Carbon Stock of Seagrass Community in Barranglompo Island, Makassar

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Abstrak

Stok Karbon pada Komunitas Lamun di Pulau Barranglompo, Makassar

Konsep blue carbon yang diperkenalkan oleh UNEP, FAO dan UNESCO pada tahun 2009 memasukkan padang lamun sebagai salah satu ekosistem yang mempunyai peran dalam penyerapan karbon global. Karbon yang diserap disimpan dan dialirkan dalam beberapa kompartemen, antara lain di sedimen, herbivora, kolom air, ekosistem lain dan dalam bentuk biomassa. Penelitian dilakukan di Pulau Barranglompo, Makassar, untuk melihat potensi stok karbon yang tersimpan dalam biomassa lamun. Kepadatan lamun diukur dengan melakukan sampling menggunakan metode transek kuadrat dengan ukuran 50cm x 50cm. Sedangkan untuk biomassa dilakukan dengan transek 20cm x 20cm. Hubungan antara kepadatan, biomassa dan kandungan karbon dari lamun digunakan untuk menentukan jumlah stok karbon. Kepadatan lamun disurvei pada 236 titik, sedangkan untuk pengambilan sampel biomassa dilakukan pada 30 titik. Hasil penelitian menunjukkan bahwa komunitas lamun mempunyai total stok karbon sebesar 73,86 ton dari total luas padang lamun 64,3 ha. Karbon di bawah substrat sebesar 56,55 ton (76,3%), lebih tinggi dibanding karbon di atas substrat yang hanya 17,57 ton (23,7%). Jenis lamun Enhalus acoroides menyumbang lebih dari 70% terhadap total stok karbon. Berdasarkan kelas karbon, kontribusi terbesar ditemukan pada kelas 100-200 gC.m^{-2} sebesar 29,41 ton (39,7%). Hasil ini menunjukkan bahwa ekosistem lamun berperan sangat penting dalam menjaga stok karbon di laut sehingga perlu mendapatkan perhatian untuk konservasinya.

***Kata kunci:** konsep blue karbon, lamun, Barranglompo*

Abstract

Blue carbon concept as introduced by UNEP, FAO and UNESCO in 2009 included seagrass beds as one ecosystem having a significant role in global carbon absorption. Absorbed carbon was stored and distributed in various compartments such as in sediments, herbivores, water column, other ecosystems and in form of biomass. The research was conducted in Barranglompo Island, Makassar City to analyze the potency of carbon stock that stored within seagrass biomass. Seagrass density was sampled using quadrat transect method with size of 50cm x 50cm. While for biomass was done by harvesting seagrass at transect of 20cm x 20cm in root penetration depth. Relationship between density, biomass and carbon content of seagrass were used to determine total carbon stock. Seagrass density was surveyed at 236 points, while for biomass sampling was conducted in 30 points. The results showed that seagrass community had total carbon stocks as much as 73.86 tonnes from overall 64.3 ha of seagrass bed areas. Below ground carbon had 56.55 tonnes (76.3%), higher compared to that aboveground which only 17.57 tonnes (23.7%). Seagrass species Enhalus acoroides contributed more than 70% to the total carbon stocks, whereas, based on the carbon classes, the highest contribution was found at class 100-200 gC.m^{-2} i.e. 29.41 tonnes (39.7%). These results suggest that seagrass ecosystem plays an important role in maintaining the carbon stock in the ocean and should receive good attention for its conservation.

***Keywords:** blue carbon concept, seagrass, Barranglompo*

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Introduction

Seagrass bed is one of important ecosystems in Spermonde Islands, South Sulawesi. This ecosystem is very important in maintaining ecological or economic function. Seagrass bed has the ability to protect the beach from abrasion (Peterson *et al.*, 2004; Koch *et al.,* 2006; Bos *et al.,* 2007). It also acts as habitat and shelter for various organisms (Supriadi *et al.*, 2004; Uku, 2005; Curtis dan Vincent, 2005; Azis *et al.*, 2006, Giovannetti *et al.*, 2006; Idris *et al.*, 2006; Vonk *et al.*, 2008a; Unsworth *et al.*, 2009; Nyunja *et al.*, 2009); and a breeding site for certain organisms (Unsworth *et al.*, 2009).

For the last few years, however, the role of seagrass bed as one of absorbent of carbon emission in the seawaters has been discussed (Duarte *et al.*, 2005; Duarte *et al.*, 2008; Kiswara & Ulumuddin, 2009; Nellemann *et al*, 2009; Kiswara, 2010). Formerly, experts only focused on role of land vegetation, such as forest and plantation, as carbon absorbent (Ulumuddin *et al.*, 2005; Aminudin, 2008) and neglected the role of coastal ecosystem. This ignorance is likely due to the limitation of coastal vegetation, which is only less than 2% of the sea surface (Duarte *et al.*, 2005).

