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Preface

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PREFACE

On behalf of the Organizing Committee, I would like to extend our warmest regards to all participants of the International Conference on Tropical and Coastal Region Eco-Development (ICTCRED) 2019. This annual conference is the fifth event at Semarang, Central Java, Indonesia that is organized by the Faculty of Fisheries, Universitas Diponegoro. This year we brought an essential global topic the *Integrated Coastal Zone Management for Sustainable Development*. The conference aims to provide a forum to exchange ideas and their current achievements for researchers, academicians, professionals, and industries to expose and exchange innovative ideas, methods, and experiences in the areas related to tropical life sciences and coastal development.

We have accepted 156 abstracts for oral and poster presentations coming from different universities and research centers from many countries, which were consisted of 13 big interests. Besides, we have cordially invited five highly respected researchers as keynote speakers with different fields to share their knowledge and expertise. I am grateful for each one of them for setting aside their valuable time to participate in this conference.

The committee extent very kind thank all participants for the success of the conference. They were Rector of Universitas Diponegoro, Dean of Faculty of Fisheries and Marine Science, the keynote speakers. I also would like to acknowledge the Institute of Physics (IOP) for the collaboration in publishing the conference proceedings, our sponsors the Bionesia, Faculty of Law, Universitas Diponegoro, COREM Undip, and Deltares.

Finally, we proudly present some selected papers in IOP Conference Series: Earth and Environmental Science. I do hope that the 5th ICTCRED 2019 event brings a fruitful knowledge and be a memorable event not only from the scientific perspective but also in the joy of meeting with other scientists for mutual collaboration.

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Table of contents

Volume 530

2020

◀ Previous issue Next issue ▶

The 5th International Conference on Tropical and Coastal Region Eco Development 17-18 September 2019, Semarang, Indonesia

Accepted papers received: 26 June 2020

Published online: 15 September 2020

Open all abstracts

Preface

OPEN ACCESS 011001

Preface

+ Open abstract  View article  PDF

OPEN ACCESS 011002

Peer review statement

+ Open abstract  View article  PDF

Papers

OPEN ACCESS 012001

Utilization of liquid smoke nanoencapsulation in fresh fish fillets as a preservation material

F Swastawati and Romadhon

+ Open abstract  View article  PDF

OPEN ACCESS 012002

Effect of calcium and enzyme involvement to survival rate and development of the early stage zoea *Portunus pelagicus*

S Permadi, I S Pratama, I T Suryaningtyas and Jasmadi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012003

Legal scenario towards the policy of marine natural resources on the continental shelf:
Ambalat case study

Pulung Widhi Hananto, Anggita Doramia Lumbanraja, Rahandy Rizki Prananda and Aisyah Ayu Musyafah

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012004

Population dynamic of indian scad (*Decapterus russelli*) based on data in tasikagung fishing
Port of Rembang

Aprilia Nur Khasanah, Suradi Wijaya Saputra and Wiwiet Teguh Taufani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012005

Serious gaming for port development as a learning tool: a case study of port constructor

A D Ningrum and M Van Schuylenburg

[+ Open abstract](#) [View article](#) [PDF](#)

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012006

Mitigation of floodwaters inundation due to land subsidence in the coastal area of Semarang
City

Sugeng Widada, Muhammad Zainuri, Gatot Yulianto, Alfi Satriadi, Yusuf Jati Wijaya and Muhammad Helmi

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012007

Effect of ENSO and IOD on the Variability of Sea Surface Temperature (SST) in Java Sea

Yunvita Wisetya Dewi, Anindya Wirasatriya, Denny Nugroho Sugianto, Muhammad Helmi, Jarot Marwoto and
Lilik Maslukah

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012008

The effect of different temperature on the stability of phycocyanin on microcapsule
Spirulina platensis

FNW Purnama, TW Agustini and RA Kurniasih

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012009

Analysis of capture fish demand in Indonesia

Firmansyah, Shanty Oktavilia, Ryan Prayogi and Dita Wahyu Puspita

[+](#) Open abstract [View article](#) [PDF](#)

OPEN ACCESS

012010

Quality deterioration kinetics and shelf-life estimation of fish *koya*

RBK Anandito, Kawiji, L Purnamayati and AMS Putri

[+](#) Open abstract [View article](#) [PDF](#)

OPEN ACCESS

012011

Antioxidant activity in seaweed (*Sargassum* sp.) extract fermented with *Lactobacillus plantarum* and *Lactobacillus acidophilus*

L Rianingsih and Sumardianto

[+](#) Open abstract [View article](#) [PDF](#)

OPEN ACCESS

012012

Thermal degradation kinetic study of *Pangasius* fish oil

L Purnamayati and R A Kurniasih

[+](#) Open abstract [View article](#) [PDF](#)

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012013

The characteristics of nanocalcium flavor powder made from waste stewed water of swimming crab *Portunus pelagicus* L.

