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Research Article

Marine Ecotourism Potential in Unggeh Island Tapanuli Tengah Regency, North Sumatra, Indonesia

Zulham Apandy Harahap[1]*, Ipanna Enggar Susetya

Study Program of Aquatic Resources Management, Faculty of Agriculture, Universitas Sumatera Utara, Medan, North Sumatera .Indonesia.

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*) Corresponding author:
E-mail:zulham.apandy@usu.ac.id

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Abstract

Unggeh Island located in the administration of the Village Sitardas Badiri District, Central Tapanuli Regency into a marine tourism area. The development of marine ecotourism Unggeh Island is an alternative to the economic improvement of society. This study aims to assess the potential of coral reef ecosystem in the form of percentage of life form coral, coral species and species and abundance of reef fish found in Unggeh Island waters of Central Tapanuli Regency and to analyze the suitability of coral reef ecosystem in Unggeh Island for tourism utilization especially marine diving and snorkeling. Coral reef community data collection was done by using SCUBA divers equipment, in identifying The coral community used underwater photo transect (UPT) method, while coral fish diversity was observed by underwater visual census (UVC) method. Physical and chemical oceanography parameter data such as temperature, salinity, pH, current, transparency and DO are performed at each observation station. The survey results of coral reef observation at four stations showed different results. Percentage of live coral cover of station 1 to 4 were 25.40 %, 12.33%, 28.53%, and 25.53 respectively. Therefore, reef fishes found 36 species that consist of ten families and 423 individual fishes. The results showed that Unggeh Island was suitable (S2) for diving and snorkeling activities, with the carrying capacity was 3.054 persons/day.

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1. Introduction

Utilization and empowerment of potential resources and marine services of small islands directed at tourism and fisheries development. This is based on two main reasons. The first reason is that Indonesia has an area of 70% which is the sea and has more than 10,000 small islands with high biodiversity. Second, most of the population who live on the coast and small islands work and have activities related to the sea (Bengen *et al.*, 2006). Development of ecotourism in coastal areas and small islands is one alternative to improve the economy of coastal communities.

Ecotourism is a natural tourism activity in the area that is responsible for paying attention to the elements of education, understanding, and support for efforts to conserve natural resources, as well as increasing the income of local people (Minister of Home Affairs Regulation No. 33 of 2009). Based on these regulations, one type of regional ecotourism is marine ecotourism. Coral reef utilization is one of the environmental services in the form of marine tourism, such as diving and snorkeling. Diving and snorkeling are very popular marine tourism in the coral reef ecosystem. Good management can support local income and open up opportunities for local economic growth, for example by developing it as a diving and snorkeling resort (Swearer *et al.*,1999; Cesar *et al.*, 2003 in Zulfikar *et al.*, 2011).

Unggeh Island is in the administration of Sitardas Village, Badiri Subdistrict, Central Tapanuli Regency which located at coordinates 1°34'23" - 1°34'37" N and 98°45'26" - 98°45'42" E. The distance of Unggeh Island is about 11 miles from the mainland of Sumatera. The topography of this island consists of lowland with a little hilly in the west. Unggeh Island has rocky beaches in the west and south and sandy beaches in the north and east. Exposure to the eastern seafloor is steep with a deep sea floor. Exposure to the southern, western and northern seabed of Unggeh Island was overgrown with coral reef ecosystem (Harahap *et al.*, 2019). Sandy beach conditions and coral reefs make this island an object of marine ecotourism (Coremap, 2008). The great natural resources potential, the lack of data availability and information about the characteristics of Unggeh Island, so that the necessary research concerning the preparation of management plans and development of marine tourism that is according to carrying capacity. Information and data currently on Unggeh Island is the relationship between coral reef ecosystem and coral fish communities (Harahap *et al.*, 2019). Utilization of coral reef ecosystem on the island is currently only a place to find fish for local fishermen. The potential may be more used to be a marine tourism object, especially for snorkeling and diving activities. Unggeh Island has many various coastal ecosystem resources (coral reef, sea grass, mangrove, and reef fishes), and especially this site has been designated as conservation area.

Therefore, it is necessary to have a research to reveal the maritime potential of Unggeh Island, especially in coral reef ecosystems, so that known condition of coral reef ecosystems, species, and abundance of reef fish found in the island to be analyzed suitability to be a marine tourism object especially for snorkeling and diving.

