

Analysis of the Success Level of Transplant Coral Life in the Seventh Year at the Tawara Dive Point in the Bunaken National Park Area, North Sulawesi



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ABSTRACT: Coral transplantation is the grafting or cutting of live coral to be grafted elsewhere or in places where the coral has been damaged, with the aim of restoring or forming natural coral reefs. Coral transplantation plays a role in accelerating the regeneration of damaged coral reefs, and can also be used to build new coral reef areas that did not previously exist. While the objectives of the study are: To describe the initial conditions, artificial coral transplantation in Tawara, at the Bunaken National Park location; Analyze the number of transplanted corals that survived for 7 years; Analyze the condition of transplanted corals by measuring the length and number of coral branches that survived for 7 years. Transplantation was carried out in 2018, after a year of measuring coral growth, namely in 2019. Data from the results of the study from 77 transplanted coral fragments, there were 3 dead coral modules, and those that survived were 74 coral fragments or 96% success in survival, while those that died were 4%.

KEYWORDS: Transplantation, Coral, Seventh Year

INTRODUCTION

Coral reefs are ecosystems with the highest species diversity, even exceeding the productivity of existing land systems such as forests. The main component of coral reefs is coral (rock coral) which has the highest distribution of around 590 species from 793 types. There are around 1650 species of fish identified only in the Eastern Indonesian region that are associated with coral reef areas. The combination of mangrove ecosystems, seagrass beds and coral reefs supports thousands of types of organisms from various taxonomies living in association in this ecosystem. In Indonesia, the total area of coral reefs is estimated to be around 82,200 km² or around 18% of the total area of coral reefs in the world and 65% of the total area of the coral triangle, which includes Indonesia, the Philippines, Malaysia, East Timor, Papua New Guinea, and the Solomon Islands. The coral reefs in these 6 countries are called the coral triangle, because if a boundary line is drawn that encompasses the coral reef areas in these countries, the shape resembles a triangle with a total area of around 75,000 km². In Bunaken National Park itself, the total area is almost 90,000 hectares, coral reefs have a wide area of around 8,010.7 hectares (Mehta et al. 1999: Erdmann 2004). For the type based on research by Devantiar (2006) and Turak (2003), there are around 63 genera and around 400 types of stony coral (scleractinia) found in Bunaken National Park so that it supports around 1000 types of fish living in this coral reef ecosystem. The unique and artistic topography of the reef supports various associations of living biota and produces a marine park of very important value. Coral transplantation activities themselves have benefits for rehabilitating coral reefs to health conditions that have almost been completely damaged, this needs to be done considering the high tourist activity in Bunaken National Park, due to the presence of ships, diving and snorkeling carried out by tourists. When the rehabilitation process is not carried out, there will be a threat to the coral reef ecosystem itself which will affect the biota associated with it. Based on the background stated previously, the author identified the problem in general: The placement of transplanted corals had been carried out several years earlier and the type of coral transplanted was the acropora type, and in previous studies around 90% survived. Based on this, a study was conducted to determine the condition of the coral for 7 years since the placement of coral seedlings in 2018.

RESEARCH METHODOLOGY

This research was conducted in May 2024. The location is in the Bunaken National Park area, precisely in front of Bunaken Island. The observation point or location is located at 124 ° 45'35.9 "E and 1 ° 37'04.9" N, with the name "Tawara", which is a diving or

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snorkeling point for tourists visiting Bunaken. The following image is the observation location that was carried out with a number according to the observation location.



Figure 1. Map of the "Tawara" Research Location on Bunaken Island

Data Collection Technique

Data collection was carried out using diving equipment, by observing the living and dead coral transplantation modules. The initial transplantation consisted of 7 coral modules, each consisting of 11 coral fragments. The shape of the module is 4 rectangles with a size of 1 x 0.5 meters.