I Wijayanti and E N Dewi

[+](#) Open abstract [View article](#) [PDF](#)

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012014

Non-destructive freshness assessment of *Cyprinus carpio* based on image analysis

M Bachrun Alim, A Suhaeli Fahmi, Lukita Purnamayati and Tri W Agustini

[+](#) Open abstract [View article](#) [PDF](#)

OPEN ACCESS

012015

Fisheries industry strategy in Indonesia

Miar, Firmansyah, Shanty Oktavilia, Dita W Puspita and Ryan Prayogi

[+](#) Open abstract [View article](#) [PDF](#)

OPEN ACCESS

012016

Drying process characteristics of dried anchovy (*Stolephorus* sp.) by using cabinet and tunnel of sun dryer

R B D Sormin and I K E Savitri

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012017

Competitiveness identification of fisheries export in Indonesia

Rian Destiningsih, Rr. Retno Sugiharti, Lorentino Togar Laut, Sudati Nur Safiah and Andhatu Achsa

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012018

Chemical, physical, and sensory characteristics of milkfish (*Chanos chanos*) and mung bean flour (*Vigna radiata* L.) simulations chips

Sigit Prabawa, Fadlilah Arrosyid and Bara Yudhistira

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012019

The effect of high voltage electric shock on the quality attribute of carp fish (*Cyprinus carpio*) meat

Apri Dwi Anggo and Slamet Suharto

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012020

The classification of upwelling indicators base on sea surface temperature, chlorophyll-a and upwelling index, the case study in Southern Java to Timor Waters

Kunarso, Safwan Hadi, Nining Sari Ningsih, Mulyono. S. Baskoro, Anindya Wirasatriya and Anastasia R. T. D. Kuswardani

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012021

The morphological variance *Polymesoda erosa* and *Polymesoda expansa* (Mollusc; Corbiculidae) in the Laguna Segara Anakan, Cilacap, Indonesia

Widianingsih Widianingsih, Retno Hartati, Ria Azizah Tri Nuraeni, Ita Riniatsih Hadi Endrawati and Sri Redjeki

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012022

The potential stocks and carbon uptake by seagrass meadows at Pari Island, Kepulauan Seribu, Indonesia

Febi Amanda Citra, Suryanti Suryanti and Max Rudolf Muskananfola

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012023

Analysis of mangrove forest changes as a natural beach protection in Surabaya, East Java Indonesia

A K Wardhani and M Zikra

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012024

Mapping Coastal Ecotourism Potential in Panggul District, Trenggalek, East Java

Eska Nia Sarinastiti and M. Sidiq Wicaksono

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012025

Non-performing loan in fishery sector, Indonesia

Shanty Oktavilia, Firmansyah, FX. Sugiyanto, Ryan Prayogi and Hendy Aprilian Hidayat

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012026

Social and economic influences on CO₂ emission from capture fisheries in West Java Province

Sitti Hamdiah, Jatna Supriatna, Yosef Prihanto, Novi Susetyo Adi and Widodo Setiyo Pranowo

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012027

The contamination of filter feeder mussel *Perna viridis* Linnaeus, 1758 (Bivalvia: Mytilidae) by organophosphate pesticide at Brebes marine waters Central Java, Indonesia

C A Suryono, Irwani, A Sabdono, Subagiyo, P Abi, E Yudiati, A Indardjo and R T Mahendrajaya

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012028

In vitro antibacterial study and spectral analysis of brown seaweed *Sargassum crassifolium* extract from Karimunjawa Islands, Jepara

Wilis Ari Setyati, Rini Pramesti, A.B. Susanto, A.S. Chrisna and Muhammad Zainuddin

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012029

Multidrug-resistant antibacterial activity and active compound analysis several types of seaweed from Karimunjawa, Jepara

A.B. Susanto, Wilis Ari Setyati, Rini Pramesti, Delianis Pringgenies and Muhammad Zainuddin

[+ Open abstract](#) [View article](#) [PDF](#)

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012030

Estimating carbon emission and baseline for blue carbon ecosystems in indonesia

Novi Susetyo Adi, Mohammad Sumiran Paputungan, Agustin Rustam, Alfabetian Harjuno Condro Haditomo and Medrilzam

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012031

Exploration of bacteria associated with Nudibranchs to control *Vibrio* spp.

