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PREFERENCE OF SPONGIVORE FISHES ON CORAL REEF ECOSYSTEMS WITH DIFFERENT ENVIRONMENTAL CONDITIONS ON HOGA ISLAND, WAKATOBI

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ABSTRACT

Degradation of coral reefs due to changes in environmental conditions causes corals to experience a decline in the number of organisms. Sponges, one of the components that make up the coral reef ecosystem, are known for their adaptability. Thus, the role of spongivore as distribution controllers is essential to assess. This research aims to determine the relationship between hard coral cover and sponge cover, the relationship between environmental parameters and sponge cover, and the preferences of predatory sponge fish. This research was conducted in July 2018 on Hoga Island, Wakatobi, by taking two stations with different conditions between clear and turbit water. At each station, benthic cover data was collected using the LIT (Line Intercept Transect) method, and environmental parameter data was collected using CTD (Conductivity Temperature Depth) and sediment traps. Predatory fish abundance data was collected using the belt transect and UVC (underwater visual census) methods, and the preferences of predatory fish were observed with visual observations for 5 minutes. The research results found that hard coral cover and sponge cover had an inverse relationship. Environmental parameters that significantly affected sponge cover were turbidity and sedimentation rate and high preference values for spongivore fishes.

Keywords: sponge, coral reef, environmental parameter, predatory sponge fish, Hoga Island

INTRODUCTION

Currently, coral reefs are facing serious degradation, a pressing issue caused by various factors such as global warming, high sedimentation levels, and environmentally unfriendly fishing behaviour (Hughes et al., 2010). Ecologically, sponges are a component of coastal and marine ecosystems, especially coral reef ecosystems. Lesser (2006) even calls it one of the organisms with quite a high abundance and diversity of species after coral.

Many associative organisms are found in the water channel system, such as brittle stars, small crustaceans, and other benthic biota (Harris, 2013). The existence of sponges, which have the potential to become degraders for coral reef ecosystems, was further explained by Power et al. (2010) that sponges act as competitors in the struggle for space and are an integral component of tropical coral reef systems that play several functional roles including nutrient cycling, coral consolidation, bio-ion erosion, facilitating primary production and benthos.

As one component of the coral reef ecosystem, sponges are also influenced by environmental conditions such as temperature, salinity, brightness, and currents. However, Bell et al. (2013) stated that it will likely be the ablest to adapt to the onslaught of changing environmental conditions and will dominate the competition for habitat in aquatic areas (Bell et al., 2013).

Sponges are also associated with several species of coral fish, which act as predators. Predatory fish have a central position in ecological development (Peterson, 1979), and the presence of predatory sponge fish may not only be for consumption but also play a role in habitat competition (Reidenauer and Thistle, 1981). In addition, a requirement to determine the role of predation in controlling sponge distribution and abundance is to identify sponge predators and see differences in sponge predator predation under certain environmental conditions (Powell et al., 2015).

Hoga Island is one of the islands in the Wakatobi National Park Area, which has an average coral reef community structure and was identified from 2002 to 2015 (Powell et al., 2014) and based on Minister of Forestry Decree No. 7651/Kpts-II/2002. Following Law No. 5 of 1990, National Parks are managed using a zoning system. Currently, the zoning of the Wakatobi Islands National Park is divided into five zones, and Hoga Island is included in the utilization zone. Hoga Island has long been used and developed by Operation Wallacea for research activities and has dive sites with different conditions. The differences in the conditions of the Hoga Island dive sites are based on the results of research by Sakaria (2018), which shows differences in environmental parameters at the Sampela site and the Pak Kasim's site.

Given the many functional roles of sponges (Bell, 2008), changes in sponge abundance could haveess essential effects on coral reef complexity, biodiversity, and productivity of tropical reef systems, with subsequent implications for the socio-economic well-being of communities. Therefore, it is essential to assess the factors that control sponge distribution and abundance patterns, such as their potential as degradators, the influence of changing environmental conditions, and the role of predatory fish—especially considering that sponges may be more abundant due to increased ocean acidification and global warming (Bell et al., 2013). Our research on the preference of spongivore fishes on coral reef ecosystems with different environmental conditions on Hoga Island, Wakatobi, is a timely and crucial contribution to the understanding of this complex problem.

MATERIALS AND METHODS

This research was conducted in July 2018 on Hoga Island, Wakatobi National Park, Southeast Sulawesi (Figure 1).

