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RESEARCH PAPER

Determining seagrasses community structure using the Braun – Blanquet technique in the intertidal zones of Islas de Gigantes, Philippines

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Abstract. The seagrass ecosystem which is considered the most productive ecosystem occurs in tropical and subtropical shallow marine waters where it supports diverse flora and fauna. Seagrasses of Islas de Gigantes, Carles, Iloilo were assessed to determine species diversity, abundance, canopy height, and percentage cover. Braun – Blanquet technique was used where 3 transects were laid in each station in three barangays of Islas de Gigantes, namely: Barangay Asluman, Barangay Granada and Barangay Gabi. A total of 7 species were found, *Thalassia hemprichii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halodule pinifolia*, *Halodule uninervis*, *Enhalus acoroides*, and *Syringodium isoetifolium*. Using the Shannon Diversity Index, the seagrass bed in Gabi was the most diverse with a value of 2.8. Sorenson's coefficient (CC) used to compute the species similarity attributes indicating that the three communities have many similarities to each other in terms of species diversity and environmental parameters that affect seagrass ecosystems. *Syringodium isoetifolium* had recorded the highest number of shoots (475 shoots/m²) in Granada. The percentage cover of seagrasses varied across the sampling sites ranging from 55% - 67.50%, with a mean value of 62.50%. However, *E. acoroides* had the tallest canopy height recorded that ranged from 12.33 – 24.83 cm.

Keywords: Abundance; Braun-Blanquet technique; Islas de Gigantes; Percent cover; Seagrass

1. Introduction

Seagrasses are marine plants belong to a group of angiosperms, mostly growing in shallow coastal waters. Seagrass ecosystems that occur in tropical and subtropical shallow marine waters are ranked high amongst the Earth's most efficient ecosystem and thus function as a source of energy for complex food webs in shallow coastal waters (Duarte, 1991). They function as a nursery, refugia, tract, and residential to several marine fishes, reptiles, and invertebrates with important economic, ecological, and conservation value (Thorhaug, 1986; Walker &

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McComb, 1992). They form an ecosystem dominating it as a discrete functional, not as a taxonomic category (McKenzie et al., 2010). In the Philippines, 18 seagrass species from three families (Den Hartog & Kuo, 2007) have been found from 529 sites visited (Fortes, 2008, 2012). Seagrasses attach to all types of substrates occurring mostly extensively on soft ones. They are commonly found in the intertidal region up to 30 meters in depth (Alimen et al., 2010). According to Waycott et al. (2009), seagrasses are important in cycling the nutrients, enhancing the reef fish productivity, the habitat of fish and invertebrates species, and major source food of species like the manatee and green sea turtle. Seagrass meadows are comparably important as mangrove and reef ecosystems. According to McManus (1992), around 20 MT of fish, invertebrates, and seaweeds could also be harvested per km²/year. According to Salita et al. (2003), seagrasses in the Philippines have significant importance to small fishermen because of the rabbitfish fishery. The change of fish assemblage in the system causes fish migration into a suitable environment and other fish to emigrate. The changes of marine organisms during the loss are relative to the change in the diversity of the seagrass meadow (Alimen et al., 2010). In a seagrass meadow, sea cow (*Dugong dugon*), for instance, is specific to eat *Thalassia hemprichii* (main diet), *Syringodium isoetifolium* and *Cymodocea spp.*, while green marine turtle (*Chelonia mydas*) consumes primarily *Thalassia hemprichii* and *Enhalus acoroides* (André et al., 2005).

In Gigantes Islands, all seagrass areas have been enacted by the Local Government Unit (LGU) of Carles as fish sanctuaries, however, a lot of local fisherfolks still utilize the area for shellfish gleaning, boat anchoring, and fishing activities even though the fishery ordinance for prohibition in the sanctuaries is in place. With these important values both in economic and ecological services of seagrass habitat, hence, this study was conducted. The objectives of this study were to determine the present status of the seagrass ecosystem in the islands and the diversity indices which will serve as baseline information for the LGU.

2. Literature review

Seagrass ecosystems in the Southeast Asia region are being susceptible to natural and human-induced disturbances (Fortes, 1990). More than 60% of the required animal protein in the coastal diets is from marine fisheries, partly dependent upon the seagrass ecosystem for productivity and maintenance (Heck & Orth, 1980).

A large number of the population in the Philippines is dwelling adjacent to its coastal areas or shores and it is projected that this population will continue to increase in the coming years. The Philippines' marine environment has become an avenue of people as a source of food, transportation, repositories of effluents, residential sites, and sources of both recreational and aesthetic pleasures. Sedimentation due to coastal denudation and coastal construction is another issue that endangers the seagrass meadows. Degradation of water quality due to pollution has diminished biodiversity and natural productivity. The degradation of water quality due to the increase of coastal population and activities is supported in the study of Tuahatu et al. (2016), in which population growth in Ambon Island, Indonesia and the increasing construction activities such as the conversion of coastal land for various purposes resulting in the reduction of water quality. This is proven in the other research of Tuahatu (2010), that the water column and sediment of Ambon Bay surrounding waters contain heavy metals.

