Coral Recruitment, Survival and Growth of Coral Species at Pari Island, Thousand Islands, Jakarta: A Case Study of Coral Resilience

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Abstract

Research concerning survival and growth of coral recruits has been conducted in Pari Islands, Kepulauan Seribu, Jakarta, from March to November 2010, which purpose to determined the effect of biotic and abiotic factors on coral recruitment survival and growth. We observed two life forms of coral recruit, Massive and Branching within a transect area of 2 meter x 70 meter at 5-7 meter depth. Furthermore, for each life form, the coral recruit was grouped into 3 classes, Small (<3 cm), Medium (3-6 cm), and Large (> 6 cm and 10 cm ≤) and all colonies were marked by plastic tag. Coral recruits in this study site were diverse with species diversity reaching 14 genera from 9 families, consisting of 9 genera at ST1-Pari Site and 8 genera at ST2-Tikus Site which there were 2 genera founded at each site, Porites and Fungia, and genera of Faviidae were the most dominate. Diversity of coral recruits was moderate level with 1,85 diversity index at ST1-Pari Site and 1,59 at ST2-Tikus Site. The growth of coral recruitment was varied, according to the colony form and size class, which the highest growth of massive colonies to 4.4 mm / month in the small size and branching colonies to 9.2 mm / month in large size. The result of study show that survival of massive corals was higher than branching corals. Survival of medium size colonies was lower compared to the other size categories.

Keywords: coral recruitment, survive, species competition, coral reef, Pari Islands

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INTRODUCTION

Coral reefs ecosystem are highly dynamic, but more sensitive and very vulnerable to changing environmental conditions. Conditions of coral reefs is indicated by dynamic changes that occur in the corals community and the existence of strong interactions between the corals and others reef biota and also with abiotics conditions (Nybaken and Bertness, 2003). Changes in environmental conditions as a result of various human activities or by environment stressor have affected the damage to coral reefs on a wide scale. Naturally, the response of coral reefs to environmental change and the pressure are trying to resistance, adaptation or tolerant and showing signs of recovery and to the formation of a stable community (resilience) after they have been damaged (Obura and Grimsditch, 2009).

Indication of coral reefs recovery can be seen from the increase in cover of coral colonies (scleractinia) as the main component of building reefs. In nature, the early stages of recovery is marked by the emergence of young corals (juvenile) with relatively small size as a sign has been the addition of a new colonies on coral community (recruitment) (Harrison and Wallace, 1990). Coral recruitment with planktonic larvae are grouped in three main stages prior to the settlement of larvae (pre-settlement), settlement and metamorphosis of larvae (settlement and metamorphosis) recent developments and mortality after attachment (post-settlement and mortality) (Lamare and Barker, 2001). Many estimates of recovery based solely on the stage before and during the settlement of larvae and predict the colonies that appear after the settlement is a successful colony forming coral communities. In fact many studies show no like that, high coral recruitment rate when the attachment is not followed by an increase in live coral cover as an indication of recovery.

Group of Pari Island including one of all island in Kepulauan Seribu with the condition of coral reefs that tend to decline over time. Sukarno (2008) classifies coral reefs Pari Island group into zone III with the percentage of live coral cover of 40-60% at a depth of 1-3 meters. Furthermore Suharsono (1994) reported that the condition of coral reefs in Pari Island continued to decline with they were 30-50% live coral cover on reef slopes and 5-20% on reef flats. The results of TERANGI study (2007) also shown that condition continued to decline with they have been live cover only 29.13% to 38.13% in the southern island of Pari and 30.85% to 54.15% in the northeastern part. On the observation that recovery is signed by the emergence of new coral colonies (recruitment) results are quite high. The results of Rudi Study (2006) shows that the density of settlement of coral colonies on artificial substrates in Pari Island to reach 5-9 colonies /0.4 m² or about 12-22 colonies/m² with very high recruitment category (Engelhardt, 2000).

The research on the survival and growth after the attachment of coral recruitment was conducted in Pari Island on two different sites. In this study, observations were made of bio-ecological aspects of coral recruitment and its relation to biotic factors and abiotas (oceanographically chemical physics) in order to get the causes of success and failure of natural recruitment. The base data are expected to answer the following questions: Is the ability to survive of coral larvae after the attachment is depended on by internal conditions such as colony shape, size or more influenced by external factors such as abiotis factors by environmental conditions or interactions with biotic factors such as predators, competitors or disease infections. Based on the above formulation of the problem, this study aims to determine the ability of recruits live and graduation rates based on the shape and size of coral colonies and determine the impact of environmental and biological interactions to it.

