Coral cover and generic diversity in degraded reef communities of Anda, Pangasinan

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Abstract: The combined effects of climate change and human impacts have led to widespread degradation of reef communities around the Philippines. This degradation has resulted in a phase shift to algal dominance. We report on the changes in reef communities of Anda, Pangasinan and focus on the changes in scleractinian coral cover and generic diversity in three sites (with two station each) from May 2009 to June 2011 as monitored by five randomly positioned 50m photo-transects per station. Over this period, coral cover in five of the six stations declined from an average of 7.1 ±5.6% (percentage cover ± SD) to 5.5 ±4.4% in September 2009 and increased to 8.6 ±5.9% by June 2011. In contrast, algal cover remained high at an average of 85.6 ±6.2% in September 2010 until a drastic decline to 43.2 ±7.3% by June 2011. Coral generic diversity remained low, ranging from 1-2 genera to 4-7 genera during every monitoring visit. Species of Porites were most abundant. Their slow growth rates could be a factor in the slow recovery of the coral communities studied despite the decline in algal cover.

Key words: coral communities; coral cover; generic diversity; phase-shift

1. INTRODUCTION

There is an increasing awareness that the coral reef ecosystems are being rapidly degraded (Osborne, Dolman, Burgess, and Johns, 2011; Bruno and Selig, 2007). This degradation is due to several factors like global climate change especially sea surface temperature increases; and human activities such as overfishing, coral mining, and their consequences such as sedimentation and eutrophication (Dikou and van Woesik, 2006; Anstett, Makhani, and Liang, 2011).

The coastlines are home to many people and also to coral reefs. Unfortunately this means coastal development in their immediate vicinity of coral reefs (Erftemeijer, Reigl, Hoeksema and Todd, 2012) leading to increased level of sediments and nutrients a general decline in the coral cover (Dikou and van Woesik, 2006) and loss of reef resilience (Hughes, Rodriguez, Bellwood, Ceccarelli, Hoegh-Guldberg, McCook, Moltschaniwskyj, Pratchett, Steneck and Willis, 2007). Resilience, as defined by Hughes *et al.* (2007), is the ability of the reefs to absorb frequent disturbance (e.g. from cyclones, outbreaks of predators, or coral bleaching events) and rebuild coral-dominated systems. This loss of resilience could lead to a regime or phase shift into a substitute assemblage of seaweeds or other opportunistic species (Hughes *et al.,* 2007). The presence of seaweed assemblage then influences coral diversity, species composition, and coverage. Sedimentation also obstructs coral growth, recruitment, and recovery potential (Anstett *et al.*, 2011). A classic example is how Caribbean coral reefs shifted from coral-dominated state to an algal dominated state as an outcome of the combined effects of overfishing, eutrophication, and hurricanes (Hughes, 1994).

In the Philippines, the combined effects of global warming, climate change and human impacts have contributed to the degradation of the coral reefs. However, there is limited up-to-date information on the state of its coral reefs and the changes they have undergone (Licuanan and Aliño, 2014). This study aims to provide information on the coral cover and diversity in reef communities in NW Luzon that is subject to the effects of sedimentation and eutrophication.

1.1 The Town of Anda: Recent to Present

Anda is known as the only island town in the Province of Pangasinan. It could be found in Cabarruyan Island in the central western part of Luzon, the west coast of Lingayen Gulf, south of Bolinao and north of Alaminos. The town of Anda could be accessed through a 400 meter bridge across the Caquiputan Channel. This channel has an average depth of 5 meters and water movement is dominated primarily by semi-diurnal tides (Escobar *et al.*, 2013).

There is extensive fish farming of bangus (*Chanos chanos*) in Guiguiwanen and Caquiputan channels between the town of Bolinao and Anda. Due to this activity, high inputs of nutrients and organic matter have rendered these areas eutrophic (Escobar *et al.*, 2013). The presence of fish pens and cages also restricts the natural flow of water thereby affecting the flushing rates or water residence time (Escobar *et al.*, 2013). Furthermore, the study conducted by San Diego-McGlone *et al.* (2008) revealed that the water quality conditions in Bolinao have become eutrophic. For the past decade there were increase in levels of ammonia, nitrite, nitrate, and phosphate by 56%, 35%, 90%, and 67%, respectively. This is due to the release of organic materials from the leftover feeds and fecal matter that were accumulated in the water and sediments.

