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Assessment of coral reefs community health in Pulau Berhala, Pahang, Malaysia

Mohamad Saupi Ismail*[1], Gerald B. Goeden[2,3]

[1]Fisheries Research Institute (FRI), Department of Fisheries Malaysia, Batu Maung, 11960 Pulau Pinang, Malaysia. [2] Fizzy Transition Ventures, 9727 KB Groningen, The Netherlands. [3]Blue Planet Environment PLT, 1 Lorong Edgecumbe, 10250 Pulau Pinang, Malaysia.

Abstract: Pulau (= island) Berhala is not currently within the marine park system. It is located on the east coast of Peninsular Malaysia. In September 2016, three sites on the fringing reef of the island were surveyed during neap tides, using a 50m Point Intercept Transect method. The result showed that reefs of the island were in fair condition with the total live corals of 45.84%, which is a little higher than the mean coral cover for Malaysia (43.71%). However, the coral mortality index, of 0.31, suggested that the community might be stressed. Scleractinian corals dominated the benthic community along all transects. Twenty-three genera of scleractinian corals were observed in this survey, monopolised by *Acropora* (17.17%), *Montipora* (15.45%) and *Porites* (12.88%). Using the relative abundance categories, most of the genera (17) of scleractinians belonged to the "common" categories. The dominant coral growth form was massive / thick colonies (30.04%), followed by branching (24%) and thin plates and crusts (23%). Sessile life forms other than corals were dominated by sponges (24.62%). The abiotic categories were dominated by dead corals (21.01%). This study is an important first assessment of the coral community of Pulau Berhala. Based on our assessment, the reef surrounding Pulau Berhala is a healthy coral community. It is hoped that this information will play a vital role in future coral reef management, especially in consideration as to whether this island is suitable to be gazetted as a new Marine Protected Area (MPA) in Malaysia.

Keywords: Coral community, coral cover, scleractinian corals, marine protected area, Pulau Berhala, *Acropora, Montipora, Porites*.

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* **E-mail:** saupi@rocketmail.com | **Phone:** +604-6263925.

I. INTRODUCTION

Coral reefs are widely accepted as being one of the most important ocean resources for the world's sustainable development and they represent the ecosystem that is the most biodiverse on Earth [1-2]. Their contribution to food security and eco-tourism are significant among a number of important system services benefiting hundreds of millions of people [3-4]. Malaysia's coral reefs area is about 4,006 km^2 and home for nearly 500 identified coral species [5-7]. Many studies have been conducted in coral reef communities around the world to rank the health of the reefs [8]. There has been a consistent loss of coral diversity as the result of anthropogenic impacts on a global scale [1] and, more locally, on Malaysian reefs [2,9,10]. Many of these impacts were detailed by Reef Check Malaysia (RCM), such as over-fishing, which can result in detrimental changes to reef ecology; destructive fishing, which destroys the reef structure; and coastal development, releasing silt and sediment that can smother reefs and alter hydrological flows [4].

One strategic measure taken to protect the coral reef resources in Malaysia is by establishing the Marine Protected Area (MPA), such as marine parks, fisheries prohibited areas and sanctuaries. This measure aims to protect vital marine ecosystems by limiting fisheries and destructive activities in the specific area, normally through closure of marine habitats from such activities. Also, Malaysia is moving forward to achieve its Aichi Biodiversity Target of conserving at least 10% of marine habitats by establishing more MPAs by the year 2020. [11]. Today, 42 islands have been gazetted as marine parks in Peninsular Malaysia and the Federal Territory of Labuan, managed by the Department of Fisheries Malaysia, with a total area of 235,723 ha [2,9]. However, such protective measures are yet to be applied to all

offshore islands in Malaysia, including Pulau (= island) Berhala, exposing the reefs to many stresses driven by nearby coastal development. Over-exploitation of coral reefs continued to occur outside the MPAs [9]. Without clear information on coral coverage and the composition of the community, the level of exploitation of the reefs could not be assessed. Thus, our objective in this study was to conduct an initial assessment of the coral coverage and coral community of Pulau Berhala. This in turn would lead to a set of baseline information potentially useful to the future management and decision relating to the establishment of new MPA for the waters surrounding the island.