Sarjito, S B Prayitno, M Y Farisa, R T C Nast, R Kristiana, A Sabdaningsih and A Sabdono

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012032

The strategies of Pekalongan fishing port development, Indonesia

Putri, Alayya Eka, H. Boesono and D. Wijayanto

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012033

Submerged breakwater effectiveness based on wave spectrum changes in Panjang Island, Jepara

T W L Putra, D N Sugianto and H Siagian

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012034

Engineering culture using natural filter differences based on microsatellite to improve the quality of Snakehead (*Channa striata*)

Istiyanto Samidjan and Diana Rachmawati

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012035

Heavy Metal (As and Hg) contamination of shallow groundwater in the coastal areas of Pati and Rembang, Central Java, Indonesia

Baskoro Rochaddi, Agus Sabdono and Muhammad Zainuri

[+ Open abstract](#) [View article](#) [PDF](#)

OPEN ACCESS

012036

The effect of metal ion Cd(II) concentration on the growth of *Spirulina* sp. cultured on BG-11 medium

Risfidian Mohadi, Hermansyah, Helpi Mavala and Hilda Zulkifli

[+ Open abstract](#) [View article](#) [PDF](#)

-
- OPEN ACCESS** 012037
The effects of exogeneous papain enzyme in the feed on growth and blood profiles of Sangkuriang catfish (*Clarias* sp.) cultivated in the pond
Diana Rachmawati, Istiyanto Samidjan and Johannes Hutabarat
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012038
Persistence of high sea surface temperature (> 30°C) in Tomini Bay
Aprilia Da Cruz Tita, Anindya Wirasatriya, Denny N Sugianto, Lilik Maslukah, Gentur Handoyo, Hariyadi, Muhammad Helmi and Praditya Avianto
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012039
Characteristics of Halmahera Eddy and its relation to sea surface temperature, chlorophyll-a, and thermocline layer
Muhammad Firdaus Ramadhan, Denny Nugroho Sugianto, Anindya Wirasatriya, Heryoso Setiyono, Kunarso and Lilik Maslukah
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012040
Biodiversity of phytoplankton from polyculture milkfish and white shrimp vanname pond culture waters, Pekalongan region
Istiyanto Samidjan, Safar Dody and Diana Rachmawati
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012041
The effect of periodical estradiol-17 β injections with different doses on Java barb (*Puntius javanicus*) gonadal development
Tristiana Yuniarti, Fajar Basuki, Sri Hastuti, Ristiawan Agung Nugroho and Shelfiya Fany
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012042
Diversity of brittle star and sea urchin (Echinoderm: Ophiuroidea, Echinoidea) of Krakal and Watu Kodok beach, Gunung Kidul, Yogyakarta
R S Tarigan, R Hartati and I Widowati
[+ Open abstract](#) [View article](#) [PDF](#)
-
- OPEN ACCESS** 012043
Co-existence between *Scylla serrata* and *Scylla transquebarica* in the lagoon of Segara Anakan, Cilacap, Indonesia

Sri Redjeki, Retno Hartati, Ria Azizah Tri Nuraeni, Ita Riniatsih, Hadi Endrawati and Widianingsih Widianingsih

[+ Open abstract](#)

[View article](#)

[PDF](#)

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[Information for authors](#)

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The potential stocks and carbon uptake by seagrass meadows at Pari Island, Kepulauan Seribu, Indonesia

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The potential stocks and carbon uptake by seagrass meadows at Pari Island, Kepulauan Seribu, Indonesia

