the present survey.

While reef fish populations are known to be heavily overfished throughout Curaçao, reefs of Oostpunt are reported to be in the best condition (Van't Hof et al., 1995). Oostpunt's reefs are located off an undeveloped coastline that is upstream from terrestrial sources of pollution. In addition, fish populations are offered limited protection by their inclusion in a marine park and reefs are in close proximity to important nursery areas. The mangroves, seagrass beds and shallow-reef communities in Spaanse Water were identified as the most important nursery biotope for many of the species found on fringing reefs near Oostpunt, and 32 species on the AGRRA list were identified here (Nagelkerken et al., 2001). However, there did not appear to be substantial differences between reef fish populations at Oostpunt and those at the western end of the island in terms of species composition and size. In addition, it was difficult to approach most fish in all locations with exception of small resting schools of grunts, butterflyfishes, and the small herbivores.

Several factors appear to have contributed to the island-wide decline of reef fish populations. Heavy fishing pressure and the use of harmful gear (fish pots, gillnets and spearguns) are widespread and, until recently, were not managed (Van't Hof et al., 1995). Although Oostpunt is designated as a park, the island lacks no-take marine-protected areas (MPAs) and hook-and-line fishing is permitted within park boundaries. Until 1998, spearfishing was prevalent throughout Curaçao even though it had been prohibited more than 20 years earlier. As early as 1984, researchers reported a decline in abundance and size of groupers compared to the neighboring island of Bonaire which was thought to be

caused by spearfishing (Pors and Nagelkerken, 1998). The other major factor affecting fish populations may be the loss or degradation of important nursery areas. Rapid urbanization of Spaanse Water has been associated with the degradation of mangroves and seagrass beds and a precipitous decline of its coral populations (Debrot et al., 1998). The long-term effects of these changes on reef fish populations are largely unknown. However, in a recent survey within Spaanse Water, groupers were completely absent and other commercially important species, such as white grunts (*Haemulon plumieri*), margates (*H. album* and *Anisotremus surinamensis*) and most snappers, occurred at very low densities (Nagelkerken et al., 2001).

This study provides only a very limited snapshot of four reefs in the more remote locations of Curaçao and more extensive surveys are necessary to obtain a representative picture of the overall diversity, size and abundance of commercially and ecologically important reef fish. Nevertheless, these data may provide a baseline of their status at the onset of a full enforcement of the spearfishing prohibition. The elimination of spearfishing represents a critical step towards protecting and restoring Curaçao's reef fish populations but there is a need for other tools such as the establishment of no-take marine protected areas (Bohnsack et al., in press). It is hoped that this study will help convince resource managers and policy makers of the need for additional management measures for Curaçao's reefs (Van't Hof et al., 1995).

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Table 1. Site information for AGRRA fish surveys in Curaçao, Netherland Antilles.

Site name	Reef type	Latitude (° ' " N)	Longitude (° ' " W)	Survey date	Depth (m)	% live stony coral cover (mean ± se)	AGRRA fishes		
							30 m transects (#)	Mean density (#/100 m ²)	Species (#)
Oostpunt	Fringing	12 02 29.4	68 44 59.8	Aug 15 1998	9-12	27 ± 2.9	3	80.6	26
Lagun	Fringing	12 19 6.9	69 09 54.0	Aug 13 1998	10-11	25 ± 3.0	4	62.5	26
Jeremi	Fringing	12 19 44.3	69 09 1.2	Aug 14 1998	10-11	31 ± 3.9	3	94.4	24
Kalki	Fringing	12 22 31.3	69 09 29.8	Aug 14 1998	9-12	40 ± 4.1	3	54.4	21

Table 2. Number of species, plus density and length (mean ± standard deviation) of AGRRA fishes in four reefs off Curaçao.

