第 49 卷 第 9 期
2022 年 9 月

湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

Vol. 49 No. 9
September 2022

Open Access Article https://doi.org/10.55463/issn.1674-2974.49.9.1

Diversity, Ecological Index, and Distribution Pattern of Seagrass in Coastal Waters of North Bali

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Abstract: The coastal ecosystem that has high biological productivity is seagrass. Seagrass has ecological functions, namely as nursery, foraging, and spawning areas for organisms. Identification of seagrass species using the transect method in the waters of Penimbangan Beach, North Bali, was conducted in 2020, aiming to identify seagrass species and seagrass cover conditions in the coastal waters of Penimbangan, North Bali. The method used in this activity was the quadratic transect method, which consisted of a transect (straight line) and a quadratic frame (a rectangular frame placed on a line). The seagrass species found consisted of six species, which belonged to two families: the *Hydrocharitales* family with three species, namely *Thalassia hemprichii*, *Halophila ovalis*, and *Halophila decipiens*, and the *Potamogetonaceae* family with three species, namely *Halodule uninervis*, *Cymodocea rotundata*, and *Syringodium isoetifolium*. The density of seagrass varied but did not exceed 25 stands/m^2, indicating very rare density of seagrass in these waters. *Halodule uninervis* species played an important role in seagrass communities in the waters of Penimbangan Beach with an Important Value Index of 89.36% at station I and 73.43% at station II. The novelty of this research is that there has not been any research on seagrass at the coast of Penimbangan, North Bali.

Keywords: seagrass, density, closure, North Bali.

巴厘岛北部沿海海域海草的多样性、生态指数及分布格局

摘要：具有高生物生产力的沿海生态系统是海草。海草具有生态功能，即作为生物的育苗区、觅食区和产卵区。于2020年在巴厘岛北部彭宁邦甘海滩水域使用样带方法鉴定海草物种，旨在确定巴厘岛北部彭宁邦甘沿海水域的海草物种和海草覆盖情况。本次活动使用的方法是二次样带法，它由样带（直线）和二次框（放置在一条线上的矩形框）组成。所发现的海草种类共6种，分属2科：水草目属3种，即海藻、嗜盐菌和嗜盐菌；眼子菜科属3种，即无神经光晕、圆头仙人掌和紫丁香异叶草。海草的密度各不相同，但不超过25株/平方米，表明这些水域的海草密度非常稀少。光晕物种在彭宁邦甘海滩水域的海草群落中发挥了重要作用，I站的重要价值指数为89.36%，II站为73.43%。这项研究的新颖之处在于，尚未对巴厘岛北部彭宁邦甘海岸的海草进行任何研究。

关键词：海草，密度，封闭，北巴厘岛。

1. Introduction

Seagrass plant or commonly called seagrass is a plant that lives and grows at shallow sea levels [1-4]. Factors that affect the distribution of seagrass in the

Received: June 4, 2022 / Revised: July 2, 2022 / Accepted: August 7, 2022 / Published: September 30, 2022

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waters include light, temperature, salinity, sediment, and nutrients [5]. Seagrass has true flowers, fruit, leaves and roots and grows on muddy, sandy to rocky substrates. Seagrass has a physical function to stabilize waters with a root system that can capture sediment, modify biogeochemical processes in the water column and sediment, and change hydrodynamics [6, 7]. Seagrass ecosystems are the most productive ecosystems in shallow marine waters [8-10]. The high density and sheltered shape allows seagrass to function as a direct food provider for herbivorous organisms and a shelter for small organisms [11]. The great role of seagrass in terms of maintaining the survival of biota, especially fish, also helps the surrounding community in supporting food needs [12]. One of the locations of seagrass beds in Bali that is often used by local communities is the southern area of Bali [13]. According to [14], there are eight types of seagrass in the waters of Bali: *Enhalus acoroides*, *Halophila decipiens*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halodule uninervis*, *Syringodium isoetifolium,* and *Thalassodendron ciliatum*. One of the places where seagrass grows is Mengiat Beach, which is located in the Nusa Dua area.

The coastal area of Bali has an area of seagrass that is around 1,316 ha, and damage to seagrass in Bali ranges from 8% to 30.23%. The seagrass ecosystem in Bali has been degraded a lot due to community activities and developments such as coral extraction, reclamation of Serangan Island, seaweed cultivation in Nusa Penida and Lembongan islands, as well as water tourism activities in locations close to the seagrass habitat in Sanur Beach. Therefore, there is still little data regarding information on the condition and potential of seagrass beds in the Serangan Beach area. The basic problem is the lack of understanding by the community and the government regarding the important role of the seagrass ecosystem. This is because seagrass beds are still seen as "useless grasses," so that they are degraded. Batu Jimbar Beach, as part of the Sanur Beach area with a coastline of approximately 1 km, has a stretch of seagrass beds along the coastline and toward the sea of approximately 0.4 km. This beach is used as a place for sightseeing, fishing, and landing traditional fishing boats. These various activities can affect the seagrass ecosystem, which will lead to more serious degradation of the coastal environment. Considering the importance of the seagrass ecosystem, research is needed on the condition of the seagrass ecosystem in North Bali's Weighing Beach. This study aimed to determine the community structure and distribution pattern of seagrass species at Penimbangan Beach, North Bali.

2. Materials and Methods

2.1. The Description of the Study Sites

This research was conducted at Penimbangan Beach, Baktiseraga Village, Buleleng District, Buleleng Regency, North Bali in March-April 2020, which was directly coordinated by POKMASWAS. The tools used in this study were roll meter, 50x50-cm quadratic transect, under-water camera, snorkeling equipment, pH tester, refractometer, thermometer, and Global Positioning System (GPS). The material used was seagrass as an object of observation and as a species sample.

2.2. Research Method

The method used in the identification of seagrass in the waters of Penimbangan Beach a quadrant transect (perpendicular to the shoreline). Quadrant transects consist of transects and quadratic frames. The transect is a straight line drawn above the seagrass beds, while the quadrant is a rectangular frame that is placed on a straight line. The edge transect is determined where seagrass plants began to be seen or grow, in the middle and near the edge. The study used a quadrant transect with a size of 50x50 cm, and data collection for seagrass was carried out at low tide to facilitate observation. Measurement of water condition parameters related to seagrass ecosystem habitat conditions, such as brightness, salinity, current, substrate, and pH with the aim of observing water conditions that were in accordance with seagrass ecosystems. Data were collected on three transects with a length of 100 m each and the distance between one transect and another was 50 m. The square frame was placed on the right side of the transect with a distance between the squares of 10 m, so that the total square of each transect was squared. The starting point of the transect placed at a distance of 5–10 m from where the seagrass was first discovered.

