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Changes in the Ambon Bay Seagrass for the Past Five Years (2011 – 2016)

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Abstract. Ambon Bay is located on Ambon Island, which most of the area is within the Ambon City, the capital of Maluku Province. The coastal ecosystem such as coral reefs, mangroves, and seagrass beds still exist on this bay. However, as a coastal ecosystem in a crowded city, the potential of degradation for these ecosystems is immense. Over the past five years, many changes have taken place in this bay. In the land section, the construction of housing and large buildings such as shopping centers has occurred. Besides, on the coast, there has been a construction of new docks, and several locations have been reclaimed. Therefore, in 2016 there was a re-observation of the seagrass condition at all transect locations of 2011, to see the changes that have occurred in the seagrass bed in Ambon Bay over the past five years. The results will be compared to the satellite imagery of each location. Overall, the condition of seagrass beds in Ambon Bay in 2016 has decreased from the initial observation in 2011. Of the seven research locations, only one location (Halong) has an increase in its conditions, with seagrass canopy cover rise by almost twofold from previous data (24.29% rise to 50.00%). Four locations experienced a decline in condition, from a slight decrease in Waiheru and Lateri (25.00% down to 20.91% and 47.14% down to 39.33% respectively) to a sharp decrease in Tanjung Tiram and Passo (65.67% down to 39.33% and 48.33% down to 16.25% respectively). The remaining two locations (Tantui and Hative) were in worse condition because they were damaged by the reclamation project. From 2011 to 2016 satellite image comparison, almost all locations show changes in their land use, with more buildings built near and on the coastal area, except in Halong. This finding indicates that seagrass condition negatively affected by coastal development.

Keywords: seagrass meadows, degradation, landscape changes, monitoring, coastal development.

1. Introduction

Ambon Bay is located in Ambon Island in which as if split into two parts which called the Outer Ambon Bay and the Inner Ambon Bay due to the existence of a peninsula inside the bay. The outer part has an open water character, whereas the inner part is more protected from waves. Most of this bay area is within the administrative area of Ambon City, the capital of Maluku (Mollucas) Province.



Inside the bay, there are still coastal ecosystems that can be found on its coasts, such as coral reefs, mangroves, and seagrass beds [1]. The coral reefs are more abundant in the outer bay than in the inner bay, while the mangroves and seagrass are mostly grown in the inner part. However, as a coastal ecosystem in a crowded area of Ambon, the potential for degradation is very large. The mangrove condition has become increasingly alarming, and the area has diminished [2, 3], as well as the coral reefs [4]. With the decreasing area of mangroves and corals, seagrass beds could be the last fortress to protect coastal ecosystems in Ambon Bay, especially on the inner part. Unfortunately, seagrass degradation also has been observed in one location in Ambon Bay [5], which may be incorporated with the over sedimentation that happened there [6].

Over the past five years, many changes have taken place in the Ambon Bay area. In the land section, the construction of housing and large buildings such as shopping centers has occurred. In addition, on the coast, there is a new dock construction and several locations have been reclaimed. These developments put pressure on coastal ecosystems such as seagrass. Therefore, in 2016 there was a re-observation of seagrass conditions at all transect locations of 2011, to see the extent to which seagrass ecosystems survived the changes that occurred due to development in Ambon Bay

2. Methods

This research was conducted at seven sites in Ambon Bay, which are in Hative Besar, Tanjung Tiram, Waiheru, Passo, Lateri, Halong, and Tantai (Figure 1). Data were collected at the same coordinates with the previous study in 2011. Data collection was conducted in November during periods of low tide occurred during the day.

