The Correlation Between Coral Cover and The Associated Reef Fishes Abundance in Enggano Island Bengkulu

AB Kusuma, PP Renta, D Purnama, BFSP Negara, C Claudea, T Budiharto, and I Kholid

Marine Science Department, University of Bengkulu
E-mail: aradea.bujana@gmail.com

Abstract. The coral reef is the habitat for more than a million marine species. The damage of the coral reef could decrease associated marine biodiversity, and the coral reef fishes are one of the groups impacted by the coral reef destruction. This study aimed to measure the coral coverage, to estimate the abundance of coral fishes, and to determine the correlation between coral coverage and abundance of coral reef fishes in Enggano Island, Bengkulu. The line intercept transect method was used by applying 25 m length transects to measure the coral cover in 12 sampling stations. The visual census method was implemented to count the presence of coral reef fishes around the transect line. The correlation between coral coverage and abundance of coral reef fishes was estimated using the multiple-linear-regression method. The results revealed that the coral coverage in Enggano Island varies from 99.6%-6.6%. The highest coverage was observed in station one at the leeward of Dua Island, whereas the lowest was found in station nine at Kahabi. The depth that measured 21 m could cause low coral coverage in condition. The substratum at this depth receives low sunlight intensity; thus, photosynthesis could not function efficiently. The highest coral reef fish abundance was estimated at 603 ind/125 m² was found in station 12 at Berhau, whereas the lowest at 8 ind/125m² was in station eight at Kahabi. The analysis showed a positive but considerably a weak correlation between coral coverage and abundance of coral reef fishes with an r-value of 0.61 and the determination coefficient of 61.00%.

1. Introduction

Enggano Island is located in Bengkulu Province; it has a distance of more than 90 miles from the Sumatra mainland. The condition has led to a high illegal fishing activity due to a lack of legal enforcement agents in the area. Consequently, it threatens marine ecosystems, including the coral reef, which is typical in the area. The tropical corals are mostly stony coral characterized by a variety of life forms [1]. The coral reef provides shelter for many marine organisms, including coral fishes. An area with high coverage of coral will also have high diversity and abundance of coral fishes [2,3,4].

Coral reef fishes are associated-fishes with the coral reef ecosystem. The coral reef provides habitat and nursery ground for almost all coral reef fishes that create dependencies for the fishes to the coral reef ecosystem. The damage of the coral community will directly affect the existence of associated reef fishes [5,6]. Therefore, coral reef fishes can be used as a bioindicator to measure the health of coral reef ecosystems [7]. The presence or absence of certain types of reef fishes in the coral reef ecosystem is an accurate indication of the health of a coral reef ecosystem. Thus, the decline of coral coverage also has a significant impact on Indonesia's marine biodiversity.
Research concerning coral coverage conditions in Enggano Island has recently reported severe damage at the western coast of Enggano Island [8]. An inventory study on the reef fishes also has been completed in the same areas [9]. That recent research has no record on the correlation between coverage of the coral and the abundance of coral reef fishes. Therefore this study aimed to measure the coral coverage, to estimate the abundance of coral fishes, and to determine the correlation between coral coverage and abundance of coral reef fishes in Enggano Island, Bengkulu.

2. Methods

This study was conducted in April 2018 at Enggano Island of Bengkulu Province, Indonesia. Four dive sites were designated i.e., leward and windward side of Dua Island, Berhau, and Kahabi (Figure 1). The SCUBA dive was conducted to quantify the coral cover and to tally the coral reef fishes abundance at the 3 to 21 m depth in each location.

