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Seagrass diversity and dugong observation in North Minahasa Regency, North Sulawesi

T S A Meidina[1*], M M Kamal[2], F Kurniawan [2], H S Darusman [3] and A A Digdo[4,5]

[1] Magister Program in Aquatic Resources Management, Graduate School of IPB University, Indonesia
[2] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Indonesia
[3] Department of Anatomy Physiology Pharmacology, School of Veterinary Medicine and Biomedical, IPB University, Indonesia
[4] Indonesian Environmental and Conservation Education (YAPEKA), Bogor, Indonesia
[5] Sirenia Species Survival Commission member, IUCN

*E-mail: trimeidina@gmail.com

Abstract. Dugong is a marine mammal that only eats seagrass. Feeding tracks of dugongs in the seagrass beds indicate their presence. The dugong population is currently experiencing a decline due to habitat destruction and other anthropogenic factors. This study aimed to determine the seagrass diversity and their relationship to the presence of dugongs. The research was conducted in villages of Bahoi, Tarabitan, Bulutui, and Gangga I Island using the seagrass-watch method. Analysis of the data used was the percentage of seagrass cover, density of seagrass species, and indicators of the presence of seagrass, which was carried out by interviewing fishermen and surveying their feeding tracks. The results showed that the waters in the North Minahasa Regency had seven seagrass types. The average percentage of seagrass cover was 61.73% and the density of seagrass species was 766.88 shoots/m^2. Feeding tracks observed in three locations, in Bahoi, Tarabitan, and Bulutui villages. The most tracks of feeding tracks were in Bahoi Village, with the type of seagrass that dominated being eaten by dugongs was *Halodule pinifolia*. Based on the results obtained, it concluded that certain types of seagrass are related to the location of the emergence of dugongs in the North Minahasa Regency.

Keywords: dugong, dugong sighting, seagrass, seagrass diversity

1. Introduction

The dugong (*Dugong dugon*) is a marine mammal species that feed mainly on seagrass. Indonesian diversity in these marine plants comprises of 13 species of which 5 of them are dugong's diet preferences [1], particularly the small-leaved pioneer seagrass such as *Halophila* and *Halodule* [2]. The two are high in nitrogen (N) and low in fiber substances but contain high carbohydrates hence high in calories. The presence of dugong is often seen from its feeding tracks which formed a long irregular groove with a length of about 30 cm to 6 meters and a width of 10 to 12 cm [1].

According to IUCN status, dugong is categorized into vulnerable species (VU), defined as likely to become endangered and the threats to it survival need to be lowered and reproductive capacity need to be improved. Vulnerable category is at high risk of extinction in the wild. In Indonesia this coastal mammal is protected under the Government Act No. 7 of 1999, reinforced by a Decree from the Ministry of Environment and Forestry No. P20 of 2018. Both global and national protection level show clear evidence that the natural population of the dugong is being threatened [1]. Currently, the dugong's

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existence is declining due to habitat destruction and other anthropogenic factors. It was estimated that dugongs in Indonesia in the 1970s were around 10 000 individuals, and it has greatly reduced to only around 1 000 in 1994 [3].

In the northern part of Sulawesi, the North Minahasa Regency waters are considered as the main habitats of dugongs. According to [4], the area where the dugong is encountered has an area of ± 5962 ha of seagrass beds. The appearance of this animal has long been detected through direct encounters, observation of the feeding track, and the occurrence of stranded dugongs [5; 6; 7]. Sightings of marine mammals play an important role in understanding their diversity, distribution, abundance, and behavior patterns [16]. Information on the existence of dugongs in the waters of North Sulawesi is rarely reported. The present research deals with the exploration of the seagrass conditions linked with the appearance of dugongs based on feeding track evidence [22]. Seagrass, in the context of small-scale fisheries also play important roles to provide provisions of food resources [23]. In Bahoi, North Minahasa, local fishermen can use up to 23 items of fishes, molluscs and crustacean associated with seagrass ecosystem [24].

2. Materials and methods

Four selected sites namely the villages of Bahoi, Tarabitan, Bulutui, and Gangga I Island, North Minahasa Regency, North Sulawesi were defined to observe dugong feeding tracks. The site coverage was nearby village settlements, inside Marine Protected Areas (MPA), and outside settlements (Figure 1). The research was performed from October to November 2021.