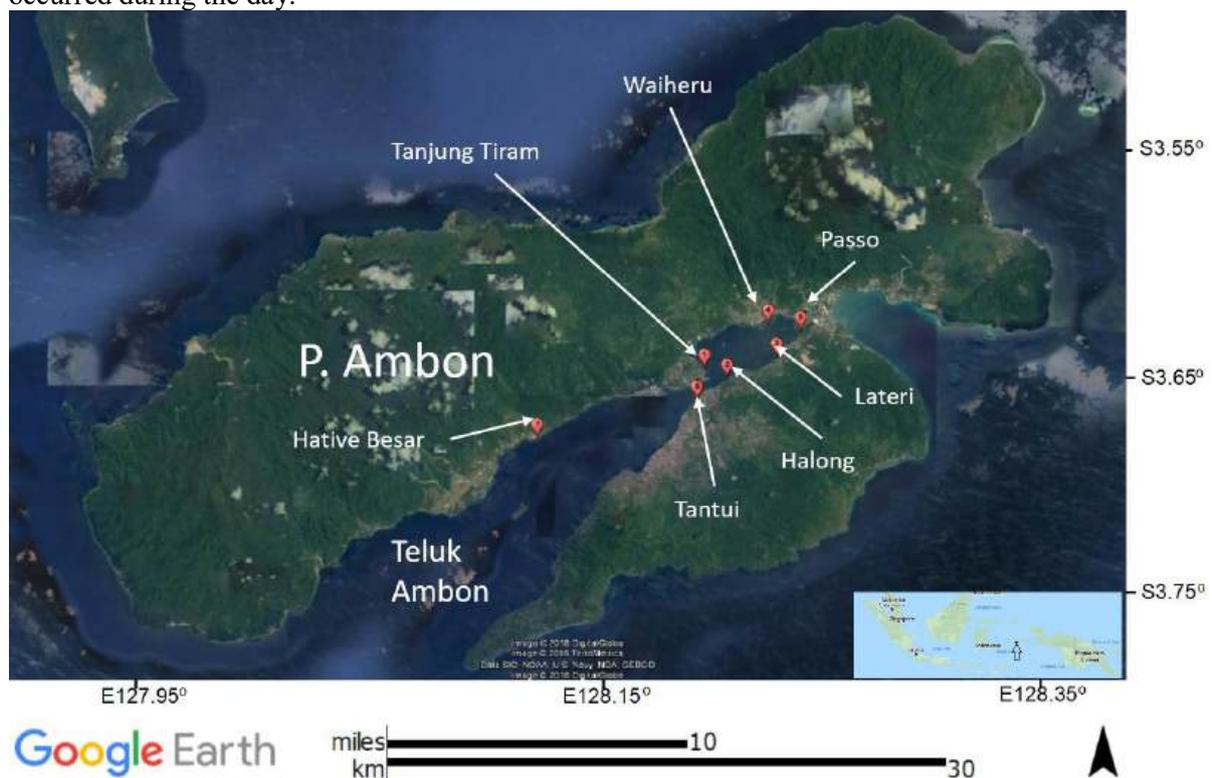


Figure 1. Study sites in Ambon Bay.

Observation of seagrass conditions was carried out using the transect method by adopting a protocol from UNESCO [7]. A transect was laid perpendicular to the shoreline, from the start of seagrass bed until the seagrass was not observed anymore. At an interval of 10 meters on the transect line, a quadrat frame with a size of 50x50 cm was placed. The percentage of seagrass cover in the frame and the

percentage of coverage for each species in the frame were observed and recorded. The references for species identification were *The Sea-grasses of the World* [8], *Seagrass Inventory Guidelines* [9], and *Seagrasses: Biology, Ecology and Conservation* [10].

To visually see the changes in landscape perspectives of each location, their Google Earth satellite images of 2011 and 2016 were compared. In addition, the development of the built area in Ambon City and its surrounding were analyzed from the cloud-free Sentinel satellite imagery of 2014 and 2018 to get the qualitative value of the land-use changes during that period.

3. Results

Of the seven research locations, only one location (Halong) has an increase in its conditions, with seagrass canopy cover rise by almost twofold from previous data (24.29% rise to 50.00%). Four locations experienced a decline in condition, from a slight decrease in Waiheru and Lateri (25.00% down to 20.91% and 47.14% down to 38.00% respectively) to a sharp decrease in Tanjung Tiram and Passo (65.67% down to 39.33% and 48.33% down to 16.25% respectively). The remaining two locations (Tantui and Hative) were in worse condition because they have lost (Figure 2).

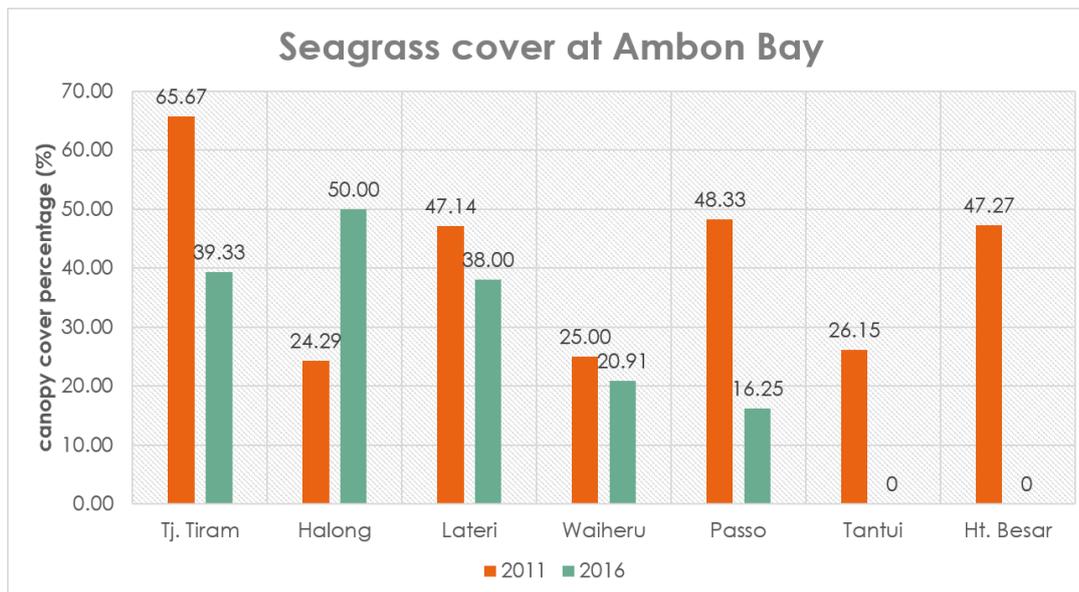


Figure 2. Averages of seagrass canopy cover in seven seagrass beds at Ambon Bay in 2011 and 2016.

