A coral reef health study and its problem in Leti, Moa and Wetar Island, Mollucas Province

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***D D Pelasula[1], R Alik[1], F Ruli[1], F D Hukom[2], La Pay[1] and J Hehuat[1]**

[1]Deep sea Research Center – Indonesia Institute of Science, Ambon
[2]Oceanography Research Center - Indonesian Institute of Science, Jakarta

*Email: *pelasuladaniel@gmail.com*

Abstract A study on coral reefs status was conducted on the island of Wetar, Leti, and Moa of Southwest Maluku District. Nine stations were assigned as sampling stations to analyze the coral reefs' condition of these three islands. The Underwater Photo Transect method was applied to analyze the percentage of biotic and abiotic components of coral reef communities with Coral Point Count Excel (CPCe) software, whilst the underwater visual census for reef fish data. Coral reef health indices were determined based on benthic lifeform components and reef fish biomass. Our findings showed that the coral cover in Wetar, Moa, and Letti island consists of 124 species that belong to 44 genera and 15 families of hard coral. The condition of coral reefs was considered at category 3 due to the high percentage of coral cover that range between 20.85 – 71.55 % with an average of 42.87 %. The average biomass of target fish in the waters of Wetar, Letti, Moa, and its surrounding areas was 129.309 g/m2 or 3,694 kg/ha. The Kaiwatu site (BWI03) was recorded to have the highest biomass of 305,487 g/m2 or 8,728 kg/ha and the lowest was the Klis site ((BWI 08) with a value of 1285 g/m2 or 36,70 kg/ha. The coral reef health index values of nine study sites ranged between grade 5 and 10, of which two locations got a score of 10 (very good) categories, five locations got a good category and two locations got a low score. The overall results indicate that the coral reef is in a healthy condition, yet, the use of non-environmental friendly fishing gears partly damages coral reef beds.

1. Introduction

Coral Reef ecosystem is one of coastal ecosystems that plays an important functions as sources of natural variety of marine biota habitats, temporary or fixed settling, feeding areas, spawning and nursery grounds as well as shading for other marine biota. This ecosystem also acts as the harbor for biological processes, chemical and physical cycles, which globally attain high productivities. Coral reefs are a barrier for coastal area against the wave and serves as a main source for construction materials. Coral Reefs provide suitable grounds for supporting coastal fishery activities such as marine biota culture areas and tourist activities including snorkelling, diving as well as natural laboratory for educational purposes and protection area for rare marine biota [1]. In Indonesia, the Coral reef ecosystem contains high marine biodiversity, of which more than 480 corals are identified at Eastern Indonesia regions and are 60 % of descripted coral stones in the world [2]. On the other hand, coral reefs are very vulnerable to human activities and natural factors that cause coral reef degradations due to drivers such as over exploitation, impact of anthropogenic, pollution sediment on higher layer and global climate change. Anthropogenic activity is known as the main factor that causes fast destructions of this

ecosystem due to activities such as using explosive bomb for fishing at coral reef, clearing for coastal tourism and land clearing for construction which directly flow the sediment by river to the sea [3].

The paradigm of development orientation that based on economy growth needs to to bee agree with the sustainable development. Sustainable development defined by World Commission on Environment and Development is the development to meet current generation needs without destroying nor lowering the ability of the next generation to meet their need. [4]. Sustainable development concept is a consent by most of nations in the world since The Earth Summit Conference in Rio de Janeiro 1992. Ecologically there are four requirements to ensure the achievement of sustainable development on coastal and marine resources : (1) spatial harmony, (2) natural resources are used optimally (3) the waste area shall in line to assimilative capacity, and (4) design and build pre-facility and facility in line with character and ecosystem dynamic of coastal and sea [5]. When we work on coastal area and there is discard of unneeded material, there should be a warranty that the total amount and the disposal should not exceed assimilative capacity. Destruction at coral reef in Indonesia are caused by various factors such as sedimentation, water contamination, coral pouching, unfriendly environmental fishing gears (explosives, poison cyanide), storm and strong wave , increase of coral predators (*Acanthaster planci*), coral whitening because of surge temperature by global warming [6, 7, 8, 9].

Research on healthy condition of coral reef at Wetar Basin and Palung Timor is an interesting topic to be examined due to its strategic positions, as these area located at the border of Timor Leste and Australia. In addition, the present study conveys new insights of intended coral reefs and important coral reef fish biodiversity. The purpose of the present study is to investigate coral reef condition at the island of Wetar, Leti Moa and the results will have a benefit to the local government in devising course and development strategies at Maluku Barat Daya Regency.