Fortes (1990) studied that seagrass is one of the most important resources in the coastal area. It supports and provides a habitat for several coastal organisms. Siganids, sea urchins, sea

cucumbers, sea horses, crabs, shrimps, scallops, mussels, snails, and scallops look for their niche environment in seagrass beds. A seagrass ecosystem is a good place for the spawning, breeding, nursing, and refuge of these organisms. Aside from giving food, it also stabilizes and holds bottom sediments, maintaining balance, biodiversity, and favorable symbiosis among the living aquatic organisms. There are 18 seagrass species found in the Philippines from three families (Den Hartog & Kuo, 2007) that were found from the 529 sites visited (Fortes, 2008, 2012). The species so far recorded are *Cymodocea rotundata*, *Enhalus acoroides*, *Cymodocea serrulata*, *Halophila beccarii*, *Halodule uninervis*, *Halophila decipiens*, *Halodule pinifolia*, *Halophila gaudichaudii*, *Syringodium isoetifolium*, *Halophila minor*, *Thalassodendron ciliatum*, *Halophila ovalis*, *Halophila ovata*, *Halophila spinulosa*, *Halophila sp1*, *Halophila sp2*, *Thalassia hemprichii* and *Ruppia maritima*.

Kelleher et al. (1995) proved that dugongs (Dugong dugon, sea cow) and sea turtles (*Chelonia mydas*) are also very much dependent on seagrasses for survival. Studies show that about 40,000 fishes and 50,000 invertebrates are often supported by the 10,000 tons of leaves produced in an acre of seagrass beds (Mukhida, 2007).

According to Kuo et al. (2006), the warm water of the Kuroshio Current determines the distribution of seagrass species along with its affected areas. This current originates from the equator and flows along the east coast of the Philippines and Taiwan to Japan. Notwithstanding seagrass's importance to productivity that goes along with the Kuroshio Current, the other coastal habitats (coral and mangrove) would not exist without seagrass (Ame & Ayson, 2009).

Environmental factors such as temperature, substratum features, salinity, turbidity, depth, nutrient characteristics, and light regulate the distribution and growth of seagrasses (Abal & Dennison, 1996) though species of seagrasses have their habitat requirements. This is supported in the study of Livingston et al. (1998) in the Gulf of Mexico, which determined a hierarchy of habitat requirements for three species of seagrass (*Halodule wrightii*, *S. filiforme*, and *T. testudinum*).

The adoption of a sound management system for our coastal habitat such as seagrass meadows would bring about sustainable use, which will improve economic capability among fisherfolks. Hence, this research study was conducted.

3. Methodology

3.1. Study Site

The study was conducted along the two intertidal zones of North Gigantes at 11°36'N; 123°20'E (Granada) & 11°36'N; 123°21'E (Asluman) and one in South Gigantes Islands at 11°35'N; 123°20'E. These two islands are an island chain within the larger Western Visayas archipelago in the Visayan Sea. They are the largest and major islands of the well-known Gigantes group of islands or simply called *Islas de Gigantes*, consisting of about 10 islands. They are a part of the municipality of Carles, Iloilo, Philippines. It is the northernmost municipality of Iloilo Province. The Gigantes islands group is comprised of 4 barangays, namely: Barangay Asluman and Barangay Granada in Gigantes Norte, and Barangay Lantangan and Barangay Gabi in Gigantes Sur.

3. 2. Transect Survey

Seagrass assessment using the Braun – Blanquet (BB) technique (Southeast Environmental Research Center - Florida International University (SERC-FIU), 2020) was done on February 25 - 27, 2016 by determining the biophysical parameters: abundance, frequency, density, percentage cover, shoot density, and canopy height. Seagrass sampling sites representing the overall condition of seagrass beds in Islas de Gigantes (*e.g. close to mangrove forest, near a residential area, etc.*) were considered for the transect survey. The transect survey was done at 3 sites: Asluman, Granada, and Gabi as shown in Figure 1. Lantangan was not assessed due to scattered small patches and low density of seagrasses during the ocular survey conducted in the area. Data on seagrasses was collected inside the 0.5m x 0.5m (0.25m²) of BB – quadrat placed on every 10 – meter interval along the transect line laid perpendicular to the shore up to 100 meters. The BB – quadrat design can be seen in Figure 2. Each site has three transect lines and approximately 100 meters away from each other. Percentage cover (% cover) of each seagrass species by visual observations in each quadrat was estimated using a percentage cover standard of Seagrass - Watch. A sample of percentage cover standard of Seagrass - Watch is shown in Figure 3. Each species, % cover was obtained by estimating the fraction of the total quadrat area (0.25m²) that was occupied by the particular species when viewed directly above the quadrat. Then, the assessment activities were done during low tide with a tidal range of 0.5 to 1.0 m. The identification of seagrass was based on: a) Key to the families and species of Philippine seagrasses by Miguel D. Fortes (Fortes, 2013); and b) Philippine Field Booklet – Seagrass Watch (www.seagrasswatch.org).

