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Index of Seagrass Ecology at Prawean Beach, Jepara

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ABSTRACT: Seagrass ecosystems are limited by several environmental factors, namely temperature, light, salinity, depth, primary substrate, nutrients and movement of seawater (waves, currents, tides). The type of substrate can cause differences in the composition of seagrass species and affect differences in the fertility and growth of each kind of seagrass. Seagrasses are suitable for living on muddy, sandy, loam, or substrates with coral fragments and rock crevices. This study aims to determine the ecological index of seagrass in Prawean Beach, Jepara. The research was conducted using an exploratory descriptive method. The study was carried out in November 2021. The materials used in this study were sediment and seagrass samples. The research was carried out in November 2021. Identification of seagrass species using the LIPI method and grain size analysis of sediments using the granulometric method. PCA analysis aims to determine the variables of ecological factors that affect the ecological index of seagrass. PCA analysis will show necessary information regarding the relationship between variables in one graph. The results obtained four seagrass types: *Thalassia hemprichii, Enhalus acoroides, Cymodocea serrulata* and *Cymodocea rotundata*. The species density value is classified as relatively dense and the species cover value is classified as less rich/unhealthy with the type of sediment in the form of fine sand. PCA analysis resulted in 3 main factors formed, namely: F1) *Enhalus acoroides* cover, gravel, silt, temperature, pH and current; F2) Sand and salinity; and F3) Density and cover of *Cymodocea rotundata.*

Keywords: Seagrass, Substrate, Density, Cover, Prawean Beach

INTRODUCTION

Seagrass ecosystems function as primary producers, habitats, spawning grounds, and foraging for food (Purnama *et al*., 2019). Physically, seagrass beds work to see sedimentation in the waters and to withstand waves and currents that come to the coast. Seagrass ecosystems are limited by several environmental factors, namely temperature, light, salinity, depth, primary substrate, nutrients and the movement of seawater (waves, currents, tides) that affect the density and density of seagrass in an area, so the amount and varies in each area seagrass beds (Minerva *et al*., 2014). The water substrate influences the structure and seagrass (De Silva and Amarasinghe, 2007). Seagrasses are suitable for living on muddy, sandy, clay, or coral substrates and in rock crevices, so they can still be found in coral and mangrove ecosystems (Newmaster *et al*., 2011). Seagrasses in Indonesian waters generally grow in tidal areas and around coral islands (Nienhuis *et al*., 1989).

Seagrass ecosystems in the tropics can occupy various habitats, meaning that the nutritional requirements are very influential. Vegetative forms of seagrasses show a high degree of uniformity. The composition of the type of substrate can cause differences in the design of seagrass and can affect differences in the fertility and growth of each kind of seagrass. The waters of Prawean Beach include closed waters located in the promontory area and close to the mouth of the Kali Wiso River with a primary substrate of a mixture of coral, sand and mud (Turnip *et al*., 2021). Prawean Beach has relatively calm currents and waves due to its location on the north coast of Java, and Panjang Island is located directly opposite Prawean Beach (Baeti *et al*., 2019). This allows the seagrass to grow sufficiently to see the bottom of the water. Seagrass beds in Prawean Beach are areas where seagrass distribution is uneven, resulting in varying densities. Prawean Beach has quite a lot of seagrass with a wide distribution of vegetation, seen from along the coast. Seagrass plants are under various conditions (Setiani *et al*., 2019).

