Typhoon-driven Coral-Algal Phase-shifts in Southern Negros Oriental, Philippines

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Abstract

An underwater visual census (UVC) conducted to assess the biophysical conditions of the two marine protected areas (Antulang Marine Protected Area and Andulay Marine Protected Area) in Siaton, Negros Oriental revealed slow recovery from severe damage resulting from Typhoon Sendong in December 2011, suggestive of “coral-algal phase-shift”. Live hard coral (LHC) cover was consistently poor in the survey sites (2.25±0.78 % in Antulang Marine Protected Area; 1.25±0.50 % in the Control Site; and 3.33±0.17 % in Andulay Marine Protected Area) following destruction by the typhoon and colonization of algae (between 37-53%), dominated by *Bornetella oligospora*. Mean total fish biomass (including fusiliers and schooling juvenile *Caranx sexfasciatus*) was highest in Antulang Marine Protected Area at 70.60±28.07 kg/500m^2 (equivalent to 141.21±56.14 tonne/km^2) while lowest in Andulay Marine Protected Area at 9.83±4.32 kg/500m^2. Mean total fish density was highest in Antulang Marine Protected Area at 597.0±114.7 fish/500m^2 followed by the Control Site with 361.7±159.0 fish/500 m^2, while Andulay Marine Protected Area had 200.7±31.6 fish/500m2. Fish species composition was slightly altered, i.e. decline in coral-dependent species such as damselfishes.

Keywords: coral reef, macroalgae, phase-shift, resilience, recovery, typhoon

INTRODUCTION

Coral reefs are among the most important yet severely threatened ecosystems due to the increasing scale and frequency of human impacts (Hughes et al., 2003; West and Salm, 2003; Hughes et al., 2005; Harley et al., 2006). In addition to the threats from human impacts, coral reefs and reef biodiversity are facing an emerging threat from global climate change (Hoegh-Guldberg et al., 2007).

Integration of management strategies that support coral reef resilience (capacity of the ecosystem to absorb or recover from disturbance) needs to be vigorously implemented (Hughes et al., 2003). Protection of coral reefs through the establishment of no-take marine reserves is one of the management options that can enhance resilience of coral reef ecosystems (West and Salm, 2003). Stockwell et al. (2009) underscore the role of functional no-take Marine Protected Areas in increasing coral cover associated with the recovery of herbivorous fishes, thereby enhancing the resilience of coral reefs. In a review of small Marine Protected Areas in the Visayas, Philippines, Weeks et al. (submitted manuscript) propose other important criteria to ensure that regional objectives are met and suggest that other indicators be adopted such as proximity to deep water, connectivity, size, "representativeness," etc. when planning to establish Marine Protected Areas. Other authors have stressed the importance of abundance of herbivorous species in addition to top carnivores (Hughes et al., 2007; Stockwell et al., 2009), high recruitment and diversity of corals, healthy and disease-free corals, and history of surviving stress (McLeod et al., 2009).

In the Philippines, no-take Marine Protected Areas have been established throughout the archipelago (Aliño et al., 2002; Arceo et al., 2004; Weeks et al., 2010). They have been shown to be effective tools for reef fishery enhancement and conservation of marine biodiversity if fully and consistently implemented (e.g., Abesamis et al., 2006; Maliao et al., 2009; Weeks et al., 2010). Aside from effective management, another requirement for successful (functional) MPAs appears to be the nature of the sites at which they are established. Certain bio-physical features of these sites appear to confer resiliency or resistance to such impacts of climate change as rising sea water temperatures, acidity, etc. and secondary effects such as phase-shifts from coral to algal communities (e.g., West and Salm, 2003; Stockwell et al., 2009).

Recent studies have shown that some Marine Protected Areas, if fully protected, are resilient to environmental stresses caused by human-induced activities and exacerbated by climate change (West and Salm, 2003; Grimsdith and Salm, 2006; McLeod et al., 2009; Obura and Grimsdith, 2009; Green et al., 2009; Weeks et al., 2010).

Aside from extreme warming events, one of the effects of climate change is the occurrence of an abnormal weather pattern (Yusuf and Francisco, 2009) such as having stronger and destructive typhoons, which destroy coral reefs as an external source of physical disturbance (Mumby, 2006). Damaged coral reefs, under certain conditions such absence of algal grazers, would eventually become dominated by macroalgae, a condition known as "phase-shift" (West and Salm, 2003; Grimsdith and Salm, 2006; McLeod et al., 2009; Mumby, 2006; Obura and Grimsdith, 2009; Green et al., 2009).