2. Materials and Methods

2.1 Study site

This research was conducted in July 2017, located in Unggeh Island of Sitardas Village, Badiri Subdistrict, Tapanuli Tengah Regency, North Sumatera Province. The data collection consists of 4 points of the observation station. The observation station represents all of the research locations. Coordinate of each stations as follows: station 1 (098°45'50.15"E ; 01°34'39.00"N), station 2 (098°45'27.5"E; 01°34'16.35"N), station 3(98°45'24.11" E;01°34'45.18"N), station 4(098°45'26.60"E; 01°34'44.97" N) (Figure 1).

2.2 Procedures

These activities include primary data collection by measuring in situ several parameters of aquatic environments, coral reefs, and reef fish. While the material used is the identification book of coral reef and identification book of reef fish (Kuiter and Tonozuka, 2001). Coral reef ecosystem data was measured using Underwater Photo Transect (UPT) method by determining the lifeform type of coral reef ecosystem and the percentage of coral reef cover and data analysis is done with software CPCe 4.1 (Kohler and Gill, 2006). Reef fish data collection using Underwater Visual Census (UVC) method (English *et al.*, 1997).

2.3 Matrix analysis of diving and snorkeling tourism categories

Tourism feasibility analysis is conducted to determine the suitability of the area for tourism development. This is based on the territorial ability to support activities that can be done in the area. The formula used for the suitability of marine ecotourism is as follows: (Yulianda, 2007).

$$TFI = \sum \left[\frac{Ni}{N_{max}}\right] x100\%$$

Where:

TFI = Tourism Feasibility Index

N_i = Parameter value (weight x Score)