![Figure 1](image.png)

**Figure 1.** Study Sites of Correlation between Coral Coverage and the Coral reef fishes Abundance In Enggano Island, Bengkulu

2.1 Data Collection

The line intercept transect method was used to determine the condition of the coral health based on the coral cover [10]. The roll meter used as 25 m transect was placed parallel to the coastline with three replicates in every dive site. The coral lifeform found along the roll meter was recorded and calculated for the number lifeform and coverage area [10, 11]. For the abundance of coral reef fishes, the visual census method was used to count the number within a virtually 2.5 x 2.5 m window on the right and left side of the same line transect [10]. All the fishes found were identified and calculated [12]. The water quality parameters, such as temperature, salinity, visibility, and pH, were measured in situ during the research.
Life forms of coral covers

The life forms of coral and dead coral were calculated based on [10] as follows:

\[ C_i = \frac{n_i}{L} \times 100\% \]

Where \( C_i \) (%) is life forms of coral covers, \( n_i \) is the total length of bottom subtracting (cm), and \( L \) is the length of the transect (cm). Furthermore, the category of coral reefs condition was categorized based on Kepmen LH Republic of Indonesia No. 4, Year 2001 (Table 1).

Table 1. The category of life forms of coral covers (Kepmen LH Republic of Indonesia, No. 4, Year 2001)

| Category          | Life forms of coral cover (%) |
|-------------------|-------------------------------|
| Severely damage   | 0 – 24.9                      |
| Moderately damage | 25 – 49.9                     |
| Good              | 50 – 74.9                     |
| Very good         | 75 – 100                      |

Coral reef fishes Abundance

The abundance of coral reef fishes was calculated based on [13] as follows:

\[ N = \frac{\sum_{i=1}^{i} n_i}{A} \]

Where \( N \) is the abundance (Ind/m\(^2\)), \( n_i \) is the total of individual fish \( i \), \( A \) is an area of the census, and \( i \) is replications.

Correlation between Coral coverage and Coral reef fishes abundance

The correlation between coral coverage and abundance of coral reef fishes was analyzed using multiple linear methods in Microsoft excel, where the variable independent (X) was coral coverage and variable dependent (Y) was the abundance of coral fishes.

3. Results

3.1 Coral Coverage

The percentage of coral coverage ranged from 6.6 – 96.9 %. The lowest coral coverage was in Kahabi (6.6%) that categorized into severely damage category according to Kepmen LH Republic of Indonesia No. 4, 2001. The highest coral coverage was found in the leeward side of Pulau Dua (99.6%) that categorized into a very good category based on Kepmen LH Republic of Indonesia No. 4, 2001.

3.2 Coral reef fish Abundance

In general, there are 21 coral reef fishes observed in this location including Halichoeres hortulanus, Neoglyphidodon melas, Labroides dimidiatus, Chromis retrofasciata, Acanthurus pyroceferus, Chaetodon reticulatus, Chaetodon unimaculatus, Chromis margaritifer, Siganus magnificus, Pseudochromis moorei, Lutjanus Fulvilamama, Acaniehaochromis polyacanthus, Dascyllus aruanus, Pentapodus trivitatus, Acanthurus triostegus, Heniochus acuminatus, Scolopsis bilineatus, Zebrasoma scopas, Pomacentrus bankanensis, Scarus flaviretoralis, Halichoeres prosopeion. The results of coral reef fishes abundance ranged 8 – 603 Indv/125 m\(^2\). The lowest coral reef fishes abundance found in Kahabi (8 Indv/125 m\(^2\)), and the highest coral reef fishes abundance found in Berhau (603 individual/m\(^2\)) (Table 3).
Table 2. The diversity of lifeforms and percent cover of coral in Enggano Island, Bengkulu

