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Coral resilience inside and outside of *Pesisir Timur Pulau Weh* conservation zone, Sabang City, Indonesia

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Abstract. *Aldyza N, Barus TA, Mulya MB, Sarong MA. 2022. Coral resilience inside and outside of* Pesisir Timur Pulau Weh *conservation zone, Sabang City, Indonesia. Biodiversitas 23: 5744-5751.* Conservation is one of the efforts to conserve marine life and provide opportunities for an ecosystem to recover. One of the water areas protected by the community is *Pulau Weh* (Weh Island). In 2010 and 2016, coral reef ecosystems in the waters of Weh Island suffered a lot of damage due to the pressure from nature, i.e., the bleaching phenomenon. As a result, the benthic experienced a vacuum of the substrate. The emptiness of the substrate occurred due to the death of corals and the appearance of a layer of grass algae. Therefore new corals were difficult to recover without a solid and conducive substrate. Hence, this study aims to measure the resilience of corals and benthic conditions inside and outside conservation areas on Weh Island. Benthic data collection used the Point Intercept Transect method while measuring the potential resistance of corals using the resilience index through coral cover, fleshy seaweed, and rubble indicators. Benthic conditions were viewed based on the value of the results of the resilience component with the condition of the coral cover. The result showed that coral reef ecosystems inside and outside the *Pesisir Timur Pulau Weh* (PTPW; East Coast of Weh Island) conservation area had a high level of resilience (with scores ranging from 3 to 6, out of 6 for benthic condition scores). The benthic inside the conservation area averagely has a good score and it is likely to be in the recovery period from disturbances. While the score for the benthic outside the conservation area is only 3 (out of 6 for benthic condition scores), which indicates that the area is very vulnerable to disturbance even though it has a chance to recover. If there is another bleaching phenomenon in the future, corals that have just tried to recover in this vulnerable area may be damaged again and the coral cover will be decreased.

Keywords: Conservation, corals, fleshy seaweed, resilience, rubble

INTRODUCTION

Pulau Weh (Weh Island) is located in Aceh Province, Indonesia. This island is one of the outer islands where the 0-kilometer point of Indonesia begins (Mustaqim 2017) and is surrounded by various types of coral shapes. The coral reefs in Aceh waters are a mixture of species from the Indo-Pacific, Indian Ocean, and Andaman Sea (Rudi et al. 2012). Coral reef ecosystems provide living space, change, and improve physical conditions, influence biological interactions, (potentially) increase diversity, and change patterns of species composition and dominance in nature. Hermatific corals form large reefs in shallow tropical waters in the oceans (Miller et al. 2012).

Coral reef ecosystems are dynamic, so they experience continuous changes. However, these ecosystems are very vulnerable to environmental changes originating from outside the reef (Gumbira et al. 2017). Those changes can occur due to human activities as well as a natural phenomenon. Corals in the Pesisir Timur Pulau Weh (PTPW; East Coast of Weh Island) conservation zone are dominated by massive corals *Porites* spp., *Montipora* spp., and *Heliopora* spp., based on preliminary studies. Some zones in this area are suspected of having coral cover decreasing due to the bleaching phenomenon that occurred in 2010. This phenomenon had a significant impact on the reduction of marine resources and the catch of fishermen on Weh Island (Ilhamsyah et al. 2014). Bleaching has been reported in several areas of Indonesian waters such as Aceh and Karimunjawa (Ampou et al. 2017; Setiawan et al. 2017), and also in some waters of the world such as the Great Barrier Reef-Australia (Hughes et al. 2017).

After bleaching, the damage to coral cover in the eastern part of Weh Island is inevitable because this phenomenon has a far-reaching impact on coral life. Corals that are unable to survive the effects of bleaching will die. The results of the preliminary study also revealed that almost all observation sites found a lot of rubble, so it is assumed that broken corals can be caused by current strength and cause corals of Acropora were found rarely in *Pesisir Timur Pulau Weh* (PTPW).

In addition, some coral damage can occur due to community activities that use environmentally unfriendly fishing gear such as potassium poison, Japanese trawls, ring trawls, jaring pisang-pisang (an Acehnese traditional net), and explosives (Marine, Fisheries and Agriculture Service of Sabang City, Aceh Province, 2010). Based on the impact of the destruction that occurred, Panglima Laot

Lhok (Acehnese commanders) with Sabang City Government established a conservation zone in the waters of PTPW based on the Decree of the Minister of KEPMEN-KP No. 57 of 2013 with the status of Suaka Alam Perairan (Siregar et al. 2016). It is expected to reduce the occurrence of damage and provide opportunities for corals to recover (resilience).

