Journal of Coastal and Ocean Sciences *e-issn: 2746-4512*
Volume 6 No. 3, September 2025: 157-165 *p-issn: 2745-4355*

Relationship between Coral Reefs and the Abundance of Reef Fish of the Pomacentridae Family in the Waters of Setan Island, West Sumatra

Rangga Wardana[1*], Thamrin[1], Rifardi[1]
[1]Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru 28293 Indonesia
Corresponding Author: rangga.wardana60@gmail.com

Received: 9 July 2025; Accepted: 28 August 2025

ABSTRACT

Coral reefs play a role in maintaining marine biodiversity by providing habitat for various aquatic organisms, including reef fish from the Pomacentridae family. This study aims to analyze the relationship between coral reef cover and the Abundance of Pomacentridae reef fish in the waters of Setan Island, West Sumatra. The underwater photo transect (UPT) method is employed for coral cover analysis, while the underwater visual census (UVC) method is utilized for collecting fish abundance data. The results showed that the average percentage value of coral reef cover at a depth of 3 m was 20.38%, and at a depth of 6 m, it was 17.51%, indicating a poor category for the percentage value of coral reef cover. Data collection was conducted at four different stations. The highest coral cover was recorded at Station I (31.35%), while the lowest was at Station IV (0.33%). The Abundance of Pomacentridae reef fish varied between stations, with the highest Abundance observed in areas with higher coral cover. Based on simple linear regression analysis, the percentage of live coral cover accounts for 56.19% of the variation in the abundance value of Pomacentridae coral fish ($R^2 = 0.5619$), with a strong correlation ($r = 0.7496$). This indicates that declining coral reef conditions can harm fish populations. This finding underscores the significance of coral reef conservation efforts in maintaining marine biodiversity and ecosystem balance.

Keywords: Coral Reef Cover, Fish Abundance, Pomacentridae, Setan Island, Marine Ecosystem

1. INTRODUCTION

Coral reefs are a complex ecosystem built primarily by lime-producing biota (especially coral) and other biota living on the bottom and in the water column. Meanwhile, coral refers to a group of animals from the order Scleractinia that produce calcium carbonate (Rumambi, 2022). Corals are animals that symbioses with algae plants called Zooxanthellae to form reefs and provide pigment to corals (Agustina et al., 2016). The outer skeleton of a coral is called a corallite, which is composed of $CaCO_3$. The environment causes differences in branching shape (budding) and size. Still, the dominant factor causing differences in corallites is the type of polyp or type of coral animal (Luthfi, 2018).

The relationship between coral reefs and reef fish is rooted in the ecological functions that coral reefs provide for fish, serving as spawning grounds, nursery grounds, feeding grounds, and rearing grounds (Ridwan, 2022). Pomacentridae is a large family with generally omnivorous eating habits, including plankton and small invertebrates found on coral reefs (Rondonuwu et al., 2013). Coral reef–fish abundance relationships arise naturally but are modulated by dynamic oceanographic factors (temperature, salinity, currents), and poorly managed tourism on Setan Island can harm the reef ecosystem (Musaddun et al., 2013).

Previous research on the condition of coral reef cover on Setan Island was conducted by Frananda et al. (2019), based on the conclusions. The percentage of coral reef cover was categorized as medium, with a value of 47.13%. Another study by Zakaria (2013) found that the condition of coral reef cover was classified as poor due to high levels of algae and sedimentation. Similar research conducted by Khaidir et al. (2015) found that the percentage of live coral reef cover at a depth of 3 meters ranged between 44.64% and 63.10%, while at a depth of 6 meters, it ranged between 50% and 74.9%. The absence of the latest data regarding the condition of coral reefs and the Abundance of Pomacentridae fish provides a basis for researchers to conduct further research.

This research aims to describe and analyze the percentage of coral reefs and coral fish of the Pomacentridae family on Setan

Island, which serves as the background for this study. The research undertaken is expected to provide the latest data as a reference for projecting the condition of coral reef cover and coral fish of the Pomacentridae family on Setan Island, West Sumatra.

