Coral cover and reef fishes in the Karang Takat patch reef, Sumenep, Madura, Indonesia

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Abstract. Karang Takat Patch Reef Sumenep is a coral reef ecosystem located between Gili Labak Island and Gili Genting Island, which means that the coral reef ecosystem is directly impacted by activities that occur on both islands. The abundance of reef fish is closely tied to the health of the coral reef ecosystem. This study aims to determine the coral cover and community structure of reef fish communities, including abundance, diversity index, evenness index, and dominance index. The study was conducted in August 2023. Coral cover was collected using an Underwater Photo Transect. Reef fish data were collected using the Underwater Visual Census method with transects of 70 meters and a width of 5 meters. Coral cover in Karang Takat was 5.13%, categorized as damaged. 17 species of fish were found with a total of 148 individuals, including the families Chaetodontidae, Pomacentridae, and Labridae. Species of the family Pomacentridae are the most common compared to other species. The reef fish diversity index (H') was 2.35, which is included in the moderate diversity. The Evenness Index (E) in the Karang Takat was 0.48, which indicates less stable conditions. The reef fish dominance index (D) is 0.14, which indicates a low dominance.

1 Introduction

Coral reefs are an ecosystem that is in symbiosis with members of the Cnidaria phylum which can produce an exoskeleton from calcium carbonate. Coral can be colonies or solitary, but almost all hermatypic coral are colonies with various individual coral animals or polyps living in small bowls or corallites within a massive framework [1]. Coral reefs are usually known as complex and productive ecosystems with a high diversity of biota such as molluscs, crustaceans, and reef fishes. The biota that lives on coral reefs is a unified community that includes a collection of biota groups from several trophic levels, where each part of the coral reef community is closely dependent on the others [2].

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Reef fish communities are one of the components of the coral reef ecosystem. The presence of reef fishes in a coral reef ecosystem is very important from ecological and economic aspects [3]. From the ecological aspect, reef fishes play an important role, one of which is in maintaining the balance of the ecosystem. The economic aspect of reef fishes functions as a source of food, ornamental fish and potential income for human life [4]. Reef fishes are a bioindicator of good coral reef conditions. Reef fishes are a group of fish taxa whose lives are associated with the coral reef ecosystem environment [5]. Shi et al. [6] found 252 fish families inhabiting coral reefs and majority are from the order Perciformes, consisting of 10 families, namely Gobiidae, Labridae, Pomacentridae, Apogonidae, Bleniidae, Serranidae, Murraenidae, Syngnathidae, Chaetodontidae, and Lutjanidae. The reef fish species diversity and abundance is determined by aquatic environment condition, the shape and extent of coral reefs, so that coral reefs state and the aquatic environment in terms of space utilization and food provision will increase the reef fishes species diversity and abundance in the coral reef ecosystem [7].

Sumenep District is part of the districts in East Java Province that has many small islands with a total of 126 islands, including 48 inhabited islands and 78 uninhabited islands [8]. Karang Takat is patch reef located between Gili Labak Island and Gili Genting Island, Sumenep Regency. Karang Takat has a very extensive coral reef ecosystem and many diverse marine animals in the area. These waters are used as a fishing route for fish, and not far from this location, there are cages used by fishermen to store fish catches. It is believed that the activities of fishermen can affect the condition of coral reefs in these waters. This study needs to be carried out because coral reefs have a very important function for coastal and coastal ecological life, especially for coral animals that require nutrients. This study aims to determine the coral cover and the reef fish community structure in the Karang Takat, Sumenep.

2 Materials and methods

This research was conducted in August 2023. This research location is between Gili Labak Island and Gili Genting Island. These waters are known as Karang Takat (Figure 1).

