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Coral Cover Assessment of Five Marine Protected Areas in Davao Oriental for Reef Conservation and Management

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ABSTRACT

Marine protected areas (MPAs) are being established in coral reefs with the goal of protecting and conserving these habitats and the resources therein. The Integrated Coastal Resource Management Project (ICRMP) aims to help Davao Oriental realize this by providing the necessary support to coastal communities for them to establish and manage their MPAs. The objective of this study is to determine the status of coral reefs in five of the ICRMP-assisted MPAs in Davao Oriental to obtain baseline data needed to inform their management. The five MPAs are located in the barangays of Luban, Lanca and Lawigan in the City of Mati; Barangay San Ignacio in Manay; and Barangay Jovellar in Tarragona. The Line Intercept Transect (LIT) method was used in the assessment of benthic life forms. Coral cover inside the MPAs of Barangay Luban and Lawigan in Mati Rising Jovellar MP Lawigan MPA Luban MPA MPA Sun MPAA City and Barangay San Ignacio in Manay all fall within the fair category whereas the coral cover of the MPAs in Barangay Lanca, Mati City and Barangay Jovellar, Tarragona are poor. Meanwhile, coral covers outside of the MPAs in this study are all poor except for

Barangay Luban, which has a fair coral cover. Among the MPAs, Barangay Lawigan has the highest live hard coral cover while Barangay Jovellar has the lowest. Of the sites assessed outside of the MPAs, Barangay Luban has the highest coral cover while Barangay San Ignacio has the lowest. The results of the assessment in this study will be used as baseline data for future monitoring to determine whether protection has resulted to better coral cover inside the MPAs.

Keywords: coral reef, marine protected area, Integrated Coastal Resource Management, MPA management, biomass

INTRODUCTION

Coral reefs have one of the highest productivities among the various coastal and marine ecosystems. The goods and services reef habitats delivered are innumerable.[1] In order for communities to benefit from corals, however, reefs must remain in relatively good health.[2] But coral reefs are also among the most vulnerable ecosystems, due in large part to their proximity to land and exposure to anthropogenic impacts. Exacerbating this is the slow growth of corals and gradual recovery of reefs once they are damaged.[3] This is why most coral reefs throughout the world have been degraded.[4] The alarming decline in reef productivity has made it imperative to set up coastal management mechanisms. These will help arrest the degradation and conserve coral reefs and the biodiversity they host. One such mechanism is the establishment of marine protected areas (MPA). Resolution 17.38 of the 1998 World Conservation Union (WCN) General Assembly defined MPA as "any intertidal or sub tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment".[5]

In the Philippines, the establishment of locally-managed MPAs in coastal municipalities was obligated by Republic Acts No. 7160 (Local Government Code of 1991) and 8550 (Philippine Fisheries Code). Larger scale MPAs are administered by the Department of Environment and Natural Resources (DENR) and encompassed by the National Integrated Protected Areas System (NIPAS) Act of 1992, or RA 7586. Many of these MPAs are coral reef areas.[4] Stakeholders particularly prefer coral reef MPAs because not only do they help to conserve biodiversity but they have the potential to generate income from ecotourism. Tourists are known to pay a premium amount to experience relatively pristine coral reefs.[6]

The success story of Apo Island is a good case in point. Three decades of protection has resulted to the recovery of coral reefs and fish abundance within the marine sanctuary. The community is now reaping the rewards not just in the form of increased fish biomass but also in additional income from tourism. The Integrated Coastal Resource Management Project (ICRMP) aimed to replicate

such a success. Through the project, the DENR assisted coastal municipalities in the province of Davao Oriental to establish MPAs and supported their management in their early years. Alternative livelihood projects, intensified information campaigns, and increased participation from local governments were also part of the sustainability mechanism of project.8

An MPA may be said to be successful if coral reefs staff to recover and fish become more abundant due to protection.9, 10 It will take several years of protection before any impact will be noticeable. At the onset, base line data has to be gathered so that future monitoring results will have some information upon which they may be benchmarked.[11] The main objective of this study is to provide baseline information regarding the coral cover, diversity, and community structure of coral reefs in five MPAs along the Pujada Bay Corridor and adjacent waters for their management, sustainable use, and conservation.

