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

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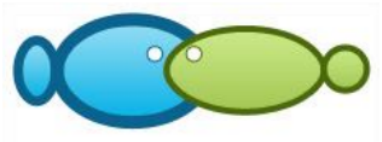

Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia

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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 SeagrassWatch 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).

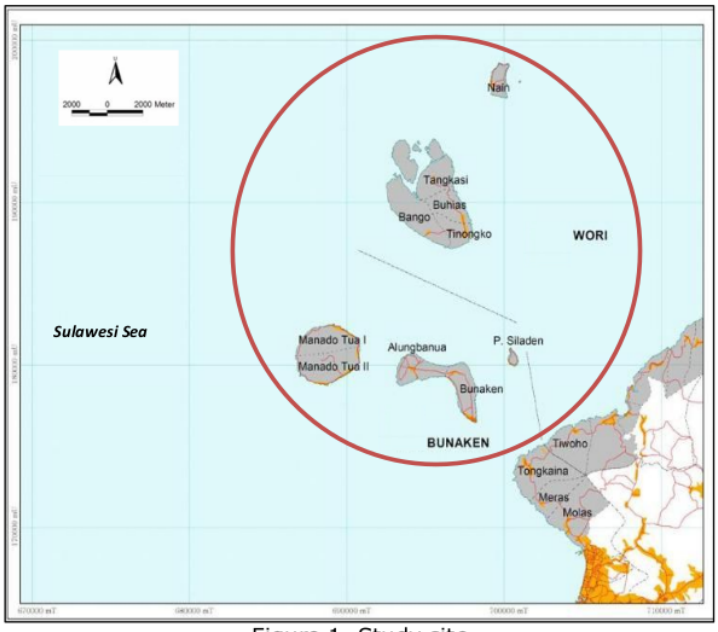

Figure 1. Study site.

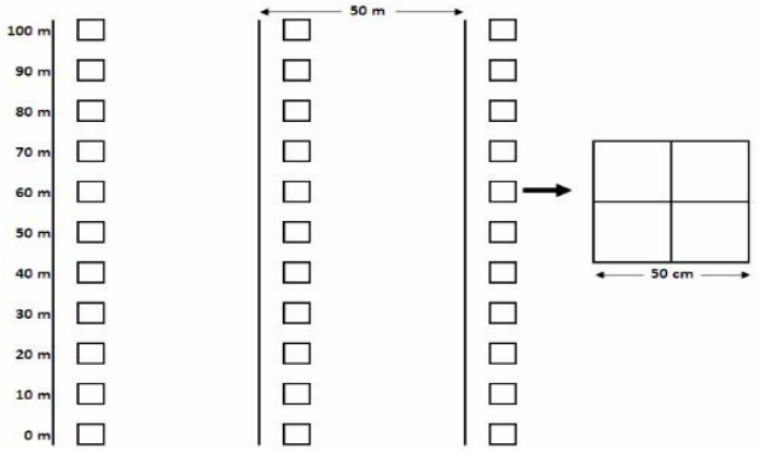

Figure 2. Quadrat transect scheme in the seagrass bed.

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, 19.72%. 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*.

Species composition. Seven species were found in all observation points, *E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. pinifolia, S. isoetifolium*, *C. serrulata*, and *H. uninervis*. 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).

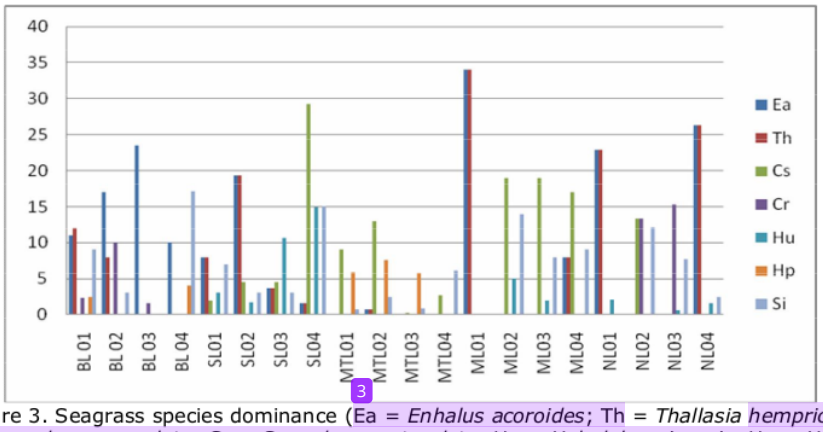

Figure 3. Seagrass species dominance (Ea = *Enhalus acoroides*; Th = *Thallasia hemprichii*; Cs = *Cymodocea serrulata*; Cr = *Cymodocea rotundata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Si = *Syringodium isoetifolium*).

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.

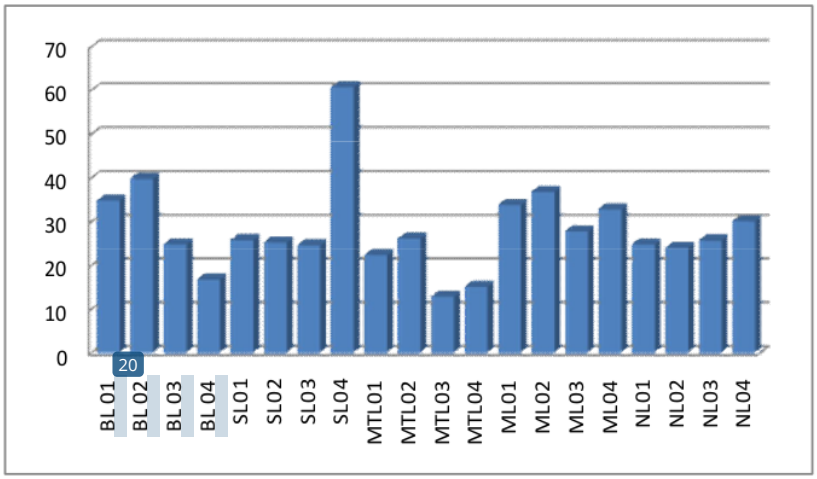

Figure 4. Seagrass percent cover.

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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