N_{maks} = Maximum value of a category

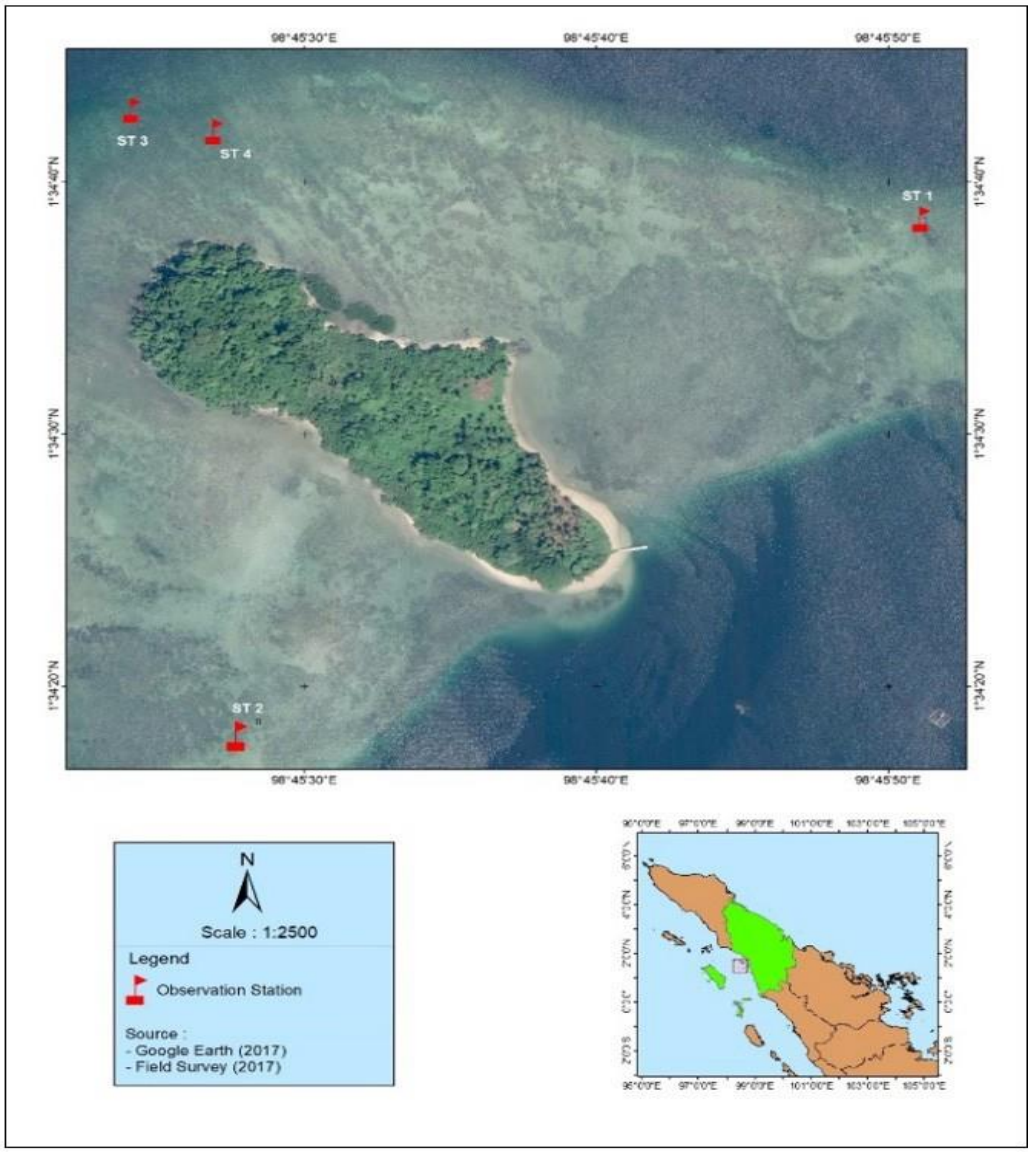


Figure 1. Location of research (Unggeh Island, North Sumatera, Indonesia)

Based on the matrix of feasibility, subsequent preparation of feasibility classes for marine tourism activities. The feasibility parameters are arranged into conformity classes for each type of tourism activity divided into four categories of feasibility, namely: very suitable (S1), suitable (S2), conditional (S3), and unsuitable (N). Matrix of tourism suitability for diving and snorkeling category (Table 1 and 2).

2.4 Analysis of the Regional Carrying Capacity

The method to calculate the carrying capacity of natural ecotourism development is by using the area of carrying capacity concept. Carrying capacity of the area is the maximum number of visitors that physically can be accommodated in the area that is provided at certain times without causing destruction to nature and humans. The estimation of carrying capacity for the marine tourism area can be seen in the following formula (Romadhon *et al*., 2014).

$$RCC = Kx\left(\frac{L_p}{L_t}\right)x\left(\frac{W_t}{W_p}\right)$$

Where:

RCC : Regional carrying capacity
K : Ecological potential of visitors per unit area
Lp : Large of utilized area
Lt : a unit area for a certain category
Wt : Time providedby the region for the tourism activity in a day
Wp : Time spent by visitors for each activity

The ecological potential of visitors was determined by the condition of the resources and type of activities that will be developed. The large area that will be used by visitors should be based on nature capability to tolerate visitors so the conservation of nature and the safety of visitors is maintained. The ecological potential

Table 1. Matrix of tourism suitability for diving category

No	Parameter	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	Water Transparency (%)	5	>80	3	50-80	2	20-<50	1	<20	0
2	Coral coverage (%)	5	>75	3	>50-75	2	25-50	1	<25	0
3	Type of life form	3	>12	3	>7-12	2	4-7	1	<4	0
4	Type of reef fish	3	>100	3	50-100	2	20-<50	1	<20	0
5	Current velocity (cm/sec)	1	0-15	3	>15-30	2	>30-50	1	>50	0
6	Depth of coral reef (m)	1	<6-15	3	>15-20	2	>20-30	1	>30	0

Source: Yulius et al., 2018

Table 2. Matrix of tourism suitability for snorkeling category

No	Parameter	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	Water transparency (%)	5	100	3	80-<100	2	20-<80	1	<20	0
2	Coral coverage (%)	5	>75	3	>50-75	2	25-50	1	<25	0
3	Type of life form	3	>12	3	>7-12	2	4-7	1	<4	0
4	Type of reef fish	3	>50	3	30-50	2	10-<30	1	<10	0
5	Current velocity (cm/sec)	1	0-15	3	>15-30	2	>30-50	1	>50	0
6	Depth of coral reef (m)	1	1-3	3	>3-6	2	>6-10	1	>30	0
7	Wide of reef flat (m)	1	>500		>100-500	2	20-100	1	<20	0

Description: Very Suitable(75-100%); Suitable (50-<75); Not Suitable (<50 %)
Source: Yulius et al., 2018

Table 3. The ecological potential of visitors (K) and unit area (Lt)

No	Type of activity	Visitor (person)	Unit Area (Lt)	Information
1	Diving	2	2000 m^2	Every 2 persons in 200 x 10 m
2	Snorkeling	1	500 m^2	Every person in 100 x 5 m

Source: Yulianda, 2007

Table 4. Prediction time for each tourism activity

No	Type of Activity	The time required Wp (hours)	Total time per day Wt (hours)
1	Diving	2	8
2	Snorkeling	3	6

Source: Yulianda, 2007

3. Results and Discussion

3.1 Condition of coral reef

The category of coral reefs condition was based on the Ministry of Environment Decree of Indonesia Republic No. 4, 2001. Severely damage (0-24.9 %); moderate damage (25-49.9 %); good (50-74.9%); very good (75-100%). Based on the observation and analysis that has been done in Unggeh Island shows the condition of coral reef in moderate damage condition at station 1, 3 and 4, severely damage condition at station 2 (Table 5).

