Journal of Coastal and Ocean Sciences *e-issn: 2746-4512*
Volume 5 No. 3, September 2024: 208-214 *p-issn: 2745-4355*

The Effect of Coral Reef Ecological Changes on the Socio-Economic Community in Mapur Village

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Received: 6 August 2024; Accepted: 10 September 2024

ABSTRACT

The condition of coral reefs is still good on Mapur Island, which benefits community activities such as fishing and marine tourism. However, continuous activities can degrade the coral reef ecosystem, so the government has made it a Marine Conservation Area for the Eastern Region of Bintan Island. This research aims to determine the ecological condition of coral reefs on Mapur Island, the influence of the coral reef ecosystem on socio-economics, as well as the impacts felt before it was designated and after it was designated as a conservation area in Mapur Village, Marine Conservation Area in the Eastern Region of Bintan Island. The results show that increasing live coral cover and decreasing dead coral cover have shown a positive recovery trend. Establishing a coral reef ecosystem conservation area in Mapur Village has several substantial impacts. Even though most people have good knowledge and perception about the function and benefits of conservation areas, primarily as fish habitats, the main challenge still lies in access to infrastructure, which is considered inadequate. The economic impact of establishing a conservation area is not yet significant because most people do not see a substantial increase in income. However, the community feels support for their livelihoods through the sustainability of fish resources. Changes in coral cover on the socio-economic conditions of the people of Mapur Island influence the ecosystem and local communities, fisheries and marine resources, the marine tourism sector of Mapur Village, natural resource management, direct economic influence, diversification of livelihoods, education, and environmental awareness, improving infrastructure and facilities, as well as challenges and limitations.

Keywords: Impact, Economic, Mapur Island, Social, Coral Reefs

1. INTRODUCTION

Mapur Island, located east of Bintan Island, has a developed stretch of coral reef in the western part of the island. Most of Mapur Island's coral reefs are in the west and southwest, usually covered by a layer of sand of varying thickness and composed of coral fragments. In some places, seagrass vegetation grows. Based on Landsat image data, the total area of coral reefs on Mapur Island reaches 1,046.29 ha. Many parts of the coastal waters on Mapur Island are attractive enough to be used as marine tourism objects, such as coral reefs, which attract visitors to swim or snorkel.

The excellent condition of coral reefs on Mapur Island makes the water area around the coral reefs a place for community activities, such as fishing or tourist attractions. Previous research shows that the condition of coral reefs on Mapur Island is categorized as very good to damage, with a live coral cover of 79.46% to 1.00%. Threats to coral reef resources can cause dramatic damage in a short time, such as destructive fishing practices and other mechanical damage, such as anchor damage, ship groundings, and storms. As society's needs for consumption and tourism increase, so do the activities in the area, putting more significant pressure on coral reef ecosystems.

Social, economic, and ecological problems in coastal areas are important and interrelated issues (Adi et al., 2019). One of the linkages is between poverty and environmental management. An example is the decline in fisheries productivity due to damage to mangrove and coral reef ecosystems caused by rising sea surface temperatures and groundwater changes. Assessment of fishermen's welfare is seen from the income of capture fisheries business and must also be compared with their expenses. The NTN value based on fishing gear in Mapur Village ranges from 0.81 - 1.54,

meaning that most fishermen can only fulfill primary needs.

Community understanding of coastal resources is needed in every activity so that the community feels ownership and responsibility to preserve coastal resources sustainably, especially in managing TWP Timur Bintan Island, especially on Mapur Island. Coastal communities, especially fishermen, are the first to feel the impact of environmental damage in coastal areas. Perception is the observation of objects, events, or relationships obtained by interpreting information and messages (Hresc et al., 2018).

Sustainable livelihood characteristics are evaluated based on human, social, natural, financial, and physical capital through the sustainable livelihood approach. The aspects considered are coastal communities' condition, existence, and ability to access capital following the sustainable livelihood approach (Arthur, 2018). This approach was chosen because efforts to fulfill social, economic, and ecological needs are carried out reasonably and rationally by combining activities and using various capitals in the living system (Arifasihati & Kaswanto, 2016).

This study aimed to determine the condition of the environment and surrounding communities, the influence of coral reef ecosystems on socio-economics, and the impacts felt before and after being designated as a conservation area in Mapur Village, Eastern Region Marine Protected Area, Bintan Island. Environmental, social, and economic aspects were examined in this study.