2.3. Analysis of the Data

2.3.1. The Density of Seagrass Species

The density of seagrass species is influenced by the number of stands of a type of seagrass in a certain area.

$$Di = \frac{ni}{A}$$

where:
Di - density of seagrass (ind/m^2);
Ni - total amount of seagrass in the i-th sampling (stand);
A - transect area (m^2).

Table 1 Seagrass conditions based on density

Scale	Density (Ind/m^2)	Condition
1	< 25	Very rarely
2	25–75	Rarely
3	75–125	Somewhat tightly
4	125–175	Tightly
5	> 175	Very tightly

2.3.2. Relative Density (RDi)

Relative density is the ratio between the number of individuals of a species and the total number of individuals of all species.

$$\text{RDi} = \frac{\text{Ni}}{\sum \text{n}} x100$$

where:
RDi - relative density;
Ni - total number of species stands (stands);
∑n - total number of individuals across transects.

2.3.3. Species Frequency

Species frequency is the probability of a species being found in the observed sample points.

$$\text{Fi} = \frac{\text{Pi}}{\sum \text{p}} x100$$

where:
Fi - frequency type;
Pi - number of sample plots where species *i* is found;
∑p - total number of sample plots observed.

2.3.4. Relative Frequency (RFi)

The relative frequency (RFi) is the ratio between the i-species frequency and the total frequency for all species.

$$\text{RFi} = \frac{\text{Fi}}{\sum \text{Fi}} x100$$

where:
RFi - relative frequency;
Fi - the i-th type frequency;
∑Fi - the total number of frequencies of all types.

2.3.5. Seagrass Coverage (%)

Coverage (Ci) is the area covered by the i-species:

$$Ci = \frac{ai}{A}$$

where:
C_i - closure of the i-th seagrass species;
a_i - total area covered by the i-th species;
A - total sampling area.

Table 2 Seagrass condition based on coverage seagrass

	Condition	Coverage (%)
Good	Rich/Healthy	≥ 60
Damaged	Less Rich/Unhealthy	30-59,9
	Poor	≤ 29,9

2.3.6. Relative Closure (RCi)

Relative closure is the ratio between individual species closures and the total number of species closures.

$$\text{RCi} = \frac{\text{Ci}}{\sum \text{Ci}} x100$$

where:
Rci - relative closing;
Ci - area of type closure;
∑Ci - total coverage area for all types.

2.3.7. Important Value Index

Important value index is used to calculate and estimate the overall role of seagrass species in a community.

INP = FR + RC + RD

where:
INP - value index;
RC - relative closure;
FR - relative frequency;
RD - relative density.

2.4. Ecological Index (Diversity, Uniformity, and Dominance Indices)

2.4.1. Diversity Index

The diversity index shows the diversity of species and is a characteristic of the community structure. Diversity is determined based on the Shannon-Wiener diversity index.

$$H' = \sum Pi \ln Pi$$

where:
H' – the Shannon diversity index;
P_i - $\frac{n_i}{N}$ (the proportion of the *i*-th type);
n_i - number of individuals of type *i*;
N - total number of individuals of all species.

Table 3 Diversity index level criteria

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

2.4.2. Uniformity Index

The uniformity Index is used to determine how much the similarity of the distribution of the number of individuals for each type of seagrass is used, namely by comparing the diversity index with its maximum value.

$$E = \frac{H'}{H'maks}$$

where:
E - uniformity index;
H' - diversity index;
H'maks - diversity index, maximum (ln S) (where S = number of species).

Table 4 Uniformity index criteria

Uniformity Index (E)	Category
1,0 ≥ E > 0,6	High uniformity, which means the number of individual species from one species to another is not very different, environmental conditions are said to be stable.
0,6 ≥ E > 0,4	Medium uniformity, which indicates that the environmental conditions are not very stable.
0,4 ≥ E ≥ 0	Low uniformity, which means the individual wealth owned by each species is quite different, environmental conditions are unstable due to pressure.

2.4.3. Dominance Index

The dominance index is a description of the most common types of seagrass found, it can be known by calculating the dominance value. Dominance can be expressed in the Simpson dominance index [15].

$$D = \sum_{i=1}^{s} \left(\frac{n_i}{N} \right)^2$$

where:
D - Simpson's dominance index;
ni - number of individuals of type *i*;
N - total number of individuals of all species.

Table 5 Dominance index level criteria

Dominance (C)	Category
0,6 < C ≤ 1,0	High dominance, one species whose number of individuals is very large and much different from that of other species, unstable environmental conditions due to an ecological pressure
0,4 < C ≤ 0,6	Moderate dominance, fairly stable environmental conditions
0 ≤ C ≤ 0,4	Low dominance, no dominance between species, stable environmental conditions, no ecological pressure on biota in the environment

2.4.4. The Distribution Pattern of Seagrass

The distribution pattern of seagrass was calculated using the Morisita dispersion index formula.

$$Id = n \frac{\sum xi2 - N}{N(N-1)}$$

where:
Id - the Morisita dispersion index;
n - number of sampling plots/sampling;
N - total number of individuals in *n* plots;
xi^2 - the sum of the individual squares in the *i*-th plot.

3. Results

3.1. Species Diversity

The results of seagrass research found in the waters of Beach, North Bali, showed that there were six species of seagrass consisting of two families: the *Hydrocharitaceae* family and the *Potamogetonaceae* family. The *Hydrocharitaceae* family consisted of one species, namely *Thalassia hemprichii*, while the *Potamogetonaceae* family consisted of five species: *Halodule uninervis*, *Cymodocea rotundata*, *Syringodium isoetifolium*, *Halophila ovalis*, and *Halophila decipiens* (Table 6). Of the two stations, *Halodule uninervis* was the most commonly found and appeared at each station.

