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Carbon Absorption Potential on Seagrass Types Enhalus acoroides and Thalassia hemprichii in Morotai Island Water

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Abstract: Seagrass is one of the most important ecosystems in coastal areas. Seagrass beds can absorb carbon of 1.15 tons/ha, with a carbon content below the substrate of 0.88 tons/ha (76.3%), higher than the carbon above the substrate, which is only 0.27 tons/ha (23, 7%). Research on carbon absorption in seagrass is still relatively carried out, so it is necessary to research the potential for carbon absorption in seagrass types Enhalus acoroides and Thalassia hemprichii in Morotai waters. The research will be carried out from September to December 2021, starting with seagrass sampling in three sub-districts (South Morotai, East Morotai, and South West Morotai Districts). The types of seagrass used were *Enhalus acoroides* and *Thalassia hemprichii*. Biomass sample analysis was carried out at the Basic Laboratory of the Faculty of Fisheries and Marine Sciences, Pacific Morotai University. Carbon analysis on seagrass was carried out at the Chemical Oceanography Laboratory of the Faculty of Marine and Fisheries Sciences, Hasanudin University Makassar. The seagrass sampling method used the quadratic transect method and sample analysis using the method Loss On Ignition (LOI). The results showed that *Thalassia hemprichii* has the highest carbon content in the roots, with a value of 38.94 gC/m^2 to 49.48 gC/m^2. In contrast, Enhalus acoroides has the highest carbon content in the roots with a carbon value of 30.77 gC/m^2 to 37.86 gC/m^2.

Keywords: Seagrass, carbon, Morotai Island

1. Introduction

Climate change occurs due to global warming from the effects of greenhouse gases which can hurt the environment. Greenhouse gases are gases in the atmosphere that have the potential to inhibit solar radiation reflected by the earth, causing the temperature on the earth's surface to be warm or high. One of the biggest contributors to greenhouse gas emissions is CO_2 (Uthbah, 2017). Carbon is one of the elements absorbed from the atmosphere and stored in the form of plant biomass on land and sea through photosynthesis. Seagrass is one of the most marine ecosystems that have the potential a carbon sink. Seagrass is a flowering plant that grows in shallow waters (Tristanto et al., 2014). Seagrass is one of the most important ecosystems in coastal areas. Seagrasses also have a major role as a carbon source storage called blue carbon that needs to be considered (Rahmawati, 2011). According to Supriadi (2014), seagrass beds can absorb carbon of 1.15 tons/ha, with a carbon content below the substrate of 0.88 tons/ha (76.3%), higher than the carbon above the substrate, which is only 0.27. ton/ha (23.7%). The bottom of the seagrass substrate has the potential of the substrate is likely to be stored longer and will continue to grow if the seagrass ecosystem is protected from damage, while the upper part of the substrate is used more in the food chain (Rustam, 2014). Based on research by Graha (2016), seagrass is one of the marine resources that act as a CO_2 gas absorber. The carbon sequestration of seagrass during the photosynthesis process will be stored in the form of biomass both at the top and bottom of the substrate. (Supriadi, 2014). The existence of seagrass is very necessary because it can absorb carbon in the ocean. Research on carbon sequestration in seagrass is still relatively carried out, so it is necessary to research the potential for carbon absorption in seagrass types *Enhalus acoroides* and *Thalassia hemprichii* in Morotai waters.

2. RESEARCH METHOD

Time and place

The research will be carried out from September to December 2021, starting with seagrass sampling in three sub-districts (South Morotai, East Morotai, and South West Morotai Districts). The types of seagrass used were Enhalus acoroides and Thalassia hemprichii. Biomass samples were analyzed at the Basic Laboratory of the Faculty of Fisheries and Marine Sciences, Universitas Pasifik Morotai. Carbon analysis on seagrass was carried out at the Chemical Oceanography Laboratory of the Faculty of Marine and Fisheries Sciences, Hasanudin University Makassar.

Research Tools and Materials

The tools used in this research are a diving knife, shovel, plastic sample, GPS, thermometer, hand refractometer, pH meter, permanent marker, oven, electric furnace, digital scale, roll meter, exchange cup, porcelain dish, desiccator and 1x1 m square. While the materials used are aluminum foil, label paper, and seagrass as the test samples.

