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Association between Coral Community Coverage with Coral Reef Fish Communities at Samber Gelap Island, South Kalimantan, Indonesia

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ABSTRACT

Coral reefs are rich marine ecosystems that support a great degree of biodiversity. This is important for fish, with many fish species relying on coral reefs as their primary habitat. The current study aimed to analyze the variations of coral coverage and their relationship to fish abundance. This study was conducted in April 2019, in the waters of Samber Gelap Island, Kotabaru, South Kalimantan. The research used LIT (Line Intercept Transect) and UVC (Underwater Visual Census) methods to study coral coverage and fish abundance at 5 different stations, with each station having 3 transects of 50 meters in length. The results indicated that the highest coral coverage was station 5 (42.08%), which was classified as fair category. This result was directly proportional to the abundance of coral reef fish at station 5 (781 individuals). In addition, the correlation test results between the effect of coral coverage and coral reef fish abundance showed a correlation value of 0.972. It was indicated that coral coverage had a strong influence on the abundance of coral reef fish in the waters of Samber Gelap Island, Kotabaru, South Kalimantan. The water conditions of Samber Gelap Island were classified as being supportive of coral reef life, except current speed and brightness. In general, the percentage of coral cover in this location was categorized as being damaged, with the highest coverage found at station 5. In addition, station 5 also exhibited the highest number of coral reef fish abundance.

INTRODUCTION

Coral reefs are ecosystems with important ecological, social and economic roles. Ecologically, those ecosystems provide many services for marine biotas, such as habitats, spawning areas, foraging opportunities and ecological processes. Besides, coral reefs also play an essential role in protecting coastal areas from wave action, as well as providing significant benefits to the tourism industry. Despite their importance, coral reefs all around the world face a severe threat of degradation and potential extinction.

Fish communities in coral reef ecosystems are present in large numbers and occupy a variety of ecological niches, meaning that fish help to support many processes and relationships within the ecosystem. This high species diversity is mainly due to the great variation in coral reef habitats and the ability of fish species to utilize many different resources. Coral reef habitats are not only composed of coral communities but also include areas of sand, crevices and fissures, algae and different oceanic zones **(Nur *et al*., 2020)**.

Coral reefs, mainly coastal coral reefs, were found in mainland waters of Kalimantan and around the Pulau Laut, South Kalimantan, Indonesia. The most common types of coral reef structures were fringing reefs, such as those found in Kotabaru District, and takat corals (patch reefs or platform reefs), which are commonly found in Tanah Bumbu, South Kalimantan, Indonesia. The conditions of the reefs varied significantly, ranging from areas that were in excellent condition to areas that were dead. However, most of the reef ecosystems identified had been severely damaged **(Iskandar *et al*., 2010)**.

Kotabaru District is one of eleven districts in South Kalimantan Province, which is located between 3° 10' and 4° 20' South Latitude and 115° 25' and 116° 20' East Longitude. Kotabaru District covers 9,422.46 km^2 and consists of one large island and 140 small islands **(Tony *et al*., 2020; Olga *et al*., 2020)**. Samber Gelap Island is one of the islands' marine natural park area. The island is famous as a tourist site that offers the beauty of coral reefs and turtle conservation **(Pahlevi, 2019)**. In 2014, an increase in tourist visits on Samber Gelap Island was observed. Nevertheless, the rise in ecotourism activity will increase the risk of damage to coral reef ecosystems on Samber Gelap Island.

Munasik and Siringoringo (2011) stated that the coral reef community in South Kalimantan Province was unstable and depressed. In addition, in the past few years, the uniqueness of the marine ecosystem in Kotabaru District has been threatened by illegal fishing activities carried out by fishing communities **(As-Syahri *et al*., 2018)**. No research has examined the condition and status of coral reefs in the waters around Samber Gelap Island. A previous study only showed the condition of coral reefs on Halang Melingkau Island, which is adjacent to Samber Gelap **(Tony *et al*., 2021)**. The condition of coral reefs on Halang Melingkau Island in the medium category were categorized by **Minister of Environment of the Republic of Indonesia (2001)** No.4. Additionally, **Dharmaji (2013)** addressed coral cover in Sepagar Village Waters, Kotabaru, in South Kalimantan. Yet, no research has examined the condition of reef fish in Samber Gelap Island. Therefore, this study was carried out to study the condition of coral cover and the status of reef fish in Samber Gelap Island to support sustainable tourism.

The Samber Gelap Islands consist of four small islands; namely, Maraeng Island, Halang Malingkau Island, Samber Gelap Island and Sawa Island. Even though those islands are far from Pulau Laut (the regency's capital), this island is one of the foremost marine tourist destinations. This is partly due to the uniqueness of the islands, as they possess attractions such as white sandy beaches, turtle breeding grounds and large areas of coral reef. Recently, no research has reported the condition of the coral reef or the conservation status of sea turtles on Samber Gelap Island since Samber Gelap Island has become a tourist destination. Markedly, previous studies examined only the ecotourism potential and development on Samber Gelap Island **(As-Syahri *et al*., 2018; Pahlevi, 2019)**. In addition, the **Indonesian Ministry of Marine Affairs and Fisheries (2015)** reported that in Samber Gelap and Halang Islands, there are conservation tours for green turtles (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*). The use of turtle eggs in the Kotabaru District was only reported by **Salim and Saputra (2016)**. However, there has been currently preliminary research on the coral reefs and the fish communities in Samber Gelap Island, South Kalimantan, Indonesia. Therefore, complete information is required for the condition of coral reefs and coral reef fish and the relationship between both. This research aimed to analyze the association between the coverage of coral reefs and the abundance of fish based on this rationale.

