Eco. Env. & Cons. 27 (2) : 2021; pp. (847-854)
Copyright@ EM International
ISSN 0971–765X

Identification of seagrass types to support coastal resilience at Kondang Buntung Beach, Indonesia

Andik Isdianto[1, 2], Oktiyas Muzaky Luthfi[1, 2], Muchamad Fairuz Haykal[1], Nuddin Harahab[3], Andi Kurniawan[4], Agus Dwi Wicaksono[5], Supriyadi[6], Trisnadi W.C. Putranto[7]* and Agoes Soegianto[7]

[1]Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, University of Brawijaya, Jalan Veteran, Malang, Indonesia 65145
[2]Coastal Resilience and Climate Change Adaptation (CORECT) Research Group, Universitas Brawijaya, Jalan Veteran, Malang, Indonesia 65145
[3]Department of Socio-Economy Fisheries and Marine, Faculty of Fisheries and Marine Sciences, University of Brawijaya, Jalan Veteran, Malang, Indonesia 65145
[4]Department of Aquatic Resource Management, Faculty of Fisheries and Marine Sciences, University of Brawijaya, Jalan Veteran, Malang, Indonesia 65145
[5]Department of Regional and City Planning, Faculty of Engineering University of Brawijaya, Jalan Veteran, Malang, Indonesia 65145
[6]Department of Maritime Security, Faculty of National Security, Indonesia Defense University, IPSC Sentul, Bogor, Indonesia 16810
[7]Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia 60115

(Received 30 August, 2020; Accepted 29 October, 2020)

ABSTRACT

Seagrass is a flowering plant (Angiosperms), one seed (monocot) which has leaves, flowers, fruit, roots and rhizomes (rhizomes). Seagrass is a plant that lives and grows in relatively shallow waters (1 - 10 meters), has a mud or sand bottom. Seagrass is a plant that lives in groups, groups of seagrass are called seagrass beds. Seagrass beds are ecosystems that can maintain the balance of the aquatic ecosystem. Seagrass ecosystems have several ecological benefits, such as being a food source for aquatic biota, stabilizing substrate, primary producers of sediment trapping, and protecting marine organisms. Collecting seagrass data in the field includes identification of seagrass species, calculating the percentage of cover of each species on quadrant transects measuring 1 X 1 m^2, and calculating the density of the number of individuals / stands. The type of seagrass found on Kondang Buntung Beach is *Halodule uninervis*. With seagrass density values ranging from 590 - 740 stands / m^2. As well, the percentage of seagrass cover ranges from 18-19%. The seagrass ecosystem is one of the ecosystems that can support the resilience of coastal ecosystems, because the seagrass ecosystem has high biodiversity that can support the survival of biota and its surrounding ecosystem.

Key words : *Seagrass, Percentage Cover, Density, Kondang Buntung*

Introduction

Coastal resilience is one part of regional resilience, which aims to guarantee coastal safety from the emergence of coastal environmental hazards caused by natural and anthropogenic factors. Coastal resilience must be a shared responsibility of all levels of society in an area resilience, both stakeholders, the private sector, and the community in a coastal resilience area (Irma *et al.,* 2018).

Seagrass is a flowering plant (Angiosperm) which usually lives and grows in relatively shallow waters (1 - 10 meters), and generally has a water bed composed of mud or sand (Azkab, 1999). Seagrass is a single seed plant (monocot) which has leaves, flowers, fruit, roots and rhizomes (rhizomes) just like plants in the sea (Tomlinson, 1974). There are about 50 types of seagrass consisting of two tribes (families), namely the Potamogetonacea tribe (9 genera, 35 species) and the Hydrochoraticea tribe (3 genera, 15 species). Of these 50 species, there are 12 types of seagrass that can be found in Indonesia. The types are Syringodium isoetifolium, Halodule uninervis, Halodule pinifolia, Halophila decipiens, Halophila ovalis, Halophila spinulosa, Halophila minor, Cymodocea serrulata, Cymodocea rotundata, Thalassodendron, Enhalus acoroides, and Thalassiahempii (Den Hartog, 1970).

