Journal of Natural Resources and Environmental Management
13(4): 624–633. http://dx.doi.org/10.29244/jpsl.13.4.624–633
E-ISSN: 2460-5824
http://journal.ipb.ac.id/index.php/jpsl

The conditions of coral reef ecosystem on Seureudong Island, South Aceh, Indonesia

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Article Info:
Received: 25 - 03 - 2023
Accepted: 21 - 05 - 2023

Keywords:
Fringing reef, lifeform pocillopora, turf alga

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Abstract. *The coral reef ecosystem on Seureudong Island, Sawang Bau Village, Sawang District, South Aceh is very important for the surrounding ecosystem, with the fringing reef type, namely the shape of its growth around the island. This study aims to determine the current condition of coral cover and the types available on Seureudong Island. The Point Intercept Transect (PIT) Method was used. The results showed that the coral forms found at the study site were branching, digitate, encrusting, foliose, massive, mushroom, plates, and submassive. The percentage of the bottom substrate is dominated by hard coral (hard coral) at 45.33%, Dead Coral with Algae/DCA (37.11%), sand (9.89%), rubble of 3.56%, rock (1.56%), algae turf (1.44%), macroalgae (1%) and dead coral (0.11%). At the study site, 25 genera were identified, with Porites (36%) being the most common genus. At the research location, there were also genera with a total presence of less than 1%. These genera were Acanthastrea, Ctenactis, Favia, Favites, Fungia, Gardineroseris, Goniopora, Halimeda, Heliopora, Hydnophora, Leptastrea, Montastrea, Pavona, and Seriatopora. The water quality at the research location still complies with the standards of coral life. The results of these observations must be carried out periodically so that they can always update the condition of coral reefs on Seureudong Island.*

How to cite (CSE Style 8th Edition):
Najmi N, Lisdayanti E, Lubis F, Darmarini AS. 2023. The conditions of coral reef ecosystem on Seureudong Island, South Aceh, Indonesia. **13**(4): 624–633. http://dx.doi.org/10.29244/jpsl.13.4.624–633.

INTRODUCTION

The territory of Indonesia, which is an archipelagic country, has high biodiversity, especially coral reefs (Astrawan et al. 2021). Coral reefs are areas of interaction between aquatic organisms (Purnama et al. 2020) and habitats for coral fish and invertebrates (Sukandar et al. 2021). These are diverse and complex ecosystems in terms of biodiversity, including the megabenthic (Syahrul et al. 2022). This ecosystem also provides direct benefits to humans, such as providing food and medicine (Azis and Ahmad 2020). Coral reef ecosystems provide ecosystem services (Carlot et al. 2020) and transform them as a result of climate change (Tebbet et al. 2020). Both natural and human causes cause damage to coral reef ecosystems (Febrizal et al. 2009). Natural factors that result in damage include changes in temperature and coral diseases, whereas human factors are usually caused by fishing and tourism activities (Mutahari et al. 2019). Anthropogenic and environmental

changes can affect the distribution of coral reef genera (Crehan et al. 2019). Furthermore, it will have an impact on economic value, because healthy coral reefs have high economic value (Sukandar et al. 2022).

Coral reef ecosystems are widespread in various areas, including the waters of the Aceh Province in the West and South. The condition of coral reefs in the province of Aceh, especially the southwest region of Aceh, has its own uniqueness due to a combination of species originating from the Indo-Pacific, Indian Ocean, and Andaman Sea (Rudi et al. 2012). Coral reef ecosystems in the waters of the Indian Ocean are unique, although according to Veron (1995), the reef-forming corals in the Indian Ocean are the least known globally. This uniqueness arises because coral biogeography throughout the Indian Ocean is influenced by current patterns, speciation, and species extinction (Spalding et al. 2007).

Studies of coral reefs, both identification and cover, are still very limited in the waters of West South Aceh. Several studies related to this topic have been conducted in Aceh everal studies related to this topic have been carried out in Aceh Province, namely Pulau Weh (Rudi et al. 2012), Johan Pahlawan and Samatiga, West Aceh (Annas et al. 2017), and Krueng Raya, Aceh Besar (Najmi et al. 2021). Therefore, it is necessary to conduct studies on the current conditions of coral reefs in the region. The coral reef ecosystem that requires special attention is the coral reef ecosystem on Seureudong Island, South Aceh. This island is in the waters of South Aceh, specifically in the Indian Ocean. This island is a fishing tourism area on the southwestern coast of Aceh.

