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# DISTRIBUTION OF CORAL REEFS IN THE WATERS OF PANGEMPANG MUARA BADAK DISTRICT KUTAI KARTANEGARA REGENCY

## Sebaran Terumbu Karang di Perairan Dusun Pangempang Kecamatan Muara Badak Kabupaten Kutai Kartanegara

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**ABSTRACT**

Kutai Kartanegara Regency, particularly the waters of Pangempang in Muara Badak District, has great potential in marine resources, with high biodiversity and serving as one of the primary sources of livelihood for the local coastal communities, including the presence of coral reefs. Nevertheless, valid scientific information regarding the distribution and existence of coral reefs in this area remains very limited. Accurate data is essential to support the sustainable management of marine resources, particularly in ensuring the long-term ecological and economic benefits they provide. Understanding the verification and existence of coral reef distribution in this area is crucial to support data-driven and sustainable management efforts. This study aims to verify the presence and map the distribution of coral reefs in the waters of Pangempang Hamlet, Muara Badak District, Kutai Kartanegara Regency. The methods used include field surveys, remote sensing image interpretation, and GIS-based spatial analysis. Data collection was conducted at 13 locations with varying depths and distances from the shore. The research results show that four locations have been verified to contain coral reef ecosystems, with areas ranging from 0.41 to 6.26 hectares. The location with the largest coral reef area is Batu Lampe Besar (6.26 hectares), which has great potential for conservation and marine ecotourism. Acropora coral is the dominant coral species found, as it was identified at every surveyed location. Based on these findings, it is recommended to implement community-based conservation efforts, regular monitoring, and further research to ensure the sustainability of the coral reef ecosystem in the Pangempang area.

**Keywords:** Conservation, Coral Reef, Distribution, Verification

**ABSTRAK**

Kabupaten Kutai Kartanegara khususnya di perairan pangempang kecamatan Muara Badak memiliki potensi sumberdaya laut yang besar, dengan keanekaragaman hayati yang tinggi menjadi salah satu sumber mata pencaharian utama bagi masyarakat pesisir setempat, termasuk

keberadaan terumbu karangnya. Namun demikian, informasi ilmiah yang valid mengenai sebaran dan keberadaan terumbu karang di wilayah ini masih sangat terbatas. Data yang akurat sangat penting untuk mendukung pengelolaan sumber daya laut yang berkelanjutan, terutama dalam memastikan manfaat ekologi dan ekonomi jangka panjang yang diberikannya. Memahami verifikasi dan keberadaan sebaran terumbu karang di wilayah ini sangat penting untuk mendukung upaya pengelolaan yang berbasis data dan berkelanjutan. Penelitian ini bertujuan untuk memverifikasi keberadaan dan memetakan sebaran terumbu karang di perairan Dusun Pangempang, Kecamatan Muara Badak, Kabupaten Kutai Kartanegara. Metode yang digunakan meliputi survei lapangan, interpretasi citra penginderaan jauh, dan analisis spasial berbasis GIS. Pengambilan data dilakukan di 13 lokasi dengan berbagai variasi kedalaman dan jarak dari pantai. Hasil penelitian menunjukkan bahwa 4 lokasi telah terverifikasi memiliki ekosistem terumbu karang dengan luas yang bervariasi antara 0,41 hingga 6.26 hektar. Lokasi dengan luas terumbu karang terbesar adalah Batu Lampe Besar (6.26 hektar), yang memiliki potensi besar untuk konservasi dan ekowisata bahari. Jenis terumbu karang Acropora merupakan jenis karang dominan yang ditemui karena disetiap lokasi ditemukan jenis karang tersebut. Berdasarkan temuan ini, direkomendasikan adanya upaya konservasi berbasis masyarakat, pemantauan rutin, serta penelitian lanjutan untuk memastikan keberlanjutan ekosistem terumbu karang di wilayah Pangempang.

