Jurnal Biologi Tropis

Original Research Paper

Gastropod Community Structure as a Bioindicator of Water Quality n The Seagrass Ecosystem at Samuh Beach, Bali

Made Dendy Pratama[1]*, I Putu Gede Eka Handrayana Putra[2], I Kade Alfian Kusuma Wirayuda[2]

[1]Aquaculture Study Program, Faculty of Marine Science and Fisheries, Udayana University, Bali, Indonesia;

[2]Aquatic Resources Management Study Program, Faculty of Marine Science and Fisheries, Udayana University, Bali, Indonesia;

Article History
Received : June 19th, 2025
Revised : June 26th, 2025
Accepted : July 10th, 2025

*Corresponding Author:
Made Dendy Pratama,
Aquaculture Study Program, Faculty of Marine Science and Fisheries, Udayana University, Bali, Indonesia;
Email: dendypratama@unud.ac.id

Abstract: Coastal ecosystems, such as the seagrass meadows at Samuh Beach, Bali, are vulnerable to anthropogenic pressures from high-intensity tourism. This degradation necessitates effective monitoring tools, and gastropod communities are potential bioindicators due to their sensitivity to environmental change. The objective of this study was to evaluate the gastropod community structure as a bioindicator of water quality within this ecosystem. The study was conducted from November to December 2024 at two stations representing different levels of human activity, using line transects and quadrat sampling. A total of 10 gastropod species were recorded. The community structure was characterized by low species diversity (H' = 1.25), moderate evenness (E = 0.52), and low dominance (C = 0.35). In contrast, all measured water quality parameters were found to be within optimal ranges for marine biota. The dissonance between the low biodiversity and favorable water chemistry suggests that the gastropod community is responding to unmeasured stressors, likely physical disturbances or specific pollutants associated with tourism. This study validates the efficacy of using gastropod assemblages as sensitive bioindicators of ecosystem health, capable of detecting impacts that standard water quality tests may miss. Continuous monitoring is recommended to safeguard the area.

Keywords: Bali, bioindicator, gastropods, samuh, seagrass.

Introduction

Seagrass meadows are globally significant coastal ecosystems that provide ecological services disproportionate to their spatial extent. As highly productive habitats, they function as critical carbon sinks, enhance coastal resilience by stabilizing sediments, and improve water clarity (Duarte et al., 2005). They also form essential, structurally complex habitats that act as nurseries, spawning grounds, and feeding areas for a diverse array of marine fauna, thereby underpinning coastal fisheries, marine biodiversity, and global food security (Yunita et al., 2019; Unsworth et al., 2019). The ecological integrity of the nearshore environment is therefore heavily dependent on the health of these foundational ecosystems. Effective environmental monitoring is imperative to safeguard these valuable habitats. Bioindicators, defined as organisms or communities whose population dynamics reflect ambient environmental quality, offer a powerful tool for an integrated assessment of ecosystem health. In contrast to discrete chemical measurements that represent a single point in time, bioindicators provide a cumulative record of exposure to environmental stressors (Holt & Miller, 2011). Benthic macroinvertebrates, particularly molluscs, are effective sentinels of marine pollution due to their relatively sedentary nature and prolonged exposure to local water and sediment conditions (García-March et al., 2020).

Despite their importance, seagrass ecosystems are globally in decline due to escalating anthropogenic pressures, especially in densely populated coastal zones (Orth et al., 2006). In regions such as Bali, intensive tourism, coastal development, and agricultural runoff introduce a suite of pollutants and physical disturbances that degrade water quality (Cullen-Unsworth & Unsworth, 2013). These stressors manifest as reduced light penetration, eutrophication, and hypoxia, which directly threaten the viability and spatial coverage of seagrass meadows. This presents an urgent need for robust, cost-effective methodologies to monitor the impacts of human activity on these vulnerable ecosystems. This study investigates the efficacy of using gastropod community structure as a bioindicator of environmental quality in the seagrass ecosystem at Samuh Beach, Bali. Gastropods are a functionally significant component of these systems, contributing to nutrient cycling through the consumption of detritus and periphyton (Faizal et al., 2022). Their sensitivity to pollutants and habitat degradation makes their community metrics a powerful diagnostic tool. Therefore, the primary objective of this research is to analyze the gastropod assemblage at Samuh Beach to evaluate its utility as a bioindicator of local water quality, with the urgent goal of developing a practical ecological assessment framework to inform coastal management and conservation strategies.

