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Application Of Environmental Management On The Farming Practice Of Mud Crab *Scylla Serrata* At Coastal Area Of Ujung Alang, Cilacap, Indonesia: Efforts Toward Sustainable Aquaculture

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Abstract

One of the biota associated strongly to the presence of mangrove forests as their habitat is the mangrove crab, *Scylla serrata*. Mangrove crab farming done in coastal areas the village of Ujung Alang, Cilacap was aimed to enlargement of the size of the juvenile (60 g/ind.) to the commercial size (200 g /ind.). Mutilation was done to determine the effect of the removal of part of locomotors and molting process. The experiment included 10 crabs without mutilation as a control (C); 10 crabs by removing the 3 left walking legs (T1) ; 10 crabs by removing the 3 right walking legs (T2); and 10 crabs by removing the 3 pairs of walking legs (T3). Monosex farming was done using a box made of polyethylene as a shelter. Based on observations during the 8 weeks, T3 treatment gave the highest score in body weight and carapace width and length. The first molting (M1) occurred for the crab - treated T3 has the best percentage of molting (100 %) compared to other treatments. The observation area of crab farming, the natural habitat of mangrove forests or in the control area found as many as 82 species of macrobenthos of 44 families and of the 4 classes that include gastropods (60 species), polychaetes (14 species), bivalves (6 species), and crustaceans (2 species). Based on biotic and abiotic factors, the area of aquaculture and mangrove areas did not show significant differences, indicating the farming practices *Scylla serrata* in the shelter system is environmentally save.

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Keywords: Scylla serrata; mutilation; shelter; macrobenthos; crab growth; sustainable aquaculture

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1. Introduction

Mangrove crabs are member of the Family Portunidae (Order Dechapoda; Class Crustacea). The growth of crustaceans are characterized by the process of molting. Order Dechapoda is characterized by the presence of five pairs of legs, the first pair of legs are called claws that act as a catcher/food holder, the fifth pair of legs in a fan-shaped (flat) serves as the swimming leg, and the rest are for crawling/walking legs. With the claws and legs, crab can run fast on land and they can swim quickly in water using the swimming legs so theay are classified as swimming crab (Portunidae). Genus *Scylla* is characterized by the oval shape of the carapace with the front has 9 spines on both left and right sides and 4 spikes in between the eyes. There are 3 types of mangrove crabs are considered to have a potential market; they are *Scylla serrata, Scylla oceanica,* and *Scylla transquebarica*. *S. serrata* can be distinguished from the other two species based on morphology particularly clear form of spines on the carapace, the claws and the dominant colour on the body [1], [2].

Mud crab is one of many fisheries commodities that have a bright prospect in the future. The demand for commodities is likely to increase from year to year, not only in Indonesia but also abroad. Currently the market stock of mangrove crab in Indonesian are mostly from direct capture in nature. In the future, the activity of direct capture for sale should be replaced by aquaculture activities in order to sustain the live stocks. Planning and development of farming techniques are very important for the development of the various aspects to sustainability objectives, the increase in production capacity, and market opportunities with regard to the balance and stability of the mangrove ecosystems. A natural feed of mangrove crabs are all kinds of organic matter, both animal (dead/alive) as well as plants using his claws (*omnivorous scavenger*). Crabs are very sensitive to contamination or pollution especially toxic gases such as H_2S and ammonia (NH_3). Therefore, the farming of environmental management is very important to implement [2]. The objectives of this study were to assess the effect of the effect of cutting/removal of part of the locomotion appendages (mutilations) of the crabs on their growth and molting process, the spatial and temporal change of environmental condition caused by crab farming practice using abiotic and biotic datas, and to evaluate the environmental impact of farming practices of *Scylla serrata* using the shelter system.