Expert awareness shown by the introduction of blue carbon concept that launched in cooperation between UNEP, FAO and UNESCO in the end of 2009. The concept was based on a belief to the ability of the three important marine ecosystems i.e. mangrove, seagrass and salt marsh, in maintaining the balance of absorption and reduction of carbon emission (Nellemann *et al.*, 2009; Silva *et al.*, 2009). As one of coastal ecosystem components, the existence of seagrass ecosystem is important for carbon cycle in this zone (Kennedy *et al.*, 2010).

The results of carbon absorption by seagrass in photosynthesis processes are stored or channeled to some compartments. One of the results is in the form of biomass, either above or below the substrate. Carbon storage especially as belowground biomass increases seagrass role since it will be kept for a longer period (Kiswara & Ulumuddin, 2009). Absolute carbon content in biomass at particular time is termed as carbon stock (Apps *et al.*, 2003).

This research was conducted as preliminary study to observe the ability of seagrass to store carbon. Results of research may be used as one reference in planning management of seagrass ecosystems. It also could be used to estimate seagrass carbon stock in wider areas, especially in Spermonde Archipelago that generally has relatively similar seagrass condition.

Material and Methods

This research was conducted in Barranglompo Island, Makassar from December 2010 to November 2011. The research was divided into 4 (four) periods. Period 1 (December 2010–January 2011), which was the rainy season with average rainfall of 660.7 mm; period 2 (April–May 2011), which was transition season I with average rainfall of 272.4 mm; period 3 (July–August 2011), which was dry season with average rainfall of 0.4 mm; and period 4 (October–November 2011), which was transition season II with average rainfall of 110.0 mm. The sampling period was conducted to see the possibility of seasonal influence on carbon stock of seagrass community. Data on rainfall average is obtained from BMG Marine Station of Paotere Makassar.

Total carbon stock was determined using relationship approach between density, biomass and carbon content of seagrass. Sampling of seagrass density was done using quadrat transect method with size of 50cm x 50cm and conducted systematically every 20 m from the coastline to the outer part. The number of sampling point of seagrass density was 236 points that dispersed on seagrass bed and biomass sampling was conducted in 30 points (Figure 1).

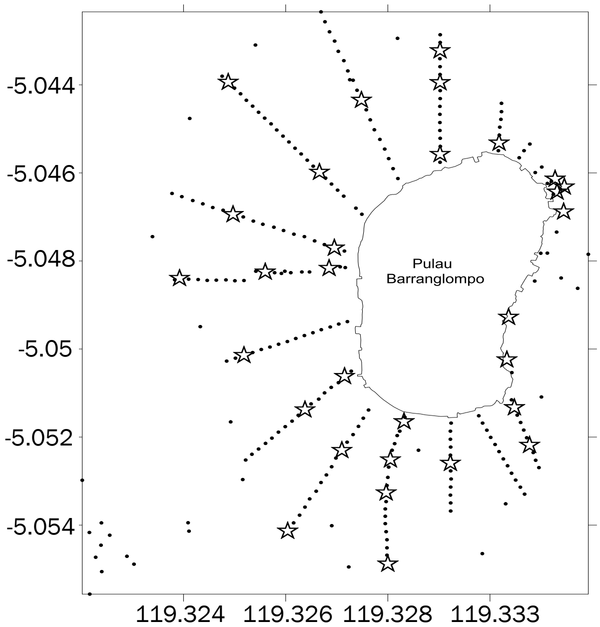

Figure 1. Sampling points of seagrass density and biomass. Points indicate density sampling and stars indicate density + biomass sampling.

Biomass sampling was conducted by harvesting seagrass at transect of 20cm x 20cm in root penetration depth. The collected seagrass was washed from substrate and stored into sample bags and were brought to the laboratory. Samples, then, were sorted based on seagrass species and parts (leaf, rhizome and root). Samples were cleaned and the number of stands was counted; they were dried using oven and weighted. Biomass per seagrass stand can be determined by dividing total weight of each sample with number of stand. The relationship between seagrass density and biomass can be used to predict seagrass biomass in all sampling points of density. Sampling of seagrass density and biomass was conducted every period.