**Kata Kunci:** Konservasi, Terumbu Karang, Distribusi, Verifikasi

## INTRODUCTION

Coral reefs are a vital marine ecosystem that play a crucial role in maintaining ecological balance and supporting the life of various marine organisms. This ecosystem provides habitat for numerous species, supports biodiversity, protects coastlines from erosion, and serves as an economic resource for communities through fisheries and tourism (Burke *et al.,* 2011). Coral reefs thrive in tropical waters with temperatures ranging between 23–29°C and stable salinity (Kleypas *et al*., 1999). Sufficient light is also required to support the photosynthesis process of zooxanthellae algae, a microalga that lives within coral tissues and provides energy to its host through a symbiotic relationship (Wooldridge, 2010). Coral reef ecosystems serve as a habitat for more than 25% of the world's marine species, despite covering less than 0.1% of the ocean floor. Reefs provide shelter for fish, crustaceans, mollusks, and other invertebrates, making them one of the most diverse ecosystems on the planet (Knowlton *et al*., 2010). Coral reefs interact closely with other coastal ecosystems such as seagrass beds and mangroves. Mangroves provide physical protection against sedimentation, while seagrass acts as a natural filter, helping to maintain water clarity to support coral growth (Nagelkerken *et al.,* 2008).However, coral reef ecosystems in various regions of Indonesia are facing increasing pressure due to human activities, such as destructive fishing, sedimentation, pollution, and climate change (Hughes *et al*., 2002). Morphologically, coral reef ecosystems are divided into three types: (1) fringing reefs or marginal reefs; (2) barrier reefs; and (3) atolls. Fringing reefs or marginal reefs, as the name suggests, are located along marginal coastlines, while barrier reefs are separated from the mainland by a lagoon, and atolls are coral reefs that form a ring or oval shape surrounding a lagoon (Aryanto and Permanawati, 2016). Coral reef ecosystems are ecosystems that have value important, because the coral reefs have a high level of productivity than any other marine ecosystem (Huda *et al*., 2015). Coral reefs are one of the most productive ecosystems on earth, although they usually occur in waters which are relatively low in nutrients (Kunzmann, 2001). Coral reefs are one of the primary marine ecosystems with an extremely high level of biodiversity. The coral reef ecosystem plays many roles, not only as a coastal protector against erosion but also as a provider of essential compounds for food, supplements,

and medicine. From an ecological perspective, coral reefs serve as an ideal habitat for marine organisms. Additionally, coral reefs function as spawning grounds, feeding areas, and shelters for small fish. Healthy reef conditions can enhance fisheries productivity (Nabil, 2019). Although coral reefs cover only 0.2% of the world's oceans, they harbor 25% of the planet's diverse marine species (Hoegh-Guldberg, 2010).

The coral reef ecosystem is crucial in coastal ecosystems as it is highly interconnected with other ecosystems and the surrounding communities. In ecology, coral reefs play a vital role in sustaining life in coastal and marine areas (Failler *et al*., 2015). Kutai Kartanegara Regency, particularly the waters of Pangempang in Muara Badak District, has great potential in marine resources, with high biodiversity and serving as one of the primary sources of livelihood for the local coastal communities, including the presence of coral reefs. The waters of Pangempang Hamlet host a rich and diverse coral reef ecosystem. This location offers several beautiful coral reef spots, such as Batu Lampe Besar and Batu Lampe Kecil, located approximately 7 km from the shore, as well as Batu Tengah, which is about 5 km away. The water depth around these spots varies, ranging from 4 meters for snorkeling to 14 meters for diving. This area is one of the key regions for local fishing activities. However, the intensity of human activities in this region has the potential to impact the condition and sustainability of the coral reefs. Nevertheless, valid scientific information regarding the distribution and existence of coral reefs in this area remains very limited. Accurate data is essential to support the sustainable management of marine resources, particularly in ensuring the long-term ecological and economic benefits they provide. Understanding the verification and existence of coral reef distribution in this area is crucial to support data-driven and sustainable management efforts.

