# Abundance and Diversity of Coral Reef Megabenthos in Karimunjawa Islands, Central Java

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***Abstract***

*Karimunjawa is an archipelago which has a large coral reef area. However, the human and natural factors that put environmental pressure on coral reef ecosystem in recent years have caused the need to update data on the abundance and diversity of megabenthos in Karimunjawa. Data collection was carried out on 9 islands in Karimunjawa out on 30 September-4 October in 2023. The megabenthos data collection method was carried out using the belt transect method with data collection carried out at the family level in the survey area. The method for collecting data on hard coral cover was underwater photo transect (UPT). Megabenthos data analysis was carried out using Microsoft Excel software Coral Point Count with Excel Extensions (CPCe) software for coral cover analysis. Analysis of megabenthos data also includes ecological indices consisting of the Shannon-Wiener diversity index, Pielou evenness index, and dominance index. The relationship between hard coral cover and megabenthos was sought using simple regression analysis. The research results found 8 megabenthos classes and as many as 16 families. The results showed a weak relationship between megabenthos abundance and hard coral cover (r=0.03), but a strong and moderate relationship with the megabenthos ecological index (r=0.434 to 0.568). The regression analysis showed that there was no significant influence between hard coral cover and the abundance and ecological index of megabenthos (P>0.05).*

***Keyword*:** *Belt Transect; Coral Cover; Ecological Indices; Karimunjawa Island; Megabenthos*

## INTRODUCTION

Coral reef ecosystems are the key to the high level of marine biodiversity in Indonesia. This is because coral reefs can be a habitat, breeding ground, nursery ground, and feeding ground for many other marine biotas, therefore forming an ecosystem that contains many interactions and associations of various marine biota that live in it (Lakastri *et al*., 2018). Megabenthos is one of the important components in the coral reef ecosystem. Megabenthos is a benthic biota measuring more than 1 cm and can be an indicator of coral reef ecosystem conditions because it can respond to water quality conditions sustainably due to its relatively large size, long life cycle, and slow mobility (Mutaqin *et al*., 2020). The effects of changes in aquatic environmental conditions can be shown through changes in the abundance and diversity of megabenthos in the coral reef ecosystem. Megabenthos can consist of attached, burrowing and crawling biota belonging to the phyla Chordata, Crustacea, Echinodermata, Mollusca and Polychaeta (Kang *et al*., 2019).

Megabenthos can be a bioindicators because they have a close relationship with coral reef health. According to Syahrul *et al*. (2022), there are megabenthos that have a negative relationship with coral reefs because they are predators of coral polyps, such as Drupella snails and Thorny Starfish which, if they experience a population explosion, will cause a decline in coral reef conditions due to high levels of predation on coral polyps. A positive relationship can be shown from sea urchins according to coral reefs because they have an important ecological function as algae eaters. The existence of sea urchins is important in coral reef ecosystems because they act as controllers of algae populations which are competitors of corals (Mutaqin *et a*l., 2020). Economically valuable megabenthos such as sea cucumbers, shellfish, and others, do not have a direct relationship with corals, but can indicate the level of exploitation in a coral reef ecosystem. Excessive fishing of economically valuable megabenthos can disrupt the balance of the ecosystem and food chain (Toruan *et a*l., 2024).

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The Karimunjawa Islands are an archipelago located in the north of Central Java, in Java Island which has a large coral reef area with a high level of biodiversity. Megabenthos has become an important component in the coral reef ecosystem in Karimunjawa. In recent years, coral reef in Karimunjawa have been influenced by several factors, such as natural factors and anthropogenic factors. Natural factors such as the occurrence of the La Niña phenomenon in 2021-2022 which caused a decrease in sea surface temperatures and affected the condition and quality of the waters (Yuniasih *et al.*, 2022). While anthropogenic factors were the high levels of human activities in the coral reef ecosystem area such as tourism, fishing activities, ship traffic, and others that can damage or affect the condition of the coral reef ecosystem in Karimunjawa. This is supported by data from the Karimunjawa National Park in 2022, that there were 21,262 visitors to Karimunjawa National Park. Both factors are assumed to be able to provide environmental pressure that can affect the composition of the abundance and diversity of megabenthos in Karimunjawa.