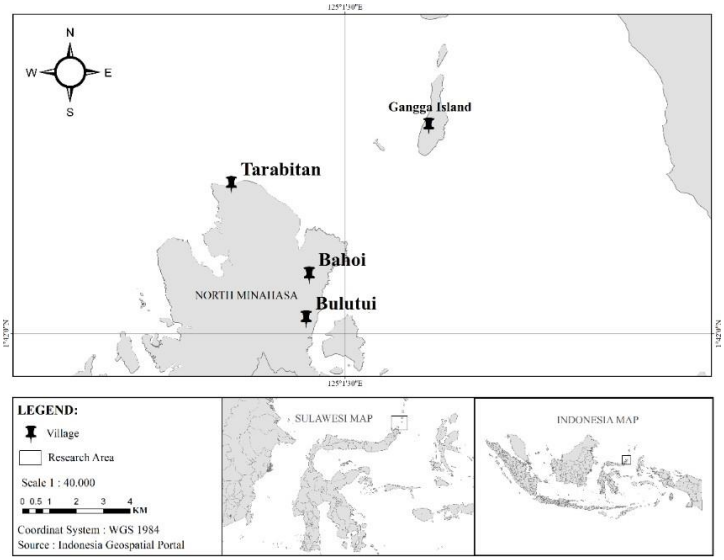


Figure 1. Research sites in seagrass habitats shown by black pinned where dugong presence was based on the encountered feeding tracks in North Minahasa Regency

2.1 Research procedure

Data collection begins with searching for information on seagrass beds which are presumed to be the dugong's grazing sites. At the same time seagrass beds in the research sites are important location for small-scale fishery activities and fishers are knowledgeable in term of their fishing grounds. Therefore interviews with fishers and local community need tobe done. To provide more objective consideration, systematic visual scoping by snorkeling in the designed areas where dugongs were found also

implemented. The characteristics of such specific site was referred to [1], i.e. the shape of an elongated groove (which can reach 6 m) and a width of ± 9 to 25 cm, found in seagrass beds that grow on sand substrates, grooves or new feeding tracks, left by dugongs 98% clean of seagrass, but on feeding tracks that have been left for a long time are starting to be overgrown with seagrass. As the feeding track identified, the coordinates' locations were recorded by using GPS. In the following, the general conditions were documented by means a waterproof camera, the leftover of the seagrass were observed. This data was then recorded on the dugong feeding track data sheet [1].

Seagrass quality was determined by the transect method. According to [1], transects on seagrass aim to determine the condition of seagrass beds, including many types, densities, and statuses. The transect method used is an adaptation of the seagrass-watch method [8]. Information about tidal conditions at the site needs to be known to determine the best time to go down to the field. Tidal data was obtained through information from local fishers and using an application named Tides.

The study conducted a cross-sectional survey using a tape measure to run from the shore (shallow) to the outer edge of the seagrass beds (deep) to form a perpendicular cross section [25]. Three transect lines each with 50 m length with a distance between transects of 25 m were established. On each line, a 50 x 50 cm square was determined to observe on seagrass species and its coverage. Each transect was placed within 5 m interval distance (Figure 2). Seagrass species were identified using a seagrass identification guide [8], of which each species coverage was estimated.

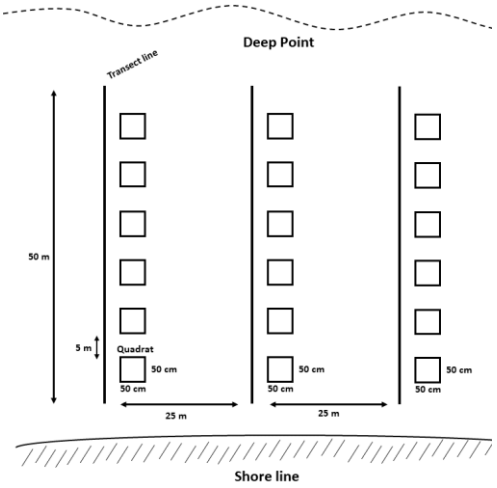


Figure 2. Seagrass-watch method using transect line in the study area

2.2 Data analysis

Seagrass species density is determined in total individual number of seagrass in one unit area, and was calculated using the following formula [15]:

$$K_{\mathrm{i}} = \frac{N_{\mathrm{i}}}{A}$$

K_i is seagrass species density (shoots/m^2), N_i is number of individuals (shoots), and A is transect area (m^2).

