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JURNAL : AACL BIOFLUX

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FAKULTAS PERIKANAN DAN ILMU KELAUTAN

UNIVERSITAS SAM RATULANGI

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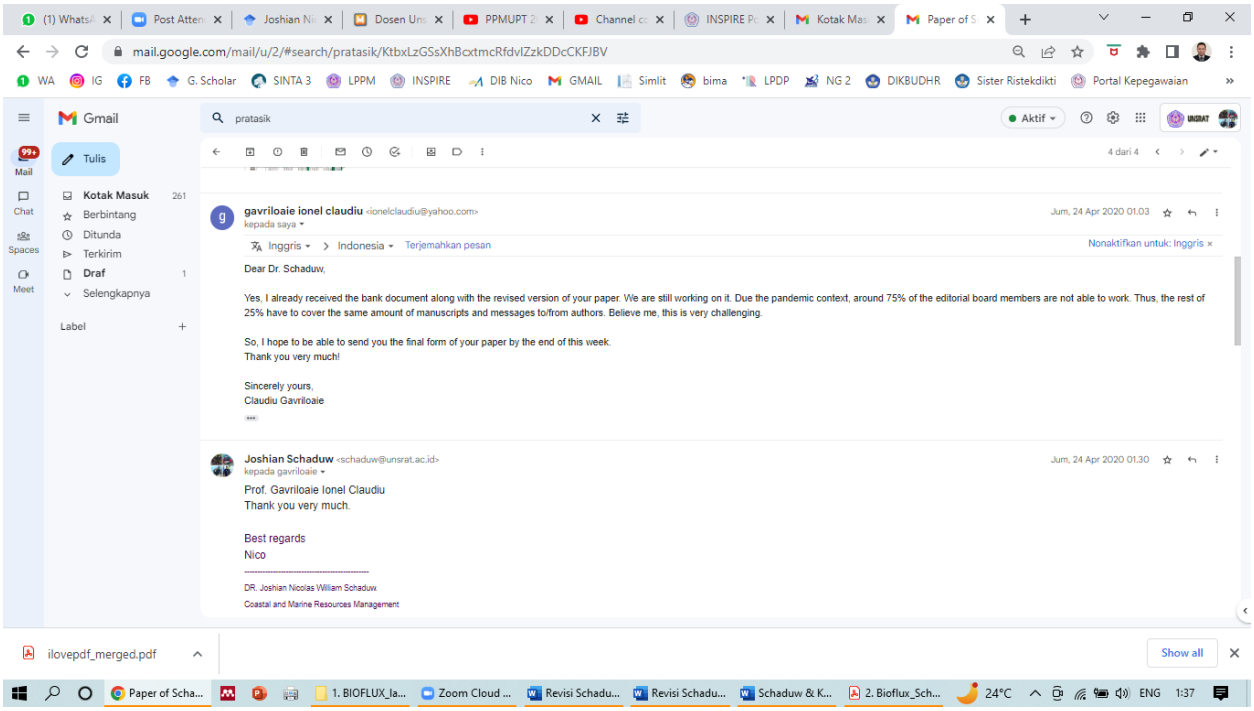

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Thank you very much.

Best regards
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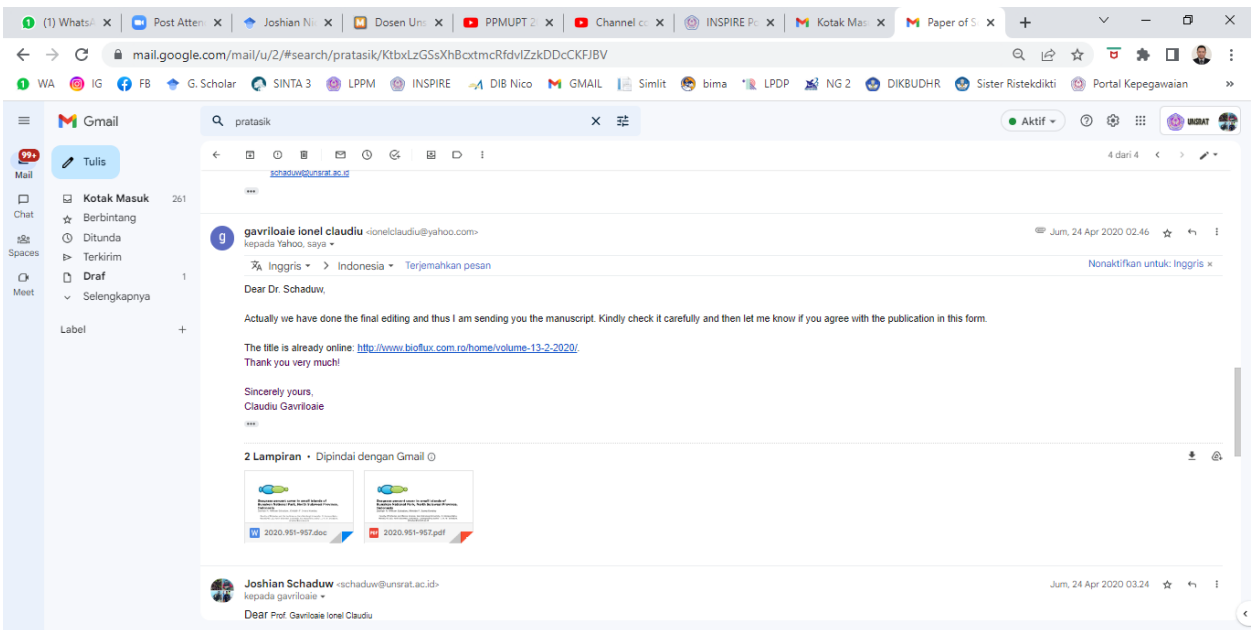

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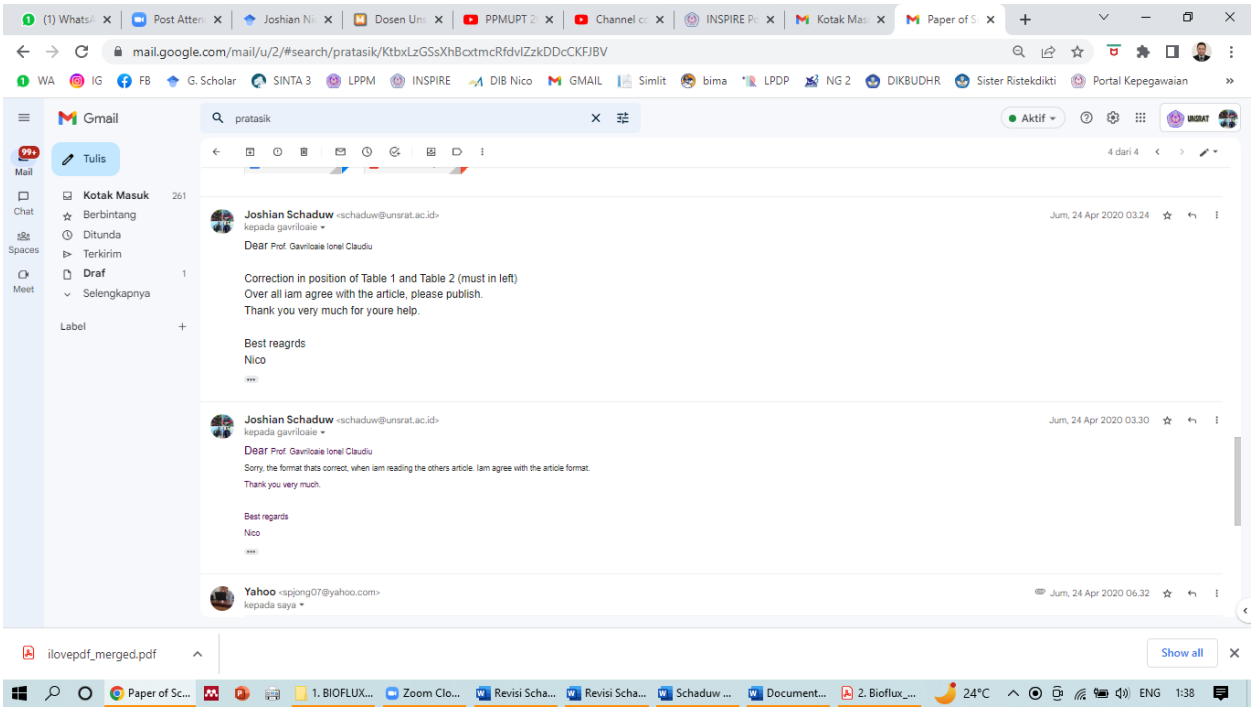
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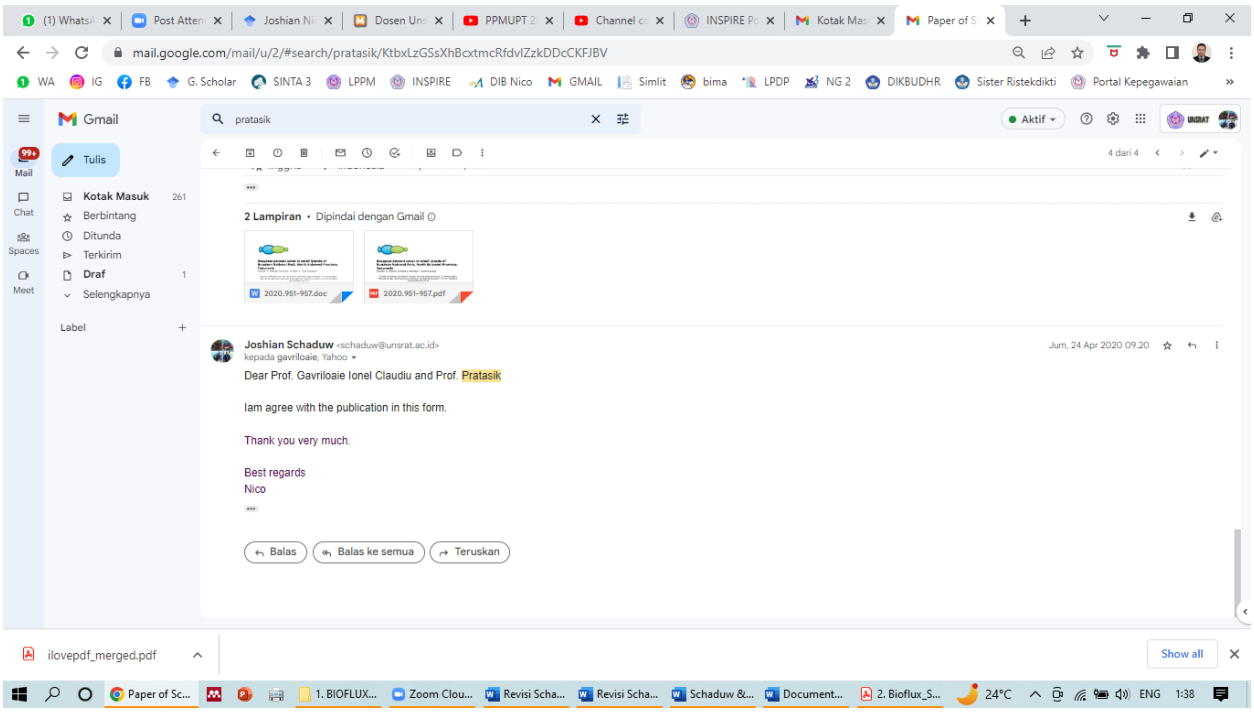
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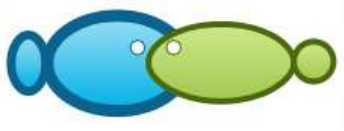

Seagrass community structure in small islands of Bunaken National Park, North Sulawesi Province, Indonesia

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Abstract. This study was carried out in Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands. It aims to analyze the seagrass composition, dominance, and mean percent cover in each island. The seagrasses were surveyed using quadrat transect perpendicular to the shore modified from Seagrass Watch method. Data processing and analysis followed the seagrass bed monitoring guide using Microsoft Excel software or other suitable program. There were 7 genera recorded in the study site, *Enhalus acoroides* (Linn. F.) Royle (Ea), *Thalassia hemprichii* (Ehrenbeg) (Th), *Cymodocea rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *C. serrulata* (R. Brown), *Halodule pinifolia* (Miki) den Hartog S (Hp), *Syringodium isoetifolium* (Ascherson) Dandy (Si) Ascherson & Magnus (Cs), and *Halodule uninervis* (Forskal) Ascherson (Hu). Four of 5 islands surveyed were categorized as moderate, Siladen Island 34.29%, Mantehage Island 33%, Bunaken Island 29.25%, and Nain Island 26.4%. However, Manado Tua Island was categorized as scarce, 19.32%.
Key Words: survey, quadrat transect, composition, dominance, percent cover.