Research on the latest abundance and diversity of megabenthos in coral reef ecosystems in Karimunjawa after the La Niña phenomenon and antrophogenic activity in 2021-2022 needs to be conducted. Changes in the abundance and diversity of megabenthos in coral reef ecosystems in Karimunjawa can indicate the condition of the aquatic environment and the condition of the coral reef ecosystem, so that it can be the basis for coral reef conservation measures in Karimunjawa. This research aims to determine the latest conditions of the abundance and diversity of megabenthos, and to investigate its correlation with coral cover and anthropogenic activity in nearby area in Karimunjawa.

## MATERIAL AND METHODS

The research material in this study was megabenthos which was studied to determine its abundance and diversity as well as coral cover to determine the relationship between hard coral cover and the abundance and ecological indices of megabenthos in Karimunjawa. The research was conducted on 30 September – 4 October 2023 on 9 islands in Karimunjawa, i.e. Sambangan Island, Sintok Island, Tengah Island, Cemara Besar Island, Cemara Kecil Island, Menjangan Kecil Island, Taka Menjangan Besar, Geleang Island, and Burung Island. The research location was chosen because it is close to the main island and is affected by human activities and is spread across the west, north and east sides of the Karimunjawa Islands. Ecological data collection the west side of the island for safety reasons due to waves from eastern monsoon.

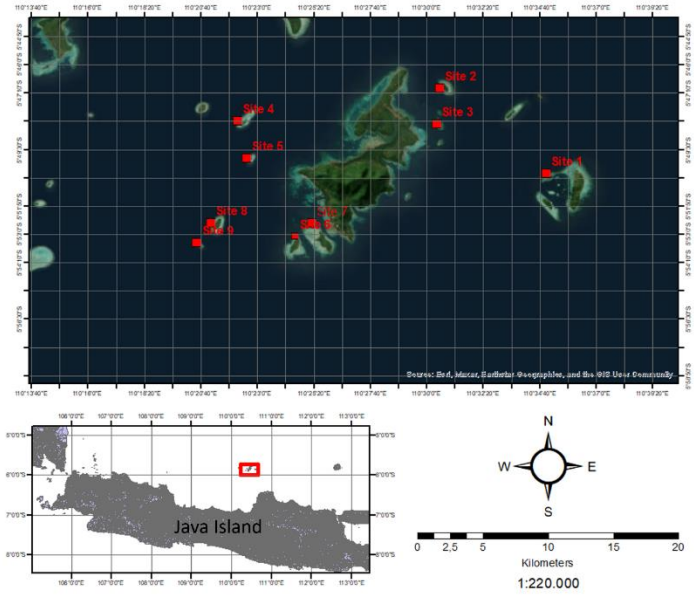


**Figure 1.** Research Location Map. Site 1 to 9 are Sambangan, Sintok, Tengah, Cemara Besar, Cemara Kecil, Menjangan Kecil, Taka Menjangan Besar, Geleang and Burung island, respectively.

Megabenthos data collection was carried out using the belt transect method with a transect length of 70 meters and a visual boundary of 1 meter to the right and left of the transect which has an observation area of 140 $m^2$ and conduct data collection for every megabenthos that found in observation area down to the family level (Arbi & Sihaloho, 2017). Coral cover data was collected using the underwater photo transect method with one 50 meters long transect per island, and a 0.5 x 0.5 m frames placed on every 1 meter, with a total of 50 photos per transect (Giyanto *et al*., 2017).