2. Materials and Method

2.1. Study site description

The research on existence of coral reefs was done at Wetar basin covering islands of Wetar, Leti, and Moa (Figure 1). The survey was conducted on September 2019 at nine locations as a sampling stations that consists of two stations at Wetar Island , 6 stations at Moa Island, and 1 station at Leti island. Table 1 listed the station name, code, and its coordinate position.

Table 1. The Observation Stations

Location Code	Location	Coordinate	
		Latitude	Longitude
BWTC 01	Uhak	7 41' 40,90"	126 30’ 68.96"
BWTC02	Lurang	7 55' 32,83"	126 30’ 68.98"
BWLC03	Laitutuan	08 10' 24.09"	127 44’ 42.72"
BWLC04	Batumiau,	08 09’ 48.47"	127 43’ 14.87"
BWMC05	Kaiwatu	08 09’ 03.40"	127 47’ 05.49"
BWMC06	Tiakur pasar ikan	08 07’ 44.27”	127 06’ 28.95"
BWMC07	Patti	08 12’ 36.97”	127 51’ 08.30"
BWMC08	Klis	08 13’ 03.33”	127 54’ 43.97"
BWMC09	Toinawan Tiakur	08 07’ 46.22”	127 46’ 36.02"

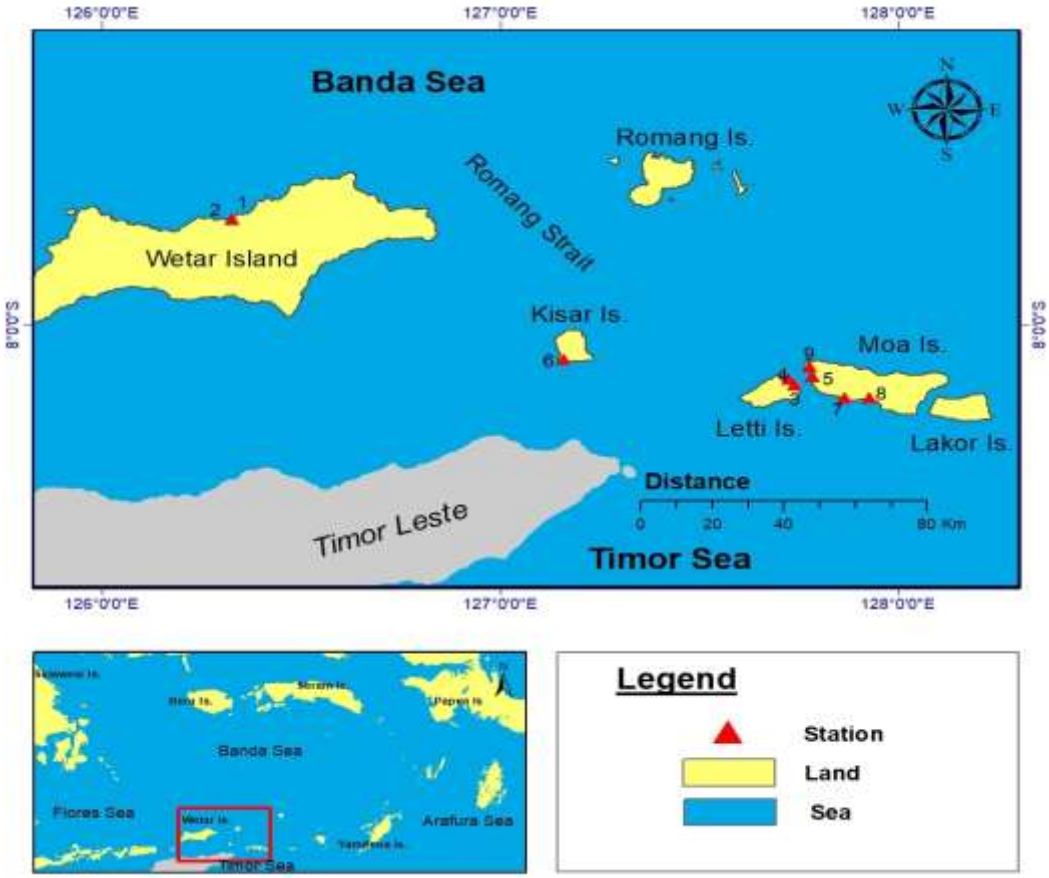

Figure 1. The Map of observed stations in the Southwest Maluku Waters

2.2. Methodology

The method used to attain health index values of coral reefs followed the method according to [10]. Two methods were applied here namely for the benthic component and coral reef fish component. The benthic component was calculated based on the variable of live coral coverage, and the resilience factor was calculated based on fleshy seaweed coverage and rubles coral coverages. Coral reef fish variable in this study is the total biomass of economically important fish (target fish), including tribes from 7 families viz. Scaridae, Siganidae, Acanthuridae, Serranidae, Lutjanidae, Lehtrinidae, Haemulidae, and fishes that susceptible to extinction. Transect 70 m was placed parallel the steep or coastal line with safety area of 2.5m at left and right transect line. Areas of observations for each transect is 7 x (2 x 2.5 m) = 350 m² (Figure 2).