| Lifeform          | Dua Island, Leeward | Dua Island, Windward | Kahabi | Berhau |
|-------------------|---------------------|----------------------|--------|--------|
|                   | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 | Station 7 | Station 8 | Station 9 | Station 10 | Station 11 | Station 12 |
| Other             |           |           |           |           |           |           |           |           |           |           |            |            |
| Dead Coral        | 0.4       | 18        | 29.6      | 3.6       | 53.4      | 6.8       | 81.64     | 69.76     | -         | -         | -           | -           | -           |
| Rubble            | -         | -         | -         | 1.52      | 3.16      | 0.32      | -         | -         | -         | 19.6      | 45.2        | 16          |
| Rock              | -         | -         | -         | -         | -         | -         | -         | 75.68     | 9.2       | -         | -           | -           |
| Sand              | -         | -         | -         | -         | -         | 23.2      | 10.2      | 18.56     | 15.12     | 17.4      | 14          | 0.4         |
| Algae             | -         | -         | -         | 8.4       | 0.6       | 3         | -         | 2.08      | 2.6       | -         | -           | -           |
| Softcoral         | -         | -         | -         | -         | -         | -         | -         | 0.4       | -         | -         | -           | -           |
| Sponge            | -         | -         | -         | -         | -         | 0.68      | -         | -         | -         | -         | -           | -           |
| **Acropora**      |           |           |           |           |           |           |           |           |           |           |            |            |
| Acropora Submassive | 26.56   | 44.6      | 20.6      | 1         | -         | -         | 0.6       | 1.2       | -         | 34.2      | 8.6         | 34.2        |
| Acropora Branching | 73.04   | 26.6      | 48        | 86.48     | 38.88     | 57.08     | 3         | 1.4       | 1         | -         | 34.8        | 3           |
| Acropora Digitate | -         | -         | -         | -         | 1.2       | 2.16      | 1.04      | 2.52      | -         | -         | -           | -           |
| Acropora Encrusting | -       | -         | -         | -         | -         | 0.4       | -         | -         | 0.4       | -         | -           | -           |
| **Non-Acropora**  |           |           |           |           |           |           |           |           |           |           |            |            |
| Coral Massive     | -         | 1.6       | -         | -         | -         | 3.4       | 0.8       | 4.16      | 2.8       | -         | -           | 2.4         |
| Coral Submassive  | -         | 6.8       | 1.4       | -         | 2.76      | 5.12      | -         | -         | -         | -         | -           | -           |
| Coral Mushroom    | -         | 0.4       | 0.4       | -         | -         | -         | -         | -         | -         | -         | -           | -           |
| Coral Foliose     | -         | 2         | -         | -         | -         | -         | 1.6       | 0.2       | -         | -         | -           | 5.2         |
| Coral Encrusting  | -         | -         | -         | -         | -         | -         | -         | 0.8       | -         | -         | -           | -           |
| Coral Branching   | -         | -         | -         | -         | -         | -         | -         | -         | 19.6      | 2.8       | 43.2        | 0.8         |
| Meliopora         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | 2           | 0.8         |
| **Total Percent Cover** | 99.6    | 82        | 70.4      | 87.48     | 42.84     | 66        | 8.16      | 9.2       | 6.6       | 53.8      | 53.4        | 83.6        |
3.3 Correlation Between Coral coverage and Coral reef fish Abundance

Based on the correlation analysis between coral coverage and abundance of coral reef fishes showed a positive correlation with $r=0.61$ and categorized into not a sufficiently strong correlation. Interaction between coral reef fishes and coral reef as its habitat studied by Choat and Bellwood [20].

Table 3. Correlation Between Coral coverage and Coral reef fishes Abundance

| Location                     | Station | Cover Percentage | Abundance N/125m² |
|------------------------------|---------|------------------|-----------------|
| Windward side of Dua Island  | Station 1 | 87.48            | 162             |
|                              | Station 2 | 42.84            | 131             |
|                              | Station 3 | 66               | 61              |
| Leeward side of Dua Island   | Station 4 | 99.6             | 499             |
|                              | Station 5 | 82               | 390             |
|                              | Station 6 | 70.4             | 415             |
| Berhau                       | Station 7 | 53.8             | 272             |
|                              | Station 8 | 53.4             | 292             |
|                              | Station 9 | 83.6             | 603             |
| Kahabi                       | Station 10 | 8.6              | 8               |
|                              | Station 11 | 9.2              | 8               |
|                              | Station 12 | 6.6              | 11              |