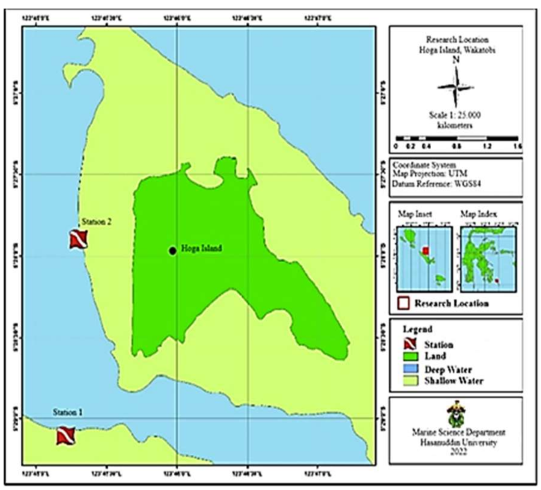

Figure 1. Map of research locations on the western and south-southwestern Hoga Islands.

Taking two points on the Hoga Island dive site, namely Sampela as Station 1 (S: 123°45'14.888" "E: 5°29'4.699), which was chosen because it has environmental conditions with turbidity and high sedimentation rates. Station 2 is Pak Kasim's site (S: 123°45'18.143" E: 5°27'20.915") as a comparison station. Initial observations consisted of observing the research location at the two previously determined sites to determine reef zone for data collection: reef crest and reef slope.

Data of Benthic Coverage

Benthic cover data collection used the LIT (Line Intercept Transect) method to record life form categories (Manuputty and Djuwariah, 2009). This method collects field data by installing line transects 30 meters long in two reef zones, four repetitions, each with an interval of 10 meters at each station. So, the total number of transects is eight per station, which are then coded A, B, C, D, E, F, G, and H. Observations are made by recording video along the line transect and then determine benthic cover from the recorded video.

Environmental Parameter

Environmental parameters measurement such as temperature, salinity, and turbidity uses CTD (Conductivity Temperature Depth), which has been placed at each station. CTD consists of 3 main sensors: a pressure sensor for depth measurement, a thermistor as a temperature sensor, and an inductive cell as a salinity sensor. Apart from that, sensors for chlorophyll, turbidity, oxygen, and so on can be provided.

Sedimentation Rate

Sedimentation rate was collected by placing six sediment traps each on the reef crest and reef slope at 5-meter intervals for seven days (Figure 7). After that, the sediment trap is closed and removed from the water (Adriman et al., 2013). Next, filter the existing sediment with Millipore Whattman GF/C filter paper with a diameter of 47 mm and pore size of 0.45 µm, then dry in a 105ºC oven for 1 hour. After drying, the filter paper was weighed using a Pioneer digital scale.

Abundance of Fishes

Observation of the abundance of spongivore fishes species using a belt transect with the underwater visual census (UVC) method. Observations were carried out by installing a 30m transect four times in two reef zones at 10m intervals. Then carry out UVC observations with a range of 2.5 meters to the left and 2.5 meters to the right of the transect and then record the number of species of spongivore fish that have been determined, namely *Centropyge bicolor*, *C. tibicen, C. vloriki, Chaetodon kleinii, Pomacanthus imperator, P. xanthometopon*, *Pygoplites diacanthus*, and *Zanclus cornutus* (Mortimer 2018, kompers., July 9).

Fish Preferences

The preferences of spongivore fishes were observed by observing the feeding activities of all spongivore fishes found at both research stations. Then, from the results of these observations, a comparable number and type of both research stations were determined, namely 14 predatory sponge fish, 7 each at Station 1 and 7 at Station 2. Observations were carried out visually by following the mobilization of the spongivore fish for 5 minutes while counting and recording the number of bites on the sponge and other food choices.

Data Analysis

Benthic Coverage

Data obtained from the LIT (Line Intercept Transect) method is then calculated by comparing the total length of each category with the total transect length using the following formula:

$$\text{Coverage Percentage (\%)} = \frac{Total\ Len\quad of\ the\ Category}{Total\ Length\ of\ Transect} \text{x } 100$$

Sedimentation Rate

The sedimentation rate was determined by following APHA (1976) as cited by Supriharyono (1990), i.e.:

$$\text{Sedimentation Rate} = \left(\frac{10000}{\pi r^2}\right)(\text{A-B})$$

Where:
A: Aluminum foil + sediment weight after heating at 105^{o}C in gram
B: Initial weight of aluminum foil after heating at 105^{o}C in gram

