Research Journal of Marine Sciences ISSN 2321-1296
Vol. **9(1),** 8-12, December **(2021)** *Res. J. Marine Sci.*

Coral reef performance in Pieh Island, West Sumatra, Indonesia

Ainul Jariah Alhamra[1], Basuki Rachmad[1], Sinung Rahardjo[1] and Ahmadi[2*]
[1]Aquatic Resource Management Technology Program, Jakarta Fisheries High School Jakarta, Indonesia
[2]Faculty of Marine and Fisheries, Lambung Mangkurat University, Banjarbaru, Indonesia
ahmadi@ulm.ac.id

Available online at: www.isca.in, www.isca.me
Received 25th February 2021, revised 25th May 2021, accepted 28th August 2021

Abstract

Pieh Island coral reefs deliver substantial benefit to the communities and the global ecosystem health. The present study aimed at assessing the coral reef performance of Pieh Island by doing under water observation at different site locations.The biophysical aspects of coral reefs including reef fish were performed by Under water Photo Transect (UPT) and Under water Visual Census (UVC) at 5 and 10m deep with a 50-m transect line. The coral reefs were typically categorized as 'fringing reefs'. The coral life-forms included Acroporadigitate, A. submassive, A. branching, A. encrusting, Coral encrusting, C. massive, and C. foliose. The ratio of live coral to dead coral was 1.64:1. The coral reef health index was classified as 'high' (39.35 ± 17.94%). The best performance for coral reefs was found in station 1B interm of diversity, uniformity and dominance indexes with stable communities. The reef fishes were dominated by family Chaetodontidae. Forcipiger flavissimus (24.32ind/m^2) and Cephalopolisargus (14.06ind/m^2) were abundant at 5m and 10m deep, respectively. Water quality parameters are within tolerable levels for coral reef growth and survival. After all, community based-concervation should be taken into account.

Keywords: Diversity index, dominance index, Pieh Island, uniformity index, UPT, UVC.

Introduction

Coral reefs are one of the most complex and most productive ecosystems in the world. Indonesia has a vast coral reef about 14% of the world's coral reefs with beautiful shapes, designs and colors, which is an ideal place for coral growth[1]. Indonesia is part of the Coral Triangle, a region that contains the highest diversity of marine life in the world. The Coral Triangle covers areas within six countries, namely, Indonesia, Philippines, Malaysia, Solomon Islands, Papua New Guinea, and Timor-Leste. The coral triangle as the center of coral reef biodiversity with 581 individuals of coral species identified from a total of 700 individuals in the Indo-Pacific region[2].

Coral reef is an underwater ecosystem characterized by reef-building corals. Reefs are formed of colonies of coral polyps held together by calcium carbonate. This area supports more than 7,000 species of fishes, lobsters, plants, seahorses, sea turtles[3]. Coral reefs are one of the most sensitive ecosystems in the world. Damaging activities such as blast fishing, destructive fishing practices, coral mining, water pollution and global warming potentially threat coral reef ecosystem[4-8]. Wilkinson[9] estimated that about 19% of the world's coral reefs have been lost and a further 35% are seriously threatened resulted in one-third of all reef-building corals are at extinction risk[10]. Damage to coral reef ecosystems has also occurred in Indonesia. According to Hadiet al.[11], about 36.18% of them are in bad condition and only 6.56% are in excellent condition. Zakaria[12] reported that West Sumatra, particularly Pieh Island is one of coral reef areas in Indonesia that generally experienced damage due to the global climate change and anthropogenic activity. Conservation measures in marine protected area are needed for sustainable coral reef ecosystem[13], which complied with The International Union for the Conservation of Nature (IUCN).

For this reason, we carried out field observations to outline the performance of the coral reefs biophysical aspects including the abundance of reef fish and also water quality parameters as limiting factors of coral reef life. Outcome of research would be useful for sustainable coral reefs management in Pieh Island and the surrounding sea.