Introduction. Seagrass ecosystem is one of the productive shallow water ecosystems and has an important role in supporting the life and the development of marine organisms. The role of seagrass in shallow waters is known as primary producer, habitat, sediment trap, nutrient provider (Bengen 2002) and rare element recycling (McKenzie & Yoshida 2009).

Seagrass has economic benefit as well, since it can be used as food material, animal's feed, paper raw material, craft material, fertilizer, and medicine (Nur 2011). In tropical waters as Indonesia, seagrass bed is more dominant to grow in colony of mixed species in certain areas different from temperate or cold waters that are mostly dominated by single species plant. There are about 63 species of seagrasses in the world, and 12 of them occur in Indonesia waters, dominated by several genera and species, such as *Enhalus acoroides, Cymodocea* spp., *Halodule* spp., *Halophila ovalis, Syringodium isoetifolium, Thallasia hemprichii,* and *Thalassodendron ciliatum* (Rahmawati et al 2014). The observations on seagrass community have been conducted in several waters with seagrass ecosystem. Seven species of seagrass was found in Tayando-Tam Island, *E. acoroides, T. hemprichii, Cymodocea serrulata, Cymodocea rotundata, Halodule pinifolia, H. ovalis,* and *S. isoetifolium*. *H. pinifolia* has the highest density in Tam Island (Fitrian et al 2017).

Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands have sufficiently good condition seagrass beds and their occurrence needs to be sustained due to their crucial role in marine ecosystem. However, quantitative information on seagrass community in natural ecosystems of these localities is still very few. This work focuses on the environmental condition and the seagrass communities around those 5 islands.

Material and Method. This study was conducted around 5 islands belonging to Bunaken National Park (Bunaken, Siladen, Manado Tua, Mantehage, and Nain). On each island, four stations have been set, in order to evaluate the local seagrass bed conditions (Figure

Commented [indra1]: actually you provide the species

Commented [indra2]: perhaps sites since you had several islands?

Commented [indra3]: it has no use to load the text with the auhtors names. Moreover, you did not write the complete names for some species. So, keep the species names only.

Commented [indra4]: I suggest not to complicate the Abstract with these short names. It is enough to mention them further in text

Commented [indra5]: be more specific here. Moderate from which point of view? Based on what parameter / index?

Commented [indra6]: in the Discussion section you say 60.98%

Commented [indra7]: in the Discussion section you say 40%

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Commented [indra13]: it would be great to mention the books / fieldguides you used for detemining the seagrass species. Do not forget to add these papers on the References list too

Commented [indra14]: you definitely can add more information regarding the methods. See the comments within the section.

In addition, within the Abstract you said "It aims to analyze the seagrass composition, **dominance**, and mean percent cover in each island". So, we see no references on the dominance parameter within the Material & Method section.

1). The study was conducted from July 2019 to February 2020. In seagrass ecosystem monitoring, the main parameter measured is the percent cover. This measurement is taken as a form of resources management and protection effort in the system. The study utilized a quadrat transect method perpendicular to the shore modified from Seagrass Watch method (McKenzie 2003). This technique used transect line and quadrat-shaped frame. In data collection, the transect line was laid on the seagrass bed, and all seagrasses included in the quadrat were recorded.

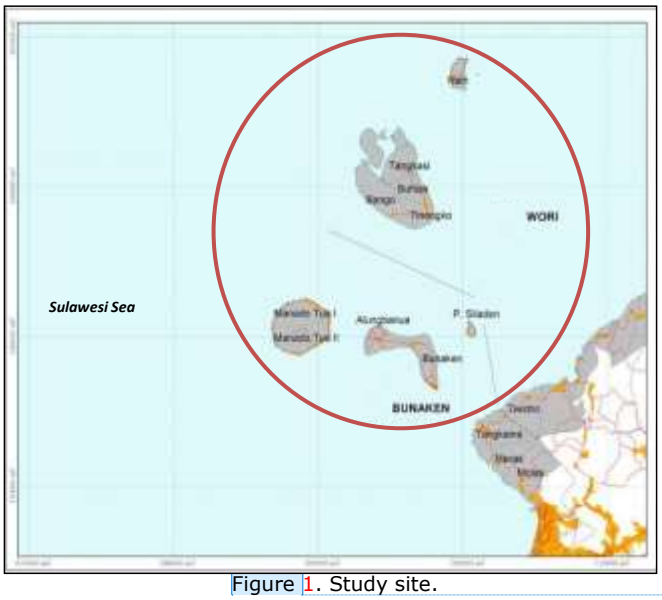

Figure 1. Study site.

Data were collected by placing three 100 m-transects with 50 m distance between the transects so total transect cover was 100 x 100 m². Eleven 50x50 cm quadrats were placed along the right hand of the transect at the distance of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 m (Figure 2).

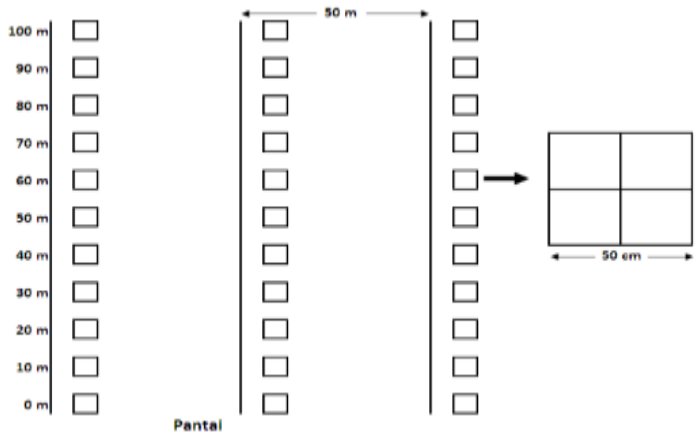

Figure 2. Quadrat transect scheme in the seagrass bed.

Commented [indra15]: on a montly basis? Be more specific, add more info about the sampling intervals and duration.

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Commented [indra17]: how? See one of the previous comments

Commented [indra18]: add the scale and the North arrow to the map.

Commented [indra19]: how you did actually? Visual observation from the boat? By Scuba diving? Be more specific

Commented [indra20]: we suppose you did this on each isand. So, clearly state this

Commented [indra21]: how did you place the quadrats? Which were the actions? How did you make them stable in the water column since they had to stay there for few months (between July and February, which is 8 months)?

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Data processing and analysis. Data analysis followed the Seagrass Monitoring Guide (Rahmawati et al 2014) using Microsoft Excel software or other appropriate program. The processed data were then tabulated and used to describe the seagrass condition in each island. The seagrass condition is monitored every year based on mean seagrass cover per island or site. Mean cover in a locality is categorized as presented in Table 1.

Table 1

Criteria of seagrass cover category (Susi et al 2014)

Cover (%)	*Category*
0-25	Rare
26-50	Moderate
51-75	Dense
76-100	Very dense

Results and Discussion

Bunaken Island. There were 40% seagrass around Bunaken Island and recorded 5 species in point 1 of east Bunaken (BL01) and point 2 at the southeast Bunaken, in front of the village (BL02), *E. acoroides* (Linn. F.) Royle (Ea), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp) and *S. isoetifolium* (Ascherson) Dandy (Si). Point 3, Bunaken Fukui (BL03), was recorded 2 species, *E. acoroides* and *C. rotundata,* and point 4, Bunaken Alungbanua (BL04), was found 2 species, *H. pinifolia* and *S. isoetifolium.* The dominant species was *E. acoroides* with mean cover of 15.37% in points 1, 2, and 3. The seagrass cover in Bunaken Island belonged to single seagrass plant with 2-3 associated seagrass species and clumped in different cover with species.

Siladen Island. Seagrass bed in Siladen Island had the highest cover among islands on study, 60.98%, at point 4. There were 5 seagrass species found at point 1, north Siladen (SL01), point 2, east Siladen (SL02), point 3, in front of Siladen resort (SL03), and point 4, Siladen yetty (SL04), i.e. *E. acoroides* (Linn. F.) Royle (Ea), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), and *S. isoetifolium* (Ascherson) Dandy (Si). The dominant species was *E. acoroides* with mean cover of 10.12% and occurred in each study point. The area is dominated by sandy bottom, then followed by dead corals and mud.

Manado Tua Island. Seagrass ecosystem in Manado Tua waters had the lowest cover among the islands, 19.32%. Four species were recorded at point 1, Manado Tua Pangalingan 1 (MT01), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), and *S. isoetifolium* (Ascherson) Dandy (Si), 5 species at point 2, Manado Tua Pangalingan 2 (MT02), *E. acoroides* (Linn. F.) Royle (Ea), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), and *S. isoetifolium* (Ascherson) Dandy (Si), 4 species at point 3, Manado Tua Bualo 1 (MT03), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), and *S. isoetifolium* (Ascherson) Dandy (Si), 3 species at point 4, Manado Tua Bualo 4 (MT04), *T. hemprichii* (Ehrenbeg) (Th), *H. pinifolia* (Miki) den Hartog (Hp), and *S. isoetifolium* (Ascherson) Dandy (Si). The dominant species was *T. hemprichii* with mean cover of 13.8%.

Mantehage Island. Based on the seagrass monitoring in 4 study points of Mantehage Island, there was mean cover of 33%. Point 1, Mantehage Bango (ML01), was recorded only one species *E. acoroides* ((Linn. F.) Royle (Ea), point 2, Mantehage Tinongko (ML02), was found 3 species, *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), and *H. pinifolia* (Miki) den Hartog (Hp), point 3, Mantehage Buhias (ML03), was found 3 species, *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata*

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Commented [indra26R25]: ke sure there is a perfect match bewteen the data provided in text and the data provided in table 2 for each Island. Due to the authors names and short names of the species, the text is difficult to be followed.

Commented [indra27]: you provided a different value within the Abstract

Commented [indra28]: all these points (stations) need to be briefly presented in the Material & Method section as well

Commented [indra29]: see the comment in the Abstract regarding these authors' names

Commented [indra30]: basically you only use theseshort names only in Table 2. Allover the text you used the scientific names. So, I see no use to add these short names in text. The best option is to remove them.

Commented [indra31]: how did you calculate this? Did you use the Dominance index formula?

However, you did not mention anything about this parameter (the dominance) in the Material & Method section. Please do this.

Commented [indra32]: I would rather say "single dominant seagrass species"

Commented [indra33]: you provided a different value within the Abstract

Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), point 4, Mantehage Bella Point (ML04), was recorded 3 species, *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp). The dominant species was *T. hemprichii* with mean cover of 13.8%. The dominant substrate was mud.

Nain Island. Monitoring activitiy in Nain island found 26.4% seagrass cover. Two species, *E. acoroides* ((Linn. F.) Royle (Ea) and *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr) were found at point 1, Nain Batu kapal (NL01), 3 species at point 2 Nain Jalan Masuk (NL02), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata*, and *H. pinifolia* (Miki) den Hartog (Hp), 3 species at point 3, south Nain island (NL03), *C. serrulata* (R. Brown) Ascherson & Magnus(Cs), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), and *H. pinifolia* (Miki) den Hartog (Hp), and 3 species at point 4, Nain Pasir Timbul (NL04), *E. acoroides* ((Linn. F.) Royle (Ea), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), and *H. pinifolia* (Miki) den Hartog (Hp). The dominant substrate was mud (Table 2).

Commented [indra34]: in the table you have the cover dominance of the seagrass species, not the substrate.