2. RESEARCH METHOD

Time and Place

The research was conducted in September 2023 in Mapur Village, Eastern Region Marine Protected Area of Bintan Island, Bintan Regency, Riau Islands Province. A map of the research location is shown in Figure 1.

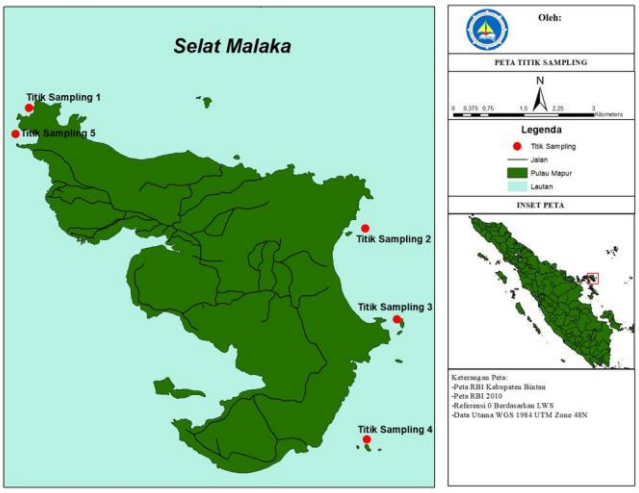


Figure 1. Research location

Procedures

Data collection was divided into data on coral reef cover and socioeconomic conditions. The coral reef cover sampling points are determined by purposive sampling based on the presence of corals in the waters. The sampling points consisted of 4 locations around the seas of Mapur Island. Depths of 5 meters and 10 meters became the sampling location because it represents the condition of corals that generally grow well, and high diversity of coral species is also obtained at these depths (Paing et al., 2022). Coral reef observations were conducted using the 50m long Line Intercept Transect Method. The Line Transect was installed parallel to the depth contour parallel to the shoreline. In addition, water data such as temperature, salinity, and current were collected.

Socio-economic data collection was conducted through interviews and distribution of research questionnaires to respondents. The number of respondents was selected based on the Slovin formula with 111 people.

Data Analysis

Data analysis is divided into the analysis of the percentage of coral cover, social conditions, economic conditions, and the influence of coral cover on the socio-economic conditions of the community. Analysis of the

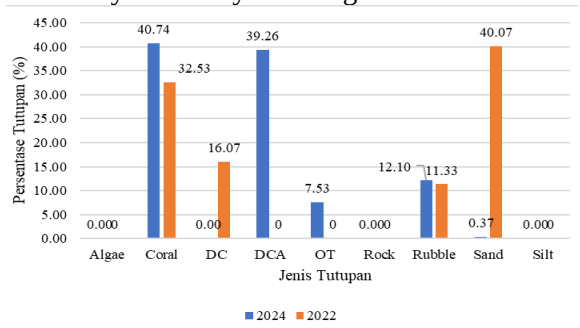
percentage of coral cover was carried out using the Coral Point Count with Excel Extension (CPCe) application, which can be exported to produce statistical analysis for each form of coral growth in Microsoft Excel.

The social condition of the community was known through interviews with 111 respondents. The questions were about community knowledge about conservation areas, community knowledge about regulations, community knowledge about conservation area policies, community knowledge about environmentally friendly fishing, and community knowledge about coral reefs. Another question was about access to infrastructure in the Mapur Island conservation area. Meanwhile, the community's economic condition is known through questions about their income and the existence of coral reefs as a marine conservation area of Mapur Island.

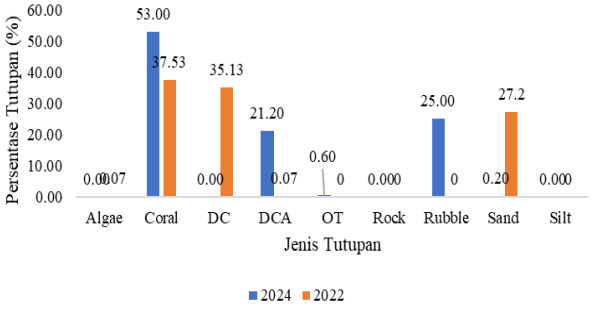
The influence of changes in coral reef cover on the socio-economic conditions of the community was analyzed using the PCA method processed using Minitab software. This method is a multivariate analysis that can transform the original variables that are correlated with each other into new variables that are not associated with each other by reducing the number of variables so that they have smaller dimensions but can explain most of the diversity of the original variables.