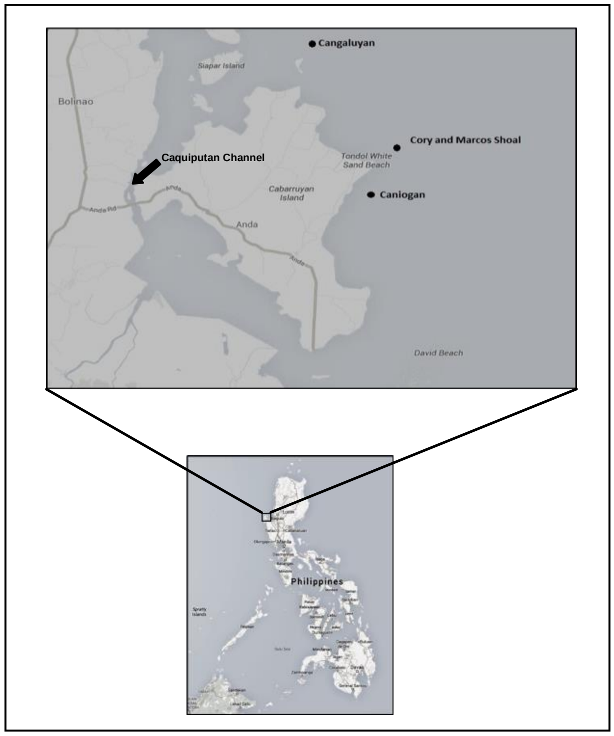

Figure 1. Map of the Town of Anda, Pangasinan, showing the three sites (Cangaluyan, Cory and Marcos Shoal, and Caniogan).

2. METHODS

2.1 Data Collection

The sites for sampling were found in the eastern part of Anda. The data collection was done in the three sites located in the town of Anda, Pangasinan, namely Cangaluyan, Cory and Marcos Shoal, and lastly Caniogan. For the purpose of comparison and verification, two stations for each site were established. These stations were named Cangaluyan A and B, Cory and Marcos Shoal, and lastly Caniogan A and B. The data were gathered through the phototransect method (van Woesik *et al.*, 2009) which involves 50 contiguous photographs covering 1m^2 each taken on the shallow side of each transect. In each of the six (6) stations, five 50 meter transects were randomly placed every monitoring period. The positions of the start of each transect were identified by random numbers generated with Microsoft Excel®. Monitoring in these stations was done between the following dates: (a) May 27-June 09, 2009, (b) September 02-03, 2009, (c) March 27-29, 2010, (d) September 08-10, 2010, and (e) June 12-14, 2011.

2.2 Data Processing

The data were processed with the use of Coral Point Count with Excel extensions (CPCe) and were saved in Microsoft Excel® format. CPCe is a Windows-based software program that facilitates the determination of coral cover using transect photographs. The program randomly scatters 10 points on each photograph. The features underlying the points were then identified and counted. Corals were identified, mostly to genus level, using an expanded form of the Taxonomic Amalgamation Units (TAUs) of van Woesik *et al.* (2009).

2.3 Data Analysis

Single factor ANOVA and post hoc Tukey tests were done in R Studio (Torfs and Brauer, 2014). Coral cover and coral generic diversity were graphed with the use of Microsoft Excel®. Mean percentage cover and standard deviation per station were computed. Overall increase or decrease in percentage cover (coral, algae and abiotic material) was also computed from monitoring in May/June 2009 to June 2011.

The percentage cover per genus was calculated using the formula:

$$\%\ \text{cover per genus} = \frac{\%\ \text{cover of the genus}}{\text{coral cover percentage}}$$

The three genera of corals with highest percentage cover per station were then graphed.

3. RESULTS AND DISCUSSION

The coral reef communities in the town of Anda are experiencing major stress from typhoons and anthropogenic activities such as fish farming, overfishing, coastal development and their consequences, sedimentation and eutrophication.