Calculation on seagrass coverage of each species was expressed in the percentage within each 50 x 50 cm square [9] as follows:

$$C = \frac{\Sigma C_{\mathrm{i}}}{N}$$

C is seagrass species coverage (%), C_i is percentage of the seagrass cover on each transect (%), and N is number of transects

An assessment of the area's seagrass ecosystem condition is determined according to the Decree of the Minister of the Environment No. 200 of 2004 shown in Table 1 below.

Table 1. Seagrass status criteria

Condition		Coverage (%)
Good	Rich/Healthy	≥ 60
Bad	Not rich/unhealthy	30 – 59,9
	Poor	≤ 29,9

3. Result and discussion

3.1. Seagrass species characteristics

Two seagrass families were found in the study area, i.e. Hydrocharitaceae and Potamogetonaceae. The former is comprised of three genera namely *Enhalus*, *Thalassia*, and *Halophila*, while the latter consisting of *Syringodium*, *Cymodocea*, and *Halodule*. In total, there are seven species identified in the study area including *Enhalus acoroides* (Ea), *Thalassia hemprichii* (Th), *Cymodocea rotundata* (Cr), *Syringodium isoetifolium* (Si), *Halophila ovalis* (Ho), *Halodule uninervis* (Hu), and *Halodule pinifolia* (Hp).

Each species was all encountered at each location but *Halodule uninervis*, which is absent in Tarabitan Village (Table 2). Species-site distribution and coverage pattern revealed that the dominant species was *Halophila pinifolia* in Bahoi Village by 39%, *Enhalus acoroides* in Tarabitan Village by 45%, and *Thalassia hemprichii* in Bulutui Village by 29%, and Gangga I by 35% (Figure 3).

Table 2. Seagrass species presence in North Minahasa Regency

Village	Species						
	Ea	Th	Cr	Si	Ho	Hu	Hp
Bahoi	✓	✓	✓	✓	✓	✓	✓
Tarabitan	✓	✓	✓	✓	✓	-	✓
Bulutui	✓	✓	✓	✓	✓	✓	✓
Gangga I	✓	✓	✓	✓	✓	✓	✓

The seagrass species shows different leaves characteristic. *Enhalus acoroides* whose leaves can grow up to 1 meter are characterized by overgrown black fiber rhizomes with small hairy fruit. *Thalassia hemprichii* looks like *Cymodocea* but they are distinguished by segmented and thick roots with brown stripes or spots leaves. *Cymodocea rotundata* has rounded, unserrated leaf margins with completely closed leaf sheaths. *Syringodium isoetifolium* has a cylindrical leaf shape. The leaves of *Halodule uninervis* seagrass are long but small in shape and have a trident-shaped tip, unlike *Halodule pinifolia*, which has slightly rounded leaf tips and the centre of the leaf tip is also marked with a black triangular line [10]. *Halophila ovalis* is small seagrass with 1-2 cm oval-shaped leaves, 5-7 cm stem height 5-7 cm, and 2-3 cm roots [11].

