Status of seagrass beds in Ternate and surrounding areas

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Abstract. Seagrass bed is one of important ecosystems usually located adjacent to coral reefs and serves several important ecological roles such as feeding and nursery ground for several marine biotas. Physically, seagrass bed protects the reef from inland sedimentation. The status of seagrass beds, therefore, becomes an important thing in protecting the coral reef ecosystem. The study was conducted on July 2018 with the objective to analyze the current status of seagrass bed at Coral Reef Rehabilitation and Management Program (COREMAP) site in Ternate Island. Ten stations were chosen for this study and linear transect method was used to analyze species composition and canopy coverage. The result showed that there are 8 species found in this area with 5-7 species commonly found at each station. Among 8 species found, Thalassia hemprichii being the most common species inhabiting all of the sites. Average canopy coverage in seven stations was below 59.9% which considered as less healthy, whilst at other three locations was below 29.9% which considered as poor status. Overall, the status of seagrass beds in this area is less healthy with moderate canopy cover. This status has remained the same since 2015 to the present time.

1. Introduction

Seagrass is a group of flowering plants from the order of Alismatales that adapted to live in the oceans [1, 2]. This plants can form a marine vegetation on a monospecific or multispecies composition which called seagrass bed/meadow. This bed usually used by various marine organism as a habitat which in turn resulting a lot of interaction inside the beds that made this bed considered as an ecosystem.

Seagrass plants are ecosystem engineers because they significantly modify their environment [2]. Because of it, they form important marine and estuarine habitats providing valuable ecosystem services and functions [3]. Seagrass ecosystem have an enormous ecological function [4], such as reducing coastal erosion dan coral reef siltation [5], as a habitat and food for invertebrates, fishes, dugong, sea turtles and on the material source for detrital food webs and his role on sediment stabilization [6]. This ecosystem also provide service to the interconnected habitats (mangroves and coral reefs) and population through nursery and foraging areas also by carbon and nutrient sequestration and export [7].

The ecosystem services value of $ 19004/ha/year [8] that monetized the loss to $ 209,044,000 per year. Even the ecosystem have high service value, seagrass ecosystem is globally declining at rate of 110 km²/year and continue to accelerate [9]. A large–scale losses of seagrasses have reported worldwide due to combinations of human pressure such as increased nutrient and sediment runoff, invasive species, hydrological alterations, and commercial fishing practices [10, 3].

Seagrass bed also interact with other coastal ecosystem such as mangrove and coral reef. Coral reef protect the seagrass and mangrove from wave energy, whereas mangrove and mangrove filter sedimentation from land which could harm the coral. The presence of connectivity between the three coastal ecosystems indicate that management effort on one of the ecosystem wouldn’t be optimal without adequate knowledge on the surrounding ecosystem. By this reason, the Coral Reef
Rehabilitation and Management Program – Coral Triangle Initiative (COREMAP – CTI) include the monitoring of seagrass beds and mangrove as a part of the activities alongside the main program on coral reef. One of the location of the program is in Ternate Island and surrounding. Therefore, the objective of this research is to assess the current conditions or status of the seagrass beds and in Ternate and surrounding areas and the changes over several years.

2. Method

2.1. Time and locations
The study was conducted in July 2018 at COREMAP-CTI monitoring sites in North Maluku area, Indonesia (Figure 1). There are 10 sites in five area, which are Hiri Island, Ternate Island, Maitara Island, Tidore Island, and West Halmahera. The sites are seagrass beds on a reef flat which varied between 10 m and more than 100 m in width. The substrate of reef flat also varied, from mud to grave affected by the existence of coastal ecosystem. Some of location had low water clarity during the studies due to the weather condition such as rain or the muddy substrate from mangrove.