Table 6 Types of seagrass in North Bali's coastal waters

Number	Seagrass Type	Station 1	Station 2
1	*Halodule uninervis*	√	√
2	*Thalassia hemprichii*	√	√
3	*Cymodocea rotundata*	√	√
4	*Syringodium isoetifolium*	√	√

Continuation of Table 6

5	*Halophila ovalis*	√	√
6	*Halophila decipiens*	√	√

Note: √ = ada

3.2. Density

The condition of seagrass density in the waters of the beach included in scale 1 with a density value of < 25 stands/m^2 means that the density of seagrass in the waters of the weighing beach is very rare. The highest density of the seagrass species, *Halodule uninervis*, was around 18.3 stands/m^2 at station I and 13.3 stands/m2 at station II. The lowest density of seagrass, *Halophila decipiens*, was around 4.9 stands/m^2 at station I and 5.2 stands/m^2 at station II (Fig. 1). *Halodule uninervis* had the highest density because the substrate found in the field was a good substrate for the growth of *Halodule decipiens* seagrass, namely sandy substrate. The water temperature in Bali ranged within 29–30^{0}C. The optimum temperature for seagrass growth was around 15–30^{0}C.

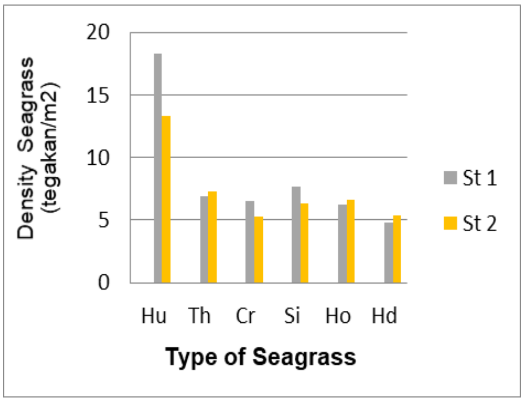

Fig. 1 Density of seagrass species

The relative density of seagrass is the ratio between the number of individual species and the total number of individuals of all species, aiming to determine the percentage per species in the total number of all species. Based on the calculation results, seagrass, which had a high density value, namely *Halodule uninervis*, was about 36.25% at station I and at station II about 30.01%. The species with the lowest density value *Halophila decipiens* at station I around 9.48% and station II around 12.17% (Fig. 2).

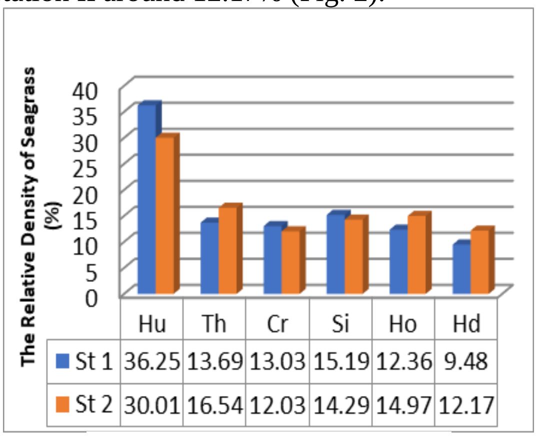

Fig. 2 The relative density of seagrass

3.3. Species Frequency

Frequency is the magnitude of the presence of organisms, in this case seagrass, in a community or ecosystem. The more certain species in a sample plot, the greater the frequency of that plant. Species that have a large frequency generally have a greater adaptability to environmental factors. The highest frequency species was *Halodule uninervis*, which was around 78.8 and the lowest was about 51.5 at station I and at station II. The other highest species were *Cymodocea rotundata* and *Halophila decipiens*, which were around 66.7, the lowest species was *Halophila ovalis* at 51.5 (Fig. 3).

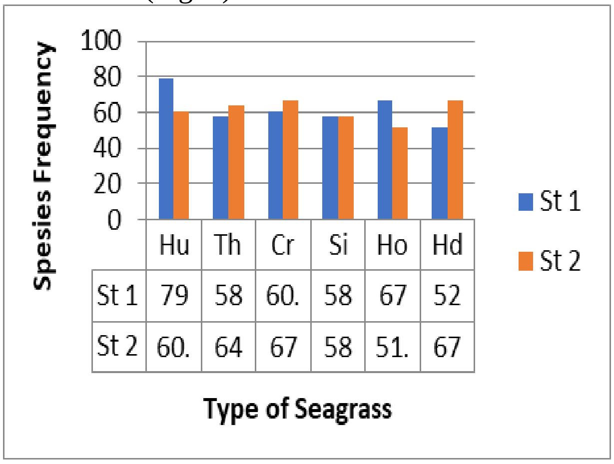

Fig. 3 Frequency of seagrass species

The relative frequency is the ratio between the frequency of a species and the total frequency for all types of species. The highest relative frequency for seagrass species *Halodule uninervis* at station I was around 21.1% for seagrass species. *Cymodocea rotundata* and *Halophila decipiens* at station II were around 18.2%. The lowest frequency was at station I with seagrass species *Halophila decipiens* namely around 13.8%, whereas, at station II, *Halophila ovalis* seagrass was about 14% (Fig. 4). The factor making the frequency of the seagrass species *Halophila sp.* be low was its small morphology, so it is easily damaged by strong currents and even being stepped on.

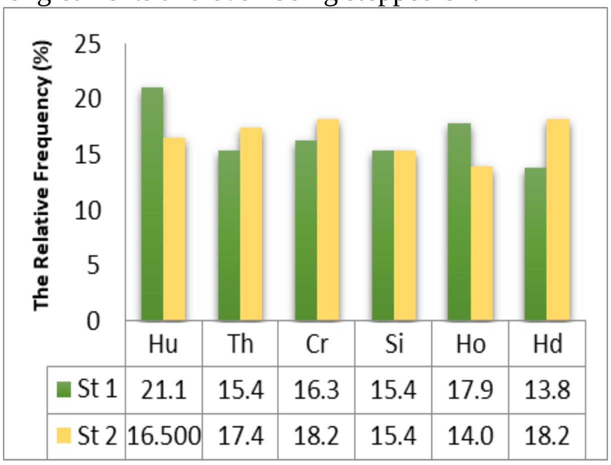

Fig. 4 Relative frequency of seagrass species

3.4. Coverage

The coverage percentage is the area of water covered by seagrass species. The highest seagrass cover was at station I, namely *Halodule uninervis* seagrass at about 18.91%. The lowest seagrass was *Halophila decipiens* at 6.24%. At station II, the highest seagrass Halodule uninervis was around 14.36% and the lowest was *Cymodocea rotundata*, namely at 6.97% (Table 7).