Resilience is the process of an ecosystem's ability to recover from disturbances and changes while still maintaining its function for a certain period of time (Trialfhianty 2018). According to Giyanto et al. (2017), resilience is a recovery potential where coral reef ecosystems can recover to their original condition when they get disturbed or under pressure. In this study, Beurawang, the location that was not included in the conservation zone, was also observed to compare with coral conditions inside and outside conservation. Beurawang is an area used by local people to support the economy and meet their daily needs that depend on natural and marine products, such as fish that inhabit coral reef ecosystems. However, the presence of people who continue to carry out activities on the beach, of course, can impact the condition of the benthic and the coral ecosystem. Anthropogenic activities produced by the local people can pose a threat to the survival of coral ecosystems (Brandl et al. 2019). In addition, the composition of coral life forms was also observed to determine the type of coral that survived after bleaching. The research data on coral resilience in PTPW, Sabang City, has not been studied. Therefore, it is necessary to conduct a study to determine the level of resilience and the value of benthic conditions in each zone of the conservation area. The results of this study are expected to provide basic data on coral resilience that can be used as a preliminary assessment towards better conservation management in the future.

MATERIALS AND METHODS

Study area

The study was conducted in Pesisir Timur Pulau Weh conservation zone, Weh Island, Sabang City, Indonesia. The PTPW conservation area has a status as an Aquatic Nature Reserve (*Suaka Alam Perairan*), which is under the supervision of 3 Panglima Laot Lhok, namely Panglima Laot Lhok Ie Meulee, with 1 area, namely Sumur Tiga, Panglima Laot Lhok Ujung Kareung with 1 area namely Ujung Kareung, and Panglima Laot Lhok Anoi Itam with four areas namely Reuteuk, Benteng, Anoi Itam, and Ujung Seuke. Therefore, in this study, PTPW conservation areas were conducted in these six locations. The area outside conservation, namely Beurawang, is also supervised by Panglima Laot Lhok Beurawang. Beurawang is an open access area for researchers, so the Beurawang location is the chosen location for the observation station. In the western part of Weh Island, there is no research conducted because it is a protected area with a different status from PTPW, namely the Weh Island Nature Park (*Taman Wilayah Alam Laut Pulau Weh*). Based on these conditions, the researchers only conducted research in Beurawang (an area outside of conservation) to see the condition of corals and the potential for coral resilience if the area was not protected. Data collection was carried out from August to September 2021 at 7 observation locations (Figure 1). The six locations were Sumur Tiga (Station 1: 5°53'18.1"N; 95°20'43.6"E), Ujung Kareung (Station 2: 5°52'34.2"N; 95°21'13.0"E), Reuteuk (Station 3:5°51'26.0"N; 95°21'40.9"E), Benteng (Station 4: 5°50'44.5"N; 95°22'23.5"E), Anoi Itam (Station 5: 5°49'32.6"N; 95°22'41.7"E), Ujung Seuke (Station 6: 5°48'29.9"N ; 95°22'34.7"E), and Beurawang waters (Station 7: 5°46'39.0"N; 95°20'12.6"E).