II. Results and Discussion

The assessment found that the three sites varied little in percentage cover within the six most recognized categories, as summarized in Table 1. Only Site 1 contained representatives from each category. Pooled, the scleractinian and non-scleractinian corals dominated the benthic community and covered most of the substrates (45.84 ± 7.15%). Scleractinian corals were dominant at Site 2, representing almost half (45.45%) of the benthic community. Non-scleractinian corals were absent from Site 3 samples and only poorly represented at Sites 1 and 2 averaging 9.34 ± 7.73% for the pooled Pulau Berhala reef transects. Since, no earlier assessment has been carried out, we are unable to conclude if Pulau Berhala's reef is in a stable or declining situation. We can, however, compare our data with other reefs and find that the live coral coverage (LCC) of Pulau Berhala (45.84 ± 7.15%) is lower compared to the nearby marine park island of Pulau Tioman (59.48% in 2016), but it may be a little higher than the average LCC for Malaysia (43.71% in 2016) [12].

To put this in perspective, nearly one third of the Malaysia's reefs have LCC between 25 to 50% (fair condition) and only a few of them have LCC greater than 75% (excellent condition) [10,13]. As a comparison, in the Philippines, most reefs surveyed were generally in fair condition [14]. Thus, live coral cover can be used as a broad indicator of coral reef health [4].

In the present survey, sessile life forms other than corals were dominated by sponges (24.62 ± 8.88%). Sponges were plentiful at all sampling sites, especially at Site 2. The dominance of sponges in all sites is indicative of suitable reef morphology and physical parameters of water quality. At the present time, no conclusive explanation can be proposed for these observations. No giant clams and seagrasses were observed along any of the transects. Sea anemones were found at all sites; however, they were not recorded because they did not fall under our sessile life form category. The abiotic categories were dominated by dead coral (21.01 ± 8.71%). The average mortality index (MI) was calculated at 0.31 ± 0.13. The value of less than 0.33 is taken to indicate that the reefs were still in good condition. Our measurement is close to (but less than) the indicator of an unhealthy coral community, as stated by Gomez et al. [14]. As comparison, mortality rates for most of Malaysia's coral reefs were between 10-15% [9]. Most of the dead coral was in the form of unconsolidated coral rubble, indicative that live corals populated the area in the recent past [15]. The high percentage of rubble suggests there is a necessity for involvement of local authorities to determine the cause and take action to lessen damage to the reefs as stated by RCM [4]. A total of 11 families and 23 genera of scleractinian corals, and 7 families and 8 genera of non-scleractinian corals were recorded throughout the survey.

Table 1: Percentage coverage of live corals and other benthic substrates at Pulau Berhala:

S.No	Substrates	Site 1	Site 2	Site 3	Mean ± SD
1.	Scleractinian corals (SC)	27.03	45.45	37.04	36.51 ± 7.53
2.	Non-scleractinian corals (NC)	18.92	9.09	0	9.34 ± 7.73
3.	Dead corals	24.32	9.09	29.63	21.01 ± 8.71
4.	Rocks	8.11	0	0	2.70 ± 3.82
5.	Sands	8.11	0	7.41	5.17 ± 3.67
6.	Sponges	13.51	36.36	25.93	25.27 ± 9.34
7.	Giant clams / Seagrass	0	0	0	0
Total live corals (SC+NC)		**45.95**	**54.55**	**37.04**	**45.84 ± 7.15**
Coral Mortality Index (MI)		**0.35**	**0.14**	**0.40**	**0.31 ± 0.13**

Table 2: Percentage coverage and relative abundance (RA) of coral genera of Pulau Berhala.

S.No	Coral Family	Coral Genera	Coverage %	RA
		Scleractinian Corals		
1.	Acroporidae	*Acropora*	17.17	****
2.		*Montipora*	15.45	****
3.	Dendrophylliidae	*Turbinaria*	1.72	***
4.	Euphyllidae	*Euphyllia*	2.58	***
5.		*Plerogyra*	1.29	***
6.	Faviidae	*Diploastrea*	2.58	***
7.		*Echinopora*	1.72	***
8.		*Favia*	2.58	***
9.		*Favites*	1.72	***
10.		*Goniastrea*	3.43	***
11.		*Oulophyllia*	0.86	**
12.		*Platygyra*	4.29	***
13.	Fungiidae	*Fungia*	2.58	***
14.		*Heliofungia*	1.29	***
15.	Merulinidae	*Hydnophora*	1.72	***
16.	Mussidae	*Cynarina*	0.43	**
17.		*Lobophyllia*	0.86	**
18.		*Symphyllia*	2.58	***
19.	Oculinidae	*Galaxea*	2.58	***
20.	Pectiniidae	*Echinophyllia*	4.29	***
21.	Pocilloporidae	*Pocillopora*	6.87	***
22.	Poritidae	*Goniopora*	2.58	***
23.		*Porites*	12.88	****
		Non-Scleractinian corals		
24.	Alcyoniidae	*Sarcophyton*	0.43	**
25.	Clavulariidae	*Clavularia*	0.43	**
26.	Discosomatidae	*Rhodactis*	0.86	**
27.	Ellisellidae	*Ctenocella*	0.43	**
28.		*Junceella*	1.72	***
29.	Gorgoniidae	*Gorgonia*	0.86	**
30.	Nephtheidae	*Dendronephthya*	0.43	**
31.	Zoanthidae	*Zoanthus*	0.86	**

