Seagrass diversity in Poncan Gadang Island, Sibolga, Indonesia

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Abstract. This study was conducted to obtain data related to the diversity of seagrass species that live in the waters of Poncan Gadang Island, Indonesia. Data was collected directly using the quadratic transect method from January to April 2019. There were 4 observation points in this study. There were 5 transects at each observation point, with a distance of 10 m to the sea from the shoreline. There were 5 species in the observation location that belong to 2 genera, *Enhalus acoroides* and *Halophila ovalis* from the genus *Hydrocaritaceae* and *Cymodocea rotundata*, *Cymodocea serrulata*, and *Halodule pinifolia* from the genus *Potamogetonaceae*. The diversity index value was between 1.22 and 1.59, classified in a low diversity category. The similarity index (IS) showed a high level of similarity, with values between 88.88% and 100% at the observation locations. The dominance index (C) had a value close to 0, which means that no species dominates the observation location. The percentage of seagrass cover at the observation location ranged from 75.2 to 91%. It can be concluded that the condition of the seagrass cover in Poncan Gadang Island is good, with a low diversity level.
Key Words: similarity index, species composition, species density.

Introduction. Seagrass can be found throughout the world. However, the highest diversity is in the Indo-Pacific region, including Indonesia (Waycott et al 2004). Seagrass is a flowering plant (Angiospermae) with a root system and a rhizome. Seagrass can be found growing in tidal areas up to a depth of 40 m (Hashim et al 2001; Short et al 2007; Athiperumalsami et al 2008; Kawaroe et al 2016). The seagrass ecosystem is one of the marine ecosystems that have a high productivity. Seagrass productivity is only limited by light intensity and nutrient availability (Peterson & Heck 1999; Ruiz & Romero 2003). Seagrass beds can function as coast protection from abrasion (Peterson et al 2004; Koch et al 2006). Seagrass can also become shelters for breeding and foraging for various marine animals (Supriadi et al 2004; Giovannetti et al 2006; Unsworth et al 2009). The existence of seagrass is not only beneficial for aquatic biota, but also has an important role in the carbon cycle in the atmosphere (Kawaroe et al 2016).

Indonesia is one of the countries with the highest diversity of seagrass, Tanto et al (2018) report that Indonesia having 12 of 69 seagrass species in the world. Seagrass grows on various types of substrates such as sand, muddy sand, mud, and gravel (Kawaroe et al 2016). Based on data validated from The Indonesian Institute of Sciences (LIPI), Indonesia has 25.742 hectare of seagrass spread across 29 locations. One of them is on the west coast of North Sumatera. Studies on the seagrass ecosystem on Poncan Island have been widely reported, but studies on its diversity are still very limited. Poncan Island is a tourism site surrounded by a seagrass ecosystem. It is feared that the high human activity in this area will have an impact on the existing seagrass ecosystem

(Ambo-Rappe 2014; Kaewsrikhaw & Prathep 2014; Rustam et al 2014; Prarikeslan et al 2019).

Damage to the seagrass ecosystem continues to occur throughout the world, including Indonesia. In several areas, it was reported that the damage to seagrass was caused by human activities such as recreation, port activities, farming, and sand mining. According to Waycott et al (2009), it is estimated that the area of seagrass ecosystem in the world decreased by 58% at the time of study. Meanwhile, in Indonesia, the decline in seagrass area has reached 30 to 40% (Vo et al 2013). This damage continues to occur due to increasing human activity. Safeguards must be conducted to prevent wider damage through in-depth studies of seagrass diversity in Poncan Island. This study aims to describe the conditions of seagrass cover, and the structure of the seagrass species composition, which could later be useful for tourism management policies in Poncan Island.

Material and Method

Description of the studysites. This study was conducted from January to April 2019, around Poncan Gadang Island, Sibolga, Indonesia. Observations were focused on points located around Poncan Island. 4 sampling points were selected. Sampling points 1 and 2 were in the ecotourism area of Poncan Island, sampling point 3 was in the port of Poncan Island, and sampling point 4 was in an uninhabited area.

