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Seagrass vegetation analysis and mapping in a biodiversity-rich cove of the West Philippine Sea

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ABSTRACT

There were three identified species of seagrass in the coastal waters of Maragondon, Cavite. It was recorded in the year 2020 during the first Cavite Seagrass Exploration. The study was conducted during the month of November 2021, the last month of the wet season in the Philippines. The study determined the vegetation structure, percent cover, total area, and location of the seagrass meadows. Line transect and quadrat methods were used to determine the vegetation structure and biodiversity index of the seagrass meadows. The Braun-Blanquet technique was used to determine the percent cover of the seagrass, epiphytes, and macroalgae. There were three species found in the area - *Thalassia hemprichii*, *Halophila ovalis*, *Halodule univervis*, with a very low diversity index (< 1.9999 H'). This number could have a significant impact on the marine ecosystem as well as on the local communities. The most frequently occurring, highly dense, and most abundant species among the species present is *H. hemprichii*. The seagrass covers range from 32% to 42% while the macroalgal cover and epiphyte cover range from 12.7% to 32% and 15% to 53.6% respectively. The newly discovered seagrass meadows in Cavite have a total area of 1.05 hectares and it is located in Patungan Cove in Maragondon, Cavite. These seagrass meadows play a vital role in the preservation and nursery of fish and other marine organisms and are also an important source of livelihood for the fishermen and local communities. Lastly, continuous assessment and monitoring of the seagrass meadows and rehabilitation programs were proposed for the sustainable management of the area.

Keywords: biodiversity, conservation, marine ecosystem

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1. Introduction

Seagrasses are home to many economically important marine organisms, including shrimps, sea urchins, clams, various fish species, and endangered animals like sea turtles and the enigmatic dugong, some 95% of whose diet is seagrasses. All these make the conservation, rehabilitation, and persistent scientific research on seagrass habitats a high priority in the coastal action agenda of governments in Southeast Asia [1].

For decades, the main interest of marine scientists of Southeast Asia focused almost solely on the corals, seaweeds, animals, or fish that either live in the coastal habitats or are associated with them [2]; thus, the seagrass ecosystem is considered as least studied.

According to the interview conducted with the Provincial Environment and Natural Resources Office (PENRO)-Cavite in 2019, there has been no data for seagrass in the province for several years. However, last February 17, 2020, the PENRO-Cavite, together with Cavite State University, located the last seagrass ecosystem of Cavite in Maragondon. Approximately, seagrass coverage is lost globally at 1.5 percent annually [3]. The different threats to seagrass ecosystems are physical disturbances (wind-driven waves and storms); nutrients causing algal blooms that block sunlight; sediments washing into the water that smother seagrass and block sunlight; anchors and propellers from boats; episodes of warm seawater temperature; encroachment and seagrass modification; and introduction of waterborne pollutants [3,4].

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Seagrass has 72 different species. It receives little attention but is considered one of the most productive ecosystems in the world. With the numerous benefits it can provide, approximately a hectare of seagrass is worth over US$19,000 per year.

Among the key services that seagrasses can provide are modification of the physical environment, creation of living habitat, foundation of coastal food webs, and blue carbon [3]. Seagrass ecosystems could store as much as 19.9 Pg (Petagram) of organic carbon and approximately the seagrass carbon pool slander between 4.2 and 8.4 Pg carbon, reflecting the importance of seagrass ecosystems in mitigating the effects of global warming and climate change [5]. According to [1], seagrasses are home to many economically important marine organisms, including shrimps, sea urchins, clams, various fish species, and endangered animals like sea turtles and dugongs. In addition, this ecosystem plays a significant role in the sea turtles in the province of Cavite, which releases 4,000-5,000 hatchlings per year. Throughout the years, seagrass ecosystems have been relatively unknown and often underappreciated by coastal communities, which significantly indicates that they are undervalued [6]. Seagrass ecosystem services are difficult to value and rank, and in many areas, the loss of seagrass would not directly affect the local communities [7]. The root causes of seagrass degradation in both tropical and temperate regions are biological, environmental, and climatological events [6]. The largest causes of seagrass degradation are primarily due to anthropogenic activities [8] such as coastal reclamation [9], urban planning and coastal development [10], and the intensified degree of the parameters such as sewage pollution, siltation/sedimentation, agricultural pollution and sea level rise that eventually leads to the destruction of mangrove forest and undervalues seagrass ecosystems [11]. Population pressure and economic necessities generate coastal development as well as destruction in areas occupied by seagrass, which is evident in the present time [12]. It is most certain that the percentage of the population living adjacent to coastal waters, shores, or estuaries will increase, indicating that the demand for marine products and other services associated with coastal resources will also increase, leading to the degradation and abuse of marine resources [13].