MATERIALS AND METHODS

Sampling

Assessments of coral cover were conducted in five marine protected areas in the province of Davao Oriental identified through the ICRMP. Of the five, three are located in the City of Mati, namely: Luban MPA in Barangay Luban; Lanca MPA in Barangay Lanca; and Lawigan MPA in Barangay Lawigan.

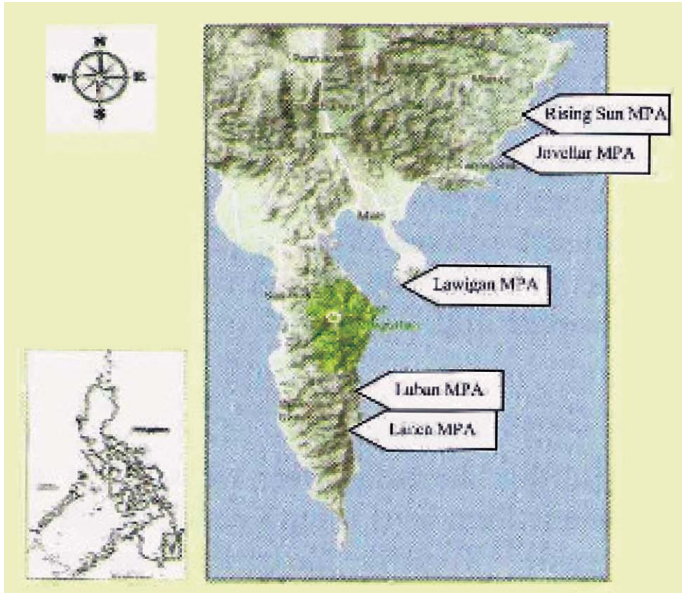

Figure 1. Map of the study sites.

Table 1. Information regarding MPA study sites and coordinates of sampling areas.

MPAs	Location	Size (ha)	Legal Basis	Status	Sampling Area	
					Inside MPA	Outside MPA
Luban MPA	Barangay Luban, City of Mati, Davao Oriental	Core: 18.00 Buffer: 38.54	Barangay Resolution	Boundary delineated; process of ordinance formulation is in progress; with Management Plan	6° 25' 32.74" N 126° 13' 23.77" E	6° 25' 06.02" N 126° 12' 48.42" E
Lanca MPA	Barangay Lanca, City of Mati, Davao Oriental	Core: 40.53 Buffer: 133.11	No Brgy Resolution or Ordinance	MPA boundary delineated; with Management Plan	6° 21' 15.37" N 126° 12' 16.02" E	6° 22' 19.20" N 126° 12' 05.14" E
Rising Sun MPA	Barangay San Ignacio, Manay, Davao Oriental	Core: 24.13 Buffer: 25.32	Resolution No. 1 S. 2009 and Municipal Ord. No. 01, S. 2009	Established and with Management Plan	7° 07' 20.75" N 126° 30' 32.73" E	7° 07' 06.74" N 126° 30' 16.17" E
Jovellar MPA	Barangay Jovellar, Tarragona, Davao Oriental	Core: 11.90 Buffer: 17.58	Municipal Ord. No. 01, S. 2009	Established and with Management Plan	7° 03' 25.51" N 126° 27' 22.93" E	7° 03' 33.04" N 126° 27' 38.53" E
Lawigan MPA	Barangay Lawigan, City of Mati, Davao Oriental	Core: Buffer:	No Brgy Resolution or Ordinance	MPA boundary delineated; MPA Management Planning in progress	6° 47' 56.76" N 126° 20' 34.12" E	6° 49' 22.44" N 126° 20' 47.29" E

The other two MPAs are Rising Sun MPA in Barangay San Ignacio, Manay and Jovellar MPA in Barangay Jovellar, Tarragona (Figure l). The sizes, legal basis for MPA establishment, the current status of the MPA and the coordinates for the sampling sites are given in Table l. Sampling activities were conducted from June to July of 2011.

