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Ecology of cubes artificial reef of Pantai Damas, East Java, Indonesia

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ABSTRACT

Damage to the coral reef ecosystem in the Damas coastal region is associated with various things such as large sedimentation due to mangrove deforestation in the upper area, destructive fishing practice, tourism activity and increasing temperature and organic material in the seawater. Fragile coral as main reef builders can recover themselves with slow rate mode and humans introduce a low technology that can accelerate the recovery of coral reefs by using artificial reefs (AR). In the 2017 local community supported by scientists deployed 25 cubes artificial reef in Damas area. Cubes structure have the main purpose of establishing the sea substrate to attract coral juvenile and to harbor reef fishes. The result from underwater video and photographs showed that 3 ARs missed and 22 ARs found with various conditions: 15 ARs buried with sediment; 1 AR covered by a net; 3 ARs in a tilted position and 4 ARs in good condition. The density of sessile organisms on the AR surface consists of 16 sessile organisms with a total density of 6.94 individual/m². The abundance of reef fish in the AR area comes from 16 families with a total abundance of 1.73 individual/m².

Key words: *Evaluation, Artificial reefs, Sessile organism, Reef fish, Pantai damas, Habitat enhancement.*

Introduction

The coral reef is one of the ecosystems in tropical waters that has a complex structure and importance for others marine invertebrates also important for reef fishes population (León and Bjorndal, 2002; Nurdin *et al.,* 2016; Linggi *et al.,* 2019; Nugraha *et al.,* 2020) besides the beauty of coral reef become attracting factor for humans as aesthetic appearance (Haas *et al.*, 2015; Apri *et al.*, 2018; Harahap *et al.*, 2019). In the ecosystem view, coral reef has the main function as a shelter, foraging for organisms, fisheries resources, tourism objects, and protectors from the waves, but this ecosystem is very sensitive to pressure (Kerry and Bellwood, 2012; Mulya and Arlen, 2018; Suryanti *et al.*, 2018). Coral reef can reestablish and recover from disturbances with slow way. For instance, rapid recovery of coral reef in Hawaii under low pH and high temperature, after mass bleaching event destroyed those areas (Jury and Toonen, 2019). Genetic adaptation rate for adapting to high temperature need 4-8 years in Indo-Pacific areas (Roche *et al.*, 2018). But in some cases, as in the Indo-Pacific area that high sedimentation, unstable substrates (rubble) and dominance of algae become serious threats for coral reef recovery, and need artificial structures to manipulate habitats, and restore damaged coral reefs.

Artificial reefs are man-made structures that are placed at the bottom of waters to mimic the ecological role of coral reefs and to repair damaged habitats. Artificial reef structures are mostly concrete modules that are specially designed and have various shapes such as Reef Ball, concrete pipes, concrete cubes, and shipwrecks (Lemoine *et al.*, 2019). Once AR deployed on the seabed it will change original light, shadows will be created from the structure forming dark area in surround AR. The presence of ARs also changed the topography of seafloor and altered the current flow. Some of the currents is moving upward bring nutrients from bottom to surface of water that can obviously attract fish.

A drawback of many ARs projects is the shortage of specific and well-defined goals, resulting in it difficult to determine if the program meets its original objectives. The model of ARs and structural entanglement in ecosystems creates multiple types of microhabitats and is expected to result in greater diversity and abundance of related marine organisms. The choice of location for deploying artificial reefs must consider water quality studies (temperature, salinity, clarity, turbidity, DO) generally indicating normal conditions for the life of marine organisms to allow the growth of natural coral reefs and their associated organisms (Setiawan, 2009). The placing of artificial reefs is carried out by a preliminary survey of locations to determine suitable places where artificial corals will be placed(As-Syakur and Wiyanto, 2016).

