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Study of Coral Reefs in the Tourism Zone of Hoga Island, Wakatobi National Park, Southeast Sulawesi, Indonesia

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Abstract

One of the ecosystems in tropical waters is the coral reef. Coral reefs serve multiple functions, both ecologically and economically. The marine waters in Wakatobi Regency boast diverse coral reefs, and this study aims to assess the coral reefs in one of its regions, specifically in the waters around Hoga Island, part of Wakatobi National Park. The research was conducted from March to May 2023, involving direct observations at the research site. The collected data were then analyzed and presented descriptively concerning the percentage of coral reefs in the study area. The percentage of coral cover in the growth forms (lifeform) of the Wakatobi National Park tourism zone, region II, revealed that, at the first station, coral cover was 46.33%, dominated by Coral Branching (CB) at 22.36%, and Biotic, primarily Soft Coral (SC), at 14.95%. At the second station, coral cover was 36.13%, with Coral Branching (CB) accounting for 11.53%, and Soft Coral (SC) at 25.33%. The third station exhibited a coral cover percentage of 60.37%.

Introduction

The coral reefs in Indonesia cover an area of 39,583 km2, approximately 45.7% of the total area of 86,503 km2 at the summit of the reef with a total of 590 hard coral species and 2,200 coral fish species (Giyanto et al., 2014). According to Zurba & Trimble, 2014) one of the ecosystems in tropical waters is the coral reef. The presence of coral reefs plays a crucial role in shoreline protection against erosion caused by currents, winds, and waves. Economically, coral reef ecosystems have high potential and economic productivity, as coral reefs are areas of exceptionally beautiful underwater scenery and hold significant potential for the development of marine tourism (Hargreaves-Allen, 2010).

Asserts that coral reef ecosystems are a wealth of marine resources with several crucial roles in supporting the life of various aquatic organisms (Sutono, 2016; Woodhead et al., 2019; Yee et al., 2015). Consistent with this narrative, these roles include serving as habitats, feeding grounds, shelters, and breeding sites for a significant portion of marine biota (Suryono et al., 2018). According to Giyanto et al. (2014), monitoring the condition of coral reefs is defined as the activity of collecting bio-ecological data on groups of organisms used as indicators of coral reef health. Continuous monitoring of coral reef conditions is carried out to provide an up-to-date overview of the coral reef status in Indonesia (White et al., 2014; Yasir et al., 2017).

Wakatobi is the name of an archipelago and regency in the province of Southeast Sulawesi, Republic of Indonesia. Wakatobi is also the name of the Wakatobi National Marine Park, covering an area of 1,390,000 hectares, consisting of 97% marine and 3% terrestrial

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ecosystems, situated in the heart of the world's coral triangle (La Didi et al., 2018). It was designated as a National Marine Park through the Minister of Forestry of the Republic of Indonesia Decree No.7661/Kpts-II/2002 (2013). In terms of marine biodiversity, the waters of Wakatobi showcase a rich diversity of coral reefs and marine life, particularly having the highest diversity of fish species in the world (Supriyatna, 2008). Effective coral reef monitoring processes contribute to the formulation of appropriate coral conservation regulations, and these regulations, in turn, support sound coral reef management. The overall process can restore the natural state of coral reefs, benefiting fisheries, marine tourism, and coastal ecosystem recovery. Referring to the aforementioned points, this research aims to examine the coral reefs in one of the locations in the Wakatobi Regency, specifically in the coastal area of Hoga Island.

Methods

Time and Location

This research was conducted from March to May 2023 in the waters of Wakatobi National Park, Hoga Island, Southeast Sulawesi Province (Figure 1).

