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Seagrass biomass on the coast of Bahoi Village, North Sulawesi

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ABSTRACT

Seagrass meadows contribute to coastal carbon sequestration through biomass accumulation in plant tissues and sediments. This study quantified dry seagrass biomass along the coast of Bahoi Village, North Sulawesi, using original field data collected in May 2017. Three stations representing a mangrove-adjacent area, a seagrass meadow, and a coral-reef-adjacent area were selected purposively, with three replicate sampling units at each station. Seagrasses within 50 × 50 cm quadrat frames were collected, cleaned, oven-dried for 24 h, separated into leaves, rhizomes, and roots, and weighed. Six species were recorded. *Enhalus acoroides* had the highest mean biomass at all stations, reaching 75.7 g DW m^{-2} at Station 1, 68.9 g DW m^{-2} at Station 2, and 58.6 g DW $^{m-2}$ at Station 3; *Thalassia hemprichii* reached 45.7 g DW m^{-2} at Station 2. Total biomass did not differ significantly among stations ($p = 0.379$), whereas species-specific ANOVA detected differences for *E. acoroides* ($p = 0.032$) and *Syringodium isoetifolium* ($p = 0.026$). Large-bodied seagrasses contributed most strongly to standing biomass. The 2017 dataset provides a baseline for future assessment of biomass-related blue-carbon functions in Bahoi coastal habitats

INTRODUCTION

Climate change is intensifying pressure on marine and coastal ecosystems through warming, ocean acidification, and other interacting stressors (Birchenough et al., 2015; Dmuchowski et al., 2022; Khan et al., 2020). Vegetated coastal ecosystems are therefore increasingly recognized for their capacity to capture and retain organic carbon. Seagrass meadows are a central component of this blue-carbon framework because carbon is stored both in living tissues and, over longer periods, in associated sediments (Fourqurean et al., 2012; Kennedy et al., 2010). Quantifying plant biomass is consequently an important first step for understanding the standing biological component of carbon storage, although biomass alone should not be interpreted as the total ecosystem carbon stock.

Beyond carbon sequestration, seagrass meadows provide habitat, nursery and feeding areas, sediment stabilization, and support for coastal fisheries and other ecosystem services. These functions are increasingly considered in conservation and management assessments (Nordlund et al., 2018a, 2018b; Unsworth et al., 2019). At the same time, seagrass meadows face spatially variable pressures and have shown both long-term declines and localized recovery across global bioregions (Dunic et al., 2021; McKenzie et al., 2020). Recent studies also emphasize that seagrass ecosystem services and vulnerability are strongly context dependent, requiring locally grounded measurements of meadow condition and function (Herrera et al., 2022; Kaewsrikhaw et al., 2022; Nguyen et al., 2022).

In tropical seagrass systems, standing biomass varies among species because leaf size, rhizome development, root architecture, growth form, and local habitat conditions influence the amount of plant material retained above and below the sediment. Indonesian seagrass research has documented variability in meadow structure and associated ecological communities (Fahruddin et al., 2017; Latuconsina et al., 2014), as well as biomass and carbon-related attributes among species and sites (Analuddin et al., 2023; Gunawan et al., 2019; Hartati et al., 2017), while work on *Enhalus acoroides* demonstrates the importance of large below-ground structures to plant biomass and persistence (Supriadi & Arifin, 2005). Experimental evidence further shows that the growth and physiology of *E. acoroides* can vary with environmental conditions (Artika et al., 2020). At broader tropical scales, seagrass carbon storage is also shaped by plant–sediment processes and landscape setting (Gullström et al., 2018). In Bahoi Village, previous surveys reported high seagrass cover and a diverse meadow structure (Fahruddin et al., 2017), and more recent Indonesian studies continue to demonstrate strong spatial variability in seagrass composition and density (Fahruddin et al., 2024; Fifianingrum et al., 2020).

Against this background, the present study was designed to provide a quantitative assessment of seagrass biomass along the coast of Bahoi Village, West Likupang Subdistrict, North Sulawesi. Specifically, the study aimed to determine the dry biomass of seagrass tissues by considering both above-substrate components, represented primarily by leaves, and below-substrate components, including roots and rhizomes. Measurements were conducted at three sampling stations representing different coastal habitat settings to capture potential spatial variation in seagrass biomass. In addition to estimating total biomass at each station, the study also sought to compare biomass values among the three stations and among the seagrass species recorded during sampling. Through these comparisons, the study was intended to identify differences in biomass contribution across species and habitat settings and to provide a clearer description of the spatial pattern of seagrass standing biomass in the coastal waters of Bahoi Village.