2. Methods

2.1. Preparation of land farming

Installation of farming areas for *Scylla spp.* conducted in the area of farming in the village of Ujung Alang, Cilacap, Central Java, Indonesia as Location I for sampling site, and mangrove forest areas without crab farming as Location II. Mutilations experiments conducted to determine the effect of cutting/removal of part of the locomotion appendages and acceleration of crab molting process. The experiment included 10 crabs without mutilation as a control (C); 10 crabs by removing the 3 left walking legs (T1); 10 crabs by removing the 3 right walking legs (T2); and 10 crabs by removing the 3 pairs of walking legs (T3). Monosex farming was done using a box made of polyethylene as a shelter, as shown in Figure 1. Carapace length was measured using a meter tape. Measurements were taken before treatment and twice after treatment, which were in the fourth week and eighth week. The meter tape was placed right at the top of the carapace, and then measured the length-width to follow the curve of the carapace. During the treatment process and maintenance, the crabs were fed about 10-15% of the biomass. Due to the natural cannibalism within crabs, it is necessary to provide quality food and sufficient, maintenance and provision of shelter monosex as a shelter, especially useful molting crabs and small crabs. Planting mangrove vegetation in the farming plots were carried out in limited quantities, used as shelter and reduce the influence of high temperatures when water level decreases.

The growth rate of mangrove crab body weight is obtained based on the difference between the body weight of mud crab after 4 weeks, 8 weeks of treatment compared to the data mangrove crab body weight before treatment.

Fig 1. Crab farming procedures, including shelter preparation, mutilation, measuring biomass, and instalatin of the shelter at the farming sites: (A) a shelter for crab farming; (B) process of mutilation; (C) Measuring the weight of treated crab; (D) instalation of crab farming using shelter on the surrounding the mangrove vegetation.

2.2. Measurement of water and sediments quality

Water quality measurements performed in situ using a Horiba U-10 Water Checker multiprobe and YSI DO meter to determine water quality parameters at the first location and a second location. Parameters measured include water temperature, conductivity, salinity, oxygen content (DO), turbidity, and pH. Sediment sampling was done using hand-corer diameter 70 mm, length 500 mm, operated directly by hand. Retrieval is done every four months for full year, each consisting of three stations with four replications. The samples were used for analysis of physico-chemical analysis of sediment and macrobenthic animals. Determination of the quality of the sediment included the composition of sediment particles (gravel, coarse sand, soft sand, loam, and clay), and organic matter content (total content of organic carbon, nitrogen).

2.3. Analysis of macrobenthic animals

Sediment samples were put into Bennett solution (a mixture of 50% formalin-10% and 50% formaldehyde) and stored in a plastic jars. Sediments were then filtered using a 1 mm mesh size sieve Organisms suspended were put into 70% ethanol solution for subsequent analysis, which includes identification, counting the number of species, density, and classification of taxa. Statistical parametric analysis using Analysis of variance (ANOVA) was performed to compare the differences among treatments of mangrove crabs [3. Multivariate analysis using ordination and cluster with non-metric method of Multi Dimensional Scaling (MDS) of Bray-Curtis similarity were performed to determine the level of differences of macrobenthic structure between sampling stations in two-dimensional scale [4]; [5]; [6].

3. Results and Discussion

3.1. The growth rate of biomass

Increased body weight mud crab after 4 to 8 weeks of treatment are presented in Figure 2. Based on the graph, the growth of mangrove crab body weight for each treatment at week 4 ranged between 15-50 grams of initial body weight. Increased body weight is highest in crabs treated by cuts all the way leg (T3), which is an average increase in body weight of 50.2 grams, and the lowest in the crab treatments 1 (T1), which is an average increase in body weight 16 grams, followed by Control (K) of 17.4 grams. Test results on body weight after four weeks of treatment showed a significant difference [F (3,16) = 3.353, p = 0.045]. Further Post Hoc test using Tukey HSD test showed a significant difference in the value of the increase in body weight between the mangrove crab crab control (K) (M = 0:54, SD = 0.74) with crab treated by cuts all the way leg (T3) (M = 1.70, SD = 0.0039). Crab treated by cuts all the locomotion legs (T3) increased body weight significantly compared with other treatments, especially the crab control (K). This is likely due to the crab (T3) concentrate to improve