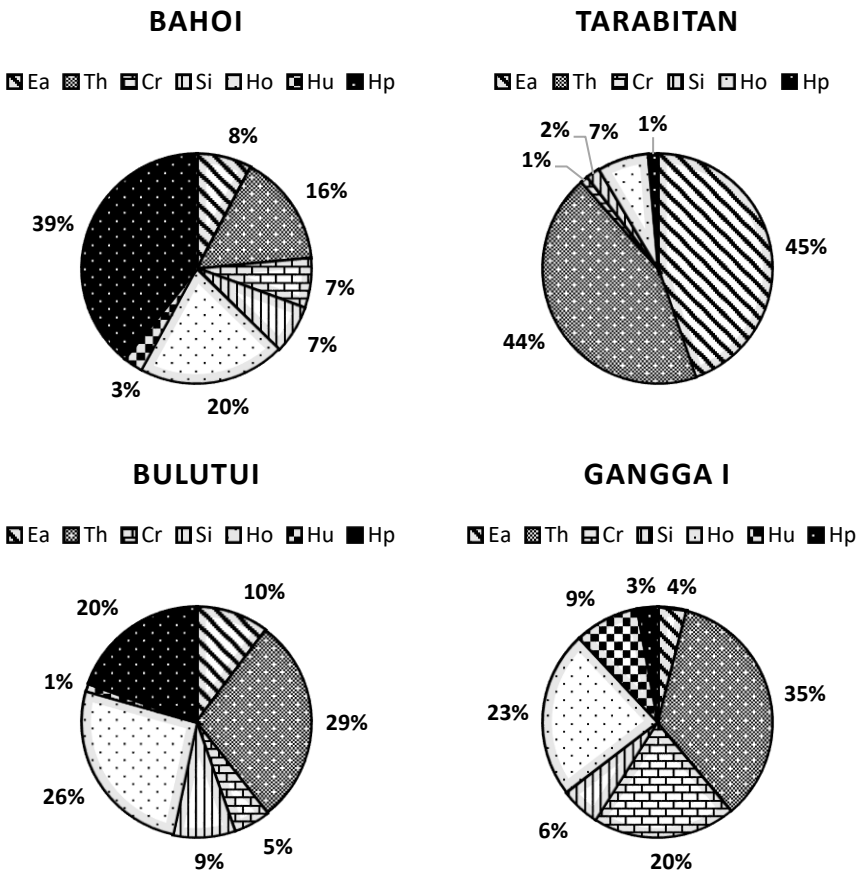


Figure 3. The composition of seagrass species in each village in the North Minahasa Regency

3.2. Seagrass density

Seagrass species density showed variation among sites (Figure 4). The density of seagrasses found in the villages of Bahoi, Tarabitan, Bulutui, and Gangga I, in sequence, were 885.05, 482.71, 836.7, and 863.09 shoots/m^2. The highest seagrass density was *Halodule pinifolia* in Bahoi Village with 347.20 shoots/m^2, *Thalassia hemprichii* in Bulutui and Gangga I villages with 244.77 shoots/m^2 and 301.57 shoots/m^2. Whereas *Enhalus acoroides* was slightly higher in density compared to *Thalassia hemprichii* in Tarabitan Village, i.e. 215.80 shoots/m^2 to 211.15 shoots/m^2. Seagrass distribution and density depends on environmental factors including temperature, salinity, light, basic substrate, nutrients, and seawater movement (waves, currents, tides) [12]. Beside, human activities in coastal areas such as tourisms, settlements, and other anthropogenic activities may also modify those factors.

3.3. Seagrass cover

The percentage of seagrass cover illustrates how wide the seagrass covers water [12]. The percentage value of seagrass cover is based not only on the density value of seagrass species but also on the width of the seagrass strands. The width of the seagrass leaf blade greatly affects the substrate cover. The wider the leaf, the greater the ability to cover the substrate [13]. Seagrass cover had a significant effect on the creation of feeding spots and influenced the feeding patterns of the dugongs [17].

The percentage value of seagrass cover in four villages in the North Minahasa Regency can be observed in Graph 3 below. Seagrass in Bahoi Village has a closing value of 66.05 %, Tarabitan Village of 52.70 %, Bulutui Village of 65.16 %, and Gangga I Village of 63.01 %.

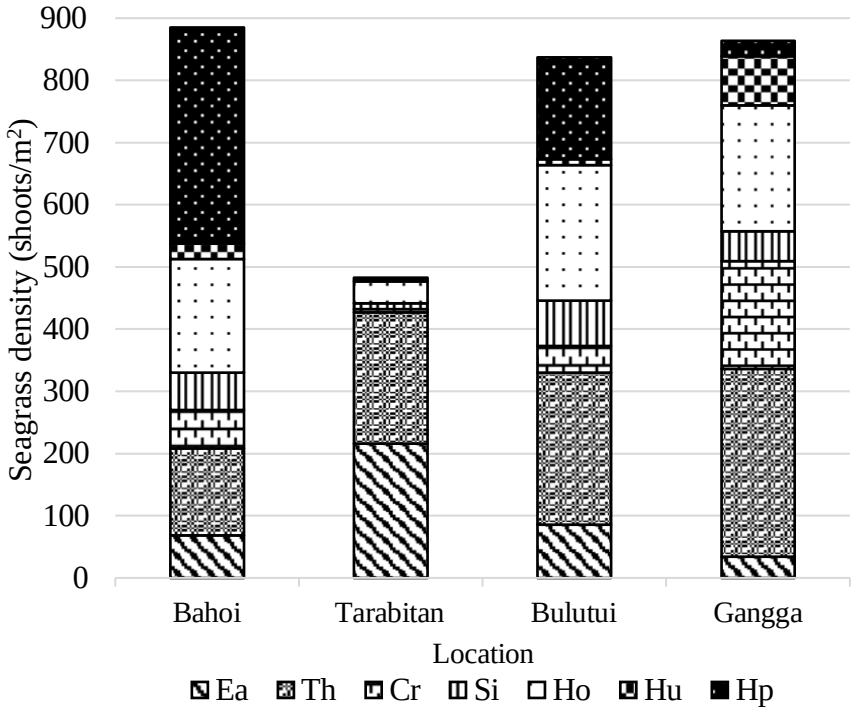


Figure 4. Seagrass density in the villages of area study in North Minahasa Regency

