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Biophysical profile of Kawas Marine Sanctuary in Alabel Sarangani Province, Philippines

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Abstract. Kawas Marine Sanctuary in Alabel Sarangani Province is an Marine Protected Area (MPA) inside Sarangani Bay Protected Seascape (SBPS) noted for its dense mangrove forest and enormous coral reef which is threaten from both anthropogenic and natural factors affecting the status of mangroves, seagrass and coral reef ecosystem. The status and condition of this ecosystem is highly substantial that this research aimed to monitor the status of the resources by means of rapid assessment. Some physico-chemical parameters were obtained from both in situ and in vitro water sample testing. Belt transect walk method was used for assessing the mangrove area, quadrat methods for seagrass, line intercept transect (LIT) for reef status, while fish visual census (FVC) for reef fishes. Simple analytical tool such as the Shannon index formula, fish biomass formula and percent cover formula was utilized quantifying the data gathered. The results of physico-chemical parameters were within the range of the biological requirements for all ecosystems present. The 6,312 hectares of mangrove forest is dominated by *Avicennia lanata* with 0.159 diversity index. Seagrass was distributed from patches to extensive cover with six (6) seagrass species in 0.639 diversity index. The reef areas exhibited fair to excellent coral cover with 53 percent live hard corals with reef fishes composed of 27 species in 0.925 diversity index with family Pomacentridae as the most dominant species. The physico-chemical parameters of the area greatly contribute to the overall diversity of the Kawas Marine Sanctuary concluding that the area is in good condition.
Key Words: mangroves, coral reef, ecosystem, Kawas, marine sanctuary, Sarangani Province.

Introduction. The Philippines is one of 18 megabiodiversity countries due to its geographical isolation, diverse habitats and high rates of endemism. Unluckily, there is a growing evidence of continuing degradation of the coastal ecosystem. The combined impacts of human overexploitation, physical disturbance, pollution and sedimentation adversely affect the ecological balance of the ecosystem (White & Cruz-Trinidad 1998). To combat the trend on depleting resources Marine Key Biodiversity Areas (MKBA) are identified as sites of global significance for biodiversity conservation identified using globally standard criteria and thresholds, based on the needs of biodiversity requiring safeguard at the site scale (Conservation International 2008). Locally, a key management strategy to address the issues is being initiated through implementation of marine protected areas (MPA's) (Alino et al 2007). MPAs are a useful tool for conserving biodiversity and managing fisheries (Bennett 2015). To date, more than 1,300 MPAs in the Philippines were established but only around 10% are actually being effectively managed (PhilReefs 2008), a reason why most MPAs have had mixed success in meeting their management objectives in terms of ecological, socio-economic, and fisheries benefits (Claudet et al 2011). Among the small number is Kawas Marine Sanctuary.

Kawas Marine Sanctuary is the only marine protected area established within the three coastal Barangays of the municipality of Alabel, Sarangani Province, located at 6° 3.460' North 125°16.272' East of Southern Mindanao in Philippine Archipelago. Although one of the smallest MPA in SBPS, Kawas Marine Sanctuary's Size which is 29 hectares also provide some recruitment benefits within and close to their boundaries (Planes et al

2009). The 5 km coastal stretch is inhabited by mangrove forest, seagrass beds and coral reef ecosystem (De Jesus et al 2001).

Mangroves forest provides numerous important ecological functions, though they are in rapid and global decline (Friess et al 2012). Friess & Webb (2014) states that many countries showed high variability in deforestation specially in Asian countries including the Philippines. The seagrass bed though with a lot of ecological benefit was threatened from the cumulative impact of human activities on coastal ecosystems (Adams et al 2015). The threatened ecosystem of coral reefs has already lost 20% and 26% are under imminent threat due to combine effects of anthropogenic modification of chemical and physical atmospheric dynamics (Reigl et al 2009). The adjacent areas of the MPA were fish cages and fishponds contributing to high siltation which probably damages coral reef. To further evaluate the biological impact of the establishment of Kawas Marine Sanctuary a biophysical profiling is imperative (Integrated Coastal Management Plan 2015-2020).

