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ECOLOGICAL INDEX AND DISTRIBUTION PATTERNS OF SEAGRASS IN BANDA SEA TOURISM PARK (TWP)

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ABSTRACT

Seagrass beds have an important role as the main source of primary productivity or organic matter producers, habitat for various biota, nursery grounds, spawning grounds, food sources for rare biota, and support for the diversity of marine biota species, as well as the economic value of seagrass ecosystem services. This study aims to determine the ecological index and distribution pattern of seagrass in the Banda Sea Aquatic Tourism Park (TWP). The method used is a line transect with a quadrant size of 50 cm x 50 cm that is placed perpendicular to the shoreline. The results showed that the seagrass diversity index at the study site consisted of 7 types of seagrass, namely Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis, and Syringodium isoetifilium. The diversity index is categorized as moderate with a value of H' = 0.01-0.05, and a uniformity value of 0.71 has a high uniformity, which means that the number of individual species from one species to another is not much different from a stable environmental condition. The distribution pattern of seagrass with Id > 1 is a grouped category. The physicochemical parameters obtained were in accordance with the growth of seagrass life.

***Keywords**: Banda sea, Distribution pattern, Diversity, Dominance, Seagrass, Uniformity*

INTRODUCTION

Seagrass is a higher plant that lives and is immersed in the marine environment, is vascular, rhizome-rooted, and reproduces generatively and vegetatively (Supriyadi *et al.,* 2018). The rhizome is a brushy stem, growing immersed and creeping in a substrate of sand, mud, and coral fragments (Mahesswara *et al.,* 2021). The rhizome is a brushy stem that grows immersed and creeping in sandy, sandy-muddy, and mud substrates (Pham *et al.,* 2006). Seagrass ecosystems have high primary productivity and complex habitat structures, so seagrasses are very supportive of benthic and pelagic biota living in surrounding waters (Kikuchi, 1996). The function and role of seagrasses depend on the number of leaves, leaf length, leaf width, and total biomass, which are highly determined by local conditions (Wangkanusa *et al.,* 2017). Seagrass meadows also have economic value, which is around IDR 21,014,756 in seagrass ecosystem services (Wawo *et al.,* 2014) and IDR 20,579,103 per year per ha from the tourism and fisheries sectors (Dirhamsyah, 2007). Seagrass meadows are very effective at absorbing CO2, with an uptake of 1,867 t/km^2 (48%), which is relatively higher than mangroves at 806 t/km^2 (21%), and corals at 1,197 t/km^2 (31%) (Simamora, 2010).

Seagrass beds can form single vegetation, composed of one seagrass species that grows to form a dense field, while mixed vegetation consists of 2-12 seagrass species that grow together on one substrate. Seagrass species that usually grow with single vegetation are *Thalassia hemprichii, Enhalus acoroides, Halophila ovalis, Halodule uninervis, Cymodocea serrulata,* and *Thalassodendrom ciliatum* (Wagey and Sake, 2013). Kiswara (2000) said that the reduction of seagrasses or the widespread loss of seagrasses in various places around the world is caused by the direct impact of human activities, including mechanical damage such as dredging and mining, the influence of coastal areas, and marine sand mining activities. As a result of these activities, it is feared that the loss of seagrass beds will continue to increase due to increased human activity in coastal areas. Therefore, a study was conducted on the ecological index and distribution pattern of seagrasses in the Banda Sea Marine Tourism Park (TWP).

MATERIALS AND METHOD

The research was conducted in the Banda Sea Waters, Banda District, Central Maluku Regency, Maluku Province. The tools and materials used were a 50 x 50 cm quadrant transect, a roll meter, Global Positioning System (GPS), an underwater camera, a refractometer, diving equipment, an identification book, distilled water, tissue, a camera, and sample bag.

The research method used was the quadrant transect method by dividing into three research stations, and each was carried out data collection on five transects with a length of 100 m each, and the distance between one transect and another transect was 50 m. Frame quadrats were placed on the right side of the transect with a distance of 10 m between quadrats, so that the total quadrats in each transect were 10 quadrants. The starting point of the transect was placed at a distance of 5-10 m from where the first seagrass was found.

