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Mangrove Forest and Seagrass Bed of Eastern Samar, Philippines: Extent of Damage by Typhoon Yolanda

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Abstract: **Three months after typhoon Yolanda hit the Philippines, the mangrove forest and seagrass bed in Eastern Samar, Philippines was assessed to determine the extent of damage by comparing the status of mangrove and seagrass in the same area in 2009. A 10 m X 10 m plot was used for mangrove assessment and 0.50 x 0.50 m quadrat for seagrass assessment. The extent of mangrove damage in terms of tree density and basal area were 86 percent and 68 percent, respectively; while the saplings and seedlings density were 79 and 93 percent, respectively. *Sonneratia* is the only species with high percentage of survival. Typhoon Yolanda did not negatively affect the condition of the seagrass, instead it contributed to the increase of density of *E. acoroides* by 40 percent and *C. rotundata* by 18 percent but it decreased the density of *T. hemprichii* by 29 percent. Damaged mangrove areas should be replanted with *Sonneratia* and *Avicennia* species, which are found to be storm surge resilient, especially in the seaward zone. However other species previously present in the area should also be planted to maintain biodiversity.**

Keywords: **Mangrove forest, Seagrass bed, Storm surge, Typhoon Yolanda, Sonneratia , Avicennia.**

1. INTRODUCTION

Seagrass beds and mangrove forest are the two most important coastal ecosystems that promote organic matter flow, production of food and refuge of fishes and invertebrates aside from its role in shoreline stabilization and protection. However these two ecosystems are occasionally battered by strong water current and waves brought by typhoon, tsunami and monsoon winds.

The effects of strong typhoons (hurricane) to these ecosystems have been studied and reports show that the extent of damage to mangrove is enormous compared to that of seagrass beds. Studies have been done folowing hurricane Katrina (Anton et al, 2009), hurricane Mitch (Michot et al, 2011), hurricane Paloma (Guimarais et al, 2013) and hurricane Ivan (Heck &Byron, 2005). In China, no major damage on seagrass bed has been reported. Of more than 50% typhoons landing in the south coast of China, the seagrass leaf length, stem biomass and above ground biomass on average showed no evidence of reduction after typhoon Tianying and Dawei (Yang & Huang, 2011).

In Eastern Samar, Philippines, one of the badly hit coastal area by Typhoon Yolanda is the town of Balangkayan, which was assessed three years before the typhoon. Three months after the typhoon visual observation on the mangrove forest in areas directly hit by typhoon Yolanda showed massive destruction as indicated by dead trees with broken trunks and stems, but no uprooted mangrove stand was observed, an indication that the trees resisted the strong surge. This showed that the function of mangrove in shoreline protection did not work since the mangrove forest itself was totally devastated. The expected surge reduction is negligible since according to McIvor et al (2012) storm surge reduction by mangroves range from 5 to 50 centimeters water level reduction per kilometer of mangrove width and surface wind waves are expected to be reduced by more than 75% over one kilometer of mangroves. The extent of mangrove in Balangkayan, Eastern Samar from the landward to seaward zone is less than one kilometer, hence it did not reduce the strength of the storm surge.

The coastal area in Balangkayan was selected as the study area since this is one of the badly hit municipalities with available data that could be used as basis in determining the extent of damage. Ocular survey on the mangrove damage in other areas facing the Pacific Ocean appeared to have the same extent of damage as the research site. The coastal resources included in this research were the mangrove forest and seagrass bed since these are the resources that were directly exposed to the strong water current brought by the storm surge.

There were several studies conducted in Eastern Samar after typhoon Yolanda. The research arm of the Philippine Department of Environment and Natural Resources (DENR) reported that the damage left by Super Typhoon Yolanda (Haiyan) to mangrove beach forests in Eastern Visayas was two to three times bigger than initial estimates. According to the Ecosystems Research and Development Bureau (ERDB), mangroves in a 206-hectare plantation in the villages of Campoyong and Bungtod in Guiuan, Eastern Samar, failed to grow back its leaves six months after the typhoon struck in November 2013, an indication that the trees had died even if their roots were still attached to the ground. Such was also the case at mangrove sites in three other towns of Eastern Samar, namely, Lawaan-Balangiga (150 ha), Giporlos (400 ha) and Quinapondan (940 ha). (www.asianewsnet.netcom). In the study of mangrove resilience in Gen Mcarthur and Quinapondan in Eastern Samar by Carlos et al. (2014) the density, tree height and circumference at breast height were monitored and analyzed for allometry. Based on the field data, the monitored *Rhizophora* (n=135), *Sonneratia* (n=47) and *Avicennia* (n=177) were aggregated to assess the vegetation resistance coefficient (VR) per genus through numerical equations. Results showed that Sonneratia species yielded the highest VR at 344, indicating higher resilience to wave action while Rhizophora had the lowest VR at 68. The sequences of VR from highest to lowest were as follows: *Sonneratia sp*., *Avicennia sp* and *Rhizophora sp*.