Pantai Damas is a remote area in the southern of Trenggalek Regency. The accessibly toward this area very difficult through land transportation due to the Southern Java Crossline still under construction (Islami *et al.*, 2018). One river empty in this area and during rainy seasons bring a lot of sediment and increasing the turbidity of the seawaters and threaten the health of coral reef. Coral reef growth in the east part of Pantai Damas and the condition categorize as poor (Wibowo and Adrim, 2014; Luthfi *et al.*, 2018). In 2017, 25 cuboid structures of artificial reefs deployed in the seabed of Pantai Damas which lied in 5-7 m depth and arranged inline.This study aims to monitor physical ARs, ecosystem from fouling assemblage structure and reef fish bundance surround on an artificial reef.

Materials and Methods

Study site

This research was conducted in the Pantai Damas, Trenggalek Regency which is geographically located at 8° 32’60"S and 111° 69’14" E. Pantai Damas

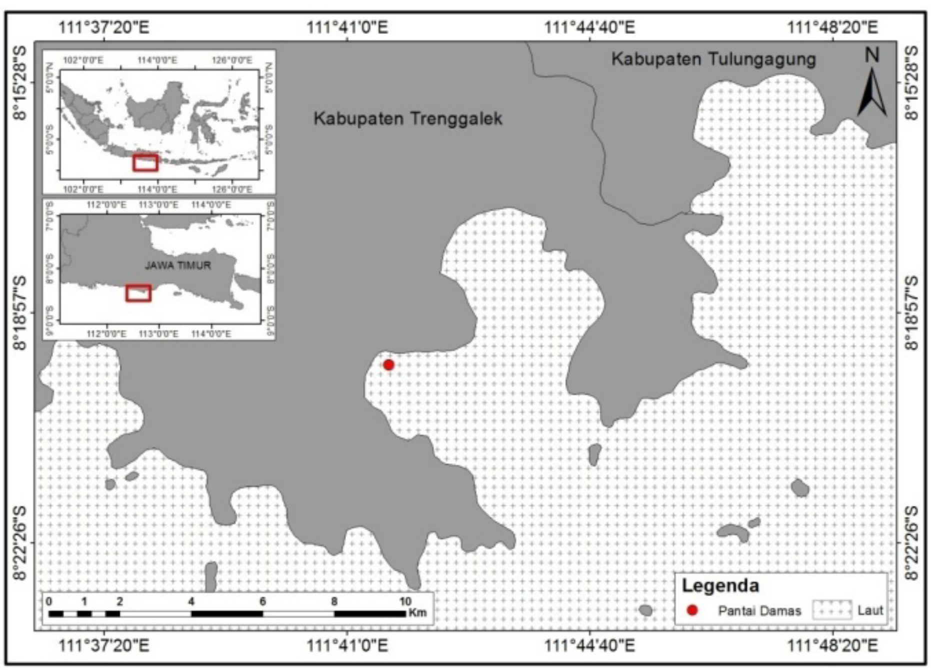

Fig. 1. The research location marked by red point in the Pantai Damas, Trenggalek.

is part of Prigi Bay that a Nusantara fishing port built by the government to anchor more 709 fishing vessels in various types (Luthfi *et al.*, 2018). The bay of Prigi in general is a semi-closed area that affect the current and wave in this location not so strong. Monitoring of ARs conducted in March 2020.

ARs Structure Monitoring

The physical condition of ARs was monitored two times in March 2020. During monitoring SCUBA used to observing, counting, recording all physical conditions of ARs. All ARs were photographed using an underwater camera, Olympus Tough TG-6, and also sketched on underwater slates, the data collection includes AR sinking depth, AR buried by sediment, AR covered by Net, and AR tilted condition. Each AR also measured manually with a soft tape of sewing tailor ruler and each should meet 60 cm long and 8 cm thick (Figure 2).

