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Condition of Coral Reefs at Mentigi Beach, North Lombok Regency

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Abstract: Climate change and excessive anthropogenic activities have an impact on coral reef damage. Coral reef damage can be seen from several criteria, one of which is the percentage of live coral cover. North Lombok is one of the districts on Lombok Island whose coral cover has been damaged. This research aims to identify marine biota, coral reef genus, analyze community structure and condition of coral reefs at Mentigi Beach. Coral reef genus data was taken using Coral Finder 2.0 Indo Pacific by Russel Kelley, while coral reef data was obtained using the UPT (Underwater Photo Transect) method at three stations with depths of 1-5 meters and 6-10 meters. The results showed that live coral cover at stations I, II, and III were 12.44%, 17.42%, and 32.46%, respectively. At a depth of 1-5 meters, it was found to be 21.93%, and 19.62% at a depth of 6-10 meters. There are 11 benthic categories, and 30 coral reef genera identified. The Porites genus is cosmopolitan in the research location. The diversity, evenness and dominance indices show that coral reef genera are evenly distributed with no one dominating the coral reef ecosystem at Mentigi Beach, Pamenang, North Lombok Regency.

Keywords: Condition of Coral; Coral Reef; Percentage of Coral Reef; Underwater Photo Transect.

Introduction

Indonesia is an archipelagic country consisting of 13,466 islands with an area of 1,922,570 km^2 and a water area of 3,257,483 km^2. Based on Law No. 4 of 2011, the total wealth of hard coral species *(ordo scleractinia) in* Indonesia reaches 2.5 million hectares, with 569 total species belonging to 82 genera [1]. Coral reefs are one of the most diverse ecosystems in the world, playing an important role in maintaining marine biodiversity [2]. Coral reefs are composed of the class Anthozoa, Phylum Cnidarians, which includes hermatypic corals or types of coral that can produce the lime substance $CaCO_3$ [3]. Ecologically, coral reefs are a place for breeding (breeding grounds), a growing place (nursery grounds), a place for fish to feed (feeding grounds), and provide shelter for various types of fish and other invertebrates [4].

Coral reefs in Indonesia experienced changes from 2015 to 2018. Of 1067 sites observed throughout Indonesia, 386 sites were found in the poor category, namely around 36.18%, 245 sites in the fair category, namely around 22.96%, and 70 sites in the very good category, namely around 6.56%. In observations made by Hadi et al, it was stated that when compared with the previous year, the coral reefs in the good and fair categories had decreased, but on the contrary, the coral reefs in the very good and bad categories had increased. Meanwhile, the percentage of cover for coral reefs in the Lombok Island region from a total of 36 sites is (2%) in the very good category, (7%) in the good category, (9%) in the fair category, and (18%) in the poor category [5].

Coral reefs are widespread along the coast throughout Indonesia because the water conditions are very supportive for coral reef life [4]. One of them is on Mentigi Beach, Pamenang, North Lombok Regency. This beach is one of the tourist destinations which is threatened with damage to the coral reef ecosystem due to human activities such as fishing, snorkelling, *spear fishing*, transportation across the three Gilis (Gili Meno, Gili Air, and Gili Trawangan) and so on. To ascertain the level of damage to coral reefs on Mentigi beach, it is necessary to conduct coral reef research. It is hoped that the results of this research will become additional references for the community, academics and government in managing coral reefs at marine tourism locations, especially Mentigi Beach. This research needs to be carried out because there is little information regarding the existence of coral reefs on Mentigi Beach, and as an effort to investigate the existence of coral reefs on Mentigi Beach.

Research methods

The tools and materials used in this research include Camera Underwater, Coral Finder 2.0, Global Positioning System (GPS), Hand Refractometer, pH meter, Roll Metter, Scuba Set, Thermometer, Plot (size 58 x 44 cm), Boat, Software Coral Point Count with excel Extension (CPC 4.1).

Field data collection was carried out at three-point areas determined based on human activity, namely station 1 is an area of minimal human activity located in the western part, station 2 is a port area located in the middle of Mentigi beach and station 3 is a beach tourism area located in the eastern part of Mentigi (Figure 1). In each area, data were collected at two different depth locations, namely 1-5 meters deep and 6-10 meters deep.