MATERIAL AND METHODS

Study site. Field sampling was conducted in May 2017 along the coast of Bahoi Village, West Likupang Subdistrict, North Minahasa Regency, North Sulawesi, Indonesia (Figure 1). Three observation stations represented different coastal-habitat settings: Station 1 was positioned near the mangrove habitat, Station 2 within the seagrass meadow, and Station 3 near the coral reef area.

Tools and materials. Field and laboratory equipment comprised 50 × 50 cm PVC quadrat frames, a trowel, dissolved oxygen meter, thermometer, handheld refractometer, writing materials, snorkeling gear, a laboratory balance, and a drying oven.

Sampling method. Purposive sampling was employed to select the three stations. Three replicate sampling units were examined at each station (n = 3), resulting in nine sampling units overall. Within each 50 × 50 cm quadrat, seagrass plants were carefully excavated with a trowel to retain the leaves, rhizomes, and roots. The samples were then rinsed with freshwater to remove sediment and attached epiphytes, transported to the laboratory, oven-dried for 24 h, separated into leaf, rhizome, and root components, and weighed. An identical sampling and processing protocol was used at all three stations.

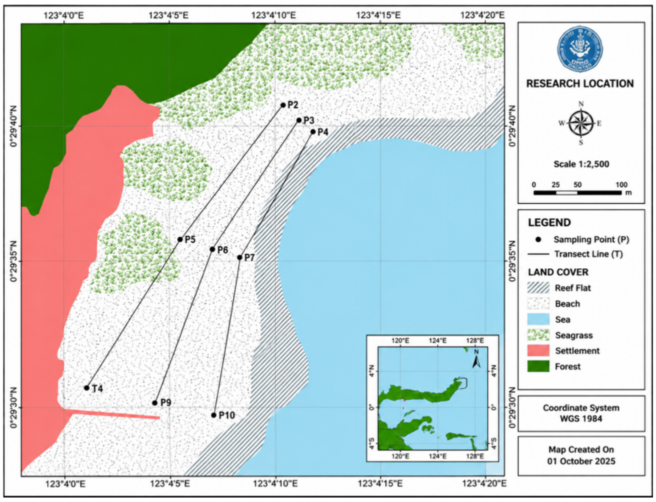

Figure 1. Study site and sampling stations along the coast of Bahoi Village, North Sulawesi, Indonesia

Data analysis. Dry biomass was expressed as B = W/A, where B is biomass (g DW m^{-2}), W is dry mass (g), and A is sampled area (m^2), following the general approach of Zieman and Wetzel (1980). Means and standard deviations were calculated from the three replicate sampling units per station. Overall differences among stations were evaluated using one-way ANOVA on total dry biomass per replicate ($p = 0.379$). Species-specific one-way ANOVAs were then used to compare each seagrass species among stations. The significance threshold was set at $p < 0.05$.

RESULTS AND DISCUSSION

Seagrass biomass. Six seagrass species were recorded: *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Syringodium isoetifolium*, *Halophila ovalis*, and *Halodule uninervis*. Mean total dry biomass was 121.4 ± 23.5 g DW m^{-2} at Station 1, 132.6 ± 5.2 g DW m^{-2} at Station 2, and 106.9 ± 26.9 g DW m^{-2} at Station 3. Total biomass did not differ significantly among stations ($F (2, 6) = 1.146$, $p = 0.379$). *Enhalus acoroides* had the highest mean biomass at all stations, reaching 75.7 g DW m^{-2} at Station 1, 68.9 g DW m^{-2} at Station 2, and 58.6 g DW m^{-2} at Station 3 (Figure 2).