Biomass was converted into organic carbon based on ratio values between the two of them after carbon content analysis was conducted. Carbon analysis of each species and part of seagrass obtained from the four sides of the island was performed based on Walkley and Black method (Sulaeman *et al.*, 2005). Carbon stock in each sampling point was used as the basis in drawing carbon map using surfer version 9.0. Several carbon stock classes are made based on data obtained on the field to make calculation easier. The average of carbon stock and area of each class was counted. Area was counted using ArcView GIS 3.3.

Total carbon stock of seagrass was calculated using the following formula:

$$C_t = \sum (L_i \times c_i)$$

where C_t= total carbon (tonnes); L_i= area of seagrass bed class-i (m^2); c_i= seagrass carbon stock class-i ($tonnes.m^{-2}$)

Environmental variables observed include temperature, salinity and dissolved oxygen (using water quality checker), current (drift float), light (lux meter), depth (portable depth meter). Those variables were measured *in situ*. Whilst, other variables were further analyzed in the laboratories include phosphate and nitrate contents on water and sediment (spectrophotometer), size of sediment grain (sieve net), and sediment carbon analysis using Walkley and Black method (Sulaeman *et al.*, 2005). The measurement and sampling of water and sediment were conducted at seagrass bed in southern, western, northern and eastern sides of Barranglompo Island. These variables were measured every period except for sediment grain size.

Similarity level of seagrass species based on their carbon contents was determined using cluster analysis with carbon average method of the three parts of seagrass (root, rhizome and leaf). Stepwise multiple regression analysis method was applied to examine the influence of environmental variables on total carbon stock of each seagrass species.

Results and Discussion

There were eight seagrass species found in Barranglompo Island i.e., *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halodule uninervis*, *Halodule pinifolia*, *Halophila ovalis* and *Syringodium isoetifolium.* In overall, these seagrass species form a meadow of mixed seagrass bed composed of two or more species. Monospecific seagrass bed composed by *E. acoroides* is generally found in areas close to the coastline with 20-30 m of width. *E. acoroides, T. hemprichii* and *C. rotundata* were dominant seagrasses distributed in the southern, western and northern part with limited distribution in the eastern part of Barranglompo Island.

Average of seagrass density in the eastern station ranged from 14.5–530.2 $stands.m^{-2}$, in *E. acoroides* and *S. isoetifolium* species, respectively, (Figure 2). Seagrass density did not change significantly in respect to the season. In the southern and northern stations, seagrass with the highest density was *H. pinifolia*, in the western station was *T. hemprichii* and *S. isoetifolium* in the eastern station.

Analysis of carbon content indicated variability among these species including among seagrass parts and sampling stations in the same seagrass species. There are two seagrass species having the highest carbon content on leaf i.e. *C. serrulata* and *S. isoetifolium*; two species on root, *C. serrulata* and *H. uninervis*; and four species on rhizome, *E. acoroides*, *T. hemprichii*, *H. pinifolia* and *H. ovalis* (Table 1).

Cluster analysis with average method showed that relatively similar carbon content was shown between *E. acoroides* and *H. pinifolia*; whilst, *C. rotundata* was the most different to other species (Figure 3). *C. rotundata* has the lowest carbon content average (34.17%); *H. pinifolia*, however, has the highest carbon content average (39.15%). At similarity level of 60.3%, three groups were formed, group 1 consists of *E. acoroides, H. pinifolia* and *T. hemprichii*; group 2 consists of *C. serrulata, C. rotundata* and *H. uninervis*; and group 3 consists of *H. ovalis* and *S. isoetifolium*. Biological closeness of seagrass species did not indicate the closeness of carbon content.

Carbon content of *E. acoroides* and *C. rotundata* in Pari Island was bigger than the one in Barranglompo Island, but *T. hemprichii* was lower with carbon content average of 41.87%, 40.95%, 35.99%, respectively (Kiswara, 2010). Vonk *et al.* (2008c, 2008d) found carbon content of *T. hemprichii*, *H. uninervis* and *C. rotundata* leaves in Bonebatang Island was higher than Barranglompo

Island, but the contradiction was found in *E. acoroides* for every part of seagrass. Carbon content on inter-specific and inter-parts from the same species was significantly different (P<0.05), however, no differences found on inter-season (P>0.05). Carbon content of *C. rotundata* and *S. isoetifolium* was significantly different to *H. ovalis* and *H. pinifolia*; other species, however, were not significantly different. Meanwhile, interpart of seagrass in *E. acoroides, T. hemprichii, C. rotundata, C. serrulata* and *H. uninervis* species showed significant difference (P<0.05); but *H. pinifolia, H. ovalis* and *S. isoetifolium* did not show significant difference.

