The relationship of substrate types and density of seagrass species in the waters of Mount Botak, South Manokwari Regency, West Papua Province

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Abstract. The current research was carried out in August-September 2021, in Mount Botak waters, South Manokwari Regency, West Papua Province, with the aim of determining the composition, density, percentage cover of seagrass species, and the relationship between substrate types and seagrass species in the area. Primary data in this research consisted of seagrass and substrate type, while secondary data was obtained from various sources of information related to the research object, such as information from scientific articles or other literature studies. Seagrass data was collected using the line transect method with a length of 50 m for each transect, drawn from the shoreline towards the sea, with 3 transects with a distance of 50 m between the transect lines; each transect line determined 10 observation quadrats, each of them measuring 50 x 50 cm, with a distance of 5 m between the quadrats. Substrate data uses a modified sediment corer made from a PVC pipe with the diameter of 2 inches and a length of 75 cm (tide water). The results showed that the composition of seagrass species in the waters of Mount Botak is dominated by the *Cymodacea rotundata* species with a total population abundance of 1437 individuals, while the seagrass species density ranges from 69.87–196.40 ind m^{-2}, and their relative density ranges from 11-32%. *C. rotundata* dominates with a specific density of 196.40 ind m^{-2} and a relative density as big as 32%, while the lowest density is recorded for the types *H. ovalis* and *H. uninervis*. The total percentage of seagrass cover at the research location was 51.022%, in the less rich category. The medium sand substrate type had a very real relationship with the seagrass *C. rotundata* demonstrated by a positive correlation similarity value of 0.847 ($0.5<0.847$), while the very fine sand substrate type does not have a real influence because it has a negative correlation similarity value of −0.558 ($0.5>-0.558$).
Key Words: seagrass, substrate, density, relationship.

Introduction. Papua is an island that has the highest biodiversity in Indonesia. This is supported by the location of the region, climate, topography, diversity of species and genetics of flora and fauna, as well as the diversity of ecosystems ranging from land, water (rivers, low land swamps and high lands), and oceans (beaches, coral reefs to the sea) (Mampioper 2017). Seagrass beds play an important role in shallow marine ecosystems, because they are habitat for fish and other aquatic biota. The seagrass ecosystem, apart from being a wave damper and a barrier against marine abrasion, also has an important function as a habitat for aquatic biota, a place for foraging, spawning, larval rearing, and an area of protection from natural threats for small biota (Hutomo & Nontji 2014). The substrate in the waters influences the existence of coastal vegetation such as seagrass beds. Seagrass has an important role for the life of marine biota as a habitat for various types of marine organisms and plays a role in the food chain. Seagrass ecosystems also play a role in coastal areas where they can prevent coastal erosion and slow down currents and waves. Substrate characteristics influence the structure and cover of seagrass. Each type of seagrass has a different habitat, depending on the required sediment substrate (Korwa 2020). The existence of a substrate is very important for seagrasses because the depth of the substrate plays a role in maintaining sediment stability which includes protecting plants from sea water currents and supplying nutrients. Sufficient sediment depth is a primary requirement for the growth and development of seagrass habitat. Fine substrates have a higher percentage of organic material than coarse substrates. The high organic content in the substrate really supports the growth process of seagrass (Tomascik et al 1977). Apart from that, the morphology or shape of the seagrass also influences the density of the seagrass. The density and morphometrics of seagrass beds are influenced by several factors such as the type of seagrass habitat substrate and nutrients.

Mount Botak is one of the areas in South Manokwari Regency, West Papua Province, which is in the shape of a bay and is located directly opposite to the coastal area and sea. The waters around Mount Botak have the potential for a seagrass ecosystem, which shows quite extensive expanses of seagrass beds in the coastal area of this bay. The water bottoms covered with a sandy, muddy substrate is an ideal habitat for seagrass to grow and develop. The types of seagrasses found in the waters of Mount Botak, namely *Enhalus acroides*, *Halophila ovalis*, *Halophila minor*, and *Cymodacea rotundata*, belong to two families, namely the Hydrocharitaceae and Potamogetonaceae (Runtuboi et al 2018).