Table 2

Mean seagrass cover and dominance in the study site

Locality	*Station*	*Mean cover*	*Dominance*						
			Ea	*Th*	*Cs*	*Cr*	*Hu*	*Hp*	*Si*
Bunaken Is.	TNB-L01	35	11	12	0	2.34	0	2.46	9.09
	TNB-L02	40	17	8	0	10	0	0	3
	TNB-L03	25	23.5	0	0	1.52	0	0	0
	TNB-L04	17	10	0	0	0.0	0	4	17.1
	Mean	29.25	15.3	5.00	0	3.46	0	1.62	7.30
	SD	10.28	6.23	6.00	0	4.46	0	1.97	7.55
Siladen Is.	TNB-L05	26	8	2	0	3	0	7	9
	TNB-L06	25,4	19.3	4.55	0	1.70	0	3.03	3.03
	TNB-L07	24.8	3.60	4.55	0	10.6	0	3.03	3.03
	TNB-L08	60.98	1.52	29.3	0	14.9	0	15	14.73
	Mean	34.29	8.11	10.1	0	7.57	0	6.95	7.45
	SD	17.80	7.95	12.8	0	6.30	0	5.52	5.61
Manado Tua Is.	TNB-L09	22.54	0	9.09	0	0	5.87	0.76	6.82
	TNB-L10	26.32	0.75	13.0	0	0	7.57	2.46	2.46
	TNB-L11	13.06	0	0.18	0	0	5.8	0.9	5.3
	TNB-L12	15.34	0	2.65	0	0	0	6.06	6.62
	Mean	19.32	0.19	6.24	0	0	4.83	2.56	5.30
	SD	6.18	0.38	5.89	0	0	3.32	2.46	2.01
Mantehage Is.	TNB-L13	34	34	0	0	0	0	0	0
	TNB-L14	37	0	19	0	5	0	14	0
	TNB-L15	28	0	19	0	2	0	8	0

Commented [indra35]: pay attention to all these values, because there are differences between the values in the table and the values in the Abstract and in text!!!

Commented [indra36]: you did not mention this species above in text, when you presented the seagrass species in the Manado Tua Island

	TNB-L16	33	8	17	0	0	0	9	0
	Mean	33	10.5	13.8	0	1.75	0	7.75	0
	SD	3.74	16.1	9.22	0	2.36	0	5.80	0
Nain Is.	TNB-L17	25	22.9	0	0	2.08	0	0	0
	TNB-L18	24.2	0	13.3	13.3	0	0	12.1	0
	TNB-L19	25.9	0	0	15.3	0.56	0	7.76	0
	TNB-L20	30.3	26.3	0	0	1.52	0	2.46	0
	Mean	26.4	12.3	3.32	7.15	1.04	0	5.59	0
	SD	2.71	14.3	6.63	8.30	0.94	0	5.43	0

Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Si = *Syringodium isoetifolium*.

Species composition. Seven species were found in all observation points, *E. acoroides* (Linn. F.) Royle (Ea), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), *S. isoetifolium* (Ascherson) Dandy (Si), and *C. serrulata* (R. Brown) Ascherson & Magnus(Cs), *H. uninervis* (Forskal) Ascherson (Hu). None of the observation points was found 7 species, and each species was distributed over the 20 study points. Several points were recorded 5 species and the other was found only 2-4 species.

Commented [indra37]: see the comment in the table

Commented [indra38]: check the English

Species dominance. Seagrass community was dominated by *E. acoroides* in Bunaken waters with 15.3% cover, *T. hemprichii* in Siladen waters with 10.1% cover, *T. hemprichii* in Manado Tua waters with 6.24% cover, *T. hemprichii* in Mantehage Island with 13.8% cover, and *E. acoroides* in Nain waters with 12.3% cover (Figure 3). As a whole, two islands were dominated by *E. acoroides* and three others by *T. hemprichii*. This species is mostly found in the study sites. It could occur from that the species is one of the pioneer species that naturally exists in the open tidal area (Hidayat et al 2014). Alie (2010) reported high seagrass productivity at high water temperature, and salinity could also affect the biomass, productivity, and recovery rate. Water turbidity could indirectly influence the seagrass occurrence, since it can inhibit light intensity need for photosynthesis, especially in rainy season pada saat hujan air akan menjadi keruh sehingga pertumbuhan lamun menjadi lambat (Dwindaru 2010; Tanaka & Kayanne 2007). Dobo (2009) found very high tolerance of *T. hemprichii* to the sediment in Hatta Island. *E. acoroides* can even live in the terrigenous muddy sediment to coarse sediment of carbonate or from low water salinity near the river mouth to high salinity around the islands far from the river mouth (Erftemeijer et al 1993; Waycott et al 2004).

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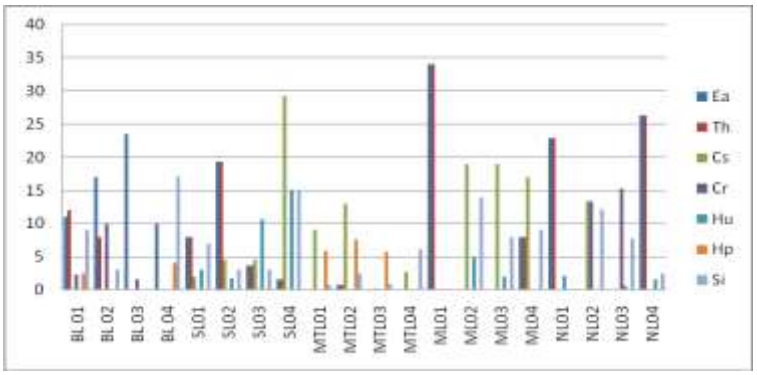

Figure 3. Seagrass species dominance.

Percent cover of seagrass. Field observations showed different seagrass cover, 29.25% in Bunaken waters, 34.29% in Siladen waters, 19.32% in Manado Tua waters, 33% in Mantehage waters, and 26.4% in Nain waters. These differences could result from different ecological conditions and morphology of the islands. Siladen Island has wide seagrass bed because it has slant coastal type and is dominated by large coral reef area. This island possesses high seaweed productivity, while Mantehage Island had the second largest cover with very wide mangrove ecosystem that supported the seagrass survivorship there. Based on the percent cover, the seagrass condition in Bunaken, Siladen, Mantehage, and Nain wasters was moderate, while that in Manado Tua was rare (Figure 4). This study reflects that the seagrass condition in the small islands of Bunaken National Park is good and could support the survivorship of the associated biota, and thus, the present seagrass cover condition needs to be protected from degradation, since this condition is highly susceptible to the anthropogenic activities.

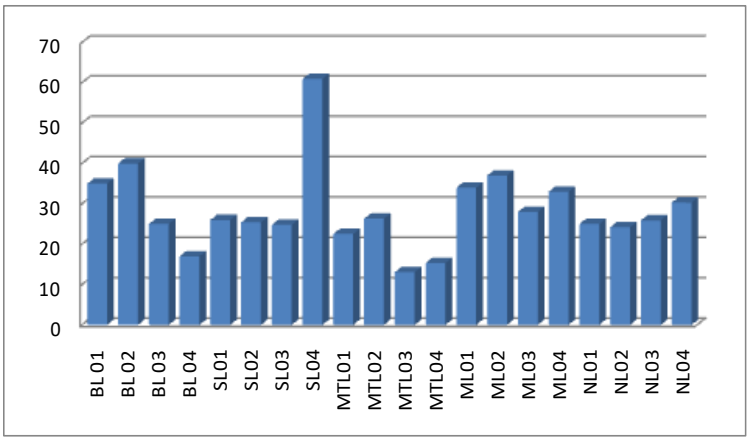

Figure 4. Seagrass percent cover.

Conclusions. There were 7 seagrass species recorded at 20 observation points around 5 islands of Bunaken National Park, *E. acoroides* (Linn. F.) Royle (Ea), *T. hemprichii* (Ehrenbeg) (Th), *C. rotundata* Ehrenbeg & Hemprich, ex Acherson (Cr), *H. pinifolia* (Miki) den Hartog (Hp), *S. isoetifolium* (Ascherson) Dandy (Si), and *C. serrulata* (R. Brown) Ascherson & Magnus (Cs), and *H. uninervis* (Forskal) Ascherson (Hu). Seagrass percent cover indicated that the waters around 4 islands was in moderate category, 34.29% for Siladen Island, 33% for Mantehage Island, 29.25% for Bunaken Island, and 26.4% for Nain Island, respectively. Manado Tua Island was categorized as rare, 19.32%.

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Acknowledgements. The authors would greatly appreciate the Directorate General of Research and Development Strengthening, the Ministry of Education and Culture of Indonesian Republic, the Education Fund Managing Board of the Ministry of Financial Affairs of Indonesian Republic, Bunaken National Park Office, the Ministry of Living Environment and Forestry, the Indonesia Science Institution, the Faculty of Fisheries and Marine Science, Sam Ratulangi University, and all stakeholders who have participated and supported this work.

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Commented [indra41]: add more references in the list, especially from the recent years (2019-2018), the most recent one being from 2017.

As far as we know, there are quite many papers regarding this National Park, Bunaken

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Commented [indra44]: such theses can have only one author. So, keep the graduate student's name only, and remove the coordinators' names.

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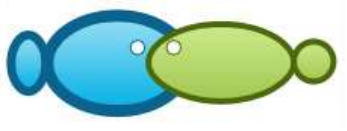

Seagrass community structure in small islands of Bunaken National Park, North Sulawesi Province, Indonesia

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Abstract. This study was carried out in Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands. It aims to analyze the seagrass composition, dominance percent of species, and mean percent cover in each island. The seagrasses were surveyed using quadrat transect perpendicular to the shore modified from Seagrass Watch method. Data processing and analysis followed the seagrass bed monitoring guide using Microsoft Excel software or other suitable program. There were 7 species recorded in the study sites, *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule pinifolia, Syringodium isoetifolium* and *Halodule uninervis*. Four of 5 islands surveyed were categorized as moderate base on Criteria of seagrass cover category (Susi et al 2014), Siladen Island 34.29%, Mantehage Island 33%, Bunaken Island 29.25%, and Nain Island 26.4%. However, Manado Tua Island was categorized as scarce, 19.32%. Berdasrkan hasil kajian ini maka kondisi padang lamun pada pulau-pulau kecil Taman Nasional Bunaken secara keselurahan dalam kondisi yang baik, dan memiliki tingkat keanekaragaman yang cukup tinggi. Pemantauan secara berkala terhadap kondisi persentase tutupan lamun sangat dibutuhkan untuk meminimalkan degradasi pada ekosistem ini.
Key Words: survey, quadrat transect, composition, dominance, percent cover.

Introduction.

Seagrass ecosystem is one of the productive shallow water ecosystems and has an important role in supporting the life and the development of marine organisms. The role of seagrass in shallow waters is known as primary producer, habitat, sediment trap, nutrient source Bengen 2002) and rare element recycling (McKenzie & Yoshida 2009).

Seagrass has economic benefit as well, since it can be used as food material, animal's feed, paper raw material, craft material, fertilizer, and medicine (Nur 2011). In tropical waters as Indonesia, seagrass bed is more dominant to grow in colony of mixed species in certain areas different from temperate or cold waters that are mostly dominated by single species plant. There are about 63 species of seagrasses in the world, and 12 of them occur in Indonesia waters, dominated by several genera and species, such as *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Cymodocea. serrulata, Haludole pinifolia, Halodule uninervis, Halophila decipiens, Halophila ovalis, Halophila minor, Halophila spinulosa, Syringodium iseotifolium, and Thalassodendron ciliatum* (Rahmawati et al 2014). The observations on seagrass community have been conducted in Tayando-Tam Island with seagrass ecosystem. Seven species of seagrass was found in Tayando-Tam Island, *E. acoroides, T. hemprichii, Cymodocea serrulata, Cymodocea rotundata, Halodule pinifolia, H. ovalis,* and *S. isoetifolium*. *H. pinifolia* has the highest density in Tam Island (Fitrian et al 2017).

Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands have sufficiently good condition seagrass beds and their occurrence needs to be sustained due to their crucial role in marine ecosystem. However, quantitative information on seagrass community in natural ecosystems of these localities is still very few. This work focuses on the environmental condition and the seagrass communities around those 5 islands.

Commented [indra1]: actually you provide the species kenapa disebut genera, tetapi yang diberikan adalah spesies? (sudah diperbaiki)

Commented [indra2]: be more specific here. Moderate from which point of view? Based on what parameter / index?

