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Reef Development on Artificial Patch Reefs in Shallow Water of Panjang Island, Central Java

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Abstract. Reef restoration methods are generally developed by propagation of coral fragments, coral recruits and provide substrate for coral attachment using artificial reefs (ARs). ARs have been widely applied as a tool for reef restoration in degraded natural reefs. Successful of coral restoration is determined by reef development such as increasing coral biomass, natural of coral recruits and fauna associated. Artificial Patch Reefs (APRs) is designed by combined of artificial reefs and coral transplantation and constructed by modular circular structures in shape, were deployed from small boats by scuba divers, and are suitable near natural reefs for shallow water with low visibility of Panjang Island, Central Java. Branching corals of *Acropora aspera*, *Montipora digitata* and *Porites cylindrica* fragments were transplanted on to each module of two units of artificial patch reefs in different periods. Coral fragments of Acropora evolved high survival and high growth, Porites fragments have moderate survival and low growth, while fragment of Montipora show in low survival and moderate growth. Within 19 to 22 months of APRs deployment, scleractinian corals were recruited on the surface of artificial patch reef substrates. The most recruits abundant was Montastrea, followed by Poritids, Pocilloporids, and Acroporids. We conclude that artificial patch reefs with developed by coral fragments and natural coral recruitment is one of an alternative rehabilitation method in shallow reef with low visibility.

Keywords: Keywords: artificial patch reefs, reef development, Panjang Island, Central Java

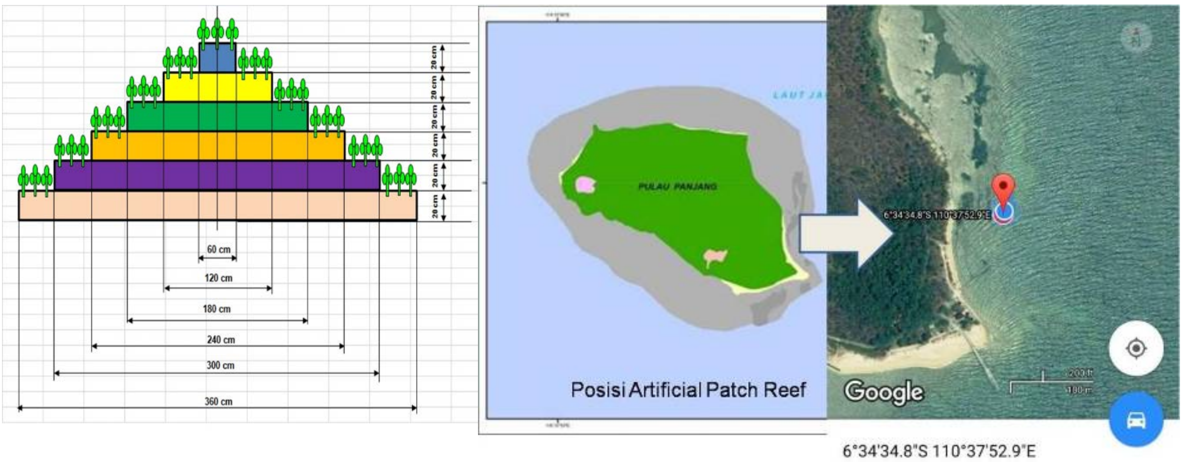
1. Introduction

The coral reefs of tropical waters ecosystems are very important in order to support in food security. However, recently status of coral reefs is threatened due to the practice of fisheries that are not environmentally friendly and the impact of the development of the coastal area [1]. Artificial reef is one of the tools to rehabilitate or restoration coral reefs [2-3]. A variety of artificial reefs have been deployed for a variety of purposes, as the home of fish, marine tourism and rehabilitation of coral reefs. A lot of material that was applied in the manufacture of artificial reef construction either natural or artificial materials. Natural materials made of stone, bamboo and wood, while artificial materials, namely tires, concrete blocks, a former vehicle, iron, etc. [4]. In Indonesia, the artificial reef that was applied for the rehabilitation of coral reefs are generally using concrete blocks with various shapes: pyramid, pipe, rod and loop and cubic forms [5]. All it aims to replace or mimic natural reefs [6]. Unfortunately, most are not generally successful. Failure caused by unstable structures and unsuccessful methods in increasing biomass of coral on the substrate of artificial reef.