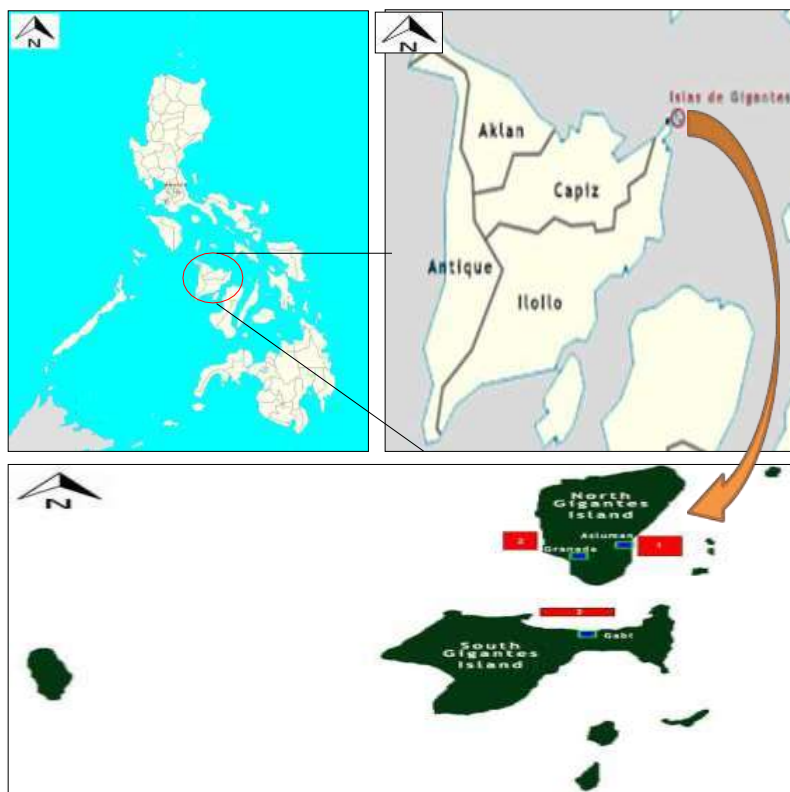


Figure 1. Map of the Philippines with inset details of sampling sites: 1. Brgy. Asluman; 2. Brgy. Granada and; 3. Brgy. Gabi



Figure 2. Braun – Blanquet (BB) quadrat design with small quadrat (10 x 10 cm) at the center (black wire)



Figure 3. Percentage cover standard used in the assessment of seagrass in three sampling sites

3.3. Shoot Densities

Shoot density per seagrass species and total seagrass shoot density were assessed at each site by placing a 10 cm x 10 cm shoot counting quadrat in the center of each BB - quadrat and counting all of the shoots present. The shoot density values were reported on a square meter basis (shoots/m²) after multiplying the shoot counts in each small shoot counting quadrat by 100 (Kenworthy et al., 1993).

3.4. Abundance, Density, Frequency, and Percentage Cover

In each BB – quadrat, the coverage (frequency, abundance, and density) of each seagrass species and the total seagrass community were evaluated using the globally standardized Braun-Blanquet visual assessment method in 0.25 m² quadrats (Al Jamali Environmental Consultancy (AJEC), 2014; Braun-Blanquet, 1932; Kenworthy et al., 1993). The score for each seagrass species and total seagrass was assigned a BB - scale value with corresponding ranges of cover for each score (Table 1). Three variables (frequency, abundance, and density) were then calculated from the scores according to Equations (1, 2, and 3).

Table 1. Braun – Blanquet (BB) score values and corresponding seagrass cover

Braun Blanquet Score (BB – Score)	% Cover Value
0	Absent
0.1	Solitary specimen
0.5	Few, with a small cover
1	Numerous, but less than 5% cover
2	5% – 25%
3	25% – 50%
4	50% – 75%
5	75% – 100%

$$Frequency = \frac{\text{Number of occupied quadrats}}{\text{Total number of quadrats}} \quad (1)$$

$$Abundance = \frac{\text{Sum of BB – score values}}{\text{Number of occupied quadrats}} \quad (2)$$

$$Density = \frac{\text{Sum of BB – score values}}{\text{Total number of quadrats}} \quad (3)$$

3.5. Canopy Height

Inside the 10 cm x 10 cm BB - quadrat used for shoot counts, the canopy height of each seagrass species was measured *in situ* using a metric ruler. The maximum length of the seagrass shoots (cm) of each species inside the small counting quadrat was recorded and rounded off to the nearest 0.5 cm.