To give an idea of the extent of damage to mangrove forest and seagrass bed, quantitative information is needed as an input to the coastal resources rehabilitation initiatives of the Government.

2. OBJECTIVES

The research intended to determine the extent of damage by typhoon Yolanda to the mangrove forest and seagrass bed in Balangkayan. Specifically, it aimed to:

1. Compare the status of seagrass bed before and after typhoon Yolanda in terms of:

a. Shoot density per square meter

b. Vertical growth rate

c. Average growth rate

d. Plastochron interval

2. Determine the percentage of damage of the mangrove forest by typhoon Yolanda in terms of:

a. Tree density and basal area per hectare

b. Saplings and seedlings density per hectare

3. Identify mangrove species that survived and regenerated three months after typhoon Yolanda.

3. METHODOLOGY

Location of the Study:

The research site is located in the southern part of Eastern Samar facing the Pacific Ocean. The adjacent town of balangkayan was totally submerged by the storm surge of typhoon Yolanda. The coastal area is lined with mangrove forest, seagrass bed in the reef flat and a coral in the reef slope.

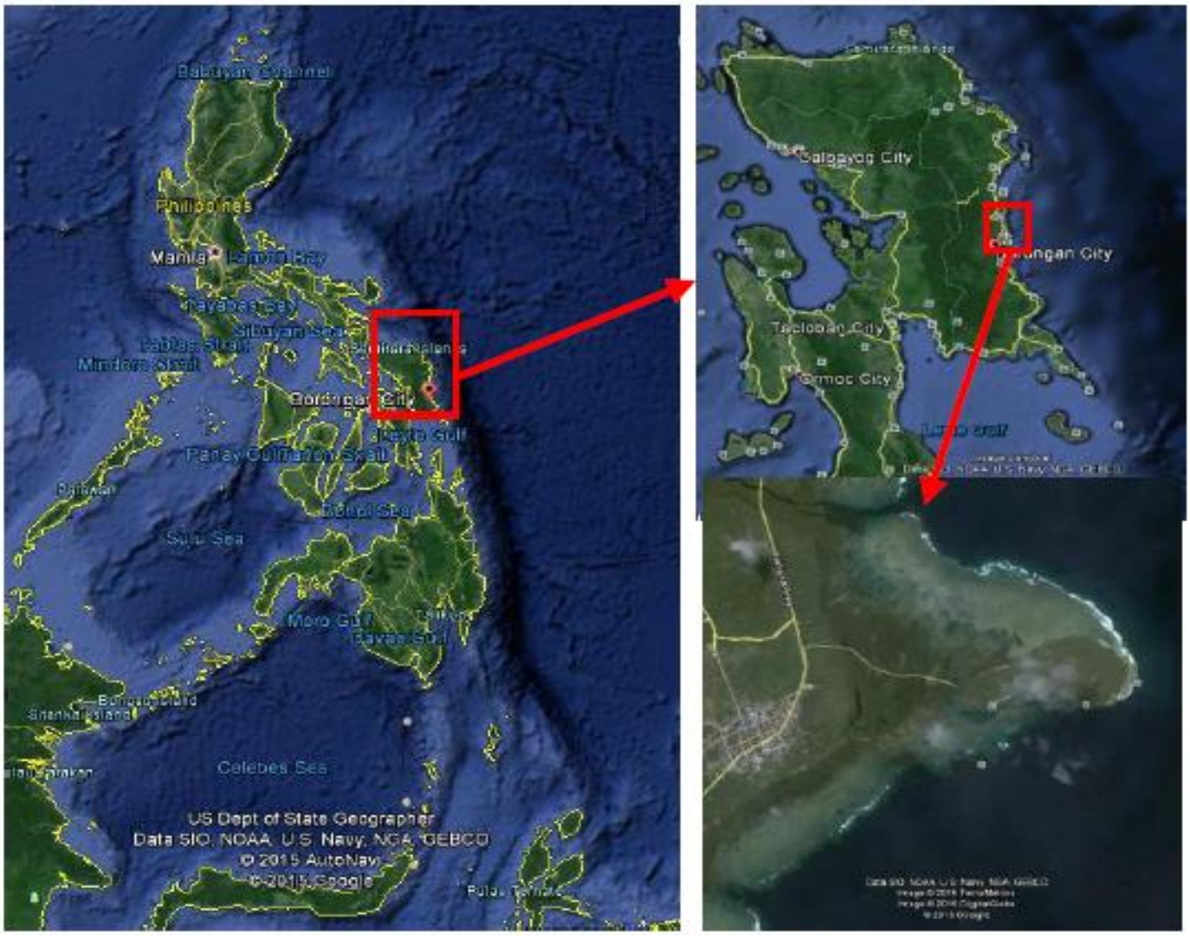

Figure 1. The location of the study site in Eastern Samar, Philippines (Source: Google earth)

