Community Structure of Seagrass in Harapan Island, Seribu Islands, Indonesia

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Abstract

Seagrass is an aquatic biota that is ecologically and economically beneficial. This study aims to determine the community structure of seagrass in Harapan Island, Seribu Islands, Indonesia. The research was conducted using purposive sampling method, that divided into two sites which is considered to represent the ecology’s condition of Harapan Island. The site 1 was located adjacent to the mangroves area, while the site 2 was placed near a reclamation development and ship anchoring. Every site had three subsites as replications, each was 50 meters apart. Water parameters temperature, salinity, turbidity, pH, dissolved oxygen (DO), depth, and organic compound of each site were measured. The results showed that coverage of seagrass in site 2 is higher than site 1 that categorized as frequent-common coverage. The site 2 had the density of 220 individuals seagrass per square meter that dominated by Cymodocea rotundata. The highest diversity index was found in the site 1 at 1.15, with the lowest dominance index being 0.39. The distribution pattern in site 1 is clustered and uniform, while site 2 is uniform. The Importance Value Index in site 1 was 114.8 by Halodule uninervis, while site 2 was 125.5 by C. rotundata. It is thought that the low diversity of seagrass at the site 2 due to it was near a reclamation development and ship anchoring that disturb the abundance and community structure of seagrass in Harapan Island. Habitat destruction and anthropogenic impact of seagrass need to be minimized to support environmental coastal and fisheries sustainability.

Keywords: coverage, density, diversity, Harapan Island, seagrass

Introduction

Seagrass is a flowering plant that is an essential part of aquatic food webs, helps to mitigate climate change, and supports biodiversity (Irawan et al., 2018; Unsworth et al., 2019). Seagrass support biodiversity by providing food for herbivores, grazers, and predators (Hartati et al., 2017; Scott et al., 2018). Seagrass has high productivity that reach 6825 g cm⁻² y⁻¹ (McRoy and McMillan, 1977). Van Dam et al. (2020) found that seagrasses can exchange water and carbon dioxide in shallow tropical and subtropical waters much better than other submerged vegetation.

Seagrass can be found in shallow oceanic coastlines worldwide, except Antarctica (Pham et al., 2016). The Tropical-Indo Pacific Zone has the highest seagrass diversity globally, with 24 species in shallow to deep waters (Short et al., 2007). According to Yaakub et al. (2018), seagrass are typically found in relatively shallow waters, covered beaches, and throughout extensive estuaries in Southeast Asia, including Indonesia. The pattern of decline in seagrass ecosystems has accelerated globally due to the growth of human population and climate changes that put environmental pressures on coastal areas (Short et al., 2007; Evans et al. 2018; Sugianti and Mujiyanto, 2020). Eventhough seagrass population is also affected by natural disturbance (Ahmad-Kamil et al. 2013). Environmental factors play a critical role in determining the location and growth of seagrasses (Yaakub et al., 2018). McCluskey and Unsworth (2015) explained that the loss of seagrass was caused by physical disturbances, which in turn caused habitat degradation. According to the Oceanographic Research Center (P2O) of the Indonesian Institute of Sciences (LIPI), there are 15 types of seagrass found in Indonesia, but only nine of them are easy to observe (LIPI, 2016). At the same time, most seagrass fields in Indonesia are within unhealthy conditions. Of the 37 locations sampled, 27 were less healthy, five were not healthy, and the remaining were in good conditions.

Seagrass fields can be found in most of the island’s waters within the Kepulauan Seribu National
Park (TNKpS) area, such as Pramuka Island, Panggang Kelapa Island, and Harapan Island. Research on seagrass in Pramuka Island found seven seagrass species that are part of the family Potamogetonaceae and Hydrocharitaceae (Haviarini et al., 2019). The continued pressure leads to ecosystem decline, decreased seagrass conditions, and diminishing seagrass' ecosystem function (Unsworth et al., 2019). Therefore, monitoring the seagrass ecosystem from the impact of ecosystem changes that happened in Kepulauan Seribu is needed. This study aims to determine the structure of seagrass communities including coverage, species composition, density, diversity and dominancy, distribution pattern, and important value index in Harapan Island, Kepulauan Seribu.

Materials and Methods

The study sites were selected using the purposive sampling method, that divided into two sites which is considered to represent the ecology’s condition of Harapan Island. The site 1 was located adjacent to the mangroves area, while the site 2 was placed near a reclamation development and ship anchoring. See Figure 1.