2.2. Data collecting
Data gathered from 100 x 100 m permanent plot in each site. Inside the plot, three 100 m transect placed perpendicular to the coastline with 50 m interval between transects. Observation done in a 50 x 50 cm quadrat that placed at every 10 m interval in each transect. In total, there were 33 quadrats in a permanent plot, if the seagrass meadows occupied at least 100m wide. There were four parameters observed in each quadrat which were seagrass composition, total seagrass cover, and seagrass cover of each species and number of Enhalus acoroides (if present).

2.3. Analysis
All the data entered to spreadsheet program and analyzed for their average in each site. Change of seagrass community in Ternate, Tidore, and West Halmahera since 2015 was compared with the previous year data and analyzed statistically using gls (Anova) and pairwise t-test as post hoc analysis if the p-value < 0.05. Statistical analysis was conducted by R version 3.1.3 and the change of seagrass cover was illustrated by graph (ggplot 2). The condition of seagrass was determined based on decree of Minister of Environment (KepMenLH) No 200 in 2004 (Table 1).
Table 1. State of seagrass condition based on Indonesia Ministry of Environment Decision No 200 of 2004 [11].

| Condition | Cover (%) |
|-----------|-----------|
| Good      | Healthy   |
| Damage    | Unhealthy |
| Poor      | ≤29       |

| 3. Result and discussion |

3.1. Seagrasses richness

There were eight seagrasses species in this study (Table 2). Seagrass communities in all sites were mixed vegetation with minimum consist of two species (two sites) and maximal 7 species (four sites). *Thalassia hemprichii* was the most common species because observed in all sites. While, *Halodule pinifolia* and *Cymodocea serrulata* was two of the less common species, just found in five sites.

Table 2. Species richness and cover of seagrass community in permanent plot across 2018 study areas.

| Locations | Num. of species | EA (%) | TH (%) | CR (%) | CS (%) | HO (%) | HU (%) | HP (%) | SI (%) |
|-----------|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Hiri Is.  |                 |        |        |        |        |        |        |        |        |
| Tafraka   | 7               | 0.09   | 10.20  | 15.81  | ++     | 5.6    | 0.28   | 2.11   | 0.00   | 21.97  | +++    |
| Ternate Is. |            |        |        |        |        |        |        |        |        |        |
| Sasa      | 2               | 5.80   | 5.36   | 0.00   | -      | 0.0    | 0.00   | 0.0    | 0.00   | 0.0    | -      |
| Kastela   | 7               | 8.48   | ++     | 15.33  | +++    | 1.49   | +      | 8.1    | +      | 0.0    | 0.15   | +      |
| Maitara Is. |            |        |        |        |        |        |        |        |        |        |
| Akibui    | 6               | 17.78  | ++     | 23.29  | +++    | 1.64   | +      | 3.0    | +      | 0.00   | 1.7    | +      |
| Pasimanyou| 7               | 14.33  | ++     | 17.87  | +++    | 0.68   | +      | 0.7    | +      | 0.54   | 0.3    | 0.00   | -      |

| Tidore Is. |               |        |        |        |        |        |        |        |        |        |
| Rum Balibunga |       | 6       | 0.00   | -      | 12.30  | ++     | 0.00   | 4.7    | -      | 3.32   | 3.9    | +      | 1.17   | 15.23  | +++    |
| Dowora     | 6               | 9.26   | ++     | 18.19  | +++    | 2.01   | -      | 2.8    | +      | 0.45   | 0.0    | -      | 0.00   | 0.56   | +      |
| Zikoisa    | 2               | 14.06  | +++    | 4.42   | +      | 0.00   | -      | 0.0    | -      | 0.00   | 0.0    | 0.00   | -      |

| West Halmahera |           |        |        |        |        |        |        |        |        |        |
| Ake Jailolo | 7              | 2.54   | +      | 12.50  | +++    | 6.05   | +      | 0.0    | -      | 2.15   | 2.9    | +      | 1.37   | 0.59   | +      |
| Sidangoli Gam | 5            | 11.24  | ++     | 15.02  | +++    | 5.29   | +      | 0.0    | -      | 0.20   | 0.6    | +      | 0.00   | 0.00   | -      |