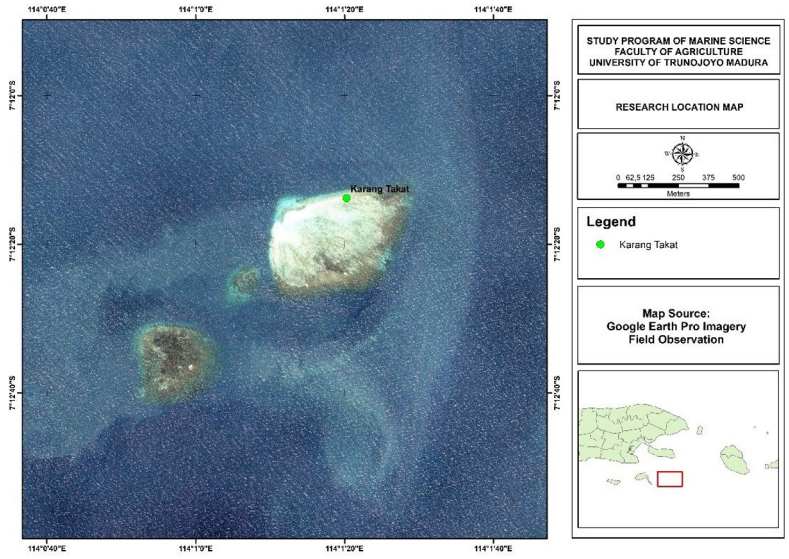

Fig. 1. Map of research locations of coral cover and reef fish community structure in Karang Takat, Sumenep.

2.1 Coral cover data collection

This data collection uses the UPT (Underwater Photo Transect) method [9]. The UPT method is a method that utilizes advances in digital camera and computer software technology. Underwater data collection using an underwater camera, data taken in the form of photos. Each data collection point is drawn along a 50-meter line using a roll meter, and each meter is photographed using an iron frame with a size of 58 x 44 cm. Taking photos is done vertically in the water (Figure 2). Photos taken were analyzed with CPCe (Coral Point Count with Excel extensions) software to help obtain coral cover data.

Coral cover percentage was classified according to the criteria in the quality standards of the Decree of the Minister of Environment No. 4 of 2001 can be seen in Table 1.

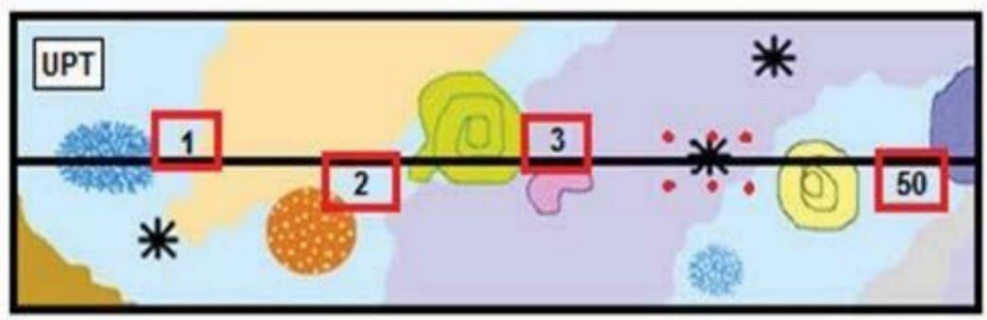

Fig. 2. Illustration of data collection with the UPT (underwater photo transect) method [9].

Table 1. Coral cover criteria.

Condition	Category
Damaged	0 – 24,9 %
Medium	25 – 49,9%
Good	50 – 74,9%
Very Good	>75%

2.2 Reef fish data collection

Reef fish data were collected using underwater visual census on line transects. The transect line is stretched 70 meters aligned to the coastline, installed to represent the coral reef area (Reef Flat) [10]. The laying of the line transect was done using scuba diving equipment. The observation area for reef fishes is 2.5 meters to the left and 2.5 meters to the right, so that the observation area is 350 m^2 (Figure 3).