MATERIALS AND METHODS

1. Study area

The research was conducted in April 2019 in the waters of the Samber Gelap Islands, Kotabaru, South Kalimantan, Indonesia (Fig. 1). Samber Gelap Island is located in Kotabaru District, South Kalimantan, Indonesia. Samber Gelap Island is famous for its white sand. The area of Samber Gelap Island is ± 0.01 km^2 and has no residential areas, only villas managed by the private sector. Tourist visits, both domestic and foreign, have increased from 2014 till now. **Indonesian Ministry of Marine Affairs and Fisheries (2015)** and **(Pahlevi, 2019)** reported that there is turtle conservation on Samber Gelap Island.

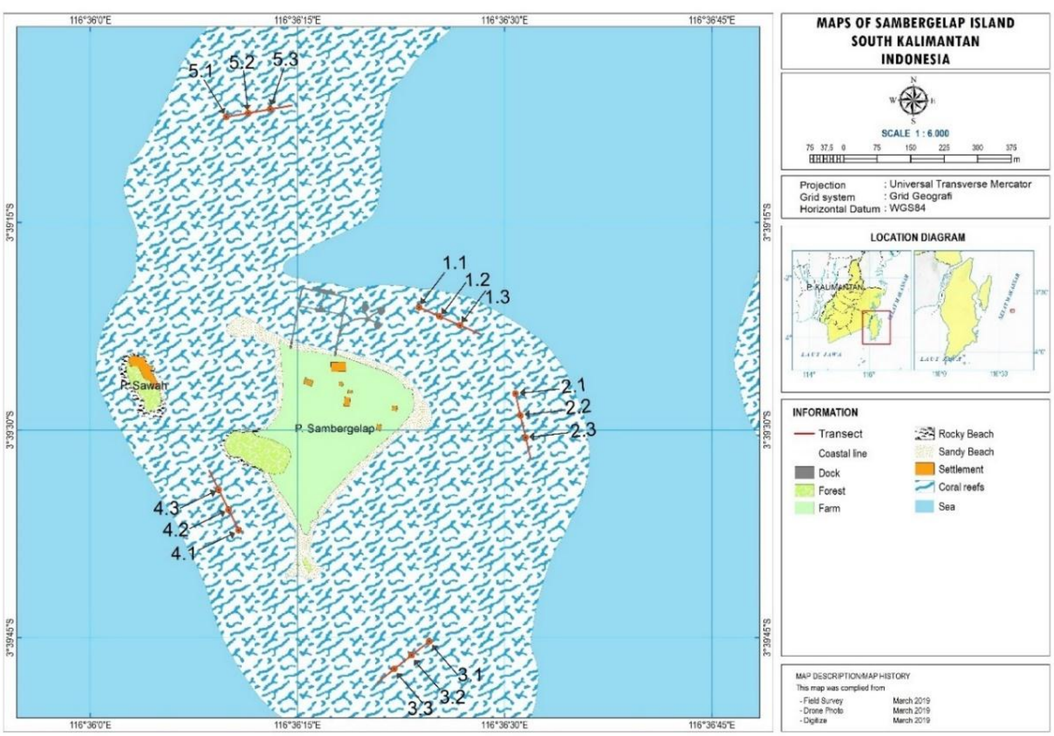


Fig. 1: Research Location Map of Samber Gelap Island, South Kalimantan - Indonesia.

The observation location (station) was determined purposively (purposive sampling), considering that the selected site would be a good representation of the Samber Gelap area as a whole. The research was conducted at five stations with fifteen observation points considered to represent the condition of coral reefs and reef fish in island waters. Table (1) presents the coordinates of the observation location.

Table 1: Coordinates of the Observation Points.

Station		Coordinates	
	1.1	116° 36' 23,803" E	3° 39' 21,14" S
1	1.2	116° 36' 25,287" E	3° 39' 21,795" S
	1.3	116° 36' 26,773" E	3° 39' 22,445" S
	2.1	116° 36' 30,774" E	3° 39' 27,375" S
2	2.2	116° 36' 31,141" E	3° 39' 28,961" S
	2.3	116° 36' 31,513" E	3° 39' 30,546" S
	3.1	116° 36' 9,829" E	3° 39' 7,394" S
3	3.2	116° 36' 11,425" E	3° 39' 7,114" S
	3.3	116° 36' 13,021" E	3° 39' 6,830" S
	4.1	116° 36' 24,543" E	3° 39' 45,275" S
4	4.2	116° 36' 23,265" E	3° 39' 46,277" S
	4.3	116° 36' 21,991" E	3° 39' 47,283" S
	5.1	116° 36' 10,737" E	3° 39' 37,245" S
5	5.2	116° 36' 10,018" E	3° 39' 35,786" S
	5.3	116° 36' 9,295" E	3° 39' 34,328" S

2. Data collection

2.1 Water quality parameters

The sampling method used was a purposeful sampling technique, under the assumption that the samples taken would suitably represent the study site's population. Measurement of water quality parameters was carried out in the morning (06.00-09.00 a.m.) and evening (15.00-18.00 p.m.) on the water's surface at each station, along with the simultaneous gathering of coral reef and fish data. Data on water quality, coral cover and reef fish were carried out per station at 7 specific times. The first water quality data collection was carried out, then followed by coral fish observations, then followed by coral cover observations. Water quality parameters were measured: current speed (m/s) by a current meter (Flowatch FL-03), brightness (m) by a Secchi disk with a diameter of 30 cm, temperature (^oC) by a thermometer (Hanna Instruments TM-1), pH by pH meter (HACH-HQ11d), and salinity (‰) by a refractometer [ATAGO Master S/Mill M (2493)] at each observation station. The data obtained were compared with the standards in the **Minister of Environment Decree (2004)** No. 51, the Republic of Indonesia, about seawater quality.

