Assessing coral reefs condition for rehabilitation site selection using diver-towed survey in an island of Anambas Islands

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Abstract. To select a rehabilitation area of coral reefs in Pahat Island within Anambas Islands, this study was conducted to assess coral reefs condition using diver-towed or manta tow surveys and underwater photo transects (UPT). The results of the manta tow surveys showed coral cover dominated by hard corals percentage ranged between 11% and 50% (categories 2 and 3) in the western, northern and southern parts of Pahat Island. Distribution of hard coral percentage with more than 50% (Category 4: 51% - 75% and 5: 76% -100%) was observed in the eastern part of Pahat Island. While results from UPT showed the hard coral percentage of 62.5%, 33.67% and 17% in the eastern, western and northern of Pahat Island, respectively. There are similarities in the results of coral reef cover Obtained by the manta tow and UPT methods. Conclusions, this study recommends western Pahat Island as a good alternative for a rehabilitation site as the coral coverage was in poor condition.

1. Introduction

Indonesia has a distribution area with small islands with high seas biodiversity. One of those islands is Anambas islands, which is one area that has been determining nationally. Pahat Island, including into the National Water Conservation Areas in Anambas. Coral reefs are important ecosystem that has a lot of benefits (foods and services) for coastal communities[1][2][3]. Coral reefs importance as advocate and provider, including coastal fisheries as a provider of a wide range of farming land and sea [4] Coral reefs also be able to serve as a recreation area, good beach and underwater recreation[5][6].

One of the efforts to restore the ecosystem in Pahat Island is making conservation areas for turtle rehabilitation. The past fisheries activities in Anambas islands are not sustainable, therefore that was declined the number of coral reefs ecosystems[7][8], the information on distributions and covers of the coral reefs ecosystem is still lacking. Coral reefs have declined globally due to human activities and natural disturbances. Human impact contributes[9][10] in most of the reduction in developing countries, through factors such as sedimentation[11][12], nutrient enrichment [13] and loss of habitat by destructive fishing[14][15]. Climate change is accelerating the natural influences such as the prevalence of coral disease, coral bleaching events, and hurricanes often occur[16].

To determine the area of coral reef rehabilitation, zoning needs to be studied coral reefs in Pahat Island as information about the kinds of coral and rehabilitation methods to be used[17]. This study aims to provide information about the distribution of the base substrate and the cover percentage, calculate
the dominant species of coral growth, and determine the grouping of species of coral growth on Pahat Island.

2. Method
Data were collected using manta tow method [18] and the Underwater photo transects (UPT) method (UPT) [19]. The purpose of the manta tow method is to describe the distribution of percent cover of corals in the waters around the Pahat Island. Then proceed, using UPT in an area that has been determined from the results of the manta tow method, so it can see the kind of growth in the area of coral and manta tow method results. Analysis Manta crane, using the monitoring guidelines by[18]. Underwater modification method of photo transects (UPT) [19] using 50-meter transect lines. Underwater camera using the Canon G16 type and canon underwater housing (WP-DC52) is used in photographing the quadratic transects. by the method following processed using software CPCe [20].

1.1. Image processing and analysis of data
For the evaluation of benthic community composition and substrate composition, photographs were Analyzed using the software CPCe 4.1 [20]. A total of 50 random points were placed on each photograph, and each point is assigned to one category (in [19], To avoid point, we used stratified random as a method of deployment with 30 sample points.

1.2. Data analysis
Analysis of coral reef condition assessment using four categories According to [21]. To see a real difference in the distribution of coral healing group at every station, using the analysis of test results T [22]. Furthermore, to Determine the dominant coral species used analysis CA [23].

2. Results
2.1. The coral condition with manta tow method
The number of Manta Tow Obtained samples was 30 points, starting from the starting point (0) to returning to the starting point (29). Each category is given by citizens as follows: (1) Category 1 (0-10%) is colored red; (2) Category 2 (11-30%) is colored orange; (3) Category 3 (31-50%) is yellow (4) Category 4 (51-75%) is green; (5) Category 5 (76-100%) is colored blue.