The development of coastal settlements and the opening of the Trans Manokwari – Bintuni road has had an impact on coastal ecosystems, such as disruption or damage to coastal ecosystems as well as decreasing the water environmental quality in areas around seagrass ecosystems. Therefore, the current study aimed at determining the composition, density and percentage cover of seagrass species, as well as the relationship between substrate types and seagrass species in the waters of Mount Botak, South Manokwari Regency, so that it can provide information about the influence of habitat conditions (substrate types) on seagrass density, in support to the management of seagrass ecosystems in the coastal area.

Material and Method

Time and place. This research was carried out from August to September 2021, around Mount Botak Waters, South Manokwari Regency, West Papua Province (Figure 1).

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Figure 1. Map of research locations.

Types of research data*.* This research uses 2 types of data was primary data and secondary data. Primary data is obtained by collecting data directly related to the object being studied at the research location, such as seagrass and substrate types, while secondary data was obtained from various sources, such as the literature related to the current study's topic.

Research variable. In this research, observations were made on variables of seagrass types and substrate types around the waters of Mount Botak, South Manokwari Regency. The observed types of seagrasses were then analyzed to determine the composition, density and percentage of species cover, while the substrate types were observed and differentiated to be able to determine their types, which may be related to certain types of seagrass, at the research location.

Data collection procedures

Seagrass data. Seagrass data was collected using the line transect method, in several steps: (1) Drawing 3 transect lines 50 m long, perpendicular on the shoreline, towards the sea according to the seagrass distribution conditions. The distance between transect line 1 and the other transects is 50 m, (2) Each transect line determines an observation quadrat measuring 50 x 50 cm, with a distance of 5 m between the quadrats (in one transect line there are 10 seagrass observation quadrats, as indicated in the Figure 2), (3) After placing the quadrats, the next step is to identify the types of seagrass contained in each observation quadrat by referring to the identification book of Rahmawati et al (2014), (4) Once identified results the population of each type of seagrass was determined for each observation quadrat, (5) Next, Excel software was used to determine the population density by type of seagrass and the percentage of seagrass cover found during the research.

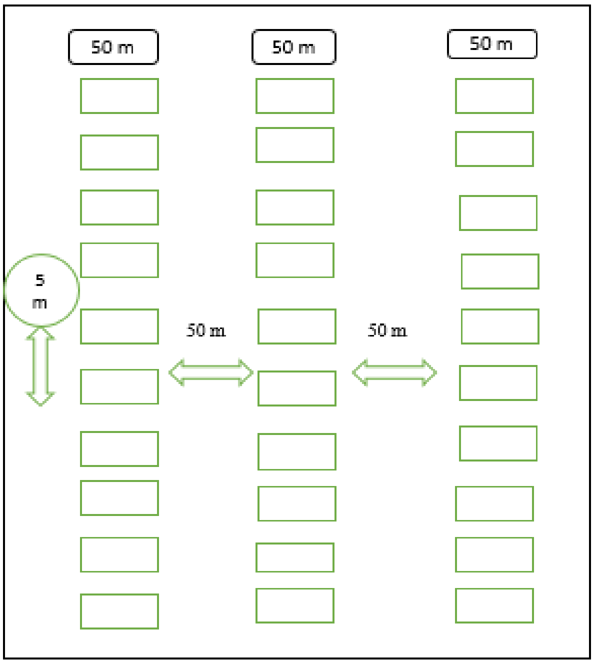

Figure 2. Line transect and quadrat observation of seagrass.

Substrate type data based on sediment. Sediment sampling was carried out on each transect line using a modified sediment corer made from a PVC pipe with the diameter of 2 inches and a length of 75 cm (high tide). The sediment core is stuck into the substrate and pressed to a depth of 75 cm to take the substrate in the middle of the sediment core, then the top of the sediment core is covered with a rubber tire, pulled out slowly, and put into a sample bag for analysis. The sediment sampling was carried out 4 times at the same points (plots 1, 4, 7 and 10, on each transect line) as the seagrass sampling points, for determining the seagrass habitat substrate. The selection criteria of the sediment samples were based on the distribution vertical distribution pattern of the seagrass species, from the coast towards the sea. The sediment samples that have been obtained were put into plastic bags and labeled according to the transect and quadrat. The sediment was weighed to get the net weight and analyzed for the type and size of the sediment grains at the Aquatic Resources Laboratory, Faculty of Fisheries and Marine Sciences, University of Papua.

