Mar. Res. Indonesia Vol.35, No.2, 2010: 1-7

TRANSPLANTING *ENHALUS ACOROIDES* (L.F) ROYLE WITH DIFFERENT LENGTH OF RHIZOME ON THE MUDDY SUBSTRATE AND HIGH WATER DYNAMIC AT BANTEN BAY, INDONESIA

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Received: 21 June 2010 Accepted: 25 August 2010

ABSTRACT

This study is a part of transplanting *Enhalus acoroides* carried out from November 2006 to February 2007 as a compensation of 1.6 ha loss of seagrass beds at Bojonegara, which was facilitated by NGO Rekonvasi Bhumi and funded by oil drilling company, PT Apexindo. The transplanting site was located at Terate, Banten Bay which has muddy substrate with high water dynamic. Healthy transplant seedlings were collected from monospecific vegetation with muddy substrate of donor site at Kepuh. The seedlings of *Enhalus* have different length of rhizome, 5 and 10 cm, with leaf length of 60 cm and removed roots. Transplanting of *Enhalus acoroides* was conducted using single shoot seedlings with 9 seedlings per unit in 1 meter square with 5 replicates. Light coefficient (1.17–5.06) and percentage of silt and clay (86.45 ± 2.18 %) at transplant site Terate were both higher than the donor site Kepuh with light coefficient values of 1.21–2.46 and percentage of silt and clay 64.00 ± 5.57 %, respectively. Seedling growth survival of *Enhalus acoroides* in February 2007 with rhizome length of 10 cm was higher (51.11 ± 25.58%) than seedlings with rhizome length of 5 cm (17.78 ± 18.59%). Leaf length and wide *Enhalus acoroides* transplants decreased during the study. Water dynamic (waves) influenced light coefficient and turbidity at the transplant site. Field observations showed that mortality of *Enhalus acoroides* transplants was caused by mud smoothering the leaves and barnacle growing on them. They made the leaves lost their buoyancy, laid on the surface, rotten and finally died. Wave is one of the important physical factor affecting the transplanting seagrass on the muddy substrate.

Keywords: Transplanting, *Enhalus acoroides*, compensation seagrass loss, Banten Bay

INTRODUCTION

Decline in seagrass communities can be linked to natural (geomorpological climate and biotic) and human-induced (reduction in water transparency, mechanical damage, toxic compounds) disturbances. Most studies on the decline of seagrass meadows focused on anthropogenic effects as these can be controlled and are important to management decisions regarding estuaries and coastal habitats (Dawes *et al.*, 1997).

Banten Bay (05°55'00"–06°05'00" S and 106°05'00"–106°15'00" E) is located in the north-western part of West Java, about 60 km west of Jakarta. It lies in area east to Tanjung Pontang and west to Tanjung Piatu. The bay has an area of 120 km^2, with a depth up to 10 m. The sediment consists mainly of mud and sand. Several coral islands lie in the bay. The biggest, inhabited, island is Panjang Island. Others are small and uninhabited. Several rivers, i.e., Domas, Soge, Kemayung, Cibanten, Pelabuhan, Baros, Wadas, and Ciujung) discharge the land-based water into the bay (Kiswara, 1992).

The ecological role of seagrasses as nursery and shelter for commercially important vertebrates and invertebrates has become a topic of increasing interest in recent years. *Enhalus acoroides* mead-

DOI: 10.14203/mri.v35i2.472

ows are dominant and important beds in Banten Bay. They are ecologically important as feeding grounds and nurseries for economically important fishes such as grouper, siganids and snappers and fishing grounds for the local people for catching fries of grouper, shrimps, and fish.

The degradation of seagrass beds in Banten Bay, due to reclamation for industrial estates and harbour development, was assessed in 1990. A decline of the seagrass affected especially *Enhalus acoroides* meadows at Grenyang Bay and Bojonegara. This decline amounted to approximately 30% of the total area of seagrass beds in Banten Bay. Increased sediment load due to stone mining and reclamation activities increased the turbidity of the coastal waters, and had deleterious effects on the seagrasses in the bay (Kiswara, 1994).