Table 7 Seagrass coverage

Seagrass Type	**Coverage (Ci)**		**Relative Coverage (Rfi) %**	
	ST 1	**ST 2**	**ST 1**	**ST 2**
Halodule uninervis	18,91	14,36	31.97	26,89
Thalassia hemprichii	8,36	9,06	14,14	16,96
Cymodocea rotundata	8,27	6,97	13,99	13,05
Syringodium isoetifolium	9,42	7,91	15,93	14,80
Halophila ovalis	7,94	8,03	13,42	15,03
Halophila decipiens	6,24	7,09	10,55	13,27
Amount	59,14	53,42	100	100

The total cover of seagrass in the waters of Penimbangan Beach at station I was 59.14% and station II was 53.42%. According to the decision of the Minister of the Environment No. 200 of 2004, the status of seagrass beds in the coastal waters is in a damaged condition with the category of less healthy/less rich because it is not more than 59.9% or less than 60%. This is presumably due to high waves of water currents and human activities considering that Penimbangan Beach is a tourist spot that indirectly affects the closure of seagrass beds and will threaten the survival of seagrass beds. This condition is said to be decreasing because the observation of seagrass conditions in the last three years (2016–2018) has increased by 30% from 2017 to 2018. The percentage of closures was 30% in 2016 and 2017 and 60% in 2018.

3.5. Important Value Index

Importance value index is determined by the sum of the relative frequency, relative density, and relative closure. The important value index is a description of the influence or role of a species on a seagrass community. The higher the importance value of a species, the higher its role and influence in its community. To determine what types of seagrass play an important role in coastal waters, see Table 8.

Table 8 Important value index of seagrass

Seagrass Type	RDi		RFi		Rci		INP	
	ST 1	ST 2	ST 1	ST 2	ST 1	ST 2	ST 1	ST 2
Halodule uninervis	36,25	30,01	21,14	16,53	31,97	26,89	89,36	73,43
Thalassia hemprichii	13,69	16,54	15,45	17,36	14,14	16,96	43,28	50,86
Cymodocea rotundata	13,03	12,03	16,26	18,18	13,99	13,05	43,28	43,26
Syringodium isoetifolium	15,19	14,29	15,45	15,7	15,93	14,8	46,57	44,79
Halophila ovalis	12,46	14,97	17,89	14,05	13,42	15,03	43,77	44,05
Halophila decipiens	9,48	12,17	18,82	18,18	10,55	13,27	38.85	43,62
Total	100,1	100,1	105,01	100	100	100	305,11	300,01

3.6. Ecological Index of Seagrass

The ecological index is used to observe the balance of seagrass communities. From the calculation results, the diversity index value (H'), uniformity index (E), and dominance index (D) were obtained. From the ecological index value obtained, it can be concluded that the ecological index of seagrass in the waters at the beach is balanced (Table 9).

Table 9 Ecological index of seagrass

Ecological index	Value	
	ST 1	ST 2
Diversity	1,67	1,73
Uniformity	0,93	0,97
Dominance	0,21	0,19

3.7. The Distribution Pattern

The distribution pattern describes the distribution of seagrass species. The distribution pattern is categorized into three: the uniform distribution pattern, the random distribution pattern, and the clustered distribution pattern. The calculation results for the distribution pattern of seagrass beds in the waters of Penimbangan Beach can be seen in Table 10. The distribution of seagrasses in coastal waters was grouped because the number of seagrass species found in pots was more than one stand.

Table 10 The distribution pattern of seagrass

Seagrass Type	Station I				Station II			
	Id	X table (0.05)	Calculated X_2	Distribution	id	X table (0.05)	Calculated X_2	Distribution
Halodule u.	1,51186	46,19	340,65	Group	2,89202	46,19	860,7	Group
Thalassia h.	2,45989	46,19	363,39	Group	2,17503	46,19	315,18	Group
Cymodocea r.	2,44585	46,19	344,3	Group	3,76607	46,19	516,06	Group
Syringodium i.	2,23188	46,19	342,43	Group	3,30668	46,19	511,79	Group
Halophila o.	2,12707	46,19	263,05	Group	1,8725	46,19	222,21	Group
Halophila d.	2,45844	46,19	260,97	Group	1,91468	46,19	193,9	Group

3.8. Water Quality Parameters

Water conditions are an important factor in the survival of biota or organisms in marine waters. Water conditions greatly determine the abundance and distribution of organisms in it, but each organism has different environmental needs and preferences for living, which are related to its environmental characteristics (Table 11).

Table 11 Water conditions

Parameter	Value
pH	6,8-8,2
Salinity (ppm)	33-34
Water Temperature (^{0}C)	29-30
Ait Temperature (^{0}C)	28-29
Substrate	Sand

The quality parameters of weighing coastal waters are still classified as seawater quality standards for seagrass based on the Decree of the Minister of Environment No. 51 of 2004. The degree of acidity/pH of Bali's waters ranged from 6.8 to 8.2. This range is still in accordance with water quality standards for aquatic biota based on the Decree of the State Minister for the Environment No. 51/MNLH/I/2004 that the normal pH range of water that can support the life of aquatic organisms is 6.5–8.8, some aquatic biota prefer a pH value of around 7–8.5. This means that the pH range of the waters is quite optimal for seagrass growth. The salinity of the water was in the range of 33–34 ppm. The seagrass species had different tolerances of salinity. However, most had a range between 10 and 40 ppm. The salinity range at Penimbangan Beach, North Bali, was fairly optimal for seagrass development. The optimum salinity for the seagrass was 35 ppm. The water temperature ranged from 29 to 30 °C, the temperature still optimum for the photosynthesis of seagrass. The optimal temperature range for seagrass species for development is 28–30°C. The ability of the photosynthesis will decrease sharply if the water temperature is outside the optimal range.

Therefore, the temperature range at Penimbangan Beach at the time of the study was in the optimal range for seagrass growth. While the air temperature ranged from 28 to 29°C. Visual observation of the substrate produced a sandy substrate.