Data Analysis

Changes in coral size and growth rate were calculated using the following formula: $\beta = Lt - Lo$ Description:

β = Change in length/width of transplanted coral fragments (cm)

Lt = Average length/width of fragments at observation time t (cm) Lo = Average initial length/width of fragments (cm)

Meanwhile, the growth rate of transplanted coral is calculated using the following formula:

$$\alpha = \frac{L_{i+1} - L_i}{t_{i+1} - t_i}$$

Description: α = Rate of increase in length/width of transplanted coral fragments

L_{i+1} = Average length/width of fragments at time to-i+1

L_i = Average length/width of fragments at time to-i

t_{i+1} = Time to i+1

t_i = Time to i

The method for calculating the survival rate of transplanted coral uses the following formula (Ricker, 1975):

$$SR = \left(\frac{N_t}{N_0} \right) \times 100\% \text{ Description:}$$

SR = Survival rate

N_t = Number of individuals at the end of the study

N_0 = Number of individuals at the beginning of the study

The growth rate of *Acropora* coral is processed and analyzed and presented in the form of tables, graphs, and narrated according to the results of the analysis obtained. The data processing was done manually with the help of Microsoft Excel and SPSS software.

RESULTS AND DISCUSSION

In accordance with the objectives stated above, the following are the results of the research carried out. This coral transplantation was carried out in 2018, where the coral planting consisted of 7 modules, each module consisting of 11 coral fragments and the total initial planting amounted to 77 fragments of the *Acropora formosa* species. The following image shows when the coral seedlings were taken and when the coral was transplanted.

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Figure 2. Collecting coral seeds and when corals are transplanted.

In 2019, observations were made, the results of which will be displayed in the following table. Within a period of 6 years, research was again conducted to see the growth of the transplanted coral. The research location "Tawara" is located in Bunaken National Park which is one of the diving spots for tourists located at 1 ° 37'04.12 "N and 124 ° 45'35.12" E. Karauwan, M. A. J and Gumolili (2023), stated that the Tourism Suitability Index at this location for physical supporting factors of waters in the form of brightness, depth, current speed that supports in the category $2.0 \leq IKW < 2.5$ with an index value of 2.25 with a category suitable for diving tourism. The water depth is 7 meters with a basic substrate in the form of coral fragments. Brightness ranges from 3 - 10 meters. While the environmental parameters of the waters are as follows:

Table 1. Parameters of "Tawara" Waters

| Parameters | Nilai |
|-----------------------|---------------------|
| Salinity | 29.70 ‰ |
| Temperature | 29,5 ^o C |
| Turbidity | 5.35 |
| Dissolved Oxygen (DO) | 5.7 ppm |
| Nitrite | 0.04 ppm |
| Phosphate | 0.05 ppm |
| pH | 7.6 |

Coral Transplant Growth Results

In accordance with what has been stated previously, the initial transplantation was carried out in 2018, after a year of measuring coral growth, namely in 2019. The research data has been displayed in the following table. Of the 77 coral fragments that were transplanted, there were 3 coral modules that died, and those that survived were 74 coral fragments or 96% success in survival, while 4% died (Table 2)



Figure 3. Measurement of transplanted coral in 2019

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Table 2. Branch Length and Number of Branches of Transplanted Coral in 2019