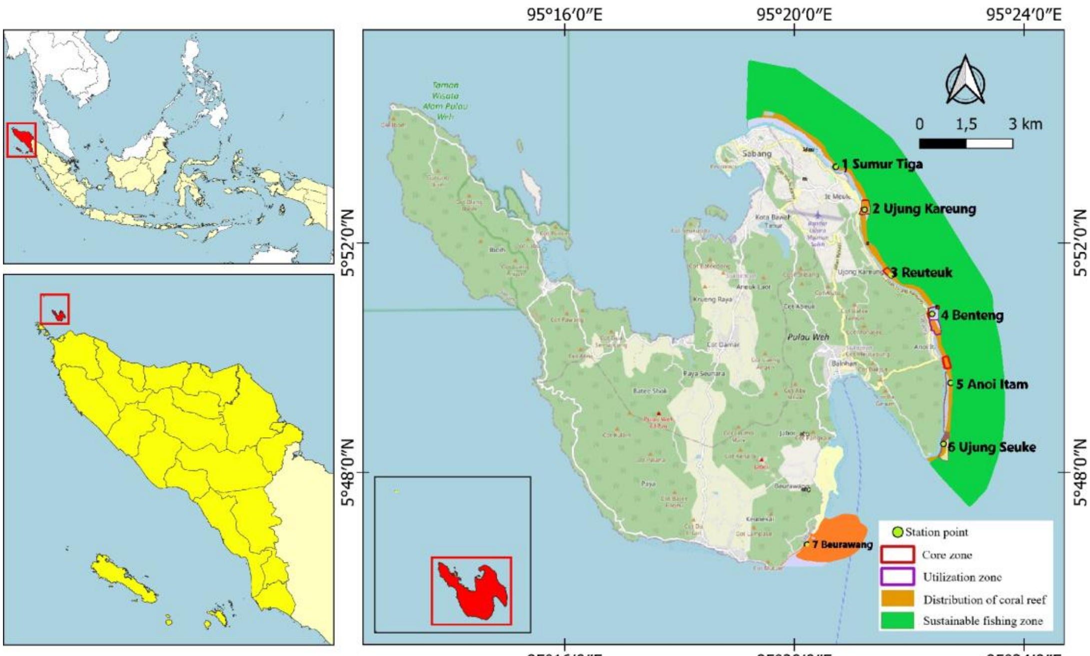

Figure 1. Research location map. The green area is the conservation zone of *Pesisir Timur Pulau Weh* (PTPW; East Coast of Weh Island), while the orange area is the outside of PTPW, Weh Island, Sabang City, Aceh, Indonesia

Table 1. Criteria of values of benthic components by Giyanto et al. (2017)

Coral cover	Resilience	Score	Condition
High	High	6	Corals are healthy, with high recovery potential if it is disrupted.
High	Low	4	Corals are healthy, but when there is a disturbance, it will be difficult to recover.
Moderate	High	5	Corals are in sufficient condition and probably in the process of recovering from disturbances.
Moderate	Low	2	Corals are in sufficient condition but are at risk of decline.
Low	High	3	Coral cover is low, but has the potential to improve.
Low	Low	1	Coral cover is low, and it is difficult to improve.

Procedures

Coral resilience and benthic conditions

Measurements of coral resilience were measured based on coral cover, fleshy seaweed, and rubble (Giyanto et al. 2017). The researcher and the team collected data on the benthic, coral substrate, rubble, and fleshy seaweed for each station at two depths, namely 3-5 meters (shallow) and 6-8 meters (deep). It was conducted through 3 repetitions, and observations were made using the Point Intercept Transect (PIT) method (Erdana et al. 2022). The length of the transect used was 50 meters, and it was placed parallel to the coastline. The type of coral along with the life form, fleshy seaweed, and rubble that offend sub transects was recorded every 50 centimeters. Benthic conditions were observed based on component values obtained from coral cover conditions and the coral recovery potential level. According to Giyanto et al. (2017) the category values of benthic components are divided into 6 (Table 1).

Data analysis

The percentage of coral cover is determined by dividing the number of points recorded by the total number of points (on transects) and multiplying by one hundred percent (Jokiel et al. 2015). The result of the percentage of coral cover was used to determine the condition of coral reef ecosystems. The condition of coral cover was evaluated based on the categories proposed by Giyanto et al. (2017). The categories were: low (< 19%); moderate (19% ≤ coral cover ≤ 35%); and high (> 35%).

The resilience of coral reef ecosystems was assessed through indicators by Giyanto et al. (2017), namely coral cover, fleshy seaweed, and rubble. The categories for each indicator were determined as follows: low (fleshy seaweed ≥ 3%; rubble > 60%; hard coral ≤ 5%) and high (fleshy seaweed < 3%; rubble ≤ 60%; hard coral > 5%). In this resilience case, the velocity of the water current was measured to know the relationship with the rubble cover at the observation site because the rubble value almost reached the coral cover value. The relationship between the percentage of rubble with current speed used the Simple Linear Regression Test. Data presentation and analysis were carried out with the help of Minitab software version 16 and Excel 2013 (15.0).

RESULTS AND DISCUSSION

The component of resilience

The results showed that there are differences in the condition of coral cover, fleshy seaweed, and rubble within the conservation zone (L1-L6) and in outside of the conservation zone (L7) (Figure 2).