Family name	Site Names											
	Oostpunt			Lagun			Jeremi			Kalki		
	Spp. (#)	Density (#/100 m ²)	Length (cm)	Spp. (#)	Density (#/100 m ²)	Length (cm)	Spp. (#)	Density (#/100 m ²)	Length (cm)	Spp. (#)	Density (#/100 m ²)	Length (cm)
Acanthuridae	3	17.8 ± 11.1	15.5 ± 0	3	9.2 ± 4.0	14.1 ± 2.9	2	8.9 ± 8.6	15.5 ± 0	3	8.3 ± 6.7	15.0 ± 1.9
Balistidae	0			0			1	0.6	25.5	0		
Chaetodontidae	4	6.7 ± 3.3	10.5 ± 3.5	2	4.2 ± 2.9	8.8 ± 2.4	3	6.1 ± 1.0	8.0	3	8.9 ± 4.2	12.8 ± 3.7
Haemulidae ¹	5	20.0 ± 6.0	14.7 ± 3.2	5	16.7 ± 22.6	15.7 ± 1.4	4	43.3 ± 20.2	12.6 ± 4.5	3	3.9 ± 5.4	17.7 ± 4.2
Lutjanidae	3	7.2 ± 6.7	21.7 ± 4.9	3	10.4 ± 8.2	22.7 ± 4.5	2	3.9 ± 6.7	24.1 ± 3.5	2	3.9 ± 3.5	21.2 ± 4.9
Pomacanthidae	3	2.8 ± 1.0	17.5 ± 4.0	1	0.8	20.5 ± 5.0	0			1	0.6	15.5
Scaridae ¹	3	17.2 ± 8.2	19.9 ± 5.7	6	16.3 ± 8.3	15.6 ± 4.6	7	25.0 ± 4.4	18.7 ± 8.9	5	23.3 ± 5.4	16.2 ± 3.0
Serranidae ²	2	1.7 ± 1.7	25.5 ± 0	3	2.9 ± 1.6	25.5 ± 7.6	3	3.3 ± 1.7	20.5 ± 7.6	2	1.7 ± 1.4	18.8 ± 4.0
<i>Microspathodon</i>	1	5.6 ± 5.1	15.5 ± 0	1	1.3 ± 2.5	15.5 ± 0	0			1	2.2 ± 1.9	8.0 ± 0
<i>Barracuda</i>	1	0.6	25.5	1	0.4	35.5	1	1.1	25.5	1	1.1	25.5
<i>Bodianus</i>	1	1.1	15.5	1	0.4	15.5	1	2.2 ± 3.8	35.5 ± 0	1	0.6	15.5
All	26	80.6		26	62.5		24	94.4		21	54.4	

¹≥5 cm only²*Epinephelus* spp. and *Mycteroperca* spp.

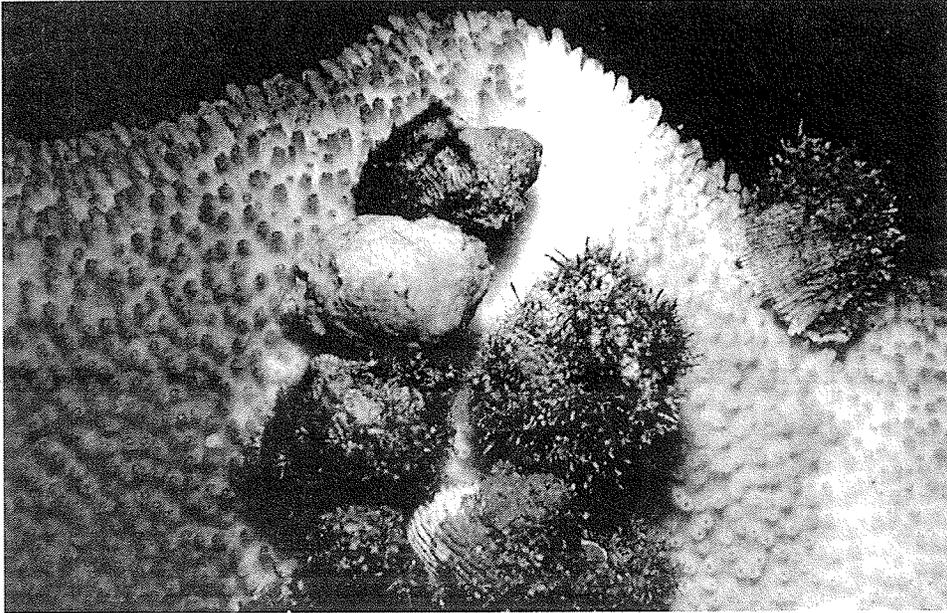


Plate 10A. Areas of recent mortality and adjacent coral tissues are examined closely for evidence of predation by corallivores, such as these *Coralliophila abbreviata* snails that preferentially feed on *Acropora palmata* (as shown) and other acroporids. (Photo Andrew W. Bruckner)



Plate 10B. Threespot damselfish (*Stegastes planifrons*) create algal gardens within the living tissues of this *Acropora palmata* and other species of stony corals which they defend against intrusion by other herbivores. Damselfish predation is reported in AGRRA by the presence of an aggressive fish or its gardens. (Photo Kenneth W. Marks)