Megabenthos data was analysed to determine its density, referring to the Arbi & Sihaloho (2017) formula, namely:

$$\text{X Density} = \frac{\text{number individuals of x}}{\text{belt transect area } (140\ \text{m}^2)}$$

In addition, an ecological index analysis was carried out consisting of a diversity, evenness and dominance indices to understand the condition of megabenthos diversity in Karimunjawa. The diversity refers to the Shannon-Wiener diversity indices from Magurran (1988):

$$H' = \sum_{i=1}^{n} \left| \frac{\text{ni}}{\text{N}} \times ln \frac{\text{ni}}{\text{N}} \right|$$

The Shannon-Wiener diversity index has low diversity criteria if H'<1, medium diversity if 1<H'<3, high diversity if H' >3.

The evenness index refers to the Pieolu evenness index from Pielou (1977):

$$E = \frac{\text{H}'}{\text{Hmaks}} = \frac{\text{H}'}{\ln S}$$

Pielou's evenness index has a value range of 0-1, with the closer to 1 the higher the level of evenness. The dominance index refers to Odum (1971):

$$C = \sum_{i-1}^{n} \left[\frac{\text{ni}}{\text{N}}\right]^2$$

The criteria for the dominance index are: if C is close to 0, then almost no species dominate; if C is close to 1 then there are species that is dominating.

Coral cover was analysed using photos from the underwater photo transect using the CPCe application with a random 30-point selection technique with a total of 1500 points for 50 photos (Kohler & Gill, 2006). Simple regression analysis was used to determine the relationship between coral reef cover and the abundance and value of the megabenthos ecological index. Simple regression analysis was carried out on Microsoft Excel using the formula of Rafli *et al*., (2022):

$$Y = \text{a} + \text{bx}$$

## RESULTS AND DISCUSSION

The results of the coral cover analysis showed that the average category of coral cover conditions at the research location was in good condition or excellent condition, while three locations, namely Sambangan Island, Sintok, and Menjangan Kecil having moderate and poor coral cover conditions (Table 1) This category was obtained from the Keputusan Menteri Lingkungan Hidup

(Ministry of Environment) No. 4 of 2001 regarding the standard criteria for coral reef damage with a value range of 0 – 25% being severely damaged, 25 – 49.9% being moderately damaged, 50 – 74.9% being good or fair condition, and 75 – 100% being very good or excellent condition.

The results of the study conducted in Karimunjawa showed findings of megabenthos from 8 Classes, namely Bivalvia, Asteroidea, Echinoidea, Holothuroidea, Gastropoda, Polychaeta, Ascidiacea, and Crinoidea. Based on the results of the abundance of megabenthos in each location shown in Figure 2., the location with the largest number of megabenthos is in Taka Menjangan Besar with 297 individuals with the largest composition of Bivalvia and Echinoidea. Ascidiacea is the most commonly found megabenthos class with an average of 77 individuals. The large number of Ascidiacea can be caused by Ascidiacea having rapid growth and reproduction and being able to live in various types of habitats and depths (Tatipata & Mashoreng, 2019).

**Table 1.** The percentage of hard coral covers from 9 islands. The highest percent cover was in Tengah, Cemara Besar and Cemara Kecil island, while the lowest were in Sambangan, Sintok and Menjangan Kecil islands.

| Location | Coral cover (%) | Category* | Distance from Karimunjawa main port (KM) |
|---|---|---|---|
| Sambangan | 22.41 | severely damaged | 16.5 |
| Sintok | 35.1 | moderately damaged | 13.5 |
| Tengah | 77.49 | very good | 11.2 |
| Cemara Besar | 72.47 | good | 11.7 |
| Cemara Kecil | 72.6 | good | 9.22 |
| Menjangan Kecil | 33.09 | moderately damaged | 3.4 |
| Taka Menjangan Besar | 57.64 | good | 2.38 |
| Geleang | 64.39 | good | 9.84 |
| Burung | 50.17 | good | 10.9 |
| Average | 53.93 | good | 9.85 |

*According to the Decree of Ministry of Environment No. 4 of 2001 regarding the standard criteria for coral reef condition

