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STUDY OF CORAL REEF FISH IN RELATION TO LIVE CORAL REEF COVER IN THE TUING MARINE PROTECTED AREA, BANGKA, INDONESIA

Studi Ikan Terumbu Karang Terhadap Tutupan Terumbu Karang Keras Di Kawasan Konservasi Tuing, Bangka, Indonesia

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ABSTRACT

Coral reefs play an important role as marine habitat, but are threatened by climate change and human activities. The Tuing Marine Conservation Area, which still has a relatively good coral reef ecosystem, needs to be evaluated to ensure the effectiveness of conservation and support sustainable management. This research evaluates the condition of coral reefs, coral fish biomass and the relationship between coral reefs and coral reef fish in the Tuing Marine Conservation Area located in Tuing Hamlet, Mapur Village, Bangka Regency. Data collection was carried out in March 2024 at three coral reef locations using the underwater photo transect method to observe the percentage of coral cover and the visual census and visual census methods to observe coral reef fish. The average live coral cover is 60.21%, included in the good category. The density of coral fish is 4,905 individuals per hectare with a total of 10 – 14 species. Reef fish biomass is 65.51 kg per hectare. The relationship between coral reefs and coral fish shows that the better the condition of the coral reef, the higher the number of species and biomass of coral fish. These findings highlight the importance of preserving coral reef ecosystems to support biodiversity and sustain fisheries. Conservation efforts should focus on reducing anthropogenic activities, increasing public awareness, and implementing effective management and rehabilitation strategies.

Keywords: Hard Coral reefs, Coral Reef fish, Biomass, Marine conservation, Tuing MPA.

ABSTRAK

Terumbu karang berperan penting sebagai habitat laut, tetapi terancam oleh perubahan iklim dan aktivitas manusia. Kawasan Konservasi Laut Tuing, yang masih memiliki ekosistem terumbu karang relatif baik, perlu dievaluasi untuk memastikan efektivitas konservasi dan mendukung pengelolaan berkelanjutan. Penelitian ini mengevaluasi kondisi terumbu karang, biomassa ikan karang dan hubungan terumbu karang dengan ikan karang di Kawasan

Konservasi Laut Tuing yang terletak di Dusun Tuing, Desa Mapur, Kabupaten Bangka. Pengumpulan data dilakukan pada bulan Maret 2024 di tiga lokasi terumbu karang dengan menggunakan metode transek foto bawah air untuk mengamati persentase tutupan karang dan metode sensus visual dan sensus visual untuk mengamati ikan terumbu karang. Rata-rata tutupan karang hidup sebesar 60,21% termasuk dalam kategori baik. Kepadatan ikan karang 4.905 individu per hektar dengan jumlah 10 – 14 jenis. Biomassa ikan karang sebesar 65,51 kg per hektar. Hubungan antara terumbu karang dengan ikan karang menunjukkan bahwa semakin baik kondisi terumbu karang maka semakin tinggi jumlah spesies dan biomassa ikan karang. Temuan ini menyoroti pentingnya melestarikan ekosistem terumbu karang untuk mendukung keanekaragaman hayati dan mempertahankan perikanan. Upaya konservasi harus fokus pada pengurangan kegiatan antropogenik, peningkatan kesadaran masyarakat, dan penerapan strategi pengelolaan dan rehabilitasi yang efektif.

Kata Kunci: Terumbu Karang Keras, Ikan Terumbu Karang, Biomassa, Konservasi Laut, KKP Tuing.

INTRODUCTION

The Tuing Marine Protected Area (MPA) is located in Dusun Tuing, Mapur Village, Riau Silip District, Bangka Regency, covering an area of 7372.511 hectares. This area is recognized for its crucial coral reef ecosystem, as indicated by the Bangka Belitung Islands Provincial Regulation Number 3 of 2020 concerning Coastal and Small Island Zoning Plans. The coral reefs in this region provide a variety of ecological, economic, and social benefits to the local community and contribute to global marine environmental sustainability (Saputra *et al*., 2022). However, similar to other coral reef ecosystems in Bangka Belitung waters, this area faces significant threats, particularly from unsustainable fishing practices, climate change, and tin mining activities in proximity to Tuing MPA.