Materials and methods

Study site: The field survey was carried out in Pieh Island of Padang Pariaman District, West Sumatera Province, located between 00°52'22"S, 100°05'59"E and 00°52'31"S, 100°06'7"E (Figure-1). Pieh Island has the area of 10.7 ha comprising 9 ha of the land covered by vegetation and 1.7 ha of sand beach. The research activity started from February to May 2016. Aquatic Tourism Park Conservation Area of Pieh Island and the surrounding sea are located in West Sumatra Province particularly in the western administrative regions of Padang City, Pariaman City and Padang Pariaman. This area was one of the eight Natural Conservation Areas and Nature Sanctuary Area, which was handed over from the Ministry of Forestry to the Ministry of Marine Affairs and Fisheries in 2009. Later on, Pieh Island and the surrounding sea were established as a National Water Conservation Area -Marine Tourism Park of Pieh Island in West Sumatera Province through the Ministerial

Decree of Marine Affairs and Fisheries No.70/2009. Based on the public consultation and the working group meeting of Pulau Pieh and the surrounding sea, there are four planned zoning areasi.e. core zone, utilization zone, sustainable fisheries zone and rehabilitation zone.

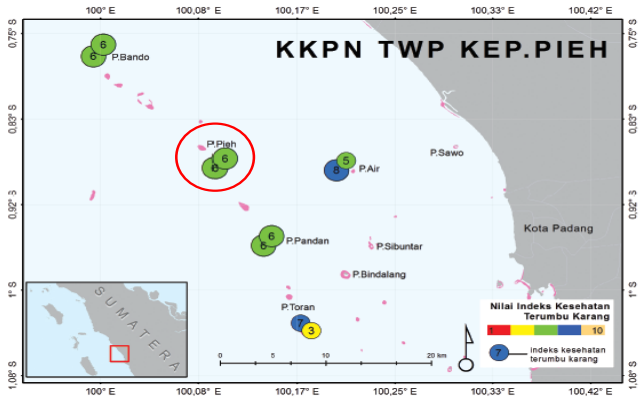

Figure-1: The map showing the location of Pieh Island (red cyrcle). The numbers inside map revealed the index value of coral reef health in National Marine Protected Areas (KKPN) Marine Tourism Park (TWP) of Pieh Island 2014 [14].

Refer to Pieh Island topography, the core zone and utilization zone were selected as study sites by considering that these zones were shallow and coral reefswere still available, while other zones were deep seas and coral reefs were rarely found.

Field Observation: To get more information on the performance and management of coral reefs in Pieh Island, the research activities were started by doing a direct observation at three stations using the survey method to collect the primary data. Performance of biophysical coral reefs was observed by using Under water Photo Transect (UPT) on the depth of 5 m for shallow waters and 10m for the deep waters with a 50-m transect line.While the abundance of reef fish using the Underwater Visual Census (UVC).

Data collection: Data collected were the coral reefs colony, the percentage of coral covers, and the index of diversity, uniformity and dominance. The coral reef health refers to criteria of Indonesian Coral Reef Health Index. It is categorized as 'low' if the index of live coral cover < 19%, 'moderate' between 19 and 35% and 'high' if the index > 35%[14].

Diversity index (H'): Diversity index was estimated using the Shannon-Weiner index[15]:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

Where H' = Shannon-Weiner index; ni = number of individuals of a species, N =Total individuals of all species. The diversity index criteria are as follows: if if the value of H' ≤ 1 = 'low'; 1 < H' ≤ 3 = 'moderate'; and H' ≥ 3 = 'high'.

Uniformity Index (E): The balance of the distribution of a species in the community can be seen from the uniformity index[16], which is expressed as:

$$E = \frac{H'}{Ln\ S}$$

Where E = Uniformity Index; H' = Shannon-Wiener Diversity Index; and LnS = number of species. The uniformity index criteria are as follows: 0 < E ≤ 0.5 = distressed community; 0.5 < E ≤ 0.75 = labile community; and 0.75 < E ≤ 1 = stable community.