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In conducted by Ikhsan *et al*. (2019), on Wanci Island, Wakatobi Regency, Southeast Sulawesi, the results were the type of sediment that was dominated by sandy substrate, with the composition of the seagrass species found were *Cymodocea rotundata, Halodule uninervis, Syringodium isoetifolium, Thalasondendron ciliatum, Thalassia hemprichii, Enhalus acoroides* and *Halophila ovalis*. Research conducted by Chamidy *et al*. (2020), in the waters of Pulau Panjang and Teluk Awur, Jepara, the results of the type of gravel sand, muddy sand with a composition of seagrass species found were *Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata and Oceana serrulata.* Ganefiani *et al*. (2019), Karimunjawa Harbor found sediment types dominated by sand and coral, with the composition of seagrass species found *Enhalus acoroides, Cymodocea rotundata, Oceana serrulata, Thalassia hemprichii, Halophila minor, Halodule uninervis, Halophila ovalis and Syringodium isoetifolium*. This study aims to determine the ecological index of seagrass beds and analyze some of the most dominant environmental factors of seagrass in Prawean Beach, Jepara.

MATERIALS AND METHODS

This research was conducted in November 2021 in Prawean Beach, Jepara waters. The materials used in this study were sediment samples for grain size analysis and seagrass for identification of species, density and cover, as well as water parameters such as bottom substrate, temperature, salinity, pH, and dissolved oxygen (DO), currents and brightness. The research method used is an exploratory descriptive (Supriyantini *et al*., 2016). Determination of the sampling point using the purposive sampling method (Sofiana *et al*., 2016). The sampling location consisted of three stations. Each station has three sampling points determined randomly with a distance of 50 meters at each end. Determination of the observation point is done using GPS.

Seagrass data were collected using the line transect quadrant method (Rahmawati *et al*., 2014). Determination of seagrass species is carried out directly by referring to KMNLH No. 200 of 2004. Data were collected on three transects with a length of 100 m each and the distance between one transect on a substation and another was 50 m with a total area of 100 x 100 m^2. The quadrant transect is placed on the right side with a distance of 10 m from one quadrant to the other so that the total quadrant in one substation is 11 points.

Sediment sampling was carried out at three stations using a 30 cm sediment core with a diameter of 10 cm. The sediment core is inserted into the substrate, then pressed to a depth of 10-15 cm. The sediment grain analysis is based on grain size using the sieve shaker method. The sieve shaker method aims to determine the grain size composition of the sediment with a diameter above 0.074 mm. water parameters measured were temperature, current, salinity, pH, DO and brightness. The sea water temperature is measured using a thermometer. Measurement of the pH of seawater using a pH meter. Measurement of salinity using a refractometer. DO measurement is done using a DO meter. Current measurements were carried out using a guessing ball and brightness measurements were carried out using a Secchi disk (Santana *et al*., 2018). Measurement of water parameters was measured three times at the same time on three repetitions. Data analysis was conducted to determine the ecological index, namely species density and species cover, sediment grain size, and the Principal Component Analysis (PCA) method. The density of seagrass species was calculated using the formula by English *et al*. (1994). Braun-Blanquet (1965), based on the density of seagrass species, has a condition scale that can be seen in Table 1.

Table 1. The scale of Seagrass Conditions Based on Density

Scale (stands/m^2)	Density (%)
5	>175 Very Dense
4	125-175 Dense
3	75-125 A bit Dense
2	25-75 Rare
1	<25 Very Rare

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Coverage of seagrass species can be calculated by the formula (Tuwo, 2011):

$$PJ = \frac{\alpha i}{A}$$

Note : PJ = Seagrass coverage of one specific type (%/m^2); αi = Total area covered of one specific type (%); A = Total area covered by seagrass (m^2)

Data from the calculation of seagrass cover is known to determine the status of seagrass beds according to the Minister of Environment Decree No. 200 of 2004, which can be seen in Table 2. Principal Component Analysis (PCA) statistical analysis was carried out using the XLSTAT 2015 application. Principal Component Analysis is a multivariate analysis that transforms correlated original variables into new, uncorrelated variables by reducing the number of these variables so that they have smaller dimensions but can explain most of the variability of the actual variables.

