 https://doi.org/10.1051/bioconf/202515602006

Seagrass communities on the North Coast of Aceh

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Abstract. Seagrass density and biomass are key indicators of the health and productivity of seagrass ecosystems. This study aims to address the seagrass communities on the North Coast of Aceh. Seagrass data collection was conducted using the Seagrass Net parallel transect plot method. The data analyzed include density, biomass, and carbon estimates. Three species of seagrass have been identified in the northern waters of Aceh, include *Halodule pinifolia Halophila ovalis*, and *Halophila minor*. Seagrass density ranged between 301 - 440 ind/m^2. the dry biomass measurements across various seagrass species and research stations indicate that the belowground biomassa generally exceeds the above ground biomass. The carbon stock at the research site ranged from 58.85 to 69.82 g C/m². By focusing on species diversity, density, biomass, and estimation of carbon storage capacity, this research will provide valuable insights into the ecological and carbon storage functions of seagrass ecosystems in this region, contributing to their conservation and sustainable management.

1 Introduction

Seagrass, a flowering marine plant forming dense underwater meadows, provides critical ecosystem services with ecological, economic, and social significance. These meadows support marine biodiversity by serving as nurseries for aquatic species, filtering sediments to enhance water quality, and providing food for species like dugongs and sea turtles. They also stabilize sediments, protect coastlines from erosion, and as carbon sequester, aiding in climate change mitigation. Additionally, seagrasses contribute to fisheries production, vital for food security. Preserving and sustainably managing seagrass meadows is essential for maintaining marine biodiversity and supporting human livelihoods [1-3].

Seagrass density and biomass are key indicators of the health and productivity of seagrass ecosystems. Typically, seagrass density is directly proportional to biomass, as higher density often results in greater biomass due to the contribution of each individual plant to the system, both above and below the substrate. Dense root and rhizome networks play a crucial role in stabilizing sediment, preventing coastal erosion, and enhancing substrate stability in coastal areas. Additionally, dense seagrass leaves help dissipate wave energy, offering protection against shoreline abrasion [4]. Biomass, on the other hand, reflects the ecosystem's capacity

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to store carbon. Seagrass meadows are highly efficient in sequestering "blue carbon," capturing atmospheric CO_2 and storing it in plant tissues and sediments over extended periods, which is vital for mitigating climate change [5].

Despite their ecological and environmental significance, seagrass communities face increasing threats from anthropogenic activities such as coastal development, pollution, and unsustainable fishing practices. These pressures not only endanger seagrass biodiversity but also diminish their functional capacity to serve as effective carbon sinks. The degradation of these ecosystems compromises their role in supporting marine biodiversity, stabilizing sediments, and mitigating climate change [6-8]. Furthermore, scientific data on the species composition, density, biomass, and carbon sequestration potential of seagrass meadows in this region remain limited. This knowledge gap hinders the development of targeted conservation strategies and the assessment of their ecological contributions, particularly in the context of global blue carbon initiatives. Filling this gap through comprehensive research is essential for guiding sustainable management and preservation efforts.

This study aims to address the seagrass communities on the North Coast of Aceh. Several studies on seagrass have been conducted along the North Coast of Aceh. Adding the latest research findings would provide significant benefits by enriching the existing data and offering updated insights. The study focuses on species diversity, density, biomass, and carbon storage capacity, providing valuable insights into the ecological role and carbon storage potential of seagrass ecosystems to support their conservation and sustainable management.

2 Method

2.1 Study area

The research was conducted in the waters of Ahmad Rhang Manyang, Teluk Lamteng, and Ujung Pancu in July 2024 (Fig 1). The research was conducted in July - August 2024. The sites were selected based on their ecological importance.