Materials and Methods

Study Area and Period

This study was conducted from November to December 2024 at Samuh Beach, South Kuta District, Badung Regency, Bali. Two distinct sampling stations were established within the study area, with their locations shown in Figure 1.

Methodology

Two research stations were established within the study area at Samuh Beach using a purposive sampling method. Station locations were selected based on two primary criteria: the visible presence of gastropod populations and representative habitat characteristics. Station 1 (8°47'12.61"S, 115°13'42.77"E) was characterized by a mixed sand and rock substrate with seagrass cover and was subject to high levels of anthropogenic activity. In contrast, Station 2 (8°47'16.81"S, 115°13'49.00"E) featured a sandy substrate with seagrass cover and was situated in an area with minimal tourism activity.

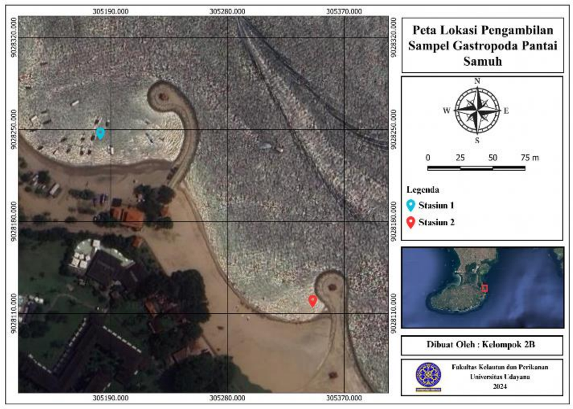

Figure 1. Map of the study area at Samuh Beach, Kuta Selatan, Bali, indicating the locations of the two research stations (e.g., Station 1 and Station 2).

Data collection occurred at two research stations. At each station, a 30 m line transect was laid perpendicular to the shoreline, and gastropod populations were sampled using 1 m x 1 m quadrats placed at 10 m, 20 m, and 30 m along the line. All gastropods within the quadrats were identified and counted to provide data on composition and density. This was supplemented by a free collection method around each transect to ensure a complete inventory for diversity, evenness, and dominance analyses. Concurrently, key *in situ* water quality parameters were measured, including pH, temperature, dissolved oxygen (DO), salinity, and Total Dissolved Solids (TDS) using a pH meter, thermometer, DO meter, refractometer, and TDS meter, respectively.

Research Procedure

The research procedure was as follows:

1. Determine the location points. Data was collected at 2 different stations, based on locations with high and low activity levels.
2. Observe the research location. Observation started from the edge of the beach with a distance of 10 m, followed by the second and third points also at a distance of 10 m.
3. At each 10 m point, place a 1x1 m transect and dig the substrate in each plot. Any biota found was collected and recorded.
4. Measure water quality. Water quality was measured at the 2 research stations. The

DOI: http://doi.org/10.29303/jbt.v25i3.9574

parameters measured were pH, salinity, DO, TDS, and temperature.

5. The results obtained were then photographed and analyzed based on journal sources.

Data Analysis

1. Species Composition

Species composition was analyzed using the formula according to Brower et al. (1990):

$$Kj = \frac{\sum ni}{N} \text{X } 100\% \qquad (1)$$

Where:

Kj = Species composition (%)

∑ni = Number of individuals of species i

N = Total number of individuals at each station

2. Abundance

Abundance was analyzed using the formula according to Fachrul (2007):

$$\mathrm{Ki} = \frac{\mathrm{ni}}{\mathrm{A}} \qquad (2)$$

Where:

Ki = Abundance of species i (individuals/m²)

ni = Number of individuals of species i

A = Area of the sampling plot (m²)

3. Diversity Index

Species diversity of gastropods was analyzed using the Shannon-Wiener equation (Odum, 1993):

$$\mathrm{H}' = -\sum_{\mathrm{i}=1}^{\mathrm{n}} pi \ln pi \qquad (3)$$

Where:

H' = Species diversity index

pi = Proportion of individuals of each species

Criteria for H' value:

H'>3 = High diversity

1<H'>3 = Medium diversity

H'<1 = Low diversity

4. Species Evenness Index

Evenness was analyzed using the Evenness index (Odum, 1993):

$$\mathrm{E} = \frac{\mathrm{H}'}{\ln \mathrm{S}} \qquad (4)$$

where:

E = Species evenness index

H' = Species diversity index

S = Number of species

ln = Natural logarithm

Criteria for E value:

0<E≤0,4 = Low evenness

0,4<E≤0,6 = Medium evenness

0,6<E≤1 = High evenness

5. Dominance Index

Data analysis to calculate the dominance of gastropod species (Krebs, 1985) used the formula:

$$C = \sum (pi)^2 \qquad (5)$$

Where:

C = Species dominance index

pi = Proportion of the number of individuals of species i to the total number

Criteria for C value:

0<C≤0,5 = Low dominance

0,5<C≤0,75 = Medium dominance

0,75<C≤1 = High dominance

Result and Discussion

Gastropod Community Structure and Composition

The composition and structure of the gastropod community were analyzed to provide an initial assessment of the ecological condition at Samuh Beach. A total of 10 gastropod species were identified across the two sampling stations during the study. The complete list of species, their distribution at each station, and their taxonomic classification are presented in **Table 1**. A total of 116 individual gastropods were recorded during the study. Station 1, characterized by high human activity, yielded 66 individuals across six species. Station 2, located in an area with lower tourism activity, contained 50 individuals, also comprising six species. The species Littorina scabra and Euplica scripta were the most abundant at both stations and were the dominant species overall within the ecosystem (Table 1). To quantify the health and stability of the gastropod community, several ecological indices were calculated. These indices, including species diversity (H'), evenness (E), and dominance (C), provide a standardized measure of community structure. The results of these calculations are detailed in Table 2.

Table 2. Calculation of Diversity, Evenness, and Dominance Indices

pi	ln pi	pi ln pi	H	E	Pi^2	C
0,0303	-3,4965	-0,1059	1,2517	0,5220	0,0009	0,3549
0,4242	-0,8574	-0,3637			0,1799	
0,0606	-2,8033	-0,1699			0,0036	
0,0303	-3,4965	-0,1059			0,0009	
0,4090	-0,8938	-0,3656			0,1673	
0,0454	-3,0910	-0,1405			0,0020	

The gastropod community exhibited low species diversity (H' = 1.25). The evenness index indicated a medium level of uniformity in the distribution of individuals among species (E = 0.52). Correspondingly, the dominance index was low (C = 0.35), suggesting that no single species overwhelmingly dominated the community.

Environmental Water Quality Parameters

In situ water quality measurements were taken at both stations to characterize the prevailing environmental conditions during the sampling period. These physicochemical parameters provide essential context for interpreting the biological data. The results for dissolved oxygen (DO), pH, temperature, and salinity are summarized in Table 3.

Table 3. Results of Water Quality Parameter Measurements at Samuh Beach

Parameter	Station 1	Station 2
Dissolved Oxygen (DO)	14,25	10,51
pH	7,78	7,46
Temperature (°C)	29	31
Salinity (ppt)	30	31

The measured parameters showed slight variation between the two stations. Temperature ranged from 29°C to 31°C, while salinity was stable at 30-31 ppt. The pH values were slightly alkaline, ranging from 7.46 to 7.78, and dissolved oxygen levels were high, measuring 10.51 mg/L and 14.25 mg/L at the respective stations.

Discussion

The findings of this study present a complex ecological picture of the seagrass ecosystem at Samuh Beach. While the physicochemical water quality parameters appear to be within the optimal range for supporting marine life, the gastropod community structure suggests a system under ecological stress. The low species diversity (H' = 1.25) is a primary indicator of this condition, implying that the community has low stability and may be vulnerable to environmental perturbations. This outcome is particularly noteworthy given that the evenness (E = 0.52) was moderate, and dominance (C = 0.35) was low, indicating that the few species present were relatively evenly distributed. The dominance of generalist species like *Littorina scabra* is often indicative of disturbed habitats where more sensitive species cannot survive (Reid, 2015).

When compared with established tolerance limits, the measured water quality conditions appear favorable. The recorded temperatures (29-31°C) and salinity levels (30-31 ppt) fall comfortably within the optimal ranges for both gastropod survival and seagrass photosynthesis. Similarly, the pH (7.46-7.78) and high dissolved oxygen levels are indicative of productive waters suitable for supporting a healthy aquatic community. The slight difference in temperature between stations is attributed to different sampling times (07:30 at Station 1 and 10:00 at Station 2). This contrast—between optimal water chemistry and a low-diversity biological community—suggests that other unmeasured factors may be the primary drivers of ecological stress at Samuh Beach. These stressors likely include direct physical damage from boating and trampling (Cullen-Unsworth & Unsworth, 2013) and chronic exposure to chemical pollutants not captured in standard tests, such as compounds from sunscreen (Downs et al., 2016), which are common in areas vulnerable to high-intensity tourism.