Based on the results, benthic characteristics for each station showed differences in the percentage of hard coral cover (HC), turf algae (TA), fleshy seaweed (FS), rubble (RB), and several other components (Figure 3). At Sumur Tiga station, the results showed the percentage of the hard coral was 36.83%, CCA was 3.33%, turf algae was 29.67%, rubble was 12.67%, and sand was 17.50%, while fleshy seaweed was not found at the station.

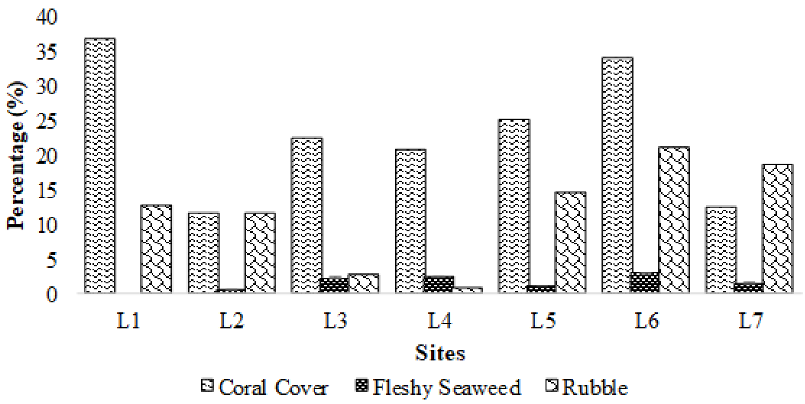

Figure 2. Percentage of coral cover, inside and outside PTPW conservation area, Weh Island, Aceh, Indonesia. Note: L1: Sumur Tiga; L2: Ujung Kareung; L3: Reuteuk; L4: Benteng; L5: Anoi Itam; L6: Ujung Seuke; L7: Beurawang

At Ujung Kareung station, the hard coral had a cover of 11.50%, CCA was 5.67%, turf algae were 61.33%, fleshy seaweed was 0.50%, rubble was 11.50%, sand was 8.67%, and OT was 0.83%. At Reuteuk station, hard coral was 22.33%, CCA was 2.83%, turf Algae was 46.67%, fleshy seaweed was 2.17%, rubble was 2.67%, sand was 23.17%, and OT was 0.17%. Then, the hard coral in Benteng station was 20.67%, CCA was 1.83%, turf algae was 40.83%, fleshy seaweed was 2.33%, rock was 16.50%, rubble was 0.67%, sand was 15.50%, and OT was 1.67%. Anoi Itam had 25% of hard coral, 1.50% of CCA, 37.17% of turf algae, 1% of fleshy seaweed, 14.67% of rubble, 18.67% of sand, and 2% of OT. For Anoi Itam station, the benthic condition is not much different from Benteng because the distance between these two locations is rather close. However, compared to Benteng, Anoi Itam had more rubble. Then, at Ujung Seuke station, the hard coral cover was 34%, CCS was 7.50%, turf algae was 25.33%, fleshy seaweed was 3%, rubble was 21.17%, sand was 8.50%, and OT was 0.50%. Finally, Beurawang station had a hard coral cover of 12.33%, then CCA was 1.67%, turf algae was 24.33%, fleshy seaweed was 1.33%, rubble was 18.50%, sand was 41.00%, and OT was 0.83%. Overall, on average, the stations had higher turf algae cover than hard coral cover, except at Sumur Tiga and Ujung Seuke stations.

Based on Figure 3, the coral cover tends to be lower and is dominated by corals from the massive and submassive groups. From all locations, *Acropora* corals were only found at stations 1, 3, 4, and 6, with a total number of only 9 points, while massive corals were found in all stations, with the highest number of points found at station 6 (Table 2).

Based on Table 2, there were nine coral life forms in all stations. Sumur Tiga Station (L1) has the most coral types found. However, when viewed from the whole station, the life forms of *Acropora*, Coral Branching, and Coral Foliose were very few points found. As with *Acropora digitate*, there were only 2 points found along the observation transect, *Acropora tabulate* only found 7 points, Coral branching 10 points, and Coral foliose 5 points. Meanwhile, massive and submassive corals are the most common types of coral found at the observation site, so it can be concluded that branching and foliose corals are very vulnerable to environmental conditions.