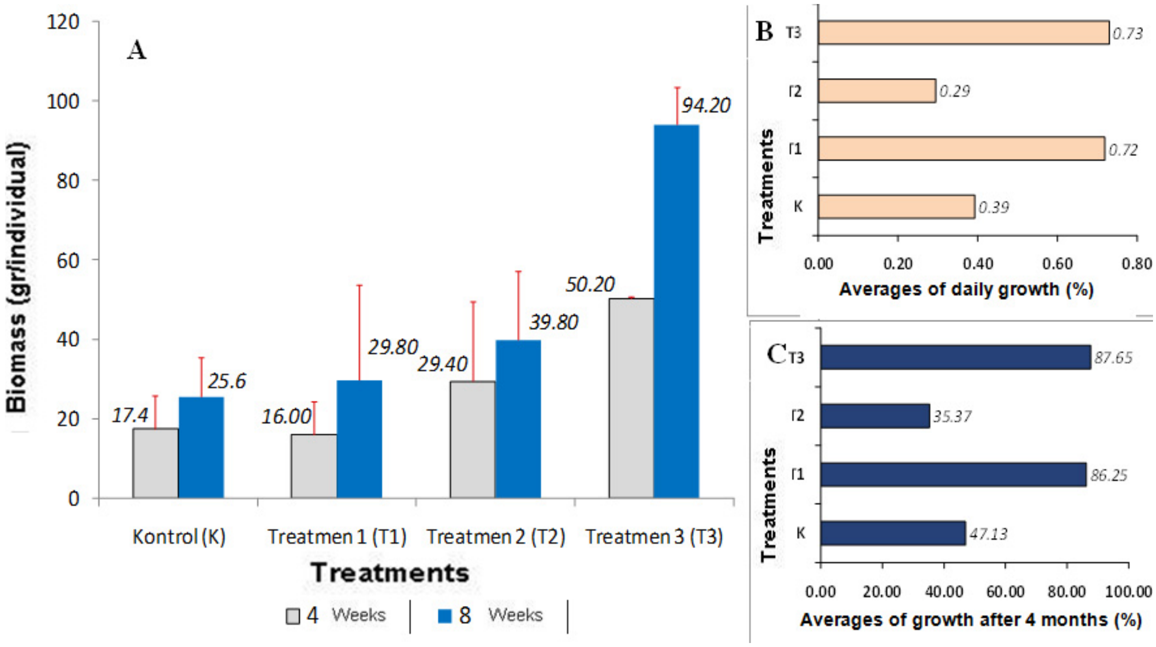


Fig 2. Biomass and growth rate of the crab *Scylla spp* .: (A). Average biomass (g/individual) at the age of 4 weeks and 8 weeks post-treatment; (B). Average of daily growth; (C). Average of growth after 4 months post-treatment.
Notes: * C = control, T1 = crab legs treated by cuts in the road to the right just T2 = treated with a crab leg cuts roads left alone, and T3 = crabs treated by cuts all the legs.

and re-build of the missing part of their body (locomotion legs) so that the energy were mainly used to grow and stimulate the production of growth hormones used to improve the structure of the body, by which the molting process was faster. It is likely that the technique of farming by means of cutting crab legs biologically can stimulate their growth or molting process. This is due after the crab legs were mutilated, crabs will be stimulated to improve the morphological function of the body by molting. Molting is not just aimed to stimulate and accelerate growth of the crabs, but it also serves to re-grow organs defective. Molting process involves four phases: intermolt, premolt (preparation to achieve molting), molt (molting), and post-molt (recovery of molting) [7]. Furthermore, the process of cell regeneration is parts repair cells damaged by synthesis/formation of proteins controlled by genes in the cell nucleus chromosomes [8]. The foot path originally colored black, but it will change color as former legs before it had been broken. Crab treated by cuts all the locomotion legs (T3) experienced growth their weight after molting process took place and a broken legs grew.

For the control crabs (K), the growth of their body weight were considered lower than treated crabs by cutting all legs off (T3). This may be because the energy source of the control crabs (K) are not used to repair damaged structure, but it is used for other needs, such as for activity (motion) of the body. Growth hormone in control crabs (K) also did not stimulate the process of molting to perform faster because there is nothing to stimulate growth hormone to work faster, so their molting process were longer than the treated crabs (T3). Based on the graph Figure 3 (A), an increase in body weight of mud crab after eight weeks of treatment ranged from 25-94 grams compared to the initial body weight. The body weight of mangrove crabs was highest for treated crabs (T3) after four weeks of treatment, which is average increase in body weight of 94.2 grams. Increased body weight mud crab after eight weeks of treatment was lowest for the crab Control (K), which is an average increase in body weight of 25.6 grams. Test results on the growth of crab body weight after eight weeks showed a significant difference [$F(3,16) = 5.380$, $p = 0.009$]. Further Post Hoc test using Tukey HSD test showed a significant difference in the value of the increase in body weight between the mangrove crab crab control (K) ($M = 1.13$, $SD = 0.65$) with crab treated by cuts all the way leg (T3) ($M = 1.97$, $SD = 0.043$), and among the treated crab legs in the form of cuts to the right path only (T1) ($M = 0.94$, $SD = 0.57$) with crab treated by cuts in all foot path (T3) ($M = 1.97$, $SD = 0.043$). The increase in body weight after eight weeks of treatment showed not much different compared to data taken after four weeks of treatment. The tendency of an increase in body weight in treated crabs T3 indicates that molting may stimulate and accelerate growth, but it also serves to re-grow the defective organs.