4. Discussion

The diversity of seagrass species at Penimbangan Beach shows that the value of seagrass diversity is high because 60% of seagrass species were found at Penimbangan Beach, North Bali. *C. rotundata* prefers waters exposed to sunlight. This type of seagrass is a cosmopolitan type of seagrass, which can grow in almost all habitat categories. *Halophila seagrasses* are found on sandy beaches, reefs, and muddy sands from the average tidal limit to the lower limit of the tidal zone. *Halophila sp.* has a smaller morphology compared to other seagrass species and is sensitive to environmental changes [16]. *E. acoroides* grows in waters that have a muddy sand bottom in a protected environment on the lower edge of the tidal zone and at the upper limit of the littoral zone, while the species *C. rotundata* grows on sandy beaches and muddy sand.

Different density values were obtained from different research locations. This is possible due to the different substrate characteristics between transects so that the seagrass is unevenly distributed and other environmental factors, such as the activities of residents around the research location (both local fishing activities and for tourism), that caused the water and environmental conditions to be slightly disturbed. Therefore, it affected the seagrass ecosystem. This also shows that the density of seagrass species be higher if the environmental conditions of the waters where the seagrass grows were in good condition. The density of seagrass species is influenced by factors where the seagrass grows, such as depth, brightness, water currents and substrate type. The high density of *Halodule uninervis* and *Halophila decipiens* was because the substrate at the research site was fine sand and muddy. These types of seagrass are generally found in intertidal areas and usually grow on sandy or muddy substrates. They are classified as fast-growing seagrass species and are dominant pioneer species in disturbed and unstable waters [17]. Variations in the density of seagrass species at a location have a significant relationship with the morphology of each type of seagrass. The smaller the morphology of the seagrass leaves, the larger the possibility of high seagrass density. The seagrass species with low density values were the genus *Halophila sp.* of the species *Halophila decipiens*. This species of seagrass can thrive in shallow or not deep waters, likes muddy sandy substrates and is even found on the sidelines of coral ecosystems. Campagne et al. [18] say that seagrasses can stabilize soft water bottoms through the influence of dense and intersecting root systems.

The percentage of seagrass cover serves to describe the area of seagrass that covers the water (substrate) within a predetermined square limit with the observer's position perpendicular to the square expressed in percentage (%) [19, 20], the percentage of seagrass cover is not always linear with the high density of species. This is influenced by the observation that the observed cover is leaf blades, while the density seen is the number of seagrass stands. The wider the length and width of the seagrass leaves, the greater the cover for the bottom substrate of the waters. The type of stable substrate is a strong indicator of where to grow seagrass species of *T. hemprichii* and *C. rotundata* [21]. Both species are pioneer species in the seagrass ecosystem. This species has excellent adaptability through its root system, so that it can absorb nutrients in different substrate conditions. According to Hoek et al. [22], the sandy mud substrate is dominated by *Thalassia hemprichii* species. Sukandar and Dewi [23] state that *Halophila pinifolia* is a pioneer seagrass species that can live in habitat conditions where the seagrass species cannot grow. Regarding the seagrass species, namely *Thalassia hemprichii*, Kilminster et al. [24] state that this species is a persistent species and is often dominant in open areas. They also added that the seagrass species *Thalassia hemprichii* and *Enhalus acoroides* are the most common and widespread seagrass species in Indonesia. In determining the percentage of cover, the type of *Enhalus acoroides* seagrass is superior, because it has a larger leaf cross-sectional area, so it tends to have a higher closing value.

The diversity index was 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 included two important things, namely the number of species and the number of individuals of each species in an area, the more the number of species, the more diverse the community. From the calculation of Shannon diversity, the diversity of seagrass in the waters of Penimbangan Beach was 1.67 at station I and 1.73 at station II. From this value, it can be said that the level of diversity of seagrass species in the weighing coastal waters is in the medium category because only six seagrass species were found in the beach waters.

The uniformity index was used to determine the abundance of the community based on the level of similarity of several stands in an area. From the calculation results, the uniformity index value of the seagrass species was 0.93 at station I and 0.97 at station II. From this value, it can be said that the individuals between species are evenly distributed with a stable community abundance. Thus, the number of individual seagrass species found was quite balanced or did not have a significant difference for each species. The smaller the uniformity index, the greater the difference in the number between species (the presence of dominance), and vice versa if the greater the uniformity index, the smaller the difference in the number between species, so that there is no tendency for dominance by certain species [25].

The dominance index used to see how much a species dominates in an area. The dominance index criteria can be grouped into three: high dominance ($0.75 < D \leq 1.00$), moderate dominance ($0.50 < D \leq 0.75$), and low dominance ($0.00 < D \leq 0.59$). From the calculation results, the seagrass dominance index 0.21 at station I and 0.19 at station II. From this value, we can conclude that the dominance index in the waters of Penimbangan Beach in the low dominance category because there no single dominant species found. The greater the value of the dominance index, the greater the tendency of the species to dominate the population.

The coastal waters had a dispersion index value for all types of seagrasses obtained, which were included in the category of clustered distribution patterns. The distribution pattern that groups seagrass species revealed the same density of seagrass species from each water, which is the result of individual gatherings. The clustered distribution pattern obtained from the distance between individuals with other similar individuals in one area is the same. The shape of the clustered distribution pattern of the species found in the waters of Lombok Island is directly influenced by the type of substrate. Certain types of seagrass tend to gather on a specific type of substrate with its adaptation form. Substrates with conditions rich in nutrient content and certain nutrients will form a pattern of seagrass distribution in it, namely with the dominance of specific types of seagrass formed in these waters. The distribution pattern of seagrass in the waters of Lombok Island, which is all included in the category of clustered distribution pattern, is not much different from the distribution pattern of seagrass in other Indonesian waters. The same results were reported by Yunus et al. [26] on the waters of Tomini Bay, Gorontalo. All types of seagrass found in the waters of Tomini Bay, Gorontalo, were included in a clustered distribution pattern. In the waters of the Seribu Island, seagrass distribution patterns are also influenced by coastal topography with sea water movements, tidal patterns, and reproduction processes.