Seureudong Aceh Island is a small uninhabited area located in the village of Sawang Ba'u, Sawang District, South Aceh District. Based on the results of initial observations, this island has a coral reef ecosystem that is still natural and has not been managed optimally. Reports and information about this island are limited to the diversity of molluscs reported by Khairani et al. (2015), while the existence of coral reef ecosystems has not been reported. This location is very interesting for studying the condition of coral reefs because it is in the Indian Ocean, which is known to have unique ecosystem characteristics. Based on the description above, it is important to conduct a study that aims to analyze the current condition of coral cover in the waters of Seureudong Island, South Aceh.

METHOD

Study Area

This research was conducted in the waters of Seureudong Island, South Aceh, between September and October 2022. The research locations are shown in Figure 1. This research was conducted in Seureudong Island, South Aceh, between September and October 2022. The research location is shown in Figure 1. Three sampling stations were carried out three times at each observation station to represent these waters. This island is close to residential areas and is used as a water catchment area, so its condition needs to be seen to be used as a basis for coral reef management in the future. Sampling points around the island are used as snorkeling and fishing spots. So, research needs to be carried out to monitor the condition of coral reefs experiencing bleaching.

Data Collection

Data were collected using a survey method. Coral reef data collection on Seureudong Island was carried out, including 1) calculating the percentage of coral cover and 2) measuring the water quality. Observation of live coral cover was carried out using the Point intercept transect (PIT) method with three replicates; each replicates 50 m away. This method is used to quickly and easily monitor the growth of coral reefs (Hill and Wilkinson 2004). The coral genus was identified using the coral identification book by Veron and Smith (2000). Water quality parameters were measured in situ, consisting of temperature (°C), salinity (‰), depth (m), and brightness (m), with respective measuring instruments, namely, a thermometer, refractometer, deep gauge, and Secchi disc. Water quality measurements were carried out between 10.00–12.00 am with three repetitions.

Data Analysis

The percentage of coral cover was determined at three observation stations around the island using the PIT technique. Observations of coral species and their life forms were recorded. The percentage of coral cover was calculated using the Gomez and Yap equation (1988) with four categories: score 0 with coverage of 0–24.9% (damaged category), score 1 with coverage of 25–49.9% (moderate category), score 2 with coverage of 50–74.9% (good), and score 75–100% (very good). The formula for the percentage of coral reef cover used was following the equation (English et al. 1997).

$$N_i = \frac{L_i}{L} \times 100\%$$

Description:
Ni = Percentage of life form to-i (%)
Li = Number of lives points form I
L = Number of point life forms per transect (50 m)