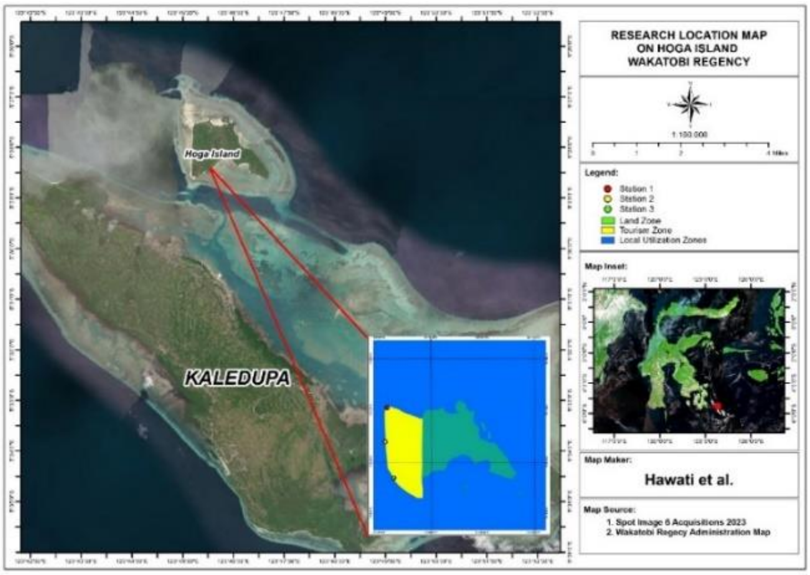

Figure 1. Map of the Research Location

Tools and Materials

The tools and materials utilized for the data collection on the coral reef conditions were presented in Table 1 below.

Table 1. Tools and Materials

Number	Items	Purpose
1	SCUBA set	Tools for data collection
2	Motorboat	Transportation equipment
3	Underwater camera	Capturing images
4	Frame (square transect)	Area demarcation
5	Roll meter	Transect line drawer
6	GPS	Coordinate point retrieval
7	External hard drive	Photo storage
8	Computer/laptop	Data/image processing
9	CPCe program	Data processing

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Data Collection Method

Before conducting data collection, several preparations had to be made, including determining the location and preparing the equipment to be used. In the first point, several considerations were taken into account in determining the location, namely the factors of representativeness (location synchronization) and transect safety. For the first factor, the placement of transect stations was chosen to be representative, with at least 3 transects representing one village, depending on the size of the village. Furthermore, for transect safety, signs installed on the chosen transect line were protected from wave/flow disturbances, so that the signs placed at permanent transect stations could be easily found in the same position during monitoring in the following year. In addition to the two previous factors, there was also the last factor, which was safety and comfort during data collection. In the second point, the preparation of equipment for coral data collection included scuba equipment, underwater cameras, frames, roll meters, motorboats, and all equipment that supported the smooth collection of coral reef data.

Technical Data Collection

The data collected consisted of primary data, encompassing observations of coral reef conditions through the implementation of the Underwater Photo Transect (UPT) method. This involved underwater photography using a digital underwater camera. Field data collection was carried out using SCUBA diving equipment. The procedural steps for data collection using the Underwater Photo Transect (UPT) method were as follows: utilizing GPS to identify the area and determine coordinate points; recording coordinate points for new observation locations, and ensuring that coordinates matched the previously recorded ones for existing locations. The diver responsible for deploying the transect would locate the starting point marked by stakes or buoys. The diver then began pulling the measuring tape for a distance of 50 meters parallel to the coastline, with the island located to the left of the diver (Figure 2).

Figure 2. (a) Transect Deployment (b) Transect Direction

Subsequently, the assigned diver for photography located the starting point of the transect. Underwater data collection involved capturing images of the area around the transect to obtain a general overview of the seabed and substrate. Photography commenced from the first meter with one-meter intervals along the transect line. The photography was conducted perpendicular to the substrate at a distance of 60 cm, resulting in a photographing area of 2,552 cm^2 when using a 58 x 44 cm^2 frame as an aid (Figure 3).

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Figure 3. Frame Placement

Data collection was performed by photographing according to the frame size. Zoom photography was employed for organisms that were deemed challenging to recognize or identify during the subsequent data identification process. Additionally, photographing within the frame boundaries was conducted from the 1st meter on the left side of the transect line, followed by capturing images at the 2nd meter on the right side. Photography continued in this alternating manner until reaching the 50th meter.

Figure 4. Illustration of the UPT Method

Source: Suharsono, 2014

Data Analysis

The application of CPCe Version 4.1 (Coral Point Count with Excel Extension) is a computer program used to calculate the area of the seafloor substrate from underwater digital camera observation photos. This program not only computes the percentage of seafloor substrate coverage using the point count method but also determines the area of each type of substrate for further analysis (Giyanto et al., 2014).