This study determined the physicochemical parameters of the seagrass ecosystem in terms of temperature, pH, salinity, dissolved oxygen, and total dissolved solids. Moreover, it determined the vegetation structure of seagrass, percent seagrass cover, epiphyte cover, and macroalgal cover in the seagrass ecosystem in the Maragondon coastal waters.

2. Materials and methods

2.1. Study site

The study was conducted at the coastal water of Maragondon, Cavite, Philippines. Based on the initial field observation, the newly discovered seagrass meadows of Cavite are located in Maragondon coastal waters. This was discovered by Cavite State University and DENR PENRO Cavite last 2020. This seagrass meadow is located near the coastal barangay (formerly Barangay Sta. Mercedez), which has land ownership issues. The study site is in the coastal area of the Mts. Palay-Palay and Mataas na Gulod National Park.

2.2. Quadrat sampling and biodiversity index

The sampling was conducted on the month of November 2021, the last month of the wet season in the Philippines. One -time sampling was employed to determine the baseline data of the newly discovered seagrass site of Cavite. Annually, monitoring of the site was conducted, and the monitoring data were handled by the local government of Maragondon and the Provincial Environment and Natural Resources Office-Cavite. A 50 m transect line was placed on the seagrass area parallel to the shore, and another 50 m transect line was placed parallel to the first transect. Each quadrat was laid in the transect line with a 5m interval, and some were adjusted based on the patchiness of the seagrass meadows. There were 11 quadrats with a size of 0.5 x 0.5m in each transect line. There were 33 quadrats for the three transect lines. In each quadrat, the number of species and the number of individuals per species were counted. This method was adopted and modified from [14,8,15]. Species diversity and abundance were computed using the Shannon-Weiner diversity index [16]. This will be computed as, $H' = N \ln N - \sum(n_i \ln n_i) / N$, where *N* is the total number of species and n_i is the number of individuals in species *i*.

2.3. Vegetation analysis

In each transect, the number of individuals per species was counted. These data were used to determine the frequency, relative frequency, density, relative density, abundance, and importance value. These parameters were calculated using the following formula:

$$Frequency = \frac{no.of\ quadrats\ in\ which\ the\ species\ occurred}{Total\ no.of\ quadrat\ studied} \quad (1)$$

$$Relative\ Frequency = \frac{no.of\ quadrats\ in\ which\ the\ species\ occurred}{Total\ no.of\ quadrats\ occupied\ by\ all\ species} x100 \quad (2)$$

$$Density = \frac{Total\ no.of\ individuals\ of\ species}{Total\ no.of\ quadrats\ used\ in\ sampling} \quad (3)$$

$$Relative\ Density = \frac{Total\ no.of\ individuals\ of\ species}{Sum\ of\ all\ individuals\ of\ all\ species} x100 \quad (4)$$

$$Abundance = \frac{Total\ no.of\ individuals\ of\ species}{No.of\ quadrats\ which\ they\ occurred} \quad (5)$$

$$Importance\ Value = Relative\ Frequency + Relative\ Density \quad (6)$$

2.4. Seagrass and associated species percentage cover

At each quadrat, the seagrass cover and associated species (macroalgae and epiphytes) cover in general and for each species were estimated visually using the Braun-Blanquet technique [17]. It was estimated using the following Braun-Blanquet (B-B) scale values: 5 covers of more than 75% 4=50-75% cover; 3=25-50% cover; 2=5-25% cover; 1 numerous, but less than 5% cover or scattered with up to 5% cover; + few, with small cover (assigned a value of 0.5); r solitary, with small cover (assigned a value of 0.1).

2.5. Seagrass mapping

The whole perimeter was determined by getting the point-by-point coordinates of the area using GPS. The map was generated by inputting the coordinates in the ArcMap Software.