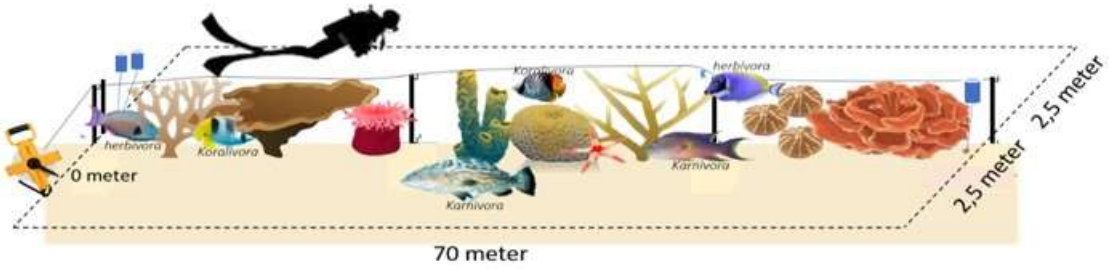

Figure 2. Illustration of lines transect and large area surveys [11])

2.3. Coral data collection

The sampling technique and the analysis of benthic component and coral fishes are described as follows: the Underwater Photo Transect Method (UPT) was used in this research is a data collection technic to analyze the coral reef condition [11, 12]. On the principal, UPT is a transect method of an underwater photo using Scuba diving and underwater camera using frames with the size of 58 x 44 cm, marked with a scotch light color like red, and yellow, placed on a 10 m transect line. Stretching transect lines were determined on a flat area and steep reef along coastal area at the depth of 3 – 7 m. After measuring, photos were taken along the transect line from the 1meter to the 50 m. Placing frame and photo at the 1st meter (first frame), 3rd meter (third frame), and the next frame with an odd number was conducted consecutively at the right side of transect lines, for a frame with even and so on. Photos were taken at a distance of 60 cm from the substrate.

2.4. Data analyzis

Live percentage coverage of coral reef form was assessed by using the Coral Point Count Excel (CPCe) [13]. Pictures on coral reef habitat were obtained from field transects, then analyzed to get percentage of coral reef coverage per photo. Analysis technique on coral reef coverage was done by distributing 10 random points on each picture and categorized according to the data base, which available in the CPCe Program (Figure 3). This process produced the coral coverage percentage that transferred into microsoft excel form. Meanwhile, the coral reef health determination was done based on criteria provided by [14] shown in Table 2.