3.1. Tanjung Tiram.

A comparison of satellite imagery for this location shows that there is not much change in coastal conditions where seagrass beds are located (Figure 3). In addition to seagrass beds, mangrove vegetation has not changed much since 2011. However, some land-use changes can be seen with the increasing number of new buildings replacing green spaces on land, as well as widening the road. If this continues, the pressure on coastal ecosystems will continue to increase because the function of land vegetation in filtering water and sediment runoff is decreasing.



Figure 3. Google Earth satellite images of seagrass bed and coastal area in Tanjung Tiram in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

In terms of seagrass cover along the transect, there has been a change in the distribution of each seagrass species and their cover at this location (Figure 4). The distribution of *Halodule pinifolia*, which in 2011 spread along 50 meters at the beginning of the transect, is now only slightly left in the 60th meter. *Halophila minor* and *Halophila ovalis* are even worse because in 2016 they were no longer found. *Enhalus acoroides* spreads before the end of the transect, and its cover decreases from around 80% to around 50%. Unlike the other species, the distribution of *Thalassia hemprichii* is broader, but the cover in the middle of the transect is smaller than it was five years ago.

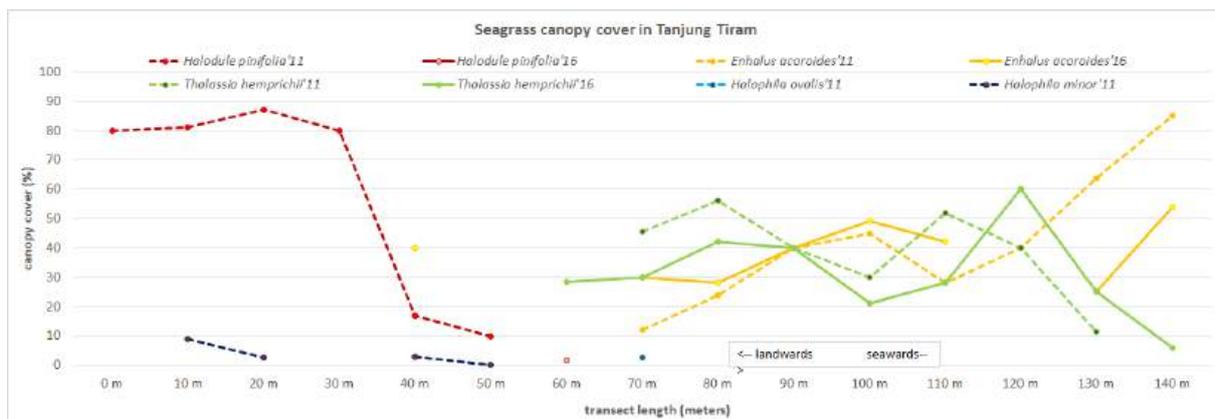


Figure 4. Seagrasses canopy cover along the transect in Tanjung Tiram. Each color represents a different seagrass species. Note: dashed line = 2011 data, solid line = 2016 data.

3.2. Halong.

Comparison of satellite imagery for seagrass beds in Halong and its surroundings does not seem to be much different, and even some areas were previously open in the land area, now covered by vegetation (Figure 5). This location is a military area so that the development of the area is limited to the interests of the military base.



Figure 5. Google Earth satellite images of seagrass bed and coastal area in Halong in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

In terms of seagrass species cover along the transect at the Halong site there did not seem to be much difference between the 2011 data and the 2016 data (Figure 6). *Enhalus acoroides* shifts landward and grows at the beginning of the transect, besides that its cover rises by about 10 in each quadrat. *Halodule pinifolia* remained in its position, and its cover rises compared to five years ago. Unlike other species, the distribution of *Halophila ovalis* is down to half but the cover increase. In the 2016 observation, *Thalassia hemprichii* was found which was not found on this transect five years earlier.