Fish Abundance

The following formula calculated the abundance of spongivore fish:

$$\frac{\Sigma\ ind.of\ coral\ fishes\ at\ station - i}{transect}$$

Descriptive analysis was carried out on data on the relationship between hard coral cover and sponge cover, as well as data on the average cover of environmental parameters and the preferences of predatory sponge fish, which were displayed using bar graphs. Statistical analysis of the Independent-Samples T-Test to see the differences in parameters at the two stations. Then, test the Bivariate Pearson correlation to see further the relationship between hard coral cover and sponge cover as well as the relationship between environmental parameters and sponge cover

RESULTS AND DISCUSSION

Relationship between Hard Coral and Sponge Cover

Benthic cover at both stations is dominated by abiotic components (dead coral, dead coral algae, sand, rubble, and rock). This abiotic cover percentage exceeds 50% of the overall cover percentage, but a higher percentage was obtained at Station 1, which reached 69.17%. Likewise, the percentage of sponge cover was higher at Station 1. Meanwhile, other covers, namely, algae, soft coral, and hard coral, were found to be higher at Station 2 (Figure 2).

Coral animals are the main builders of coral reef ecosystems, whereas animals that produce lime for their body skeletons are important to coral reef ecosystems (Guilcher 1988).

Coral reef condition criteria are based on Minister of Environment Decree No. 4 of 2004 divides the condition of coral reefs into several sections based on the percentage of living coral cover, including 0.0-24.9% (poor), 25.0-49.9% (medium), 50.0-74.9% (good), and 75.0-100.0% (very good). Even though, based on the average calculation, the two stations are in poor coral reef condition (Figure 8), each Station 1 data collection transect is all in poor condition, but the data from each Station 2 data collection transect shows better conditions, namely around between poor to moderate conditions (Figure 8).

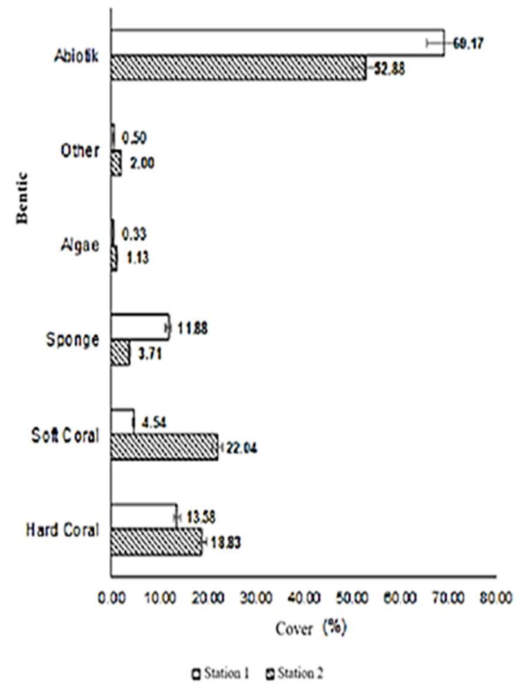

Figure 1. Benthic cover station 1 and station 2

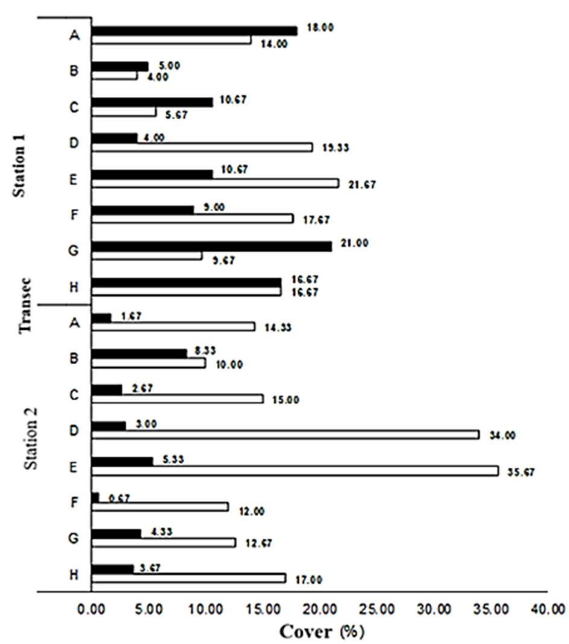

Figure 3. Comparison of hard coral cover and sponge cover for each observation transect at Station 1 and Station 2

A comparison of hard coral and sponge cover at Station 1 and Station 2 reveals that sponge cover is relatively high when hard coral cover is low, and sponge cover is low when hard coral cover is high. As one of the constituent components of the coral reef ecosystem, sponges were mentioned by Lesser (2006) as one of the organisms with relatively high abundance and species diversity after coral.