Dominance Index (C): The Simpson dominance index used to determine the degree of dominance by certain types of organisms. It can be calculated by using the following formula[17]:

$$C = \Sigma\ [ni/N]^2$$

Where C= Simpson dominance Index, ni= number of individuals per species, and N = total number of individuals. The dominance index criteria are as follows: if the value of 0 < C ≤ 0.5 = 'low'; 0.5 < C ≤ 0.75 = 'moderate'; and 0.75 < C ≤ 1.0 = 'high'.

The limiting factors of coral reef life such as brightness, temperature, salinity, and current velocity were also recorded. Measurement of water quality is under taken three times a day: in the morning, at noon and late afternoon, except for observation of brightness done twice a week at noon during research period. The secondary data were obtained from the Pekanbaru LKKPN office in Padang.

Results and discussion

Based on its geomorphology structure, the coral reefs in Pieh Island were typically categorized as the fringing reefs where the reef growth can be found from the depth of less than 1 m. According to Romimohtaro and Juwana[18], about 30% of the world's coral reefs had the fringing reef type with the growth spread in the waters of small and moderate islands. Mean while, Nybakken[19] stated that the fringing reef can grow along the coast and not more than 40m deep.

The coral life-forms in the investigated areas were *Acropora digitate* (ACD), *Acropora submassive* (ACS), *Acropora encrusting* (ACE), *Acropora branching* (ACB), *Coral encrusting* (CE), *Coral massive* (CM) dan *Coral foliose* (CF). The reef fish species were dominated by family Chaetodontidae. For *cipiger flavissimus* (24.32ind/m^2) and *Cephalopolisargus* (14.06 ind/m^2) were abundant at 5m and 10m deep, respectively.

In present study, the percentage of coral reef cover was divided into two groups, namely live coral cover and dead coral cover. The measurement results of three different observation stations

were given in Table-1. It has been clearly demonstrated that the highest percentage of live coral cover was found at station 1B = 62.48%, followed by station 2B = 49.53%, station 1A = 48.5%, station 3B = 40.83%, station 2A = 26.49% and station 3A = 17.40% or about 39.35 ± 17.94% in average. By referring to Indonesian Coral Reef Health Index[14], the stations 1A, 1B, 2B and 3B were categorized as 'high' since the indexes of live coral cover > 35%, while stations 2A and 3A were categorized as 'moderate' (19-35%) and 'low' (< 19%). The percentages of live coral reef in the present study were comparatively lower than those found in Menjangan Kecil Island of Karimun Jawa, ranged of 73.6-76.0% [20]. The outcome could have been otherwise, the sites with higher dead coral *cover* were generally indicative of 'un healthy' coral reefs. In this study, we found the highest percentage of dead coral cover was atstation 3A = 38.37%, followed by station 1A = 31.77%, station 2B = 31.57%, station 3B = 21.07%, station 2A = 13.47%, and station 1B = 7.6% or about 23.98 ± 11.94% in average. The ratio of live coral to dead coral was 1.64:1, implies that the live coralshighly contributed about 64% of coral reef colonies across all the locations.

The best growth performance for coral reefs was found in station 1B supported by nutrient input from substrate of dead corals located at 10m deep. The dead coral substrates also substantially benefit for macroalgae growth. In other words, the rise in macroalgal cover on the reefs was a side effect of decline in coral cover[21]. The worst condition found at station 3A; despite this area underthe core zone but destructive fishing practices still occurs. Overall, the coral reefs in the investigated areas were still much better than coral reef condition in Tanahmasa and some of Mentawai Islands, which were seriously damaged by 74% and only 3.7% of the locations were in good or very good conditions[22].