Lebih spesifik. Berdasarkan apa disebut moderate? (Sudah diperbaiki)

Commented [indra3]: in the Discussion section you say 60.98%

di pembahasan dise but 60.98% (ditabel 34,29) akan diubah di pembahasan

Commented [indra4]: in the Discussion section you say 40%

di pembahasan 40% (diperbaiki ditabel mean =29,25)

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sama (diperbaikiditabel mean = 19,32)

Commented [indra6]: add some concluding remarks too

Tambah kesimpulan (sudah ditambahkan, tolong Mner Ciu terjemahkan)

Commented [indra7]: you say 12 and then provide only 7

Disebut ada 12, tapi hanya disebutkan 7 (sudah diperbaiki ada 12)

Commented [indra8]: be more specific here. Do you refer to Indonesian waters? Or to the waters around the Bunaken only? Besides, is Fitriani et al (2017) the only study regarding these waters?

Lebih spesifik. Ini hanya di perairan Indonesia atau Bunaken? Fitriani hanya meneliti di perairan ini. (kondisi di Pulau Tayando -Tam)

Material and Method.

This study was conducted around 5 islands belonging to Bunaken National Park (Bunaken, Siladen, Manado Tua, Mantehage, and Nain). On each island, four stations have been set, in order to evaluate the local seagrass bed conditions (Figure 1). The study was conducted from July 2019 (Bunaken Is; Siladen Is; Manado Tua Is) and February 2020 (Mantehage Is ; Nain Is).Stasiun pengamatan mewakili bagian utara, selatan, timur dan barat masing-masing pulau. In seagrass ecosystem monitoring, the main parameter measured is the percent cover. This measurement is taken as a form of resources management and protection effort in the system. The study utilized a quadrat transect method perpendicular to the shore modified from Seagrass Watch method (McKenzie 2003) and guide to segrass bed monitoring dor identification (Rahmawati et al, 2014) . This technique used transect line and quadrat-shaped frame. Pengambilan data dilakukan pada tiga transek dengan panjang masing-masing 100 m dan jarak antara satu transek dengan yang lain adalah 50 m sehingga total luasannya 100 x 100 m2. Frame kuadrat diletakkan di sisi kanan transek dengan jarak antara kuadrat satu dengan yang lainnya adalah 10 m sehingga total kuadrat pada setiap transek adalah 11 (Gambar 2). Titik awal transek diletakkan pada jarak 5 – 10 m dari kali pertama lamun dijumpai (dari arah pantai) data diambil pada saat surut dengan cara berjalan menyusuri transek, kuadran yang digunakan diambil kembali setelah melakukan pencatatan data (Rahmawati et al, 2014). In data collection, the transect line was laid on the seagrass bed, and all seagrasses included in the quadrat were recorded.

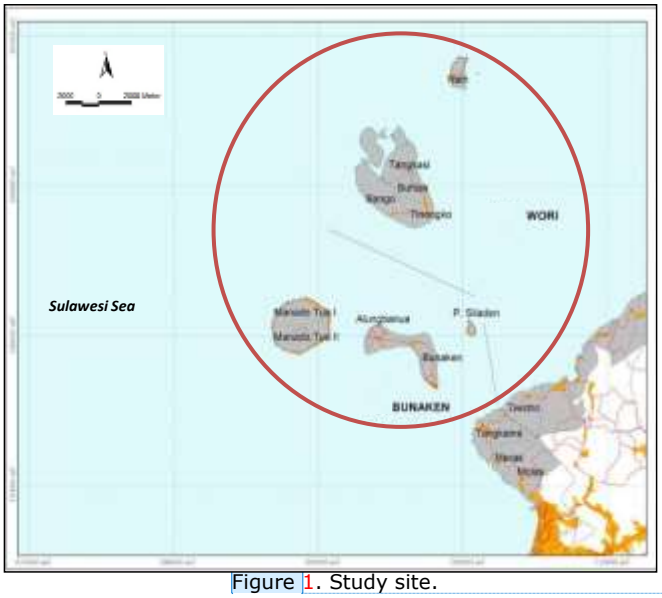

Figure 1. Study site.

Commented [indra9]: it would be great to mention the books / fieldguides you used for detemining the seagrass species. Do not forget to add these papers on the References list too

Buku identifikasi spesies yang dipakai perlu ditampilkan dan juga ditambahkan pada DP.(sudah di tambahkan di bawah)

Commented [indra10]: you definitely can add more information regarding the methods. See the comments within the section.

In addition, within the Abstract you said "It aims to analyze the seagrass composition, **dominance**, and mean percent cover in each island". So, we see no references on the dominance parameter within the Material & Method section.

Di Material & Method tidak ada pustaka tentang parameter dominasi (yang dimaksud dominasi adalah dominasi spesies dlm persentase)

Commented [indra11]: on a montly basis? Be more specific, add more info about the sampling intervals and duration.
Ini atas dasar bulanan? Tambah informasi tentang selang waktu sampling dan lamanya. (sudah dijelaskan pembagiannya)

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Jelaskan prosedurnya (sudah ditambahkan, tolong Mner Ciu terjemahkan)

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Jelaskan (dijelaskan dibagian atas)

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Tambahkan skala dan arah pada peta (sudah diperbaiki)

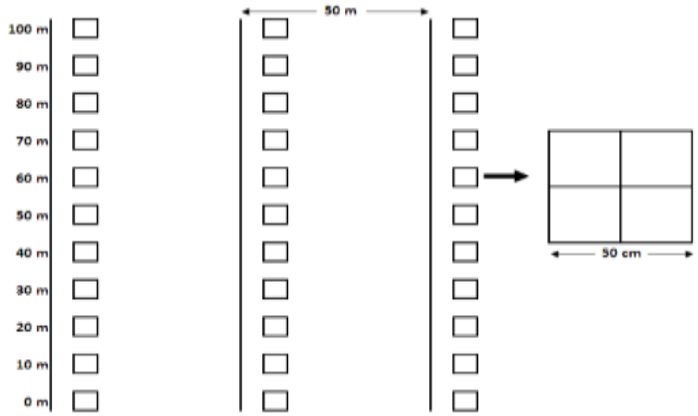

Figure 2. Quadrat transect scheme in the seagrass bed.

Data processing and analysis.

Data analysis followed the Seagrass Monitoring Guide (Rahmawati et al 2014) using Microsoft Excel software. The processed data were then tabulated and used to describe the seagrass percentage cover in each island. The seagrass condition is monitored every year based on mean seagrass cover per island or site. Mean cover in a locality is categorized as presented in Table 1.

Table 1 Criteria of seagrass cover category (Susi et al 2014)

Cover (%)	*Category*
0-25	Rare
26-50	Moderate
51-75	Dense
76-100	Very dense

Results and Discussion

Bunaken Island.

There were 29,25% seagrass around Bunaken Island and recorded 5 species in point 1 of east Bunaken (BL01) and point 2 at the southeast Bunaken, in front of the village (BL02), *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia* and *S. isoetifolium*. Point 3, Bunaken Fukui (BL03), was recorded 2 species, *E. acoroides* and *C. rotundata,* and point 4, Bunaken Alungbanua (BL04), was found 2 species, *H. pinifolia* and *S. isoetifolium.* The dominant percentage species was *E. acoroides* with mean cover of 15.37% in points 1, 2, and 3. The seagrass cover in Bunaken Island belonged to single dominant seagrass species with 2-3 associated seagrass species and clumped in different cover with species. Kondisi yang baik terhadap persentase penutupan lamun Pulau Bunaken didukung oleh kondisi kualitas perairan yang mendukung kelangsungan hidup biota didalamnya dan ekosistem terkait lainnya (Mangrove dan terumbu karang) (Schaduw, 2018a). Selain memilik padang lamun, pulau ini juga memiliki ekosistem terumbu karang yang baik, beberapa lokasi penyelaman yang menjadi destinasi wisata bawah air terdapat dipulau ini (Kamagi et al, 2016 and Luasunaung et al, 2015)

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Gambar masih Bahasa Indonesia "pantai" (sudah dihapus)

Commented [indra16]: in fact, you evaluated the seagrass percentage cover, not its condition

Jelaskan persentase tutupan seagrass, bukan kondisinya(sudah diperbiki)

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Data table 2 tidak sesuai data di teks. Karena nama penulis dan nama singkat spesies, teks sulit diikuti.(sudah dihapus nama orang dan singkatannya)

Commented [indra19]: you provided a different value within the Abstract

Di abstraak nilai ini berbeda. Mana yang benar? (sudah diperbaiki)

Commented [indra20]: all these points (stations) need to be briefly presented in the Material & Method section as well.

Semua deskripsi stasiun perlu dijelaskan di metode (sudah dijelaskan dimetode, tolong diterjemahkan)

Commented [indra21]: how did you calculate this? Did you use the Dominance index formula?
Bagaimana menghitung dominasi? Taruh di method

However, you did not mention anything about this parameter (the dominance) in the Material & Method section. Please do this.
(Dominasi yang dimaksud adalah persetase dominasi jenis)

Siladen Island.

Seagrass bed in Siladen Island had the highest cover among islands on study, 34,29%, at point 4. There were 5 seagrass species found at point 1, north Siladen (SL01), point 2, east Siladen (SL02), point 3, in front of Siladen resort (SL03), and point 4, Siladen yetty (SL04), i.e. *E. acoroides*, *T. hemprichii* , *C. rotundata* , *H. pinifolia* , and *S. isoetifolium* . The dominant species was *E. acoroides* with mean cover of 10.12% and occurred in each study point. The area is dominated by sandy bottom, then followed by dead corals and mud.

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Nilai ini berbeda dengan nlai di abstrak (sudah diperbaiki)

Manado Tua Island. Seagrass ecosystem in Manado Tua waters had the lowest cover among the islands, 19.32%. Four species were recorded at point 1, Manado Tua Pangalingan 1 (MT01), *T. hemprichii*, H. *uninervis* , *H. pinifolia* , and *S. isoetifolium* , 5 species at point 2, Manado Tua Pangalingan 2 (MT02), *E. acoroides* , *T. hemprichii,* H. *uninervis*, *H. pinifolia* , and *S. isoetifolium* , 4 species at point 3, Manado Tua Bualo 1 (MT03), *T. hemprichii*, H. *uninervis*, *H. pinifolia* , and *S. isoetifolium* , 3 species at point 4, Manado Tua Bualo 4 (MT04), *T. hemprichii*, *H. pinifolia* , and *S. isoetifolium* . The dominant species was *T. hemprichii* with mean cover of 6.24%. Kualitas air ekosistem sekitar padang lamun juga sangat mendukung kelangsungan hidup biota dan konektivitas ekologi pulau ini (Schaduw, 2018a)

Mantehage Island. Based on the seagrass monitoring in 4 study points of Mantehage Island, there was mean cover of 33%. Point 1, Mantehage Bango (ML01), was recorded only one species *E. acoroides*, point 2, Mantehage Tinongko (ML02), was found 3 species, *T. hemprichii*, *C. rotundata* , and *H. pinifolia* , point 3, Mantehage Buhias (ML03), was found 3 species, *T. hemprichii*, *C. rotundata* , *H. pinifolia* , point 4, Mantehage Bella Point (ML04), was recorded 3 species, *T. hemprichii* , *C. rotundata* , *H. pinifolia* . The dominant species was *T. hemprichii* with mean cover of 13.8%. The dominant substrate was mud. Pulau Mantehage yang merupakan salah satu pulau terluar Indonesia selain memiliki ekosistem lamun yang besar, juga memiliki keanekaragaman yang tinggi pada ekosistem mangrove dan terumbu karang,diantara kelima pulau kecil yang ada di Taman Nasional Bunaken Pulau Mantehage memiliki ekosistem mangrove terbesar (Schaduw, 2015), Pulau ini juga memiliki kondisi terumbu karang yang baik dan dijadikan lokasi penyelaman (Kase et al, 2019)

Nain Island. Monitoring activitiy in Nain island found 26.4% seagrass cover. Two species, *E. acoroides* and *C. rotundata* were found at point 1, Nain Batu kapal (NL01), 3 species at point 2 Nain Jalan Masuk (NL02), *T. hemprichii*, *C. rotundata*, and *H. pinifolia*, 3 species at point 3, south Nain island (NL03), *C. serrulata*, *C. rotundata*, and *H. pinifolia* and 3 species at point 4, Nain Pasir Timbul (NL04), *E. acoroides*, *C. rotundata*, and *H. pinifolia* (Table 2). The dominant species was *E. acoroides* with mean cover of 12.3%. Ekosistem lamun Pulau Nain sangat didukung oleh keberadaan ekosistem lainnya seperti mangrove dan terumbu karang, pulau ini memiliki mangrove yang masih baik dan terjaga, degradasi pada ekosistem ini sangat kecil, sehingga konektivitas antar ekosistem pesisir disana terjalin dengan baik (Schaduw, 2018b)