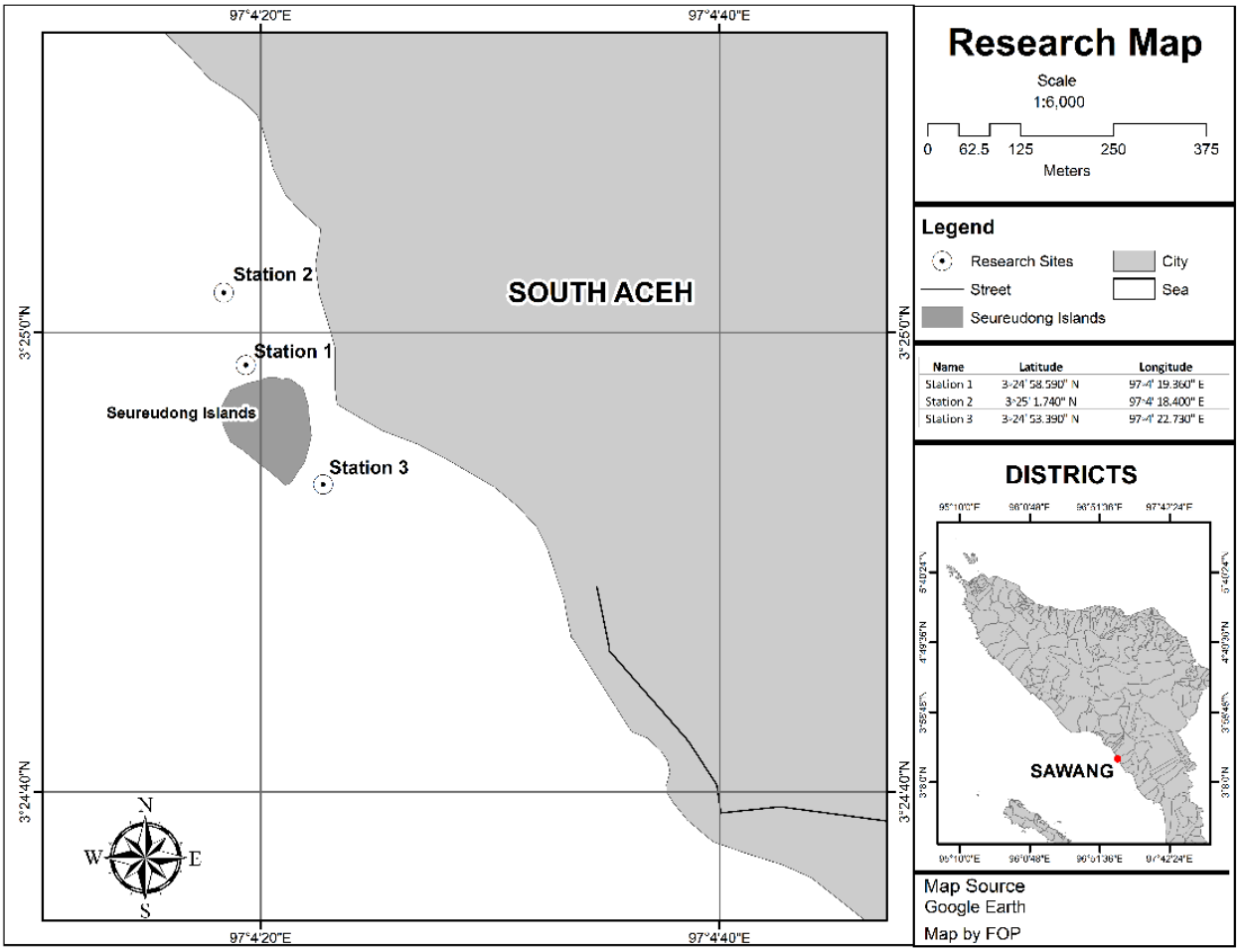

Figure 1 Research site location in South Aceh

RESULTS AND DISCUSSION

The coral reefs on Seureudong Island, Sawang Bau Village, Sawang District, South Aceh are fringing coral reefs with a growth shape around the island. Location of live corals in the reef crest zone. The coral forms found at the study site consisted of branching, digitate, encrusting, foliose, massive, mushroom, plates, and

submassive (Figure 2). The dominant growth form was the massive form, whereas mushrooms and foliose were found in small amounts. The massive form was found with a high percentage, presumably because of its shape, which is like a large and strong lump, so that it is more resistant to hard waves, considering that the location is a type of water with large waves. According to Heemsoth (2014), the massive form is similar to that of a large domed rock.

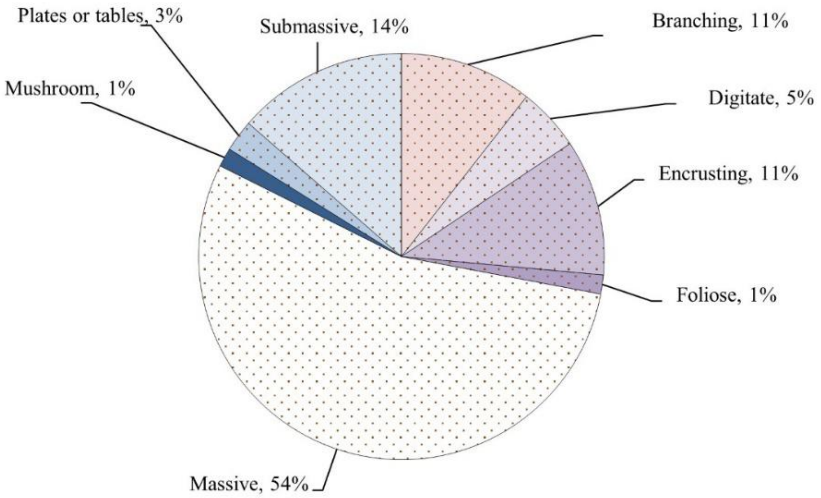

Figure 2 Base substrate composition based on station

They are slow growing and sturdy. They can withstand strong wave action. Mushrooms and foliose forms are rarely found in the research locations. Both have almost similar characteristics, namely, they are wide. Both types were found in very small numbers, presumably because of their similar shapes, which widened. Although found in small quantities, this mushroom coral plays an important ecological role (Bayley and Mogg 2022). The composition of different coral growth forms can be affected by the conditions of the surrounding water. As stated by Saptarini et al. (2017), coral life will be dominated by massive forms if the water is affected by heat, whereas branching corals will be abundant if there is no warming of the waters.