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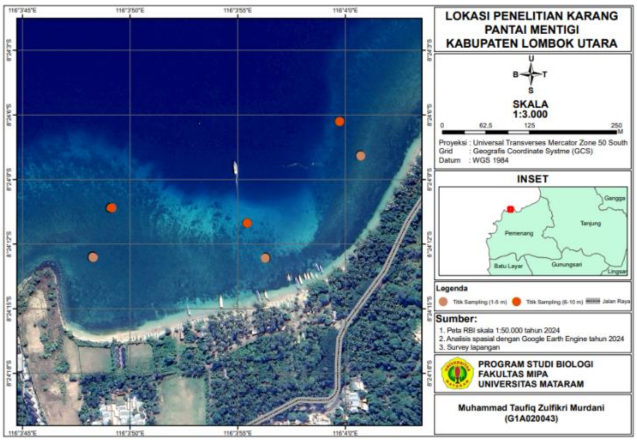

Figure 1. Map of Mentigi Beach Research Locations

Coral Reef Data Collection

Coral reef data is collected by diving (scuba dive*)* using the UPT method (Underwater Photo Transect) (Figure 2). Transects 50 m long were placed parallel to the coastline at the three stations at different depths (1-5 meters and 6-10 meters). Taking photos of coral reefs using a plot made from a 4-inch pipe measuring 58 cm long and 44 cm wide. Taking photos starts from the 1st meter for odd plots (1, 3, 5,...) on the left of the transect, while plots with even numbers (2, 4, 6,...) are taken on the right of the transect [6].

Figure 2. Method Underwater Photo Transect (UPT)

The UPT method is very effective in monitoring coral reef conditions because, according to Cahya et al., the UPT method has the lowest standard error and coefficient of variation compared to the LIT and PIT methods. Although the PIT method provides a higher average estimate of live coral cover, this method also has a relatively larger standard error and coefficient of variation, making it less effective for monitoring coral reef conditions [7]. Apart from that, the advantage of the UPT method is that it can shorten the time for collecting coral reef data, because the data is collected by taking underwater photos using an underwater camera. The photos obtained can also be used as archives that can be viewed again.

Data analysis

Identification of Benthic and Genus Coral Reefs

Photo samples of coral reefs in each plot identified the benthic category and genus of coral reefs with reference to Coral Finder 2.0 by Russel Kelley [8] and types of Indonesian coral reefs by Suharsono [9].

Coral Reef Coverage Percentage

Each photo of a coral reef plot is read using software Coral Point Count with Excel Extension (CPCe 4.1) to analyse the percentage cover of coral reef communities. The cover of each benthic in all coral reef plots is calculated using the formula from Giyanto et al., 2017 to obtain the percentage cover of the coral reef community [6]:

$$\text{Coverage percentage} \frac{\text{Number of points with live coral}}{\text{total number of observation point}} \text{x100\%}$$

Then the percentage cover value is interpreted as the condition of the coral reef status using the Decree of the State Minister for the Environment No. 4 of 2001 concerning quality standard criteria for damage to coral reef ecosystems [10], as listed in Table 1.

Table 1. Quality standard criteria for coral reef damage

Status	Category	(%) Cover
Good	Very well	100-75%
	Good	74.9-50%
Damaged	Currently	49.9-25%
	Damaged	24.9-0%

Diversity Index

The coral reef genus diversity index was calculated using the Shannon-Wiener formula in Odum (1993) [11].

$$H' = -\sum_{i=1}^{s} P_i \ln P_i$$

Information:
H': diversity index
P_i: ni/N
Ni: number of individuals or % cover of genus i or lifeform i of coral reefs
N: total number of individuals or total % cover of the genus in the coral research area obtained
S: number of coral reef genera

Based on the Shannon-Wiener diversity index, the following criteria were determined