Analyzing sugar and starch in the plant parts of *E. acoroides* (Kiswara *et al.*, 1999) showed that photosynthetically produced reserves are stored as starch in the rhizomes and as sugar in the root. *Enhalus acoroides* is the largest tropical seagrass species with the biggest rhizomes and roots as compared to the other species, so this species should be most successful when transplanted due to its amount of carbohydrates in rhizomes and roots.

The investigation is a part of transplanting *E. acoroides* as a compensation of 1,6 ha loss of seagrass at Bojonegara-Banten Bay facilitated by NGO Rekonvasi Bhumi-Serang and funded by oil drilling company PT Apexindo, Jakarta. The activities were carried out with the support of local peoples and fishermen of Terate, Banten.

MATERIAL AND METHODS

Transplanting *E. acoroides* was conducted from December 2006 to February 2007 at Terate, Banten Bay. *E. acoroides* shoots were collected from a 120 ha, healthy bed with a muddy substrate and turbid water at Kepuh which was 5 km away from Terate. Plants at the edge of the patch were chosen as they were easier to remove and may be better suited for transplanting their seedlings (Thom, 1990). Plants with a minimum of 5 leaves were chosen and uprooted with approximately 8–15 cm of the rhizome by digging under the rhizome manually. Plants with the same length of rhizome and number of leaves were selected for transplantation. The rhizomes were cut to 5 and 10 cm length, the roots were removed and the leaves were cut to 60 cm length. They were temporarily stored in the large plastic boxes and covered by cut leaves of *Enhalus* and stored in the hull of the boat to prevent exposure and desiccation. The time between harvesting and planting seedling varied from 1 to 2 days.

The technique for transplanting *E. acoroides* was a rapid and simple method for transplanting single shoot which was adapted from Orth *et al.* (1999). *Enhalus* seedlings were transplanted near the mainland on the muddy subtrate with high water dynamic at Terate. The distance between donor site to the transplant site was about 5 km (Figure 1). The seedlings with different length of rhizome were planted in two transects. The first transect was the seedlings with the length of rhizome 10 cm and the other transect for seedlings with the length of rhizome 5 cm. Each planting unit consisted of 9 seedlings per square meter and 5 replicates. The distance between seedlings was 50 cm (Figure 2).

The seedlings were planted using an anchoring system made from a bamboo stake, with their rhizomes aligned parallel. Beside each seedlings, a bamboo stake was inserted into the substrate as a reference point for measuring total length of the leaves, assessing the growth or mortality of the seedlings for assessing percentage survival of the seedlings and observation on seedlings in the turbid water. The leaves were cut 25 cm from the bamboo reference point (Figure 3). Observation on the survival of the seedlings, wide and length of the leaves were measured every month and dead seedling was replaced with a new seedling.

Photosynthetically Active Radiation (PAR, 400–700 nm) was measured using LiCor Quantum Photometer type Li-250 with LiCor underwater-quantum sensor type Li-192SA between 10:00–14:00 h. Light readings were taken 50 cm above the water surface, just below the water surface, and in the water column every 10 cm down to maximum depth at 10 cm above the sediment. Each month, the vertical extinction coefficient (k,m^{-1}) was calculated from the Lambert-Beer equation. This vertical extinction coefficient

