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Bottom Sediment Characteristics Affecting the Success of Seagrass (*Enhalus acoroides*) Transplantation in the Westcoast of South Sulawesi (Indonesia)

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Abstract. Natural and anthropogenic disturbances in the coastal and estuarine areas have resulted in declines in seagrass coverage in Indonesia. Because of the essential roles of seagrass in estuarine and coastal ecosystems, efforts to prevent further losses and restore disturbed seagrass habitats through transplantation are desirable. In this study, a seagrass transplantation experiment was conducted at two contrasting field sites in the Westcoast of South Sulawesi, Indonesia:1) the reef flat of Lae-lae, and 2) the tidal flat of Labakkang, to investigate influence of bottom sediment characteristics on seagrass transplantation success. The staple method was used to transplant seagrass *Enhalus acoroides*. Vegetative shoots (sprigs) of *E. acoroides* were collected from a healthy donor bed located nearby the plantation site, and planted into unvegetated areas. Test-transplant survival was assessed every month for five months. The survival rates of transplants were significantly lower in Lae-Lae than those in Labakkang. The difference in survival rates of transplanted seagrass due to difference in sediment characteristics of two transplanting sites is discussed.

Keywords: sediment, seagrass, restoration, transplantation, staple method, South Sulawesi, Indonesia

1. Introduction

Seagrass communities play a major role world wide in the marine ecology of coastal and estuarine areas, supporting fish, shellfish and invertebrate communities (Bastyan and Cambridge, 2008). Major losses have occurred in Indonesia, usually due to eutrophication or turbidity from industry, dredging or catchment run-off, mariculture activates, backfilling (reclamation), transportation, overfishing as well as natural disturbances (Tomascik et al., 1997). Damage or loss of seagrass in a place not only threaten the sustainability of seagrass ecosystems, but also the risk of increase coastal erosion by wave action and currents, which may result in loss of terrestrial and marine aquaculture areas. Because of the essential roles of seagrass bed in estuarine and coastal ecosystems, efforts are under way to prevent further losses and restore disturbed seagrass habitats.

Seagrass habitat restoration can be accomplished by improving the habitat quality and transplanting seeds or adult shoots. Habitat improvement may be a very slow process and consequently, requires long periods of time, whereas seagrass transplantation might be a rapid way to restore seagrass habitats. Transplanting can establish seagrass habitat before natural processes might permit recolonization.

There are many seagrass transplantation have been attempted in many countries since the 1940s including New Hampshire, USA (Davis and Short, 1997); Carnac Island, Australia (van Keulen et al., 2003); Koje Bay, Korea (Park and Lee, 2007) and Oyster Harbour, Australia (Bastyan and Cambridge, 2008). However, very few seagrass transplantation studies have been made In Indonesia to restore the damaged seagrass bed. To our knowledge, there was only one seagrass transplantation study has been reported, i.e. conducted by (Azkab, 1988) at reef flat of Pari Island (Kepulauan Seribu, Jakarta).

Sediments are important parameters that have a major influence on the growth and spread of seagrass and therefore affect the success of seagrass transplantation (Newell and Koch, 2004). Moreover, sediment characteristics also an important and critical factor in choosing a suitable transplanting method for a specific area. In this study, seagrass transplantation experiment using Staple method at two different sites was conducted to investigate influence of sediment characteristics on seagrass transplantation success.

2. Methods

The seagrass transplantation experiment was conducted from May to October 2010 in two contrasting field sites in the Westcoast of South Sulawesi, Indonesia: (1) the reef flat of Lae-lae, a coral island situated 1.2 km from the coast, and (2) Labakkang, a coastal tidal flat located 3.5 km north of the Pangkajene river mouth. Both sites are characterized by extensive and well developed seagrass beds. The mean water depth at the two sites was about 0.6 m during low tide. The tidal regime at the planting site in Lae-lae is mixed tide, predominantly semi diurnal with tidal range of 1.16 and diurnal tide with a tidal range of 1.22 m in Labakkang.

In order to determine the sediment characteristics, one sediment sample was taken at each site using sediment cores with diameter of 7.4 cm and 15 cm in length. Only the top 3 cm of the sediments were used for grain size analysis. In the laboratory, sediment samples were dry sieved using standard laboratory test sieves of mesh sizes 0.063 mm, 0.125 mm, 0.250 mm, 0.500 mm, 1.0 mm, and 2.0 mm.

Vegetative shoots of *Enhalus acoroides* seagrass used for transplanting were collected from a healthy donor bed located in nearby the plantation site. *E. acoroides* is selected because the species is widely distributed at broad range of substrate (muddy, sandy and even in the reef flat) in The West Coast of South Sulawesi [8]. Shoots of *E. acoroides were* collected individually by hand to minimize damage to the donor bed. Special care was taken to avoid damage or loss of roots and rhizomes. The collected plants were stored in a large plastic bucket with small amounts of seawater to prevent desiccation during transport to the planting sites and will be transplanted within 24 h.