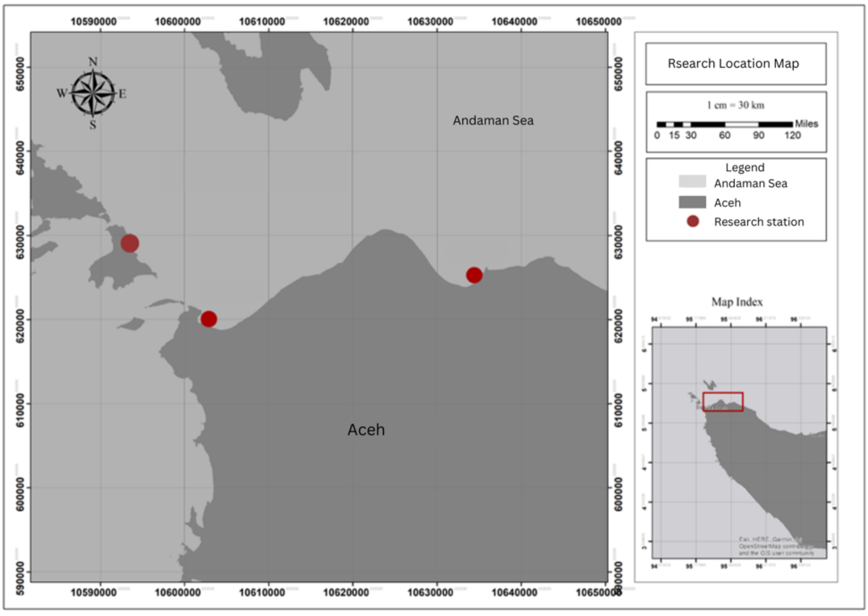

Fig. 1. Study area.

2.2 Collection data

Seagrass data collection was conducted using the Seagrass Net parallel transect plot method [9]. This method was selected based on the characteristics of the seagrass meadows at the study site, where seagrass predominantly grows horizontally along the coastline. The length of the transect lines was adjusted to accommodate the spatial extent of the meadows. Sampling points were established at 5-meter intervals from the first occurrence of vegetation identified along the shoreline. Visual assessments of seagrass cover were performed using 50 cm × 50 cm quadrats placed adjacent to a 50-meter transect line. This approach allowed for standardized measurements of seagrass distribution, density, and coverage, facilitating a detailed evaluation of the ecological characteristics of the meadow.

2.3 Data analysis

2.3.1 Density

Visual observations for seagrass density were carried out on a plot grid using formula [10]:

$$D = \text{shoots} * 16 \quad (1)$$

where:
D = density (ind/m^2)
16 = conversion factor

2.3.2 Biomass and carbon conversion

Biomass refers to the organic material produced through the process of photosynthesis, encompassing both primary products and residual byproducts. Biomass is generally categorized into two components: aboveground biomass (AGB), which includes leaves and stems, and belowground biomass (BGB), which comprises roots and rhizomes. These components provide insights into the productivity and ecological functions of ecosystems such as seagrass meadows. To quantify biomass, specific formulas are employed, as outlined by [10]:

$$\text{AGB (g/shoot)} = \frac{AG\ dry\ weight\ (g)}{shoots} \quad (2)$$

$$\text{BGB (g/shoot)} = \frac{BG\ dry\ weight\ (g)}{shoots} \quad (3)$$

where:
AGB: a*boveground biomass*; BGB: *Belowground biomass*

The estimation of carbon content was conducted using Duarte's conversion factor of 0.336, which is applied to the dry weight of seagrass biomass.

3 Results and discussions

3.1 Seagrass species

Three species of seagrass have been identified in the northern waters of Aceh, distributed across different locations (Table 1). In Ahmad Rhang Manyang and Pulo Aceh, the species identified include *Halodule pinifolia* and *Halophila ovalis*, while in the waters of Ujung

Pancu, *Halodule pinifolia* and *Halophila minor* were observed. Among these species, *Halodule pinifolia* is the dominant species, coexisting with H. ovalis and H. minor in smaller proportions.

