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Submission Letter

Submission letter

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Study on Condition and Potency of Seagrass Ecosystem in Guraping Village, Tidore Islands. North Maluku. Indonesia

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Hereby I would like to submit the manuscript entitled "**Study on Condition and Potency of Seagrass Ecosystem in Guraping Village, Tidore Islands. North Maluku. Indonesia**" to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarised text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve of this submission.

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Reviewers' Comments

The condition and potency of the seagrass ecosystem in Guraping Village, Tidore Islands, North Maluku

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Abstract. Seagrass functions to maintain ecological processes for biota sustainability and serves as a provider of goods and services. The purpose of the research was to determine the condition of seagrass beds in Guraping Village, North Oba sub-district, and to examine the potential of the seagrass ecosystem based on the condition and structure of the associated biota community. Observations were conducted using the method of *line* transect with squares of 50 cm x 50 cm (10 points). The results showed that the condition of the seagrass ecosystem in Guraping Village was in the damaged (poor) category. The same was observed for seagrass in Tanjung Gosale, while in Sibu Island, the seagrass was in the healthy category. Sibu Island has a healthy category of seagrass, with 42 species of biota. In Cape Gosale there were 34 species of biota, and Guraping village had 18 species. The structure of the biota community included it in the medium diversity of species, with a low dominance and normal spread of species.
Key Words: biota, diversity, ecological, potential, seagrass.

Introduction. Marine seagrasses have a high salinity adaptation. They have true roots, stems and leaves, and are associated with a large number of fish and other species. Seagrass communities that have the same species form homogeneous ecosystems, while different species form heterogeneous ecosystems (Dewi et al 2017).

Ecologically, seagrass ecosystems play an important role in coastal areas, including: primary production of organic matter, habitat of various biota (360 species of fish, with 60 economically important fish, 117 macro species of algae, 24 species of mollusks, 70 species of crustaceans and 45 species of echinodermates); they act as substrates for biota, shelter for fish larvae and other biota, food sources for many species, including endangered species such as dugong (*Dugong dugon*), turtles and seahorses (*Hippocampus* sp.), growth habitats for of some biota, supporting the high diversity of marine biota. Physical functions include the stabilization of soft basic substrates and slowing currents along the coast (Supriyadi et al 2018). Economically, seagrass ecosystems influence fish production and are also destinations for tourists (Iftinaan et al 2017). Marine biota with important commercial and recreational value, in certain stages of life, may depend heavily on the existence of seagrass ecosystems. Along with increasing industrial activity and development in coastal areas, ecological pressures on seagrass ecosystems are also increasing, thus damaging the ecosystem and decreasing its ecological roles (Abubakar & Ahmad 2013).

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Seagrass ecosystem research was previously conducted, but specifications about the potential of seagrass ecosystems based on seagrass condition are still minimal. Little information was found regarding the subject in the small islands of Indonesia's North Maluku Province. Previous research was conducted by Kaeli et al (2016) on fish communities in seagrass ecosystem, while Rina et al (2018) studied fish communities in seagrass ecosystems and coral reefs.

The scarce public knowledge on the importance of seagrass ecosystems decreses the attention on this matter. This study aims to examine the composition of biota associated with the condition of the seagrass ecosystems in the waters of Guraping Village North Oba District Tidore Island City, Indonesia. It is important to determine the condition and potential of seagrass ecosystems in Guraping Village waters, to establish a basis for further development and utilization of coastal areas in North Oba sub-district, while maintaining the sustainability of seagrass ecosystems.

Material and Method.

Study site. This study was conducted in Guraping Village, Oba sub-district, North Tidore Islands, from April to September 2020 (Figure 1). The research location included 3 stations of sampling: station 1 - Guraping Village, Station 2 - Pulau Sibu; and Station 3 - Tanjung Gosale.

Observation and sampling. The transect line method was used for the observation of seagrass species in each station, based on the seagrass-net western pacific monitoring method (Abubakar & Ahmad 2013). Sampling was carried out at low tide, with the crossing of transect lines vertically from land to sea along the zoning of seagrass ecosystems. Each station had 3 transect lines, with a distance of 20 m between them. 10 squares measuring 50 cm x 50 cm were selected randomly from each transect line. These were further divided in 4 smaller squares (quadrants 1 to 4).

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- it was not mentioned in the text
- most importantly, it did not bring new info (the info was already clearly presented in the text)

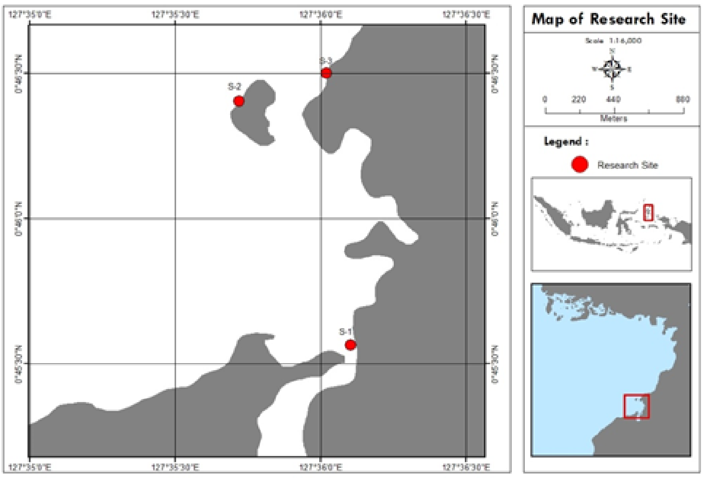

Figure 1. Research Site in Guraping Village.

Seagrass coverage. The percentage of seagrass cover was calculated in conjunction with the observation of seagrass species based on each quadrant (Hutomo & Nontji 2014). The percentage of seagrass coverage was calculated per transect plots, by analyzing the values obtained for each quadrant (Table 1). Total coverage per transect line was determined by analyzing all plots selected for the transect line. If the coverage was between 0 and 25%, it was considered rare; if it was between 26-50%, it was considered medium; if it was between 51-75%, it was normal; and if it was between 76-100, it was considered high. While determining coverage, seagrass species were identified based on ...

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Table 1

Seagrass coverage assessment

Categories	*Coverage (%)*
Full coverage	100
Coverage ¾ quadrant	75
Coverage ½ quadrant	50
Coverage ¼ quadrant	25
Empty	0

Marine biota. Fish were collected with the help of fishermen using gill nets. Nets were placed around the seagrass area. Nets were operated at low tide, assuming that fish exit the seagrass ecosystem in search of deeper waters, and were caught in the nets. Net operations were carried out during 6 trips. Fish were identified based on the guidelines of Peristiwady (2006).