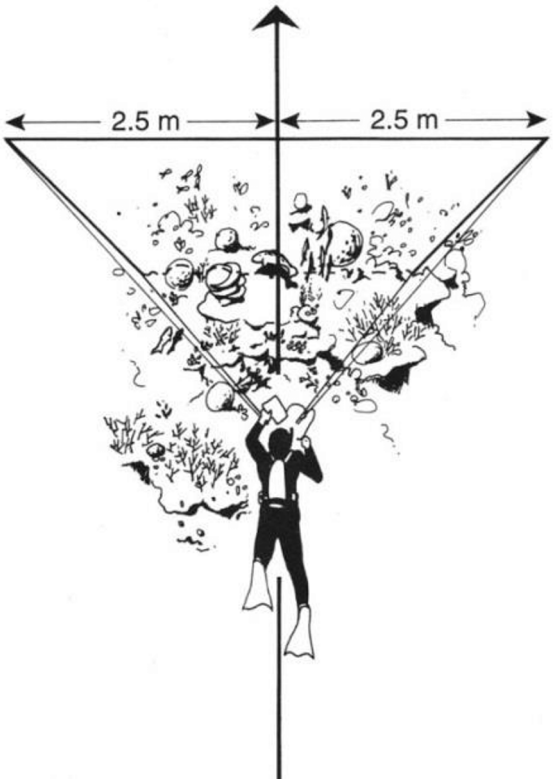

Fig. 3. Illustration of reef fish data collection using underwater visual census

2.2.1 Reef fish density

According to Ernaningsih et al. [11] Fish density can be calculated using the formula:

$$N = \frac{n}{A} \quad (1)$$

With N is individual fish density (ind/unit area), n is the number of individual fish, and A is the observation area (350 m^2).

2.2.2 Fish diversity index

The condition of reef fishes and the surrounding ecosystem can be determined through the diversity index. The diversity index (H') The diversity index (H') is used to assess the level of biodiversity of a community. The formula of Shannon-Weiner index used is [12]:

$$H' = \sum_{i=1}^{n} Pi \ln Pi \quad (2)$$

With H' is diversity index, Pi is comparison of the number of individuals of the i-th species with individuals, and i is 1, 2, 3, …, n

The diversity index categories are as follows: $H' \leq 1$ is low diversity, $1 < H' \leq 3$ is medium diversity, and $H' \geq 3$ is high diversity.

2.2.3 Evenness index

The Evenness Index (E) is used to measure the degree of equilibrium in the number of individuals between species in a community. Ecosystems are considered balanced indicated by evenly distributed individuals. The formula used is [11]:

$$E = \frac{H'}{\ln(s)} \quad (3)$$

With E is the evenness index, H' is the diversity index, and S is the species richness (total number of species).

The evenness index value ranges from 0-1. Furthermore, the uniformity index value based is categorized as follows: $0 < E \leq 0,5$ is communities that are stressed, $0,5 < e \leq 0,75$ is a community is unstable, and $0,75 < e \leq 1$ is a stable community.

2.2.4 Dominance Index

The dominance index (D) is used to see the presence of certain species whose numbers dominate in a community. The dominance index formula is as follows [11]:

$$D = \sum_{i=1}^{n} Pi^2 \quad (4)$$

With D is the dominance index, Pi is the number of individuals in the i-th species, and i is 1,2,3,..,n

The dominance index value ranges from 0 - 1 with the following categories: $0 < c < 0,5$ is low dominance, $0,5 < c \leq 0,75$ is medium dominance, $0,75 < c \leq 1,0$ is high dominance.

3 Materials and methods

3.1 Coral cover

The results of the research on coral cover in the Karang Takat waters obtained Hard Coral (HC), Dead Coral (DC), Dead Coral with Algae (DCA), Fleshy Seaweed (FS), Other (OT), Rubble (R), Sand (S), Rock (R) (Figure 4). Hard Coral gets 5.13% which is based on the percentage category of coral reef cover according to the Decree of the Minister of Environment No. 4 of 2001, categorized as damaged. Dead Coral in this study had the highest result of 48.07%. The amount of dead coral and rubble in these waters is due to these waters being a fishing boat route and a location to look for fish. According to Luthfi et al. [13] damaged coral reefs could be triggered by human activities like placing anchors carelessly. According to Magris et al. [14], overfishing can alter the coral reefs state and can reduce coral species population. Marine activities that can threaten coral reef damage, such as oil spills, port activities, littering, and dropping anchors carelessly, can result in not maximizing coral reef growth [15].

