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Disease Prevalence of Scleractinian Corals on Selected Reefs of Iligan Bay

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ABSTRACT

The steady decline of reef productivity and coral disease outbreaks emphasized the need to mitigate the effect of coral diseases within reef communities. Given that marine protected areas (MPAs) are effective reef management tools, this paper examined the hypothesis that inside MPAs coral diseases are less prevalent than outside MPAs. Five disease categories were documented, three of these – white disease (0.7% to 3.4%), growth anomalies (12.2% to 22.7%) and coral bleaching (3.1% to 6.2%) were observed site wide, targeting the genus Porites. Pooled disease and growth anomalies (GAN) prevalence was significantly less inside Capayas Island Marine Sanctuary (CIMS) than outside. Similars, white disease (WD) was significantly less prevalent inside Tubajon fish sanctuary (TFS) than outside. Prevalence of disease on all surveyed reefs is high but not as high as the very high coral around central Visayas where most disease data of the country are concentrated. Massive and branching forms of corals display the highest likelihood to develop coral disease. The preference of Porites both in its massive and branching form present an ever posing threat - as it is considered one of the country's major reef building coral genera.

KEYWORDS: Coral death, Coral disease, Coral tissue loss, Philippine reef, Reef health, Susceptible corals.

INTRODUCTION

Coral diseases were once an unknown threat to corals prior to its discovery by Antonius (1973). Since then, disease induced coral mortality and deterioration has steadily increased (Hayes and Goreau, 1998; Porter, et al. 2001; Weil, 2001; Harvell, et al. 2002; Weil, et al. 2002; Weil, 2004; Weil, et al. 2006) asserting the great influence of coral diseases on our reefs future. Hayes and Goreau, (1998) strongly pointed out that the heightened prevalence, severity, and deadly outcome of coral diseases could be more damaging to the reefs than the combination of all other previously known threats. In literature there are around 29 known coral diseases worldwide (Weil, 2001) but this figure varies among various authors as the nomenclature of coral disease is not yet fully standardized (Harvel, et al. 2007). Limited information on disease pathogens makes it difficult to categorize syndromes to a particular disease (Weil, 2001; Harvel, et al. 2007). These lead researchers to base the name of a disease on its ecological characteristics causing discrepancy in the actual disease count worldwide (Weil, 2001).

A marine protected area (MPA) is a globally used conservation tool to managed threatened marine resources (Clark, et al. 1989). The protective confines of MPAs have been successful in restoring depleted fish stock and invertebrate population as well as increasing overall fish biomass (Halpern, 2003). Among coral communities however, factors such as site selection, years of protection, prior condition before MPA establishment and implementation of MPA rules could influence how a reef flourishes in an MPA (Page, et al. 2009). Nonetheless, it is clear that over time, coral cover in MPAs stabilizes while nearby unprotected reefs experience a steady decline in cover (Bruno and Selig, 2007). The success of an MPA in restoring populations of reef species sensitive to fishing and its long term stabilizing effect on coral cover fuelled the optimism that they could also be effective in managing coral disease. Albeit worldwide literature produced varied results on how an MPA influences coral disease prevalence (Coelho and Manfrino, 2007; McClanahan, 2008; Page, et al. 2009; Raymundo, et al. 2009) several analogies positively implicate an MPA to reduce coral disease progression and spread on the reef. For instance functionally diverse reef fish communities as operating within MPAs encourage the balance between corals and potential disease vectors that could have been ecologically released on fished areas (Raymundo, et al. 2009). Strict implementation of MPA rules and full banning of destructive fishing activities reduce the incidence of coral injury, a known trigger to onset coral disease (Bak and Criens, 1981; Page and Willis, 2008). Conversely, MPAs might assist the spread of coral disease within a reef especially if protection leads to an increased density of disease susceptible coral. Overall, the popular use of MPA as a resource management tool, the limited available options to manage coral disease (Harvel, et al. 2004) and the complex coupling of disease outbreaks with environmental conditions highlight the need for more ecological research towards this focus.

