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Comparison of Benthic Communities on Six Coral Reefs in the Veracruz Reef System (Mexico)

J. Jones, K. Withers, J.W. Tunnell Jr.

Texas A&M University-Corpus Christi, 6300 Ocean Dr., Corpus Christi, Texas, USA

Abstract. The Veracruz Reef System consists of 25 platform reefs that are split into two subgroups, northern and southern, by the influence of the Río Jamapa. Scleractinian coral cover on all reefs has declined dramatically since the 1960s. Using historical data and regression analysis, we predicted ~15% cover for the northern subgroup and no coral cover in the southern subgroup. Anegada de Adentro and Blanquilla, in the northern group, and Anegada de Afuera, Cabezo, Enmedio, and Santiaguillo, in the southern group, were surveyed during Fall 2002 with photo-transect techniques. Scleractinian cover averaged 3.2% in the northern subgroup and 6.3% in the southern. Algae, particularly turf and crustose forms, dominated reef benthic communities, with greater than 50% cover on all reefs and at all depths. Coral cover was much less than predicted in the northern subgroup and was greater than predicted in the southern subgroup. Numerous natural impacts (low salinity, heavy sedimentation, diseases, winter cold fronts, hurricanes) and anthropogenic impacts (coral mining, dredging, landfill, ship groundings overfishing, coral and shell collection, others) have undoubtedly caused much of this decline. In the southern group, declines appear to have leveled off while becoming more severe in the northern group.

Key Words: coral decline, Veracruz Reef System, southwestern Gulf of Mexico

Introduction

The coral reefs of the southwestern Gulf of Mexico lie along the western boundary of the Caribbean Biotic Province (Tropical Western Atlantic Region) (Briggs 1974, Tunnell 1988). The highly endangered Veracruz Reef System (VRS) (Bryant et al. 1998) located off the state of Veracruz, Mexico (Fig. 1) consists of 25 platform-type coral reefs. These reefs are divided into two subgoups by the influence of the Río Jamapa: the northern near the city of Veracruz and the southern near Antón Lizardo, a small fishing village. Compared to other reefs within this biotic realm, these reefs have lower stony coral diversity, primarily due to frequent climatological events and turbidity from coastal runoff. Southwestern Gulf of Mexico corals occur at the limits of their distribution limiting reef biodiversity thus anthropogenic stressors have profound effects on the ecosystem (Tunnell 1988, Nelson 1991). The combination of both natural and anthropogenic disturbances exacerbates reef impacts and reduces coral cover.

Historically, live benthic coral cover on reefs in this area has been less than 40% and on nearly all reefs coral cover has declined in recent years (Lang et al. 1998). Most of these reefs have been greatly affected by overharvesting, pollution, and recreational diving; the amount of stress and destruction depends on their proximity to urbanized areas (Tunnell 1985, 1988, 1992, Chávez and Tunnell 1993). Due to the city of Veracruz's large size and reef geographic location, the VRS has suffered the heaviest anthropogenic impacts of any reefs in Mexico (Bryant et al. 1998, Jordán-Dahlgren and Rodríguez-Martínez 2003). Coral cover has declined since the 1960's and algal cover has increased.

Figure 1: Reefs of the Veracruz Reef System, in the southwestern Gulf of Mexico, near Veracruz and Antón Lizardo, Mexico. Modified from Tunnell (2006).

The goal of this research was to assess the condition of six reefs in the VRS: Anegada de Adentro and Blanquilla in the northern subgroup and

Anegada de Afuera, Enmedio, Santiaguillo, and Cabezo in the southern subgroup. Cover of scleractinian corals on reefs in the VRS has declined by more than 60% since the 1960's (Horta-Puga and Barba-Santos 1999). Based on regressions of historic coral cover data (Kühlmann 1975, Rannefeld 1972, Secretaría de Marina 1987, Nelson, 1991, Horta-Puga 2003), we predicted ~15% cover for the northern subgroup in 2002 and no coral cover for the southern subgroup (Fig. 2).