The staple (sprigs) method was used to transplant seagrass *E. acoroides*. Two seagrass shoots (one planting unit) with a bamboo skewers were used. The rhizomes (sprigs) of *E. acoroides* were aligned in parallel, pointing in opposite directions, and pressed into the sediment approximately 5-7 cm deep, and held in place with a 20-cm U-shaped bamboo skewer (Davis and Short, 1997). Bamboo skewers were selected to anchor the planting units because they are biodegradable, less expensive than metal staples, and avoid potential human health risk of the metal staple traditionally used in bare root transplanting (Fonseca et al., 1982).

Ten planting units (i.e., 20 shoots) were planted in each 50 x 50-cm plot to achieve 80 shoots m^{-2}, and four plots were planted at each transplanting sites. Planting unit survival was monitored up to 5 times at irregular intervals over a 5-month period by enumeration of live planting units. Transplant survival rates were calculated as the percentage of plants that survived after the time required for the establishment of seagrass transplants that occurred 1–5 months following transplantation. Oceanographic condition of planting sites were also monitored every month during the experimental period by measuring seawater temperature, salinity, pH, and dissolved oxygen, total suspended solid (TSS) concentration, current speed, and wave height.

3. Results

3.1. Type of Sediment

The reef flat of transplanting site in Lae-lae is covered by carbonate sediments. These sediments are biogenic, mainly consisting of skeletal components eroded from the coral reef by wave action. Grain size analysis revealed that the sediment was mainly composed of coarse sand with grain diameter of 0.60 mm and mud content of 0.16%. The transplanting site in Labakkang is characterized by terrigenous sediments originated from fluvial transport and consist of erosion material from the (mainly volcanic) mainland of Sulawesi. Grain size analysis revealed that the sediment was mainly composed of fine sand with grain diameter of 0.21 mm and contained higher mud content (1.31%). Histogram of grain size distribution of bottom sediment at the transplanting sites is presented in Fig. 1.

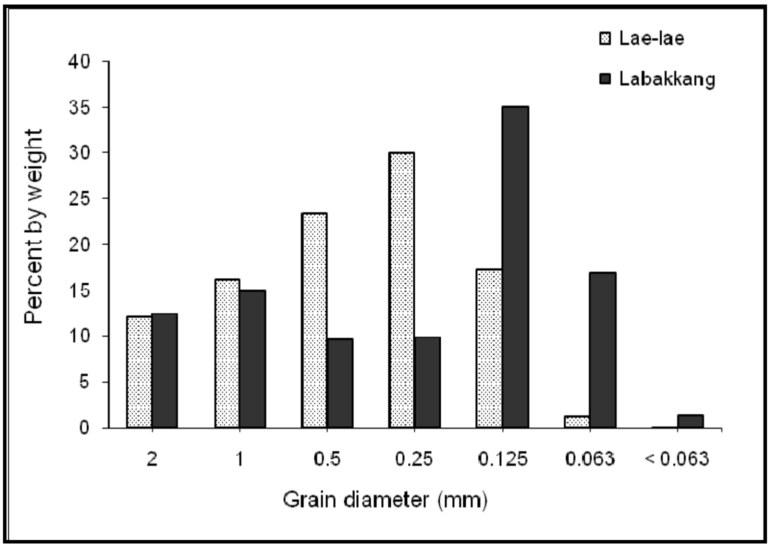

Fig. 1. Histogram of sediment grain size distribution at the study sites.

3.2. Oceanographic Conditions

Results of the oceanographic parameters measurement at the study sites are presented in Table 1. All measured oceanographic parameters fall within the range of seagrass growth except TSS concentration. TSS concentrations at the transplanting sites varied from 160 to 360 mg/l (Table 1). These concentrations had already exceeded the quality standards (criteria) established by Decree Minister of Environment of Indonesia Number 41 Year 2004. According to the criteria, seagrass can grow well when TSS concentration of the waters less than 20 mg/l.

Table 1. Results of oceanographic parameter measurement in Lae-lae and Labakkang.

	Temperature (°C)		Salinity (°/oo)		pH		Dissolved oxygen (mg/l)		TSS (mg/l)	
	Lae	Lab	Lae	Lab	Lae	Lab	Lae	Lab	Lae	Lab
June	29	31	28	26	7,86	7,91	5,8	5,8	295	255
July	29	32	30	30	7,83	7,93	6,2	7,7	160	170
August	29	32	31	31	8,4	8,7	7,0	7,4	160	180
September	30	33	31	31	8,36	8,37	7,2	8,2	280	290
October	31	33	32	31	8,07	7,52	7,5	7,5	310	360

Lae: Lae-lae; Lab: Labakkang;

3.3. Survival rate of transplanted seagrass

Survival rates of the transplants are presented in Fig. 2. To compare the survival rate of transplants in Lae-lae and Labakkang, a *t*-test was performed on survival rate data of October (end of the transplantation experiment period). *T-test* results showed that the survival rate of transplanted seagrass in Labakkang was higher than the survival rates in Lae-lae ($P < 0.05$).