Seagrass shoot density:

A transect line quadrat method was used to determine the seagrass density. A transect line was laid perpendicular to the shore from the landward to seaward boundaries at 100 meters apart between sampling stations. Samples were taken at 5 meters interval along the transect line using a 0.50 x 0.50 meter quadrat. For smaller species such as *Thalassia* and *Cymodocea*, the number of shoots inside the 5 diagonal squares were counted as sub sample. For *Enhalus acorioides*, the total number of shoots inside the quadrat were counted.

Production rate of dominant seagrass:

Two dominant seagrass species (*Enhalus acoroides* and *Thalassia hemprichii*) were monitored for the production rate and biomass studies. The growth of the two species were measured by marking the end part of the leaf sheath with 3 punches of needle and clipping with twist tie. After 7 days the 100 shoots were harvested by cutting with a piece of scissor just below the twist tie clip. Based on the data taken from the harvested seagrass, the vertical growth rate (VGR) average growth rate (AVR) and plastochron interval (P.I.) were computed using the formula below.

$$P.I. = \frac{\Sigma \text{ length from base to pricked mark}}{\text{Number of days}}$$

$$VGR = \frac{\Sigma \text{ length from base to pricked mark } X \text{ width}}{\text{Number of days}}$$

$$AGR = \frac{\text{Total no. of shoots marked X 7 days}}{\text{Total no. of new leaves}}$$

Mangrove Structure:

A 10 x 10-meter plot was used in this study. These were laid at 100-meter intervals from the reef flat zone to the last mangrove stand in the landward zone. A 5 x 5-meter plot was laid inside the main plot for saplings and seedlings study. The live mangrove with indication of regeneration were measured for its diameter at breast height (DBH). Live sapling and seedlings inside the 5 X 5 meters were counted. A transect walk was undertaken to identify mangrove species with indications of regeneration or with new leaves that emerged from the trunk.

4. RESULTS AND DISCUSSION

General Observation:

The mangrove forest was heavily devastated by strong water turbulence brought about by the storm surge of typhoon Yolanda. The mangroves behind the Minasangay Islet was not severely damaged compared to those directly exposed to the open sea. Inspite of the strong wind and water current during the typhoon, the mangrove trees were not uprooted but the branches were cut and removed. Based on the ocular survey, the *Rhizophora*, *Aegiceras* and *Lumnitzera* species that were directly exposed to storm surge were dead. However, the *Sonneratia* species showed indication of regeneration due to the presence of new branches that emerged from the trunk even if the trunk left is less than one (1) meter from the base. The *Avicennia* species which are only found near the reef flat, showed indication of regeneration. The seagrass bed showed no destruction caused by the storm surge. The leaves were intacked with no sign of substrate disturbance.

Seagrass density and growth:

There were three (3) seagrass species found in the sampling sites in the seagrass bed. In terms of density, *Thallasia hemprechii* was the dominant seagrass but the density decreased from 585.67 in 2009 to 414.68 shoots per sq. meter after typhoon Yolanda. Other seagrass species increased in density from 4.64 to 16.32 shoots per sq. meter for *Enhalus acoroides* and from 2.79 to 18.16 shoots per sq. meter for *Cymodoceae rotundata*, respectively. This showed that typhoon Yolanda did not affect the seagrass bed and contributed to the increase of density of *E. acoroides* by 40 percent and *C. rotundata* by 18 percent but it decreased the density of *T. hemprichii* by 29 percent. It was noted that many *T. hemprichii* shoots were bearing flowers which was probably the seagrass response to stress caused by the storm surge. According to Menez (1997), stress cause flowering response of seagrass. The nutrients needed by the seagrass in developing new shoots are used in the reproduction hence, the shoots density decreased after the storm. The increase of the density of other seagrass species can be attributed to less disturbance of the seagrass bed since there it was observed that there were no gleaners and there was less human activity in the seagrass bed since the associated edible invertebrates disappeared from the seagrass bed after the storm.

The findings of this study that the strongest typhoon did not significantly damage the seagrass beds in Eastern Samar parallels to the reports of Michot et al (2002) on the effect of Huricane Mitch which states that in Guanaja, the site showed an increase in growth of seagrass in the year immediately following Hurricane Mitch. From the general observations of Mitchot et al, they noted other evidence of changes that may be associated with Mitch, but most of the changes appeared to have been relatively small. The seagrass communities that were examined appeared healthy and to have received little significant alteration because of Mitch. In Hunduras, Cuba and Bahamas, the effect of Hurricane Paloma on November 10, 2008 to seagrass bed was insignificant as reported by Guimarais et al (2013) which states that Seagrass meadows were partly affected by sediment accumulation on the shoots of *T. testudinum* and uprooted rhizomes. The 7.6 km^2 disturbed area represented 1% of the total seagrass area. Other sites, closer to the centre of the hurricane, did not show any damages on the marine vegetation.

