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The benefit of one cannot replace the other: seagrass and mangrove ecosystems at Santa Fe, Bantayan Island

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Abstract

Background: In the Philippines, the practice of planting mangroves over seagrass has been a practice done to promote coastline protection from damages done by storms. Despite the added protection to the coastline, the addition of an artificial ecosystem gradually inflicts damage to the ecosystem already established. In this study, seagrass communities that had no history of mangrove planting were compared with those that had mangrove planting. The percent substrate cover of seagrass in the sampling areas was determined, and the macroinvertebrates present in the sampling areas were also observed. The study was conducted based on reports of mangrove planting activity that disrupted seagrass functions on Santa Fe, Bantayan Island, Cebu. Transect-quadrat method sampling was done to assess the chosen sites.

Results: Six species of seagrass was found on the site without mangrove planting which was barangay Ocoy (*Cymodocea sp.*, *Thalassia sp.*, *Halodule sp.*, *Enhalus sp.*, *Halophila sp.*, and *Syringodium sp.*) and had a higher percent cover, while only four were found on the site with mangrove planting (barangay Marikaban). It was also found that barangay Marikaban had a lesser Shannon-Wiener and Simpson's index compared to barangay Ocoy. Jaccard's index of similarity between the two sites was low.

Conclusion: With the results of the assessment, we recommend proper monitoring of future mangrove planting activities and that these activities should not disrupt another ecosystem as all ecosystems are important.

Keywords: Seagrass, Mangrove planting, Diversity index

Background

Coastal seas, a part of the ever abundant marine ecosystem, have been utilized by humans as a source of livelihood such as transportation and fishery. Human activity has contributed to the deterioration of quality in seas all over the world (Park et al. 2015). A big part of the marine ecosystem that is found in coastal areas is the seagrass beds.

Seagrass beds have a role in maintaining the population of fish and invertebrate species that are of economic significance by providing a permanent habitat in some fish or a temporary nursery for the development of juveniles in other fish. The beds indirectly maintain fisheries by supplying organic matter that is incorporated into the coastal nutrient cycles which supports secondary production (Jackson et al. 2001). Another component of coastal ecosystems is the mangroves. Mangroves act as the buffer between land and sea, and they are not only utilized as breeding grounds and habitats for marine life but they are also used as source of provisions such as firewood, timber, and charcoal (Brander et al. 2012). In the Philippines, many seagrass beds are being planted with mangroves to protect coastlines from the tropical storms and other water-related calamities. According to reports by Cebu Chamber of Commerce and Industry-Bantayan Island Chapter (CCCI-BC) of the Department of Environment and Natural Resources (DENR), the implementation of seagrass rehabilitation in Bantayan Island, Cebu, is a must, due to the obstruction done by mangrove planting on the seagrass beds which affected the livelihood of fishermen who rely on shells

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and fish that live in the seagrass beds (Mangubat 2012). The country has the tendency to plant mono-specific *Rhizophora* mangrove forests in areas that are not the natural habitat of the species. This practice leads to stunted growth and high mortality of the planted mangrove seedlings (Samson and Rollon 2008).

Some barangays in Santa Fe, Bantayan Island, depict these practices of planting mangrove propagules on seagrass beds. A "barangay" by definition is the smallest territorial and political subunit in the Philippine government which consists of 50 to 100 families headed by the barangay captain. Before mangrove planting activities occurred, Barangay Marikaban of Santa Fe, Bantayan Island, naturally had a scanty number of mangrove species growing in their beaches as reported by the locals during site visit. In the year 2013, Typhoon Haiyan devastated Bantayan Island, and strong storm surges destroyed the mangroves. Due to this, mangrove planting activities on the island were initiated. In the process, members of the Sea Fisherman's Association in Barangay Marikaban planted *Rhizophora* species on seagrass beds. However, not all barangays participated in this practice. One of these is Barangay Ocoy which is situated near the port of the same island. There was no activity of mangrove planting in the area as observed.

