Macrozoobenthos community structure in restored seagrass, natural seagrass and seagrassless areas around Badi Island, Indonesia

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Macrozoobenthos community structure in restored seagrass, natural seagrass and seagrassless areas around Badi Island, Indonesia

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Abstract. Seagrass ecosystems play an important role in providing food and protection to the organisms that live in and around seagrass meadows. However, due to heavy pressure from human activities, many seagrass beds have been degraded, with the loss or reduction of important ecological functions. Therefore, seagrass restoration needs to pay attention to the recovery of these ecological functions. This study aimed to determine the success of the seagrass restoration activities around Badi Island, South Sulawesi, Indonesia, in supporting the recovery of ecological functions, as viewed from the macrozoobenthos community structure. Data on macrozoobenthos community structure in transplanted seagrass areas was compared with the macrozoobentos community structure of nearby natural seagrass beds and seagrassless areas. The macrozoobenthos identified comprised 34 species from 3 classes in the seagrass restoration area, 73 species from 9 classes in natural seagrass beds, and 24 species from 4 classes in areas without seagrass. A one way ANOVA test indicated significant differences in macrozoobenthos density between the transplanted areas and natural seagrass beds but not sites without seagrass. Ecological indicators such as the diversity index and evenness index showed a higher level of macrozoobenthos community structure in all the sampling sites. We conclude that, as transplanted seagrasses become established, they can provide ecological functions and serve as habitat for a wider variety of other organisms, as reflected in the community structure of the associated macrozoobenthic organisms.

1. Introduction

Seagrass ecosystems play important roles for the organisms that live in and around seagrass meadows, as primary producer, feeding grounds, nursery grounds, and spawning grounds. The leaves can trap sediment suspended in the water column, while the network of roots and rhizomes can both trap and stabilise sediment originating from erosion [1]. However, due to heavy pressure from human activities, substantial proportion of seagrass habitats around the world have been lost, with one study giving an estimate of approximately 29% [2]. One of the negative effects from the decline in seagrass extent or condition is the loss of important ecological functions [3].

Seagrass restoration is one way to address this problem, with the main objectives being to recover the ecological functions and the structure of living communities of marine organisms that live around

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the area where habitat has been lost [4]. In this context, one way to evaluate the success of seagrass restoration is to assess the community structure by comparing the organisms found in the restoration area and in nearby sites [5]. A previous study provided evidence that seagrass restoration could recover epifaunal richness and total density in one year [6]. This study focussed on the assessment of the success of seagrass restoration in supporting the recovery of ecological functions, as viewed from the macrozoobenthos community structure, which is related to the functions of seagrass as a habitat from marine organisms. Our hypothesis was that seagrass restoration would provide habitat for a greater variety of marine organisms than bare (unvegetated and unrestored) substrate.

2. Methods

2.1. Site location and sampling design

The study was conducted in and around a seagrass restoration site in Badi Island, South Sulawesi, Indonesia [7] during August 2016. The approximate coordinates were S 4°57′56.32″–4°57′58.18″, E 119°17′17.03″–119°17′19.63″. In order to compare the macrozoobenthos community structure, three different areas were sampled: the seagrass restoration area, a nearby natural seagrass bed, and a seagrassless (unvegetated and unrestored) area. These three areas had otherwise similar sandy substrate and a water depth of 1 to 1.5 m. Macrozoobenthic organisms present were collected from sample plots (20 x 20 cm quadrats), with three replicate plots in each area. A spade was used to dig out the sediment of each plot to a depth of around 20 cm; this was then sieved (1mm mesh size) to separate the organisms present from the sediment. Each macrozoobenthos sample (all the organisms collected from one plot) was placed in a separate plastic ziplock sample bag and labelled. The sample was then preserved through the addition of 70% alcohol before the bag was sealed and transferred to the Marine Ecology Laboratory of Universitas Hasanuddin laboratory. The organisms contained within each sample were identified and counted in the laboratory, based on [8], and the data were tabulated.

2.2. Data analysis

Analysis of the tabulated data was conducted in SPSS 16. Community structure indices calculated for each plot were density (*D*), diversity index (*H'*), and evenness index (*E*). These parameters were calculated using the following formulae based on [9].

$$D = n \cdot 10{,}000 \cdot A^{-1} \quad (1)$$

$$H' = -\sum pi \ln pi \quad (2)$$

$$E = H' \cdot (\ln S)^{-1} \quad (3)$$

Where:

D =	Density (ind/m^2) of organisms in the plot
E =	Evenness index
H' =	Diversity index combined)
A =	sampling area in m^2
n =	total number of individual organisms (all species) collected from the plot
S =	number of species found in the plot
ni =	number of individuals of the its species (from 1 to S)
pi =	$ni \cdot N^{-1}$

The analysis of variance (ANOVA) function in SPPS 16 was used to evaluate the difference in macrozoobenthos community structure between the 3 areas based on these three indices. If there was a significant between area difference at the 95% confidence level ($\alpha = 0.05$), the Tukey honestly significant difference (HSD) post hoc test was applied.