RESULT AND DISCUSSION

Prawean beach also serves as a berth for fishing boats, tourist boats, PT Pura Bahari boat berths, rice fields, and residential areas, with the majority of residents relying on local fishermen for a living (Subiakto *et al*., 2019). Mangroves, coral reefs, and seagrass ecosystems are just a few of the significant ecosystems in the waters around Prawean Beach. Along Prawean Beach, seagrass vegetation can be found in a variety of types and conditions and is distributed widely (Setiani *et al*., 2019). Seagrass species composition, density and cover, sediment grain size, water parameters, and principal component analysis were among the study's findings.

Composition of Seagrass Types on Prawean Beach

The types of seagrass found in Prawean Beach, Jepara Regency consist of 4 species which are presented in Table 3 and Figure *1*. The type of seagrass found on Prawean Beach is thought to be because the substrate is mostly sand and the depth of the waters at the research location is insufficient to support life for other seagrass species. This indicates that at low tide stations dominated by *E. acoroides* seagrass with sand as a substrate, the depth only reaches a depth of 30-50 cm. This is thought to be related to the ability of a type of seagrass to adapt to its environment. Conditions of seagrass beds on Prawean Beach include sandy mud substrate, fine sand and sand with coral fragments. Seagrass plants are believed to be able to grow and develop well in this location because of the relatively stable currents. This follows the statement of Handayani *et al*. (2016), that calm current conditions allow seagrass to grow and develop, making it easier for seagrasses to stick their roots into the substrate and seagrasses can absorb nutrients in the substrate as a food source for seagrass. The substrate has an essential role for seagrass because it protects it from the influence of ocean currents and serves as a source of nutrients for seagrass (Dahuri *et al*., 2013).

Density of Seagrass Species at Prawean Beach

The results of the calculation of species density and relative density of seagrass species in Prawean Beach can be seen in Figure *2.* Based on the Figure 2, it can be seen that the seagrass species with the highest number of stands were *O. serrulata* seagrass with 2027 stands, then *T.*

Table 2. The scale of Seagrass Conditions Based on the Percentage of Coverage

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

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hemprichii seagrass with 358 stands, then *C. rotundata* seagrass with 86 stands and the seagrass species had 86 stands. The lowest stand was seagrass, *E. acoroides*, with 56 stands. The density condition of seagrass on Prawean Beach based on the Braun-Blanquet scale (1965) is classified on a scale of 3 with a density value of 75-125 (stands/m^2) which indicates that seagrass in Prawean Beach includes seagrass with relatively dense conditions, this density scale is a reference for determining seagrass conditions.

The distribution of seagrass in Prawean Beach is uneven and not many types of seagrass are found. The density of seagrass in an area is influenced by its abiotic conditions, such as brightness, depth, substrate and nutrient content (Zieman, 1985). Differences in seagrass species density are induced by topography and substrate differences at the observation site. Because many varieties of seagrass have various ways of adapting to these environmental conditions (Ikhsan *et al*., 2019). This is following research conducted by Tampubolon *et al*. (2020), the highest species density value on Prawean Beach, which is 170.55 stands/m^2, is *O. serrulata*. This seagrass can be found in diverse communities with other types of seagrasses (Sarfika, 2012). The distribution of *O. serrulata* at each observation station is thought to be due to the ability of this species to grow and adapt to the substrate conditions of the Prawean Coast. Following the statement of Yunitha *et al*. (2014) that the

Table 3. Presence of Seagrass Species at Observation Station

No	Type	Station 1	Station 2	Station 3
1	*Thalassia hemprichii*	*	*	*
2	*Enhalus acoroides*	*	*	*
3	*Oceana serrulata*	*	*	*
4	*Cymodocea rotundata*	*	*	*