Table 1. Status of Seagrass in Balangkayan before and after Typhoon Yolanda

Species	Density/m^2		VGR (cm/day)		AGR(cm^2/day)		P.I.	
	Before	After	Before	After	Before	After	Before	After
Enhalus accoroides	4.64	16.32	0.42	0.69	0.51	0.77	34	41
Thallasia hemprechii	585.67	414.68	0.17	0.33	0.19	0.32	12	9
Cymodocea rotundata	2.79	18.16	-	-	-	-	-	-

Legend: VGR – Vertical Growth Rate

AGR – Average Growth Rate

P.I. - Plastochron Interval

The vertical growth rate of the two dominant seagrass (*E. accoriodes* & *T. hemprechii*) increased after the storm. Likewise, the average growth rate of both dominant seagrasses also increased which showed that the typhoon Yolanda did not negatively affect the growth of seagrass. Due to strong water current that hit the seagrass bed, the old shoots and leaves were removed which allowed new shoots to emerge which subsequently increased all growth parameters of seagrass. This observation conforms with the findings of Yang and Huang (2011) on the effect of typhoon to seagrass bed in Xincun Bay, Hainan Province, China which states that typhoons Tianying and Dawei damaged seagrass bed and removed aged and dead leaves, which consequently facilitated seagrass growth.

Mangrove extent of damage:

The extent of damage to the mangrove forest in Balangkayan in terms of tree density and basal area are 86 percent and 68 percent, respectively. *Aegiceras* was 100 percent damaged which means live species were intercepted in the plot. The second heavily damaged species is *Rhizophora* at 98 percent damage followed by *Lumnitzera* at 85 percent and the lowest was *Sonneratia* with 62 percent damage.

In terms of basal area, *Aegiceras* was 100 percent damaged followed by *Lumnitzera* with 96 percent, followed by *Rhizophora* with 53 percent and the lowest was *Sonneratia* with 24 percent. The data showed that *Sonneratia* species was the least affected mangrove by typhoon Yolanda in terms of tree density. Although the mangrove were exposed to the same water turbulence and wind intensity, it was noted that only the *Sonneratia* species developed new branches which was considered as live or not damaged mangrove. The live saplings and seedlings intercepted in the plots was only the *Rhizophora*.

Table 2. Extent of Damage (%) of mangrove in Balangkayan by Typhoon Yolanda

Species	Tree		Saplings	Seedlings
	Density	Basal Area		
Rhizophora	98	53	15	73
Lumnitzera	85	96	100	100
Aegiceras	100	100	100	100
Sonneratia	62	24	100	100
Mean	86	68	79	93

Storm Surge Resilient Mangrove Species:

The mangrove species that survived in the sampling site was the tall, less branched *Lumnitzera* located in the middle and landward zone of the mangrove forest. In the seaward zone, it was noted that the *Avicennia marina* survived. Throughout the mangrove forest, the *Sonneratia* was the species considered hardy and regenerated even if the trunk was cut one meter from the base. These species was considered as storm surge resilient due to its high percentage of survival. This finding coincided with the results of the study on comparison of resiliency and protective function of *Rhizophora*, *Sonneratia* and *Avicennia* species in Gen Mc Arthur & Quinapondan, Eastern Samar by Carlos et al. (2014) which states that the *Sonneratia* species yielded the highest vegetation resistance (VR) at 344, indicating higher resilience to wave action while *Rhizophora* had the lowest VR at 68. The lowest percentage of damage of *Sonneratia* (62 percent) in Balangkayan mangrove forest showed that this species is considered as the most storm surge resilient among mangrove species.

5. CONCLUSION

Based on the findings of the study, it was concluded that the seagrass bed was not negatively affected by typhoon Yolanda. The mangrove damage was 86 percent in terms of tree density, 68 percent in damage of basal area, 79 percent sapling damaged and 93 percent seedling damaged. The mangrove species with highest percentage of survival was the *Sonneratia sp.*

6. RECOMMENDATION

It is recommended that *Sonneratia* species be used in mangrove reforestation in all mangrove zone, *Avicennia* in the front reef zone and *Lumnitzera* and other mangrove species in the middle and landward zone. However planting other mangrove vegetation naturally present in the area should be considered to maintain biodiversity of the mangrove forest. A research in the nursery propagation of *Sonneratia* and *Avicennia* should be conducted.

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