3.2. The growth rate of the width and length of carapace

The growth rate of mangrove crab carapace width is obtained based on the difference between the carapace width before treatment and after four weeks of treatment, also the difference between carapace width before and after eight weeks of treatment. Figure 3 shows the mangrove crab carapace width increase after four weeks of treatment. This suggests a growing tendency on the mangrove crab carapace width for each treatment. Increased mud crab carapace width after four weeks of treatment ranged from 0.86 to 4.02 cm from the initial carapace width. The increase in carapace width of crabs was highest at the treated crabs T3, which is an average increase of 4.02 cm carapace width, and lowest in the treated crab T1 by an average of 0.76 cm followed by control group (K) by an average of 0.86 cm.

Test results for carapace width after four weeks of treatment showed a significant difference [$F(3,16) = 6.126$, $p = 0.006$]. Further Post Hoc test using Tukey HSD test showed a significant difference in the increase in value between the mud crab carapace width of crab control (K) ($M = 0.016$, $SD = 0.19$) with crab treated crab T3 ($M = 0.60$, $SD = 0.025$), and among the treated crab T1 ($M = 0.073$, $SD = 0.25$) with crab treated by cuts all the way leg (T3) ($M = 0.60$, $SD = 0.025$). Growth is essential for mangrove crabs, including growth in carapace width. Mud crab has a carapace width greater than its own size.

The growth of carapace width is always inline with the increase in body weight. After four weeks of treatment, mud crab carapace width increased. Treated crab T3 increased highest in carapace width compared to the control (K) and treated crab T1. Treated crab T3 experienced molting faster than other treatments. Crabs are undergoing a process of change of skin periodically (molting), thus increasing the size of the carapace width. Energy can be stored in mangrove crabs to assist in the process of molting because its movement is limited. In addition to accelerating the growth, molting crab can also help to re-grow the lost leg due to the treatment. Figure 4 indicate a trend of growth in the carapace width of each treatment after eight weeks of treatment, which ranges from 1.0 to 5.6 cm from the initial carapace width. The highest increase in carapace width of crabs was the treated crab T3, which is an average increase of 5.6 cm carapace width, and lowest in the treated crabs T1, the average has increased 1.0 cm carapace width. Test results against carapace width after eight weeks of treatment showed a significant difference [$F(3,16) = 19.664$, $p = 0.000$].

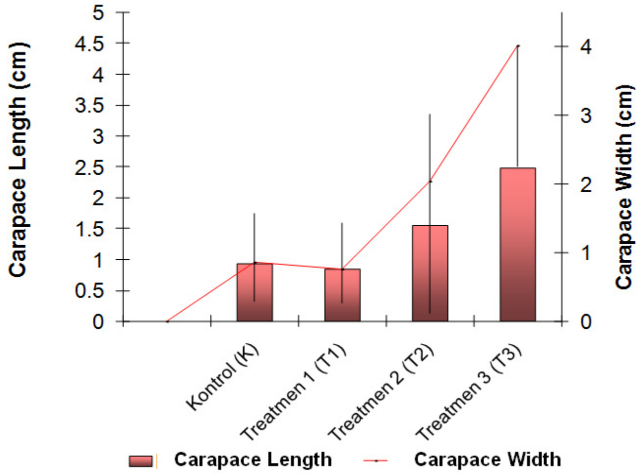


Fig. 3. Comparison of the mean length and width of the mangrove crab carapace between the control group (K) and treated crabs T1, T2, and T3 after 4 weeks.