Table 2 Mean seagrass cover and dominance in the study site

Locality	*Station*	*Percentage Cover (%)*	*Dominance species (%)*						
			Ea	*Th*	*Cs*	*Cr*	*Hu*	*Hp*	*Si*
Bunaken Is.	BL01	35	11	12	0	2.34	0	2.46	9.09
	BL02	40	17	8	0	10	0	0	3
	BL03	25	23.5	0	0	1.52	0	0	0
	BL04	17	10	0	0	0.0	0	4	17.1
	Mean	29.25	15.3	5.00	0	3.46	0	1.62	7.30
	SD	10.28	6.23	6.00	0	4.46	0	1.97	7.55
Siladen Is.	SL01	26	8	2	0	3	0	7	9
	SL02	25,4	19.3	4.55	0	1.70	0	3.03	3.03
	SL03	24.8	3.60	4.55	0	10.6	0	3.03	3.03
	SL04	60.98	1.52	29.3	0	14.9	0	15	14.73
	Mean	34.29	8.11	10.1	0	7.57	0	6.95	7.45
	SD	17.80	7.95	12.8	0	6.30	0	5.52	5.61
Manado Tua Is.	MT01	22.54	0	9.09	0	0	5.87	0.76	6.82
	MT02	26.32	0.75	13.0	0	0	7.57	2.46	2.46
	MT03	13.06	0	0.18	0	0	5.8	0.9	5.3
	MT04	15.34	0	2.65	0	0	0	6.06	6.62
	Mean	19.32	0.19	6.24	0	0	4.83	2.56	5.30
	SD	6.18	0.38	5.89	0	0	3.32	2.46	2.01
Mantehage Is.	ML01	34	34	0	0	0	0	0	0
	ML02	37	0	19	0	5	0	14	0
	ML03	28	0	19	0	2	0	8	0
	ML04	33	8	17	0	0	0	9	0
	Mean	33	10.5	13.8	0	1.75	0	7.75	0
	SD	3.74	16.1	9.22	0	2.36	0	5.80	0
Nain Is.	NL01	25	22.9	0	0	2.08	0	0	0
	NL02	24.2	0	13.3	13.3	0	0	12.1	0
	NL03	25.9	0	0	15.3	0.56	0	7.76	0
	NL04	30.3	26.3	0	0	1.52	0	2.46	0
	Mean	26.4	12.3	3.32	7.15	1.04	0	5.59	0
	SD	2.71	14.3	6.63	8.30	0.94	0	5.43	0

Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Si = *Syringodium isoetifolium*.

Commented [indra23]: you did not mention this species above in text, when you presented the seagrass species in the Manado Tua Island

anda tidak sebutkan spesies ini di teks ketika ada sebutkan spesies lamun di p. manado tua.(sudah diperbaiki)

Species composition.

Seven species were found in all observation points, *E. acoroides* (Ea), *T. hemprichii (Th)*, *C. rotundata* (Cr), *H. pinifolia* (Hp), *S. isoetifolium* (Si), *C. serrulata* (Cs), and *H. uninervis* (Hu). None of the observation points had 7 species, and each species was distributed over the 20 study points. Several points had 5 species and the other had only 2-4 species.

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lihat komentar di tabel (sudah diperbaiki)

Species dominance.

Seagrass community was dominated by *E. acoroides* in Bunaken waters with 15.3% cover, *T. hemprichii* in Siladen waters with 10.1% cover, *T. hemprichii* in Manado Tua waters with 6.24% cover, *T. hemprichii* in Mantehage Island with 13.8% cover, and *E. acoroides* in Nain waters with 12.3% cover (Figure 3). As a whole, two islands were dominated by *E. acoroides* and three others by *T. hemprichii*. This species is mostly found in the study sites. It could occur from that the species is one of the pioneer species that naturally exists in the open tidal area (Hidayat et al 2014). Alie (2010) reported high seagrass productivity at high water temperature, and salinity could also affect the biomass, productivity, and recovery rate. Water turbidity could indirectly influence the seagrass occurrence, since it can inhibit light intensity need for photosynthesis, especially in rainy season, the seagrass growth becomes slow due to high water turbidity.

(Dwindaru 2010; Tanaka & Kayanne 2007). Dobo (2009) found very high tolerance of *T. hemprichii* to the sediment in Hatta Island. *E. acoroides* can even live in the terrigenous muddy sediment to coarse sediment of carbonate or from low water salinity near the river mouth to high salinity around the islands far from the river mouth (Erftemeijer et al 1993; Waycott et al 2004).

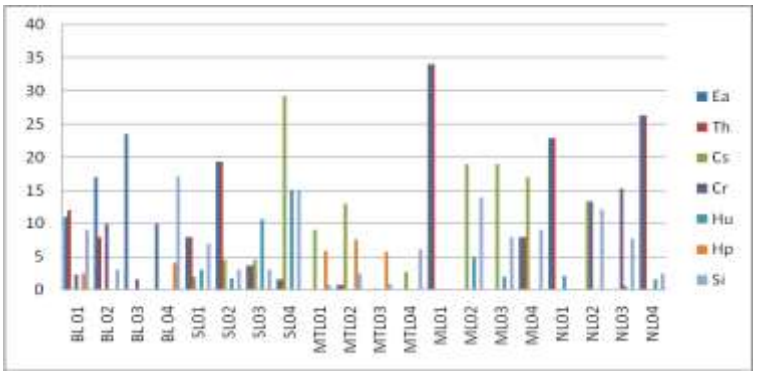

Figure 3. Seagrass species dominance.

Percent cover of seagrass.

Field observations showed different seagrass cover, 29.25% in Bunaken waters, 34.29% in Siladen waters, 19.32% in Manado Tua waters, 33% in Mantehage waters, and 26.4% in Nain waters. These differences could result from different ecological conditions and morphology of the islands. Siladen Island has wide seagrass bed because it has slant coastal type and is dominated by large coral reef area. This island possesses high seaweed productivity, while Mantehage Island had the second largest cover with very wide mangrove ecosystem that supported the seagrass survivorship there. Based on the percent cover, the seagrass condition in Bunaken, Siladen, Mantehage, and Nain wasters was moderate, while that in Manado Tua was rare (Figure 4). This study reflects that the seagrass condition in the small islands of Bunaken National Park is good and could support the survivorship of the associated biota, and thus, the present seagrass cover condition needs to be protected from degradation, since this condition is highly susceptible to the anthropogenic activities.

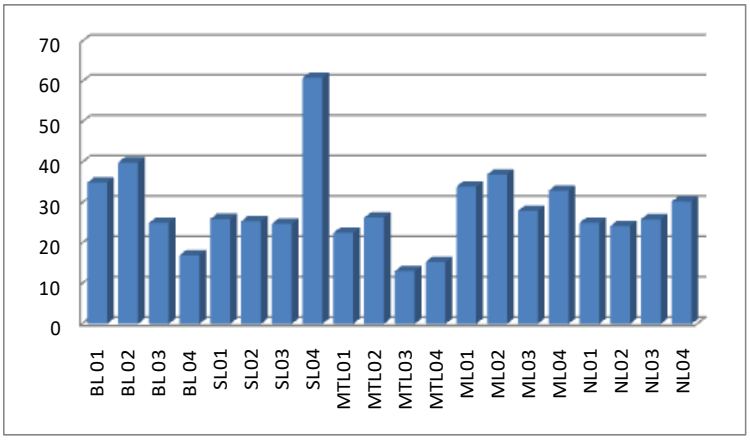

Figure 4. Seagrass percent cover.

Conclusions.

There were 7 seagrass species recorded at 20 observation points around 5 islands of Bunaken National Park, *E. acoroides* , *T. hemprichii* , *C. rotundata* , *H. pinifolia* , *S. isoetifolium* , and *C. serrulata* (R. Brown) Ascherson & Magnus (Cs), and *H. uninervis* (Forskal) Ascherson (Hu). Seagrass percent cover indicated that the waters around 4 islands was in moderate category, 34.29% for Siladen Island, 33% for Mantehage Island, 29.25% for Bunaken Island, and 26.4% for Nain Island, respectively. The seagrass percent cover in Manado Tua Island was categorized as rare, 19.32%.

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Commented [indra25]: add more references in the list, especially from the recent years (2019-2018), the most recent one being from 2017.

As far as we know, there are quite many papers regarding this National Park, Bunaken

Banyak artikel tentang p. Bunaken. Jadi tambahkan pustaka 2017-2019 (sudah ditambahkan, minta tolong diterjemahkan)

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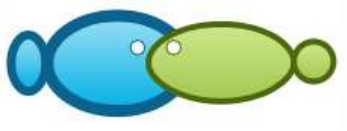

Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia

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Abstract. This study was carried out in Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands. It aims to analyze the seagrass composition and percent cover in each island. The seagrasses were surveyed using quadrat transect perpendicular to the shore modified from Seagrass Watch method. Data processing and analysis followed the seagrass bed monitoring guide using Microsoft Excel software or other suitable program. There were 7 species recorded in the study sites, *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule pinifolia, Syringodium isoetifolium* and *Halodule uninervis*. Four of 5 islands surveyed were categorized as moderate based on the seagrass cover category, Siladen Island 34.29%, Mantehage Island 33%, Bunaken Island 29.25%, and Nain Island 26.4%, while Manado Tua Island was categorized as scarce, 19.32%. As a whole, the seagrass bed condition in small islands of Bunaken National Park is in good condition and has sufficiently high diversity. However, periodic monitoring activities on the seagrass percent cover is strongly needed in order to minimize the ecosystem degradation.
Key Words: survey, quadrat transect, composition, dominance, percent cover.

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Jangan taruh pustaka di abstrak, tapi kategori ini perlu disebutkan dalam metodologi. [sudah diperbaiki]

Pustaka ini juga tidak ada di DP(ada kesalahan pengutipan seharusnya Rahmawati et al, 2014)

Introduction.

Seagrass ecosystem is one of the productive shallow water ecosystems and has an important role in supporting the life and the development of marine organisms. The role of seagrass in shallow waters is known as primary producer, habitat, sediment trap, nutrient source Bengen 2002) and rare element recycling (McKenzie & Yoshida 2009).

Seagrass has economic benefit as well, since it can be used as food material, animal's feed, paper raw material, craft material, fertilizer, and medicine (Nur 2011). In tropical waters as Indonesia, seagrass bed is more dominant to grow in colony of mixed species in certain areas different from temperate or cold waters that are mostly dominated by single species plant. There are about 63 species of seagrasses in the world, and 12 of them occur in Indonesia waters, dominated by several genera and species, such as *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, C. serrulata, Haludole pinifolia, H. uninervis, Halophila decipiens, H. ovalis, H. minor, H. spinulosa, Syringodium iseotifolium, and Thalassodendron ciliatum* (Rahmawati et al 2014). The observations on seagrass community have been conducted in Tayando-Tam Island with seagrass ecosystem. Seven species of seagrass was found in Tayando-Tam Island, *E. acoroides, T. hemprichii, C. serrulata, C. rotundata, Halodule pinifolia, H. ovalis,* and *S. isoetifolium*. *H. pinifolia* has the highest density in Tam Island (Fitrian et al 2017).

Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands have sufficiently good condition seagrass beds and their occurrence needs to be sustained due to their crucial role in marine ecosystem. However, quantitative information on seagrass community in natural ecosystems of these localities is still very few. This work focuses on the environmental condition and the seagrass communities around those 5 islands.

Material and Method.