Morphologically, seagrass plants have rhizomes, which are stems that are buried by the substrate, and spread horizontally, and have books. On these books grow short stems that are upright, and there are flowers and leaves. Seagrass has thin leaves that are elongated like ribbons and have water channels (Nybakken, 1992). These leaves can absorb nutrients directly from the surrounding waters. Seagrass leaves also have a cavity that functions as a floating device, which aims to make the individual stand upright in the water column (Hutomo, 1997). This leaf shape can maximize gas diffusion and nutrient content between leaves and water, and also maximize the photosynthesis process on the leaf surface (Phillips and Menez, 1988).

Seagrass beds are ecosystems that can maintain the balance of the ecosystem in the waters (Dahuri *et al.*, 1996). Seagrass beds have high primary productivity and have the ability to reduce the strength of currents and waves which are useful for aquatic organisms, both as a spawning ground, a place for juvenile rearing (nursery ground), and a place to find food (feeding ground) (Danovaro *et al.,* 2002).

The seagrass ecosystem is an ecosystem in shallow seas that has an important role for marine biota (Minerva *et al.,* 2014). The seagrass ecosystem is one of the marine ecosystems that can support high potential resources. According to Nontji (1993), seagrass usually lives in shallow, sandy waters and is often found near coral reefs. Seagrass generally forms broad fields on the seabed that are still covered by sunlight to support its growth. Water depth, tidal influence along with substrate structure can affect the distribution zone of seagrass and its growth form (Nugraha and Rudi, 2015). Sediment formation or sedimentation can also affect the condition of the substrate in the seagrass ecosystem (Supriyadi *et al.,* 2017).

Seagrass is a type of organism that lives in groups, either with the same species or with different species. Seagrasses that live in groups with the same species form homogeneous seagrass beds, while different species will form heterogeneous seagrass beds (Sukandar and Dewi, 2017). The seagrass ecosystem has an ecological function as a nutrient recycler, sediment catcher, primary producer, substrate stabilizer, habitat and food source as well as a place to protect marine organisms. When the density of seagrass beds is higher in waters, the abundance of organisms in the ecosystem will increase (Hartati *et al.*, 2012).

Seagrass can usually grow in the waters of tropical and subtropical areas, where the form of its exposure and the factors controlling its growth are not known with certainty. Until now, it is not known when and where these factors can affect seagrass growth (Tangke, 2010). Indonesia's seagrass area is 3 million hectares. Along with the development of development, especially in coastal areas, the potential for this area will decrease. According to data from P2O-LIPI, the area of Indonesian seagrass in 2018 was 293,464 hectares, this data was obtained through remote sensing using satellite imagery. This value only describes 16% - 35% of Indonesia's seagrass area from the existing potential area (Dewi *et al.,* 2020).

The purpose of this study was to determine the types of seagrass species, seagrass density and the percentage of seagrass cover found at Kondang Buntung Beach. The expected result from this research is to know and measure the influence of the seagrass ecosystem on the resilience of the coastal ecosystem in Sendang Biru waters.

Materials and Methods

Study Site

This research was conducted in the Kondang Buntung Beach, Malang Regency in July 2020. This

