Assessment of coral reef health conditions in Juru Seberang Village, Tanjung Pandan District, Belitung Regency-Bangka-Belitung Province

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Abstract. Belitung has potential coral reefs as many as 244 species and 89 species of reef fish. However, the current condition of coral reefs in Belitung is under high pressure, caused by illegal tin mining activities. For this reason, need studies related to their impact on the health of marine life, especially on coral reefs so that the policy can be reviewed, to see the important role of coral reefs for other marine biotas. The aim of this study is focused on knowing the condition of substrate coverage, diversity, and biomass of target fish as well as assessing the health of coral reefs at the observation site. Data were collected with SCUBA diving equipment at 6 stations, at depth of 5–7 m. Retrieval of basic substrate data is done by the Underwater Photo Transect method and for reef fish using belt transect. The results showed substrate coverage was dominated by hard corals, dead corals, sand, and dead corals with algae. Fleshy seaweed cover ranges from 0.07–4.77%, coral fragment cover ranges from 0–2.6%, target fish biomass value obtained varies between 0.0006–0.0299 kg/ha, and coral reef health index at each observation station ranges from 3 to 6.

Keywords: Bangka-Belitung; coral reef health; fleshy seaweed; reef fish; rubble

1. Introduction

1.1. Background
Indonesia is known as the center of diversity and the place where the coral reef was first discovered. Suharsono [1] estimated as many 590 species from 80 genera were spread from Sabang to North Jayapura. However, 2.5 million ha area of Indonesian coral reefs, is spared only 6.56% was in very good condition [2]. The damaged of coral reefs in Indonesia caused by sedimentation, water pollution, ship grounding, coral mining, destructive fishing, extreme and strong wave, uprising predator of coral reefs, and rise of sea surface temperature from global warming [3, 4].

Assessment of coral reef health has been done a lot by considering the local condition and a wide variety of environmental parameters. The parameter that is used to analyze starts from slight to comprehensive [5-8]. Based on those studies, we believe that the use of a comprehensive parameter does not necessarily guarantee a good result. Research center for oceanography LIPI that has scientific
authority, published the method for calculating Coral Reef Health Index from two key parameters: percentage of coral reefs cover and biomass of reef fish target [9]. In assessment condition coral reefs, that formula can be delivered comprehensive information based on a national standard.

Belitung District has numerous diverse species in the coastal ecosystem, such as 244 coral reefs from 15 families, 89 reef fishes from 21 families, 80 macrobenthos, 9 seagrasses, and 6 mangroves [2]. Located at west Belitung, Juru Seberang Village has high potential in the coral reef ecosystem. Unfortunately, due to the intensive mining, coral reefs in Juru Seberang are under pressure. The mining started from land but continued to coastal areas, devouring protected forest and marine ecosystems [10-13]. Therefore, need studies to focus on coral reef health index which can be used to support management and policy in the Marine Protected Area.

2. Methods

2.1. Study site

This research was conducted on 20–22 January 2018, located in Juru Seberang Village, Belitung. The Observation station was spread in several locations including Kalimambang Island, Ulat Bulu Island, Gosong Karang Tukul, and Gosong Karang Kijang (figure 1).

![Map of Research locations Juru Seberang Village, Belitung](image)

**Figure 1.** Map of the data collection in Juru Seberang Village.

Data were collected with SCUBA diving equipment at 6 stations and each station was repeated 2 times. The observation transect was laid for 50 m at a depth of 5–7 m. Data observation taken include:

2.1.1. Benthic substrate. Benthic substrate cover data was carried using the underwater photo transect (UPT) method (figure 2). Data were collected at 6 stations and each station was repeated 2 times at a depth of 5–7 m. Furthermore, the benthic substrate data is used to calculate the coral reef health index
value from the percentage of live coral cover and recovery potential (fleshy seaweed and rubble). Fleshy seaweed is a term used for macroalgae communities that are visible to the naked eye, such as sargassum, padina, and other macroalgae. Rubble is crushed coral fragments caused by crashing waves or using explosives (bombs) to catch fish [9].

![Figure 2. Illustration of sampling point observation using frames](image)

2.1.2. Reef fishes. Data collection for coral reef fishes was carried out on the reef slopes using belt transects [15]. Observations of reef fish communities were carried out by visual census using a transect of 50 meters long and 5 m wide. Fish that are used as the target for observation are target fish that have economic value, with the hope that many fish will describe the good condition of the coral reef ecosystem.

Determination of the coral reef health index value was calculated based on the biomass values of herbivorous fish (Family Scaridae, Siganidae, and Acanthuridae) and carnivorous fish (Family Serranidae, Lutjanidae, Lethrinidae, and Haemulidae). Data recording includes individual abundance, species diversity, and estimated total length of each individual [16].

2.2. Data analysis
2.2.1. Benthic substrate cover. Underwater photographic data on each transect were analyzed using CPCe software, Coral Point Count with Excel extensions [17]. Analysis of the percentage cover of biota refers to English et al. [18] by calculating the percentage category of substrate cover obtained from the formula:

\[
\text{Percentage of category cover} = \frac{\text{sum categories}}{\text{sum of random points}}
\]

The assessment of the condition of coral reefs uses standard criteria for coral reef damage based on the criteria developed by Zamani and Madduppa [19].