At the study site, fleshy seaweed cover is slightly found, namely from the *Padina* sp. and *Halimeda* sp. groups (Figure 4A, 4B). According to Rasher and Hay (2014), the abundance of fleshy seaweed can interfere with the coral recruitment process and result in a decrease in coral fecundity, so the potential for coral recovery is very low. It can be assumed that the condition of the corals in PTPW can recover well, based on the low fleshy seaweed cover. This is in accordance with the calculation results using resilient parameters by Giyanto et al. (2017) as follows (Table 3).

The relationship between the rubble cover and the current water

Viewed from the current speed, the current inside the Sumur Tiga station has a strength of 0.15±0.03 m/s, Ujung Kareung 0.15±0.04 m/s, Reuteuk 0.07±0.01 m/s, Benteng 0.11±0.02 m/s, Anoi Itam 0.13±0.005 m/s, and Ujung Seuke 0.12±0.03 m/s, then the area outside the conservation, namely Beurawang, has a current speed of 0.20±0.04 m/s. According to Mardani et al. (2021), a good current speed for coral ecosystems is 0.05 m/s. The results of the regression analysis between the rubble cover and current water can be seen in Figure 5.

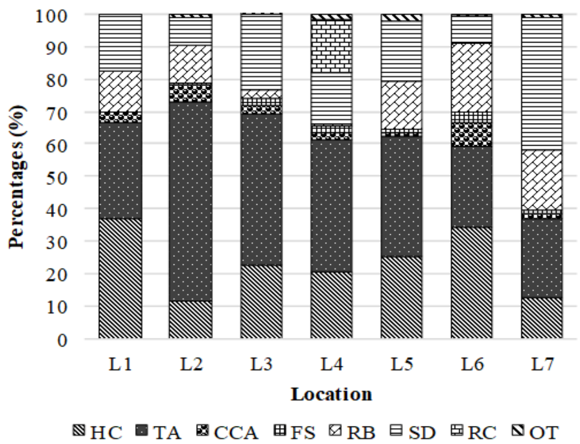

Figure 3. Benthic characteristics inside and outside the PTPW conservation area, Weh Island, Indonesia. Note: L1: Sumur Tiga; L2: Ujung Kareung; L3: Reuteuk; L4: Benteng; L5: Anoi Itam; L6: Ujung Seuke; L7: Beurawang), (HC: Hard coral; TA: Turf algae; CCA: Crustose Coralline Algae; FS: Fleshy Seaweed; RB: Rubble; SD: Sand; RC: Rock; and OT: Others (exp: Sea anemone sp., Sponges sp.

Table 2. Coral life form in PTPW and Beurawang conservation areas (in point)

Life form	Code	L1	L2	L3	L4	L5	L6	L7
Acropora digitate	ACD	-	-	2	-	-	-	-
Acropora tabulate	ACT	2	-	-	2	-	3	-
Coral branching	CB	10	-	-	-	-	-	-
Coral foliose	CF	5	-	-	-	-	-	-
Coral Heliopora	CHL	5	1	5	-	8	25	-
Coral massive	CM	117	61	120	111	118	163	73
Coral Millepora	CME	1	3	2	-	1	1	-
Coral mushroom	CMR	2	1	5	1	-	1	-
Coral submassive	CS	79	3	-	10	23	11	1

