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Assessment of Seagrass Distribution in Dugong Grazing Areas of Pujada Bay, Mati City, Philippines

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ABSTRACT

The study was conducted to assist and map the distribution of seagrass in dugong grazing areas of Pujada Bay, Mati City, Davao Oriental, and determine the seagrass composition, percent cover, shoot density, and relative abundance within the dugong grazing areas of Pujada Bay. Conducted from December 2016 to January 2017, it also examined environmental parameters and identified anthropogenic threats. Data on management interventions were gathered from ICRMP secondary sources. Three dugong grazing sites were studied: Taganilao (Station 1), Pujada Island (Station 2), and Lawigan (Station 3). Using aerial surveys, manta tow, and transect quadrat methods, five seagrass species were identified: *Thalassia hemprichii, Syringodium isoetifolium, Halophila ovalis, Cymodocea rotundata,* and *Enhalus acoroides. Halophila ovalis* was the only confirmed food source for dugongs. *Thalassia hemprichii* had the highest shoot density (3,890/m²) and relative abundance (40.62%), followed by *Syringodium isoetifolium* (3,451/m²; 36.03%). *Cymodocea rotundata* and *Halophila ovalis* had lower densities and abundances at 1,798/m² (18.78%) and 429/m² (4.48%), respectively. *Enhalus acoroides* showed the lowest values, with 9/m² and 0.09%. Environmental factors such as pH, salinity, and water depth, along with human activities like siltation, destructive fishing, and land conversion, were found to negatively impact seagrass growth. These findings highlight the need for conservation strategies to protect seagrass meadows and dugong habitats in Pujada Bay.

Keywords: *Halophila ovalis*, Dugong, Mati City, Manta tow, seagrass distribution

INTRODUCTION

Seagrasses are flowering plants that flourish in mildly oxygen-depleted sediments along shallow tropical and subtropical coastlines. They established a distinct ecosystem in these environments, functioning as a dominant group based on their ecological role rather than taxonomic classification (Fortes, 2013). It makes up between 0.1 and 0.2% of the world's oceans and creates extremely productive marine ecosystems essential to the coastal ecosystem (Duarte, 2002).

Seagrass is a vital resource in coastal regions, offering essential habitat and support for numerous marine organisms (Fortes, 1995). Seagrass supports complex food webs through its physical structure and primary production. It is also an essential breeding and nursery ground for crustaceans, finfish, and shellfish populations (Short and Cole, 2001). In addition to providing food, seagrass helps stabilize and secure bottom sediments, promoting ecological balance, biodiversity, and harmonious interactions among aquatic organisms (Kelleher et al., 1995). Seagrasses are also essential to the survival of turtles and dugongs (Dugong dugon) (Ame and Ayson, 2009).

Seagrasses preferred by dugongs belong to the genera Halophila and Halodule (Preen and Marsh 1995). There is a correlation between the structural and chemical composition of seagrass and diet choices (Lanyon, 1991; Aragones, 1996). The specific dietary needs of the dugong indicate that only particular seagrass meadows can serve as suitable habitats for them (Preen et al., 1995). According to Aragones and Marsh (2000), it has been proposed that the grazing behavior of dugongs changes the composition of seagrass species in specific areas to suit their food preferences better. Thus, regions that harbor large populations of dugongs might be able to offer higher-quality food compared to areas with few or no dugongs, which depend solely on natural turnover processes for nutrient recycling and distribution (Aragones and Marsh 2000).

This study aimed to assess and map the distribution of dugong seagrass grazing areas in Pujada Bay, Mati City, Davao Oriental. Specifically, it seeks to determine the grazing areas of dugongs within the bay and identify the seagrass composition, percent cover, shoot density, and relative abundance in these areas.

This study will help the local community in Pujada Bay, Mati City, Davao Oriental, to protect and conserve seagrasses. The study is significant for the local community as it serves as a basis for preserving and managing seagrasses. In addition, seagrass mapping is needed for recovery and restoration. This study will also serve as a future reference for dugong-favored seagrass species that thrive in the area and will also assist the students and future researchers who are willing and interested in studying seagrass species and gaining a better understanding of seagrass.

METHODOLOGY

Samping site

Pujada Bay, Mati City, Davao Oriental, is situated between Lawigan Point on the east and Tumago Point on the west, it lies between 6º45’ N. Latitude and 126º09’ E. Longitude. It has a distance of 9.72 km away from Mati Poblacion. This is the study area surveyed where data was gathered (Figure 1).