Biophysical profiling through Biodiversity assessment is a means of collecting information on the species present in a specified area (Halpern & Warner 2002). This procedure provides a reliable data through scientific procedure and gives a baseline of information for comparison over regional up to global scale. It is usually done on a time frame that many careful and thorough studies are administered with the generated data purposely utilized to create optimum conservation measures by resource managers and policy makers.

In general, biodiversity assessment involves conducting a survey or inventory of the species in a certain area. The assessment could focus on one taxonomic group, such as animals or plants. A multi-taxa coastal resource assessment would survey more than one taxonomic group, most typically mangrove forest, seagrass beds and coral reef ecosystems (Philippine Coastal Management Guidebook 2001). Biodiversity assessment is not an exhaustive inventory and does not record every species in an area. A standard procedure has been designed to allow those with less experience to begin data collection and environmental management them to gradually build up a data base that can effectively contribute to a global monitoring effort (White et al 2002).

This paper is guided by the following objectives: to evaluate some physico-chemical parameters of the area; to identify the mangrove, seagrass and reef fishes species composition of Kawas Marine Sanctuary; and to assess the status of mangrove, seagrass and coral reef ecosystem. This paper is limited to the 28.9 hectares sanctuary established by the Local Government Unit (LGU). Mangroves, seagrass and reef fishes were identified up to species level. Coral reef was identified based on the life forms and physico-chemical parameters limited to salinity, temperature, pH, visibility and depth were taken.

Material and Method

Study area and period. The study was conducted during the period from August 2014 to December 2014 at Kawas Marine Sanctuary, Alabel Sarangani Province (Figure 1).

Physico-chemical parameters. The physico-chemical parameters were obtained in same time in all sampling stations located in the buffer zone and the core zone (Figure 1). In situ sampling were conducted for the salinity, water temperature, pH, visibility and depth while water samples for total suspended solid was collected and brought to the laboratory for further analysis. Temperature, pH, and salinity were taken using a digital conductivity water sampling kit Horiba water Quality checker U-50. Visibility was recorded using a Secchi disk, at the point of disappearance of the disk, the length of the string submerged, from the surface of the Secchi disk was measured with the use of a meter stick recorded in centimetres. Depth was taken using the depth gauge provided in SCUBA divers equipment, total suspended solids (TSS) was taken through filtering a 100 mL water sample in dry weight filtering paper and was allowed to dry completely in an oven and was weighted again. The difference in weight was the value of the total suspended solid of a sample express in mg L^{-1}.