Halodule pinifolia exhibit intermediate traits between persistent and colonizing species. These medium-sized seagrasses are well-adapted to dynamic coastal environments and are commonly found in shallow waters near the shoreline at depths of less than 3 meters. Their adaptability allows them to establish and thrive in areas with moderate environmental fluctuations, making them prevalent in disturbed or transitional habitats [11].

Table 1. Seagrass species in the North Aceh.

No.	Seagrass species	Ahmad Rhang Manyang		Ujung Pancu		Pulo Aceh	
		St 1	St 2	St 3	St 4	St 5	St 6
1	*Halodule pinifolia*	+	+	+	+	+	+
2	*Halophila ovalis*	+	+	-	-	+	+
3	*Halophila minor*	-	-	+	+	-	-

3.2 Seagrass density

The observed seagrass density values are presented in Fig. 2. Among the surveyed stations, the lowest seagrass density was recorded at Ahmad Rhang Manyang, with a total density of 301 individuals per square meter. In contrast, the highest density was observed at Pulo Aceh, where the seagrass community reached 440 individuals per square meter. These variations in density reflect the differing ecological conditions across the study sites, such as substrate type, water quality, and anthropogenic influences.

The seagrass density in the waters of Pulo Aceh is notably higher compared to that in Ahmad Rhang Manyang. This variation can be attributed to several factors, including fishing activities, the extent of seagrass beds, and substrate composition. In Ahmad Rhang Manyang, seagrass meadows are more limited due to their proximity to coral reef systems, which influences the overall coverage and density of seagrass. Conversely, Pulo Aceh is characterized by a predominance of muddy substrates, which enhance nutrient retention and facilitate seagrass growth. Muddy sediments are generally richer in organic matter compared to sandy substrates, providing a more favorable environment for seagrass development [12].

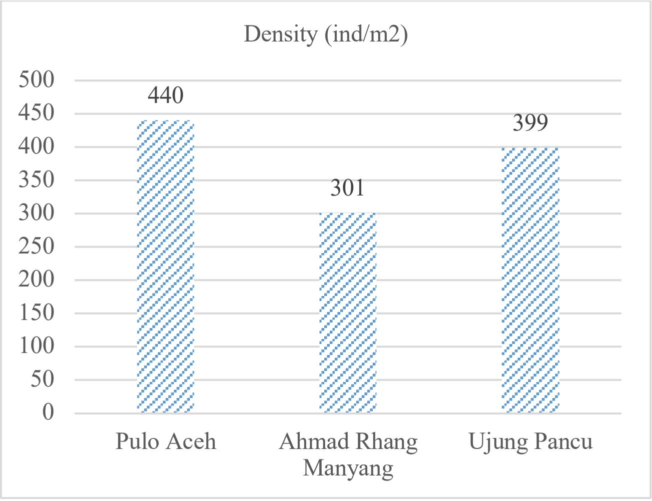

Fig. 2. Seagrass density.

To date, no rehabilitation efforts, such as replanting, have been conducted in the seagrass ecosystems along the North Coast of Aceh. This finding highlights the need for such initiatives and can serve as a basis for planning and implementing future rehabilitation activities.

3.3 Seagrass biomass

Seagrass biomass is typically measured using the dry weight approach, divided into Above-Ground Biomass (AGB) and Below-Ground Biomass (BGB). AGB represents the dry weight of the upper parts, such as leaves, while BGB refers to the dry weight of the lower parts, including roots and rhizomes. As shown in Fig 3, the dry biomass measurements across various seagrass species and research stations indicate that the BGB generally exceeds the AGB. This suggests that a significant proportion of biomass is concentrated in the root and rhizome structures beneath the substrate, which play a critical role in anchoring the plants and storing nutrients for growth and resilience. The biomass value beneath the substrate is largely influenced by nutrients absorbed by the roots from sediment and organic materials produced through photosynthesis, which are primarily stored in the rhizomes. This value is closely linked to the seagrass's ability to anchor itself to the substrate, enabling it to resist ocean currents and wave action.