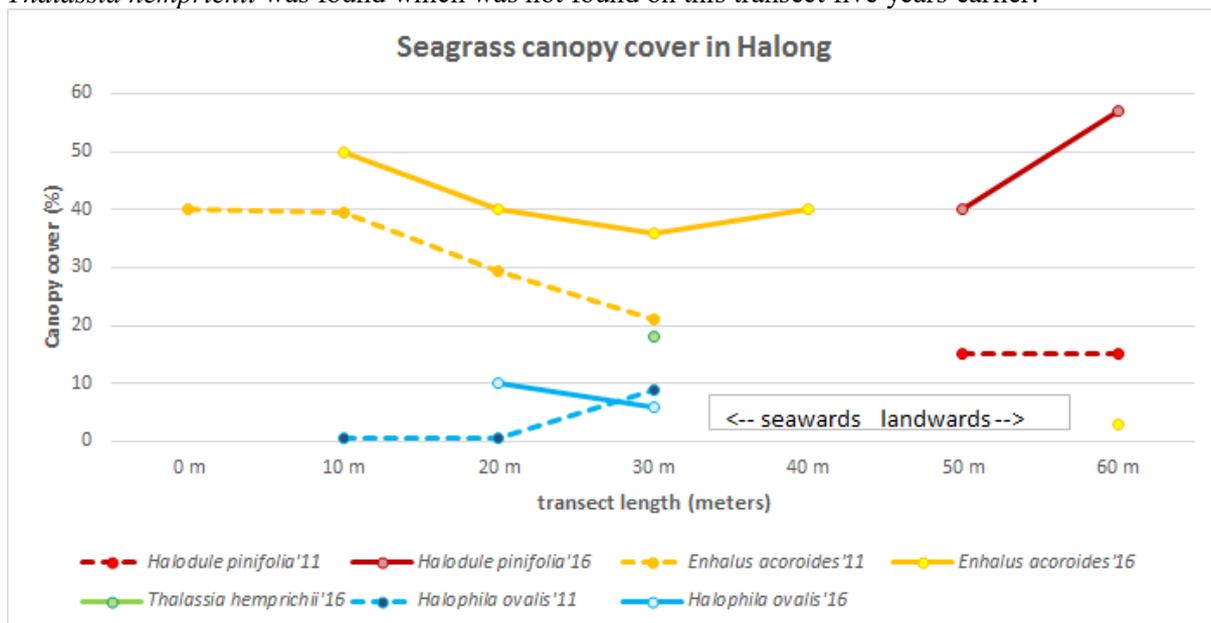


Figure 6. Seagrasses canopy cover along the transect in Halong. Each color represents a different seagrass species. Note: dashed line = 2011 data, solid line = 2016 data.

3.3. Lateri.

A comparison of satellite images of seagrass beds at the Lateri location indicates a difference in the presence of a new pier standing on seagrass beds (Figure 7). Seagrass beds still appear and have not changed much, but unfortunately, the new pier was built right on the observation transect in 2011. This caused the condition of seagrass beds to be incomparable because seagrasses on the previous transect were lost due to the construction of the pier.



B

Figure 7. Google Earth satellite images of seagrass bed and coastal area in Lateri in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

Although the 2011 transect (Figure 8) cannot be re-observed, new parallel transects were made near the location (Figure 9). In the 2016 transect, the two species of seagrasses observed in 2011 were still present (*Enhalus acoroides* and *Thalassia hemprichii*). However, none of the seagrass species covers surpassed 50% as in 2011.

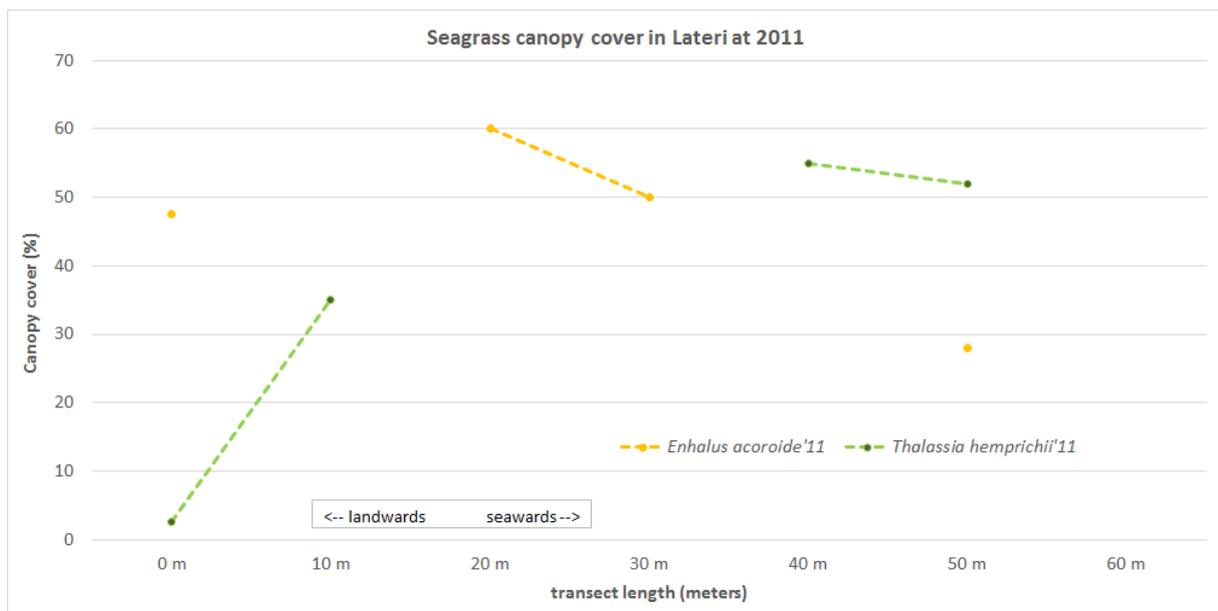


Figure 8. Seagrasses canopy cover along the 2011 transect in Lateri. Each color represents a different seagrass species.