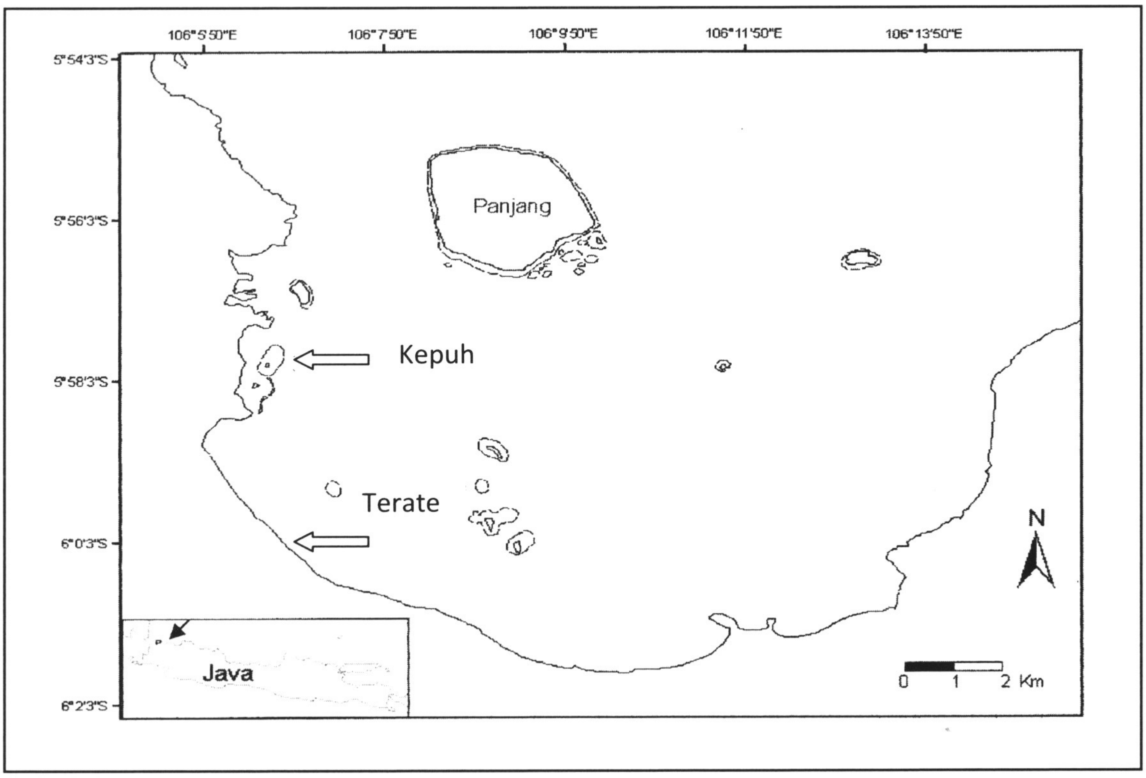

Figure 1. The Location of donor (Kepuh) and transplanting site (Terate) of *Enhalus acoroides* in Banten Bay, Indonesia

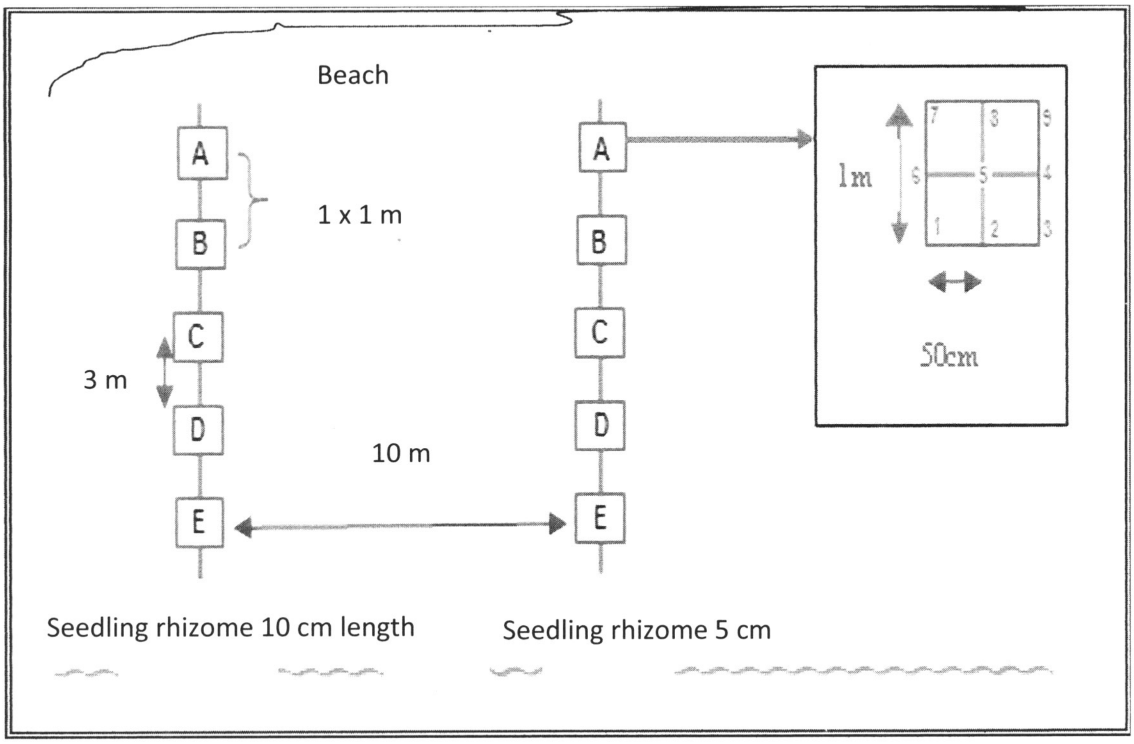

Figure 2. Planting unit of *Enhalus acoroides* seedlings in Banten Bay, Indonesia