Research data analysis
Seagrass density data analysis. The population density of each type of seagrass found on each observation transect was calculated using the Odum's (1993) formula:

$$\mathrm{Di} = \frac{Ni}{A}$$

Where:
Di - specific density (ind m^{-2});
Ni - number of stands of species i in a quadrat;
A - quadrat area (m^2).

Analysis of seagrass cover presentation data. The percentage cover of seagrass species is calculated using the following formula (English et al 1994):

$$\mathrm{Ci} = \frac{\Sigma(\mathrm{Mi} \times f\mathrm{i})}{\Sigma fi}$$

Where:
Ci - percentage of seagrass cover for type i;
Mi - midpoint;
*F*i - frequency of appearance of type I;
ΣFi - total frequency of occurrence of all types.

Substrate type data analysis based on sediment. Substrate analysis was carried out using a graduated sieve (sieve shaker) and then classified according to Wentworth's criteria, to determine the type and size of sediment grains (Affandi & Heron 2012). The sediment samples that have been dried are weighed initially (±200 g), then placed in a multi-level sieve and sieved for ±10 minutes, then the sediment sieve results are weighed based on the diameter of the multi-level sieve (mm). After weighing, the percent (%) weight of sediment at each level of the sieve shaker was calculated using the following equation, according to Purnawan et al (2012):

$$\text{Fraction i (\%)} = \frac{sediment\ weight\ at\ the\ level\ i\ of\ the\ sieve}{total\ weight\ of\ the\ sediment\ sample} \times 100$$

The sediment weight calculation results obtained based on the formula above are then classified according to grain size using the Wentworth scale as presented in Table 1 below, according to Hutabarat & Evans (1985).

Table 1

Classification of sediments according to Wentworth scale grain size

Category	*Terminology*	*Diameters (mm)*
Gravel	Bolder (Boulder)	>256
	Cobble	64-256
	Pebble	4–64
	Gravel (Granule)	2–4
Sand	Very coarse sand (Very coarse sand)	1–2
	Coarse sand	0.5-1
	Medium sand	0.25-0.5
	Fine sand	0.125-0.25
	Very fine sand	0.0625-0.125
Mud	Silt	0.00039-0.0625
	Clay	<0.0039

Analysis of the relationship between substrate type and seagrass density. The relationship between substrate type and density of seagrass species was analyzed using the Principal Component Analysis (PCA) statistical approach model and represented as a dendrogram of the similarity value to determine the correlation cut off point, using the Agglomerative Hierarchical Clustering (AHC) statistical approach model.

Results and Discussion

Population abundance of seagrass types in the waters of Mount Botak. From the results of observations, 5 seagrass species were found in the waters of Mount Botak, South Manokwari Regency, consisting of the types *Thalassia hemprichii* (Th), *Cymodocea rotundata* (Cr), *Enhalus acoroides* (Ea), *Halodule uninervis* (Hu), and *Halophila ovalis* (Ho). Each type of seagrass has a different population abundance (Figure 3).

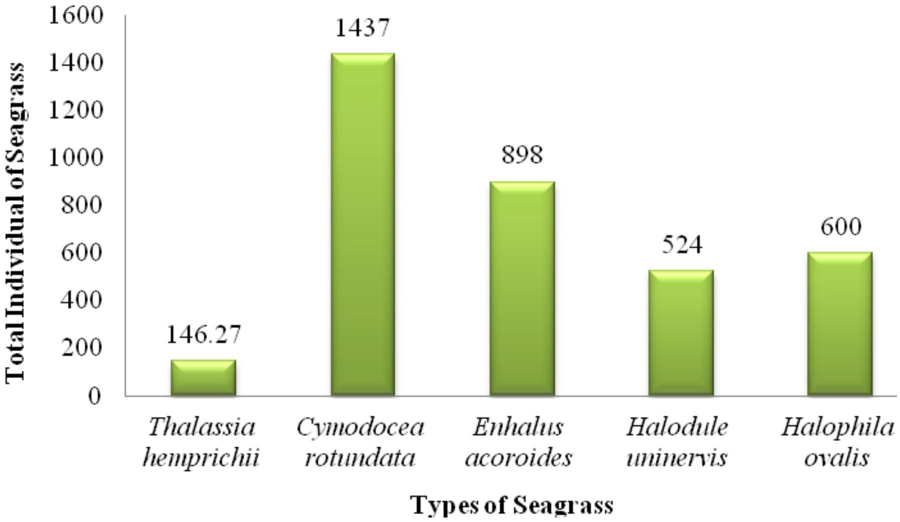

Figure 3. Composition of seagrass species in the waters of Mount Botak.