METHODS

Periode and study site

Research carried out for nine months from March to November 2010. Allocation periode for nine months indicated that the representation of the season at Pari Island, they are the end of West Moonsoon (March), the transition from West Moonsoon to East
(June-September), and transition of East Moonson to West Moonson, (October - November), where each of season show oceanographically and the weather that typically. Monitoring of coral recruitment made at intervals of time every one month start on March to August (T0-T5) and the time interval of three months September to November (T5-T6). Research sites is reef of Pari Island, Thousand Islands, Jakarta. Observations in the field is spatially divided into two sites based on characteristics of the marine environment, and the condition of coral. Besides, the form of utilization and conservation status of territorial waters is also a consideration. Based on these criteria established two study site namely Pari-South (ST1-Pari) in position 05° 52' 212" latitude and 106° 36' 754" longitude and Tikus-North (ST2-Tikus) at position 05°51' 168" latitude and 106°34'795" longitude

**Sampling methods**

At study site were taken measurements survival and growth rate of coral recruitment at two massive and branching colonies, and also at three different size classes, they were small (<3 cm), medium (3-6 cm) and large (> 6 cm ≤ 10 cm) respectively they were number 5 colonies and marking by plastic tag. Recruitment of corals in the area selected on permanent belt transect 2 meters x 70 meters in size. First monitoring record (T0) was included the number of colonies, colony size and type of bottom substrate, and continued monitoring record in the second month as T1 covered the number of dead live colonies and size colony that still living (Obura and Grimsditch, 2009), and so on as T2, T3, T4, until T6. Identification was conducted directly in the field supported underwater photographs and sample collections for further identification and was done until genus level by reference to Veron (2000), and Suharsono (2008). At the same time water quality measurements were taken, covered salinity by refractometer, the acidity by pH universal, the surface current by conventional method, the surface temperature by thermometer, visibility by secchi disc, the levels of nutrients by DR/980 Colorimeter unit, and sedimentation by sediment traps. Data supporting a population of coral recruitment was conducted at both stations in the one depth 5-7 meters. Sampling method of observation was a method of benthic quadrate 1 x 1 meter with 6 replications and placement randomly along the permanent transect same depth using the method of Line Intercept Transect (LIT), whereas

![Fig. 1. Map of research location and sites, ST 1 Pari and ST 2-Tikus, Pari Island Kepulauan Seribu Jakarta](image)
groups of reef fish populations using belt transect method with under water visual census.

DATA ANALYSIS

Population structure analysis carried out on the recruitment of corals and other biota associations. Community structure is calculated after the identification and the number of colonies are known. Measurement of community structure include species richness, density, diversity index based on Shannon-Wiener and uniformity index (Krebs, 1989). The rate of the coral recruitment survive were analyzed based on the recruitment is still alive every month monitoring. Measurement survival rate of coral recruitment is calculated based on the number of colonies of coral recruitment was still alive minus the amount of time living at the beginning of the monitoring divided length of time of monitoring. To find out the differences and correlations of growth rate variation with time of observation performed statistical tests with a simple linear regression. Recruitment of corals that can survive analysis was performed by measuring the rate of growth that is broad accretion time (t) minus the initial observation area divided by the length of observation time. To further the relationship between time and rate of growth of each observation time were tested with simple linear regression. Water quality data in the form of physical and chemical factors measured are characteristic of sea water quality at the sites. Analysis of water quality characteristics at different stations and time done with descriptive statistics.