Total area of seagrass bed in Barranglompo Island is 64.3 ha or three times of its island area (20.64 ha). That large of seagrass bed has stock carbon potential of 73.86 tonnes. Seagrass bed on the eastern side has restricted seagrass coverage due to narrow and steep reef flat. This different from those in the northern and western part. Carbon stock fluctuated during research with the smallest value was found in rainy season by 69.55 tonnes and the highest one was observed in transition season I by 77.80 tones (Table 2). Carbon stock of seagrass bed *P. oceanica* was higher compared to the carbon stock of seagrass community in Barranglompo Island (Kennedy and Bjork, 2009; Mateo, 2010). Carbon stock of *P. oceanica* in Balearic Island reaches 56 x 10^6 tonnes carbon in area of 66.997 ha. Laverg *et al.* (2013) showed that the carbon stock of *P. ocenica* in Australian segrass bed was 10,500-40,000 g.cm^{-2}. Total Carbon stock in the seagrass bed in the Barranglompo Island was greater than total carbon stcok in the Australian seagrass bed.

Table 1. Carbon content of seagrass in Barranglompo Island (% of dry weight)

Species	Tissue			Average
	Root	Rhizome	Leaf	
E. acoroides	35.02 ± 1.71[a]	38.59 ± 0.88[b]	37.49 ± 0.85[b]	37.03 ± 1.83(1,2)
T. hemprichii	36.21 ± 1.82[a]	39.63 ± 2.32[b]	33.77 ± 1.21[a]	36.53 ± 2.94(1,2)
C. rotundata	34.44 ± 0.81[a]	32. 56 ± 1.09[b]	35.51 ± 0.92[c]	34.17 ± 1.50(1)
C. serrulata	36.54 ± 0.18[a]	35.56 ± 0.10[b]	35.89 ± 0.95[c]	36.00 ± 0.50(1,2)
H. uninervis	41.24 ± 1.16[a]	37.41 ± 1.59[b]	33.58 ± 2.99[c]	37.41 ± 3.83(1,2)
H. pinifolia	37.63 ± 2.36[a]	40.90 ± 2.40[a]	38.93 ± 2.69[a]	39.15 ± 1.65(2)
H. ovalis	34.45 ± 2.71[a]	35.06 ± 3.60[a]	35.65 ± 1.61[a]	38.86 ± 0.25(2)
S. isoetifolium	38.74 ± 2.17[a]	39.16 ± 1.85[a]	38.69 ± 1.99[a]	35.05 ± 0.60(1)

Note: Different letters in the same row and different number in parenthesis in the same column indicate significant differences (P= 0.05)

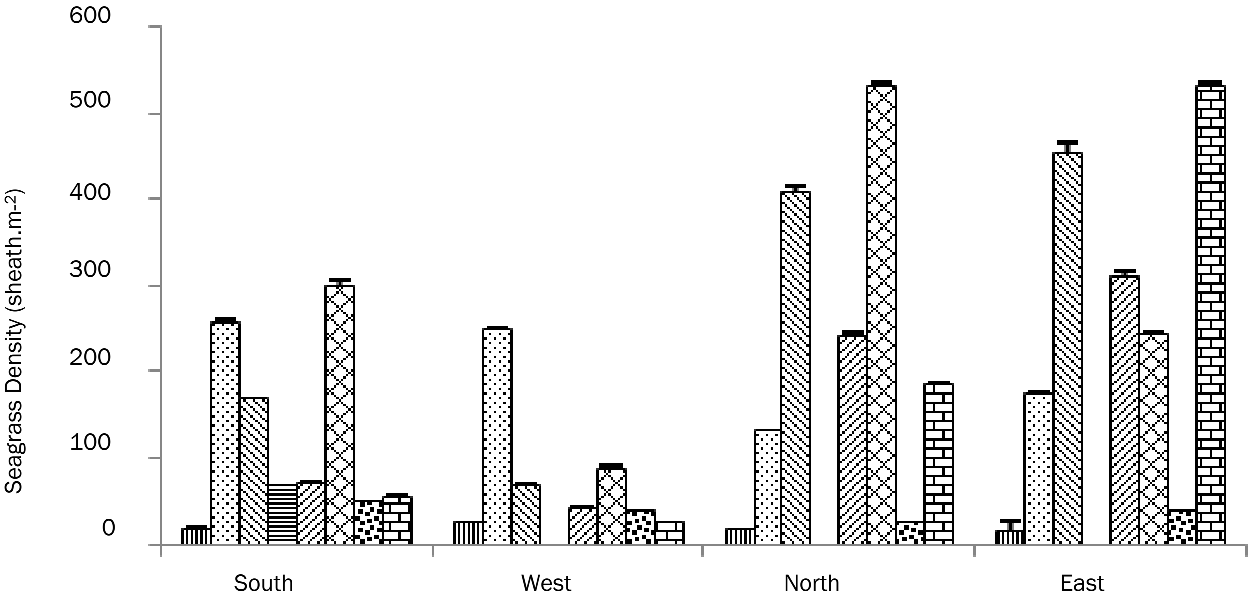

Figure 2. Seagrass density in Barranglompo Island (sheath.m^{-2})