Previous studies on coral reefs in Tuing MPA (Fajar *et al*., 2019; Paradise *et al*., 2019) have primarily focused on the suitability and carrying capacity for snorkeling and diving tourism. In the context of coral reef conservation, understanding the state of live coral cover is critically important (Selig & Bruno, 2010). Key indicators of the health and resilience of coral reef ecosystems include the percentage of live coral cover, the abundance of reef fish, and the biomass of reef fish, as these reflect the availability of suitable habitat for reef fish and other marine organisms (Castaño *et al*., 2021; Nugraha *et al*.,2020)

Previous research has demonstrated a positive correlation between hard coral cover and fish abundance, highlighting the importance of maintaining coral reef health to sustain fish populations (Adrian *et al*., 2020; Ferizal *et al*., 2024;) Coral reefs are known to provide critical habitats for various fish species, including those that depend on coral structures for shelter, breeding, and feeding (Arbi, Harahap, & Cappenberg, 2020; Munua *et al*.,2019; Satyawan & Artiningrum, 2021) Preserving coral reefs in the Tuing KKP is very important because these waters constitute water area conservation and are also the spawning habitat for Bangka squid, so it is necessary to preserve biodiversity and support sustainable fisheries (Minister of Maritime Affairs and Fisheries, 2023). This research examines the condition of coral reefs, coral reef fish species and coral fish biomass, as well as the correlation between coral reefs and coral fish in the Tuing KKP.

MATERIALS AND METHODS

This study was conducted in March 2024 at Tuing MPA. Observations were made at three coral reef sites, as presented in Table 1, with the location map shown in Figure 1.

Table 1. Research Location Coordinates

Site Name	Latitude	Longitude	Information
TDST.01	1°35'8.41"S	106° 1'26.67"E	Fishing area
TDST.02	1°35'18.44"S	106° 1'48.78"E	Fishing areas, shipping lanes for local fishing boats
TDST.03	1°35'28.75"S	106° 2'6.32"E	Fishing area, there is a headland (land jutting out)