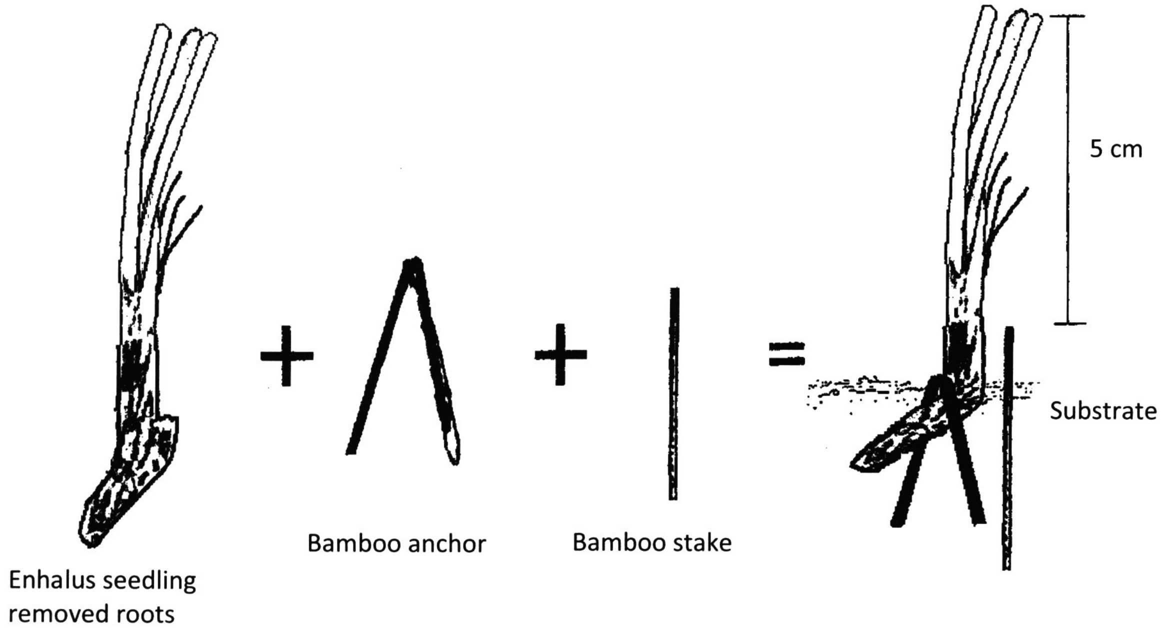

Figure 3. Technique of transplanting a single shoot *Enhalus acoroides*

was calculated by exponential regression of the light-depth profile.

$$IH = I_o * e^{-kH}$$

where IH is light intensity (µmol.m^{-2}.s^{-1}) at depth H, Io is light intensity just below the water surface (µmol.m^{-2}.s^{-1}) and H is bottom depth (m).

Temperature of surface water (°C) was taken at all study sites. Water samples were collected for analizing the salinity (‰) which was determined using a salinometer Beckman RS7C. Depth of water was measured by using bamboo stake with scales in cm.

Sediment properties of the study sites were analyzed before the transplantation experiment was conducted. Wet sieving of sediment over 4 mm, 2 mm, 1 mm, 0.5 mm, 0.025 mm, 0.0125, and 0.063 mm mesh sieves was followed by drying and weighing the fractions. The sediment particles smaller than 0.063 mm were categorized as mud (silt and clay), from 0.063 to 1.000 mm fine sand, and particles larger than 1.000 mm gravel.

Current speed of the water outside the transplant site was measured using a plastic bottle, a bamboo stake with a mark of 1 m length, and a stop watch. The plastic bottle was filled with sea water to 90 % submergence and a small bamboo stake was fixed to the top of the bottle. The duration of plastic bottle moving along 1 m was measured with a stop watch. The current measurements were repeated 10 times.