The sampling of macrozoobenthos and seaweed was conducted using the method of blocking an area measuring 20 x 20 m (3 areas in total). Observation of biota species was conducted with the sweep area method. Samples were inserted in plastic containers to be further identified by using the following references: Calumpong & Menez 1997; Rohmimohtarto & Juwana 2001; Dharma 2005.

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Seagrass density. Analysis of seagrass species density was done using the formula D=N/A, where D is species density (ind m^{-2}), N is the total number of individuals from the species and A is the area (Fajarwati et al 2015). The density was interpreted based on Martha et al (2019) (Table 2).

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Table 2

Seagrass ecosystem density interpretation

Scale	Density (ind m^{-2})	Criteria
5	>175	Very high
4	125–175	High
3	75–125	Normal
2	25–75	Rare
1	<25	Very rare

Seagrass ecosystem condition. The condition of the seagrass ecosystem can be reviewed based on the percentage of coverage. There can be two conditions, namely good and damaged (Ministry of Environment 2004) (Table 3).

Table 3

Seagrass condition assessment

	Status	Coverage (%)
Good	Rich/Healthy	≥60
Damaged	Less rich/less heathy	30–59.9
	Poor	≤ 29.9

Biota community structure. The fish abundance is number of fish unity wide sampling, calculated using formula (Sarisma et al 2017). The diversity index of species is the wealth of the community based on the number of species in the community, as well as the number of individuals in each species. Diversity was determined used the Shannon-Wiener index

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(Rondo 2015). The dominance index shows the distribution of individuals (Rondo 2015), and was determined with the formula (Wibisono 2005):

Results and Discussion

Composition and distribution seagrass species. The composition of seagrass species showed 2 families, Potamogenaceae and Hydrocaritaceae, with 4 species each: *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, and *Syringidum isiotifolium* for Potamogenaceae, and *Enhalus acoroides*, *Thalassia hemprichii*, *Halohila minor* and *Halophila ovalis* for Hydrocaritaceae (Table 4).

The composition of seagrass species differs in each location. All species were found in Sibu Island. In Tanjung Gosale, 5 species were found: *C. serrulata*, *S. isiotifolium*, *E. acoroides*, *T. hemprichii* and *H. minor*. The lowest species composition was found in Guraping Village, with 4 species: *S. isiotifolium*, *E. acoroides*, *T. hemprichii* and *H. minor* (Table 4).

Table 4

Composition and distribution seagrass species

Families	Species	Distribution		
		Guraping	Sibu	Gosale
Potamogenaceae	*Cymodocea rotundata*	-	√	-
	Cymodocea serrulata	-	√	√
	Halodule uninervis	-	√	-
	Syringidium isiotifolium	√	√	√
Hydrocaritaceae	*Enhalus acoroides*	√	√	√
	Thalassia hemprichii	√	√	√
	Halophila minor	√	√	√
	Halophila ovalis	-	√	-

The composition of seagrass species on Sibu Island is different due to the heterogeneous substrate in the form of sand, muddy sand, mud, sandy mud and sand mixed with faults. The photosynthesis processes in the area can run well because the waters are very clear. In Guraping Village there is a low seagrass species composition, because the substrate is dominated by mud and muddy sand. Another factor is the presence of liquid waste and solid waste coming from the settlement, inhabiting the growth of seagrass. Seagrass grows on substrates including sand, mud, muddy sand, sandy mud and sand mixed with coral faults. Seagrass thrives mainly in open tidal areas and coastal waters with a depth of 4 m. In very clear waters, some seagrass species are even found to grow in depths of 8-15 m and even 40 m. Seagrass requires a high light intensity for photosynthesis. The distribution of seagrass ecosystems is limited to sunlight-free waters (Murhum et al 2018).

Seagrass ecosystem condition. The seagrass condition of each research station was determined by analyzing the percentage of seagrass cover (Figure 2). The percentage of seagrass cover in Guraping Village ranged between 26.88 and 28.75%, with an average of 27.92%. The percentage of seagrass cover in Sibu Island ranged from 86.88 to 93.75%, with an average of 90.83%. The percentage of seagrass cover in Tanjung Gosale ranged from 28.75 to 76.25%, with an average of 56.04%. The seagrass cover was highest in Sibu Island and lowest in Guraping Village.

Seagrass growth can be known based on the value of seagrass cover. Guraping village and Tanjung Gosale have seagrass growth in the moderate category, while seagrass in Sibu Island has a very dense growth. Based on the percentage value of seagrass cover obtained, the seagrass condition in Guraping Village is damaged or poor, with an average coverage of 27.92%. Seagrass conditions in Sibu Island are good, or rich/healthy, while seagrass in Tanjung Gosale is damaged or less rich/unhealthy.

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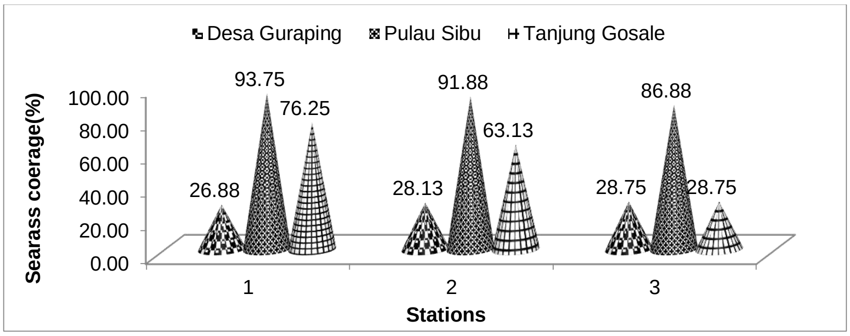

Figure 2. Seagrass coverage.

The condition of the seagrass ecosystem in Guraping Village is influenced by community activity in the form of liquid and solid waste disposal. Moreover, the location is on a marine transportation line, which damages the seagrass area by increasing turbidity, and preventing photosynthesis. In addition, the substrate is dominated by sandy mud. The condition of the seagrass ecosystem in Sibu Island is good/healthy, because the island is uninhabited, so community activities are rare. The water is very clear and substrates vary (sand, muddy sand, mud, sandy mud and sand mixed with coral faults). The seagrass growth is very dense, with coverage of up to 100% in some places. The seagrass ecosystem conditions in Tanjung Gosale are damaged or unhealthy. This is evidenced by the moderate growth of seagrass and by the activity of fishermen that land boats on seagrass beds.