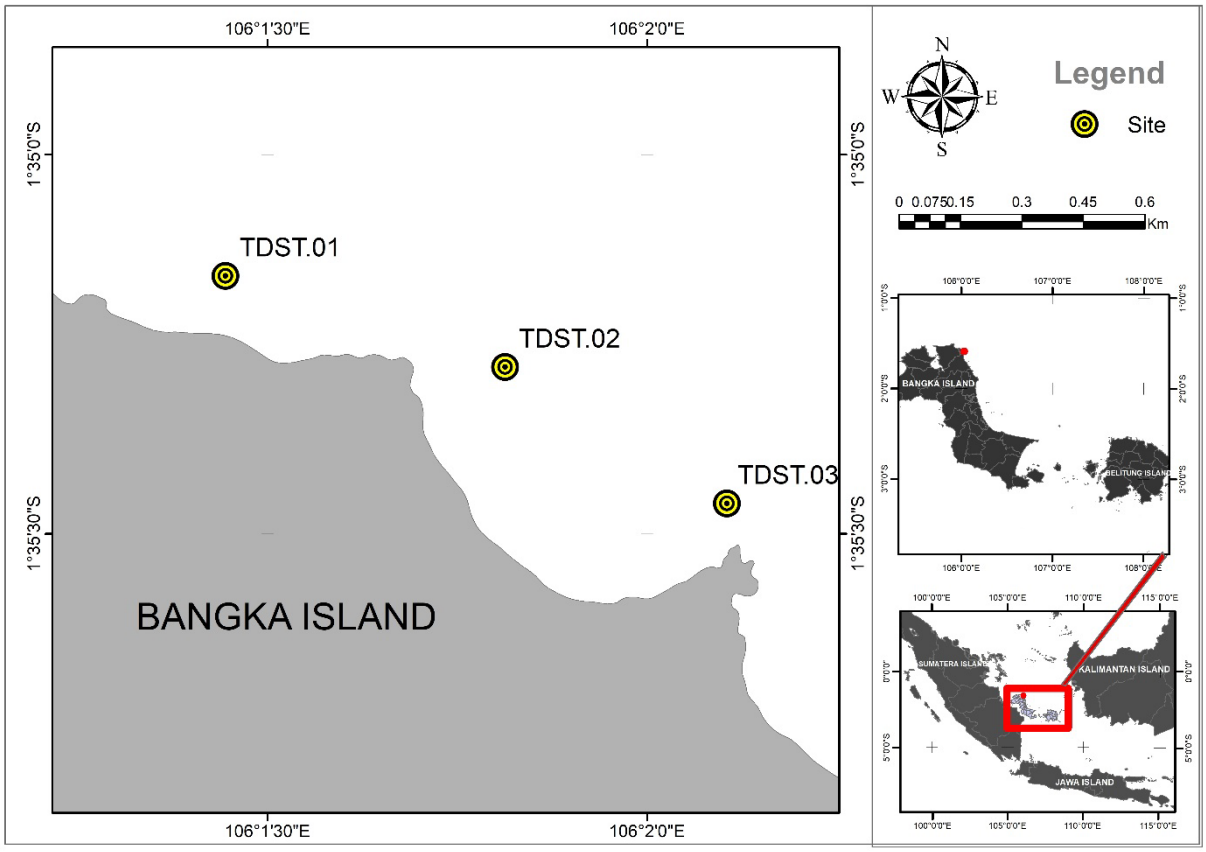

Figure 1. Research sites

Water Quality Data Collection

Water quality data were collected both in the field and in the laboratory. Parameters were aligned with the marine water quality standards for biota as stipulated in Government Regulation Number 22 of 2021 concerning Guidelines for Environmental Protection and Management. The parameters measured included pH, dissolved oxygen, currents, salinity, total suspended solids (TSS), depth, and temperature.

Coral Reef Data Collection

Coral reef data were gathered using the Underwater Photos Transect (UPT) method, which involved laying a 50-meter roll meter and photographing quadrants measuring 58 cm x 44 cm. A diver is tasked with installing a transect line using a rolling meter (scale tape) 50 meters long. The transect line is installed parallel to the coastline, starting from the 0 meter, with the island positioned to the left of the transect line for uniformity. After the transect line is installed, photographs or videos are taken of the habitat conditions around the transect line to get a general picture of the waterbed. For uniform photo analysis, an iron frame measuring 58

cm x 44 cm was used. Shooting starts from the 1st meter on the left of the transect line as "Frame 1", then the 2nd meter on the right of the transect line as "Frame 2", and so on until the end of the transect. Odd-numbered frames (1, 3, 5,...) are taken to the left of the transect line, while even-numbered frames (2, 4, 6,...) are taken to the right of the transect line. (Giyanto *et al*., 2017). Hard coral (HC) was used as a key classification to describe the coral reef conditions in the study area.

Coral Reef Fish Data Collection

Coral reef fish data were collected using the Underwater Visual Census (UVC) method. An effective and cost-effective underwater survey method, Underwater Visual Census (UVC) uses direct diving to observe and record biodiversity, especially fish and coral reefs. To get accurate results, divers need special skills (English *et al.,* 1997; Suharti *et al.,* 2017). Employing a 70-meter roll meter with a 2.5-meter boundary on each side. All coral reef fish species encountered were recorded based on type, quantity, and length (Regulation of the Minister of Manpower of the Republic of Indonesia No. 154 of 2019;Suharti *et al*., 2017). Fish length was estimated using the stick method. The stick method is a technique in coral reef fish surveys that uses a stick as a reference to estimate fish size and observation distance. Divers carry sticks of a certain length as a comparative scale, so that the recorded data is more accurate. (Wilson & Green, 2009). Fish species identification referenced WORMS and FishBase (Ahyong *et al*., 2023; Froese & Pauly, 2022).