Ecologically, the gastropod community is an important component in the food cycle of seagrass meadows. Therefore, gastropods can be used as bioindicators of water quality in the seagrass ecosystem at Samuh Beach. The identification of gastropods found at Samuh Beach yielded ten different species with a total of

116 individuals (Table 1). The number and types of species found at each research station varied. At Station 1, six species were found with a total of 66 individuals, including *Turris virgo, Littorina scabra, Nassrius pullus, Conus virgo, Euplica scripta*, and *Canarium urceus*. At Station 2, six different species were found with a total of 50 individuals, including *Vexillum collinsoni, Burnupena lagenaria, Conus sanguinolentus, Semiricinula bozzettii, Littorina scabra,* and *Euplica scripta*. Some of the species found were the same across both stations, which is due to the two locations being only 50 meters apart with nearly identical sediment/substrate characteristics.

After identification, the calculation results (Table 2) showed a total abundance of 2.32, a diversity index of 1.25, an evenness index of 0.52, and a dominance index of 0.35. The diversity index value of 1.25 indicates that the level of gastropod diversity at both stations is low, and their community stability is also low. This is based on the Shannon-Wiener diversity index range (1949), where H' < 2.3026 = low diversity and low community stability. Values of 2.3026 < H' < 6.9078 indicate medium diversity and medium community stability, while H' > 6.9078 indicates high diversity and high community stability. The evenness index of 0.52 is in the medium range, indicating that the distribution of individuals among species is quite even. This aligns with the evenness index range (Magurran, 1982), where E approaching 0 = uneven distribution of individuals among species/a certain species is dominant, and E approaching 1 = even distribution of individuals among species.

The dominance index is 0.35. According to the Simpson dominance range (Odum, 1993), the smaller the dominance index value, the less likely it is that any species dominates. Conversely, a larger dominance index indicates the presence of a dominant species. A dominance value of 0.35 is at a dominance level that is not too high, which means that no gastropod species is significantly dominant. This is consistent with the evenness index calculation, which shows that the distribution of individuals among species is relatively even. In addition to gastropod sampling, tests were also conducted on several water parameters (Table 3). The temperature measurement at station 1 was 29°C and at station 2 was 31°C. This condition was influenced by the different data collection times between the two stations, where data at station 1 was collected at 07:30 and at station 2 at 10:00. This temperature range is still tolerable for gastropod life, as stated by Hutabarat & Evans (1985) in Kasim et al. (2014), that the tolerable temperature for gastropod life is 25-32°C. For seagrass, the optimal temperature for photosynthesis ranges from 25-35°C (Suryanto et al., 2014).

The second parameter is salinity, where results of 30 ppt at station 1 and 31 ppt at station 2 were obtained. These results are consistent with the water type listed in Government Regulation No. 22 of 2021. The optimal salinity for gastropod life is also in the range of 28-34 ppt (Satria, 2014 in Mogea et al., 2021). The optimal salinity for seagrass growth ranges from 25-35 ppt (Supriharyono, 2000 in Puspitasari et al., 2019). pH measurements yielded results of 7.78 at station 1 and 7.46 at station 2. Aquatic organisms have varying tolerances to pH values; gastropods can live in a pH range of 5-8 (Rahmasari et al., 2015). Kaswadji (1997) in Syafrizal (2020) states that waters with a pH range of 6.5-8.5 are productive waters. This indicates that seagrass grows well at this pH. The measurement of Dissolved Oxygen (DO) at Stations 1 and 2 yielded results of 14.25 mg/L and 10.51 mg/L, respectively. These DO measurements are very good for supporting aquatic life and are in accordance with what is stated in Government Regulation No. 22 of 2021.

The results point toward the need for further investigation to resolve this discrepancy. The low gastropod diversity could be linked to anthropogenic pressures not captured by standard water quality tests, such as physical disturbance from tourism or the presence of specific pollutants. As the study concludes that the ecosystem is less supportive of gastropod diversity, future research should focus on these potential stressors. A long-term monitoring program is essential to track community stability over time and to better understand the impacts of surrounding human activities, a need highlighted by the authors.

It is important to acknowledge the limitations of this study. The research was conducted over a relatively short period (November to December 2024) and thus represents an ecological snapshot that does not account for potential seasonal variations in community structure or water quality. Furthermore, the sampling was confined to two stations at a single beach, which may not be representative of the broader region. The absence of nutrient analysis (e.g., nitrate, phosphate) and sediment quality data also limits the ability to fully diagnose the cause of the observed low biodiversity. Future studies should aim to incorporate these elements to build a more comprehensive understanding of the pressures facing the Samuh Beach seagrass ecosystem.