RESULTS AND DISCUSSION

Physical condition of aquatic chemistry

Physico-chemical condition of the waters at both stations showed a temporal variation during the study period. Overall indicates the normal range and support the development of coral recruitment. Sedimentation rate measurements tend to increase and peaked at T3 or when East Moonson was 9.7 mg/cm²/day at ST1-Pari Site and 10.19 mg/cm²/day in ST2-Tikus Site with a mean range from 5.07 to 6.09 mg/cm²/day, was predicted an impact on coral recruitment survive. It was also supported by the data current velocity and visibility that also tend to increased at T3 as an indication of excessive sedimentation. Pastorok and Bilyard (1985) mentions that the rate of sediment 1-10 mg/cm²/day effect on the decrease in abundance, suppressing the recruitment and decrease the number of types of coral populations. High sedimentation also detered sunlight penetration into the water column so that disrupt photosynthesis zooxanthella associated with corals (Richmond, 1993)

Population structure of coral recruitment

Population structure can be seen from the total number of taxa and the number of colonies on each research station. The total genus at the study site is 14 genera of 9 families with a number of genera at both stations are not too different from the 9 genera in the stations ST1-Tikus Site, and 8 genus at station ST2-Tikus Site. The genus of Faviidae was found which is 5 genera more than the others family. Recruitment of coral genus Porites and Fungia present at both stations, indicating the presence of a high frequency of this genus. Recruitment of massive coral colony form is more common than other shape of colonies (Muller-Parker and D’Ellia, 1997).

Total recruitment of coral colonies counted high density of 44 colonies with 7.3 colony/m². The number of colonies on the stations ST1-Pari Site was higher at 26 colonies with a density of 8.7 colony/m², compared to ST2-Tikus Site colonies with a density of 18 6 colony/m². Variations in the number of colonies on both stations for each genus ranged from 1-11 colonies, with highest by genus Porites. Genus diversity at stations ST1-Tikus Site was higher than the ST2-Tikus, but tend to be the same diversity index is respectively 1.85 and 1.60. It is understandable that at both sites did not show the existence of the genus to genus dominating the other. Distribution of colonies between different genera shown by the similarity index value 0.84 at ST1-Pari Site was higher than the ST2-Tikus Site was 0.77. Values above indicate that the genus diversity of coral recruitment at the study site was high and tend to be
Survival of coral recruitment

The survival rate of coral recruitment at ST1-Pari Site was showed that the massive colony tend to be higher than the branching colony for all size classes except large size. Colonies with small size in the shape of massive colonies have higher survivability than the other sizes of up to 80%, while the lowest was the large size is 40%. Unlike the branching colony of the highest survival was 40% respectively on small and large sizes, while the lowest was 20% in medium size (Fig. 2). At the station ST2-Tikus Site live with a graduation rate higher than the massive form of branching except at small sizes. In the shape of massive, coral recruitment with large sizes have the ability to survive higher, reaching 100% are small and medium size both 80%. In contrast in the form of branching ability betahan highest living at 80% each in sizes small medium and large sizes, while the lowest is 60% (Fig. 2).

Overall, the survival rate of coral recruits were shown to decline during the periods. It was decline began at the T2 or early East Moonson and continues T5-T6 or transition East Moonson to West Moonson Transition and early West Moonson, except at ST1-Pari Site began to decline during the end of West Moonson to East Moonson Transition. Survival rate decreased peaked at T3-T4 or the East Monsoon (Fig. 2). This indication shows that the seasonal changes have an impact on coral recruits survive. The season symptom showing changes of weather that could be impact to wind velocity and direction, volume of rain fall and also other physical conditions of the waters, like waves, currents and turbulence. When East Moonson in the waters of the Thousand Islands including Pari Island which low currents moving along the north coast of Java with consist high suspended solids (Ilahude, and Liasaputra, 1980). As a result of suspended solids in the water column thereby blocking the penetration of sunlight which affects to aquatic benthic biota including coral recruits. Besides the low currents will allow suspended solids down to the bottom as sediment or siltation which will cover the recruitment of corals and other benthic biota (Edmunds, 2008).

![Fig. 2. Survival rate of coral recruits on massive and branching colonies for nine month periods at Pari Island, Kepulauan Seribu Jakarta.](image)
The results of regression analysis showed that the stations ST1-Pari there was a significant connection between the survival of coral recruits due to periods to large and massive in size medium (P<0.05, where the large $r^2 = 0.8$ and $r^2$ medium = 0.78). While in the branching occurs in medium and small size (P<0.05, showed that only the survive of the medium size from both massive and branching colonies that impact to the change of periods, they were decreased (P <0.05, where the $r^2 = 0.77$ massive-medium and $r^2 = 0.84$ branching-medium). This condition indicated that the size of a medium was a vulnerable stage in the survival of coral recruits both massive and branching colonies. In a medium size is predicted to begin a change of orientation and dimensions of growth and energy needs for space in its development (Ritson-Wiliam et al. 2010).

