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Status of coral communities in San Jose de Buenavista, Antique, Philippines

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Abstract

The Lamawan Pony Marine Protected Area (MPA) in San Jose de Buenavista, Antique, Philippines was created to improve marine conservation and fisheries management. This study evaluated the current status using the biophysical indicators on the MPA and the reef systems. The biophysical parameters include coral cover quality and diversity, fish composition and baseline sedimentation rate employing Coral Point Count Excel Extension (CPCe), Fish Visual Census (FVC) and sediment traps, respectively. Two study sites were established: inside the core zone and within the buffer zone to assess possible significant difference in the status of marine resource at sites. Results of the study showed that the estimated total area of the MPA core zone was 0.0586km^2. The mean of live coral cover is poor (15.99%) that includes the vulnerable species of *Heliopora coerulea* (0.24%) and *Diploastrea heliopora* (0.34%). Fish composition is generally low (M=1.15individuals/m^2). Baseline sedimentation rate is high (M=6.5mg/cm^2/day). Between sites, coral cover (t=2.24, *p*=0.028) and baseline sedimentation rate (t=4.65, *p*=0.00097) significantly differed, while fish density do not differ significantly (t=-0.374, p=0.3554) at sites. Despite these conditions, results suggest that increasing the no-take zone area to at least 20% of the total MPA size is necessary to achieve the goals set for an MPA.

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Introduction

The coral reef of San Jose de Buenavista, Antique, Philippines is considered as fishing ground for most of its local fishers for food and income. Within its marine area is a 0.672km² Marine Protected Area (MPA) called Lamawan Pony MPA, where several interesting species of marine organisms were found during the 2012 assessment (Martin and Martin, 2012). These species include the blue coral (*Heliopora coerulea*), the humphead wrasse (*Cheilinus undulates)* and black corals which are listed as vulnerable, endangered and as commercially threatened species by International Union for Conservation of Nature (IUCN), respectively. For the municipality, Lamawan Pony is their "last jewel" (BFAR, 2010). However, an average annual decrease of coral cover was observed from 2010 to 2012 by 5%. Fish density in the area was also low at 1.23individuals/m² that could be due to anthropogenic impacts (Martin and Martin, 2012).

In the Philippines, species richness and abundance of fishes are significantly higher in coral reefs compared to other marine habitats (Honda *et al*., 2013). This only proves that next to fishes, corals rank next in importance in terms of coastal marine biodiversity (Wafar *et al*., 2011). A large number of studies have attempted to demonstrate the correlations and relationships between fish abundance and/or diversity and the amount of live coral cover (Wilson *et al*., 2006). For instance, studies found a 2.4% decrease in reef biomass for each 1% annual decrease in coral cover caused by logging-induced siltation (Dalby and Sorensen, 2002). Further, records of fisheries yields show that areas of relatively shallow water with dense cover of live coral can produce extremely high fish yields (Skoglund, 2014).

In general, the threats to corals and coral reefs are caused by their exposure to multiple environmental stressors contributed by climate change and human impacts (Licuanan and Aliňo, 2014). While a changing climate brings many challenges to coral reefs, one of the most serious and immediate threats is from mass coral bleaching associated with unusually high sea temperatures (Wilkinson, 2008). Temperature anomaly of 1-2ºC for 5-10 weeks in summer season result to loss of zooxanthellae (a symbiotic dinoflagellates) photosynthetic pigments necessary for coral respiration, growth, and the deposition of its calcium carbonate skeleton (Saxby, 2000). The coral tolerance to temperature varies among species as determined by both the natural temperature environment at a geographical location and the coral's taxonomic distinctions (Schoepf, 2015). Reportedly, branching *Porites*, *Montipora*, *Acropora* and *Pocillopora* are highly susceptible to bleaching, massive *Porites* and *Favia* are susceptible but tolerant to bleaching, while *Heliopora coerulea* is tolerant to high temperature and was the least susceptible to bleaching (Kayanne *et al*., 2002).

Overfishing, destructive fishing and sedimentation are the three most common human activities significantly affecting coral reefs (Halpern *et al*., 2013). Good to excellent coral reefs can produce 20 tons per square kilometre per year or more of fish and other edible products; producing less than 4 tons/km²/year once destroyed (Rivera *et al*., 2002). Overfishing and removal of grazers in the marine environment accelerates a shift towards algal dominance (Maina *et al*., 2011). On the other hand, high sediments stress coral polyps by increasing water turbidity, limiting light availability and reducing photosynthetic capacity of zooxanthellae (Junjie *et al*., 2014). In the study of Erftemeijer *et al*. (2012), light requirements of corals range from <1% to as much as 60% of surface irradiance. Maximum tolerance by different corals to sedimentation rates range from <10mg/cm²/day to >400mg/cm²/day. Tolerance to suspended-sediment concentrations exposure are short-term (<24 hours) to some individual coral species as high as 1mg/cm² while others show longer (>4 weeks) mortality after exposure to low concentrations such that of 0.03mg/cm² (Erftemeijer *et al*., 2012).