In Figure 3 above, it can be seen that the composition of seagrass species in the waters of Mount Botak is dominated by the *Cymodocea rotundata* species, with a total composition of 1437 individuals, followed by the *Enhalus acoroides* species, with 898 individuals, and the *Halophila ovalis* and *Halodule uninervis* species, while the lowest abundance was found in the *Thalassia hemprichii* type, there were 146.27 individuals. The composition and abundance of seagrass species found at the research location are in line with the results of the research conducted by Kaiway (2021) in the waters of Mount Botak Wind Gate. The research explains that the distribution of seagrass from the coast to the sea is classified as mixed vegetation because more than one type of seagrass was found, which was corroborated by Nainggolan (2011) who stated that in shallow subtidal areas more than two types of seagrass share a habitat.

Seagrass with mixed vegetation types does not always have a high abundance of each species, because differences in location, habitat conditions and environmental aspects greatly influence the composition and population of seagrass species, as is the case of Waisai waters, Raja Ampat Regency, where as many as 7 types from 2 families of seagrass have been identified: *E. acoroides*, *H. decipiens*, *H. ovalis*, *T. hempricii*, *H. pinifolia*, *Syringodium isoetifolium*, and *C. rotundata* (Ansal et al 2017). Each type of seagrass has differences in distribution, due to differences in substrate, environmental conditions, and physiological needs which are influenced by abiotic conditions such as turbidity, depth, substrate, and nutrient content (Latuconsina 2012).

Density of seagrass types in the waters of Mount Botak. Species density is the total number of seagrass stands per area of the observation, while relative density is the ratio of the number of individuals of the species and the total number of individuals of all species. The analysis of the specific and relative density of seagrass around the waters of Mount

Botak indicates that the highest values were obtained for the *C. rotundata* and the lowest for *H. uninervis*. The results of this research are in line with those of Ansal et al (2017), obtained in the waters of Waisai, Raja Ampat Regency, namely the highest density and relative density values of the seagrass species at several observation stations are dominated by the *C. rotundata* type. Density is influenced by the seagrass types found at each observation station and by the condition of water areas off the coast, compared to the coastal waters. Figures 4 and 5 detail the density and relative density values of seagrass species in the waters around Mount Botak.

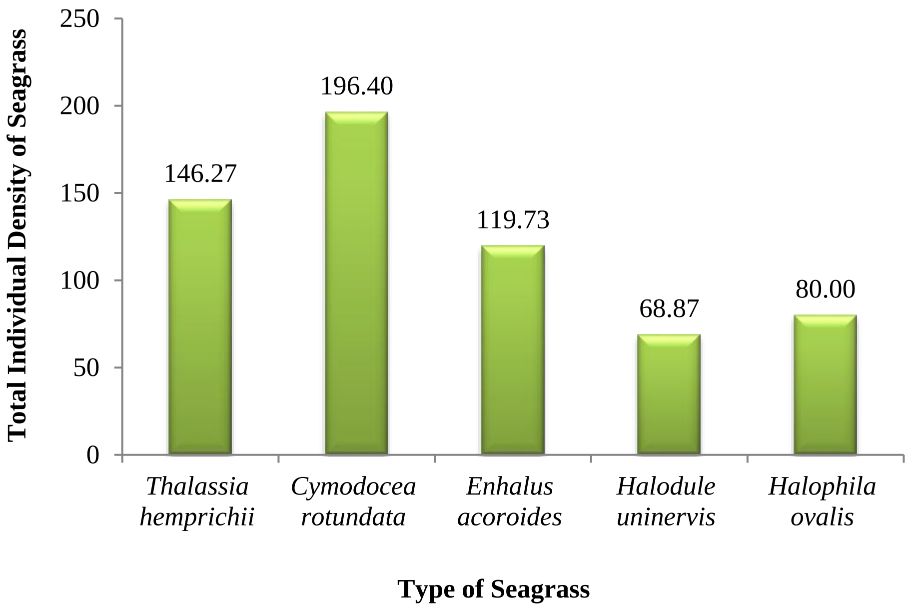

Figure 4. Density of seagrass species in the waters of Mount Botak.