Yusuf and Francisco (2009) have identified the Philippines (along with other countries in SouthEast Asia) as an area highly vulnerable to the effects of climate change. In December 2011, Typhoon "Sendong" hit the Visayas area and greatly damaged the coral reefs of southern Negros. It is an opportune time for me to study the impact of the said typhoon and whether or not the damaged coral reefs (especially the Marine Protected Areas) recovered. The study sites were chosen because baseline studies have been undertaken by SU-AKCREM researchers in 2008-2009 (Alcala et al., 2008; Nillos-Kleiven and Stockwell, 2009) and by Dr. Arthur R. Bos in 2010-2011 (Bos, 2010, 2011).

The study sites are within the jurisdiction of Barangay Siit, Municipality of Siaton in southern Negros Oriental. The Antulang Marine Protected Area (MPA) was established in 2007 but it was only in 2010 that a legal instrument was approved (Municipal Ordinance No. 26, s. 2010), covering an area of 3,000 sq.m (0.30 ha). Andulay Marine Protected Area (6.4 ha) was established in 1993 through Municipal Ordinance No. 7 s. 1993 but protection was only implemented in 1996 is located north of the Antulang MPA. Detailed technical descriptions of these MPAs are found in the aforementioned municipal ordinances. The Fished or Control Site is located roughly in between the two marine protected areas.

RESEARCH METHODS

Fish Visual Census

The procedures described by English et al. (1997) were followed with a few modifications. An individual census area was demarcated by laying out a 50m transect tape parallel to the shore. Visual census was carried out by a single observer swimming (with SCUBA equipment) along the length of each transect. The abundance of all visually-obvious species was estimated and the sizes of target species were estimated within 5m on either side of the transect and above the observer. Target or commercially important species included: Scaridae, Caesionidae, Serranidae, Lutjanidae, Nemipteridae, Acanthuridae, Haemulidae, and Mullidae. The transects were placed 5-10m apart. Three transects were established in Andulay Marine Protected Area (10-15m depth) and six transects (3 in 5m; 3 in 10-15m depth) in the Control (Fished) Site while only four transects (2 in 5m; 2 in 10-15m depth) were established within the Antulang Marine Protected Area, considering the small area (0.3 ha) of the latter.

Biomass of total reef fish, target species, and top predator was computed using known length-weight relationships in Froese and Pauly (2000), of which the constant *a* and *b* values were downloaded from Fish Base (www.fishbase.org).

Benthic Composition

The point-intercept transect (PIT) method, modified from Uychiaoco et al. (2001), was used to estimate the relative abundance, expressed in percent cover, of biotic or living (live hard corals, soft corals, algae, etc) and abiotic or non-living (sand, rock, etc) components of the reef. The PIT was conducted by a single observer along the same transects as the fish census. Benthic components directly underneath each 0.25 m interval along the transect line were identified and recorded. Percentage cover for each reef component was obtained using the following formula:

$$\frac{\text{Number of recorded points per benthic category}}{\text{Total number of recorded points}} \times 100$$

RESULTS AND DISCUSSION

Benthic Composition (Figure 1)

Live hard coral (LHC) cover was consistently poor in the survey sites (2.25±0.78 % in Antulang Marine Protected Area; 1.25±0.50 % in the Control Site; and 3.33±0.17 % in Andulay Marine Protected Area, in ascending order). Macroalgae (mainly *Bornetella oligospora*, see Fig. 2) dominated the substrate of the sites (first noticed 4-5 weeks after the typhoon in December 2011), with mean per cent coverage as follows: 37.375±17.28% in Antulang, 45.17±6.46% in Andulay Marine Protected Area, and 53.25±5.93% in the Control Site, in that order. Sand was also found relatively higher in both MPAs (28.67±6.50% and 36.5±11.68% in Andulay and Antulang Marine Protected Areas, respectively) as compared to the Control Site (9.5±1.44%), being dominated by bare limestone rock (35.83±4.99%).

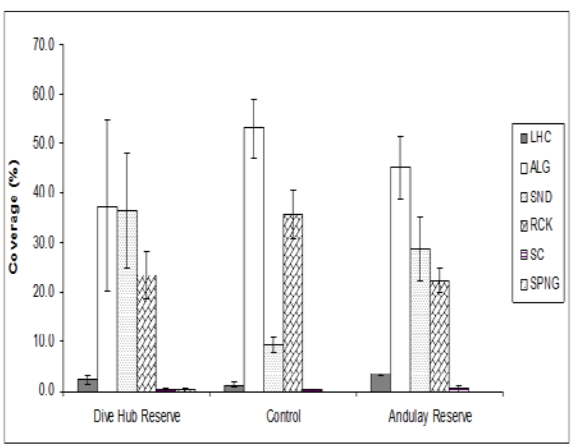

Figure 1. Benthic composition of the study sites (LHC-live hard coral; ALG-algae; SND-sand; RCK-rock; SC-soft coral; SPNG-sponge). Error bars indicate standard error (±S.E.)