Table1. P-value of cover (%) per station based on single factor ANOVA test at the 5% level of significance.

STATION	CORAL		ALGAE		ABIOTIC	
Cangaluyan A	6.4E-04	S	1.4E-11	S	2.7E-04	S
Cangaluyan B	5.8E-02	NS	3.0E-09	S	3.4E-04	S
Cory Shoal	1.3E-02	S	1.6E-08	S	4.7E-05	S
Marcos Shoal	8.5E-01	NS	2.3E-17	S	1.8E-11	S
Caniogan A	1.3E-01	NS	1.0E-09	S	1.2E-09	S
Caniogan B	7.2E-06	S	2.3E-09	S	6.6E-06	S

S = Significant
NS = Not Significant

From May 2009 to June 2011 monitoring, the province of Pangasinan experienced direct hits from two typhoons. In May 2009, before the conduct of the first monitoring, the province of Pangasinan was directly hit by *Typhoon Emong* (international name: *Typhoon Chan-Hom*) and in October 2010, *Super Typhoon Juan* (*Super Typhoon Megi*). Unfortunately, there is no published information on

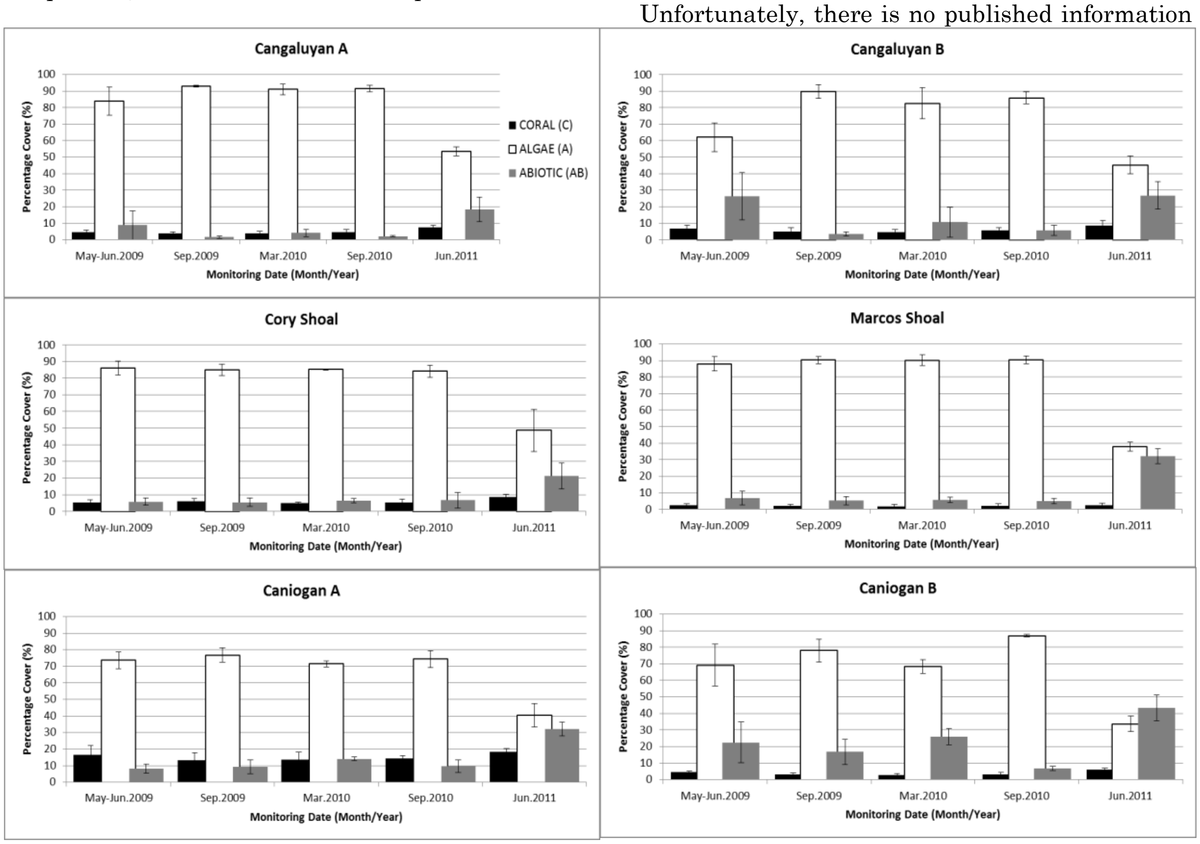

Figure 2. Comparison of the percentage covers of major benthic categories over time in three Anda reef stations.

