Feeding ground indications are based on species, seagrass density and existence of *Dugong dugon* in Hiri Island Sea, North Maluku, Indonesia

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**Abstract.** Seagrass ecosystems are located between mangrove ecosystems and coral reefs. Seagrass ecosystems are habitats and foraging area for many marine organisms. Eco-biological cycles in seagrass ecosystems are important for maintaining populations of many organisms. Seagrass at Hiri Island is distributed horizontally along the coast. This island is also a location where *Dugong dugon* is found North Maluku. *Dugong dugon* is an endangered species that has been included in the IUCN and Appendix I Cites. This study aimed to identify species, density of seagrass and existence of *Dugong dugon*. The survey method used quadratic transect method to collect seagrass data. The results found 6 species of seagrass at Hiri Island. Five species of those seagrass (*Cymodocea serrulata*, *Cymodecea rotundata*, *Halodule uninervis*, *Halodule pinifolia*, *Halophila spinulosa*) are known as food of *Dugong dugon*. The highest species density was shown by *Halodule uninervis*. The presence of *Dugong dugon* and its feeding trail was found during field survey. Information on seagrass species and *Dugong dugon* sightings location can be used for endangered species conservation policies. Management and conservation efforts need to be done to maintain seagrass ecosystem and *Dugong dugon* potential habitat at Hiri Island.

**1. Introduction**
Coastal areas have three main ecosystems, namely mangroves, seagrasses and coral reefs. These ecosystems have an important ecological role in safeguarding coastal areas and marine biota. Seagrass ecosystem is an ecosystem that is usually found between mangrove and coral reefs. Hiri Island has seagrass meadow that is distributed horizontally along the coast. Seagrass is an important ecosystem that supports various marine organisms, as well as a protein barn for living things. Seagrass is a shallow marine ecosystem that plays an important role in coastal waters. Ecologically, it has an important function as a primary producers, habitat, sediment trap, spawning ground, nursery ground, feeding ground and erosion prevention, sediment traps and reduce the action of currents and waves [1], [2], [3], [4]. The existence of seagrass ecosystems has an ecological impact on the presence of...
marine organisms. This ecosystem serves as a feeding ground for dugongs, green turtles, fish, echinoderms and gastropods [4], [5]. Dugong is a plant-eating mammal or herbivor that feeds on seagrass [5]. *Dugong dugon* is one of 35 species of marine mammals found distributed in Indonesia, especially in areas having extensive seagrass meadows[6]. *Dugong dugon* belongs to the Mammalian Class which is characterized by animals that feed on cubs, and under the Order of Sirenia which is characterized by herbivorous marine mammals [7].

Seagrass research on *Dugong dugon* ecology has been conducted by [5] at Busung Village in North Bintan Riau Islands, [8] in Spermonde Islands, [9] in Bangka Belitung Islands, [10] in some small islands of Indonesia, and [11] in Lamteng Bay, Aceh. Hiri Island is a place having extensive seagrass and has been reported by island community as habitat of *Dugon dugon*. *Dugon dugon* conservation and protection strategy has not been implemented, although *Dugong dugon* is included in the protected animals, due to the declining global population. According to the IUCN, *Dugong dugon* species are vunerable and Appendix I CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora) is not to be utilized. The low encounter with dugongs in territorial waters is due to its rare status and is included in the IUCN red list. *Dugong dugon* scarcity can be caused by several factors, namely reproductive biology, hunting by humans, and threatened habitat conditions [9]. Generally people and domestic tourists make use of seagrass and *Dugong dugon* of Hiri Island as marine attractions. The presence of dugong and seagrass ecosystems at Hiri Island has not gained enough attention; in other words there has been very limited scientific information on Hiri Island seagrass and dugong ecology. At the end, as [8] said there is a strong need for scientific study to raise good scientific data and information for developing effective *Dugong dugon* management strategy.

2. Method

2.1. Research location
This study location was at Tafraka Village on Hiri Island (0°53’42.454” N, 127°19’4.494” E), North Maluku Province in Indonesia, as shown on map in Figure 1.
2.2. Data sampling
2.2.1. Water quality and substrate
Environmental parameters were measured in situ that included sea water temperature, salinity, dissolved oxygen (DO), and substrate.

2.2.2. Seagrass
Seagrass identification was done using guide of [12] and [4]. Seagrass data collection applied quadratic transect method. The transect used was 50 m long placed vertically to shoreline. Distance or space between transects was 50 m. Each transect was placed quadrants of 50 x 50 cm size with the distance between quadrants was 10 m.

2.2.3. Dugong existence detection
Two data collection methods were applied to detect dugong presence on Hiri Island coastal ecosystem. The first method was diving and snorkelling to visually observe dugongs and their feeding trails in seagrass ecosystems. [13] it explained that, it found that the feeding trail was visually at an average size of 5.1 m². The second method was to conduct interviews with fishermen who usually fish on seagrass areas.

