Eco. Env. & Cons. 28 (February Suppl. Issue) : 2022; pp. (S85-S92)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i02s.014

Visualization of Coral Reef Cover with Photogrammetry Method at Coastal Waters of Lemon Island, Manokwari, Indonesia

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(Received 17 July, 2021; Accepted 9 August, 2021)

ABSTRACT

Lemon Island waters are an island that has a diversity of coral reef ecosystems. The coastal areas of Lemon Island have different coral reef structures, so it is necessary to conduct research using underwater photogrammetry to visualize the condition of coral reefs. Photogrammetry is a process of obtaining information about an object through measurements made from photographs. The use of underwater photogrammetry in visualizing coral reefs can also be used to extract coral conditions such as size, condition, and percentage of coral colony cover. This study aims to determine the shape and condition of the visual life form of coral reefs in the waters of Lemon Island. The method used in this research is the photogrammetric method which is then analyzed using CPCe, using the number of random points used to analyze 30 photos for each frame. Based on the results obtained, it can be seen 6 forms of coral growth found in the waters of Lemon Island, namely, Acropora Branching, Acropora Submassive, Coral Branching, Coral Massive, Coral Submassive and Coral Mushroom. The total percentage of coral reef cover is 45.84%, so it is categorized in moderate condition.

Key words : *Lemon Island, Photogrammetry, Visualization of the bottom of the water, Percentage of cover, Lifeform, CPCe.*

Introduction

Indonesia is one of the countries located below the equator that has abundant wealth and diversity of marine biological and non-biological resources. Three areas of coastal ecosystems that have great natural potential are mangrove, seagrass and coral reef ecosystems (KKP, 2014). Coral reef ecosystem is one of the marine ecosystems that has a variety of associated biota and high primary productivity. Coral reefs have several functions such as high physical, ecological and economic functions. Physically, coral reefs act as beach protectors from waves and abrasion (LIPI, 2017). Ecologically, coral reefs are also a place to find food (feeding ground), a place for care and grow up (nursery ground), as well as a spawning ground (spawning ground) for various other marine biotas (Asyawati and Akliyah 2014). Economically, coral reefs are a habitat for various types of marine biota, ornamental fish, construction materials, jewelry, pharmaceutical raw materials that have high economic value (Romadhon, 2014). In addition, coral reef ecosystems can be used as marine tourism objects that are very attractive to tourists. However, currently the condition of the coral reef ecosystem is being damaged.

Several anthropogenic factors that cause changes in the structure of coral reefs are reclamation, run off, factory waste, aquaculture, minimal awareness of coral reefs, the use of fishing gear that is not environmentally friendly and the development of beaches (Johan, 2003). In addition, natural factors also contribute greatly to changes in the structure of coral reefs, such as global climate change. According to Syahailatua (2008) the impact of global climate change such as rising sea surface temperatures can cause coral bleaching which can lead to death. Climate change with a continuous increase in temperature will result in rising sea levels which will directly reduce the area of coastal areas. Therefore, it is necessary to use a method that can determine changes in coral cover area properly and correctly. Photogrammetry is a process of obtaining information about an object through measurements made from photographs both from the air and from the ground (Purwanto, 2014). Besides being able to be used in the air and ground, photogrammetry can also be used underwater. Underwater photogrammetry has been widely used as a tool for exploration and mapping of the underwater environment. Its flexibility, low cost, and the availability of easily available processing tools such as underwater cameras and computers with high specifications have made it popular among scientists and practitioners in several fields, including archeology (Nocherino *et al.*, 2019) and marine ecology (Figueira *et al*., 2015; Peck *et al*., 2021). The use of underwater photogrammetry in visualizing coral reefs can also be used to extract general coral health indices such as size, condition, and percentage of coral colony cover (Gintert *et al*., 2012, Peck *et al.*, 2021; Urbina-Barreto *et al*., 2021). This makes this photogrammetry suitable for measuring coral reef conditions applied on Lemon Island.