The rate of global seagrass damage is unpredictable. The dominant cause of damage comes from anthropogenic activities. The damage to seagrass is caused by fishing boats, development activities and the increasing number of people living in coastal areas. A source of seagrass degradation is the increasing rate of physical development such as port construction, fishing docks, industrial development and unfriendly utilization activities. Other threats to seagrass come from nature, such as storms, volcano eruptions and global warming (Syukur et al 2017).

Seagrass density. Figures 3, 4 and 5 show the seagrass densities in the 3 locations. The highest density in Guraping Village was in the case of *T. hemprichii* (108.27 ind m^{-2}). The lowest density was in the case of *H. minor* (14.53 ind m^{-2}). *T. hemprichii* had the highest density (528.13 ind m^{-2}) in Sibu Island, and *H. ovalis* the lowest (29.2 ind m^{-2}). *T. hemprichii* also had the highest density in Tanjung Gosale (214.4 ind m^{-2}) and *H. minor* the lowest (27.87 ind m^{-2}).

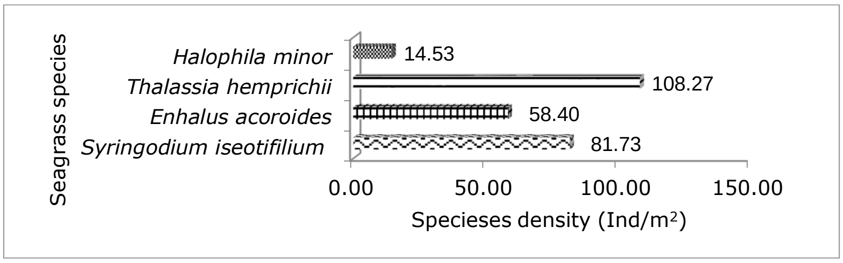

Figure 3. Seagrass species density in Guraping Village.

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- "species" is both the singular and plural form of the word (in English)

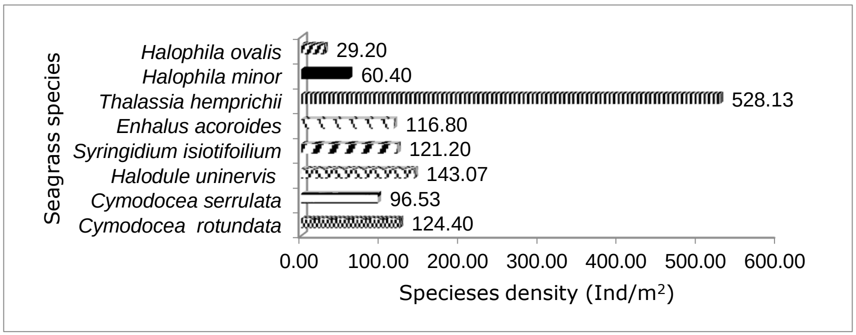

Figure 4. Seagrass species density in Sibu Island.

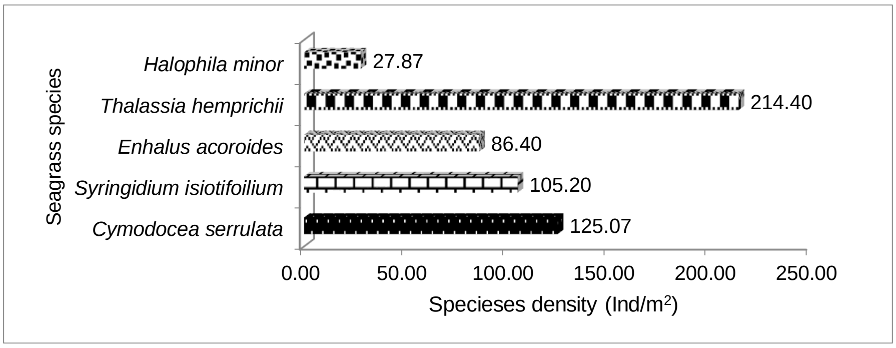

Figure 5. Seagrass species density in Gosale.

T. hemprichii had the highest density in all stations and *H. minor* the lowest. The high density of *T. hemprichii* could be due to substrate species at all research sites is very suitable for the growth of this species. Environmental factors also affect the density of the species, including depth, light intensity and salinity. The research site is an intertidal area with depths ranging from 0.5 to 1.25 m. *H. minor* species had the lowest density because of its size; sediments can cover the plant and inhibit its growth. *Thalassia hemprichi* memiliki pertumbuhan yang baik pada zona intertidal dengan ukuran sedimen yang lebih besar dan kedalaman perairan antara 0,7 – 1,35. Sedangkan lamun spesies *Halophila minor* sangat sensitif terhadap perubahan lingkungan sehingga sulit ditemukan pada daerah yang tercemar apalgi tertutup sedimen yang berasal dari limbah masyrakat (Fajarwati *et al,* 2015).

Seagrass species density is the highest at 558.93 ind m^{-2} in Sibu Island and lowest in Guraping Village, with 262.93 ind m^{-2}. The density of seagrass species is related to the upright distance and number of individuals as well as the area of the research site. Seagrass species density can be used to determine the condition of seagrass ecosystems. Sibu Island has conditions in a good category, while Tanjung Gosale presents damaged/unhealthy conditions. Guraping Village has a lower density, being included in the damaged/poor condition.

Marine biota. Fish species, macrozoobenthos (Holothuroidea, Echinoidea, Asteroidea, gastropods, bivalves) and macroalgae were observed and identified. 4 fish families and 8 species were identified. The family Siganidae was present with the *Siganus canaliculatus*, *S. spinus* and *S. chrysospilos* species. The family Scaridae was present with *Scarus quiyo* and *S. scarus fraenatus* species. The only representative of the Mullidae family was

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Mulloidichtys flavolineatus. The Lutjanidae family had two species present, *Lutjanus gibbus* and *Pristipomoides auricillia*. Sibu Island had all 8 species, 6 species were observed in Cape Gosale (*S. canaliculatus*, *S. spinus*, *S. chrysospilos*, *S. quiyo*, *M. flavolineatus* and *L. gibbus*). The lowest number of fish species was found in Guraping Village, with only 4 species (*S. canaliculatus*, *S. spinus*, *M. flavolineatus*, *P. auricillia*).