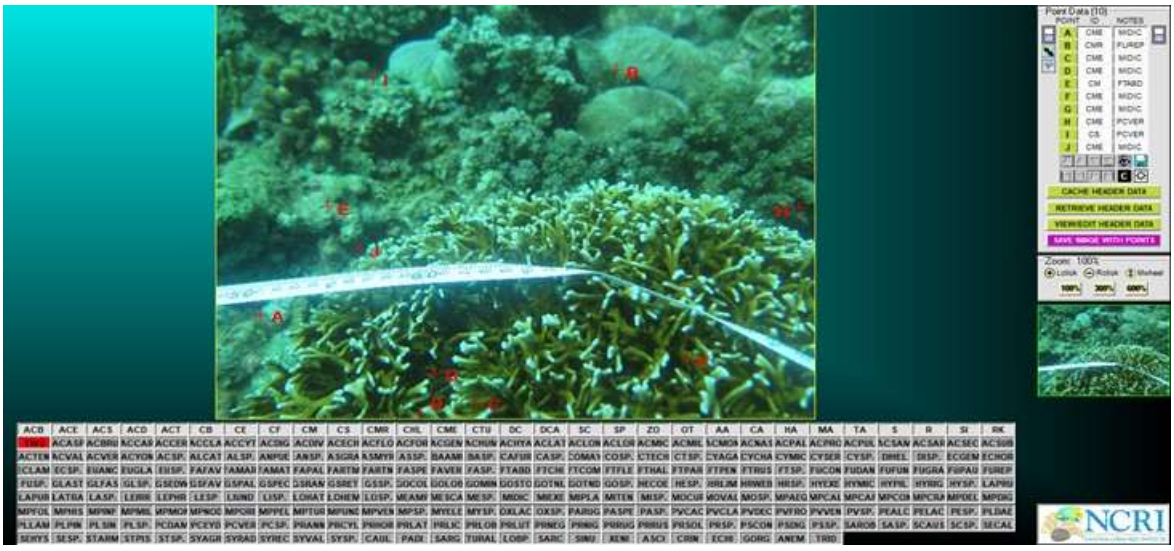

Figure 3. Analysis process of percent coral reef coverage

Table 2. Classification of coral reef conditions based on the percent cover of live coral.

Percent Cover live coral (%)	Assessment criteria
75 – 100	Very good
50 – 74,9	Good
25 – 49,9	Fair
0 – 24,9	Bad

2.5. Fish Stock per census (biomass)

Observation on coral fish using Underwater Visual Census method (UVC) at the island of Wetar, Leti, Moa of Southwest was done at 9 sampling stations. The amount and length of coral fish were obtained by Visual Census method, developed by Asean Australia Project [15]. Length of each fish species is converted into biomass using formula of length to weight relatinship $W = aL^b$. The value

of coefficient *a* and *b* could be found at fish-base (http://fishbase.sinica.edu.tw/search.php) or from available literatures. Fish stock biomass unit (B) is calculated on individual weight (W) base of target fish size of observation area.

$$B = \frac{W(\text{Total weight of each species})}{350\text{m}^2}$$

2.6. Coral reef health index

The health index values of coral reef were determined following the index developed by [9]. The indices were the combination of benthic component area and coral fish component, which consists of 18 combination of values range 1 to 10. Value 10 indicates the healthy coral, whereas value 1 indicates the worst index (Table 4).

Table 3. The Index value of coral reef health

No	Benthic Component		Fish Component	Coral Reef Health Index Value
	% Live Coral Coverage	Recovery Potential	Coral Reef Fish Category	
1	High	High	High	10
2	Moderate	High	High	9
3	High	High	Moderate	8
4	High	Low	High	8
5	Moderate	High	Moderate	7
6	Low	High	High	7
7	High	High	Low	6
8	High	Low	Moderate	6
9	Moderate	Low	High	6
10	Moderate	High	Low	5
11	Low	High	Moderate	5
12	Low	Low	High	5
13	High	Low	Low	4
14	Moderate	Low	Moderate	4
15	Low	High	Low	3
16	Low	Low	Moderate	3
17	Moderate	Low	Low	2
18	Low	Low	Low	1

Variables that were used in the calculation of coral reef healthy index consists of two component namely benthic component and coral reef fishes. Component of coral reef fish were determined as the variable of the total biomass of economic fishes. Each criteria of coral reef quality, resilience, and fish biomass is displayed at Table 4 to Table 6 respectively.

Table 4. The quality criteria of live coral percent coverage

No	Category	Criteria
1	Low	Coverage on live coral < 19%
2	Middle	19 % ≤ coverage on live coral≤ 35 %
3	High	Coverage live coral > 35 %

Table 5. The category of resilience level or recovery potential

No	Category	Criteria
1	Low	(coverage of fleshy seaweed > 3 %) or coverage of ruble coral > 60 % and coverage live coral ≤ 5 %)
2	High	(Coverage of fleshy seaweed < 3 %) or (coverage by ruble coral ≤ 60 % and coverage by live coral>5 %)

Table 6. Quality variabel categories of coral fish total biomass

No	Category	Criteria
1	Low	Total biomass coral fish < 970 kg/ha
2	Middle	970 kg/ha < total biomass coral fish ≤ 940 kg/ha
3	High	Total biomass coral fish> 1940 kg/ha