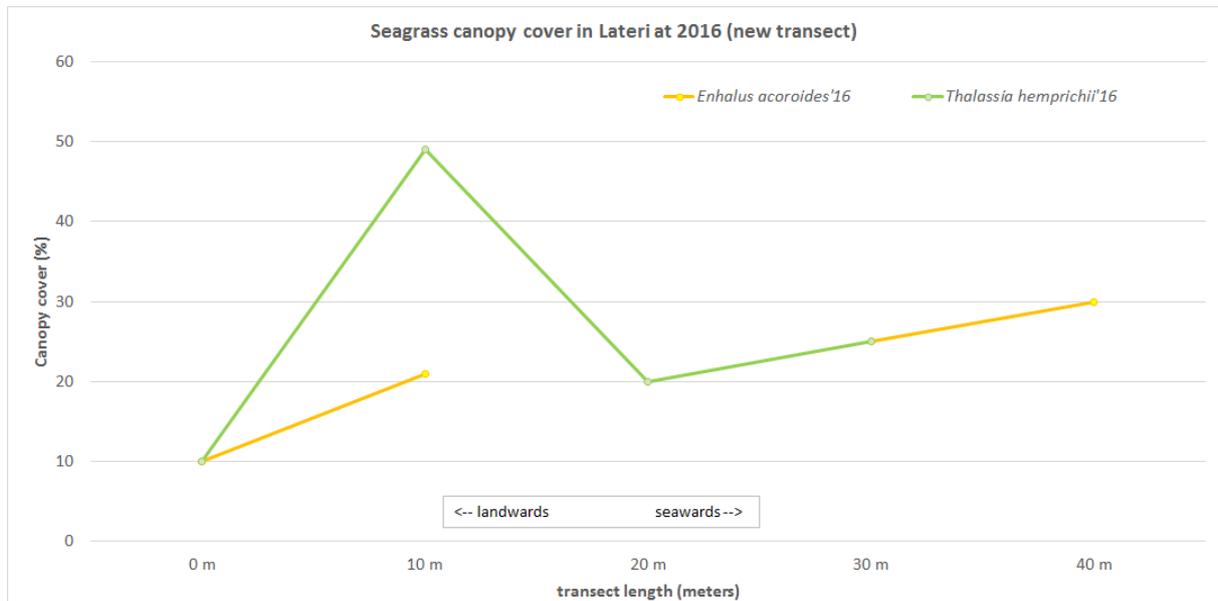


Figure 9. Seagrasses canopy cover along the 2016 transect in Lateri. Each color represents a different seagrass species.

3.4. Waiheru

Images of satellite images in 2011 and 2016 for the location of Waiheru do not seem to be very different (Figure 10). The seagrass bed that observed in 2011 are also still visible in 2016 and have not changed much. However, the cover of *Enhalus acoroides*, as the only seagrass present in this location, indicates a change in its distribution. The distribution is reduced by almost a half so that in the 2016 observation, the distribution of seagrass was only 40 m towards the sea (Figure 11)



Figure 10. Google Earth satellite images of seagrass bed and coastal area in Waiheru in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