*rare, **uncommon, ***common, ****abundant, *****dominant

The scleractinian coral numbers of Pulau Berhala are low compared to other nearby reefs in the region, such as Pulau Mertang [15] and Pulau Tioman [16], with 25 genera from 12 families and 57 genera from 17 families respectively. The percentage covers of coral genera are shown in Table 2 along with the relative abundance (RA) of each coral genus. Of these only 3 genera of scleractinians were considered abundant; these are *Acropora*, *Montipora*, and *Porites* in descending order; *Acropora* spp. with 17.17%, followed by *Montipora* spp. with 15.45%, and *Porites* spp. (12.88%) respectively. The most abundant genera at Pulau Berhala (*Acropora*, *Montipora* and *Porites*) are consistent with those nearby reefs [15-16] where they accounted for almost 50% of the LCC. The *Montipora-Acropora* community was the most typical community around Peninsular Malaysia [10].

Figure 1: The uncommon corals, *Cynarina* sp. (Top) and *Lobophyllia* sp. (bottom), found in Pulau Berhala.

Thus, based on our assessment, the reef surrounding Pulau Berhala is clearly a healthy coral community in fair condition. Using the terminology of Rilov and Benayahu [17], none of the scleractinian coral genera encountered were ranked as "dominant". With exceptions of *Cynarina*, *Lobophyllia* and *Oulophyllia*, all other 17 genera belonged to the "common" category. *Cynarina* sp. (Figure 1), which was found only once throughout the survey, is usually considered to be very uncommon in Peninsular Malaysia and has only been observed on the eastern part of the Peninsula [5]. All corals were converted to their most common growth form, based on categories simplified by Kelly [18], as a means of characterizing the "reef-scape". Table 3 lists these growth forms together with their percentage cover of the reef. The reefs showed the dominance of massive / thick coral colonies with their live coral cover value greater than 30%. Branching type corals were the second most commonly encountered as percent cover (24%), followed by thin plates and crusts (23%).

Only solitary/isolated forms were poorly represented. These three major growth forms made up more than three quarters (77%) of the total live coral coverage. This result was in accordance to others [15], where they also recorded 75% coverage of live coral growth when summed for those growth forms. The future protection for this island is critical in order to conserve its reef ecosystem. It has been already assessed that Malaysia's overall live coral cover has declined by 3% from 43.71% [12] to 40.63% [4] in a span of three years. Our findings suggest that the management authority can utilise this baseline information to begin to plan their conservation and protection strategies until more specific and detailed information becomes available. Such strategies should include conserving this important habitat and establishing the island as an MPA, so that activities conducted in this area will be controlled. Data by Reef Check Malaysia [4] clearly indicates that higher live coral cover is found within the MPAs compared to the non-marine park areas. Urgent action must be taken to protect Malaysia's remaining reefs, thus safeguarding the huge economic benefits they provide.

Table 3: Coverage of the live coral growth forms at Pulau Berhala, as percentage of total coral cover:

Growth Form	Percentage Cover
Massive / Thick Colonies	30.04
Branching	24.03
Thin Plates & Crusts	23.18
Meandering Ridges & Valleys	11.16
Solitary / Isolated	5.58
Non-Scleractinian Corals	6.01

III. CONCLUSION

Our assessment of the Pulau Berhala reef is that it is in 'fair condition' and compares favourably with other Malaysian coral reefs. We would express some concern that the mortality index (MI) at 0.31 suggests that the coral community is likely to be experiencing stress. This may be due to warmer sea conditions and recent bleaching events and/or it may be the result of fishing pressure. Significantly, coral cover is similar to nearby Marine Park reefs even though Pulau Berhala lacks the additional protection afforded by Malaysia's MPA status. With additional protection, Pulau Berhala should show a further increase in coral cover. The present study is an important first assessment of the coral community of Pulau Berhala and should provide the basic information with which further long-term monitoring can be compared. More coral surveys need to be conducted at Pulau Berhala over time. It is hoped that this study will play an important part in future coral reef management efforts for this island and other similar marine areas in Malaysia. Moreover, as Malaysia aims to establish many other areas as an MPA in the near future, Pulau Berhala can be one of the candidates for that.