Surveys of the benthic life form were done using the line intercept transect (LIT) method described by English and others.[12] The LIT method involved recording in situ the length of the benthic attributes that were intercepted by the transect tape in order to generate the percent cover of reef assemblages. At each study site, four areas were sampled inside the MPA and another four areas were sampled outside the MPA. At each sampling area, a 50 m transect line was laid on the reef roughly parallel to the shore and at a uniform depth of about 7.5 to 9 m. When coral reefs were absent at this depth, sampling was done at shallower portions of about 4.5 to 6 m. This method generated the percent cover of different benthic life forms and abiotic components.

Coral Cover Assessment

Benthic attributes were recorded up to the generic form level using a coral identification guide. To derive the benthic conditions in each of the MPA study sites, data 'were summarized as percentage cover of live hard coral (branching,

encrusting, foliose, massive mushroom, sub-massive, Heliopora sp., Millepora sp.), soft corals, dead corals and

dead corals with algae, algae, other fauna, abiotic (sand, silt, rock), and marine plants, using the classification of English and others. 12 Analysis of data included the use of descriptive statistics such as mean frequencies, totals, and standard en•or of the mean.

Reef condition was determined by comparing the proportion of live hard coral to other benthic attributes. The quartile index established by Gomez and Alcala14 was used as guide for classifying the status of the reef. The categories are: "excellent" (100—75%

live coral), "good" (74.9—50% live coral), "fair" (49.9—25% live coral), and "poor" (24.9—0% live coral).

RESULTS AND DISCUSSION

Coral reef status of the MPA sites

Percentages of the live hard coral in the MPAs of Rising Sun, Luban, and Lawigan fell under the "fair" category, averaging 25.82%, 32.06%, and 36.17%, respectively (Figure I and Table 2). Inside the MPAs of Jovellar and Lanca, live hard coral cover was of the "poor" category, the former having an average of 23.96% and the latter 24.89%. Of the coral cover outside of the MPAs assessed, only Luban was of the "fair" category and all other sites fell under the "poor" category. Their live hard coral cover ranged from 14.44% (Jovellar) and 23.82% (Lanca). These findings are not considerably different from the data gathered in various sites all over the Philippines between 2008 and 2011, which was consolidated in a paper by De Jesus and others.[15] The study reported that nearly half of the observed reefs were in "fair" condition (46.67%) while those in "poor" condition tallied 31.04%; reefs in "good" condition accounted for 20% and only 2.29% of reefs fell under the "excellent" category. Davao Oriental is encompassed within the South Philippine Sea biogeographic region. This is the same biogeographic region wherein De Jesus and others 5 observed the highest live hard coral cover and their study sites were concentrated in Surigao del Sur.

Predominance of branching corals

One of the important attributes of the LIT method used to assess coral cover in this study is the identification of the life form categories of live hard corals. From Figure 2, it will be noted that the branching type of coral is most predominant in six of the ten sites assessed. Branching corals even make up more than half of the total live hard corals in the following reef areas: inside and outside of Luban MPA, inside Lawigan MPA, and inside Rising Sun MPA. Branching corals have been considered as the equivalent of opportunistic species in a forest as opposed to massive corals, which have been considered as the equivalent of climax vegetation.[16] Thus, the predominance of branching corals, especially in

light of declining massive corals, indicates persistent disturbance to the coral reef system. Branching corals are also more prone to breakage and fragmentation.[16] This is cause for concern particularly in shallow reef areas, which appear to typify the MPAs of Luban, Lanca and Jovellar. As no-take reserves, these areas are ideally off-limits to any and all forms of human activities but that's not to say that they are no longer vulnerable. For instance, branching corals are more susceptible to damage due to strong wave action such as during typhoons compared to other coral life forms. As cited by Grim ditch and Salm,[17] several studies have observed that branching corals also have a higher propensity for bleaching mortality compared to massive corals though the exact causes have not been fully defined. With the expected rise in water temperatures due to the impending global warming, reefs dominated by branching corals may prove to be less resistant to massive coral bleaching, thus, their very survival may be at risk.