4. Discussion

4.1 Coral Coverage

The highest of coral percent cover in Dua Island in Leeward site might be caused by low wave (0.53 m/s). In contrast, a study observing coral reports that live in strong water flow would grow well [1]. Coral coverage more than 30%, and less rubble and sand are categorized into a health condition [16]. The recent study of coral coverage in this location reported coral coverage ranged at 24.02 – 49.06 % [8]. It might be coral in this location have been recovered after an earthquake. Furthermore, Kahabi has the lowest coverage of coral than others. The low coral coverage could be caused by depth in Kahabi, which was more than 21 m (Table 2). This depth received low sunlight intensity; thus, photosynthesis could not occur. On the other hand, this location closed to the river that leads to sedimentation.

4.2 Coral reef fishes Abundance

The highest abundance of coral reef fishes was found in Berhau. The results of this study are higher than that reported 493 individual/2100 m² [3]. The presence species *Scarus flavipectoralis* and *Dascyllus aruanus* triggered high coral reef fishes abundance in this location. *Scarus flavipectoralis* and *Dascyllus aruanus* live schooling and feeding in a coral reef ecosystem. High coral coverage provides a home for nursery, feeding, and spawning ground for many coral fishes [17, 18]. Kahabi has the lowest abundance in Enggano island. It might the low coral coverage lead to low fish abundance in this location. Coral reef fishes are one fish that live sedentary in the coral reef. The damaged coral reefs will cause declining coral reef fishes abundance [15]. Kahabi also located in an open water area that has a depth of more than 21 m and utilized by the local community as the fishing ground of fish and sea cucumber.
Based on the correlation analysis between coral coverage and coral reef fish abundance, it is known as the characteristic distribution of coral fish. Coral reef fishes prefer to associate with a coral reef that has higher coverage than lower. It was shown that Kahabi had low coral coverage, followed by low coral reef fish abundance (Figure 2). There are three interactions between coral reef fishes and coral reefs. Firstly, the coral reef has a function as a nursery ground, feeding ground, and spawning ground. Secondly, there are interactions and associations of organisms associated with a coral reef. Last, there was an interaction of abiotic factors, including environmental conditions and sedimentation. Similar results have been reported in which high fish abundance found in high coral coverage in west Halmahera, west Maluku Province, Indonesia, in contrast to low fish abundance that was found in low coral coverage [15]. This finding shows that the complexity and coral coverage are interrelated with coral reef fishes abundance. The presence of coral reef fishes depends on coral coverage in some areas [19].

5. Conclusion

Based on the results, Kahabi has the highest prevalence rate compared to other places (7.60%) and the lowest prevalence observed in the windward side of Dua Island (1.22%). This prevalence is classified as not risky for the coral reef ecosystem. Coral coverage in Enggano Island ranged from 6.66% to 99.6%. The highest coverage found in the leeward side of Dua Island (99.6%), and the lowest coverage was in Kahabi (6.6%). The highest coral reef fishes abundance found in Berhau (603 ind/125 m2), and the lowest was in Kahabi (8 ind/125 m2). The correlation analysis showed a positive correlation with r was 0.61, and a determination coefficient of 61%. Multiple linear analysis showed $y = 4.9483x - 35.942$ that indicated there is an increasing the abundance of coral reef fishes for each addition of coral cover.

References

[1] Kusuma A B, Ardli E R and Prabowo R E 2018 The diversity of stony coral and the tendency to bleach based on lifeform in the Tengah patch-reef of Karimunjawa islands Scripta Biologica 5 13–8

[2] Ilyas I S, Astuty S, Harahap S A and Purba N P 2017 Keanekaragaman ikan karang target kaitannya dengan keanekaragaman bentuk pertumbuhan karang pada zona inti di taman wisata perairan kepulauan Anambas Jurnal Perikanan dan Kelautan 8 103–11
[3] Ghiffar M A, Irham A, Harahap S A, Kurniawaty N and Astuty S 2017 Corellation between coral reef condition and reef target fishes abundance in Tinabo Besar island, Taka Bonerate National Park, South Sulawesi Spermonde 2 17–24