Further Post Hoc test using Tukey HSD test showed a significant difference in the increase in value between the mud crab carapace width of crab control (K) (M = 0.36, SD = 0.22) and treated crab T1 (M = 0.073, SD = 0.25), between the control crabs (K) (M = 0.36, SD = 0.22) and the treated crab T3 (M = 0.75, SD = 0.037), between treated crab T1 (M = 0.073, SD = 0.25) and treated crab T2 (M = 0.48, SD = 0.096), and between the treated crab T1 (M = 0.073, SD = 0.25) and treated crab T3 (M = 0.75, SD = 0.037). The increase in carapace width after eight weeks of treatment showed that the results are not much different from the increase in carapace width after four weeks of treatment. Increasing trend in crab carapace width of treated crab T3 indicates that cuts all the legs showed a significant effect on the increase in carapace width compared with the other treatments.

The carapace length after four weeks of treatment showed a tendency of growth of their length in each treatment, which ranges from 0.85 to 2.48 cm from the initial carapace length. The increase in carapace length was highest in crabs treated by cuts all the way leg (T3), which is an average increase of 2.48 cm carapace length, and the lowest in control crabs (K), which is an average increase of carapace length 0 , 48 cm. Test results against carapace length after four weeks of treatment showed a significant difference [F (3,16) = 8.414, p = 0.001]. Further Post Hoc test using Tukey HSD test showed a significant difference in the increase in the value of mangrove crab carapace length between the control crabs (K) (M = 0.021, SD = 0.11) with treated crab T3 (M = 0.40, SD = 0.05), between treated crab T1 (M = 0.03, SD = 0.17) and treated crab T3 (M = 0.40, SD = 0.05), and between the crab treated by cuts in the left foot only (T2) (M = 0.09, SD = 0.20) and treated crab T3 (M = 0.40, SD = 0.05).

Increased carapace length after eight weeks of treatment ranged from 0.8 to 5.7 cm. The increase in carapace length of test animals is highest in treated crabs T3, which is an average increased 5.48 cm carapace length, and lowest in the treated crabs T1, which is an average increase of 0.82 cm carapace length. Test results against carapace length after eight weeks of treatment showed a significant difference [F (3,16) = 14.43, p = 0.000]. Further Post Hoc test using Tukey HSD test showed a significant difference in the increase in the value of mangrove crab carapace length between the control crabs (K) (M = 0.12, SD = 0.29) and treated crab T3 (M = 0.73, SD = 0.02), between treated crabs T1 (M = 0.018, SD = 0.18) and treated crabs T3 (M = 0.73, SD = 0.02), and between the treated crab T2 (M = 0.28, SD = 0.18) and treated crabs T3 (M = 0.73, SD = 0.02).

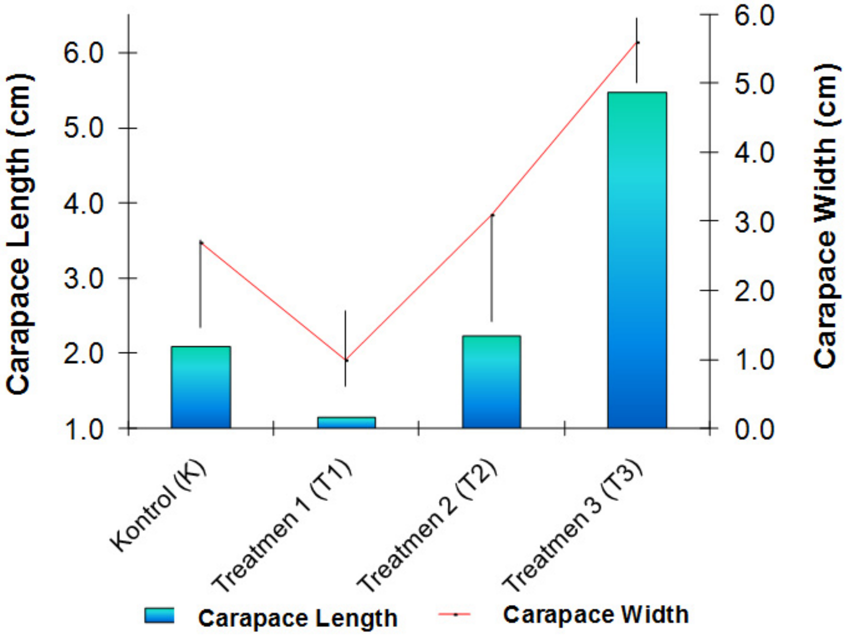


Fig. 4. Comparison of the mean length and width of the mangrove crab carapace between the control group (K) and treated crabs (T1, T2, and T3) after 8 weeks.