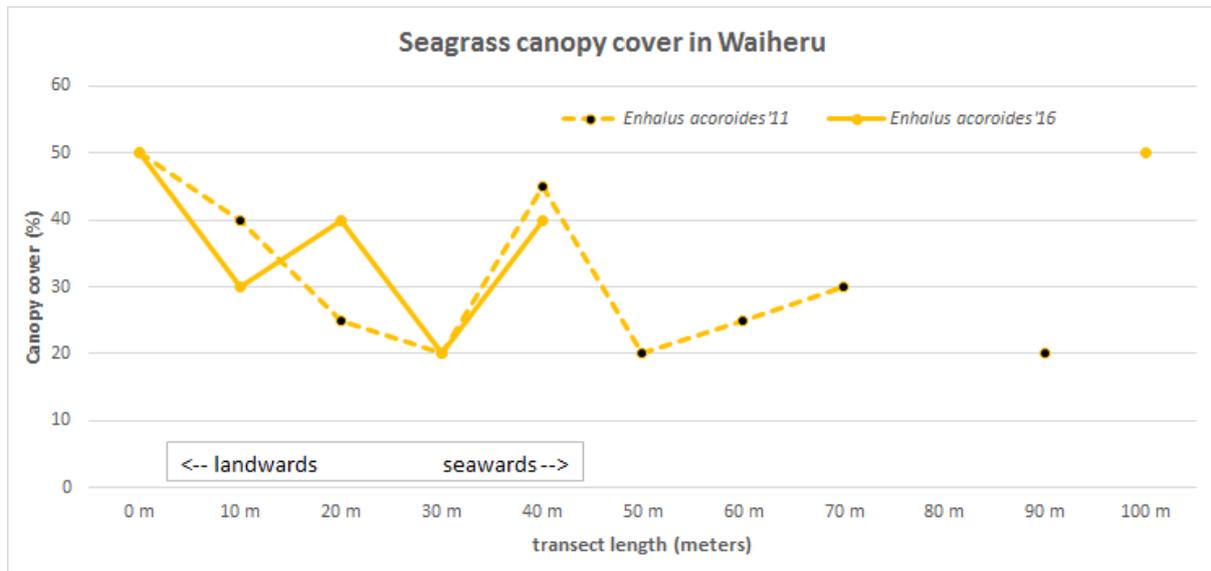


Figure 11. Seagrass canopy cover along the transect in Waiheru. Note: dashed line = 2011 data, solid line = 2016 data.

3.5. Passo

Comparison of satellite imagery for the Passo location shows that there is not much change in the coastal location where the seagrass is located. However, some land-use changes can be seen with the increasing number of new buildings replacing mangrove vegetation and green space on land (Figure 12). If this continues, the pressure on seagrass ecosystems will continue to increase because the function of land vegetation in filtering water and sediment runoff is decreasing.



Figure 12. Google Earth satellite images of seagrass bed and coastal area in Passo in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

Halophila minor cover, as the only seagrass present in this location, shows a change in the distribution of seagrass along the transect. In 2016, this species was only found at the beginning and end of the transect, not as continuous as in 2011, this made the distribution decreased by more than half compared to 2011 (Figure 13). In addition, the seagrass cover also has decreased compared to 2011 data.

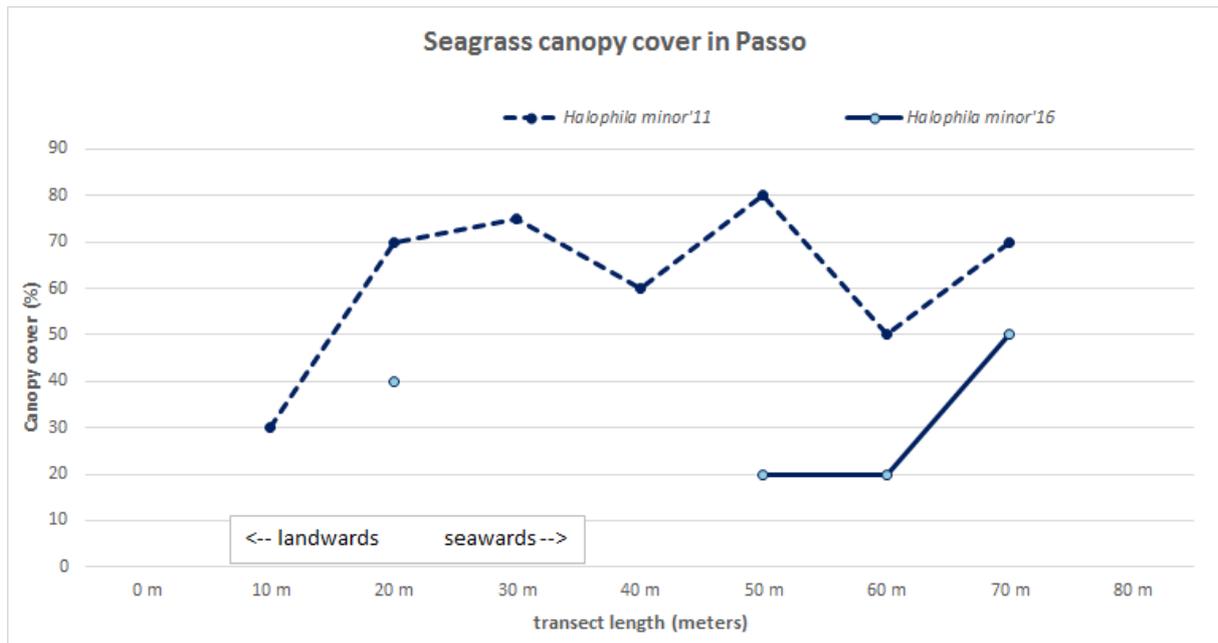


Figure 13. Seagrasses canopy cover along the transect in Passo. Note: dashed line = 2011 data, solid line = 2016 data.

3.6. Tantui.

Comparison of satellite imagery at the Tantui location shows several changes that occurred in the area from 2011 to 2016 (Figure 14). On land, many buildings stand in place of green open land. On the coast, the changes are more evident with the presence of coastal reclamation, which causes the coastline to change and the land to increase towards the sea. Unfortunately, the reclamation took place in seagrass beds, and half of the transects in 2011 have now become mainland. Even in the surrounding area of previous transect, there is no longer any seagrass that can be seen (Figure 15).