This study aims to verify the existence and map the distribution of coral reefs in the waters of Pangempang. By using field survey methods, this research is expected to provide a clear overview of the coral reef distribution in the area. This information can serve as a basis for decision-making by local governments, communities, and other stakeholders in designing management and conservation strategies for coastal ecosystems. This study is expected to make a significant contribution to the preservation of coral reef ecosystems, particularly in Kutai Kartanegara Regency, while also serving as an important reference for sustainable coastal environment management. The benefits of this research are to support the sustainable management of marine resources by providing scientific information on the distribution of coral reefs and contributing to coastal ecosystem studies, particularly the verification of coral reefs in the coastal areas of East Kalimantan. This information can be utilized by stakeholders, including local governments, local communities, and other relevant parties.

## METHODS

### Research Location and Time

This research was conducted in the waters of Pangempang, Muara Badak District, Kutai Kartanegara Regency, East Kalimantan Province. The research was carried out over a period of three months, from September to November 2024. The waters of Pangempang, Muara Badak District, Kutai Kartanegara Regency, East Kalimantan Province, have a rich and diverse coral reef ecosystem, consisting of both soft and hard coral species. Popular coral reef spots such as Batu Lampe Besar, Batu Lampe Kecil, and Batu Tengah are ideal locations for snorkeling and diving, with depths ranging from 4 to 14 meters. The research location map is presented in the following figure.


Figure 1. Research Location Map

**Tools and Materials**

The tools used for data processing in this research include Microsoft Word, Microsoft Excel, and ER Mapper 7.0 software. The materials used in the study consist of SPOT imagery data and Landsat 8 satellite imagery. Complete diving equipment includes BCD, regulator, mask, wetsuit, gloves, booties, fins, weight belt, and scuba tank. Field equipment includes a boat, GPS, and an underwater camera.

**Data Collection Method**

This coral reef distribution mapping study employs remote sensing image interpretation, GIS, survey methods, and spatial-based descriptive analysis. Remote sensing image interpretation is conducted to obtain current and historical information based on digital values recorded in remote sensing data. Field surveys are carried out to verify the interpretation results, including the identification of water, sand, and coral reefs at the research site. The determination of coral reef coverage is conducted in the waters around Pangempang Village through field data collection at several locations by the research survey team. Satellite image data collection using SPOT imagery is utilized to identify detailed coral reef morphology, while Landsat 8 imagery is used to monitor changes in the extent and distribution of coral reefs. Geographic Information System (GIS) is used to analyze the spatial and temporal data of coral reefs, including the integration of field data and remote sensing imagery. GIS enables the visualization of coral distribution in a way that is easier to understand for stakeholders (Hedley *et al*., 2016).

**Research Procedure**

The research is conducted in two stages: (1) Processing and analyzing satellite image data, and (2) Surveying to verify the existence of coral reefs.

**A. Processing and Analysis of Satellite Image Data**

Satellite image data processing is conducted using a Personal Computer (PC) or laptop with ER Mapper software. The satellite images processed include SPOT-7 and Landsat 8 imagery from the years 2012, 2020, 2023, and 2024 to determine the extent of coral reefs. The image classification process is carried out using the Supervised Classification method. The steps in satellite image analysis are as follows:

1. Composite Image Formation – Initially, composite images are created to obtain a general overview of the data to be processed. The RGB composite used includes bands 4, 2, and 1.

2. Geometric Correction – Performed to align the image coordinates with field data coordinates, while radiometric correction is applied to enhance the visual quality of the image.
3. Image Cropping – Used to limit the area to be analyzed. This selected area is then classified based on its coral reef habitat.
4. Classification Method – The Supervised Classification method is applied with guidance from field data, where the coral reef locations have been previously identified.
5. Presentation of Classification Results – The final classification results are presented in the form of maps.