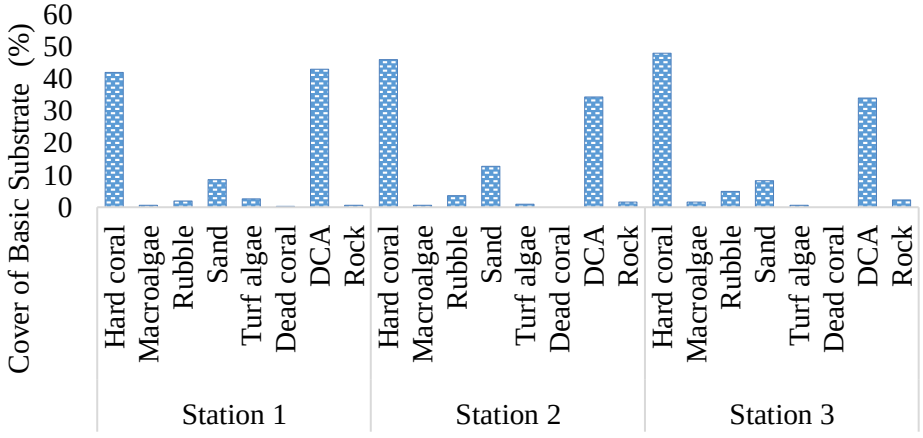

Figure 3 Base substrate composition based on station

The coral reefs of Seureudong Island showed differences in the composition of the bottom substrate. The differences in the composition of the average bottom substrate are shown in Figure 3. The percentage of the bottom substrate was dominated by hard coral (45.33%), Dead Coral with Algae/DCA (37.11%), sand (9.89%), rubble (3.56%), rock (1.56%), turf algae (1.44%), macroalgae (1%), and dead coral (0.11%). The results of the

research on the percentage of hard corals with a value of 45% have greater coverage than the results of the study by Sukandar et al. (2021) in Brumbun Bay, Tulungagung. The results of observations of the condition of coral reefs at the three stations did not show a significant difference in the growth of hard corals. The results of the analysis showed that the highest hard coral growth was at Station 3 (48%), and the lowest growth was at Station 1 (42%) (Figure 3). The hard-coral cover on Seureudong Island is almost the same as that on Durai Island (47%) and Anabas Islands (Milner et al. 2013).

Macroalgae at each station showed a relatively low percentage, and each station had almost the same composition. Macroalgae were found in small quantities at the study site, but their presence was very important for the coral reef ecosystem. Based on the research report, it is stated that macroalga is the main functional group in coral reef ecosystems that have vital physiological functions (Chaudhury et al. 2018), one of which is support for primary productivity (Chaudhury et al. 2018; Brown et al. 2018). The interaction between the two (coral-algae) is affected by hard corals, not just macroalgae cover, and increasing the interaction between the two does not necessarily result in coral degradation (Fulton et al. 2019). However, their presence also needs to be examined, because the high abundance of macroalgae can be influenced by the high availability of nutrients and substrates and low grazing on coral reefs near the coast (Schaffelke et al. 2005).

The abundance of rubble was highest at station 3 (5%) and lowest at station 1 (2%). The presence of rubble in the study area, which ranges from 2% to 5%, is thought to be due to coral damage and a small amount of debris. This indicates that the number of dead corals was also limited. Rubble in a location is an indication of having died coral previously, as stated by Milner et al. (2013). The range of sand percentage from stations 1 to 3 is between 8.3–12.7%. Turf algae at all stations were in the range of 0.7–2.7%. The range of turf alga composition at the study site was low, but it needs to be studied continuously in the following year. This is because trump algae are benthic macroalgae with low biomass per unit area but can dominate the area of coral reefs, even in healthy coral conditions (Hendra et al. 2014). Dead coral (DC) on Seureudong Island at each station shows a very low percentage. The presence of DCs in low coral reef ecosystems is thought to be a habitat that can support the diversity of another benthic biota.