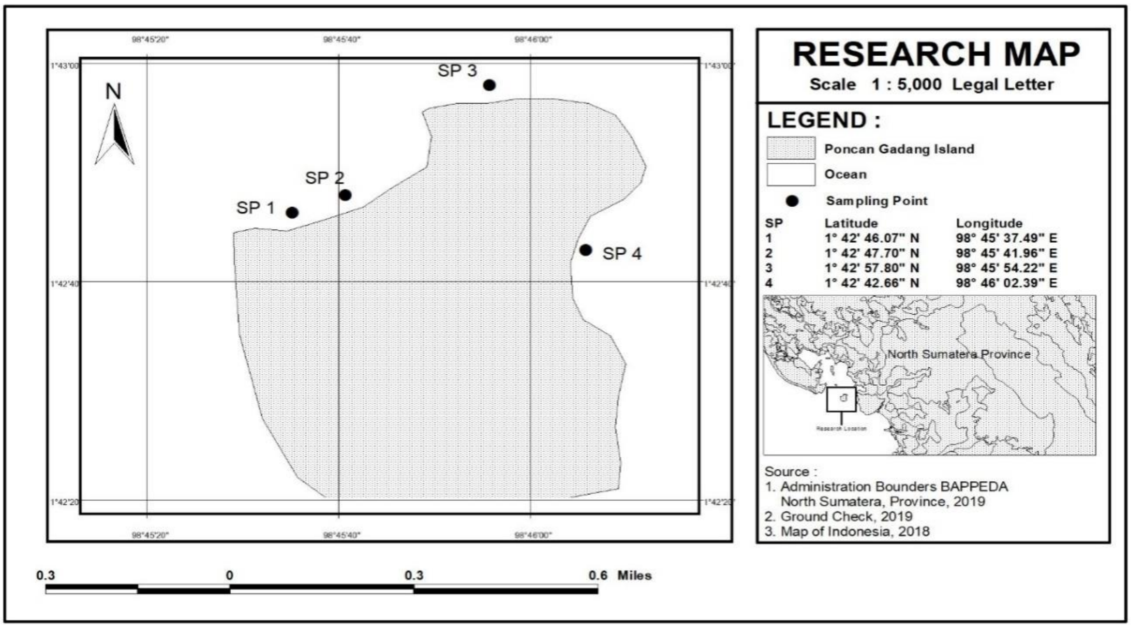

Figure 1. The location of observations in Poncan Gadang island, Sibolga, Indonesia.

Sampling methods. Sampling was carried out by direct observation method, which was conducted during low tide, to avoid currents and waves. The observation quadrant using the quadratic transect method had a size of 1x1 m^2 (Figure 2). The points of placement of the transect from the coastline were as far as 5 m to the sea. Furthermore, the sampling process was carried out 5 times (Machrizal et al 2019).

The Index of Diversity (H'). It mathematically describes population diversity to facilitate the analysis of the number of individuals from each type in a community. The Diversity index (H') can be calculated using the Shannon-Wiener equation (Krebs 1978):

$$H' = -\sum_{i=1}^{s}\left(pi \ln\ pi\right)$$

Where: H′ - Shannon-Wiener diversity index; S -the number of species; Pi - the number of individuals from each type (i=1,2,3, …, n). A value of H′<2.302 shows a low diversity; H′ between 2.302 and 6.907 shows a moderate diversity and H′ higher than 6.907 shows a high diversity.