2.3. Data analysis
Data analysis was carried out to obtained seagrass dominance and density [14]

3. Results and discussion
3.1. Water quality and substrate
Data resulted from in situ measurement sea water parameters, namely temperature, salinity, pH, and dissolved oxygen (DO), was shown in Table 1.

| No | Water Quality | Station I | Station II | Station III |
|----|---------------|-----------|------------|-------------|
| 1  | Temperature   | 29.5°C    | 30°C       | 29°C        | 30°C         | 30°C        |
| 2  | Salinity      | 33‰       | 33‰       | 33.5‰       | 33.5‰       | 33.4‰       | 33.5‰       |
| 3  | DO            | 7.5        | 7.5        | 7           | 7           | 7           | 7           |
| 4  | Substrate     | Sandy      | Muddy sand | Muddy sand  | Muddy sand  | Muddy sand  | Rocky sand  |

Information: T = Transect

Water temperature at study site ranged 29-30°C. This sea water temperature was normal category. Optimal value of water temperature for seagrass is 28-30 °C [15]. [16] explained that seagrass can tolerate up to 35°C temperature of sea water but its optimal temperature is range of 28-30°C. Salinity of sea water found was in range of 33-33.5‰ with an average of 33.5‰ and it was in normal category. Seagrass salinity preference range is 25-35‰ [15], [16]. Seagrass species' tolerance to salinity are differ among species, where seagrass living in estuary has wider salinity tolerance while seagrasses living at open sea has narrower tolerance. Dissolved oxygen measured was in range of 7-7.5 mg/L. Normal dissolved oxygen (DO) for marine organisms is >5 mg/L [15]. All aquatic organisms live on dissolved oxygen >5 mg/L [17].

Composition of substrate determines content of organic matters in a sea bed, such as nitrates and phosphates that seagrass needs to grow and develop. Type of fine substrates is called sludge, containing more organic matter compared to the rougher substratee [18]. Substrate at study site was found to be muddy sand, thus affecting the ecology of seagrass. Seagrass density was generally influenced by substrate types and high seagrass density was generally found on sandy substrates [19]. Mud-sandy substratee conditions have seagrass density normal to tight category. Substrate factors
were also closely related to the development and growth of seagrass. [20] stated that composition of substrate also influenced distribution of seagrass in a location.

3.2. Seagrass compositions

There were 6 species of seagrass found in study area, they were Cymodocea rotundata, Cymodocea serrulata, Halophila spinulosa, Halodule pinifolia, Halodule uninervis, and Enhalus acoroides (Figure 2). Seagrass species were found to be different among stations, due to differences in coastal topography and substrate sediment types (Tables 2, 3 and 4).

| Tabel 2. Seagrass species at Station I |
|---------------------------------------|
| Seagrass species at Station I (Transect I) |
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Cymodocea serrulata | Halodule uninervis | Cymodocea serrulata | Enhalus acoroides |
| Cymodocea rotundata | Halodule pinifolia | Halodule pinifolia | Halodule pinifolia |
| Halodule uninervis | Cymodocea serrulata | Cymodocea rotundata | Cymodocea rotundata |
| Halodule pinifolia | Cymodocea serrulata | Halodule uninervis | Halodule uninervis |
| Halophila spinulosa | Cymodocea serrulata | Halodule uninervis | Halodule uninervis |

| Seagrass species at Station I (Transect II) |
|---------------------------------------|
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Enhalus acoroides | Cymodocea rotundata | Enhalus acoroides | Halodule uninervis |
| Halodule uninervis | Halodule pinifolia | Halodule pinifolia | Halodule pinifolia |
| Cymodocea rotundata | Cymodocea serrulata | Halodule pinifolia | Cymodocea rotundata |
| Cymodocea serrulata | Enhalus acoroides | Cymodocea serrulata | Enhalus acoroides |
| | Halodule uninervis | | |

| Tabel 3. Seagrass species at Station II |
|---------------------------------------|
| Seagrass species at Station II (Transect I) |
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Enhalus acoroides | Cymodocea serrulata | Enhalus acoroides | Enhalus acoroides |
| Halodule uninervis | Halodule uninervis | Cymodocea rotundata | Halodule uninervis |
| Cymodocea rotundata | Enhalus acoroides | Halodule uninervis | Halodule uninervis |
| Halodule uninervis | Halodule uninervis | | |

| Seagrass species at Station II (Transect II) |
|---------------------------------------|
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Enhalus acoroides | Cymodocea serrulata | Enhalus acoroides | Enhalus acoroides |
| Cymodocea rotundata | Halodule uninervis | Halodule uninervis | Halodule uninervis |
| Halodule uninervis | Enhalus acoroides | Cymodocea rotundata | Cymodocea serrulata |
| Cymodocea serrulata | | | |