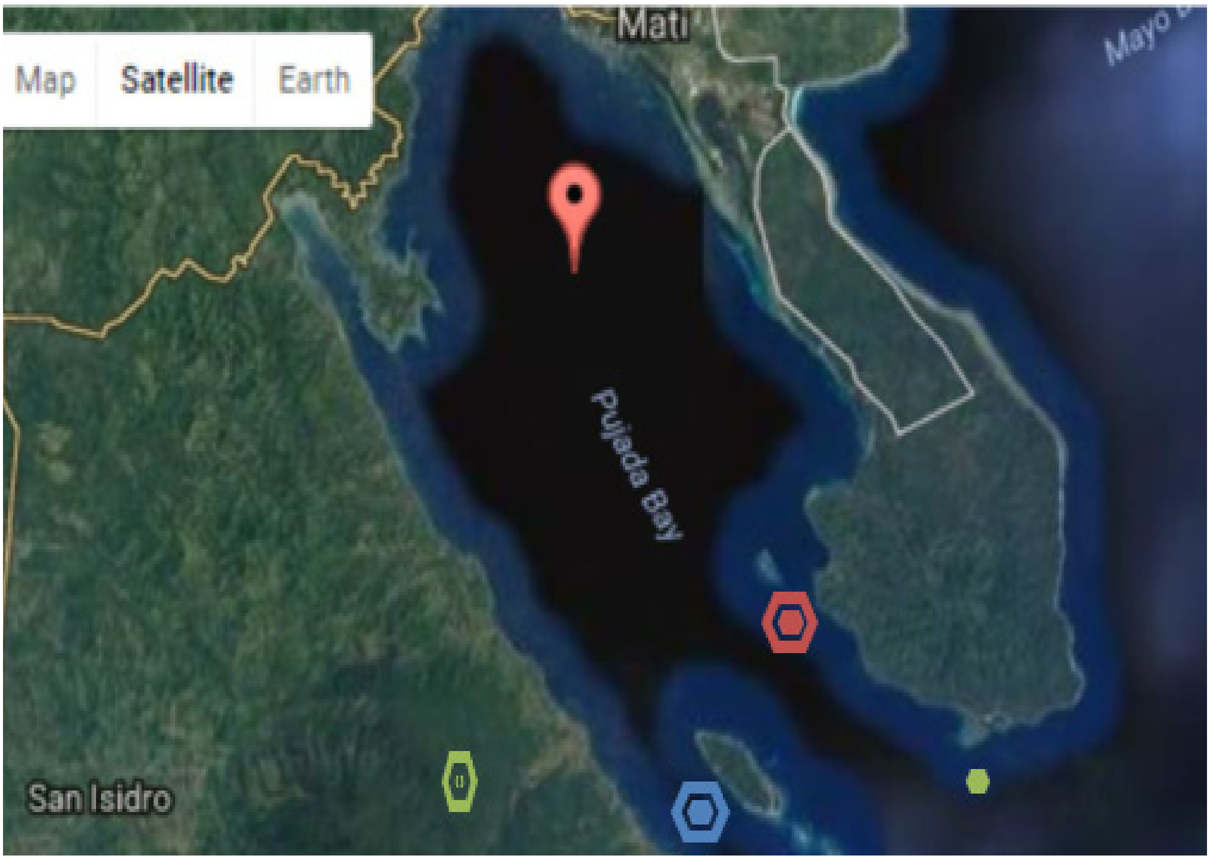

Figure 1. The map of the study area in Pujada Bay, City of Mati, Davao Oriental

Legend: Sampling sites.

Station 1 (Taganilao)

Station 2 (Pujada Island)

Station 3 (Lawigan)

Data collection

Aerial photograph

A reconnaissance survey was done in the field using aerial photographs. Aircraft and Go-Pro devices were used to photograph from the air to determine the extent of seagrass in Pujada Bay. This pre-mapping activity gives more accurate information regarding the location and general extent of seagrass meadows to be mapped (Mckenzie, 2003).

Manta tow

A manta tow was used to get the parcellary survey of the Dugong (Dugong dugon) feeding ground. The advantage of this technique over other survey techniques is that it enables large areas of seagrass meadows to be surveyed quickly and with minimal equipment. Manta tow involves towing a snorkel diver behind a small boat along the upper reef slope to observe the distribution of seagrasses on a broad scale directly (Mckenzie, 2003).

Transect-quadrat method

Three stations were established at the study site. These stations were determined based on the use of remote sensing. An aerial photo from the remote sensing was used as a guide for manta tow to assess the extent of seagrass extent and to verify the information from the images. Every station consists of three transects measuring 50m each. Ten 0.5m x 0.5m quadrats were randomly established along the transect line, each quadrat has two replicates and was documented using an underwater camera/ Go Pro (Mckenzie, 2003). Figure 3 shows the data gathering using the transect-quadrat method.