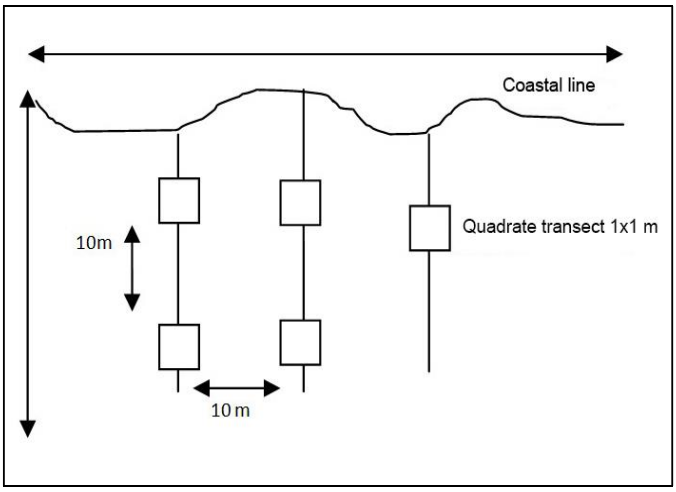

Figure 2. Sampling design (Machrizal et al 2019).

The Index of Similarity (IS). IS is used to find similarities between species that are in different locations. IS can be calculated using the following formula (Michael 1984):

IS = [2c/(a+b)]x100

Where: a - the number of species at location a; b - the number of species at the location b; c - the number of the same species in locations a and b. If IS is higher than 75%, it shows a high similarity; if it is between 50 and 75%, it shows similarity between the number of species; if it is between 25 and 50%, it shows that the number of species is not similar in the 2 locations; and, if the IS value is lower than 25%, the number is highly not similar.

Dominance Index (C). The Dominance Index is used to obtain information about the dominating species in a community. The formula for calculating this index is as follows (Odum 1993):

$$C = \sum_{i=1}^{S} \left(\frac{ni}{N} \right)^2$$

Where: C - dominance index; Ni - the number of each species (the number of i-th individuals); N - total number of all species (total number of individuals found). Values of dominance index range from 0 to 1. The value of 1 indicates that the dominance of a species is very high (there is only one species at one station). The value of 0 indicates that none of the found species dominates the area.

Seagrass density. Species density for seagrass is represented by the number of seagrass individual (stands) per unit area. Seagrass density can be calculated by using the formula proposed by Brower (1990):

Di = ni/A

Where: Di - density of species (indm^{-2}); ni - total number of stands of i-th species; A - area of the observation plot.

The composition of seagrass species. The percentage of species composition is the percentage of the number of individuals from a species of seagrass towards the total number of individuals. According to Brower (1990), the formula that can be used is as follows:

$$P = (Ni/N)x100$$

Where: P- percentage of each seagrass species (%); Ni - the number of each species i; N - total number of all species.

Seagrass cover. The percentage of seagrass cover can be calculated using Saito and Atobe's method, as follows (English et al 1997):

$$C = \Sigma Ci/N$$

Where: C - percentage of seagrass cover at each location; Ci - percentage of seagrass cover on each transect plot; N - the number of transect plots in each substation. The criteria for seagrass conditions based on the percentage of seagrass cover are: if C is higher than 75%, the condition is very good; if C is between 50 and 57%, the condition is good; if C is between 25 and 49%, the condition is moderate; and if C is lower than 25%, the condition is bad.

Results and Discussion

The diversity of seagrass species. The results showed 5 species of seagrass from 2 genera that live in the waters of Poncan Gadang Island, Indonesia: *Enhalusa coroides* and *Halophila ovalis*, from the genus *Hydrocaritaceae* and *Cymodocea rotundata*, *Cymodocea serrulata,* and *Halodule pinifolia* from the genus *Potamogetonaceae* (Table 1). The same results were also obtained by Machrizal et al (2019). They found 2 families with 4 species of seagrass that live in the coastal waters of Christmas Island. Furthermore, Kawaroe et al (2016) reported 2 families with 10 species spread over 3 ecoregions in Indonesia. The findings of this study were analyzed to obtain the values of diversity and dominance indices (Table 2), and the similarity index (Table 3).