Some have applied to do a transplant coral reef rehabilitation [2-3]. Coral transplantation is usually performed using nursery shelves but not until coral fragments transferred to rehabilitation areas because many deaths. The combination of artificial reef with coral transplantation be alternatives in supporting the successful rehabilitation of coral reefs in the coral biomass increase. The success of the artificial reef is determined also by the proximity of natural reef, it can support recruitment of hard corals [5] and increased biomass of coral, the occurrence of recruitment in a natural increase of biota associated with artificial reef [7]. This paper will discuss the development of reefs on the artificial reef which is combined with the coral transplantation technique later called artificial patch reefs (APRs) have been applied in the reef flat of Panjang Island, Central Java which evolved shallow and murky [8-9].

2. Material and Methods

The APR is a structure of artificial reef in circular shaped which constructed modules (modular) and made by concrete blocks and consists a multilevel up to 5 levels (Figure 1A). The artificial reef structures placed on the East side of Panjang Island reefs at a depth of 3-5 meters (6° 34' 34.8" LS and 110° 37' 52.9" BT; Figure 1B). APRs deployment were built by inserting a concrete block module (weight 30-40 kg) one by one using SCUBA Dive equipment, each structure composed of 180 modules. Two unit of the APRs (APR_1 and APR_2) were installed adjacent to natural reefs on June 8th, 2015 and September 22, 2015. Each module attributed holes in order to coral transplantation using underwater cement. APR_1 which deployed on 8 June were transplanted by using branching coral Acropora while APR_2 which deployed on September 22, and then were transplanted using branching coral Montipora and after death in the West Monsoon then transplanted with Branching coral Porites in mid-June 2016. Observation on growth of Acropora coral fragments on the APR_1 performed on the 100 and 145, Montipora coral fragments on growth of the APR_2 on a day-to-55 days whereas growth of Porites coral fragments was conducted in the first week of transplanting until 8th weeks (June-August 2016). Observations of the recruitment of corals and reef fish were performed in early June 2017, after the APR_1 was 2 years old and the APR_2 was 18 months.



A B

Figure 1. A. Structure of artificial reef APR; B. Deployment site of APR at Pulau Panjang, Central Java

3. Results and Discussion

3.1. The growth of coral fragments

Artificial reef APR_1 deployed on June 2015 which is composed by branching *Acropora aspera* whereas APR_2 deployed on September 2015 consists of fragments of branching coral *Montipora digitata* (Figure 2). The selection of this type of reef with consideration of time period reproduction coral Acropora and election time also with consideration of water quality. June is the start of the season, and September is the end of the season and entered the transitional season. Combined with design/construction APR that supports regeneration of coral branching resulting in the survival of moderate coral transplant ranges from 25% to 57% in the observation day-155. The results also showed that the coral colonies have the highest survival is at the top of the circle to the middle of the otherwise the lowest survival is in the circle of the base.

Figure 2. Reef condition of Artificial Patch Reef I (APR_1) deployed on 8 Juni 2015 and APR_2 deployed on 21 September 2015.

Condition of APR_1 after 100-days show reef development indicated by increasing biomass of coral, a colony of coral branches grows rapidly, covered CCA (Crustose Coralline Algae), macro algae as Padina. Thus, APR have been promoting a new habitat in initial period. Fragments of coral branching Acropora can grow significantly on the substrate of APR using cement. It is indicated that structure of APR is suitable for coral propagation, particularly branching coral Acropora on (Figure 3). Observation on the growth of coral colonies showed 145 Acropora rapidly increased up to 15 cm in diameter, the growth of coral fragments up to more than 1000%.

Figure 3. Growth of biomass of coral propagation Acropora on APR_1 which deployed on 8 June 2015 (A. initial propagation; B. 100 days; C. 145 days).

Propagation of Acropora coral fragments on artificial reef APR_1 can increase biomass of coral *Acropora aspera*, one of the extinct coral population in of Panjang Island. As many as 50% of coral fragments Acropora have survive until 155 days (Figure 4). When coral fragments that are planted on June 8th, 2015 as much as 360 then until 2015, November 14, observations have been obtained 180 colony of coral branching *Acropora aspera*. Fragments of coral can grow rapidly into large coral colonies with a size reached Ø 16 cm on the 155 or 5 months (Figure 5). However not all colonies grow rapidly, some coral colonies obtained measuring Ø 6 cm. These results indicated that coral *Acropora aspera* can evolved asexual reproduction in order to increase population by coral fragmentation on artificial reef APR [10].