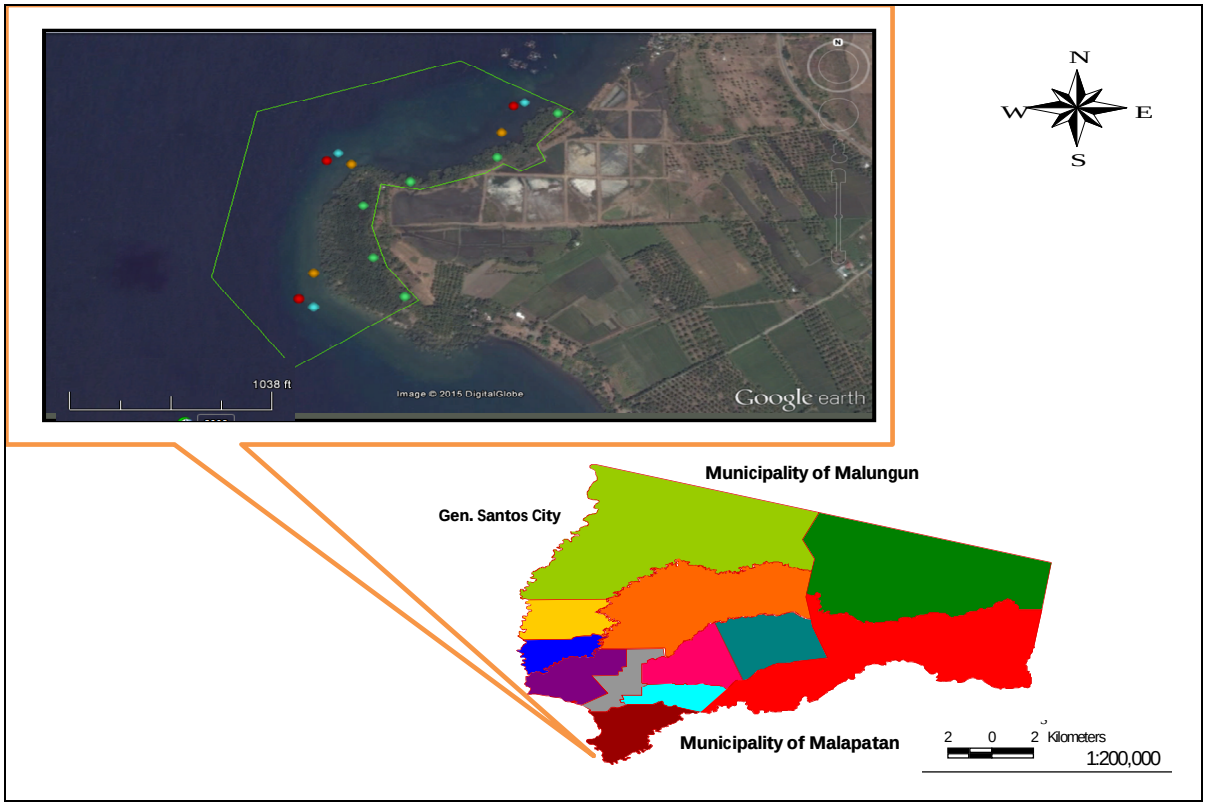

Figure 1. Water bodies map of Alabel Munipality (DENR-CLUP) showing road networks , river and creeks. Kawas Marine Sanctuary magnified satellite image (Google Earth 2015) showing boundaries of the MPA and sampling stations. Mangroves (green), seagrass (orange), coral reef (blue), reef fishes (red).

Biodiversity assessment. Resource inventory and assessment on the present biodiversity status of the coastal and marine resources include the species composition and abundance of true mangrove, seagrass, and coral reef and reef fishes.

Mangroves were assessed using belt transect walk method. Coordinates were taken in every plot measuring 10 x 10 meters in established mangrove area of true mangrove species, identification and counting of each individual followed. Mangrove condition was assessed using the criteria presented at Table 1.

Table 1

Criteria for mangrove condition

Condition	*Criteria*
Excellent	Undisturbed, no cutting, clean, etc.
Good	Some cutting for firewood, etc.
Fair	Heavy cutting, fishpond conversion, etc.
Poor	Nearly destroyed, reclaimed or filled pollution, etc.

To determine the extent of seagrass beds in the area a reconnaissance survey was conducted by laying three (3) transect lines perpendicular to the shoreline and a quadrat measuring 50 cm x 50 cm with 25 grids laid down on the seagrass beds. A ten meters interval was observed upon quadrat reading on species composition and percentage cover up to the extent of the seagrass meadows. Seagrass condition was based on the criteria provided by English et al (1994) as shown in Table 2.

Table 2

Criteria for seagrass cover

Status	*Cover*
Excellent	> 75% seagrass cover
Good	50-74.9% seagrass cover
Fair	25-49.9% seagrass cover
Poor	< 25% seagrass cover

Line intersect transect was used to each dive site surveyed, a 50 m transect lines was laid at a depth of 10 meters. After lying the transect, the observer moved slowly along the transect, recording on data sheets the life forms encountered under the tape. At each point where the benthic life form changed, the transition point in centimeters and the code of the life form was recorded. Coral covers were categorized based on the criteria provided by English et al (1994) as shown in Table 3.

Table 3

Criteria for life form cover

Status	*Cover*
Excellent	75%-100% coral cover
Good	50-74.9% coral cover
Fair	25-49.9% coral cover
Poor	< 25% coral cover

Reef fish assessment was done by laying a 50 meter transect perpendicular to the shoreline. Reef fishes are then observed every 5 meter interval observing an imaginary 5 meter transect from the left and right of the transect.

