Coral reef condition at north coastal of Haruku Island Maluku Tengah

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Abstract: This research was conducted in the waters on the north coastal of Haruku Island, in 2018, to analyze the condition of coral reefs in the area. The application of the manta-tow method was used as an initial survey of coral reef ecosystems at three research stations (Pelau, Waimital, and Hulaliu), and then the Point Intercept Transect (PIT) method approach was used to analyze the life form of benthic growth at each location at a depth of 3 and 10 meters. Analysis of the percentage of existing life forms was performed to determine the level of damage to coral reefs. The results showed that the percentage of hard coral cover at a depth of 3 meters for the three locations of Pelau, Waimital, and Hulaliu was 16.33%, 14.67%, and 65.3%, respectively. Meanwhile, the depth of 10 meters is 40.67%, 35%, and 66.67%. The condition of coral reefs at Pelau and Waimital stations at a depth of 3 meters is classified as poor, and at a depth of 10 meters is classified as moderate. Meanwhile, at Hulaliu Station, the condition of coral reefs at both depths was classified as good.

1. Introduction
Haruku, an island within the Lease Islands cluster, located on the east of Ambon Island. Haruku’s coastal area has common traits as the surrounding islands, with a coastal ecosystem consisting of mangroves, seagrass, and coral reefs. Other similar characteristics found for instance is the use of the high coastal area as a residential area and as a place for the local community’s livelihood.

The northern coast of Haruku is not directly impacted by the dynamics of the Banda Sea if compared to the southern area, seeing how it is dominated by sandy beaches whereas the southern area is dominated by rocky beaches or hard coral. Moreover, more residential areas are to be found in the north of Haruku in comparison to the south. The high utilization of coastal and marine areas by the community is inseparable from the good condition of the waters. It can be assumed that the coral reef ecosystem in this area is still high enough to support the productivity of capture fisheries.

However, the condition of coral reefs cannot be separated from human activities in the coastal and marine areas, due to its roles for humans, such as being a media of research as well as having social and economic benefits [1, 2]. In the utilization of coastal areas, the important role of coral reef ecosystems often also puts the same pressure on its existence. For example, sedimentation as a result of development on upper land, overfishing, and usage of unfriendly fishing gear [3]. Furthermore, it has been argued that the pressure on coral reef ecosystems could have an impact on reducing their sustainable potential and causing economic losses.

Several studies examining the condition of coral reef ecosystems or related to these ecosystems have been carried out in Indonesia [4, 5, 6, 7]. Similar research has also been carried out in several locations in Maluku such as Ambon Island [7, 8, 9, 10, 11, 12, 13], Pombo Island [14, 15], Haruku Island [16], Saparua Island [17], Pelita Jaya West Seram Regency [18], Lirang Island [19]. Meanwhile, information about the condition of coral reefs on Haruku Island has not been widely reported. Several studies related to Haruku Island emphasize its socio-economic conditions [20, 21].
The high level of utilization occurs in waters of Maluku, including Haruku. In the northern part of Haruku Island, the usage is multivarious, such as ports of numerous types of sea transportation, fisheries practicing, etc. By the increasing of coastal dynamics (both at the upper land and the coastal), it certainly triggers high impact to coastal ecosystems, including coral reefs ecosystem. Hence, this research was conducted to provide a basic data and information on coral reefs condition at coastal of northern of Haruku Island.

2. Materials and Methods

2.1 Study site

The research was conducted in 2018, using three research stations *i.e.* Pelau, Waimital, and Hulaliu, and each station was divided into three transects (Figure 1). The methods applied to determine the condition of the coral reef were the Manta Tow [22] dan Point Intercept Transect/PIT [23].

![Figure 1. Study site and stations](image)

**2.2 Sampling procedure**

The observation was carried out on the ledge and flat of coral reefs ecosystem at a depth of 3 meters and 10 meters, and data collection techniques were guided by the category and presentation of coral cover to determine the presentation of live coral, dead coral, soft corals, which refers to Dahl, 1981 *in English et al.*, 1997 [22]. Then, the life form of coral was analyzed and the presentation was determined based on the form [22]. Furthermore, the condition of the coral reefs was concluded based on the damage level of coral reefs referring to the criteria adjusted by the Minister of Environment Decree no. 04/MENLH/02/2001 [24].