2. RESEARCH METHOD

Time and Place

This study was conducted in December 2024 in the waters of Sikuai Island, West Sumatra.

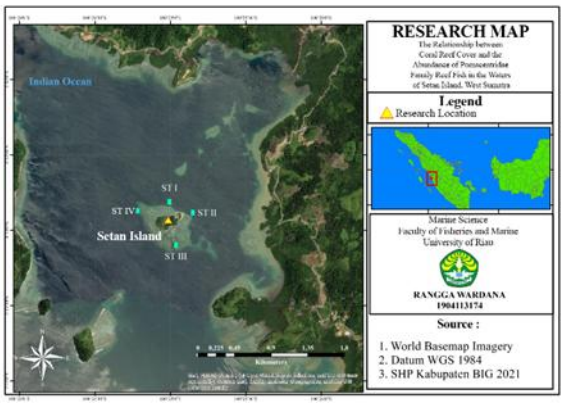

Figure 1. Research location

Method

Water quality was measured simultaneously at the surface of four fixed stations. Measuring sea surface temperature using a thermometer. Start by immersing ¾ of the thermometer in water and letting it sit for approximately 2-3 minutes. Then, lift it slowly, maintaining contact with the water. Then, observe the thermometer's value quickly and accurately (Kusumawati et al., 2018).

Salinity data are collected using a hand refractometer. It begins with a water sample being taken from the water surface using a bottle or dropper, which is then dripped onto the calibrated hand refractometer glass, which has been prepared with fresh water. The daylight plate is then closed. Then the observer's eyes observe through the lens while facing the prism towards the light. The scale value listed on the lens is indicated by a horizontal blue line in permil (‰) units, which are then recorded (Bibin et al., 2017).

Brightness measurement is performed using a secchi disk, which is inserted into the water until the white part of the disk is no longer visible. The length of the rope tied to the secchi disk at the water surface is then noted. Then, it is pulled slowly until the white part is visible again, and then the length of the rope at the surface boundary is recorded. The apparent lost distances are added together and then averaged in the calculation.

Current speed is measured using a current drogue. It begins by placing the current drogue tied using a predetermined rope on the water's surface. Prepare a stopwatch to measure the travel time until the rope stretches straight due to the current. The equation for calculating current speed can be seen as follows:

$$V = \frac{s}{t}$$

Description:

V : Current speed (m/s)
s : Distance travelled by the current drogue (m)
t : Time traveled by the current drogue (s)

Each parameter was sampled in triplicate and averaged to indicate environmental conditions affecting marine biota, particularly coral reefs and reef fishes.

Coral reef cover data were obtained using the Underwater Photo Transect method. This method utilises the development of camera technology and computer software to analyse and calculate the percentage of coral cover (Giyanto, 2014). The coral reef photo data collection uses an underwater camera equipped with housing. Then, the analysis activity is carried out on land using CPCe (Coral Point Count with Excel extension) software to obtain quantitative data. The level of analysis carried out on CPCe is intermediate; at this level, the percentage of coral reef cover can be determined from the life form of coral.

Data collection on the Abundance of coral fish from the Pomacentridae family was carried out using the Underwater Visual Census (UVC) method. According to Turan & Doğdu (2022), the UVC method is commonly used to assess fish density and biomass. The Visual Census method is a technique that utilizes vision to collect data on the Abundance of coral fish, including the types and numbers found along predetermined transects while underwater (Erdana et al., 2022). The location of the sample points for collecting fish abundance data is the same as for collecting coral reef data, but with a different observation width, namely 2.5 m to the right and left of the middle of the transect stretch (Ampou et al., 2020).

Procedures

Determining Research Locations

The selection of sampling stations was conducted using a purposive sampling approach. It began with snorkelling to obtain a general overview of the waters that would serve as observation points for coral reefs and reef fish. The observation stations were selected based on areas with visible coral reef flats and reef fish observed during the initial survey, taking into account several parameters that may influence the distribution of coral reefs and reef fish.