Data analyses. Simple tools were utilized in data interpretation. Data were presented in simple averages, percentages, graphs, charts and tables to determine changes and compare the trends biophysical conditions of the Marine Protected Areas.

$$\text{Percent crown cover of mangrove} = \frac{\text{Total crown cover of all trees}}{\text{Total area sampled}}$$

$$\text{Percent cover of seagrass} = \frac{\text{summation (M1 x f1)}}{F}$$

where:
M1 = midpoint percentage of class 1;
f1 = frequency of class 1;
F = total no. of squares.

$$\text{Percent cover of corals} = \frac{\text{Total length of category}}{\text{Length of transect}} \times 100$$

Fish biomass (W)= aLb

Where:
W = length;
L = length;
a, b = coefficient is constant.

Diversity index was measured using the Shannon Index (H') formula:

$$H' = -\sum_{i=1}^{R} p_i \log p_i$$

Where:
H = the Shannon diversity index;

Pi = fraction of the entire population made up of species i;
R = numbers of species encountered;
∑ = sum from species 1 to species R.

Results and Discussion. Results showed that the average pH value of all sampling areas in the sanctuary was at 7.53 which is nearly neutral (pH 7). Water temperature is at 28.04^{o}C, below the limits of maximum rise of 3^{o}C for the ambient temperature on class SC water provided by DENR (1990). The aquatic environment's thermal stability drives partly from the high capacity of water to absorb heat energy without changing temperature (Molles 2008). Furthermore salinity reading is at 29.2 ppt, highest salinity reading among the recorded salinity of MPA inside the SBPS. Kawas Marine Sanctuary is far from freshwater bodies that may contribute to change of salinity.

Depth of water from the shoreline to the reef areas is at 0 to 45 ft. Sixty percent of the areas was totally exposed during highest low tide having a bottom topography of wide tidal reef flat and slope reef areas with a depth ranged from 25 ft to 45 ft. Visibility is at two meters while (TSS) in all stations is at 0.50 mg L^{-1} which is beyond the minimum level of standards set by the DENR (1990). The obtained results in the physico-chemical sampling were within the level of the optimum growth of true mangrove, seagrass and coral reef (Table 4).

Table 4

Physico chemical results in Kawas marine sanctuary

Parameters	*Kawas*	*DENR (1990) standards (Class SA)*
pH	7.53	6.5-8.5
Temperature (^{o}C)	28.04	Max rise of 3^{o}C
Salinity (ppt)	29.2	Not stated
Depth (ft)	0-45	Not stated
Visibility (m)	2	Not stated
TSS (mg L^{-1})	0.50	3

Mangrove forest was present in the study area with a total of seven (7) species identified such as *Avicennia lanata, Avicennia marina, Aegiceras floridum, Ceriops tagal, Rhizophora apiculata,* and *Sonneratia alba.* It has a total mangrove forest of 6.312 hectares. The extent of mangrove vegetation is about 20 meters going seaward zone grows well in a coralline sandy muddy substrate. The Mangal community is in close canopy with some of wildlings grows extensively on the ground. Kawas Marine Sanctuary obtained the diversity index of 0.561 highest among other MPA's in SBPS with *Avicennia lanata* as the most abundant with 0.159 diversity index (Table 5).

