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SEAGRASS ORGANIC CARBON STOCK IN ALANG-ALANG BEACH, KARIMUNJAWA

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ABSTRACT

The research was conducted in Alang-alang beach, Karimunjawa, in December 2019. The research method used descriptive explorative. Sampling was carried out at 18 points on Alang-Alang beach using a purposive sampling method with the help of line transects and transect quadrants. Observation method seagrass using seagrass watch. The results of this study indicate that found four different types of seagrasses were in Alang-alang beach, Karimunjawa, namely *Enhalus acoroides* (Ea), *Thalassia hemprichii* (Th), *Cymodocea rotundata*, (Cr) and *Cymodocea serrulata* (Cs), with a kind of seagrass that dominate these waters are the type of *Thalassia hemprichii*. The highest seagrass density is on line 6, which is 256 shoot m^{-2} with Th as a dominant, and line 5 (238 shoot m^{-2}) with Cr as a dominant. While, the lowest density is on line 1 (28 shoot m^{-2}) with Ea as a dominant. In this research above ground biomass (1.35 g m^{-2}) has a higher value than below-ground biomass (1.25 g m^{-2}), with Ea having the highest biomass, while Cr has the lowest, but Cr has a high density. Therefore, the highest organic carbon stock (OCS) is Ea (103.216 g Corg m^{-2}), while the seagrass species that has the smallest OCS is Th (61.562 g Corg m^{-2}). The average organic carbon stock obtained was 35.07 g Corg m^{-2}.

Keywords: biomass; carbon; seagrass; Alang-alang; Karimunjawa

INTRODUCTION

Human activities that are not environmentally friendly are increasing every year, this has led to an increase in greenhouse gases (IPCC, 2019, Friedlingstein et al., 2020). One of the ways that can be done to reduce CO_2 gas is by maintaining forests and oceans as carbon storage (A. Wahyudi et al., 2019). According to (Rustam et al., 2019), anthropogenic CO_2 in the atmosphere can be absorbed by land vegetation and aquatic biota as a material for photosynthesis. Marine and coastal ecosystems have a large role in the global carbon cycle. Kawaroe (2009) and Le Quéré et al. (2013) reported that marine plants in coastal ecosystems are quite efficient in helping to prevent global warming because they can store 27-50% of the carbon in the ocean.

Seagrass beds are one of the ecosystems that can absorb and store anthropogenic CO_2 (Alongi et al., 2016, Bulmer et al., 2020, Kim et al., 2022). The function of seagrass is as carbon storage in the ocean (carbon sink) or known as blue carbon and is used for the photosynthesis process (Kawaroe, 2009, Alexandre et al., 2012). Types of seagrass that play a major role in carbon storage are *Enhalus acoroides*, *Cymodocea serrulata*, and Syringodium *isoetifolium* (Case et al., 2014). The result of (Wahyudi et al., 2020) reported that 13 types of seagrass were found from 34 provinces in Indonesia. The contribution of seagrass vegetation to carbon storage begins with the process of the oceans being able to absorb CO_2 from the atmosphere, then CO_2 turns into bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) which seagrass use for photosynthesis and is stored in the above-ground and below-ground biomass then deposited in sediments.

Karimunjawa is a National Park which functions to support nature conservation, tourism, research, and education. Karimunjawa Islands are in Central Java Province. Seagrass beds in the Karimunjawa Islands are included in three important ecosystems that need to be preserved. According to (Ristina et al., 2018), Alang-Alang Beach is a settlement with seagrass beds that are still in good condition. The results research of (Hartoko et al., 2021) showed that in Karimunjawa waters there were 4 types of seagrass: *Enhalus acoroides*, *Thalassia hemprichii*, *Halophila ovalis*, *Halodule pinifolia* at Pokemon Beach and Bobby Beach, with an estimated seagrass carbon content of 12.44 – 77.30 gC.m^{-2}. These results show a lack of estimation of carbon content in Alang-Alang Beach, Karimunjawa. Therefore, the purpose of this study to determine the type of seagrass, seagrass density, estimate the biomass and carbon content of seagrass (above and below ground) and determine the factors that affect seagrass carbon contents.

RESEARCH METHODS

This research was conducted in December 2019 in the waters of Alang-Alang Beach, Karimunjawa. The method used in this research is the descriptive exploratory method. Determination of the point of field data collection was done by purposive sampling. Sampling was carried out at 1 station with 6 points measuring transect lines and 18 points on the transect quadrant (Fig. 1.).