The data were processed by using MS. Excel 2010. The coverage percentage was measured based on the formula proposed by English et al. (1997), as following:
Coverage Percentage (%) = \frac{L_i}{N} \times 100

where \( L_i \) is the length of life form (intercept) for the type \( i \) category, and \( N \) is the length of the transect line.

3. Result and Discussion

Based on analysis of the PIT data, five categories of benthic coverage were identified on all stations (Acropora-ACR, Non Acropora-NON ACR, Fauna Lain/Other Fauna-OT, Alga/Algae-ALG, dan Abiotik/Abiotic-ABI). The percentage values shown are varied, however, it is dominated by the Abiotic category at the Pelau and Waimital station at a depth of 3 meters or 10 meters, whereas at the Hulaliu station, Acropora is the most dominant category for both depths (Figure 2 and Figure 3). The graph showed that the Pelau and Waimital stations are held the same trend, and tend to be higher at the percentage value of Abiotic category, then following by Non-Acropora category, and more varied to the subsequent categories. The Algae category in Pelau station is high in percentage (3.3% and 9.0%). The percentage values of each category at all 3 stations at depths of 3 and 10 meters are depicted in Figure 2 and Figure 3.

Further analysis towards the major live form categories is presented in Figures 4 and 5. The graphs shows that not all of the live forms proposed by English, et al (1994) are found at three location at both depths. At a depth of 3 meters, for the ACR category, the live forms of coral at Pelau station are found to be Acropora Tabulate-ACR (4.0%) and Acropora Branching-ACB (3.0%), respectively, at the Waimital station they were ACT (6.0%) and ACB (2.6%), and at Hulaliu Station that shows the highest percentage values, namely ACT (24.0%) and ACB (17.0%). Whereas, at a depth of 10 meters, ACB dominates the three stations with a percentage value respectively (Hulaliu 11%, Waimital 6.3%; Pelau 4.6%). ACT is found only at Waimital (4.6%) and Hulaliu (3.2%) stations. For other sub-categories, neither Pelau nor Waimital stations shows zero finding, yet, Hulaliu station presents 0.2% respectively in the Acropora Encrusting-ACE and Acropora Submassive-ACS sub-categories.

Compared to the ACR category, at a depth of 3 meters the Hulaliu station shows lower percentage value in the NON-ACR category, however, it is more varied in numbers than the other two stations. Hulaliu Station has the highest percentage value for the NON-ACR sub-category in Coral Massive-CM whereas Pelau station is on Coral Branching-CB (both of them are 6.3%). Apart from CB, the high fractions at Hulaliu station are also found in the Coral Sub-Massive-CS and CB sub-categories (5.6% and 5.3%, respectively). The CB percentage value at Waimital station is lower compared to the other two stations, yet, is the highest in the NON-ACR category at that station. Meanwhile, at a depth of 10 meters, the live form and percentage are found to be more varied at the three stations. The highest percentages are found at Hulaliu for CM category (12%), Pelau for CB category (12%), Waimital for CB and CM categories (5.6%).

For the OT category, the Hulaliu station presents higher value compared to the other stations at a depth of 3 meters that being dominated by Soft Coral-SC (14%). The other two stations only show the SC percentage of 1.3%. At a depth of 10 meters, the fauna has been more varied. At Hulaliu stations, SC category is more dominant (11%), meanwhile station Waimital and Pelau are dominated by sponges (5.3% and 5.0%). However, at Hulaliu station, Hydroids-Hy (0.4%) and Xenia-XN (0.1%) are found.

As stated earlier, the percentage value for ALG category is found higher at Pelau station for both depths. At at depth of 3 meters, Turf Algae-TA has a higher percentage (2.6%), 1.6% at Waimital station, and 1.3% at Hulaliu station. In addition, Coralline Algae-CA is also found with lower percentage at the three stations. The ALG percentage is the smallest at the three stations for this depth. At a depth of 10 meters, the highest percentage of ALG is shown at Pelau station with the highest value at CA (5.3%). Waimital and Hulaliu stations also show higher CA numbers than other types of algae, however, they are smaller in value than those at Pelau stations. Halimeda-HA is not found at the three stations for either depth. Meanwhile, Macroalgae-MA is found at Hulaliu station for both depths, and Pelau station is merely at 10 meters.
Figure 2. Graph of percentage of benthic coverage at 3 meters

Figure 3. Graph of percentage of benthic coverage at 10 meters
The components of the Abiotic category are found at the three stations differed from Sand-S, Rubble-RB, Rock-RCK, and Dead Coral-DC, on the contrary, no Silt-SI and Bleached Coral-BC are present.
found. At a depth of 3 meters, the substrates at Pelau and Waimital stations are more dominated by RB and discovered in a high percentage (55% and 58%), yet, the value of the sub-category RB at Hulaliu station is very low (4.3%). The more dominant substrate at Hulaliu station is DC showing the percentage of 8.6%. At a depth of 10 meters, the trend is the same at Pelau and Waimital stations with lower percentage value compared to the previous depth (24% and 22%), conversely, presented 9.4% for the same sub-category at Hulaliu station. Hulaliu station is dominated more by RCK substrate (20%).