Guiding the course of this study were two implicit assumptions of coral disease prevalence. First, if coral diseases were consequences of reef stress, then reefs within MPA would have lesser prevalence of coral disease. Second, if unique characteristics inherent for each organism make a coral more or less prone to disease, then, specific coral genera and growth formations are more likely to experience coral disease than other genus and growth forms. These concepts serve the framework of this study that aims to identify the types of coral disease within selected reefs of northern Mindanao; quantify their prevalence; know if there is difference in disease prevalence between protected and unprotected reefs and determine the dominant disease infected coral genera and growth formations.

MATERIALS AND METHODS

Site Description

Both Capayas Island Marine Sanctuary (N8°35’3.9978”; E123°45’59.9976”) and Tubajon Fish Sanctuary (N8°37’43.665”; E124°27’15.8322”) lie along the margins of Iligan bay of northern Mindanao (Fig. 1). Capayas Island, also known as Capayas Islet, is on the northwestern part of the bay under the municipal jurisdiction of Lopez Jaena. Tubajon, on the other hand, lies along the northeastern bay area within Laguindingan municipality of Misamis Oriental. In 2002, Lopez Jaena through Memorandum Order 02 series 2002, established the Capayas Island Marine Sanctuary or CIMS that spans 63.197 hectares. On the same year, Laguindingan Memorandum Order 94 series 2002, allocated 22 hectare of marine waters as Tubajon Fish Sanctuary or TFS in Barangay Tubajon. Despite their size difference, both MPAs received a Level three MPA rating in 2008 (www.coast.ph//).

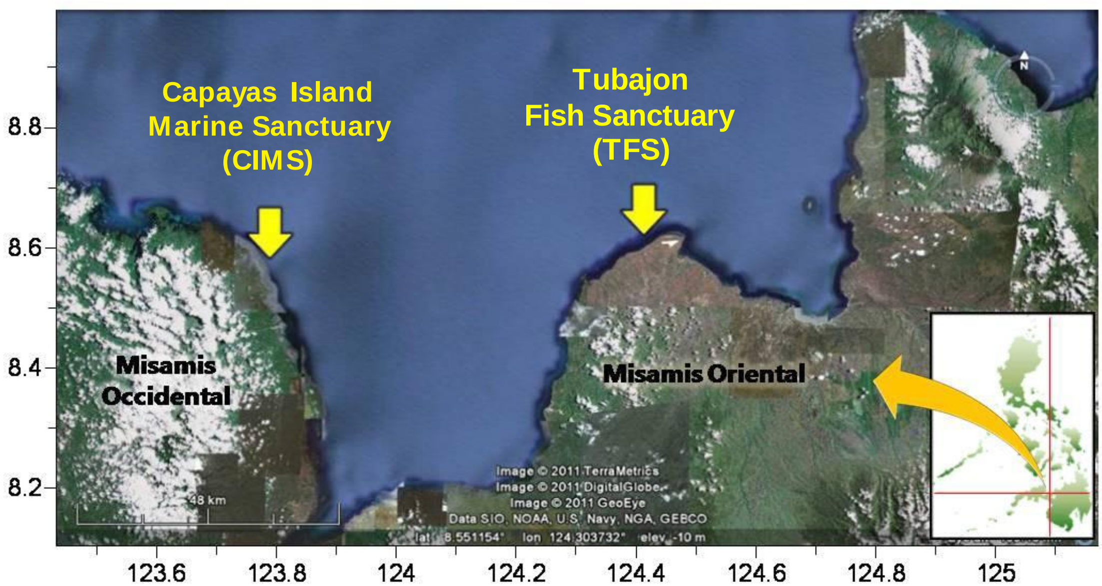

Figure 1. Map of Iligan Bay showing the study sites with inset indicating the sites position within northern Mindanao.

Coral Disease Prevalence

On both protected and unprotected reefs of Capayas Island and Tubajon, five 20m x 1m belt transects were laid end to end parallel to shore and spaced 10m apart (Raymundo, et al. 2003; Page, et al. 2009). In order to minimize the influence of depth on live coral cover estimates but given that depth is not a factor for disease prevalence (Raymundo, et al. 2003), transects were laid at depths ranging from 5m to 8m (Raymundo, et al. 2009). To reduce the "edge effect," stations for protected and unprotected reefs were at least 200m away from the MPA borders (Raymundo, et al. 2009). Within transects, growth formations of discrete coral colonies (>2cm in diameter) with more than 50% of its colony inside the belt were noted and the genus were identified using Veron, (2000). After genus identification, the same colony was inspected for signs of tissue loss or damage due to disease as adapted from the published Underwater Cards for Assessing Coral Health on Indo-Pacific Reefs by Beeden, et al. (2008). Given the drawbacks of purely ocular disease identification and limited survey time by scuba (Richardson, 1998; Weil, 2001), scleractinian diseases were grouped into seven categories characterized as follows:

