Relationship between coral reef ecosystem and coral fish communities in Unggeh Island Central Tapanuli Regency

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Abstract. Coral reef ecosystems in Unggeh Island waters have recently declined in quality due to natural factors and human activities. The declining quality can affect the biota of the coral reef ecosystem, such as coral reef fish. Coral reef fish belong to the groups of fish whose lives are associated with the coral reef ecosystem environment. This study aims to determine the abundance and diversity of coral reef fish and the relationship between abundance of coral reef fish and the percentage of coral cover in Unggeh Island Waters, Badiri District, Central Tapanuli Regency, North Sumatra. This research was conducted in December 2017 and April 2018. The method used to observe the coral was Underwater Photo Transect (UPT) method. And the method used to observe the coral reef fish was Underwater Visual Census (UVC) method. To determine the relationship between coral cover and coral reef fish was by using a simple linear regression equation. The results showed that the relationship of coral cover with coral reef fish was in the correlation value (R) of 0.418.

1. Introduction
Coral reef is shallow water ecosystem that consist of reefs made of calcium carbonate. They play multiple important roles for both human livelihood and food security throughout the tropics, housing high levels of biological diversity as well as providing key ecosystem goods and services such as habitat for fisheries and coastal protection [1].

Reef fishes are those individual fishes that live on coral reefs. A little coral loss will lead to a decline in the abundance of reef fishes. Some effects of coral loss on fishes will become evident over a relatively short time frame (weeks/months), such as reduced physiological condition and reproductive activity [2].

Variability in habitat characteristics is one of the most studied factors influencing the structure of reef fish communities. The structural complexity of the habitat, depth and wave energy affect for fish abundance and diversity in different spatial and temporal scales [3]. Significant declines in the abundance and diversity of major habitat-forming species have been recorded in coral reefs [4]. Coral loss and degradation of coral reef habitats have a significant influence on the abundance and diversity of coral reef fishes [5].

Unggeh Island is in the administrative area of Sitardas Village, Badiri District, Central Tapanuli Regency which is on the west coastline of Sumatra Island, and have a coordinate of 01°34'23" - 01°34'37" N and 98°45'26" - 98°45'42" E. Exposure to the southern, western and northern seabed of Unggeh Island was overgrown with coral reef ecosystem. This study aims to determine the abundance and diversity of coral reef fish and the relationship between abundance of coral reef fish and the percentage of coral cover in Unggeh Island.
2. Materials and methods

The study was conducted in December 2017. Data collection located in Unggeh Island, Sitardas Village, Pandan District, Central Tapanuli Regency (Figure 1). The method used in determining the sampling location was purposive random sampling at four observation stations.

![Research location](Figure 1)  

2.1. Procedures

Referring to [6] about the guidelines for monitoring coral reef health, this study used the Underwater Photo Transect (UPT) method. The assigned divers drew the transect line using a roll meter (scale band) along of 70 m at a depth of 5 m and parallel to the coastline. The picture taking was conducted at every 1 m range. Then, data collection was begun by performing underwater photo taking, where the angle produced upright photographs of the base of the substrate. The minimum area of photo taking was 2552 cm$^2$ or (58 cm x 44 cm).

To collect the data of coral reef fish, the method used was Underwater fish Visual Census (UVC) [6]. The transect length at the observation station was 50 x 5 m. Fish data were identified referring to a manual with pictures [7-8]. Habitat conditions were measured of the physical-chemical parameters of the waters and measured directly in the field. The parameters were the temperature, current velocity, depth, dissolved oxygen, pH and the type of substrate.

2.2. Data analysis

The data of coral cover were processed using CPCe software (Coral Point Count with Excel extension) using 30 random points for each frame. Coral mortality index was known after obtaining the data of live coral cover and dead coral cover. The diversity of nekton communities in a certain watershed was known through several attributes such as Shannon-Wiener diversity index (H), evenness (E) and dominance (D). Nekton diversity was calculated using the diversity index of Shannon and Wiener with the formula [9]:

$$H' = -\sum (p_i \ln p_i)$$  \hspace{1cm} (1)

Where: $H'$ = Shanon-Wiener diversity index; $n_i$ = Number of individuals from each species; $N$ = Number of all individuals; $P_i$ = Important probability for each species $s = \frac{n_i}{N}$