IV. MATERIALS & METHODS

Pulau Berhala, also known as Varela Island, is located approximately 30km NE of Nenasi in Pahang, Malaysia (N 3°15'13" and E 103°39'43") (Figure 2). The island itself is nearly vertically-sided and about 28m high sitting atop an erosion platform of about 150m diameter. There is a small amount of vegetation on the island's upper-most surface that also serves as the base of a navigational light. Pulau Berhala is surrounded by a small fringing reef that is popular with both recreational and commercial fishermen. The reef also attracts limited numbers of scuba divers interested in exploring the wreck of the Geoshin Maru, also known as the Varela Wreck, lying in about 20m of water. However, little is known about the reef and its ecological importance to the marine environment and the island itself. It is safe to assume that the water at Pulau Berhala is of a high quality, although no proper comparative study has been conducted. This offshore island, however, is not part of a marine protected area (MPA) and so visitors and fishermen are not regulated or monitored.

During September 2016, researchers from the Fisheries Research Institute (FRI) in Pulau Pinang, Malaysia carried out a coral assessment at three sites located around Pulau Berhala. The survey team included two groups of divers equipped with scuba gear. Visibility was greater than 10m and conditions (sea state and currents) were advantageous to data collection.

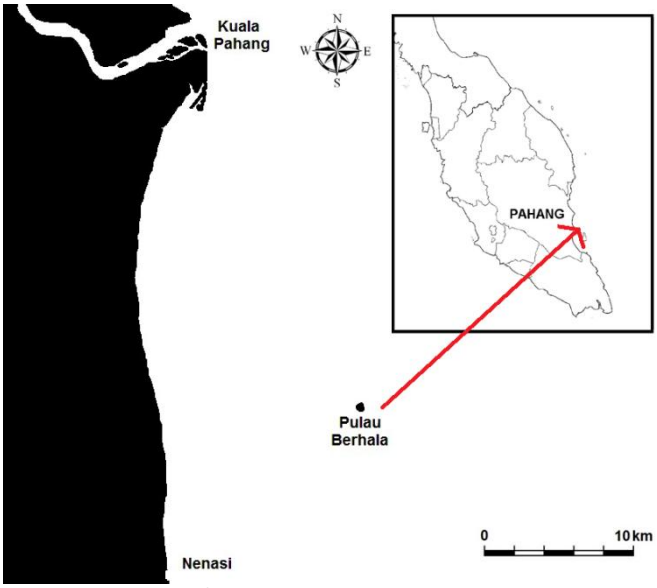

Figure 2: Location of Pulau Berhala, Pahang waters.

Samplings were done during neap tides. The assessment was based on two parallel transects each 50m long and 10m apart and set perpendicular to the island so as to run from shallow to deeper water. A transect laid perpendicular to shore is appropriate in order to include different reef zones or depths in the same transects [19]. Depth at the beginning of each transect was about 5m. Data was collected at every 1m intervals using the point intercept transect (PIT) method outlined by others [19-20]. The PIT method was also conducted by others [21-22], and managed to give as good result as other transect methods (line and video intercepts) in estimating the percentage of coral cover and diversity [19].

Table 4: The values used for the Relative Abundance (RA) categories.

RA Category	Percentage Cover
Not recorded	0
Rare	0 < RA < 0.1
Uncommon	0.1 < RA < 1
Common	1 < RA < 10
Abundant	10 < RA < 20
Dominant	RA > 20

Corals and other benthic communities were recorded. All live corals (scleractinian and non-scleractinian) were identified to the generic level using published guides [18,23]. Sessile life forms other than corals were identified based on their common categories such as giant clams, seagrass and sponges. Non-living substrates were recorded under the categories of dead corals, rocks and sands. Dead corals included those covered with algae, coral rubble and recently dead corals. Live coral cover (LCC) followed the classification

employed by Chou et al. [24]. This was categorized as poor, fair, good and excellent with values of 0-24.9%, 25-49.9%, 50-74.9% and 75-100% live coral respectively. Coral mortality index (MI) follows the method of Gomez et al. [13]. They have set a value of MI more than 0.33 to be indicative of an unhealthy coral community. The Relative Abundance (RA) was determined based on Rilov and Benayahu [17]. The values used for RA categories are % coverage and are shown in Table 4. Data from this study were summarized using basic univariate statistics such as mean and standard deviations, performed by software SPSS 21.0.

Author's contribution: MSI designed the study, executed the work and analyzed the data. MSI and GBG wrote the manuscript. All authors have read and approved the final manuscript.

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