Figure 4 above shows that the density of seagrass species in the waters of Mount Botak ranges between 68.87 and 196.40 ind m^{-2} dominated by *C. rotundata*, followed by the *T. hemprichii* and *E. acoroides,* while the lowest density is found in *H. ovalis* and *H. uninnervis*. The results of this study are different from those found by Awom et al (2023) in the waters of Pasir Putih, Manokwari Regency, where the highest density was found in the species *S. isoetifolium* with a density value of 113.4 ind m^{-2}, while the *C. rotundata* type only had a density value is 580.8 ind m^{-2}. In this study, the *C. rotundata* species' density was higher in the waters of Pasir Putih compared to the waters of Mount Botak, meaning that the density of seagrass species is influenced by several environmental factors such as brightness, current speed, and substrate type (Dahuri 2001).

According to Jesajas et al (2016), *C. rotundata* is a type of seagrass that is generally found in Indonesian waters, because it is able to grow and live on various types of substrates, especially coral sand. Apart from that, this type of seagrass also lives in the intertidal zone with the ability to adapt to drought conditions and low tide conditions. This type of seagrass is able to tolerate temperatures of 40˚C (Collier & Waycott 2014). *C. rotundata* also likes open water areas that are exposed to direct sunlight and is classified as a cosmophytic plant adapting to almost all habitats (Den Hartog 1967; Brouns & Heijs 1986), while the less populous species tend to avoid excessive light exposure. At low tide, these types of seagrasses grow in areas still submerged in water. This is in accordance with Nurzahraeni (2014), who stated that the seagrass type *H. uninervis* will find it difficult to grow and develop in bottom waters that are exposed to direct sunlight.

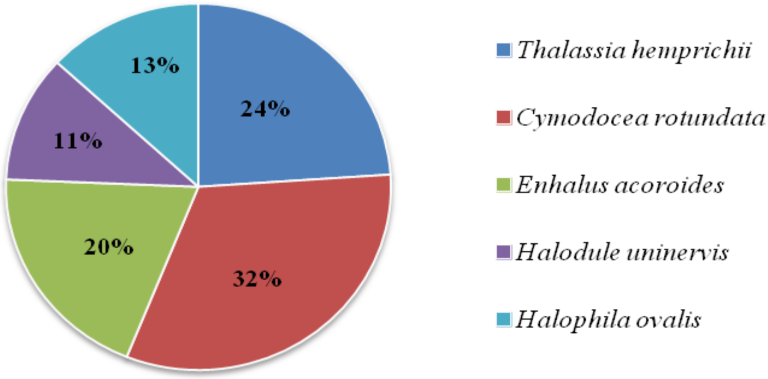

Figure 5. Relative density of seagrass species in the waters of Mount Botak.

The relative density of seagrass species found in the waters of Mount Botak ranges between 11% and -32%, with the highest relative density being recorded for the *C. rotundata* species, while the lowest relative density was observed for *H. ovalis* and *H. uninervis* (Figure 5). According to Wicaksono & Widianingsih (2012), the seagrass type *C. rotundata* likes waters exposed to sunlight, being a cosmopolitan species which can grow in almost all habitat categories. Asirah et al (2019) stated that *C. rotundata* can adapt well to intertidal areas (submerged at high tide and exposed to sunlight at low tide). *H. ovalis* has the lowest relative density. According to Gosari & Haris (2012), this type has a small size compared to other types of seagrasses, experiencing an unstable growth, also due to a strong competition for nutrients. This is in accordance with Fajarwati et al (2015), who stated that seagrass species that have a small morphological size are very sensitive to environmental changes and are usually covered by sediment, which inhibits their growth.

Percentage cover of seagrass types in the waters of Mount Botak. The percentage of seagrass cover describes the distribution of seagrass vegetation covering the bottom of the waters. The cover value not only depends on the density of seagrass species, but is also influenced by the morphology of each seagrass species. The community structure and density can be used to estimate the seagrass production (Mukai et al 1980). From the results of data analysis, it was found that the seagrass type *C. rotundata* had a higher cover, with 49.1%, followed by the type *T. hemprichii*, with 36.6%, and the type *E. acoroides*, with 29.93% (Figure 6).