Description: (*) = available, (-) = none

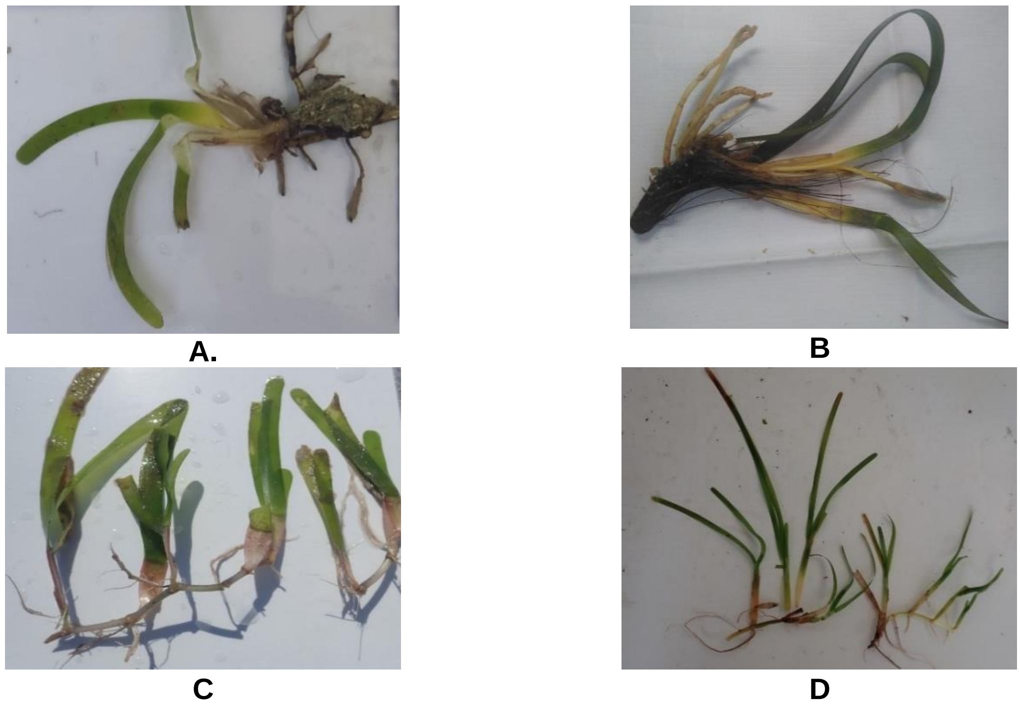

Figure 1. Seagrass species found in Pantai Prawean, (A) *T. hemprichii*, (B) *E. acoroides*, (C) *O. serrulata*, dan (D) *C. rotundata*

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seagrass species *O. serrulata* can live in sandy sediments. The type of seagrass can affect the density of seagrass. According to Hartati *et al*. (2012), the density of seagrass stands is influenced by various factors such as seagrass species, substrate conditions, seasons, tides, wave strength, organic matter content in sediments and other environmental factors. The density of seagrass species varies greatly depending on the type of seagrass because each has its kind of morphology.

Seagrass Coverage at Prawean Beach

The average value of seagrass cover for each species is presented in Figure 3. Observation of the value of seagrass cover based on the three stations, each type of seagrass was found in each station. The seagrass cover value is expressed in units of percent (%). The highest average seagrass cover in Prawean Beach was at station 1. In contrast, stations 2 and 3 had a difference of 9.46%, namely 40.9% for station 2 and 31.43% for station 3. based on the average calculation, it was obtained that the average amount of seagrass cover from the three stations was 42.1% (SD ± 11.31%).

The cover value of the seagrass type *O. serrulata* had the highest value compared to other types at 24.62% overall. Based on this cover value, seagrass species *C. rotundata* has an average of 6.5%. The next seagrass found was *T. hemprichii*. This seagrass has the highest average after *O. serrulata* of 8.07%. The last type of seagrass found was *E. acoroides*. This species has the lowest average value among the four types of seagrass found, which is 2.9%. This is influenced by the observation that the cover is leaf blades, while the density is the number of seagrass stands. The wider the length and width of the seagrass leaves, the greater the bottom substrate covered by the water. The seagrass with the highest closing value was *O. serrulata*. This seagrass forms a vast expanse called seagrass meadow, where other species are also overgrown in some places. The percentage of seagrass cover describes the area of seagrass that covers water, where the height of the coverage is not always linear with the high density of species (Kasim, 2013). Low seagrass cover area (<10%) can be found in areas with a lot of disturbance and open at the lowest tide. In contrast, seagrass beds with a high cover area are located in areas constantly inundated with seawater and protected from the waves (Wiryawan *et al*., 2005). Ecologically, it can be assumed that the environmental conditions of the waters are cloudy due to sedimentation from fishing activities and a large number of community activities around the research location.