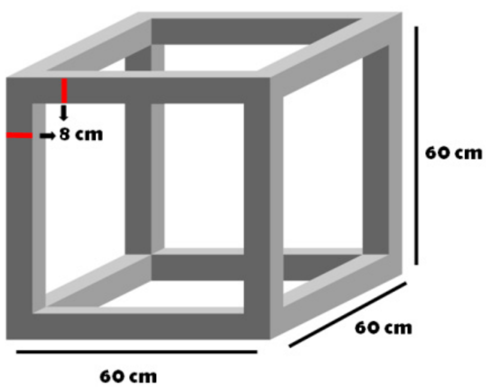

Fig. 2. The dimension of cubic artificial reefs.

Distribution of Sessile Organisms in ARs Structure

All species composition and abundance of a macro sessile organism in reef structure also be quantified. The data are taken from three dimensional AR structures using underwater photographs. Red, yellow, green and blue is representative of the survey in each layer of AR (Figure 3). The cube has 6 sides, but because 1 side is at the bottom so only 5 sides can be observed (Figure 3). AR cube consists of columns (vertical) and sloof (horizontal). All sessile organisms then counted and identified using the protocol of Edgar and Stuart-Smith (2014).

Distribution of Reef Fish

The observation of reef fish is using the stationary visual census method(Sanabria-Fernandez *et al.*,

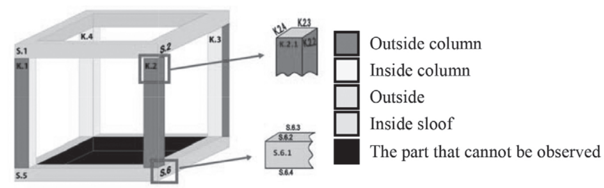

Fig. 3. Division side of the cube

2018). The observation area is the entire surface area of the AR, as well as the area around the AR within 5 meters of the AR using imaginary lines (Figure 4).

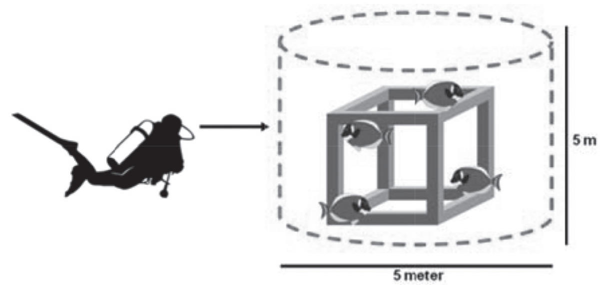

Fig. 4. Observation of Reef Fish.

Data Analysis

The surface area of an AR is calculated by measuring the column and sloof length of each AR found. The density of sessile organisms is calculated by the number of the organism I divided by surface area (m^2) while for the abundance of reef fishes is calculated by the number of fish I divided by the area of the observed transect. Water parameters have been measured such as depth, temperature, pH salinity, DO use AAQ 1183, the current speed with current meter Flowatch, water clarity with Secchi disc, and Nitrate phosphate with Prodac test kit.

Results and Discussion

Physical and Chemical Oceanography

The physical and chemical data (depth, temperature, current speed, water clarity, salinity, pH, dissolved oxygen (DO), phosphate, and nitrate) Pantai Damas showed in Table 1. All ARs deployed on 6-7 m depth which the water clarity on average only 30%. The main factor of low water clarity in Pantai Damas are run-off sediment from the river and suspended sediment. The seabed where the ARs deployed are the soft substrate and composed by mud. Strong current can force the sediment in the water column and remain state on it. The suspended sediment literally can affect a wide range of environmental damage such as, including benthic suffocate, the annoyance of fish gills, and as a harbor of micro bacteria (Davies Colley and Smith, 2001). Much of the impact is reducing light in the water column that is needed for photosynthesis of plankton alga and coral.