This is in line with the statement that dead coral reefs have the potential to become habitats for various decapods (Madduppa et al. 2019) and even become one of the crab habitats (Ardiansah et al. 2021). Another base substrate that has an almost equal percentage at each station is DCA, with the highest value at station 1, while stations 2 and 3 have almost the same percentage (34.3% and 34.0%, respectively). The presence of DCA as dead coral was found to be 40%, which is higher than the cover on Mandangin Island, Sampang Madura (Rosi et al. 2016). The composition of the bare substrate at each station was dominant, and the bare substrate consisted of dead coral and dead coral that had been overgrown with algae and stones. Dead coral overgrown with algae was found along the observation transect at all the stations. The average composition of corals overgrown with algae was similar to the number of hard corals. This indicates that there is a competition for space between the growth of coral larvae and algae.

This condition resulted in the emergence of competition between corals and algae; as mentioned by McCook et al. (2001), algae and coral competition is widespread in coral reefs, which have varied interactions. Corals that have died because of unfavourable environmental and water conditions cannot survive for long periods. Thus, zooxanthella algae, which are symbiotic with corals, leave their hosts and cause corals to die. Within a certain period, dead coral grows algae, making it difficult for the coral planula to stick to the substrate. The difficulty in attaching the planula to the substrate is thought to be due to the presence of algae on dead coral. This is reinforced by the opinion that coral tissue can detect growth/substrates that are not overgrown by algae or thick sediment (Edwards and Gomez 2007). Algae can also compete for coral growth, thereby inhibiting growth in height, and their growth tends to be sideways (McCook et al. 2001). Changes in reef profile and zooxanthella density are also affected by nutrient enrichment (Ruswahyuni and Purnomo 2009).

The coral cover of Seureudong Island was classified as a medium category based on the Decree of the Minister of Environment No. 04 of 2001 (KepMenLH 2001). The analysis revealed the presence of 25 genera. The 45% dominance of hard coral consisted of Porites, Acropora, Pocillopora, Galaxea, Montipora,

Diploastrea, Goniastrea, Astreopora, Coeloseris, Platipora, Symphyllia and other species of 10% (Figure 4). Based on the genera, the composition of hard corals is shown in Figure 4. The number of genera found in this study was less than the number of coral genera in the Malacca Strait, that is, as many as 30 coral genera (Najmi et al. 2021). The genera found with percentages between 2% and 7% consisted of nine genera (Figure 4). The genus Porites was found to have the highest composition at the study site, presumably because this genus has higher resistance to various water conditions on Seureudong Island. This assumption is reinforced by the opinion that the genus Porites has a wide distribution area in Indonesian waters (Riyanti et al. 2016) and can withstand environmental pressure (Zainuddin et al. 2022). The Acropora genus in this ecosystem has a composition 19% lower than that of Porites.