H' < 1 = Low diversity
H' 1-3 = Medium diversity
H' > 3 = High diversity

Uniformity Index

The uniformity index can describe the stability of a coral reef ecosystem [12]. The uniformity index is calculated using the following formula:

$$E = \frac{H'}{lnS}$$

Information:
E : Uniformity index
Ln : Natural logarithm
S : Number of coral reef genera

The uniformity index criteria according to Krebs [13] are as follows:
$0 < E \leq 0.5$ = depressed community
$0.5 < E \leq 0.75$ = unstable community
$0.75 < E \leq 1$ = stable community

Dominance Index

The dominance index shows whether a genus dominates the coral reef ecosystem. The dominance of coral reef genera was calculated using the formula from Odum (1993) [11].

$$C = \sum_{i=1}^{s} \left(\frac{in}{N}\right)^2$$

Information:
C : dominance index
Ni : the number of colonies in each colony
N : number of colonies throughout the genus
S : number of coral colonies

Dominance index criteria according to Odum (1993) [11]. are as follows:
$0 < C \leq 0.5$ = Low dominance
$0.5 < C \leq 0.75$ = Moderate dominance
$0.55 < C \leq 1$ = High dominance

Results and Discussion

Based on research results at Mentigi Beach, 11 benthic categories were found including that is Hard Coral (HC), Recent Dead Coral (DC), Dead Coral with Algae (DCA), Soft Coral (SC), Sponge (SP), Fleshy Seaweed (FS), Other Biota (OT), Rubble (R), Sand (S), Silt (SI), And Rock (R). When compared with research by Derksen et al on the Kecinan coast, 9 benthics were found [14]. The benthic category that is not found at this location is silt and rocks.

This can happen because the current at Kecinan Beach is relatively strong; this current is what causes the mud deposition process not to occur, so that there is no silt found at this location. On the other hand, the substrate structure at Mentigi Beach was found to have a layer of mud, supported by the topography of Mentigi Beach in the form of a bay, so it has relatively calm currents. A calm current can cause sedimentation so that the mud cannot be washed away by the current.

Coral reefs generally carry out mutualistic symbiosis with *zooxanthellae*, the result of photosynthesis by algae *zooxanthellae*, whose symbionts make corals form reefs producing shell deposits made of calcium carbonate ($CaCO_3$) [2]. The photosynthesis process causes the production of calcium carbonate in coral reefs to increase, thus corals are divided into two, namely corals hermatipik, known as reef-forming corals, are characterised by the presence of *zooxanthellae*, unicellular symbionts, whereas corals ahermatipik do not have *zooxanthellae* [15]. The result of this activity is calcium carbonate deposits, which have a unique structure and shape. These characteristics are ultimately used to determine the type or species of coral animals [2].

Based on the identification results, a total of 30 coral reef genera were found, consisting of 29 hard coral genera and 1 soft coral genus. Based on this number, 20 genera were found at station I, 17 genera at station II, and 26 genera at station III. For different depths, the Genera obtained were 27. The following are the results of the identification of coral reef genera found in the waters of Mentigi Beach (Table 2) and (Table 3).

Table 2. Existence of Mentigi Beach Perstasiun Coral Reef Genus

Genus	ST I	ST II	ST III
Acropora	+	+	+
of the cave	-	+	+
Cyphastrea	+	+	+
Echinopora	-	+	+
Favia	+	+	+
Favites	+	+	+
Freeze	+	+	+
Galaxy	-	-	+
Goniastrea	+	+	+
Goniopora	+	-	+
Heliopora	+	+	+
Hydnophora	-	-	+
Leptastria	+	+	+
Lobophyllia	+	+	-
Merulina	+	-	+
Montastrea	-	-	+
Montipora	+	+	+
Oxypora	-	-	+
Pachyseris	+	-	-
Pavona	-	-	+
Platygyra	-	-	+
Pocillopora	+	+	+
Porites	+	+	+
Psammocora	-	+	+
Seriatopora	+	-	+
Stylophora	+	+	+
Caulastrea	+	-	-
After 100 years	+	-	-
Tubipora	+	+	+
Symphyllia	-	-	+