3.6. Species Diversity and Similarity Indices

The indices of seagrasses in the three sites were computed using the Shannon - Weiner index (H') and Sorenson's coefficient index (CC) for diversity and similarity indices, respectively, Equations (4 and 5).

a. Shannon - Weiner index (H')

$$H' = - \left(\sum P_i \times \ln P_i \right) \quad (4)$$

where:

H = Diversity index (Shannon - Weiner)

$$P_i = \frac{\text{Number of individuals of a species}}{\text{Total number of species}}$$

\ln = natural logarithm

b. Sorenson's coefficient index (CC)

$$CC = \frac{2C}{S1 + S2} \quad (5)$$

where:

C = is the number of species the two communities have in common

$S1$ = is the total number of species found in community 1

$S2$ = is the total number of species found in community 2

4. Results

In Asluman, Gigantes Norte, Carles, Iloilo, six species of seagrass found, namely: *Cymodocea rotundata*, *Cymodocea serrulata*, *Thalassia hemprichii*, *Syringodium isoetifolium*, *Enhalus acoroides*, *Halodule uninervis*. *C. rotundata*, *C. serrulata*, *H. uninervis*, and *S. isoetifolium* belong to Family Cymodoceaceae while *Thalassia hemprichii* and *Enhalus acoroides* belong to Family Hydrocharitaceae.

There were five species of seagrass found in Granada, Gigantes Norte, Carles, Iloilo, namely: *Cymodocea serrulata*, *Syringodium isoetifolium*, *Enhalus acoroides*, *Halodule uninervis*, and *Thalassia hemprichii*.

On the other hand, seven seagrass species were found in Gabi, Gigantes Sur, Carles, Iloilo, namely: *Enhalus acoroides*, *Halodule uninervis*, *Syringodium isoetifolium*, *Thalassia hemprichii*, *Halodule pinifolia*, *Cymodocea rotundata*, and *Cymodocea serrulata*. *Halodule pinifolia* also belongs to Family Cymodoceaceae.

4.1. Shoot Density

At Asluman and Granada, *Syringodium isoetifolium* species had recorded high densities with 432 shoots m^{-2} and 475 shoots m^{-2} , respectively. In Gabi, *Halodule uninervis* had the highest shoot density of 280 shoots m^{-2} than the other species. *Cymodocea rotundata* was only present at 2 sites, in Asluman with minimal densities at 30 shoots m^{-2} and high in Gabi with 230 shoots m^{-2} . *Halodule pinifolia* was only present at Gabi with 170 shoots m^{-2} . Granada had slightly higher total shoot densities (1,041 shoots m^{-2}) than in Asluman (1,034 shoots m^{-2}). However, Gabi got the lowest total shoot density (723 shoots m^{-2}) (Fig. 3).

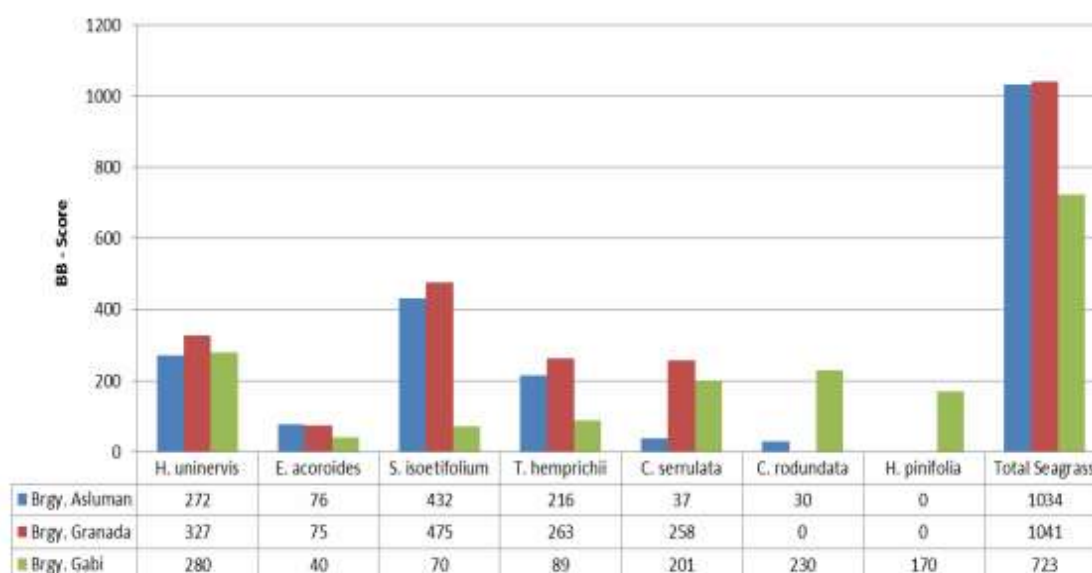


Figure 3. Shoot density of seagrass species and total seagrass at three sampling sites

4.2. Abundance

In the quadrats occupied by all seagrass species, *H. uninervis* had the highest abundance value at every site and its highest value was found in Granada (2.27). In three sites, *C. rodundata* had the lowest average abundance values (0.31) and found only in Asluman and Gabi. The average abundance value of *H. pinifolia* (0.44) at the 3 sites was slightly higher than *C. rodundata* (0.31) even though *H. pinifolia* was recorded only in Gabi (Figure 4).