This study aims to compare seagrass communities that had no history of mangrove planting with those that had mangrove planting with the following specific objectives: to determine the percent cover of seagrass in the sampling areas and to observe the macroinvertebrates present in the sampling areas. We limit our study to percent cover since we only sought to assess if there is a difference with those seagrass beds that had reports (Mangubat 2012) of mangrove planting and those without. This study will enlighten readers of the importance in conserving the natural seagrass ecosystem despite the notion that mangrove ecosystems are more beneficial.

Materials and methods

The site chosen for this study was Santa Fe, Bantayan Island of Northern Cebu. The island is known to have abundant seagrass beds as mentioned by the Bureau of Fisheries and Aquatic Resources Region-VII (2009). Since there has already been reports (Mangubat 2012) of a community planting mangrove on the seagrass bed in some areas, this place was chosen. Biodiversity indices and physico-chemical parameters were measured for comparison.

Study site

The study was conducted in two barangays of Santa Fe in Bantayan Island. Site selection was based on mangrove planting activity in the area as learned from reports (Mangubat 2012; Codilla 2015a, b; Quintas 2015). Barangay Ocoy had no reports of mangrove planting in the area while barangay Marikaban had reports of mangrove planting. Figure 1 is a map showing the different sampling areas while Fig. 2 shows photographs taken in areas with mangrove and without mangrove.

Seagrass assessment

Transect-quadrat method was utilized for sampling. Two 100-m transects per barangay were positioned from where the seagrass patches started, going seaward, and were 100 m apart. A 0.5 × 0.5-m quadrat was established every 10 m of each transect line (10 quadrats). These two transects were established on both barangays. Species identification of seagrass was done with the aid of field guides (McKenzie et al, 2003). Identification was only up to genus level. Percent seagrass cover on the substrate and macroinvertebrates that were inside the quadrats were taken into account. Investigation of both seagrass and macroinvertebrates was done on foot since the sampling was done during low tide.

Physico-chemical parameters

Physico-chemical parameters such as dissolved oxygen (DO), temperature, pH, relative humidity (RH), and salinity were assessed at each quadrat (3 trials). Different probes were used in the collection of physico-chemical data. The values for dissolved oxygen (DO) were acquired with the use of DO meter-thermo scientific model (Thermo Orion star A123) by dipping the tip of the probe 3 in. below the surface of the water. A Psychrometer-Bacharach model (12-7043 RED SPIRIT °C) was then used in the gathering of data for relative humidity by comparing the temperature from the dry bulb and the wet bulb to the given scale on the meter after it was spun for 5 min while exposed to the atmosphere. The pH values were then acquired with the use of pH meter-thermo scientific model (Thermo Orion Star A121) by dipping the tip of the probe 3 in. below the surface of the water. A standard glass thermometer was also used to acquire data for the water temperature and air temperature by touching the tip of the glass thermometer on the surface of the water and by exposing the thermometer to the atmosphere respectively. Lastly, an ATAGO model (ATAGO S/Mill-E) was used for the collect of data for salinity by placing a drop of saltwater on the sample plate.

Data analysis

Measures of biodiversity for the macroinvertebrates, species richness, dominance, Simpson's index, Shannon-Wiener, and evenness were calculated. Jaccard's similarity index based on the absence and presence of macroinvertebrates