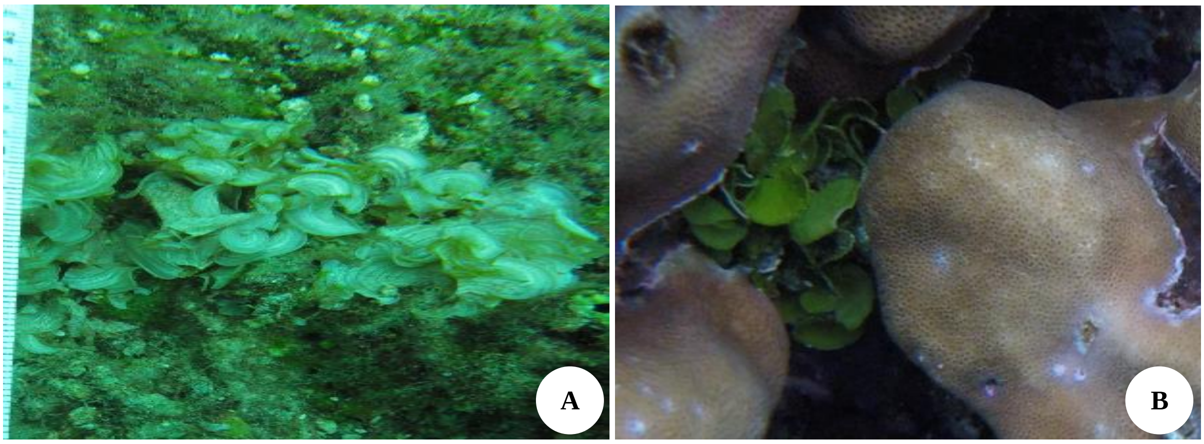

Figure 4. A. *Padina* sp.; B. *Halimeda* sp.

Table 3. Coral resilience in PTPW and Beurawang waters

Location	Station	1	2	3	Resilience*
PTPW conservation zones	Sumur Tiga	36.83	0	12.67	High
	Ujung Kareung	11.5	0.5	11.5	High
	Reuteuk	22.33	2.17	2.67	High
	Benteng	20.67	2.33	0.67	High
	Anoi Itam	25	1	14.67	High
	Ujung Seuke	34	2.83	21.17	High
Outside conservation areas	Beurawang	12.33	1.33	18.5	High

Note: 1. Coral cover; 2. Fleshy seaweed; 3. Rubble (%). *Resilience assessment: Low (fleshy seaweed ≥ 3%; rubble > 60%; hard coral ≤ 5%), and High (fleshy seaweed < 3%; rubble ≤ 60%; hard coral > 5%) (Giyanto et al. 2017)

Table 4. Benthic conditions

Location	Station	Coral condition	Resilience	Score
PTPW conservation zone	Sumur Tiga	High	High	6
	Ujung Kareung	Low	High	3
	Reuteuk	Moderate	High	5
	Benteng	Moderate	High	5
	Anoi Itam	Moderate	High	5
	Ujung Seuke	Moderate	High	5
Outside conservation areas	Beurawang	Low	High	3

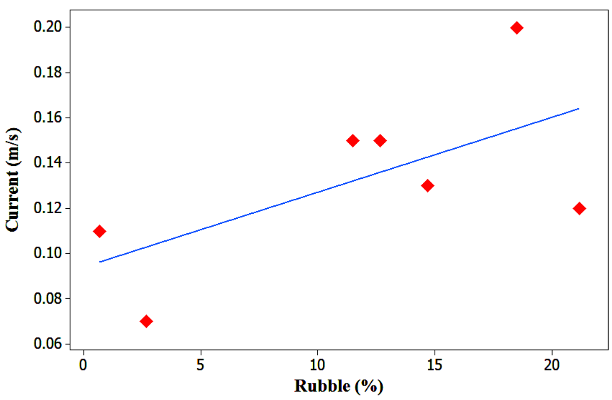

Figure 5. The linear regression graph of the relationship of the rubble percentage with the velocity of the current

Benthic conditions

Corals have a role as the main provider of complex structural habitats, most of which are responsible for the high diversity of benthic organisms and the provision of various ecosystem services, such as food resources (Chong-Seng et al. 2012). Therefore, the benthic condition is important to see the potential for coral recovery in the future.

Discussion

The corals in Sumur Tiga have a high percentage of cover, i.e., 36.83%, then the Reuteuk, Benteng, Anoi Itam, and Ujung Seuke stations are in a moderate level with a value order of 22.33%, 20.67%, 25%, and 34%, while the locations of Ujung Kareung and Beurawang are in low levels with percentage values of 11.5% and 12.33%.

Beurawang is a station located outside the conservation area, which explains that the establishment of a conservation zone has a positive influence on coral cover conditions compared to the absence of zoning. Although the condition of the corals in the conservation area is good, there is one location (Ujung Kareung station) that is in poor condition. The coral surface in Ujung Kareung (L2) is covered with turf algae, so many corals die. This can be seen in Figure 3. From all locations, the highest turf algae cover reached 61% in Ujung Kareung. At this location also, the coral cover was very low compared to other locations, which was only 11.5%. The existence of turf algae that exceeds the coral cover is very worrying because turf algae that dominate the substrate can make it difficult for corals to regenerate. This follows the statement of O'Brien and Scheibling (2018) that the breeding turf algae cover can form a thick and dense matrix and inhibit the formation of coral larvae. Furthermore, Fricke et al. (2014) suggested that coral reef degradation was generally associated with a reduction in coral cover and diversity and increased algal communities. The ability of turf algae that grow quickly has a negative impact on corals that are slow growing, then the loss or destruction of a coral colony can increase macroalgae cover by about 20% (Reverter et al. 2020; Ditzel et al. 2022).