Coral Reef Coverage Data Analysis

Photographs of the coral reefs taken in the field were analyzed using the Coral Point Count with Excel extension (CPCe) software (Kohler & Gill, 2006). This software facilitated the identification of coral lifeforms, coral genera, and other aspects from random points on 50 photos per station. The analysis results included the percentage cover and types of coral lifeforms, classified according to the standards set by the Minister of the Environment in 2001, as shown in Table 2. The results of the analysis include the percentage cover and types of coral reef lifeforms in an Excel spreadsheet file, with the percentage cover calculated based on a predetermined equation:

$$\frac{\text{Number of points in that category}}{\text{Number of random points}} x\ 100$$

Table 2. Criteria for Percent Cover of Hard Coral Reefs

No	Value (%)	Categorys
1	0.00 - 24.99	Out of whack (Damaged)
2	25.00% - 49.99	Damaged (Medium)
3	50.00 - 74.99	Good (Good)
4	75.00 - 100.00	Good (Very Good)

Information: Minister of the Environment in 2001

Coral Reef Fish Abundance Data Analysis

Fish abundance analysis followed (Odum, 1959), where Xi is fish abundance per square meter, Ni is the number of individual fish observed, and A is the observation area (m^2). The abundance categories for coral reef fish referenced (Djamali & Darsono, 2005) and are presented in Table 3.

$$X_i = \frac{N_i}{A}$$

Table 3. Fish Abundance Category
Information : (Djamali & Darsono, 2005)

Category	Individual/m^2	Individual/350m^2	Individual/Ha
Very rare	1-5	1-1.750	1-50.000
Rarely	5-10	1.750-3.500	50.000-100.000
Moderately abundant	10-20	3.500-7.000	100.000-200.000
Abundant	20-50	7.000-17.500	200.000-500.000
Very abundant	>50	>17.500	>500.000

Coral reef fish species analysis data

The composition of fish species is the number of types found in the area observation. Species composition refers to (Setyobudiandi *et al*., 2009)

Length-Weight Relationship Data Analysis

Fish weight was determined from their length-weight relationship, with conversion from length to weight using coefficients "a" and "b," easily calculated using Microsoft Excel (Suharti *et al*., 2017). The coefficients followed (Froese & Pauly, 2022), where W represents weight in grams, L represents fish length in centimeters, and "a" and "b" are the coefficients.
The length-weight relationship equation for coral reef fish is:

$$W = a \times L^b$$

$$B = \frac{W\ Total\ per\ family\ (gram))}{transect\ (350\ m2)}$$

Data Analysis Presentation

Data on coral reef cover, abundance of coral reef fish, number of coral reef fish species and coral reef fish biomass were analyzed and presented using graphs to show the percentage of coral cover, total abundance, number of species and biomass of coral reef fish.

Statistical Analysis

Correlation analysis is used to identify and measure the relationship between two variables so that researchers can assess the strength of the relationship, predict the value of one variable based on another variable, and evaluate linear relationships accurately. In this research, correlation analysis is applied to determine the relationship between hard coral cover and coral reef fish biomass, hard coral cover, and coral reef fish species, as well as between dead coral and these two variables. The value of the correlation coefficient relationship level refers to (Sugiyono, 2020).The analysis process was carried out using the Past.4.16c application. The level of correlation coefficient is presented in the following table 4.

Table 4. Guidelines for interpretation of correlation coefficients

Coefficient interval	Relationship level
0,00 – 0,199	Very Low
0,20 – 0,399	Low
0,40 – 0,599	Normal
0,60 – 0,799	Solid
0,80 – 1,000	Very Strong

Information: (Sugiyono, 2020)

RESULTS

Condition of Coral Reefs

The components that make up the coral reef substrate include hard coral, dead coral, abiotic elements and other fauna. Hard coral consists of various forms of life, while dead coral includes parts that are no longer inhabited by coral polyps, categorized as Death Coral (DC), Death Coral Algae (DCA), and Rubble. Abiotic elements include inanimate components such as Water (WA), Sand (S), and Mud (SI). Other fauna includes sponges, anemones, and diadema. The highest percentage of hard coral cover in the very good category was at TDST.02 at 75.14%, while the lowest was at TDST.03 at 46.24% with the classification being moderately damaged. The percentage of hard coral cover at TDST.01was 50.26% in the good category. The percentage of components that make up coral reefs is depicted in Figure 2.