**1) Survey for Coral Reef Existence Verification**

The map generated from the processing and analysis of satellite imagery, which contains estimated coral reef locations, is then verified through field surveys. At the designated points, diving is conducted to confirm the presence of coral reefs at those locations. As verification evidence, documentation is carried out by the diving team. The verification results are then presented in the form of maps and profiles for each coral reef point. Coral reef distribution verification refers to the process of confirming and mapping the location of coral reefs in a specific marine area. It is a validation process to confirm the presence and distribution of coral reefs in a particular location. This process aims to ensure the existence of coral reefs and obtain accurate data on their distribution through direct field surveys as well as technologies such as remote sensing and Geographic Information Systems (GIS). The purpose of verification is to ensure spatial data accuracy and assess coral reef conditions for effective management and conservation (Greene *et al*., 2011).

## RESULT

### Verification of Coral Reef Distribution in the Waters of Pangempang

The research was conducted to verify the distribution and existence of coral reefs in the waters of Pangempang. Based on field surveys at these 4 locations, the collected data showed significant variations, with coral reefs found in most locations, varying in size. These locations can be categorized based on their verification status, as presented in the following table.

Table 1. Coral Reef Distribution Results

| No. | Location | Distance | Area | Coordinate | | Verification Status |
|---|---|---|---|---|---|---|
| | | | | Lat | Long | |
| 1 | Batu Darat | 8,1 Km | 0,83 Ha | 0°12'44.30"S | 117°28'19.09"E | Verified |
| 2 | Batu Lampe Kecil | 9,7 Km | 0,41 Ha | 0°13'9.22"S | 117°29'27.12"E | Verified |
| 3 | Batu Lampe Besar | 10,1 Km | 6,26 Ha | 0°13'2.83"S | 117°29'36.33"E | Verified |
| 4 | Batu Laut Bagang | 13,5 Km | 2,16 Ha | 0°12'35.78"S | 117°31'23.79"E | Verified |

*Source : Primary Data, 2024.*

4 locations have been identified as having coral reefs (status: verified), with areas varying from 0.41 Ha to 6.26 Ha. The location with the largest coral reef area is Batu Lampe Besar (6.26 Ha), located 10,1 km from the survey center. This area indicates significant potential for conservation and ecotourism if the presence of coral reefs is verified. It is followed by Batu Laut Bagang (2.16 Ha). The smallest coral reef area is found at Batu Lampe Kecil (0.41 Ha), which is closer at a distance of 9.7 km. The nearest location to the survey center is Batu Darat (8.1 km), while the farthest is Batu Laut Bagang (13.5 km). In general, the verified locations are situated at an average distance of 8.1–13.5 km from the survey center.

The presence and distribution of coral reefs in the Pangempang area show a wide spread with varying location characteristics. A total of 4 locations have been verified to have active

coral reefs. This indicates good marine ecosystem sustainability in the area, with habitat size variations that can support biodiversity. According to Wilkinson (2008), coral reefs are among the most productive marine ecosystems in the world, providing ecological benefits such as coastal protection and habitats for marine life.

In this context, locations such as Batu Lampe Besar with areas of 6.26 Ha respectively have great potential as biodiversity centers or priority conservation areas due to their significant size. Areas with substantial coral reef coverage have the potential to be developed into marine ecotourism destinations. Coral reef ecotourism has been proven to contribute economically to coastal communities, as reported by Cesar et al. (2003) is Conservation-based ecotourism management can be an essential strategy in balancing economic benefits with ecosystem preservation.

This research is essential to confirm the existence of coral reefs and to map appropriate management strategies. The presence of coral reefs distributed across this area contributes significantly to the balance of the marine ecosystem. Coral reefs serve as habitats for various species of fish, invertebrates, and other organisms that support marine life. Location accessibility varies greatly, ranging from the nearest site, such as Batu Darat (8.1 km), to the farthest site, Batu Laut Bagang (13.5 km). Closer locations, such as Batu Darat and Batu Lampe Kecil, are easier to reach and have the potential to become research centers and community education hubs. On the other hand, more distant locations such as Batu Laut Bagang require specialized strategies for monitoring and management to ensure the sustainability of the ecosystem there. This research provides essential preliminary data to support coral reef conservation efforts in Pangempang Hamlet. With a significant total coral reef area across 4 locations, this region is one of the strategic areas in Kutai Kartanegara Regency. Community groups such as Pokmaswas Bina Lestari can utilize this data to design routine monitoring programs, community-based conservation, and environmental education initiatives. Additionally, synergy with the government and conservation organizations is crucial to support coral reef preservation. The distribution of these coral reefs aligns with the characteristics of the coastal ecosystem in East Kalimantan, which has high biodiversity.