Uniformity index was used to describe how much balance in an ecosystem. Uniformity of individuals caught between species (equitability) was calculated by following the equation [9]:

$$E = \frac{H'}{H_{\text{max}}}$$  \hspace{1cm} (2)

Where: $E$ = Evenness uniformity index; $H$ = Species balance; $H_{\text{max}}$ = Maximum diversity index (lnS);
Dominance index was used to obtain information about the type of fish which dominated a community in each habitat. Dominance index describes species composition in the community. Dominance index was calculated according to the Simpson index [10]:

\[ c = \sum_{i=1}^{S} \left( \frac{n_i}{N} \right)^2 \]  

Where: \( C \) = Dominance index; \( n_i \) = Number of individuals from each species; \( N \) = Total individual community

Statistical analysis (correlation, regression, and determination) was carried out using SPSS tools with the variable of live coral cover and abundance of coral reef fish in each station.

3. Results and discussion

3.1. Percentage of coral reef cover

The components of coral reef that was found in Unggeh Island Waters in Badiri District, Central Tapanuli Regency, North Sumatra were: acropora branching, coral branching, coral encrusting, coral mushrooms, soft coral, coral submassive, coral massive, macro algae, halimeda, coral foliose, dead coral with algae, dead algae, sand, silt, rubble, turf algae, and others. The percentage of the types of coral from each lifeform obtained from the four stations can be seen in Table 1.

| Type          | Lifeform     | Station I | Station II | Station III | Station IV |
|---------------|--------------|-----------|------------|-------------|------------|
| Live Corals   | Acropora     | 0.33      | 0.4        | 0           | 0          |
|               | ACD          | 0         | 0          | 0           | 0          |
|               | ACE          | 0         | 0          | 0           | 0          |
|               | ACS          | 0         | 0          | 0           | 0          |
|               | ACT          | 0         | 0          | 0           | 0          |
| Non-Acropora  | CB           | 0.67      | 1.8        | 0.03        | 0          |
|               | CS           | 0.47      | 0          | 0.73        | 1.07       |
|               | CM           | 20.93     | 9.73       | 16.13       | 16.07      |
|               | CE           | 1.93      | 0.13       | 7.2         | 6.93       |
|               | CF           | 0.87      | 0          | 4.27        | 0.93       |
|               | CMR          | 0         | 0.07       | 0           | 0.33       |
|               | CME          | 0         | 0          | 0           | 0          |
|               | CHL          | 0         | 0          | 0           | 0          |
| Total         |              | 25.2      | 12.13      | 28.47       | 25.33      |
| Dead Coral    | DC           | 9.87      | 0.53       | 9.33        | 19.67      |
|               | DCA          | 38.8      | 20.47      | 52.33       | 43.00      |
|               |              | 48.67     | 21         | 61.66       | 62.67      |
| Other fauna   | SC           | 0.2       | 0.2        | 0.07        | 0.20       |
|               | SP           | 0         | 0          | 0           | 0          |
|               | ZO           | 0         | 0          | 0           | 0          |
|               | OT           | 0.07      | 0.27       | 0           | 0          |
|               |              | 0.27      | 0.47       | 0.07        | 0.20       |
| Algae         | AA           | 0         | 0          | 0           | 0          |
Ty
type

Lifeform

Percentage of coral cover (%)

| Type | Station I | Station II | Station III | Station IV |
|------|-----------|------------|-------------|------------|
| CA   | 0         | 0          | 0           | 0          |
| MA   | 0         | 3.33       | 1.07        | 0.33       |
| TA   | 0         | 0.07       | 0           | 0          |
|      | 0         | 3.4        | 1.07        | 0.33       |
| Abiotic | S  | 13.37     | 1           | 1.67       | 3.33       |
|       | R       | 7.6        | 8.87        | 1.33       | 5.80       |
|       | SI      | 2.87       | 52.6        | 0          | 0          |
|       | RK      | 1          | 0           | 1.27       | 0          |

24.84  62.47  4.27  9.13

The percentage of coral reef cover shows the value of condition of live coral reefs in a certain water, coral reefs categorized as living coral reefs are acropora, non acropora and soft coral. At the station I, the percentage of coral cover was 25.4% classified as medium category, at the station II, the percentage of coral cover was 12.33% classified as damaged, at the station III, the percentage of coral cover was 28.54% classified as medium category, and at the station IV, percentage coral cover was 25.53% classified as medium category. The condition of coral reef cover in Unggeh Island was generally classified as damaged with the average percentage of coral cover as much as 22.09 %.