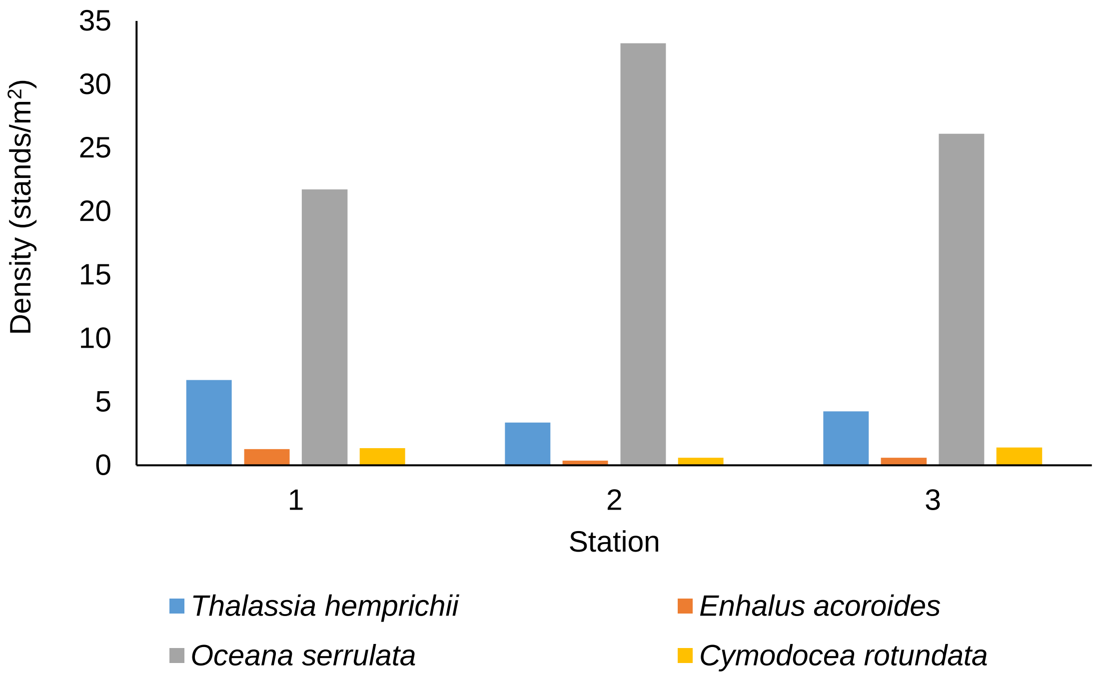

Figure 2. Seagrass Species Density Value

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Grain Size of Sediment at Prawean Beach

Grain size analysis was carried out to determine the type of sediment used as a seagrass substrate, which could be related to the nutrient content of the sediment in the seagrass. The sediment samples that have been analyzed show that there is a fine-sand type sediment fraction at each station. Table 4 shows the grain size of the sediment at each sub-station of the research location at Prawean Beach, Jepara.