Lemon Island is an island located in Manokwari City, West Papua Province. Access to Lemon Island can be reached by using sea transportation for ± 15 minutes from Manokwari City (Dasmasela *et al*., 2019). The coastal areas of Lemon Island have different coral reef structures, so it is necessary to conduct research using underwater photogrammetry to visualize the condition of coral reefs. This research was conducted for (1). Knowing the visual form of coral reefs in the waters of Lemon Island based on the results of photogrammetry; (2). Knowing the condition of coral reef cover which is known from the process of photogrammetric techniques in the waters of Lemon Island; and (3). Knowing the condition of aquatic environmental factors on Lemon Island. The results obtained from this study are the availability of databases and information about the condition of coral reef ecosystems in the waters of Lemon Island.

Materials and Methods

Location and time of research

This research was conducted in May 2020, for one month. The location of data collection is in the waters of Lemon Island, Manokwari Regency (Figure 1).

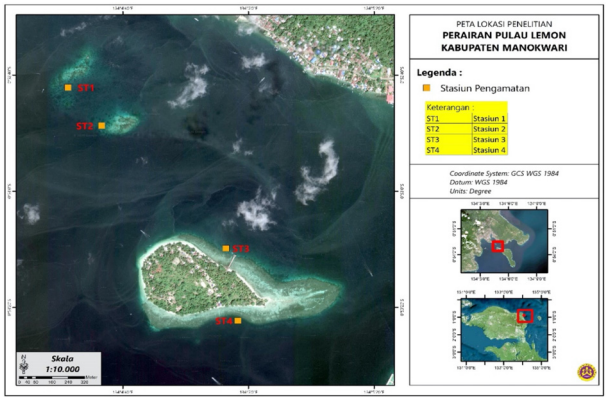

Fig. 1. Map of Research Location

Data Collection Procedures

Determination of the research location was carried out using a purposive random sampling method selected through a snorkeling tracking process, in which the researcher made a brief observation of the condition of coral reefs parallel to the coastline with visibility and sunny weather (Ubaidillah, 2008). The determination of observation stations and sampling points were chosen based on the representative aspects of the abundance of coral reefs in these waters. The data taken were four stations with a depth of 5-10 meters according to the conditions and shape of the waters.

Coral reef data collection uses the LIT method combined with Underwater Photogrammetry (Urbina-Barreto *et al.*, 2021). The data taken later will be in the form of videos which are processed using agisoftphotoscan software into visuals in image format and then analyzed using CPCe software. The steps for collecting coral data are as follows. Two divers make an underwater transect. A line transect

of 20 meters is required and the distance between one plot and the next plot is 10 meters to assess the coral reef status of the specified sentinel coral reef habitat (Quod *et al.*, 2016). Set a plot measuring 2x2 meters above the area of interest (Figure 2). One station requires only one transect. Furthermore, the diver who is in charge of making the transect line starts diving and looks for the starting point of the transect which is marked by the presence of four iron stakes and a buoy tied around the plot as a marker. Then the data was collected by recording underwater with a consistent swimming speed. The diver swims with a camera and moves in a double lawn mower pattern with a height of 0.5-1 meters above the bottom of the water (Gintert *et al.*, 2012) (Figure 2b).

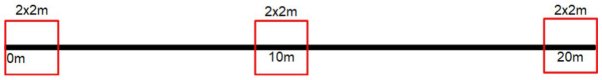

Fig. 2a. Transect illustration for Photogrametry (Quod *et al.*, 2016)

Fig. 2b. Image taking position (Teague and Scott 2017)

Identification of Coral Growth Forms

Identification of coral growth forms will be carried out using the guidebook for coral species in Indonesia based on Suharsono (2008). From the results of the analysis, the condition of the reef or the level of damage to coral reefs was determined based on the categories/criteria proposed by Gomez and Yap (1988) in Manuputty and Djuwariah (2009) (Table 1).

Table 1. Coral Cover Assessment Categories

Life Coral Cover (%)	Criteria
0-24,9	Poor/Very damaged
25-49,9	Moderate
50-74,9	Good
75-100	Very good

To determine the oceanographic conditions of the waters around the Lemon Island data collection, several parameters were measured directly in the field, namely temperature, salinity brightness, pH, DO. Each parameter is measured at each data collection location using different tools according to the parameters to be measured (Nurul, 2017).