Figure 1. Distribution of Manta Tow point.
Based on the data manta tow, the lowest percentage of live coral cover by category 1 (0-10%) are in the north (station 18, 19, 20), category 2 (11-30%) is dominant in the northeast part of the Pahat Island. Category 3 intermediate percentage of live coral cover (31-50%) color are 4, 14, 16 station. Category 4 (51-75%) are on stations 0.1 and 12 and the top 5 categories (76-100%) are at stations 2 and 3 on the show in Figure 1.

**Figure 2.** Distribution category of hard coral cover, soft coral, dead coral and sand/rubble in Manta Tow point.
Hard coral cover/life with the highest coral cover (category 5) there is at station 2, 3 and 5. The soft corals (SC) with the highest cover (category 4) are at stations 3, 4 and 7. The dead coral cover (DC / DCA) the highest (Category 4) are at station 9, 15, 17, 18, 19, 20, 26 and 30. While the cover percentage of sand/rubble highest (category 4) is at station 15.

2.2. The coral condition with Underwater Photo Transects (UPT) method

Results Manta Tow is known that the condition of coral reefs spread covers over 50% in the east and west of Pahat Island. UPT method performed at the east station East 1, east 2 and 3 representing the eastern part of the eastern and western station west 1, west 2, and 3 represent the western west. Figure 3, a map of election results that the composition station reef life above 50%.

On the eastern side of the island of Pahat, the coral station grows in groups with rock substrates or DC. Antibiotics are dominated by an average coverage of 26.47% Followed by the abiotic category dominated by Dead coral with algae (DCA) 20.29%. The DCA's highest coverage was recorded at the East 1 with 48.11 % coverage. This site is dominated by a massive, submassive, and soft corals. At this station, the currents and waves can be too strong for juvenile corals to attach to the substrate.

Based on the Data Unit, the live coral coverage ranged from 24.63 % to 76.73% (Figure 3). The average live coral cover at east Pahat Island was 51.88 ± 26.14 and west Pahat Island was 33.53% ± 3.01. The highest live coral cover was found at the east Pahat Island. Reviews these two sites had different substrates, Pahat east site is mostly dominated rock substrate meanwhile abiotic site sand on the west. For Rehabilitation Coral artificial reef area at stable substrates, a more significant chance to grow Compared to unstable substrates area. In the western of Pahat, a stable substrate is a sand.

![Figure 3](image-url)  
**Figure 3.** Percentage coverage of benthic categories by the method of UPT.
2.3. Frequency life form coral and distribution

Frequency of attendance growth of coral reef species (Table 1), in the eastern part of the Pahat Island dominated by massive corals that as many as 139 - 210. On the west found that type of table coral growth (tabulate) with a frequency value found as many as 190-311 (Table).

Table 1. Frequency presence kind of growth in the eastern part of the Pahat Island.

| Coral (Hc) East | Found frequency Hc / Life Form |
|----------------|-------------------------------|
|                | East 1 | East 2 | East 3 |
| Branching Acropora (ACB) | 46     | 50     | 23     |
| Digitate Acropora (ACD)    | 20     | 0      | 11     |
| Encrusting Acropora (ACE)  | 0      | 159    | 0      |
| Acropora Submassive (ACS)  | 0      | 0      | 0      |
| Acropora Tabulate (ACT)    | 0      | 18     | 7      |
| Branching Coral (CB)       | 11     | 364    | 18     |
| Coral Encrusting (CE)      | 41     | 178    | 40     |
| Coral Foliose (CF)         | 0      | 3      | 5      |
| Coral Heliopora (CHL)      | 0      | 0      | 0      |
| Massive Coral (CM)         | 210    | 139    | 210    |
| Coral Millepora (CME)      | 0      | 0      | 0      |
| Coral Mushroom (CMR)       | 1      | 4      | 3      |
| Coral submassive (CS)      | 37     | 149    | 497    |
| Coral Tubipora (CTU)       | 0      | 0      | 0      |
Table 2. Frequency presence kind of growth in the western part of the Pahat Island.