Based on the laboratory analysis of sediment grain size at three observation stations, the sediment fractions found, gravel, sand, silt, and clay, were tested using Shepard's triangle. It can be seen that stations 1, 2, and 3 on Prawean Beach have fine sand sediment types. This type of sand contains more sand particles than other substrate particles. Muddy sand has the most sand composition but contains less silt. This condition allows the seagrass to grow and develop well because the sandy substrate allows the seagrass to sink its roots deeper into the substrate. Sand gravel substrate consists mainly of sand particles with a small amount of gravel mixture. The composition of the particles on the substrate determines the classification of substrate types such as rocky, sandy, muddy sand and sandy silt. Fine sand dominates the sediment type at the observation station, caused by sediment transport from the river (Feryatun *et al*., 2012).

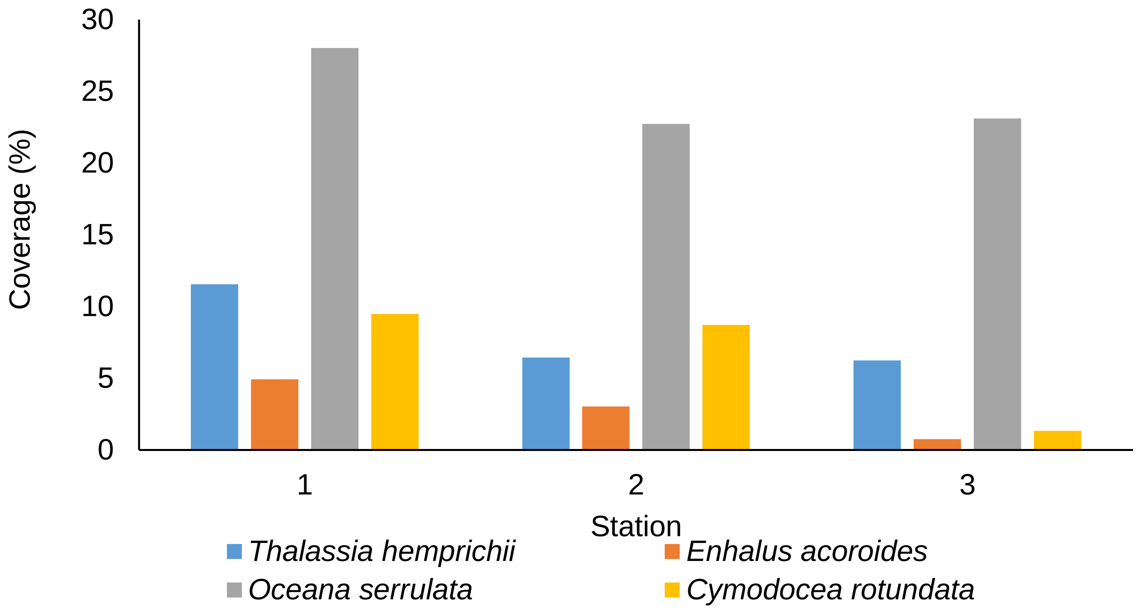

Figure 3. Seagrass Type Coverage Percentage

Table 4. Sediment Grain Size of Prawean, Jepara

Station	*Gravel (%)*	*Sand (%)*	*Silt (%)*	*Clay (%)*	Sediment Types
Sub 1 Station I	15,2	2,2	2,6	0	Fine Sand
Sub 2 Station I	15,6	72,44	11,96	0	Fine Sand
Sub 3 Station I	15,4	72,3	12,3	0	Fine Sand
Sub 1 Station II	16,73	73,51	9,76	0	Fine Sand
Sub 2 Station II	16,93	73,61	9,46	0	Fine Sand
Sub 3 Station II	16,8	73,7	9,5	0	Fine Sand
Sub 1 Station III	17,79	72,1	10,11	0	Fine Sand
Sub 2 Station III	17,99	72,13	9,88	0	Fine Sand
Sub 3 Station III	17,89	72,26	9,85	0	Fine Sand

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The goal of the sediment grain size analysis was to determine the type of material employed as seagrass habitat, which would be connected with seagrass density and cover conditions. The majority of the sediment bulk at all monitoring locations is fine sand. The seagrass life will be unstable due to the substrate (sediment) of the waters; yet, the more abundant the seagrasses are, with long, lush leaves and a greater capacity to trap sediment, the thicker the substrate (Berwick, 1983). In general, seagrass thrives, particularly in exposed tidal zones and coastal waters with a silt, sand, gravel, and dead coral rubble-filled bottom. Sufficient sediment depth is the most crucial sedimentary feature for the growth of seagrass meadows.