Based on the analysis of live forms on the ACR and NON-ACR categories, it is found that the highest percentage of hard coral coverage is at Hulaliu Station for both depths, namely 65.3% (3 meters depth) and 66.67% (10 meters depth). The percentage of hard coral cover at Pelau and Waimital stations is lower at a depth of 3 meters (16.33% and 14.67%) and still higher at 10 meters (40.67% and 35%) (Figure 6). By referring to the standard criteria of coral reef damage, these results indicate that at a depth of 3 meters the coral reefs are in the bad category, and are found to be good near the eastern part of the island (Hulaliu station). Meanwhile, at a depth of 10 meters, coral reefs are categorized as moderate, and are also found to be good near the eastern part of the island.

Coral growth is generally influenced by several factors, such as brightness, temperature, salinity, and water circulation, as well as sedimentation [3, 25]. However, by the increasing of local population, it will usually put pressure on the coastal environment, including the coral reef ecosystem. Dahuri (2003) explained that some of the most common examples in Indonesia are overfishing and the use of non environmentally friendly fishing gear. Both of these activities are able to increase the damage to coral

![Graph of Percentage of Hard Coral Coverage at all 3 Research Stations](image-url)
reefs [3]. The degradation of coral reef ecosystems due to human activities is also described in many parts of the world [26, 27, 28, 29]. It has been explained that various coastal pressures occur in the form of development in coastal areas, pollution and sedimentation, shipping port activities, and overfishing. Compared to Waimital and Hulaliu, the population in Pelau is higher, as well as the coastal activities, such as the presence of a port, high fishing activity, and large coastal areas directly utilized by the community.

The damage of coral reefs ecosystem due to coastal stresses is assumed to be more affecting than the damage caused by natural such as temperature changes and acidification, as the three stations are located at the same region, whereas, the result shown are relatively different. At Pelau and Waimital stations, this activity is quite high. In addition, it is also indicated that no bleach corals are transpired at the three stations. Coral bleaching is most susceptible to occur due to current climate dynamics such as global warming [28].

The low percentage of hard coral coverage at these two stations is thought to be a direct impact of high ship, boat, or speed boat activity in coastal areas. It is directly causing the damage of coral reefs, leading to the destruction of coral colonies and triggering the formation of coral rubble (including the Abiotic rubble component) as well as increasing the amount of sand as a result of coral fracture break or other factors such as the result of large waves (showed at higher percentages of rubble and sand at Pelau and Waimital station than to Hulaliu station). The destroyed corals caused by shipping activity are potent to increase water turbidity that implies to reduce the light intensity to the water.

Sukmara, et al. (2001) explained that the destruction or breakage of corals due to boat activities has an impact on decreasing the percentage of coral cover, as well as the colony abundance and diameter, and increasing the percentage of dead coral and the Abiotic rubble component[30]. According to Limmon and Marasabessy (2019), the reduction of light penetration restricts the vertical distribution of corals, in addition to reducing coral recruitment and resulting in lower coral coverage [13]. Veron (1995) and Birell, et al. (2005) explicated that clarity of water is required in corals life and growth related to the photosynthetic process by Zooxanthellae, the symbiont algae that live in mutualism symbiotic with coral animals [31, 32]. The reduction of light penetration is resulted by current movement carrying sand components in the water column. The higher percentage of sand at Pelau and Waimital station creates the possibility in reducing the light penetration.

Another factor that affects the damage of coral reefs at Pelau and Waimital stations is presumed in connection with indirect impacts due to overfishing and non eco-friendly fishing activities. Overfishing activity in coral reef ecosystems results in the rapid growth of algae which causes a negative impact on coral life. The decreasing of herbivorous fish on coral reefs that are the target of catching instigates low grazing activity. McCook (1999) and Littler and Littler (2013) described that the growth of macro algae is influenced by the feeding activity of herbivores [33, 34]. Low activity triggers a macro algae explosion that is able to cover up the coral animals and prevents the photosynthesis by Zooxanthellae.