3. Result and Discussion

3.1. Condition of Coral reefs

Wetar Island, Leti Island, and Moa Island are islands located in the midle of Banda Sea at the Wetar basin and Timor Trench. Oceanographic conditions in these areas is influenced by Banda sea, thus directly affects coral reef ecosystem. Oceanographic factors such as water mass circulation, salinity, temperature, and current pattern in the Banda Sea indeed influence the coral reef growth. The photos transect obtained shows the percentage of coral coverage, variety, and composition of coral species from 9 sampling station. Data obtained for the taxa of live coral were 124 coral species. Distribution of the number of live corals among research stations range between 11 and 15 ordo. The number of family identified among research stations showed a complete different number, which ranged between 26 to 44 family number. The number of species were significantly high, ranged between 60 to 124 species. Distribution of taxa of live corals could be seen at Figure 4. This figure shows that the existence of the number of live coral species among research stations were varies both in the number of species and family.

The highest number of coral reef was found at Keiwatu water of Moa Island with total number coral species amounted to 124 (Figure 4). On the other hand, the lowest number of species (distribution) of live coral was at Pati Village water that amounted to 60 species. The number of genera existence among research stations shows that highest number was found at Kaiwatu Village (with amount of 44, and the lowest one was found at Killis Village (with the number of 26. The Coral family number found varies between sites where the highest number was found at Kaiwatu Village (with 15 families (ordo) and the lowest one was at Patti village with total number of 11. The complete result of coral reef species number, the family, and ordo can be seen at Figure 4

Table 7 displays the percentage of benthic components found to distribute at nine sampling stations at the study site. This table shows that all the benthic component coverage varies between the component and between the sampling station. From 11 benthic components that compose the coral at the study site, hard coral was found to have the highest average percentage (42.87%). From the nine sampling stations, station 1 (Uhak Village) has the highest hard coral coverage (71.55%) and the lowest one was found at Station 8 (Klis Village) with a coverage of 20.85%. From all the 11 benthic components, the last three-component (silt, rock, and tape, wand, and shadows) have the lowest percentage.

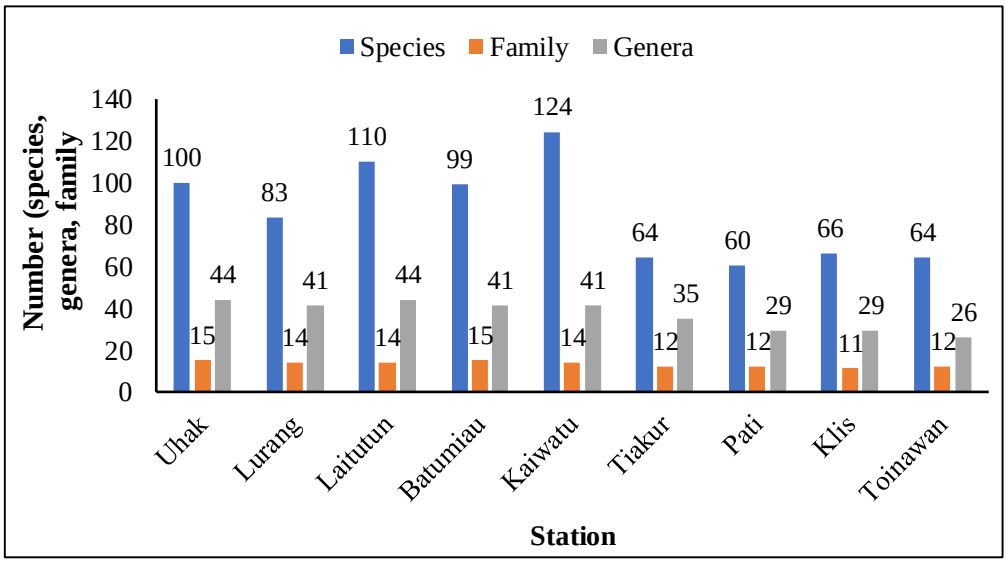

Figure 4. Species composition, genera, and family of coral reef found at 9 sampling stations