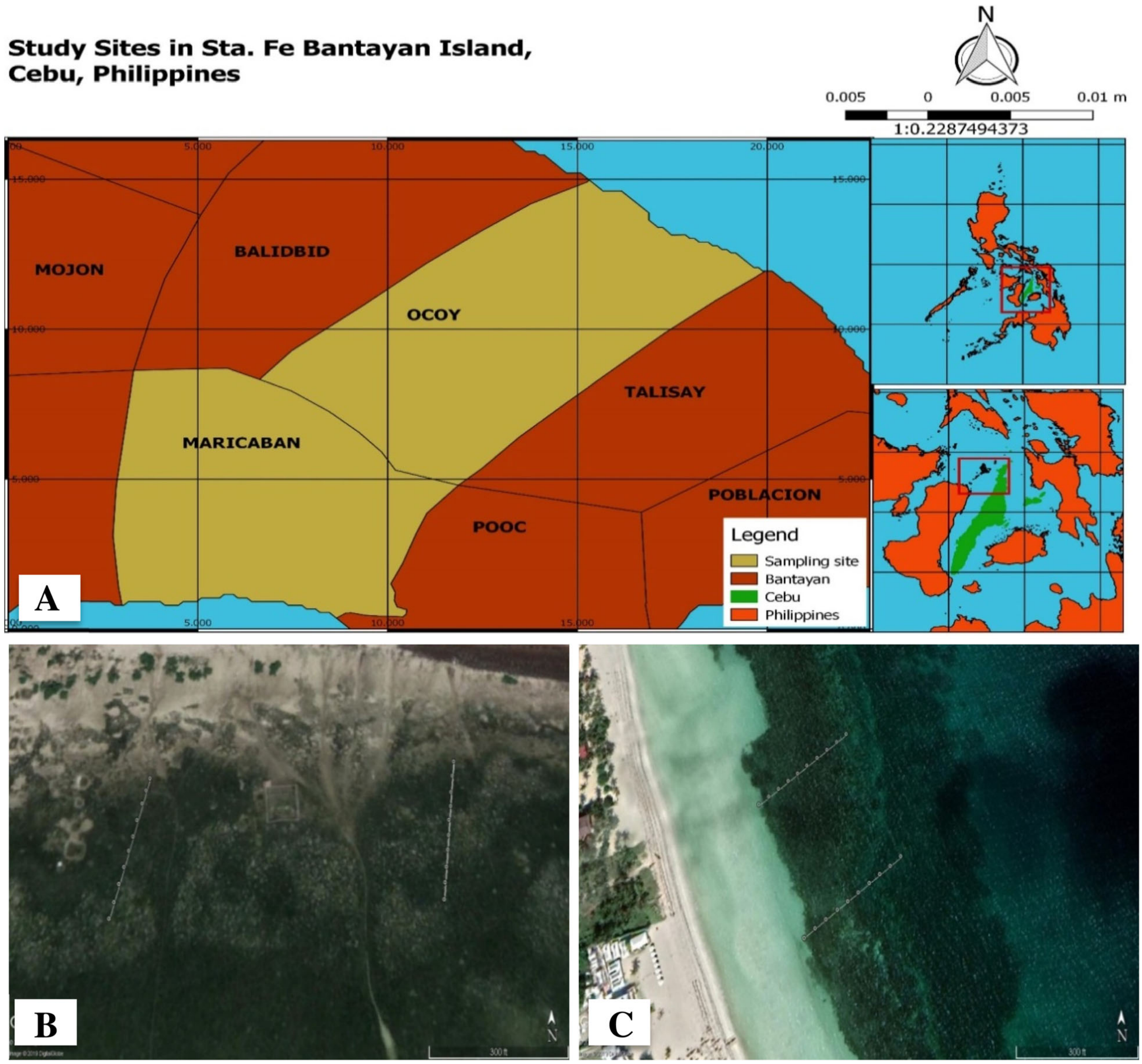

Fig. 1 Map of the two study sites in Bantayan, Cebu (**a**) which shows the two transect lines with their corresponding points for each quadrat established in areas with mangrove (**b**) and without mangrove (**c**)

and seagrass species was used to determine similarity of seagrass communities between barangays Ocoy and Marikaban. Macroinvertebrates were considered as they are bioindicators (Roozbahani et al. 2010). All calculations were done by using Paleontological Statistic Software (PAST) version 3.20. The software was used to determine measures of macroinvertebrate diversity, as these animals are associated with seagrass ecosystems and some are sources of livelihood for locals (gleaning). Statistical analysis was done using Microsoft Excel 2010. An unpaired *t* test was conducted to determine significant differences of physico-chemical parameters, biodiversity measures, and seagrass substrate cover between the two sites.