- **Black Band Disease (BBD)** – identifiable by its black bacterial mat that separates healthy tissues from a clear band of exposed coral skeleton (Beeden, et al. 2008).
- **White Disease (WD)** – collective category for disease that manifest as band/s of white tissue and/or skeleton on its host coral (Porter, et al. 2001; Willis, et al. 2004). White-type diseases are difficult to distinguish in the field without considering progression rates and without laboratory analysis of their pathogens. Hence, this category could potentially encompass different types of WB and WP as well as WPX and the early stage of AtN (Willis, et al. 2004).
- **Skeletal Eroding Band (SEB)** – manifest a black band similar to Black Band Disease along its tissue-skeleton interface but unlike BBD, it leaves a black speckled skeleton (Willis, et al. 2004; Beeden, et al. 2008).
- **Growth Anomalies (GAN)** – generally denotes colonies that exhibit focal or multifocal, circular or irregularly shaped lesions comprised of abnormally arranged or abnormally sized skeletal elements. Visually GAN typically appears as large lumps or plaques over healthy colonies with different surface rugosity from healthy tissues (Raymundo, et al. 2008; Beeden, et al. 2008). GAN pigmentation could be normal, pale or totally un-pigmented. Invertebrate associated skeletal deformations or invertebrate galls have patterns caused by skeletal depositions around the borrowing invert in patterns that are characteristic for each invertebrate (Beeden, et al. 2008).
- **Coral Bleaching** – coral colonies with tissue pigmentation loss whether in parts or as a whole colony (Beeden, et al. 2008).
- **Trematodiasis** – corals with multi focal pink/white tissue swelling (1-2mm) caused by encysted Trematodes (Beeden, et al. 2008).

In order to avoid substantial misidentification, any encountered coral diseases that do not fit the above-mentioned categories were lumped under Other Diseases (Raymundo, et al. 2005, Porter, et al. 2001).

Disease prevalence or the proportion of diseased colonies to the total measured population (Raymundo, et al. 2008) was computed per category and as a collective whole. Values for coral disease prevalence were calculated as follows (Raymundo, et al. 2005; Raymundo, et al. 2008; Raymundo, et al. 2009):

$$\text{Prevalence} = \frac{\text{number of diseased colonies per transect}}{\text{total number of colonies per transect}} \times 100\%$$

Susceptible or Target Genera and Growth Forms

Following Borger, et al. (2005), for each disease syndrome the relative number of infected colony per genus and dominant infected growth form denotes the susceptibility of both to that particular disease. Hence, coral genus and growth formations that constitute an overall ≥75% incidence of infection per disease represented the target genera and growth forms for that disease.

Statistical Analysis

Analysis of variance (ANOVA) tested the existence of a significant relationship between factors, while t-test pinpointed the actual factors whose relationships were significant. Computations for both ANOVA and student t-test analysis were done in Excel 2007 at 5% significance level.

RESULTS AND DISCUSSIONS

Coral Disease Prevalence

Despite its limited temporal scale, this study has verified the presence of coral disease in Capayas Island and Tubajon. Within the 400m2 surveyed reef area, 4238 coral colony was examined and 932 had positive signs of disease. Disease was present on all reef sites but majority of the sightings were in Capayas Island than Tubajon. Disease ranged from 16.91±1.52% to 30.72±0.77% in mean collective prevalence. Spatial difference in overall prevailing coral diseases was significant (ANOVA ρ=0.002) between Capayas Island Marine Sanctuary and the adjacent reef outside (Fig. 2).