**Geographical Distribution of Coral Reefs**

The Pangempang area in Muara Badak District, Kutai Kartanegara Regency, is part of the East Kalimantan coast, which has a significant coral reef ecosystem. Based on research, coral reefs in this area are distributed across several locations, both near the shore and in deeper waters. The verification results map is presented in the following figure.


Figure 2. Verified Coral Reef Distribution Map

This map shows that coral reef locations are distributed throughout the waters of Pangempang, with most being positioned in offshore areas, farther from the shoreline. Locations such as Batu Darat, Lampe Kecil, Lampe Besar, and Batu Laut Bagang are closer to the shore. This distribution indicates variations in sea depth as an environmental factor influencing the presence of coral reefs.

1. Nearshore Locations

Batu Darat and Lampe Kecil are the closest locations to the shoreline, making them more vulnerable to the effects of sedimentation and human activities such as fishing or waste disposal from land. However, these locations also have high potential for community-based education and conservation activities due to their easy accessibility.

2. Offshore Locations

Locations such as Batu Laut Bagang is situated farther into the open sea, where human influence is lower. However, these areas require more advanced technology and logistics support for conservation and management purposes.

## DISCUSSION

### Coral Reef Locations Based on Verification Results

#### 1. Batu Darat

The coral reef location named Batu Darat is approximately 8.1 km from Pokmakwas Bina Lestari, with an estimated area of 0.83 hectares. The location map of Batu Darat can be seen in the following figure.


Figure 3. Batu Darat Map

Various types of coral reefs were found at Batu Darat. The verification results of the coral reef presence are presented in the following figure.

Figure 4. Coral Reefs at Batu Darat

Based on the image above, various types of coral reefs can be found while diving around the Batu Darat location, including Acropora and Goniastrea, both hard and soft corals.

**2. Batu Lampe Kecil**

The coral reef location named Batu Lampe Kecil is approximately 9.7 km from Pokmakwas Bina Lestari, with an estimated area of 0.41 hectares. This site has the smallest area compared to the other 3 locations. The location map of Batu Lampe Kecil can be seen in the following figure.

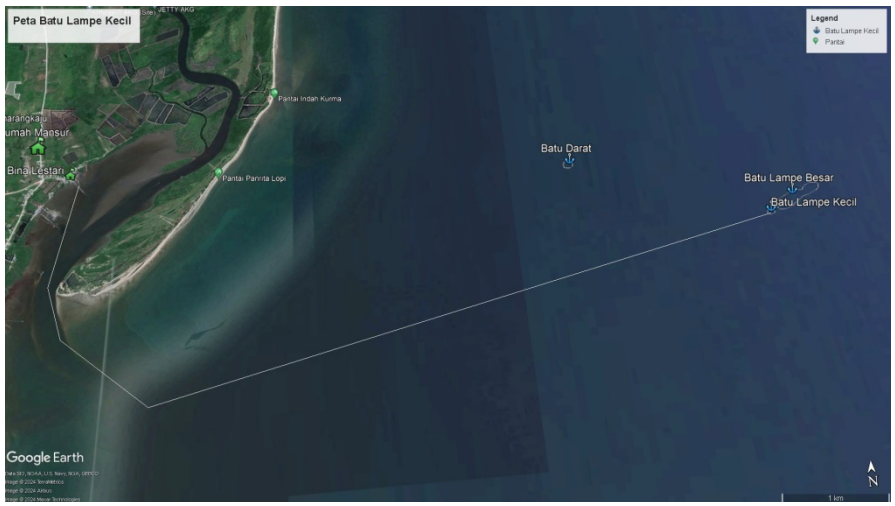


Figure 5. Batu Lampe Kecil Map

Various types of coral reefs were found at Batu Lampe Kecil. The verification results of the coral reef presence are presented in the following figure.