The composition of macrozoobenthos species living in seagrass ecosystems consists of echinoderms (Holothuroidea Class, Echinoidea, Asteroidea) and mollusks (Gastropoda and Bivalva classes). The Holothuroidea class presented two families, Holothuridae and Aspidochirotea, with 5 species. The Holothuroidea family had 4 species present, namely *Holothuria opheodesoma*, *H. marmorata*, *H. atra* and *H. scabra*, while the Aspidochirotacea family was present with the species *Bohadschia graeffei*. All sea cucumber species identified were present in Sibu Island, 3 species were present in Tanjung Gosale (*H. opheodesoma*, *H. scabra*, *B. graeffei*) and 2 species in Guraping Village (*H. opheodesoma*, *H. atra*).

The class Echinoidea presented 4 families with 5 species. The family Diadematidae had two species in the research locations, *Echinothrix calamaris* and *Diadema setosum*. The families Temnopleuridae, Toxopneustidae and Echinometridae had one species each, *Mespilia globulus*, *Tripneustes gratila* and *Echinometra mathei*, respectively. All sea urchin species were found in Sibu Island, 3 species in Guraping Village (*E. calamaris*, *D. setosum*, *E. mathei*).

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The Asteroidea class had 3 families (Ophidlasteridae, Oreasteridae, Astropetcinidae) and 4 species. The family Oreasteridae had 2 species (*Protereaster nodosus* and *Culcita novaguineae*), while the families Ophidlasteridae and Astropetciniidae had 1 species each, *Linckia laevigata* and *Astropecten polyacanthus*, respectively. 3 species were found in Sibu Island (*L. laevigata*, *P. nodosus*, *A. polyacanthus*). Cape Gosale also presented 3 species (*L. laevigata*, *P. nodosus*, *C. novaguineae*). Only 2 species were found in Guraping Village (*L. laevigata*, *P. nodosus*).

The gastropods had 5 families with 9 species. The family Strombidae had 4 species (*Strombus labiatus*, *S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*). The family Cypraeidae presented 3 species (*Cypraea tigris, C. annular*). The families Cerithiidae, Nerithiidae and Trochiidae had one species each, namely *Rhinoclavis vertagus*, *Nerita albicilla* and T*ectus fenestratus*. Sibu Island had 9 species present, namely *S. labiatus*, *S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*, *C. tigris*, and *T. fenestratus*. Cape Gosale had 6 species (*S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*, *C. tigris*, *R. vertagus*, *T. fenestratus*). Guraping Village had only 2 species (*C. tigris*, *T. fenestratus*).

The bivalves presented 4 families and 4 species: Cardiidae (*Trachycardium orbita*), Isognomondae (*Isognomon isognomon*), Mytillidae (*Modiolus auriculas*) and Spondylidae (*Valaclamys singaporina*). All 4 species were present in Sibu Island. 3 species were present in Cape Gosale (*T. orbita*, *I. isognomon*, *V. singaporina*). Only *Isognomon isognomon* was present in Guraping Village.

The composition of macroalgae species consists of 3 phyla, namely Chlorophyta (green algae), Rhodophyta (red algae) and Pheophyta (brown algae). The Clorophyta and Rhodophyta phyla have a larger number of species, namely 4 species each. Clorophyta phylum presented the species *Halimeda tuna*, *Halimeda opuntia*, *Codium bartletti* and *Neomeris annulata*. The Rhodophyta phylum was present through the following species: *Amansia glomerata*, *Galaxaura filamentosa*, *Mastophora rosea* and *Ceratodictyon spongiosum*. Phaeophyta presented 3 species: *Padina minor*, *Padina australis*, and *Lobophora veriegata*.

In total, Sibu Island had is 42 species (8 species of fish, 25 species of macrozoobenthos and 9 species of macroalgae. Tanjung Gosale has 34 biota species consisting of 6 species of fish, 19 species of macrozoobenthos and 9 of macroalgae. Guraping Village had 4 species of fish, 10 species of macrozoobenthos and 4 species of macroalgae (Figure 6).

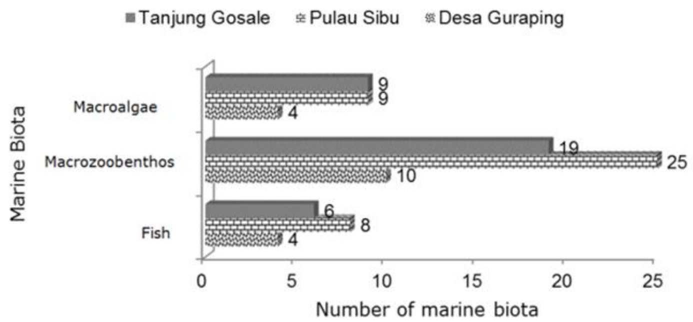

Figure 6. Differences in biota species composition per research site.

The difference in the composition of biota species is noticeable based on seagrass conditions and density. Seagrass ecosystems in good condition and high density have more biota species than seagrass ecosystems with poor conditions. This suggests that seagrass ecosystems have ecological functions as a place of care, growth, foraging, and shelter for various biota species.

Community structure marine biota in seagrass ecosystem. The structure of biota species communities in Sibu Island and Tanjung Gosale has a medium species diversity. Guraping Village has a relatively moderatediversity, where no species dominates and the spread is even (Figure 7).

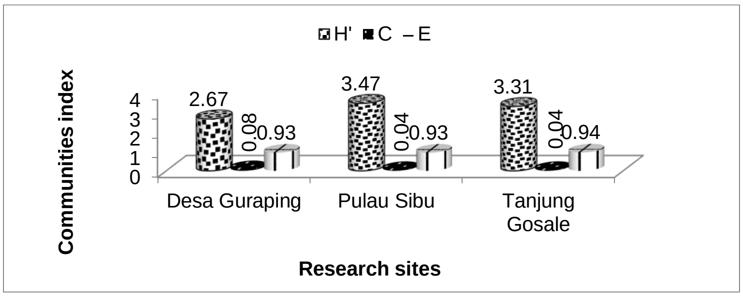

Figure 7. Community structure marine biota.

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The highest diversity of species was on Sibu Island, with 42 species and 478 individuals. The lowest diversity was in Guraping Village, with 18 species and 138 individuals. The value of the dominance index of all research sites was classified as low, with no dominant species. This means that there was no meaningful competition for space, food, or living space for organisms in all research locations. The species evenness values show that the marine biota had a normal spread. The high uniformity index indicates that the division of individuals found is high and even, showing that environmental conditions at all research sites were relatively suitable for the growth and development of organisms. Stable communities show that the ecosystem had a high diversity, but no species are dominant.

Species diversity, species dominance and species evenness have a very close association. If species diversity is smaller in the community, then the spread of the number of individuals of each species is not the same or there is a tendency that the community is dominated by a particular species. A high uniformity index in the community decreases the chances to have a dominant species.