Data analysis

Images for each quadrant were compiled using AgisoftPhotoscan, which aims to combine one photo with another (Figure 2a). According to AWN Archeologie (2018) the steps taken are as follows: (a). Align Photos. From the photo data, the software first calculates the properties of the lens used and then the location from which the photo was taken. From this location, each feature point is calculated to the XYZ coordinates for alignment. (b). Build Dense Cloud. Through this step, knowing the original camera position as well as lens calibration data, the software can calculate exactly which photos are overlapping. In general this is the most time consuming part of image processing. (c). Build Mesh. To model a structure, a cladding is needed. Cladding is a process of overwriting an image on top of another image to provide a skin or layer, (d). Build Textures. In this step the software checks each surface image from which the photo is coming from and copies part of that photo on the open or blank image surface. The end result of this process is an image of the bottom of the water that looks realistic. These textures are saved in separate files and are known as texture maps or texture atlases, and (e). Export. After all stages are completed, the model is saved and exported in jpg format. There are several file types available, depending on the export destination.

Analysis using CPCe

CPCe (Coral Point Count with Excel extension) 4.1 application is a computer application that can be used to calculate the area of the base substrate from an observed photo using an underwater digital camera. Besides being able to be used to calculate the percentage of base substrate cover with the point count method, it can also be used by calculating the area of each type of base substrate that we will analyze.

CPCe has limitations to limit the Area of Interest (AoI) of a photo that we analyze. Therefore, before being analyzed, a photo must be cropped so that only the photo of the base substrate is visible and does not include the frame transect. For example, a frame transect measuring 100x100 cm will be cropped to obtain photos that are ready for analysis.

The underwater video recorded at every 10 meter interval of the transect line is then analyzed to obtain quantitative data such as the percentage of cover for each biota or substrate.

This technique is used by using the number of random points used to analyze the photo. The number of random points used is 30 for each frame, and this is representative for estimating the percentage of category and substrate cover (Giyanto *et al.*, 2010). This technique is an application of sampling, where the population is all the biota and substrates contained in the photo frame, while the samples are randomly selected points on the photo. In this way, only biota and substrate are recorded at the point positions that have been randomly determined by the CPCe software. Based on the photo analysis process carried out for each photo frame, it can be obtained that the percentage value of category cover for each frame is calculated based on the following formula:

$$Coral\ coverage\ (\%) = \frac{Number\ of\ dots\ in\ the\ category}{Total\ number\ of\ random\ dots}\ x\ 100\%$$

Results

General Condition of Research Location

Geographically, Lemon Island is located at the position of 134º04'775''E and 00º53'343''S and is included in the waters of Doreri Bay. The land area of Lemon Island is about 16.3ha with a coastline of around 1693.39 m. Almost all of the residents who live on this island make their main livelihood as traditional fishermen with very diverse patterns of utilization of coastal resources by people who catch fish using traditional fishing gear in the form of fishing rods and nets (Larsen *et al.*, 2018). In addition, previously the community used fishing gear and materials that damaged coral reef and seagrass ecosystems and other biota, such as using bombs, potassium, and nets stuck in corals. In addition, improper anchor placement can cause coral fractures. Fishing activities are usually carried out around coral reefs, seagrass, and waters around the island which have an impact on the condition of coral reefs as fish habitats and fishing locations, especially in coral reef areas. The catch of the community is often sold to the Sanggeng Fish Market in Manokwari and some of it is also consumed by the family. In addition to fishermen, there are also those who work in sea transportation services using traditional boats to take/pick up passengers from Manokwari City to Mansinam Island or Lemon or vice versa (Siburian *et al.*, 2021).

Photogrammetry Results and Coral Reef Growth Forms in Lemon Island Waters. The results of photogrammetry and the shape of coral reef growth in Lemon Island waters were listed in Figures 3 and 4.