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Abstract. The development of human civilization during the last century has increased carbon dioxide content in nature that will contribute to global climate change. However, ocean water will reduce this increase by absorbing CO₂. The increasing CO₂ content in the ocean could decrease pH and carbonate ion, which will have negative impacts on the life of marine organisms, food production and human life. Seagrass meadows through photosynthetic processes could absorb CO₂ and store carbon in large amounts for an extended period. This process could be the strategic way of resolving global climate change. The purpose of this research was to identify the species of seagrass, quantify the density and coverage of seagrass, and calculate biomass and carbon stock in seagrass meadows at Pari Island, Kepulauan Seribu. The research was carried out in February 2019. This research used quantitative field observation with the purposive sampling method. Samples were collected from 3 locations with nine stations. The obtained samples were analyzed at the Laboratory of Faculty of Fisheries and Marine Science, Diponegoro University. Carbon and sediment samples were analyzed using Loss in the Ignition (LOI) method. The results showed that there are three species of seagrass in Pari Island, i.e. *Enhalus acoroides*, *Thalassia hemprichii*, and *Cymodocea rotundata*. Total density value was 129.19 individual m⁻² and total coverage value was 62.59%. Total stock potential of carbon value in Pari Island was 87.80 ton per ha with total area of seagrass meadows of 3.48 ha. Silty-sands mainly dominated sediment textures. It can be concluded that seagrass meadows are potential habitats to control CO₂ concentration in coastal waters and to hold the rate of climate change.

1. Introduction

Carbon dioxide (CO₂), which has increased in nature since the industrial revolution, accompanied by the development of human civilization is a result of increased emissions, mainly from burning fuel and biomass [1]. Carbon dioxide content is thousands of times more than the pre-industrial era 200 years ago (before the increase in fossil fuels burning). The higher CO₂ partial pressure in the atmosphere indicates the large amount of carbon dioxide in marine waters [2]. This condition has contributed to changes in weather patterns, food production and human life [3].

Carbon can be absorbed by plants and stored at a specific time. Therefore, the role of plants becomes essential in dealing with climate change. Previous studies only focused on the role of soil plants such as forests and gardens in carbon sequestration and ruled out the role of marine ecosystems [4]. UNEP, FAO, IPCC, and UNESCO have introduced the concept of blue carbon by emphasizing the importance of marine and coastal ecosystems as controllers of climate change, concerning carbon uptake by marine ecosystems, namely: mangroves, seagrasses and brackish swamps [5]. These ecosystems have carbon potential of around 300 to 900 metric tones of CO₂ annually, which is equivalent to 7 to 20% of annual emissions resulting from global deforestation and forest degradation [6]. Therefore, the knowledge of the role of natural ecosystems in capturing CO₂ becomes necessary for developing strategies in dealing with climate change [7].

Pari Island has a reasonably good seagrass ecosystem. It was stated that there are seven species of seagrass on Pari Island, i.e., *Thalassia hemprichii*, *Enhalus acoroides*, *Cymodocea rotundata*, *Halophila ovalis*, *Halodule uninervis*, *Cymodocea serrulata* on the southern coast and *Enhalus*



acoroides on the western coast. The *Enhalus-Thalassia* seagrass community on Pari Island has carbon reserves of 200.5 g C m^{-2} or equivalent to $2.005 \text{ tons C ha}^{-1}$ while the total carbon stock is 67.21 tons C [8].

The vital role of seagrass in carbon storage, mitigation, and adaptation to climate change needs to be studied; further, this research will examine the potential carbon stocks and uptake by seagrass meadows.

2. Methodology

2.1. Study Site

The research was carried out at Pari Island, Kepulauan Seribu, Indonesia. Geographically, Pari Island is located on the coordinates $5^{\circ} 50' 20''$ to $5^{\circ} 50' 25''$ S and $106^{\circ} 34' 30''$ to $106^{\circ} 38' 20''$ E (Figure 1). The determination of sampling points was based on the distribution of seagrass in Pari Island, and sampling activities were carried out in a representative manner that it was expected to represent all conditions of the study area. There were three research locations that were divided into nine stations and 27 points.