MPAs are increasingly considered as useful option for coral reef management. Potential uses of MPAs are for conservation, for tourism and for fisheries management (ISRS, 2004).

Despite the presence of MPA, coral reef health showed signs of getting worse over time. This study aimed to determine the quality of coral cover within and outside Lamawan Pony MPA. Results could serve as basis for monitoring coral diversity, reef-associated fish density and sedimentation rate baseline data needed for the local government and its people to a more effective and science-based coastal resource management effort.

Materials and methods

The study site

San Jose, the capital town of Antique (a province in the Island of Panay, Region VI, the Philippines) is located at the west of Sulu Sea at 10° 45' North Latitude and 122° 56' East Longitude. It has relatively extensive flatlands which extend towards the coast of Sulu Sea. It has two major river systems which serve as natural boundaries in the adjacent towns; in the south the Malandog River separates San Jose from the municipality of Hamtic and in the north the Sibalom River from the Municipality of Belison. Its marine areas include a 13.65km coastline and coral reef areas. The majority of coral reef areas located in San Jose are found from Barangay Funda-Dalipe going south towards Barangay San Angel (MPDO, 2014).

The study was carried out in Lamawan Pony MPA of San Jose, Antique. Two sampling areas were established; one inside and one outside of Lamawan Pony MPA. Determination of sampling area was qualified as locally recognized areas of good coral reef or fisheries value (Fig. 1).

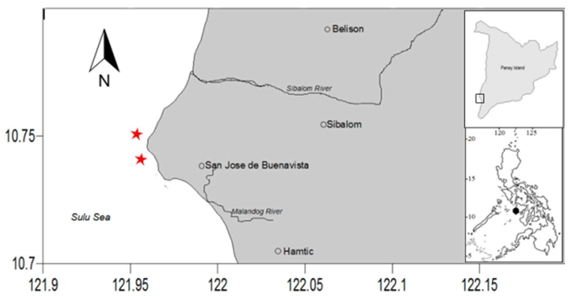

Fig. 1. Map of the study site

Biophysical survey

Assessments on coral condition and fish census were conducted, where; estimates of the community statistics of benthos were determined using still images according to methods of Kohler and Gill (2006).

Coral cover

Study stations for the transect surveys were selected based on the availability of the identified coastal resource. Five 25m transect lines in each study site were placed parallel to the shoreline. Transect lines for the core zone were laid at N10°45.29' E121°55.40' to N10°45.33' E121°55.41', while transect lines for buffer zone were at N10°45.58' E121°55.37' to N10°45.53' E121°55.39'. The lines were marked every 0.5 m and photos were taken with a digital camera along each transect line (50 photos=25m transect line) by maintaining a constant vertical distance (approximately 1m) between the camera and transect lines (Nakajima *et al.*, 2010). A Global Positioning System (GPS) device recorded the location of each transect line and each marked point. The transect lines were draped directly on the bottom in a straight line, and both edges of the lines were secured by weight. SCUBA diving and photoquadrat method were employed in laying the transects and in obtaining the photographs for study procedures. From the digital photos taken, corals were identified to the taxon level (Veron, 2000) with the aid of CPCe software. Coral health was determined using the standardized criteria developed by Zamani and Madduppa (2011) from the proposed criteria of Gomez and Yap (1998) in Table 1.

Table 1. Standardized criteria for coral reef as a development from the proposed criteria of Gomez and Yap (1998).

Parameters	Standard Criteria for Coral Health			
	Excellent	Good	Fair	Poor
Live coral coverage	75-100%	50-74.9%	25-49.9%	0-24.9%
Algae coverage	0-24.9%	25-49.9%	50-74.9%	75-100%
Sand coverage	0-24.9%	25-49.9%	50-74.9%	75-100%

Comparisons from previous research were also performed to get insight about the decreasing condition of the live hard coral cover of the reef.

Sedimentation rate

Three sets of sediment traps (length: 11.50cm; diameter: 5.00cm) were installed in each station (a set was composed of three individual traps) on the same day. The traps were installed at the end of the 25m transect line of transect 5 in each study site, 0.5m away from the Fisheries Resource Management Project (FRMP)-markers at N10°45.32 E121°55.41 of the core zone and N10°45.53 E121°55.39 of the buffer zone. The three replicates were mounted close to each other. During the samplings, traps were only left for 24 hours at the sampling sites during rainy season (November 2015 and January 2016). Traps were sealed with cellophane before removing them from the rod to prevent loss of material while bringing the sample to the laboratory (Becira, 2009).