3. RESULT AND DISCUSSION

Sea surface temperature in Bintan Island waters ranges from 28 to 30°C. This condition is similar to the research, which states that Bintan Island's average sea surface temperature ranges from 28°-31°C. The pH range obtained from the measurement results is 6.5-8.5. Salinity obtained at the research site is between 15-25 ‰. At the same time, ocean currents have speeds of about 0.02 to 0.32 m/s or 2 to 32 cm/s. This value follows the results obtained in research on hydro-oceanographic conditions in the waters of Bintan Island.



Gambar 1. Jenis dan persentase tutupan karang pada stasiun T1

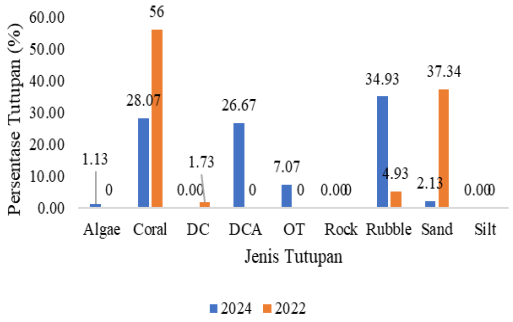


Gambar 2 Jenis dan persentase tutupan karang pada stasiun T2

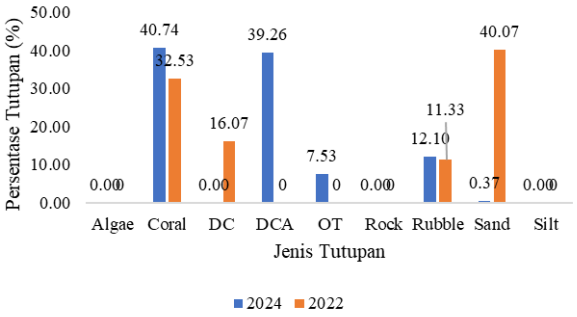
There is a significant increase in live coral cover from 32.53% in 2022 to 40.74% in 2024 at observation point T1. Appropriate human interventions, such as establishing marine protected areas, can promote coral recovery by providing more stable and favorable conditions for coral growth (Mohan & Kumari, 2008). In contrast, dead coral cover (DC) experienced a drastic decrease from 16.07% to 0% over the same period. This decrease suggests that factors causing coral mortality, such as pollution and disease, may have been successfully controlled, and ecosystem conditions have improved, allowing live corals to grow back. Reductions in environmental stressors such as pollution and destructive fishing practices can reduce coral mortality (Perdinan et al., 2024). There was a significant increase in dead coral cover with algae (DCA) from 0% to 39.26%, meaning that algae have begun to colonize areas previously occupied by dead corals (Kohler & Gill, 2006).

An increase in the other category (OT) from 0% to 7.53%, which includes a variety of other unspecified cover types. Meanwhile, rock cover remained at zero, suggesting that rock substrate was not a significant factor in coral cover dynamics at this site. Dead coral fragments (rubble) slightly increased from 11.33% to 12.10%, while sand cover drastically decreased from 40.07% to 0.37%. This significant reduction in sand may indicate reduced sedimentation, which could support live coral recovery by lowering barriers to coral photosynthesis. Overall, data from observation point T1 showed a positive recovery trend with an increase in live corals and a decrease in dead corals. However, increases in DCA and changes in other cover categories require further

attention to ensure recovery is healthy and sustainable.



Gambar 3 Jenis dan persentase tutupan karang pada stasiun T3



Gambar 4. Jenis dan persentase tutupan karang pada stasiun T5

At observation point T3, there was a significant decrease in live coral cover from 56% in 2022 to 28.07% in 2024. This decline indicates a severe problem of coral recovery at this site, which various environmental stressors such as ocean warming, pollution, or destructive fishing practices may cause. Dead coral cover (DC) decreased from 1.73% to 0%, indicating that although live corals decreased, there was no significant increase in new coral mortality. The decrease in DC could also be due to reduced environmental stressors such as pollution and disease that previously caused coral mortality (Perdinan et al., 2024).

There was a significant increase in dead coral cover with algae (DCA) from 0% to 26.67%. This increase in DCA indicates that algae have colonized areas previously occupied by dead corals. There was a significant increase in the other category (OT) from 0% to 7.07%, including various other unspecified cover types. Dead coral fragments (rubble) increased significantly from 4.93% to 34.93%, indicating an accumulation of dead coral fragments at this site. Dead coral fragments may inhibit coral recolonization due to substrate instability. Handling and managing dead coral fragments may be necessary to improve substrate conditions to support live coral growth (Mohan & Kumari, 2008).