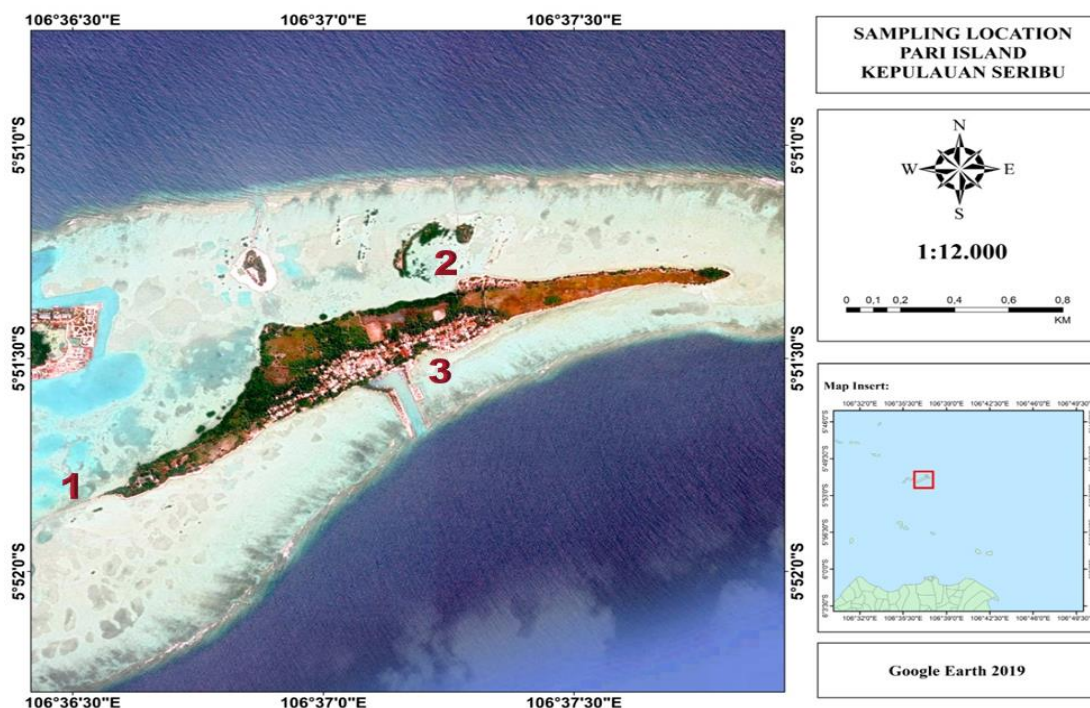


Figure 1. Map of research location

2.2. Field Sampling

2.2.1. Seagrass observation

Identification of species, density, and percentage of seagrass coverage was conducted through observations of seagrass. Data were collected based on the Seagrass watch method [9]. The three transects were made with length about 50 m each other and the distance between one transect and the other is 25 m. The quadrant frame was placed on the right side of the transect with the distance between one quadrant, and the other is 25 m, resulting in three quadrants on each transect (Figure 2). The starting

point of the transect was placed at a distance of 0 m from the first time the seagrass was encountered (from the coast) [10].

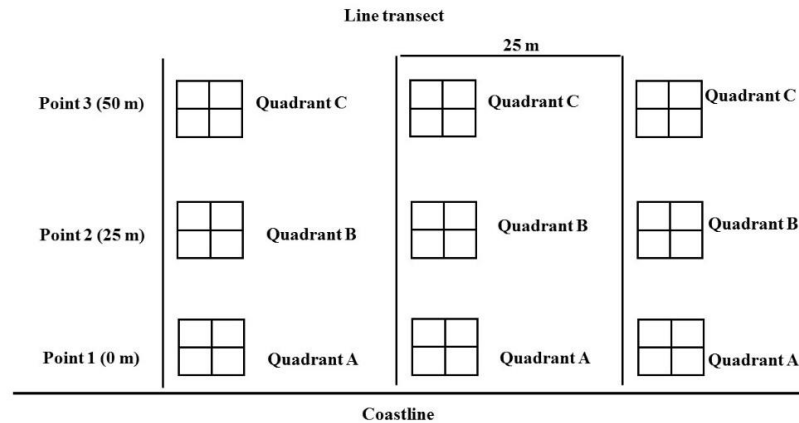


Figure 2. Quadrant transect illustration in seagrass with Seagrass watch modified

2.2.2. Seagrass sampling process

Seagrass samples were taken on each transect by sampling method which three sticks in one transect were taken. One root is defined as one bud (leaf), one segment of rhizome and root so that each root has three parts, namely leaves, rhizome, and roots. The total of root taken as a sample was recorded [11]. The samples were then cleaned of sediment and put in a sample bag and then stored in an icebox to maintain freshness. Then, seagrass samples were winded and also cut into leaves, rhizomes and roots. The samples were brought to the laboratory for analysis [4]. Seagrass samples taken were seagrasses that dominated in quadrant transect [12].

2.2.3. Sediment sampling process

Sediment sampling was conducted by taking surface sediments using sandpit. One sample was collected at each location and put into plastic zipper, therefore in total, and there were nine sediment samples from 9 points at 3 study sites. Then the samples were stored in a cool box for further analysis in the laboratory.