Results

Seagrass composition and substrate cover

We went to these barangays, conducted assessments, and interacted with the locals. Table 1 displays the seagrass species that were present in the barangays. Barangay Ocoy had six species of seagrass while Barangay Marikaban had four. This is consistent with the Participatory Coastal Resource Assessment (PCRA) of Santa Fe, Cebu, report done by BFAR[7]. Their assessment was conducted in the year 2009. In their report, Barangay Marikaban also only has four species as it lacked *Halophila sp.* and *Syringodium sp.* while Ocoy had all six. As the study was conducted, it was observed that the

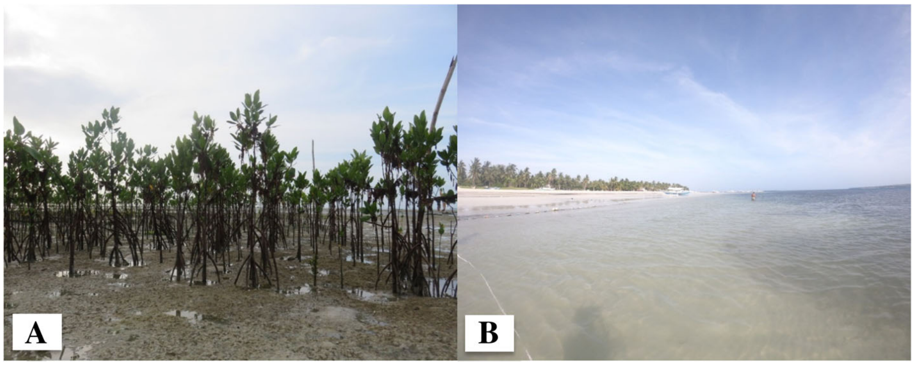

Fig. 2 Mangrove planting on seagrass beds (**a**) and site with no mangroves on seagrass beds (**b**)

seagrass composition in the quadrats that were nearing the mangrove seedlings was lesser. Species of *Cymodocea* were the ones that could grow with mangroves. Mean percent substrate cover of the seagrasses in both areas is presented in Fig. 3.

The mean percent substrate cover of the seagrasses in Barangay Marikaban was a bit lower (48.67%) compared to Barangay Ocoy that had a mean percent substrate cover of 50.78%. The lower seagrass cover experienced in Marikaban was most likely attributed to the mangrove seedlings that were planted over them. It was observed that the mangrove seedlings and seagrasses were competing for space in the area. The seagrasses were also patchier in their beach. The seagrass cover of Barangay Ocoy was higher, but their difference was not statistically significant ($p = 0.84$). This could be because some quadrats were already gradating towards the coral ecosystem. These quadrats were ecotones between the natural seagrass and coral ecosystems, so a mix of their growth was observed.

Macroinvertebrate diversity

Table 2 presents the measures of biodiversity that were generated for macroinvertebrates.

Table 1 Distribution of seagrass species in the study areas planted with mangroves (Barangay Marikaban) and without mangrove plantation (Barangay Ocoy)

Species	With mangrove	Without mangrove
Cymodocea sp.	+	+
Thalassia sp.	+	+
Halodule sp.	+	+
Enhalus sp.	+	+
Halophila sp.	−	+
Syringodium sp.	−	+
Total number of species	4	6

"+" indicates present and "−" indicates absent

As presented, the diversity of macroinvertebrate fauna associated in the seagrasses of Barangay Marikaban was a bit lower compared to that in Ocoy. The difference between the scores in the biodiversity indices of the two areas was however not statistically significant. Marikaban had higher species richness but lower scores in diversity indices (H and D_s) because there were species that dominated the community. This is also evident by the dominance index (D) of Marikaban being higher than in Ocoy. It was observed that hermit crabs were most abundant in Marikaban. Jaccard's coefficient of similarity (S_J) was calculated to see how similar the macroinvertebrate species of the two areas was. The S_J was about 0.14; this means that their similarity was very low.