The field observations we made were observing seagrass species, calculating seagrass density, measuring water quality variables (depth, pH, temperature, salinity, and light intensity), and taking seagrass samples from the leaves (above-ground) to the rhizomes and roots (below-ground). The seagrass samples were then put into a ziplock and stored in a coolbox. Furthermore, analysis of seagrass samples uses the Loss of Ignition (LOI) method so that the %LOI value will be obtained. The test was carried out at the Nutrition and Feed

Science Laboratory (INP), Faculty of Animal and Agriculture (FPP), Universitas Diponegoro. While the analysis of water quality was carried out at the Laboratory of Resource Management for Aquatic Sciences (PSDIL), Faculty of Fisheries and Marine Sciences (FPIK), Universitas Diponegoro.

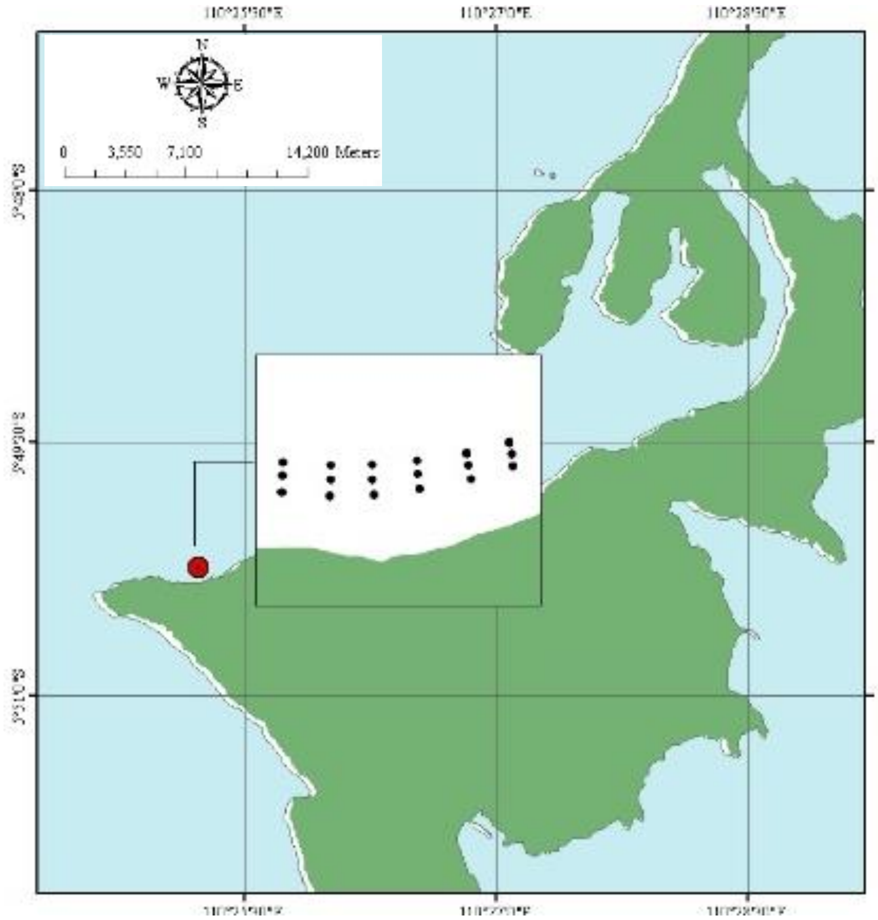

Figure 1. Map of Research Location

Seagrass Density and Cover Percentage

The formula for calculating the density of seagrass according to (Khouw, 2009) is:

$$Di = \frac{\sum ni}{Ai} \quad \text{.......................1)}$$

Di: density of type-i seagrass (individual.m^{-2}), ∑ni: number of i-type seagrass shoots (individual), Ai: total area of the transect when the i-type seagrass was found (m^{2})

According to (Susi Rahmawati et al., 2014) how to calculate seagrass cover in one square is to add up the value of seagrass cover in each small box in the transect quadrant and divide by the number of small boxes:

$$\text{Average seagrass cover} = \frac{\Sigma \text{ seagrass cover for all transects}}{\Sigma \text{ quadrant across transects}} \quad (2)$$

Diversity, Uniformity and Dominance Index

Data analysis was performed using the diversity index, uniformity and dominance can be determined using the Shannon-Wienner information theory. Diversity is determined based on the Shannon-Wiener diversity index (Krebs, 1978) with the formula:

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad \text{.......................(3)}$$

H '= ShannonWienner's index of diversity, pi = ni / N, ni = Number of individuals of type I, N = total number of individuals, S = Number of genera / species. With value: H 'value> 3 high species diversity, the value of H '1 ≤ H' ≤ 3 is moderate species diversity, and H 'value <1 species diversity is low.