Data Analysis

Diversity Index

The Diversity Index shows the diversity of species and is a characteristic of community structure. Diversity is determined based on the Shannon-Wiener diversity index with the following formula (Brower *et al.,* 1990):

$$H' = \sum Pi \ln Pi \quad \text{.......................................} (1)$$

Where, H': Shannon Diversity Index, $P_i \frac{n_i}{N}$ (proportion of the -i species); n_i: Number of individuals of the -i species; N: Total number of individuals of all species

Table 1. Diversity index level criteria

Diversity Index	Category
H' > 3	High diversity level
3 ≥ H' ≥ 1	Medium diversity level
H' ≤ 1	Low diversity level

Source : Alhanif, 1996

Uniformity Index

The Uniformity Index is used to determine how much similarity there is in the distribution of the number of individuals of each seagrass species, namely by comparing the diversity index with its maximum value using the formula:

$$E = \frac{H'}{H'maks} \quad \text{.......................................} (2)$$

Where, E: Uniformity Index; *H'*: Diversity Index; *H'maks*: Maximum of Diversity Index (ln S) (where S= number of species)

Table 2. Criteria for uniformity index level

Uniformity Value (E)	Category
1,0 ≥ E > 0,6	High uniformity, which means the number of individuals of one species and another species is not much different, environmental conditions are said to be stable.
0,6 ≥ E > 0,4	Medium uniformity, indicating that environmental conditions are not too stable.
0,4 ≥ E ≥ 0	Low uniformity, which means that the wealth of individuals owned by each species is much different, means that environmental conditions are unstable because they are under pressure.

Source: Rappe, 2010

Dominance Index

The Dominance Index is a description of the most common seagrass species, which can be known by calculating the dominance value. Dominance can be expressed in Simpson's dominance index (Brower *et al.,* 1990):

$$D = \sum_{i-1}^{s} \left(\frac{n_i}{N}\right)^2 \quad \text{.......................................} (3)$$

Where, D: Simpson's dominance index; ni: Number of individuals of the -i species; N: Total number of individuals of all species

Table 3. Criteria for dominance index level

Dominance Value (C)	Category
0,6 < C ≤ 1,0	High dominance, where one species has a high number of individuals in contrast to other species, and the environment is unstable due to ecological pressures.
0,4 < C ≤ 0,6	Moderate dominance, environmental conditions are quite stable.
0 ≤ C ≤ 0,4	Low dominance, no dominance between species, stable environmental conditions, and no ecological pressure on biota in the environment.

Seagrass Distribution Pattern

Seagrass distribution patterns were calculated using the Morisita Dispersion Index formula (Brower *et al.,* 1990) with the following formula:

$$Id = n\frac{\sum xi^2 - N}{N(N-1)} \quad \text{.............................} (4)$$

Where, Id: Morisita dispersion index; n: Number of sampling plots/samples; N: Total number of individuals in n plots; xi^2: Sum of squares of individuals in the -i plot

RESULT AND DISCUSSION

Diversity

Diversity is used to determine the abundance of seagrass communities based on the number of species and the number of stands of each species in an area. Diversity includes two important things, namely the number of species and the number of individuals of each species in an area. The higher the number of species, the more diverse the community.

Table 4. Diversity value

Jenis Lamun	Station 1	Station 2	Station 3
Thalassia hemprichii	0,18	0,16	0,19
Enhalus acoroides	0,13	0,14	0,08
Cymodocea rotundata	0,37	0,002	0,50
Cymodocea serrulata	0,03	0,002	0,04
Halodule uninervis	0,01	0,003	0,03
Halophila ovalis	0,02	0,003	0,05
Syringodium isoetifilium	0,23	0,003	0,07

From the calculation of Shannon diversity, the largest seagrass diversity on Banda Island is found at station 3 of the *Cymodocea routundata* type of 0.50 and the lowest at station 1 of the *Halodule uninervis* type of 0.01. From this value, it can be said that the level of seagrass species diversity on Banda Island is in the medium category because only 7 seagrass species were found on Banda Island. The diversity index is moderate because at the research location there are local community activities such as fishing, boat transportation, and recreation that can damage the seagrass ecosystem.