3.2. Restraint factors for coral growth
As an important component, physical-chemical factors play an important role in supporting coral life. In conclusion, the physical-chemical conditions in Unggeh Island waters were still feasible to support the coral reef life. But coral life does not only require the environment supports, but also other variables such as local fishermen activities, for instance the using of fishing gear that is not environmentally friendly, tourism activities, and law enforcement.

Table 2. Measurement results of restraint factors for coral growth in Unggeh Island.

| Parameter Station | Temperature (°C) | DO (mg/L) | Depth (m) | Salinity (ppt) | pH | Current Velocity (m/s) | Clarity (%) | Substrat | NO3 (mg/l) | PO4 (mg/l) |
|-------------------|------------------|-----------|-----------|----------------|----|------------------------|-------------|----------|------------|------------|
| I                 | 31               | 4.7       | 4         | 33             | 7.91 0.075 | 100 | Sand                 | 0.95       | 0.03     |
| II                | 31               | 4.6       | 3         | 34             | 7.91 0.05  | 100 | Sand                 | 0.62       | < 0.001  |
| III               | 30               | 4         | 6         | 34             | 7.94 0.083 | 100 | Sand                 | 0.02       | < 0.001  |
| IV                | 31               | 4.8       | 5         | 34             | 7.99 0.1  | 100 | Sand                 | 0.11       | < 0.004  |

3.3. Coral reef fish composition
The results of observation and identification of coral reef fish in December 2017, for all observation stations, showed 36 species of coral reef fish consisting of 10 families and 423 individuals of fish. The fish families found at the observation sites were pomacentridae, serranidae, chaetodontidae, lutjanidae, lethrinidae, siganidae, labridae, apogonidae, zanclidae, and acanthuridae, as can be seen completely in the Table 3.
Table 3. The types of coral reef fish in Unggeh Island during the sampling in December 2017.

| Species Name | Group | Station |
|--------------|-------|---------|
| **Pomacentridae** | | | I | II | III | VI |
| Pomacentrus moluccensis | Major | 14 | 16 | 11 | 3 |
| Dischistodus sp | Major | 3 | | | | |
| Pomacentrus nigromarginatus | Major | 1 | | | | |
| Abudelfuf sexfasciatus | Major | 4 | | 3 | | |
| Amphirion sebae | Major | 9 | 2 | | | |
| Pomacentrus sp | Major | 52 | | | | |
| Chaetodonoplus mesoleucus | Major | 6 | 5 | 3 | | |
| Pomacentrus alleni | Major | 8 | | | | |
| Neopomacentrus aczysron | Major | 30 | 37 | 20 | 24 | |
| Amphiriona kallopisos | Major | 3 | | | | |
| Pomacentrus albicaudatus | Major | | | 1 | | |
| Pomacentrus geminospilos | Major | | 1 | | | |
| Pomacentrus amillatus | Major | | 1 | | | |
| **Serranidae** | | | | | | |
| Ephinephelus flavocaeruleus | Target | 22 | | | | |
| Cephalopholis argus | Target | 1 | | | | |
| Amphirion sebae | Target | 10 | | | | |
| Pseudanthias evansi | Target | 16 | | | | |
| Cephalopholis argus | Target | 3 | | | | |
| **Lutjanidae** | | | | | | |
| Lutjanus bahar | Target | 2 | | | | |
| Lutjanus carponotatus | Target | 2 | | | | |
| Lutjanus sp | Target | 25 | | | | |
| Lutjanus bigutatus | Target | 13 | 1 | | | |
| Lutjanus decussatus | Target | 2 | | | | |
| Paracaesio xanthurus | Target | 15 | 1 | | | |
| **Lethrinidae** | | | | | | |
| Lethrinus lentian | Target | 3 | | | | |
| Lethrinus sornatus | Target | | 1 | | | |
| Lethrinus sp | Target | 3 | | | | |
| **Siganidae** | | | | | | |
| Siganus magnificus | Target | 9 | | | | |
| Siganus tetrazona | Target | 2 | | | | |
| **Labridae** | | | | | | |
| Cheilinus fasciatus | Major | 7 | | | | |
| Halichoeres chrysothaenia | Major | 2 | | | | |
| Halichoeres bicolor | Major | 3 | | | | |
| **Apogonidae** | | | | | | |
| Cheilodipterus quinquelinicatus | Major | 9 | | | | |
| **Chaetodontidae** | | | | | | |
| Chaetodon trifasciatus | Indicator | 3 | | | 1 | |
| **Zanclidae** | | | | | | |
| Zanclus cornutus | Indicator | | | | 1 | |
Spec
Name
Group
Station
I
II
III
VI