Every site has three subsites as replications, each was 50 meters apart. The transects was stretched perpendicular to the coastline along 100 meters which was divided into 10 observation plots (0.5 m x 0.5 m) that performed at the lowest low tide. Seagrass data was taken once at the beginning of data retrieval performed at each plot in two sites and six subsites, i.e., the number of stands of each type.

Coverage of seagrass is determined using this formula by Rahmawati et al. (2014). The coverage of seagrass then categorized by Rahmawati et al. (2014) where: 0%-25% is rare; 26%-50% is frequent; 51%-75% is common; 76%-100% is abundance.

Seagrass samples in each plots were taken and put into plastic bags that have been labeled as markers for identification and documentation. Seagrass was identified by the book "Seagrass Monitoring Guide" by Rahmawati et al. (2014).

Seagrass density ($Di$) is the number of seagrass individuals per unit area. The density of each type at each site is calculated using a formula (Brower et al., 1998):

$$Di = \frac{n_i}{A} \text{ (ind/ha)}$$

Note: $Di$= the number of individuals (stands) seagrass $i$ per unit area; $n_i$= the number of individuals (stands) seagrass $i$ in the squared transect; $A$= the area of the quadratic transect.

Figure 1. Seagrass study sites in Harapan Island, Seribu Islands
The Abundance of Gonyaulax polygramma and Chaetoceros sp. (I. Kesaulya et al.)

Calculation of seagrass species diversity index using Shannon-Wiener diversity formula (Brower et al., 1998):

\[ H' = - \sum_{i=1}^{n} P_i \times \log P_i \]

Note: \( H' \) = Diversity Index; \( P_i = N_i / N \); \( N_i \) = number of individuals (stands) seagrass \( i \) in the squared transect; \( N \) = number of individuals of all species. The diversity index then categorized following this criteria: \( H' < 1 \) = low diversity; \( 1 \leq H' \leq 3 \) = moderate diversity; \( H' > 3 \) = high diversity.

The dominance index formula is used to determine whether or not a particular type is dominant following Simpson Index of Dominance (Brower et al., 1998):

\[ D = (\Sigma P_i)^2 \]

Note: \( D \) = Dominance Index; \( P_i = N_i / N \); \( N_i \) = number of individuals (stands) seagrass \( i \) in the squared transect; \( N \) = Total number of individuals of all species. The diversity index then categorized following this criteria: \( D < 0.4 \) = low dominancy; \( 0.4 \leq H' \leq 0.6 \) moderate dominancy; \( D > 0.6 \) high dominancy.

The distribution pattern of seagrass is determined by calculating Morisita Dispersion Index (Brower et al. 1998) with the equation:

\[ Id = \frac{n (\sum_{i=1}^{x} x_i^2 - N)}{N (N - 1)} \]

Note: \( Id \) = Morisita Dispersion Index; \( n \) = the number of sample plots; \( N \) = the number of individuals in \( n \) plots; \( x \) = the number of individuals on each plot. The seagrass dispersion pattern is determined by Morisita Index which using the following criteria (Brower et al., 1998):

\( Id < 1 \) = uniform dispersion pattern; \( Id = 1 \) = random dispersion pattern; \( Id > 1 \) = cluster dispersion pattern.

Environmental parameters of the observed waters include water temperature, salinity, brightness, depth, and organic matter were observed in both locations.

**Result and Discussion**

**Percent coverage of seagrass**

Coverage of seagrass in the site 2 is higher than in the site 1. The average of percentage coverage of seagrass in site 2 is 45,83%, while site 1 is 26,46%. Coverage of seagrass in the site 1 based on Rahmawati et al. (2014) is categorized as frequent coverage. While the site 2 is categorized as frequent-common coverage. Based on Decree of Indonesian Minister of Environment No 200 in 2004, site 1 is categorized as unhealthy, while site 2 is less healthy (Figure 3).

Site 2 has higher seagrass coverage but lower of diversity than site 1. The higher coverage of seagrass in site 2 was dominated by C. rotundata which has high tolerance to environmental pressure. The lower diversity in site 2 presumably because it is affected by reclamation and ship anchoring, which led to the destruction of the seagrass habitat... Physical disruption to seagrass ecosystems can trigger seagrass fragmentation or fracture, decrease in density, height, seagrass cover, and potentially eliminate biota habitats therein (McCloskey and Unsworth, 2015). Meanwhile Ahmad-Kamil et al.
(2013) stated that percentage cover of seagrass also affected by weather as natural disturbances. However, this study also showed that certain types of seagrass species have a high tolerance to environmental pressures that occur in the presence of high of organic compound in site 2. It is also evidenced by the higher dominance index at site 2 is due to C. rotundata domination which is resistance to polluted water conditions. But different result reported by Aboud and Kannah (2017) that unprotected area had higher seagrass coverage than protected area because of predation and grazer activities in protected area.