The increase in carapace length after eight weeks of treatment tend to show different results with four weeks of treatment. Crab treated by cuts all the way leg (T3) affects the control crabs (K). Increased crab carapace length in the treated leg by cuts all the way (T3) also affect the crabs treated by cuts in the road to the right leg only (T1), and crabs are treated by cuts in the left foot only (T2).

3.3. Water quality and macrobenthic structure

Parameters measured include water temperature, conductivity, salinity, oxygen content (DO), turbidity, and pH. Results of water quality measurements at Ujung Alang, Cilacap shows relatively normal conditions, both in the control area and in crab farming area, except for turbidity parameters are relatively higher in farms compared to control sites. Water turbidity can be caused by mud, soil particles, pieces of plants, dissolved organic matter or phytoplankton. Reduced light penetration in turbid waters may affect the depth of the water plants [9]. The high turbidity at the site of farming can be caused by the presence of organic matter from aquaculture activities are dissolved in water, can be caused by feed/pellets as well as phytoplankton growth in response to organic enrichment waters.

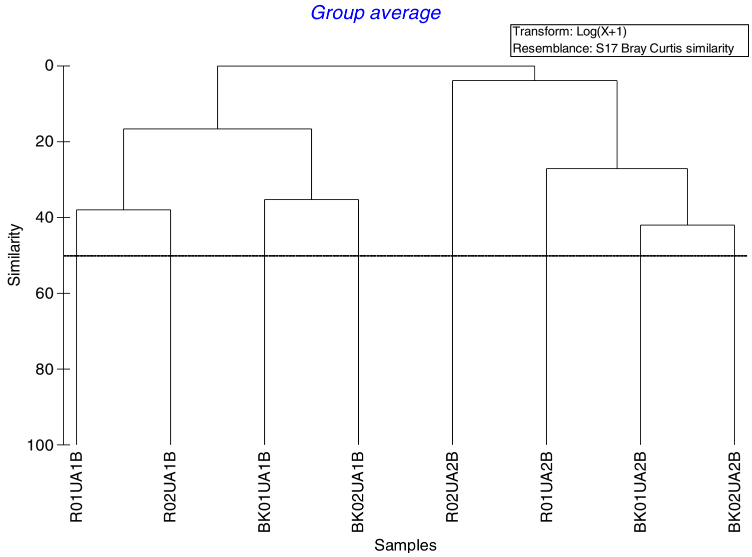
Macrobenthic community structure in the Ujung Alang, Cilacap dominated by Class Gastropoda, especially from Family Thiaridae and Nassarriidae, as presented in Table 1. The observation area of crab farming, the natural habitat of mangrove forests or in the control area found as many as 82 species of macrobenthos of 44 families and of the 4 classes that include gastropods (60 species), polychaetes (14 species), bivalves (6 species), and crustaceans (2 species). Results of multivariate analysis using Cluster analysis and Metric Multidimensional Scaling Non ordination (NMDS) showed clustering between sampling times (Figure 5). This indicates that the abundance of macrobenthos varies over time (temporal).

Table 1. Composition of macrobenthic assemblages at each station of both farming and reference sites.