Table 7. Percentage cover of benthic component found at 9 sampling stations

Benthic component	Location									Mean
	Uhak	Lurang	Laitutun	Batu miau	Kaiwatu	Tiakur 01	Patti	Kliss	Tiakur 02	
Coral (hc)	71.55	65.60	37.87	37.87	38.33	43.93	44.5	20.85	25.29	42.87
Recent dead coral (dc)	0.00	3.02	0.20	0.20	0.07	0.07	2.00	0.34	1.96	0.87
Dead coral with algae (dca)	5.69	9.26	17.80	17.80	23.33	46.07	18.33	64.75	31.57	26.07
Soft coral (sc)	5.00	4.91	19.60	19.60	27.93	0.93	1.00	0.00	22.94	11.32
Sponge (sp)	1.55	0.19	0.07	0.07	0.00	0.13	0.17	0.17	0.00	0.26
Fleshy seaweed (fs)	0.34	0.00	0.33	0.33	0.07	0.00	0.83	0.17	0.00	0.23
Other biota (ot)	8.28	7.94	1.00	1.00	8.60	0.40	1.17	0.68	6.47	3.95
Rubble (r)	0.85	0.00	0.60	0.60	0.67	6.13	30.83	5.76	8.43	5.99
Sand (s)	0.72	5.86	22.53	22.53	1.00	2.27	1.17	7.29	2.35	7.30
Silt (si)	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01
Rock (rk)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.11
Tape, wand, shadow (tws)	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

Using criteria in Table 4, all the hard coral in this study site is in good to very good condition (live coral coverage > 35%). Only Station 8 (Klis) and Station 9 (Toinawan) have live coverage of ≥ 19% and ≤ 35%. From the resilience category level (Table 5), all the 9 stations have high resilience since their fleshy seaweed coverage < 3%, rubble < 60%, and hard coral coverage > 5%. During the research, it was also found a sign of some coral destruction and was most likely arise from unfriendly fishing activity (Figure 5).

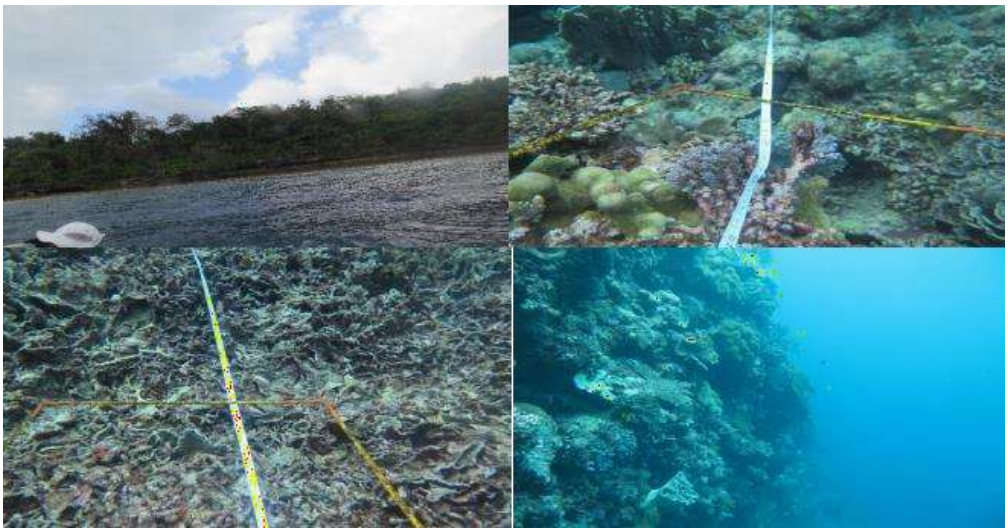

Figure 5. Rubble on the reef flat, shows the effects of fishing activities

3.2. Coral fish species richness

Table 8 shows number of coral reef fish, species, and family found to distribute at the study site during the research. This table reveals that there are differences in number of fish, species, and family of coral reef fish among study site. Among all sampling stations, Station 5 of Kaiwatu (Moa Island) has the highest number of species (138), and the lowest one was found in Batumiau of Leti Island (15 species). The coral fish family varies between study site with the least number of 11 families and the highest number of 21 families.