[4] Riansyah A, Hartono D and Kusuma A B 2018 Ikan Kepe-kepe (Chaetodontidae) sebagai bioindikator kerusakan perairan ekosistem terumbu karang pullu Tikus Majalah Ilmiah Biologi Biosfera: A Scientific Journal 35 103–10

[5] Yusuf S and Rani C 2006 Environmental characteristic of ornamental corals (Scleractinia) in the Spermonde Islands South Sulawesi Torani Journal of Mar. Sci. 4 241–7

[6] Muniaha H, Nur A I and Rahmadani 2016 The study of coral reef fishes abundance based on coral reef condition in Tanjung Tiram village Kabupaten Konawe Selatan Jurnal Manajemen Sumber Daya Perairan 2 9–19

[7] Giyanto, Manuputty A E W, Abrar M and Siringoringo R M 2014 Monitoring Terumbu Karang. In: Panduan Monitoring Kesehatan Terumbu Karang (Jakarta: COREMAP CTI LIPI) p 8–31

[8] Zamdial, Kusuma A B and Bakhtiar D 2017 Percent cover condition of coral reef at west coastal of Enggano island Proc. International Seminar and Expo on Subsustainable Utilization of Coastal Resources in Tropical Zone (ISECOASTAL) (Bengkulu: University of Bengkulu) p 167–73

[9] Suhaimi A dan D Bakhtiar 2005 Inventarisasi Terumbu Karang di Propinsi Bengkulu (Bengkulu: Dinas Kelautan dan Perikanan Propinsi Bengkulu)

[10] English S, Wilkinson C and Baker V 1997 Survey Manual for Tropical Marine Resources (Townsville: Australian Institute of Marine Science)

[11] Veron J E N 2002 Coral of Australian and Indopacific (Townsville: Australian Institute of Marine Science)

[12] Kuitert R H and Tonozuka T 2001 Pictorial Guide to Indonesia Reef Fishes Part 3 Jawfishes-Sunfishes, Opistognathidae-Molidae (Australia: Seaford, Vic.) p 623–893

[13] Odum E P 1993 Dasar-dasar Ekologi Terjemahan Tjahjono Samingan Edisi Ketiga (Yogyakarta: Gadjah Mada University Press)

[14] Sutono D 2016 Hubungan persentase tutupan karang hidup dan kelimpahan ikan karang di perairan Taman Nasional Laut Wakatobi Jurnal Perikanan dan Kelautan 6 169–76

[15] Rundonuwu A B 2014 Ikan karang di wilayah terumbu karang Kecamatan Maba Kabupaten Halmahera Timur Provinsi Maluku Utara Jurnal Ilmiah Platax 2 1–7

[16] Godfrey S 2001 Factors Affecting Nudibranch Diversity in The Wakatobi Marine National Park Consultant Entomologist Wallace Available at: http://www.opwall.com/.../Invertebrates/Godfrey,%20S%20Factors%20affecting%20nudibranch%20distribution.pdf

[17] Mann R P, Herbert-Read J E, Ma Q, Jordan L A, Sumpter D J T and A J W Ward 2013 A model comparison reveals dynamic social information drives the movements of humbug damselfish (Dascyllus aruanus) J R Soc Interface 11 1–9

[18] Adrim M 2008 Aspek biologi ikan kakatua (Suku Scaridae) Oseana XXXIII 41–50

[19] Hutomo M 1987 Coral reef fishes resources and their relation to reef condition: some case studies in Indonesian waters Proceedings of the Symposium on Coral Reef Management in Southeast Asia eds D Soedharma, Purwanto J, et al (Bogor: SEAMEO-BIOTROP, Southeast Asian Regional Center for Tropical Biology) pp 67–78

[20] Choat J H and Bellwood D R 1991 Reef Fishes: Their History and Evolution Ecology of Fishes on Coral Reefs (San Diego: Academic press)