Uniformity

Uniformity is used to determine community abundance based on the degree of similarity of several stands in an area.

Table 5. Uniformity value

Station	Total
Station 1	1,021
Station 2	0,345
Station 3	0,764

From the calculation results, the seagrass species uniformity index value is 1.021 at station 1, 0.345 at station 2, and 0.764 at station 3. From these values, it can be said that the distribution of individuals between species is evenly distributed with stable community abundance, so it can be concluded that the number of individual seagrass species found is quite balanced or does not have a significant difference for each type. If the evenness index is less than 0.4, then the ecosystem is in a depressed condition and has low evenness. The low value of the seagrass evenness index at the four stations is caused by the low seagrass diversity index, where a community is said to have high diversity if there are abundant species evenly distributed.

Dominance

Dominance is used to see how much a species dominates an area. Setyobudiandi et al. (2009) stated that the dominance index criteria can be grouped into three, categories: high dominance (0.75<D≤1.100), medium dominance (0.50<D≤0.75), and low dominance (0.00<D≤0.59).

Table 6. Dominance Value

Seagrass Species	Station 1	Station 2	Station 3
Thalassia hemprichii	0.032	0.028	0.039
Enhalus acoroides	0.017	0.022	0.006
Cymodocea rotundata	0.143	5.391	0.255
Cymodocea serrulata	0.001	7.338	0.001
Halodule uninervis	0.0003	9.585	0.001
Halophila ovalis	0.0004	1.213	0.002
Syringodium isoetifilium	0.053	1.497	0.006

From the calculation of the seagrass dominance index value of 0.143 at station 1, 9.585 at station 2, and 0.255 at station 3. From this value, we can conclude that the dominance index on Banda Island is in the high dominance category.

Distribution Pattern

The pattern of seagrass distribution at stations 1, 2, and 3 calculated using the Morisita Dispersion Index can be seen in **Tables 7**, **8**, and **9**.

Table 7. Seagrass distribution pattern at station 1

Seagrass Species	Id	X^2 Count	X^2 Table	Conclusion
Thalassia hemprichii	2.5995	1010.5075	72.15	Clustering
Enhalus acoroides	3.5589	301.47297	72.15	Clustering
Cymodocea rotundata	2.5232	1970.1859	72.15	Clustering
Cymodocea serrulata	13.7575	1584.9091	72.15	Clustering
Halodule uninervis	6.6861	156.9090	72.15	Clustering
Halophila ovalis	17.7472	453.79661	72.15	Clustering
Syringodium isoetifolium	44.8722	21215.732	72.15	Clustering

Table 8. Seagrass distribution pattern at station 2

Seagrass Species	Id	X^2 Count	X^2 Table	Conclusion
Thalassia hemprichii	2.2517	598.5298	72.15	Clustering
Enhalus acoroides	3.86830	771.4285	72.15	Clustering
Cymodocea rotundata	2.56590	2095.9387	72.15	Clustering
Cymodocea serrulata	3.9535	570.875	72.15	Clustering
Halodule uninervis	11.3492	416.2222	72.15	Clustering
Halophila ovalis	9.6573	1655.6129	72.15	Clustering
Syringodium isoetifolium	55.4505	3266.5833	72.15	Clustering

Table 9. Seagrass distribution pattern at station 3

Seagrass Species	Id	X^2 Count	X^2 Table	Conclusion
Thalassia hemprichii	2.2166	724.3587	72.15	Clustering
Enhalus acoroides	3.6736	666.26087	72.15	Clustering
Cymodocea rotundata	2.1827	1707.5368	72.15	Clustering
Cymodocea serrulata	8.9715	970.7241	72.15	Clustering
Halodule uninervis	4.4128	415.7570	72.15	Clustering
Halophila ovalis	8.9088	1216.5946	72.15	Clustering
Syringodium isoetifolium	3.2800	1515.5078	72.15	Clustering