Table 8. Number of individu, species and family of coral reef fish found at study site

No	Station	Individual	Species	Family
1	Uhak Wetar Island)	492	33	11
2	Lurang (Wetar Island)	413	33	11
3	Laitutun (Leti Island)	704	110	15
4	Batumiau (Leti Island	2,013	15	9
5	Kaiwatu (Moa Island)	2,213	138	19
6	Tiakur (Moa Island)	1,280	103	19
7	Pati (Moa Island)	1,225	107	19
8	Klis (Moa Island)	557	133	11
9	Toinawan (Moa Island)	585	143	21

From under waterl census that coral reef fishes with the Family of Labtidae has the highest species number (53 species) followed by order with Family Pomacentridae (44 species), Family Acanthuridae (28 species), Family Chaetodontidae (25 species), Family Serranidae and Holocentridae (8 species each), Family Balistidae and Caesionidae (5 species). Coral fishes were found to distribute at all observation sites. Coral fish family with the highest numbur belonges to the family of Caesionade (*Pterocaesio tile*, *Caesio lunaris*, *C. pisang*, *C. teres*) with the number of 1,275 individual, and this was found at at Batumiau village (Leti Island)) and Tiakur (Moa Island). The top ten coral fishes found with high abundant number could be seen at Figure 6. Interestingly, coral

fishes from the family of Pomcentridae (*Chromis ternatensis*) and Balistidae (*Melichthys niger*) was found abundantly at Toinawan vilage (Moa Island), Kaiwatu village MoaIsland),and Laitutuan village (Leti Island)

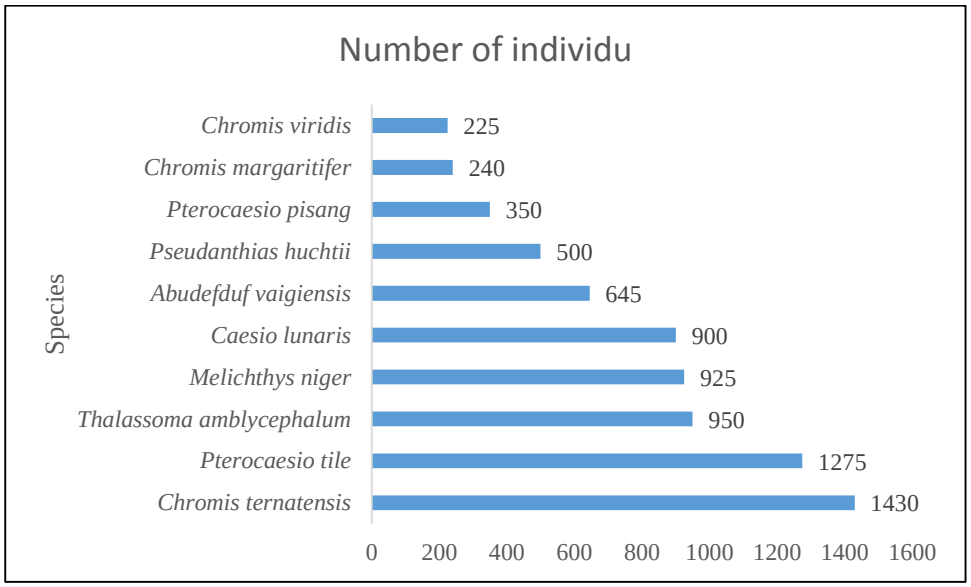

Figure 6. Ten coral reef fishes found with high abundant number at study site

Ten of each species group according to fish category for coral fish monitoring [16] was displayed at Figure 7. -This figure shows that the highest number of fish was found at major species category with the number of 127 individuals (48.66%). The major species is the fish that mainnly used as decorative fishes. The fish target is group of fish that consumed mostly by the community that belongs to the family of Acanthuridae, Scaridae and Serranidae.

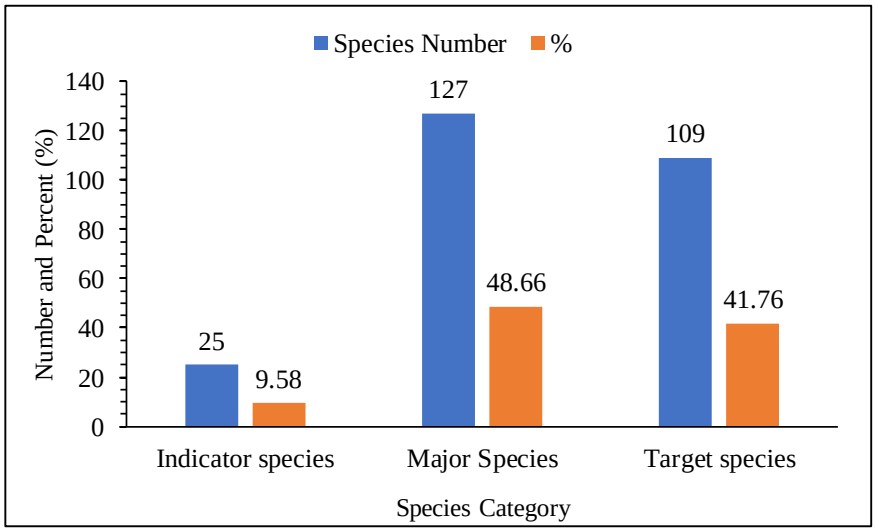

Figure 7. Distribution of indicator, major, and target species found in study site