Table 5

Diversity indices of mangroves at Kawas marine sanctuary

Mangrove species	*Diversity index (p_i (log p_i))*
Avicennia lanata (Bungalon)	0.159
Avicennia marina (Bungalon, Piapi)	0.143
Aegiceras floridum (Tinduk-tindukan)	0.021
Ceriops tagal (Tangal, Tungog)	0.023
Rhizophora apiculata (Bakuan lalake)	0.158
Sonneratia alba (Pagatpat)	0.057
Total	0.561

The seagrass meadow occurs in a sandy muddy substrate and interspersed to the coral reef substrate. Its distribution ranges from patches to extensive cover of a mixture of seagrass species. Health and distribution of seagrass species is also affected by continuous sedimentation prompting burial and erosion (Cabaco et al 2008). Six seagrass species were identified in the area, namely: *Syringodium isoetifolium, Halophila ovalis, Halodule pinifolia, Cymodocea rotundata, Thalassia hemprichii* and *Enhalus acoroides*

(Table 6). *H. pinifolia* is abundantly distributed in a sandy substrate observed after the mangrove zonation while other species like *C. rotundata, H. ovalis, S. isoetifolium* and *T. hemprichii* grow in the middle portion of seagrass zonation and the *E. acoroides* was observed in a coralline substrate. Halophila species was also observed in greater depths compared to other seagrass species. *Halophila* spp. have the greatest depth limits and lowest light requirement among seagrass species (Lee et al 2007). Diversity index (H') for seagrass in the area is 0.639 (Table 6). Based on the criteria on seagrass cover provided by English et al (1994), Kawas Marine Sanctuary was in fair condition.

Table 6

Diversity indices of seagrass found at Kawas marine sanctuary

Seagrass species	*Diversity index (p_i (log p_i))*
Cymodocea rotundata	0.122
Enhalus acoroides	0.159
Halophila ovalis	0.083
Halodule pinifolia	0.155
Syringodium isoetifolium	0.043
Thalassia hemprichii	0.077
Total	0.639

In terms of reef fishes species composition, Kawas Marine Sanctuary recorded nine families and 25 species (Table 7). Pomacentridae is the largest family in terms of number of individuals. The average fish biomass is 26,973 grams per 500 m^2 with a class size ranges from 1-10 and 10-20 cm. The large value of reef fish biomass is attributed with the excellent coral cover although the area is still disturbed as indicated with smaller sizes of reef fish species recorded.

Table 7

Species Composition and Class Sizes of Reef Fishes in Kawas Marine Sanctuary

Family name	*Species*	*Number of individuals*	
		1-10 cm	*11-20 cm*
Aulostomidae	*Aulostomus chinensis*		1
Acanthuridae	*Acanthurus thompsoni*	55	15
	Ctenochaetus strigosus		2
Apogonidae	*Ostorhinchus aureus*	4	
	Ostorhinchus cyanosoma	7	
	Ostorhinchus nigrofasciatus	3	
Chaetodontidae	*Chaetodon* sp.	3	
	Forcipiger longirostris	1	
Holocentridae	*Myripristis vittata*	3	
Labridae	*Halichoeres* sp.		2
	Thalassoma lunare	1	
Mullidae	*Mulloidichthys* sp.		3
Nemipteridae	*Scolopsis bilineata*		3
Pomacentridae	*Amblyglyphidodon* sp.	15	
	Amphiprion clarkii	3	1
	Amphiprion perideraion	1	
	Abudefduf sexfasciatus	12	5
	Adudefduf vaigiensis	50	
	Chromis margaritifer	50	
	Chromis viridis	135	
	Dascyllus trimaculatus	80	8
	Amblyglyphidodon leucogaster	240	
	Neoglyphidodon melas	15	
	Pomacentrus brachialis	52	
	Pomacentrus philippinus	8	13

The fringing reef of Kawas Marine Sanctuary exhibited fair to excellent coral cover as depicted in Figure 2. Transect 1 and transect 3 located outside the sanctuary area have fair condition wherein it is considered as recreational and buffer area constantly disturbed with human activities. However, inside the marine sanctuary, it has an excellent coral cover with Live Hard Coral (LHC) of 53%. Live hard coral is composed of *Acropora, Astreopora, Pocillopora, Symphyllia, Lobophyllia, Acanthastrea, Turbinaria, Pectinia, Oulophyllia, Montastrea, Echinopora, Euphyllia, Plerogyra, Goniopora* and *Porites* coral genera. Coral growth formation varies from table *Acropora*, foliose, encrusting, branching, massive and submassive formation. Most of the massive formation was located near the reef edge strong enough to stand up with the strong waves and currents. Among the culprit of the declining Coral cover is the sewage waste from fish cages bringing inorganic nutrients, endocrine disrupters, suspended solids, and sediments that can severely impair coral growth and/or reproduction (Wear & Thurber 2015).