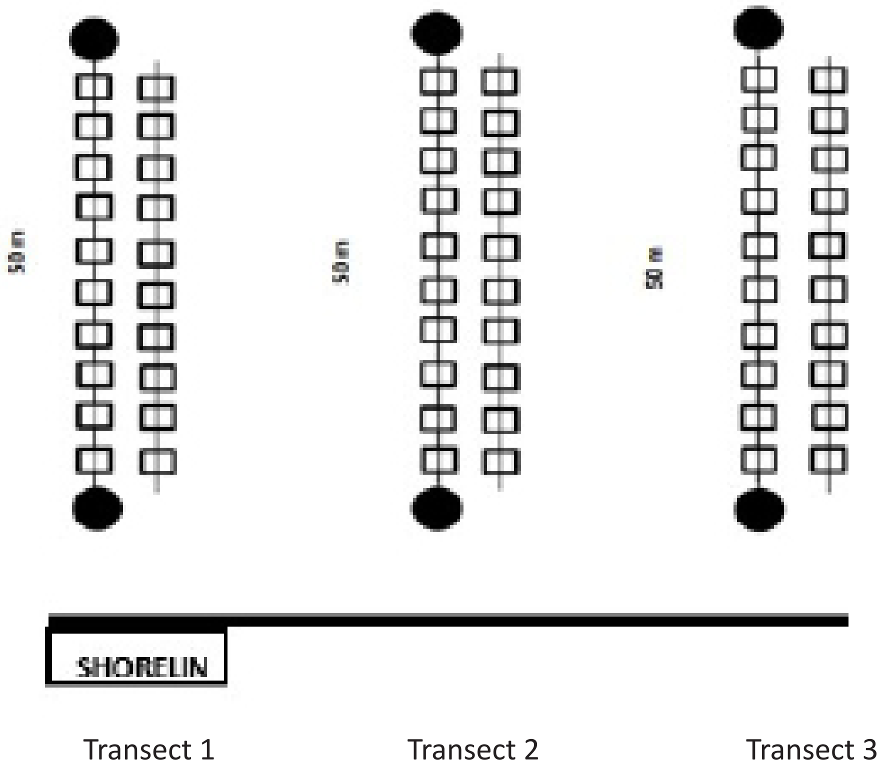

Figure 2. Illustration of the sampling method using Transect – Quadrant Method.

Legend:

- Buoy
- Quadrat
- Transect

Environmental parameters

Some environmental parameters were recorded, such as water depth, turbidity, salinity, pH, temperature, and dissolved oxygen. Water depth and turbidity were recorded using a Secchi Disc; salinity was recorded using a refractometer; pH was recorded using a pH meter; and the temperature and dissolved water were recorded using a DO meter. Readings were taken three consecutive for salinity, pH, temperature, and dissolved water.

Data analysis

1. Percent cover

The percent cover photo standard (Appendix) was used as a guide to estimate the total cover of seagrass within the quadrat (Mckenzie, 2003).

2. Population shoot density

Population Shoot Density was determined by counting the number of seagrass shoots per species in the quadrat (Calumpong et al., 1997; English et al., 1997).

$$Population\ shoot\ density = \frac{No.of\ shoots}{Area\ sampled}$$

3. Relative abundance

Relative Abundance was determined by getting the shoot counts of every species compared to the total of the species (English et al., 1997).

$$Relative\ abundance = \frac{Frequency\ value\ for\ seagrass\ species\ x\ 100}{Total\ frequency\ for\ all\ seagrass\ species}$$

4. Correlation analysis

This formula will determine the relationship between relative abundance and some environmental parameters.

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum)y^2}}$$

Data gathering

The researcher used the secondary data of ICRMP to document the management interventions.

RESULTS AND DISCUSSION

Grazing areas of dugongs (Dugong dugon)

Figure 3 below shows where Dugong (*Dugong dugon*) grazing areas are located within Pujada Bay. Taganilao (06080’81.8’’N East 126029’98.7’’E) is the Station 1, station 2 is in Pujada Island (06079’11.3’’N 126025’91.8’’E), and station 3 was located in Lawigan (06098’02.3’’N 126019’18.3’’E). Using the two methods, aerial photography and manta tow, three stations were identified as the grazing area of Dugongs because there were Dugong trails found in this area.

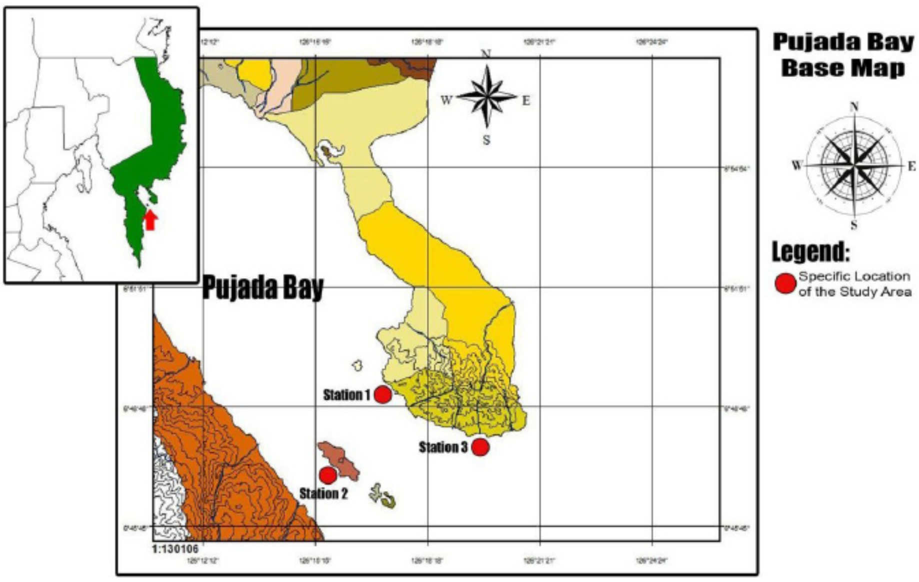

Figure 3. Map of dugong (*Dugong dugon*) grazing area in Pujada Bay.