Note : = *E. acoroides*, = *H. uninervis*, = *T. hemprichii*, = *H. pinifolia*, = *C. rotundata*, = *H. ovalis*, = *C. serrulata*, = *S. isoetifolium*

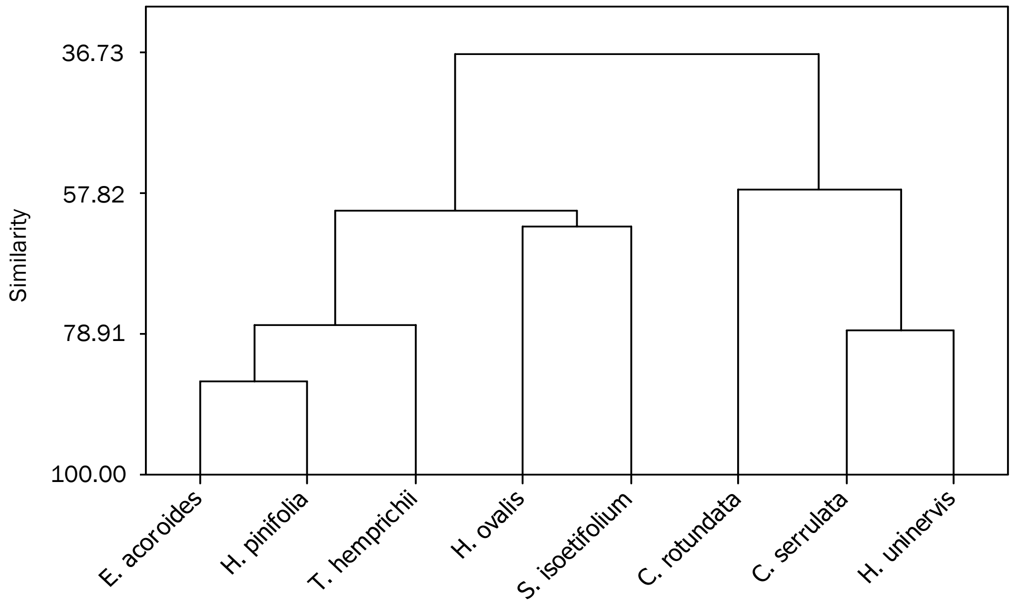

Figure 3. Cluster analysis of carbon content for each seagrass species (average method) in Barranglompo Island