Table 5. Coral reef *Lifeform* in Unggeh Island

Station	Coral reef coverage	Condition
1	25.40 %	Moderate damage
2	12.33 %	Severely damage
3	28.54 %	Moderate damage
4	25.53 %	Moderate damage

The type of live coral is divided into two namely Acropora and Non-Acropora. The station that has the highest percentage of live coral is station 3 at 28.47%. Station two has the lowest percentage of live coral among the other stations. Non-Acropora live corals found on Unggeh Island are coral branching, coral sub massive, coral massive, coral encrusting, coral foliose and coral mushroom. The form of live coral with a high percentage at all stations is coral massive Dead coral dominates in 3 stations namely stations 1, 3 and 4 while station 2 is dominated by abiotic. Damage to coral reefs on the Unggeh Island caused by human activities such as fishing with poisons, explosives, fishing gear that are not environmentally friendly. Damage is also caused by the disposal of anchors, rubbish, coral mining and water pollution. Supported by Sirait *et al*., (2009) research suggests that the condition of coral reefs in Central Tapanuli, Sitardas waters suffered a lot of damage, due to fishing with bombs and potassium as well as the use of boat anchors.

The coral identification results on Unggeh Island as a whole obtained 6 types of coral life form. Station 1 has 6 types of life forms, while stations 2, 3 and 4 have only 5 types of life forms. Based on Yulianda (2007), the number of types of life forms is grouped into 3 classes. Class 1 for the number of types of life form 4-7, class 2 for the number of types of life form between 7-12, while class 1 for the number of types of life form > 12. In general, the condition of corals on Unggeh Island based on the number of types of life forms included in class 2 (Table 1).

The highest percentage of dead coral is at station 4 and the lowest is at station 2. Another fauna found on Unggeh Island is soft coral and other fauna species. Soft coral was found in all research stations. The percentage of algae in the study area ranged from 0-3.4% consisting of macroalgae and algae turf. Macroalgae is found at stations 2, 3 and 4 and algae turf at station 2. Highest abiotic component with a percentage of 62.47% is at station 2 while the lowest at station 3 is 8.73%. Below are some types of coral reefs in the research location.

3.2 The diversity of reef fish

The results of identification of reef fish in four observation stations found 36 species of reef fish consisting of 10 families and 423 individual fish. The fish families found in the location of observation are Pomacentridae, Serranidae, Chaetodontidae, Lutjanidae, Lethrinidae, Siganidae, Labridae, Apogonidae, Zanclidae and Acanthuridae (Table 7). The most abundant families were Pomacentridae (damselfishes). Fish species from the families Pomacentridae and Achanthuridae were found at all research stations. Fish species from other families are found only at one or two stations. The presence of reef fish in the waters depends on coral health indicated by the percentage of live coral cover. It is very possible because of the live reef fish associated with coral reef as a shelter, protection and feeding ground (Madduppa, 2006).

The potential of coral reef ecosystems with the diversity of reef fish species in water is one ecosystem unit. The development of marine ecotourism, to determine the suitability of diving and snorkeling classes, the parameters of coral cover and the number of reef fish species are very important to note.

3.3 Aquatic chemical physics parameters

Physical-chemical parameters of the aquatic environment of Unggeh Island observed are the parameters that become limiting factors of coral reef growth.

3.4 Feasibility analysis and carrying capacity of marine ecotourism in Unggeh island

Based on the visual observation of the coral reef condition of Unggeh Island water, the value of the tourism feasibility index of Unggeh Island was suitable (S2) for diving and snorkeling (Table 8 and 9), where the highest value is at station 1. As diving activities, the extent of coral reef ecosystems is also assumed to be an area that will be used for snorkeling activities.

The carrying capacity of diving and snorkeling is determined based on the distribution and condition of coral reefs by considering the ecological potential of visitors, the area and the prediction of time required

for each tourism activity. Unggeh Island has an area of 109.265 m^2, while the area that can be used for marine tourism activities is 763.800 m^2. The whole snorkeling area is also an area for diving activities, so the area of snorkeling and diving is the same. Based on the area of utilization, Unggeh Island has a carrying capacity of 3054 people per day for diving and snorkeling. The carrying capacity of these waters is important to know so that diving and snorkeling activities while maintaining the preservation of natural resources and the environment.