Table 1. Gastropod Species Composition at Samuh Beach

No	Species	Station 1	Station 2	Picture	Classification
1	***Turris virgo***	2			Kingdom: Animalia Phylum: Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Turridae Genus : Turris Spesies : *Turris virgo*
2	***Littorina scabra***	28	23		Kingdom: Animalia Phylum : Mollusca Class : Gastropoda Ordo : Mesogastropoda Family : Littorinidae Genus : Littorina Spesies : *Littorina scabra* (Linnaeus, 1758)
3	***Nassrius pullus***	4			Kingdom: Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Nassariidae Genus : Nassarius Duméril, 1805 Spesies : *Nassarius pullus* (Linnaeus, 1758)
4	***Conus virgo***	2			Kingdom : Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Conidae Genus : Conus Linnaeus, 1758 Spesies : *Conus virgo Linnaeus*, 1758
5	***Euplica scripta***	27	18		Kingdom : Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Columbellidae Genus : Euplica Dall, 1889 Spesies : *Euplica scripta* (Lamarck, 1822)

DOI: http://doi.org/10.29303/jbt.v25i3.9574

6	***Canarium urceus***	**3**			Kingdom : Animalia Phylum : Mollusca Class : Gastropoda Ordo : Littorinimorpha Family : Strombidae Genus : Canarium Schumacher, 1817 Spesies : *Canarium urceus* (Linnaeus, 1758)
7	***Vexillum collinsoni***		**4**		Kingdom : Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Costellariidae Genus : Vexillum Röding, 1798 Spesies : *Vexillum collinsoni* (A.Adams, 1864)
8	***Burnupena lagenaria***		**1**		Kingdom: Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : incertae sedis Genus : Burnupena Spesies : *Burnupena lagenaria* (Lamarck, 1822)
9	***Conus sanguinolentus***		**3**		Kingdom: Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Conidae Genus : Conus Linnaeus, 1758 Spesies : *Conus sanguinolentus* Quoy & Gaimard, 1834
10	***Semiricinula bozzettii***		**1**		Kingdom : Animalia Phylum : Mollusca Class : Gastropoda Ordo : Neogastropoda Family : Muricidae Genus : Semiricinula E.von Martens, 1879 Spesies : *Semiricinula bozzettii* Houart & Héros, 2013

Conclusion

The gastropod community within the seagrass ecosystem of Samuh Beach was characterized by a composition of 12 species. The ecological structure was defined by a low diversity index (H' = 1.251732), a moderate evenness index (E = 0.522013), and a low dominance index (C = 0.354913). The species *Littorina scabra* and *Euplica scripta* were identified as the dominant species across both sampling stations. These results suggest that the environmental conditions of the Samuh Beach seagrass ecosystem are less supportive of high gastropod diversity, which indicates low community stability. In contrast, measured water quality parameters were found to be within optimal ranges for both gastropod and seagrass life. Therefore, it is recommended that further monitoring research be conducted in the Samuh Beach area to better protect the ecosystem from the impacts of surrounding anthropogenic activities.

Acknowledgements

Gratitude is expressed to our colleagues and fellow researchers for their invaluable assistance during the data collection process.

References

Afrijal, A., Hilyana, S., & Rahman, I. (2024). Potensi sumber daya ekosistem padang lamun sebagai atraksi ekowisata bahari di dusun poton bako, jerowaru, lombok timur. Jurnal Perikanan Unram, 13(4), 1214-1224. DOI: 10.29303/jp.v13i4.1031

Brower, J.E., & Zar, J.H. (1990). Field and laboratory methods for general ecology. Brown Company Publishers. Ohio.

Cullen-Unsworth, L. C., & Unsworth, R. K. (2013). A review of the threats to seagrass meadows to inform their conservation. Ocean & Coastal Management, 84, 115-123. DOI: 10.1016/j.ocecoaman.2013.07.009

Downs, C. A., Kramarsky-Winter, E., Segal, R., Fauth, J., Knutson, S., Burdick, B., ... & Lott, C. (2016). Toxicopathological effects of the sunscreen UV filter, oxybenzone (benzophenone-3), on coral planulae and cultured primary cells and its environmental contamination in Hawaii and the U.S. Virgin Islands. Archives of Environmental Contamination and Toxicology, 70(2), 265-288. DOI: 10.1007/s00244-015-0227-7

Duarte, C. M., Middelburg, J. J., & Caraco, N. (2005). Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences, 2(1), 1-8. DOI: 10.5194/bg-2-1-2005

Fachrul, M. F. 2007. Metode Sampling Bioekologi. Jakarta, Bumi Aksara. 198 hlm

Faizal, B. D., Irawan, A., & Sari, L. I. (2022). Hubungan Kerapatan Lamun Dengan Kelimpahan Megagastropoda di Perairan Pulau Miang Besar Kutai Timur. *Tropical Aquatic Sciences*, *1*(1), 17–23. DOI: 10.30872/tas.v1i1.468.