This is due to habitat comptetition between hard corals and sponges. As stated by Amang (2017), one of the competitions occurring in benthic communities is between hard corals and sponges. Competition is a crucial process in determining the structure and composition of benthic coral reef communities. The competition is natural and constitutes a dynamic present in aquatic environments.

Consequently, the observations and analyses conducted indicate that sponges have the potential to act as degraders of corals, referring to the decline in coral organisms. Amir & Budiyanto (1996) stated that, similar to algae, sponges also compete with corals for light, with sponges able to grow among branching corals. Bell et al. (2013) further emphasized that the decline in coral organisms within the ecosystem makes sponges one of the most adaptable components of the coral reef ecosystem, likely to dominate habitat competition in aquatic areas. Amang (2017) also added that sponges will become competitors in conditions where corals have already degraded.

Relationship of Environmental Parameters to Sponge Cover

The following are the average environmental parameters obtained at Station 1 and Station 2, which are presented along with the average sponge cover. The left Y-axis displays the sponge cover, temperature, salinity, and turbidity values, while the right Y-axis displays the sedimentation rate values in Figure 3. The average environmental parameters, such as temperature, salinity, turbidity, and sedimentation rate for Station 1, are higher compared to Station 2. The average environmental parameter is directly proportional to the sponge cover, which is also higher at Station 1 compared to Station 2. The average turbidity and sedimentation rates show quite a striking difference.

The results of the Independent Sample T-Test on all environmental parameters showed significant differences between Station 1 and Station 2. Koesobiono (1979) stated that temperature is an important limiting factor in the marine environment. The water temperature at both stations showed almost the same results; both were in the temperature range of 27^{0}C; this temperature is still within the optimal temperature limit for sponges (Figure 3). According to De Voogd (2005), sponges grow at a temperature range of 26-31^{0}C. Fromont (1994) added that water temperature is important among the external factors influencing gametogenesis in sponges and other marine animals in areas with large seasonal changes.

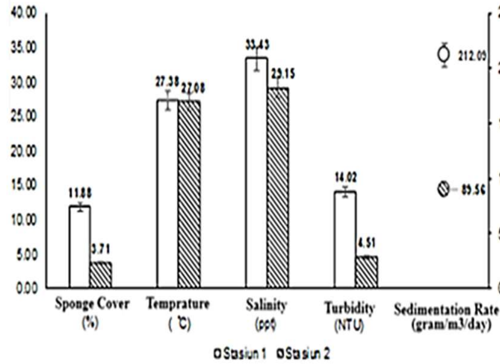

Figure 4. Average environmental parameters and sponge cover at station 1 and station 2.

The results of the Independent Sample T-Test on all environmental parameters showed significant differences between Station 1 and Station 2. Koesobiono (1979) stated that temperature is an important limiting factor in the marine environment. The water temperature at both stations showed almost the same results; both were in the temperature range of 27^{0}C; this temperature is still within the optimal temperature limit for sponges (Figure 3). According to De Voogd (2005), sponges grow at a temperature range of 26-31^{0}C. Fromont (1994) added that water temperature is important among the external factors influencing gametogenesis in sponges and other marine animals in areas with large seasonal changes.

According to Storr (1976), the optimum salinity for sponge life is 30-36 ppt. The salinity at Station 1 (33.43%) is classified as optimal salinity for sponges. The high salinity value at Station 1 is assumed to be influenced by Bajo tribal settlements. Kausai et al. (2005) state that increased salt levels can also be caused by changes in land use in residential areas. The salinity value of station 2 (29.16%) is not included in the optimum salinity for sponges. Canadian (1993) stated that sponges could tolerate a minimum salinity of 22 ppt, optimum salinity ranges from 30-33 ppt, and the maximum seawater salinity limit that sea sponges can tolerate is around 34 ppt.