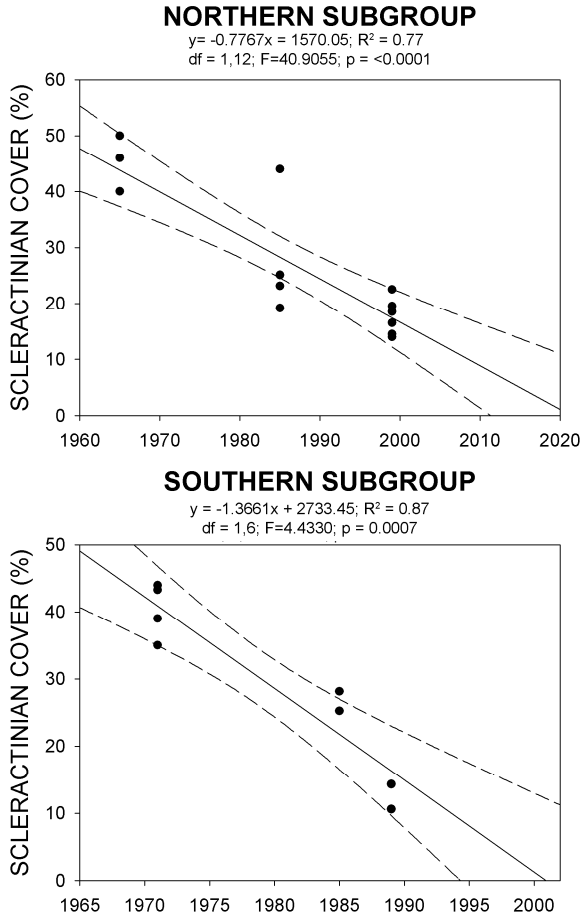

Figure 2: Trends in scleractinian coral cover in the northern and southern reef subgroups of the Veracruz Reef System, Mexico.

Methods

Each of the six reefs was surveyed using photographic techniques (Liddell and Ohlhorst 1987) at 6m, 12m, 18m, and when depth permitted, 30m. Six transects, each consisting of 12 non-overlapping photos, were completed at each depth although not all transects produced usable images. Photographs were processed to produce digital images. Each photo was projected and overlain with 144 points arranged in a uniform pattern. The coral taxon or benthic category (e.g., crustose algae, bare etc.) under each point was determined and recorded. Percent cover of scleractinian corals, algae and bare areas were calculated for each transect and averaged by reef and depth.

Results

Algae dominated benthic communities of all reefs and at all depths (Fig. 3). In the northern subgroup, coral cover averaged 3.2% and algal cover averaged 69.4%. Although very low, coral cover varied substantially with depth ranging from 1% or less at 6m and 18m on Blanquilla to the maximum of 6% at 12m. On Adegada de Adentro, maximum coral cover was also found at 12m (8%) and ranged from 0.5% at 6 m to 4% at 18m. Algal cover was greatest at 6 m on both reefs, and varied slightly with depth ranging from 58-76% on Blanquilla and 66-80% on Adentro.

In the southern subgroup, coral cover averaged 6.3% and algal cover averaged 66.2%. Average coral cover was higher in this subgroup largely due to greater cover at Santiaguillo, which ranged from 9% at 30m to 18% at 18m. Maximum coral cover on the other reefs was similar to that seen in the northern subgroup: 6% at Enmedio (12m) and Cabezo (18m), and 7% at Anedgada de Afuera (30m). Algal cover was least at Santiaguillo (50-57%) and ranged from lows of ~65% at Afuera (30m) and Cabezo (18m) to a high of 78% at Cabezo (6m).