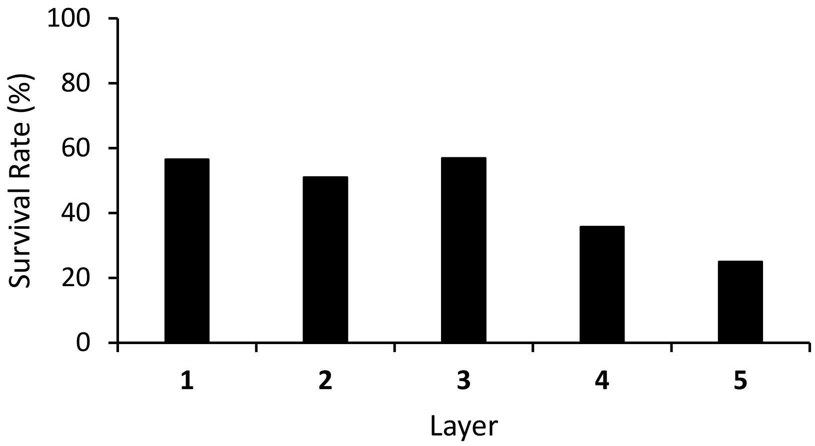


Figure 4. Survival rate of coral propagation Acropora on APR_1 after 155 days.

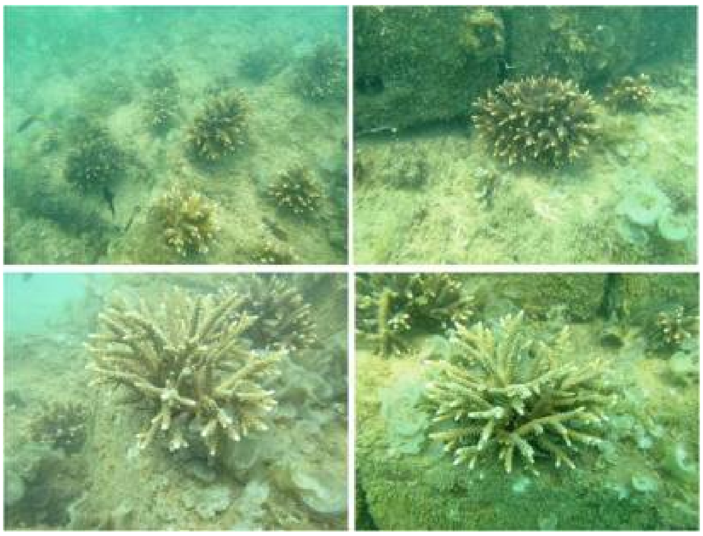


Figure 5. Growth of biomass of coral propagation Acropora on APR_1 after 45 days.

The deployment of artificial reefs APR_2 on September 21, 2015 has also provided a new habitat (Figure 6). Substrate concrete block has been covered with CCA (Crustose Coralline Algae), however these macro algae are not found in APR_1. Initially, reef development of APR_2 on 11 October 2015 showed that fragments *Montipora digitate* grow rapidly. Growth of Montipora fragments reach in various size in this periods. However, all of the coral fragments died during in west monsoon (December-February 2016).

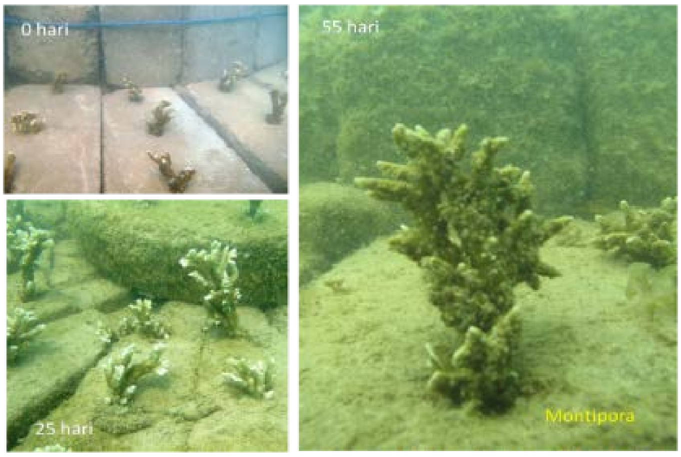


Figure 6. Growth of biomass of coral propagation Montipora on APR _2 deployed on 21 September 2015

After mortality of Montipora fragments, coral branching of Porites fragments replaced onto artificial reef APR_2. The coral fragments can survive longer on APR_2, coral fragments can last up to 1 year of observation later. Early growth of fragments of branching coral *Porites cylindrica* of large range 47-350% during 6 weeks however slowly growth occurred in the coral fragments after a year of transplanted (Figure 7).