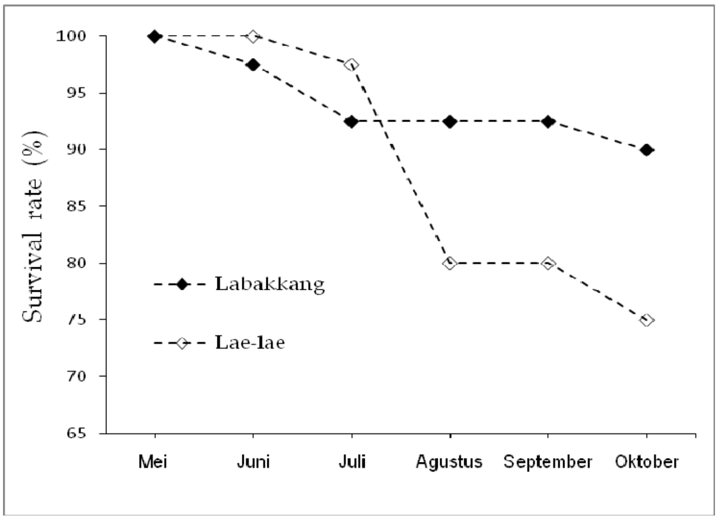

Fig. 2. The survival rate of transplanted seagrass using Staple method in Lae-lae and Labakkang.

4. Discussion

All measured oceanographic parameters fall within the range of seagrass growth except TSS concentration. Although the concentrations of TSS at transplanting sites were already exceeds the quality standards established by Decree Minister of Environment of Indonesia Number 41 Year 2004, light intensity reaching the bottom was still enough to support seagrass growth. Seagrasses require a minimum of 20% of surface light to survive (Dennison, 1987). All transplanting sites had >20% surface irradiance (Lanuru et al., 2009), and hence still favorable for seagrass growth.

The survival rates of seagrass *E. acoroides* were relatively high after one month transplantation, i.e. more than 95% in Labakkang and even all transplanted seagrass were still alive (survival rate 100%) in Lae-Lae (Figure 2). First one-month period is a phase of adaptation for the transplants to their new substrate and environments. High survival rate after one month transplantation indicated that no critical physical and biological disturbances to the transplants at transplanting sites during the period.

The survival rate of transplants transplanted in Lae-lae declined considerably in August and continued to decrease in September and October. In contrast to Lae-lae, transplants transplanted in Labakkang were relatively stable until the end of experiment, and survival rate did not decrease considerably as in Lae-lae. The difference in survival rate of transplants between Lae-lae and Labakkang can not be attributed to the difference in oceanographic condition as oceanographic condition at both transplanting sites were still favorable for seagrass growth. Instead of oceanographic condition, the difference in survival rate was likely caused by differences in sediment characteristic of the transplanting sites.

Assuming appropriate light levels, sediments are important parameters that have a major influence on the growth and spread of seagrass and therefore affect the success of seagrass transplantation (Newell, and Koch, 2004). Sediment can affect the stand material of transplanted seagrass material through a process of erosion/deposition of sediment. Both transplanting sites located in the West Coast of South Sulawesi and bottom sediment at both sites are subject to the erosive effects of wave exposure during south and north westerly winds in August to December (Erftemeijer and Herman, 1994) . Therefore sediment stabilization play important role to keep sediment and transplants in place and being not swept away by strong currents and waves.

Bottom sediment as a substrate of seagrass in Labakkang consists of fine sand mixed with mud, so have a cohesive nature that are not easy to move/experienced erosion (sediment is more stable). While coarse sand with very little mud at transplanting site in Lae-lae was more susceptible to erosion due to lack of cohesiveness. van Katwijk and Hermus (2000) who conducted research on the effects of water and sediment movement to the transplanted seagrass at different depths in the Dutch Wadden Sea (Netherlands), concluded that the reduction of sediment movement had a positive effect on survival of seagrasses (*Zostera marina*) especially transplanted at a depth of 0.20 m. Similarly, van Keulen et al., (2003) in Western Australia reported that installation plastic garden mesh on the bottom to stabilize the sediment improved the survival rate of the transplanted *Amphibolis griffthii* up to 90%.