Aquatic Quality Parameter at Prawean Beach

The measurement of environmental quality parameters of the waters of Prawean Bandengan Beach was conducted at each station. Observations of ecological parameters in this study include temperature, salinity, pH, brightness, DO and current velocity. The results of the range of environmental parameters at the location show that they are still in the optimum category for seagrass growth which is presented in Table 5.

Environmental factors strongly influence the high seagrass cover in water. Temperature, depth, brightness, pH, current velocity, DO and salinity can affect seagrass growth and development. The temperature of these waters ranges from 28 to 31 degrees Celsius. Stations I, II, and III had temperatures of 28, 30, and 31 degrees Celsius, respectively. One of the environmental elements that can impact seagrass production is temperature, which can also have an impact on other ecological and physiological processes like photosynthesis, nutrient availability, respiration, and seagrass growth (Adli *et al.*, 2016). The salinity values at the three stations have a comparison that is not much different and is included in the category that is still optimal for seagrass growth. According to Dewi and Prabowo (2015), seagrass is euryhaline, meaning it can tolerate salinities between 10 and 45 parts per trillion (ppt), with 35 ppt serving as the ideal salinity. Seagrass cover is influenced by salinity, related to the presence of nutrient absorption, which is strongly affected by salinity (Hartati *et al*., 2012). Current conditions at the research site have an average speed of 0.38 m/s. The current factor based on Rahman *et al*. (2013) explained that the current did not contribute optimally to the growth of seagrass in the location even though the value was below a good standard, namely 0.5 m/s. According to the assertion made by Setiani *et al*. (2019), the wind that blows is not too strong, the current measurements were taken in the early morning before midday. Seagrass beds benefit from currents' ability to remove stuck-on debris or muddy sand particles (Minerva *et al*., 2014). Water production is impacted by PH, or the degree of acidity. The pH values found in the seas at Prawean Beach ranged from 7.3 to 8.1. The highest pH value at station I exceeds the quality standard compared to stations II and III. Based on PP RI No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, the optimal pH quality standard for seagrass growth is 7-8.5. This is confirmed by James *et al*. (2020), who state that the optimal pH value for seagrass growth is between 6.5 - 8.5. Dissolved Oxygen (DO) or dissolved oxygen ranges from 5.45-6.76 mg/L. The low dissolved oxygen at station I is located in a fishing boatyard. Besides

Table 5. Aquatic Quality Parameters in the waters of Prawean Beach, Jepara

Aquatic Parameters	Station			Optimum Value*)
	I	II	III	
Temperature (ºC)	28	30	31	28 – 30
Salinity (ppt)	32	31	34	33 – 34
pH	8,1	7,9	7,3	7 – 8,5
Water Brightness (cm)	50-70	50-60	40-70	> 3 meter
DO (mg/L)	5,45	6,76	5,74	> 5
Water Flow (m/s)	0,25	0,35	0,55	< 0,10

*) Source: PP RI No. 22 Tahun 2021

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that, fishermen also often dispose of dead fish caught that are not worth selling at that location, which causes high organic matter. Because the breakdown of organic matter requires dissolved oxygen, the amount of organic matter in waterways can lower the oxygen content. The brightness values obtained in the waters of Prawean Beach ranged from 70-90 cm. This explains that at the observation location, irradiation still occurs to a certain depth (Tampubolon *et al*., 2020). The growth of seagrass can be affected by shallow water conditions. Temperature, light intensity, and water dynamics are a few other aquatic environmental parameters that can be impacted by changes in water depth. For seagrass to develop and produce, sunlight intensity that penetrates a specific depth in the water is a limiting element.

