Survival and growth of transplanted coral reef in lagoon ecosystem of Ihamahu, Central Maluku, Indonesia

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Abstract. Lagoon ecosystem in Ihamahu has a high potential of biological resources which is utilized by the local community to catch fish in order to fulfill their daily needs. High level of utilization affects coral reef community in the lagoon. This study aims to analyze the survival and growth of life coral transplantation in the lagoon of Ihamahu village. Life corals were transplanted on an artificial substrate of block cement and placed into two lagoons namely Ayao lagoon (Acropora millepora, Porites nigrenscens, and P. cylindrical) and Besar lagoon (Acropora divaricata, A. cardus, Anaropora peurtogelerae, Montipora stelata, and Pavona cactus). The results showed that after three months, all transplanted coral reef in Ayao lagoon survived (100%) whilst only 57% of those in Besar lagoon survived. The results also showed that during the study period, P. nigrenscens grew faster (2.1 cm yr⁻¹) than two other species in Ayao lagoon whereas, in Besar lagoon, A. peurtogelerae showed faster growth (2.70 cm yr⁻¹) compare to the other four species.

1. Introduction

Ecology function of coral reef is life supporting for many marine biotas such as nursery ground, feeding ground, spawning ground, protection, and habitat [1, 2]. One of other function apart from mangrove and sea-grass ecosystem in global warming is carbon dioxide reduction [3, 4]. Coral reef also becomes an object for marine ecotourism [5].

Coastal and marine resources potency in coastal waters of Ihamahu Village has contributed economically towards the community of that village. This is due to some important ecosystems found in this area like mangrove, seagrass, coral reef and lagoon. Lagoon ecosystem in Ihamahu village belongs to a coastal lagoon, utilized by the community for their livelihood. Live percentage of coral reef distributes along Besar Lagoon is in poor and damage condition where the abiotic component percentage was 72.12% whilst live coral only 23.045 [6]. This is mainly due to environmental stressors come from a variety of human activity surrounding that area.

A study has shown that 36.90 ha of coral reef and lagoon ecosystem in Ihamahu Village are in damaged condition and that area has been plotted as a rehabilitation zone [7]. This is important since these ecosystems have produced many marine resources which are important to the local community. Based on that reason, this study was aimed to analyze growth rate and survival rate of coral transplanted alongside coastal lagoon ecosystem at Ihamahu waters.

2. Materials and Method

The research was conducted at two lagoons, namely Ayao and Besar Lagoon in the coastal waters of Ihamahu Villages, Central Maluku Regency (Figure 1) from March to June 2018. Data on growth rate and survival were obtained from coral transplanted according to [8, 9, 10, 11] were used to obtained
data of coral growth and examined the survival rate of transplanted coral species. A 30x20x10 cm³ concrete cement block was used as a media for transplantation.

![Figure 1. The map showing research station at coastal waters of Ihamahu Village](image)

Transplanted coral species was identified follows [12, 13, 14, 15]. The first and end (n-month) data of branch length of each transplant coral species were measured and transferred into data sheet. The growth of coral species were estimated by an equation as follow [16]:

\[
CG = \frac{(L_t - L_0)}{t}
\]

Where:

- \(CG\) = growth of coral
- \(L_t\) = mean length of coral branching at time \(t\) (end of observation)
- \(L_0\) = mean length of coral bracing at first observation

The survival rate of the transplanted coral species was calculated by an equation as follow [16]:

\[
\text{Survival Rate} = \frac{N_t}{N_0} \times 100\%
\]

Where:

- \(N_t\) = number of survive coral at time \(t\)
- \(N_0\) = total number of live coral transplanted at start

3. Results and Discussion

3.1. Growth of transplanted coral

This study shows that average coral length increment of transplanted coral at Ayao Lagoon varies between species (Table 1). Significant coral growth range was found at *Porites nigroenescens* and *Acropora millepora* compared to *P. cylindrica*. The average growth of *P. nigroenescens* and *A. millepora* was 0.18 and 0.15 cm month\(^{-1}\) or 2.1 and 1.80 cm yr\(^{-1}\) respectively, whilst for *P. cylindrica* was 1.20 cm yr\(^{-1}\).