Figure 7. Growth of coral propagation Porites on APR_2 transplanted mid of June 2015.

3.2. Recruitment of hard corals

Reef development of APR is also indicated by the occurrence of coral recruitment showed settlement of hard corals. The viable of corals juvenile were found in the second year of deployment. Genera of Scleractinian coral were found settled to the surface of substrate of the APR is Montastrea, Porites, Acropora, and Pocillopora Goniastrea (Figure 8). In order to highlighted in composition of the genus coral recruits, Montastrea was highest followed by Porites (Figure 9). Constituent types of observations on natural reefs around the APR is Faviid and Poritiid [11]. This suggests that coral recruitment in accordance with the composition of the genus corals there are nearby [6].

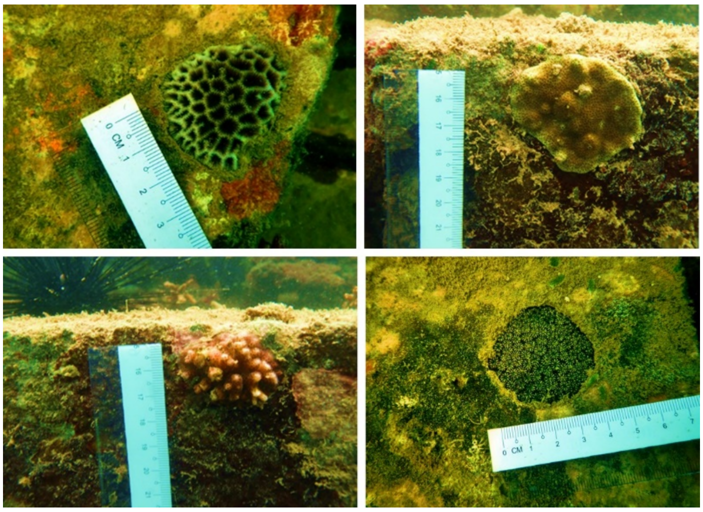


Figure 8. Generic composition of juvenile corals recruit on APR after 18-24 months (A. Goniastrea; B. Porites; C. Pocillopora; D. Montastrea)

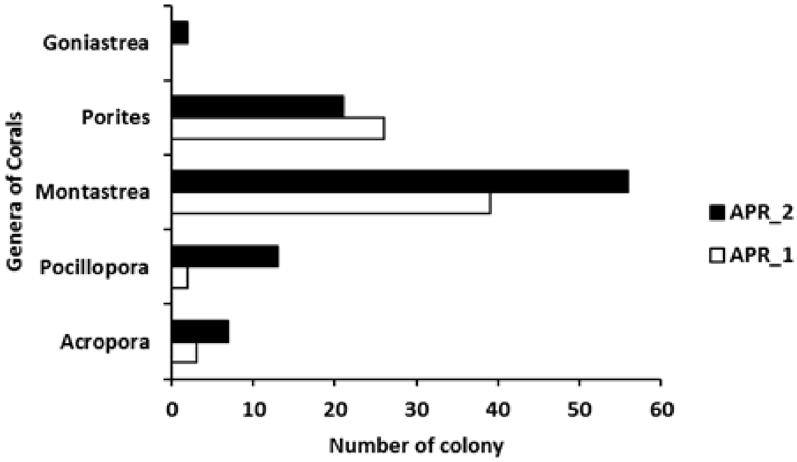
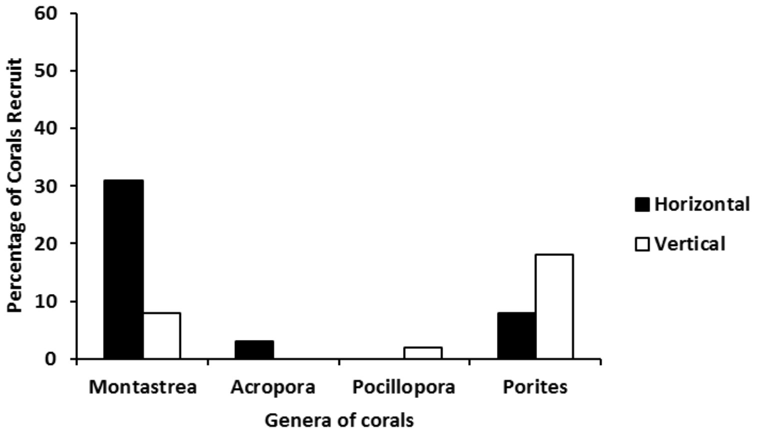