Description: (+) Yes, (-) No, (ST) Station

Several coral reef genera are cosmopolitan, meaning they can adapt to various environmental conditions. One of them is porites. Research conducted by Barcinta et al shows that the genus Porites is more dominantly found at a depth of 3-10 meters [16]. These results indicate that porites can be found in coral reef flat areas, Coral reef areas that appear at low tide (reef crest), and coral reef areas (reef slope) [17]. The Porites genus can be found at three stations and at different depths in relatively large numbers. The Porites genus is the most dominant among other hard corals, with a total of 326 colonies. Based on research that has been carried out, the genus Porites is more commonly found at Mentigi Beach compared to research conducted by Hakimi et al in Kuta Mandalika, namely 2% at PIT 1, 4% at PIT 2, and 2% at PIT 4 [18]. According to Aldyza, the Porites genus can adapt to environmental changes very well, even when compared to other types of hard corals [19]. Apart from that, porites can live in waters with high sedimentation and waters with fluctuating salinity [20], the distribution of the porites genus is relatively wide throughout Indonesian marine waters, so that the presence of porites in the ecosystem acts as a superior competitor for algae so that the growth of algae can be significantly hindered. However, on the contrary, the presence of algae does not have a major effect on the growth of porites [21].

Table 3. Existence of Mentigi Beach Deep Coral Reef Genus.

Genus	Depth 1-5 m	Depth 6-10 m
Acropora	+	+
of the cave	+	-
Cyphastrea	+	+
Echinopora	+	+
Favia	+	+
Favites	+	+
Freeze	+	+
Galaxy	+	+
Goniastrea	+	+
Goniopora	+	+
Heliopora	+	+
Hydnophora	-	+
Leptastria	+	+
Lobophyllia	+	+
Merulina	+	+
Montastrea	+	+
Montipora	+	+
Oxypora	-	+
Pachyseris	+	+
Pavona	+	+
Platygyra	+	+
Pocillopora	+	+
Porites	+	+
Psammocora	-	+
Seriatopora	+	+
Stylophora	+	+
Caulastrea	+	+
After 100 years	+	-
Tubipora	+	-
Symphyllia	+	+

Description: (+) Yes, (-) No, (Depth) Depth

Meanwhile, coral reefs that are very rarely found at the research location at each station are the Ctenactis genus. The presence of the Ctenactis genus cannot be found at stations II and III, factors that influence the low presence of the Ctenactis genus. caused by unsupportive environmental conditions caused by human activities that are not environmentally friendly [22], such as at station II there is a harbor, and at station III there is a beach tourism area with activities such as snorkeling, swimming, and kayaking or canoeing which causes the genus ctenactis very rare to find. On the Mentigi coast, the fungidae family is often found upside down, and the ribs are upwards so that the corallites, which should be facing upwards, cannot survive. Corallites that face downwards will make it difficult for coral animals to get sunlight, so that the photosynthesis process takes place, *zooxanthellae* will be disturbed. Meanwhile, at different depths, more coral reefs were found at a depth of 1-5 meters, with 526 colonies found, compared to a depth of 6-10 meters, with 468 colonies found. According to Loya (1972), the number of corals will decrease significantly with water depth, and the average size of coral colony species in the reef flat area (reef flat) is smaller than the reef top area (reef crest) [23]. The difference in the number of corals found on Mentigi Beach at different depths is influenced by the supply of sunlight entering the waters. This is in accordance with the statement from Tanamal et al that a small amount of light absorbed will inhibit the process of photosynthesis and hinder the survival of coral reefs [24].

Benthic Structure in Coral Reef Ecosystems

Based on the results of research conducted, 11 benthic species were found at Mentigi Beach. The percentage of benthic cover (%) varied. The number of benthic categories found is different at each station. At stations I and II, 11 benthics were found, while at station III, 10 benthics were found. Category: The benthic values found are generally the same, but the difference is in the category of *Sponge*. At station III, nothing was found. *Sponges* generally can live in clear waters and do not have strong currents, because sponges have a fragile structure and are susceptible to strong currents [25], which makes them unviable in these areas. At station III, when collecting field data, the current was quite strong because the water flow was from the east.