Figure 6. Coral Reefs at Batu Lampe Kecil

Based on the image above, various types of coral reefs can be found while diving around the Batu Lampe Kecil location, including round mosaic coral (Astreopora), Porites, Acropora, and others.

3. Batu Lampe Besar

The coral reef location named Batu Lampe Besar is approximately 10.1 km from Pokmakwas Bina Lestari, with an estimated area of 6.26 hectares. Batu Lampe Besar is adjacent to the Batu Lampe Kecil coral reef location and is the second largest among the 4 surveyed coral reef distribution points. The location map of Batu Lampe Besar can be seen in the following figure.

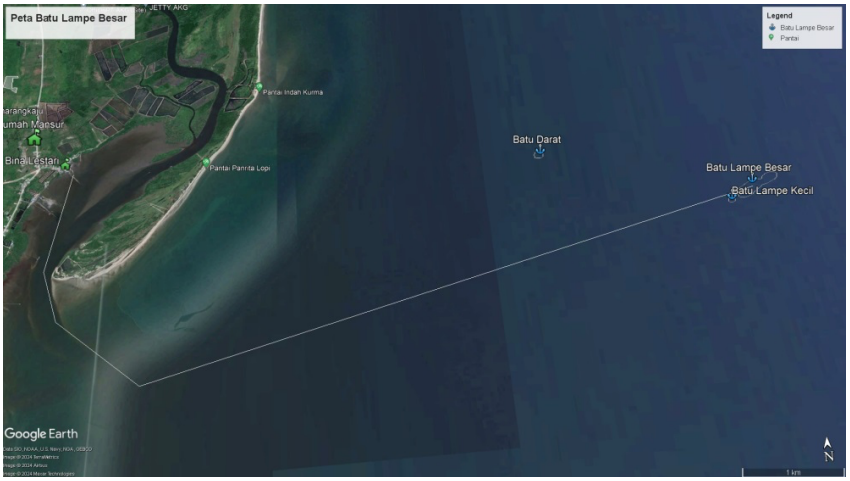


Figure 7. Batu Lampe Besar Map

Various types of coral reefs were found at Batu Lampe Besar. The verification results of the coral reef presence are presented in the following figure.