Physico-chemical parameters

The different physico-chemical parameters of the seagrass ecosystems in the two barangays were measured to see if the presence of mangroves altered these environmental parameters. The measuring of these parameters was however done only during the seagrass assessment dates, so results would not be entirely conclusive. These results would provide a snapshot of the environmental conditions of the area. Figure 4 presents the different physico-chemical parameters that were measured in the two areas.

All the physico-chemical parameters measured between the two sites were different. Their difference was statistically significant (Fig. 4). The relative humidity in Barangay Marikaban was higher because it was raining during the time of assessment. This also explains why the salinity of Marikaban was lower. The waters of Marikaban, however, were warmer than that of Ocoy despite the rain. The pH of the two areas were both alkaline. Waters around the seagrass of Ocoy was more basic. The dissolved oxygen of Marikaban was higher than that of Ocoy. Years of monthly monitoring to see the effect of mangrove planting on the environmental parameters of the

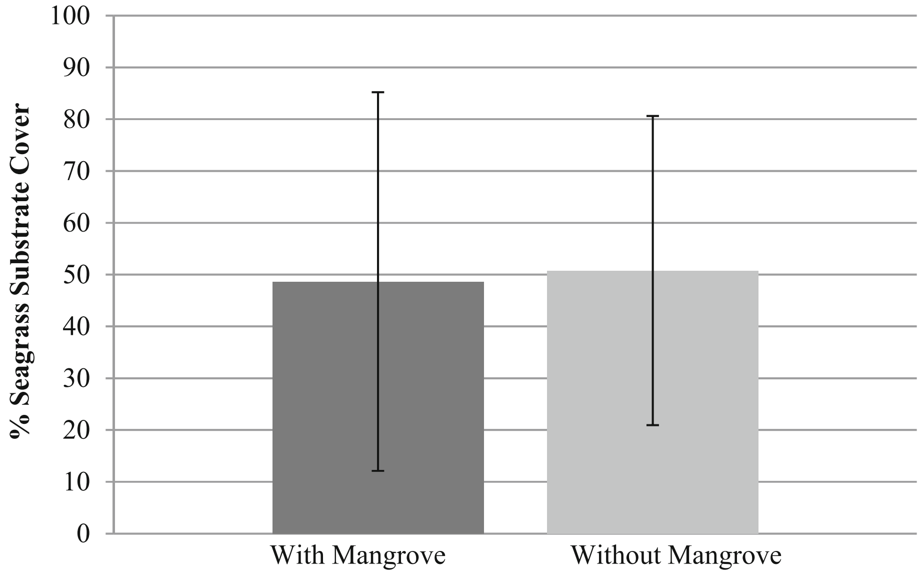

Fig. 3 Variation in mean percent seagrass substrate cover at sites planted with mangroves (Barangay Marikaban) and without mangrove plantation (Barangay Ocoy) having $p = 0.84256$

seagrass ecosystem is recommended for better and conclusive insights.

Discussion

In the Philippines, mangrove planting has become an activity that the government encourages. The country has had a problem of mangrove forests being turned into aquaculture ponds, but since the 1930s and to the present, this problem has slowly been addressed through mangrove planting initiatives. The importance of mangrove forests with the ecosystem services they provide has become known and appreciated. Various assistance funds from local and international agencies as much as 100 to 500 USD per hectare have already been allotted for mangrove planting (Primavera and Esteban 2008).

Bantayan Island is an island in the province of Cebu that is famous for its white sand, but they are also known for their scallops and the production of a dried fish which the locals call “danggit.” This dried “danggit” (*Siganus fuscescens*) is a delicacy that the area is known for, and this contributes a lot to their economy. The fish is known to inhabit seagrass beds. The beaches of Bantayan have abundant seagrass meadows which explain the abundance of this fish and shells like scallops. Only a few areas in the island are known to have mangrove forests.