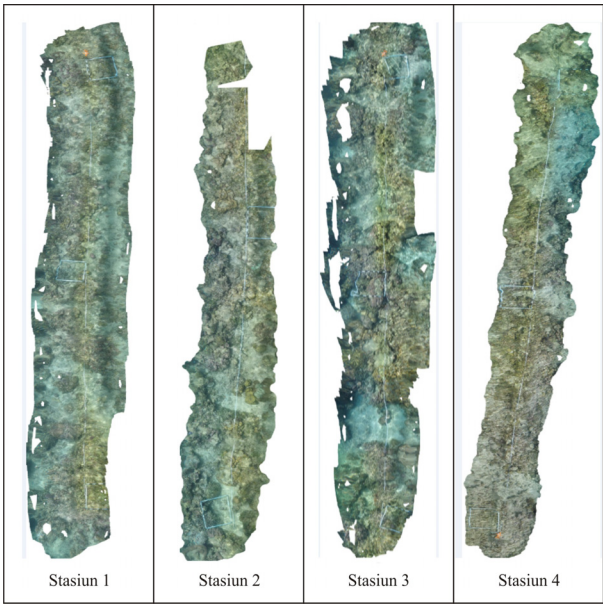

Fig. 3. The results photogrammetry process at each research station.

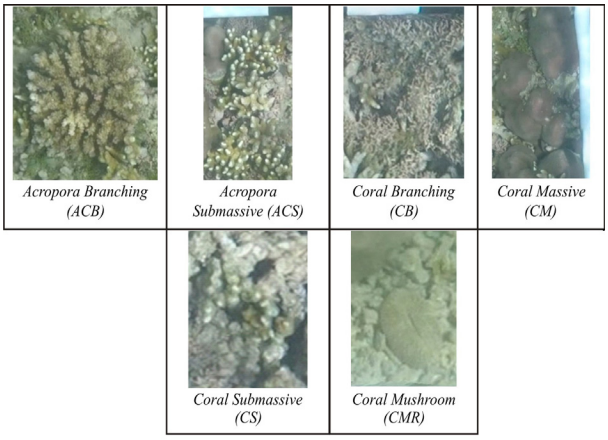

Fig. 4. Growth forms found in the waters of Lemon Island

The waters of Lemon Island have various forms of coral reef growth. The growth forms found were *Acropora Branching* (ACB), *Acropora Submassive* (ACS), *Coral Branching* (CB), Coral Massive (CM), Coral Submassive (CS) and *Coral Mushroom* (CMR).

Five types of growth formswere identified at station I:*Acropora Branching* (ACB), *Acropora Submassive* (ACS), *Coral Branching* (CB), *Coral Massive* (CM), *Coral Submassive* (CS) and *Coral Mushroom* (CMR). Station II had three types: *Acropora Submassive* (ACS), *Coral Branching* (CB), and *Coral Massive* (CM). Station III and station IV had the same growth form:*Acropora Submassive* (ACS) and *Coral Massive* (CM).

Coral Cover Condition

Based on observations at station I at a depth of 3m, it was found that the non-acropora Coral Massive (CM) life coral category cover 22.78%, Coral Branching (CB) 3.89%, Coral Submassive (CS) 1.67%, Coral Mushroom (CMR) 0.56%. There were also Acropora coral categories: Acropora Submassive (ACS) 17.22% and Acropora Branching (ACB) 2.22%. The total percentage of live coral cover found at station I was 48.3% in the medium category. At this station, Rubble (R) was found of 23.33%, while Dead Coral (DC) was 12.78%.

The percentage of live coral cover at station II was 60.01% at a depth of 5mdominated by non-acropora corals in the category of Coral Massive (CM) 41.57% and Coral Branching (CB) 4.44% followed by the category of Acropora Submassive (ACS) 14%. Category Dead Coral (DC) 9.00% and Rubble (R) 7.24%. The total percentage of live coral cover found at station II was 60.01% with good category.

The lowest percentage of live coral cover was at Station III placed at a depth of 7m with total health coral only 27.78% and was categorized poor (very damaged). The station was dominated by the Rubble (R) of 30.00% and followed by Dead Coral (DC) 18.89%.