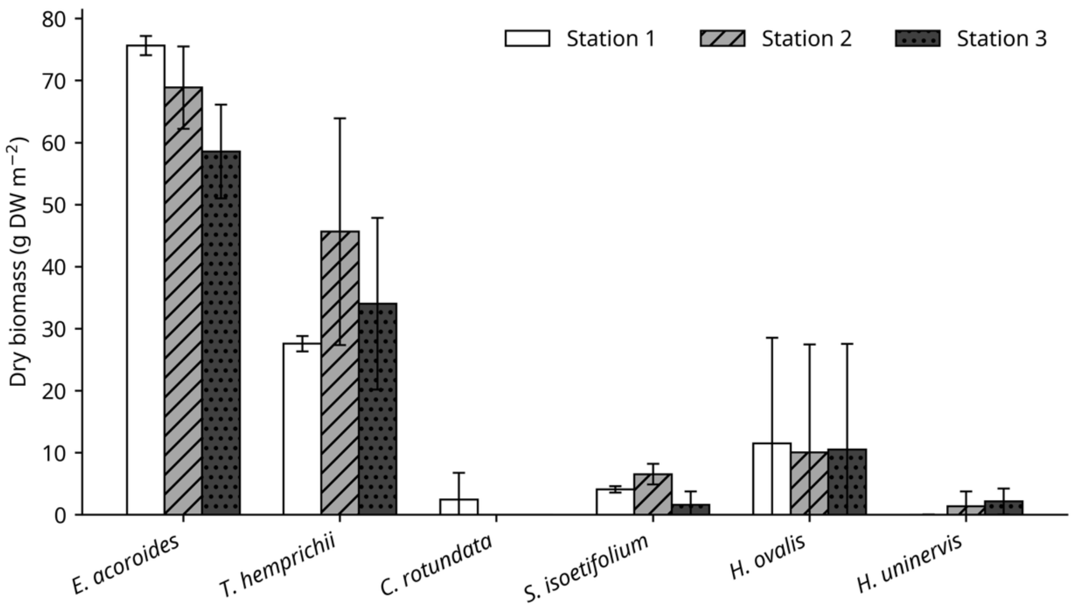

Figure 2. Mean dry biomass of six seagrass species at the three observation stations (g DW m^{-2}; mean ± SD, n = 3 per station). Error bars show one standard deviation.

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Thalassia hemprichii also contributed substantial biomass, with its highest mean at Station 2 (45.7 g DW m^{-2}). Species-specific ANOVA detected significant station effects for *E. acoroides* ($F(2, 6) = 6.436$, $p = 0.032$) and *S. isoetifolium* ($F(2, 6) = 7.161$, $p = 0.026$). No significant station effect was detected for *T. hemprichii* ($p = 0.310$), *C. rotundata* ($p = 0.421$), *H. ovalis* ($p = 0.995$), or *H. uninervis* ($p = 0.409$). All biomass values are reported consistently on a dry-weight basis.

The strong contribution of *Enhalus acoroides* and *Thalassia hemprichii* is consistent with their relatively large plant morphology. Large leaves and extensive below-ground rhizome and root systems increase standing dry mass, and below-ground biomass can also support anchorage and carbohydrate storage (Alcoverro et al., 2001; Supriadi & Arifin, 2005). Comparable Indonesian studies have reported substantial biomass and carbon-related contributions from large-bodied seagrasses (Gunawan et al., 2019; Hartati et al., 2017). For *E. acoroides* specifically, environmental conditions can modify growth and physiological performance (Artika et al., 2020), which may help explain spatial differences among sites in addition to intrinsic species morphology.

Biomass should nevertheless be interpreted as one component of the broader blue-carbon function of a meadow. Long-term carbon storage also depends on sediment accumulation, organic-matter preservation, carbonate dynamics, and landscape context (Fourqurean et al., 2012; Gullström et al., 2018; Kennedy et al., 2010). The comparatively low standing biomass of smaller species in this dataset may reflect a combination of morphology and local habitat conditions, but tidal currents and wave exposure were not measured directly; therefore, they should not be treated as demonstrated causal drivers. Global and regional evidence shows that seagrass condition can change through time in response to multiple stressors (Dunic et al., 2021; McKenzie et al., 2020; Strydom et al., 2020; Unsworth et al., 2019). Accordingly, because the present measurements were collected in 2017, they are best interpreted as a historical baseline for Bahoi rather than as an estimate of current meadow condition.

CONCLUSION

Six seagrass species were identified along the coast of Bahoi Village. Across the three sampling stations, *Enhalus acoroides* contributed the greatest proportion of dry biomass, while *Thalassia hemprichii* also accounted for a substantial share, especially at Station 2. Although total dry biomass showed no significant differences among stations, significant spatial variation was detected for *E. acoroides* and *Syringodium isoetifolium*. Since biomass estimates included both above-ground tissues, primarily leaves, and below-ground components such as roots and rhizomes, the findings emphasize the important contribution of large-bodied seagrasses to overall standing biomass and their potential role in blue-carbon-related functions. The 2017 dataset also serves as a valuable baseline for future monitoring and temporal comparisons of the seagrass meadows in Bahoi.