Table 2. Percentage of Benthic Attributes, Coral Condition and Number of Genera of MPA

Site		Benthic Attributes							Coral Condition	Number of Genera
		LHC	SC	DC/A	AL	OT	AB	MP		
Luban MPA	In	32.06	3.44	28.20	7.83	2.18	14.86	11.44	Fair	16
	Out	28.25	1.25	33.61	14.53	1.61	8.79	11.88	Fair	17
Lanca MPA	In	24.89	0.64	26.75	30.28	2.65	14.81	0.00	Poor	22
	Out	23.82	3.04	42.52	13.19	4.25	12.75	0.45	Poor	20
Lawigan MPA	In	36.17	2.91	30.46	22.30	1.68	4.99	1.52	Fair	25
	Out	23.13	0.46	38.11	24.29	2.21	11.82	0.00	Poor	28
Rising Sun MPA	In	25.82	3.35	24.47	2.06	4.95	13.69	25.66	Fair	21
	Out	14.44	0.05	25.80	15.77	2.81	10.08	31.33	Poor	20
Jovellar MPA	In	23.96	0.74	46.90	3.28	1.14	24.0	0.00	Poor	16
	Out	22.57	2.44	34.93	17.87	4.01	17.61	0.58	Poor	26

High proportion of dead corals

In all of the sites assessed, dead corals comprised at least about a quarter of the coral reefs (Table 2). The five sites outside of the MPAs all have higher proportions of dead corals compared with live hard corals, two sites within MPAs - those of Lanca and Jovellar have higher proportions of dead corals than live Scleractinian's. Corals die off for a variety of reasons: breakage due to boat

grounding, divers, the use of destructive fishing gears, or strong wave action such as during a storm; warmer water temperatures that lead to bleaching episodes; and siltation.[18] Any of these could have been the cause of the considerably high proportion of dead corals in the MPA sites studied.

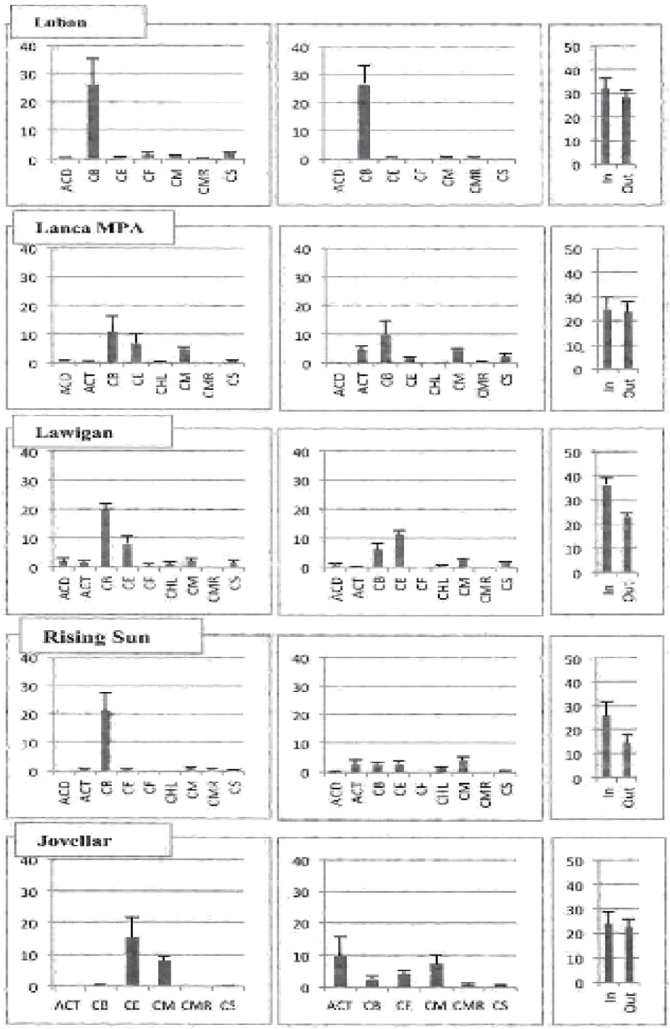

Figure 2. Average percent cover (ASE) of coral life form categories inside and outside of the MPA study sites. Coral life form categories: Acropora digitate (ACD), Acropora tabular (ACT), branching (CB), encrusting (CE) foliose (CF), Heliopora sp. (CHL), massive (CM), mushroom (CMR), submassive (CS). Average percentage of live hard corals (LIIC) inside and outside of the MPAs were also compared.