Subsequently, the analysis based on the photographed images was conducted using a computer and the CPCe software (Kohler & Gill, 2006; Tabugo, 2016). Thirty random point samples were selected for each photo frame, and each point was coded according to the respective category, biota, and substrate code present at that random point. The percentage coverage of each biota and substrate category for each photo frame was then calculated using the formula:

$$Percentage\ of\ category\ cover = \frac{The\ number\ of\ point\ per\ category}{The\ quantity\ of\ points\ per\ category} x\ 100$$

The coral reef condition, based on the percentage of live coral cover, is categorized according to the Minister of Environment Decree No. 4 of 2001 into four categories as follows (Darwish

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et al., 2011): (a) Excellent: 75%-100%; (b) Good: 50%-74.9%; (c) Moderate: 25%-49.9%; and (d) Poor: 0%-24.9%.

Results and Discussion

Conducting monitoring or research on the percentage of coral reef cover is carried out using the Underwater Photo Transect (UPT) method. The use of this method involves detailed-scale monitoring to assess coral reef cover by considering various components. This method allows for the collection of both abiotic and biotic components present in the coral reef ecosystem. The advantage of this method is that the monitoring process does not require a lengthy data collection time compared to the Point Intercept Transect (PIT) and Line Intercept Transect (LIT) methods, as it leverages technological advancements using cameras and software.

Regarding data in the form of images, it can be stored as an archive so that it can be accessed again when needed.

Coral Reef Cover Percentages Per Station

The processed coral cover percentages using the CPCE software per station can be observed in the following diagram (Figure 5).

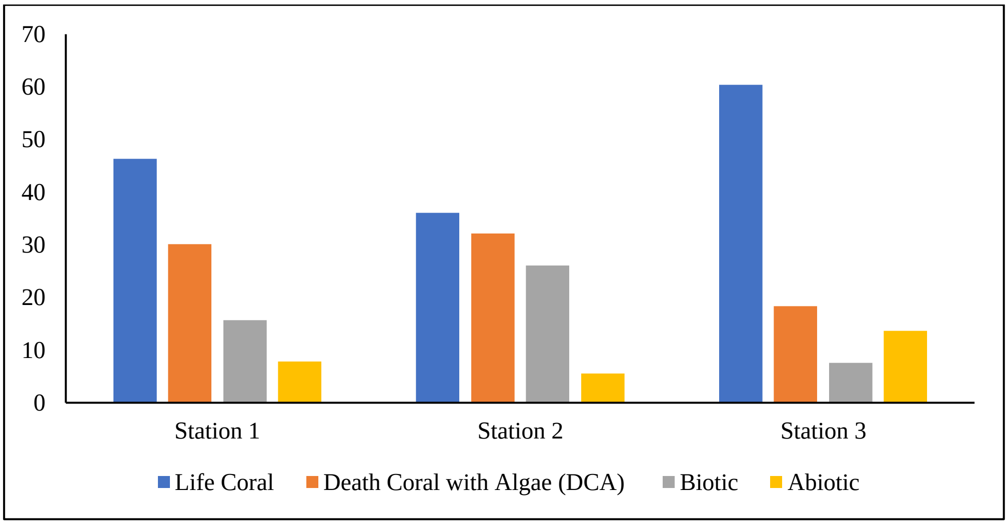

Figure 5. Coral Growth Category Diagram

The graph in the above figure indicates that at station 1, the percentage of live coral cover is the highest at 46.33%, dominated by Coral Branching (CB) at 22.36%, and the lowest form of live coral growth is Coral Encrusting (CE) at 0.07%. Dead coral cover is 30.11%, mainly dominated by Dead Coral With Algae (DCA), biotic cover is 15.68%, dominated by soft coral (SC) at 14.95%, and abiotic cover is 7.88%, mainly dominated by Sand (S).

At the second station, the percentage of live coral cover obtained is 36.13%, dominated by Coral Branching (CB) at 11.53%, with the lowest percentage found in Acropora Branching (ACB) at 0.07%. Dead coral cover is 32.2%, predominantly Dead Coral Algae (DCA) at 32%, the biotic cover is 26.07%, with the largest percentage dominated by Soft Coral at 25.33%, and the abiotic cover is 5.6%, mainly dominated by Rubble (R) at 3.07%.