**Seagrass species composition**

Five seagrass species were discovered in site 1, i.e., Cymodocea rotundata, Cymodocea serrulate, Halodule uninervis, Syringodium isoetifolium, and Thalassia hemprichii, which belong to Cymodoceaceae and Hydrocharitaceae families. In comparison, there were three species found in site 2, i.e., C. rotundata, H. uninervis, and T. hemprichii (Table 1).

All of those seagrasses in both sites are classified into the Alismatales order. The Hydrocharitaceae family was also found on Pramuka Island, Kepulauan Seribu (Haviarini et al. 2019). Both islands have almost the same aquatic conditions and match the seagrass habitat of this family. Genus of Cymodocea, Thalassia and Halodule were found in both 2 sites, while Genus of Syringodium were found only in site 1. Therefore, site 1 has a more supportive environment for the existence of various seagrass than at site 2.

**Density, diversity, and dominancy index of seagrass**

The highest density of seagrass at site 1 is H. uninervis. The highest density of seagrass at site 2 is C. rotundata, meanwhile the density of C. rotundata in site 1 were very low (Figure 4.). This is showed that C. rotundata grow dominantly in site 2 than other species.

The average diversity index and dominancy index in Harapan Island are 1.03 and 0.43, and both are within a moderate level, respectively (Figure 5). Site 1 has higher diversity index than site 2 because site 1 consist of 5 different species of seagrass, while site 2 only has 3 different species.

H. uninervis is mostly found in site 1 with sand and coral rubble, which agrees with the studies by Short et al., (2007) and Haviarini et al., (2019). Halodule inhabit in shallow water with little salinity fluctuation (Copertino et al. 2016). Site 2 is an intertidal zone with a relatively narrow tidal area, and the construction of concrete walls and reclamation also narrowed the tidal zone at this study site. This zone is heavily overgrown by C. rotundata.

According to Haviarini et al. (2019), C. rotundata has a habitat preference in intertidal zones with a narrow area between the highest and lowest tidal areas. T. hemprichii is found in both sites, and this indicates that T. hemprichii matches the environmental conditions. Fitrian et al. (2017) state that T. hemprichii has a wide range of water conditions tolerance and can live on various substrates. However, Tupan and Uneputty (2018)

![Figure 3. Coverage of seagrass in two study sites in Harapan Island](image-url)
state that this seagrass type tends to thrive in sandy substrates rather than muddy substrates, and predominantly grows in substrate waters of coral shards (Short et al., 2007).

**Important Value Index of seagrass**

Seagrass species found on Harapan Island have different indices of important values. See Table 2. Species of *H. uninervis* has the highest IVI rating at site 1 (114.8%) but the lowest at the site 2 (30.53%). It is inversely proportional to *C. rotundata*, which has the lowest IVI at site 1 (0.32%), and the highest at site 2 (125.2%). It seemed that the presence and role of each seagrass species is depend on the environment condition. *H. uninervis* species has the most considerable role in the seagrass community at the site 1, while the *C. rotundata* species has the largest role in the site 2. This species can survive well under the conditions of site 1, but not at the second site because of the environmental condition. *C. rotundata* has good adaptability that can live and grow in polluted conditions (site 2) due to its adaptability. The low IVI value of *C. rotundata* at the first site is likely due to the scramble for food between seagrass species in a community that has been pre-dominated by *H. uninervis*. Furthermore, Rasheed et al. (2014) revealed that *Halophilla* spp. that inhabits in deep water has good capacity to recover from disturbance or damage.

**Distribution pattern of seagrass**

Distribution pattern of seagrass in Harapan Island are presented in Table 3. The distribution pattern of *C. rotundata* and *T. hemprichii* at both sites are uniform, except for the *Halodule uninervis* that found clustered at site 1 and uniformly distributed at site 2. Uniform pattern distribution in site 2 showed that the species grow dominantly, and the site has low diversity. It also indicates that the water conditions at site 2 are disrupted and less supportive for seagrass. Seagrass's ability to colonize surrounding habitats is influenced by tolerance and variability to its abiotic environment (Kilminster et al., 2015).
Table 2. The average of Important Value Index of seagrass in Harapan Island