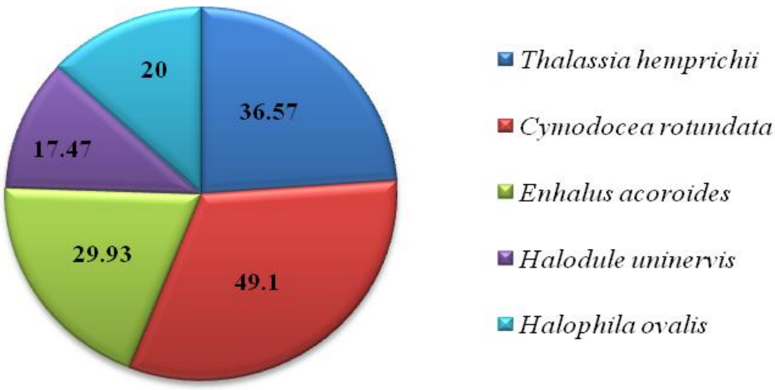

Figure 6. Percentage of seagrass cover in the waters of Mount Botak.

The total percentage of seagrass cover at the research location was of 51.022%. Dewi et al (2017), referring to the Decree of the State Minister for the Environment No. 200 of 2004 (concerning the damage criteria and guidelines for determining the status of seagrass beds), stated that waters with a seagrass cover ≥60% are classified as rich, while at 30–59.9% they are classified as moderate and with ≤29.9% they are classified as poor, which put the waters of Mount Botak in the less rich category. Factors that influence the percentage of seagrass cover at the research location, based on observations, include the construction of a pier, disposal of waste (garbage) originating from tourist visitors around the Mount Botak area, as well as landslides from the mountain into the surrounding waters, resulting in inputs of sediment, such as sand and Rocks, in areas of seagrass ecosystems. This is in accordance with the statement by Short & Wyllie-Echeverria (2000), that high sedimentation density and tidal conditions at the time of observation can influence the estimated value of seagrass species cover. Apart from that, Azkab (2006) also stated that the disposal of rubbish and waste flows from land increase the water turbidity and the solid particle concentration in the sediment deposits, negatively impacting on the intensity of light entering the waters around the seagrass ecosystem areas and thus inhibiting the photosynthesis process.

Characteristics of substrate types in seagrass habitats in the waters of Mount Botak. Substrate type is an inseparable part of the seagrass ecosystem. Seagrass requires a certain substrate to be able to grow and develop into a functional aquatic. Laboratory observations and analysis were performed in order to determine the characteristics of the substrate types around the seagrass habitat at the research location. The Wenworth scale criteria approach to the substrate analysis indicated the presence of 3 categories of substrates: medium sand, fine sand and very fine sand. The percentage of dominance for each substrate category is presented in Figure 7.

The results of the analysis of substrate type categories (in the seagrass ecosystem at the research location) show that the substrate type in the fine sand category is dominant, compared to other substrate types (Figure 7). The type of substrate in a body of water, whether closed water or open water, is greatly influenced by natural sedimentation and by human activities on land, which cause piles of sediment in the form of sand and rock around the coastal areas, where most seagrass ecosystems develop.

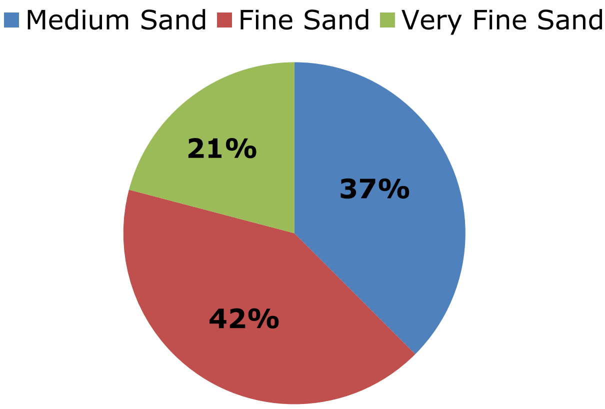

Figure 7. Percentage of substrate type categories in seagrass habitat in the waters of Mount Botak.