Then, at the third station, the percentage of coral cover obtained is 60.37%, with the highest percentages found in Coral Foliose (CF) at 21.48%, Coral Millepora (CME) at 17.21%, and the lowest in Acropora Submassive (ACS) at 0.07%. Dead coral cover is 18.35%,

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predominantly Dead Coral with Algae (DCA) at 18.28%, biotic cover is 7.6%, and abiotic cover is 13.67%, mainly dominated by Sand (S) at 6.87%.

In stations one and two, the most dominant coral growth is of the branching type, namely Coral Branching (CB). This is attributed to the high brightness and low turbidity levels at these stations. Additionally, the water current speed at both stations still supports the growth of branching coral types. Pratchett et al. (2015) states that branching coral growth typically occurs in clear waters and locations where wave breaking occurs. This type of coral is easy to grow but sensitive to suspended particles.

The high percentage of Dead Coral with Algae (DCA) in this area is suspected to be due to some local communities engaging in fishing activities, despite this area being legally designated as a tourism zone where fishing is prohibited. However, some individuals may disregard these regulations and use environmentally unfriendly fishing methods, such as using poisons. The category Rubble (R), representing broken coral, is caused by tourism activities where many visitors engage in diving and snorkeling, leading to tourists stepping on the coral reefs. Another cause is foreign vessels entering the area and anchoring indiscriminately, resulting in damage to the coral reefs.

Coral Reef Cover Per Lifeform Category

The coral reef cover per lifeform category is analyzed as follows:

Acropora Branching (ACB)

ACB, characterized by branch-like structures resembling tree branches, is found at all stations, with the highest percentage at Station II on Hoga Island. The overall average growth across all stations is 22.05%.

Acropora Digitate (ACD)

ACD, characterized by densely branched structures resembling fingers, is found at Station I (0.87%), Station II (1.80%), and Station III (1%), with relatively lower growth in all three stations.

Acropora Encrusting (ACE)

ACE, characterized by creeping forms usually found on immature corals, is present at Station I (0.13%) and Station II (0.27%), while absent at Station III.

Acropora Submassive (ACS)

ACS, with double branching/platelike structures, forms colonies of submassive corals. The highest growth is observed at Station I (1.67%), with lower percentages at Station II (0.47%) and Station III (0.07%).

Acropora Tabulate (ACT)

ACT, with flat and branched structures resembling a table, is only found at Station I (0.33%) and Station III (0.67%), and is absent at Station II.

Coral Branching (CB)

CB, characterized by longer branches compared to its diameter, is found at every station, with percentages at Station I (22.36%), Station II (11.53%), and Station III (4.80%).

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Coral Encrusting (CE)

CE, growing over the reef substrate with a rough and hard surface, featuring small holes, is the most frequently encountered category across all stations. It has the highest percentage of 5.27% overall and dominates at Station II.

Coral Foliose (CF)

CF, growing in leaf-like protrusions on the reef substrate, small-sized, and forming folds or circles, has the highest percentage at 21.48% across all stations and dominates at Station III.

Coral Heliopora (CHL)

CHL, a non-scleractinian coral also known as blue coral, typically grows in shallow areas. It is only found at Station II (0.27%).

Coral Massive (CM)

CM, spherical with varying sizes, a smooth and dense surface, is found at Station I (7.88%), Station II (9.80%), and Station III (10.34%).

Coral Millepora (CME)

CME, also known as fire coral, recognizable by yellow tips and a burning sensation upon touch, has the highest percentage at 17.21% and dominates at Station III.

Coral Mushroom (CMR)

CMR, oval and mushroom-shaped with numerous protrusions, is most abundant at Station I (0.8%).

Coral Submassive (CS)

CS, with robust growth and small protrusions, is found only at Station I (0.93%) and Station II (0.47%).

Soft Coral (SC)

SC is almost ubiquitous across all stations, with percentages at Station I (14.95%), Station II (25.33%), and Station III (7.20%), the lowest among all stations.

Sponge (SP)

Sponge, the abiotic component in the coral reef ecosystem, is found at all stations, with percentages ranging from 0.13% to 0.27%.