| Tabel 4. Seagrass species at Station III |
|---------------------------------------|
| Seagrass species at Station III (Transect I) |
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Enhalus acoroides | Enhalus acoroides | Cymodocea serrulata | Enhalus acoroides |
| Halodule uninervis | Halodule uninervis | Halodule uninervis | Cymodocea rotundata |
| Cymodocea serrulata | | | |

| Seagrass species at Station III (Transect II) |
|---------------------------------------|
| Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
| Halodule uninervis | Halodule uninervis | Halodule uninervis | |
There were 6 seagrass species found in Station I, they were *Cymodocea serrulata*, *Cymodecea rotundata*, *Halodule uninervis*, *Halodule pinifolia*, *Halophila spinulosa*, and *Enhalus acoroides*. Station I was dominated by *Cymodocea serrulata*, *Cymodecea rotundata* and *Halophila spinulosa*, due to the existence of sandy and muddy sand. Seagrass species found in Station II were *Enhalus acoroides*, *Halodule Uninervis*, *Cymodecea rotundata*, and *Cymodocea serrulata*. Species dominant at Station II was *Halodule uninervis*, *Enhalus acoroides* and *Cymodocea serrulata* that may related to muddy sand substrate of the stations. Sign of foraging activities of *Dugong dugon* were found at Station II. Some fishers also confirmed the presence/appearances of *Dugong dugon* at Station II.

Station III had 4 species of seagrass, namely *Enhalus acoroides*, *Halodule uninervis*, *Cymodocea serrulata* and *Cymodecea rotundata*. The most dominant species at Station III were *Enhalus acoroides* and *Halodule uninervis*. No signs of dugong presence found at Station III since there is a port nearby with high transportation activity.

*Figure 2.* Photos of seagrass found at study site.
3.3. Seagrass species density

Analysis of seagrass species density at all stations showed differences in species, aquatic contours and substrate types (Figures 3, 4 and 5). Species with the highest density value at Station I was *Halodule uninervis* with density of 21.17 ind/m$^2$. The species *Enhalus acoroides* had the lowest density with 3.50 ind/m$^2$. At Station II, the highest species density value was *Halodule uninervis* with 16.83 ind/m$^2$ and *Enhalus acoroides* was the species with the lowest density with 5.33 ind/m$^2$. The highest species density value found at Station III was 16.17 ind/m$^2$ that was for *Halodule uninervis* species, while the lowest density value was for *Enhalus acoroides* which was 5.67 ind/m$^2$.

The highest seagrass density over all station was *Halodule uninervis* species which is assumed to related to existing aquatic environment condition and substrate or sediment type. The lowest density value was found for *Enhalus acoroides*. Low density value of *Enhalus* sp was due to their existence is limited to the shallowest part of the beach.
Figure 5. Seagrass species density (Station III)

Figure 6. a) Feeding trail and b) Dugong dugon at Tafraka coast at Hiri Island.
3.4. Functional relationships (Dugong dugon and seagrass)

The frequency of *Dugong dugon* appeared in Tafraka Village coast was high at Stations I and II because seagrass species at both stations were food of *Dugong dugon*, namely *Halophila spinulosa*, *Halodule uninervis* and *Cymodocea serrulata*. The three species were supported by a substrate type of muddy sand. A different environment was found at Station III where there was little seagrass species that was preferred by *Dugong dugon*. Station II also had high intensity of human activity such as sea transportation.

Other factors such as substrate types play critical roles in dugong feeding activities. Sandy substrate were type of substrate that *Dugong dugon* prefer for foraging since this substrate was smooth having about 56% of fine sand material. Such environmental conditions make it easier for dugongs to graze, because when eating dugongs stick their mouths to pry and dig up the entire seagrass plant up to seagrass roots to eat. During field observation, one *Dugong dugon* (with size about 2 meters long) found foraging at research station (Figure 6). The presence of seagrass species which is a favorite food of dugongs was an indicator of *Dugong dugon* presence [20].

Data on distribution of seagrass species and appearance of dugongs at Stations I and II indicated that both stations were feeding grounds of *Dugong dugon*. Availability of seagrass species in those stations was a reason for *Dugong dugon* existence. Found feeding trails were also support *Dugong dugon* presence at Tafraka Village coast of Hiri Island.

4. Conclusion

Dugong preferred seagrass species were found at some parts of Hiri Island. Stations I and II had a high density of seagrass and was found to be a grazing or feeding ground of *Dugong dugon*. Study results indicated the relationship between seagrass species and *Dugong dugon* presence in a seagrass meadow.

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