2.2 Underwater Visual Census (UVC) and Line Intercept Transect (LIT)

An Underwater Visual Census (UVC) involving a transect was used to obtain coral reef data **(English *et al*., 1994; Prato *et al*., 2017)**. The transect was positioned as close to the substrate as possible using a 50 m roll measuring tape. From the selected starting point, each transect was placed parallel to the coastline. Three transects were laid out at each station. Observations were made on a 5 m wide belt transect centered on the transect band, giving a total area of observation at each station of 750 m^2. The substrate composition was recorded by the line intercept transect (LIT) method based on **English *et***

***al*. (1997)**. The advantage of the LIT method is the accuracy of the data. The data obtained have better quality and quantity, displaying a more comprehensive community structure, such as the percentage of live or dead coral cover, colony size, and species diversity. In addition, the LIT method can provide high-quality data on the structure of biota communities that are symbiotic with coral reefs **(Lam *et al*., 2006)**.

Observations are made by installing transects along 50 m parallel to and following the coastline. At the starting point, observers waited for about five minutes after the transect line was installed. That time was used to get an overview of the reef fish present at the observation site, thereby allowing the fish to return to normal behavior after disturbance due to transect placement. The transect was also recorded with an underwater camera that was set to video mode. Fish abundance was calculated using a monitoring distance of 2.5 m to the left and right of the transect for fish less than 35 cm, and a distance of 5 m to the left and right for fish measuring ≥ 35 cm **(English *et al.*, 1997)**. Observations were made using the visual census method (UVC). Observations of fish body characteristics (mouth shape, body shape, fins, color) were recorded directly by an observer on waterproof paper and filmed by other observers using a camera (in the form of photos or videos). The coral reef fish that could not be identified directly by the observer were briefly described on the waterproof writing tool and photographed. Reef fish were identified using the identification key **(Kuiter, 1992)**. Fish and coral data were collected sequentially. After the fish data collection was complete, there was a break for a few minutes, followed by coral data collection **(Levinton, 2013)**.

3. Data analysis

3.1 Hard coral coverage

The percentage of hardcoral coverage was calculated with the following formula **(English *et al*., 1997)**:

$$C = \frac{\alpha}{A} \times 100\% \qquad (1)$$

Where:

- C= lifeform i coverage percentage (%);
- α= lifeform i transect length; and
- A= Total transect length (meter).

According to **Gomez and Yap (1988)** and the **Minister of Environment of the Republic of Indonesia (2001)**, four criteria were used to evaluate the hardcoral coverage, and data are presented in Table (2).

Table 2: Criteria of Hard Coral Coverage Percentage.

% cover	Category
75 – 100	Excellent
50 – 74.9	Good
25 – 49.9	Fair
0 – 24.9	Poor

Note: Based on Decree of the Minister of Environment of the Republic of Indonesia No. 4 of 2001

3.2 Community structure of coral reef fish

The community structure of coral reef fish was assessed using the following indexes.

3.2.1 Shannon Wiener Diversity Indeks (H')

$$H' = \sum_{i=1}^{s} pilnlnpi \quad (2)$$

Where:
H' = Shannon Wiener diversity index;
s = number of coral reef fish species;
p = individual number of coral reef fish species proportion.

A diversity index is calculated by criteria according to **Brower and Zar (1977)**:

a. **H'** ≤ 2.30 : diversity is low, environmental pressure is very strong;
b. 2.30 <**H'** ≤ 3.30 : diversity is moderate, environmental pressure is moderate;
c. **H'**> 3.30 : diversity is high, ecosystem balance occurs.

3.2.2 Homogeneity index €

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

Where:
E = homogeneity index;
Hmax = species balance in maximum balance = ln s.

Index values range from 0-1 with criteria **(Brower & Zar 1977)**:

- E ≤ 0,4 : homogeneity is small, community is depressed;
- 0,4 < E ≤ 0.6 : homogeneity is moderate, community is unstable;
- E > 0.6 : homogeneity is high, community is stable.

3.2.3 Dominance index (C)

$$C = \sum_{i=1}^{s} pi^2 \quad (4)$$

Where:
C= Dominance index;
Pi= Individual number of coral reef fish species proportion; and
s = Coral reef fish species number.

The dominance index value ranges from 0 to 1, meaning that if the value approaches 1 then there is a tendency for one individual to dominate another.

3.3 Coral reef fish abundance

Abundance of coral reef fishes was calculated using the following equation **(English *et al.* 1994)**:

$$N = \frac{ni}{A} \quad (5)$$

Where:
N is fish abundancy (ind/m^2);
ni is individual number no-i; and
A is area width (m^2).

3.4 Correlation analysis between coral cover and structure of coral reef fish communities

The linear regression method in Microsoft Excel 2016 was used to determine the relationship between coral reef coverage and the number of coral reef fish. Linear regression analysis was used to determine the intensity of the association between two or more variables and to forecast the expected y value (the number of coral reef fish) using the x value (coral reef coverage). The following linear regression equation was used, as suggested by **Kutner *et al*. (2004).**

$$y = a + bx \quad (6)$$

Description:
Y= Dependent variable;
a = Constant;
b = Regression coefficient; and
x = Independent variable.

RESULTS

1. Seawater quality parameters

Generally, seawater quality was a limiting factor affecting the life and growth of coral reef ecosystems and reef fish. The measurements of seawater quality parameters collected during the study period are presented in Table (3).

Table 3: Seawater Quality Parameters at Samber Gelap Island, South Kalimantan, Indonesia.