| Module 1 | | Module 2 | | Module 3 | | Module 4 | | Module 5 | | Module 6 | | Module 7 | |
|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches | Branch Length (Cm) | Number of Branches |
| 20.9 | 19 | 24.8 | 7 | 27.9 | 13 | 21.9 | 10 | 25.8 | 18 | 29.9 | 23 | 26.8 | 8 |
| 30.3 | 16 | 19 | 5 | 23.9 | 11 | 25.8 | 13 | 8.9 | 2 | 26.8 | 10 | 29.9 | 13 |
| 26.8 | 41 | 22.8 | 6 | 26.8 | 8 | 27.9 | 12 | 19 | 7 | 21.9 | 8 | 27.8 | 15 |
| 28.7 | 18 | 13.9 | 2 | 20.9 | 18 | 27.8 | 16 | 26.8 | 16 | 21.8 | 12 | 10.9 | 10 |
| 21.4 | 12 | 20.9 | 8 | 26.7 | 43 | 21.9 | 8 | 19.9 | 15 | 28.9 | 9 | 23 | 25 |
| 22.1 | 25 | 5.9 | 2 | 23.9 | 16 | 24.7 | 20 | 23.8 | 13 | 23.7 | 15 | 25.7 | 9 |
| 19.8 | 28 | 30.7 | 12 | 12.9 | 2 | 31.8 | 13 | 19.9 | 16 | 11.9 | 15 | 22.9 | 19 |
| 26.3 | 24 | 13.9 | 1 | 24.8 | 5 | 18.9 | 6 | 25.8 | 40 | 22.9 | 10 | 31.9 | 14 |
| 26 | 18 | 27.6 | 8 | 20.9 | 42 | 20.9 | 3 | 9.9 | 10 | 13.8 | 15 | 12.9 | 5 |
| 21.5 | 32 | 14.9 | 16 | 18.9 | 5 | 22.8 | 13 | 17.9 | 18 | 0 | 0 | 16.8 | 12 |
| 18 | 8 | 19.9 | 22 | 29.8 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 25.9 | 5 |
| Total Tinggi dan Jumlah Cabang | | | | | | | | | | | | | |
| 261.8 | 241 | 214.3 | 89 | 257.4 | 178 | 244.4 | 114 | 197.7 | 155 | 201.6 | 117 | 254.5 | 135 |

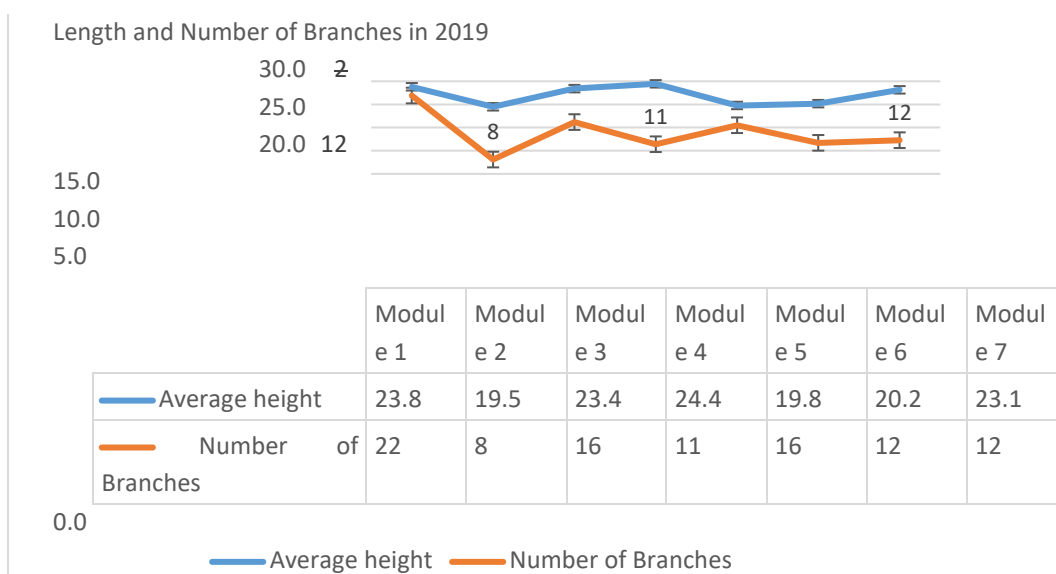


Figure 4. Graph of Length and Number of Branches in 2019

Based on the objectives to be achieved, using the method presented above, the research results for 2024 are as follows. The results of the study showed that the transplanted corals grew well, and the survival rate was 96%, which means it is still the same, for 6 years starting from data collection in 2019 and only 4% died. According to Haris et al., 2017, the concrete media has a success rate of between 91.7-100%. Meanwhile, the Acropora coral species can survive in turbid water conditions (Johan et al., 2008). The number of branches and branch lengths based on the table below have increased. From observations made, the growing corals have formed coral colonies, because the number and length of branches have increased, so some corals have broken. This needs to be followed up in moving the coral modules.