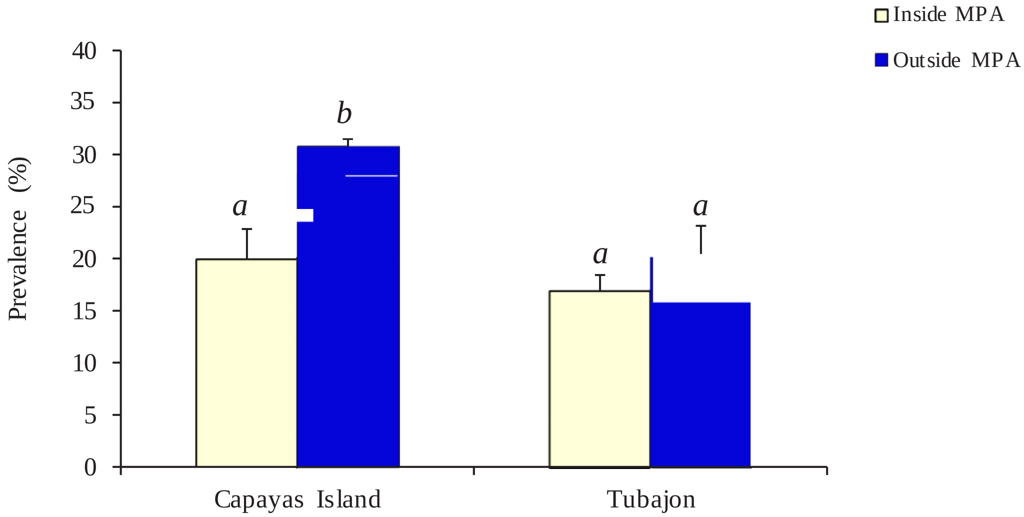

Figure 2. Diseased corals as collectively sighted on Capayas Island and Tubajon (MPA and non-MPA). Data obtained from pooled sampling observations (June to July 2011). Letters above bar graph, if different indicate a significant difference (t-test) at 5% significance level.

Corals were suffering from white disease (WD), growth anomalies (GAN), trematodiasis (TR), coral bleaching (BL), and other disease. No trace was found for either black band disease or skeletal eroding band diseases that were reported in central Philippines (Kaczmarsky 2006, Raymundo, et al. 2009) and in western Palawan (Kaczmarsky 2006). Site wide observations of WD, GAN and BL extend the spatial sightings of these diseases within Philippine waters which were noted in Lingayen Gulf, central Visayas and Palawan (Raymundo, et al. 2005, Raymundo, et al. 2009 and Kaczmarsky 2006). The most prevalent coral disease on all sampled reef sites was GAN. These findings were comparable with Raymundo, et al. (2005) and Kaczmarsky (2006) who reported GAN as the most common coral disease in central Visayas and Lingayen Gulf. Infection ranged from 12.19±3.10% to 22.70±0.40% in prevalence with significant (t-test a=0.001) spatial difference between CIMS and the adjacent reef outside. Most observation of GAN occurs outside CIMS and least inside TFS (Fig. 3).

Bleaching among corals, regardless if bacterial or temperature induced, ranged from 3.12±1.29% to 6.21±0.69% in prevalence. Although spatially not significant, all sites showed bleaching as the second dominant disease affecting coral colonies. Notably most bleached