Station		Seawater Quality Parameters					
		Weather Status	Temperature (°C)	Salinity (‰)	Ph	Current (m/s)	Brightness (m)
Morning	1	Clear	29.82 ± 0.41	33.93 ± 1.69	7.99 ± 0.12	0.44 ± 0.26	1.86 ± 0.23
	2	Clear	30.01 ± 0.23	33.26 ± 1.41	7.61 ± 0.46	0.96 ± 0.72	3.79 ± 0.58
	3	Clear	30.06 ± 0.28	35.37 ± 1.88	7.71 ± 0.21	0.49 ± 0.27	3.49 ± 0.28
	4	Clear	30.02 ± 0.27	33.94 ± 1.44	7.54 ± 0.32	0.58 ± 0.25	3.50 ± 0.41
	5	Clear	30.09 ± 0.26	32.50 ± 1.04	7.37 ± 0.21	1.02 ± 0.40	5.29 ± 0.54
Evening	1	Clear	30.41 ± 0.43	34.11 ± 2.29	8.00 ± 0.24	0.43 ± 0.33	1.94 ± 0.30
	2	Clear	30.41 ± 0.43	33.71 ± 1.11	7.84 ± 0.37	0.94 ± 0.69	4.04 ± 0.52
	3	Clear	30.17 ± 0.52	35.07 ± 1.49	7.81 ± 0.29	0.56 ± 0.18	3.76 ± 0.24
	4	Clear	30.17 ± 0.52	34.90 ± 1.79	7.71 ± 0.23	0.74 ± 0.30	3.89 ± 0.25
	5	Clear	30.08 ± 0.70	33.11 ± 1.64	7.56 ± 0.26	1.23 ± 0.51	5.30 ± 0.36
Minister of Environment Decree No. 51 of 2004, the Republic of Indonesia			28-30	33-34	7-8.5		>5

2. Hard coral coverage

Hard coral coverage in the study area was conducted at five stations, with each station having three transects. The average hard coral coverage on Samber Gelap Island was 18.66 ± 3.92%, which is considered a poor coverage. The results of hard coral coverage for each station are presented in Table (4).

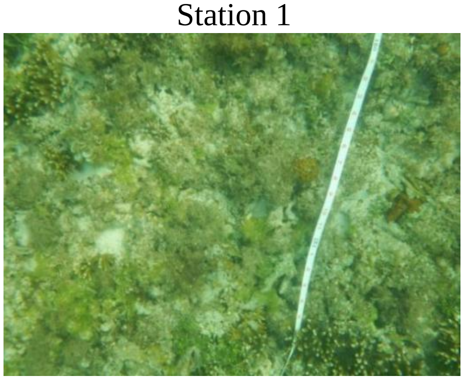
Table (4) shows that the hard coral coverage at Samber Gelap Island is in poor condition, especially at stations 1, 2, 3, and 4. The poor conditions at stations 1, 2, 3, and 4 are thought to be related to low current velocities. In addition, it is suspected that the brightness level at the four stations was below 5 m, while the water quality at station 5 supported the growth of hard corals. Fig. (2) presents a visualization of hard coral conditions at each station at Samber Gelap Island, South Kalimantan, Indonesia.

Table 4: Seawater Quality Parameters at Samber Gelap Island, South Kalimantan, Indonesia.

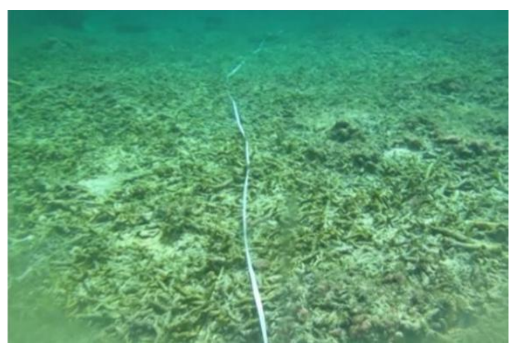
Station	**Hard Coral Coverage (%)**	**Categories based on Decree of the Minister of Environment of the Republic of Indonesia No. 4 of 2001**
1	1.27 ± 0.69	Poor
2	24.41 ± 5.28	Poor
3	11.24 ± 3.91	Poor
4	14.29 ± 5.47	Poor
5	42.08 ± 8.97	Fair

Station 1

Station 2



Station 3



Station 4

Station 5

Fig. 2: Hard Coral Conditions on Five Stations Observed on Samber Gelap Island, South Kalimantan, Indonesia.

The data showed a correlation between the percentage of hard coral cover and the number of fish observed at each station. The coral substrate can be categorized as living substrate (biotic) and dead substrate (abiotic) based on its characteristics. Live substrate observed at each station consisted of hard corals (HC), dead corals with algae (DC), coralline algae (CA), soft corals (SC), and other fauna (OT), while non-living substrates included sand (S), rubble (RB), and rock (RC). The cover of biotic and abiotic life forms at each station is presented in Fig. (3).

Fig. (3); shows that hard corals dominate the live (biotic) substrate at station 5. In addition, there is a form of dead coral with algae (32.73 ± 16.28%), which indicates an opportunity for corals to recover from damage. The non-living (abiotic) substrate at station 5 was dominated by coral fragments (23.79%) and sand (1.40%). Moreover, Fig. (4); shows that station 1 (67.61%), station 3 (54.64%), and station 4 (57.31%) mostly consist of coral fragments. The level of coral fragments is an indication of mortality and damage to coral reefs at the observed station.

There is a composition of hard coral life forms of acropora and non-acropora species at the observation station. Acropora species are found in two forms: Acropora branching (ACB) and Acropora tabulate (ACT). Furthermore, non-Acropora corals are found in four life forms: coral branching (CB), massive coral (CM), coral foliose (CF), and coral mushroom (CMR). As shown in Fig. (4), the composition of hard coral life forms at station 5 is more varied when compared to other stations.