Station 1 is located in an area influenced by anthropogenic activities. Station 2 is situated on the island's eastern side, where the main pier is located. Station 3 is on the southern side, which is also affected by anthropogenic activities. Station 4 is on the western side of the island, which is far from tourist attractions. The coordinates of each station were determined using a GPS (Global Positioning System).

Data Analysis

Coral Reef Cover

The analysis of coral reefs was conducted using CPCe software, with more than 50 photos collected at each depth. Each image was analysed by selecting 30 random points. Each point was coded according to the category code of the corresponding biota or substrate. The percentage cover of each biota and substrate category in each photo frame was then calculated using the following formula (Giyanto, 2014):

$$\text{category cover percentage} = \frac{\text{number of category points}}{\text{number of random points}} \times 100\%$$

There are two transects at s, and 6 meters at each sample point. The data in photos is then analyzed in the CPCe application using 30 random points. Each point will represent a type of substrate category. The Criteria based on coral cover percentage:

Table 1. Criteria for coral reef damage

Parameter	Standard criteria for coral reef damage	Percentage of living coral reef coverage area (%)
Damaged	Bad	0 – 24.9
	Average	25 – 49.9
Good	Good	50 – 74.9
	Very Good	75 – 100

Fish Abundance

Analysis of the Abundance of coral fish shows the number of individuals per unit area at the research location. According to Sudarmaji & Efendy (2021) explain that fish density can be calculated using the following equation:

$$N = n/A$$

Description:

N = fish Abundance (ind/m^2)
n = number of individual fish (ind)
A = area of observations (m^2)

Assessment of the status of coral fish at the research location of the waters of Setan Island follows the assessment categories of Critic Sahetapy et al. (2019) as follows:

Table 2. Categories of fish abundance

Fish Abundance (ind/ha)	Category
1 – 210	Low
211 – 870	Medium
> 870	High

Regression Analysis

The analysis used to examine the relationship between coral reefs and the Abundance of coral fish employs regression analysis, facilitated by Microsoft Excel software. The simple linear regression equation is calculated using the following (Tanjung, 2014):

$$Y = a \times bx$$

Description:

Y : Dependent variable (Abundance of coral fish)
x : Independent variable (coral reef cover)
a : Constant
b : Regression coefficient

The criteria for the degree of correlation coefficient (r) according to Tanjung (2014) can be seen as follows:

Table 3. Correlation coefficient relationship

Correlation coefficient (r)	Criteria
0 – 0.25	Weak relationship
0.26 – 0.50	Medium relationship
0.51 – 0.75	Strong relationship
0.76 – 1.00	Very Strong relationship

3. RESULT AND DISCUSSION

Oceanographic Parameter

Oceanographic parameter sampling was done directly before collecting coral reef data in

February 2024. The results of the data collection are presented in Table 4. Obtaining a temperature value of 30ºC to 31.7ºC, salinity has a value of 30 -31 ppt, while the brightness level has a constant value of 6 m, and current speed with a value of 0.10 - 0.16 m/s.

Table 1. Oceanographic parameter

Parameters	Sampling Point			
	1	2	3	4
Temperature (ºC)	30.90	30.00	30.50	31.70
Salinity (‰)	30	33	31	30
Brightness (m)	6	6	6	6
Current Velocity (m/s)	0.13	0.10	0.16	0.10

Measuring water quality is one way to determine the standard quality conditions of a water area. The results of water quality measurements will serve as indicators that affect biota in the waters, particularly coral reefs and reef fish. Temperature is one of the factors affecting coral metabolism, reproduction, and classification. Coral can optimally grow at temperatures between 23 °C and 30 °C. High temperatures over a long period will cause the coral to become stressed. Then, the intertentacular dinoflagellate symbiont (Symbiodinium), which is symbiotic with the coral, will leave the coral, and eventually, the coral will experience bleaching or coral bleaching (Aulia & Sari, 2020). As a supplier of energy and nutrients to corals, zooxanthellae play a critical role. If this symbiont leaves the coral, this will cause a reduction in the source of energy and nutrients received by the coral, then reducing the coral's ability to produce $CaCO_3$ (Calcium Carbonate) and affecting the speed of reef building (Fachrurrozie, 2012).