REFERENCES

Alcoverro, T., Manzanera, M., & Romero, J. (2001). Annual metabolic carbon balance of the seagrass Posidonia oceanica: The importance of carbohydrate reserves. *Marine Ecology Progress Series*, 211, 105–116. https://doi.org/10.3354/meps211105

Analuddin, K., Sharma, S., Kadidae, L. O., Haya, L. O. M. Y., Septiana, A., Rahim, S., Syahrir, L., Aba, L., Fajar, L. O. A., MacKenzie, R. A., & Nadaoka, K. (2023). Blue carbon stock in sediments of mangroves and seagrass ecosystems at Southeast Sulawesi, Indonesia. *Ecological Research*, 38(4), 508–520. https://doi.org/10.1111/1440-1703.12374

Artika, S. R., Ambo-Rappe, R., Teichberg, M., Moreira-Saporiti, A., & Viana, I. G. (2020). Morphological and physiological responses of Enhalus acoroides seedlings under varying temperature and nutrient treatment. *Frontiers in Marine Science*, 7, 325. https://doi.org/10.3389/fmars.2020.00325

Birchenough, S. N. R., Reiss, H., Degraer, S., Mieszkowska, N., & Borja, A. (2015). Climate change and marine benthos: A review of existing research and future directions in the North Atlantic. *WIREs Climate Change*, 6(1), 203–223. https://doi.org/10.1002/wcc.330

Dmuchowski, W., Dąbrowska, A. H. B., & Gworek, B. (2022). Agronomy in the temperate zone and threats or mitigation from climate change: A review. *Catena*, 212, 106089. https://doi.org/10.1016/j.catena.2022.106089

Dunic, J. C., Brown, C. J., Connolly, R. M., Turschwell, M. P., & Côté, I. M. (2021). Long-term declines and recovery of meadow area across the world's seagrass bioregions. *Global Change Biology,* 27(17), 4096–4109. https://doi.org/10.1111/gcb.15684

Fahruddin, M., Ilyas, A. P., & Jondani, D. R. (2024). Jenis dan kerapatan lamun di Pantai Ai Lemak Kabupaten Sumbawa. *Jurnal Perikanan Terapan*, 1(1), 24–28.

Fahruddin, M., Yulianda, F., & Setyobudiandi, I. (2017). Kerapatan dan penutupan ekosistem lamun di pesisir Desa Bahoi, Sulawesi Utara. *Jurnal Ilmu dan Teknologi Kelautan Tropis*, 9(1), 375–383. https://doi.org/10.29244/jitkt.v9i1.17952

Fifianingrum, K. P. N. D., Endrawati, H., & Riniatsih, I. (2020). Simpanan karbon pada ekosistem lamun di Perairan Alang-Alang dan Perairan Pancuran Karimunjawa, Jawa Tengah. *Journal of Marine Research*, 9(3), 289–295. https://doi.org/10.14710/jmr.v9i3.27558

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., Apostolaki, E. T., Kendrick, G. A., Krause-Jensen, D., McGlathery, K. J., & Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience*, 5, 505–509. https://doi.org/10.1038/ngeo1477

Gullström, M., Lyimo, L. D., Dahl, M., Samuelsson, G. S., Eggertsen, M., Anderberg, E., Rasmusson, L. M., Linderholm, H. W., Knudby, A., Bandeira, S., Nordlund, L. M., & Björk, M. (2018). Blue carbon storage in tropical seagrass meadows relates to carbonate stock dynamics, plant–sediment processes, and landscape context: Insights from the Western Indian Ocean. *Ecosystems*, 21, 551–566. https://doi.org/10.1007/s10021-017-0170-8

Gunawan, J. V., Parengkuan, M., Wahyudi, A. J., & Zulpikar, F. (2019). Estimasi stok karbon pada biomassa lamun di Pulau Semak Daun, Kepulauan Seribu. *Oseanologi dan Limnologi di Indonesia*, 4(2), 89–99. https://doi.org/10.14203/oldi.2019.v4i2.229

Hartati, R., Pratikto, I., & Pratiwi, T. N. (2017). Biomassa dan estimasi simpanan karbon pada ekosistem padang lamun di Pulau Menjangan Kecil dan Pulau Sintok, Kepulauan Karimunjawa. *Buletin Oseanografi Marina*, 6(1), 74–81. https://doi.org/10.14710/buloma.v6i1.15746