Fish census

Fish census was conducted at each site, using the same five 25m lines previously laid in the benthic survey. Two fish observers swam side-by-side along a transect, each recording all fishes >20cm total length (TL) that were observed within a belt that is 4m wide, 4m high and perpendicular to their respective side of the transect. Then, these fish divers made a second pass along each transect, recording all fishes <20cm TL that were observed within belt that is 2m wide and 4m high (Ayotte *et al.*, 2011). Fish density and abundance were also calculated for each study site.

Results and discussion

Biophysical surveys of Lamawan Pony MPA

The core zone or no take zone of every MPA takes a vital role in promoting health of the coral reef. As well recognized, its impact to the communities in the reef is size dependent (Dalby and Sorensen, 2002). Fig. 2 below showed the extent of coral cover in Lamawan Pony MPA. The delineation of MPA core zone was conducted by the researchers from Phil-LIDAR project assigned in Region 6. Based on their shared data, the estimated total area of the MPA core zone was 0.0586km². This showed a difference of 0.004km² as compared to the municipality's previous estimate which was 0.062km² (Martin and Martin, 2012). This might be attributed to the movement of the markers due to wave action which were the basis in reassessing the delineation.

Fig. 2. Map of San Jose MPA showing the delineated MPA core zone and the extent of coral cover. (Source: Region VI Phil-LIDAR Project).

More than the core zone area, the determination of the size of the core zone should consider also the condition of fisheries management in the area (Dalby and Sorensen, 2002). The declared 0.062km² Lamawan Pony core zone is 9.25% of the total MPA area. As evident in this assessment, both its natural and social component revealed challenges in resource management both inside and outside the MPA. Dalby and Sorensen (2002) in their study mentioned that if resource management is poor outside the MPA; the core zone should be increased to a minimum of 20% of the total MPA area to ensure effective conservation of fish stocks.

Coral Cover and Composition

Using the CPCe software, it directly analyzes and input data in Microsoft Excel spreadsheets. Major categories in each study site as identified by the system were: coral (C), gorgonians (G), sponges (S), zoanthids (Zo), macroalgae (MA), other live organisms (OL), dead coral with algae (DCA), coralline algae (CA), diseased corals (DC), sand, pavement, rubble (SPR) and others. In this study, silt was also identified and categorized under the SPR.

There were 500 still images (15,000 points) that were taken and subjected to analysis for coral coverage and diversity. A total mean of 15.99% was computed for live corals in all ten transect lines. Among the major categories, some notable results were the SPR and DCA having the highest total mean in the Lamawan Pony Coral Reef with 41.56% and 24.04%, respectively.

Using the parameters in the standardized criteria proposed by Zamani and Madduppa (2011), Lamawan Pony MPA has an overall unhealthy coral reef condition (Table 1). Algae coverage of 35.75% and the silt smothering the corals to about 41% may still be categorized under good condition; however, the live coral coverage of 15.99% was poor in both study sites. This indicates the probability of the area experiencing a decrease of water quality or pollution, hence, encouraged space competition between the corals and the algae over time (Ban *et al.*, 2014).

In the study area, there are two major rivers that naturally bound San Jose from adjacent municipalities; the Sibalom River that is about 5.5km from Dalipe Point and Malandog River which is about 3km from Barangay 4. Sediment contamination and river runoff might cause the resulting low coral cover and genera present (Fuad, 2010). Increased sedimentation can cause smothering and burial of coral polyps, shading, tissue necrosis and population explosions of bacteria in coral mucus (Erftemeijer *et al.*, 2012), hence coral mortality. Fine sediments greatly reduce the recruitment, survival and settlement of coral larvae (Erftemeijer *et al.*, 2012). Maximum durations that corals can survive high sedimentation rates range from <24 hours for sensitive species to less than four weeks for very tolerant species (Gomez 2004 in Cuadrado *et al.*, 2016).

Table 2 shows that the mean composition of live corals differs at 7.31% between core and buffer zones. The core zone of the reef being a no take zone has a mean live coral cover of 19.64%, while inside the buffer zone has 12.33%. Among all transects laid, transect 5 of the core zone has the highest mean of 27.04% and transect 5 of the buffer zone has the lowest at 7.42%. The independent t-test of mean live coral cover between sites revealed a significant difference ($t=2.24$, $p=0.028$) (Table 5). The mean live coral cover changes as transects move away from the core zone. This result suggests that differences in coral communities maybe related to the reef ecosystem disturbances, like degradation in seawater quality and anthropogenic impacts, such as overfishing and sediment influx (Li *et al.*, 2013).

Table 2. A, B. Mean of major categories found in each study stations.