| CORAL (HC) Western                  | Found frequency HC / life form |
|-------------------------------------|-------------------------------|
|                                     | WEST 1 | WEST 2 | WEST 3 |
| Branching Acropora (ACB)            | 81     | 114    | 178    |
| Digitate Acropora (ACD)             | 12     | 1      | 22     |
| Encrusting Acropora (ACE)           | 1      | 0      | 0      |
| Acropora Submassive (ACS)           | 0      | 0      | 0      |
| Acropora Tabulate (ACT)             | 190    | 311    | 234    |
| Branching Coral (CB)                | 22     | 0      | 0      |
| Coral Encrusting (CE)               | 86     | 3      | 20     |
| Coral Foliose (CF)                  | 28     | 5      | 11     |
| Coral Heliopora (CHL)               | 0      | 0      | 0      |
| Massive Coral (CM)                  | 57     | 99     | 7      |
| Coral Millepora (CME)               | 0      | 0      | 0      |
| Coral Mushroom (CMR)                | 3      | 6      | 2      |
| Coral submassive (CS)               | 0      | 16     | 0      |
| Coral Tubipora (CTU)                | 0      | 0      | 0      |

The results of the T-test (Table 1) shows the t-stat (0.62) < T-tables (1.68), it can be concluded that between the West and the East station of Pahat Island Coral lifeform has different criteria.

Table 3. Results of T-tests Coral lifeform Stations between East and West on Pahat Island.

|                      | East station | West station |
|----------------------|--------------|--------------|
| mean                 | 3.117        | 2.096        |
| variance             | 23.937       | 19.0785      |
| Observations         | 16           | 16           |
| pooled Variance      | 21.51        |              |
| Hypothesized Mean Difference | 0          |              |
| df                   | 30           |              |
| t Stat               | 0.622        |              |
| P (T <= t) one-tail  | 0.269        |              |
| t Critical one-tail  | 1.697        |              |
| P (T <= t) two-tail  | 0.538        |              |
| t Critical two-tail  | 2.042        |              |
Figure 6. Results of the correspondence analysis test at any observation point lifeform reef on the Pahat Island.

Correspondence analysis test chart types of reef growth were found (Figure 1) shows the differences in the reef lifeform criteria were found between east station to station west of Pahat Island. At the East Pahat Island station, there were noticeable differences in the coral lifeform between the three stations. On the East 1 station is identified with lifeform Reef Coral Massive (CM), East 2 is identified with lifeform Reef Coral Branching (CB), Coral Encrusting (CE), and Acropora Encrusting (ACE), the last station of East 3 is identic with lifeform Coral Reef Submassive (CS). Focus on Pahat Island West station, visible tendency Coral lifeform same criteria at all three stations. Coral reef lifeform foliose (CF), Acropora Branching (ACB), and Acropora Tabulate is dominant lifeform found in the western station on Pahat Island. Type of lifeform coral is commonly used for rehabilitation because of its growth is faster, we found in the west of Pahat Island.

3. Discussion
In the eastern part of the open waters, the dominant form of coral growth is massive. It is a form of growth that can survive and survival rates are quite high at that location. Of the value of the percentage of coral growth form, then the form of massive coral growth in the eastern part of the Pahat Island found as much as 61%. Unlike in the western part of the Pahat Island, coral growth forms that are found are coral growth form table (tabulate) of 40-56%.

Table coral growth form is only found in the genus Acropora. But other forms of tabulate coral growth, branching coral growth form (branching) is also found in the western part of the Pahat Island. Learn percentage form coral growth in the eastern and western islands of Pahat. The composition of coral growth in different forms of Pahat islands between the east with the west. In the eastern part of the Pahat Island dominated by hard coral growth forms (massive), while in the western part of the Pahat Island dominated by coral growth form table (tabulate).

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Rehabilitation of coral reef waters are influenced by the environment[6][17]. Feasibility condition with crystal clear waters, currents quiet and sheltered location to reduce the risk of disruption of media transplant when the weather is bad. Then the recommended location for transplantation is the west side. The location is on the west sloped ramps, support is attached substrate for coral transplantation [17]. In the western part of the Pahat Island, have seedlings to transplant coral reefs as many donor areas, some coral growth forms such as branching, encrusting foliose and pretty much found.

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