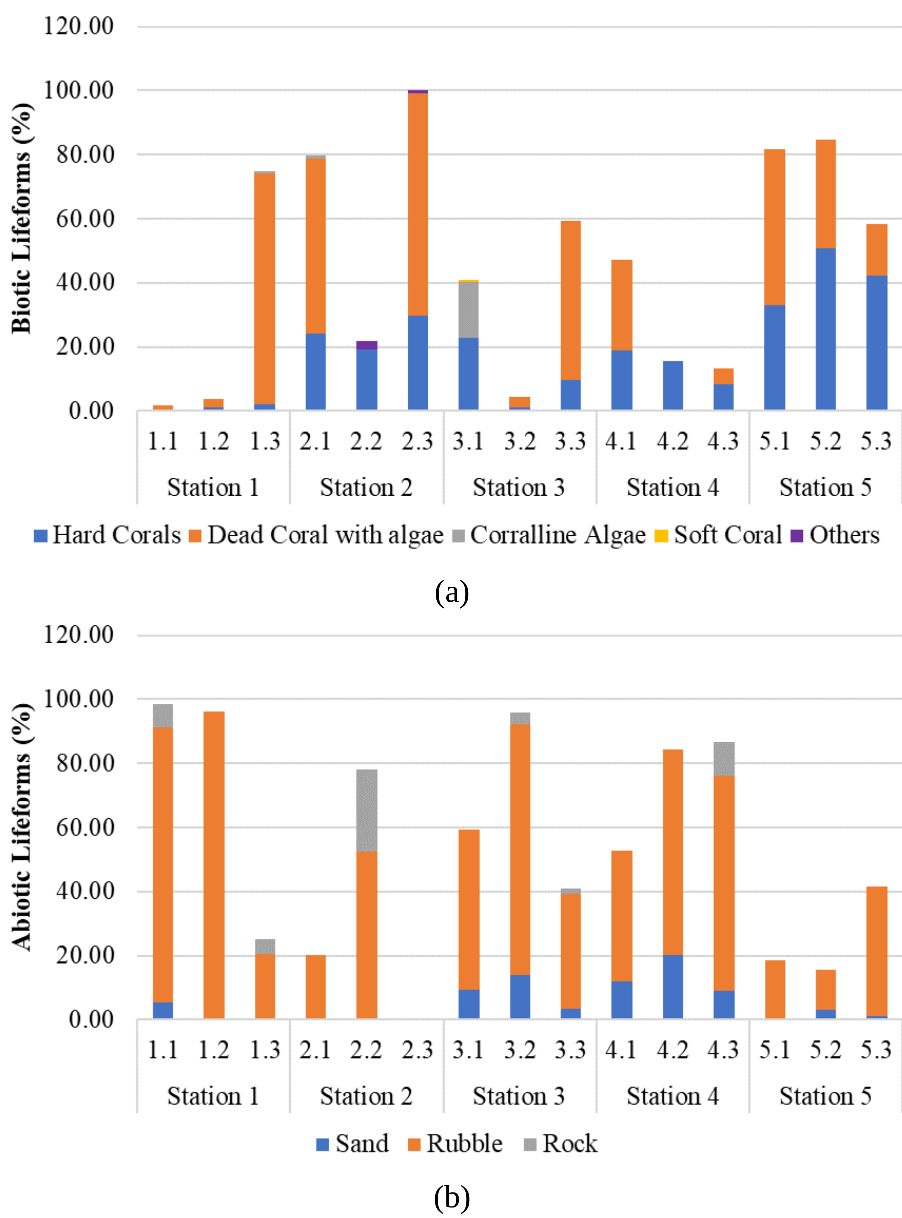


Fig. 3: Biotic (a) and Abiotic Lifeforms (b) on Samber Gelap Island, South Kalimantan, Indonesia.

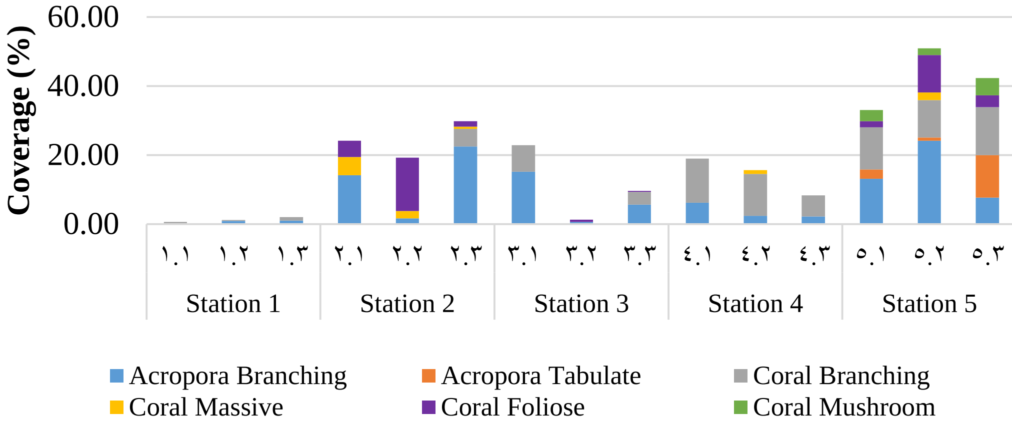


Fig. 4: Composition of Hard Coral Life forms on Samber Gelap Island, South Kalimantan, Indonesia.

3. Coral reef fish community structure

The results showed that there were 43 species on Samber Gelap Island monitored during the study period. During the study period, the types of fish monitored were identified into 9 families: Pomacentridae, Scaridae, Labridae, Balistidae, Holocentridae, Caesionidae, Lutjanidae, Serranidae, and Chaetodontidae. The dominant family was Pomacentridae, with many 1180 individuals. In addition, the results showed that the number of major group fish was 1350 individuals, a target group of 344 individuals, and an indicator group of 22 individuals. The species and numbers of fish monitored in the Samber Gelap Island are presented in Table (5).

Table 5: Coral Reef Fish Community in Samber Gelap Waters.