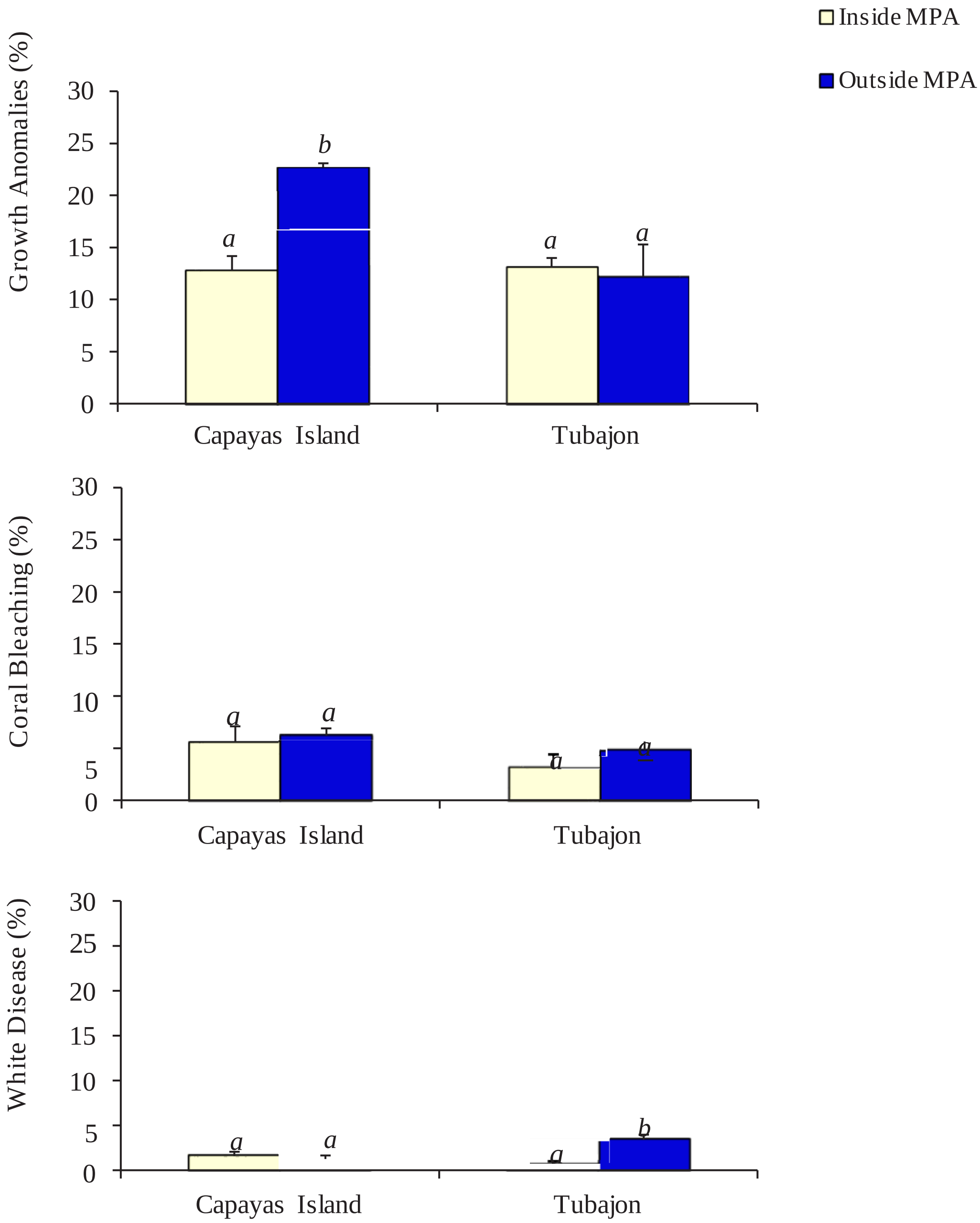

Figure 3. Mean prevalence of growth anomalies, coral bleaching and white disease in Capayas Island and Tubajon (MPA and non-MPA). Values obtained from pooled observation (June-July 2011). Letters above bar graph, if different, indicate a significant difference at 5% significance level (t-test).

corals outside CIMS are mushroom types. Colony infection of WD range from 0.72±0.29 to 3.39±0.57% in prevalence with significant (t-test; a=0.006) spatial difference between TFS and the adjacent reef outside. Remarkably, prevailing WD outside TFS accounts to more than half of all WD observations in this study. Trematodiasis infected colonies was only observed outside CIMS. Prevalent at 0.57±0.25%, all six TR observations had massive type Porites as host. Other disease or a disease not among the targeted coral diseases of this study was accounted once. Prevalent at 0.06±0.06%, this disease manifested on a massive Porites as irregular patches of dead coral skeleton bordered by a dark blue narrow margin separating healthy coral tissues (Fig. 3). Records of the Global Coral Disease Database identify other disease as pink line disease which is a misnomer as the advancing border of pink line disease can be pink, blue, light brown or purple (http://coraldisease .org// ; Appendix 1).

Collectively, disease prevalent in Capayas Island and Tubajon are both high yet are comparatively less than (not even half) the very high prevailing disease along eastern (±SEM; 72.6±16.5%) and western Sumilon as well as along northern Bais Bay (Raymundo, et al. 2003). Furthermore, disease prevalence as a collective whole and individually was variable to answer the main hypothesis of the study. Nonetheless it is clear that each site has a different dominant coral disease which is notably less prevalent inside each sites' respective MPAs than outside. The present gaps in coral disease information in northern Mindanao make it important to note other observations of coral diseases. The collective categorization of white disease in this study, however, limits the capability of this paper to detect the presence and prevalence of PUWS/ UWS, white bloch, white plague, white pox, and patchy necrosis that wreck havoc in other parts of the country as long term coral killers.