This study was conducted around 5 islands belonging to Bunaken National Park (Bunaken, Siladen, Manado Tua, Mantehage, and Nain). In each island, four stations were set in order to evaluate the local seagrass bed conditions (Figure 1). The stations represent the northern, southern, eastern, and western parts of the island. The study was conducted from July 2019 (Bunaken Is, Siladen Is, and Manado Tua Is) and February 2020 (Mantehage Is and Nain Is). In seagrass ecosystem monitoring, the main parameter measured is the percent cover. This measurement is taken as a form of resources management and protection effort in the system. The study utilized a quadrat transect method perpendicular to the shore modified from Seagrass Watch method (McKenzie 2003) and guide to seagrass bed monitoring and identification based on the seagrass cover category (Rahmawati et al, 2014). This technique used transect line and quadrat-shaped frame. Data were collected in 3 100 M-transects with inter-transect distance of 50 M so that total coverage was 100 x 100 m2. The quadrats were placed at the right side of the transect, and the distance between transects was 10 m so that there were 11 quadrats along each transect 11 (Figure 2). The initial point of the transect was set at the distance of 5 – 10 m from the first seagrass encountered (from the coast). The data were taken at low tide along the transect. The quadrats were removed after data sampling (Rahmawati et al 2014). In data collection, the transect line was laid on the seagrass bed, and all seagrasses included in the quadrat were recorded.

Figure 1. Study site.

Commented [indra3]: you definitely can add more information regarding the methods. See the comments within the section.

In addition, within the Abstract you said "It aims to analyze the seagrass composition, **dominance**, and mean percent cover in each island". So, we see no references on the dominance parameter within the Material & Method section.

Di Material & Method tidak ada pustaka tentang parameter dominasi (yang dimaksud dominasi adalah dominasi spesies dlm persentase)

Tidak dijelaskan bagaimana dominance dihitung (untuk menghindari kesalahan persepsi tentang dominansi, hal ini sebaiknya dihilangkan saja, menyesuaikan judul diatas, dominansi akan dihilangkan dari pembhasan)

Commented [A4]: Mohon diperiksa kalimatnya jika sudah sesuai

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Tambahkan skala dan arah pada peta (sudah diperbaiki)

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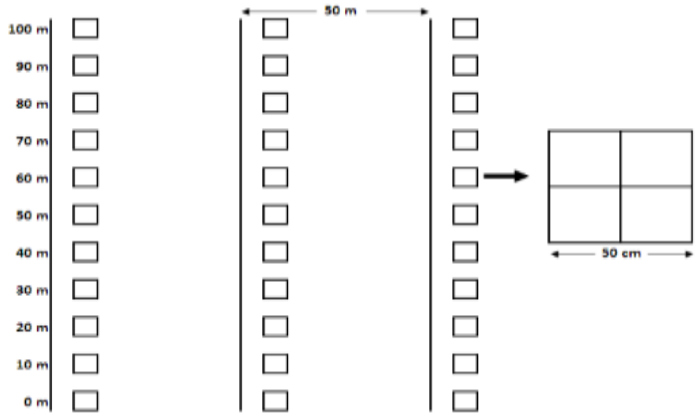

Figure 2. Quadrat transect scheme in the seagrass bed.

Data processing and analysis.

Data analysis followed the Seagrass Monitoring Guide (Rahmawati et al 2014) using Microsoft Excel software. The processed data were then tabulated and used to describe the seagrass percent cover in each island. The seagrass condition is monitored every year based on mean seagrass cover per island or site. Mean cover in a locality is categorized as presented in Table 1.

Table 1 Criteria of seagrass cover category (Susi et al 2014)

Cover (%)	*Category*
0-25	Rare
26-50	Moderate
51-75	Dense
76-100	Very dense

Results and Discussion

Bunaken Island.

There were 29.25% seagrass around Bunaken Island and recorded 5 species in point 1 of east Bunaken (BL01) and point 2 at the southeast Bunaken, in front of the village (BL02), *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia* and *S. isoetifolium*. Point 3, Bunaken Fukui (BL03), was recorded 2 species, *E. acoroides* and *C. rotundata,* and point 4, Bunaken Alungbanua (BL04), was found 2 species, *H. pinifolia* and *S. isoetifolium.* Persentasi penutupan tertinggi adalah spesies *E. acoroides* with mean cover of 15.37% in points 1, 2, and 3. The seagrass cover in Bunaken Island belonged to single dominant seagrass species with 2-3 associated seagrass species and clumped in different cover with species. Good condition of the seagrass percent cover in Bunaken Is could result from the water quality condition that supports the survival of biota living there and other related ecosystem, such as mangroves and coral reefs (Schaduw 2018a). Besides seagrass bed, this island has also good coral reef ecosystem, and several dive spots of the island have become underwater tourism destination (Kamagi et al 2016; Luasunaung et al 2015)

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Commented [indra7]: how did you calculate this? Did you use the Dominance index formula?
Bagaimana menghitung dominasi? Taruh di method

However, you did not mention anything about this parameter (the dominance) in the Material & Method section. Please do this.
(Dominasi yang dimaksud adalah persetase dominasi jenis)

Kenapa tidak gunakan indeks dominasi? Nilai % tidak memiliki kategori dominasi, kecuali hanya menyatakan percent tutupan pada metode ini dominasi spesies hanya dilihat dari nilai rata-rata tertinggi persentase penutupan, untuk menghindari kesalahan kata dominasi dihilangkan saja, menyesuaikan judul diatas)

Siladen Island.

Seagrass bed in Siladen Island had the highest cover among islands on study, 34.29%, at point 4. There were 5 seagrass species found at point 1, north Siladen (SL01), point 2, east Siladen (SL02), point 3, in front of Siladen resort (SL03), and point 4, Siladen yetty (SL04), i.e. *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia*, and *S. isoetifolium*. Persentasi penutupan tertinggi adalah spesies species was *E. acoroides* with mean cover of 10.12% and occurred in each study point. The area is dominated by sandy bottom, then followed by dead corals and mud.

Manado Tua Island. Seagrass ecosystem in Manado Tua waters had the lowest cover among the islands, 19.32%. Four species were recorded at point 1, Manado Tua Pangalingan 1 (MT01), *T. hemprichii*, H. *uninervis* , *H. pinifolia* , and *S. isoetifolium* , 5 species at point 2, Manado Tua Pangalingan 2 (MT02), *E. acoroides* , *T. hemprichii,* H. *uninervis*, *H. pinifolia* , and *S. isoetifolium* , 4 species at point 3, Manado Tua Bualo 1 (MT03), *T. hemprichii*, H. *uninervis*, *H. pinifolia* , and *S. isoetifolium* , 3 species at point 4, Manado Tua Bualo 4 (MT04), *T. hemprichii*, *H. pinifolia* , and *S. isoetifolium* . Persentasi penutupan tertinggi adalah spesies *T. hemprichii* with mean cover of 6.24%. The water quality around the seagrass bed ecosystem strongly helps the survival of the biota and the ecological connectivity of the island (Schaduw 2018a).

Mantehage Island. Based on the seagrass monitoring in 4 study points of Mantehage Island, there was mean cover of 33%. Point 1, Mantehage Bango (ML01), was recorded only one species *E. acoroides*, point 2, Mantehage Tinongko (ML02), was found 3 species, *T. hemprichii*, *C. rotundata* , and *H. pinifolia* , point 3, Mantehage Buhias (ML03), was found 3 species, *T. hemprichii*, *C. rotundata* , *H. pinifolia* , point 4, Mantehage Bella Point (ML04), was recorded 3 species, *T. hemprichii* , *C. rotundata* , *H. pinifolia* . Persentasi penutupan tertinggi adalah spesies *T. hemprichii* with mean cover of 13.8%. The dominant substrate was mud. Mantehage Is, as one of the largest outermost islands of Indonesia, has high diversity in mangrove and coral reef ecosystems. Among five islands of Bunaken National Park, Mantehage Is holds the largest mangrove ecosystem (Schaduw 2015). This island has also good coral reef condition that is used for dive sites (Kase et al 2019).

Nain Island. Monitoring activitiy in Nain island found 26.4% seagrass cover. Two species, *E. acoroides* and *C. rotundata* were found at point 1, Nain Batu kapal (NL01), 3 species at point 2 Nain Jalan Masuk (NL02), *T. hemprichii*, *C. rotundata*, and *H. pinifolia*, 3 species at point 3, south Nain island (NL03), *C. serrulata*, *C. rotundata*, and *H. pinifolia* and 3 species at point 4, Nain Pasir Timbul (NL04), *E. acoroides*, *C. rotundata*, and *H. pinifolia* (Table 2). Persentasi penutupan tertinggi adalah spesies *E. acoroides* with mean cover of 12.3%. The seagrass ecosystem of Nain Island is highly supported by other ecosystems, such as mangrove and coral reefs. The mangrove ecosystem in this island is still good and well managed. The degradation of this ecosystem is very little so that the connectivity among the coastal ecosystems works well (Schaduw 2018b).

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Table 2 Mean seagrass cover and dominance in the study site

Locality	*Station*	*Percentage Cover (%)*	*Species Percent Cover (%)*						
			Ea	*Th*	*Cs*	*Cr*	*Hu*	*Hp*	*Si*
Bunaken Is.	BL01	35	11	12	0	2.34	0	2.46	9.09
	BL02	40	17	8	0	10	0	0	3
	BL03	25	23.5	0	0	1.52	0	0	0
	BL04	17	10	0	0	0.0	0	4	17.1
	Mean	29.25	15.3	5.00	0	3.46	0	1.62	7.30
	SD	10.28	6.23	6.00	0	4.46	0	1.97	7.55
Siladen Is.	SL01	26	8	2	0	3	0	7	9
	SL02	25,4	19.3	4.55	0	1.70	0	3.03	3.03
	SL03	24.8	3.60	4.55	0	10.6	0	3.03	3.03
	SL04	60.98	1.52	29.3	0	14.9	0	15	14.73
	Mean	34.29	8.11	10.1	0	7.57	0	6.95	7.45
	SD	17.80	7.95	12.8	0	6.30	0	5.52	5.61
Manado Tua Is.	MT01	22.54	0	9.09	0	0	5.87	0.76	6.82
	MT02	26.32	0.75	13.0	0	0	7.57	2.46	2.46
	MT03	13.06	0	0.18	0	0	5.8	0.9	5.3
	MT04	15.34	0	2.65	0	0	0	6.06	6.62
	Mean	19.32	0.19	6.24	0	0	4.83	2.56	5.30
	SD	6.18	0.38	5.89	0	0	3.32	2.46	2.01
Mantehage Is.	ML01	34	34	0	0	0	0	0	0
	ML02	37	0	19	0	5	0	14	0
	ML03	28	0	19	0	2	0	8	0
	ML04	33	8	17	0	0	0	9	0
	Mean	33	10.5	13.8	0	1.75	0	7.75	0
	SD	3.74	16.1	9.22	0	2.36	0	5.80	0
Nain Is.	NL01	25	22.9	0	0	2.08	0	0	0
	NL02	24.2	0	13.3	13.3	0	0	12.1	0
	NL03	25.9	0	0	15.3	0.56	0	7.76	0
	NL04	30.3	26.3	0	0	1.52	0	2.46	0
	Mean	26.4	12.3	3.32	7.15	1.04	0	5.59	0
	SD	2.71	14.3	6.63	8.30	0.94	0	5.43	0

Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *H. pinifolia*; Si = *Syringodium isoetifolium*.

Species composition.

Seven species were found in all observation points, *E. acoroides* (Ea), *T. hemprichii (Th)*, *C. rotundata* (Cr), *H. pinifolia* (Hp), *S. isoetifolium* (Si), *C. serrulata* (Cs), and *H. uninervis* (Hu). None of the observation points had 7 species, and each species was distributed over the 20 study points. Several points had 5 species and the other had only 2-4 species.

Species dominance.

Seagrass community was dominated by *E. acoroides* in Bunaken waters with 15.3% cover, *T. hemprichii* in Siladen waters with 10.1% cover, *T. hemprichii* in Manado Tua waters with 6.24% cover, *T. hemprichii* in Mantehage Island with 13.8% cover, and *E. acoroides* in Nain waters with 12.3% cover (Figure 3). As a whole, two islands were dominated by *E. acoroides* and three others by *T. hemprichii*. This species is mostly found in the study sites. It could occur from that the species is one of the pioneer species that naturally exists in the open tidal area (Hidayat et al 2014). Alie (2010) reported high seagrass productivity at high water temperature, and salinity could also affect the biomass, productivity, and recovery rate. Water turbidity could indirectly influence the seagrass occurrence, since it can inhibit light intensity need for photosynthesis, especially in rainy season, the seagrass growth becomes slow due to high water turbidity.