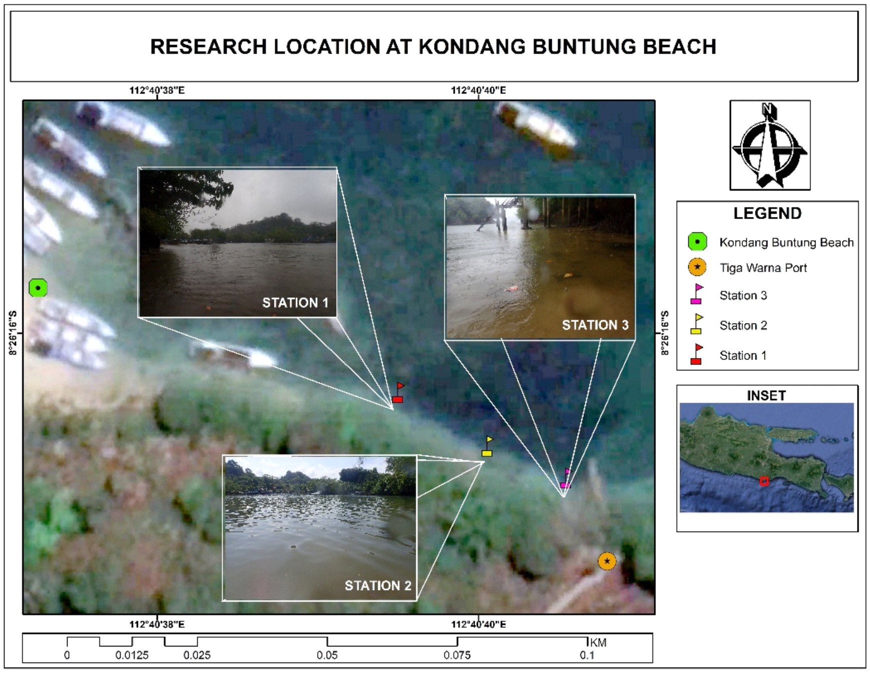


Fig. 1. Research Location

research method were carried out semi-quantitatively or exploratively at the research location. Seagrass data was collected at 3 stations, it can be seen in Figure 2.

Collecting data on seagrass observations in the field includes identification of seagrass species, calculating the percentage of cover for each species on the transect, and counting the number of individuals/stands. Seagrass cover percentages and seagrass density were observed using a quadrant transect with a size of 1 X 1 m^2 on a seagrass bed. Seagrass sampling is carried out horizontally parallel to the coastline. There are 3 sampling points starting at 0 meters, 15 meters and 30 meters along the coast.

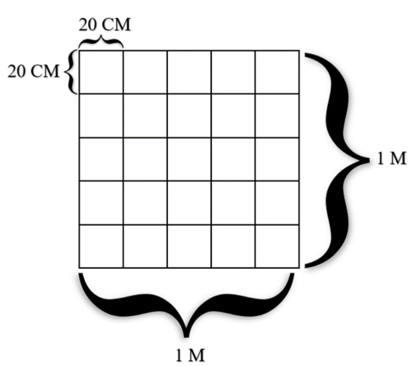


Fig. 2. Transect Quadrant

Data Collection Method

Seagrass cover percentages and seagrass density were observed using a quadrant transect measuring 1 X 1 m^2 on a seagrass bed. The transect is divided into 25 grids with a size of 20 cm^2, can be seen in Figure 3. The number of stands was observed directly by visual observation.

The calculation of seagrass cover is estimated using a standard percentage of cover in the determination by KEPMEN LH (2004). The use of this standard aims to avoid bias from qualitative or semi-

Fig. 3. Field Documentation : *Halodule uninervis*

quantitative visual observations. The percentage of seagrass cover is influenced by several factors, such as types of seagrass, density of seagrass, and distribution of seagrass.

The results of observations of seagrass data in the field visually will be observed to identify types of seagrass, density of seagrass species, and percentage of seagrass cover. The identification of seagrass species is observed based on identification standards based on the book "Status of Indonesian Seagrass Beds" Research Center for Oceanography - LIPI (2018). Measurement of seagrass density values will calculate the number of seagrass individual on a 1 X 1 m^2 transect at each station. Seagrass density was calculated by the formula of Brower, Zar and Ende (1990) :

Explanation

D : Density (ind / m^2)
Ni : Number of Stands (individual)
A : Area to be sampled (m^2)

After measuring the density of seagrass species, the results will be classified according to Brower, Zar and Ende (1990). Seagrass density scale table can be seen in Table 1.

Table 1. Seagrass Density Scale

Scale	Density (ind/m^2)	Condition
5	≥ 625	High Dense
4	425 – 624	Dense
3	225 – 424	Dense Enough
2	25 – 224	Rarely
1	< 25	Very Rarely

The Indonesian government has determined quality standards for the seagrass ecosystem, formulated in the Minister of Environment Decree no. 200 of 2004. Based on the Saito and Adobe methods, the determination of the percent cover of seagrass refers to the dominance can be seen in Table 2.