The values obtained from data collection are in accordance with the optimal salinity level, which is between 30 - 35 ppt (Ding et al., 2022). Changes in salinity can affect the transfer of photosynthetic energy provided by zooxanthellae symbionts to corals, so metabolism in coral reefs will be disrupted. Changes in salinity levels in waters that affect cellular electrochemical processes in coral tissue will cause coral death.

The brightness or visibility of the waters that can be penetrated by the sun from the surface of the waters as deep as 6 m at each research station, which can be caused by bright weather factors, and the time of taking brightness parameters is almost the same. Light plays a crucial role in the photosynthesis process of zooxanthellae algae symbionts in corals, serving as a source of energy and nutrients to coral polyps (Rembet, 2012). The brightness on Setan Island is classified as an optimal condition for coral reef growth at every sampling station.

Bibin et al. (2017) explained that the current speed, with a range of 0-0.17, is considered slow. The slow current speed can be attributed to the movement and speed of the wind being obstructed by the islands surrounding Setan Island. According to Harahap et al. (2019), the condition of closed waters tends to have slow water currents. The speed of the current on the water surface is greatly influenced by wind and tidal movements (Prasetyo et al., 2018).

Coral Cover Percentage

The results of the analysis on the CPCe software project coral cover with various types of growth (lifeforms) and several category covers, which can be seen in the following Table 5:

Table 4. Percentage of live coral

Sampling Point	Depth (m)	Coral Cover (%)
I	3	31.35
	6	30.50
II	3	26.60
	6	18.56
III	3	23.27
	6	17.53
IV	3	0.33
	6	3.47

Based on Table 5, which shows the percentage of coral reef cover on Setan Island, the values range from 0.33% to 31.35%. The average rate of coral reef cover at a depth of 3 m is 20.38%. In comparison, at a depth of 6 m, the coral reef cover is 17.51%, indicating a poor category according to the standard classification. The highest percentage of coral

reef cover was found at Station I, with 31.35% at a depth of 3 m and 30.50% at a depth of 6 m. In contrast, the lowest percentage was recorded at Station IV, with 0.33% at a depth of 3 m and 3.47% at a depth of 6 m.

In this study, the author suspects that the location of the waters around Setan Island, which is surrounded by nearby islands, results in a current speed that is classified as slow. Yulianda, as cited in Bibin et al. (2017), stated that water current speeds ranging from 0 to 0.17 m/s are generally slow. The positioning of Cubadak Island, Sironjong Gadang Island, and Sumatra Island surrounding Setan Island protects the area from strong waves and currents. According to Harahap et al. (2019), enclosed water bodies tend to have slow current speeds. Wind and tidal movements strongly influence Surface water current speed (Prasetyo et al., 2018).

Slow current speeds can impact sediment transport and the formation of sand deposits that create layers on the surface of coral reefs. This can block sunlight penetration, thereby affecting the zooxanthellae algae symbionts that live in symbiosis with corals and prevent them from performing photosynthesis (Tuttle & Donahue, 2022).

Current speed will affect sediment movement, and sedimentation conditions accumulating on the water's bottom substrate will negatively impact coral. Piles of sand not carried away by the current will settle on the coral's surface, so the need for light as a material for photosynthesis of zooxanthellae will be disrupted.