| Species of Seagrass | RF (%) | RD (%) | IVI |
|---------------------|--------|--------|-----|
| Site 1 | Site 2 | Site 1 | Site 2 | Site 1 | Site 2 |
| C. rotundata | 0.32  | 62.6  | 0.32  | 62.6  | 0.64  | 125.2 |
| C. serrulate | 9.3   | -     | 9.3   | -     | 18.6  | -     |
| H. uninervis | 57.4  | 15.27 | 57.4  | 15.27 | 114.8 | 30.53 |
| S. isoetifolium | 13.73 | -     | 13.73 | -     | 27.46 | -     |
| T. hemprichii | 19.24 | 22.12 | 19.24 | 22.12 | 38.5  | 44.25 |
| Total | 100  | 100  | 100  | 100  | 200  | 200  |

Description: RF (Relative frequency); RD (Relative density); IVI (Important Value Index)

Table 3. Distribution pattern of seagrass in two study sites in Harapan Island

| Species of Seagrass | Morisita Index | Description |
|---------------------|----------------|-------------|
| Site 1 | Site 2 | Site 1 | Site 2 |
| C. rotundata | -3  | 0.87  | Uniform | Uniform |
| C. serrulate | 1.56  | -     | Clustered | -     |
| H. uninervis | 1.48  | 0.48  | Clustered | Uniform |
| S. isoetifolium | 1.14  | -     | Clustered | -     |
| T. hemprichii | 0.46  | -0.03 | Uniform | Uniform |

Figure 5. The average of diversity and dominancy index of seagrass in Harapan Island

Water quality parameter

Water quality parameter in Harapan Island during research are presented in Table 4. Water parameter in site 1 was higher in temperature with lower depth than it was in site 2. Dissolved oxygen in site 1 was also higher than site 2. It might because site 2 had higher organic compound than site 1. Therefore the water parameter in site 1 was better than site 2.

Natural and anthropogenic disturbance affect the seagrass ecosystem. The measured water temperature at site 1 and 2 are within the optimal temperature of seagrass. Temperatures above 40°C will decrease growth and may even result in seagrass deaths (Collier and Waycott, 2014). Because rising of temperature and exposure desiccation impact on declination of photosynthetic rate (Aboud and Kannah 2017). The measured salinity and pH at both sites is relatively low because of rainy season which caused lower salinity and pH. Refer to Copertino et al. (2016), the changes in salinity affect in physiological stress, while acidification affect on photosynthetic response. The turbidity also good because it clear to the bottom. Meanwhile, Ahmad-Kamil et al. (2013) stated that turbidity correlated significantly to seagrass percentage cover. High turbidity increased sedimentation that covering the seagrass affected on its photosynthesis ability (Soe-Htun et al. 2017).
Grech et al. (2011) describe that anthropogenic activities and their effects on seagrass are caused by waste produced by agriculture, domestic, industrial, and development of settlements and ports in coastal areas. The water conditions at the site 1 tend to be optimal for seagrass since reclamation or construction of residential foundations is not observed. Instead, the mangroves could be found on the north side of site 1, close to the beach. Meanwhile, no vegetation was found around the site 2. Furthermore, reclamation and ships anchoring at the second site causing damage to seagrass habitat. Evans et al. (2018) stated that the Seagrass damage can be more severe because of human activities e.g. boating, dredging, dumping, bottom trawling, hazardous wastes pollution, tourism, reclamation (Soe-Htun et al. 2017; Evans et al. 2018; Karlina et al. 2018; Riniatsih et al. 2021). In site 2 also has higher organic compound than site 1, that might be caused site 2 is nearer from residential area therefore produced more household waste and nutrient load which contain nitrogen and phosphorus. Meanwhile, Joseph et al. (2018) reported that the high of nitrate impacts on decreasing of seagrass coverage and growth.

Low diversity in the site 2 is also affected by the pollution since the waters at this site are dominated by the waste in the form of foam and moss floating on the water surface, thus blocking sunlight from entering the water, disrupting the light source for photosynthesis. Collier et al. (2012) state that light penetration affects seagrass abundance and diversity. However, seagrass growth is also limited by nutrient supply and temperature to carry out photosynthesis (Collier et al., 2012). The widespread anthropogenic impacts threaten seagrass habitats and change the balance of ecosystems in coastal areas (Yaakub et al., 2018). Increased degradation of seagrass ecosystems will increase habitat fragmentation (Ricart et al., 2015). Recovery of seagrass ecosystem conditions from damage is affected by the species type and habitat location of the species (Rasheed et al., 2014).

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