Table 2. Seagrass Cover Area Based on Presence Class

Class	Amount of Substrate Covered by Seagrass	% Seagrass Cover	% Midpoint (Mi)
5	1/2 to full	50 – 100	75
4	1/4 to 1/2	25 – 50	37.5
3	1/8 to 1/4	12,5 – 25	18.75
2	1/16 to 1/8	6,25 – 12, 5	9.38
1	< 1/16	6,25	3.13
0	Absent	0	0

After knowing the class determination, the results of the domination class observation results will be calculated the area of cover (% coverage) in every 1 X 1 meter quadrant using the Saito and Adobe methods (KEPMEN LH, 2004) :

Explanation

C : Seagrass Cover Area (%)
Mi : Class Percentage Middle Value - i
Fi : Frequency Type i
F : Frequency (Transect)

Results and Discussion

Seagrass Identification

Seagrass ecosystem is a comfortable habitat for marine organisms to live in (Rani, Budimawan and Rohani, 2010). This is because the seagrass ecosystem has high nutrients and food sources. Seagrass ecosystem is a shallow water area that still gets penetrating sunlight. The seagrass ecosystem has good water circulation, so the recycling of nutrients and oxygen goes well. This causes the metabolism of seagrass to be transported to the surrounding aquatic environment.

According to field observations, on 15 July 2020 Kondang Buntung Beach was identified 1 type of seagrass. This type is the Halodule uninervis. This type is obtained at a depth of ≤ 1 meter. Halodule uninervis has the characteristics of long flat leaves but small in size, has one clear leaf center vein, smooth rhizome with clear black leaf marks, and leaf tips like trident (Sjafrie *et al.*, 2018). Halodule uninervis is a type of seagrass that has fast growth and is a pioneering species. This species is able to grow on coarse sand substrates to coral fractures (Latuconsina, 2012). The type of seagrass Halodule uninervis is a type of seagrass that is favored by turtles, one of which is the green turtle (Roem, 2013). At Kondang Buntung Beach, the bottom of the waters is mostly composed of mud with a little sand and rocky substrate. The results of observation of seagrass identification data can be seen in Figure 4.

The Halodule uninervis has the following classification:

Kingdom : Plantae
Phylum : Trachophyta

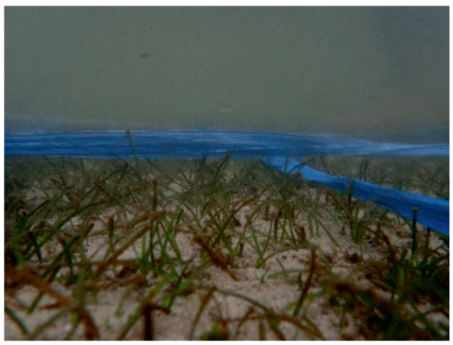
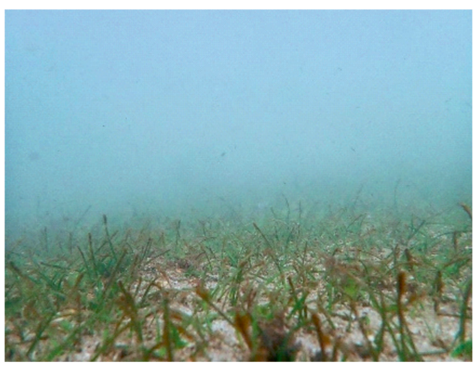
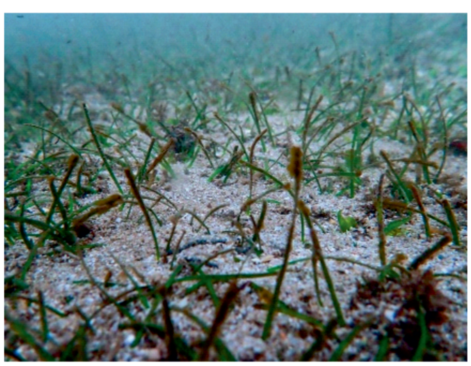
Class : Mognoliopsida
Orde : Alismatales
Famili : Cymodoceaceae
Genus : Halodule
Species : Halodule uninervis

According to Rawung, Tilaar and Rondonuwu (2018), the general characteristics of Halodule uninervis have rhizomes that are small and white in color. The uninervis halodule is characterized by no more than three leaf bones, and a leaf tip that is shaped like a trident. Halodule uninervis has an average leaf length of 37.83 mm and an average width of 2.22 mm. This species usually grows in muddy sand substrate areas.