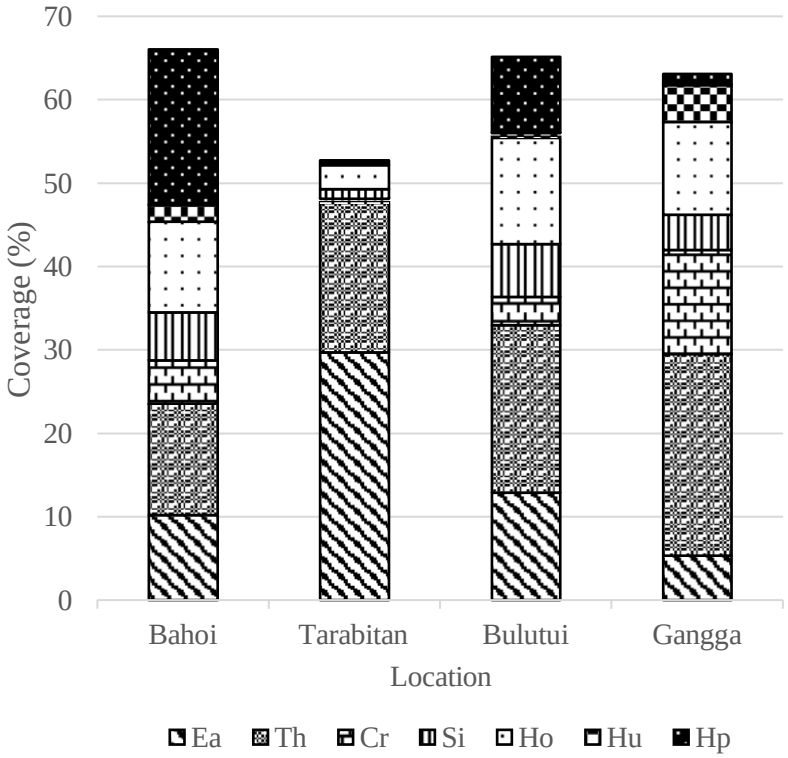


Figure 5. Seagrass cover data in North Minahasa Regency

Based on percent coverage, the seagrass conditions in the study area was determined [14]. The waters in all villages but Tarabitan were characterized by healthy seagrass community and this may support to the presence of dugong (Table 3).

Table 3. Seagrass cover category and condition

Location	Coverage (%)	Category [14]	Condition
Bahoi	66,05	Dense	Healthy
Tarabitan	52,70	Dense	Unhealthy
Bulutui	65,16	Dense	Healthy
Gangga I	63,01	Dense	Healthy

3.4. Dugong sighting

Figure 6 shows the locations of dugong encounters based on information from fishers. Their appearance was visible at the distance approximately 10 m from the boat. Appearance frequency was highest in Bahoi.