2-A. Core Zone

Major Category % of Transect	Mean Core Zone					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Total
Coral (c)	13.42	18.67	16.28	22.80	27.04	19.64
Gorgonians (g)	0.00	0.27	0.21	0.34	0.90	0.34
Sponges (s)	0.00	0.00	0.00	0.00	0.00	0.00
Zoanthids (z)	0.22	0.07	0.00	0.00	0.00	0.06
Macroalgae (ma)	14.72	9.47	3.38	6.34	4.50	7.69
Other live (ol)	0.73	0.54	1.03	0.20	0.76	0.65
Dead coral with algae (dca)	14.87	28.61	32.62	31.04	21.37	25.70
Coralline algae (ca)	4.59	4.02	3.10	5.94	1.31	3.79
Diseased corals (dc)	0.58	3.07	3.66	2.23	6.43	3.20
Sand, pavement, rubble (spr)	50.87	35.29	39.38	31.11	37.62	38.85
Unknowns (u)	0.00	0.00	0.34	0.00	0.07	0.08
Tape, wand, shadow (tws)	8.53	2.13	3.33	1.20	3.60	3.76
Totals	100.00	100.00	100.00	100.00	100.00	100.00

Sum (excluding tape+shadow+wand)

2-B. Buffer Zone

Major Category % of Transect	Mean Buffer Zone					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Total
Coral (c)	19.86	14.45	9.58	10.38	7.42	12.33
Gorgonians (g)	0.07	0.00	0.07	0.00	0.00	0.03
Sponges (s)	0.00	0.00	0.00	0.00	0.00	0.00
Zoanthids (z)	0.14	0.00	0.00	0.00	0.27	0.08
Macroalgae (ma)	12.22	14.80	15.49	6.48	11.82	12.16
Other live (ol)	0.14	0.62	0.48	0.14	0.14	0.30
Dead coral with algae (dca)	16.11	14.80	27.65	28.46	24.81	22.37
Coralline algae (ca)	0.27	0.83	0.95	0.20	0.21	0.49
Diseased corals (dc)	5.19	10.30	11.41	5.60	7.22	7.94
Sand, pavement, rubble (spr)	45.94	44.12	34.38	48.74	48.11	44.26
Unknowns (u)	0.07	0.07	0.00	0.00	0.00	0.03
Tape, wand, shadow (tws)	2.33	3.60	1.87	2.33	3.00	2.63
Totals	100.00	100.00	100.00	100.00	100.00	100.00

Sum (excluding tape + shadow + wand)

Additionally, the two study sites had high combined percent cover both in algae and abiotic components like dead corals, rubbles and silt. The buffer zone has 75.06% and the core zone has 61.54% (Table 2 A&B). According to Roxas *et al.* (2009), the aforementioned condition suggests recent coral deaths that have occurred in the area. Further, during the study period, it was observed that there were pressing anthropogenic activities even inside the core zone (transect 5). Fig. 3d shows a recently dead corals left fragmented a day after illegal fishers were caught by authorities (MENRO) right in the middle of the core zone. Using bottom set gill-net, branching corals were dragged along with their nets. Destructive fishing practices like bottom trawling, cyanide and dynamite fishing cause disturbances and stress to the coral reef ecosystem leading to coral mortality (Gomez, 2004 in Cuadrado *et al.*, 2016). Any form of extractive fishing inside MPA core zone is destructive to the reef ecosystem and is completely prohibited (Cabral *et al.*, 2014).

In previous studies, the live corals were categorized based on their physiognomic life forms, thus, comparison is not a viable option. In this study, the researches choose coral genera level for categorization because of the limited experience of the researcher as an observer.

Other live organisms observed in the study sites are blue starfish, sea anemone, crab, crown of thorns and giant clam *Tridacna* sp. Giant clams are ecologically important to coral reefs. As filter feeders, they potentially counter eutrophication by water filtering and are source of zooxanthellae (Neo *et al.*, 2014).

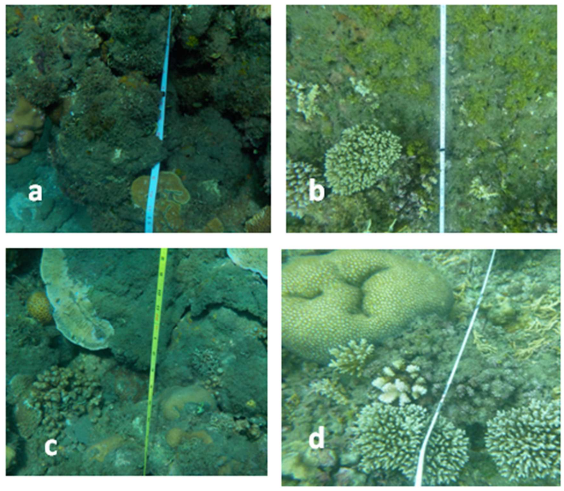

Fig. 3. Some condition of Lamawan Pony coral reef: (a) dead coral covered with algae, (b) live coral with algae, (c) dead and diseased coral covered dominantly by silt and (d) recently dead corals inside the core zone.