(Dwindaru 2010; Tanaka & Kayanne 2007). Dobo (2009) found very high tolerance of *T. hemprichii* to the sediment in Hatta Island. *E. acoroides* can even live in the terrigenous muddy sediment to coarse sediment of carbonate or from low water salinity near the river mouth to high salinity around the islands far from the river mouth (Erftemeijer et al 1993; Waycott et al 2004).

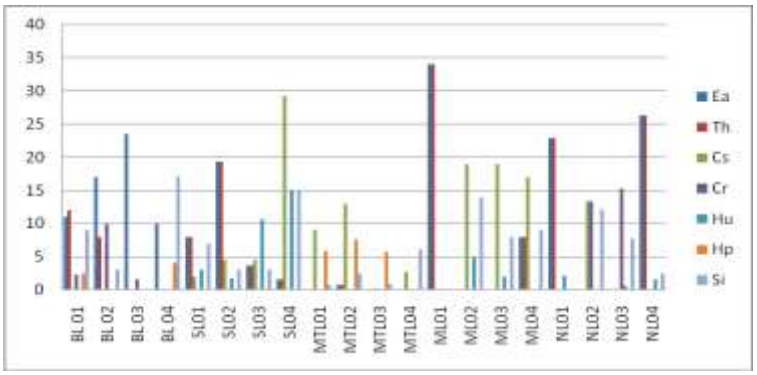

Figure 3. Seagrass species dominance.

Percent cover of seagrass.

Field observations showed different seagrass cover, 29.25% in Bunaken waters, 34.29% in Siladen waters, 19.32% in Manado Tua waters, 33% in Mantehage waters, and 26.4% in Nain waters. These differences could result from different ecological conditions and morphology of the islands. Siladen Island has wide seagrass bed because it has slant coastal type and is dominated by large coral reef area. This island possesses high seaweed productivity, while Mantehage Island had the second largest cover with very wide mangrove ecosystem that supported the seagrass survivorship there. Based on the percent cover, the seagrass condition in Bunaken, Siladen, Mantehage, and Nain wasters was moderate, while that in Manado Tua was rare (Figure 4). This study reflects that the seagrass condition in the small islands of Bunaken National Park is good and could support the survivorship of the associated biota, and thus, the present seagrass cover condition needs to be protected from degradation, since this condition is highly susceptible to the anthropogenic activities.

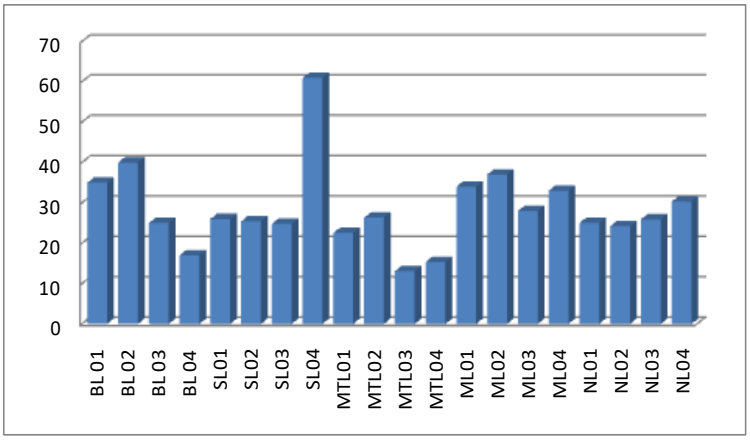

Figure 4. Seagrass percent cover.

Conclusions.

There were 7 seagrass species recorded at 20 observation points around 5 islands of Bunaken National Park, *E. acoroides* , *T. hemprichii* , *C. rotundata* , *H. pinifolia* , *S. isoetifolium* , and *C. serrulata* (R. Brown) Ascherson & Magnus (Cs), and *H. uninervis* (Forskal) Ascherson (Hu). Seagrass percent cover indicated that the waters around 4 islands was in moderate category, 34.29% for Siladen Island, 33% for Mantehage Island, 29.25% for Bunaken Island, and 26.4% for Nain Island, respectively. The seagrass percent cover in Manado Tua Island was categorized as rare, 19.32%.

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Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia

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Abstract. This study was carried out in Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands. It aims to analyze the seagrass composition and percent cover in each island. The seagrasses were surveyed using quadrat transect perpendicular to the shore modified from Seagrass Watch method. Data processing and analysis followed the seagrass bed monitoring guide using Microsoft Excel software or other suitable program. There were 7 species recorded in the study sites, *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule pinifolia, Syringodium isoetifolium* and *Halodule uninervis*. Four of 5 islands surveyed were categorized as moderate based on the seagrass cover category, Siladen Island 34.29%, Mantehage Island 33%, Bunaken Island 29.25%, and Nain Island 26.4%, while Manado Tua Island was categorized as scarce, 19.32%. As a whole, the seagrass bed condition in small islands of Bunaken National Park is in good condition and has sufficiently high diversity. However, periodic monitoring activities on the seagrass percent cover is strongly needed in order to minimize the ecosystem degradation.
Key Words: survey, quadrat transect, composition, dominance, percent cover.

Introduction. Seagrass ecosystem is one of the productive shallow water ecosystems and has an important role in supporting the life and the development of marine organisms. The role of seagrass in shallow waters is known as primary producer, habitat, sediment trap, nutrient source (Bengen 2002) and rare element recycling (McKenzie & Yoshida 2009).

Seagrass has economic benefit as well, since it can be used as food material, animal's feed, paper raw material, craft material, fertilizer, and medicine (Nur 2011). In tropical waters as Indonesia, seagrass bed is more dominant to grow in colony of mixed species in certain areas. Different from temperate or cold waters, it is mostly dominated by single species plant. There are about 63 species of seagrasses in the world, and 12 of them occur in Indonesia waters, dominated by several genera and species, such as *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, C. serrulata, Haludole pinifolia, H. uninervis, Halophila decipiens, H. ovalis, H. minor, H. spinulosa, Syringodium iseotifolium,* and *Thalassodendron ciliatum* (Rahmawati et al 2014). The observations on seagrass community have been conducted in Tayando-Tam Island with seagrass ecosystem. Seven species of seagrass was found in Tayando-Tam Island, *E. acoroides, T. hemprichii, C. serrulata, C. rotundata, Halodule pinifolia, H. ovalis,* and *S. isoetifolium*. *H. pinifolia* has the highest density in Tam Island (Fitrian et al 2017).

Bunaken, Siladen, Manado Tua, Mantehage, and Nain islands have sufficiently good condition of seagrass beds and their occurrence needs to be sustained due to their crucial role in marine ecosystem. However, quantitative information on seagrass community in natural ecosystems of these localities is still very few. This work focuses on the environmental condition and the seagrass communities around those 5 islands.

Material and Method. This study was conducted around 5 islands belonging to Bunaken National Park (Bunaken, Siladen, Manado Tua, Mantehage, and Nain). In each island,

four stations were set in order to evaluate the local seagrass bed conditions (Figure 1). The stations represent the northern, southern, eastern, and western parts of the island. The study was conducted from July 2019 (Bunaken Island, Siladen Island, and Manado Tua Island) to February 2020 (Mantehage Island and Nain Island). In seagrass ecosystem monitoring, the main parameter measured is the percent cover. This measurement is taken as a form of resources management and protection effort in the system. The study utilized a quadrat transect method perpendicular to the shore modified from Seagrass Watch method (McKenzie 2003) and guide to seagrass bed monitoring and identification based on the seagrass cover category (Rahmawati et al 2014). This technique used transect line and quadrat-shaped frame. Data were collected in three 100 M-transects with inter-transect distance of 50 M so that total coverage was 100 x 100 m^2. The quadrats were placed at the right side of the transect, and the distance between transects was 10 m so that there were 11 quadrats along each transect 11 (Figure 2).

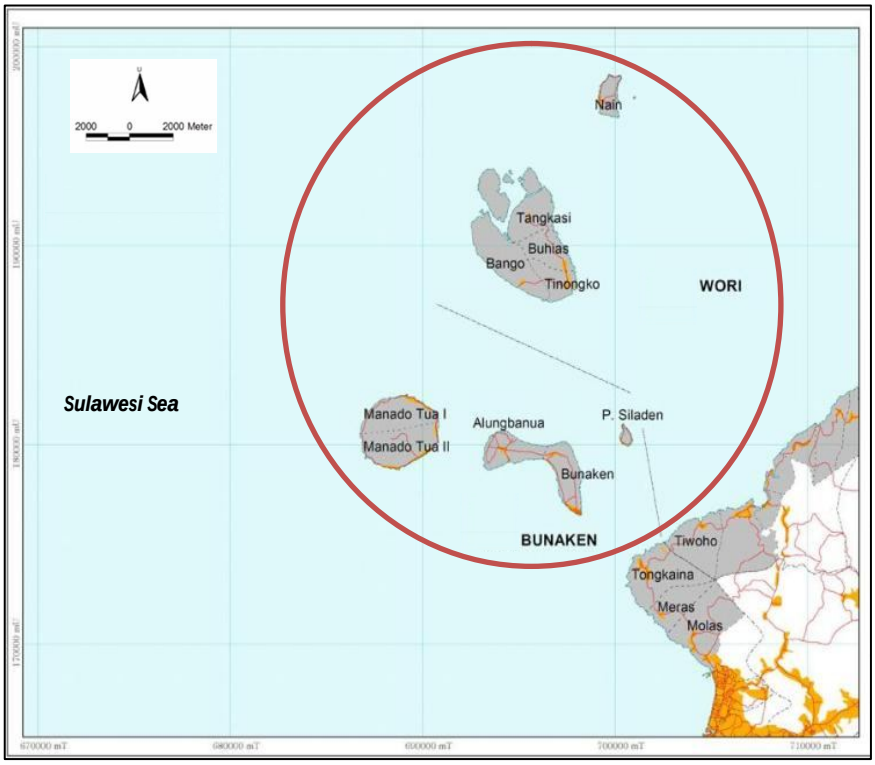

Figure 1. Study site.

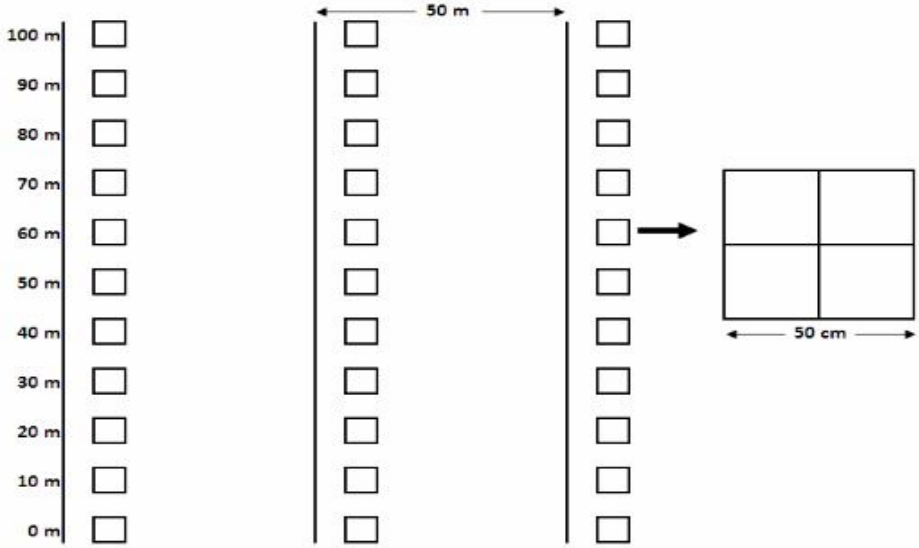

Figure 2. Quadrat transect scheme in the seagrass bed.

The initial point of the transect was set at the distance of 5-10 m from the first seagrass encountered (from the coast). The data were taken at low tide along the transect. The quadrats were removed after data sampling (Rahmawati et al 2014). In data collection, the transect line was laid on the seagrass bed, and all seagrasses included in the quadrat were recorded.

Data processing and analysis. Data analysis followed the Seagrass Monitoring Guide (Rahmawati et al 2014) using Microsoft Excel software. The processed data were then tabulated and used to describe the seagrass percent cover in each island. The seagrass condition is monitored every year based on mean seagrass cover per island or site. Mean cover in a locality is categorized as presented in Table 1.