Determination of carrying capacity is intended to minimize the external pressure from visitor activities in utilizing coral reef ecosystems and other coastal ecosystems as tourist objects. A sustainable marine ecotourism management approach needs to pay attention to the limiting factors for each type of activity that will be utilized. The carrying capacity of marine ecotourism is also expected to balance the level of visitor activity for each activity.

3.5 Condition of coral reef

Coral reef type located in the study sites is fringing reefs. It is life from the shoreline to the direction of the sea that forms reef flat that protects the island. According to White (1987), Fringing reefs are the most common corals found in Indonesia. Generally, the condition of the coral reef in Unggeh Island was (moderate damage). The problems are high sedimentation, pollution, and illegal fishing. The sedimentation is caused by erosion of watershed or water catchment area due to deforestation (logging), while the pollution comes from domestic and tourism activities (Annas *et al*., 2017). Illegal fishing is often done by fishermen in Central Tapanuli using explosives (destructive fishing). These can be seen by the number of rubble which supported by observation data (approximately more than 5%).

Destructive fishing causes damage to coral reefs. Saila *et al*., (1993) state that, destructive fishing practices lead to loss of coral cover which reduces both fish abundance and diversity over time. The high percentage of dead coral and the presence of abiotic elements such as rubble at each station indicated that the condition of coral reefs in Unggeh Island was damaged. Lelloltery *et al*. (2018) also states that other abiotic coral cover components such as sand, dead coral covered algae and coral fragments (rubble) indicated that there were disruptions to the coral reefs. The percentage of coral

Figure 2. Percentage of coral reef in Unggeh Island

reef ecosystem potential for the utilization of marine ecotourism is an important parameter of snorkeling and diving tourism activities.

The live coral found on Unggeh Island, consisting of Acropora and Non-Acropora types with the highest percentage of life form at each station is coral massive (CM). The form of massive coral such as chunks of rock makes this type of coral stronger than other forms such as branching. Generally, corals with CM life form can live in turbid and strong currents. According to Barus *et al*.(2018) which states that the average shallow reefs that are affected by wave action, high turbidity and sediment resuspension (TSS) generally these corals have massive forms.

The form of massive corals like chunks of rock also makes it easy for coral animals to clean themselves from the accumulation of sediment only with the help of currents. Branching life forms from both Acropora and Non-Acropora have a smaller percentage of cover than CM. This is because the branching corals are more vulnerable to damage either due to human activities or natural conditions. Branched corals have relatively fast colony growth compared to the other forms, but are more easily broken if stepped on by tourists who are snorkeling, shipping activities and illegal fishing. Branching coral including fast growing species that can survive and dominate coral reefs at depths of three meters and above (Lutfi and Anugrah, 2017).

