IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

Transplantation of *Enhalus acoroides* on a sedimentary beach in Ambon Bay

To cite this article: Andi Irawan 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **118** 012054

IOP Conf. Series: Earth and Environmental Science **118** (2018) 012054 doi:10.1088/1755-1315/118/1/012054

Transplantation of *Enhalus acoroides* on a sedimentary beach in Ambon Bay

Andi Irawan[1]

[1] Research Centre for Deep Sea – Indonesian Institute of Sciences (P2LD – LIPI), Y. Syaranamual Street, Ambon 97233, Indonesia
E-mail: andri.irawan@lipi.go.id

Abstract. Coastal development in Ambon Bay has been contributing to coastal ecosystem degradations in recent years. One of the negative effects was the over sedimentation that changes the landscape of coastal ecosystem such as seagrass beds. These changes have made this ecosystem lost some of its functions especially as the habitat for other biotas, because the vegetation has been buried and reduced in density. So, in December 2015, a rehabilitation effort has been done at Kate-kate Beach with transplantation techniques of *Enhalus acoroides*. After 3-11 months of observation, it was noticed that only the transplants in the deeper area survived; on the contrary, the transplants in exposed and dry area during low tide did not survive. Overall, the survival rate of the transplantation project was 49.73% because the transplants need enough submerged condition to support their lives. The study recommends that to rehabilitate damaged seagrass beds due to the over sedimentation, we have to remove the sediment until certain depth during low tide to ensure the transplants are submerged in seawater. On top of that, the local government has to reduce the sedimentation rate from land because over sedimentation will make the beach profile become too shallow and too exposed during the low tide.

1. Introduction

Seagrasses are flowering plants whose whole life processes in the shallow seawaters [1]. They often grow in vast meadows and provide nurseries, shelter and food for a variety of commercially, recreationally and ecologically important species such as fish, sea turtles, dugongs, manatees, sea horses, crustaceans, gastropods, bivalves, sea cucumbers and many others [2,3,4,5,6]. These meadows are a highly productive and dynamic ecosystem; it ranks among the most productive in the ocean [7] and it is also more productive than cultivated corn or rice field [8]. However, this important ecosystem is globally declining due to human activities in coastal areas such as dredging, reclamation and pollutions [9]. One of the locations that undergoes seagrass degradation is Ambon Bay, Ambon.

Over the past years, there have been many landscape changes in Ambon Bay due to coastal development such as land clearing to build houses and other buildings and also beach reclamation to extend available land. The positive effect from this development is that human lives have become more advanced because more facilities to support modern lifestyle have been built. On the other side, the coastal development has also led to the degradation on ecosystem such as seagrass beds. The seagrasses vegetation has been buried and their density has been reduced. This has led to the loss of several important ecosystem functions such as habitat, carbon uptake, and productivity, which in the end can impact the human lives near this area. So, to reduce this negative effect, a rehabilitation effort on coastal ecosystem such as seagrass beds needs to be done as soon as possible.

In 2015, with the grants from The Indonesian Ministry of Environment and Forestry (KLHK), a seagrass rehabilitation effort was conducted on Kate-kate Beach, one of the locations which was affected by sedimentation from land (Figure 1). The objectives from this effort were to rehabilitate 1000 m2 seagrass beds with seagrass density of 1 shoot/m^2 and to promote public awareness about the importance of the seagrass beds. This paper will evaluate the outcome of the rehabilitation and discuss about the factors that contribute to the success of the effort.

2. Methods

The rehabilitation was done by using seagrass transplantation techniques of *Enhalus acoroides* which were gathered from a healthy seagrass beds near the rehabilitation site (approximately 300 m). The species was chosen because there are small patches of this species that still can be found at the project site, so this species is most likely to survive than other species.

The location of this seagrass transplantation was at Kate-kate Beach, which was divided into two sites (Figure 1) because the main site (A) does not have adequate area suitable for seagrass transplantation. Seagrasses are sea plants, so they need seawater for their lives. Unfortunately, the sediment in site A is so thick that makes most of the area less inundated by seawater, especially at low tide. So, another site (B) has been added to pursue 1000 m^2 target of this activity. Because of the limited space for transplantation, in general, there are three location's characters in each site (regarding their condition at low tide), which are dry/exposed area, wet/muddy/shallow area and deep/submerged area. This difference gives us an opportunity to evaluate the survival rate of the transplant in each area.

Figure 1. Seagrass transplantation site in Kate-kate Beach, Ambon. Site A has a muddy sand substrate and site B has a stony sand substrate.