According to Hasim et al. (2020), the condition of corals that experience degradation will trigger algae growth and make algae a competitor. Then algae can attack corals starting from dead colonies and then extending to colonies of living corals. A similar case also occurred in coastal Belizean America that the damage to coral tissue and changes in coral pigmentation were mediated by turf algae (Wild et al. 2014). The dominance of coral reefs may shift to algal-abundant conditions through localized human activities such as overharvesting of herbivorous fish, waste disposal, and overuse of fertilizers along adjacent coastlines, as well as large-scale processes, including climate change effects and regional sea urchin mortality (Renfro and Chadwick 2017).

Hadi et al. (2018) state coral ecosystems have been threatened globally by intense anthropogenic factors and natural disasters. This situation became a trigger for the decline of Scleractinian corals in both abundance and diversity. This coral degradation leaves room for other benthic communities, especially fleshy seaweed, to settle and occupy. This new condition is generally associated with the combined impact of nutrient enrichment and low herbivore abundance.

Based on Figure 2, the very low fleshy seaweed cover only reached 2.83% at Ujung Seuke station. While in Beurawang, which is an area outside of conservation, only around 1.33%. The types of fleshy seaweed that were found at the observation site were *Padina* sp. and *Halimeda* sp. *Padina* sp. was found in the dead coral and it was overgrown with filamentous algae (Figure 4A). In contrast, *Halimeda* sp. tended to be found in the crevices of Porites colonies (Figure 4B). These results are similar to those of Nugues and Szmant (2006) that *Porites* spp. surrounded by macroalgae from the *Halimeda* group in large numbers. This is because *Halimeda* sp. is the dominant macroalgae growing in tropical waters. According to Ortegon-Aznar et al. (2017), *Halimeda* contributes to the carbonate sediment mass in the reef area. Then, when viewed from the characteristics of *Halimeda,* this type of macroalgae has a thallus that contains a lot of calcium (Tampubolon et al. 2013). Porites is a genus that tends to be strong in terms of resistance, so the presence of this small amount of *Halimeda* does not indicate damage to corals. This follows the statement of Longo and Hay (2015) that the result of contact between corals and fleshy seaweed depends on the conditions of their interaction. Because each particular type of coral has a different ability to compete with fleshy seaweed, and fleshy seaweed also has different strengths and mechanisms related to its impact on corals. Based on these observations, it can be concluded that the low cover of fleshy seaweed in the damaged coral substrate area at least allows the coral to recover and be free from stress because previously, corals have competed with turf algae first.

Besides *Porites* spp., the most common genera in the PTPW marine conservation area are *Montipora* spp. and *Heliopora* spp. Of all the transects at 6 locations, the genus *Acropora* spp. was very few, and some transects were completely absent from this genus. Meanwhile, at the Beurawang location, only corals from the massive and submassive groups were found (Table 2). This case is similar to that of Masucci et al. (2019), which stated that the average coral cover in the Ryukyu Islands, southern Japan, was only around 7.2%, then branching corals from the genus *Acropora* spp. were almost completely absent on the observation transect. This condition is believed to be due to the bleaching phenomenon leaving massive corals such as *Porites* rather than branching corals such as *Acropora* spp. According to Idris et al. (2020), *Acropora* spp. is one of the coral groups most vulnerable to disturbances or stresses, both natural and anthropogenic. This indicates that *Porites* is a genus that tends to have good resistance than a genus with branched forms (Guest et al. 2016; Aldyza et al. 2022).

Referring to the coral condition category by Giyanto et al. (2017), coral conditions in the waters of the PTPW conservation area and outside the conservation area have high resilience potential, so it can be interpreted that the coral ecosystem has a chance to recover. However, this recovery process allegedly takes a very long time. This follows Gilmour et al. (2013) and Graham et al. (2015) that coral reefs can recover from extensive coral bleaching, but it takes more than a decade for coral cover to reach pre-bleaching levels. Furthermore, Bachtiar and Hadi's research (2019) in Sekotong Bay also states that the possibility of coral cover recovery will take longer due to anthropogenic stress, which is still increasing along with the development of the tourism industry in Teluk Sekotong. The development of the tourism industry has had a negative impact on the environment due to the presence of terrestrial runoff due to the construction of accommodation in the coastal areas and nearby highlands.