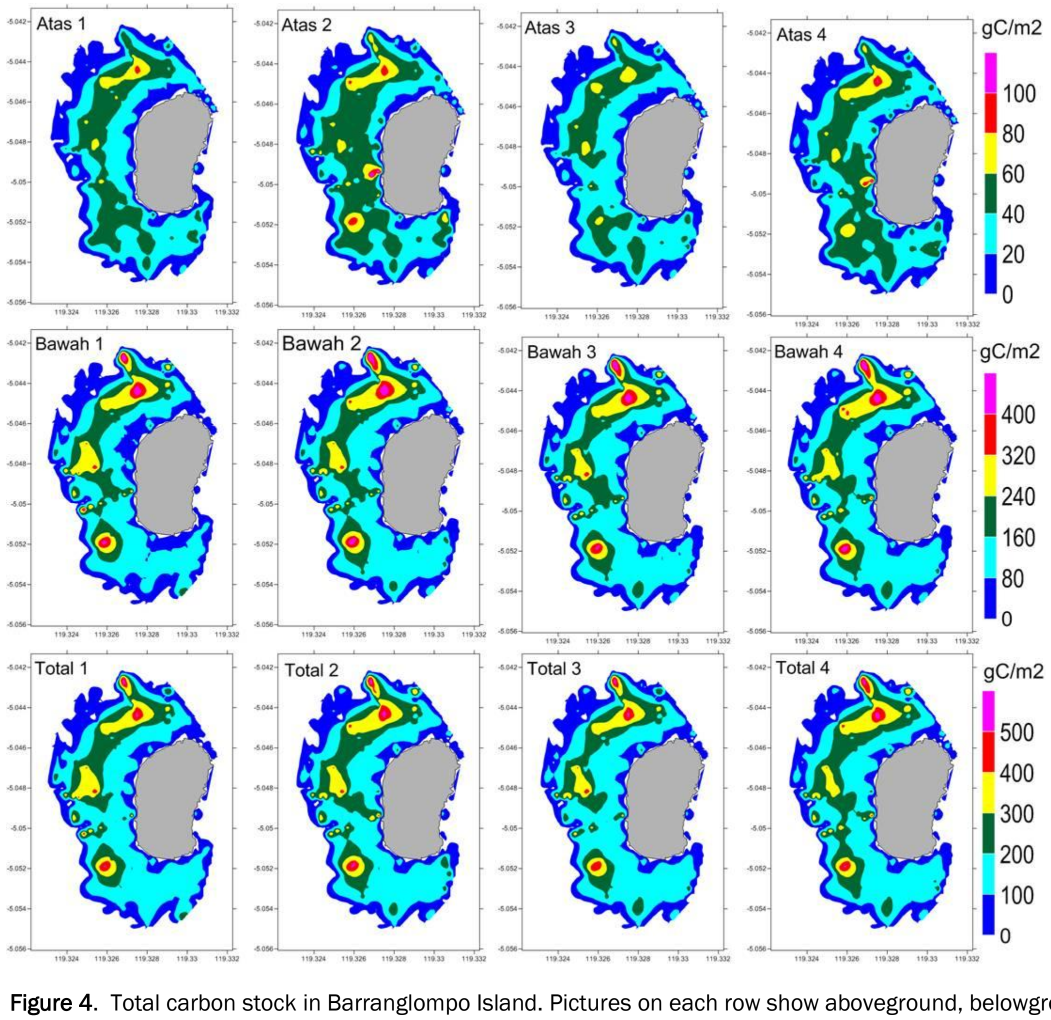

Figure 4. Total carbon stock in Barranglompo Island. Pictures on each row show aboveground, belowground and total carbon stock. Pictures on column show sampling period 1 to 4

Table 2. Contribution of belowground and aboveground to the total carbon stock

Sampling Period	Belowground		Aboveground		Total (tonnes)
	Carbon (tonnes)	%	Carbon (tonnes)	%	
1	53.15	76.4	16.39	23.6	69.55
2	57.75	74.2	20.06	25.8	77.80
3	56.97	78.9	15.21	21.1	71.17
4	58.31	75.8	18.61	24.2	76.92
Average	56.55	76.3	17.57	23.7	73.86

The fluctuation is more apparent in aboveground carbon stock, especially in the middle part of seagrass bed in the northern and western sides of Barranglompo Island. The carbon stock class experiencing more fluctuation was the first three classes, which was from 0–60 gC.m^{-2}. These classes dominated the stock carbon in Barranglompo Island that made the difference is clearly observed, other classes are relatively stable. Belowground carbon stock is different since it does not show any changes. A relatively small change was only found in the southwestern and southern sides. The absence of adequate changes on total carbon stock is related to this relatively small changes on belowground carbon stock and its large contribution to the total carbon stock (Figure 4).

Changes on aboveground carbon stock mostly related to the physical condition of environment. Low carbon stock during rainy season was caused by more litter produced by high wave. In dry season, seagrass bed is more exposed at noon due to low tide. Erftemeijer (1993) found a phenomenon of decreasing leaf biomass in *E.acoroides* due to low tide, causing high frequency of seagrass exposure. The exposed seagrass at noon will result in dry leaves that in turn will washed away during the high tide (Supriadi *et al.*, 2006).

Belowground carbon has significant contribution to the total carbon, which was 76.3% in average that ranged between 74.2% in transition season I to 78.9% in transition season II. Aboveground carbon stock contribution was 23.7% that ranged from 21.1–25.8% (Table 2). One of functions of high belowground biomass is to strengthen seagrass anchorage (Supriadi and Arifin, 2005). According to Kuriandewa (2009), *E. acoroides* has biomass in rhizome of 6–10 times compared to the above ground biomass. High belowground carbon stock is very important since that carbon is trapped within sediments. Duarte *et al.* (2005) stated that the estimation of sedimentation rate of seagrass organic carbon was 83 gC.m^{-2}.year^{-1}. Biomass carbon in seagrass was stocked for several decades compared to the one in mangrove that only stocked for ten years (Kiswara and Ulumuddin, 2009).