Herrera, M., Tubío, A., Pita, P., Vázquez, E., Olabarria, C., Duarte, C. M., & Villasante, S. (2022). Trade-offs and synergies between seagrass ecosystems and fishing activities: A global literature review. *Frontiers in Marine Science*, 9, 781713. https://doi.org/10.3389/fmars.2022.781713

Kaewsrikhaw, R., Upanoi, T., & Prathep, A. (2022). Ecosystem services and vulnerability assessments of seagrass ecosystems: Basic tools for prioritizing conservation management actions using an example from Thailand. *Water*, 14(22), 3650. https://doi.org/10.3390/w14223650

Kennedy, H., Beggins, J., Duarte, C. M., Fourqurean, J. W., Holmer, M., Marbà, N., & Middelburg, J. J. (2010). Seagrass sediments as a global carbon sink: Isotopic constraints. *Global Biogeochemical Cycles*, 24(4), GB4026. https://doi.org/10.1029/2010GB003848

Khan, F. L., Hu, M., Kong, H., Shang, Y., Wang, T., Wang, X., Xu, R., Lu, W., & Wang, Y. (2020). Ocean acidification, hypoxia, and warming impair the digestive parameters of marine mussels. *Chemosphere*, 256, 127096. https://doi.org/10.1016/j.chemosphere.2020.127096

Latuconsina, H., Sangadji, M. B., & Sarfan, L. (2014). Struktur komunitas ikan padang lamun di Perairan Wael Teluk Kotania. *Agrikan: Jurnal Agribisnis Perikanan*, 6, 24–32. https://doi.org/10.29239/j.agrikan.6.0.24-32

McKenzie, L. J., Nordlund, L. M., Jones, B. L., Cullen-Unsworth, L. C., Roelfsema, C., & Unsworth, R. K. F. (2020). The global distribution of seagrass meadows. *Environmental Research Letters*, 15(7), 074041. https://doi.org/10.1088/1748-9326/ab7d06

Nguyen, X.-V., Phan, T. T. H., Cao, V.-L., Nguyen Nhat, N.-T., Nguyen, T.-H., Nguyen, X.-T., Lau, V.-K., Hoang, C.-T., Nguyen-Thi, M.-N., Nguyen, H. M., Dao, V.-H., Teichberg, M., & Papenbrock, J. (2022). Current advances in seagrass research: A review from Viet Nam. *Frontiers in Plant Science*, 13, 991865. https://doi.org/10.3389/fpls.2022.991865

Nordlund, L. M., Jackson, E. L., Nakaoka, M., Samper-Villarreal, J., Beca-Carretero, P., & Creed, J. C. (2018a). Seagrass ecosystem services—What's next? *Marine Pollution Bulletin*, 134, 145–151. https://doi.org/10.1016/j.marpolbul.2017.09.014

Nordlund, L. M., Unsworth, R. K. F., Gullström, M., & Cullen-Unsworth, L. C. (2018b). Global significance of seagrass fishery activity. *Fish and Fisheries*, 19(3), 399–412. https://doi.org/10.1111/faf.12259

Strydom, S., Murray, K., Wilson, S., Huntley, B., Rule, M., Heithaus, M., Bessey, C., Kendrick, G. A., Burkholder, D., Fraser, M. W., & Zdunic, K. (2020). Too hot to handle: Unprecedented seagrass death driven by marine heatwave in a World Heritage Area. *Global Change Biology*, 26(6), 3525–3538. https://doi.org/10.1111/gcb.15065

Supriadi, & Arifin. (2005). Pertumbuhan, biomassa dan produksi lamun Enhalus acoroides di Pulau Bone Batang Makassar. *Protein*, 12(2), 293–302.

Unsworth, R. K. F., McKenzie, L. J., Collier, C. J., Cullen-Unsworth, L. C., Duarte, C. M., Eklöf, J. S., Jarvis, J. C., Jones, B. L., & Nordlund, L. M. (2019). Global challenges for seagrass conservation. *Ambio*, 48, 801–815. https://doi.org/10.1007/s13280-018-1115-y

Zieman, J. C., & Wetzel, R. G. (1980). Productivity in seagrasses: Methods and rates. In R. C. Phillips & C. P. McRoy (Eds.), Handbook of seagrass biology: An ecosystem perspective (pp. 87–116). Garland STPM Press.