Figure 9. Abundance of juvenile corals recruit on APR after 18-24 months

Coral recruitment occur two of APRs, number of corals recruited in APR_2 was higher than in APR_1. Coral recruits were generally found on level 2 and 3 of APRs. Montipora are found on horizontal surface of the substrate, Pocillopora settled on vertical surface of substrate. Branching coral Porites can settle on both horizontal and vertical surface of substrate (Figure 10). Generally, coral settlement of Pocilloporid in the column water [12], while other coral taxa can settle in horizontal plate in the bottom of the sea [13] (Munasik, 2008b). Larva of Scleractinian corals have settlement preference in various morphotypes [14], substrate structure and substrate composition [15-17]. Local current pattern of Panjang Island waters may also effect on distribution of adult corals and juvenile corals [18]. The combination of tidal, monsoon system, bathymetry depth resulting may increase coral recruitment in APR of Panjang Island.



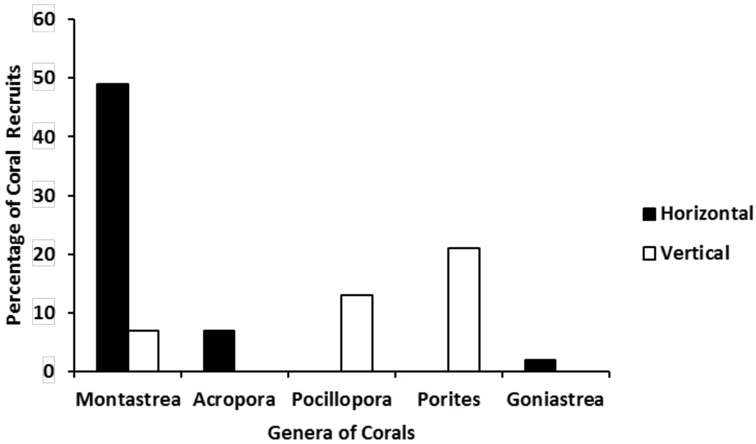


Figure 10. Settlement preference of coral generic on substrate surface of APRs after 18-24 months (A. APR_1 dan B. APR_2).

3.3. Recruitment of Reef Fish

Fish health indicators of coral reefs of the Caetodontidae have also been found around the colonies of coral transplantation results. Juvenile of butterflyfish *Chaetodon octofasciatus* has been found associated with colonies of coral Acropora branch at the age of more than 100 days APR. In addition, the artificial reef APR has also been presenting schooling group Caesionidae who often travels in a natural reef environment. These results suggest that artificial reef presents a new habitat has been the APR in shallow waters and along with increasing time will be able to increase the biodiversity gradually (Figure 10). The second artificial reef has been presenting new habitat on the 20th day of monitoring is indicated by the presence of reef fish Pomacentridae (Figure 11).