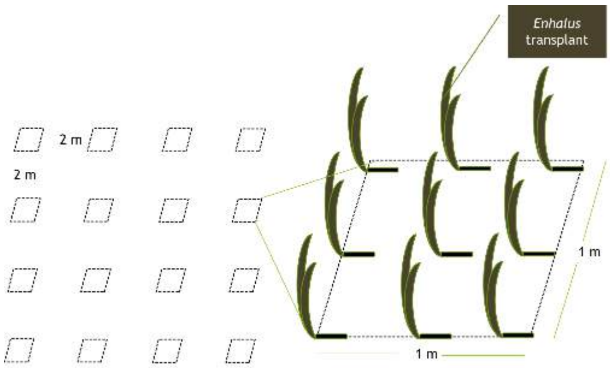

Figure 2. Transplanting arrangement for seagrass transplants.

The transplantation techniques were done in several steps. First, one thousand shoots of *Enhalus acoroides* were collected from donor sites, which can be called as transplants. Then, leaf height for each transplant was suited at 40 cm from rhizome. The transplants are then planted in the rehabilitation area with transplantation arrangements as follows: nine shoots of seagrass inside 1x1 m quadrat, every quadrat was 2 m apart from each other (Figure 2). Before planting the transplants, a transplantation holes had been created by using a crowbar to ensure that the rhizome of the transplants can be buried horizontally with the depth of 15-20 cm. The transplantation itself was done by the favor of local residents who had been trained on how to plant the transplants to ensure the uniformity of the planting techniques.

Monitoring transplant's survival was done three and eleven months after transplantation. The first three months was intended to give the transplants a period for adaptation. Monitoring in the eleventh months was intended to observe the transplants ability to grow in the new area.

3. Results and Discussion

From the target of 1000 m^2 rehabilitated area, this activity has achieved a total of 792 m^2 transplanted area, comprised of 360 m^2 in site A and 423 m^2 in site B. This achievement is lower than the target because the rehabilitated area did not offer enough suitable area for seagrass transplantation. Although the beach area that was impacted with sediment is more than 1000 m^2, the sediment (consists of sand and stones) is already too thick and has made the bottom surface level of the beach lift up almost at the same level as high tide mark. The thickness of the sedimentation could be the possible cause on why the seagrasses have been depleted in the area, as sedimentation is one of the most important environmental factors controlling this ecosystem [10]. This condition has made most of the beach area more exposed and dry at most of the day. This finding also shows that although the area used to be a healthy seagrass bed, if the sedimentation has changed the landscape of the area, it is not as easy as just by simply replanting the seagrass to make it good again.

Beside adding site B for transplantation, this condition also has made changes in transplanting arrangements from planting one transplant with the distance of one meter apart from other transplant to nine transplants in one m^2 quadrate with two meters distance with other quadrate (Figure 2). With this arrangement, almost all transplants have been planted even with reduced area. Total of 927 transplants were planted, comprised of 603 transplants in Site A and 324 transplants in site B. Even though the rehabilitated area is lower than the target (79,2%), the transplanted seagrass density is actually higher than the target, because 927 transplants divided by 729 m^2 area means 1,71 transplant/m^2.

In the first month after transplantation, the general result could already been seen. Almost all the transplants grown in exposed area became dry and die (Figure 3A). In the wet/muddy area, their leaves became dry but the buried organs such as roots, rhizomes and leaf sheaths were still fresh in some transplants. On the other hand, the transplants in submerged still survived (Figure 3B). The condition where *Enhalus acoroides* transplants were more likely to survive in submerged location could be related to this species's habitat preference. On the other study of seagrasses in this bay, it was found that distribution and abundance of this species was related to salinity and depth [11]. In other word, this species prefers to live in deeper or submerged location.

Figure 3. Transplant condition in the first month after transplantation: A= in dry and muddy area, B = in submerged area.

Three months after transplantation, total survival of all (927) transplants was observed at 54,05 % (Figure 4). Almost all the transplants that survived were the ones that were planted in the submerged condition, contributing to 77% of the survival transplants or 49,73% from the overall transplants. The dry and muddy condition contributes at 10 and 13 % of survival transplants respectively, or 1,83 and 2,48 % from overall transplants.