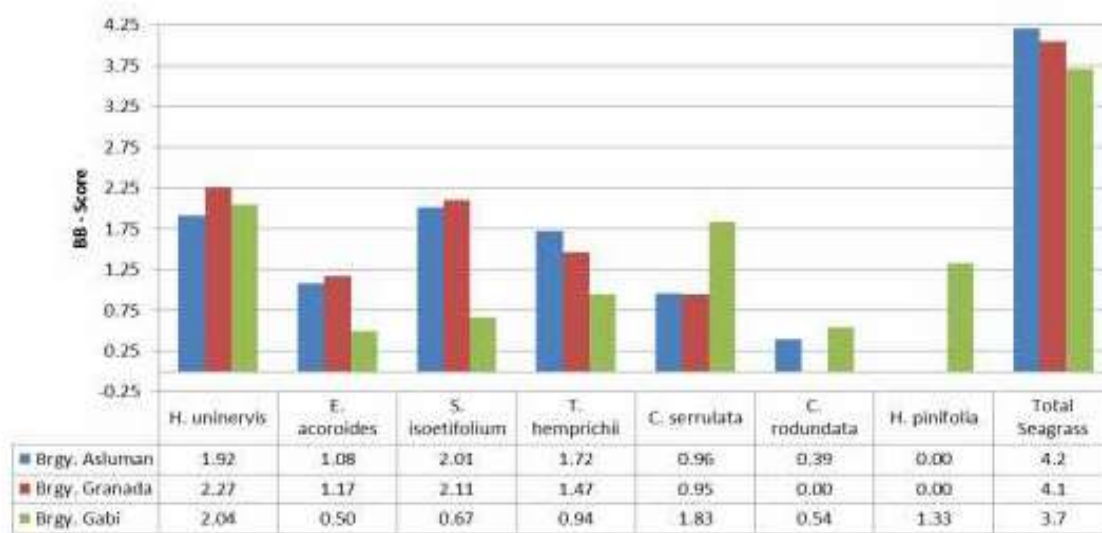


Figure 4. Abundance for seagrass species and total seagrass at three sampling sites

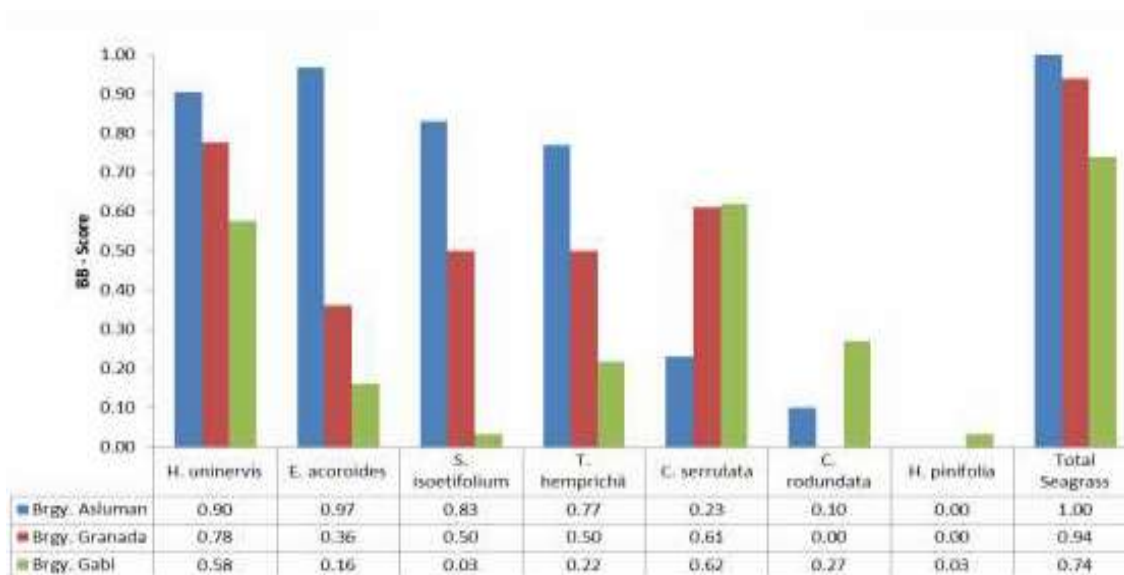


Figure 5. Frequency for seagrass species and total seagrass at three sampling sites

4.3. Frequency

Halodule uninervis recorded the highest frequency compared with other species with an average of 0.75. In all sites, Asluman had the highest frequency of 0.90 for *H. uninervis*. Among the species, *H. pinifolia* had recorded the lowest average frequency value (0.01) due to its absence at Asluman and Granada but it was a negligible value at Gabi (0.03) (Fig. 5).