Seagrass species at stations 1, 2, and 3 *Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis,* and *Syringodium isoetifolium* have clustered distribution patterns where the value of Id is greater than 1. From the calculation of the Morisita Dispersion Index, this is indicated by the X2hit value, which is greater than the X2 (table) value (Id> 1), meaning that the distribution pattern of all seagrass species is clustered. Clustered distribution patterns are caused by the habitat environment that suits the growth needs of these species, such as substrate, pH, and other parameters and responses to weather changes. Seagrasses like *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata,* and *Halophila ovalis* usually grow and spread in shallow areas and are always open at low tide to a depth of <1 meter at the lowest tide (Kiswara, 2000). According to Takaendengan and Azkab (2010), colored and whitish sand with a fine texture is the preferred substrate type for *Enhalus acoroides* and *Thalassia hemprichii*. These two seagrass species are considered to have a high tolerance for living and developing in a water body. According to Azkab (2006), in tropical waters such as Indonesia, seagrass beds are more dominant, with colonies consisting of several types (mix species) in a particular area. In contrast to the temperate or cold regions, which are mostly dominated by one type of seagrass (a single species).

Water Quality Parameters

Water temperature indirectly affects photosynthesis because some metabolic processes, such as respiration and nutrient uptake, are highly dependent on temperature. The temperature measured at stations 1 and 2 is around 29-30 °C at high tide and low tide. This shows that the temperature at stations 1 and 3 does not have a large enough temperature change. This temperature range is an optimum condition for seagrasses to perform photosynthesis, because the optimal temperature for seagrasses to photosynthesis ranges from 25-35 °C according to Berwick (1983).

Strong currents are found at station 1, which is 0.052 m/s, at station 2, which is 0.054, and at station 3, which is 0.047 m/s. This is because these waters are areas that get the influence of wind, waves, and currents directly (windward). The low speed of the current is very favorable for the growth and development of seagrass. The pH value of each station is not much different, with a range of 7-8. This range is still in accordance with the standard water quality standards for aquatic biota based on the decision of the Minister of Environment, KEP No. 51/MNLH/I/2004, that the normal pH range of waters that can sustain the life of aquatic organisms is 6.50-8.50 (MNLH 2004). According to Effendi (2003), most aquatic biota like pH values around 7-8.5, this means that the range of water pH values is optimal for seagrass growth.

Seagrasses have different tolerances for salinity. A decrease in salinity will reduce the photosynthetic ability of seagrass. According to Herkul & Kotta (2009), seagrass photosynthetic ability is directly proportional to the decrease in salinity. Salinity also affects biomass, primary productivity, density, leaf width, and recovery speed. High salinity will increase seagrass density. The salinity of stations 1 and 2 at high tide 27-29 ‰ and low tide 26-27 ‰ at station 3. The low salinity at low tide is due to the measurements taken after the rain, resulting in mixing between rainwater and seawater. But the salinity is still suitable for seagrass growth. As stated by Supriharyono (2009) in general, the optimum salinity for seagrass growth is between 25-35 ‰.

Table 10. Water quality parameters

Parameters	Unit	Station 1	Station 2	Station 3
Temperature	°C	29	32	30
Current	m/s	0,052	0,054	0,047
Brightness	%	100	100	100
pH		6,97	7,45	6,78
Salinity	‰	28	28	27

CONCLUSIONS AND SUGGESTION

The conclusion of this study is that the seagrass diversity index at the research site consists of 7 seagrass species, namely *Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis* and *Syringodium isoetifilium*. The diversity index is classified as moderate with a value of H' = 0.01-0.05, a uniformity value of 0.71 has high uniformity, which means the number of individuals of one species with other species is not much different with stable environmental conditions. Seagrass distribution patterns with Id> 1 are categorize clustered. The physico-chemical parameters obtained are in accordance with the growth of seagrass life.

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