De Voogd (2005) suggests that high turbidity can increase sedimentation. Turbidity will directly affect the benthic animal community in these waters and the distribution of sponges (Hawkes, 1978). Furthermore, De Voogd (2005) stated that the presence of total suspended solids in water affects the intensity of sunlight entering the water body, which causes the brightness value of a body of water to be closely related to the penetration of sunlight into the water body, where this affects the photosynthesis process of sponges. Based on research that has been carried out, it was found that the average sedimentation rate was much higher at Station 1 than at Station 2. According to Sakaria (2018), Station 1 has a high sedimentation rate due to high anthropogenic activity, and the housing location is at sea level and in the future. In the past, many residents mined coral to make foundations for houses. Bell and Barnes (2000) also stated that sedimentation has been shown to affect sponges in the tropics, but little information is available on sponge assemblages in the tropics. Sponge cover, diversity, and abundance are lower in areas with high sedimentation (Bell & Smith, 2004). Descriptively, the value of sponge cover is higher at Station 1, with a high level of turbidity, compared to Station 2, with a low level of turbidity and low sponge cover. The Bivariate Pearson correlation test results between each environmental parameter and sponge cover also showed that turbidity (P=0.006) and sedimentation rate (P=0.024) had a significant relationship with sponge cover. Some researchers suspect that sponges have different adaptation abilities. Bell and Smith (2004) and Carballo et al. (2006) stated that the strategy that sponges must survive is thought to be in the form of passive adaptations that can prevent sediment, such as morphological and structural modifications of sponges. Another parameter that is quite important for the survival of sponges is current. Currents are essential in the circulation of water, carriers of dissolved materials, and suspended solids (Dahuri, 2003). According to Storr (1976), sponges can grow normally at current speeds less than 0.6 m/s. Amir and Budiyanto (1996) believe sponges can grow in calm and current waters.

Preference of Spongivore Fish

The research results on the abundance of spongivore fish have been previously determined to include eight species of spongivore fish. Based on observations of the abundance of spongivore fish at both stations, a higher total abundance was found at Station 1 compared to Station 2 (Figure 4). The presence of 8 species was recorded at Station 1, while Station 2 only recorded four species: *Centropyge bicolor*, *Centropyge vroliki*, *Pygoplites diacanthus*, and *Zanclus cornutus*. As Effendie (1997) stated, food availability is one factor that determines a population's abundance. Zanclus cornutus had the highest total abundance at both observation stations. Fish with high abundance, even in different environmental conditions, show high ecological niche breadth because they are generalists and are unaffected by conditions' differences (Levins, 1968 in Krebs, 1989). This situation shows that the species has a wide ecological niche and is not significantly affected by changes in habitat composition.

This also influenced the absence of several species at Station 2, including *Centropyge tibicen*, *Chaetodon kleinii, Pomacanthus imperator*, and *Pomachanthus xanthometopon*. Apart from that, coralfish have a narrow ecological niche. As a result, certain types of coral fish are limited and localized only in some regions of the coral reef (Ilham, 2007). Observing the preferences of spongivore fish, it was found that four species were found in comparable numbers at both stations at the time the observations were made, including 1 *Centropyge bicolor*, 3 *Chaetodon kleinii*, 2 *Pygoplites diachantus*, and 1 *Zanclus cornutus* each at Station 1 and Station 2. Observing the preferences of *Centropyge bicolor*, the preference at Station 1 was highest for rock and lowest for sponge, while Station 2 showed the opposite (Figure 5).

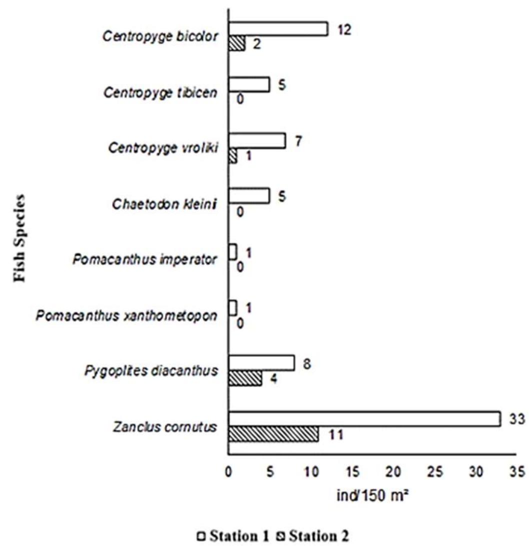

Figure 5. The abundance of spongivore fish species at stations 1 and 2.