A coral is said to be dead when there is a removal of the colony. Within weeks, algae and other benthic organisms settle on the hard substrate of a dead coral's surface. 1 $ In a resilient coral reef, there is sufficient supply of coral recruits and these can settle on the dead coral substrate within months. Planulae assisting calcareous encrusting algae may even help the recruitment along. 18 In some reef areas, the disturbance may be persistent which can cause coral colonies to gradually die off. An example of this is a reef area where diving activities are intense or boat anchorage is common. Other reefs may experience acute perturbations that can cause a high death toll among corals such as during a storm, coral bleaching events, disease outbreaks, or crown of thorns starfish (COTS) infestation, to name some. In both cases, there may be a loss of coral resilience — defined by Hughes and others 19 as "the ability of reefs to absorb recurrent disturbances (e.g., from cyclones, outbreaks of predators, or coral bleaching events) and rebuild coral-dominated systems". Loss of resilience could mean a shift from a coral-dominated reef to one that is characterized by a hyper abundance of opportunistic species, mostly fleshy macroalgae.

High proportion of macroalgae

Macroalgal cover may be considered relatively high in the sites where the percent cover of macroalgae is at least half of the percent cover of live hard corals. From the MPAs surveyed, it will be noted that seven sites have relatively high macroalgal cover, ranging from 13.19% to 30.28% (Table 2). The seven sites include: outside of Luban MPA; inside and outside of Lanca MPA; inside and outside of Lawigan MPA; outside of Rising Sun MPA; and outside of Jovellar MPA. Of the seven, the macro-algae inside Lanca MPA and outside Lawigan MPA were highest, their macroalgae percent cover averaged 30.28% and 24.29%, respectively. Moreover, the percent cover of macroalgae in these two sites were higher than that of live Scleractinian's. whether the higher proportion of macroalgae constitutes a phase shift from a coral dominated reef to one that favors algal dominance. The algal dominance may be seasonal, considering that surveys were conducted towards the end of summer. A phase shift may only be several months of the algal dominance persisting.[18]

Increase in macroalgae may be brought about by a number of causes. A coral-algal phase shift is often preceded by a perturbation in the reef that results to its lowered state of structural complexity. Often, such disturbances may be associated with coral bleaching, outbreaks in coral-eating species, and diseases (both among corals and the herbivores that consume the algae) that cause corals to die off.[19] In resilient reefs, the settlement of algae is temporary and a long-term phase shift is resisted due to the recruitment of coral planulae.[18] But if exacerbating conditions such as reduced herbivory (possibly due to overfishing) and eutrophication are prevalent, a shift to algal dominance may be favored. In the MPA study sites, none of the above-mentioned disturbances have been verified, A diagnostic test of the nutrient load of the marine waters, however,

shows nutrient levels to be within standard levels. Another study shows that herbivorous fish species that feed on algae are present in these areas,[20] it was not established whether their population is such that this is sufficient to keep the fleshy algae in check. The study of Hughes and others[19] suggests that the exclusion of large predatory and herbivorous fish in a bleached coral reef can lead to the loss of resilience of the reef, causing an explosion of macroalgae that suppresses the fecundity, recruitment and coral cover over a three-year period. Another study also suggested that macroalgae interlaced in branching corals have lower removal rates; that is, herbivorous fish feed less on macroalgae in predominantly branching coral habitats.[21]