Table 1

Criteria of seagrass cover category (Susi et al 2014)

Cover (%)	*Category*
0-25	Rare
26-50	Moderate
51-75	Dense
76-100	Very dense

Results and Discussion

Bunaken Island. There were 29.25% seagrass around Bunaken Island and recorded 5 species in point 1 of east Bunaken (BL01) and point 2 at the southeast Bunaken, in front of the village (BL02), *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia* and *S. isoetifolium*. Point 3, Bunaken Fukui (BL03), was recorded 2 species, *E. acoroides* and *C. rotundata,* and point 4, Bunaken Alungbanua (BL04), was found 2 species, *H. pinifolia* and *S. isoetifolium.* The highest percent cover was found in *E. acoroides* with mean cover of 15.37% in points 1, 2, and 3. The seagrass cover in Bunaken Island belonged to single dominant seagrass species with 2-3 associated seagrass species and clumped in different cover with species. Good condition of the seagrass percent cover in Bunaken Island could result from the water quality condition that supports the survival of biota living there and other related ecosystem, such as mangroves and coral reefs (Schaduw 2018a). Besides seagrass bed, this island has also good coral reef ecosystem, and several dive spots of the island have become underwater tourism destination (Kamagi et al 2016; Luasunaung et al 2015).

Siladen Island. Seagrass bed in Siladen Island had the highest cover among islands on study, 34.29%, at point 4. There were 5 seagrass species found at point 1, north Siladen (SL01), point 2, east Siladen (SL02), point 3, in front of Siladen resort (SL03), and point 4, Siladen yetty (SL04), i.e. *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia*, and *S. isoetifolium*. The highest cover was recorded in *E. acoroides* with mean cover of 10.12% and occurred in each study point. The area is dominated by sandy bottom, then followed by dead corals and mud.

Manado Tua Island. Seagrass ecosystem in Manado Tua waters had the lowest cover among the islands, 19.32%. Four species were recorded at point 1, Manado Tua Pangalingan 1 (MT01), *T. hemprichii*, *H. uninervis*, *H. pinifolia*, and *S. isoetifolium*, 5 species at point 2, Manado Tua Pangalingan 2 (MT02), *E. acoroides*, *T. hemprichii, H. uninervis*, *H. pinifolia*, and *S. isoetifolium*, 4 species at point 3, Manado Tua Bualo 1 (MT03), *T. hemprichii*, *H. uninervis*, *H. pinifolia*, and *S. isoetifolium*, 3 species at point 4, Manado Tua Bualo 4 (MT04), *T. hemprichii*, *H. pinifolia*, and *S. isoetifolium*. The highest was found in *T. hemprichii* with mean cover of 6.24%. The water quality around the seagrass bed ecosystem strongly helps the survival of the biota and the ecological connectivity of the island (Schaduw 2018a).

Mantehage Island. Based on the seagrass monitoring in 4 study points of Mantehage Island, there was mean cover of 33%. Point 1, Mantehage Bango (ML01), was recorded only one species *E. acoroides*, point 2, Mantehage Tinongko (ML02), was found 3 species, *T. hemprichii*, *C. rotundata*, and *H. pinifolia*, point 3, Mantehage Buhias (ML03), was found 3 species, *T. hemprichii*, *C. rotundata*, *H. pinifolia*, point 4, Mantehage Bella Point (ML04), was recorded 3 species, *T. hemprichii*, *C. rotundata*, *H. pinifolia*. The highest cover was recorded in *T. hemprichii* with mean cover of 13.8%. The dominant substrate was mud. Mantehage Island, as one of the largest outermost islands of Indonesia, has high diversity in mangrove and coral reef ecosystems. Among five islands of Bunaken National Park, Mantehage Is holds the largest mangrove ecosystem (Schaduw 2015). This island has also good coral reef condition that is used for dive sites (Kase et al 2019).

Nain Island. Monitoring activity in Nain island found 26.4% seagrass cover. Two species, *E. acoroides* and *C. rotundata* were found at point 1, Nain Batu kapal (NL01), 3 species at point 2 Nain Jalan Masuk (NL02), *T. hemprichii*, *C. rotundata*, and *H. pinifolia*, 3 species at point 3, south Nain island (NL03), *C. serrulata*, *C. rotundata*, and *H. pinifolia* and 3 species at point 4, Nain Pasir Timbul (NL04), *E. acoroides*, *C. rotundata*, and *H. pinifolia* (Table 2). The highest cover was represented by *E. acoroides* with mean cover of 12.3%. The seagrass ecosystem of Nain Island is highly supported by other ecosystems, such as mangrove and coral reefs. The mangrove ecosystem in this island is still good and well managed. The degradation of this ecosystem is very little so that the connectivity among the coastal ecosystems works well (Schaduw 2018b).

Table 2

Mean seagrass cover and dominance in the study site

Locality	*Station*	*Percent cover (%)*	*Species percent cover (%)*						
			Ea	*Th*	*Cs*	*Cr*	*Hu*	*Hp*	*Si*
Bunaken Island	BL01	35	11	12	0	2.34	0	2.46	9.09
	BL02	40	17	8	0	10	0	0	3
	BL03	25	23.5	0	0	1.52	0	0	0
	BL04	17	10	0	0	0.0	0	4	17.1
	Mean	29.25	15.3	5.00	0	3.46	0	1.62	7.30
	SD	10.28	6.23	6.00	0	4.46	0	1.97	7.55
Siladen Island	SL01	26	8	2	0	3	0	7	9
	SL02	25,4	19.3	4.55	0	1.70	0	3.03	3.03
	SL03	24.8	3.60	4.55	0	10.6	0	3.03	3.03
	SL04	60.98	1.52	29.3	0	14.9	0	15	14.73
	Mean	34.29	8.11	10.1	0	7.57	0	6.95	7.45
	SD	17.80	7.95	12.8	0	6.30	0	5.52	5.61
Manado Tua Island	MT01	22.54	0	9.09	0	0	5.87	0.76	6.82
	MT02	26.32	0.75	13.0	0	0	7.57	2.46	2.46
	MT03	13.06	0	0.18	0	0	5.8	0.9	5.3
	MT04	15.34	0	2.65	0	0	0	6.06	6.62
	Mean	19.32	0.19	6.24	0	0	4.83	2.56	5.30
	SD	6.18	0.38	5.89	0	0	3.32	2.46	2.01
Mantehage Island	ML01	34	34	0	0	0	0	0	0
	ML02	37	0	19	0	5	0	14	0
	ML03	28	0	19	0	2	0	8	0
	ML04	33	8	17	0	0	0	9	0
	Mean	33	10.5	13.8	0	1.75	0	7.75	0
	SD	3.74	16.1	9.22	0	2.36	0	5.80	0
Nain Island	NL01	25	22.9	0	0	2.08	0	0	0
	NL02	24.2	0	13.3	13.3	0	0	12.1	0
	NL03	25.9	0	0	15.3	0.56	0	7.76	0
	NL04	30.3	26.3	0	0	1.52	0	2.46	0
	Mean	26.4	12.3	3.32	7.15	1.04	0	5.59	0
	SD	2.71	14.3	6.63	8.30	0.94	0	5.43	0

Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Si = *Syringodium isoetifolium*.

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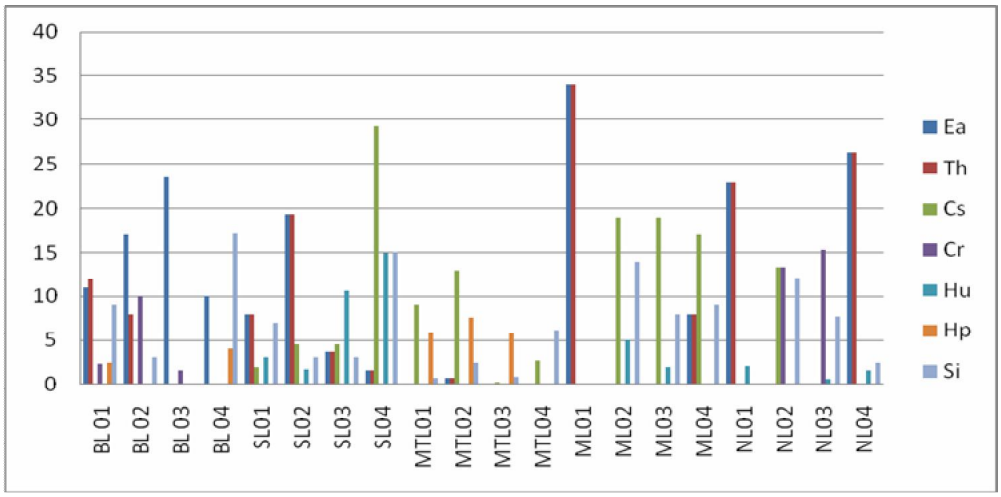

Figure 3. Seagrass species dominance (Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Si = *Syringodium isoetifolium*).

Percent cover of seagrass. Field observations showed different seagrass cover, 29.25% in Bunaken waters, 34.29% in Siladen waters, 19.32% in Manado Tua waters, 33% in Mantehage waters, and 26.4% in Nain waters. These differences could result from different ecological conditions and morphology of the islands. Siladen Island has wide seagrass bed because it has slant coastal type and is dominated by large coral reef area. This island possesses high seaweed productivity, while Mantehage Island had the second largest cover with very wide mangrove ecosystem that supported the seagrass survivorship there. Based on the percent cover, the seagrass condition in Bunaken, Siladen, Mantehage, and Nain wasters was moderate, while that in Manado Tua was rare (Figure 4). This study reflects that the seagrass condition in the small islands of Bunaken National Park is good and could support the survivorship of the associated biota, and thus, the present seagrass cover condition needs to be protected from degradation, since this condition is highly susceptible to the anthropogenic activities.

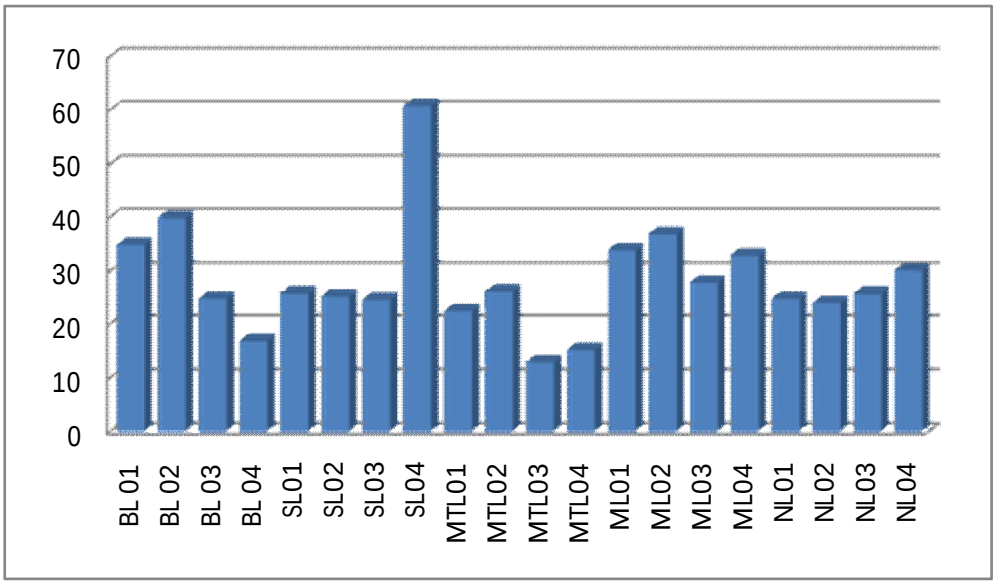

Figure 4. Seagrass percent cover.

Conclusions. There were 7 seagrass species recorded at 20 observation points around 5 islands of Bunaken National Park, *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia, S. isoetifolium*, and *C. serrulata* (Cs), and *H. uninervis* (Hu). Seagrass percent cover indicated that the waters around 4 islands was in moderate category, 34.29% for Siladen Island, 33% for Mantehage Island, 29.25% for Bunaken Island, and 26.4% for Nain Island, respectively. The seagrass percent cover in Manado Tua Island was categorized as rare, 19.32%.

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