Based on seagrass species, *E. acoroides* and *T. hemprichii* have high carbon stock contribution, which is more than 90% of total carbon stock (Table 3). This is different from *C. serrulata, H. uninervis, H. pinifolia, H. ovalis* and *S. isoetifolium* that have contribution less than 1%, respectively. This low contribution is related to their limited distribution and their relatively smaller size than *E. acoroides* and *T. hemprichii*. The largest contribution of *E. acoroides* was found during dry season (70.56%) and in rainy season of 24.93% for *T. hemprichii*.Based on carbon stock classes, the large contribution to total carbon was found in the three first classes, which was carbon content of 0–300 gC/m^2. For class above 500 gC.m^{-2} had the least contribution, which was less than half percent or less than half tonnes of carbon. The largest contribution was found in class of 100–200 gC.m^{-2}, which was above 30% or between 24.21–32.22 tonnes (Table 4).Results from measurement on environmental variables were shown in Table 5. In the first sampling period, environmental variables of current velocity and water depth was relatively high, but salinity was low. High current velocity was triggered by huge wave because the sampling period is coincided with the peak of rainy season. Strong current and wave are among reasons for low carbon stock above the substrate in this season.

Table 3. Contribution of carbon stock of each seagrass species to total carbon stock (tonnes)

Species	Sampling Period 1		Sampling Period 2		Sampling Period 3		Sampling Period 4		Average	
	Carbon	%	Carbon	%	Carbon	%	Carbon	%	Carbon	%
E.acoroides	48.32	69.48	54.70	70.30	50.94	70.56	54.27	70.56	52.06	70.23
T.hemprichii	17.34	24.93	18.71	24.04	17.25	23.91	18.15	23.60	17.86	24.10
C.rotundata	2.99	4.29	3.29	4.24	3.01	4.18	3.30	4.28	3.15	4.25
C.serrulata	0.02	0.03	0.03	0.03	0.02	0.04	0.02	0.03	0.02	0.03
H.uninervis	0.17	0.25	0.20	0.26	0.19	0.26	0.21	0.26	0.19	0.26
H.pinifolia	0.27	0.39	0.42	0.54	0.31	0.43	0.49	0.63	0.37	0.50
H.ovalis	0.05	0.07	0.40	0.51	0.40	0.56	0.44	0.56	0.32	0.43
S.isoetifolium	0.38	0.55	0.05	0.07	0.04	0.06	0.05	0.07	0.13	0.18

Table 4. Contribution of carbon of each class to the total carbon (tonnes)

Class (gC.m^{-2})	Sampling Period								Average	
	1		2		3		4			
	Carbon	%	Carbon	%	Carbon	%	Carbon	%	Carbon	%
< 100	18.83	27.06	16.92	21.75	17.48	24.22	15.55	20.22	17.20	23.20
100 – 200	24.21	34.81	32.22	41.41	29.60	41.01	31.62	41.10	29.41	39.68
200 – 300	18.68	26.86	19.40	24.94	18.47	25.59	20.97	27.27	19.38	26.15
300 – 400	6.65	9.56	7.19	9.25	5.36	7.42	6.92	9.00	6.53	8.81
400 – 500	1.14	1.64	1.85	2.37	1.18	1.64	1.59	2.06	1.44	1.94
> 500	0.04	0.06	0.22	0.28	0.08	0.12	0.27	0.35	0.15	0.21

Table 5. Average (±SD) of environmental parameters in Barranglompo Island

Environmental Parameters	Sampling Period			
	1	2	3	4
Temperature (^{0}C)	29.8 ± 0.7	30.3 ± 0.4	30.4 ± 1.1	29.1 ± 0.4
Salinity (ppt)	28.7 ± 0.5	32.4 ± 0.3	33.6 ± 0.2	31.2 ± 0.2
Dissolved oxygen (ppm)	5.69 ± 0.38	5.58 ± 0.42	7.23 ± 0.29	6.25 ± 0.41
Current velocity (m.s^{-1})	0.046 ± 0.019	0.034 ± 0.004	0.025 ± 0.007	0.038 ± 0.020
Light Intensity (lux)	41250 ± 1936	57000 ± 2415	76375 ± 3250	65125 ± 3198
Depth (cm)	113 ± 26	93 ± 26	83 ± 26	103 ± 26
Phosphate (water, ppm)	0.27 ± 0.03	0.23 ± 0.06	0.22 ± 0.02	0.28 ± 0.03
Nitrate (water, ppm)	0.20 ± 0.04	0.27 ± 0.05	0.16 ± 0.06	0.48 ± 0.04
Carbon (sediment, %)	2.84 ± 0.75	2.96 ± 0.52	2.65 ± 0.52	2.25 ± 0.27
Phosphate (sediment, ppm)	9.95 ± 1.18	10.42 ± 0.51	11.12 ± 1.45	10.72 ± 0.47
Nitrate (sediment, ppm)	14.20 ± 2.17	12.93 ± 2.06	14.38 ± 1.67	14.07 ± 1.81
Ammonium (sediment ppm)	1.61 ± 0.44	1.70 ± 0.41	1.47 ± 0.50	1.50 ± 0.26
Coarse sand (%)	40.8 ± 7.5	40.8 ± 7.5	40.8 ± 7.5	40.8 ± 7.5
Medium sand (%)	21.3 ± 1.1	21.3 ± 1.1	21.3 ± 1.1	21.3 ± 1.1
Fine sand (%)	34.3 ± 8.0	34.3 ± 8.0	34.3 ± 8.0	34.3 ± 8.0
Silt (%)	3.6 ± 2.9	3.6 ± 2.9	3.6 ± 2.9	3.6 ± 2.9