Coral reef ecosystems are the most productive ecosystems and have high biodiversity due to their diversity. This results in many benthic variations which make the diversity of coral reef ecosystems even higher [26,14]. The highest percentage of benthic components is at Mentigi Beach at each station, namely sand (16.59% - 36.71%), while the lowest is soft coral (0.04% - 0.07%).

Table 4. Percentage Cover of Perstation Benthic Category

Category benthic	% Cover Benthic Category Station		
	S I (%)	St II (%)	St III (%)
Coral (HC)	12.44	17.42	32.46
Recent Dead Coral (DC)	0.60	0.40	0.58
Dead Coral with Algae (DCA)	11.10	11.60	11.82
Soft Coral (SC)	0.04	0.04	0.07
Sponge (SP)	0.30	0.22	0.00
Fleshy Seaweed (FS)	33.97	21.23	15.09
Other Biota (OT)	12.96	5.97	12.88
Rubble (R)	6.82	3.70	4.40
Sand (S)	16.59	36.71	21.59
Silt (SI)	0.75	1.27	1.06
Rock (RK)	4.42	1.44	0.04

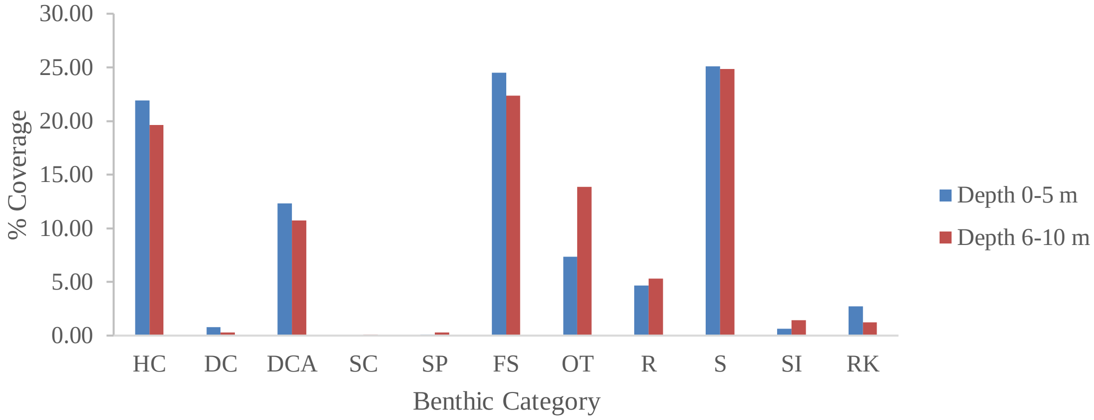

Figure 3. Percentage Coverage Diagram of Deep Benthic Category

Figure 4. Human Activities at Mentigi Beach

The percentage of live coral cover at the three stations ranges from 12.44% - 32.46%, which shows that Station I is in the damaged category and has damaged status with a live coral cover percentage of 12.44%, while Station II is in the damaged category and has damaged status with a live coral cover percentage of 17.42%, and Station III is in the damaged category and has moderate status with a live coral cover percentage of 32.46%.

The percentage of live coral cover at different depths is below 25%, namely around (19.62% - 21.93%). This value is very different from the percentage of live coral cover between stations, which is above 25%. This value is compared with the percentage of live coral cover in Hakimi, et al.'s research in Kuta Mandalika, which was 2% - 30% [18], and when compared with the percentage of live coral cover on Kecinan Beach conducted by Derksen, et al., which was 3.58% - 0.90% [14]. The percentage of coral reef cover found at Mentigi Beach is higher when compared to the two research locations. The percentage of live coral cover obtained at each station ranged from 12.44% - 32.46%. Only one of the three stations is in the medium category at station III, namely 32.46%.