3. Results and discussion

3.1. Vegetation analysis and biodiversity index of the seagrass meadows

Table 1 shows the seagrass species present per line transect. There were three identified species of seagrass found in all of the transect lines, namely *Halophila ovalis*, *Thalassia hemprichii*, and *Halodule uninervis* (Figure 1). Species in the third transect are more diverse compared to transects 1 and 2 since the three identified species can be found in the third transect line. Moreover, *Thalassia hemprichii* is the most abundant species among the two other species since it is present in all the transect lines. It was observed that the three species were not evenly distributed in the area, which explained the absence of some species in some transect lines. The highly dense species of seagrass in the study site provide a wide variety of ecosystem services, such as habitat for other aquatic organisms and nursery grounds for fishes and invertebrates; it can also improve the quality of the water [18,19].

Figure 1. Species of seagrass in the study site (*E. acoroides, H. ovalis, H. uninervis*).

Table 2 shows the vegetation analysis of the seagrass meadows. Based on the results, there were three (3) identified species of seagrass present in the seagrass site: the *H. ovalis*, *T. hemprichii*, and *H. uninervis*. From the three transect lines, *T. hemprichii* is the most frequently occurring, highly dense, and most dominant species among the three present species in the area, this was followed by *H. uninervis* and *H. ovalis*. In terms of importance value (IV), *T. hemprichii* also ranked first and then followed by *H. uninervis* and *H.ovalis*.

Table 1. Seagrass species per line transect

Species	Transect 1 Quadrat											Transect 2 Quadrat											Transect 3 Quadrat										
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11
H. ovalis																			✓						✓			✓	✓	✓			
H. uninervis	✓	✓	✓	✓	✓	✓	✓				✓																	✓					
T. hemprichii				✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2. Vegetation analysis of the seagrass meadows

Transect	Species	No. of individuals	Frequency	Relative Frequency	Density	Relative Density	Abundance	Importance Value
1	*H. uninervis*	148	0.73	6.61	13.5	0.75	204	7.36
	T. hemprichii	49	0.55	4.96	4.45	0.25	89.8	5.21
	H.ovalis	0	0	0	0	0	0	0
	Total	197						
2	*H. uninervis*	0	0	0	0	0	0	0
	T. hemprichii	93	0.91	8.26	8.45	0.9	102	9.17
	H.ovalis	10	0.09	0.83	0.91	0.1	110	0.92
	Total	103						
3	*H. uninervis*	3	0.09	0.83	0.27	0.02	33	0.85
	T. hemprichii	96	1	9.09	8.73	0.76	96	9.85
	H.ovalis	27	0.36	3.31	2.45	0.21	74.3	3.52
	Total	126						

Table 3 shows the biodiversity index results. In terms of richness and evenness, the first transect has a close representation (Evenness= 0.807) of species in the transect line, and the most diverse (Richness= 3) is the third transect, since the three species were all present in the transect line. The first transect also has the highest number of individuals (198) of all the species identified, with an average population size of 99 individuals per transect. Moreover, seagrass species in the Patungan cove, Maragondon, Cavite are very low with less than 1.9999 H' [20]. The seagrass meadow is in an isolated and private cove, which has no direct community that can be a contributor of pollution and conversion. However, it was observed that there were some fishing activities near the study site.

Table 3. Biodiversity index of the seagrass meadows

	Transect 1	**Transect 2**	**Transect 3**
Shannon *Diversity Index* (H')	0.56	0.319	0.626
Evenness	0.807	0.46	0.57
Richness	2	2	3
Average population size	99	51.5	42

These low numbers of diversity index of seagrass can alter the habitat structure as well as the faunal abundance and structure communities [21]. The low number of seagrasses in the area can decrease the capacity to attenuate the waves, which is vital for coastal protection [22]. Destructive fishing practices, including trawling, overfishing, and seine fishing, have been shown to directly impact seagrass habitats. These fishing practices directly impact seagrass beds through physical uprooting [23] and a decrease in diversity [24]. Additionally, [25] found that these practices indirectly affect seagrass beds by resuspending sediments, which leads to a reduction in light availability, prohibiting the seagrasses from reproducing. Similarly, dredging or sand mining significantly impact seagrass populations by increasing the water turbidity and sedimentation. Light and water transparency are one of the key environmental factors crucial for the survival and growth of seagrass populations. Decreased amount of light penetrating the water due to increased turbidity is one of the major causes of seagrass loss globally [26]. Additionally, [27] found that fine sediments deposited by excessive sedimentation matter infiltrate the pore spaces of the substrate, negatively impacting the physicochemical conditions of the seagrass rhizosphere and reducing oxygen availability. Moreover, these threats are directly or indirectly caused by poor policy and decision-making, resulting in unwise practices by people. Hence, positive human initiatives, including strict and proper implementation of regulations, transplantation and rehabilitation of seagrass, and efforts to monitor marine ecosystems have a significant role in the protection and restoration of seagrass in the study area [28].