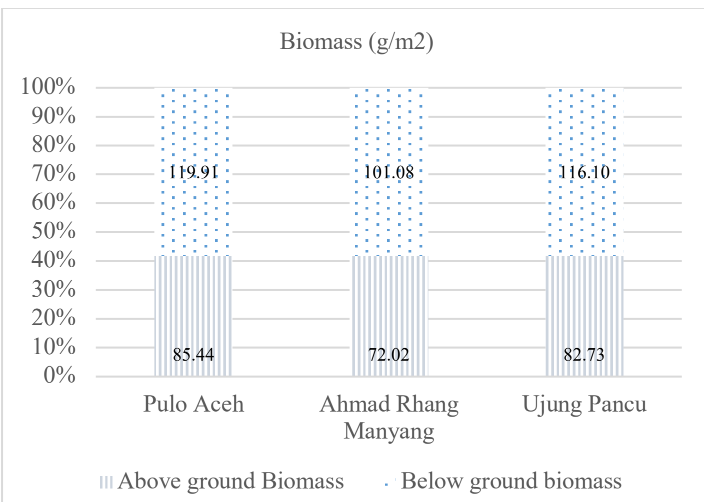

Fig. 3. Seagrass biomass.

The carbon stock at the research site ranged from 58.85 to 69.82 g C/m² (Fig 4). While the Duarte conversion factor (0.34) was primarily developed for temperate and subtropical seagrasses, it has been shown to be reliable for use in studies on Indonesian seagrasses [13]. Different seagrass species exhibit varying capacities for carbon absorption, similar to their biomass production potential. Smaller species, such as, *Halodule pinifolia*, *Halophila minor, and Halophila ovalis* typically have lesser carbon content compared to bigger species like *Enhalus acoroides.*

The carbon stock value in this study is lower compared to the findings of [14]. This decline is likely attributed to a decrease in seagrass density at the sampling location. The reduction in density can be caused by natural factors, such as storms and climate change, as well as anthropogenic activities, including fishing, tourism, ship traffic, sediment

dredging, and other disturbances [15].

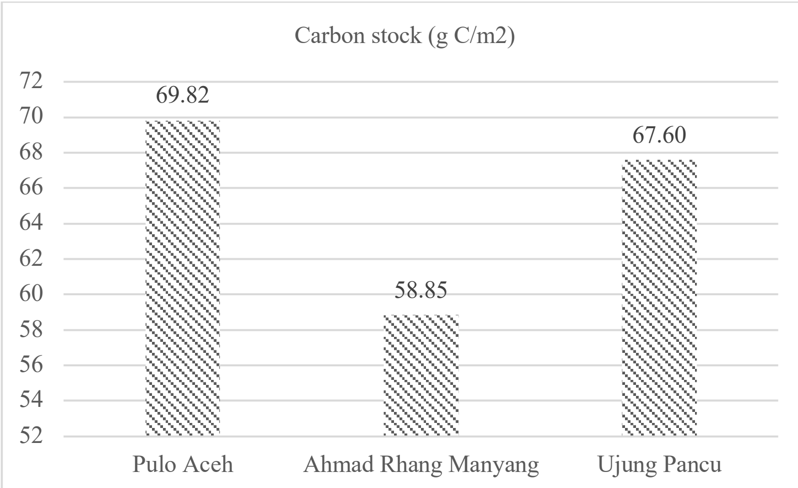

Fig. 4. Carbon stock estimation.

4 Conclusion

Three species of seagrass have been identified in the northern waters of Aceh, include *Halodule pinifolia Halophila ovalis*, and *Halophila minor*. Seagrass density ranged between 301 - 440 ind/m^2. the dry biomass measurements across various seagrass species and research stations indicate that the belowground biomassa generally exceeds the above ground biomass. The carbon stock at the research site ranged from 58.85 to 69.82 g C/m^2.

Acknowledgment

The study is funded by PTNBH Universitas Syiah Kuala with contract number 490/UN11.2.1/PG.01.03/SPK/PTNBH/2024 on May 3rd 2024.