Relationship between substrate type and density of seagrass types in the waters of Mount Botak. The relationship between substrate type and density of seagrass species found at the research location was analyzed using the Principal Component Analysis (PCA) statistical approach model, which is used to determine the relationship between substrate type and seagrass species density. The highest density values, corresponding to the *C. rotundata*, *T. hemprichii*, and *E. acoroides* were used. The relationship between substrate type and density of seagrass species was analyzed to determine the suitability of habitat conditions for a particular type of seagrass whose dominance is quite high, so that its relationship to the substrate type at the research location can be determined. Based on the results of PCA analysis with a variable test level of 100%, namely F1 70.78% (substrate type) and F2 29.22% (seagrass species density), the substrate type in the medium sand category has a positive relationship with the seagrass species density, compared to the fine sand and very fine sand substrate types around the waters of Mount Botak. The results of the relationship analysis can be seen in Figure 8.

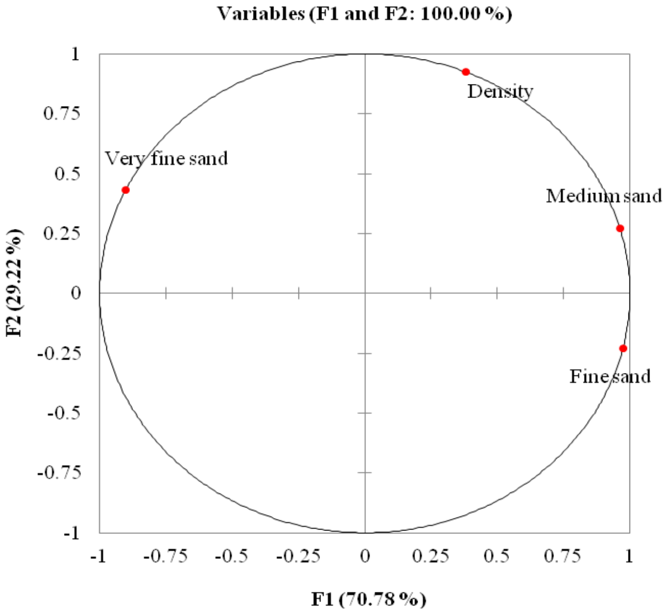

Figure 8. Relationship between substrate type and density of seagrass species.

After carrying out further tests to see the level of significance of the relationship between substrate type and the density of certain seagrass species specifically, it was found that the medium sand substrate type had a real relationship with seagrass species *C. rotundata*, compared to the 2 other types of seagrass that had a negative relationship, namely *T. hemprichii* which had a significant negative relationship to the fine sand substrate type, and *E. acoroides* which has absolutely no real relationship to the 3 types of substrates (Figure 9).

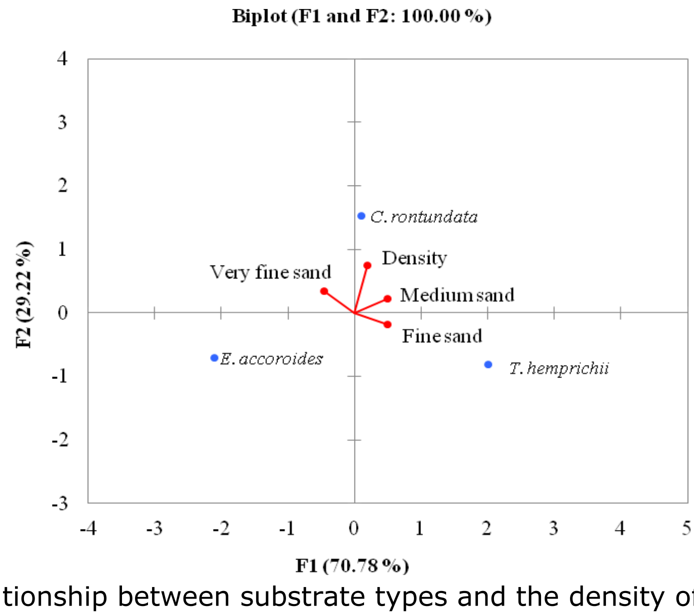

Figure 9. Relationship between substrate types and the density of certain seagrass species.

The seagrass type *E. acoroides* is more commonly found on muddy substrates, so there is no kinship relationship with the 3 types of substrates in waters Botak Mountain. According to Tomascik et al (1997), *E. acoroides* is the most commonly found species in fine to muddy sediments, although in medium to coarse sediments it can still grow because it has a long and strong root system, so it is able to absorb food well and can stand firmly (Wangkanusa et al 2017).