Observing the preferences of three *Pygoplites diacanthus* at Station 1 and Station 2, species from the same family as *Centropyge bicolor*, namely Pomacanthidae, found varying preferences between the three individuals observed. The preference of *Pygoplites diacanthus* (a) at Stations 1 and 2 shows no preference for sponges with several bites of 0. *Pygoplites diacanthus* (b) prefers sponges with 5 attacks at Station 1, while Station 2 prefers two bites (Figure 5). *Pygoplites diacanthus* (c) prefers seven bite of sponges at station 1 and 15 bite of sponges at Station 2 (Figure 5). Froese and Daniel (2005) stated that food from the Pomacanthidae family is zooplankton, algae, and benthic invertebrates such as sponges, tunicates, bryozoans, and hydroites. The species and amount of feed consumed by a fish species usually depends on the age of the fish, feed availability, and time (Effendie, 1979). This difference in preferences is due to age, food availability, and time differences.

Another species observed was *Chaetodon kleinii*, a species from the Chaetodontidae family. Observations of two *Chaetodon kleinii* at Station 1 and Station 2 showed that the two *Chaetodon kleinii* at both Station 1 and Station 2 had the highest preference values for sponges (Figure 5). Chaetodontidae are coral eaters, sessile invertebrate eaters, and sedentary (Bell & Harmelin-Vivien, 1983). Chaetodontidae, generally known to eat coral polyps but found at both research stations, showed the highest preference for sponges, presumably because the condition of the benthic cover at both stations influenced them. The feeding habits of

Chaetodontidae are influenced by the conditions of the benthic cover where the Chaetodontidae reside (Gregson et al., 2008; Sano, 1989). Apart from that, based on the observations, it was also found that a very high number of bites were found in *Chaetodon kleinii* compared to observations of other species at Station 1 and Station 2. This is because Chaetodontidae tend to mobilize little and stay around their food if it is plentiful or sufficient. As explained by Crosby and Reese (1996) Chaetodontidae are very territorial, where the amount of food determines their territory. If the availability of food in an area is low, the Chaetodontidae will expand their territory.

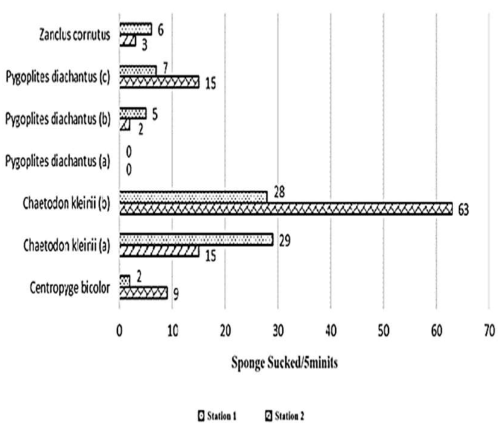

Figure 6. Spongivore fish preference

Observation of the preferences of *Zanclus cornutus*, the single species of the Zanclidae family, found a preference for sponges at both stations. Sponge is the main food of *Zanclus cornutus* (Randall et al., 1990). Although sponges are the main food of *Zanclus cornutus*, this species also shows interest in all other food options. As stated by Hartati and Edrus (2010), the ecological niche of coral reef fish also shows territorial behavior with their constant mobility around their food. So, comprehensive mobility can mean a wide search area for food and is not limited by certain conditions.

Observations and experiments have shown that spongivore fish on coral reefs can influence sponge distribution, limiting some species to lagoons, mangrove habitats, and on coral reefs (Wulff, 1997; Pawlik, 1998; Hill & Hill, 2002). Fish predation has also been shown to reduce the capacity of some sponges to grow coral (Hill, 1998).

Sponge predators can also have differential effects on different species, particularly between species that differ in chemical defenses. This can result in changes in the combined position of sponge assemblages if predation pressure changes (Pawlik et al., 2013). In addition, if predators play an essential role in controlling sponge populations, then a decrease in sponge predation (e.g., through overfishing) could lead to an increase in sponges and further strengthen the transition to a sponge dominance system (Bell et al., 2013; Loh & Pawlik, 2014). So, the role of predatory sponge fish is expected to be able to control the growth of sponges.

CONCLUSION

Based on the research conducted, it can be concluded that there is an inverse relationship between hard coral cover and sponge cover, primarily due to habitat competition. Environmental factors such as turbidity and sedimentation rate have significant impacts on sponge cover. Additionally, sponges are highly preferred by sponge-predator fish. These findings highlight the intricate dynamics within coral reef ecosystems and underscore the importance of considering multiple environmental parameters

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