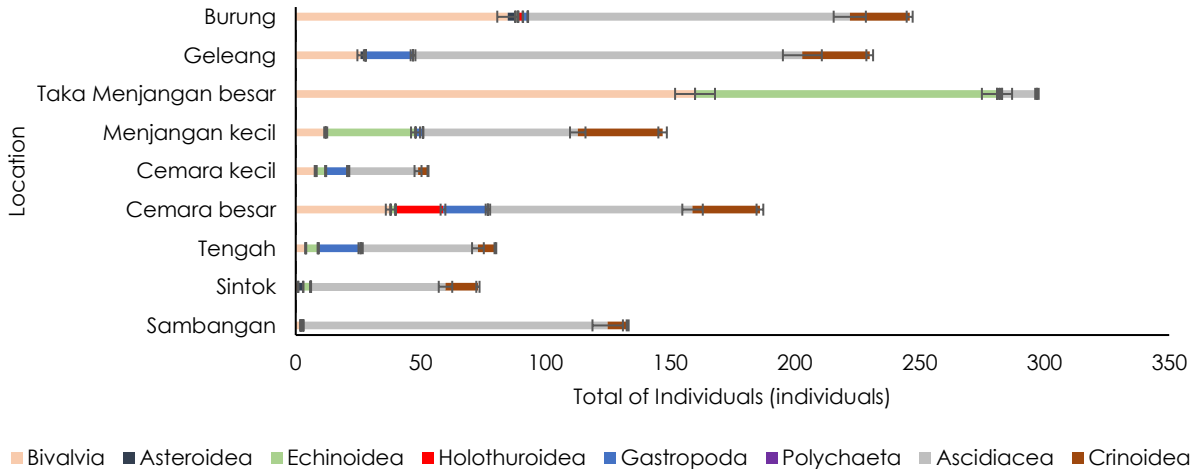


**Figure 2.** The abundance of megabenthos from 9 islands. The highest abundance was in Taka Menjangan Besar, while the lowest were in Cemara Kecil

According to Arbi & Sihaloho (2017), there are megabenthos that are targeted in monitoring, namely giant clams, trocha, lobsters, sea cucumbers, sea urchins, blue starfish, crown of thorn starfish, and drupella snails. The target megabenthos that can be found at the research location are giant clams, trocha, crown of thorn starfish, sea cucumbers, drupella, and sea urchins. Based on the results of the distribution of target megabenthos at each location shown in Figure 3., the largest number of targeted megabenthos was found in Taka Menjangan Besar as many as 122 individuals dominated by sea urchins.

The dominance of sea urchins in Taka Menjangan Besar indicates poor water conditions in Taka Menjangan Besar with high nutrient content in the waters as indicated by the density of sea urchins in Figure 4., as many as 0.864 individuals/$m^2$. The high nutrients in the waters of Taka Menjangan Besar can be caused by the La Niña phenomenon which can cause nutrients to be carried from land and caused by upwelling (Uneputty *et al*., 2022). Another factor that can cause high nutrients in the waters is high human activity such as tourism, ship traffic, ponds, and others, because the location of Taka Menjangan Besar is close to the Main Island which is densely populated. This makes the concentration of nutrients in the waters tend to be higher when compared to other locations. High nutrients can cause rapid growth of algae which are a food source for sea urchins. This is in accordance with Mutaqin *et al*., (2020), that sea urchins have the nature of grazers or algae eaters, so that there is a surge in the population of sea urchins in Taka Menjangan Besar due to the abundance of food sources.