4.4. Density

Density was dominated by *H. uninervis*, with a significantly higher average value (1.50) compared with other species for the entire sampling sites (Figure 6). The total seagrass density was higher in Asluman due to the density values of *T. hemprichii* (1.33) and *E. acoroides* (1.06) being substantially greater than the values at Granada (*T. hemprichii*, 0.88; *E. acoroides*, 0.39) and Gabi (*T. hemprichii*, 0.0.37; *E. acoroides*, 0.13).

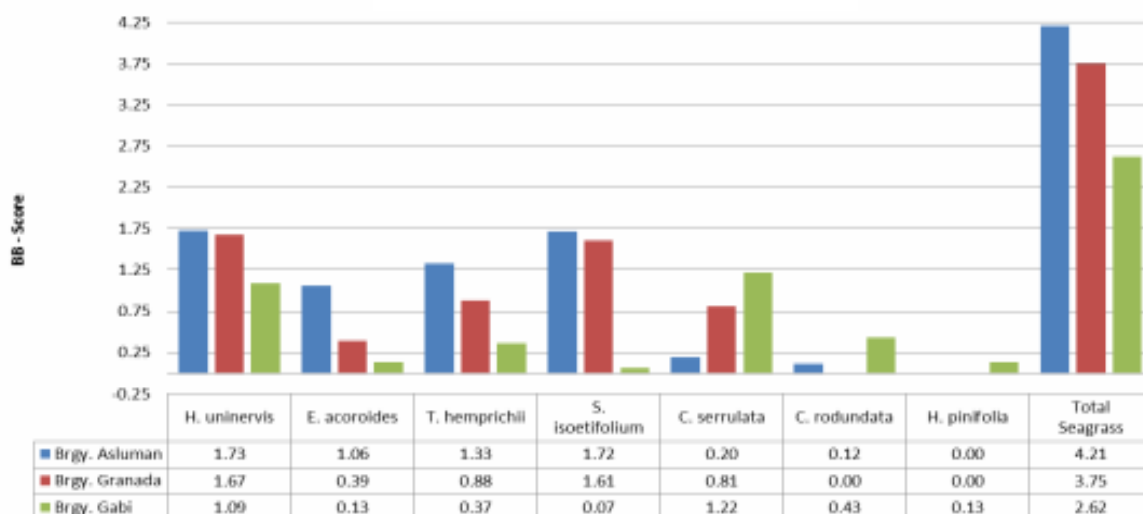


Figure 6. Density for seagrass species and total seagrass at three sampling sites

4.5. Percent Cover of Total Seagrass

The total coverage of seagrasses at the 3 sites was dominated by *H. uninervis*. *C. rodundata* and *H. pinifolia* were only very minor components of the seagrass coverage at all sites. The cover of all seagrasses (total seagrass) varied across the sampling sites. Interpolating the BB categorical scores to seagrass percentage cover, Asluman had a seagrass percent cover of 67.50%, Granada had 65.0%, and Gabi had 55% cover. Where the seagrasses occurred, the average total seagrass % cover for the 3 sites was 62.50% (BB score values ≥ 4) (Figure 7).

4.6. Canopy Heights

The seagrass canopy structure at the 3 sites was dominated by *E. acoroides*. Canopy heights for this species were slightly taller at Granada (24.83 cm) than at Asluman (24.08 cm). In Gabi, *E. acoroides* had a canopy height of 12.33 cm much smaller compared to the other 2 sites (Figure 8).

At 3 sites, *H. pinifolia* was only found at Gabi with a canopy height of 7.0 cm; hence this species makes an insignificant contribution to the canopy structure of whole seagrass sampling sites.