In addition, the higher percentage of algae at Pelau station is inferred to be originated from the nutrient input from land, which explodes the fleshy algae. This assumption is supported by the fact that Pelau has greater population than others, as well as the coastal areas utilization. Furthermore, there are rivers that supply the nutrient from the upper land to the sea. As mentioned, the excess nutrients in coral reefs ecosystem initiates the macro algae explosion [33, 34, 35]. Although Koop, et al. (2001) proposed that high levels of nutrients in the form of nitrates and phosphates increases coral survival and growth in relation to the utilization by the Zooxanthellae [36], however, the presence of macro algae raises the probability in nutrient competition between them [37]. Besides the competition of food, the organisms are competing in space and dissolved oxygen as well, along with the fast growth of macro algae that raises the coverage of young coral polyps and inhibits their growth. Nusaputro, et al. (2019) suggested that algae are competitors of hard corals particularly from the Turf Algae (TA) group that competed spatially (the percentage of this group is higher at Pelau and Waimital stations). In addition, there are groups of algae that are able to release certain chemicals and produce lethal impact to corals and certain species afford to transmit harmful microbes to corals. The low percentages of hard coral coverage at Pelau and Waimital station are clarified by this complex condition [19].
Meanwhile, the coral reef ecosystem at Hulaliu Station is still classified as good indicated by the low percentage of rubble components and associations among other fauna that utilize the ecosystem (Figure 3). The percentage can imply the low level of shipping activity, yet, the eco-friendlier fishing practices are existed. In addition, Hulaliu station that located on a strait allow better current flow to spread out the sand components and lowering the turbidity. Indrabudi and Alik (2017), for example, explained that the growth of branching corals in Outer Ambon Bay is better than in Inner Ambon Bay, allegedly due to current factors [12]. Also, the association with other fauna signifies that the coral reef ecosystem in Hulaliu constantly supports the life of the organisms in this ecosystem. The percentage of algae components found at this location is lower than at Pelau station. The dominant algae at Hulaliu station is Coralline Algae (CA), that is relatively important for coral animals. Kuffner, et al. (2008) elucidated that the role of CA is as a medium for benthos to attach carbonate fragments to reefs, as well as stimulates the attachment of larvae or juvenile corals to the substrate through the chemicals it produces [38]. In addition, CA serves as one of the main producers of carbonate in sediments.

Some of the factors mentioned above are able to explain the difference of the percentage between the two depths (3 meters and 10 meters), as the graph of the percentage cover of benthic categories shows the same trend. However, the Non Acropora category at Pelau and Waimital stations at a depth of 10 meters shows higher percentage compared to those at a depth of 3 meters. It can be assumed that substrate supporting coral growth is more accessible than at a depth of 3 meters. To grow, corals require more stable substrate. The station provides the higher percentage of rocky substrate cover and lower of coral fracture substrate. Although the texture of rubble is classified as hard, yet, in the context of the substrate, rubble is not sufficiently stabled and still be influenced by the dynamics in water column, such as being carried away by currents or breaking into smaller fraction such as coarse sand.

The growth and distribution of corals are influenced by light intesity. The clarity at the depth of 10 meters is great and suitable for the process of symbiont algae, whereas, the high clarity at the depth of 3 meters impacted the corals in different way. Siebeck (1981) explained that excess light can essentially block the photosynthesis of algal symbionts and influence the calcification process [39]. Goreau (1959) emphasized that the suitable (sufficient) light can enhance the calcification process in corals [40]. It explains the percentage of hard coral cover at a depth of 10 meters is higher than at a depth of 3 meters. The graph of Pelau and Waimital stations depicts the same trend, and it can be presumed that the characteristics of the community in relation to socio-cultural and economic aspects from both locations are comparable due to the Waimital is administratively being a part of Pelau rural community. It can suggest the related utilization pattern of the coastal in the communities.

4. Conclusion
The percentage of hard coral coverage is found to be greater at a depth of 10 meters than at a depth of 3 meters. The condition of coral reefs in the northern coastal waters of Haruku Island is classified as bad to good. The further to the east of the island, the condition of the coral reefs is located to be better with a percentage of hard coral coverage is more than 50%.

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