Acanthuridae

Chromis opercularis

Target

3
4
2
1

Total

135
80
170
38

Table 4. Number of fish (ind), number of species, number of families, diversity index (H’), uniformity Index (E) and dominance Index (C).

### 3.4. Structure of coral reef fish community

Diversity index of sampling in ranged from 1.50 to 2.41 which is categorized as the medium diversity category. According to [10], the Shannon-Wiener index smaller than 1, the community is declared unstable. This is consistent with what was conveyed by [9] that high diversity values indicate a comfortable and stable environment while low diversity values indicate a stifling and unstable environment.

[10] states that the greater the value of uniformity index shows the higher species diversity. Unggeh Island waters have moderate species diversity but high uniformity (E) values. This can be seen from Table 4, which range between 0.63-0.85 and 0.79-0.89 respectively. In the research conducted in December 2017, it can be seen that the value of dominance index of each research ranged from 0.12 to 0.42. [10] states that the dominance index value below 0.5 indicates a low dominance. Therefore, it can be concluded that there was no coral reef fish dominated in the waters of Unggeh Island, especially in the research locations.

### 3.5. Relationship between the live coral reef and coral reef fish

During the observation of coral reef fishes, it could be seen that the pomacentridae, and acanthuridae families were found at all stations. Whereas, serranidae, lutjanidae, lethrinidae, siganidae, labridae, apogonidae, chaetodontidae and zanclidae families were found only at several stations. The highest fish abundance was found at the station III with a value of 170 ind/250m$^2$ and with a percentage of coral cover 28.54%. The lowest fish abundance was in station IV with a value of 38 ind/250m$^2$ and with a percentage of coral cover 25.35%. The pattern of fluctuation of targeted coral reef fish abundance is not always in line with the pattern of the coral cover percentage fluctuation [2]. This is supported by [3] that the instability of the abundance of each family is likely to occur due to anthropogenic and natural disturbances toward the presence of fish in the observation locations. This was proven by the declining of the coral cover at station 4 also had a big impact on the declining of the abundance pattern of coral reef fish, even though the pattern of declining is very different. The unequal graphical pattern between the abundance of coral reef fish and the live coral cover percentage is due to the presence of other factors which influenced the presence of coral reef fish.

The relationship of the coral cover percentage with coral fish abundance observed, it could be seen from the results of calculations using the simple linear regression formula obtained by the equation: $y = 3.3775x + 28.245$, with a determinant value (R2) 0.1745 which shows the correlation between live coral cover percentage and the abundance of coral reef fish associated with the positive coral reef ecosystems (0.1745) and the average percentage of live coral cover is in the medium category (<50%).
The influence of the coral cover percentage on coral fish abundance of 17.45%, and the remaining of 82.55% is influenced by other factors that influence the abundance of coral reef fish.

From the results of data analysis, the abundance of coral reef fish has a low correlation values with the percentage of coral cover. Unless it is associated with indicator fish such as the chaetodontidae family, the correlation value is high. Because this type of family is found in the good condition coral reefs, locations with high algae closure, as well as areas that have a lot of crustaceans which are food for fish of this family. This is in accordance with [11] who state that although it can be proven that there is a correlation between live coral cover and abundance of coral reef fish, but these fish are not able to be used as bio indicators because of their lack of relationship. In addition, the coral reef fish do not all prey on corals (corallivore) directly. So, it is less sensitive to the changes of a coral reef system.

4. Conclusions
Percentage of coral reef cover in Unggeh island was 12.33 – 28.54% and there were 36 species of coral reef fish consisting of 10 families and 423 individuals of fish. The relationship between the coral reef cover and the abundance and composition of coral reef fish organisms in coral reef ecosystems in the Unggeh island, with the correlation value (R) of 0.418. The abundance of coral reef fish cannot be used as bioindicators, which means that the relationship is low.

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