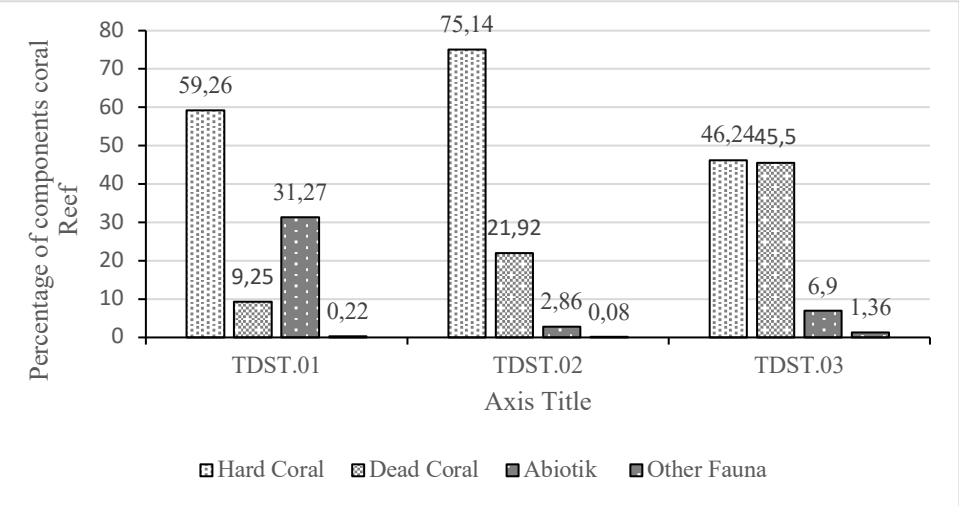

Figure 2. Components of coral reefs cover (%)

Abundance of Reef Fish

The abundance of reef fish in Tuing Pelabuhan Dalam is 4,905 individuals/ha, categorized as rare. The highest abundance is at TDST.01 with 1,892 individuals/ha, followed by TDST.02 with 1,637 individuals/ha, and the lowest at TDST.03 with 1,376 individuals/ha. The abundance of reef fish is shown in Figure 3.

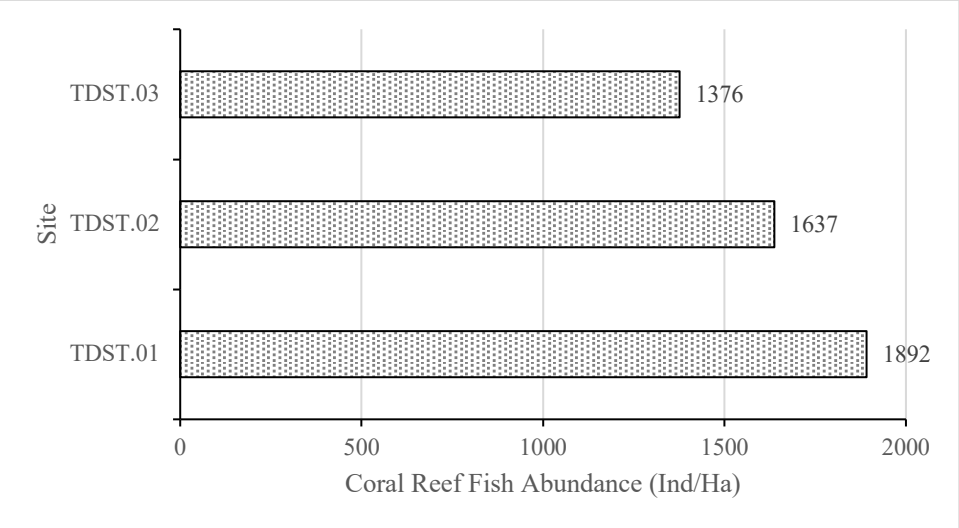

Figure 3. Coral reef fish abundance

Coral reef fish species

The number of coral reef fish species found in Tuing waters is in the range of 10-14 species. The highest was at TDST.02, namely 14 species and the lowest was at TDST.03, namely 10 species. The number of coral reef fish species is presented in Figure 4 as follows.