Table 3. Branch Length and Number of Transplanted Coral Branches in 2024

| Module 1 | | Module 2 | | Module 3 | | Module 4 | | Module 5 | | Module 6 | | Module 7 | |
|--|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|
| Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) | Panjang Cabang (cm) | Jumlah Cabang (cm) |
| 40.9 | 28 | 47.7 | 16 | 41.9 | 28 | 37.7 | 25 | 46.6 | 30 | 50.8 | 29 | 50.8 | 17 |
| 53.3 | 23 | 42.6 | 13 | 44.6 | 20 | 45.3 | 25 | 24.7 | 8 | 48.5 | 19 | 52.9 | 18 |
| 46.8 | 53 | 51.1 | 19 | 48.2 | 16 | 46.9 | 27 | 40.7 | 18 | 44.4 | 20 | 47.8 | 29 |
| 48.7 | 32 | 40.1 | 13 | 44.1 | 26 | 49.1 | 27 | 46.8 | 27 | 40.5 | 25 | 34.9 | 16 |
| 40.4 | 21 | 46.7 | 23 | 49.1 | 49 | 41.9 | 22 | 40.7 | 20 | 51.9 | 20 | 43.8 | 28 |
| 42.1 | 33 | 43.9 | 13 | 43.9 | 29 | 44.7 | 28 | 41.8 | 17 | 40.7 | 27 | 43.8 | 21 |
| 37.8 | 34 | 32.4 | 25 | 33.6 | 17 | 55.8 | 21 | 34.6 | 23 | 32.7 | 31 | 44.7 | 27 |
| 46.3 | 39 | 41.5 | 12 | 45.8 | 16 | 41 | 15 | 46.7 | 44 | 43.6 | 18 | 55.5 | 23 |
| 43 | 27 | 41.8 | 16 | 39.1 | 43 | 45 | 6 | 31.9 | 15 | 31.8 | 24 | 35.5 | 17 |
| 43.5 | 44 | 38.9 | 20 | 43.9 | 20 | 43.8 | 29 | 41.9 | 25 | 0 | 0 | 36.4 | 24 |
| 40.7 | 19 | 51.6 | 35 | 47.4 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 49.5 | 20 |
| Total Panjang dan Jumlah Cabang Karang | | | | | | | | | | | | | |
| 483.5 | 353 | 478.3 | 205 | 481.6 | 292 | 451.2 | 225 | 396.4 | 227 | 384.9 | 213 | 495.6 | 240 |

| Descriptive Statistics | | | | | | | | | | | | | |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|------------|-----------|------------|
| | Statistic | Statistic | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Statistic | Statistic | Std. Error | Statistic | Std. Error |
| Module Height 1 | 11 | 15.50 | 37.80 | 53.30 | 483.50 | 43.9545 | 1.34316 | 4.45474 | 19.845 | .844 | .661 | 506 | 1.279 |
| Module Height 2 | 11 | 19.20 | 32.40 | 51.60 | 478.30 | 43.4818 | 1.69233 | 5.61281 | 31.504 | -2.93 | .661 | 232 | 1.279 |
| Module Height 3 | 11 | 15.60 | 33.60 | 49.10 | 481.60 | 43.7818 | 1.33108 | 4.41471 | 19.490 | -1.239 | .661 | 1.919 | 1.279 |
| Module Height 4 | 11 | 55.80 | .00 | 55.80 | 451.20 | 41.0182 | 4.33608 | 14.38116 | 206.818 | -2.666 | .661 | 8.199 | 1.279 |
| Module Height 5 | 11 | 46.80 | .00 | 46.80 | 396.40 | 36.0364 | 4.15448 | 13.77884 | 189.857 | -2.060 | .661 | 4.710 | 1.279 |
| Module Height 6 | 11 | 51.90 | .00 | 51.90 | 384.90 | 34.9909 | 5.56620 | 18.46101 | 340.809 | -1.411 | .661 | 8.70 | 1.279 |
| Tinggi Modul 7 | 11 | 20.60 | 34.90 | 55.50 | 495.60 | 45.0545 | 2.13956 | 7.09611 | 50.355 | -2.23 | .661 | -1.144 | 1.279 |
| Valid N (listwise) | | | | | | | | | | | | | |