Differences in the composition of substrate types can cause differences in the composition of seagrass species and can also influence the fertility and growth of seagrass. Differences in the size of sand grains will cause differences in the nutrients for seagrass growth and in the decomposition and neutralization processes that occur in the substrate (Kiswara 1992). Almost all types of substrates can promote the of growth of seagrass, from muddy substrates to rocky substrates. Large seagrass beds are more often found in thick sandy mud substrates between mangrove swamp forests and coral reefs, determining the plants' stability and preventing the effects of the currents and waves, and also cycling of the required nutrients (Wangkanusa et al 2017).

Substrate type clusters of seagrass type density in the waters of Mount Botak. In this study, the AHC analytical model was used to study the hierarchical relationship between substrate types and the frequency of seagrass species in the waters of Mount Botak, South Manokwari. Based on the results of the analysis it was found that the fine sand and medium sand substrate types had a positive level of similarity of 0.847 (0.5<0.8475), meaning that there is a real relationship between the two types of substrates on the density of the seagrass species found. The level of similarity of seagrass species density is of 0.442, but is related to the medium and fine sand substrate types, both having a small influence on the density of seagrass species, but below the correlation value (<0.5), while the very fine sand substrate type does not have a real influence because it has a level of similarity of –0.558 (0.5>–0.558) (Figure 10). According to Sjafrie et al (2018), seagrass is influenced by the types and composition of substrate, such as the size of sand grains, which influence the availability of nutrients in seagrass growth and the decomposition and mineralization processes that occur under the substrate. Wigey (2013) added that seagrass has rhizomes that are segmented and grow immersed in a substrate of sand, mud and coral fragments. Yunitha et al (2014) stated that seagrasses in Indonesia are grouped based on their substrate type, is seagrasses that live on muddy substrates, sandy mud, muddy sand, coral rubble and coral rocks.

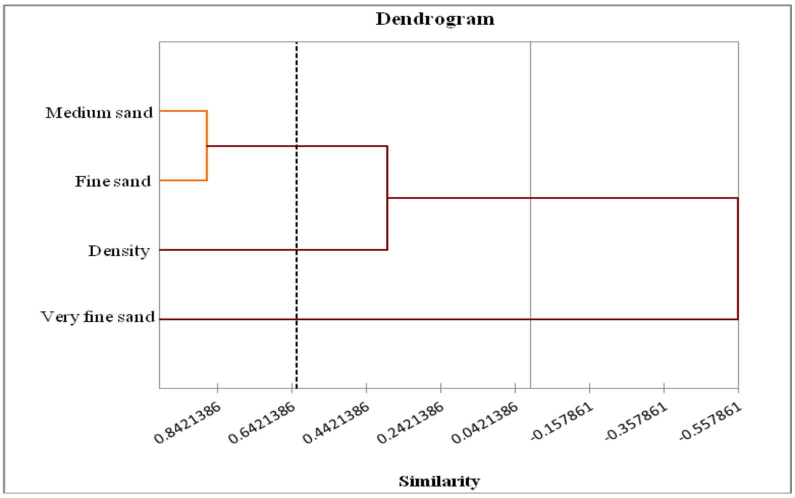

Figure 10. Clustering of substrate types with density of seagrass species.

Conclusions. Based on the results of this research, it can be concluded that the composition of seagrass species in the waters of Mount Botak is dominated by the *C. rotundata* species with a total of 1,437 individuals, specific density ranges between 69.87 and 196.40 ind m^{-2}, and the relative density ranges between 11% and 32%. Type *C. rotundata* dominate with value specific density of 196.40 ind m^{-2} and relative density as big as 32%. The type of seagrass with the lowest individuals is species *H. ovalis* and *H. uninervis*. The total percentage of seagrass cover in the waters of Mount Botak is 51.22%, meaning that the seagrass cover in these waters is in the less rich category. The type of medium sand substrate has a real relationship with the density of seagrass species *C. rotundata* because it has a similarity value (positive correlation) of 0.847 (0.5<0.8475), while the very fine sand substrate type does not have a real influence because the similarity value (−0.558) is below the specified correlation number (0.5>−0.558).

Conflict of interest. The authors declare no conflict of interest.

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