The average of annual sea surface temperature in March of south Java sea 24-28 ^oC and it will drop 20-22 ^oC in August (Sprintall *et al.*, 1999). And the current on 0.2 to 0.4 m/s in March, the slow current influenced by southeastward wind and south Java current (SJC). Salinity and pH in-depth 6-7 m in Pantai Damas were 34 $^o/_{oo}$ and 8.41. Increasing CO_2 in the ocean followed by a series of chemical reactions in the sea and ended by increasing seawater pH. The global ocean pH showed the decrease of pH in sea surface is 0.1 unit and predicted by 2050 it will decrease 0.2-0.3 units (Gagliano *et al.*, 2010). Coral decreasing pH of seawater will elevate the bioerosion rate and decrease reef cementation rate (Barkley *et al.*, 2015). Nitrite and phosphate in Pantai Damas were the low concentration in the seawater, good flushed current by SJC may the key factors of this. High nutrient in the seawater or nutrient enrichment became a threat for coral health, for example, the research conducted in the laboratory showed increasing nitrate up to 3 μM leads black band disease on coral(Voss and Richardson, 2006).

Conditions of Artificial Reefs

Units of AR were separated from each other, AR number 15 is approximately 100 m away from number 15 (Figure 5). In this monitoring, the ARs were found only 22 units and 3 units were missing. 7 ARs were in good condition without any physical threats and the others had various disturbing conditions such as buried in sediment, covered by fishing net

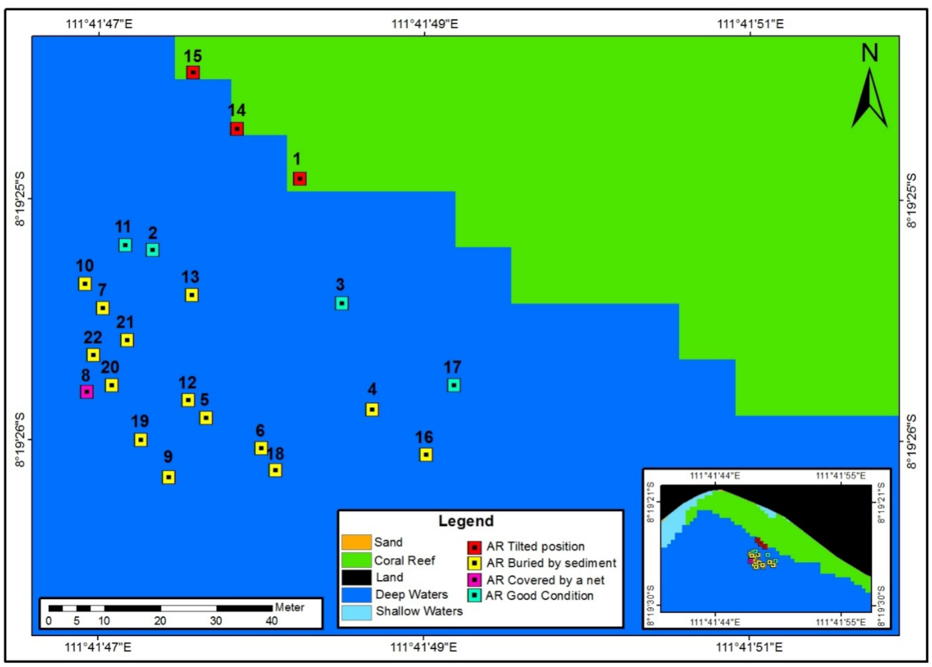

Fig. 5. Map Distribution of artificial reefs in the waters of Pantai Damas.