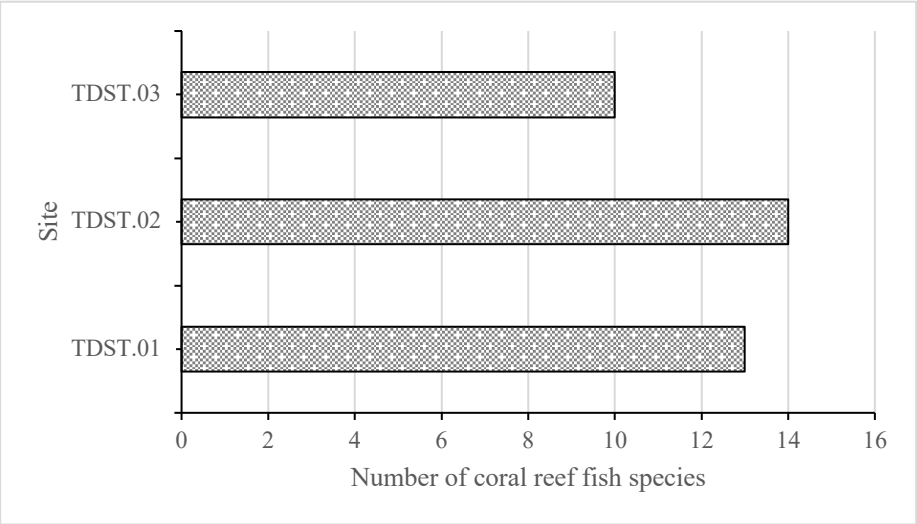

Figure 4. Coral reef fish species

Biomass of Reef Fish

The biomass of reef fish in Tuing waters across three observation site is 65.51 kg/ha. The highest biomass is at TDST.01 with 29.86 kg/ha, and the lowest at TDST.03 with 6.21 kg/ha. The biomass of reef fish is illustrated in Figure 5.