NO.	CLASS	FAMILY	SPECIES	Kelimpahan /grab (8300 mm^3)							
				BK01UA1B	BK02UA1B	BK01UA2B	BK02UA2B	R01UA1B	R02UA1B	R01UA2B	R02UA2B
1.		NASSARRIIDAE	*Nassarrius distortus*	2	31						
			Nassarrius myristicatus	1							
			Nassarrius (Telasco) luridus	3					17		
			Nassarrius dorsatus	9							
			Nassarrius (zeuxis) margaritarius			2					
			Nassarrius (Telasco) luridus								3
		PLANAXIDAE	*Pseudovertagus aluco*	7							
			Planaxis sulcatus	12	24						
		CERITHIIDAE	*Cerithium vulgatum*	1					22		
			Clypeomorus brevis		37						
			Cerithium nodulosum	7	3			2	11		
		CASSIDAE	*Semicassis saburon*	2							
		RISSODIAE	*Alvania lineata rissoa*	15							
		POTAMIDIDAE	*Terebralia sulcata*					5	22		
		THIARIDAE	*Thiara scabra*			11	9			2	
			Sermyla riqueti			12	17			58	105
			Brotia costula			15				46	43
			Thiara herklotzi			49	54			3	3
	GASTROPODA		*syrmylasma venustula*							8	
			Thiara rufis							12	
			Melanoides granifera			6	9				
			Melanoides riqueti			33				16	
		STENOTHYRIDAE	*Stenothyra glabrata*							1	1
		PLEUROCERIDAE	*Sulcospira sulcospira*			2				13	
		MARGINELLIDAE	*Marginella avana*							1	1
		EPITONIIDAE	*Epitonium perplexa*							2	
			Epitonium multistriatum								3
		PYRAMIDELLIDAE	*Pyramidella sulcata*							1	
			Odostomia scalaris		1						
			Pyramidella ventricosa							1	
		TURBINIDAE	*Turbo (lunella) cinereus*								1
		LITTORINIDAE	*Littorina neritoides*								1
			Littorina littoralis								1
		SYNCERIDAE	*Syncera wood masoniana*							2	
			Syncera hidalgoi							3	
		NERITIDAE	*Neripteron violacea*							19	2
			Theodoxus neglectus							3	
		TROCHIDAE	*Cantharidus purpureu*							1	
		TURRITELLIDAE	*Turritella communis*								1
		PHOLADIDAE	*Barnea australasiae*	1							
		PLACAMEN	*Placamen sp.*	1							
		LASAEIDAE	*Lasaeidace*	1							
2.	BIVALVIA	VENERIDAE	*Periglipta purpurea*							1	
			Bassina disjecta		1						
			Circe scripta							1	
			Bassina pachyphylla						1		
3.	POLYCHAETES	SPIONIDAE	*Prionospio coorilla*		1					16	
4.	CRUSTACEA	PORTUNIDAE	*Scylla serrata*								1

But no grouping was observed based on sampling locations, indicating that macrobenthic structure (abundance and diversity) in crab farming location and the location of mangrove vegetation/reference area showed no significant difference.

Ref. [10] stated that understanding spatial and temporal distribution and abundance has become essential part of ecological research on benthic “communities”. Environmental variability is believed to play a major role in the change of structure expressed by variation in species richness, abundance, and biomass. It has been suggested that spatial distribution of organisms in soft-bottom habitats is mainly controlled by both biotic factors (eg. life history, competition, predation) and abiotic factors (eg. food availability, sediment characteristics, tidal current).



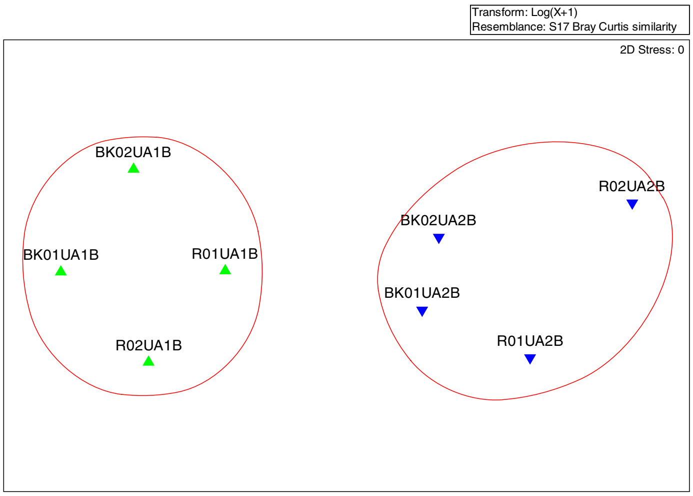


Fig 5. Cluster and ordination analysis generated from macrobenthic abundance at each station of both farming and reference sites, showing separation between sampling times.

4. Conclusion

Based on the results of research and discussion, it can be concluded that the presence of mangrove forests in the region cultivating a positive impact on the recovery of the ecological functions of the area. Based on biotic and abiotic factors, the area of aquaculture and mangrove areas did not show significant differences, indicating the farming practices *Scylla serrata* in the shelter system is environmentally save. Based on the physico-chemical quality of water and the structure of the cultivated area macrobenthos crab *Scylla spp*.dan mangvore forest in Ujung Alang, Cilacap shows relatively normal conditions, and did not differ significantly. However, there were difference in macrobentic structure between sampling time, owing to the seasonal changes of hydrodynamic and weather condition.

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