the effects of this typhoon on the coral reef ecosystem in the area.

Aside from typhoons, the prevalent stressors of the coral reef community in the Anda were caused by overfishing, coastal development, extensive fish farming sites and their consequences.

As shown in Figure 2, the six monitoring stations showed almost comparable changes in percentage cover of corals, algae, and abiotic material from May 2009 to June 2011. Five of the six stations exhibited coral cover declines from an average of 7.1±5.6% (percentage cover ± SD) in May 2009 to 5.5 ±4.4% in September 2009. However, coral cover then increase to about 8.6 ±5.9% by June 2011.

Within the same monitoring period, in the six stations, abiotic cover (mostly rubble) declined from 13.1±9.0% in May 2009 to 6.9±5.4% in September 2009, and then increased to 29.0±9.0% by June 2011. In addition, high rubble cover might be the result of the damage caused by the typhoons. In contrast, algal cover in five of the six stations showed the opposite trend, increasing from 75.4±10.7% to 85.5±7.6% in May 2009 to September 2009 and then decreasing from 85.8±6.9% in September 2010 to 42.1±7.6% by June 2011.

Single factor ANOVA showed that the changes in station Cangaluyan A are statistically significant but not in station Cangaluyan B. Another pair of stations (Cory shoal and Marcos shoal) showed different patterns in the increase and decrease of coral, algae and abiotic cover. Single factor ANOVA of coral cover showed that the changes in station Cory shoal are statistically significant but the changes in Marcos shoal are not statistically significant. In Caniogan, single factor ANOVA showed that the changes in coral cover in station Caniogan B are statistically significant but again the changes in Caniogan A are not statistically significant.

The results of the post-hoc Tukey's tests of percent coral cover among different monitoring periods are shown in Table 2.

Even if some of the changes in percent coral cover over time were statistically significant, an overall change of about two percent may not have ecological significance to the health of the coral communities studied in Anda. The very high algal cover compared to the coral cover though is cause for concern, especially given the prevalence of fish farming and coastal development in the area. This has contributed to the increase in nutrient and sediment load which likely resulted in the increase of algal assemblages at the expense of the corals (Anstett et al. 2011) This is exacerbated by chronic overfishing and consequent loss of herbivory leading to a phase shift to an algae-dominated state (Hughes et al. 2007).

Generic diversity in the six monitoring stations in Anda ranged from 1-2 genera per station to 4-7 genera per station. The top three coral genera with highest overall mean cover are shown in Figure 3. From this, it can be seen that *Porites* was observed to be relatively abundant and has the highest cover in all stations during most of the monitoring visits. The fact that this coral is known to better tolerate sedimentation, suggests the few coral genera seen are the ones that endured past

Table 2. Post hoc Tukey test on coral cover showing the significance between monitoring in relation to p=0.05 level of significance (degrees of freedom = 20).

Site	Contrast	Estimate	SE	t.ratio	p.value
Cangaluyan A	June 2009 – June 2011	-2.9	0.8	-3.6	0.0132
	September 2009 – June 2011	-3.8	0.8	-4.7	0.0011
	March 2010 – June 2011	-3.8	0.8	-4.7	0.0012
Cory Shoal	March 2010 – June 2011	-3.7	1.0	-3.7	0.0113
	September 2010 – June 2011	-3.0	1.0	-3.0	0.0493
Caniogan B	May 2009 – March 2010	1.9	0.5	3.8	0.0091
	May 2009 – September 2010	1.6	0.5	3.0	0.0452
	September 2009 – June 2011	-3.0	0.5	-5.8	0.0001
	March 2010 – June 2011	-3.4	0.5	-6.6	<.0001
	September 2010 – June 2011	-3.0	0.5	-5.9	0.0001