Coral genera

In all the sites, a total of 13 families and 37 genera were identified. In the five MPAs assessed, Porites and Acropora appeared to be the most dominant averaging 30.22 ± 7.90% and 27.28 ± 10.00%, respectively, of the live hard coral of each study site (Table 3). They are followed by Montipora, Isopora, Favia, and Favites, which averaged 7.41 ± 2.79%, 5.68 2.91%, 4.94 ± 4.10%, and 4.62 ± 3.05, respectively, of the live hard coral of each MPA. The remaining 31 genera represent less than 20% of the total live hard coral cover recorded in all the study sites. The dominance of Porites is not unusual as this genus is found in almost all reef habitats, often as a major coral component in reefs and, as such, its most important framework builder:[22] Massive Porites species often dominate back reefs while branching species appear to be more common in less exposed areas. Acropora is also a dominant reef framework-builder, especially in the Indo-Pacific region.[23] This genus is fairly common because it has the greatest number of species and they often grow in abundance but most of its species are also known to be extremely vulnerable, especially to bleaching and diseases. [24] There is, thus, cause for concern regarding its survival in a climate change scenario.

Future Directions

The marine protected areas in this study have only been recently established. Data on the status of the coral reefs in these marine reserves prior to this study have not been gathered and without such, the results of protection could not yet be quantified. Reef health outside the MPAs is not too different from conditions inside - or at least not sufficiently unalike to say that corals are benefit ting at this point from protection. Periodic monitoring employing the same methodologies and in the same areas would be particularly crucial as this would determine whether management actions are effective or not and how they can be improved, It should be noted that the MPAs in this study are but a few among the _many MPAs delineated in the coastal waters of Davao Oriental purposefully to effect network of protection. Although it is as yet undetermined whether the network formed is biologically effective — that is, it forms a corridor along which fish and coral larvae are exchanged[25] it nonetheless

Table 3. List of Coral Genera in the MPA study sites

Family	Genera	Coverage/site (%) ± SE
Poritidae	Porites	30.22 ± 7.90
Acroporidae	Acropora	27.28 ± 10.00
Acroporidae	Montipora	7.41 ± 2.79
Acroporidae	Isopora	5.68 ± 2.91
Faviidae	Favia	4.94 ± 4.10
Faviidae	Favites	4.62 ± 3.05
Pocilloporidae	Seriatopora	3.58 ± 2.85
Pocilloporidae	Pocillopora	2.76 ± 1.09
Faviidae	Platygyra	1.70 ± 0.83
Pocilloporidae	Stylopora	1.68 ± 0.57
Faviidae	Echinopora	1.40 ± 1.02
Acroporidae	Astreopora	1.35 ± 0.70
Helioporacea	Heliopora	1.05 ± 0.87
Faviidae	Goniastrea	0.95 ± 0.46
Oculinidae	Galaxea	0.75 ± 0.45
Fungiidae	Fungia	0.68 ± 0.49
Poritidae	Goniopora	0.58 ± 0.39
Agariciidae	Leoptoseris	0.40 ± 0.40
Euphyllidae	Euphyllia	0.36 ± 0.18
Pectiniidae	Echinophyllia	0.34 ± 0.34
Faviidae	Cyphastrea	0.31 ± 0.13
Agariciidae	Pachyseris	0.30 ± 0.20
Mussidae	Symphyllia	0.30 ± 0.23
Mussidae	Lobophyllia	0.16 ± 0.17
Faviidae	Oulophyllia	0.16 ± 0.13
Faviidae	Diploastrea	0.13 ± 0.08
Agariciidae	Pavona	0.12 ± 0.08
Merulinidae	Hydnopora	0.11 ± 0.07
Pectiniidae	Mycedium	0.10 ± 0.11
Fungiidae	Halomitra	0.09 ±0.09
Fungiidae	Ctenactis	0.09 ± 0.06
Fungiidae	Sandalolitha	0.08 ± 0.08
Trachyphyllidae	Trachyphyllia	0.08 ± 0.08
Agariciidae	Coeloseris	0.03 ± 0.07
Mussidae	Acanthastrea	0.06 ± 0.06
Fungiidae	Herpolitha	0.06 ± 0.06
Faviidae	Montastrea	0.03 ± 0.03