Ave. 8.36±1.80 13.45±2.90 3.30±0.84 2.49±1.05 0.88±0.43 1.15±0.66 0.27±0.21 5.36±1.58

Note: + = Present (+++ = dominant level), - = Absent

EA (*Enhalus acoroides*), TH (*Thalassia hemprichii*), CR (*Cymodocea rotundata*), CS (*Cymodocea serrulata*), HO (*Halophila ovalis*), HU (*Halodule uninervis*), HP (*Halodule pinifolia*), SI (*Siringodium isoetifolium*).
3.2. Seagrass cover

Seagrass cover percentage in the study areas in this year ranges from 11.16% to 56.07% (Table 3). Most of sites have seagrass cover on the range of 25-50% (Kastela, Pasimanyou, Rum Balibunga, Dowora, Ake Jailolo, and Sidangoli Gam) which make them on moderate cover category. Only two sites have dense cover (50-75%) which are Tafraka and Akibui. The remaining sites (Sasa and Zikoisa) have cover less than 25% which make them categorized as sparse. From the status perspective, most of the sites (7 of 10 sites) classified as unhealthy because their cover falls between 30 % until 59.9%. The remaining sites (Sasa, Zikoisa and Ake Jailolo) classified as poor because their cover less than 29.9%.

Table 3. Seagrass cover in the study area and its status in 2018

| Location          | Seagrass cover (%±SE) | Category | Status    |
|-------------------|-----------------------|----------|-----------|
| Tafraka           | 56.07±6.3             | Dense    | Unhealthy |
| Sasa              | 11.16±8.7             | Sparse   | Poor      |
| Kastela           | 41.67±3.5             | Moderate | Unhealthy |
| Akibui            | 55.21±3.8             | Dense    | Unhealthy |
| Pasimanyou        | 35.6±4.6              | Moderate | Unhealthy |
| Rum Balibunga     | 40.63±11.0            | Moderate | Unhealthy |
| Dowora            | 33.26±3.8             | Moderate | Unhealthy |
| Zikoisa (P. Tidore) | 18.49±2.8         | Sparse   | Poor      |
| Ake Jailolo       | 28.13±3.9             | Moderate | Poor      |
| Sidangoli Gam     | 32.36±2.3             | Moderate | Unhealthy |

3.3. Seagrasses dominance

The most dominant seagrass species in study areas was Thalassia hemprichii with cover average 13.45±2.9% (Table 2). This species found in all sites and its cover dominant to other seagrasses except in Tafraka, Sasa and Zikoisa (Table 2, Figure 2). In Tafraka, the dominant species was Syringodium isoetifolium, meanwhile in Sasa and Zikoisa the dominant species was Enhalus acoroides (Table 2, Figure 2).

3.4. Trend

Seagrass richness in the study area doesn’t show any changes in number of seagrass species which is eight species (Table 4), comprise of Enhalus acoroides (Linn. f.) Royle, Thalassia hemprichii (Ehrenberg) Ascherson, Cymodocea rotundata Ehrenberg & Hemprich, ex Ascherson, Cymodocea serrulata (R. Brown) Ascherson & Magnus, Halophila ovalis (R. Brown) Hooker f., Halodule uninervis (Forskal) Ascherson, Halodule pinifolia (Miki) den Hartog, and Syringodium isoetifolium (Ascherson) Dandy. However, the composition in each sites could change in different year. This species shifting phenomena is also appear in other monitoring action in the Western Pacific region [7]. Several sites show a decrease in number of species from the first year observation, such as in Tafraka, Sasa, Kastela, Akibui, Dowora, and Zikoisa. Conversely, there were increase in number of species, such as in Pasimanyou, Rum Balibunga and Sidangoli Gam. Only Ake Jailolo sites who had the same number of species from 2015 (Table 4).
Figure 2. Seagrass dominance at 10 monitoring sites

Table 4. Number of species recorded at permanent plot in study sites from 2015 to 2018.