2.3. Data Analysis

2.3.1. Measurement of seagrass biomass

Measurement of biomass was carried out by counting seagrass stands and taking seagrass samples and then biomass was counted as wet biomass. Samples that have been washed and cleaned of sediments, then sorted by type and parts, namely leaves, rhizomes and roots [9]. After that, the sample was dried in an oven at 60 °C for 24 hours to obtain a dry weight (DW) for leaves, rhizomes, and roots. Thus, the dry biomass of each species per chip can be known. Biomass per unit area was obtained by multiplying the amount of density per unit area and biomass per sample [13]. The formula used to calculate biomass is shown by the equation according to [14]:

$$B = W \times D$$

where:

B = Seagrass Biomass (gram.m⁻²)

W = Dry Weight of a Seagrass Sprout (gram.sprout⁻¹)

D = Seagrass Density (shoots.m⁻²)

2.3.2. Measurement of seagrass carbon

Measurements of seagrass carbon were carried out using the Loss On Ignition (LOI) method [15], with the following procedures:

- 1) Wash the porcelain cup then rinse and dry;
- 2) Insert the cup into the furnace (electric furnace) for 2 to 3 hours with a temperature of 550 °C;
- 3) Cool the porcelain cup in the desiccator for 30 minutes, then weigh the cup as the weight of the empty cup;
- 4) Insert 1 to 2 grams of the dry sample into the porcelain cup and record the weight of the cup plus weight of the sample;
- 5) Porcelain cup containing dry sample is then burned in the furnace for 6 hours at a temperature of 550°C until it becomes ash which is marked by greyish-white without black spots;
- 6) Cool in the desiccator then weigh the cup as the weight of the cup plus the weight of ash and calculated using a greying formula.

The formula used to calculate the carbon content of seagrass with the ashing method by [16]:

$$\text{Dust concern} = \frac{c-a}{b-a} \times 100\%$$

where:

a = cup weight

b = cup weight plus dry weight of seagrass tissue

c = weight of the cup plus weight of seagrass ash

Organic matter was calculated by the ashing method by reducing the weight when ashing by [16]:

$$\text{Levels of organic matter} = \frac{[(b-a)-(c-a)]}{b-a} \times 100\%$$

where :

a = cup weight

b = cup weight plus sample weight

c = weight (cup plus ash)

The carbon content value of seagrass tissue is calculated:

$$\text{Carbon content} = \frac{\text{levels of organic matter}}{1,724}$$

Note : 1,724 = constant value of organic matter.

The value of the carbon content results is then averaged as the carbon content value of seagrass tissue [7].

2.3.3. Total carbon stock

Total seagrass carbon stock was calculated with formulation [17]:

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

where :

C_t = total carbon (tons)

L_i = broad seagrass category class i (m²)

C_i = average carbon stock of seagrass class I (gC m⁻²)

3. Result and Discussion

3.1. Results

3.1.1. Seagrass biomass

Result of biomass c is presented in the following Figure 3. Based on the diagram above it can be seen that the percentage of biomass under the substrate is higher at 59% with a biomass value ranging from 2.28 - 186.96 gbk m⁻² while the value of biomass on the substrate ranges between 1.68 - 111.12 gbk m⁻².

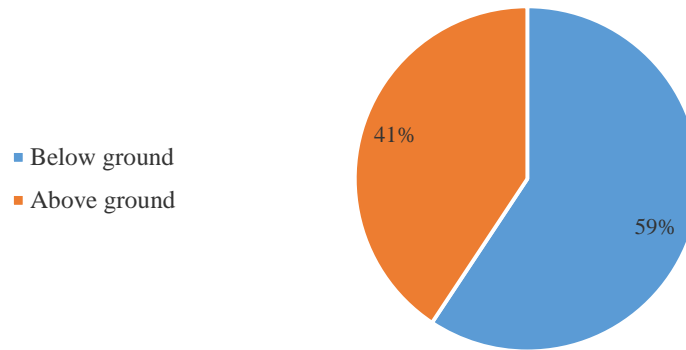


Figure 3. Percentage of carbon below ground and above-ground biomass

3.1.2. Estimation value of seagrass carbon stock

The total carbon stock obtained from the seagrass area in Pari Island is presented in Table 1. The denomination carbon g C m⁻² is converted into ton C ha⁻².