3. Results and Discussion

Macrozoobenthos data were collected 2 years post transplanting. Macrozoobenthos found in the three areas comprised 34 species in 3 classes in the seagrass restoration area, 73 species from 7 classes in the natural seagrass bed, and 25 species from 4 classes in the seagrassless area (Table 1).

Table 1. Macrozoobentos taxa from the three areas sampled

Taxonomic Group	Genus/species	Seagrass Restoration	Natural Seagrass	Seagrassless Area
Gastropoda	*Architectonica* sp.		+	+
	Aspella sp.		+	
	Atys naucum	+	+	
	Atys sp.		+	
	Bulla sp.		+	
	Calamiconus sp.	+		+
	Cerithium sp.	+	+	+
	Cerithium rostratum	+		+
	Cerithium punctatum		+	
	Cerithium rostratum		+	
	Clypeomorus sp.	+	+	+
	Conus sp.1		+	+
	Conus sp.2		+	
	Conomitra sp.	+		
	Cypraea sp.	+	+	
	Engina siderea		+	
	Engina sp.			+
	Epitonium sp.	+	+	
	Euplica scripta	+	+	
	Euthria sp.		+	+
	Fragum unedo		+	
	Gibbula sp.	+	+	+
	Granulifusus sp.	+	+	
	Herpetopoma atratum	+	+	
	Herpetopoma sp.		+	+
	Hyalina sp.	+	+	+
	Inforis sp.	+	+	+
	Latirus sp.	+		
	Lienardia sp.	+	+	+
	Mastonia sp.	+		
	Mitra sp.	+		
	Mitra avenacea		+	
	Mitra pudica		+	
	Mitrella sp.	+	+	+
	Monodonta sp.			+
	Nassarius albecens		+	
	Nassarius sp.	+	+	
	Natica sp.		+	
	Notocochlish sp.		+	
	Notocochlish venustula		+	
	Oliva tessellata		+	
	Patella sp.		+	
	Phasianella angasi		+	
	Phasianella sp.		+	
Gastropoda (continued)	*Polinices flemiangus*	+	+	
	Pseudotomatella sp.	+	+	
	Pupa sp.	+		
	Pyramidella sp.	+	+	+

Taxonomic Group	Genus/species	Seagrass Restoration	Natural Seagrass	Seagrassless Area
	Pyramidella monilis		+	
	Pyramidella teres	+	+	
	Rhioclavis aspera		+	
	Rissoina artensis		+	
	Rissoina sp.	+	+	+
	Smaragdia rangiana	+	+	+
	Strombus sp.		+	
	Tornatina sp.		+	
	Trivia sp.	+	+	
	Vexillum sp.		+	+
	Viriola sp.		+	+
Bivalvia	*Arca* sp.		+	
	Anadara sp.		+	
	Diplodonta sp.	+	+	
	Dosinia sp.			+
	Codakia sp.		+	+
	Epicodakia sp.		+	
	Euritellina sp.		+	
	Modiolus sp.		+	
	Pinna sp.		+	
	Solemya sp.		+	
	Soletellina sp.	+	+	
	Tellina remies		+	
	Tellina sp.	+	+	
	Timoclea sp.1	+	+	
	Timoclea sp.2			+
	Trachycardium sp.		+	
Ophiuroidae	*Ophiura* sp.	+	+	+
Echinoidea	*Echinocardium sp.*	+	+	
Annelida	*Sipuncula* sp.		+	
	Polychaeta		+	
	Olygochaeta		+	
Monoplacophora	*Cheila tortilis*		+	
	Diodora sp.		+	
	Neopilina sp.		+	+
Scapophoda	*Dentalium* sp.		+	

Gastropods were found in all sampling sites; forming the most common and diverse class, they represented the majority (68.14% to 88.24%) of organisms sampled. The other classes, in order of decreasing abundance, were Bivalvia (bivalves such as clams, oysters and mussels), Ophiuroidea (brittle stars), Echinoidea (sea urchins), Polychaeta and Oligochaeta (segmented worms), Monoplacopora, Schapopoda (tusk shells), (Fig. 1).

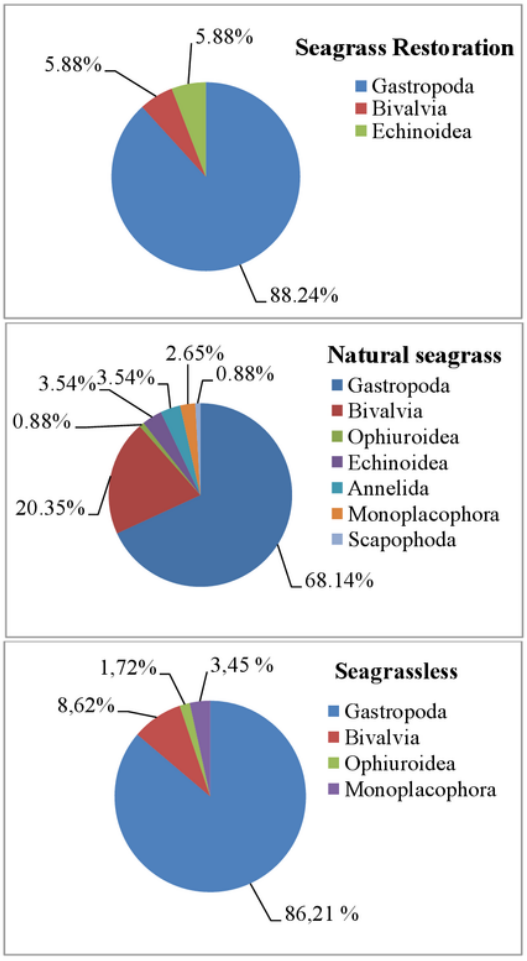

Figure 1. Macrozoobenthos community composition for each of the three areas sampled