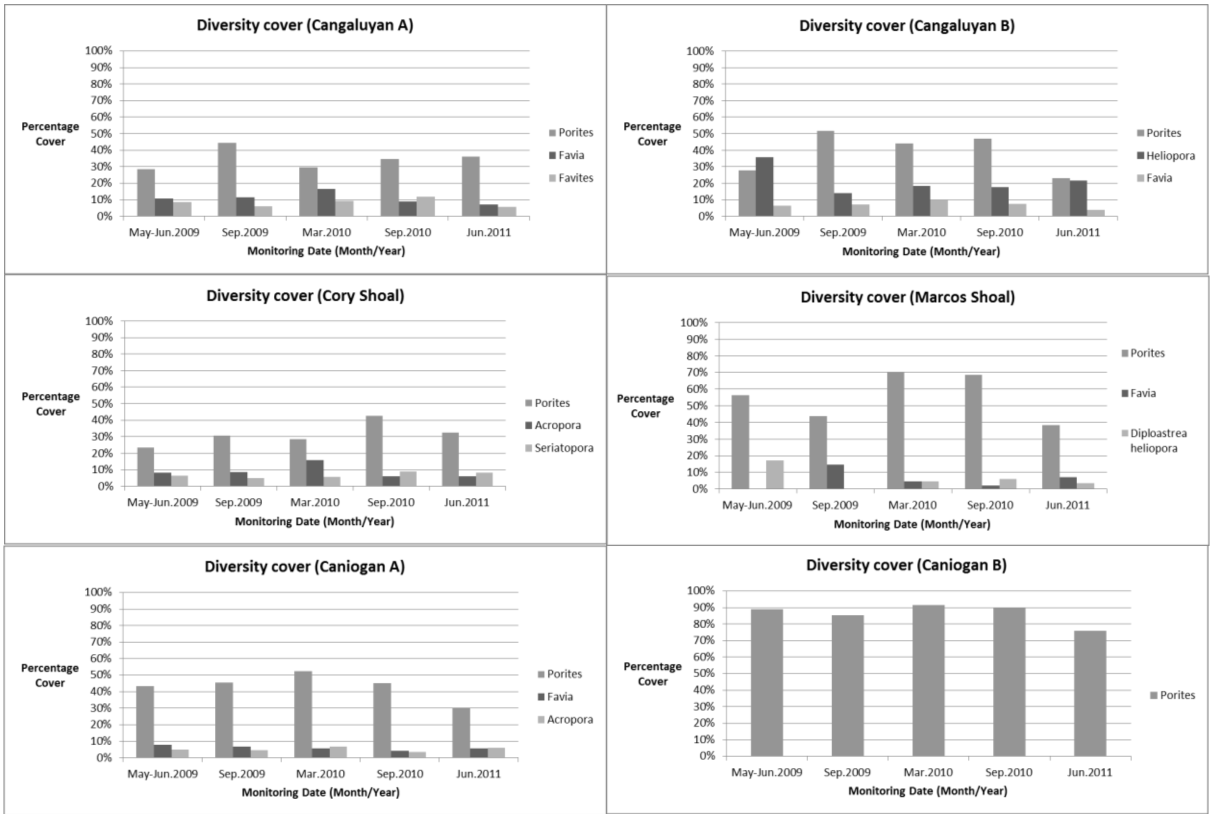

Figure 3. Comparisons of diversity (%) within coral cover per station over time.

changes in the environment. Its slow growth could also explain the apparent lack of any recovery despite the decline in algal cover. This clearly requires more study

4. CONCLUSIONS

Coral reef communities in the town of Anda have likely been suffering from chronic stressors coming from (a) strong typhoons caused by climate change; (b) anthropogenic activities (such as overfishing, coastal development and fish farming) and (c) their consequences (sedimentation and eutrophication). Continuous monitoring is needed to further determine distinguish the negative effects of human activities in the area as opposed to those driven more by climate.

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