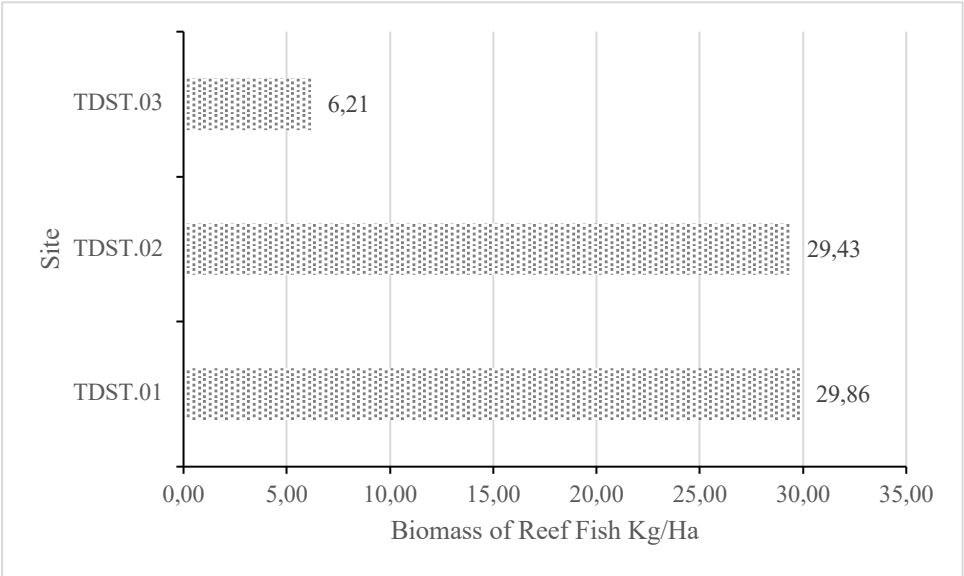

Figure 5. Coral reef fish biomass

Relationship Between Live Coral and Reef Fish

The correlation between hard coral cover and fish biomass and the number of fish species has a very strong positive relationship with an r value of 0.83 – 0.94, and r^2 0.68 – 0.88, while the relationship between dead coral and fish biomass and the number of Fish species have a negative relationship with an r value of -0.94 - -0.83. The relationship between corals and reef fish is depicted in Figure 6.

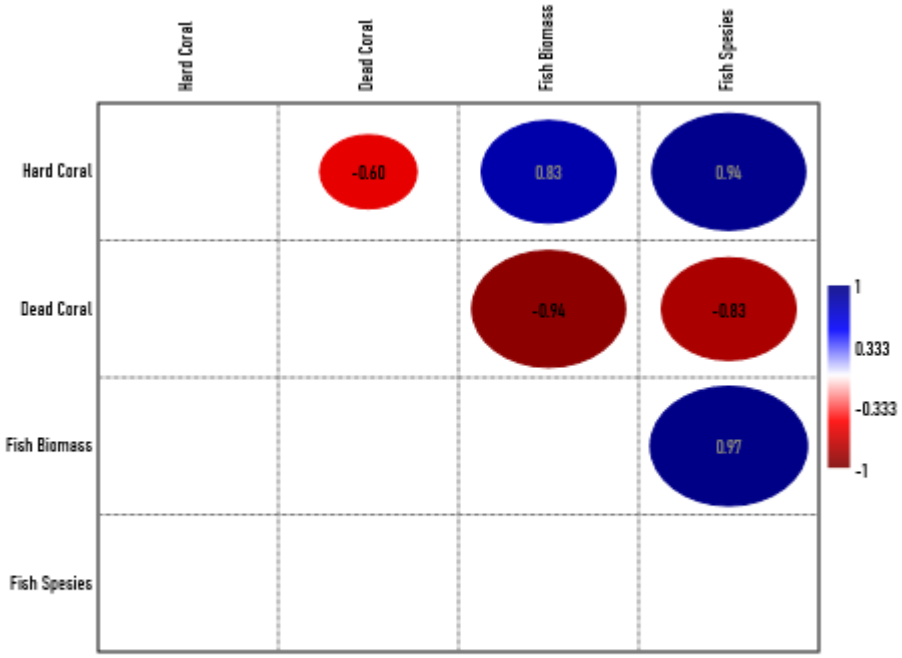

Figure 6. Relationship between coral reefs and coral reef fish

Water Quality Parameters

Environmental parameters at each station influence the percentage of live coral cover (Alif *et al*., 2017). Generally, the water quality parameters at the observation site in Tuing Pelabuhan Dalam meet the standards for the growth of marine biota, including corals and reef fish (Table 5). The environmental factors affecting coral growth include temperature, salinity, brightness, depth, dissolved oxygen, current velocity, and Total Suspended Solids (TSS). The results of water quality measurements in Tuing Pelabuhan Dalam are presented in Table 5 as follows:

Table 5. Water quality parameters in the waters of Tuing Pelabuhan Dalam

No	Parameter name	Quality	Standard Value *
1	Temperature	29^0 - 30^0C	appropriate
2	Transparency	90%	appropriate
3	Total Suspended Solid	2- 4 mg/L	appropriate
4	Water pH	7,8 – 8,1	appropriate
5	Salinity	28 – 29‰	appropriate
6	Dissolved oxygen	5,6 – 6,6 mg/L	appropriate
7	Depth	3 – 4 m	-
8	Flow Speed	0,033 – 0,05 (m/dt)	-

*Source: Government Regulation Number 22 of 2021 concerning Guidelines for Environmental Protection and Management