### Table 1. Health criteria for the coral reef ecosystem [19].

| No | Parameters         | Standard criteria for coral reef health |
|----|--------------------|-----------------------------------------|
|    |                    | excellent | Good   | Fair   | Poor   |
| 1  | Live coral coverage | 75–100%   | 50–74.9% | 25–49.9% | 0–24.9% |
| 2  | Algae coverage     | 0–24.9%   | 25–49.9% | 50–74.9% | 75–100% |
| 3  | Sand coverage      | 0–24.9%   | 25–49.9% | 50–74.9% | 75–100% |
| 4  | Mortality index    | 0.75–1    | 0.50–0.749 | 0.35–0.499 | 0.0–0.249 |

2.2.2. Reef fishes. Fishes biomass was calculated using the length-weight relationship approach for each type of fish [20].

\[
W = a \times L^b
\]

W = weight (g);
L = fork length (cm);
a and b = constant
2.3. Coral reef health index
The coral reef health index is measured using a method developed by LIPI, which is determined based on two main components, percent cover of benthic biota and biomass of reef fishes. Furthermore, fleshy seaweed and rubble are calculated to see resilience and recovery factors [8].

2.4. Statistical analysis
Correspondence analysis is used to see the closeness between the coral health index parameters and the observation station. So that can be known what parameters greatly affect the coral reef health index.

3. Results and discussion
3.1. Percentage coral cover
The coral reef ecosystem in Juru Seberang Village is a type of fringing reef. The substrate of each location was dominated by hard coral, recent dead coral, sand, and dead coral with algae (see figure 3). The percentage of hard coral cover at each observation station varied between 12.53–68.83%. The highest coral cover was found at Kalimambang station with 68.83%, while the lowest was at East Ulat Bulu Island station 12.53%. The average percentage of hard coral cover obtained was 34.55%, in the “Fair” category based on the criteria for coral reef health.

![Figure 3. The percentage substrate cover from coral reefs ecosystem in Juru Seberang Village.](image)

The low coral cover at East Ulat Bulu Island station (see figure 4) is probably due to its location near the mouth of the Juru Seberang river which carried sedimentation particles from the mainland. This can be seen from waters at East Ulat Bulu Island Station that has high turbidity. One of the causes is the loss of vegetation in the mainland due to sand and tin mining activities. Sedimentation will impact a decline in the condition of coral reefs in certain waters, some studies suggest that deposited sediments harm the health of coral communities, causing a decrease in coral cover, growth, and recruitment [21-23].
3.2. Fleshy seaweed

The result found that the fleshy seaweed value ranged from 0.07–4.77%, with the highest value at South Ulat Bulu Island Station and the lowest at East Ulat Bulu Island Station (figure 5). The higher the percentage value of fleshy seaweed, the greater the disturbance that will be received by coral reefs. This is because the fleshy seaweed is superior in habitat competition to corals [9]. In another publication, it was said that fleshy seaweed interferes with the growth process and inhibits a potential area for coral saplings to be attached because it has secondary metabolites and the presence of algae in large areas causes physical disturbance in young corals, increased sediment settling, reduces sunlight penetration and reduces the success of coral seedlings [21, 24, 25]. For example, coral reefs in Kenya, India, Singapore, and Sangiang Island, Indonesia are severely disturbed by the presence of algae [23, 26, 27].

Figure 4. The percentage of hard coral cover from each observation station.

Figure 5. The percent cover of fleshy seaweed in from each observation station.
3.3. Rubble
Rubble observations in the study area are in the range of values from 0 to 2.6% (figure 6). The stations with the highest rubble coverage were South Ulat Bulu Island Station (2.6%) and the lowest 0% (no coral fragments found) were located in Karang Kijang I, Karang Kijang II, and East Ulat Bulu Island Station. The high cover of coral debris will lower the potential for coral reef ecosystem recovery because coral debris is very difficult to be able to grow by coral larvae. Some studies say that rubble is not a good substrate for coral larvae to grow and develop, because it is always moving dynamically [9, 28, 29]. Rubble can be a medium for growing new corals if it is stable because it is bound by coralline algae. Bachtiar et al. [30] states that coral reefs will have a low resilience index value if the coral cover is low, macroalgae and other fauna cover are high and sand and mud cover is high.

| Station                      | Rubble Coverage |
|------------------------------|----------------|
| Karang Kijang II             | 0.00           |
| Karang Kijang I              | 0.00           |
| East Ulat Bulu Island        | 0.00           |
| South Ulat Bulu Island       | 2.60           |
| Gosong Karang Tukul          | 0.33           |
| Kalimambang                  | 0.07           |

**Figure 6.** The percent cover of rubble from each observation station.

3.4. Target fish biomass
Target fish are one of the economically important fish communities that are the target of fishermen’s catch. The results showed that the target fish in the observation location included the family Haemulidae, Lutjanidae, Serranidae, and Siganidae. If viewed by location, the value of the target fish biomass obtained varies between 0.0006–0.0299 kg/ha, with the highest at South Ulat Bulu Island Station and the lowest at Kalimambang Station (figure 7).