Seagrass Data Collection Procedure

The method used in sampling seagrass is the purposive sampling method (Sugiyono, 2016) which was taken at three stations, namely station I in Juanga village (South Morotai), station II in the waters of Sangowo village (East Morotai) and station III in the waters of Wayabula village (East Morotai). Morotai South West). This study intentionally chose the research location by looking at the level of cover and density of seagrass to represent or describe the seagrass condition in Morotai Island waters. The seagrass sampling method uses the quadratic transect method. As many as 3 line transects are stretched at each station point with a length of 50 m stretched perpendicular to the shoreline with a distance of each line transect is 25 m. A quadratic transect is placement of line transects on the right with a distance between squares of 25 m, the total square of the three stations is 18 squared. The quadratic transect method is modified from the Seagrass Watch method. The total transect spread in one station are three line transects and nine quadratic transects (Figure 1).

Seagrass sampling was carried out by taking seagrass to the depth of penetration in each transect. Seagrass sampling was carried out on *Enhalus acoroides* and *Thalassia hemprichii* at 0 m, 25 m, and 50 m (Graha, 2016). The quadratic transect (perpendicular to the shoreline) measures 50 m. Seagrass observations included density, percentage of cover, and types of seagrass for analysis of biomass and carbon. In addition, in situ measurements of marine water parameters include temperature, salinity, pH, and substrate at each station.

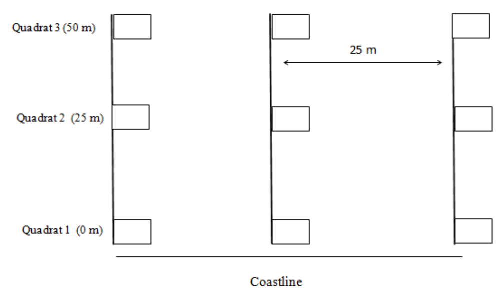

Figure 1. Schematic of laying the quadratic transect at the

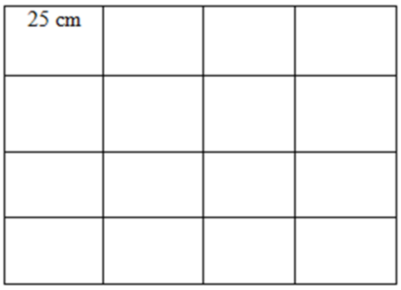

Figure 2. Quadratic plot form

Seagrass sampling for biomass was carried out at all observation points (18 squares) to represent the seagrass biomass as a whole. Seagrass samples were sampled and cleaned and then separated based on the tissue, namely leaves, rhizomes, and roots, and then put into a plastic sample that had been labeled (Azkab, 1999).

The seagrass samples put into the sample plastic were brought to the laboratory, then separated based on the tissue, cut into small pieces, and weighed into the wet weight of the sample (Graha et al., 2015). The wet samples were then dried in the sun to dry. The dried samples were then reweighed as dry weight (Duarte, 1990). Calculating the carbon content of seagrasses was analyzed using the method (LOI), which refers to Helrich (1990).

Data analysis

1. Density

Seagrass species density is the total number of individuals in one unit area (English et al., 1994). The formula used for specific density is as follows:

$$\mathrm{Ki} = \frac{\mathrm{Ni}}{\mathrm{A}}$$

Information :

Ki : density (ind/m2)

Ni: Total number stands of species-i

A: Total area of sampling

2. Seagrass Closure (%)

Analysis of seagrass cover calculations (P2O LIPI, 2014)

$$\text{Seagrass cover} = \frac{\text{Total closing value of seagrass}}{4} \times 100\ \%$$

Table 1. Seagrass ecosystem categories based on a percentage of cover, according to Kawaroe *et al*.,2016

Persentase Cover (%)	Category
0-25	Scare
26-50	Average
50-75	Compact
75-100	Very compact

3. Calculation of Seagrass Biomass and Carbon Seagrass Biomass uses the equation according to Duarte (1990);

$$B = W \times D$$

Note: B = Seagrass Biomass (gr/m2); W = dry weight of seagrass (gr/individual); D = density of seagrass (individual/m2).The carbon content of seagrass uses the equation formula according to Helrich (1990);

$$\text{ask content} = \frac{c-a}{b-a} \times 100\%$$

Note: a = weight of the cup; b = weight of cup + dry weight of seagrass tissue; c = weight of the cup + weight of seagrass ash.