Sand cover decreased significantly from 37.34% to 2.13%, while silt cover remained at zero. The significant reduction in sand cover indicates reduced sedimentation, which may support live coral recovery by lowering barriers to coral photosynthesis. According to Savilaakso & Guariguata (2017), high sedimentation can inhibit coral photosynthesis and cause bleaching. Overall, data from observation point T3 indicated problems with live coral recovery, although there were some positive signs, such as decreased dead corals and reduced sedimentation.

At observation point T5, there was a significant increase in live coral cover from 32.53% in 2022 to 40.74% in 2024. This increase reflects a substantial recovery in the coral reef ecosystem at this location. Dead coral (DC) cover decreased dramatically from 16.07% to 0% over the same period. These results indicate that better environmental conditions have been created, allowing live corals to grow and dominate again. There was a significant increase in dead coral cover with algae (DCA) from 0% to 39.26%. This increase in DCA indicates that algae have colonized areas previously occupied by dead corals. An increase in the other category (OT) from 0% to 7.53% includes various other unspecified cover types.

Meanwhile, rock cover remained at zero, suggesting that rock substrate was not a significant factor in coral cover dynamics at this site. Dead coral fragments (rubble) slightly increased from 11.33% to 12.10%, indicating an accumulation of dead coral fragments at this site. Handling and managing dead coral fragments may be necessary to improve substrate conditions to support live coral growth. Sand cover drastically decreased from 40.07% to 0.37%, while silt cover remained at zero. The significant reduction in sand cover indicates reduced sedimentation, which may support live coral recovery by lowering barriers to coral photosynthesis. Overall, observation point T5 showed a positive recovery trend with increases in live corals and decreases in dead corals. However, increases in DCA and changes in other cover categories require further attention to ensure continued recovery. Ongoing conservation efforts and continuous monitoring

are essential to support the recovery of coral reef ecosystems in the Eastern Bintan conservation area, Mapur Village.

The results of the social condition questionnaire showed that most respondents have an awareness and understanding that coral reefs are used as snorkeling sites and become fishing grounds, especially for respondents with more than 20 years of work. This suggests that work experience influences their understanding of coral reef utilization. Respondents with younger age groups and respondents with less than 20 years of service had higher levels of ignorance about the condition and appearance of conservation areas. Most respondents from different age groups and work experience knew the conditions and features of conservation areas.

Respondents also had a good understanding of the function of coral reef ecosystems, particularly fish habitats. This knowledge was consistent across all age groups and work experience over the years, reflecting a reasonably good awareness of the importance of coral reef ecosystem functions. However, ignorance is higher in younger age groups and respondents with less than 20 years of work experience. So, it is necessary to strengthen environmental education for this group. Through understanding data on ecological, social, and economic conditions, decision-makers can make the right decisions in policy making.

Respondents' knowledge of fishing gear that does not harm the environment is high, especially among respondents aged 20-40 years and with a length of service between 20-40 years. The productive and experienced age groups are more aware of environmentally friendly fishing practices. However, knowledge of fishing regulations is still low, especially among younger respondents and those working less than 20 years. Implementing sustainable fishing practices involves using fishing methods that do not deplete fish stocks or damage the environment and complying with applicable regulations and quotas to prevent overfishing. Sustainable fishing considers various aspects ranging from ecology, social, and economic aspects to support the livelihood of fishing communities and maintain food security.

Respondents understand water zoning, with the majority of respondents in the 20-40 years age group who have been working longer. More respondents positively assessed the conservation area, stating that the area was "good." This positive assessment was dominated by older respondents and those who had worked longer. This represents a higher appreciation of conservation among the more experienced. Accordingly, the positive feedback received towards conservation efforts is essential to analyze. Analyzing positive feedback on conservation efforts is crucial because it shows that various stakeholders recognize and appreciate the efforts. Positive responses to conservation efforts are an encouraging sign that these efforts have a significant impact.