Coral fragments (rubble) in these waters are a result of 39.60%. Rubble is usually caused by predatory fish, erosion, and low water brightness [16]. The presence of Dead Coral with Algae is caused by nutrient content that supports the growth of macroalgae and can cover the sunlight that coral reefs need for photosynthesis [17]. Coral reef damage can also be caused by the amount of macroalgae in the waters [18]. Too much macroalgae growth can cause coral health problems because macroalgae will cover the coral and can prohibit photosynthesizing optimally. Macroalgae will also compete with corals to fill space and interfere with the coral recruitment process [17].

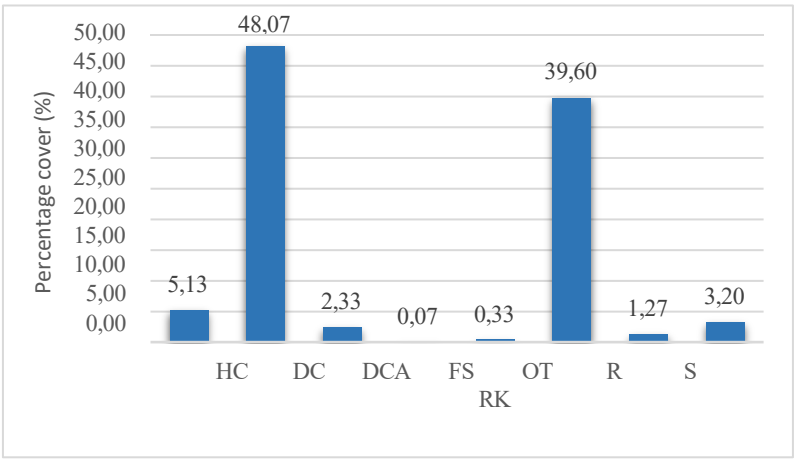

Fig. 4. Percentage of coral cover of Karang Takat, Sumenep.

The types of lifeforms obtained in these waters are Acropora Digitate (ACD), Coral Branching (CB), Coral Massive (CM), Coral Mushroom (CM), Coral Submassive (CS). The highest result was obtained by Coral Massive (CM) of 2.33% (Figure 5). Coral Massive usually lives in currents and can receive pressure from breakwaters [19]. Massive Corals grow on outer reefs that have strong currents, usually Branching Corals grow along the reef edge and the top of protected or slightly exposed slopes [20]. The absence of Branching Corals can be due to the large number of dead corals in these waters [17]. Strong waves provide a place for corals to thrive [17].

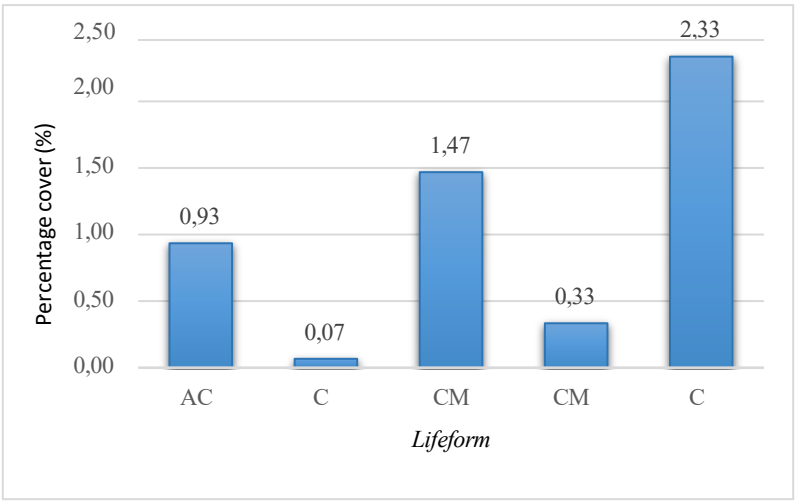

Fig. 5. Types of coral reef life forms found in Karang Takat, Sumenep.