The organic matter using the ashing method is determined by calculating the weight reduction when ashing with the equation:

$$\text{Carbon content} = \frac{\text{Organic matter}}{1{,}724}$$

Note: 1,724 = constant value of organic matter

3. RESULTS AND DISCUSSION

Water Characteristics

The environmental quality parameter affects the characteristics of an aquatic ecosystem. Environmental parameters at the research site were carried out in situ at the research location at the same time as the time of data collection for seagrass beds. The environmental parameters observed were temperature, salinity, substrate and pH. The results of environmental parameters (Table 1).

Based on the research results, the temperature parameters at the three stations have different values, namely 31-34^{0}C. The difference in the value of temperature measurements at the research location is due to different locations with different weather conditions and sampling times. Paty (2013) believes that temperature changes are caused by several factors, including sunlight, geographical differences, current circulation, wind, and seasons. Temperature plays a role in influencing the processes of photosynthesis and reproduction and affects the growth of seagrass (Repolho et al., 2016).

Table 2. Results of measuring water parameters

Station	Water Parameters			
	Temperature	pH	Salinity	Substrate
I	32	9,10	33	Muddy Sand
II	31	8,20	34	Muddy Sand
III	34	8,13	32	Muddy Sand

Description: Station I (Junga Village), Station II (Sangowo Village) and Station III (Wayabula Village).

The measurement results obtained from the waters in Juanga Village (Station I), Sangowo Village (Station II), and Wayabula Village (Station III) show different salinity values, namely 32-34. Based on the Decree of the State Minister of the Environment No. 51 of 2004, the water salinity standard quality ranges from 33-34‰. The effect of salinity on seagrass plants is that it affects the physiology of seagrasses related to the osmotic pressure of seagrass with its environment. Based on the results of measurements of pH values at station I (Juanga Village), Station II (Sangowo Village), and Station III (Wayabula Village) showed differences. The pH value at a station I was around 9.10. At the station, II was around 8.20, while at station III, it was 8.13. This condition was still in a good range for seagrass life. According to the State Minister for the Environment No. 51 of 2004, the quality standard for water pH ranges from 7-8.5. The pH value in waters can be different due to several factors, including the photosynthetic activity of marine biota, temperature, and salinity of the waters. Variations in the pH value of the water greatly affect the biota in water. Water's ideal pH value is 7-8.5 (Hamuna *et al*., 2018). Water conditions that are very alkaline or very acidic will endanger the survival of organisms because they will interfere with metabolic processes and respiration. The pH of water is one of the chemical parameters that are quite important in monitoring the stability of marine waters (Hamuna *et al*., 2018).

Based on the composition of the substrate, it is known that at stations I, II, and III, the type of substrate is dominated by sandy mud. The dynamic conditions of the waters and the surrounding environment affect the composition of the bottom substrate of the waters (Lanuru *et al*.,2018). The waters have semi-enclosed waters with relatively calm water current characteristics, which impacts the substrate's characteristics and a relatively high mud composition.

Seagrass Species Density

Seagrass density is the response of seagrass to the environment that can describe certain conditions of an environment. Seagrass density per unit area depends on various influencing factors such as brightness, depth, and substrate type. The density of seagrass species will be higher if the environmental conditions of the waters where the seagrass grows are in good condition. Based on the research results of seagrass density measurements at station I, different seagrass density values were found.

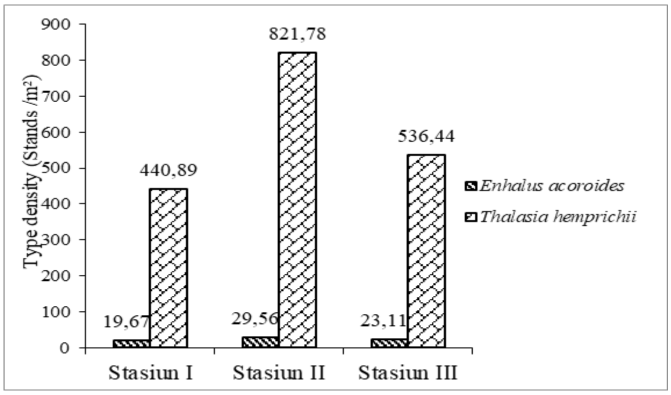

Figure 3. The density of seagrass species

At station I, the seagrass species Enhalus acoroides averaged 19.67 stands/m2, and for the seagrass species, *Thalassia hemprichii*, the average stand was 440.89 stands/m2. The highest species density at the station I was *Thalassia hemprichii* (Agustina et al., 2016). The difference in the composition of seagrass in each research station is related to the extra adaptability at each station. According to Fourqurean et al. (2012), the factors affecting seagrass density are different substrate characteristics between research stations.