In total, there were sixteen (16) coral genera observed in the study sites (Fig. 4). Results shows that transect 5 of the core zone supported the highest percentage (17%) among the ten transects, while transect 5 of the buffer zone holds the fewest (5%) live coral coverage compared to all of the remaining transects in both zones. Using the CPCe software, the three most common genera and their % mean of live coral cover are: *Porites* sp. (6.10%), *Acropora* sp. (2.71%) and *Pocillopora* sp. (1.69%).

The IUCN listed coral species, *Heliopora coerulea* observed by researchers in previous surveys, was still accounted in at least 0.24% coral cover in few transects within the sites. Noteworthy, most of the species' colonies were found along transects of the buffer zone that has an extremely poor coral health environment. Black coral was absent during the survey, instead the researcher observed colonies of black feather stars. There were two soft coral species along the sampled survey sites that were accounted under subcategory Coral General.

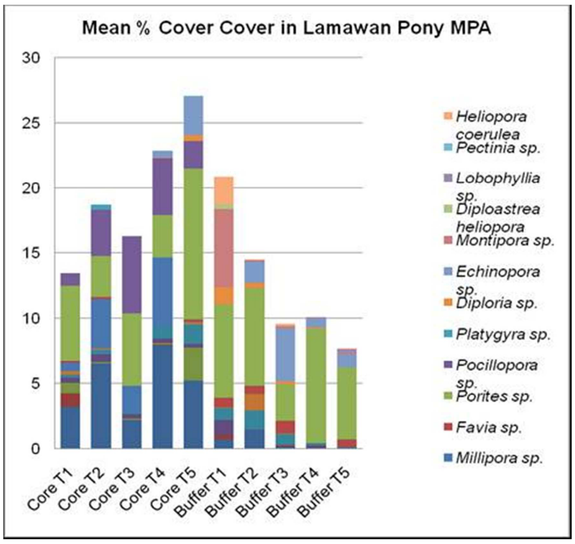

Fig. 4. Contribution of each coral genus to the total cover sampled during transects 1-5 in each of the core and buffer zones of Lamawan Pony MPA.

It was observed that coral genera (based on its abundance and richness) decreases as the transect move away from the core zone. *Porites* sp., also known as boulder or mound corals comprised of about 38% of the total live coral cover. The dominance of *Porites* sp. in the buffer zone suggests the degree of tolerance of coral species to sediments. According to Tao (as mentioned by Tabugo *et al.*, 2016), this coral type although slow growing is considered to be as very stable due to its resistance to strong water current. On the other hand, it was apparent that *Acropora* sp. being a sensitive species to sediments and have limited abilities in trapping and removing sediments from their surfaces (Cuadrado *et al.*, 2016) was hardly accounted (0.44%) in the buffer zone. This study site was near to the Sibalom River mouth.

Soft corals were observed to be absent in this particular study site. This maybe is due to the thickness of silt that smothered the site, thus, limiting the occurrence of sediment intolerant species, such soft corals (Fabricius, 2005).

Coral genera, like massive *Porites* areindicators to poor water quality. This includes turbidity, light attenuation, nutrient availability, sewage and sedimentation (Cooper *et al.*, 2009). Other coral genera observed in the study sites that are considered to have high tolerance to sedimentation are *Leptoria*, *Diploastrea heliopora*, *Favia* and *Montipora* (Pollock *et al.*, 2014; Cooper *et al.*, 2009; Junjie *et al.*, 2014). Coral genera *Acropora*, *Pocillopora* and *Millepora* are sensitive to thermal stress (Kayanne *et al.*, 2002, Banaszak *et al.*, 2003).

Taking into account the results of previous researches, a decrease of 1.71% of live coral cover was observed from the preceding 2012 research; a steep decline of 22.11% from 2008. It is difficult, however, to perform such direct comparison due to differences in methodologies employed and in the actual location of study sites. Nonetheless, looking into the trend for the past eighteen years, the health of Lamawan Pony MPA was rapidly decreasing. Bowden-Kerby (2001) in his study mentioned that natural recovery process will take from 5-10 years or less when numerous corals and coral fragments survive, hence the need for immediate intervention. Most of the MPA successes in the Philippines were collaborative efforts on coastal resource management between the government and the capacitated locals (Padayao and Sollestre, 2009).