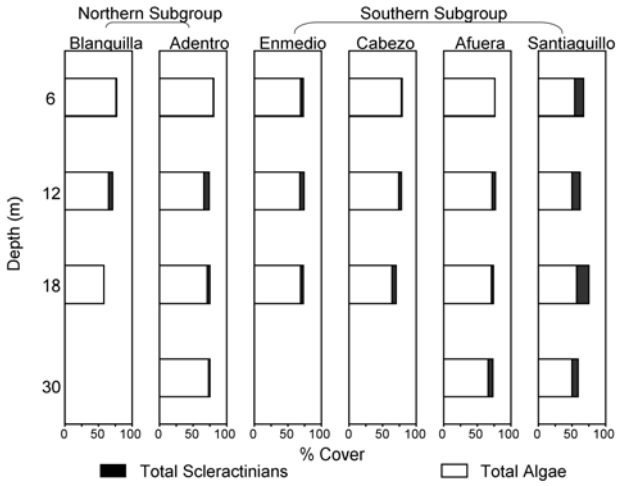

Figure 3: Average scleractinian and algal cover by depth in reefs surveyed the northern and southern subgroups of the Veracruz Reef System, Mexico. There were no 30m transects surveyed at Blanquilla, Enmedio or Cabezo.

Coral communities on the reefs surveyed were typically dominated by six species or species complexes (Table 1): *Montastraea annularis* complex, *Diploria strigosa*, *Colpophyllia natans*, *Siderastrea siderea*, *Agaricia* spp. (especially *A. lamarcki*) and *M. cavernosa*. In the northern

Table 1. Mean cover (%) of corals, algae and other taxa and categories for all depths in 2002, with standard deviation in parenthesis, on six reefs in the Veracruz Reef System, Mexico.

	Northern Subgroup			Southern Subgroup		
	Blanquilla	Anegada de Adentro	Enmedio	Cabezo	Anegada de Afuera	Santiaguillo
Algae						
Coralline red	52.4 (11.8)	32.5 (7.2)	39.1 (13.2)	66.6 (13.1)	31.5 (16.3)	46.8 (11.0)
Turf	11.1 (4.5)	23.7 (11.7)	25.7 (12.0)	1.7 (2.8)	22.3 (20.0)	0.6 (2.9)
Brown	0.7 (1.0)	5.8 (6.7)	0.4 (0.5)	1.2 (3.0)	5.9 (6.6)	5.1 (7.4)
Blue-green		3.7 (7.0)	0.1 (0.3)	<0.1	0.1 (0.3)	
Dictyota spp.	0.4 (0.7)	3.6 (3.5)	1.0 (0.8)	1.4 (1.7)	6.9 (8.0)	<0.1
Other	2.3 (1.7)	3.2 (4.0)	1.1 (1.6)	1.8 (4.0)	4.6 (5.4)	0.2 (0.5)
Scleractinians						
Acropora palmata		<0.1	0.3 (0.8)			<0.1
Agaricia spp.	<0.1	0.4 (0.9)	<0.1	0.6 (1.6)	<0.1	0.4 (0.5)
Colpophyllia natans	0.7 (1.4)	0.7 (1.7)	0.6 (1.2)	0.9 (1.7)		1.2 (2.3)
Dichocoenia stokesi	<0.1			<0.1		
Diploria strigosa	0.2 (0.3)	0.7 (1.9)	1.6 (3.2)	0.2 (0.7)	0.2 (1.2)	0.2 (0.7)
Diploria clivosa			<0.1			
Leptoseris cucullata			<0.1			0.4 (1.8)
Madracis decactis		<0.1			<0.1	<0.1
Madracis mirabilis					<0.1	
Meandrina meandrites			<0.1			
Montastraea annularis complex	0.7 (1.9)	0.5 (1.1)	1.2 (2.4)	1.0 (2.2)	0.4 (1.3)	7.9 (8.3)
Montastraea cavernosa	0.2 (0.8)	0.3 (1.3)	0.3 (0.7)	0.3 (1.0)	2.1 (0.4)	1.0 (1.6)
Oculina diffusa	<0.1	<0.1		<0.1		
Porites astreoides		<0.1	<0.1	<0.1	<0.1	0.4 (0.6)
Siderastrea radians	<0.1	<0.1	0.2 (0.6)	<0.1		
Siderastrea siderea	0.6 (1.3)	0.8 (1.8)	0.5 (1.0)	0.2 (0.9)	0.7 (1.6)	1.2 (2.5)
Solenastrea bournoni					<0.1	
Stephanocoenia michelini	0.2 (0.5)	<0.1	0.2 (0.8)	<0.1	<0.1	<0.1
Gorgonians						
Erythopodium caribaeorum	0.9 (3.3)				<0.1	
Pseudopterogorgia bipinnata					<0.1	
Hydrozoans						
Millepora alcicornis		<0.1		<0.1		
Sertularella speciosa		<0.1			<0.1	
Zoanthus spp.	<0.1	<0.1				
Stylaster roseus				0.3 (1.1)	<0.1	<0.1
Sponge	0.5 (0.5)	0.5 (0.4)	0.5 (0.5)	1.6 (1.4)	1.5 (1.5)	0.9 (0.9)
Other Fauna	0.4 (0.4)	0.2 (0.3)	0.1 (0.2)	<0.1	0.2 (0.3)	<0.1
Bare Substrate	10.2 (7.7)	3.9 (1.4)	7.3 (3.2)	8.5 (4.9)	7.4 (3.9)	17.4 (7.5)
Unidentifiable	18.2 (3.2)	19.2 (3.2)	19.5 (2.7)	13.6 (2.7)	14.7 (4.0)	15.8 (3.8)
Mean Scleractinian Coral	**2.7 (3.6)**	**3.5 (3.8)**	**5.1 (3.5)**	**3.4 (3.8)**	**3.6 (5.2)**	**12.8 (8.1)**
Mean Algae	**67.1 (8.2)**	**72.5 (6.2)**	**67.5 (4.5)**	**72.7 (6.6)**	**71.5 (7.2)**	**52.9 (9.9)**