RESULTS

Mean values of abiotic factors (water temperature, water current, salinity, depth and vertical extinction coefficient) and grain size of the substrate in the donor site at Kepuh and transplanting site of *E. acoroides* at Terate were presented in Table 1 and 2. The water temperature of donor and transplanting site did not show a wide variation, water temperature at Kepuh and Terate ranged 28–31°C and 28–30°C. The water current at transplanting site at Terate ranged 0.033–0.073 m.s^{-1} which was one and half time higher than at donor site at Kepuh, 0.019–0.046 m.s^{-1}. Salinity at both sites was lower in February during rainy season (25.3 and 24.3‰ respectively). Water depth of 93–101 cm at Kepuh was deeper than 76–91 cm at Terate. Vertical extinction coefficient of 0.65–1.71 at Kepuh was lower than 0.68–4.59 at Terate. The comparative values suggest that the water column at Kepuh was much clearer than at

Terate. The substrate at the donor and transplanting sites consisted of mud silt and clay, where contents of mud at Kepuh (76%) was lower than that at Terate (86%).

Based on the monthly observation, percentage survival of *Enhalus* transplants with the rhizome length 10 cm was higher than those with rhizome length 5 cm. The percentage survival of *Enhalus* transplants decreased from December 2006 to February 2007. *Enhalus* seedlings survival in February 2007 with length of rhizome 10 cm was higher (51.11 ± 25.58 %) than seedlings with length of rhizome 5 cm (17.78 ± 18.59 %) (Table 3). Length and width of leaves of *Enhalus* transplants decreased during the study (Tables 4 and 5). Water dynamic (wave) influenced light coefficient and turbidity of transplant site. Field observation showed that mortality of *Enhalus* transplants was caused by mud and barnacle covering their leaves. The leaves were no longer buoyant, remained at the substrate surface, being rotten and then dead. Waves and bioturbation caused by barnacle are important physical and biological factors affecting the transplantation of *Enhalus* on the muddy substrate.

DISCUSSION

Information and data on transplanting *Enhalus* are very limited compared to transplanting eelgrass (*Zostera marina* L). The first transplanting eelgrass had been done by Addy (1947) by using seeds (Fonseca *et al.*, 1988). Historical distribution of eelgrass, abiotic, and biotic factors are important information for successsful transplantation of eelgrass. Besides, eelgrass distribution must be put in consideration in selecting transplant sites.

Table 1. Abiotic factor at the donor site (Kepuh) and transplanting site (Terate), Banten Bay

Location	Kepuh				Terate			
Month	Nov 2006	Dec 2006	Jan 2007	Feb 2007	Nov 2006	Dec 2006	Jan 2007	Feb 2007
Water temperature (°C)	29	31	28	28	30	30	28	30
Current (m/s)	0.037	0.035	0.046	0.019	0.073	0.047	0.058	0.033
Salinity (‰)	31.9	31.7	32.0	25.3	32.2	31.8	32.2	24.3
Depth (cm)	97	93	101	94	91	76	82	80
Vertical extinction coefficient	0.65	1.33	1.71	0.96	0.68	3.42	1.09	4.59

Table 2. Grain size (%) of the substrate at the donor (Kepuh) and transplanting site (Terate), Banten Bay

Location	Pebble (%) (>4 mm)	Coarse sand (%) (0.5-2 mm)	Fine sand (%) (0.125-0.25 mm)	Silt and clay (%) (<0.065 mm)
Kepuh	5	5	14	76
Terate	5	2	6	86

Table 3. Percentage (%) survival of *Enhalus* seedlings with the length of rhizome 5 and 10 cm at Terate, Banten Bay

Length of rhizome	Dec 2006 (%) ± SD	Jan 2007 (%) ± SD	Feb 2007 (%) ± SD
5 cm	55.56 ± 26,06	55.56 ± 22,23	17.78 ± 18.59
10 cm	60.00 ± 18,59	66.67 ± 7,86	51.11 ± 25.58

Table 4. The width of the leaves (cm) of *Enhalus* seedlings with the length of rhizome 5 and 10 cm at Terate, Banten Bay.