Conditions at the other two locations are still classified as damaged. Based on Table 5, the highest live coral cover was found at station III. Stations I and II are thought to be due to human (anthropogenic) activities that damage coral reefs, such as traditional fishing using fishing rods which at any time can step on coral reefs, spear fishing, and crossing activities on the three Gilis which can cause sedimentation due to ship propellers which cause the corallites to close, thereby inhibiting the photosynthesis process and causing bleaching. Apart from that, the damage at these two stations was also influenced by pollution in the form of sediment from organic materials carried by the current. The sediment is thought to come from ship or boat building activities, because the people around the research location are known to be involved in this field. Apart from that, rubbish from land was also found in coral reef locations.

Damage to coral reefs at the research location is not only caused by human activities but is also influenced by natural factors. Measurement of environmental factors shows almost uniform results at all research stations. In addition, climate change is the cause of the bleaching phenomenon or bleaching on coral reefs. As research conducted by Netty et al. explains, bleaching is caused by global warming factors, which are thought to originate from human activities that do not pay attention to the preservation of the surrounding environment [27]. The changes that occur affect the hot temperature of sea water, where the increase in temperature threatens the life of coral reefs, which were previously accustomed to stable temperatures, so that they have the potential to experience damage when coral reefs face pressure or imbalance in their environment. Therefore, corals release symbiotic algae. *zooxanthellae*, which live in the tissue and play a role in providing colour and nutrition. As a result of this release, coral reefs turn white (Bleaching) [28,29].

The percentage of benthic category components does not differ much between stations, the highest percentage is between depths, namely sand (24.85% - 25.07%) and the lowest is soft coral (0.02% - 0.07%). The results of the percentage cover analysis of benthic categories that have been carried out show that the most dominant benthic category, both per station and per depth, is sand namely, at each station it was obtained (16.59% - 36.71%) while at different depths it was obtained (25.07% - 24.85%).

The second highest percentage is fleshy seaweed (FS), per station, which was obtained (15.09%-33.97%), with the highest percentage obtained at station I. The high appearance of algae could be caused by the accumulation of nutrients in that area. According to Safira et al., the higher the nutrient concentration, the higher the presence of biota such as algae (fleshy seaweed) [30]. Therefore, at station I, there is a hill that is used as agricultural land by residents, which results in a buildup of nutrients and can fertilise the growth of macroalgae itself. Meanwhile, at different depths, it was found to be around (22.37% - 24.50%). High growth of macroalgae (fleshy seaweed) in Mentigi Beach can be caused by the input of water from the river mouth or waste from the surrounding residents that bring nutrients and can cause the fertilisation of algae growth. Excess algae density will occur when the input of nutrients received is higher [31].

Dead Coral or low dead coral (DC), namely, at each station obtained, namely, (0.40% - 0.60%). Meanwhile, at different depths, it was obtained, namely (0.27% - 0.78%), with the highest percentage being at a depth of 1-5 meters. Dead corals then experience coral bleaching can occur when corals lose zooxanthellae which can cause coral death and threaten marine biodiversity [32] One of the causes of corals losing zooxanthellae is degradative or sudden changes in temperature or ambient level (increasing or decreasing) beyond the tolerance limits of the coral reef, thus causing coral bleaching [33-34].

Dead Coral Algae (DCA) has a percentage that is not very different, both at each station and at different depths. At each station, the number of DCA is found at station III, while at different depths, DCA is mostly found at a depth of 1-5 m. The death of coral reefs caused by algae cannot be separated from human activities such as development in coastal areas, which can result in dumping household waste directly into the sea.

Rubble or coral fractures were more commonly found at station I, with a percentage of 6.82%. Meanwhile, at different depths, coral fractures are more commonly found at a depth of 5-10 meters. Lots of its Rubble found on Mentigi beach due to several factors, one of the factors causing the corals to suffer Rubble, namely human activities such as fishing and tourist activities. This activity can cause coral to break due to stepping on coral and experiencing coral fractures. Apart from that, coral fractures can also be caused by ship anchors, which are characterized by damage to the coral, which is shaped like a crater and contains coral fragments [15]. Additionally, coral branching with fragile branch structures tends to be vulnerable to strong ecological stress, especially during the west monsoon from December to March, when high waves and strong currents often occur, causing damage to coral branches.