This research is much different from research conducted by Insafitri et al. [21] in the waters of Gili Labak island, were found 74% of coral cover. Research conducted by Insafitri et al. [21] with 2 points (snorkeling area and control area) produced different types of lifeforms and coral cover. In the snorkeling area, the percentage of live corals is 74% and the control area gets a percentage of live corals of 64%, at both points getting dead corals with the same results, namely 4%. According to Insafitri et al. [21] there are 11 types of lifeforms obtained, namely 5 forms of acropora and 6 forms of non-acropora. The forms of acropora

obtained include Acropora Branching, Acropora Digitate, Acropora Encrusting, Acropora Submassive, Acropora Tubulate and non-acropora forms obtained include Coral Branching, Coral Encrusting, Coral Foliose, Coral Massive, Coral Mushroom, and Coral Submassive.

3.2 Reef fish community structure

3.2.1 Composition of reef fish

The results of observations of reef fishes were found with a total of 148 individuals including the families Chaetodontidae, Pomacentridae and Labridae shown in Table 2. Observations made showed that the number of families and species of coral reef fish found in Karang Takat waters was 3 families and 17 species, respectively. The reef fish density in Karang Takat, Sumenep was 148 individual/350 m^2. Toni et al. [22] found different results, where 93 species and 19 families were found with a total of 4,300 individuals in the waters of Halang Melingkau Island, South Kalimantan Province. This difference is caused by habitat conditions and topography as well as activities in different coastal areas. The impact of community activities has an influence on changes in the quality of the aquatic environment which then directly or indirectly affects the growth and survival of coral and reef fish [22]. At the research location, namely Karang Takat, many coral fragments and rubbles were found. This is because the location of Karang Takat is between the islands of Gili Labak and Gili Genting so that the coral ecosystem is influenced by the activities of the two islands.

The reef fishes obtained can be grouped into three functional groups, namely indicator fish, target fish and major fish. The indicator fish group is from the Chaetodontidae family and the major fish group is found to be the Labridae and Pomacentridae family. No target fish was found. The number of indicator fish species from the Chaetodontidae family found was 1 species, 2 species of major fish from the Labridae family and 14 species of major fish from the Pomacentridae family.

Table 2. Types of reef fish found in Karang Takat, Sumenep.

No	Category	Species	Total	Family
1	Indicator Fish	*Chaetodon octofasciatus*	2	Chaetodontidae
2	Major Fish	*Labroides dimidiatus*	3	Labridae
3		*Halichoeres hortulanus*	4	Labridae
4		*Pomacentrus littoralis*	2	Pomacentridae
5		*Chrysiptera hemicyanea*	44	Pomacentridae
6		*Hemiglyphidodon plagiometopon*	23	Pomacentridae
7		*Abudefduf vaigiensis*	6	Pomacentridae
8		*Neopomacentrus anabatoides*	5	Pomacentridae
9		*Amblyglyphidodon aureus*	2	Pomacentridae
10		*Centropyge heraldi*	12	Pomacentridae
11		*Pomacentrus taeniometopon*	13	Pomacentridae
12		*Neopomacentrus cyanomos*	3	Pomacentridae
13		*Stegastes fasciolatus*	7	Pomacentridae

Table 2 continued. Types of reef fish found in Karang Takat, Sumenep.