subgroup, 11 scleractinian species were noted at Blanquilla with 14 species at Anegada de Adentro. In the southern subgroup, the most scleractinian species (16) were noted at Santiaguillo and the least at Cabezo (10). Live colonies of *Acropora palmata* were found on Enmedio as well as Anedgada de Adentro and Santiaguillo, although they were very rare on the latter two reefs.

Discussion

Coral cover and diversity in the Veracruz Reef System is naturally limited by weather, especially winter cold fronts ("nortes"), turbidity from coastal runoff, (Horta-Puga 2006, Chávez and Tunnell 2006) and their location on the tropical periphery (Withers and Tunnell 2006). Poor management and deteriorating water quality from pollution and deforestation affect the whole region, where only the most isolated reefs are generally healthy (Linton et al, 2002, Horta-Puga 2006). Multiple anthropogenic impacts, especially around large cities, have lead to declines or total losses of stony corals. As coral cover

has declined, crustose and fleshy algae have increased as space is freed up for them to colonize (Aronson and Precht 2001). The combination of the *Diadema antillarum* die-off in the 1980's and increased overfishing of herbivorous fishes (Lang et al. 1998, Tunnell et al. 2006), both of which controlled algal growth on reefs, has allowed algae to colonize the open spaces.

In this study, coral cover in the northern subgroup was less than the ~15% predicted mean and cover in the southern subgroup exceeded the mean prediction of no cover remaining. Greater average cover in the southern subgroup was primarily due to the influence of Santiaguillo, the reef furthest from shore. However, even when this reef is excluded, average cover for the southern subgroup, 4.1%, is substantially greater than predicted mean and exceeds the average in the northern subgroup.

Scleractinian coral cover has declined dramatically in both reef subgroups since the 1960's, when it averaged 40-50% overall (Kühlmann 1975; Rannefeld, 1972; Secretaría de Marina, 1987; Nelson, 1991; Horta-Puga, 2003). However, the decline to less than the predicted mean and lower 95% confidence interval cover in the northern subgroup shows that conditions deteriorated rapidly between 1999 (Horta-Puga, 2003) and 2002 (this study). On the other hand, coral cover in the southern subgroup exceeded the mean predicted, although it fell within the 95% confidence interval. This suggests that conditions causing the decline have stabilized or begun to be reversed in this area.

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