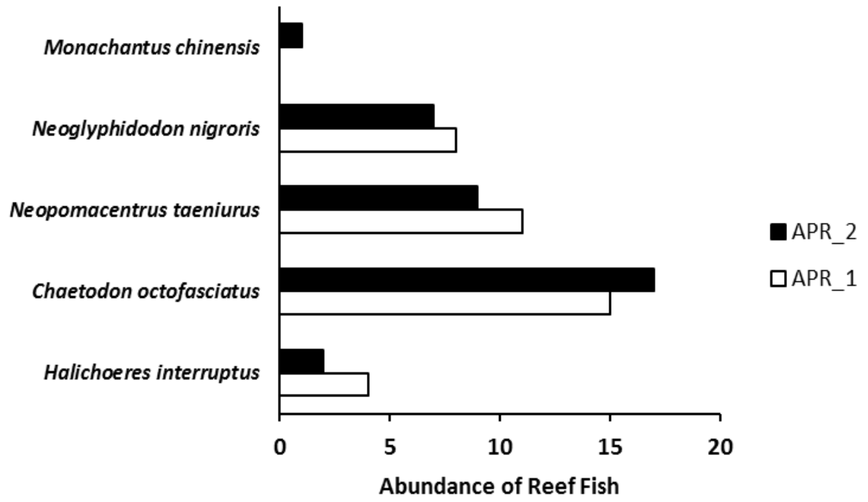


Figure 11. Abundance of reef fish which associated with APRs at Panjang Island, Central Java

4. Conclusion

APRs have provided new habitats in shallow waters indicated by increased live coral coverage from both propagation of coral fragments and larval trapped. Reef development generally occurs in the middle of APRs, indicated by the high survival of coral fragments and high coral settlement. Branching coral Acropora is one of best species in order to increase coral biomass in ARs located in the shallow water. Composition of coral species which settled in APRs seems to be similar to nearby natural reefs..

References:

[1] Wilkinson CR 2000 Executive summary In C R Wilkinson (Ed.), Status of coral reefs of the world: 2000 (pp. 7–19). Australia: Australian Institute of Marine Science.
[2] Rinkevich B 2005 *Environ. Sci. Technol*. **39** 4333-4342
[3] Abelson Avigdor 2006 *Bulletin of Marine Science* **78** (1) 151-159
[4] Baine M 2001 *Ocean & Coastal Management* **44** 241–259
[5] Munasik 2008a *Kondisi terumbu buatan berbahan beton pada beberapa perairan di Indonesia.* In: Simposium Munas Terumbu Karang II, 20 Nopember 2008, Hotel Bidakara Jakarta
[6] Perkol-Finkel, S N Shashar, Y Benayahu 2006 *Marine Environmental Research*, **61** (2) 121-135
[7] Meesters, Erik HWG, Sarah R Smith, Leontine E Becking 2015 A review of coral reef restoration. Report to IMARES Wageningen, UR
[8] Edinger EN, Jompa J, Limmon GV, Widjatmoko W, Risk MJ 1998 *Marine Pollution Bulletin* **37** 617-630
[9] Sabdono, A. et al. 2014. An Early Evaluation of Coral Disease Prevalence on Panjang Island, Java Sea, Indonesia. *Int. J Zool. Res*. **10**: 20-29.
[10] Munasik, W Widjatmoko 2004 *ILMU KELAUTAN: Indonesian Journal of Marine Sciences* **9(**4) 211-216
[11] Munasik et al. Sebaran Spasial Karang Keras (Scleractinia) di Pulau Panjang, Jawa Tengah. *Buletin Oseanografi Marina*. April: Vol. I:16-24. Tahun 2012
[12] Munasik, Suharsono, J Situmorang, Kamiso H N 2014 *ILMU KELAUTAN: Indonesian Journal of Marine Sciences* **19**(3) 171-180
[13] Munasik. 2008b. Reproduksi Karang *Pocillopora darnicornis* (Linnaeus) di Pulau Panjang, Jawa Tengah. *Disertasi*. Fakulatas Biologi Universitas Gadjah Mada.
[14] Munasik, Diah Permata Wijayanti, Retno Hartati, Rudi Pribadi, Yoko Nozawa 2016 *ILMU KELAUTAN: Indonesian Journal of Marine Sciences* **21(**4) 185-190
[15] Nozawa Y 2008 *J. Exp. Mar. Bio. Ecol.* **36** 127-130

[16] Nozawa, Y. 2010. Survivorship of fast-growing coral spats depend less and refuge structure: the case of *Acropora solitaryensis*. *Galaxea* 12(1) 31-36.
[17] Yadav S, Rathod P, Alcoverro, T & Arthur, R 2016 *Coral Reefs* **35** 211-222
[18] Munasik, Denny N Sugianto, Widodo S Pranowo, Suharsono, Jesmant Situmorang, Kamiso HN. 2006 *ILMU KELAUTAN: Indonesian Journal of Marine Sciences* **11(**1) 11-18