Figure 14. Google Earth satellite images of seagrass bed and coastal area in Tantui in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

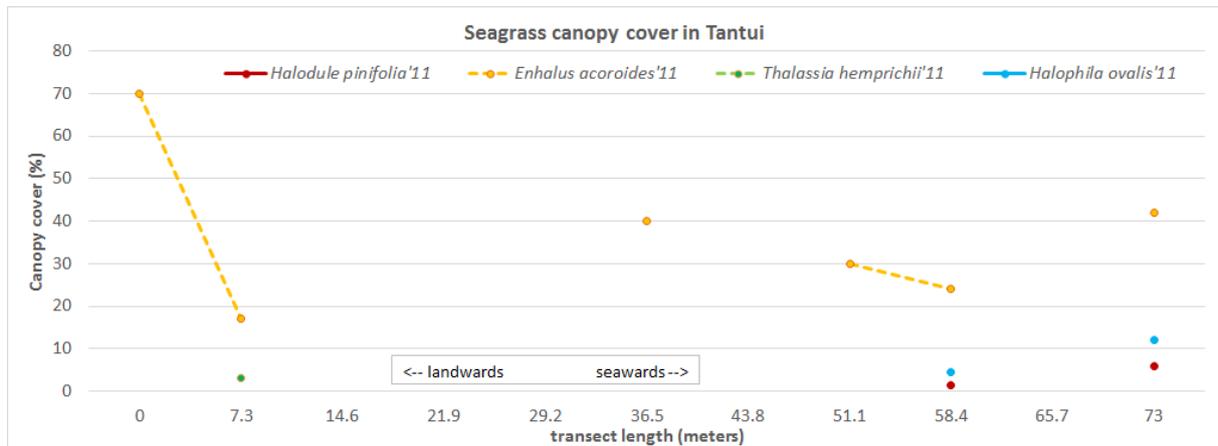


Figure 15. Seagrasses canopy cover along the transect in Tantui. Each color represents a different seagrass species. Note: dashed line = 2011 data, solid line = 2016 data.

3.7. Hative Besar

Comparison of satellite imagery in the Hative Besar location shows the major changes that occurred in the area from 2011 to 2016, both on the land and the coast (Figure 17). The area on the land was opened for the construction of buildings such as warehouses. In addition, in the coastal part, the changes were more evident with the presence of coastal reclamation, which caused the coastline to change and the land to increase towards the sea. Unfortunately, the reclamation occurred on seagrass beds and part of the transect area in 2011 (Figure 17) has now become land. The seagrass left in this location is small and not continuous, so no new observation transects have been made.



B

Figure 16. Google Earth satellite images of seagrass bed and coastal area in Hative Besar in 2011 (A) and 2016 (B). The yellow line indicates transect placement.

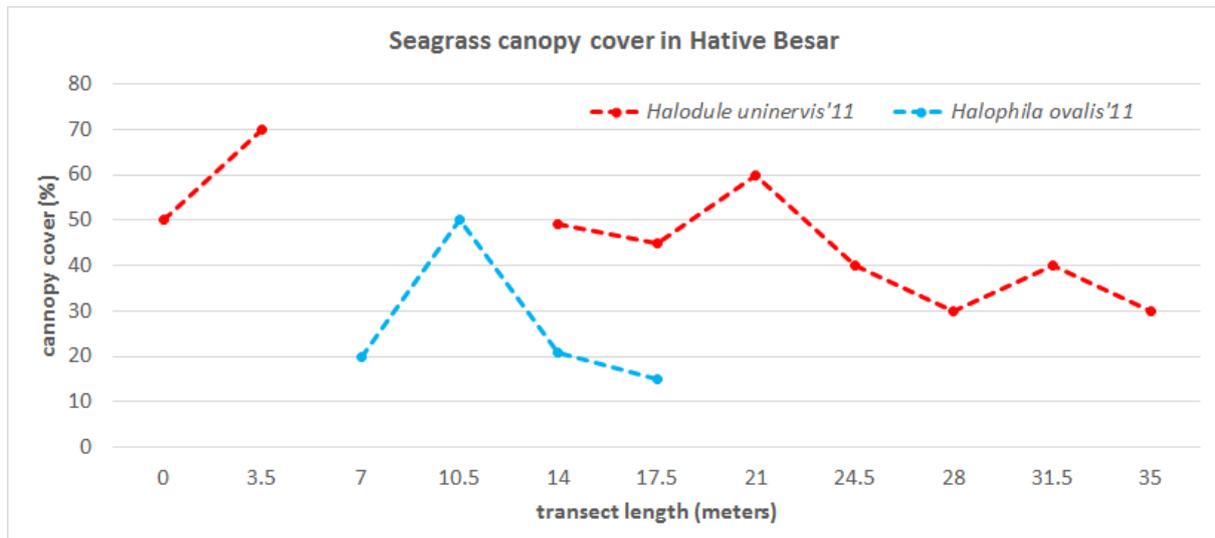


Figure 17. Seagrasses canopy cover along the 2016 transect in Hative Besar. Each color represents a different seagrass species.