Station IV was placed at a depth of 7m and the percentage of coral cover is the Coral Massive (CM) category is 30% and remaining by others to make a total 47.22% which was categorized in medium level. At this station Rubble (R) which was found at 23.33% and dead coral 10.00%.

The proportion of coral lifeform cover in all research stations was listed in Table 2. While the results of the measurement of the environmental parameters of the waters of Lemon Island were listed in Table 3.

Table 2. The percentage of Coral Cover in each station

No	Categories	Coral cover (%)			
		Station I	Station II	Station III	Station IV
1	Health Coral (HC)	48.33	60.01	27.78	47.22
2	Recent Dead Coral (DC)	12.78	9.00	18.89	10
3	Dead Coral With Algae (DCA)	2.22	1.13	3.33	1.67
4	Soft Coral (SC)	0	0.56	0	0
5	Sponge (SP)	0	0	0	0
6	Fleshy Seaweed (FS)	0	0	0	0
7	Other Biota (OT)	0.56	9.10	5.56	3.89
8	Rubble (R)	23.33	7.24	30.00	23.33
9	Sand (S)	5.56	2.24	9.44	4.44
10	Silt (SI)	0	8.41	1.67	7.78
11	Rock (RK)	7.22	2.30	3.33	1.67
12	Tape, Wand, Shadow (TWS)	0	0.56	0	0

Table 3. Physical and Chemical ParametersatMansinam Island Waters

No	Parameters	Station			
		I	II	III	IV
1	Temperature (°C)	30.2	30.6	29.6	29.5
2	Salinity (‰)	37	37	34	35
3	Current (m/s)	0.2	0.1	0.2	0.2
4	Depth (m)	3	5	7	7
5	Clarity (%)	100	100	100	100
6	pH	6.87	6.88	6.9	6.84
7	DO (mg/l)	7.24	7.07	7.21	7.13

Discussion

The low coral cover, which was dominated by the high proportion of the rubble category, was due to the fact that station III was located at the Pier, where boat and boat activities often took place at this location. Besides, it is suspected that there are often destructive human activities such as being stepped on when looking for marine life at low tide. According to Nugraha *et al*. (2016) and Tapilatu *et al.,* (2017), the effect of this activity is that the anchor of the boat or ship is lowered to hold it always moving due to waves and currents so that the anchor is directly attracted and sweeps the coral around it. This assumption can be followed by the number of small and very scattered coral fractures. The total percentage of live coral cover found at station III was 27.78% with poor category.

The highest percentage of live coral cover was at Station II (60.02%) with good category and the lowest was at Station III (27.78%) with poor category. Although it is still in the same water area as station III, coral cover at station II is still relatively moderate because at this location human activities are thought to be lower and located behind the island. The high cover of coral reefs at this station is possible because the station is far from the shoreline so that it is far from population activities. Panggabean (2008) and Tuhumena *et al.* (2019) state that coral reef ecosystems that live far from the reach of population activities will have high cover.

The total percentage of coral reef cover at all stations was 45.84%, based on the category of assessment of the condition of the coral reef ecosystem by Gomez and Yap (1988) *in* Manuputty and Djuwariah (2009), the coral reefs in the waters of Lemon Island can be said to be in moderate condition. The percentage of cover of abiotic components, namely sand, rubble and dead coral, ranged from 18.49-58.33%. The highest closure was found at Station III and the lowest was at Station II. The high abiotic component is due to the condition of the research location which is close to residential areas, so it is easily influenced by community activities. Among them are fishing rods who throw anchors in coral reef areas so that they break corals. Table 3 shows that at all stations the light intensity value is the same at 100%, this is because the waters of Lemon Island are still very clear to a depth of 10m. The level of clarity of the island's waters depends on weather conditions. at the time of data collection, the weather was very sunny.