***Principal Component Analysis* (PCA)**

According to the PCA analysis results, the state of the seagrass ecosystem in its habitat at the Prawean Beach station is on the main component axes, which are concentrated on three axes, namely F1 (37.14%), F2 (20.93%), and F3 (15.98%) of the total variance percentage. This analysis demonstrates three categories of environmental influences, specifically: Factor 1: *Enhalus acoroides*, gravel, silt, temperature, pH, and currents; Factor 2: Salinity and sand; Factor 3: Density and Coverage of *Cymodocea rotundata*.

The results of the principal component analysis establish two primary components subjectively. The variables covered by the variable cover *E. acoroides*, gravel, silt, temperature, pH, and currents are included in the dominant factor 1 component category with the substrate and water parameters. These five elements contribute to the development of seagrass. According to the loading value of the variable, which is gravel, which has the greatest impact on factor 1, the correlation value is 0.934. This is because it may be verified by direct field checks as well as laboratory granulometric analysis results. The factors sand and salinity are included in the factor 2 group of variables. Considering the loading value, the variable that has the most influence on factor 2 is sand with the highest correlation value = 0.798 (Figure 4).

Enhalus acoroides seagrass, which is one of the primary components forming factor variables in this study, had the lowest density and cover values of all the seagrass species at Prawean Beach. Muddy substrates support seagrass *E. acoroides* growth more quickly than sandy or sandy with coral substrates. This is because the muddy bottom texture of the substrate, which is smooth, soft, and rich in nutrients, causes less energy to be produced when roots are pushed into the substrate than it does when seagrasses and sandy substrates with corals release energy. The amount that

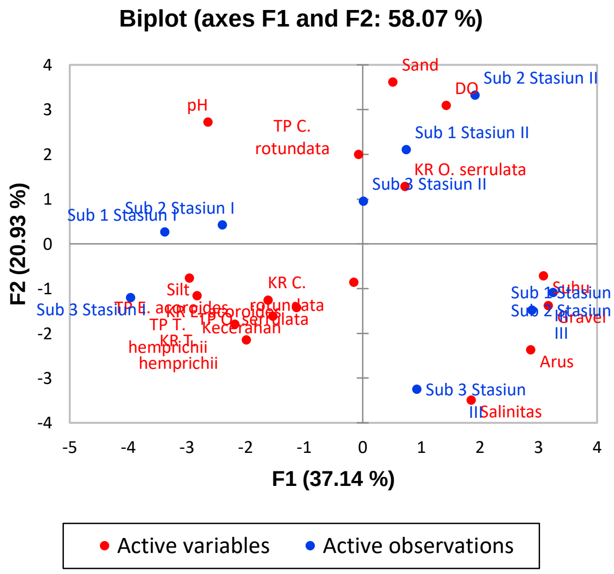

Figure 4. Biplot Formed from Each Variable

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the seagrass can grow depends on the substrate. The development and dispersion of seagrass can be impacted by differences in features. The more nitrate and phosphate nutrients are present in the substrate, the smaller the size of the sediment. Because of the smaller size of the sediment grains, the silty substrate will have a higher growth rate in seagrass *E. acoroides* than a sand substrate or a sand substrate containing coral fragments.

CONCLUSIONS

Thalassia hemprichii, *Enhalus acoroides*, *Oceana serrulata*, and *Cymodocea rotundata* are the four varieties of seagrass found on Prawean Beach, Jepara. With the kind of sediment in the form of fine sand, the species density value is relatively dense, and the species closure value is characterized as less rich/unhealthy. Three key factors were produced as a result of the PCA analysis, namely: F1 = *Enhalus acoroides* cover, gravel, silt, temperature, pH, and current; F2 = Salinity and sand; F3 = *Cymodocea rotundata* density and cover.

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