Seagrass density shows the total number of individuals or species in an observation plot area. The high and low seagrass density illustrates the seagrass's response to water conditions—the results of the seagrass density analysis at station II (Figure 3). Seagrass density values at station II had different values for the two types of seagrass. The density of seagrass in Thalassia hemprichii was 821.78 ind/m2, while in the seagrass type *Enhalus acoroides*, it was 29.56 ind/m2. Of the two types of seagrass above, the highest density value is the type of seagrass *Thalassia hemprichii*. While the density analysis results at station III showed the highest value for the species, *Thalassia hemprichii*, 536.44 stands/m2, and *Enhalus acoroides*, with a value of 23.11 stands/m2. According to Clara (2018), the high density of the seagrass species *Thalassia hemprichii* is related to the number of species found, and the presence of seagrass is closely related to the light needed by seagrass in carrying out the photosynthesis process.

The results of research conducted by Kucape (2020), the highest density of seagrass species at all research station was *Enhalus acoroides* and *Thalassia hemprichii* in the same waters, namely the village of Juanga. However, the sampling points were different, so the number of stands of seagrass was different. The high and low density of seagrass is closely related to habitat substrate type, characteristics, and a fairly shallow depth because this seagrass is a plant that affects sunlight for the photosynthesis process (Eki et al., 2018). Seagrass density determines the number of stands (stands/m2). In contrast, the percentage of seagrass cover describes the area of seagrass covering the waters expressed in units (%).

Percentage of Seagrass Type Cover

Seagrass cover describes a condition of seagrass beds covering an area of water expressed as water in the form of a percent (%). The percentage of cover can be seen from the morphology of the seagrass that covers the area, so the percentage value is not always proportional to the density seen from a large number of seagrass stands (Minerve et al., 2014). *Thalassia hemprichii* had a cover percentage of 27.28-51.33% at three stations, while *Enhalus acoroides* had a cover percentage of 1.27-1.84% at three stations.

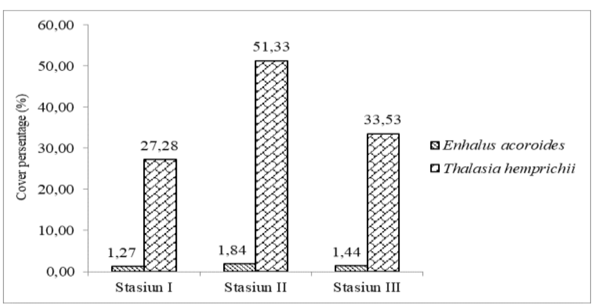

Figure 4. Percentage of Seagrass Cover

The analysis results of the percentage value of seagrass cover in the waters of the island of Morotai At station I, the *Thalassia hemprichii* species, the seagrass cover value was 27.28%, the *Enhalus acoroides* species cover the percentage value was 1.27% in the rare category. At station II the percentage of seagrass is 51.33%, classified in the dense category for the type of *Thalassia hemprichii*, and the type of *Enhalus acoroides* 1.84% is in the rare category. In comparison, at station III, the percentage value of seagrass cover is 33.53% for the type of *Thalassia hemprichii* classified in the medium category. In comparison, the type of Enhalus acoroides has a cover percentage value of 1.44%, including the rare category. It indicated that the *Thalassia hemprichii* species had a higher cover percentage than the *Enhalus acoroides* species. The percentage value of seagrass cover is influenced by leaf width. The more stands of leaf types, the wider the ability to cover bottom substrate of the waters is also greater (Khairunnisa et al., 2018).