Table 1

Types of seagrass found in the research location

Family/Species	*Locations*			
	1	*2*	*3*	*4*
*Hydrocaritaceae				
Enhalusa coroides	+	+	+	+
Halophila ovalis	+	+	+	+
*Potamogetonaceae				
Cymodocea rotundata	+	+	+	+
Cymodocea serrulata	-	+	-	+
Halodule pinifolia	+	+	+	+

Note: (*) - family; (+) - found; (-) - not found.

The Diversity Index (H') value ranges from 1.22 to 1.59. This means that the condition of seagrass diversity in the waters of Poncan Gadang Island is in a low category. The area with the lowest H' value is in sampling point 3, with 1.22. This is because this location is an area with a tourist boat port. Therefore, the life of seagrass is disrupted by the activity of ship traffic. Meanwhile, sampling points 1 and 2 are the ecotourism areas of Poncan Island, widely used for various tourism activities, so that much waste can be found at these locations. The wastes disrupt the photosynthesis of seagrass, eventually damaging the seagrass ecosystem. This is in line with the results of Kawaroe et al (2008) and Rustam et al (2014), where damage to seagrass ecosystems is mostly caused by ongoing human activities. The area with the highest H' value is sampling point 4, with 1.59. This is because this location is an uninhabited area and is not a tourism area. Therefore, human activity is not so preponderant in this area. The IS shows 100% similarity at all sampling locations. This is due to the similarity of substrate characteristics and conditions of the physical and chemical factors of the waters, which tend to be the same.

Table 2

Diversity and dominance indexes in the research location

Index	*Location*			
	1	*2*	*3*	*4*
H' (Diversity)	1.26	1.52	1.22	1.59
C' (Dominance)	0.0017	0.0016	0.0011	0.0018

Table 3

Similarity Index

Location	*Similarity Index Value (%)*			
	1st	*2nd*	*3rd*	*4th*
1st	-	-	-	-
2nd	88.89	-	-	-
3rd	100	88.89	-	-
4th	88.89	100	88.89	-

The Dominance Index (C') of all sampling locations tends to be close to zero (0). This indicates that no species dominates. We can find all of these species in almost all areas of Indonesian waters. According to Short et al (2007), *C. rotundata* can be found in almost all Indo-Pacific waters. Furthermore, according to Sangaji (1994), Bengen (2001), and Dahuri (2003), *E. acoroides* is a seagrass that can live in turbid waters with mud substrates and form single vegetation.