Group, Family, Species	Station 1	Station 2	Station 3	Station 4	Station 5	Total
Major						
Pomacentridae						
Abudefduf sexfasciatus		8	2	16		26
Abudefduf lorenzi	10		7	15		32
Amphiprion clarkii				6		6
Amphiprion ocellaris		3				3
Amphiprion sandaracinos					4	4
Chromis analis					85	85
Chromis atripectoralis					30	30
Chrysiptera glauca		26			15	41
Dascyllus melanurus				13	77	90
Dischistodus melanotus					11	11

Dischistodus pseudochrysopoecilus			10	18		28
Hemiglyphidodon plagiometopon	13	25			10	48
Neoglyphidodon crossi		65	70	55	97	287
Pomacentrus alexanderae		26				26
Pomacentrus armillatus				3		3
Pomacentrus taeniometopon					23	23
Pomacentrus coelestis					170	170
Pomacentrus littoralis	17		15			32
Pomacentrus moluccensis		14				14
Pomacentrus saksonoi					15	15
Pomacentrus tripunctatus				20		20
Pomacentrus geminospilus				23		23
Pomacentrus grammorhynchus				1		1
Pomacentrus smithi	28					28
Pomacentrus melonochir	2					2
Pomacentrus microspilus					132	132
Scaridae					132	
Bolbometopon muricatum		1				1
Labridae						
Halichoeres melanichor					3	3
Halichoeres melanurus		20		32	14	66
Labroides dimidiatus	1				22	23
Balistidae						
Rhinecantus aculeatus				1		1
Holocentridae						
Sargocentron rubrum		36		25	15	76
Target	31	87	60	178	186	
Caesionidae						
Caesio cuning	55	120	70			245
Lutjanidae						
Lutjanus decussatus	5	32	15		7	59
Serranidae						
Epinephelus corallicola		1				1
Epinephelus merra				1		1
Siganus coralinus					18	18
Siganus doliatus					16	16
Siganus puellus					4	4
Indicator						

Chaetodontidae						
Chaetodon melannotus					5	5
Chaetodon octofasciatus	2	4			6	12
Chaetodon oxycephalus	3					3
Chaetodon vagabundus					2	2
Fish per station	136	381	189	229	781	1716
Species per station	10	14	7	14	23	68
Total number of species			43			

Table (5) shows that station 5 is the station with the most number of fish and the number of species (781 individuals, 23 species) compared to other stations. At station 5, the number of major fish groups was 723 individuals, the target group was 45 individuals, and the indicator group was 13 individuals. The number of fish in the indicator group at station 5 was more than the other stations; this indicates that the water conditions at station 5 in assumed to be in good condition. Indicator fish are groups of fish that describe the condition of a coral reef ecosystem. The greater the number of indicator fish, the great health of the coral reef is indicated. The abundance data of reef fish at Samber Gelap Island are shown in Fig. (5), and analyzed based on the number of individuals at each station and area (m^2).

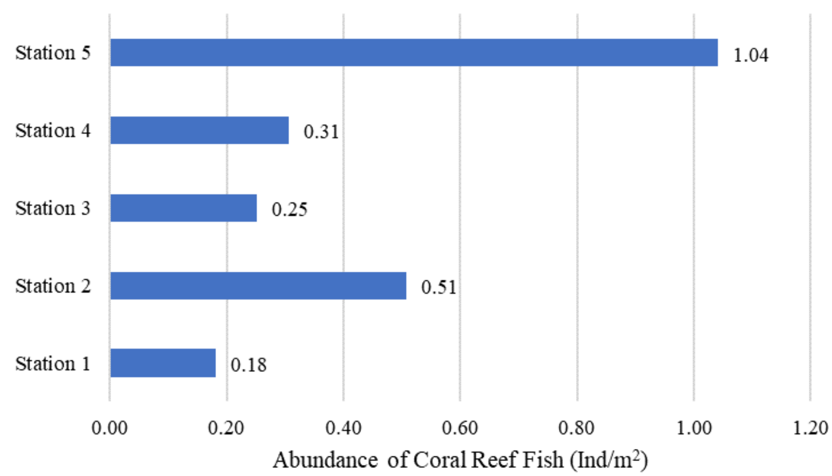


Fig. 5: Abundance of Coral Reef Fish at Each Station (Ind/ m^2).

The dominance index (C), homogeneity index (E '), and Shanon Wiener diversity index (H') of coral reef fish in Samber Gelap Island, which were observed during the study period, are presented in Fig. (6). Based on those index values, no fish dominated in Samber Gelap island. There was a high level of homogeneity and a stable community at all observation stations, but low diversity indicates environmental stress. This is presumably due to the bad condition of coral reef cover in Samber Gelap Island. Therefore, only certain types of fish can live (high dominance/homogeneity), but low diversity index.

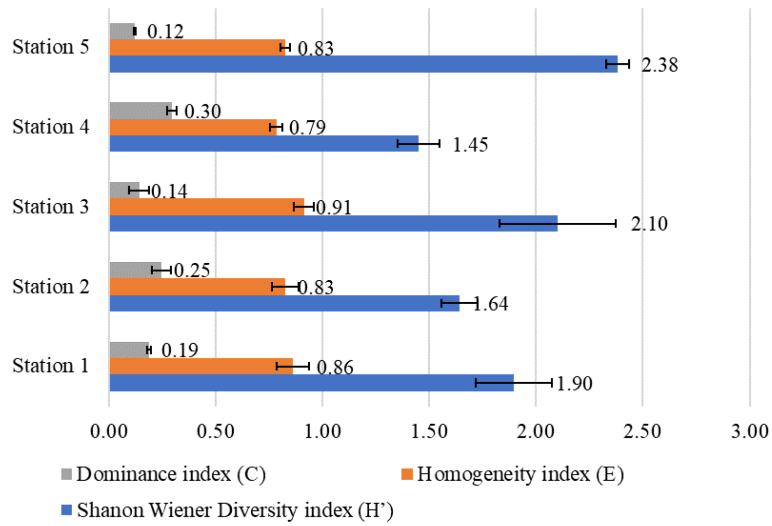


Fig. 6: Shanon Wiener Diversity Index (H'), Homogeneity Index (E), and Dominance Index (C) at Samber Gelap Island, South Kalimantan, Indonesia.

The percentage of coral cover correlated with the number of coral reef fish ($P<0.05$, $R^2 = 0.944$). The number of coral reef fish tends to increase along with the increase in the percentage of coral reef cover, as indicated by the linear regression equation $y = 16.404x + 37.135$, R-value of 0.972 (Fig. 7).