| Stasiun_ID       | Number of species |
|------------------|-------------------|
|                  | 2015 [12] | 2016 [13] | 2017 | 2018 |
| Tafraka          | 8         | 3         | 6    | 7    |
| Sasa             | 3         | 3         | 3    | 2    |
| Kastela          | 8         | 6         | 6    | 7    |
| Akibui           | 8         | 5         | 7    | 6    |
| Pasimanyou       | 6         | 4         | 6    | 7    |
| Rum Balibunga    | 5         | 4         | 5    | 6    |
| Dowora           | 8         | 5         | 5    | 6    |
| Zikoisa          | -         | 3         | 2    | 2    |
| Ake Jailolo      | 7         | 6         | 7    | 7    |
| Sidangoli Gam    | 4         | 3         | 3    | 5    |
| **Total number** | **8**     | **8**     | **8** | **8** |

Just like the composition in each site, the seagrass cover also showed a fluctuated trend over the past four years (Figure 3). There are four sites with increasing trend which are Tafraka, Akibui, Rum Balibunga, and Sidangoli Gam. In contrary, there are also three sites who have decreasing trend, which are Sasa, Pasirmanyou, and Zikoisa (P. Tidore). The remaining sites don’t show any clear trend.

Based on the overall seagrass cover, there are large ranges of value from 2015 until 2018 with minimum cover of 37.81% in 2018 and maximum cover of 67.56% in 2017 (Table 5). Statistical analyses results that there is a significant decline (p-value < 0.05) in overall seagrass cover in the last three years. The decrease was about 4.83% from initial cover 41.95% in 2015. Nevertheless, the seagrass conditions almost remain the same during the period (falls at 30 – 59.9%) which classified as
unhealthy (Table 5), except in 2017 which reach more than 60%. This exception could be related to personnel changes at that year, which could affect cover observation. Even though there are several standard for seagrass cover estimation (see [14] and [15]) and simplified method by COREMAP-CTI [16], seagrass cover is still determined by estimation that depend on personal perception of the observer. With the characteristic of multispecies vegetation in Indo-Pacific seagrass beds [5], the available standard took example from more monospecies seagrass bed, so it’s still have limitation for this region.

![Figure 3. Seagrass cover (%) in the study area from 2015 to 2018.](image)

Table 5. Seagrass cover and the overall status in Ternate and surroundings from 2015 to 2018.

| Year | Seagrass cover (%±SE) | Status     |
|------|------------------------|------------|
| 2015 | 41.95                  | Unhealthy  |
| 2016 | 44.46±1.9              | Unhealthy  |
| 2017 | 67.56±2.2              | Healthy    |
| 2018 | 37.81±1.7              | Unhealthy  |

The unhealthy status almost remain the same for four year observation, except in 2017. This indicates that Ternate and surrounding area are still having the capacity to maintain the condition of the seagrass beds. However with several sites having a decrease in number of species and seagrass cover there are a concern that this condition could decline in to poor status. The indication is strengthened by statistical analysis which shows a significant decline in the overall seagrass cover. If the local people and government don’t want the decline to continue, they must find the cause of this decline and deal with it, or starting a rehabilitation effort.

4. Conclusion
The eight seagrass species that exist in 2014 still can be found in this study, although their distribution do not remain the same. The dominant seagrass species in this area is *Thalassia hemprichii*. Overall,
the status of seagrass beds in this area is less healthy with moderate canopy cover. This status has almost remain the same every year from 2015 with an indication of decline has already happens.

Acknowledgements
This study was funded by Indonesian Institute of Sciences (LIPI) through Reef Health Monitoring COREMAP-CTI project. The authors would like to thank to Ucu Yanu Arbi as the Ternate site coordinator who involving us in the activity. The gratitude also goes to Rikardo Huwe, Sumarno, Raismin Kotta, Agus Kusnadi, Marenda Pandu Rizki and Mochtar Djabar who helps and accompanies us during the field activities.

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