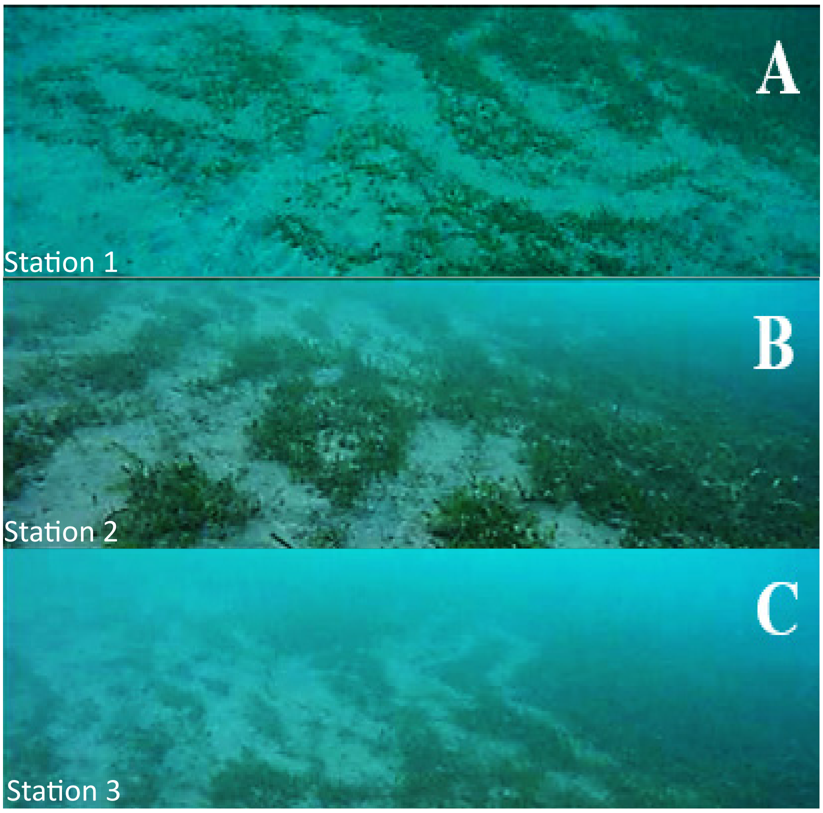

Figure 4. Dugong (*Dugong dugon*) trails found in the various station (A, B, C).

Seagrass composition

Five species of seagrass were identified in the dugong (*Dugong dugon*) grazing areas of Pujada Bay: *Thalassia hemprichii, Syringodium isoetifolium, Halophila ovalis, Cymodocea rotundata,* and *Enhalus acoroides*. All identified seagrass species were found across all sampling stations, except for *Enhalus acoroides*, which were only present in one location (Station 2). According to Short (2003), *Enhalus acoroides* is a slow-growing, persistent species with limited resistance to environmental disturbances.

Percent cover (%)

Mckenzie's (2003) photo standard of percent cover was used to estimate the percent cover of every quadrat (Figure 7). The figure shows that *Thallasia hemprichii* has the highest percent cover (%) with an average of 13.55 % in station 1, 11.9 % in station 2, and 7.5 % in station 3, followed by Syringodium isoetifolium which is also present in all station. *Halophila ovalis* and *Cymodocea rotundata* have low percent cover (%). In contrast, Enhalus acoroides has the lowest percent cover (%) of all the species and is only present in Station 2 with an average of 0.03 % (Figure 6).

According to Arriesgado (2000), *Thallasia hemprichii* and *Syringodium isoetifolium* are widespread in tropical southeast Asia, particularly in the Philippines. They are also a fast-growing and widespread species. *Halophila ovalis* is a delicate seagrass and is also more susceptible to elevated temperatures than some seagrass species (McKenzie & Campbell, 2002). Fortes (2013) states that Halophila ovalis is threatened by eutrophication, siltation, pollution, dredging, and unsustainable fishing methods. *Cymodocea rotundata* is resilient to marginal conditions, while *Enhalus acoroides* is a growing persistent species with poor resistance to perturbation (Fortes 2013).

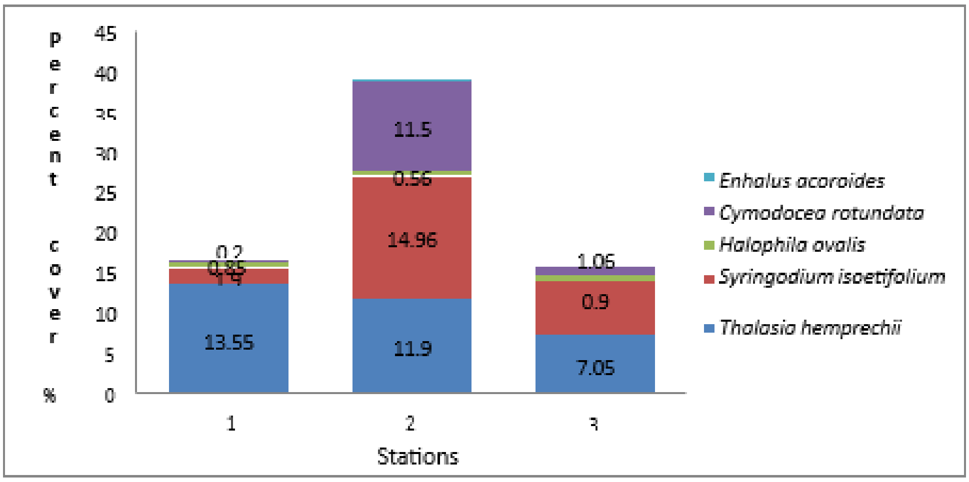

Figure 5. Percent cover (%) of the seagrass species in the grazing areas of Pujada Bay, Mati City, Davao Oriental.