Conclusions. The condition of the seagrass ecosystem in Guraping Village is damaged or poor. The same was observed in Tanjung Gosale, while in Sibu Island it is rich/healthy. Sibu Island has a composition of 42 species of biota, Cape Gosale 34 species, and Guraping Village 18 species. The community structure of marine biota species in Sibu Island and Tanjung Gosale has a high diversity, while in Guraping Village was moderate. No species were found to be dominant, and the spread was normal.

Conflict of Interest. The authors declare that there is no conflict of interest.

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Authors' Response/Revised Article

The condition and potency of the seagrass ecosystem in Guraping Village, Tidore Islands, North Maluku

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Abstract. Seagrass functions to maintain ecological processes for biota sustainability and serves as a provider of goods and services. The purpose of the research was to determine the condition of seagrass beds in Guraping Village, North Oba sub-district, and to examine the potential of the seagrass ecosystem based on the condition and structure of the associated biota community. Observations were conducted using the method of *line* transect with squares of 50 cm x 50 cm (10 points). The results showed that the condition of the seagrass ecosystem in Guraping Village was in the damaged (poor) category. The same was observed for seagrass in Tanjung Gosale, while in Sibu Island, the seagrass was in the healthy category. Sibu Island has a healthy category of seagrass, with 42 species of biota. In Cape Gosale there were 34 species of biota, and Guraping village had 18 species. The structure of the biota community included it in the medium diversity of species, with a low dominance and normal spread of species.
Key Words: biota, diversity, ecological, potential, seagrass.

Introduction. Marine seagrasses have a high salinity adaptation. They have true roots, stems and leaves, and are associated with a large number of fish and other species. Seagrass communities that have the same species form homogeneous ecosystems, while different species form heterogeneous ecosystems (Dewi et al 2017).

Ecologically, seagrass ecosystems play an important role in coastal areas, including: primary production of organic matter, habitat of various biota (360 species of fish, with 60 economically important fish, 117 macro species of algae, 24 species of mollusks, 70 species of crustaceans and 45 species of echinodermates); they act as substrates for biota, shelter for fish larvae and other biota, food sources for many species, including endangered species such as dugong (*Dugong dugon*), turtles and seahorses (*Hippocampus* sp.), growth habitats for of some biota, supporting the high diversity of marine biota (Supriyadi et al 2018). Physical functions include the stabilization of soft basic substrates and slowing currents along the coast (Supriyadi et al 2018). Economically, seagrass ecosystems influence fish production and are also destinations for tourists (Iftinaan et al 2017). Marine biota with important commercial and recreational value, in certain stages of life, may depend heavily on the existence of seagrass ecosystems. Along with increasing industrial activity and development in coastal areas, ecological pressures on seagrass ecosystems are also increasing, thus damaging the ecosystem and decreasing its ecological roles (Abubakar & Ahmad 2013).

Seagrass ecosystem research was previously conducted, but specifications about the potential of seagrass ecosystems based on seagrass condition are still minimal. Little information was found regarding the subject in the small islands of Indonesia's North Maluku Province. Previous research was conducted by Kaeli et al (2016) on fish communities in seagrass ecosystem, while Rina et al (2018) studied fish communities in seagrass ecosystems and coral reefs.

The scarce public knowledge on the importance of seagrass ecosystems decreses the attention on this matter. This study aims to examine the composition of biota associated with the condition of the seagrass ecosystems in the waters of Guraping Village North Oba District Tidore Island City, Indonesia. It is important to determine the condition and potential of seagrass ecosystems in Guraping Village waters, to establish a basis for further development and utilization of coastal areas in North Oba sub-district, while maintaining the sustainability of seagrass ecosystems.

Material and Method.

Study site. This study was conducted in Guraping Village, Oba sub-district, North Tidore Islands, from April to September 2020 (Figure 1). The research location included 3 stations of sampling: station 1 - Guraping Village, Station 2 - Pulau Sibu; and Station 3 - Tanjung Gosale.

Observation and sampling. The transect line method was used for the observation of seagrass species in each station, based on the seagrass-net western pacific monitoring method (Abubakar & Ahmad 2013). Sampling was carried out at low tide, with the crossing of transect lines 100 m perpendicularly from land to sea along the zoning of seagrass ecosystems. Each station had 3 transect lines, with a distance of 20 m between them. 10 squares measuring 50 cm x 50 cm were selected randomly from each transect line. These were further divided in 4 smaller squares (quadrants 1 to 4).

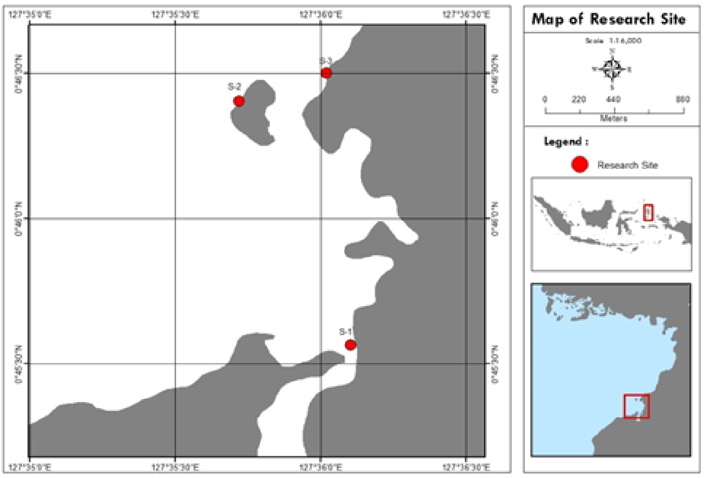

Figure 1. Research Site in Guraping Village.

Seagrass coverage. The percentage of seagrass cover was calculated in conjunction with the observation of seagrass species based on each quadrant (Hutomo & Nontji 2014). The percentage of seagrass coverage was calculated per transect plots, by analyzing the values obtained for each quadrant (Table 1). Total coverage per transect line was determined by analyzing all plots selected for the transect line. If the coverage was between 0 and 25%, it was considered rare; if it was between 26-50%, it was considered medium; if it was between 51-75%, it was normal; and if it was between 76-100, it was considered high. While determining coverage, seagrass species were identified based on (McKenzie 2003).