Coral Biodiversity

Assessment of diversityindices, Shannon's Weaver Diversityindex (H) and Simpson'sindex of Diversity (1-D) were also generated directly by the CPCe software for each transect and the overall value (Table 3). Results of the assessed diversityindices (Shannon's Weaver Diversityindex and Simpson'sindex of Diversity), of the ten transects, transect 1 of the core zone has the highest H (1.80), while transect 4 of the buffer zone has the lowest H (0.28).

On 1-D on the other hand, transects 2 and 4 of core zone has the highest 1-D of 0.77, while transect 4 of the buffer zone has the lowest 1-D of 0.21. The core zone that obtain higher values of H'= 1.67 and 1-D = 0.75 as compared to the buffer zone which were H' = 1.27 and 1-D = 0.57, respectively. These values still point towards low species diversity of live hard coral percent cover and high coral community disturbance in Lamawan Pony Coral Reef. Accordingly, in most ecological studies, value above 3.0 indicate stability in habitat and value lower than 1.0 indicate habitat pollution and degradation (Goncalves and Meneses, 2011). Possible reasons of this poor condition of hard coral cover in the reef are: (1) the reef being near to source of sedimentation and run off; (2) high fishing activities leading to high algal cover (fishing activities in the buffer zone and even in the supposed restricted core zone); and (3) low tolerance limits of corals under the action of currents, wind and waves (Erftemeijer, 2012). Sites exposed to high riverine sediment increase coral diseases (Pollock *et al.*, 2014) and mortality to wide variety of corals causing macroalgal dominance. Moreover, the resuspension of sediments in windy conditions, higher waves or during strong tidal currents in shallow (< 10m) waters reduces photosynthesis in coral reefs (Bartley, *et al.*, 2013). Analysed by independent t-test, result showed that the Shannon-Weaver index of Diversity between the two sites are significantly different (t=1.93, p=0.0449) (Table 5). This may further imply that environmental conditions are different between sites (Fuad, 2010).

Table 3. Shannon-Weaver and Simpson'sindex of Diversity in Lamawan MPA.

Zone	Transect	Shannon-Weaverindex (H)	Simpson'sindex of Diversity (1-D)
Core	1	1.80	0.75
	2	1.70	0.77
	3	1.53	0.73
	4	1.64	0.77
	5	1.70	0.75
Total		1.67	0.75
Buffer	1	1.70	0.76
	2	1.56	0.69
	3	1.53	0.71
	4	0.68	0.28
	5	0.89	0.43
Total		1.27	0.57
Overall (Transects in Core and Buffer Zones)		1.47	0.66

Fish Census Survey

In the fish census conducted within two sites in the MPA. A total of 1151 fishes were observed during the survey. Overall, fish density in Lamawan Pony MPA was 1.15ind/m², where core zone has higher fish density of 1.23ind/m² (617ind/500m²) compared to the buffer zone which was 1.07ind/m² (534ind/500m²). Despite the difference in number of fish individuals, both sites have poor fish density category (Cuadrado *et al.*, 2016), and composition of type of reef fishes are not statistically different (p=0.3554) between sites (Table 5).

Moreover, species diversity of the core zone was computed at H'= 0.27, while the buffer zone obtained H'= 0.30. Both values are so low indicating pollution and degradation of habitat since values below 1indicate this condition (Cuadrado *et al.*, 2016). This could be attributed to the overall status of corals in the MPA. According to Komyakova *et al.* (2013), the impact of reduced coral diversity may have an equal or even greater effect to reef-associated fish communities.

There were twenty-one (21) fish families that were observed. These are: Labridae, Pomacentridae, Mullidae, Acanthuridae, Serranidae, Cirrhitidae, Lutjanidae, Balistidae, Chaetodontidae, Blenidae, Nemipteridae, Microdesmidae, Pomacanthidae, Pinguipedidae, Lethrinidae, Caesionidae, Scaridae, Zanclidae, Gobiidae, Haemulidae and Siganidae (Fig. 5). Of the total fish compositions, fishes belonging to Family Pomacentridae (29%) were the most abundant population in Lamawan Pony MPA. More than food and habitat requirement (Wolf, 2012), most pomacentrids are known to be aggressive territorial herbivores that chase other reef fishes away (Jones, 2005). Studies show that the differences in the fish composition within the no-take area of an MPA is due to greater abundance of acanthurids (herbivores) like the parrotfish compared to partially protected area (Munga *et al.*, 2012). Acanthurids, having composed of different functional groups, do not have equal influence in coral reefs due to diversity in feeding rates, preferences and impacts on the benthos (Heenan and Williams, 2013).

The survey revealed that the accounted target species, indicator species and other fishes are at 46%, 3% 51%, respectively (Fig. 6). The observed coral indicator species belong to the fish families of Chaetodontidae, Pomacanthidae and Zanclidae. The result of the 2012 fish census using the same category were 28.5% target species, 6.3% indicator species and 65.3% other species (Martin and Martin, 2012). The decreasing population of indicator species in the reef suggests that environmental conditions from 2012 are more stressful to the coral communities (Kulbicki and Bozec, 2005). Declines in density of coral livorous Chaetodon is usually an effect of branching hard coral loss and recovery (Russ and Leahy, 2017).