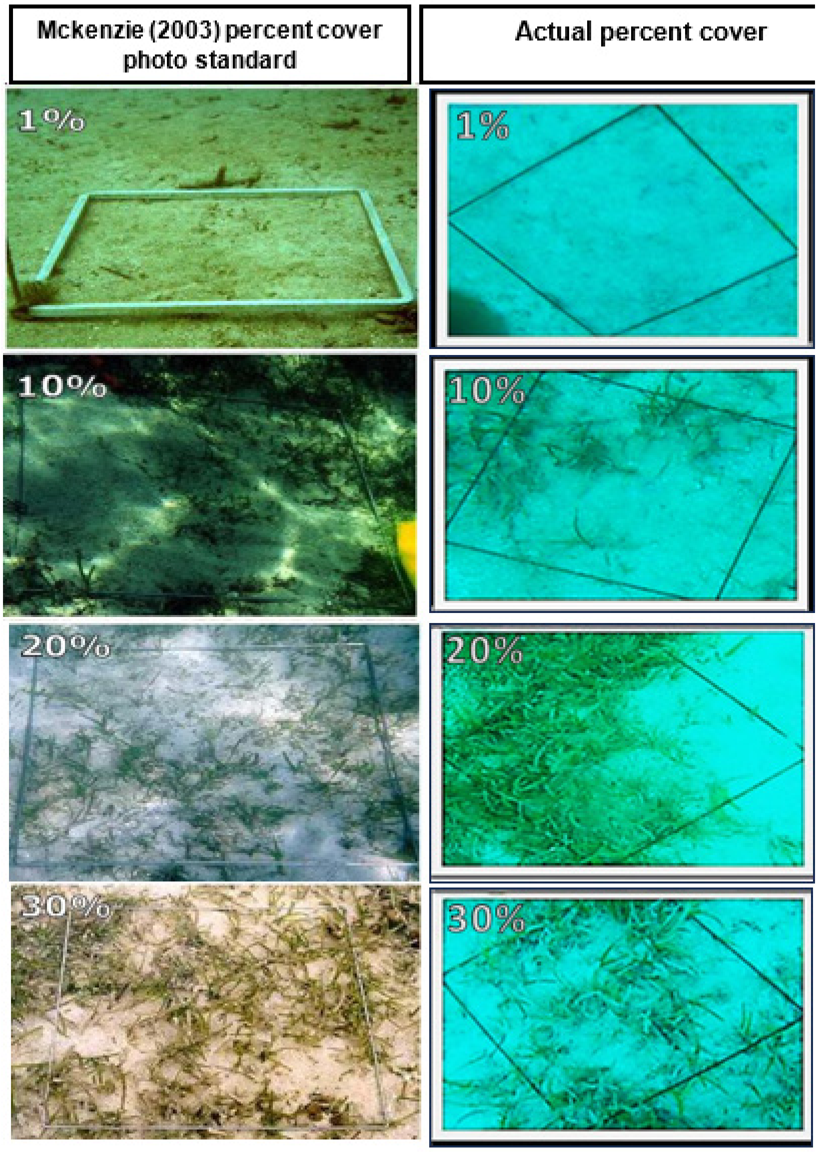

Figure 6. Seagrass percent cover standards in subtidal areas (McKenzie, 2003) and actual percent cover taken during the assessment.

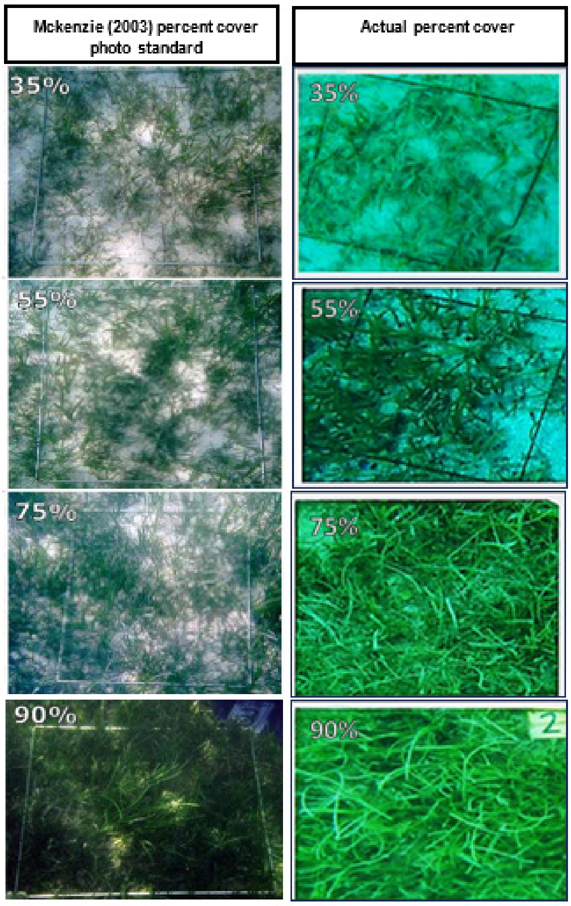

Figure 7. Seagrass percent cover standards in subtidal areas (McKenzie, 2003) and actual percent cover taken during the assessment.