The results of measuring pH parameters in the waters of Lemon Island showed results that were not much different. The value of the degree of acidity measured at the four stations ranged from 6.84-6.9. This value can still be said to be lacking for coral growth, because it is not included in the range set by the Ministry of Environment, which is 7-8.5 (Ministry of Environment Decree No. 51 of 2004). According to Kusumaningtyas *et al.* (2014), the pH is increasing towards the high seas. This causes the pH at stations I and II, which are far from residential areas, to be of high value when viewed from their location. While at stations III and IV, it is classified as high, possibly due to the large amount of waste originating from households and fossil fuels into the waters which can affect the pH value in it (Safitri and Putri, 2013).

The salinity value in the waters of Lemon Island ranges between 34-37‰ with an average of 35.75‰. It can be seen that the salinity conditions of stations I and II are slightly higher than stations III and IV, this is thought to be influenced by the weather conditions of the waters which at that time were hot so that evaporation occurred and also because this location was directly opposite the open sea and was not affected by river flow. (freshwater). While at stations III and IV, the lowest salinity value is 34‰. This is because station III is closer to the mainland so there is fresh water input. According to Supriharyono (2007), the salinity of seawater in the tropics is on average 35 and coral reefs thrive in the salinity range of 34-37‰. Thus, it can be concluded that the salinity range at each observation station is categorized as good and suitable for coral growth.

Table 3 shows that stations I and II have the highest temperature range, which is in the range of 30.2-30.6°C, this happens because the location is in the middle of the sea, so there is no vegetation that is able to absorb sunlight that directly enters the water body. While stations III and IV have the lowest temperature range of 29.5°C, where this area has a variety of vegetation that is able to absorb direct sunlight, however, the temperature range in the waters of Lemon Island is still in the normal range. According to KEPMEN LH (2004), the quality standard for good temperature conditions for coral reef life is in the range of 28–30°C.

The measured dissolved oxygen value ranged from 7.07-7.24 mg/l where the highest DO value was shown at station I and the lowest was at station

II. Dissolved oxygen levels at sea level normally range from 5.7-8.5 mg/l (Edwar and Tarigan, 2003). Thus, DO in the waters of Lemon Island is still in normal conditions, both for coral growth and aquatic biota.Current conditions in the waters of Lemon Island are in the range of 0.1-0.2 m/second with an average current of 0.175 m/second. This means that the water conditions of Mansinam Island are relatively stable. The direction of current velocity is very important to know the process of moving and stirring in water such as micronutrients and suspended material. Currents are also very important to clean coral bodies from adhering sediments. Sediment attached to coral will inhibit the process of photosynthesis.

The results of depth measurements as presented in Table 3 show that stations II, III and IV have a depth range of 5-7m, while at station I the mean depth was 3m. The influence of light is very closely related to coral growth, so the depth factor also limits the life of coral reefs (Supriharyono, 2007). The clear waters allow the penetration of light to the deeper layers so that coral colonies wouldstay alive in deeper waters.

Conclusion

Based on the results obtained, it can be concluded that:

1. There are 6 forms of coral growth found in the waters of Lemon Island, Acropora Branching, Acropora Submassive, Coral Branching, Coral Massive, Coral Submassive and Coral Mushroom. At station I there are Acropora Branching (ACB), Acropora Submassive (ACS), Coral Branching (CB), Coral Massive (CM), Coral Submassive (CS) and Coral Mushroom (CMR). Station II found 3 types of Acropora Submassive (ACS), Coral Branching (CB), Coral Massive (CM). Station III and station IV found the same growth form, namely Acropora Submassive (ACS), Coral Massive (CM).
2. Live coral cover in the waters of Lemon Island at Station I was 48.33%, Station II was 60.02% and Station III was 27.78% and Station IV was 47.22%. The highest live coral cover occurred at Station II and the lowest was at Station III. The total percentage of coral reef cover is 45.84%, so it is categorized in moderate condition.
3. Based on the results of measurements of the physico-chemical parameters of water obtained in the waters of Lemon Island, the average temperature is 29.5-30.6°C, salinity is 34-37‰, current velocity is 0.1-0.2m/s, dissolved oxygen is 7.07-7.24mg/l, pH 6.84-6.9. At a depth of 3-7m, the clarity was 100%.

In addition, visualization research using photogrammetric methods needs to be further developed to observe the shape of the structure, measure the area and identify coral species in more detail.

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