Sea urchins are the most dominant target megabenthos at the research location with a total density of 1.23 individuals/$m^2$. When compared with the findings of target megabenthos in other areas, such as from the research of Kurniawan *et al*. (2023), which was conducted in the Seribu Islands in 2021, it shows that both locations have a very high number of megabenthos dominated by sea urchins, with the density of sea urchins in the Seribu Islands reaching 4.34 individuals/$m^2$. Karimunjawa and the Seribu Islands are locations that are both greatly influenced by human activities because of their easily accessible locations and are tourist destinations, which can cause nutrient pollution in the waters which causes a spike in the population of sea urchins. Meanwhile, the lack of megabenthos with economic values such as giant clam, sea cucumber, lobster, and trocha in research location indicate the high exploitation in Karimunjawa which can disrupt the balance of ecosystem and food chains (Toruan *et al*., 2024).

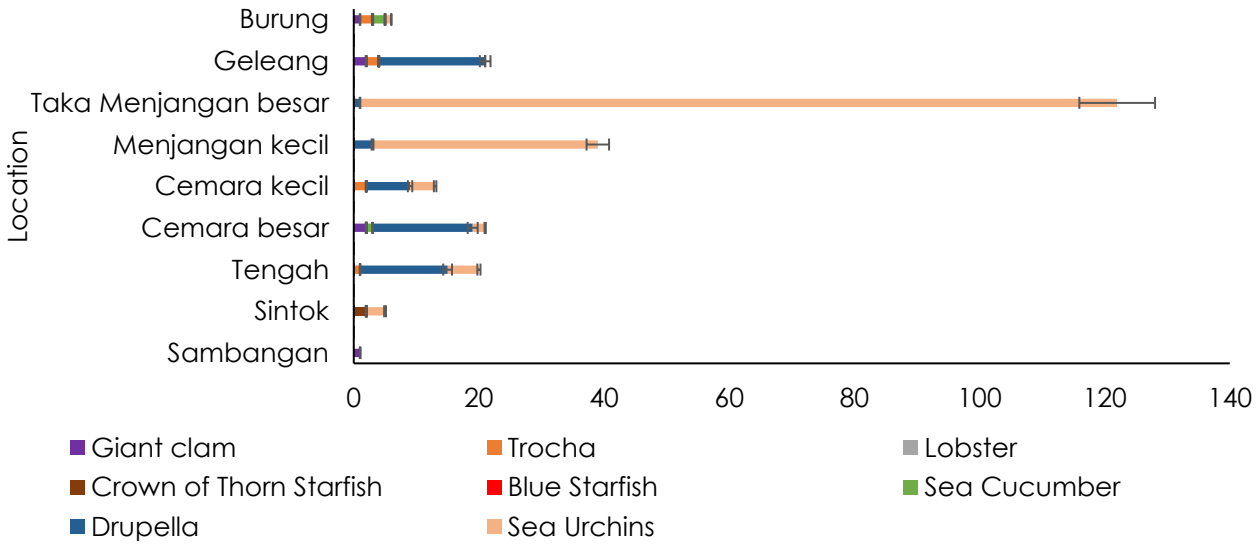


**Figure 3.** The abundance of target megabenthos from 9 islands. The highest abundance was in Taka Menjangan Besar, while the lowest were in Sambangan