Coral Reef Damage Status

Based on research that has been carried out, 30 coral reef genera were obtained with a total of 994 colonies. The genus commonly found on Mentigi Beach is the genus Porites, with a total of 326 colonies. Corals of the genus Porites are mostly solid, and corals are generally found in waters and easily adapt to turbid and sedimented water conditions, in addition to being resistant to bumpy areas [30].

The coral reef ecological index measured at the three research locations based on stations is relatively different (Table 5). The genus diversity index value at station I was 2.23, at station II was 1.74, and at station III was 2.38, belonging to the medium category. Meanwhile, the diversity index (H') values at different depths were found to be almost the same at both depths (Table 8). The diversity index value at a depth of 1-5 m was found to be 2.28, and at a depth of 6-10 m was found to be 2.25. The diversity index (H') is used to show the relationship between genus diversity found at the research location. The higher the value of the genus diversity index (H') found, the more genera there are in that area [34]. Based on the results of data analysis, the diversity index at Mentigi Beach is classified as moderate. The difference in diversity index (H') values at each station is caused by the large number of colonies of a particular genus occupying the area, resulting in space competition between genera to obtain the same living space.

The uniformity index is used to determine the uniformity of the genus population in the coral reef community (E'). The uniformity index describes the distribution of the genus in a community. The more evenly distributed the colonies between species, the more the ecosystem balance will increase [35]. The uniformity index value at each station varies, namely at station I it is 0.76, at station II it is 0.60, and at station III it is 0.74. Station II and Station III are in the unstable category. Station I is included in the stable category because it has a more even distribution of the genus. Based on the results of the uniformity index, it was found that the three stations were in the unstable community category. Meanwhile, at different depths, namely 1-5 m, a uniformity index of 0.69 was obtained and at a depth of 6-10 m, a uniformity index of 0.70 was obtained. The results obtained at different depths fall into the unstable community category. The total uniformity index, both between stations and between different depths, is in the unstable category.

Table 5. Coral Reef Community Ecological Index Based on Station Genus at Mentigi Beach.

Index	ST I	ST II	ST III
Diversity (H')	2.23	1.74	2.38
Uniformity (E)	0.75	0.60	0.73
Dominance (C)	0.15	0.31	0.14

Table 6. Coral Reef Community Ecological Index Based on Genus at Different Depths on Mentigi Beach.

Index	Depth 1-5	Depth 6-10
Diversity (H')	2.28	2.25
Uniformity (E)	0.69	0.70
Dominance (C)	0.16	0.17

The dominance index value ranges from 0 to 1; the greater the value, the greater the tendency for a particular species to dominate the population [36]. From the results of calculating the dominance index at each station, namely at station I, it was found to be 0.15, at station II, 0.31, and at station III, 0.14. Meanwhile, at different depths, it was found to be 0.16 at a depth of 1-5 m and 0.17 at a depth of 6-10 m. The results from different stations and depths at Mentigi Beach are in the low dominance category. These results indicate that there is no genus that dominates at Mentigi Beach, either from each station or in depth. These results are in accordance with the dominance index criteria from Odum (1993) [11].

The percentage of live coral cover at the three stations ranges from (12.44% - 32.46%), which shows that at Station I it is in the damaged category with a percentage of live coral cover of 12.44%, while at Station II it is in the damaged category with a percentage of live coral cover of 17.42%, and at Station III it is in the moderately damaged category with a percentage of live coral cover of 32.46%. From these results, there are more live coral reefs at Station III. Although coral reefs are often found in ecosystems that are poor in nutrients and have low primary productivity, primary productivity in the coral reef ecosystem itself is very high [3].

One of the factors that influences the life of coral reefs is currents. According to Vera et al, Poor current speed will affect the growth of coral reefs and biota in the waters [37]. This is because when sampling coral reefs at station III, the current was felt to be quite strong. Strong currents can clean coral reefs from sedimentation deposits and function to bring food to coral reefs. Meanwhile, at station I there is more macroalgae growth because at station I there are hills, which people use as land which causes a buildup of nutrients which can accelerate the growth rate of macroalgae, while at station II there are human activities such as crossings to Gili Meno, Air, and Trawangan which can increase the turbidity of sea water so that sedimentation such as sand is lifted and covers parts of the coral polyps and the turbidity that occurs can reduce the penetration of sunlight which can cause disruption to the photosynthesis process in *zooxanthellae*, a shipbuilding area and also a river that carries pollutant waste from both villa waste and community waste. This can cause damage to coral tissue and can lead to coral death.