Table 1

Seagrass coverage assessment

Categories	*Coverage (%)*
Full coverage	100
Coverage ¾ quadrant	75
Coverage ½ quadrant	50
Coverage ¼ quadrant	25
Empty	0

Marine biota. Fish were collected with the help of fishermen using gill nets. Nets were placed around the seagrass area. Nets were operated at low tide, assuming that fish exit the seagrass ecosystem in search of deeper waters, and were caught in the nets. Net operations were carried out during 6 trips. Fish were identified based on the guidelines of Peristiwady (2006).

The sampling of macrozoobenthos and seaweed was conducted using the method of blocking an area measuring 20 x 20 m (3 areas in total). Observation of biota species was conducted with the swept area method (Widodo 1990). Samples were inserted in plastic containers to be further identified in the laboratory by using the following references: Calumpong & Menez (1997), Rohmimohtarto & Juwana (2001), Dharma (2005).

Seagrass density. Analysis of seagrass species density was done using the formula D=N/A, where D is species density (ind m^{-2}), N is the total number of individuals from the species and A is the area (Fajarwati et al 2015). The density was interpreted based on Martha et al (2019) (Table 2).

Table 2

Seagrass ecosystem density interpretation

Scale	Density (ind m^{-2})	Criteria
5	>175	Very high
4	125–175	High
3	75–125	Normal
2	25–75	Rare
1	<25	Very rare

Seagrass ecosystem condition. The condition of the seagrass ecosystem can be reviewed based on the percentage of coverage. There can be two conditions, namely good and damaged (Ministry of Environment 2004) (Table 3).

Table 3

Seagrass condition assessment

	Status	Coverage (%)
Good	Rich/Healthy	≥60
Damaged	Less rich/less heathy	30–59.9
	Poor	≤ 29.9

Biota community structure. The fish abundance calculated using formula (Sarisma et al 2017). The diversity index of species is the wealth of the community based on the number of species in the community, as well as the number of individuals in each species. Diversity was determined used the Shannon-Wiener index (Rondo 2015). The dominance index shows the distribution of individuals (Rondo 2015).

Results and Discussion

Composition and distribution seagrass species. The composition of seagrass species showed 2 families, Potamogenaceae and Hydrocaritaceae, with 4 species each: *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, and *Syringodium isiotifolium* for Potamogenaceae, and *Enhalus acoroides*, *Thalassia hemprichii*, *Halophila minor* and *Halophila ovalis* for Hydrocaritaceae (Table 4).

The composition of seagrass species differs in each location. All species were found in Sibu Island. In Tanjung Gosale, 5 species were found: *C. serrulata*, *S. isiotifolium*, *E. acoroides*, *T. hemprichii* and *H. minor*. The lowest species composition was found in Guraping Village, with 4 species: *S. isiotifolium*, *E. acoroides*, *T. hemprichii* and *H. minor* (Table 4).

Table 4

Composition and distribution seagrass species

Families	Species	Distribution		
		Guraping	Sibu	Gosale
Potamogenaceae	*Cymodocea rotundata*	-	√	-
	Cymodocea serrulata	-	√	√
	Halodule uninervis	-	√	-
	Syringodium isiotifolium	√	√	√
Hydrocaritaceae	*Enhalus acoroides*	√	√	√
	Thalassia hemprichii	√	√	√
	Halophila minor	√	√	√
	Halophila ovalis	-	√	-

The composition of seagrass species on Sibu Island is different due to the heterogeneous substrate in the form of sand, muddy sand, mud, sandy mud and sand mixed with faults. The photosynthesis processes in the area can run well because the waters are very clear. In Guraping Village there is a low seagrass species composition, because the substrate is dominated by mud and muddy sand. Another factor is the presence of liquid waste and solid waste coming from the settlement, inhabiting the growth of seagrass. Seagrass grows on substrates including sand, mud, muddy sand, sandy mud and sand mixed with coral faults. Seagrass thrives mainly in open tidal areas and coastal waters with a depth of 4 m (Hadad & Abubakar 2016). In very clear waters, some seagrass species are even found to grow in depths of 8-15 m and even 40 m (Dahuri 2003). Seagrass requires a high light intensity for photosynthesis. The distribution of seagrass ecosystems is limited to sunlight-free waters (Murhum et al 2018).

Seagrass ecosystem condition. The seagrass condition of each research station was determined by analyzing the percentage of seagrass cover (Figure 2). The percentage of seagrass cover in Guraping Village ranged between 26.88 and 28.75%, with an average of 27.92%. The percentage of seagrass cover in Sibu Island ranged from 86.88 to 93.75%, with an average of 90.83%. The percentage of seagrass cover in Tanjung Gosale ranged from 28.75 to 76.25%, with an average of 56.04%. The seagrass cover was highest in Sibu Island and lowest in Guraping Village.

Seagrass growth can be known based on the value of seagrass cover. Guraping village and Tanjung Gosale have seagrass growth in the moderate category, while seagrass in Sibu Island has a very dense growth. Based on the percentage value of seagrass cover obtained, the seagrass condition in Guraping Village is damaged or poor, with an average coverage of 27.92%. Seagrass conditions in Sibu Island are good, or rich/healthy, while seagrass in Tanjung Gosale is damaged or less rich/unhealthy.

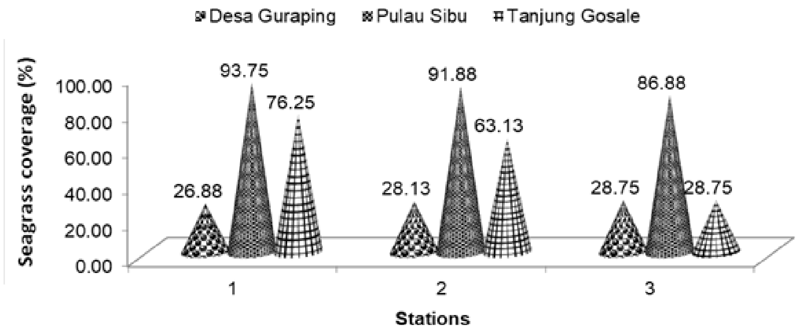

Figure 2. Seagrass coverage.

The condition of the seagrass ecosystem in Guraping Village is influenced by community activity in the form of liquid and solid waste disposal. Moreover, the location is on a marine transportation line, which damages the seagrass area by increasing turbidity, and preventing photosynthesis. In addition, the substrate is dominated by sandy mud. The condition of the seagrass ecosystem in Sibu Island is good/healthy, because the island is uninhabited, so community activities are rare. The water is very clear and substrates vary (sand, muddy sand, mud, sandy mud and sand mixed with coral faults). The seagrass growth is very dense, with coverage of up to 100% in some places. The seagrass ecosystem conditions in Tanjung Gosale are damaged or unhealthy. This is evidenced by the moderate growth of seagrass and by the activity of fishermen that land boats on seagrass beds.