DISCUSSION

Overall, the condition of coral reefs in Tuing waters is in good condition with an average hard coral cover of 60.21%. Fajar *et al*., (2019) research in Tuing Dalam waters also showed that the percentage of coral cover in the good category ranged from 46.6 - 71.04%. This shows that the stability of the ecosystem is consistent with the previous year. This means that the coral reefs in Tuing waters are in good ecological balance, effective in conservation efforts, and environmental conditions that support the health of coral reefs. This statement is supported by

Cahyani *et al*.,(2018); Triwibowo, (2023) who said that good coral reef conditions indicate a good ecological balance, as well as an environment that supports the health of coral reefs. This is important because healthy coral reefs not only provide great ecological benefits but also support the sustainability of coral fisheries resources and the economy of surrounding communities (Bartholomeus *et al*.,2018; Rosa *et al*., 2021).

The higher abundance of reef fish at TDST.01 compared to TDST.02 and TDST.03 is due to the relatively high percentage of coral cover and supportive water quality for reef fish life. Additionally, during data collection, the water depth was stable at around 3–4 meters, and the data were collected in the morning, allowing for more reef fish to be observed as they are diurnal. The abundance of reef fish is directly influenced by the health of the coral reefs, the timing of data collection, tidal conditions, and the observer's acuity (Fazillah *et al*., 2020; Ilyas *et al*., 2017).

The lower abundance of reef fish at TDST.03 is due to the moderately damaged coral cover. Additionally, data collection occurred during the afternoon when the tide was receding, causing reef fish to seek safer hiding places, impacting the observer's accuracy. This is supported by (Nugraha *et al*., 2020; Putra *et al*., 2023) who state that coral reef damage negatively affects reef fish abundance by reducing density and species diversity. Poor coral reef conditions can disrupt fish larvae behavior in settling, habitat selection, and orientation, ultimately affecting the recruitment of young fish to the reefs.

The high number of species in TDST.02 is due to healthy coral cover providing a rich and complex habitat, which supports a diversity of fish species. Optimal coral cover creates an ideal environment for protection and foraging, thereby increasing the number of fish species that can reproduce and survive. In contrast, at TDST.03 the number of fish species was low, due to the poor condition of coral reef cover, which reduced the quality of available habitat. A lack of adequate coral cover negatively impacts ecosystem structure and functionality, which in turn limits the ecosystem's ability to support a wide range of fish species. This is supported by the statement of Arisandi *et al*.,(2018); Nugraha *et al*., (2019), who stated that healthy coral cover not only provides shelter for reef fish, but also provides food sources and environmental conditions that support the diversity of fish species within it.

The high biomass of reef fish at TDST.01 is due to the high abundance of reef fish and the larger fish sizes observed. Field observations indicate that fish lengths at this station are relatively longer than at other stations, increasing the total weight of reef fish at this station. For example, *Diagramma pictum*, with lengths of 26–30 cm, and *Caesio cuning*, with lengths of 11–15 cm, were abundant at this station, with a reef fish abundance of 1,892 individuals/ha.

The low biomass at TDST.03 is due to the lower abundance of fish compared to TDST.01 and TDST.02, and the relatively small fish sizes, resulting in lower biomass. The abundance of reef fish at this station is 1,376 individuals/ha, with lengths of 1–10 cm. This aligns with statements by (Fazillah *et al*., 2020; Ritonga *et al*., 2022) who assert that high biomass is related to the number of individuals and the body length of reef fish.

The correlation between hard coral cover and fish biomass, as well as the number of fish species, has a very strong positive relationship. This can be interpreted that the higher the hard coral cover, the higher the biomass and species of coral reef fish, and conversely, the higher the dead coral, the lower the biomass. and the number of fish species.

CONCLUSION

The condition of the coral reefs in Tuing waters is in good condition, the fish species are diverse with a range of 10 – 14 species, and is in line with the high biomass of coral reef fish recorded. The relationship between coral reefs and coral fish shows that the better the condition of coral reefs, the higher the number of species and biomass of coral reef fish.

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