In October 2015, various newspaper reports of locals (Mangubat 2012; Codilla 2015a, b; Quintas 2015) from the island complaining about how some fishermen in the island have been planting propagules of *Rhizophora sp.* mangroves on seagrass beds. It has been reported that around 12 ha of these mangroves have been planted on the seagrass beds of the island as of 2015. The planting began in June 2015 when the national government allotted 1 billion Philippine peso (18 million USD) for mangrove reforestation after the typhoon Haiyan hit the country. The storm surges during the typhoon destroyed mangrove forests and devastated coastal communities like Bantayan Island which is found in the northern part of Cebu. About 89 million Philippine peso (1.7 million USD) was for the planting of mangroves in these northern areas of Cebu.

Table 2 Measures of biodiversity for macroinvertebrates found in the study site

Measures of macroinvertebrate biodiversity	With mangrove	Without mangrove
Species richness	9	7
Dominance (*D*)	0.290	0.184
Simpson’s index (D_s)	0.710	0.816
Shannon-Wiener index of diversity (*H*)	1.566	1.810
Evenness index	0.532	0.873
Jaccard coefficient (S_J)	0.143	

Shannon-Wiener index $p = 0.2770$; Simpson’s index $p = 0.1399$

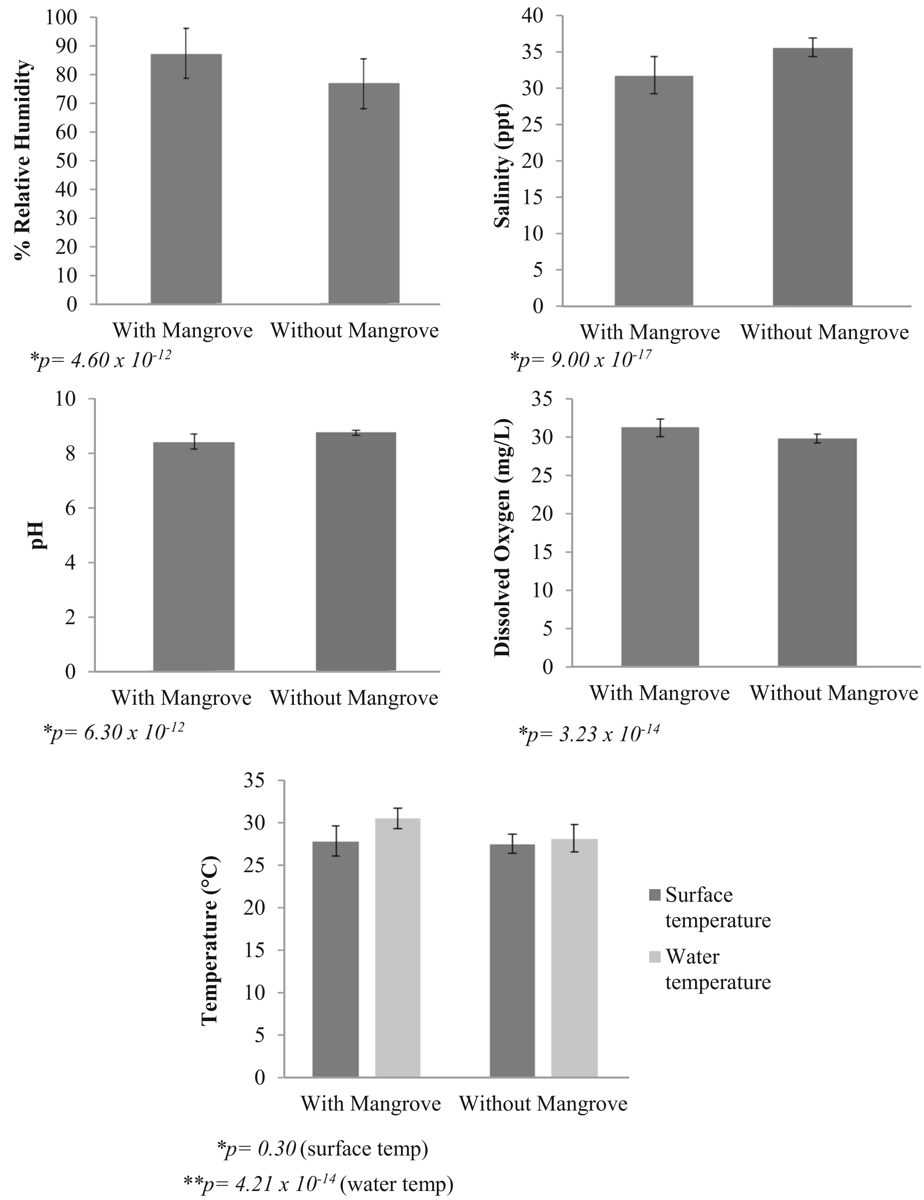

Fig. 4 The various physico-chemical parameters gathered from the study site

The local complaints mainly came from people who had businesses related to shellfish gleaning and "danggit." They complained that the planting of the mangroves has decreased their catch of "danggit" and they were afraid that further alteration of the seagrass beds would affect their economy as well as environment. It turns out that for every propagule planted, each fisherman is given 2 Philippines peso (0.04 USD) and that the money might be one of the reasons why these fishermen have been planting mangrove propagules on the seagrass beds (Mangubat 2012; Codilla 2015a, b; Quintas 2015). As of October 2015, it has been reported that the government has been sending out initiatives to properly monitor the mangrove planting done by the fishermen.