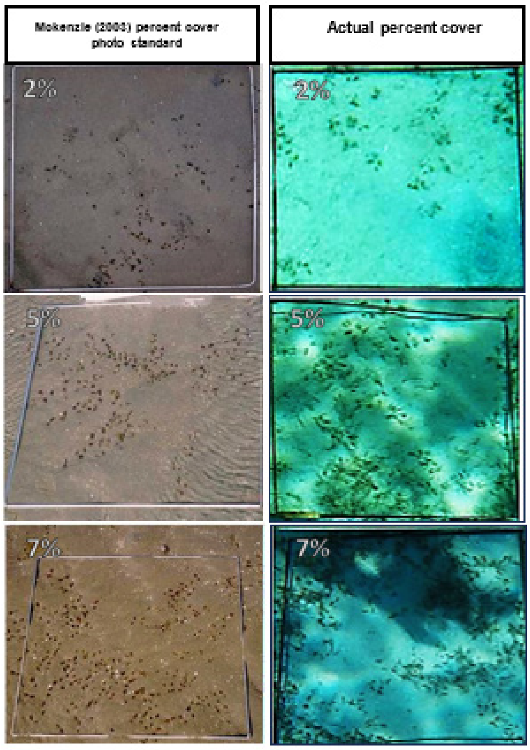

Figure 8. Seagrass percent cover standards in subtidal areas (McKenzie, 2003) and actual percent cover taken during the assessment.

Population density and relative abundance

The highest population shoot density was Thallasia hemprichii, which had a total number of 3890/m^2 shoots and a 40.62% relative abundance. At the same time, syringodium isoetifolium has the second highest population shoot density, with a total number of 3451/m^2 and 36.03 % relative abundance. Cymodocea rotundata comes third with 1798 /m^2 and 18.78 % relative abundance, followed by Halophila ovalis with 429/m^2 shoots and 4.48 % relative abundance. The lowest population shoot density is the Enhalus acoroides, which are present only in station 2 with a total number of 9/m^2 shoots with 0.09% relative abundance (Figure 9).

Seagrasses are affected by problems associated with natural events, overgrazing by marine animals, such as dugong, and severe weather conditions and changes to environmental parameters, which either cause seagrass blades to break along their length or completely uproot the plants. The most obvious source of human impact on the seagrass ecosystem is physical disturbance caused by human usage of the coastal zone for transportation,

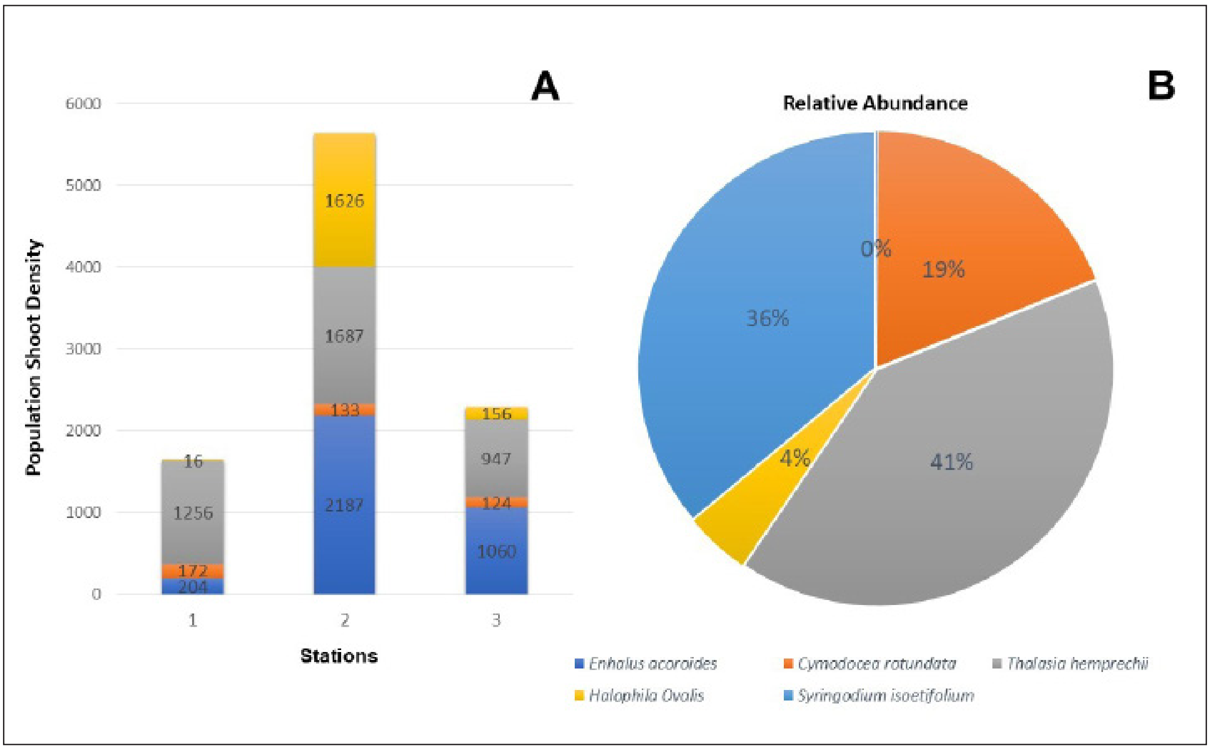

Figure 9. Population density and relative abundance of the seagrass species in the grazing areas of Pujada Bay, Mati City, Davao Oriental.