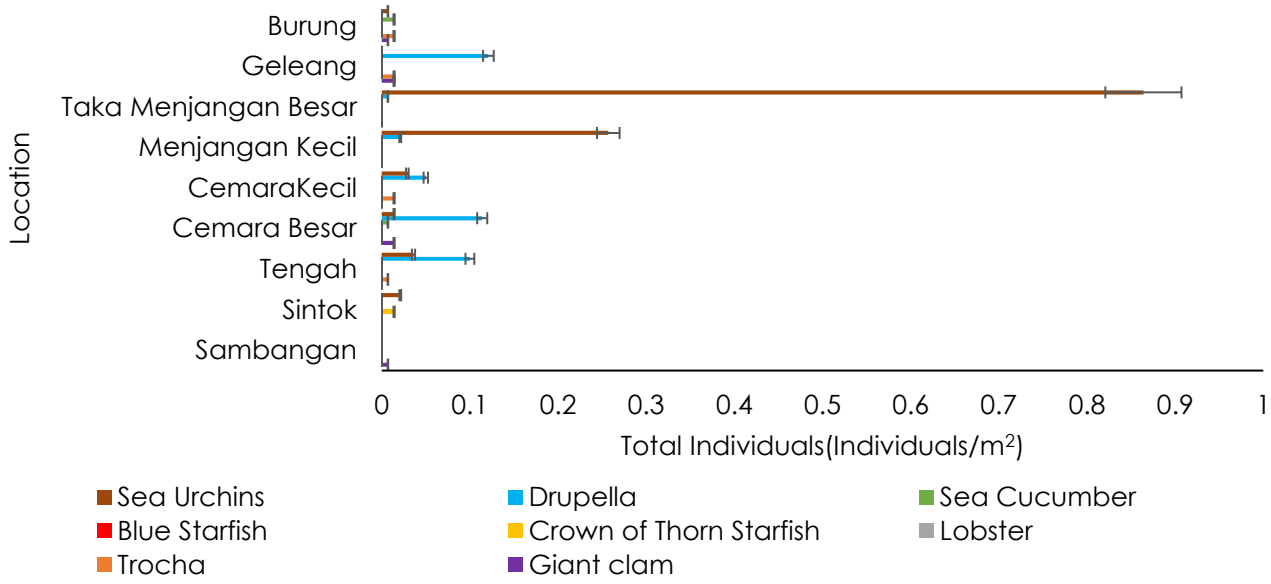


**Figure 4.** Density of target megabenthos from 9 islands. The highest density was in Taka Menjangan Besar, while the lowest were in Sambangan

The similar study was conducted by Durotunasha *et al*. (2023), which was located in Karimunjawa but on a different research island location, namely Kumbang Island in 2022, showing a significant difference in the number of giant clam with a total of 44 individuals compared to a total of 6 individuals found in all research locations in this study. This shows that Kumbang Island, which is located far from the main island, has more abundance of target megabenthos and lower levels of human exploitation when compared to all the islands that were the research locations in this study which was relatively closer to the main island. This is supported by Arbi and Sihaloho (2017), that Kima is one of the megabenthos with high economic value that is often exploited by humans.

The index results can be seen in Table 2., with the megabenthos diversity index showing that the average diversity category at the research location is moderate, high for evenness, and no dominance for a group of megabenthos. These results indicate that the condition of megabenthos diversity in Karimunjawa is still in fairly good condition, but not in ideal conditions as indicated by the highest diversity index result of only 1.578. This can be caused because the composition or number of megabenthos types can be influenced by changes and natural pressures (Na'u *et al*. 2022). This is supported by Yuniasih *et al*. (2022), which stated that there was a La Niña phenomenon that occurred in 2021-2022 which caused a decrease in sea surface temperatures and also hit Karimunjawa. Water conditions such as temperature, salinity, acidity, etc. affect the abundance and diversity of megabenthos in coral reef ecosystems (Riyantini *et al*., 2023). The growth of megabenthos depends on the optimal physical parameters of the waters, because the unsuitability of the physical parameters in the waters can cause stress on megabenthos, so that it can affect the abundance and diversity of megabenthos in a body of water (Saputri *et al*., 2023). The presence of human factors can also cause changes in the composition and number of megabenthos groups in Karimunjawa. However, the value of this diversity index can be influenced by how far the taxonomic level of the data is taken. This is because the Shannon Wiener diversity index is sensitive to changes in the number of species (Hidayat & Nurulludin 2017). This is supported by a comparison of the megabenthos diversity index values in Syahrul *et al*., (2022), which were taken to the species level, had a higher range of values, namely 1.571-1.834 compared to the range of values in this study which were taken to the family level, namely 0.359-1.578.