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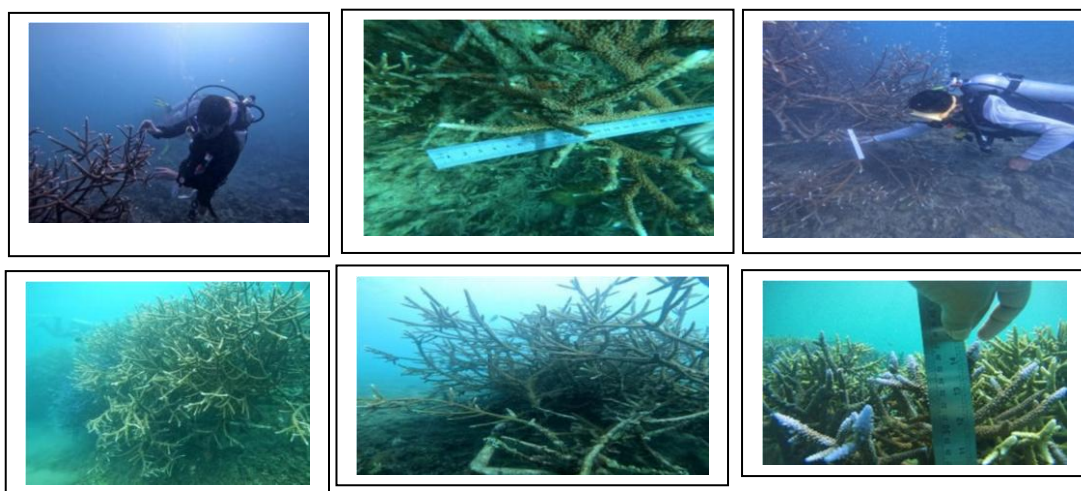


Figure 5. Measurement of Transplanted Coral in Tawara in 2024

Next, the average branch height and number of branches for each module are obtained as shown in the following table: Table 4. of Average Branch Height and Number of Branches of Transplanted Coral

| Module | Module 1 | Module 2 | Module 3 | Module 4 | Module 5 | Module 6 | Module 7 |
|---------------------|----------|----------|----------|----------|----------|----------|----------|
| Average Height (cm) | 44.0 | 43.5 | 43.8 | 45.1 | 39.6 | 42.8 | 45.1 |
| Number of Branches | 32 | 19 | 27 | 23 | 23 | 24 | 22 |

The table above shows that over seven years the average branch height was around 43 cm and the number of branches growing on each coral fragment was an average of 24 branches..

| Tests of Normality | | | | | | |
|--------------------|---------------------------------|----|-------------------|--------------|----|------|
| | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Panjang Cabang | .266 | 7 | .143 | .840 | 7 | .099 |
| Panjang Cabang | .233 | 7 | .200 [*] | .834 | 7 | .086 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Next, a normality test was carried out based on the Smirnov test, then the value obtained was a sig value of 0.0 (significant) > 0.099 and > 0.086, which means that the branch length is normally distributed, meaning that the coral grows normally with an average annual growth of 3 cm - 4 cm per year.

CONCLUSION AND SUGGESTIONS

Conclusion

Based on a series of observations and has produced data that has been discussed further, the author concludes as follows:

1. For 7 years, coral transplantation was carried out in "Tawara" Bunaken National Park, from 77 coral fragments in 7 Modules, 73 coral fragments survived, and only 4 coral fragments died, with a percentage of survival of 96%.
2. The average value of the increase in the height of the transplanted coral fragments was 43 cm, and the number of branches that increased on each coral fragment averaged 24 branches on each surviving coral fragment.

SUGGESTIONS

1. It is necessary to carry out periodic monitoring or monitoring of the coral module, with the intention that the condition of the transplanted coral needs to be cleaned of algae, so that the coral does not die
2. It needs to be moved from the module, because the module frame is only made of PVC pipe (plastic), this is because the load of the coral fragments will be greater.

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3. Further research needs to be done in controlling the level of life of the 76 surviving corals, and dead corals can be replaced with new coral fragments.

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