The latest research on coral reef cover conducted on Setan Island by Frananda et al. (2019) projects a percentage of coral reef cover at 47.13%, dominated by non-Acropora, with an Algae component cover of 47.13%. Shows that the coral reef cover on Setan Island is classified as damaged. The results of earlier studies indicate a decrease in the percentage value of coral reef cover on the Setan island. This study found a high thermographic level accompanied by slow current speeds, providing evidence of a decrease in the percentage value of coral reefs.

An abundance of Coral Fish of the Pomacentridae Family

The findings from direct observations and censuses of the Pomacentridae family of coral fish at the research location revealed several species from different genera, some of which are listed in Table 6.

The number of individual fish from the Pomacentridae family is converted into hectares to obtain an estimate of the Abundance of individuals per hectare and to project the condition of fish on coral reefs. These values at each station, with each depth, are presented in Table 7.

Coral reef areas provide habitat for fish from the Pomacentridae family. Decreased coral reef cover can reduce the availability of food sources and protection for reef fish populations. Pomacentridae is a large family with generally omnivorous eating habits, including some herbivorous "plankton feeders", as well as small invertebrate eaters found on coral reefs (Rondonuwu et al., 2013). As herbivores, pomacentridae fish eat phytoplankton that live in coral ecosystems (Sitohang et al., 2021). Therefore, the indicator of coral reef health is the best habitat for pomacentridae fish in obtaining food.

Based on the observation results, pomacentridae fish with small bodies, such as P. moluccensis, P. auriventris, and N. azysron, spend more time in coral crevices to defend themselves from predators. In contrast, fish with larger sizes, such as *A. vaigiensis, C. atripectoralis, D. trimaculatus*, and *P. favipectoralis,* tend to have a solitary lifestyle. According to the statement (Falah & Arthana, 2020), the Pomacentridae family, which has small bodies, tends to exhibit group behavior and utilizes branching coral reef crevices as shelter, while larger fish swim away from their territory to find food.

According to Rondonuwu et al. (2013), the Pomacentridae family is an omnivorous fish that obtains food from algae and small organisms within the coral reef ecosystem. The comparison of coral reef cover accompanied by algae cover in the waters of Setan Island provides a greater chance of survival for fish that depend on the complex structure of coral reefs and food availability from algae cover. Fish also utilise coral reefs from the Pomacentridae family to hatch their eggs on the ocean floor (Hadi et al., 2013).

Water conditions with high temperatures and slow current speeds greatly affect the percentage of live coral reef cover. It can be seen at station IV, which has the lowest coral reef cover, the highest temperature parameter conditions, and a slow current speed. Water quality also plays an essential role in aquatic

ecosystems in the long term, influencing individual Abundance. This is in accordance with research conducted by Nakano et al. (2004) on fish at temperatures above 30 ºC, which can cause stress in fish to the point of death. The measurement of temperature parameter values carried out on Setan Island, with a range of 30ºC to 31.7ºC, is suspected as the cause of several species with limited adaptation abilities having difficulty surviving in extreme environmental conditions.

Table 5. Number of Individual fish of the Pomacentridae family at the observation station at each depth

Genus	Species	Sampling Points								Total (ind)
		I		II		III		IV		
		Depth								
		3	6	3	6	3	6	3	6	
Pomacentrus	*P. mollucensis*	15	4	25	11	16	24	3	10	108
	P. auriventris	7	3	5	0	0	0	0	0	15
Dascyllus	*D. trimaculatus*	3	0	1	1	0	8	0	1	14
Neopomacentrus	*N. azysron*	20	15	12	19	0	0	0	0	66
Chromis	*C. atripectoralis*	3	1	1	4	0	0	0	0	9
Abudefduf	*A. vaigiensis*	1	2	0	1	0	3	0	2	9
Pycnochromis	*P. flavipectoralis*	1	2	4	3	0	0	0	0	10
		50	27	48	39	16	35	3	13	231

Table 6. Abundance of Pomacentridae family reef fish at each depth at each observation station in the waters of Setan Island