5. Conclusion

Six species of seagrass were found: *Thalassia hemprichii*, *Halophila ovalis*, *Halophila decipiens*, *Halodule uninervis*, *Cymodocea rotundata*, and *Syringodium isoetifolium*. Density < 25 stands/m^2 meant seagrass density was very rare. The highest frequency of *Halodule uninervis* was 78.8 at station I and station II, the highest was *Cymodocea rotundata* and *Halophila decipiens*, namely at 66.7. The lowest was *Halophila ovalis*, namely at 51.5. Seagrass cover at station I was 59.14% and station II was 53.42%. According to the Decree of the Minister of Environment No. 200 of 2004, the status of seagrass beds in the coastal waters of weighing is in a damaged condition with the category of less healthy/less rich because it is not more than 59.9% or less than 60%. The diversity of seagrass is in the medium category. The uniformity index was 0.93 at station I and 0.97 at station II, indicating that the distribution of individuals between species was even with the abundance of stable communities. The dominance index was included in the low dominance category because no single dominant species was found. The distribution pattern of seagrass in the categories tended to clump. The limitations in this research are the weather conditions not supportive at the time of data collection and the tools used for data collection are very limited.

References

[1] RAHMAN A. A., NUR A. I., and RAMLI M. Studi Laju Pertumbuhan Lamun (*Enhalus acoroides*) di Perairan Pantai Desa Tanjung Tiram Kabupaten Konawe Selatan. *Sapa Laut (Jurnal Ilmu Kelautan)*, 2016, 1(1): 10-16. http://dx.doi.org/10.33772/jsl.v1i1.925

[2] ROMBE K. H., ROSALINA D., JAMIL K., SURACHMAT A., and IMRAN A. Pola Sebaran dan Keanekaragaman Jenis Lamun di Perairan Tanjung Pallette dan Tangkulara, Kabupaten Bone, Provinsi Sulawesi Selatan. *Jurnal Airaha*, 2020, IX(2): 164-170. https://doi.org/10.15578/ja.v9i02.172

[3] ROSALINA D., HERAWATI E. Y., MUSA M., SOFARINI D., and AMIN M. Lead accumulation and its histological impact on *Cymodocea serrulata* seagrass in the laboratory. *Sains Malaysiana*, 2019, 48(4): 813-822. http://dx.doi.org/10.17576/jsm-2019-4804-13

[4] ROSALINA D., ROMBE K. H., JAMIL K., and SURACHMAT A. Analysis of Heavy Metals (Pb and Cd) in Seagrasses *Thalassia hemprichii* and *Enhalus acoroides* from Pulau Sembilan, South Sulawesi Province, Indonesia. *Biodiversitas*, 2022, 23(4): 2130-2136. https://doi.org/10.13057/biodiv/d230448

[5] DEWI N. K., BEKTI K., and FARIDA H. Pemanfaatan Serasah Lamun (*Seagrass*) sebagai Bahan Baku POC (Pupuk Organik Cair). *Proceeding Biology Education Conference*, 2016, 13(1), 649-652. https://jurnal.uns.ac.id/prosbi/article/view/5866

[6] BELSHE E. F., HOEIJMAKERS D., HERRAN N., MTOLERA M., and TEICHBERG M. Seagrass community-level controls over organic carbon storage are constrained by geophysical attributes within meadows of Zanzibar, Tanzania. *Biogeosciences*, 2018, 15(14): 4609-4626. http://dx.doi.org/10.5194/bg-2017-474

[7] RAHMAN F. A., QAYIM I., and WARDIATNO Y. Carbon storage variability in seagrass meadows of Marine Poton Bako, East Lombok, West Nusa Tenggara, Indonesia. *Biodiversitas Journal of Biological Diversity*, 2018, 19(5): 1626-1631. https://doi.org/10.13057/biodiv/d190505

[8] JAMIL K., SURACHMAT A., ROSALINA D., ROMBE K. H., and IMRAN A. Komposisi Jenis Lamun di Perairan Tanjung Palette dan Tangkulara, Kabupaten Bone, Provinsi Sulawesi Selatan. *Jurnal Salamata*, 2020, 2(1): 18-22. http://dx.doi.org/10.15578/salamata.v2i1.11250

[9] ROSALINA D., HERAWATI E. Y., MUSA M., and SOFARINI D. Anatomical changes in the roots, rhizomes and leaves of seagrass (*Cymodocea serrulata*) in

response to lead. *Biodiversitas*, 2019, 20(9): 2583-2588. https://doi.org/10.13057/biodiv/d200921

[10] ROSALINA D., ROMBE K. H., and HASNATANG. Pemetaan Sebaran Lamun Menggunakan Metode *Lyzenga* Studi Kasus Pulau Kapoposang, Provinsi Sulawesi Selatan. *Jurnal Kelautan Tropis*, 2022, 25(2): 169-178. https://doi.org/10.14710/jkt.v25i2.13484

[11] ROSALINA D., HERAWATI E. Y., RISJANI Y., and MUSA M. Keanekaragaman Spesies Lamun di Kabupaten Bangka Selatan Provinsi Kepulauan Bangka Belitung. *EnviroScienteae*, 2018, 14(1): 21-28. http://dx.doi.org/10.20527/es.v14i1.4889

[12] ROSALINA D., SOFARINI D., MUHSONI F. F., MUNIR M., and KHASANAH R. I. Metallothionein (MT) Expression and SEM-EDX Mapping on *Cymodocea serrulata* Seagrass. *Jurnal Ilmiah Perikanan dan Kelautan*, 2022, 14(2): 313-326.

[13] FAIQOH E., WIYANTO D. B., and ASTRAWAN I. G. B. Peranan Padang Lamun Selatan Bali Sebagai Pendukung Kelimpahan Ikan di Perairan Bali. *Journal of Marine and Aquatic Sciences*, 2017, 3(1): 10-18. https://doi.org/10.24843/jmas.2017.v3.i01.10-18

[14] RAHADIARTA I. K. V. S., PUTRA I. D. N. N.., and SUTEJA Y. Simpanan Karbon pada Padang Lamun di Kawasan Pantai Mengiat, Nusa Dua Bali. *Journal of Marine and Aquatic Sciences*, 2019, 5(1): 1-10. https://doi.org/10.24843/jmas.2019.v05.i01.p01

[15] BROWER J. E., ZAR J. H., and ENDE C. N. Field and Laboratory Methods for General Ecology. Wm. C. Brown Publishers, Dubuque, Iowa, 1990. http://www.sisal.unam.mx/labeco/LAB_ECOLOGIA/Ecologia_de_Poblaciones_y_Comunidades_files/GeneralEcology.pdf

[16] FAJARWATI S. D., ASMA I. S., and MUZANI. Analisis Kondisi Lamun (*Seagrass*) di Perairan Pulau Pramuka, Kepulauan Seribu. *SPATIAL: Wahana Komunikasi dan Informasi Spasial*, 2015, 13(1): 22-32. https://doi.org/10.21009/spatial.131.03

[17] LISDAWATI, AHMAD S. W., and SIWI L. O. Studi Biomassaa Lamun (*Enhalus acoroides*) dan (*Halodule pinifolia*) berdasarkan Kedalaman Air Laut di Pantai Desa Tanjung Tiram Sulawesi Tenggara. *BioWallacea*, 2018, 5(2): 861-870.