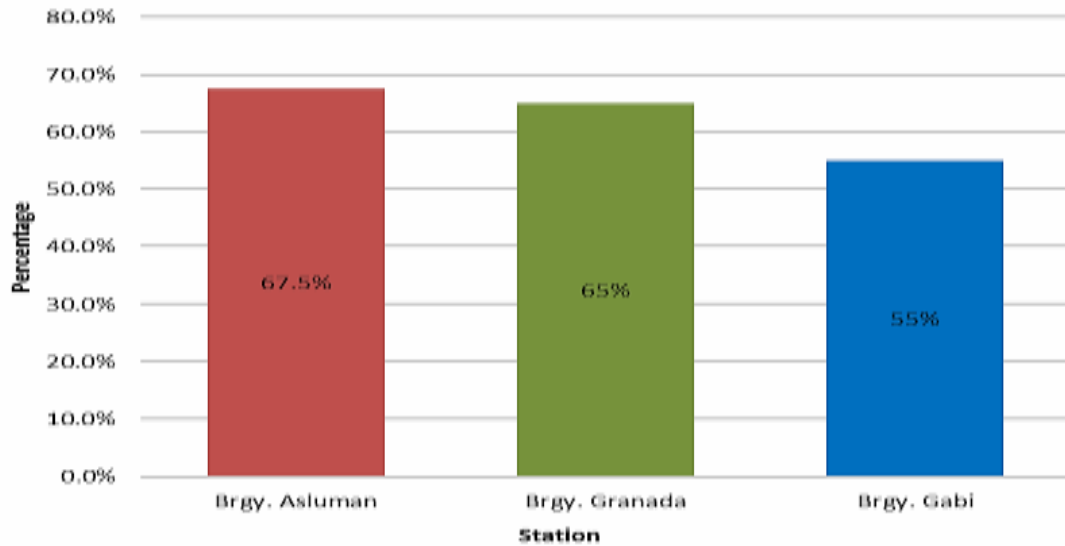


Figure 7. Percent cover of total seagrass at three sampling sites

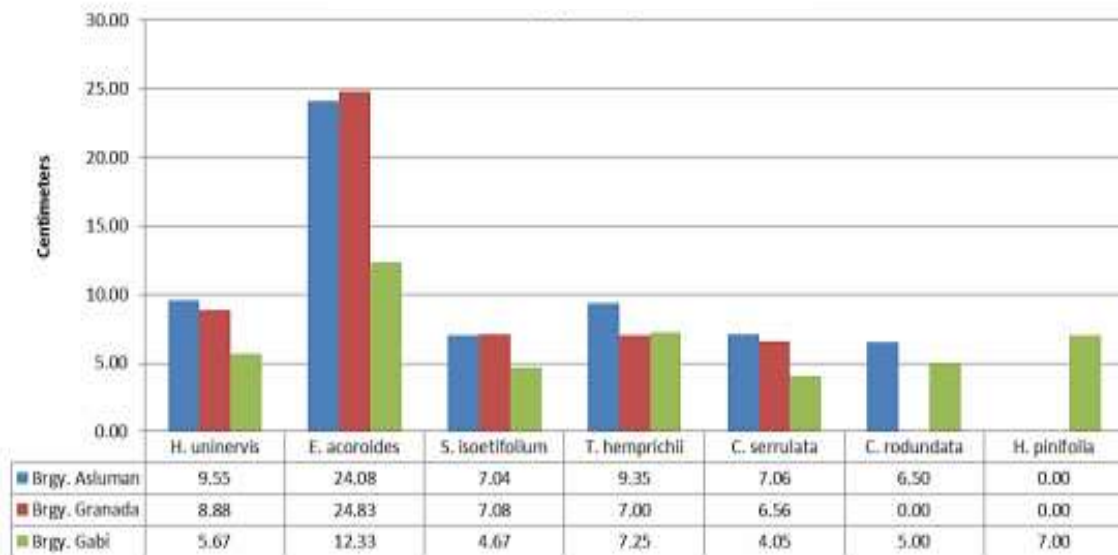


Figure 8. Canopy height (cm) of seagrass species at three sampling sites.

4.7. Diversity Indices

The Shannon – Weiner diversity index revealed that seagrass beds at Asluman had a diversity value of 1.4, Granada had 1.5 while Gabi had a diversity value of 1.8. Sorenson's coefficient (CC) values showed that Asluman vs. Granada, Asluman vs. Gabi, and Gabi vs. Granada were 0.91, 0.92, and 0.83, respectively (Table 2).

Table 2: Sorenson's Coefficient similarity index

Seagrass sites by Comparison	Sorenson's Coefficient
Asluman vs. Granada	0.91
Asluman vs. Gabi	0.92
Gabi vs. Granada	0.83

5. Discussion

A total of 7 species of seagrass were found within the study sites of Islas de Gigantes, Carles, Iloilo namely: *Enhalus acoroides*, *Halodule uninervis*, *Syringodium isoetifolium*, *Thalassia hemprichii*, *Halodule pinifolia*, *Cymodocea rotundata*, and *Cymodocea serrulata*. These species of seagrass are common in the Philippines based on the study of Fortes (2004); (Ame & Ayson, 2009). The number of species found in this study is one species higher than the previous studies conducted by Campos et al. (2012) in Islas de Gigantes. The species of *Syringodium isoetifolium* was absent in the study of Campos et al. (2012), and the difference in the number of species recorded between the two studies is the dissimilarity of sampling sites. At Gabi in Gigantes Sur, all 7 seagrass species were all present.

In terms of seagrass distribution, Asluman had the highest area of distribution followed by Granada and the last was Gabi. The wide area of the intertidal zone with a sandy substrate of Asluman is favorable for seagrass growth and distribution. Likewise, the seasonal variations in the physicochemical parameters of the area affect the occurrence and distribution of seagrass species (Aboud & Kannah, 2017).