Seagrass types with a large morphology, namely *Enhalus acoroides* and *Thalassia hemprichii*, are seagrass types also found in the research location. Both types of seagrass have good adaptations. *Enhalus acoroides* and *Thalassia hemprichii* can live on sandy and muddy substrates. At the same time, Thalassia hemprichii is also a type of seagrass that can live on coral fragments and sandy substrates. Seagrass stands with leaves, roots, and rhizomes that are quite large and have a large percentage of cover, whereas seagrasses with smaller leaves have a small percentage of cover.

Seagrass Type Biomass

The analysis of the different types of seagrass biomass in the roots, rhizomes, and leaves showed that the largest tissue in storing biomass was the rhizome part of the seagrass species *Enhalus acoroides* (Table 3) and *Thalassia hemprichii* (Table 4).

Table 3. Biomass of Seagrass Tissue *Enhalus acoroides*

Station	Tipe of Seagrass	Seagrass Biomass		
		Root	Rhizomae	Leaf
I	*Enhalus acoroides*	1121.19	4091.36	1180.20
II		1093.72	7005.72	1507.56
III		3535.83	2264.78	2195.45

Differences in biomass content are influenced by various factors, one of which is the size, density, and morphology of seagrass. The study's results showed that the bottom of the substrate had the highest biomass value compared to the top of the substrate. Rhamadany et al. (2021) reported that rhizomes yield is the largest part of storing biomass because rhizomes are seagrass tissues with large morphology, so they have high biomass compared to leaf and root tissues. According to Tasabaramo et al. (2015), the biomass stored at the bottom of the substrate comes from nutrients absorbed by roots in the sediment and organic material from photosynthesis stored in the rhizome.The highest biomass values of the two seagrass species, *Enhalus acoroides*, and *Thalassia hemprichii,* were found in the *Thalassia hemprichii* species in the rhizome section (Table 3).

Table 4. Biomass of Seagrass Tissue *Thalassia hemprichii*

Station	Tipe of Seagrass	Seagrass Biomass		
		Root	Rhizomae	Leaf
I	*Thalassia hemprichii*	10140.47	17635.60	22485.39
II		13148.48	36158.32	35336.54
III		12874.56	32186.40	21457.60

According to Azizah et al. (2017), the biomass value can be influenced by density, the higher seagrass density value, the higher the biomass value produced by the seagrass. Al-Bader et al. (2014) stated that the more rhizomes and roots penetrate the sediment, the more pore spaces will be created on the substrate, which will assist in nutrient absorption and entry into the rhizome as the substrate.

Carbon in Seagrass

Each type of seagrass had a different ability to absorb carbon, as well the ability to biomass produce, seagrasses that have a denser percentage tend to have a higher carbon content than species with small and sparse cover. The amount of carbon in *Thalassia hemprichii* is almost twice the carbon content found in *Enhalus acoroides*. The highest carbon content is found in the roots of *Thalassia hemprichii*. Rahmawati (2011) reported that the highest carbon content was found in the roots and stems. According to (Pendleton et al., 2012), a lot of carbon content is stored in the lower layers of sediment because it has a high organic content. It differs from very small seagrasses, which have a faster turnover process, so they cannot absorb large amounts of carbon and store it for a long time.