4. Discussion

There are examples of anthropogenic activities that can change the sedimentary dynamics and consequent seagrass loss, such as coastal developments (e.g. harbors, docks, breakwaters), beach stabilization, dredging, and excess siltation from changes in land catchments [11]. Unfortunately, these activities also happen in Ambon Bay. Changes in land catchments happen in Tanjung Tiram, Waiheru, and Passo. A new dock has been built in Lateri. The most noticeable is the reclamation of beaches in Tantui and Hative. Because the seagrasses require adequate light and sediment conditions, they are directly harmed by those anthropogenic activities that disturb water and sediment quality, such as shading, sedimentation, and reclamation [12].

The decline of seagrass bed may increase the mobilization of fine particles which makes the water more turbid that in turn will inhibit the recolonization of seagrass [13]. This condition might already happen in Tantui and Hative Besar in which some of the seagrass areas were lost due to the reclamation, and the remaining seagrass was not sufficient enough for recolonization. Another evidence that in line with the previous finding was the turbid condition when the field survey held in 2016. This finding also corresponds to another study that assumed that the dynamics and stability of the intertidal-coastal ecosystem are influenced by a reciprocal effect between sediment texture and seagrass density [14].

Land-use changes in Ambon City, as a possible primary cause of the degradation of seagrass bed, is not only happened near the coastal area but also happened up to the mountainous area. Based on Sentinel Sattelite imagery of this area (Figure 18), the built area in Ambon City and it's surrounding in 2014 is measured at 857.09 hectares. Meanwhile, from the imagery of 2018, the built area rises to 2,223.24 ha. Hence, in four years period, there is an addition of a new non-vegetation structure by roughly 150% or almost three-fold from its previous condition. On the other side, this also means that the vegetation area was lost up to 1,366.15 ha. This condition could reduce the capability of land as a catchment area which may lead to an increase of erosion level, which brought more sediment to the coastal area. Coastal development, land reclamation, and sedimentation as a result of deforestation are recognized as significant factors that cause seagrass loss in Indonesia [15]. The high intensity of development in the coastal city such as Ambon is likely to give a large threat to the existence of the seagrass bed.



Figure 18. Sentinel satellite image analysis on the built area (white color) in 2014 (left) and 2018 (right) shows that more land area has been converted from vegetation to man-made non-vegetational structure (building, road, etc.) in Ambon City area during those five years.

Four of five seagrass beds that still have seagrass beds may be in an alarming situation because their canopy cover falls below 40%. On a study on the interaction of flow, transport and vegetation spatial structure, it has been found that a strong current could create a damaging pressure to the seagrass vegetation and reduce its growth if the cover is below 40% [16]. This condition needs more attention from the local government and other stakeholders to prevent further damage. If there are a serious effort and long term management in this issue, there is still hope for the seagrass beds to recover. As an example, the seagrass in Arachon Bay (France), after impacted by mud, needs five years to recover [11]. Or, it may need a longer time such in a disturbed Berre lagoon in southern France that took almost three decades for seagrass to reappear in patches which may correlate with the improvement of the environmental condition [17]. Management intervention is needed to help the natural colonization to drive the recovery of seagrass meadows, such as happened in Europe in the 1990s and 2000s after the losses peaking in 1970s and 1980s [18].

The loss of a hectare of seagrass bed can be valued as many as US\$ 19,004/year from its ecosystem services on nutrient cycling and raw materials [19]. This value can be considered as minimal loss per year because there are still many ecosystem services not included in that study such as habitat/refugia, food production, biological control, and genetic resources. Nevertheless, this value can be used as a scientific base for a policy-making of coastal development. The policymaker should consider whether this ecosystem services value is going to be sacrificed when a coastal development is planned.

One of the reasons for the loss of seagrass beds is less awareness of this ecosystem. Seagrass bed is submerged aquatic vegetation [20] which the presence sometimes not realized by people because the seagrasses grow under the surface of the water. Globally, in terms of media coverage, research and conservation funding, the seagrass beds are still far from the attention compared to their neighbours such as coral reefs and mangroves [21]. This less awareness has exacerbated the loss of seagrass beds because most people do not realize their presence and importance. So, in this case, more campaign needs to be done to promote this important ecosystem.

5. Conclusion

The condition of seagrass beds in Ambon Bay in 2016 has decreased since 2011. Of the seven research locations, only one location has an increase in its conditions, which in Halong. Four locations experienced a decline in their cover that was in Tanjung Tiram, Lateri, Waiheru and Passo. The remaining two locations, which are in Tantui and Hative, were in worse condition because they were damaged by the reclamation project.

Acknowledgement

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