The abundance of seagrass species was based on the result of BB-Score. *H. uninervis* tallied with the highest abundance score at all three sites. *H. uninervis* frequently forms dense meadows on the substrate and sometimes is found mixing with other species of seagrasses and algae (F. T. Short et al., 2011). They commonly occupy the lower intertidal zone of the three sites. The characteristic of this species is that it desiccates quickly and sensitive to ultraviolet radiation that restricts it to the deeper portion of intertidal water than some other species of seagrasses (Lan et al., 2005). The high outcomes in frequency and density coincided with the abundance result of *H. uninervis* showing that this species dominated the seagrass meadows of Islas de Gigantes.

Shoot densities at all sampling sites ranged from 723 shoots m⁻² to 1,041 shoots m⁻². *Syringodium isoetifolium* dominated at all sites considering that it prefers sandy substrates and is usually found in shallow waters in the lower inter- and subtidal areas up to 15 m depth (International Union for Conservation of Nature (IUCN), 2019). It has a syringe-like structure with leaf-tip tapers to a point. However, disturbances in seagrass meadows can lead to blades fragmentation, a reduction in shoot density, canopy height, and percent coverage, as well as

potentially permanent loss of habitat (McCloskey & Unsworth, 2015). The turbid water in the sampling sites of Granada and Gabi affects the penetration of light needed for the photosynthetic processes of seagrasses that has a negative impact on the abundance and densities of seagrass.

Out of 18 species of seagrasses recorded in the Philippines by Fortes (2013), seven species of seagrasses were documented in this study. Environmental parameters are critical as to if seagrasses will grow and exist. Temperature, salinity, waves, currents, depth, substrate, and day length are physical parameters that regulate the physiological activity of seagrasses. Light, nutrients, epiphytes, and diseases, as well as nutrient and sediment loading, are natural phenomena and anthropogenic inputs, respectively, that inhibit access to available light for growth. Different combinations of the parameters will permit, encourage, or eliminate seagrass from a specific location (Seagrass-Watch, 2020), thus, these parameters considerably contribute to seagrass species diversity. According to (Paz-Alberto et al., 2015), the bottom type and the location of the seagrass beds affect the species composition of seagrasses. In this study, seagrass beds in all sites had sandy to sandy - muddy substrates that sometimes smothered the whole seagrass ecosystem. Additionally, runoff of sediments from higher grounds of the island when there is a typhoon or heavy rain settled at the seagrass bed may be the reason for mortality due to burial of the species present within the area. Likewise, illegal fishing activities, shellfish gleaning, local fishing boat anchoring, boat propeller scarring, and effluents from households located near the area may result in biodiversity loss. The insignificant difference in the diversity index values of seagrass ecosystems at all sites was supported by their Sorenson's coefficient results on similarity by comparing the ecosystems with one another which resulted in almost 1 (Asluman vs. Granada = 0.91, Asluman vs. Gabi = 0.92, Granada vs. Gabi = 0.83), indicating that these three communities have many similarities to each other in terms of species diversity and environmental parameters that affect the seagrass ecosystems.

The differences in seagrass canopy heights help to explain productivity differences among seagrass species. Local ecology plays a distinct role in determining the productivity of seagrasses species by showing clear variation within the species and between the species at different sites. In the study of Aboud & Kannah (2017), seagrass species affected by the higher daytime tides in the Laggonal Reefs of Kenya recorded high canopy height resulting in high productivity. The higher productivity of seagrass meadows may be linked to the higher production rates of associated fisheries (Short et al., 2007). The species of *H. uninervis*, *S. isotifoelium*, and *E. acoroides* which are abundant at all sampling sites significantly contribute to the coastal productively (e.g. fishes, mollusks, macroalgae, etc.) in the islands. However, *E. acoroides* had the tallest canopy height recorded that ranged from 12.33 – 24.83 cm. *E. acoroides* species were easily identified through its long ribbon-like leaf blades frequently reaching up to 2 meters long.

In Islas de Gigantes, seagrasses could thrive in a relatively exposed bed during low tide at a distance of 100 m to 200 m away from the shore. Similarly, all sites are exposed to strong wave action due to their geographic location. Fortes (1990) also states that extreme low tide during daytime creates a negative effect on seagrass abundance, biomass, growth rate, and production. It was observed also particularly at Asluman that some guests from the resort disturbed the seagrass beds for curiosity, they walked through the seagrass meadows looking for aquatic animals thriving in the area and accidentally damaged the seagrass root system. Therefore, these anthropogenic and environmental factors have contributed much to the overall percent cover (62.50%) of seagrasses in Islas de Gigantes.

6. Conclusion

Seagrass communities in Islas de Gigantes showed a diversity of species derived from the ecological assessment. Out of the 18 seagrass species that can be found in the Philippines, a total of 7 species were found in Islas de Gigantes. The community structure of seagrasses in the intertidal zones based on the data gathered was affected by the human and socio-economic activities in the islands (North and South Gigantes). Thus, the LGU - Carles must strengthen its conservation measures on this important coastal resource.

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