Environmental parameters

The researcher recorded the various environmental factors or parameters such as pH, salinity, dissolved oxygen, temperature, water depth, and substrate that may affect seagrass growth.

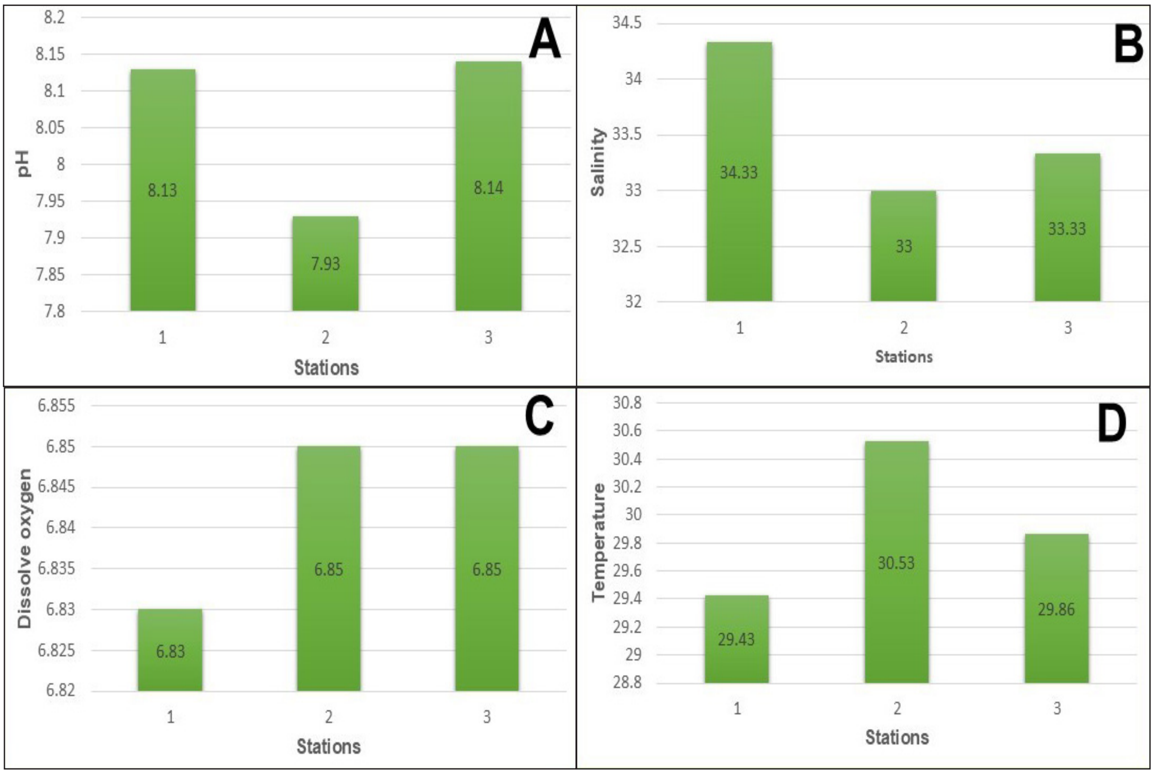

Figure 10. Observations of the water's pH (A), salinity (B), dissolve oxygen (C), and temperature (D) in the grazing areas in Pujada Bay, Mati City, Davao Oriental.

pH

The highest pH reading was observed in station 3 with a mean value of 8.14, followed by station 1 with a mean value of 8.13, while the lowest reading was observed in station 2 with a mean value of 7.93 (Figure 10). According to Odum (1971), the normal pH of seawater for seagrasses to survive is about 8.2.

The correlation for pH in the study area has an r-value of (-0.981) with remarks of high negative correlation. This implies that as the pH level increases, the abundance and density of seagrass species decreases.

Salinity (ppt)

Station 1 had the highest reading of salinity with a mean value of 34.33ppt, followed by a mean value of 33.33ppt in station 3, while the lowest mean value was station 2 with a mean value of 33 ppt. Greve & Binzer (2004) state that seagrass can withstand a salinity of about 42 to 35 ppt. Salinity influences the osmotic pressure within cells, but many seagrasses are highly adaptable to sudden fluctuations in salinity. The observed strong negative correlation (r = -0.795) suggests that as salinity levels decrease, the abundance and density of seagrass species in the area increase.

Dissolve oxygen (mg/L)

Stations 2 and 3 had the highest dissolved oxygen reading with a mean value of 68.5mg/L, while the lowest reading was recorded in station 1 with an average of 6.83mg/L (Figure 10).

The result on correlation for Dissolved Oxygen in the area has an r-value of (0.063) with a remark of negligible or zero correlation. There is no significant relationship between the dissolved oxygen and the seagrass species in the sampling area.

Temperature (^0C)

The highest temperature reading was recorded in station 2 with an average of 30.53˚C, followed by station 3 with an average of 29.86˚C. In contrast, the lowest temperature reading was recorded in station 1 with an average of 29.43˚C (Figure 10). According to Collier et al. (2017), it implies that seagrass species are suited to their respective local thermal conditions, and their growth rates are influenced by temperature fluctuations within their particular optimal ranges.

The remark for temperature in the study site had a high negative correlation with the r-value of (0.97), which implies that as temperature increases, the abundance and density of seagrass decreases and vice versa.