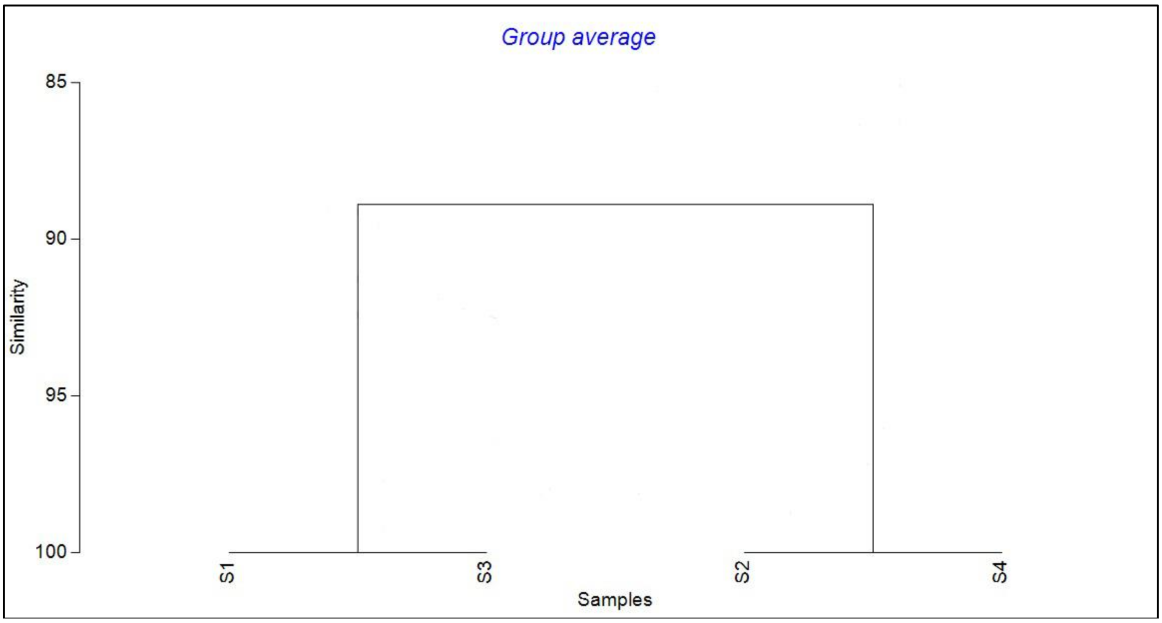

Figure 3. The dendrogram of Similarity Index (S shows the sampling point).

The density of seagrass species. The density of identified seagrass species was different in each sampling location (Figure 4). The difference in density of these seagrass species can be caused by various factors including temperature, salinity, brightness, pH, dissolved oxygen, current velocity, basic substrate, and nutrient availability. In addition, other factors such as physiology and metabolism also affect the density of seagrass species (Koch et al 2007; Kiswara 2010; Kilminster et al 2014; Garrote-Moreno et al 2014; Kaldy et al 2015; Papathanasiou et al 2015; Machrizal et al 2019).

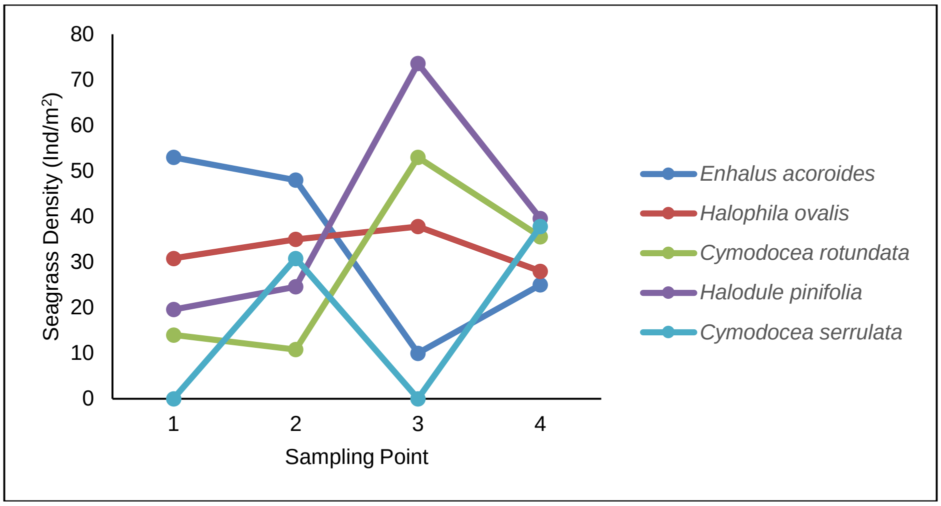

Figure 4. Seagrass density at each sampling location.

Seagrass species composition and cover (%). The composition of seagrass species that grow in each sampling location is different. There are 4 constituent species at sampling points 1 and 3. Meanwhile, at points 2 and 4, there are 5 species. Species *C. serrulata* is the differentiator between them. At sampling points 1 and 2, *E. acoroides* is the most abundant species with a percentage of more than 45% (Figure 5). Meanwhile, at sampling points 3 and 4, *H. pinifolia* is the species most abundant, with a percentage of more than 40%. The composition of seagrass species is closely related to density and dominance. This difference can be caused by the physical and chemical conditions of the waters and anthropogenic activities. According to Ambo-Rappe (2014), if an area of the seagrass ecosystem is too close to land, it will be more likely to receive negative effects from human activities.