Seagrass Ecosystem Condition

In the Table are the data from the documentation of the seagrass beds at Kondang Buntung Beach. Sta-

Table 3. Condition of Seagrass Station

Station	Documentation	Description
1	 (Field Documentation, 2020)	Station 1 is located near the cliff. Station 1 has a water bed with a sandy substrate. The density and cover of the seagrass at this station is quite tight. (Fig. 4)
2	 (Field Documentation, 2020)	Station 2 is located at the location where the ship is docked. This station has a water base with a sandy substrate. The density and cover of the seagrass at this station is very tight. (Fig. 5)
3	 (Field Documentation, 2020)	Station 3 is located near the pier, where residents can access the Tiga Warna area. At this station also has a bottom water with a sandy substrate. The density and cover of the seagrass at this station is considered less dense. This could be due to the fact that seagrass beds are often trampled or due to high anthropogenic activities. (Fig. 6)

tion 1 is located at longitude: 112 ° 40.659'E and latitude: 8 ° 26.273'S, with a position near the cliff. Station 2 is located at longitude: 112 ° 40.668'E and latitude: 8 ° 26.278'S, with a position near the dock area. Station 3 is located at longitude: 112 ° 40.676'E and latitude: 8 ° 26.281'S, with a position near the pier which is the access for residents to enter the Tiga Warna area. The following is a description of the seagrass data collection stations:

Seagrass Density

After identifying the type of seagrass, the next processing is calculating the density of the uninerv is Halodule seagrass species by counting the number of individual seagrass in each transect plot. The measurement results can be seen in the following figure :

Figure 4. Seagrass Density at Station 1

Figure 5. Seagrass Density at Station 2

Figure 6. Seagrass Density at Station 3

It can be concluded that the results of seagrass density data collection using the transect quadrant method with a size of 1 × 1 m^2 at Kondang Buntung Beach, at station 1 had an average value of 674.75 ind/m^2. The condition of the average score falls into the very tight category. Estimated condition is because station 1 is in an area that has low anthropogenic activity. So that the growth and productivity of the seagrass ecosystem at station 1 runs well. The yield average density of the 4 substations at station 2 is 739.5 ind/m^2. This density condition includes the highest density in the seagrass ecosystem of Kondang Buntung Beach. The estimation of this condition is due to the fact that station 2 has a more gentle topography and not many rocks. This topography can cause nutrient transport at this station to move faster, and also increase the productivity of seagrass species. So that the growth and development of seagrass at this station is classified as good and has a high density. At station 3, the average density value of seagrass is 598.3 ind/m^2. The seagrass density at this station falls into the tight category. However, this density is the lowest density compared to other stations. This can be due to the fact that this station is near the pier, where human or anthropogenic activities at this station are high. This can inhibit the growth of seagrass, because it is often accidentally stepped on or taken from the substrate. This activity can reduce the density and type of the seagrass ecosystem.

From the results of seagrass density data processing, at 3 stations the average density values ranged from 590 - 740 ind/m^2, referring to Table 1, it can be concluded that the density of seagrass at Kondang Buntung Beach was categorized as tight to very tight. Density is an element of community structure that can be used as an estimate of seagrass productivity (Mukai, Aioi and Ishida, 1980). Differences in seagrass density conditions are caused by several factors, namely topography, physical and chemical conditions of the waters, and anthropogenic activity in the seagrass bed area. Other factors that can also affect seagrass density are predation and biota conditions (Wahab *et al.,* 2017).

Percentage of Seagrass Cover

It can be concluded that the results of data collection on the percentage of seagrass cover using the quadrant transect method with a size of 1 × 1 m^2 at Kondang Buntung Beach, at station 1 obtained an average value of the percentage of seagrass cover of 18.721%. This average value belongs to the poor category. At station 2, the percentage of seagrass cover was obtained at 18.627%. The percentage category of seagrass cover at station 2 is in the poor category. While the percentage of seagrass cover at station 3 was 19, 345%. This average score also falls into the category of poor (Table 4).

Table 4. Seagrass Cover Status

Condition	Category	Coverage (%)
Good	Rich/Healthy	≥ 60
Fair	Fair/Healthy Enough	30 – 59.9
Damage	Poor	≤ 29.9

From the results of the average value of the percentage of seagrass cover at 3 stations ranging from 18 - 19%, referring to KEPMEN LH (2004) in Table 3, it can be concluded that the percentage value of seagrass cover at Kondang Buntung Beach is in the poor category. This can be due to the location of the seagrass ecosystem which is close to the area where the ship is docked and close to the pier. Where this area has a high level of anthropogenic activity, as well as a lack of awareness and conservative action on the existing seagrass ecosystem.