Length of rhizome	Dec 2006 (cm)	Jan 2007 (cm)	Feb 2007 (cm)
5 cm	1.89 ± 0.36	1.69 ± 0.39	1.39 ± 0.25
10 cm	1.92 ± 0.34	1.72 ± 0.34	1.49 ± 0.28

Table 5. The length of the leaves (cm) of the seedlings *Enhalus* with the length of rhizome 5 and 10 cm at Terate, Banten Bay.

Length of rhizome	Dec 2006 (cm)	Jan 2007 (cm)	Feb 2007 (cm)
5 cm	33.52 ± 15.80	32.16 ± 12.38	23.00 ± 11.41
10 cm	36.25 ± 15.34	29.77 ± 10.30	20.13 ± 8.55

Sediment grain size has been suggested as main variable influencing eelgrass growth (Kenworthy and Fonseca, 1977; Short, 1993). Water depth is limiting factor eelgrass distribution. Light is a critical factor in the survival and growth of eelgrass population (Dennison, 1987; Short *et al.*, 1995). Reduced light has been reported in limiting eelgrass metabolic. There are also very limited data and information on both abiotic and biotic aspects of *Enhalus* beds in tropical waters. Information on transplanting *Enhalus* in the literature is available only from a study by Sudara *et al.* (1992) in Khung Krabane, Chanthaburi Province, Thailand and Kiswara (2004) in Banten Bay, Indonesia. The information for transplanting of *Enhalus* is very much lacking with transplanting of *Zostera.*

Enhalus seedlings with the length of rhizome 10 cm have higher survival than those with length of rhizome 5 cm. Kiswara (1999) found that the highest content of carbohydrate in *Enhalus* was in the rhizomes. Czerny and Dunton (1995) reported that the time span a seagrass species can survive below their minimum light requirements is related to the ability of that species to store carbohydrates. Seagrasses such as *Thalassia testudinum* have extensive rhizomes and are capable to store large quantities of carbohydrates. This species is able to survive longer than other species (such as e.g. *Halodule wrightii*) which has small rhizomes and therefore little capacity to store carbohydrates. Kraemer and Alberte (1995) reported that seagrass survival during light limitation may depend upon the quantity of carbohydrates stored within roots. Populations of *Posidonia oceanica*, adapted to low light, are probably more resistant to transplantation stress, particularly when replanted to a location with higher light intensity in shallow water. This showed the importance of the rhizome for transplanting of seagrasses. The seedlings of *Enhalus* with longer rhizome hence have higher carbohydrate content and have a chance for higher percentage survival than the seedlings with shorter of rhizomes.

Decreasing leaf length, width, and growth rate after cutting the rhizome of *Thalassia hemprichii* were repoted by Uy (2001). He found isolating an individual ramet led to a significant reduction in leaf length, width, and growth rate. Cutting the rhizomes randomly reduced leaf surface area and shoot density, but it did not affect leaf relative growth rates of the remaining shoots.

Habitat restoration was used to compensate losses of fish, invertebrate, and aquatic birds after the "North Cape" oil spill of January 1996 in Rhode Island (French-McCay and Rowe, 2003). Although planting seagrass is not technically complex and seagrass beds can be created under appropriate conditions, preservation (prevention from loss) is the most effective and reliable process to sustain seagrass habitat and associated resource (Fonseca *et al.*, 1988). Compensation loss of 1.6 ha of seagrass bed at Bojonegara which was facilitated by NGO Rekonvasi Bhumi and funded by oil drilling company, PT Apexindo, is the first reported activity in restoring seagrass beds in Indonesian waters.

CONCLUSION

Wave is one of the important physical factors that give impact in transplanting seagrass on the muddy substrate. Water dynamics (wave) influenced light coefficient and turbidity of water at the transplant sites. Field observation showed that mortality of *Enhalus* transplants was caused by mud and barnacle covering their leaves. Longer buoyant, remained at the substrate surface, waves and bioturbation caused by barnacle are important physical and biological factors influencing the transplanting of *Enhalus* on the muddy substrate.

ACKNOWLEDGEMENTS

We are grateful to Mrs. Pradina, M.Sc. for her valuable comments and improving the manuscript; Agus Laksmana, S.Si., Achmad Arifin, Asep

Rasyidin for their help during the field works and Anto Suharto for his valuable help in using his boat and preparing our food and also hospitality of his family.

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