Table 1. Estimation value of seagrass carbon stock

Location	Area (ha)	Below ground (ton C ha ⁻²)	Above ground (ton C ha ⁻²)	Total carbon stock (ton C ha ⁻²)
1. LIPI Dock	1.67	14.11	28.02	42.13
2. Perawan beach	1.13	9.55	18.96	28.51
3. Pari Island Dock	0.68	5.75	11.41	17.16
Total	3.48			87.80

This table showed that total carbon stored in Pari Island is about 87.80 ton per ha with an area of about 3.48 ha. The highest carbon stored is about 42.13 ton per ha. It was in location 1 which is seagrass meadows at LIPI Dock. While the lowest carbon stored is about 17.16 ton C ha⁻². It was in Pari Island Dock seagrass meadows.

3.1.3. The sediment carbon

The sediment carbon is taken from surface sediment. It was calculated to know how much carbon is stored in seagrass sediment. Sediment carbon stock was presented in Table 2.

Table 2. Sedimen carbon stock

Station	% Organic matter	Corg	Ct	C sediment (tons ha ⁻²)
1	7.50	4.35	1.29	128.54
2	8.03	4.66	1.57	157.40
3	9.71	5.63	1.80	179.85
4	5.44	3.16	0.97	96.82
5	6.10	3.54	0.65	64.65
6	6.37	3.69	1.13	113.31

8	8.29	4.81	1.60	160.37
9	6.95	4.03	0.95	94.82

Sediment carbon content ranged between 64.65-179.85 ton C ha⁻². The highest carbon sediment value is in station three that 179.58 ton C ha⁻² while the lowest value is in station five about 64.65 ton C ha⁻².

3.2. Discussion

3.2.1. Density and coverage

The research in Pari Island, Kepulauan Seribu showed that there are three species of seagrass: *E. acoroides*, *T. hemprichii*, and *C. rotundata*. The highest density is *T. hemprichii* with density of 81.03 individuals m⁻². While the seagrass coverage ranged from 35.83 to 83.33%. The highest cover was 83.33% at stations 3 and 4; while the lowest cover was 35.83% at station 6. Then the lowest density is *E. acoroides* with a density value of 18.37 individuals m⁻². Location 1 is a location with a type Homogeneous seagrass that is *E. acoroides*, although it has a low density because it has a large size the closure at this location is quite high. Seagrass beds can form single vegetation composed of one type of seagrass that grows to form dense grasslands [18].

Furthermore found that the lowest total seagrass density in Tanjung Barari because the location had a substrate with a mixture of mud making it the only station where the seagrass *Enhalus acoroides* were found [19]. The existence of this type of seagrass causes several other species of seagrass that are small in size can not grow and develop properly, due to competition in obtaining nutrients and space for life [20].

The density and coverage significantly affect the amount of biomass in a seagrass ecosystem; the amount of biomass also affects the amount of carbon stored in it. Therefore, it is necessary to calculate the density and seagrass cover as a basis for calculating the carbon content. Components of seagrass biomass that are above the soil base can be categorized as leaf stands which are generally measured in units of dry weight per unit area (g m⁻²) related to shooting density and leaf area index [21].

3.2.2. Seagrass biomass

Calculations of seagrass biomass are separated into biomass above the substrate and below the substrate. The percentage of biomass calculated under the substrate is higher at 59% with a biomass value ranging from 2.28 to 186.96 gbk m⁻² while the value of biomass on the substrate ranges between 1.68 to 111.12 gbk m⁻². The result of this study is reinforced by the statement of [22] which confirms that the potential for carbon storage at the bottom (below ground) will likely be stored longer and continues to grow if seagrass ecosystems are protected from damage.

The results of the sequestration of carbon by seagrass in the photosynthesis process are stored or flowed into several compartments, one of which is in the form of biomass, both above and below the substrate. Storage of carbon in biomass, especially the bottom of the substrate makes the seagrass role even more critical because it will be stored for a long time [23].

Location 1, which is a homogeneous seagrass, there is a type of *E. acoroides* which has a higher biomass value than locations 2 and 3. Location 2 has a high closure and density, but seen from the calculation of biomass location 2, which is dominated by *T. hemprichii* species has low biomass. The size of the seagrass *E. acoroides* which is substantial and dry weight is also significant, allows this species to have high carbon content as well. According to large seagrass species have a higher capacity to accumulate carbon due to relatively slow root and rhizome replacement [24]. However, the speed and success of carbon sequestration vary between and within seagrass types, depending on the entire set of natural processes including herbivorous activity, nutrient export and decomposes. Research also

showed that the biomass of *E. acoroides* species is higher than other species, so it is suspected that *E. acoroides* is a high contributor to biomass [25].