The efficiency of anchoring device used in the present study is also an important factor determining the success of seagrass transplantation. The efficiency of anchoring device may depend on the sediment type at the transplanting sites. Coastal tidal flat of Labakkang composed of fine sand with a sand thickness greater than 10 cm that allows bamboo as anchoring device can be pressed deeper into the sediment so that the bamboo can hold seagrass transplants firmly against strong currents and waves. Unlike in Labakkang, sand thickness over the reef flat of Lae-lae was only about 7-10 cm and below a depth of 10 cm is a hard layer of reef rocks. Anchoring device (bamboo) did not work effectively in such thin sand thickness condition due to the bamboo can not be plugged deeper and hence the anchor it self and seagrass transplants were still possible being uprooted and swept away during strong current and wave events.

In addition to sediment type, lower survival rate of transplants transplanted in Lae-lae might be also in certain extent affected by biological disturbance. Sea urchins *Diadema sitosum* were abundant on September and October 2011 in Lae-lae. High abundance of these sea urchins in lesser extent also contributed to the mortality or loss of transplants in Lae-lae. *Diadema sitosum* is one of the main seagrass grazer in the study sites. Although the grazing impact of *Diadema sitosum* is only locally, it may cause substantially damaged or loss of seagrass if the species occurs in large numbers (booming).

5. Conclusions

The survival rate of transplanted seagrass in Labakkang was higher than in Lae-lae. The difference in survival rates of transplanted seagrass at both locations was most likely caused by differences in sediment type and thickness. Bottom sediment at transplanting site in Labakkang was more stable (not easily eroded) and had a bigger sand thickness (exceeding 10 cm) that allows bamboo (anchoring device) pressed deeper into the sediment and hence can hold seagrass transplants firmly against strong currents and waves. Lower survival rate of transplants transplanted in Lae-lae was also due to grazing by Sea urchins *Diadema sitosum* that occur in high numbers on September and October 2010 in Lae-lae.

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7. References

[1] Azkab, M.H. *Transplantasi Lamun Thalassia hemprichii (Ehrenb.) Aschers di Rataan Terumbu Pulau Pari, Kepulauan Seribu. Teluk Jakarta : Biologi, Budidaya, Oseanografi, Geologi dan Kondisi Perairan*. P3O-LIPI, Jakarta. 1988.

[2] Bastyan, G.R. and M.L. Cambridge. Transplantation as a method for restoring the seagrass *Posidonia australis*. *Estuarine, Coastal and Shelf Science* . 2008, 79: 289–299.

[3] Davis, R.C and Short, F.T. Restoring eelgrass, Zostera marina L., habitat using a new transplanting technique: the horizontal rhizome method. *Aquatic Botany*. 1997, 59: 1–15.

[4] Dennison, W.C. Effects of light on seagrass photosynthesis, growth and depth distribution. *Aquatic Botany*. 1987, 27: 15–26.

[5] Erftemeijer, P.L.A., and Herman, P.M.J. Seasonal changes in environmental variables, biomass, production, and nutrient contents in two contrasting tropical intertidal seagrass beds in South Sulawesi, Indonesia. *Oecologia*. 1994, 99: 45–59.

[6] Fonseca, M.S., Kenworthy, W.J., Thayer, G.W. *A low-cost planting technique for eelgrass (Zostera marina L.)* . USACE (US Army , Corps of Engineer) Coastal engineering technical Aid No. 82-6. 1982.

[7] Lanuru, M., Supriadi, Amri, K. *Site-selection Model for Optimal Seagrass (Enhalus acriodes) transplantation in*

the Westcoast of South Sulawesi (Indonesia). Report to the Directorate General of Higher Education, Ministry of Education of Indonesia. 2009.

[8] Newell, R. I. E. and E.W. Koch. Modeling seagrass density and distribution in response to changes in turbidity stemming from bivalve filtration and seagrass sediment stabilization. *Estuaries* . 2004, 27 (5): 793-806.

[9] Park, J.I. and Lee, K.S. Site-specific success of three transplanting methods and the effect of planting time on the establishment of Zostera marina transplants. *Marine Pollution Bulletin*. 2007, 54: 1238–1248.

[10] Tomascik, T., A.J. Mah, A. Nontji, dan M.K. Moosa. *The Ecology of The Indonesian Seas. Part Two. The Ecology of Indonesia Series*. Volume VIII. Periplus Edition (HK), Ltd, Singapore. 1997.

[11] van Katwijk, M.M., Hermus, D.C.R. Effects of water dynamics on Zostera marina: transplantation experiments in the intertidal Dutch Wadden Sea. *Marine Ecology Progress Series*. 2000, 208: 107–118.

[12] van Keulen, M., Paling, E.I., Walker, C.J. Effect of planting unit size and sediment stabilization on seagrass transplants in Western Australia. *Restoration Ecology*. 2003, 11: 50–55.