The seagrass ecosystem is one of the ecosystems that can support the resilience of coastal ecosystems, because the seagrass ecosystem has high biodiversity that can support the survival of biota and its surrounding ecosystem. According to Joseph *et al.* (2019), an ecosystem that is not given much attention, is actually a productive one. even the seagrass ecosystem is the main axis in ecological resilience. Therefore, the resilience of the seagrass ecosystem must be considered, so that the damage that occurs to the seagrass ecosystem does not affect the decline in economic value or ecological value of the coastal ecosystem (Baker *et al.*, 2015).

This study is the beginning of further research to measure the resilience of the ecosystem at Kondang Buntung Beach. So this initial identification is used as a basis for evaluating the resilience of the seagrass ecosystem at Kondang Buntung Beach.

Conclusion

This research focuses on the identification of seagrass species, seagrass density and the percentage of seagrass cover in Kondang Buntung Beach. Identified 1 type of seagrass. This type is the Halodule uninervis. This type is obtained at a depth of ≤ 1 meter. Halodule uninervis has the characteristics of long flat leaves but small in size, has a clear leaf center vein, smooth rhizome with blackened leaf marks, and trident-like leaf tips. From the results of seagrass density data processing, at 3 stations have an average density value ranging from 590 - 740 stands/m^2, referring to KEPMEN LH No. 200 th.2004 it can be concluded that the density of seagrass in Kondang Buntung Beach is classified into the tight to very tight category. From the results of the average value of the percentage of seagrass cover at 3 stations ranging from 18 - 19%, refers to the Minister of Environment Decree No. 200 (2004), it can be concluded that the percentage value of seagrass cover at Kondang Buntung Beach is in the poor category. This can be due to the location of the seagrass ecosystem which is close to the area where the ship is docked. Where this area has a high level of anthropogenic activity, as well as a lack of awareness and conservative action on the existing seagrass ecosystem.

Acknowledgement

The researcher would like to thank the Dean of the Faculty of Fisheries and Marine Sciences, Brawijaya University so that the research can be fluent. Member of CORECT (Coastal Resilience and Climate Change Adaptation - Research Group) FPIK Brawijaya University who has provided advice in creating quality research.

References

Azkab, M. H. 1999. Pedoman Inventarisasi Lamun. *Journal Oseana*. 24(1) : 1–16.

Baker, S. 2015. An Ecosystem Perpective for Food Security in the Caribbean/: Seagrass Meadows in The Turks and Caicos Islands (TCI). *Ecosystem Services*. 11(February), pp. 12–21. doi: https://doi.org/10.1016/j.ecoser.2014.07.011.

Brower, J. E., Zar, J. H. and Ende, Von, C. N. 1990. *Field and laboratory Methods for General Ecology*. Third Edit. Dubuque.

Dahuri, R. 1996. *Pengelolaan Sumberdaya Wilayah Pesisir dan Lautan Secara Terpadu*. Jakarta: PT. Pradnya Paramita.

Danovaro, R., Gambi, C. and Mirto, S. 2002. Meiofaunal Production and Energy Transfer Efficiency in a Seagrass Posidonia oceanica Bed in the Western Mediterranean', *Mar. Ecol. Prog. Ser.* 1(234) : 95–104.

Dewi, C. S. U., Yona, D. and Iranawati, F. 2020. Analisis Kesehatan Ekosistem Lamun Di Pantai Menjangan, Buleleng, Bali. *Mosharafa: Jurnal Pendidikan Matematika*. 7(1) : 199–206.

Hartati, R. 2012. Struktur Komunitas Padang Lamun di Perairan Pulau Kumbang, Kepulauan Karimunjawa. *Jurnal Ilmu Kelautan*. 17(4) : 217-225.

Den Hartog, C. 1970. *Seagrass of The World*. Amsterdam: North Holland.

Hutomo, M. 1997. *Padang Lamun Indonesia/: Salah Satu Ekosistem Laut Dangkal yang Belum Banyak Dikenal*. Jakarta: Puslitbang Oseanologi LIPI.