The uniformity index is used to determine the number of similarities in the distribution of seagrass (Odum, 1998):

$$E = \frac{H}{H'maks} \quad \text{.......................(5)}$$

E = uniformity index, H '= diversity index, H 'max = maximum diversity index (ln S, where S is the number of species) The uniformity index ranges from 0-1.

The dominance of certain types of seagrass in the waters can be determined by a dominance index (Odum, 1998):

$$D = \sum_{i=1}^{s} \left(\frac{ni}{N}\right) \quad \text{..................(6)}$$

D = Domination Index, N = Total number of individuals in the sample, ni = number of individual species i.

Calculation of Seagrass biomass

According to (Helrich, 1990) the formulas used in calculating carbon concentration include the formula for calculating the ash content. The formula used to calculate biomass:

$$B = W \times D \quad \text{.......................(7)}$$

B: seagrass biomass (g.m^{-2}), W: seagrass shoot dry weight (g.shoot^{-1}), D: seagrass density (shoot.m^{-2})

The formula used to calculate the content of the seagrass network with LOI method (Helrich, 1990):

$$\%LOI = \frac{[(b-a)-(c-a)]}{(b-a)} \times 100\% \text{......................(8)}$$

a: the weight of the cup, b: plate weight + sample weight, c: weight (cup + ash)

After the results are obtained, they are calculated tissue carbon content using the formula (Fourqurean et al., 2012):

$$\%C_{org} = 0.43 \times \%LOI - 0.33 \text{ ....(9)}$$

Calculation of Organic Carbon Stock Seagrass

Calculation of the organic carbon stock (OCS) of seagrass was analyzed by converting the biomass data into organic carbon content (OCC) (Sulaeman et al., 2005; (Rahmawati el al., 2019). The increase in biomass will have a positive correlation with the increase in seagrass carbon content in above-ground (leaves) and below-ground (rhizome and roots) (Graha et al., 2015). Then, the total carbon stock was calculated using the analysis of conversion of biomass data to carbon content. Overall carbon conversion results are averaged in units of g.m^{-2} (Howard et al., 2014).

RESULT AND DISCUSSION

Seagrass Ecological Index

Seagrass ecological index value is used to see the balance of the seagrass ecosystem in Alang-Alang Beach, Karimunjawa. The ecological index values of seagrass include diversity, uniformity and dominance. The value of the seagrass diversity index at the research location ranged from 0.956 to 1.215. The value of the research results that are categorized as low, on line 2, for lines 1,3,4,5 and 6 are categorized as having high diversity. According to (Sugianti and Mujiyanto, 2015) that the value of diversity will increase if the number of species found is increasing, and the proportion of each type is more evenly distributed.

The seagrass uniformity index value at the study location ranged from 0.834 – 0.992 which was in the high category. The highest uniformity index value is on line 3 and the lowest is on line 5, but the uniformity value on lines 1 to 6 can be categorized as having high uniformity values. According to (Sugianti & Mujiyanto, 2015) that the uniformity index value shows that the low distribution value of seagrass means there are dominant species. This can be due to changes in water quality so that only a few types of seagrass can adapt to that location.

The index value of seagrass dominance at the study location ranged from 0.330 to 0.436 which can be categorized as low. The highest dominance value is on line 2 while the lowest dominance value is on line 4, but the dominance value on lines 1 to 6 is categorized as low. According to (Hoek et al., 2013) if the dominance value is 1 or more species in a community, then usually followed by a small uniformity value.

Seagrass Density and Cover Percentage

In this study, 4 species of seagrass were found on the Alang-alang beach, namely *Enhalus acoroides* (Ea), *Thalassia hemprichii* (Th), *Cymodocea rotundata* (Cr) and *Cymodocea serrulata* (Cs). The type of seagrass that dominates this beach is Th with a total of 209 shoots of seagrass (Fig 2.) and a seagrass density of 838 shoots.ind-1 (Fig 3.). Meanwhile, Ea was the lowest seagrass species with 47 shoots and 191.33 shoots.