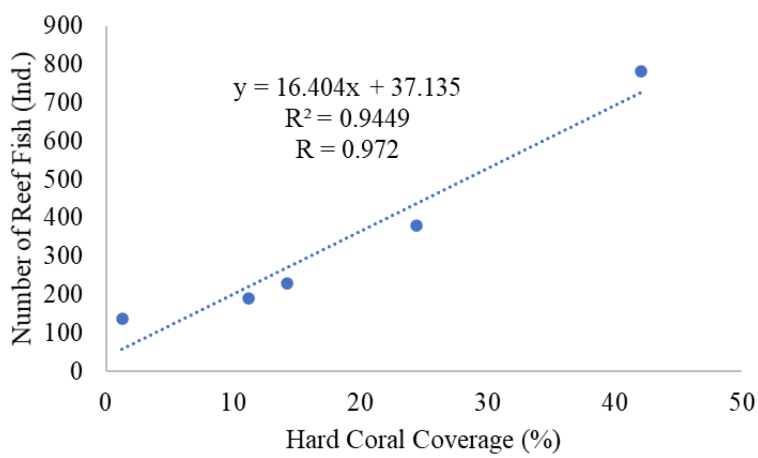


Fig. 7: Correlation of the Number of Reef Fish with Hard Coral Coverage.

DISCUSSION

1. Sea water quality parameter

Temperature is a limiting factor for coral life because a rise in temperature of only one or two degrees would affect zooxanthellae's concentration in the coral tissue. Temperature changes can cause a decrease in coral feeding response, reduce reproduction rates, increase mucus discharge, and inhibit coral functions such as photosynthesis and respiration **(Baum *et al*., 2015; Faturohman *et al*., 2016)**. According to **Saptarini *et al*. (2017)** and **Khasanah *et al*. (2019)**, the temperature needed for corals to achieve maximum growth is between 23 and 25^{o}C, with the upper limit for growth between 36 and 40^{o}C. Temperatures are high cause of zooxanthellae' release from coral tissue, disrupting photosynthesis, and causing growth disturbance and eventually death **(Rifa'i, 2016)**. Temperatures measured at the present study site were in the range of 30-31^{o}C, which indicated suitable conditions for coral growth. The results are in line with researches of **Hoey *et al*. (2016)** and **Harvey *et al*. (2018)**, who reported that temperatures between 28-32 ^{o}C are optimal for coral growth and reproduction.

The salinity level in water is another factor that affects the growth rate of coral ecosystems. Salinity at the study site was within the limits of coral tolerance and ranged between 25-40 ‰ **(Lehtonen *et al*., 2016)**. Low levels of salinity in coral ecosystems could reduce coral fertility. On the other hand, high levels of salinity in coral ecosystems tend to reduce coral growth rates. This rate of decline in growth varies among coral species and is dependent on geographical location **(Sahril, 2017)**. Salinity is also directly proportional to osmotic pressure, meaning that the osmotic pressure of zooxanthellae living in higher salinity seas is higher **(Kültz, 2015; Rifa'i *et al*., 2016)**.

The pH level of water has a vital role as a parameter of water quality. The pH supports controlling factors such as the reaction speed of substances in seawater and acts as a buffer for the balance of chemical compounds. Measured pH levels in this study were in the range that supports coral life and growth, with values between 7.37 and 8.00. If pH levels fluctuate outside the standard limit, making water more acidic or basic, coral condition decreases because the zooxanthellae photosynthesis process in corals is inhibited (Table 2) **(Putri *et al*., 2015)**.

Water currents in coral reef areas have a variety of essential roles for coral growth. For example, currents that promote water circulation help carrying oxygen, zooplankton, nutrients, and coral planula. In addition, currents help in the process of sediment rejection on the surface of the reef. Those currents can remove sediment accumulated on the surface of coral reefs, thereby reducing coral pressure and increasing the light penetration required for photosynthesis **(Tony *et al*., 2021)**. Therefore, it affects the rate of coral growth. Furthermore, the acceleration of sediment rejection by currents helps to speed up degraded reefs' physiological recovery process **(Iskandar & Tony, 2013; Sabdono *et al*., 2014)**.

Brightness was measured based on the ability of light to penetrate the water column, a factor which is determined by light intensity and decreases with increasing water depth **(Prato *et al*., 2017)**. The brightness observed at the study site was 100%, meaning light reached right to the bottom of the water column, at a depth between 1.86 m and 5.30 m. However, according to the Minister of Environment Decree No. 51 of 2004, the Republic of Indonesia, brightness must be above 5 m. The observation showed brightness level at stations 1-4 was below 5 m. This is thought to be related to the low current velocity so that that sediment could cover the coral surface. A good level of brightness in the coral ecosystem can encourage the photosynthesis process by symbiotic algae zooxanthellae coral **(Basu *et al*., 2018)**. According to **Coker *et al*. (2013)**, poor light levels can cause the photosynthesis rate to decrease, which inhibits the process of respiration and calcification in corals.

2. Coral reef coverage

Table (3) shows the variation of coral cover at each station. The highest percentage of coral coverage was found at station 5, with a value of 42.08 ± 8.97 %. The coral condition was classified in a decree of the Minister of Environment of the Republic of Indonesia No. 4 of 2001. The following highest coral coverages were found at station 2, with a coverage of 24.41 ± 5.28 %, and station 3, with a coverage of 11.24 ± 3.91 %. Coral conditions at stations 1, 2, 3, and 4 were classified in the poor category. The most damaged coral was located at station 1. The very low coral coverage at station 1 was influenced by various factors, including environmental conditions and coastal and beach activities. Station 1 was near a harbor for fishing boats. It was suspected that this factor caused high-stress levels in the coral ecosystem, both due to tourism activities and boat operations such as anchor usage. Those findings are supported by **Messmer *et al*. (2011)**, **Munasik and Siringoringo (2011)**, and **Fenner (2012)** studies which showed that damage to coral ecosystems were caused by coastal areas such as fisheries, industry, or tourism activity.