**Growth rate of coral recruitment**

The results of measurements of the rate of growth in the ST1-rays show the differences between the shape of the colony and also inter-size class. In Fig. 4 can be seen that the growth rate of branching for each measure is higher than massive corals except for size medium. The highest rate of growth shown by the massive form of 4.4 mm / month in the small size, while in the form of branching reaches 9.2 mm / month in large size. Lowest growth rate was 2 mm / month in the form of branching, slightly higher than the massive form of 3.8 mm/ month. The trend shows massive growth in the form of higher in small size and decreased successively in medium and large sizes. Unlike the branching growth form showed a higher tendency in large measure followed by small and medium size is lowest.

The growth rate of coral recruits at ST2-Tikus Site was different inter-colony shape and inter-size classes. The Shape of branching coral recruits had a higher growth rate than the shape of massive and occurs in all size classes. Massive form of the highest growth rate achieved during the small size of 3.1 mm / month and branching occurs in the form of large size is 20.4 mm/ month. Conversely the lowest growth in massive colonies of large size is achieved at 2.4 mm / month while in branching colonies occurred on the small size of 9 mm/ month (Fig. 4). In large measure

![Fig. 3. The survival rate of coral recruits in both ST1-Pari Site and ST2-Tikus for nine months periods at Pari Island, Kepulauan Seribu, Jakarta](image)
radial growth through branching occurs rapidly thus increasing the rate of growth at this size. It is directed orientation is inversely proportional to the rate of growth between massive and branching colonies seen from the class size. Conditions such as these indicate the dimensions and different orientations between the massive growth and branching. In the massive dimensions and orientation of growth tends radial symmetric in each size class, whereas in the form of radial symmetrical branching is predicted to stop at a certain size, then grows upward to form branching (Richmond, 1997).

Growth rate of corals recruit measurements at both sites shown the same condition that differ according to class size and shape of colony. Another thing that shows the same trend was the growth rate of branching were higher than massive. Different growth patterns seen in the growth rate was relatively higher at ST2-Tikus site to branching that was up to 2.04 mm / month while in ST1-Pari Site 1.53 mm / month. In contrast to a massive growth rate was higher in ST1-Tikus Site was 4.4 mm / month compared to station ST2-Pari Site is 3.1 mm / month. These conditions are caused more by local conditions such as water quality, currents and sedimentation and also geographical conditions (Dunstan and Johnson, 1998).

Overall seen the growth rate of coral recruits variation with time at both stations (Fig. 4). Response of growth rate was also seen differently based on colony form and size class at each observation time. The results of the regression test showed that the only form branching colonies for all size classes show a real relationship with the observation time (P<0.05, where the large r’ = 0.77; r’ = 0.87 medium, and r’ = 0.89 small). This shows that oceanographically conditions caused by seasonal changes have a significant impact only on the growth of branching in the ST1-Pari that has been coming down except in large sizes. Decrease in the rate of growth began to look at T2 and T5 or continuing through at East Moonson. At the time of ST-1Pari Site, East Moonson was more affected than the ST2-Tikus with relatively low flow conditions and high sedimentation. The growth of the optimal recruitment of corals are determined by environmental conditions of low sedimentation among other things, the brightness of the waters and enough current (Birkeland, 1997).

**CONCLUSIONS**

Of research has been done obtained the following conclusions:

1. Survival rate of massive recruits were higher than the branching, but growth rate of branching recruits were faster than the massive.

Fig. 4. The growth rate of coral recruits in three size classes and two different of colony shape at Pari Island, Kepulauan Seribu, Jakarta.
2. Small and large class sizes have higher survival than the medium size.
3. The rate of sedimentation and nutrient levels affect aquatic life passing coral recruitment, whereas the biological interactions of predation, competition and disease had no impact.
4. Change of time (season) gives a marked influence on the survival of coral recruitment medium size at both massive and branching colony. From the research results can be put forward suggestions as follows:
1. Conduct advanced research to a wider scale (spatial and temporal)
2. Compare the size of the colony in an effort to transplant corals and restocking
3. Make a coral recruitment data after settlement to assess the pace of recovery and resilience of coral reefs after damage

REFERENCES