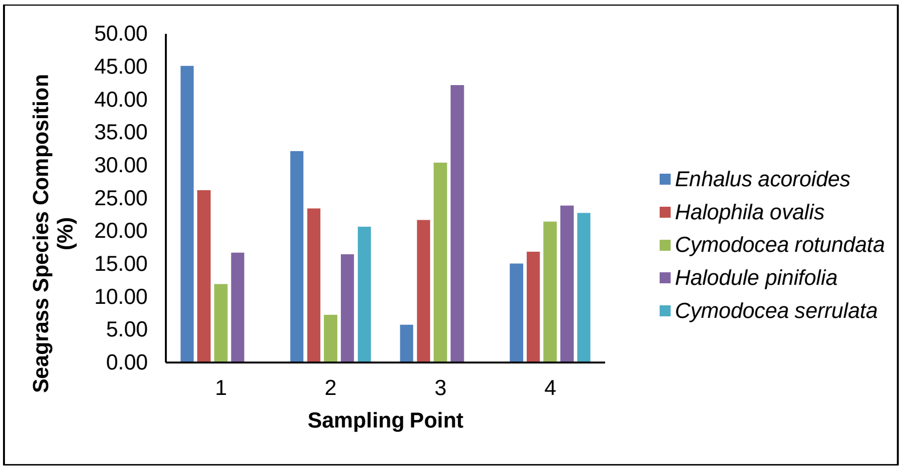

Figure 5. Composition of seagrass species at each sampling location.

The percentage of seagrass cover can be interpreted as the condition of a seagrass ecosystem at a certain location and time (Machrizal et al 2019). The results of this study show the difference in the percentage of seagrass cover at each sampling point. The percentage of seagrass cover is in the range of 75.2–88.8%. The lowest percentage of seagrass cover was at sampling point 2, while the highest was at sampling point 4 (91%) (Figure 6). The condition of the seagrass cover is better when compared to the condition of the seagrass cover in the waters of Christmas Island, which is in the range of 55.6–89% (Machrizal et al 2019).

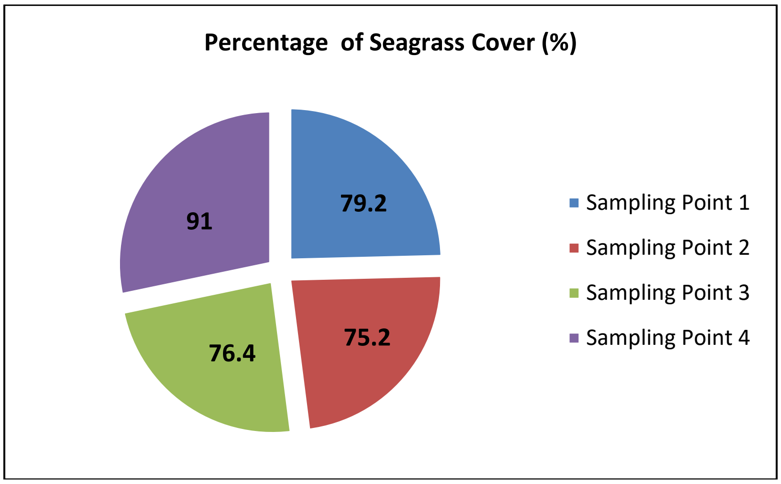

Figure 6. Percentage of seagrass cover at each sampling location.

Conclusions. The condition of the seagrass ecosystem at Poncan Gadang Island is very good, with a percentage of seagrass cover of more than 75%. This seagrass ecosystem is composed of 5 species with a low diversity index (H'): *E. acoroides*, *H. ovalis*, *C. rotundata*, *C. serrulata*, and *H. pinifolia.*

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

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