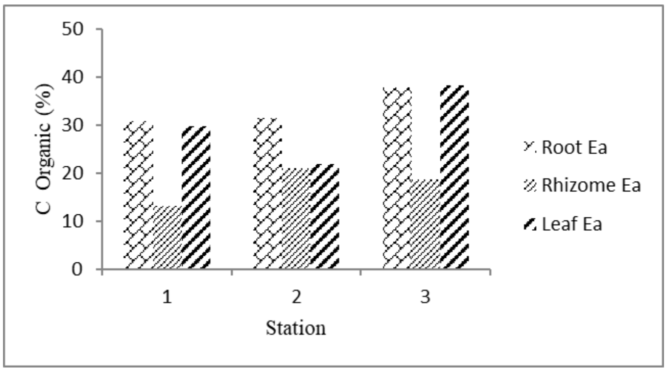

Figure 5. Carbon in Seagrass Type *Enhalus acoroides*

From the results of the carbon sequestration of *Enhalus acoroides* at each station, it was found that the total carbon content at station III was greater than that of stations I and II. At station III, the largest carbon content was found in the leaf part at 38.19 gC/m^2, while the seagrass part had The smallest total carbon absorption in the stem is 18.76 gC/m^2. While at stations I and II, the largest carbon content was found in the roots (bottom of the substrate), namely station I 30.77 gC/m^2 and station II 31.43 gC/m^2, while the smallest part of seagrass was in the stem (upper substrate) at station I 13.24 gC/m^2, and station II 20.92 gC/m^2. It is evidenced by the results of the comprehensive carbon test conducted in the laboratory. The high value of carbon under the substrate is caused because the carbon below the substrate is not too affected by physical environmental factor, as is the estimation of the carbon at the top of the substrate (Supriadi, 2012). According to Grimsditch (2013), the potential for carbon storage under the substrate has the opportunity to be stored longer and continues to grow. The lower part of the substrate has a greater carbon stock of 15-15% of primary productivity (Rahmawati, 2012).

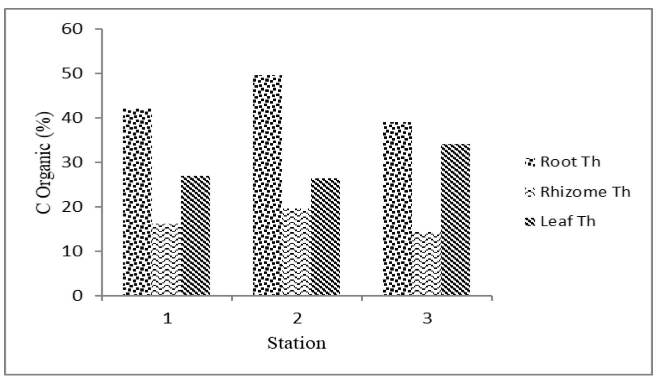

Figure 6. Carbon in Seagrass Type *Thalassia hemprichii*

This study's results indicate that the seagrass species *Thalassia hemprichii* has different carbon content at stations

I, II, and III. Where station I has the largest carbon content found in the roots (bottom substrate), which is 41.99 gC/m2, and the smallest carbon content is found in the stem (top of the substrate), which is 16.06 gC/m2, while station II has the largest carbon content in the roots (bottom of the substrate).) 49.48 gC/m2 and the smallest in the stem (on the substrate) 19.5 gC/m2, and at station III, the largest seagrass part was at the roots (bottom of the substrate) 38.94 gC/m2 and the smallest in the seagrass stem part (above the substrate) 14.32 gC /m2.

Of the three stations, the largest carbon content was at station II in the root part of seagrass, 49.48 gC/m2. It is because the bottom of the substrate is minimal to environmental disturbances so that the carbon produced by photosynthesis can accumulate continuously. The environmental disturbance in question is that the seagrass leaves are easily broken/damaged by waves and currents. Besides, the propellers on fishing boats can damage the seagrass leaves. According to Latuconsina and Dawar (2012), the upper part of the substrate is utilized more in the food chain and decomposed so that it has the potential to be stored less in the substrate. Seagrasses carry out photosynthesis by absorbing CO2, resulting in carbon (C) and oxygen (O2), where oxygen is released to the environment, and carbon is stored in the seagrass body as biomass. According to Runtuboi et al. (2018), the biomass comprises 45-50% carbon. Storage of photosynthetic products under the substrate can Support seagrass growth when photosynthesis is not optimal (Alcoverro et al. 2001).

The sediment in which seagrass grows is the best carbon storage area, according to Kennedy et al. (2009). The carbon content below the substrate will be stored even though the shoots on the seagrass have died, while the carbon above the substrate will only be stored if the seagrass shoots are still alive. The type of substrate that is good for storing carbon is silt or clay because it has a denser texture, so it is optimal for binding carbon. The results showed that the carbon content in the sediment was less than in the seagrass. The sediment at the research site is dominated by the type of sand substrate, which has a larger grain size, is hollow, and is lighter, so it is less dense. Currents and waves easily submerge this type of substrate. Large substrate granules will reduce the ability of the substrate to absorb organic carbon (Pratiwi, 2010).

4. Conclusion

Based on the results of carbon analysis in seagrass *Thalassia hemprichii* and *Enhalus acoroides*, *Thalassia hemprichii* species had the highest carbon content in the roots with a value of 38.94 gC/m^2 to 49.48 gC/m^2. *Enhalus acoroides* had the highest carbon content in the roots, with carbon values from 30.77 gC/m^2 to 37.86 gC/m^2.

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