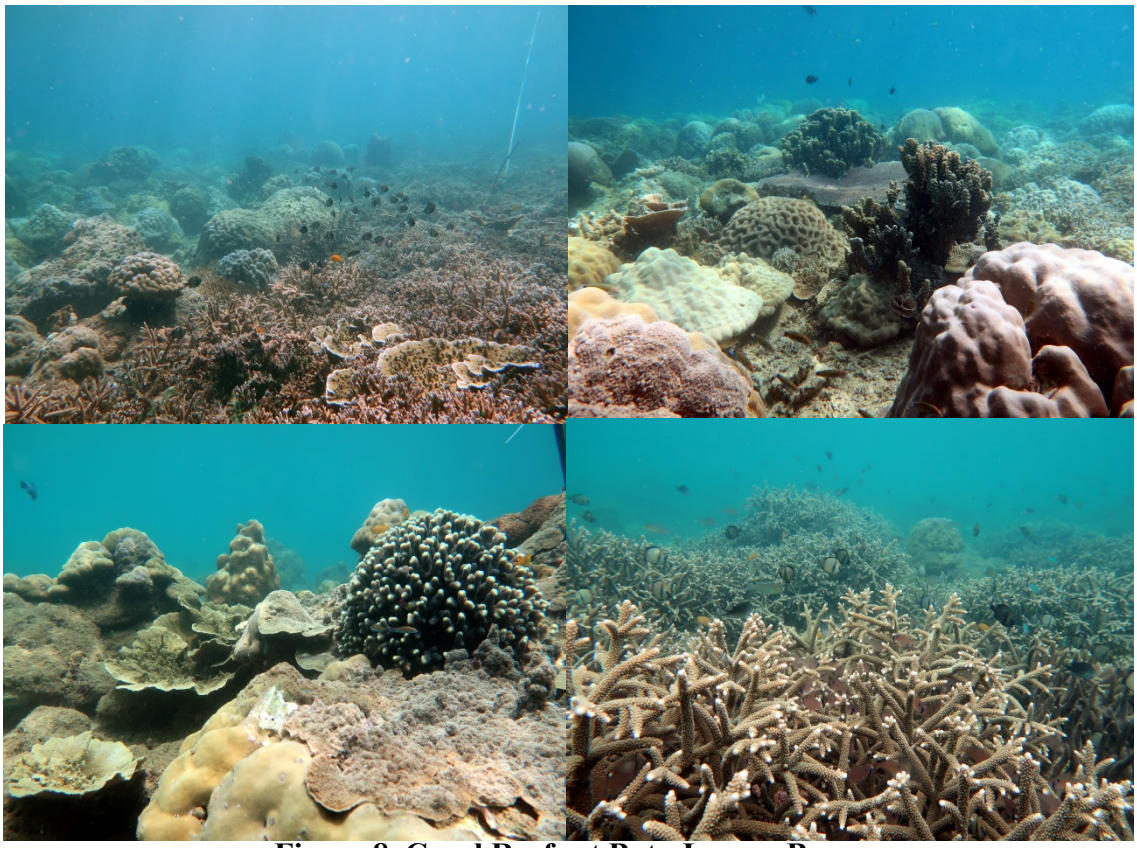

**Figure 8. Coral Reefs at Batu Lampe Besar**

Based on the image above, various types of coral reefs can be found while diving around the Batu Lampe Kecil location, including *Montastrea*, *Acropora*, brain coral, and others. According to Efendi *et al.,* (2023), Batu Lampe is one of the coral reef areas in Muara Badak that is considered to be in good condition. Gusung Batu Lampe consists of two groups, namely Lampe Besar and Lampe Kecil, with coral reefs dominated by hard coral colonies.

4. Batu Laut Bagang

The coral reef location named Batu Laut Bagang is approximately 13.5 km from Pokmakwas Bina Lestari, with an estimated area of 2.16 hectares. The location map of Batu Laut Bagang can be seen in the following figure.


Figure 9. Batu Laut Bagang Map

Various types of coral reefs were found at Batu Laut Bagang. The verification results of the coral reef presence are presented in the following figure.