It has been observed in the Philippines that there is a prevalent tendency for atypical habitat of mangroves, such as seagrass beds, to be the chosen location for mangrove plantation (Samson and Rollon 2008). This practice often uses exclusively the genus *Rhizophora* which leads to creating a monospecific *Rhizophora* mangrove forest. It is important to note that various substrates, salinity and flooding tolerance together with mangrove natural zonation, are considered for every mangrove species adaptation. The lateral roots of *Sonneratia* and *Avicennia* that firmly anchor the tree below ground allow them to dominate in the open seafront while the prop roots of *Rhizophora* species which cannot withstand the strong wave power is usually found mid-forest. Therefore, planting of *Rhizophora* from landward to seaward and most especially on seagrass beds is a common practice of placing the wrong species in the wrong sites.

Sixty 60 species of seagrasses are described worldwide[6] and 18 species are found in the Philippines (Fortes 2004). Reflected in Table 1 are the 6 seagrass species, namely *Cymodocea sp.*, *Thalassia sp.*, *Halodule sp.*, *Enhalus sp.*, *Halophila sp.*, *Syringodium sp.*, found in the site without mangroves (Barangay Ocoy) while the site with mangroves (Barangay Marikaban) only had 4 species. The species composition per study site must have varied most likely due to the physical characteristics of the study areas, especially the substratum which is a very important regulator of seagrass distribution (Greve and Binzer 2004). Both *Halophila* sp. and *Syringodium* sp., which are the species not found in the site with mangroves, prefer sandy substrates (Calumpong and Menez 1994; Meode et al. 2014). Based on observation, the site with *Rhizophora* had a muddy substrate that is suited for the seagrass species occurring in the area. Most mangroves thrive more on muddy substrates where there is a supply of muddy sediment (Bird 2005). *Enhalus* and *Thalassia* form a major association in muddy substrates (Calumpong and Menez 1994); this was also observed in the area. *Thalassia sp.* is the most ecologically important plant on the submerged mangrove bottom as it stabilizes the mud and offers substrate, food, and shelter to animals (Rutzler and Feller 1988).