Table 1. Physical and chemical oceanography surround ARs

AR	d(m)	T(pC)	C(m/ s)	V(m)	S($^o/_{oo}$)	pH-	DO(mg/L)	N(mg/L)	P(mg/L)
North	6.2	25.96	0.2	3.9	34.67	8.34	6.65	0.04	0.055
East	7.0	25.84	0.1	2.8	34.68	8.41	6.67	0.03	0.052
South	7.0	25.60	0.1	3.2	34.68	8.26	6.68	0.05	0.054
West	7.5	25.70	0.2	3.4	34.68	8.37	6.66	0.04	0.054

Information: AR (Artificial Reef), d (Depth), T (Temperature), C (Current Speed), V (Water Clarity), S (Salinity), pH (pH), DO (DissolvedOxygen), N (Nitrate), P (phosphate).

ad tilted (Table 2; Figure 6). 14 of the 22 ARswere monitored sank on the sediment. Seabed of Pantai Damas influenced by terrestrial areas where load a lot of sediments during rainy seasons. The pre-deployment stage of AR is the important phase before deploying of ARs. Where and when ARs deploy should consider the objective of ARs build. For the attractant of coral biota, the ARs should be placed on low sediment regime area and stable substrate. Unstable substrate leads ARs tilted or change the main structure and threaten the strength of ARs(Abelson, 2006; Hartati *et al.*, 2017; Munasik *et al.*, 2020).

The density of Sessile Organisms

In the first 2nd years deployment of ARs in Pantai Damas about 16 varieties of sessile organisms attached on the surface of cube ARs, they were tubeworm, barnacle, coral shrimp, hermit crab, bryozoan, green algae, tunicate, anemone, coral, soft coral, hydroid, feather star, nudibranch brown algae, sponge and red algae (Figure 7). Barnacle, tunicate and sponge showed as a top rank of fouling organism recruited by the time in the artificial reef, they density were bigger than others (4.77, 0.65, and 0.61 individual/ m²) in contrary the coral recruits in the surface of ARs is very low 0.01 individual/ m² respectively. Sponges, tunicate and barnacle reported frequently occur in man-madesubmerged structures in seawater. They present can reduce the capability of coral larvae settlement in the surface of the substrate (Perkol-Finkel and Benayahu, 2005). High sedimentation rates can also affect the density

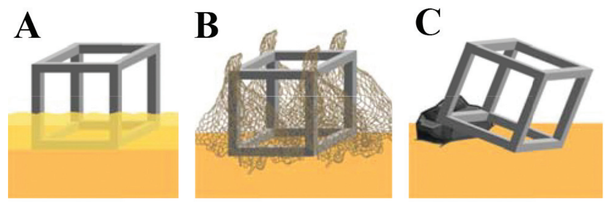

Fig. 6. Physical Condition of ARs; (A) Buried Sediment, (B) Covered Nets and (C) Tilted.

Table 2. Data Physical Condition of ARs.

AR	d(m)	Physical Conditions of Artificial Reefs					
		Buried Sediment (cm)	Category	Covered Net (%)	Category	Tilted Position (°)	Category
1	5.0	-	-	-	-	33	Bad
2	5.2	-	-	-	-	-	-
3	5.5	-	-	-	-	-	-
4	7.0	10	Minor	-	-	-	-
5	6.9	13	Medium	-	-	-	-
6	6.5	12	Medium	-	-	-	-
7	7.5	19	Medium	-	-	-	-
8	7.1	21	Bad	75%	Bad	-	-
9	8.6	13	Medium	-	-	-	-
10	8.1	20	Bad	-	-	-	-
11	7.3	-	-	-	-	-	-
12	7.6	15	Medium	-	-	-	-
13	7.3	10	Minor	-	-	-	-
14	6.5	-	-	-	-	10	Minor
15	6.5	-	-	-	-	5	Minor
16	7.2	11	Medium	-	-	-	-
17	6.9	-	-	-	-	-	-
18	7.7	14	Medium	-	-	-	-
19	8.9	12	Medium	-	-	-	-
20	7.9	10	Minor	-	-	-	-
21	7.7	10	Minor	-	-	-	-
22	6.6	10	Minor	-	-	-	-

Keterangan : Buried Sediment : Minor : 10cm; Medium : 15cm ; Bad 20 cm.
Coverd Net : Minor : 25%; Medium 50 %; Bad 75%.
Tilted Position : Minor : 10°; Medium 20°; Bad 30°.

of sessile organisms on artificial reefs. Artificial reefs with high sedimentation rates will allow inhibiting the success rate of coral recruitment (Nurman*et al.*, 2018). In the larva stage barnacle (Cirripedia) is a positive phototaxis that larvae will exhibit toward the light. Strong visible light 400-830 nm became trigger the abundance of barnacle settlement on the substrate, according to Yanagawa *et al.*, (2017) the light in a specific spectrum (409 to 412 nm) can suppress the settlement of barnacle.