Rubble is one of the important points that must be considered in seeing the potential for coral recovery. Rubble is considered unsuitable for the natural recolonization or regeneration of coral larvae because if it is exposed to currents or waves, rubble becomes unstable so that coral larvae can escape from the substrate. Successful attachment of coral larvae requires a stable and consolidated substrate (Cameron et al. 2016). According to Johns et al. (2018) stated that coral larvae can recruit unconsolidated debris, but frequent movement leads to high mortality and impaired reef recovery. Table 3 shows that rubble outside of conservation (Beurawang) has a high cover of 18.5% compared to the range of rubble cover within the PTPW conservation area. This condition is thought to be due to the Beurawang water area, which has a strong water rotation and has a fairly high wave characteristic during the transitional season, then in the reef slope area (7-8m) often receives strong wave blows so that many corals are damaged and broken. This is in accordance with the statement of Nurhasima et al. (2021) that wave blows can damage corals in the reef slope area. In the conservation area, the station with the highest rubble cover was found at the Ujung Seuke location, which was 21.17%. The high cover may occur due to the effects of bleaching in 2010 and 2016, even though the incident occurred five years ago. Ceccarelli et al. (2020) suggest that eight years after the 1998 bleaching event in the Maldives also caused mass coral mortality, debris, and high sediment cover ranging from 15 to 65%. According to Biondi et al. (2020), excessive coral rubble accumulation can impact live coral colonies.

Referring to the current velocity range ideal for coral growth by Mardani et al. (2021) and Paulangan et al. (2019), which is between 0.05 to 0.28 m/s, it can be concluded that the current velocity conditions in the conservation area and outside the conservation area are in good condition for coral growth. However, with very high rubble cover conditions, some indications are influenced by current speed due to the shift of seasons between West (Barat) to East (Timur).

The results of a simple regression analysis show that the relationship between rubble and current velocity has a moderate relationship with the value of the coefficient of determination (R-Square), i.e., 0.3953 (Figure 5). This value indicates that the current affects the percentage of rubble cover by 39.5%, while the remaining 60.5% indicates that the presence of rubble can be influenced by other factors beyond the tested variables, such as environmental conditions and community activities. The direction of the regression line shows that the greater the speed of the current, the greater the potential for corals to break and form rubble.

Climate change that has occurred can cause severe damage to coral ecosystems globally. It is feared that this could have a bad impact on benthic conditions over the next few years. This is in line with Bruno et al. (2019) that climate change has and will continue to be the most significant threat to the future of coral reefs. The observation results show that benthic conditions in PTPW conservation areas, on average, have good component values (Table 4). The water area formed by a conservation zone is at least able to provide opportunities for coral ecosystems to restore their ecosystems after the damage and disturbance. The benthic condition with the highest score, which is 6, is at the Sumur Tiga station. It explains that Sumur Tiga has a healthy coral ecosystem with a high recovery potential in the event of disturbances in the future. Stations with a benthic component score of 5 namely Ujung Kareung, Reuteuk, Benteng, Anoi Itam, and Ujung Seuke. It explains that the coral ecosystem at the site is in fairly good condition and probably in the process of recovering from disturbances. Then, the rest of Ujung Kareung and Beurawang stations have a benthic score of 3, which explains that although the coral cover at the station is low, it has the potential to recover. Based on the benthic score, maintaining the remaining coral colonies is the most important thing in forming a coral ecosystem to continue growing and replacing damaged substrates. This is in line with Ferrigno et al. (2016) that maintaining coral diversity and structure is critical for resistance to disturbance.

Overall, it can be seen that coral conditions and coral recovery potential within conservation areas are better than in the outside conservation areas. Then, the coral life form that dominates the benthic waters of the East coast of Weh Island, consisting of massive corals, is expected to be the main resource to support the coral recovery process. Finally, the survival of biota associated with corals is hoped to be continued. The result of this study may suggest that based on the condition of coral reefs and the benthic conditions, it is better to build a special zone in the conservation areas for coral transplantation, so that coral covers can increase and substrate conditions can be better.

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