Disease-Targeted Coral Growth Form and Genera

In order to understand the interaction of coral disease and its host, the host preference pattern of coral disease was examined at genus level. However, as the susceptibility measure (≥75% incidence of infection per disease) of Borger, et al. (2005) was not meet this paper instead noted the target genus and target growth form following Borger (2005). In essence, disease targeted genus and growth formations pertains to scleractinian coral genera and growth form that was mostly afflicted with coral disease (Borger 2005).

Across site, diseased corals are predominantly massive and branching types while submassive and tabular forms are the least affected (Figure 4). Disease selectively targets the genus *Porites* among massive forms, being most intensive outside TFS and least inside CIMS (Fig. 5). Disease manifestation on other genera of massive type corals was variable between sites. The susceptibility of *Porites* towards coral disease extends to its branching form (Fig. 6). Branched *Porites* suffered most from coral disease outside TFS (65%) and least on both CIMS (29%) and TFS (29%). Unlike massive forms however, diseases were not solely targeting branched *Porites*. Both *Montipora* and *Stylophora* were selectively targeted as well

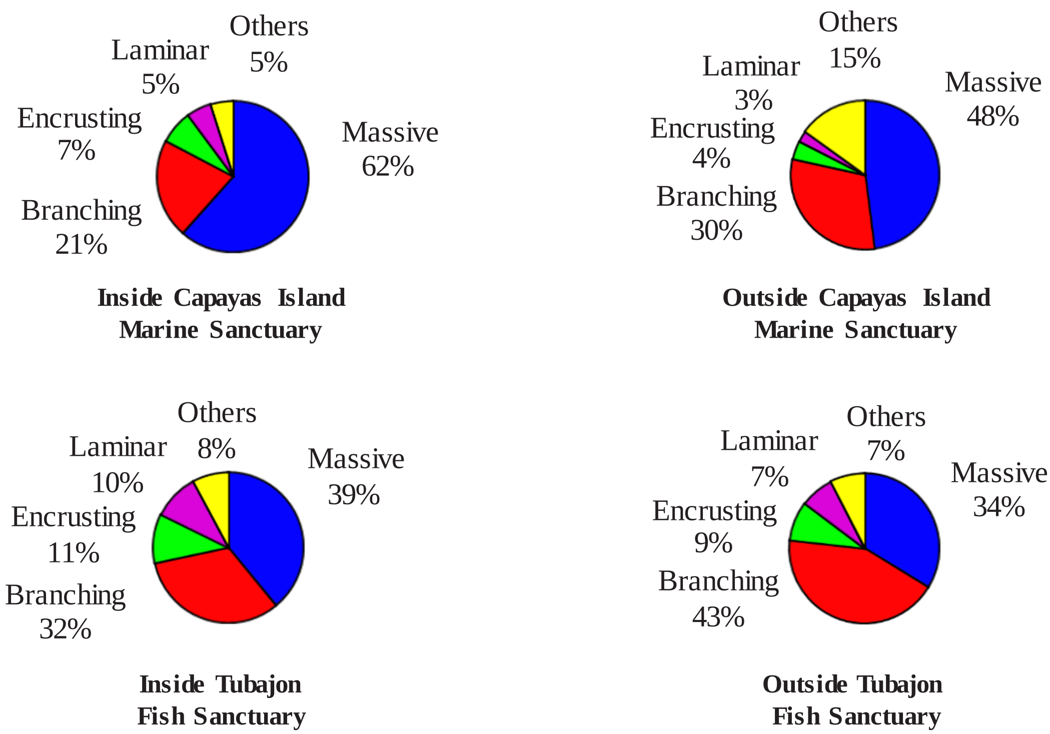

Figure 4. Coral growth form selectively affected by coral disease in Capayas Island and Tubajon (MPA and Non-MPA). Values obtained from pooled observation (June-July 2011).

albeit at varying degree, on all surveyed reefs. The preference for genus *Porites* in its massive and branched forms to develop coral diseases positively answered the second hypothesis of the study. Similarly Raymundo, et al. (2005), Kaczmarsky (2006), Raymundo, et al. (2009), and Myers and Raymundo (2009) also noted the susceptibility of *Porites* and its massive form to develop coral disease. Trematodiasis sightings on solely massive *Porites* further support prior claims of host preference for this disease (Beeden, et al. 2008).