The most commonly found and most diverse higher taxonomic group was the Mollusc Phylum (Gastropoda and Bivalvia). These animals are commonly found living in sandy substrates; gastropods are sand burying and surface dwelling [10] with various feeding habits, inhabiting a wide variety of habitat types; they belong to different feeding (trophic) guilds (carnivores, herbivores, and detritivores) depending on species. Meanwhile bivalves are filter feeder organisms, obtaining their food from the water column, and mostly bury themselves in sandy or muddy substrates. On the other hand, the least abundant Phylum, the Annelida (Polychaeta, and Oligochaeta) common live in muddy substrates, and as deposit feeders might find limited sources of nutrition in the sandy sampling area.

Despite a large difference in the total number of species, the diversity indices of the 3 sampling areas were very similar, ranging from 2.51 to 2.61. These values are within the high category. The evenness indices were also similar for the three areas, ranging from 0.80 to 0.93; these values are within the range generally thought to indicate a stable community structure. Macrozoobenthos density (Fig. 2) shows a marked and significant (at α=0.05) difference between natural seagrass and the other two areas (restored seagrass and seagrassless area).

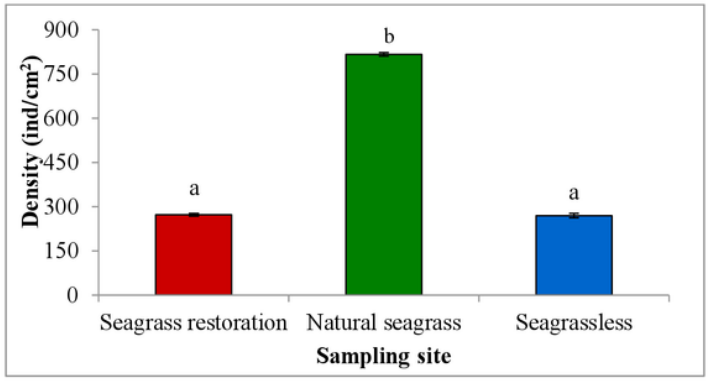

Figure 2. Average density of macrozoobenthos in each sampling site. The small case letters indicate significantly different values ($p < 0.05$)

Although the difference in macrozoobenthos density of in seagrass restoration and seagrassless area did not differ statistically at the 95% confidence level, the number of individual macrozoobenthos organisms was higher in the seagrass restoration area than in the seagrassless area. In addition, Table 1 shows that almost one third of macrozoobenthos species that we found in the seagrass restoration area were also found in the seagrassless area. However, the seagrass restoration area provide habitat for organisms that were not found in unvegetated area (21 species), and also some species not found in the natural seagrass area (5 species). Furthermore, several species were found in both the natural and restored seagrass area but not in the seagrassless area (17 species). These similarities and differences in species present could be partially caused by correlations between macrozoobenthos and seagrass characteristics such as plant morphology, canopy density, roots and rhizomes. It is also possible that some differences could be due to naturally patchy distributions, especially in less abundant species.

Some species that we found in the seagrass restoration area are herbivorous species such as members of the family Haminoeidae (genus Atys) and family Cyprinidae (genus Cypraea). This distribution is in line with the findings of [11,12], who describe that both genera can eat algae and seagrass leaves, especially in detrital layers, even though some species are carnivorous. Furthermore, both vertebrate and invertebrate communities tend to have a higher density in seagrass meadows than unvegetated areas [13]. Furthermore, it has been shown that both artificial seagrass and transplanted seagrass canopies can enable organisms to recruit, especially macrozoobenthos, because they provide a complexity of structure which can offer protection [14].

Our study results highlight that the presence of seagrasses in seagrass restoration areas will contribute to the recovery of habitat, protection and food sources for organisms that live in and around seagrass. Although many macrozoobenthos do not feed on seagrass directly, the seagrasses will provide habitat for epiphytes and a variety of tiny organisms as well as small fragments of leaf litter which can provide food for macrozoobenthos organisms directly or through the food chain. Despite the lower number of individual macrozoobenthos in the seagrass restoration compared to the natural seagrass, they already show early response to improve macrozoobenthos community and abundance than seagrassless area. Thus, we conclude that, as transplanted seagrasses become established, they can provide ecological functions as a habitat for a wide variety of other organisms, as reflected in the community structure of the associated macrozoobenthic organisms.

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