**Fish Biomass (kg/ha)**

| Station                      | Biomass (kg/ha) |
|------------------------------|-----------------|
| Karang Kijang II             | 0.0042          |
| Karang Kijang I              | 0.0122          |
| East Ulat Bulu Island        | 0.0263          |
| South Ulat Bulu Island       | 0.0299          |
| Gosong Karang Tukul          | 0.0208          |
| Kalimambang                  | 0.0006          |

**Figure 7.** Biomass target fishes in each observation station.
Overfishing will reduce the resilience of coral reefs due to reduced herbivorous fish, but on the other hand, the presence of herbivorous fish also plays a role in the death of coral saplings [25]. Understanding the role of herbivorous fish in coral recruitment and its relation to the presence of macroalgae is important in increasing the resilience of coral reefs [31]. The precise role of herbivores, in particular, small non-obligate species such as Damselfish in controlling algae needs to be considered alongside other large species [31]. Herbivorous fish biomass and rates of coral reef recovery are increased, as it increases post-settlement survival [32-34]. The loss of these fish groups will increase substrate cover from macroalgae, with poor water quality it will hard for coral reefs to recover, especially the increasing threat of climate change [35].

3.5. Coral reef health index
The results of coral health observations at each observation station varied from 3 to 6. The location with the highest health index value (6) was Kalimambang Island and Kijang II Coral Station, while the lowest (3) was found on East Ulat Bulu Island Station. In general, Juru Seberang waters have a health index of 5–6 meaning they have a high live coral cover and high recovery potential but low target fish biomass (table 2).

**Table 2. Value coral reef health index in study area.**

| No | Location                  | Benthic Component | Fish Component | Total Value | Index |
|----|---------------------------|-------------------|----------------|-------------|-------|
| 1  | Karang Kijang II          | High              | Resilience     | Value       | 8     | 6     |
| 2  | Karang Kijang I           | Fair              | Value          | 5           | 7     | 5     |
| 3  | East Ulat Bulu Island      | Poor              | Value          | 4           | 6     | 4     |
| 4  | South Ulat Bulu Island     | High              | Poor           | 5           | 7     | 5     |
| 5  | Gosong Karang Tukul        | Fair              | Poor           | 2           | 8     | 6     |
| 6  | Kalimambang               | High              | Poor           |             |       |       |

Further analysis using correspondence analysis (CA) was used to see the parameters that affect each observation station. Based on the results of the correspondence analysis, it can be seen from the closeness between the coral health index parameters and the observation station (figure 8). The coral health index parameters at the Kalimambang Islands, Karang Kijang I, and Gosong Karang Tukul Station are strongly influenced by hard coral cover and have the farthest distance from the East Ulat Bulu Island observation station which is more influenced by rubble. South Ulat Bulu Island Station is highly correlated to fish biomass and Karang Kijang 2 Station is highly correlated to fleshy seaweed (figure 8). This shows that the health of corals in Juru Seberang village is more affected by hard corals.

The complexity of coral reefs as habitat is the key to restoring coral reef ecosystems. Several studies have stated that the sapling of coral Juana is one of the factors that ensures the restoration of coral reef ecosystems and the complexity of coral reefs as a habitat to provide biodiversity for reef fish and also guarantee herbivory processes [36, 37]. Herbivores become an important ecological mechanism which supports the resilience of coral reefs through controlling macroalgae growth which harms the coral reef community. Uncontrolled growth of macroalgae will cause the dominant macroalgae community in the coral reef ecosystem, due to the low number of herbivores where filamentous algae become coral competitors in fighting for space [32, 38, 39]. One of the causes of high algal cover is the occurrence of overfishing, which is characterized by a low abundance of herbivorous fish [30].
The health of the corals in the waters of Juru Seberang Village can recover quite high with good coral cover conditions and low rubble cover, but what needs to be considered is the low biomass of herbivore fish. It is hoped that future management should maintain current coral cover or increase and reduce fleshy seaweed cover by increasing the abundance and biomass of herbivorous fish. As stated by Bachtiar et al. [30] and Petersen et al. [40] that coral reefs will have a high resilience value, if the coral cover is high, the cover for macroalgae and other fauna is low and the cover for sand and mud is low [30, 40, 41].

**Correspondence Analysis**
(axes F1 and F2: 99.93%)

![Figure 8](image)

**Figure 8.** The correspondence analysis from each observation station.

4. **Conclusion and recommendation**

4.1. **Conclusion**

It can be concluded that hard coral coverage on Juru Seberang Village was 34.55% and it was categorized as quite good. The coral health assessment index is at 5–6 with good coral cover conditions and low rubble coverage, but what needs to be considered is the low biomass of herbivore fish, which means that their ability to recover is quite high. Coral health in the waters of Juru Seberang Village is more influenced by the live coral cover condition.

4.2. **Recommendation**

It is necessary to improve fisheries activities so that they can increase the abundance and biomass of herbivorous fish to increase the resilience of coral reefs in Juru Seberang Village.

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