The results of the regression analysis on coral cover with megabenthos abundance, diversity index, evenness, and dominance showed positive correlation values (r) of 0.0004; 0.704; 0.513; 0.615

respectively. These values are in accordance with Rafli *et al*., (2022), showing a weak relationship between coral cover and abundance of megabenthos, but a strong relationship between coral cover and all other ecological indices. Following regression, analysis of variance (ANOVA) showed a significance (P value) of 0.958; 0.034; 0.158; 0.078 between coral cover and megabenthos abundance, diversity, evenness, and dominance indices, respectively. These results indicate that there is no significant effect between coral cover and abundance & ecological indices of megabenthos (P > 0.05), except for the diversity index (P < 0.05) (Fauzan *et al*., 2024). On the other hand, regression analysis showed that anthropogenic impact–represented by distance or accessibility from Karimunjawa main port– showed a medium positive correlation (r value of 0.44 and 0.37) but no significant effect (P > 0.05) on megabenthos abundance and diversity, respectively. However, there was a strong positive correlation (r value of 0.61 and 0.60) but no significant effects (P > 0.05) of distance from the main port Karimunjawa on the evenness and dominance indices of megabenthos, respectively.

The regression results show that hard coral cover does not have a significant effect on the abundance and ecological index of megabenthos other than the diversity index, and there could be other factors that have a greater influence on the abundance and ecological index of megabenthos in the coral reef ecosystem in Karimunjawa. Based on Mutaqin *et al*., (2020), there are other factors that can affect the abundance of megabenthos, namely water quality. Water quality can be influenced by natural and human factors. The La Niña phenomenon that occurred in 2021-2022 and hit Karimunjawa according to Yuniasih *et al*., (2022), caused a decrease in sea surface temperature and an increase in rainfall which could affect the concentration of salinity, acidity, and nutrient content in Karimunjawa Waters. The high human activity factor based on Kolibongso *et al*. (2024), such as tourism activities, ponds, ship traffic, and exploitation of economically valuable megabenthos can also affect the abundance of megabenthos in Karimunjawa. The proximity of coral reef ecosystems to population centers can increase the anthropological influence on the abundance and diversity of megabenthos, such as the impact on water quality due to human waste carried by water currents (Moira *et al*. 2020). The positive –although not significant– correlation between human factors and the abundance and diversity of megabenthos was seen from our research. Our research showed that, coral cover is a factor that has a significant influence on the

**Table 2.** Ecology Indices of Megabenthos in Karimunjawa

| Location | Ecology Indices | | | | | |
|---|---|---|---|---|---|---|
| | Diversity Indices | Category | Evenness Indices | Category | Dominance Indices | Category |
| Sambangan | 0,359 | Low | 0,228 | Low | 0,845 | There is a dominance |
| Sintok | 0,819 | Low | 0,510 | High | 0,582 | There is a dominance |
| Tengah | 1,267 | Medium | 0,651 | High | 0,400 | No dominance |
| Cemara Besar | 1,578 | Medium | 0,685 | High | 0,270 | No dominance |
| Cemara Kecil | 1,404 | Medium | 0,783 | High | 0,332 | No dominance |
| Menjangan Kecil | 0,896 | Low | 0,557 | High | 0,455 | No dominance |
| Taka Menjangan Besar | 1,331 | Medium | 0,827 | High | 0,298 | No dominance |
| Geleang | 1,067 | Medium | 0,548 | High | 0,490 | No dominance |
| Burung | 1,133 | Medium | 0,516 | High | 0,339 | No dominance |

level of megabenthos diversity in Karimunjawa. This can be caused by the condition of coral cover affecting the health of the coral reef ecosystem which plays an important role in the survival of the marine biota in it, including megabenthos (Kurniawan *et al*., 2023).

## CONCLUSION

This study concludes that the megabenthos in Karimunjawa is still in a good condition with the moderate diversity seem to be resulted from the good condition of coral cover. Other factor coming from the anthropogenic activity such as the distance and accessibility from the main port also strongly influence the evenness and dominance of megabenthos, therefore, with the increasing activities in Karimunjawa, further studies and monitoring will be necessary in the future.

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