Conversely, station 5, which had the highest coral coverage, was located at the farthest distance from the mainland (Samber Gelap Island) and a depth of around 5 meters. This meant the risk of damage caused by ships or humans was much smaller. In addition, station 5 also had the highest current speed than other stations, meaning sediment rejection was more significant in this area. This would prevent sediment buildup from inhibiting reef processes such as photosynthesis, meaning coral at station 5 would have better growth rates. This coincides with the finding of **Khasanah *et al*. (2019)**, who stated that currents in coral ecosystems assist in the process of physiological recovery, meaning damaged coral can recover quicker.

The observations show that stations 1 to 4 have the highest dead substrate cover (in the form of rubble). The variation of coral composition in Samber Gelap Island, at stations 1 to 4, is found very low with very high coral rubble. Coral rubble can be caused by predation of organisms, disease, bioerosion, and unstable (extreme) water conditions **(Holmes *et al*., 2000)**. The high coral fragments at stations 1 to 4 are thought to be caused by unstable water conditions and human activity **(Fox *et al*., 2003)**. Fig. (4); shows the presence of Acropora corals with non-Acropora corals. Acropora corals have axial and radial corals, while non-Acropora corals do not have axial corals **(Suharsono, 2008)**. Acropora and non-Acropora corals act as reef builders, have different sensitivity levels to different environmental stresses, and environmental factors, such as temperature, brightness, depth, and current strength. Environmental conditions affect the growth rate, life forms, and corals reproduction **(Kleypas *et al*., 1999)**. Environmental conditions also affect the abundance, composition, and diversity of coral communities **(Baker *et al*., 2008)**. Notably, the composition of coral forms at station 5 is more varied compared to other stations. This is supported by the quality of waters that meet standards and fairly good coral cover. Although the environment highly influences coral, it also has a corresponding effect on the ecosystem in return. One factor affected by coral coverage is the abundance of reef fish **(Coker *et al*., 2013; Nugraha *et al*., 2020)**.

3. Coral reef fish community structure

According to **Dartnall and Jones (1986)**, coral reef fish are classified into three main groups based on management objectives: (a) target fish (also known as economic fish), which are the main target of fishermen's catch as a source of economy and consumption; (b) indicator fish, which indicate the coral ecosystem conditions; and (c) the major fish group with fish between 5 and 25 cm whose specific role is unknown apart from the food chain cycle.

The results in Table (4) show that the number of reef fish is related to coral cover. In station 1, with the lowest coral cover, there are 31 major fish, 60 target fish, and no indicator fish. The results of this study concur with those of **Tony *et al.* (2020**) who depicted areas with low coral cover, so the presence of indicator fish was also low. Table (4) also shows the highest number of major fish groups compared to target and indicator fish groups. This is in accordance with the study of **Du *et al*. (2019),** who found that major fish groups often represent the largest portion of the fish populations in coral reef areas. However, this group of fish is not yet known for its specific ecosystem roles, other than functioning as part of the food chain.

The structure of reef fish communities shown in Table (4) was assessed by measuring diversity, homogeneity and the dominance index categorized according to **Du *et al*. (2019)**. The results show that the Shanon Wiener diversity index (H ') on Samber Gelap Island ranged from 1.45-2.38. This was classified in the medium category, with the highest value being located at station 5. The index value of homogeneity of coral reef fish communities is influenced by various factors, including coral condition and environmental factors such as temperature **(Sabdono *et al*., 2014)**. The index value of homogeneity (E) of reef fish communities on Samber Gelap Island was also calculated, with results ranging from 0.79 to 0.91. This was classified in the high uniformity category, meaning the reef did not contain many different types of biota. According to **Pratchett *et al*. (2011) and Songploy *et al*. (2017)**, greater biota uniformity in a community indicates that the community is stable. In regard to the dominance index (C), it was found that the values varied from 0.12 to 0.30, indicating that no one species within the region dominated more than the others. The five stations showed varied species results, meaning overall dominance was low. A low dominance index in an ecosystem generally results in the diversity index at that location being higher **(Madduppa *et al*., 2012)**. As a result of the poor coral cover condition in Samber Gelap waters, the diversity index is also low, and only certain fish can survive. As a result of the low diversity index, the homogeneity index is high **(Twinandia *et al*., 2011).**

A correlation assay between the abundance of coral reef fish and coral coverage was then performed to determine the relationship between the two variables (Fig. 7). Correlation assay between coral coverage and the number of reef fish. This indicates there was an increasing trendline, with a correlation coefficient of 0.972. Therefore, it can be concluded that there was a strong positive relationship between coral coverage and coral reef fish abundance.This means that if there were a decrease in coral conditions, fish abundance would also decrease **(Messmer *et al*., 2011; Komyakova *et al*., 2018)**. However, the correlation results were not close to a perfect correlation value (value 1), indicating that other factors also had an influence on the fish abundance in the waters of Samber Gelap Island. These results were in accordance with those of **Duffy *et al*. (2016), Prato *et al*. (2017)** and **Nugraha *et al*. (2020)**, who stated that the abundance of coral reef fish in an area could be influenced by factors such as coral rugosity (complexity), environmental conditions and aquatic nutrition. In general, the condition of coral cover on Samber Gelap Island is not in good condition. This can be seen from the number of indicator fish and the diversity index. The poor coral cover condition is related to current velocity and low brightness levels in the waters around the observation station.

CONCLUSION

In conclusion, the water conditions of Samber Gelap Island were classified as being supportive of coral reef life. Generally, the percentage of coral cover in this location was categorized as being damaged, with the highest coverage found at station 5. Similar results were also shown for the abundance of coral reef fish, with the highest number also being found at station 5 when compared to others. A correlation test showed that there was a strong positive relationship between coral coverage and the abundance of reef fish, meaning that a change in coral coverage would also result in a change in fish abundance. However, the results of this correlation also indicate that the abundant reef fish in the waters of Samber Gelap Island, Kotabaru, South Kalimantan was also influenced by other factors.

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