means that none of the MPAs established under ICRMP are isolated islands of protection. There is apparently much that needs to be studied but the lack of data should not hamper management nor should management wait for more studies to materialize. Pertinent to the integrated approach to management is the precautionary approach, which requires managers to work with what data they have and allowing for certain margins of uncertainty.[26] As data becomes more available, management can adapt to these new findings in an iterative process wherein MPA governance is founded more and more on scientific facts. The establishment of MPA is one way of introducing precautionary approach into management because as a no-take zone, MPAs provide a buffer against environmental perturbations.[27]The emergence of MPA as a solution to a myriad of marine ecosystem concerns is fueled as well by the sheer simplicity of the idea no matter what the anthropogenic problem is, a complete hands-off policy should fix it.[28]

CONCLUSIONS

From the surveys conducted, it was revealed that three of the MPAs - those in the Barangays of Luban, Lawigany and San Ignacio - were in fair condition, with coral cover of more than 25%. Highest coral cover inside the MPA was recorded for Barangay Lawigan while lowest coral cover was found in Barangay Jovellar's MPA.

In spite of generally fair conditions, the MPAs remain vulnerable to anthropogenic activities outside their boundaries, especially as most of the MPAs were established near coastal settlement areas. While the proximity allows the community to better keep an eye on the MPA, it also introduces possible sources. High nutrient load is one possible cause of increased algal cover, along with decreased herbivore. This study has not ascertained the cause of the high algal cover observed in some of the sites but it may very well be a confluence of several factors. In any case, it would be a cause for alarm if the pattern persists, as it would mean that a shift to a predominantly algal cover could very likely be the future of these coral reefs.

No statistical tests were conducted to confirm whether the differences between the coral cover inside the MPA and outside the MPA were significant. As the MPAs were in the nascent stages of their establishment, it was presumed that the difference in coral Cover will not be substantial. In instances where the difference is considerable, this may be attributed more to the placement of the MPA rather than as a result of protection. In any case, this study serves as baseline data for the MPA sites studied. It will be years yet before observable changes in reef structure and community will be evident and more significant comparisons can be made between the reef status inside and outside of the marine reserves. The effects of protection to the corals will not be immediately apparent as corals

take a long time to grow. What protection should ascertain, however, is that no additional corals will die of anthropogenic causes and that the coral recruitment will be successful.

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LITERATURE CITED

Roberts CM, Hawkins JP. Fully-protected marine reserves: a guide. Washington, DC: WWF Endangered Seas Campaign; 2000.

Carter E, Soemodinoto A, White AT. Guide for improving marine protected area management effectiveness in Indonesia. Bali, Indonesia: The Nature Conservancy Indonesia Marine Program; 2011, p xi - 49.

Dalby J, Sorensen TK. Coral reef resource management in the Philippines. MS Thesis, University of Copenhagen, 2002. p 166.

Mascia MB. Designing effective coral reef marine protected areas. A synthesis report based on presentations at the 9d' International Coral Reef Symposium Bali, Indonesia. 2001. p 23.

Christie P, White AT. Best practices for improved governance of coral reef marine protected areas. Coral Reefs [Online]. 2007; 26: 1047-1056.

Depondt F, Green E. Diving user fees and the financial sustainability of marine protected areas: opportunities and impediments. Ocean Coast Manage [Online]. 2006; 49: 188-202.

Alcala, AC. Marine reserves in the Philippines: Historical development, effects and influence on marine conservation policy. Makati: Bookmark, Inc.; 2001. p Xii-1 15.

Department of Environment and Natural Resources — Protected Areas and Wildlife Bureau. A national integrated coastal resources management and marine biodiversity research agenda for the Philippines; 2011.

Claudet J, Pelletier D, Jouvenel JY, Bachet F, Galzin R. Assessing the effects of marine protected area (MPA) on a reef fish assemblage in a north-western Mediterranean marine reserve: Identifying the community-based indicators. Biol Conserve [Online]. 2006;130(3): 349-369

Jameson SC, Tupper MH, Ridley JM_ The three screen doors: can marine protected areas be effective? Mar Pollut Bull [Online]. 2002; 44: 1177-1183.