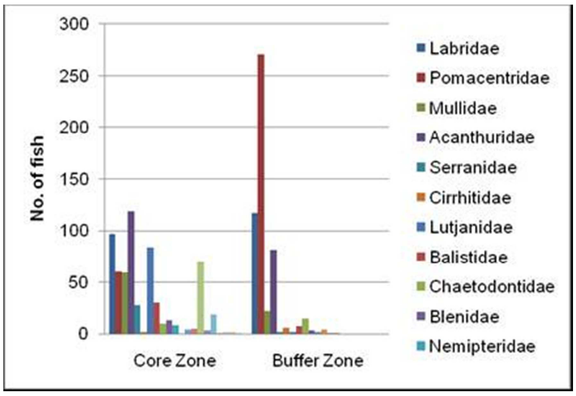

Fig. 5. Composition of fish families in Lamawan Pony MPA.

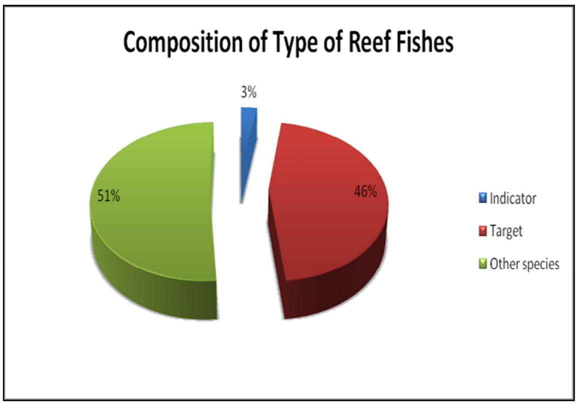

Fig. 6. Percent composition of type of reef fishes in Lamawan Pony MPA.

Target fish species observed in abundance were fish families Acanthuridae (37%), Lutjanidae (16%), Mullidae (15%), Lethrinidae (13%), Balistidae (7%) and Serranidae (6%) (Fig.7). Despite the high abundance of acanthurids, abundance of algae in the reef is also high. Findings of Vermeij *et. al.* (2010) suggests that herbivores are not capable to control algal growth and nutrient enrichment gives algae the advantage over corals.

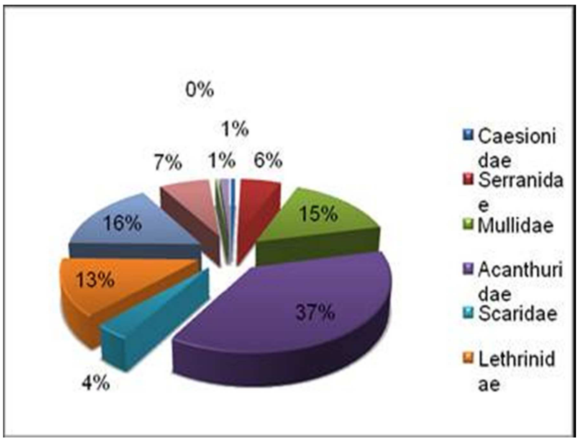

Fig. 7. Percent composition of target fishes in Lamawan Pony MPA.

On fish size distribution of all target fishes, all fishes observed in buffer zone were less than ~ 20cm in length. This suggests that the buffer zone is influenced by high anthropogenic activities (being the only area where restricted fishing is allowed) compared to the core zone.

IUCN Listed Species

Coral species *Heliopora coruelea* were observed in the shallow areas of the buffer zone at 0.24% coral cover. This species usually occurs on shallow reef under six (6) meters depth, even in disturbed or marginal habitat (Richards, 2013). Despite the high sedimentation rate in the buffer zone of Lamawan Pony MPA, this might not pose threat to *H. coruelea*. More studies supplement previous observations on its adaptations to brood on sediment-impacted reefs improving species survival (Toh *et al.*, 2015). Further, studies show that *H. coruela* are tolerant to high temperature and least susceptible to bleaching (Kayanne *et al.*, 2002) compared to other species found on sites. Though space is limited in reef ecosystems, *H. coruelea* was found to be one of the dominant reef- building corals due to its ability to inhibit the settlement of scleractinian larvae of other corals. Findings in a recent study in Bolinao Reef Philippines showed that *H. coruelea* has a behavior of overgrowing other corals which has implication to a decrease in diversity (Atregenio *et al*, 2017).

Another coral species observed at sites is the critically threatened *Diploastrea heliopora*, a sole species under its genus. In the present study, species *C. undulatus* and species of black corals were not observed. This result suggested the possibilities of rampant harvesting in the area.