Massive forms are well known for their slow growth while the genus *Porites* is acknowledged as tough, robust corals that are among the dominant reef building corals within Indo-Pacific areas. In fact within sampled reef sites of this study, the genus *Porites* was the most dominant genus observed with branching and massive forms co-dominating the reef. The apparent susceptibility of *Porites* to various diseases is disquieting as it could trigger population drop among reef-associated organisms (Loya, et al. 2001, Lessios, et al. 1984, Hughes 1994, Aronson and Precht, 2001 and Weil, 2004) and induce dramatic community shift within the reef system similar to the great Caribbean (Holden 1996, Hayes and Goreau, 1998, Harvel, et al. 2002, Weil, et al. 2002, Porter, et al. 2002 and Raymundo, et al. 2008). Conversely, Bruno, et al. (2007) reported that Philippine reefs suffered a dramatic hard coral cover reduction from 68% in 1981 now only 26% of the reefs have coral cover >25% (fair or better) but whether this reduction is primarily due to disease induced mortality is unknown.

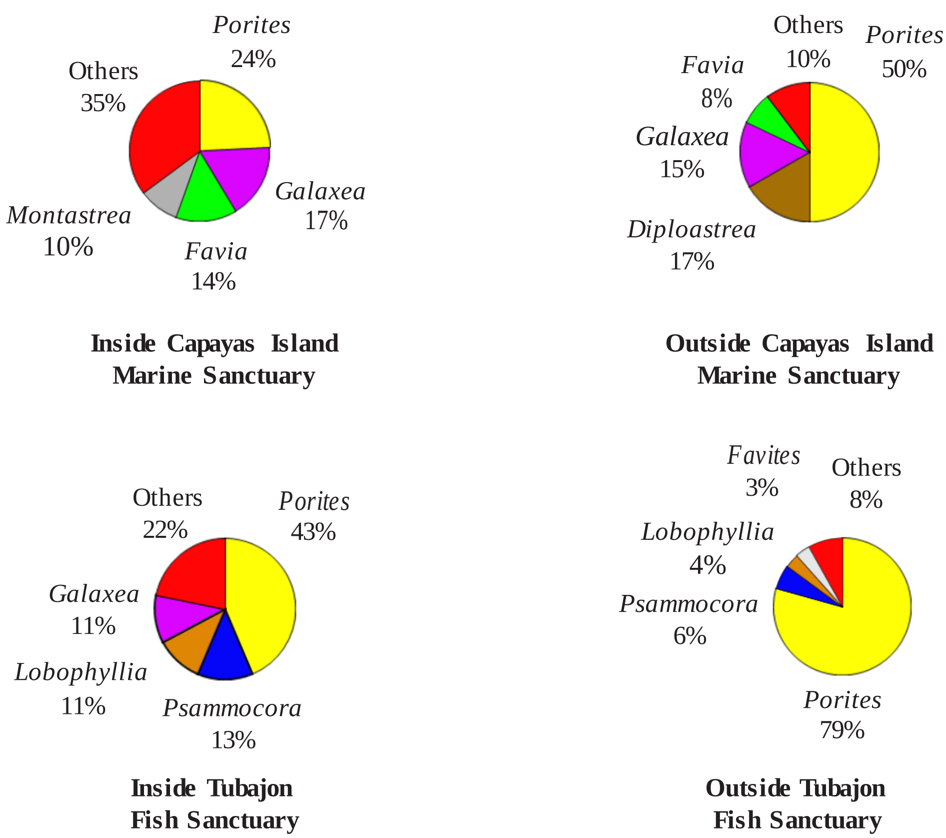

Figure 5. Massive corals selectively affected by disease in Capayas Island and Tubajon (MPA and Non-MPA). Values obtained from pooled observations (June to July 2011).