[18] CAMPAGNE C. S., SALLES J. M., BOISSERY P., and DETER J. The Seagrass *Posidonia Oceanica*: Ecosystem Services Identification and Economic Evaluation of Goods and Benefits. *Marine Pollution Bulletin*, 2015, 97(1): 391-400. https://doi.org/10.1016/j.marpolbul.2015.05.061

[19] GANEFIANI A., SURYANTI S., and LATIFAH N. Potensi Padang Lamun sebagai Penyerap Karbon di Perairan Pulau Karimunjawa, Taman Nasional Karimunjawa (Ability of Seagrass Beds as Carbon Sink in The Waters of Karimunjawa Island, Karimunjawa National Park). *Journal of Fisheries Science and Technology*, 2019, 14(2): 115–122. https://doi.org/10.14710/ijfst.14.2.115-122

[20] ROSALINA D., AWALUDDIN, and PUTRI W. M. Pemantauan Kondisi Lamun di Taman Wisata Perairan (TWP) Laut Banda, Kecamatan Banda, Kabupaten Maluku Tengah, Provinsi Maluku. *Jurnal Kelautan*, 2022, 15(1): 8-14. https://doi.org/10.21107/jk.v15i1.13240

[21] ADI W., MUFTIADI M. R., SUPRATMAN O., and ROSALINA D. Community Structure Of Seagrass In Ketawai Island, Bangka Belitung Islands Province, Indonesia. Proceedings of the International Conference on Maritime and Archipelago, Bangka Belitung, 2019, pp. 1-4. https://dx.doi.org/10.2991/icoma-18.2019.1

[22] HOEK F., RAZAK A., HAMID H., MUHFIZAR M., SURUWAKY A. M., ULAT M. A., MUSTASIM, and ARFAH A. Struktur Komunitas Lamun di Perairan Distrik Salawati Utara Kabupaten Raja Ampat. *Jurnal Airaha*, 2016, 5(1): 87-95. https://www.jurnalairaha.org/index.php?journal=airaha&page=article&op=view&path[]=85

[23] SUKANDAR S., & DEWI C. S. U. Status padang lamun di Pulau Talago, Madura dan potensinya sebagai bahan baku bioaktif. *DEPIK Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan*, 2017, 6(2): 138–144. https://doi.org/10.13170/depik.6.2.6435

[24] KILMINSTER K., MCMAHON K., WAYCOTT M., KENDRICK G. A., SCANES P., MCKENZIE L., O'BRIEN K. R., LYONS M., FERGUSON A., MAXWELL P., and GLASBY T. Unravelling Complexity in Seagrass Systems for Management: Australia as a Microcosm. *Science of the Total Environment*, 2015, 534: 97–109. https://doi.org/10.1016/j.scitotenv.2015.04.061

[25] WIJANA I. M. S., ERNAWATI N. M., and PRATIWI M. A. Keanekaragaman Lamun dan Makrozoobentos sebagai Indikator Kondisi Perairan Pantai Sindhu, Sanur, Bali. *ECOTROPHIC: Jurnal Ilmu Lingkungan (Journal of Environmental Science)*, 2019, 3(2): 238-247. https://doi.org/10.24843/EJES.2019.v13.i02.p11

[26] YUNUS A., OGUCHI T., and HAYAKAWA Y. Morphometric analysis of drainage basins in the western arabian peninsula using multivariate statistics. *International Journal of Geosciences*, 2014, 5(5): 527-539. http://dx.doi.org/10.4236/ijg.2014.55049

参考文:

[1] RAHMAN A. A.、NUR A. I. 和 RAMLI M. 南科纳威摄政区丹绒地兰村沿海水域海草（食蚁兽）生长速率研究。沙巴劳（海洋科学杂志），2016, 1(1): 10-16. http://dx.doi.org/10.33772/jsl.v1i1.925

[2] ROMBE K. H.、ROSALINA D.、JAMIL K.、SURACHMAT A. 和 IMRAN A. 南苏拉威西省骨区丹绒调色板和唐库拉拉水域海草种类分布格局及多样性。爱良叶杂志，2020年，IX(2)：164-170。https://doi.org/10.15578/ja.v9i02.172

[3] ROSALINA D.、HERAWATI E. Y.、MUSA M.、SOFARINI D. 和 AMIN M. 铅积累及其对实验室中锯叶藻海草的组织学影响。马来西亚圣贤, 2019, 48(4): 813-822. http://dx.doi.org/10.17576/jsm-2019-4804-13

[4] ROSALINA D.、ROMBE K.H.、JAMIL K. 和 SURACHMAT A. 印度尼西亚南苏拉威西省森美兰岛海草海藻和食蚁兽中的重金属（铅和光盘）分析。生物多样性，2022，23(4): 2130-2136。https://doi.org/10.13057/biodiv/d230448

[5] DEWI N. K.、BEKTI K. 和 FARIDA H. 以海草废弃物为原料生产POC（液体有机肥）。进行生物教育会议，2016，13（1），649-652。https://jurnal.uns.ac.id/prosbi/article/view/5866

[6] BELSHE E. F.、HOEIJMAKERS D.、HERRAN N.、MTOLERA M. 和 TEICHBERG M.