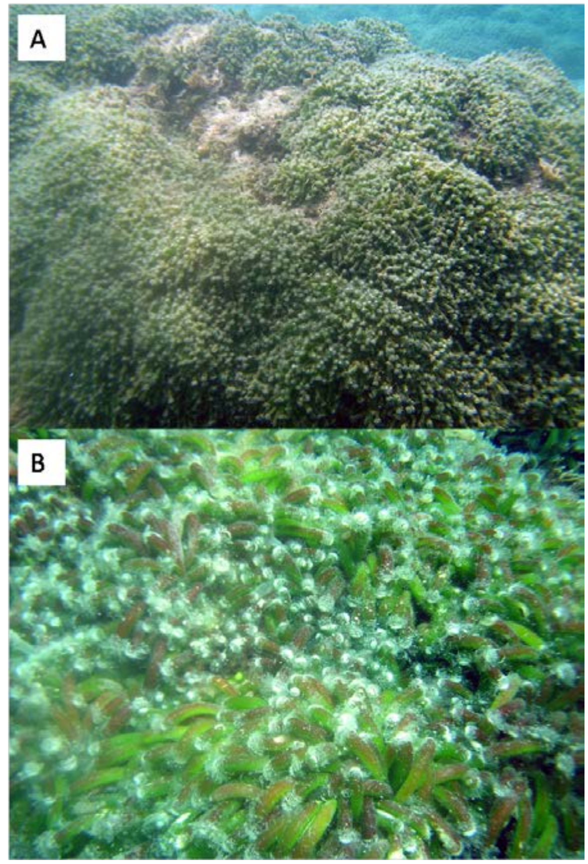

Figure 2. The green alga *Bornetella oligospora* (A-entire outcrop covered; B-close-up view) in Andulay Marine Protected Area.

Reef fishes

Species composition (Table 1)

During the survey in the three sites, a total of 173 fish species were identified belonging to 40 Families. Of this number, 156 species were found in Antulang Marine Protected Area, 104 were in the Control Site, and only 62 species were recorded in Andulay Marine Protected Area. It should be noted that the present figure for the Antulang Marine Protected Area is lower than those reported earlier by Nillos-Kleiven and Stockwell (2009) and Bos (2011) when the coral reef cover was still intact.

Fish biomass and density (Figs. 3 & 4)

Mean total fish biomass was highest in Antulang Marine Protected Area at 70.60±28.07 kg/500m^2 while lowest in Andulay Marine Protected Area at 9.83±4.32 kg/500m^2. The increase in biomass is attributable to schooling species such as fusiliers (Caesionidae), juveniles of the Jackfish *Caranx sexfasciatus* (Carangidae) and the Snapper *Lutjanus ehrenbergii* (Lutjanidae). It should be noted as well that the biomass presented herein may be an underestimate because another school of *Caranx sexfasciatus* probably between 30-35mm in length frequently visit the Antulang MPA but were not captured by the transects locations and were therefore not included in the analysis

It is of interest to note that the Control Site has higher fish biomass (31.19±23.45 kg/500m^2) than that of Andulay Marine Protected Area. The same pattern was also observed for the target fish biomass (in descending order: 64.65±26.99 kg/500m^2 in Antulang, 29.82±23.25 kg/500m^2 in Control, and 7.26±5.21 kg/500m^2 in Andulay Marine Protected Area). Herbivorous fish biomass was found relatively low among the three sites, the highest value was only 4.68±2.87 kg/500m^2 in Antulang Marine Protected Area and the lowest in the fished or control site (only 0.22±0.12 kg/500m^2). Mean predator biomass was highest in Antulang Marine Protected Area (6.50±3.05 kg/500m^2) and lowest in Andulay Marine Protected Area (0.85±0.51 kg/500m^2) while the Control Site had 2.38±1.43 kg/500m^2.

Mean total fish density was highest in Antulang Marine Protected Area at 597.0±114.7 fish/500m^2 followed by the Control Site with 361.7±159.0 fish/500m^2, and Andulay Marine Protected Area with 200.7±31.6 fish/500m^2, in descending order. A similar trend was observed in terms of target fish density, Antulang being the highest (431.3±117.7 fish/500m^2) while the Control Site had 247.5±140.7 fish/500m^2 while Andulay Marine Protected Area only had 53.3±34.8 fish/500m^2. Mean herbivore fish density was highest in Antulang Marine Protected Area (32.3±8.5 fish/500m^2) and lowest in the Control Site (4.8±1.5 fish/500m^2) while Andulay Marine Protected Area had an intermediate mean density of 13.7±3.7 fish/500m^2. Predator density was highest in Antulang Marine Protected Area (46.0±21.7 fish/500m^2) followed by Andulay Marine Protected Area (21.0±14.0 fish/500m^2) and Control Site (19.2±11.0 fish/500m^2).