The research location has a sand substrate and is close to a coral ecosystem. According to (Wicaksono & Hartati, 2012) that *Thalassia hemprichi*i is found in areas with sand and coral rubble substrates. Morphologically, this species has a thick and sturdy rhizome that allows it to grow on a variety of substrates. According to (Ristina et al., 2018) that *Thalassia hemprichii* has good adaptability because it has fibrous roots with root microzomes that are aerobic so that they are able to colonize denser in shallow habitats compared to other seagrass species.

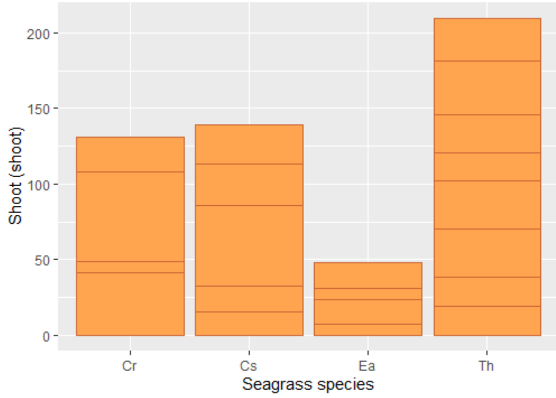

Figure 2. Number of Seagrass Stands of Alang-Alang Beach, Karimunjawa

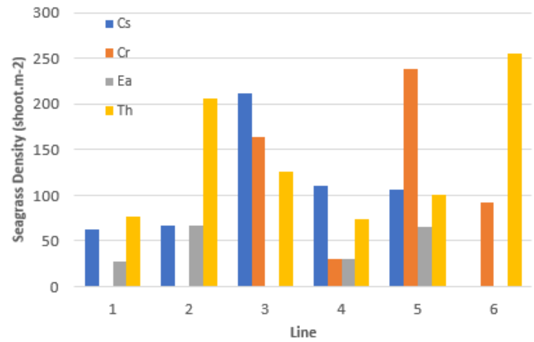

Figure 3. Seagrass Density of Alang-Alang Beach, Karimunjawa

The highest seagrass density is on line 6 (Fig. 3.), which is 256 shoot m^{-2} with Th (*Thalassia hemprichii*) as a dominant, and line 5 (238 shoot m^{-2}) with Cr (*Cymodocea rotundata*) as a dominant). While the lowest density is on line 1 (Fig 3.), which is 28 shoot m^{-2} with Ea (*Enhalus acoroides*) as a dominant.

The results of the percentage value of seagrass cover can be seen in the graph (Fig 4.). Based on this graph, it can be seen that the seagrass cover at the research location that has the highest value is located on line 5 while the lowest cover value is located on line 1. According to (Ganefiani et al., 2019) the calculation of seagrass density has a function to determine the number of stands (shoot) in one quadrant area is expressed in units (shoot m^{-2}), while the percentage of seagrass cover serves to describe the area of seagrass covering the waters expressed in units (%).

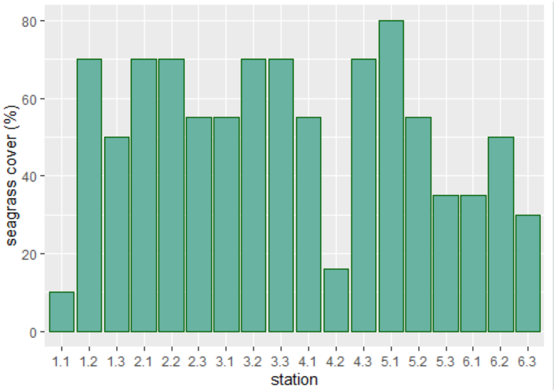

Figure 4. Seagrass Cover at Each Line

Biomass and Organic Carbon Stock (OCS) in Seagrass

Research results regarding percentage of organic carbon, dry weight, biomass and organic carbon stock seagrass in Alang-alang beach are in Table 1.

The results of Table 1 show that above ground biomass (1.35 g m^{-2}) has a higher value than below ground biomass (1.25 g m^{-2}). These results are different from research Wahyudi et al. (2016) and Case et al. (2014), that the bottom biomass of the substrate is usually of greater value than the biomass above the substrate. Ndari et al. (2019) state that the overall weight of seagrass is often dominated by the biomass below the substrate. This is because the material formed at the bottom of the substrate has a denser texture than the seagrass part at the top of the substrate.