3.2. Seagrass and associated species cover

Table 4 shows the seagrass covers, which ranged from 32% to 42% while the associated species (macroalgae and epiphytes) ranged from 12.7% to 53.6%. The entire seagrass cover is very low, resulting in isolated patches of vegetation of seagrass in the study site. The low seagrass percent cover can be attributed to the presence of macroalgae dominating the areas without seagrass and the presence of epiphytes on the leaves of the seagrass.

Table 4. Seagrass and associated species percentage covers

Transect	Seagrass Cover (%)	Associated Species Cover (%)	
		Macroalgae	Epiphyte cover
1	42	12.7	15.9
2	32	32.3	42.3
3	33	22.3	53.6

Anthropogenic and physicochemical parameters affect the percent cover of the vegetation present in the coastal water. The percent covers may be affected by the temperature, light availability, freshwater input [22], and direct anthropogenic impacts such as dredging, fishing, and anchoring (mechanical damage), eutrophication, aquaculture, and coastal constructions as well as indirect human impacts, including climate change impacts, storms, cyclones, and floods [28].

3.3. Map of the seagrass meadows

Figure 2 shows the newly discovered seagrass meadows in Cavite, which have a total area of 1.05 hectares. The coastal waters where the seagrass meadows are located belong to the province of Cavite; however, the land belongs to the province of Batangas. This case can pose management conflicts and issues.

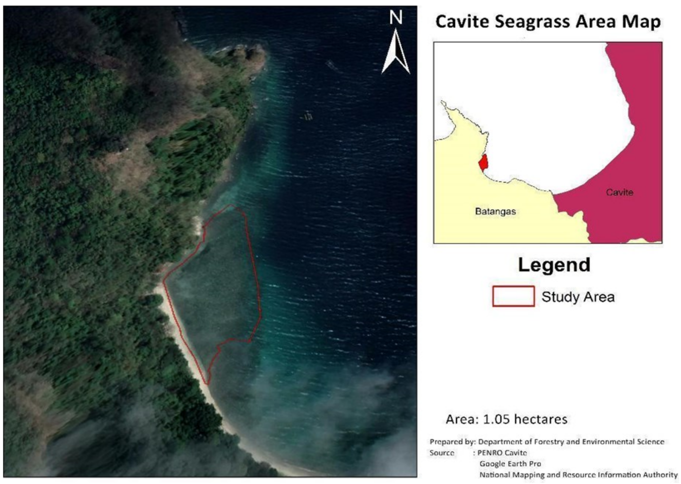

Figure 2. Map of the seagrass area in Cavite.

4. Conclusions

In light of the results of the study, the following conclusions were drawn. Three species were found in the area, *H. hemprichii*, *H. ovalis*, and *H. uninervis,* with a very low diversity index (< 1.9999 H'). The most frequently occurring, highly dense, and abundant species present is *H. hemprichii*. The seagrass covers range from 32% to 42% while the macroalgal and epiphyte cover range from 12.7% to 32% and 15% to 53.6% respectively. The entire seagrass cover is very low, resulting in isolated patches of vegetation of seagrass in the study site. This seagrass meadow has the potential to be conserved and rehabilitated if this is managed by the different stakeholders. The location of the seagrass meadow is ideal for conservation since it is on a private coast and there is limited access for tourists in the area. However, this small cover of seagrass meadows has a significant impact on the marine ecosystem as well as on the local communities since it provides a habitat and nursery for fish and other biotic diversity, and is also an important source of livelihood for the fishermen and local communities in the coastal areas. They support various kinds of biota, produce a considerable amount of organic matter, are major energy sources in the coastal marine food web, and play significant roles in nutrient regeneration and shore stabilization processes. Since the seagrass meadows are in Maragondon municipal waters and the private coast belongs to Batangas, the development of a joint province comprehensive and multi-stakeholder management plan and the declaration of protection are necessary [29].

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