Sampling Points	Depths (m)	Number of individuals	Abundance of coral fish (ind/m^2)	Abundance of coral fish (ind/ha)	Abundance Criteria
I	3	50	0.2	2000	High
	6	27	0.108	1080	High
II	3	48	0.192	1920	High
	6	39	0.156	1560	High
III	3	16	0.064	640	Medium
	6	35	0.14	1400	High
IV	3	3	0.012	120	Low
	6	13	0.052	520	Medium
Total		231	0.924	9240	High

The relationship between the Abundance of coral fish and the condition of coral reef cover

The analysis of the relationship between the Abundance of coral fish and the condition of coral reef cover, using the simple linear regression method in the Microsoft Excel application, is presented in the graph shown in Figure 2.

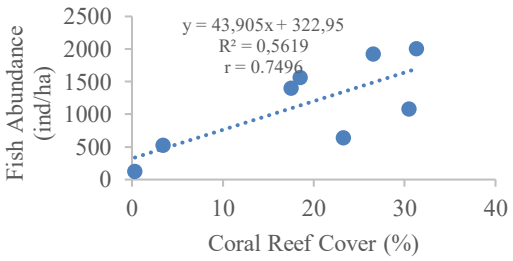

Figure 1. Results of regression analysis of coral reef cover on the Abundance of coral fish of the Pomacentridae family

Based on the results of simple linear regression calculations related to the relationship between the percentage of live coral cover and the Abundance of coral fish from the Pomacentridae family on the Setan island, the coefficient of determination (R^2) value is 0.5619, which means that 56.19% of the role given by coral reefs affects the Abundance of coral fish. In comparison, 43.81% is influenced by other factors. The correlation value (r) is 0.7496, indicating the strength of the relationship between the variables tested. Therefore, the influence of coral reefs on the Abundance of individual coral fish from the Pomacentridae family has a strong relationship (Tanjung, 2014). The significant F value in the regression calculation shows a value of less than 0.05, which is 0.032, which means that there is a relationship between live coral reef cover and the Abundance of coral fish from the

Pomacentridae family.

High fish abundance indicated average or better coral cover at four stations sampled at 3 m and 6 m depths (Station I at both depths; Station II at 3 m). This is in accordance with the statement by Adiyoga et al. (2020) that coral reefs greatly affect the Abundance of coral fish; good coral reef conditions will also increase the Abundance of these fish.

Furthermore, at 6 m depth at stations II and III, fish abundance remained high despite bad coral cover, likely due to abundant algal cover as an alternative food source. According to Rondonuwu et al. (2013), the Pomacentridae family is an omnivorous fish that obtains food from algae and small organisms within the coral reef ecosystem. The comparison of coral reef cover accompanied by algae cover in the waters of Setan Island provides a greater chance of survival for fish that depend on the complex structure of coral reefs and food availability from algae cover.

At Station III at 3 m depth and Station IV at 6 m depth, reefs with low criteria percentage cover have a medium fish abundance due to more abundant algal food sources. Station IV is at 3 m depth, with poor coral reef conditions and the lowest Abundance of pomacentridae.

These patterns suggest that reef structure, food source availability, and environmental stressors caused by high temperatures impact the Abundance of pomacentridae fish on coral reefs. Habitat unsuitability and limited food supply limit the abundance value of fish from the Pomacentridae family. Still, some forms of association between small chunks of coral and small fish can be found in several coral crevices. This is in accordance with the statement by Drew & Barber (2009), which notes that Pomacentridae fish inhabit coral reef gaps and form groups on a single piece of reef with a branching growth form (Akbar et al., 2018).

4. CONCLUSION

Research on the Abundance of Pomacentridae and coral cover in the waters of Setan Island using underwater photo-transects and visual censuses. Found coral cover conditions were categorised as low, with locations having higher cover supporting more fish. The regression value showed a strong positive correlation (r = 0.7496), although other environmental factors also affected the number of fish. These results underscore the importance of conserving coral reefs to maintain marine biodiversity and balance in the ecosystem.

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