References

1. J. Mellors, H. Marsh, T. J. B. Testing the sediment-trapping paradigm of seagrass: Do seagrasses influence nutrient status and sediment structure in tropical intertidal environments? *Bull. Mar. Sci.* **71(3)** (2020)
2. Z. Jiang, D. Huang, Y. Fang, C. Zhao, Home for marine species: Seagrass leaves as vital spawning ground and food source. *Front. Mar. Sci.* **9**, 1–9 (2020)
3. L. M. Nordlund, E. L. Jackson, M. Nakaoka, J. Samper-Villarreal, P. Beca-Carretero, J. C. Creed, Seagrass ecosystem services–What's next? *Mar. Pollut. Bull.* **134**, 145–151 (2018)
4. P. S. Lavery, M. Á. Mateo, O. Serrano, M. Rozaimi, Variability in the carbon storage of seagrass habitats and its implications for global estimates of blue carbon ecosystem service. *PLoS One* **8**, e73748 (2013)
5. J. W. Fourqurean, C. M. Duarte, H. Kennedy, N. Marbà, M. Holmer, M. A. Mateo, O. Serrano, Seagrass ecosystems as a globally significant carbon stock. *Nat. Geosci.* **5**, 505–509 (2012)

6. C. M. Duarte, N. Marbà, E. Gacia, J. W. Fourqurean, J. Beggins, C. Barrón, E. T. Apostolaki, Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. *Glob. Biogeochem. Cycles* **24** (2010)
7. L. Mtwana Nordlund, E. W. Koch, E. B. Barbier, J. C. Creed, Seagrass ecosystem services and their variability across genera and geographical regions. *PLoS One* **11**, e0163091 (2016)
8. R. K. Unsworth, R. Ambo-Rappe, B. L. Jones, Y. A. La Nafie, A. Irawan, U. E. Hernawan, L. C. Cullen-Unsworth, Indonesia's globally significant seagrass meadows are under widespread threat. *Sci. Total Environ.* **634**, 279–286 (2018)
9. F. T. Short, L. J. McKenzie, R. G. Coles, K. P. Vidler, J. L. Gaeckle, *SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat, Worldwide Edition*. University of New Hampshire Publication (2006)
10. S. Rahmawati, U. E. Hernawan, K. McMahon, B. Prayudha, H. B. Prayitno, A. J. Wahyudi, M. Vanderklift, M. Prayitno, *Blue Carbon in Seagrass Ecosystem*. UGM Press, Yogyakarta (2019)
11. S. Gole, N. Prabakaran, S. Prajapati, S. Dudhat, H. Das, S. Kuppusamy, J. A. Johnson, Latitudinal variation in seagrass communities with special emphasis on post-tsunami status in the Andaman and Nicobar archipelago, India. *PLoS One* **19**, e0300654 (2024)
12. N. El-Radaideh, A.A. Ak-Taani, T. Al-Momani, K. Tarawneh, A. Batayneh, A. Taani, Evaluating the potential of sediments in Ziqlab Reservoir (northwest Jordan) for soil replacement and amendment, *Lake and Reservoir Manag.* **2014**, 32 (2014)
13. S. Rahmawati, U.E. Hernawan, A. Rusta, The seagrass carbon content of 0.336 of dry weight can be applied in Indonesian seagrasses, *AIP Conference Proceeding.* **2120**, 030012 (2019)
14. Khairunnisa, W. Ulya, H.A. Haridhi, I. Dewiyanti. Estimation of seagrass blue carbon stocks in Ahmad Rhang Manyang and Ujung Pancu Waters, Aceh Besar District, BIO Web of Conference. **87**, 02006 (2024)
15. Y. Haditiar, M. Ikhwan, S. Mahdi, A.N. Siregar, H.A. Haridhi, I. Setiawan, M. Nanda, V. Prajaputra, M. Irham, Oceanographic characteristics in the North of Aceh waters. Regional Studies in Marine Science, **71**, 103408 (2024)