Abiotic

Abiotic components, including sand, rocks, and coral fragments, dominate the observation stations. The most prevalent category is coarse particle Sands (S) with 15.21% across all stations, followed by coral fragments (9.21%) and rocks (2.73%).

Other (OT)

Fauna associated with coral reefs, including clams and other invertebrates, is present, with varied percentages across stations.

Furthermore, we also assess that it is crucial to examine the correlation between fluctuations in coral cover percentages and their potential impact on the overall health of the ecosystem and the subsequent consequences for the local community and tourism. In this context, it is important to analyze the variations in coral cover percentages as they provide insights into the

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state of coral reef health. These fluctuations not only affect the marine ecosystem as a whole but also have significant implications for the lives of the local community and the tourism industry. A drastic decrease in coral cover could be a sign of serious issues, such as habitat degradation or a decline in biodiversity. The impact is not limited to the environment but can also harm the livelihoods and economic income of the local community dependent on the tourism sector. Therefore, identifying and understanding the relationship between coral cover fluctuations and ecosystem health is key to effective conservation efforts, as well as protecting the sustainability of the lives of the local community and the tourism industry in the area. However, our research has not delved deeply into these aspects mentioned above.

In addition, based on the data we presented earlier, such as Figure 5, we analyzed the relationship between variations in coral cover percentages and potential threats to the ecosystem, along with their consequences for the local community. For instance, at the first station (46.33% coral cover), where potential threats exist despite a relatively high percentage of coral cover, attention is needed due to the dominance of Coral Branching (CB) and Soft Coral (SC) types. Potential threats may arise from human activities, such as unregulated fishing or poorly managed tourism, which can damage habitats and reduce biodiversity. Then, at the second station (36.13% coral cover), the potential threat lies in the significant decrease in coral cover, indicating potential risks to coral reef health. Particularly, the high dominance of Soft Coral (SC) may suggest an imbalance in the ecosystem or pressure from factors such as pollution or climate change.

Lastly, at the third station (60.37% coral cover), potential threats exist despite the high percentage of coral cover, warranting collective attention to the significant fluctuation between stations, indicating ecosystem instability. Potential threats may involve factors such as changes in water temperature, pollution, or human activities that can damage coral reef structures. These potential threats could lead to habitat degradation and a decline in biodiversity around Wakatobi National Park, region II, ultimately affecting the marine ecosystem and the livelihoods of the local community dependent on marine resources, especially in the tourism and fishing sectors.

Therefore, from this data, it can be concluded that variations in coral cover provide clues about potential ecological issues, emphasizing the need for conservation efforts to protect the marine ecosystem and ensure the sustainability of the local community.

Conclusion

The conclusion that can be drawn from this study is that the percentage of coral growth cover (lifeform) in the tourist zone of Wakatobi National Park, region II, shows coral cover at the first station is 46.33%, dominated by the Coral Branching (CB) type at 22.36% and also the Biotic type dominated by Soft Coral (SC) at 14.95%. At the second station, the coral cover obtained is 36.13%, dominated by the Coral Branching (CB) type at 11.53%, and the Biotic type, particularly Soft Coral (SC), is encountered at 25.33%. At the third station, the percentage of coral cover is 60.37%.

Furthermore, the researcher's suggestion regarding this study is that the management of Wakatobi National Park, especially in the Tourism Zone of Hoga Island under the auspices of the Wakatobi National Park Office Region II, is already quite good. However, in our opinion, it would be beneficial if the management of the waters around Hoga Island conducts more frequent training or socialization sessions for the community regarding the importance of preserving and managing marine resources. This approach would raise awareness and competence among the local community, enabling them to actively participate in the

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conservation efforts of the waters surrounding Hoga Island and its vicinity. Additionally, we also propose the implementation of enhanced monitoring protocols for tourist activities to minimize coral reef damage and advocate for stricter enforcement of fishing regulations. Furthermore, we suggest conducting ongoing observations in the future. This could serve as a projection with integrated, up-to-date monitoring and data, providing insights into the coral health at the research location. Thus, if there is damage or a decline in productivity, anticipatory measures and solutions to emerging issues can be implemented.

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