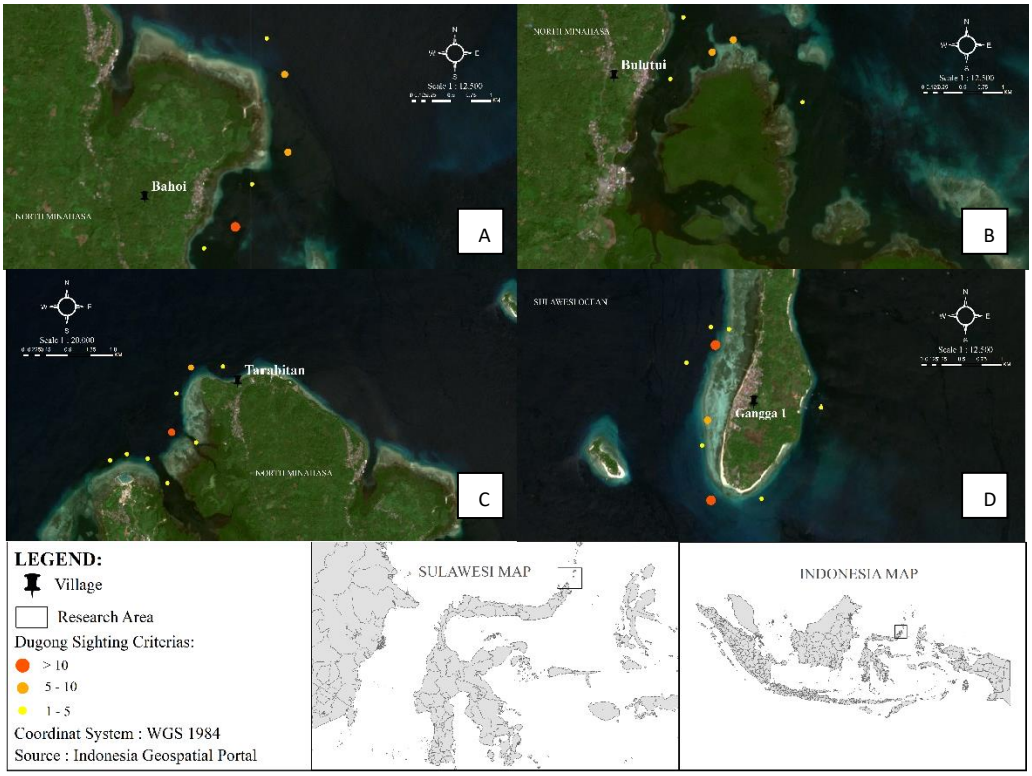


Figure 6. Dugong sighting in Bahoi (A), Tarabitan (B), Bulutui(C), Gangga I Villages (D)

The presence of dugong was also detectable based on their feeding tracks, which was not found in Gangga I Village. There are no feeding track around the village of Gangga I because the seagrass type *Halodule* and *Halophila* are very close to the mainland. The altitude in this area is no more than 1 meter when the tide is high, and the current is strong enough. It is assumed that the dugong seen by residents is just passing through. Feeding tracks dugongs in Tarabitan Village are known at high tide with a depth of ± 2 meters. The dominant type of seagrass consumed by dugongs in Tarabitan Village is *Halophila ovalis*. This species is the same as the findings in the dugong feeding track in Bulutui Village. This species is different from the seagrass track data in Bahoi Village, but the dugong in this area certainly prefers the seagrass *Halodule pinifolia* as its main food. It is evidenced by the many feeding tracks found

in Bahoi Village (Figure 7). Dugongs selectively choose contiguous meadows dominated by fast-growing species and high nutrients to actively forage to meet daily dietary requirements [20].

The relationship between seagrass quality and the appearance of dugong feeding tracks was influenced by the density composition of each type of seagrass. Feeding tracks had a positive correlation with seagrass density [26]. Waters that have the dugong's favorite seagrass type have great potential for the presence of dugong feeding tracks. For example, the waters around Bahoi village have the highest level of *Halodule pinifolia* composition compared to other villages. This is in line with the number of feeding tracks which are mostly found in this area.

Interviews and discussions shown that fishermen in these villages are knowledgeable source of information regarding of dugong sightings and seagrass distribution. This fact might indicate that there are intertwining, overlap access of use between dugong and human in seagrass ecosystem. These conditions potentially can affect seagrass ecosystem dynamics and might have management implications for species and ecosystem management [23, 24].



Figure 7. Feeding track in Bahoi Village, North Minahasa Regency

4. Conclusion

This study identified seven seagrass species in North Minahasa Regency. There are *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Syringodium isoetifolium*, *Halophila ovalis*, *Halodule uninervis*, and *Halodule pinifolia*. Seagrass density in Bahoi, Tarabitan, Bulutui, and Gangga I were 885.05, 482.71, 836.7, and 863.09 shoots/m^2. Seagrass cover in Bahoi Village has a closing value of 66.05 %, Tarabitan Village of 52.70 %, Bulutui Village of 65.16 %, and Gangga I Village of 63.01 %. Feeding tracks observed in three locations, in Bahoi, Tarabitan, and Bulutui villages. The most tracks of feeding tracks were in Bahoi Village, with the type of seagrass that dominated being eaten by dugongs was *Halodule pinifolia*. Certain types of seagrass are related to the location of the emergence of dugongs in the North Minahasa Regency.

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