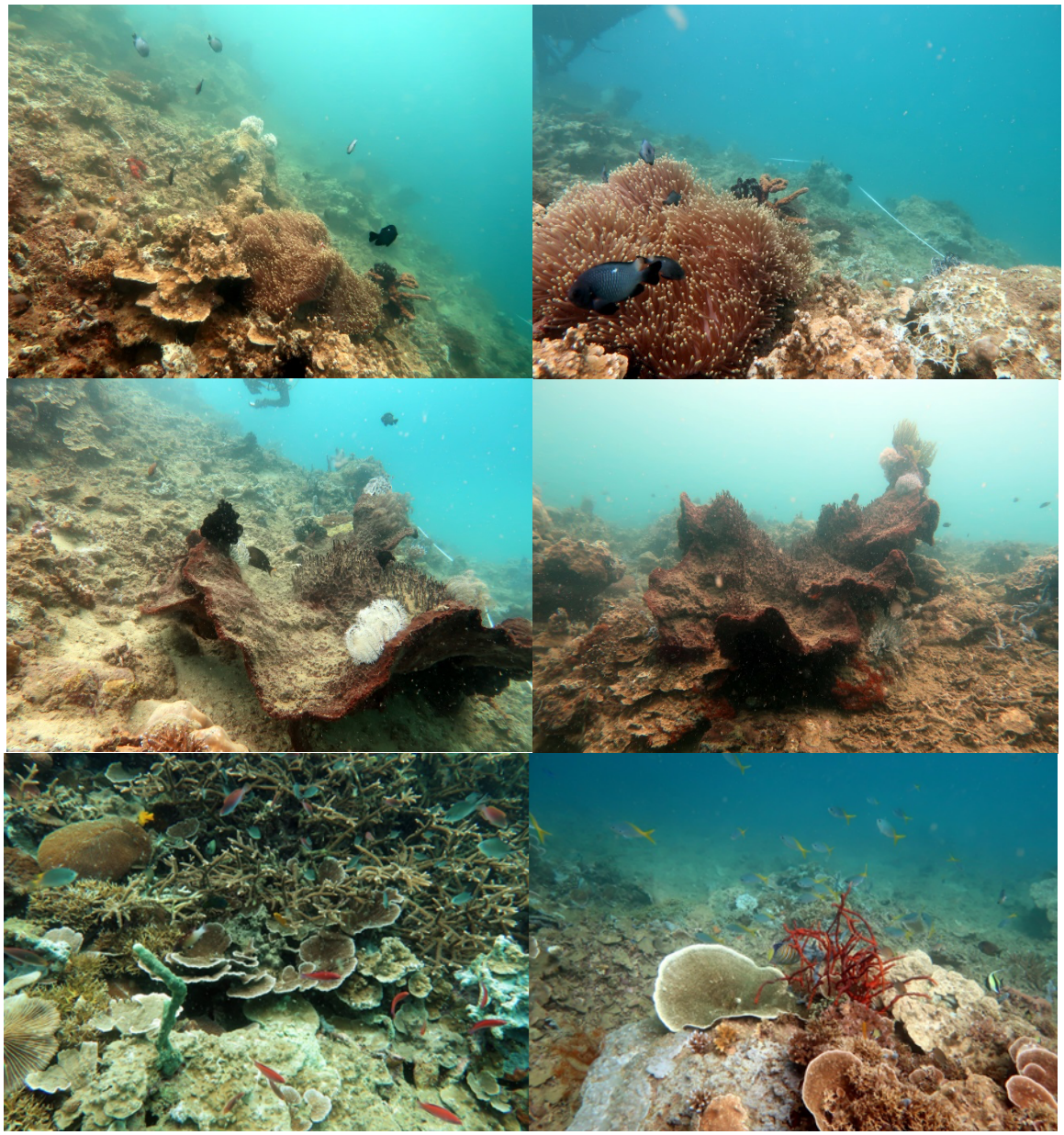

Figure 10. Coral Reefs at Batu Laut Bagang

Based on the image above, various types of coral reefs can be found while diving around the Batu Laut Bagang location, including Acropora, Montipora, and others. Based on the data, every location contains Acropora coral species. This is in line with the study by Efendi et al. (2022), which stated that the coral type with the highest number of colonies in Batu Lampe is *Acropora*.

Acropora corals are known as highly productive branching corals, commonly found in clear waters with moderate currents. Acropora supports ecosystems by providing habitat for various species of reef fish (Spalding *et al*., 2001). Acropora corals are hermatypic (reef-building) corals that live in colonies and remain abundant in tropical waters. Acropora belongs

to the family Acroporidae, which has the highest number of species compared to other coral genera. This genus of coral generally thrives in clear waters and grows well in areas influenced by currents and waves rather than in calm and sheltered waters (Mulyadi, 2018).

## CONCLUSION

The presence of coral reefs: Out of the four surveyed locations, all have been verified to have active coral reefs, with areas varying between 0.41 hectares and 6.26 hectares. The distribution of coral reefs: The coral reef locations are spread throughout the waters of Pangempang, with variations in depth and distance from the shore.

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Jika Anda memerlukan bantuan lebih lanjut atau informasi tambahan, silakan beri tahu saya.