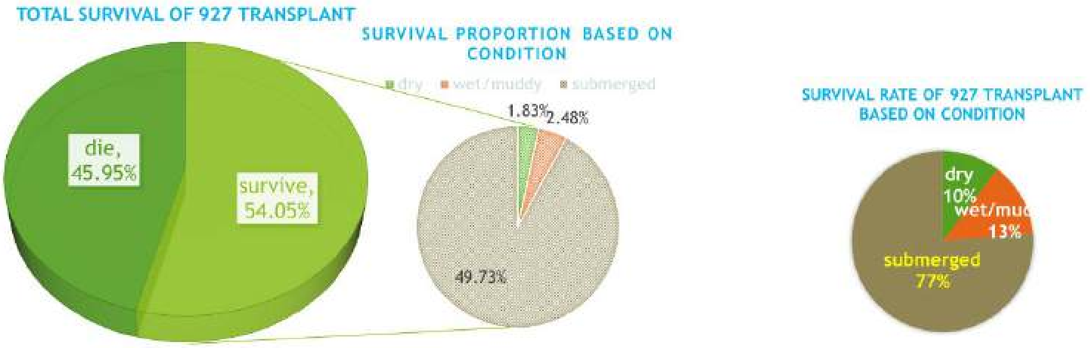

Figure 4. Survival rate of transplants after three months.

The loss of transplants could be much higher if the transplanting arrangement was maintained at one transplant with a meter distance from others (approximately 1 shoot/m^2 abundance). This arrangement would force all the beach area to be transplanted, even in the more exposed or dry area. The changes to nine transplants in one m^2 quadrate increased the transplant survival not only by selecting more suitable location, but also by increasing unit size or reducing the spacing between units [12]. It has been studied that water flow rate was reduced at the bottom of and over the *Enhalus* seagrass beds [10]. So that by increasing the abundance of seagrass transplant, the water flow could be reduced and the sediment would be stabilized more.

Eleven months after transplantation, there were no surviving transplants from dry and muddy area, conversely all the transplants in the submerged area that survived in the first three months were still alive (Figure 5). And also their leaves had grown longer than the initial height of 40 cm. This indicated that they could adapt to their new area and were able to grow.

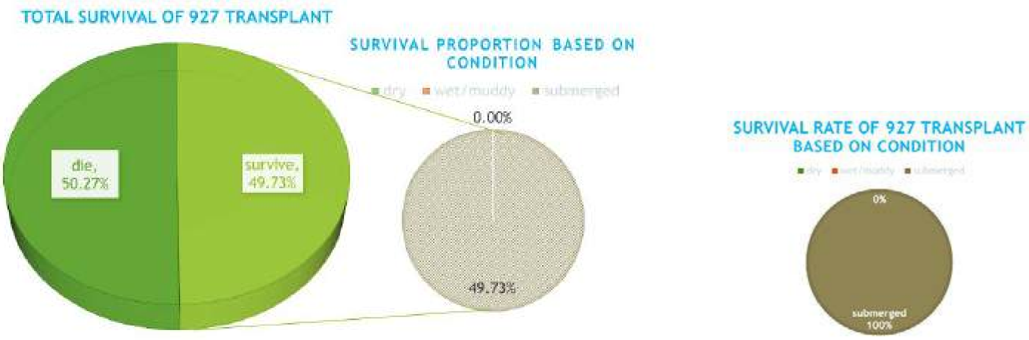

Figure 5. Survival rate of transplants after 11 months.

The final survival rate in this project was less than 50 percent. It means that the effort to rehabilitate this beach needs more than twice from the initial plan. The success of the project only occured in the submerged area whereas the dry and muddy areas were considered as failure. Even though in past these dry and muddy areas had been covered by seagrasses, it should be noticed that the landscape might have changed. This beach received heavy sedimentation from land, which was indicated by mud and stones deposit in more than 30 cm thickness in the substrate. Actually, the transplants (*Enhalus acoroides*) were able to live in this kind of sedimentation substrate, proofed by their survival in the submerged area. So, the problem was the lack of inundation in the dry and muddy areas. A low tide occurring in a long period during the day could make the transplants exposed to sun light and made the leaves dehydrated. Furthermore, to overcome this problem, another effort needs to be done to make this dry area become submerged during low tide period.

One simple but laborious solution is by digging or excavating the sediment until minimal depth of 40 cm is acquired. The digging has to be done at low tide to ensure the transplants receive enough submerged condition for their leaves. If the initial leaf height is more than 40 cm (usually 60 cm), then the depth target also needs to be raised. By increasing the depth condition, not only it will give more seawater inundation to the area but it will also reduce the wave energy caused by tidal movement. This wave energy can scrape seagrass beds [6]. So, by planting the transplants under low tide level, they can be spared from surface tidal waves.