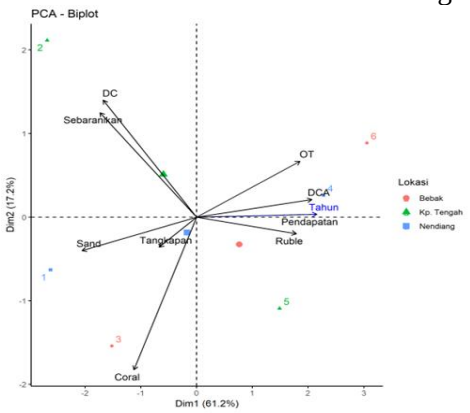
Coral reef ecosystems are critical to coastal communities, providing many ecological and economic benefits. Community perceptions towards coral reef conservation in Mapur Village revealed that most respondents realized the importance of coral reef ecosystems. This awareness is strongly recognized, especially by individuals aged 20-40, which indicates the growing awareness of the younger generation about the importance of coral reef conservation.

These results follow previous research by Agbeja et al. (2021), which highlighted the vital role of coral reefs in supporting biodiversity, protecting coastlines from erosion, and providing livelihood opportunities through ecotourism and fisheries. The results supported the establishment of conservation areas in Mapur Village. Individuals aged 20-40 years and those working for a more extended time provided solid support. This is evidence of a broad understanding of protecting coral reef ecosystems through conservation areas. The results show positive perceptions and support for coral reef conservation among the people of Mapur Village. The existence of positive perceptions and support can be used as a basis for determining effective coral reef conservation strategies in the future. However, there is also a lack of knowledge of specific policies and regulations related to coral reef conservation in Mapur Village, so it is necessary to increase education and awareness among the community. In addition, infrastructure and access are still obstacles.

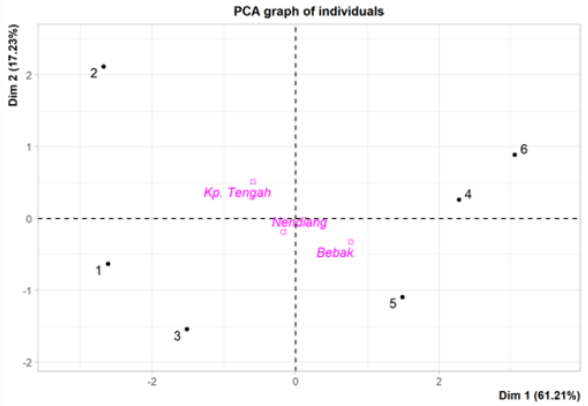
Overall, the establishment of conservation areas in Mapur Village has not significantly impacted the economy of most communities. Based on the research findings, conservation area designation has positive and negative impacts on the economic welfare of local communities. The results suggest that a

holistic approach to evaluating economic impacts should consider how community members are affected and the interaction of factors such as resource availability, market dynamics, and government policies.

The influence of coral cover change on the Pulau Mapur community's socioeconomic conditions around the TWP Bintan Island conservation area was analyzed using PCA. The results of the PCA analysis are shown in Figure 6.



Gambar 5. Grafik PCA Biplot



Gambar 6. Grafik PCA individual

The individual PCA graphs show the clustering of observation stations from the variables tested. Kp. Tengah and Nendiang stations have similarities in the influence of coral cover change on social and economic variables of the Mapur Village community. At the same time, Bebak station is not similar to other stations.

Changes in coral cover affect the social and economic conditions of the Mapur Island community around the Bintan Island Marine Tourism Park conservation area in Bintan Regency. This condition can be identified from the results of this research that has been conducted based on objectives one and objective 2. In general, changes in coral cover on the socio-economic conditions of the Mapur Island community affect the following: 1) Ecosystem context and local community, 2) Fisheries and marine resources, 3) Mapur Village marine tourism sector, 4) Natural resource management, 5) Direct economic impact, 6) Livelihood diversification, 7) Education and environmental awareness, 8) Improved infrastructure and facilities, and 9) Challenges and limitations

4. CONCLUSION

The increase in live coral cover and decrease in dead coral cover have shown a positive recovery trend. Establishing coral reef ecosystem conservation areas in Mapur Village has had several significant impacts. While most communities have good knowledge and perceptions of the functions and benefits of the conservation area, especially as a fish habitat, the main challenge remains access to infrastructure, which is considered inadequate. The economic impact of the conservation area designation has not been significant, as most of the community did not see a substantial increase in income. However, communities do feel the support for their livelihoods through the sustainability of fish resources. Changes in coral cover on the socio-economic conditions of the Mapur Island community affect ecosystems and local communities, fisheries and marine resources, the marine tourism sector of Mapur Village, natural resource management, direct economic influence, livelihood diversification, education and environmental awareness, improvement of infrastructure and facilities, and challenges and limitations.

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