The rate of global seagrass damage is unpredictable. The dominant cause of damage at the study sites comes from anthropogenic activities. The damage to seagrass is caused by fishing boats, development activities and the increasing number of people living in coastal areas. A source of seagrass degradation is the increasing rate of physical development such as port construction, fishing docks, industrial development and unfriendly utilization activities. Other threats to seagrass come from nature, such as storms, volcano eruptions and global warming (Syukur et al 2017).

Seagrass density. Figures 3, 4 and 5 show the seagrass densities in the 3 locations. The highest density in Guraping Village was in the case of *T. hemprichii* (108.27 ind m^{-2}). The lowest density was in the case of *H. minor* (14.53 ind m^{-2}). *T. hemprichii* had the highest density (528.13 ind m^{-2}) in Sibu Island, and *H. ovalis* the lowest (29.2 ind m^{-2}). *T. hemprichii* also had the highest density in Tanjung Gosale (214.4 ind m^{-2}) and *H. minor* the lowest (27.87 ind m^{-2}).

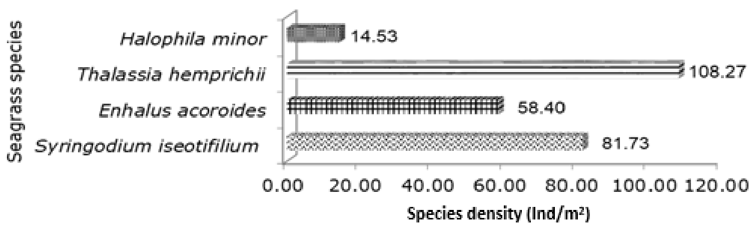

Figure 3. Seagrass species density in Guraping Village.

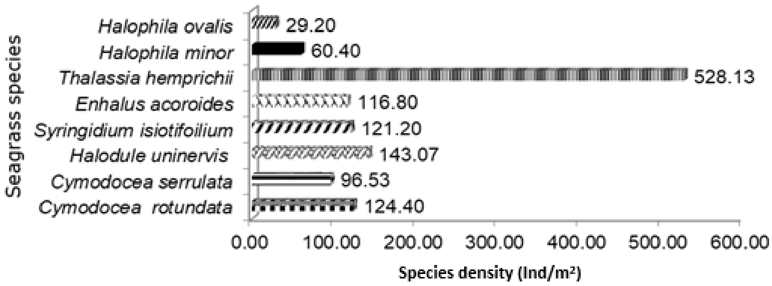

Figure 4. Seagrass species density in Sibu Island.

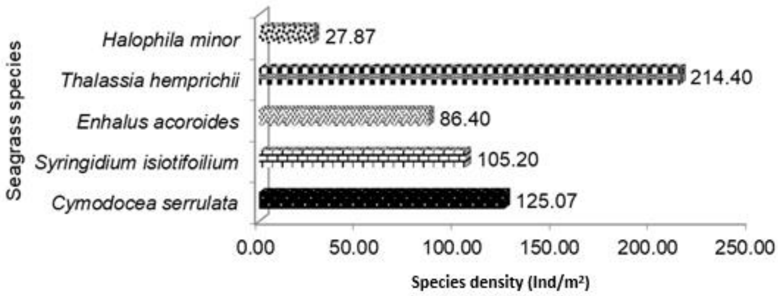

Figure 5. Seagrass species density in Gosale.

T. hemprichii had the highest density in all stations and *H. minor* the lowest. The high density of *T. hemprichii* could be due to the substrate, which is very suitable for the growth of this species. Environmental factors also affect the density of the species, including depth, light intensity and salinity (Martin et al 2020). The research site is an intertidal area with depths ranging from 0.5 to 1.25 m. *H. minor* species had the lowest density because of its size; sediments can cover the plant and inhibit its growth. *Thalassia hemprichi* has good growth in the intertidal zone with larger sediment size and water depths between 0.7-1.35. Meanwhile, *Halophila minor* is very sensitive to environmental changes, so it is difficult to find in polluted areas or areas covered with sediments from community waste (Fajarwati et al 2015).

Seagrass species density is the highest at 558.93 ind m^{-2} in Sibu Island and lowest in Guraping Village, with 262.93 ind m^{-2}. The density of seagrass species is related to the upright distance and number of individuals as well as the area of the research site. Seagrass species density can be used to determine the condition of seagrass ecosystems. Sibu Island has conditions in a good category, while Tanjung Gosale presents damaged/unhealthy conditions. Guraping Village has a lower density, being included in the damaged/poor condition.

Marine biota. Fish species, macrozoobenthos (Holothuroidea, Echinoidea, Asteroidea, gastropods, bivalves) and macroalgae were observed and identified. 4 fish families and 8 species were identified. The family Siganidae was present with the *Siganus canaliculatus*, *S. spinus* and *S. chrysospilos* species. The family Scaridae was present with *Scarus quiyo* and *S. scarus fraenatus* species. The only representative of the Mullidae family was *Mulloidichtys flavolineatus*. The Lutjanidae family had two species present, *Lutjanus gibbus* and *Pristipomoides auricillia*. Sibu Island had all 8 species, 6 species were observed in Cape Gosale (*S. canaliculatus*, *S. spinus*, *S. chrysospilos*, *S. quiyo*, *M. flavolineatus* and *L.*

gibbus). The lowest number of fish species was found in Guraping Village, with only 4 species (*S. canaliculatus*, *S. spinus*, *M. flavolineatus*, *P. auricillia*).

The composition of macrozoobenthos species living in seagrass ecosystems consists of echinoderms (Holothuroidea Class, Echinoidea, Asteroidea) and mollusks (Gastropoda and Bivalva classes). The Holothuroidea class presented two families, Holothuridae and Aspidochirotea, with 5 species. The Holothuroidea family had 4 species present, namely *Holothuria opheodesoma*, *H. marmorata*, *H. atra* and *H. scabra*, while the Aspidochirotacea family was present with the species *Bohadschia graeffei*. All sea cucumber species identified were present in Sibu Island, 3 species were present in Tanjung Gosale (*H. opheodesoma*, *H. scabra*, *B. graeffei*) and 2 species in Guraping Village (*H. opheodesoma*, *H. atra*).