The total value of seagrass biomass in each species is presented in the graph (Table 2.). Based on this graph, Ea (1.425 g m^{-2}) has the highest biomass, while Cr has the lowest (1.278 g m^{-2}). This is explained by (Indriani et al., 2017) that *Enhalus acoroides* has a greater biomass value than Thalassia hemprichii. This is also explained by (Hartati et al., 2017) that *Enhalus acoroides* has high biomass because of the morphology of the seagrass itself, while the *Cymodocea rotundata* type of seagrass has a high density so that even though the morphology of the seagrass is small.

Table 1. Seagrass Biomass and Organic Carbon Stock in Alang-Alang Beach

Line transect	%LOI (%)		%Corg (%)		Dry weight (g)		Seagrass biomass ($g.m^{-2}$)		Organic Carbon Stock ($gCorg.m^{-2}$)	
	AG	BG	AG	BG	AG	BG	AG	BG	AG	BG
1	67.06	64.95	28.51	27.60	0.30	0.31	1.19	1.26	33.89	36.08
2	68.65	67.77	29.19	28.81	0.33	0.31	1.33	1.24	39.40	37.24
3	58.34	57.38	24.75	24.34	0.28	0.27	1.12	1.06	27.84	26.08
4	70.77	67.48	30.10	28.69	0.36	0.29	1.42	1.18	42.80	33.99
5	64.05	56.49	27.21	23.96	0.40	0.36	1.59	1.46	43.15	34.77
6	62.67	50.45	26.62	21.36	0.36	0.32	1.42	1.28	37.76	27.85
Average	**65.26**	**60.75**	**27.73**	**25.79**	**0.34**	**0.31**	**1.35**	**1.25**	**37.47**	**32.67**

Table 2. Seagrass Biomass at Species in Alang-Alang Beach

Seagrass species	Average Biomass (g m^{-2})
Cr	1.278
Cs	1.289
Ea	1.425
Th	1.309

The results of the organic carbon stock (OCS) in each type of seagrass found in Alang-Alang Beach, Karimunjawa can be seen in the graph (Fig. 6.). The graph shows that the type with the highest OCS is *Enhalus acoroides* (103.216 g Corg m^{-2}), while the seagrass species that has the smallest OCS is *Thalassia hemprichii* (61.562 g Corg m^{-2}). This is explained by (Ganefiani et al., 2019) that the magnitude of the biomass value in seagrass is coinciding with the value of the resulting carbon content.

The average organic carbon stock obtained was 35.07 g Corg m^{-2}. This value is grather than the research (Ganefiani et al., 2019) conducted at Karimunjawa Port and Pancuran Beach, Karimunjawa, which has a carbon stock value of 30.92 g Corg m^{-2}. The average organic carbon stock in this study is smaller than the research (Hartati et al., 2017) with an average carbon yield of 57.05 g Corg m^{-2}. According to (Rahmawati, 2011) the decrease in carbon value every year can be caused by the entry of dissolved particles into the water column and sediment which causes environmental conditions not in accordance with the durability of seagrasses.

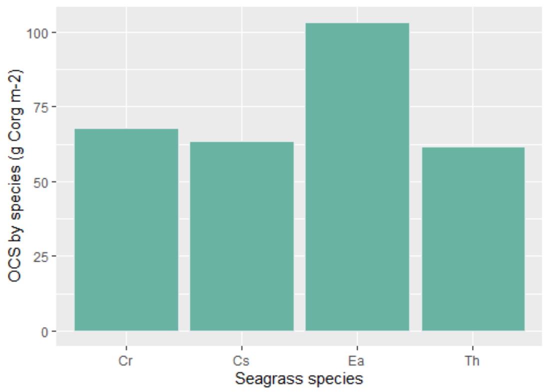

Figure 6. Total Carbon in Each Type of Seagrass

CONCLUSION

The conclusions of the research are the types of seagrass found on the coast of Alang-alang, Karimunjawa consist of 4 species: *Enhalus acoroides* (Ea), *Thalassia hemprichii* (Th), *Cymodocea rotundata* (Cr) and *Cymodocea serrulata* (Cs). The type of seagrass that dominates this beach is Th and Ea was the lowest seagrass species. The highest seagrass density is on line 6 with Th as a dominant, and line 5 with Cr as a dominant. While, the lowest density is on line 1 with Ea as a dominant.

In this research above ground biomass has a higher value than below ground biomass, with Ea has the highest biomass, while Cr has the lowest but Cr has a high density. Therefore, the highest organic carbon stock (OCS) is Ea, while the seagrass species that has the smallest OCS is Th.

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