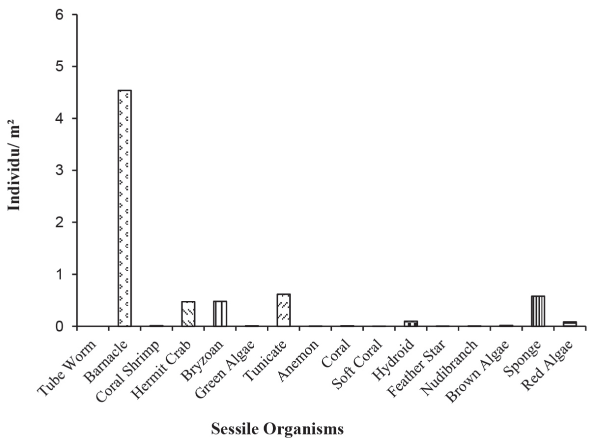

Fig. 7. Density of sessile organism.

The abundance of Reef Fish

A total 16 families of reef fishes were recorded in soround ARs of pantai Damas they were: Acanthuridae, Apogonidae, Blenniidae, Chaetodontidae, Diodontidae, Fistulariidae, Labridae, Nemipteridae, Ostraciidae, Pinguipedidae, Scorpaenidae, Solenostomidae, Tetradontidae, Tetrarogidae, Tripterygiidae and Pomacentridae (Figure 8).

The highest abundance of reef fishes obtained was the Apogonidae family with an amount of 0.41 ind / m². Fish species that are classified as major

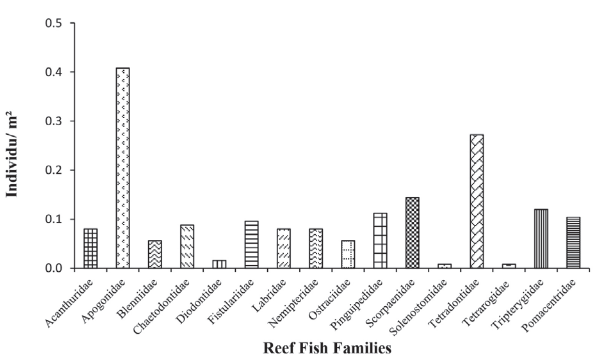

Fig. 8. The abundance of Reef Fish.

groups are generally found in large groups (schooling fish) such as the family Apogonidae, Pomacentridae, and Acanthuridae (Manembu *et al.*, 2015). Apogonidae and Pomacentridae are the families most commonly found in tropical waters, both in terms of the number of species and the number of individuals. The high abundance of this family is due to the characteristics in this family which has a grouplike nature so that each time it is found it is usually in large quantities (Utomo and Ain, 2013). The lowest abundance of reef fish obtained is the family Solenostomidae with the amount of 0.01 ind / m². The abundance of nekton organisms such as seahorses is influenced by the accessibility of fishing locations because seahorses are hunted to be used as traditional medicine and generally seahorses are found in small numbers and live solitary (Putri *et al.*, 2019).

Conclusion

The results of the physical conditions of the 22 AR include: 15 AR buried sediment, 1 AR covered net and 3 AR in a tilted position. The results density of the sesile organism is 6.94 ind/m² and the abundance of reef fish is 1.73 ind/ m². The overall physical condition of AR is in poor condition. If left unchecked for a long time the entire AR structure will be buried by sediment and cannot provide habitat for marine organisms.

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