No	Category	Species	Total	Family
14	Major Fish	*Pomacentrus smithi*	2	Pomacentridae
15		*Chrysiptera parasema*	10	Pomacentridae
16		*Chrysiptera rex*	4	Pomacentridae
17		*Pomacentrus tripunctatus*	6	Pomacentridae
		Total	148	

The three groups of fish found were also obtained by Toni et al. [22] in the waters of Halang Melingkau Island, Santoso et al. [23] in the waters of Lombok Islands and Mujiyanto et al. [24] in the waters of Tunda Island, Banten Province. This shows that the chance of the presence of these three groups of fish is very high. Toni et al. [22] stated that the major fish groups generally live in large groups (schooling fish) and are often found in coral reef areas that have branching coral reef types. The target fish groups are consumption fish or economically important fish that live in strong association with the waters. and indicator fish groups generally solitary lives and are the types of fish that are generally used as indicators.

3.2.2 Diversity, evenness, and dominance index

Diversity, evenness, and dominance indices show balance in the distribution of the number of individuals of each type and indicate species richness [11]. The results of data analysis for the reef fish diversity index, evenness index and dominance index on Karang Takat can be seen in Table 3.

Table 3. Diversity, evenness and dominance index of reef fishes in Karang Takat

	Diversity Index	Evenness Index	Dominance Index
Value	2.35	0.47	0.14
Category	Medium Diversity	Communities are stressed	Low Dominance

The reef fish diversity index is a parameter for measuring the size of the diversity of a species in one location. The diversity index (H') of reef fishes obtained was 2.35. In general, the reef fish diversity index value in Karang Takat waters is in the medium category. This shows that Karang Takat waters have a poor environment due to pressure from both the environment where organisms live and direct human activities so that the diversity index is moderate.

The evenness index describes whether the distribution of the number of individuals of each type is uniform or not. The evenness index value from the results of data analysis is 0.47. In general, the evenness index value for reef fishes in Karang Takat waters has a depressed value. This shows that the species found are not evenly distributed because there is no dominant species. Ernaningsih et al. [11] stated that the greater the Uniformity value, indicates higher the species diversity.

The dominance index value from the data processing results is 0.14. These results indicate that the dominance index value is in the low category. According to Ernaningsih et al. [11], if the dominance index value is below 0.5, it indicates low dominance, so it can be

concluded that the dominance of reef fishes in Karang Takat waters is in the low category. The abundance of fish is not dominated by a few species, so it is difficult to observe because the fish are evenly distributed. Purwanto et al. [25] said that low dominance shows that the population is evenly distributed and there is no concentration of individuals in certain types. Similar research results were also reported in Kulu waters, North Minahasa Regency [25]; in Pasir Putih Waters, Situbondo, East Java [26]; and in Batee waters, Peukan Bada District, Aceh Besar Regency [27]. Apart from that, the stability of a fish community is influenced by the diversity aspect. A high reef fishes diversity index shows that the community is in a stable condition. Ernaningsih et al. [11] stated that the greater the uniformity value, the higher the species diversity. The good condition of coral reefs provides opportunities for reef fish communities to exist and develop in this area. Reduced coral cover will influence the presence of reef fish in a water.

4 Conclusion

The conclusions of this research are that Karang Takat waters have a coral reef cover value of 5.13% (damaged category) due to the large number of fishing boats passing by and becoming a gathering place for fishermen looking for fish in these waters. The types of lifeforms found in Karang Takat waters are Acropora Digitate (ACD), Coral Branching (CB), Coral Massive (CM), Coral Mushroom (CM), Coral Submassive (CS). Coral reef fish found in Karang Takat waters were 148 individuals. The reef fish density in Karang Takat, Sumenep, was 148 individuals/350 m^2. Fish species found were dominated by the Pomacentridae family, with the highest number of individuals from the *Chrysiptera hemicyanea* species, with 44 individuals. The reef fish diversity index value found was 2.35, with a medium category. The Evenness Index was 0.48, which shows a depressed condition, which means that Karang Takat waters have a poor environment due to pressure from both the environment where organisms live and direct human activities. The Dominance Index of reef fishes was 0.14, which shows a low level of dominance which indicating that the population distribution is evenly distributed and there is no concentration of individuals in certain types.

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