Table 6. Multiple regression analysis on the influence of environmental variables on seagrass carbon stock (Stepwise Method). NiS (nitrate sediment), CoS (coarse sand), MeS (medium sand), FiS (fine sand), Sal (salinity), Ams (sediment ammonium)

Species	Multiple Regression (Stepwise Method)	R^2	Sig.
E. acoroides	Y = -578.7 - 5.43 NiS + 8.54 CoS – 15.43 Silt + 20.86 MeS	0.980	*P*<0.05
T. hemprichii	Y = -88.39 + 2.68 NiS + 3.82 MeS	0.502	*P*<0.05
C. rotundata	Y = 112.12 – 4.74 MeS – 0.27 CoS + 0.19 FiS	0.979	*P*<0.05
C. serrulata	Y = 0.091 + 0.028 Silt + 0.002 CoS – 0.010 MeS	0.997	*P*<0.05
H. uninervis	Y = 3.27 – 0.18 MeS + 0.06 NiS	0.863	*P*<0.05
H. pinifolia	Y = -4.47 + 0.04 Light + 0.26 Sal – 0.29 MeS	0.864	*P*<0.05
H. ovalis	Y = 26.89 – 0.25 CoS – 0.74 MeS + 0.08 Silt	0.996	*P*<0.05
S. isoetifolium	Y = 0.19 – 0.04 FiS + 0.00 Light + 0.01 AmS	0.967	*P*<0.05

In the third sampling period, dissolved oxygen, light intensity, salinity and temperature were relatively high, but depth was relatively low. High temperature and low depth combination caused seagrass to be exposed more and easily washed away; therefore, decreased carbon stock above the substrate. In transition season, condition of environmental variables was relatively stable. Generally, there were no extreme environmental variables found for seagrass growth requirements (Hena *et al.*, 2001; Campbell *et al.*, 2006; Ochieng *et al.*, 2010; Unsworth *et al.*, 2010; Collier *et al.*, 2012).

Results from multiple regression analysis shows that nutrient of sediment, especially nitrate, and the size of sediment fraction are influencing carbon stock in all seagrass species (Table 6). Carbon stock in *E. acoroides* was influenced by sediment nitrate and mud sediment (negatively correlated) and coarse and medium sand (positively correlated). Carbon stock of *T. hemprichii* was influenced by sediment nitrate and medium sand (positively correlated). Whereas, carbon stock in *C. rotundata* was influenced by medium and coarse sands (negatively correlated) and fine sand (positively correlated). The analysis indicated that *E. acoroides* preferred coarse sediment with medium nitrate content. *T. hemprichii* preferred medium sediment grain with relatively high nitrate. *C. rotunda* preferred fine sediment. In *C. serrulata* and *H.ovalis*, carbon stock was influenced only by the size of sediment grain which was different from *H. uninervis* that influenced by sediment grain size and sediment nitrate. Light intensity was relatively high that trigger larger storage of *H. pinifolia* and *S. isoetifolium* carbon stock.

Conclusion

Seagrass bed in Barranglompo Island has area of 64.3 ha with carbon stock potency of 73.86 tonnes in average. More than three fourth of the belowground carbon stock and less than one fourth is aboveground. *E. acoroides* contributes more than 70% of total carbon stock. Whilst, carbon class of 100-200 gC.m^{-2} has larger contribution (more than 30%). Environmental variables that have more influence on seagrass carbon stock are nutrients and size of sediments. These results indicate the importance of seagrass ecosystem in maintaining the carbon stock in the ocean and good attention should be given for its conservation.

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