3.3. Coral fish Biomass

The average biomass of target fish of study site was 129,309.95 gr/m^2 or 3,694.57 kg/Ha. The Laitutun Village of Leti Island has the highest biomass (305,487 gram/350 m^2 or 8,728.20 kg/ha) and the lowest was found at Klis Village of Moa Island (1,285 gram/350m^2 or 36.70 kg/Ha). Based on the result

obtained, there is a difference of biomass between the sampling station. Tabel 9 summarized the complete result coral reef fishes biomass at study site.

Table 9. The number of species and biomass of coral reef fish found at study site

Biomass/Number of species	Sampling Station								
	Uhak	Lurang	Laitutun	Batumiau	Kaiwatu	Tiakur	Pati	Klis	Toinawan
Biomass (g/350m^2)	48.42	215.08	305.49	205.86	145.35	304.80	178.08	1.29	18.05
Number of species	28	38	47	37	30	38	34	4	7
Biomass (kg/ha)	1,383.46	6,145.17	8,728.20	5,881.57	8,708.53	8,708.53	5,088	36.70	515.82

3.4. Reef health index

The benthic component analysis describes percent of live coral coverage, potential recovery measured from percent of macro algae cover (fleshy seaweed), and percent of coral rubble coverage, and the result of coral fish biomass measured. These data sets were displayed in Table 10.

Table 10. Life coral, macro algae and coral fragment cover and coral fish biomass

Basic Component	Sampling Station								
	Uhak	Lurang	Laitutun	Batumiau	Kaiwatu	Tiakur	Pati	Klis	Toinawan
Percent live coral coverage	71.55	65.60	37.87	38.33	43.93	43.93	44.50	20.85	25.29
Percent macro algae coverage	0.34	0	0.33	0.33	0.07	0	0.83	0.17	0
Percent consolidate rubble coverage	0.85	0	0.60	0.60	0.67	6.13	30.83	5.76	8.43
Coral fish biomass (kg/ha)	1.383,46	6.145,17	8.728,20	5.881,57	4.152,75	8.708,53	5.008	36,70	515,82

The health index of coral reef of study sites covering 9 sampling stations range from 5 – 10. From 9 stations, two stations have the score of 10 (Uhak Village and Lurang) which classified as very good. Other five stations score 9 (good) and the last two station score 5 (poor) (Table 11).

Table 11. The category value of coral reef health index of Basin Wetar(Wetar, Lati , Moa Island)

Stations	Benthic Component			Coral Fish Component		Total Value	Coral reef health index value
	Live coral coverage (%)	Recovery potential	Value	Coral fish category	Value		
Uhak	High	High	6	High	6	12	10
Lurang	High	High	6	High	6	12	10
Laitutun	Moderate	High	6	High	6	12	9
Batumiau	Moderate	High	6	High	6	12	9
Kaiwatu	Moderate	High	6	High	6	12	9
Pati	Moderate	High	6	High	6	12	9
Klis	Moderate	High	6	Low	2	8	5
Toinawan	Moderate	High	6	Low	2	8	5

Overall, the coral health index it study site is considered in good condition. There is a sign of coral degradation caused by destructive fishing by the local community (cyanide). This unfriendly fishing causes coral reef destruction which will lower the coral reef ecosystem. Although the resilience potency still high, but if the unfriendly fishing still continue, in the long run will decrease the ecosystem productivity as well as fisheries productivity as well.

4. Conclusion

There are a differences in coral reef species and coral reef fish composition among study sites. The condition of coral reef ecosystem varies between station and range between very good condition and poor condition with the average of good condition. Based on coral reef health index, two stations are in very good condition, five in good condition, and the last two in moderate condition. Even though the resilience potency still high, control on unfriendly fishing activity should be conducted to inhibit further coral reef destruction

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