García-March, J. R., García-Carrascosa, A. M., & Peña-Alonso, C. (2020). Molluscs as Sentinels of Marine Pollution: A Review. Water, 12(12), 3497. DOI: 10.3390/w12123497

Holt, E. A., & Miller, S. W. (2011). Bioindicators: Using Organisms to Measure Environmental Impacts. Nature Education Knowledge, 3(10), 8.

Hutabarat, S. & Evans, S.M. (1985). Pengantar Oseanografi. Universitas Indonesia Press, Jakarta.

Kasim, F., Sahami, F. M., & Sianu, E. N. (2014). Keanekaragaman dan Asosiasi Gatropoda dengan Ekosistem Lamun di Perairan Teluk Tomini. Jurnal Ilmiah Perikanan dan Kelautan, 2(4), 156-163.

Kaswadji, R. F. (1997). Model pendugaan produktivitas primer fitoplankton berdasarkan kelimpahan dan komposisi jenis di perairan Teluk Banten. Program Pascasarjana, Institut Pertanian Bogor, Bogor.

Krebs, C. J., (1985). Experimental Analysis of Distribution of Abudance. Third edition. Newyork: Haper & Row Publisher.

Magurran, A. E. (1988). Ecological Diversity and Its Measurement. Princeton University Press.

Mogea, A. R., Lefaan, T. P., & Putri, R. A. (2021). Komunitas Gastropoda pada Padang Lamun Perairan Pantai Manokwari. Jurnal Sumberdaya Akuatik Indopasifik, 5(1), 65-76. DOI: 10.46252/jsai-fpik-unipa.2021.Vol.5.No.1.51

Odum, E. P. (1993). Dasar-dasar ekologi. Edisi Ketiga. Gajah Mada Universitas Press: Yogyakarta.

Orth, R. J., Carruthers, T. J., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., & Williams, S. L. (2006). A global crisis for seagrass ecosystems. BioScience, 56(12), 987-996. DOI: 10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2.

Puspitasari, W.A. (2019). Struktur Komunitas Makrozoobenthos Pada Ekosistem Lamun di Paciran, Kabupaten Lamongan, Jawa Timur. *Journal of Fisheries and Marine*

Research. 3(1), 1-7. DOI: 10.21776/ub.jfmr.2019.003.01.1

Rahmasari, T., Purnomo, T., Ambarwati, R. (2015). Keanekaragaman dan Kelimpahan Gastropoda di Pantai Selatan Kabupaten Pamekasan, Madura. *Journal of Biology & Biology Education.* 7(1), 48-54.

Reid, D. G. (2015). The evolution of life on land in snails (Gastropoda, Neritopsina, Cyclophoroidea). In The Janalian Series: A Collection of Papers on the Evolution of Life, 3, 45-78.

Sugiyono (2017). Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta, CV.

Suryanto, A., Purwanto, F., Minerva, A. Analisis Hubungan Keberadaan dan Kelimpahan Lamun dengan Kualitas Air di Pulau Karimunjawa, Jepara. *Journal Of Maquares.* 3(3), 88-94.

Syafrizal., Matuakonta, C., Rugebregt. M.J. (2020). Keanekaragaman Jenis, Tutupan Lamun, dan Kualitas Air di Perairan Teluk Ambon. Jurnal Ilmu Lingkungan. 18(3), 589-594. DOI: 10.14710/jil.18.3.589-594.

Unsworth, R. K., McKenzie, L. J., Collier, C. J., Cullen-Unsworth, L. C., & Duarte, C. M. (2019). Global importance of seagrass meadows for food security. Conservation Letters, 12(1), e12599. DOI: 10.1111/conl.12599

Yunita, R. R., Suryanti, S., & Latifah, N. (2020). Biodiversitas Echinodermata pada Ekosistem Lamun di Perairan Pulau Karimunjawa, Jepara. *Jurnal Kelautan Tropis*, *23*(1), 47-56. DOI: 10.14710/jkt.v23i1.6247.