Although there is no statistically significant difference on mean percent seagrass substrate cover between the sites with and without mangrove plantation (Fig. 3), it is still evident that the area without mangroves had a higher seagrass substrate cover. This less pronounced effect is likely because the mangroves are still saplings and aboveground competition is not yet high. Presence of seagrass may still be observed in the area planted with mangrove because they are not yet under the closed canopy that may eventually reduce photosynthetically active radiation and competition for growing space (Sharma et al. 2017; Ellison et al. 1996; Simpson et al. 2013). Although only percent cover of seagrass substrates was acquired regardless of diversity indices and species composition, this study provides additional baseline data on the impact of mangrove planting in Bantayan seagrass beds.

Mangroves provide additional coastal protection; however, this planting practice of the country may lead to the alteration of seagrass ecosystems. This could change the community structure and dynamics of the seagrass ecosystem (Primavera and Esteban 2008; Orth et al. 2006).

One of the communities associated with seagrasses is the macroinvertebrate fauna. Determining their communities in the two conditions of seagrass ecosystems (with or without mangrove plantation) was investigated in this study. It was observed that seagrass beds planted with mangroves had lesser values for Shannon-Wiener and Simpson's index of diversity compared to seagrass beds without the planted mangroves (Table 2). This result is similar to a study done by Leung (2015) wherein macrobenthic communities decreased with the increase of artificial mangrove habitats. It implies that there should be proper species and site selection before mangrove planting. The decrease in macroinvertebrate diversity could also be attributed to the increased sedimentation by the mangroves. The increase in sediments may have invited new dominant invertebrates in the area that use the sediments to hide from predators. Invertebrates like crabs dig and burrow in these sediments and use mangroves as nurseries of their young (Demopoulos and Smith 2010; Kristensen 2008). This explains the low Jaccard similarity index between the two sites as more crabs were seen in the area with mangroves. The results imply that there was difference in the macroinvertebrate community structure. It was observed that between both study sites, coral species were closer to the seagrass bed without mangroves. The presence of coral species in Barangay Ocoy could be associated to having an average value of water temperature that was more optimum and favorable for coral growth in the area without mangroves. This indicates that the area void of mangroves was able to support the existence of corals because water temperature falls within the range of 25 –29 °C which is the most optimum temperature for coral growth (Vine 1986). Severe mortality of corals may occur if there are dramatic variations of temperature from the optimum value (Brown 2000).

Planting of monospecific *Rhizophora* sp. in non-mangrove areas should be discouraged. Gaining benefit for one ecosystem at the expense of another valuable ecosystem is not ecologically ideal. Negative consequences are expected when seagrass beds are replaced by mangrove plantations because of the various ecological services it offers to the adjacent coastal environment (Wright and Jones 2006; Fourqurean et al. 2012). Therefore, mangroves should be planted in their original habitat that has been converted to brackish-water aquaculture ponds (Samson and Rollon 2008; Ellison et al. 1996).

Conclusion

In the Philippines, mangrove planting has been encouraged as the mangrove ecosystem in the country has been devastated by natural calamity (typhoon) and anthropogenic activities. In the process, other coastal ecosystems such as seagrass ecosystems have been planted on with mangroves. This study compared area with intact seagrass ecosystems (Barangay Ocoy) with those that have been planted on with mangroves (Barangay Marikaban) in Santa Fe, Bantayan. Findings showed that there was not yet much significant difference between the two areas assessed. The changes between the two areas may not be so profound yet since the mangroves were still saplings (planting done in 2015). However, it was observed that the seagrass cover and macroinvertebrates in Barangay Marikaban was lesser. The Jaccard coefficient of similarity between the two communities was low (0.14) implying that the seagrass community in Barangay Marikaban has begun to alter. We recommend proper monitoring of future mangrove planting activities and that this activity should not disrupt another ecosystem as all ecosystems are important.

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Availability of data and materials
The datasets generated and analyzed during the current study are not publicly available because all were collected primarily by the authors themselves but are available from the corresponding author on reasonable request.

Authors' contributions
ARM, JMP, and JYD were major contributors in the conception, acquisition of data, analysis and interpretation of data, and writing of the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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