Seagrass transplantation in the world started in 1947 [13] and many projects of seagrass beds rehabilitation have been done worldwide [14]. However, the process of seagrass restoration is highly complex and results in a little success [12]. Seagrass transplantation relies on labour-intensive, time-consuming and is usually extremely costly [15]. Nevertheless, with the increasing rate of coastal development, the pressure on seagrass beds is also getting higher. Therefore, the effort of seagrass beds conservation still needs to be done either by protecting the existing beds or by rehabilitating the damaged ones. Research and development on low labor and cost rehabilitation methods are very much open.

4. Conclusions

Overall, the rehabilitated area reached the size of 792 m^2 (79.2% from target) with seagrass density of 1.71 transplant/m^2 (171% from target) and survival rate of the transplantation project was 49.73%. For greater survival rate, the transplant of *Enhalus acoroides* needs enough submerged condition to support its life. The study recommends that to rehabilitate damaged seagrass beds due to the over sedimentation, we have to remove the sediment until certain depth during the low tide to ensure that the transplants were submerged in seawater. On top of that, the local government has to reduce the sedimentation rate from land because over sedimentation will make the beach profile become too shallow and exposed during the low tide.

Acknowledgments

The author would like to thank the Indonesian Ministry of Environment and Forestry (KLHK) for funding the beach rehabilitation, and to other stakeholders involved such as The Government of Maluku Province and Government of Ambon City. The gratitude goes to CV. Batarajaya as the project holder for this rehabilitation, who invited us from Indonesian Institute of Sciences (LIPI) to support the activity. The author personally would like to say thank Wawan Kiswara who transferred his knowledge and experience on seagrass transplantation. The author wishes to gratitude for technical suggestions from the JSPS Core-to-core RENSEA Project. The gratitude also goes to the people of Kate-kate, Hunuth and Batu Koneng who participated in this rehabilitation project.

References

[1] Susetiono 2004 *Fauna Padang Lamun Tanjung Merah Selat Lembeh* (Jakarta: Pusat Penelitian Oseanografi) p 106

[2] Short FT, McKenzie LJ, Coles RG, Vidler KP and Gaeckle JL 2006 *SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat, Worldwide Ed.* (New Hampshire: University of Newhampshire Publication) p 75

[3] Short F, Carruthers T, Dennison W and Waycott M 2007 Global seagrass distribution and diversity: A bioregional model *J. Exp. Mar. Bio. & Ecology* **350** 3-30

[4] Hutomo M and Martosejowo S 1997 The Fishes of Seagrass Community on the West Side of Burung Island (Pari Islands, Seribu Islands) and Their Variations in Abundance *Mar. Res. in Indonesia* **17** 147-172

[5] Mudjiono and Bambang S 1994 Fauna Moluska Padang Lamun dari Pantai Pulau Lombok Selatan *Struktur Komunitas Biologi Padang Lamun di Pantai Selatan Lombok dan Kondisi Lingkungannya* ed W Kiswara, MK Moosa and M Hutomo (Jakarta: Pusat Penelitian dan Pengembangan Oseanografi – LIPI)

[6] de Boer WF 2007 Seagrass-Sediment Interactions, Positive Feedbacks and Critical Tresholds for Occurence: A Review *Hydrobiologia* **591** 5-24

[7] Dawes CJ 1981 *Marine Botany* (New York: Wiley-Interscience)

[8] Menez EG, Phillips RC and Calumpong HP 1983 *Seagrasses from the Philippines* (Washington: Smithsonian Institution Press)

[9] Dahuri R, Rais J, Ginting SP and Sitepu MJ 2004 *Pengelolaan Sumber Daya Wilayah Pesisir dan Lautan Secara Terpadu* (Jakarta: Pradnya Paramita)

[10] Komatsu T, Umezawa Y, Nakaoka M, Supanwanid C and Kanamoto Z 2004 Water flof and sediment in *Enhalus acoroides* and other seagrass beds in the Andaman Sea, off Khao Bae Na, Thailand *Coastal Marine Science* **29**(1) 63-68

[11] Irawan A and Nganro NR 2016 Sebaran lamun di Teluk Ambon Dalam *J. Ilmu & Teknologi Kelautan Tropis* **8**(1) 99-114

[12] Wear, R 2006 *Recent advances in research into seagrass restoration.* SARDI Aquatic Sciences Publication No. RD04/0038-4 (Adelaide: SARDI Aquatic Sciences)

[13] Azkab MH 1999 Petunjuk penanaman lamun *Oseana* **XXIV**(3) 1-25

[14] Green EP and Short FT 2003 *World Atlas of Seagrasses* (Berkeley: University of California Press) p 298

[15] Butler A and Jernakoff. *Seagrass in Australia: strategic review and development of an R & D plan.* Collingwood: CSIRO Publishing, 1999.