Irma, W., Gunawan, T. and Suratman 2018. Pengaruh Konversi Lahan Gambut terhadap Ketahanan Lingkungan di DAS Kampar Provinsi Riau Sumatera. *Jurnal Ketahanan Nasional*. 24(2) : 170-191.

Joseph, L. 2019. Implications of Seagrass Ecosystem Degradation on Marine Resources and People's Livelihood: A Case Study from Komave Village, Fiji. *Asian Journal of Fisheries and Aquatic Research*. 2(3): pp. 1–13. doi: 10.9734/ajfar/2018/v2i330011.

Kepmen, L.H. 2004. *Kriteria Baku Kerusakan and Pedoman Penentuan Status Padang Lamun*. Indonesia.

Latuconsina, H. 2012. Sebaran Spasial Vegetasi Lamun (Seagrass) Berdasarkan Perbedaan Karakteristik Fisik Sedimen di Perairan Teluk Ambon Dalam. *Jurnal Bimafika*. 4 : 405-412.

Minerva, A., Purwanti, F. and Suryanto, A. 2014. Analisis Hubungan Keberadaan dan Kelimpahan Lamun Dengan Kualitas Air di Pulau Karimunjawa, Jepara. *Diponegoro Journal of Maquares*. 3(3) : 88–94.

Mukai, H., Aioi, K. and Ishida, Y. 1980. Distribution and biomass of eelgrass (*Zostera marina* L.) and other sea grasses in Odawa Bay, Central Japan. *Aquat*. 8 : 337–342.

Nontji, A. 1993. *Laut Nusantara*. Jakarta: Djambatan.

Nugraha, Y. and Rudi, A. 2015. Teknik Identifikasi Lamun (Seagrass) di Kawasan Pulau Parang, Karimunjawa, Kabupaten Jawa'.

Nybakken, J. W. 1992. *Biologi Laut/: Suatu Pendekatan Ekologis*. Jakarta: PT. Gramedia Pustaka.

Phillips, R. C. and Menez, E. G. 1988. *Seagrasses: Smithsonian Contributions to the Marine Science Series*. Washington D. C.: Smithsonian Institution Press.

Rani, C., Budimawan and Rohani 2010. Kajian Keberhasilan Ekologi dari Penciptaan Habitat dengan Lamun Buatan: Penilaian terhadap Komunitas Ikan. *Indonesian Journal of Marine Science*. 2 : 244–255.

Rawung, S., Tilaar, F. F. and Rondonuwu, A. B. 2018. Inventarisasi Lamun di Perairan Marine Field Station Fakultas Perikanan and Ilmu Kelautan UNSRAT Kecamatan Likupang Timur Kabupaten Minahasa Utara. *Jurnal Ilmiah Platax*. 6(2).

Roem, M. 2013. Laju Produktifitas Biomassa Daun Halodule uninervis Padang Lamun Pulau Derawan. *Jurnal Harpodon Borneo*. 6(2).

Sjafrie, N. D. M. 2018. *Status Padang Lamun Indonesia*, *Pusat Penelitian Oseanografi-LIPI*. doi: 10.1017/CBO9781107415324.004.

Sukandar, S. and Dewi, C. S. U. 2017. Status Padang Lamun di Pulau Talago, Madura dan Potensinya sebagai Bahan Baku Bioaktif. *Depik*. 6 (2) : 138–144. doi: 10.13170/depik.6.2.6435.

Supriyadi, Hidayati, N. and Isdianto, A. 2017. Analisis Sirkulasi Arus Laut Permukaan Dan Sebaran Sedimen. *Prosiding Seminar Nasional Kelautan dan Perikanan III*, (September), pp. 175–181.

Tangke, U. 2010. Ekosistem Padang Lamun (Manfaat, Fungsi and Rehabilitasi). *Agrikan: Jurnal Ilmiah Agribisnis and Perikanan*. 3(1) : 9. doi: 10.29239/j.agrikan.3.1.9-29.

Tomlinson, P. B. 1974. Vegetative Morphology and Meristem Dependence - The Foundation of Productivity in Seagrasses. *Aquaculture*. 4 : 107–120.

Wahab, I., Maddupa, H. and Kawaroe, M. 2017. Seagrass species distribution, density and coverage at Panggang Island, Jakarta', in *IOP Conference Series: Earth and Environmental Science*. doi: 10.1088/1742-6596/755/1/011001.