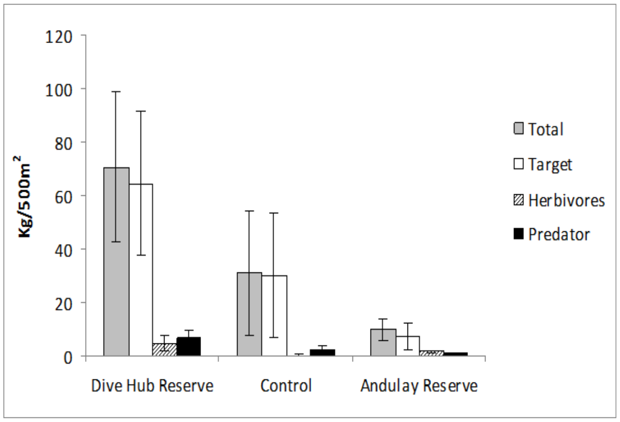

Figure 3. Fish biomass in the two Marine Protected Areas and the control (fished site) in Siaton, Negros Oriental. Error bars indicate standard error (±S.E.)

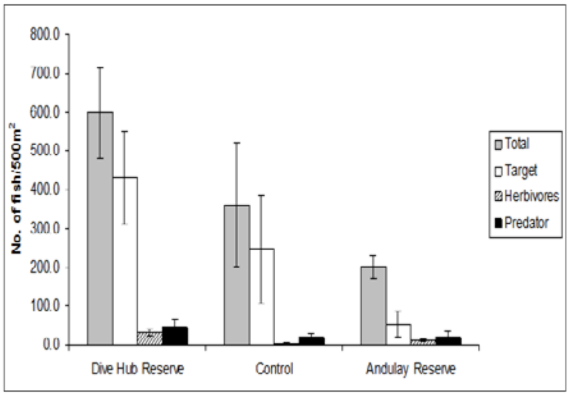

Figure 4. Fish density in the two Marine Protected Areas and the control (fished site) in Siaton, Negros Oriental. Error bars indicate standard error (±S.E.).

Of the three sites surveyed which were also severely affected by Typhoon Sendong in December 2011, only the Antulang Marine Protected Area exhibited recovery (after 6 months) in terms of fish biomass and density. Live hard coral coverage in the two MPAs, however, remained poor. Based on previous studies in 2008, these MPAs had live hard coral (LHC) cover ranging from 30-44% and 25% in Andulay and Antulang, respectively (see Alcala et al., 2008; Nillos-Kleiven and Stockwell, 2009). The dominance of macroalgae in previously coral-dominated reefs after massive coral mortality (e.g. typhoon, bleaching events) is the phenomenon known as “coral-algal phase-shift” (Roff and Mumby, 2012). This phenomenon is also driven by certain factors such as lack or loss of algal grazers (e.g. parrotfishes and surgeonfishes) in heavily fished reefs, high nutrient level, increasing sea surface temperatures, among others (Roff and Mumby, 2012). Hughes et al. (2007) demonstrated that algal-dominated reef, which is less diverse and less productive ecosystem (Gratwicke and Speight, 2005), can be reversed back to coral-dominated ecosystem with the help of algal grazers, primarily fishes (e.g. parrotfishes, surgeon fishes, and batfishes). These key herbivores, however, are heavily fished in most coral reefs of the Philippines (Stockwell et al. 2009).

Strict protection of existing Marine Protected Areas has been proposed by many authors to enhance resilience, which is the capacity of coral reefs to absorb stress or recover from a disturbance (Obura and Grimsdith, 2009; Maynard et al., 2010). Physical features of the survey sites such as proximity to deep water (Bohol and Sulu Seas), steep slope topography, and mixed water layer (due to strong current and wave action) are all indicative of reef resilience (Obura and Grimsdith, 2009; Maynard et al., 2010; Weeks et al., 2010 manuscript). One biological indicator (abundance of algal grazers), however, can be applied only to one site (Antulang MPA), probably a result to protection.

CONCLUSION AND RECOMMENDATION

The present biophysical conditions of the two Marine Protected Areas (Antulang and Andulay MPAs) and the Fished (Control) Site are indicative of algal shift, which might be due to low abundance of herbivores (parrotfishes, surgeonfishes, and sea urchins) after the typhoon caused massive coral mortality. If the present abundance of herbivorous fishes remain as a result of intensive fishing, it is unlikely that these reefs can be reverted to its original state, i.e. coral-dominated reef.

To enhance the rate of recovery of coral reefs in the damaged areas, it is recommended that full protection (from destructive and exploitative fishing gears) of these MPAs be implemented. Biophysical monitoring of these MPAs with the participation of the stakeholders (primarily fishers) is also recommended to increase public awareness and community support.

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