Baseline Sediment Accumulation Rate

From the assessment of a baseline daily sediment accumulation rate was conducted in two study sites during one season of north-eastern monsoon (November 2015 and January 2016), the result showed that in the core zone of Lamawan Pony MPA, the daily sediment accumulation rate was 4.18mg/cm^2/day while the buffer zone was 9.75mg/cm^2/day. Sedimentation rate of 9.75mg/cm^2/day was higher in the buffer zone compared to that of the core zone that was 4.18mg/cm^2/day (Table 4).

Table 4. Mean of the deposited sediments in sediment traps installed in Lamawan Pony MPA.

Location	Suspended sediment concentration (mg/cm2/day)
Core Zone	4.18
Buffer Zone	9.75
Mean	6.965

The maximum sedimentation rates that can be tolerated by corals ranges from <10mg/cm^2/day to >400mg/cm^2/day (Pastorok and Bilyard 1985, in Cuadrado *et al.*, 2016). The critical limit for coral survival is <10mg/cm^2/day (Dutra *et al.*, 2006) and >50mg/cm^2/day considered catastrophic for some coral species (Cuadrado *et al.*, 2016). Another study conducted by Becira (2009) in the fringing reef of Meara Island in Honda Bay, Puerto Princesa City revealed an almost similar sedimentation rate of 4mg/cm^2/day and 9mg/cm^2/day (mean of 6.5mg/cm^2/day). In his assessment, he concluded that the sedimentation rate has not yet reach its critical stage as indicated by its high hard coral cover of 43.20%. Although this research used the same sampling procedure of Becira (2009), both studies are not comparable since Lamawan Pony MPA has a poor hard coral cover of 15.99%.

Table 5. Result of unpaired t-test of coral and fish composition and sedimentation rate between study sites in Lamawan Pony MPA, San Jose, Antique.

Parameter	Zone	N	Mean	SD	*T*	*Df*	*P**	95% Confidence Interval
Coral Composition	Core	5	1.67	0.099	-	4	-	
	Buffer	5	1.27	0.455	-	4	-	
	Total	10	1.47	0.283	1.93	8	0.0449*	1.29, to 1.65
Fish composition	Core	20	1.23	0.075	-	19	-	
	Buffer	14	1.07	0.534	-	13	-	
	Total	34	1.15	0.283	-0.374	32	0.3554	1.05, to 1.25
Sedimentation Rate	Core	3	4.18	1.15	-	-	-	
	Buffer	3	9.75	1.73	-	-	-	
	Total	6	1.73	3	4.65	4	0.0097*	-8.899 to -2.241

The result is not significant at $p<.05$.

The corals in Lamawan Pony MPA in general are highly smothered with very thick fine sediment, specifically silt. Between the core zone (M=4.18, SD=1.15) and buffer zone (M=9.75, SD=1.73), unpaired t-test showed that the difference is considered to be very statistically different, t=4.65, p=0.00097 and CI=-8.8993, -2.2407 (Table 5). Furusawa *et al.* (2004 in Halpern *et al.*, 2013) stated that thick sediments could be a typical impact of logging in the upland area and might keep the MPA from improving its conditions. Study of Jones *et al.* (2015) revealed that dredging in rivers can release sediments in water bodies and has negative effects on the reproductive cycle of coral communities.

Conclusion and Recommendation

This study provided monitoring data on the current condition of the Lamawan Pony MPA. In general, the study found out that the MPA condition was becoming even poorer that can maybe attributed to MPA management. The coral condition of the two study sites fall under poor category. The sedimentation in the area seemed to reach its critical level as it heavily damaged hard coral coverage, specially the buffer zone in Funda-dalipe area. This continuous decline of hard coral cover suggests that it has affected the fish abundance and density. The difference of fish communities in the core and buffer zones of the MPA is most likely due to fishing pressure in the buffer zones. The presence of indicator species like angelfish (Chaetodontidae) and mooring fish (Zanclidae), however, may signify chances of resilience. The IUCN listed species observed were small patches of the vulnerable blue coral *H. coerulea* species and *D. heliopora* the shallow areas of the reef.

On sedimentation rates, the number of samples and sampling points are very limited. In spite of the low sampling, the result still shows high sedimentation rate. Upland anthropogenic activities (e.g. logging and dredging) causing sedimentation negatively impact the coral reef was not recognized by the communities. Communicating results in this area might be important to improve coral reef condition (Halpern *et al.*, 2013) on Lamawan Pony MPA. However, the data are useful baseline in planning and improving local MPA and fisheries management.

To maximize reef impact, it is recommended that the size of Lamawan Pony MPA core zone will be increased to at least 20% of the total MPA size.

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