3.2.3. Total Carbon Stock

Based on research can be known the total carbon stock value of seagrass in Pari Island is equal to 87.80 tons C ha⁻² with a total area of seagrass 3.48 ha. The highest carbon uptake is at location 1 which is at the LIPI Dock with a total carbon stock of 42.13 tons C ha⁻² while the lowest absorption at location 3 is around Pari Island Dock with a total carbon stock of 17.16 tons C ha⁻².

The results of the study among three research sites, location 1 has the highest carbon uptake. The highest carbon uptake at location 1 is *E. acoroides* vegetation. Deposits of carbon under the high *E. acoroides* substrate are caused by large rhizoma and root size, as well as root penetration which can reach 40 cm. One function of the high storage of biomass under the substrate is to strengthen seagrass insertion [26]. Morphologically large types of seagrass tend to develop high biomass under the substrate, and therefore can accumulate higher carbon. Besides, carbon under the substrate is a place to store photosynthesis results that will support the growth of seagrass if the photosynthesis process is not running optimally [4].

Carbon stock below the substrate is higher than the above substrate mentions this because the carbon content under the substrate is less affected by physical environmental factors compared to the carbon content on the substrate which is more influenced by water factors such as temperature and others [27].

The composition of seagrass species compilers and types of substrate affect the potential of seagrass reserves in an ecosystem. The type and extent also affect the amount of CO₂ that can be absorbed by an ecosystem in a certain period. The value of seagrass carbon stocks both in vegetation and in the substrate depends on the characteristics, conditions, and extent of the seagrass ecosystem [1].

The results of carbon research on surface sediments showed high carbon content, ranging from 64.65 - 179.58 tons C ha⁻². Location 1 has a higher sediment carbon content than location 2 and 3. Type 1 substrate location is muddy sand covered with *E. acoroides* vegetation, location 2 type of substrate is fine sand which is dominated by *T. hemprichii* type but *E. acoroides* is still found even though the amount a little, whereas at the location of 3 types of sand substrate with a mixture of coral fragments overgrown by *T. hemprichii* and *C. rotundata* vegetation. [28], [26] The amount of seagrass biomass on the smaller substrate is caused by a positive effect on the nutrient absorption system, while a more substantial (coarse) substrate will decrease nutrients and organic matter [24]. Sediment in healthy seagrass ecosystems and has a seagrass biomass compilation system that has an elaborate canopy and roots and is tightly intertwined with the potential to store carbon for thousands of years.

Based on the study of the potential carbon stocks and uptake by seagrass beds in Pari Island, the Kepulauan Seribu can see the role of seagrass in storing carbon in high quantities. Seagrass ecosystems can help in climate change mitigation, besides it is seen from the ecological function of seagrass ecosystems as ecosystem stability, it is essential to hold this research and it is hoped that with this research, the public will become more aware of the need to protect the environment, one of which is to preserve seagrass ecosystems.

4. Conclusion

Based on the results of research conducted on Pari Island, Kepulauan Seribu related to the potential stock and carbon uptake by seagrass beds, the conclusions that can be drawn are as follows:

1. Types of seagrass found on Pari Island include *E. acoroides*, *T. hemprichii* and *C. rotundata*.
2. The density value of seagrass species in Pari Island is *T. hemprichii* at 81.03 individuals m⁻², *E. acoroides* type at 18.37 individuals m⁻² and *C. rotundata* at 35,56 individuals m⁻².

3. Below ground biomass is higher than above-ground biomass. The percentage of biomass below substrate is higher at 59% with a biomass value ranging from 2.28 - 186.96 gbk m⁻² while the biomass value of above substrate 41% ranges from 1.68 - 111.12 gbk m⁻². The total carbon sequestration value on Pari Island is 87.80 tons C ha⁻² with total area of seagrass 3.48 ha. The highest carbon uptake is at location 1 which is at LIPI Dock with a total carbon stock of 42.13 tons C ha⁻² while the lowest uptake at location 3 is around Pari Island Dock with a total carbon stock of 17.16 tons C ha⁻².

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