Hockings M, Stolton S, Leverington F, Dudley N, Courrau J. Evaluating effectiveness: a framework for assessing management effectiveness of protected areas. 2nd edition Gland, Switzerland: IUCN; 2006. p12 xiv-105

English S, Wilkinson C, Baker V. (Eds.). Survey manual for tropical marine resources. Second Edition. Townsville, Australia: Australian Institute of Marine Science, ASEAN Australia Marine Science project; 1997. p xii-368.

Kelley R. Indo Pacific coral finder. Townsville, Australia: BYO Guides, 2009. p 34.

Gomez ED. Alcala AC. Status of Philippine coral reefs. ProclntSymp Marine Biogeogr Evol S 1979; 137:663-669.

De Jesus D, Mualil R, Mamauag S, Deocadez M, Atrigenio M, Quibilan MC, Martinez R, Panga F, Alino P. Status of Philippine coral reefs (2008-2011), p. 14-17. In Coral Reef Information Network of the Philippines (PhilReefs). State of the Coast: Sustaining the State of the Coast Reporting. Dilirnan, Quezon City: Coral Reef Information Network of the Philippines (PhilReefs). MPA Support Network. Marine Environment and Resources Foundation, Inc. and the Marine Scienc•c Institute, University of the Philippines; 2012.

Hawkins JP, Roberts CM, Van't HofT, De Meyer K, Tratalos J, Aldam C.Effects of reational scuba diving on Caribbean coral and fish communities. *Conserv Biol* [Online]. **1999**; 13 888-897.

Grimsditch GD, salm RV. Coral ReefResilience and Resistance to Bleaching. Gland, Switzerland: IUCN; 2006. p 52.

McManus JW, Polsenberg J. Coral-algal phase shifts in coral reefs: ecological and environmenta/ aspects. *Prog Oceanogr* [Online]. 2004; 60:263-279.

Hughes TP, Rodrigues MJ, Bellwood DR, Ceccarelli D, Hoegh-Guldberg O, McCook L, Moltschaniwskyj N, Pratchett MS, Steneck RS, Willis B. Phase shifts, herbivory, and the resilience of coral reefs to climate change. *curr Biol* [Online]. 2007; 17 360-365.

Eballe A. Assessment of reef fish abundance and biomass in the pujada Bay Corridor of Davao Orien21 BennetS, Verges A, Bellwood DR. Branching coral as a macroalgal refuge in a marginal coral reef system. *Coral Reefs* [Online]. 2010;

Pichon M. Porites. InD. Hopley (Ed.). Encyclopedia Of modern coral reefs: Structure, form and process. The Netherlands: Springer Science Business Media B.V.; 2011. p. 815821.

BM, PurkisSJ. Model of coral population response to accelerated bleaching and mass mortality in a changing climate. *Ecol Model* [Online]. 2009; 220: 192-208.

Wa11ace C. Acropora.InD. Hopley (Ed.). Encyclopedia Of modern coral reefs: structure, form and process. First Edition. The Netherlands: Springer Science Business Media B.V.; 3-9.

Mora C, Andréfouet S, Costello MJ, Kranenburg C, Rollo A, Veron J, Gaston K], Myers RA. Coral reefs and the global network of marine protected areas. Science. 2006; 312: 1750-1751

Pikitch EK, Santora C, Babcock EA. Bakun A, Bonfil R, Conover DO, Dayton P, Doukakis P, Fluharty D, Heneman B, Houde ED, Link J, Livingston PA, Mange' M, McAllister MK, pope J, Sainsbury KJ. Ecosystem-based fishery management Science. 2004; 305: 346-347.

National Research Council (NRC), Sustaining manne fisheries. Washington, D.C.: National Academies press; 1999. p 184.

Peterson CH. Estes JA Chapter 18. Conservation and management of marine communities, p. 469-507. In M.D S.G. Gaines and M. E. Hay (cds.) Marine tal for marine protected area management. *Davao Res J*. 2014; 10: 12-26. Community Ecology. Massachusetts: Siruaver Associates, Inc.', 2001.