海草社区层面对有机碳储存的控制受到坦桑尼亚桑给巴尔草甸内地球物理属性的限制。生物地球科学, 2018, 15(14): 4609-4626. http://dx.doi.org/10.5194/bg-2017-474
[7] RAHMAN F. A.、QAYIM I. 和 WARDIATNO Y. 印度尼西亚西努沙登加拉岛东龙目岛海洋波顿巴科海草草甸的碳储量变化。生物多样性生物多样性杂志, 2018, 19(5): 1626-1631。https://doi.org/10.13057/biodiv/d190505
[8] JAMIL K.、SURACHMAT A.、ROSALINA D.、ROMBE K.H. 和 IMRAN A. 南苏拉威西省骨头区丹绒调色板和唐古拉水域海草种类的组成。萨拉马塔日报，2020年，2（1）：18-22。http://dx.doi.org/10.15578/salamata.v2i1.11250
[9] ROSALINA D.、HERAWATI E. Y.、MUSA M. 和 SOFARINI D. 海草（毛茛）根、根茎和叶对铅的反应。生物多样性, 2019, 20(9): 2583-2588。https://doi.org/10.13057/biodiv/d200921
[10] ROSALINA D.、ROMBE K.H. 和 HASNATANG。使用利曾加方法绘制海草分布图案例研究南苏拉威西省卡波波桑岛。吉劳丹热带杂志，2022年，25(2)：169-178。https://doi.org/10.14710/jkt.v25i2.13484
[11] ROSALINA D.、HERAWATI E. Y.、RISJANI Y. 和 MUSA M. 邦加勿里洞群岛省南邦加摄政区的海草物种多样性。环境科学，2018，14（1）：21-28。http://dx.doi.org/10.20527/es.v14i1.4889
[12] ROSALINA D.、SOFARINI D.、MUHSONI F. F.、MUNIR M. 和 KHASANAH R. I. 金属硫蛋白(公吨)在毛茛海草上的表达和扫描电镜-EDX映射。杂志渔业和海洋科学, 2022, 14(2): 313-326。
[13] FAIQOH E.、WIYANTO D. B. 和 ASTRAWAN I. G. B. 巴厘岛南部海草场在支持巴厘岛水域鱼类丰度中的作用。海洋与水生科学杂志, 2017, 3(1): 10-18. https://doi.org/10.24843/jmas.2017.v3.i01.10-18
[14] RAHADIARTA I. K. V. S.、PUTRA I. D. N. N.. 和 SUTEJA Y. 门吉亚海滩地区海藻田的碳储量，巴厘岛努沙杜瓦。海洋与水生科学杂志, 2019, 5(1): 1-10. https://doi.org/10.24843/jmas.2019.v05.i01.p01
[15] BROWER J. E.、ZAR J. H. 和 ENDE C. N. 一般生态学的现场和实验室方法。米。C.布朗出版社，迪比克，爱荷华州，1990年。http://www.sisal.unam.mx/labeco/LAB_ECOLOGIA/Ecologia_de_Poblaciones_y_Comunidades_files/GeneralEcology.pdf
[16] FAJARWATI S. D.、ASMA I. S. 和 MUZANI。千岛普拉穆卡岛海域海草状况分析。空间：空间通信与空间信息，2015，13（1）：22-32。https://doi.org/10.21009/spatial.131.03
[17] LISDAWATI、AHMAD S. W. 和 SIWI L. O. 海藻生物量研究(食蚁兽)和(海洛杜勒松叶)基于位于苏拉威西岛东南部丹戎地南村海滩的海水深度。生物华莱士, 2018, 5(2): 861-870。
[18] CAMPAGNE C. S.、SALLES J. M.、BOISSERY P. 和 DETER J. 海草大洋波西多尼亚：生态系统服务识别和商品和利益的经济评估。海洋污染公报，2015年，97(1)：391-400。https://doi.org/10.1016/j.marpolbul.2015.05.061
[19] GANEFIANI A.、SURYANTI S. 和 LATIFAH N. 卡里蒙贾瓦国家公园卡里蒙贾瓦岛水域海草田作为碳吸收剂的潜力（卡里蒙贾瓦国家公园卡里蒙贾瓦岛水域海草床作为碳汇的能力）。渔业科学与技术杂志, 2019, 14(2): 115–122. https://doi.org/10.14710/ijfst.14.2.115-122
[20] ROSALINA D.、AWALUDDIN 和 PUTRI W. M. 班达海水上旅游公园(TWP)班达区、中央马鲁古摄政区、马鲁古省海草状况监测。期刊克劳坦, 2022, 15(1): 8-14. https://doi.org/10.21107/jk.v15i1.13240
[21] ADI W.、MUFTIADI M. R.、SUPRATMAN O. 和 ROSALINA D. 印度尼西亚邦加勿里洞群岛省科塔威岛海草群落结构。海事和群岛国际会议论文集，邦加勿里洞，2019年，第1-4 页。https://dx.doi.org/10.2991/icoma-18.2019.1
[22] HOEK F.、RAZAK A.、HAMID H.、MUHFIZAR M.、SURUWAKY A.M.、ULAT M.A.、MUSTASIM 和 ARFAH A. 拉贾安帕摄政区北萨拉瓦蒂区水域的海草社区结构。爱良叶杂志，2016年，5(1)：87-95。https://www.jurnalairaha.org/index.php?journal=airaha&page=article&op=view&path[]=85
[23] SUKANDAR S., & DEWI C. S. U. 马杜拉塔拉戈岛海草床现状及其作为生物活性原料的潜力。德皮克杂志水生、沿海和渔业科学, 2017, 6(2): 138–144. https://doi.org/10.13170/depik.6.2.6435
[24] KILMINSTER K., MCMAHON K., WAYCOTT M., KENDRICK G. A., SCANES P., MCKENZIE L., O'BRIEN K. R., LYONS M., FERGUSON A., MAXWELL P. 和 GLASBY T. 揭示复杂性海草管理系统：澳大利亚作为一个缩影。整体环境科学，2015，534：97-109。https://doi.org/10.1016/j.scitotenv.2015.04.061
[25] WIJANA I. M. S.、ERNAWATI N. M. 和 PRATIWI M. A. 海草和大型底栖动物的多样性作为信德省沿海水域状况的指标，巴厘岛沙努尔。生态营养：环境科学杂志（环境科学杂志）, 2019, 3(2): 238-247. https://doi.org/10.24843/EJES.2019.v13.i02.p11
[26] YUNUS A.、OGUCHI T. 和 HAYAKAWA Y. 使用多元统计对阿拉伯西部半岛流域盆地进行形态计量分析。国际地球科学杂志, 2014, 5(5): 527-539. http://dx.doi.org/10.4236/ijg.2014.55049