The class Echinoidea presented 4 families with 5 species. The family Diadematidae had two species in the research locations, *Echinothrix calamaris* and *Diadema setosum*. The families Temnopleuridae, Toxopneustidae and Echinometridae had one species each, *Mespilia globulus*, *Tripneustes gratila* and *Echinometra mathei*, respectively. All sea urchin species were found in Sibu Island, 3 species in Guraping Village that is *E. calamaris*, *D. setosum*, *E. mathei*.

The Asteroidea class had 3 families (Ophidlasteridae, Oreasteridae, Astropetcinidae) and 4 species. The family Oreasteridae had 2 species (*Protereaster nodosus* and *Culcita novaguineae*), while the families Ophidlasteridae and Astropetciniidae had 1 species each, *Linckia laevigata* and *Astropecten polyacanthus*, respectively. 3 species were found in Sibu Island (*L. laevigata*, *P. nodosus*, *A. polyacanthus*). Cape Gosale also presented 3 species (*L. laevigata*, *P. nodosus*, *C. novaguineae*). Only 2 species were found in Guraping Village (*L. laevigata*, *P. nodosus*).

The gastropods had 5 families with 9 species. The family Strombidae had 4 species (*Strombus labiatus*, *S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*). The family Cypraeidae presented 3 species (*Cypraea tigris, C. annular*). The families Cerithiidae, Nerithiidae and Trochiidae had one species each, namely *Rhinoclavis vertagus*, *Nerita albicilla* and T*ectus fenestratus*. Sibu Island had 9 species present, namely *S. labiatus*, *S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*, *C. tigris*, and *T. fenestratus*. Cape Gosale had 6 species (*S. aurisdianae*, *S. lentiginosus*, *S. gibberulus*, *C. tigris*, *R. vertagus*, *T. fenestratus*). Guraping Village had only 2 species (*C. tigris*, *T. fenestratus*).

The bivalves presented 4 families and 4 species: Cardiidae (*Trachycardium orbita*), Isognomondae (*Isognomon isognomon*), Mytillidae (*Modiolus auriculas*) and Spondylidae (*Valaclamys singaporina*). All 4 species were present in Sibu Island. 3 species were present in Cape Gosale (*T. orbita*, *I. isognomon*, *V. singaporina*). Only *Isognomon isognomon* was present in Guraping Village.

The composition of macroalgae species consists of 3 phyla, namely Chlorophyta (green algae), Rhodophyta (red algae) and Pheophyta (brown algae). The Clorophyta and Rhodophyta phyla have a larger number of species, namely 4 species each. Clorophyta phylum presented the species *Halimeda tuna*, *Halimeda opuntia*, *Codium bartletti* and *Neomeris annulata*. The Rhodophyta phylum was present through the following species: *Amansia glomerata*, *Galaxaura filamentosa*, *Mastophora rosea* and *Ceratodictyon spongiosum*. Phaeophyta presented 3 species: *Padina minor*, *Padina australis*, and *Lobophora veriegata*.

In total, Sibu Island had is 42 species (8 species of fish, 25 species of macrozoobenthos and 9 species of macroalgae. Tanjung Gosale has 34 biota species consisting of 6 species of fish, 19 species of macrozoobenthos and 9 of macroalgae. Guraping Village had 4 species of fish, 10 species of macrozoobenthos and 4 species of macroalgae (Figure 6).

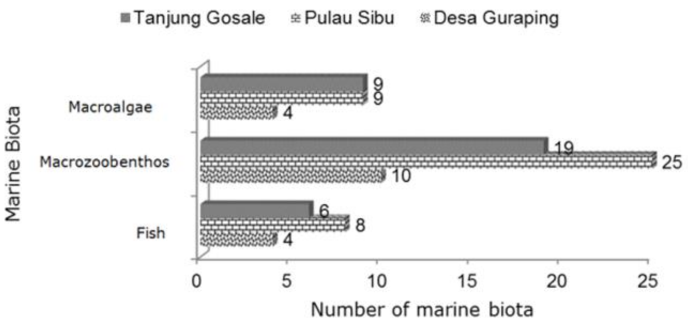

Figure 6. Differences in biota species composition per research site.

The difference in the composition of biota species is noticeable based on seagrass conditions and density. Seagrass ecosystems in good condition and high density have more biota species than seagrass ecosystems with poor conditions. This suggests that seagrass ecosystems have ecological functions as a place of care, growth, foraging, and shelter for various biota species.

Community structure marine biota in seagrass ecosystem. The structure of biota species communities in Sibu Island and Tanjung Gosale has a medium species diversity. Guraping Village has a relatively moderatediversity, where no species dominates and the spread is even (Figure 7).

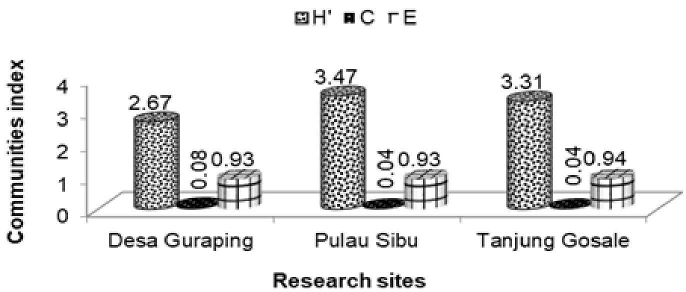

Figure 7. Communities structure marine biota; H' - diversity; C - dominance; E - uniformity.

The highest diversity of species was on Sibu Island, with 42 species and 478 individuals. The lowest diversity was in Guraping Village, with 18 species and 138 individuals. The value of the dominance index of all research sites was classified as low, with no dominant species. This means that there was no meaningful competition for space, food, or living space for organisms in all research locations. The species evenness values show that the marine biota had a normal spread. The high uniformity index indicates that the division of individuals found is high and even, showing that environmental conditions at all research sites were relatively suitable for the growth and development of organisms. Stable communities show that the ecosystem had a high diversity, but no species are dominant.

Species diversity, species dominance and species evenness have a very close association. If species diversity is smaller in the community, then the spread of the number of individuals of each species is not the same or there is a tendency that the community is dominated by a particular species. A high uniformity index in the community decreases the chances to have a dominant species.

Conclusions. The condition of the seagrass ecosystem in Guraping Village is damaged or poor. The same was observed in Tanjung Gosale, while in Sibu Island it is rich/healthy. Sibu Island has a composition of 42 species of biota, Cape Gosale 34 species, and Guraping Village 18 species. The community structure of marine biota species in Sibu Island and Tanjung Gosale has a high diversity, while in Guraping Village was moderate. No species were found to be dominant, and the spread was normal.

Conflict of Interest. The authors declare that there is no conflict of interest.

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