As many coral diseases are density-dependent, cover of disease susceptible corals can influence the level and severity of coral disease (Bruno, et al. 2007; Page, et al. 2009). In both Capayas Island and Tubajon, coral cover was notably high within MPA sites than unprotected reef sites. Cover of *Porites* was also high within both MPAs than their adjacent unprotected reefs. Albeit at the moment, further research are still needed to shed light on certain underlying issues surrounding susceptible coral host cover directly encouraging the spread of coral disease. Infectious disease outbreak on the other hand has been positively linked with its host coral density (Bruno, et al. 2007). Hence, it is alarming to conceive that a sudden infectious disease outbreak can easily wipe out the established reef system in both areas.

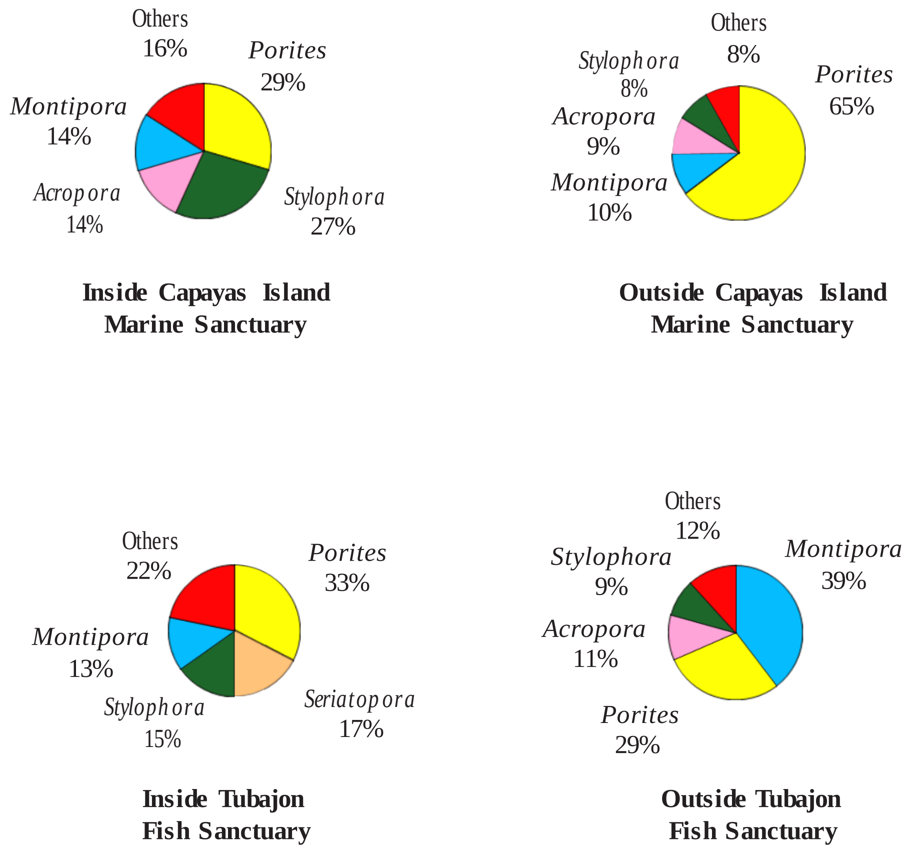

Figure 6. Branched corals selectively affected by disease in Capayas Island and Tubajon (MPA and Non-MPA). Values obtained from pooled observations (June to July 2011).

CONCLUSION

Coral disease is notably less prevalent inside each sites' respective MPAs than outside. Structurally, all reef sites had dominant massive and branching type corals. Both dominant coral forms are the most likely to develop coral disease. Ironically, *Porites* has the highest likelihood to develop a disease among corals regardless if it forms a massive or branched colony.

Although this paper verified the presence of coral disease in some parts of northern Mindanao reefs, current information about the subject is still wanting. A wide ranging, spatially and temporally, coral disease survey is recommended on subjects like diseases spread, and mortality and survival rates of corals infected with disease.

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Appendix 1. Coral diseases afflicting scleractinian corals within surveyed reef sites; arrow points the affected part. (A) White Disease on branching *Porites*. (B) Trematodiasis on massive *Porites*. (C) Growth Anomalies on branching *Porites*. (D) Coral Bleaching on mushroom coral *Herpolitha*.
(E) Other Disease on massive *Porites*.