The highest index values of diversity, uniformity and dominance were clearly defined at station 1B as 3.11, 0.78 and 1.02 respectively (Table-2), where the high substrate of dead corals was found. It means that station 1B had high abundance coral reefs diversity, stable community and high dominance. The lowest indexes of coral reefs were recorded at station 3A as 2.41 for diversity, 0.60 for uniformity and 0.76 for dominance values. This makes sense the substrate composed of the sand so that the coral reef cover was classified as 'bad'. The value of dominance increases as diversity increases. The diversity indexes obtained in the present study was relatively lower than those from Pasir Putih beach of Situbondo[23]; however, the values were considerably higher than those from Pasumpahan island of Padang City[24]. Moreover, our dominance indexes were comparatively higher thanthe authors did.

Environmental factors are the most critical limiting factor for coral growth. Table-3 shows the results of water quality measurements during the field observation. Water temperature, salinity, brightness and current speed ranged as follows: 29-33 ^{o}C, 29-35ppm, 5-10m and 0.5-0.6m/s. These levels correspond to the tolerance limits of quality standard[19] for coral reef growth and survival.

Management of coral reef ecosystem is essentially a process of controlling human actions, so that the utilization of natural resources can be done wisely by heeding the rules of environmental sustainability. To be aware of its existence of coral reef ecosystem for supporting food chain web and for the benefit of various sectors, so the management of coral reef resources cannot be done separately, but must be done in integrated by related institutions. The rationale for coral reefs management should be definitely expressed that the coral reefs are a source of economic growth that must be managed wisely, integrated and sustained by maintaining a carrying capacity and environmental quality through the empowerment of communities and stakeholders in order to meet the needs and welfare of the community and users sustained.

A high level of positive perception and participation by the community become one of the factors contributing to success of coral reef conservation projects in Pemuteran, Bali[25]. It is acknowledged that marine protected areas (MPA) beneficially support to people and the global economy. According to Brander et al.[26] MPA generated benefit-cost ratios ranging from 3 to 20 or rising from 10 to 30% protection.

Table-1: The percentage of live and dead coral reef covers in each observation station. A-stations = 5m deep and B-stations = 10m deep with a 50-m transect line.

Coral reefs status	Percentage of Coral reef cover						
	Station 1A	Station 1B	Station 2A	Station 2B	Station 3A	Station 3B	Mean ±SD
Live coral	48.50	62.48	26.49	49.53	17.40	40.83	39.35±17.94
Dead coral	31.77	7.60	13.47	31.57	38.37	21.07	23.98±11.94

Table-2: Indexes of diversity, uniformity and dominance of coral reefs at three stations.

Parameter Observed	Index Value					
	Station 1A	Station 1B	Station 2A	Station 2B	Station 3A	Station 3B
Diversity	2.64	3.11	2.90	2.85	2.41	2.92
Category[15]	Moderate	High	Moderate	Moderate	Moderate	Moderate
Uniformity	0.69	0.78	0.72	0.73	0.60	0.74
Category[16]	labile	stable	labile	labile	labile	labile
Dominance	0.95	1.02	0.97	0.98	0.76	0.97
Category[17]	High	High	High	High	High	High

Table-3: Water quality parameters of Pieh Island for coral reef growth and survival[19].

Parameters Observed	Measurement Results	Quality Standard*
Temperature (°C)	29 - 33	28 - 30
Salinity (ppm)	29 - 35	33 - 34
Brightness (m)	5 - 10	5 - 10
Current Speed (m/s)	0.5 - 0.6	0.3 - 1.0

Conclusion

The type of coral reef in Pieh Island was categorized as 'fringing reefs'. The ratio of live coral to dead coral was 1.64:1. The coral reef health index was classified as 'high' (39.35 ± 17.94%). The best performance for coral reefs was found in station 1B interm of diversity, uniformity and dominance indexes with stable communities. Water quality parameters are within tolerable levels for coral reef growth and survival. Community based-concervation should be taken into account.

Acknowledgments

Thanks to Director of Jakarta Fisheries High School and the team for supporting this research.

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