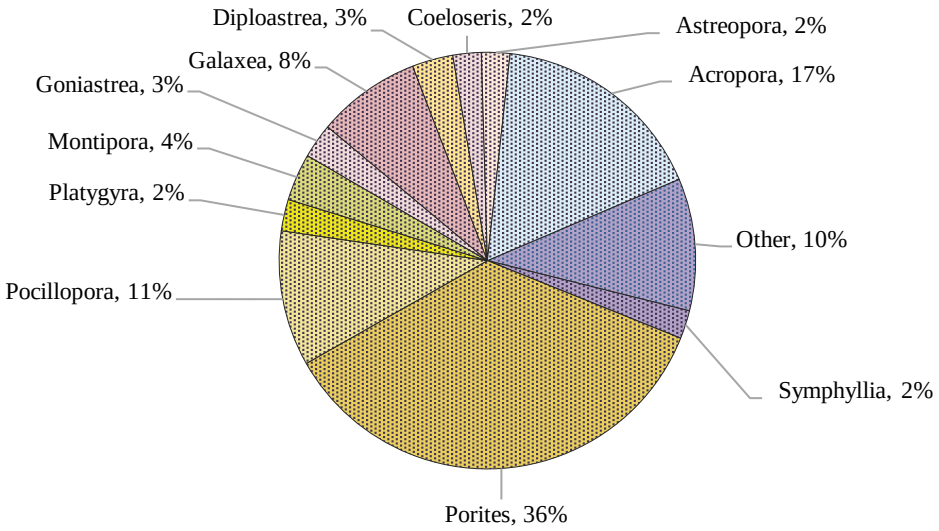

Figure 4 Composition of Coral Genera on Seureudong Island, South Aceh

When compared with coral cover of the same type on Rengat Island, the Thousand Islands, the research location has greater cover. Acropora coral cover on Rengat Island is only approximately 13.59% (Faizal et al. 2019). Compared with Larak Island (38.53%) and Khark (24.01%) in the Persian Gulf, the composition at the study site was lower (Rahmani et al. 2013). The Acropora genus has a living habitat in waters with high visibility and fast currents. Acropora coral has very small polyps, and it is difficult to clean itself from adhering particles; therefore, it requires strong currents and waves (Manuputty 1990). Another genus that has a higher percentage of presence than the others is Pocillopora. This genus had a total percentage difference of 25% from Porites. Pocillopora was found to have a lower presence than the other two genera, probably because this species is a type of coral that is vulnerable to environmental changes. In line with these results, *Pocillopora meandrina* is a group of corals that are sensitive to surface water warming (Jokiel et al. 1990).

Other genera found in very small amounts (less than 1%) consisted of 14 genera. These genera were Acanthastrea, Ctenactis, Favia, Favites, Fungia, Gardineroseris, Goniopora, Halimeda, Heliopora, Hydnophora, Leptastrea, Montastrea, Pavona, and Seriatopora. A small number of genera were suspected because this type cannot withstand strong currents. The location of the research station directly faces the open sea, making it difficult for larvae to attach. This is because strong currents can clean coral polyps from adhering to dirt, but also make it difficult for coral larvae to attach to the substrate Wicaksono et al. (2019). The environmental conditions in this case and the water quality during the sampling activity are presented in Table 1. The measured water quality parameters were the physical and chemical factors. The physical factor measured was temperature, with an average of 30 °C and an average brightness level of 2 m. The chemical factor measured was the salinity, with an average of 29 ppt and an average pH of 8.

Table 1 Average water quality parameters on Seureudong Island

Station	Parameter			
	Temperature (ºC)	Salinity (ppt)	pH	Brightness (m)
1	31	30	8	2
2	30	29	8	2
3	29	29	8	2

The results of these water parameter measurements were still within the range of the coral reef life. Healthy coral reef ecosystems depend on water quality, as reported by Salim et al. (2016). Wibawa and Luthfi (2017) added that corals, as constituents of coral reef ecosystems, to grow and regenerate corals require an optimal environmental carrying capacity. The condition of the water at the research location, especially the temperature (30 °C), is still within the normal range, which is generally 28–39 °C (Dahuri et al. 2001). The brightness level during the study was very low, which is thought to be caused by strong currents and waves. Data collection coincided with high rainfall at the study site. The rainy season on the Southwest Coast of Aceh (*Barat Selatan* Aceh/BARSELA) is dominated by rain with a long duration and is accompanied by strong winds that result in currents and waves that are quite high, up to 4 m. This condition results in a low level of brightness because of its high turbidity.

High turbidity in the study area is one of the reasons for the high rainfall. In addition, the entry of water from the estuary causes an increase in sedimentation, resulting in poor visibility of the water. This condition occurs throughout the rainy season from October to April. These two factors (turbidity and sedimentation), coupled with anthropogenic pressure from human activities, can affect the condition of coral reef cover (Taofiqurohman et al. 2021). The other side of this situation is the effect of disturbances on the growth of coral reefs. Corals that are unable to adapt to these changes experience stress and bleaching (Thompson and van Woesik 2009). Visibility is caused by sedimentation, which prevents sunlight from being absorbed at the bottom of the water. Even though Widhiatmoko et al. (2020) stated that the development and growth of corals is strongly influenced by sunlight in this case related to the brightness level of the water.

CONCLUSION

The growth of hard corals on Seureudong Island was in the "medium" category, with a hard coral cover percentage of 45.33%. The research location identified 25 genera, with the three largest genera being Porites (36%), Acropora (17%), and Pocillopora (11%). The other eight genera had abundances between 2–8%. Another genus, with a total of 10%, consisted of 14 genera and was found to be < 1%. The results of water quality measurements at the study site were in accordance with the lifespan of the corals. However, the research location faces challenges in coral growth with strong currents. In addition, during the rainy season, the location had a low level of visibility and high turbidity.

ACKNOWLEDGEMENT

The authors thank Teuku Umar University for funding this research through the Institute for Research and Community Service (LPPM-UTU). Funding for this research was through an Internal Assistant Expert Grant with a source of 2022 UTU PNBP funds contract number 128/UN59.7/SPK-PPK/2022.

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