Calcification rate which is related to coral growth varies between species. Branching coral species grow faster (2 cm yr\(^{-1}\)) than massive coral species which grow of < 1 cm yr\(^{-1}\) [1]. Study on the growth rate of the same species at Seribu Islands, Jakarta [17] shows the growth rate between 2.8 and 4.1 cm yr\(^{-1}\) for *Acropora* spp. and 2.3 to 2.5 cm yr\(^{-1}\) for *Porites* sp., whilst at Putri Menjangan, Bali, the
The growth rate of *A. formosa* was 2.41 cm yr\(^{-1}\) and *P. divaricata* was 1.36 yr\(^{-1}\) [18]. The study shows that coral growth varies between species and between sites. Many factors affecting the growth of coral such as sea surface temperature, salinity, sea level, ocean current, nutrient availability, sedimentation/turbidity and predation [19,20].

### Table 1. Range of coral growth increment at Ayao Lagoon

| Coral species          | Initial size (cm) | March | April | May | June | Growth rate yr\(^{-1}\) (cm) |
|------------------------|-------------------|-------|-------|-----|------|-----------------------------|
| *Porites cylindrica*   | 15.0              | 15.2  | 15.3  | 15.4| 1.2  |                             |
| *Porites nigrenscens*  | 15.0              | 15.3  | 15.5  | 15.7| 2.1  |                             |
| *Acropora millepora*   | 15.0              | 15.3  | 15.4  | 15.6| 1.8  |                             |

There were 5 species of coral used in transplantation study at Besar Lagoon namely *A. divaricata, Anaropora peurtogelerae, A. cardus, Montipora cardus, and Pavona cactus*. Table 2 shows growth increment of those 5 species during the study period. The highest growth rate was found at *A. divaricata* (2.70 cm yr\(^{-1}\)), whilst the lowest growth rate was found at *A. cardus* (1.20 cm yr\(^{-1}\)). This result also shows a variation in growth rate between the coral species and between sites (Ayao and Besar Lagoon). Variation in growth between species and sites was also shown by [17] at Harapan Island and Karya Island of Seribu Islands archipelago, Jakarta and in the coastal area of Putri Menjangan, Bali [18]. The study on *P. lutea*, a massive coral growth rate at Bontang of East Kalimantan shows no differences in growth at different size [19].

### Table 2. Range of coral growth increment at Besar lagoon

| Coral species           | Initial size (cm) | March | April | May | June | Growth rate yr\(^{-1}\) (cm) |
|-------------------------|-------------------|-------|-------|-----|------|-----------------------------|
| *Acropora divaricata*   | 15.0              | 15.2  | 15.4  | 15.5| 1.50 |                             |
| *Anaropora peurtogelerae* | 15.0             | 15.4  | 15.7  | 15.9| 2.70 |                             |
| *Acropora cardus*       | 14.0              | 14.1  | 14.3  | 14.4| 1.20 |                             |
| *Montipora stelata*     | 15.0              | 15.3  | 15.5  | 15.7| 2.10 |                             |
| *Pavona cactus*         | 10.0              | 10.2  | 10.4  | 10.7| 2.10 |                             |

### 3.2. Survival Rate

Transplantation of coral with concrete cement block quite seldom has low survival since the transplanted corals tend to more prone to environmental and anthropogenic stressors [22]. The survival of coral transplanted at Ayao Lagoon was considered very high since the survival rate was 100%. On the other hand, the survival rate of 5 Acropora species transplanted at 3 m depth of seawater at Kanawe Regency of Southern Sulawesi was 80% [23]. Another study in Coral Harbour of New Providence, Bahama showing a 91% survival rate of transplanted species of *P. astreoides, Orbicella* spp, and *Diploria labyrinthiformis* [24]. Accordingly, the survival rate of 3 species of coral transplanted at Ayao Lagoon was considered very high.

The survival rate of 5 coral species transplanted at Besar Lagoon was only 57% and was considered fair success compared to transplantation at Ayao Lagoon. Lows survival rate in Besar Lagoon could be due to fishing activity in this area which believed to be high.

The high survival rate of transplanted coral at Ayao Lagoon is supported by good water quality in this area. The sea water temperature in this area was 27\(^\circ\)C and was considered the best temperature for coral growth which is between 22-30\(^\circ\)C [22, 24]. Another factor which affects the survival rate of coral is salinity. The salinity in this study site was between 30.92-33.88‰, which in the range of best
salinity for coral growth i.e. between 30.00-35.00‰ [22, 24]. The collection of coral seed which is close to the transplantation site will lower the stress to the coral and can adapt to the new environment was also affecting the survival rate [25].

4. Conclusion
The growth rate of transplanted Porites nigrenscens was higher at Ayao Lagoon, whilst transplanted of Anaropora peurtogelerae was higher at Besar Lagoon. The survival rate of the transplanted coral reef was 100% at Ayao Lagoon whilst at Besar Lagoon was only amounted to 57%.

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