Water depth (m)

Station 1 and Station 2 have the highest water depth reading, with an average of 4.75m, while station 3 has the lowest reading, with an average of 4.5m. These variations in depth can affect seagrass growth, as demonstrated by Serrano et al. (2014), who found that carbon sequestration rates in seagrasses like *Posidonia oceanica* decreased at greater depths due to reduced light availability. This suggests that shallower areas like those at stations 1 and 2 may promote stronger seagrass growth than the deeper station 3. Furthermore, a slight positive correlation (r = 0.36) was found between water depth and the abundance of seagrass, suggesting that the quantity and density of seagrass generally also increase as the water depth rises.

Substrate type

The type of substrate is an essential element for the survival of seagrasses, as their roots attach to the sediment and acquire vital nutrients from it. Fortes (2013) notes that seagrasses generally inhabit benthic environments comprised of soft substrates such as sand and mud, where their roots can firmly anchor and rhizomes can extend. Observations from the current study found that at all locations where dugong trails were present, the substrate was a combination of sand and mud, corresponding with the suitable habitat for seagrasses. Additionally, seagrasses play a role in enhancing the stability of these substrates. Connolly (2009) emphasizes that seagrasses are crucial for sediment stabilization through their root systems by diminishing water flow velocity and encouraging sediment deposition. This mechanism establishes a positive feedback loop, where increased seagrass growth further improves substrate stability, thus creating an ideal environment for their ongoing development.

Management intervention

Seagrasses of East Asia (Fortes, 1995) Management interventions for addressing the loss of seagrass and soft-bottom habitats include:

- Mapping and identification of beds to catalog the extent and location of the resource;
- Zoning to prioritize the use of space between pristine seagrass meadows versus those that are disturbed, altered, or newly emergent;
- Controlling fishing methods to ban bottom trawling, blast fishing, and other methods of harvesting which tear up the bottom and cause turbidity;
- Reducing pollution by enforcing prohibitions against the discharge of urban and industrial effluent and sea dumping of solid waste or dredge spoils and by reducing the amount of impervious surface area in the upland areas abutting the shoreline. Maintaining vegetated buffers along the shoreline and around disturbed sites to filter the runoff and promote infiltration of water into the ground; improve logging,

mining, and agriculture practices to prevent erosion;

- Control coastal construction and beach nourishment;
- Transplanting shows signs of success from experimental transplanting; however, careful selection of the transplant site regarding light, nutrients, sediment type, and stability is essential while considering relative cost and benefits and
- Recreation and tourism opportunities can provide alternative sources of income to replace the revenue generated by activities that degrade seagrass beds.

Pujada Bay, located in Davao Oriental province in southeastern Mindanao, Philippines, is located roughly 165 km to the east of Davao City. The Pujada Bay Protected Seascape (PBPS) covers an area of 21,200 ha along the bay's coastline (Utzurrum et al., 2016). This area was officially recognized as a nature reserve on July 31, 1994, through Presidential Proclamation No. 431, as part of the National Integrated Protected Areas System (NIPAS). The City of Mati, in partnership with the Protected Area Management Board (PAMB), manages the Pujada Bay Protected Seascape (Reboton & Calumpong, 2015).

However, the management of seagrass ecosystems in the bay is still inadequate. The City Environment and Natural Resources Office (CENRO) in Mati performs regular evaluations and monitoring of various species, including seagrasses, yet does not carry out specific management strategies or maintain a scheduled plan for these activities. This finding aligns with the research conducted by AngSinco-Jimene et al. (2003), who examined seagrass and macrobenthic algae in Pujada Bay from September 2001 to August 2002. Their study discovered nine species of seagrasses in the region and highlighted the necessity for effective conservation and management strategies to tackle the increasing pressures on these essential ecosystems.

Anthropogenic disturbance

The most obvious source of human impact on the seagrass ecosystem is a physical disturbance caused by human usage of the coastal zone for transportation, recreation, and food production. Direct habitat destruction by land reclamation and port construction is a significant disturbance to seagrass meadows due to dredging and landfill activities and the consequent reduction in water transparency. Such disturbance is now recognized as an essential source of change to the seagrass ecosystem. These changes result from direct physical modification or indirectly through impacts on water quality, including increased nutrient loads (leading to eutrophication) and increased sediment loads in environments that support seagrass (Short and Wyllie-Echeverria 1996).

During the study sampling, it was observed that anthropogenic activities are one of the factors that affect seagrass growth. Seagrasses have been destructed by siltation, destructive fishing, and conversion to other uses such as fishponds and human settlements, increasing threats to biodiversity.

CONCLUSION

Three locations were assessed for dugong grazing in Pujada Bay, City of Mati, Davao Oriental: Taganilao (Station 1), Pujada Island (Station 2), and Lawigan (Station 3). The research found five species of seagrass present in the region: Thalassia hemprichii, Syringodium isoetifolium, Halophila ovalis, Cymodocea rotundata, and Enhalus acoroides. Thalassia hemprichii was the most prevalent, with an average relative abundance of 41.19%, while Enhalus acoroides was the least common, at just 0.09%. It was noted that human activities, along with environmental factors such as pH, salinity, and water depth, significantly influence the seagrass abundance in the region. Regarding seagrass management in Pujada Bay, the City Environment and Natural Resources Office (CENRO) in Mati indicated that no specific management measures have been implemented; their efforts are mainly focused on conducting assessments and monitoring different species.

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