At different depths, it was found that the percentage of live coral cover was below 25%, namely around (19.62% - 21.93%), falling into the damaged category. This value is very different from the percentage of live coral cover between stations, which is above 25%. From the results of the percentage of coral cover, more coral reefs live at a depth of 1-5 m compared to a depth of 6-10 m. The diversity, distribution and growth of hermatypic corals depend on their environment. This condition is not always fixed, but often changes due to disturbances, whether originating from nature or human activity. Disturbances can take the form of physical, chemical or biological factors [38]. One of the physical factors influencing the growth of coral reefs is the intensity of sunlight, because sufficient sunlight must be available so that photosynthesis can be carried out *zooxanthellae* can be implemented well, so that the coral's ability to form reefs can be implemented [39], so that the depth factor influences the growth of coral reefs. According to Kinsman (1964) that coral reefs can grow well at depths of less than 20 m [40].

Based on the Decree of the Minister of Environment No.4 of 2001 concerning quality standards for coral reef damage [10] that the coral reef ecosystem on Mentigi Beach is included in the category damaged (Table 1). The negative impacts of damage to coral reef ecosystems not only impact the environment, but also impact the lives of coastal communities, because coastal communities utilise marine resources as a source of life for the community itself [41-42]. Recent research also shows that the impact of coral reef degradation due to human activities, such as unsustainable fishing and environmental pollution, continues to worsen this situation [43]. On Mentigi beach, there are also human activities that can damage coral reefs, such as fishing activities and snorkelling activities, which, at times, step on coral reefs and affect the condition of the coral reefs.

Considering how vital the role of coral reef ecosystems is, it is necessary to take steps to conserve coral reef ecosystems, so that the recovery of damaged coral reefs can be handled quickly and precisely. Conservation strategies that can be carried out are coral reef transplant rehabilitation using the spider web method, the square iron frame method, and the PVC pipe method at locations where the coral reef status is in the damaged category to restore coral reefs and create artificial reefs from cement as a medium for attaching coral polyps. After several conservation strategies have been carried out, there needs to be consistent maintenance and monitoring to get maximum results. The monitoring process can make it easier to monitor the condition of coral reefs, as well as identify and predict changes that will occur in the future. Then the next step is to educate the public about the importance of coral reef ecosystems from an early age and to socialize the functions and benefits of coral reefs. This step requires support led by the government, as policymakers, academics, and local communities who interact with coastal areas daily and directly utilise coral reef ecosystems.

Conclusion

There are 11 types of benthic categories and 30 genera of coral reefs with a total of 994 colonies found in Mentigi Beach. Category benthic dominates on Mentigi Beach, namely sand, with the commonly found genus being genus Porites, with a total of 324 colonies. Porites are known to have a wide distribution, with higher dominance in almost all research stations. The percentage of live coral found at Mentigi Beach at each station ranged from 12.44%-32.46%. The highest percentage was found at station III, whereas the lowest percentage was found at station I. Meanwhile, at different depths, namely at a depth of 1-5 m, it was found to be 21.93%, and at a depth of 6-10 m, it was 19.62%. The results obtained show that the live coral on Mentigi Beach is in the damaged category based on the Decree of the Minister of Environment No. 4 of 2001. Therefore, the sustainability of the coral reef ecosystem on the Mentigi coast needs to be maintained. Several conservation steps can be taken, including coral reef transplant rehabilitation (methods such as spider web, square or using PVC pipes), creating artificial reefs as a place for polyps to attach, and carrying out regular monitoring.

Author's Contribution

Muhammad Taufiq Zulfikri Murdani: Conceptualized and designed the research, collected data, analyzed data, and wrote the article. Dining Aidil Candri: helped design the research. Hilman Ahyadi: revised the data analysis.

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