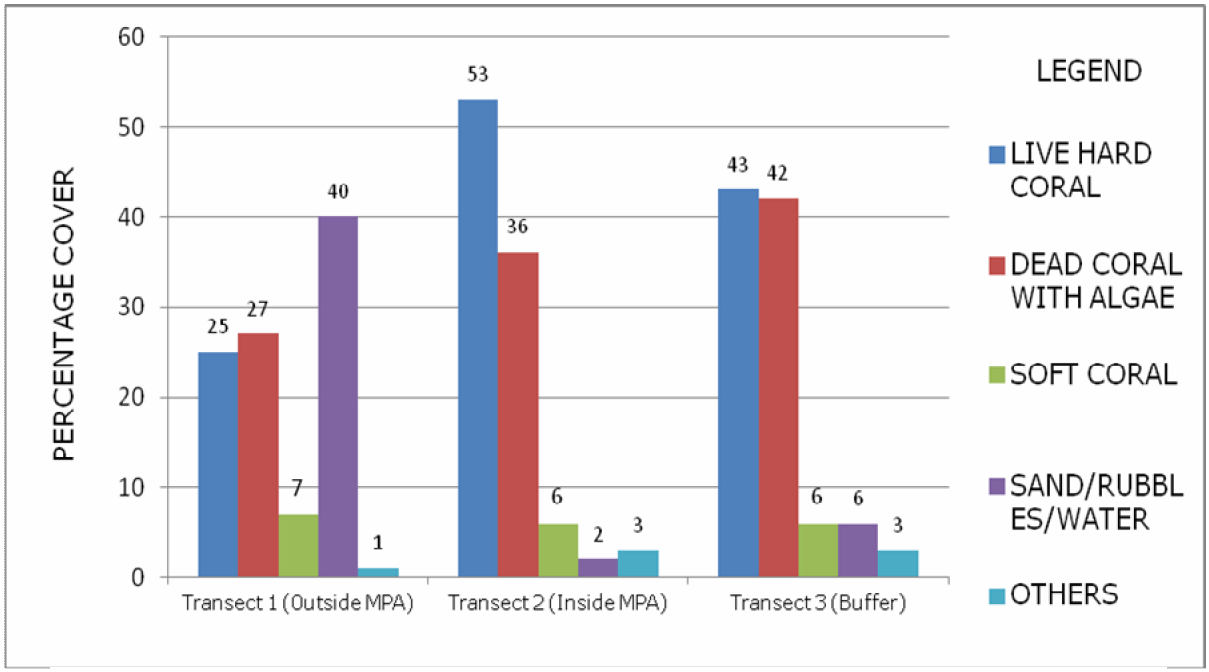

Figure 2. Coral lifeforms found on each of the three transects established at Kawas Marine Sanctuary, Philippines.

Conclusions. Based on the Data gathered, Kawas Marine Sanctuary exhibited Good Condition for Mangrove Forest dominated by *Avicennia lanata* with diversity index at 0.561 highest among the Marine Sanctuaries in SBPS. Seagrass beds on the other hand is Fair condition with *H. pinifolia* as the most abundant covering the sandy-muddy substrate of the seagrass zonation. Diversity index of seagrass in the sanctuary is at 0.639. Coral Reef resources is at Fair to Good condition with Transect 2 (Inside MPA) at 53 percent live hard coral cover. Fishery resources has nine families with 26 species recorded. Highest among these fish families is Pomacentridae dominating the total area biomass of 26,973 grams per 500 m^2. The physico-chemical parameters which includes pH of 7.53, temperature of 28.04^O Celsius, salinity of 29.2 ppt, depth at 0-45 feet, visibility of 2 meters and TSS of 0.50 mg L^{-1} are within the range to provide optimum growth and survival for the resources.

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