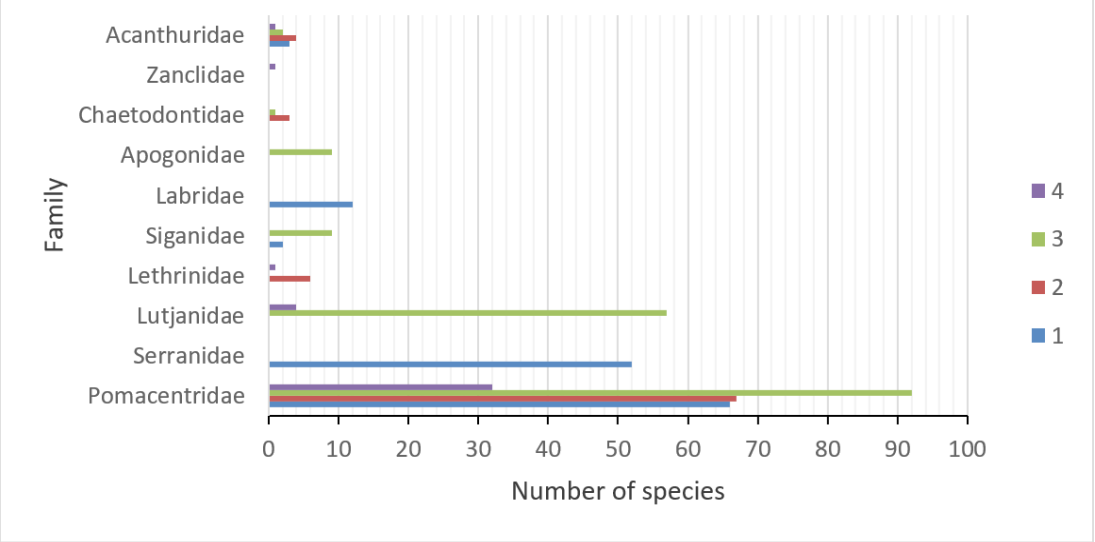
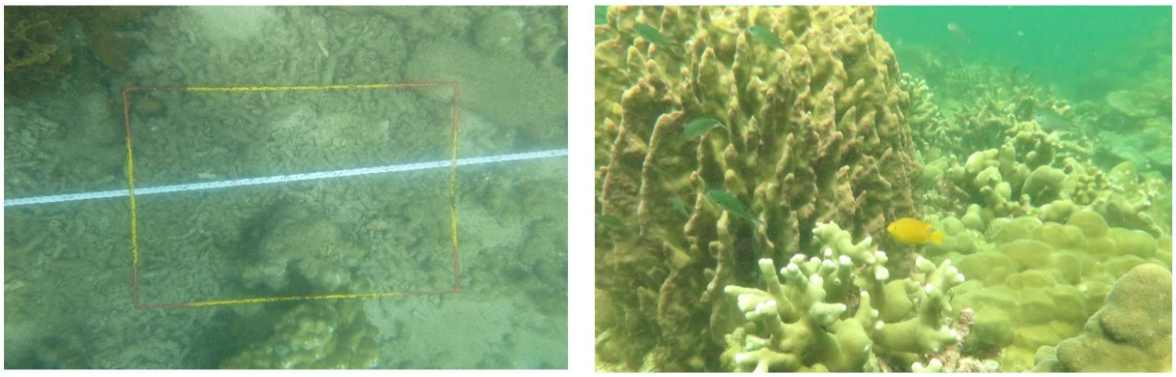


Figure 3. Comparison of the number of fish species from each family was found in stations 1,2,3, and 4.

Table 7. Parameter of Aquatic Chemical-Physics

Parameter	Station 1	Station 2	Station 3	Station 4
Temperature (℃)	31	31	30	31
Depth (m)	4	3	6	5
Water Transparancy (m)	4	3	6	4
Current velocity (m/s)	0.075	0.05	0.08	0.1
Substrate	Sand	Sand	Sand	Sand
Density (ppt)	33	34	34	34
DO (mg/l)	4.7	4.6	4	4.8
pH	7.91	7.91	7.94	7.99



(a) (b)

Figure 4. Rubble (a), healthy coral reefs (b) (source : primary data)

Table 8. Value of tourism feasibility index for diving category

No	Parameter	Weight	Station 1		Station 2		Station 3		Station 4	
			Score	Value	Score	Value	Score	Value	Score	Value
1	Water transparency	5	3	15	3	15	3	15	3	15
2	Coral Coverage	5	2	10	0	0	1	5	1	5
3	Type of life form	3	2	6	2	6	2	6	1	3
4	Type of reef fish	3	0	0	0	0	0	0	0	0
5	Current velocity	1	3	3	3	3	2	2	3	3
6	Depth of coral reef	1	3	3	3	3	3	3	1	3
	Total			37		27		31		29
	Suitability value			68,52		50,00		57,41		53.70
	Category			S2		S2		S2		S2

Table 9. Value of tourism feasibility index for snorkeling category

No	Parameter	Weight	Station 1		Station 2		Station 3		Station 4	
			Score	Value	Score	Value	Score	Value	Score	Value
1	Water transparency	5	3	15	3	15	3	15	3	15
2	Coral Coverage	5	2	10	2	10	2	10	2	10
3	Type of life form	3	2	6	2	6	2	6	1	3
4	Type of reef fish	3	0	0	0	0	0	0	1	3
5	Current velocity	1	3	3	3	3	2	2	3	3
6	Depth of coral reef	1	3	3	3	3	3	3	2	2
7	Wide of reef flat	1	2	2	2	2	2	2	1	1
	Total			39		29		33		37
	Suitability value			68,42		50,88		57,89		64.91
	Category			S2		S2		S2		S2

Table 10. Carrying capacity of diving and snorkeling areas

No	Type of activity	Wide area (m^2)	Visitor (person)	Unit Area (Lt)	Carrying Capacity (person/day)
1	Diving	763800	2	2000 m^2	3054
2	Snorkeling	763800	1	500 m^2	3054

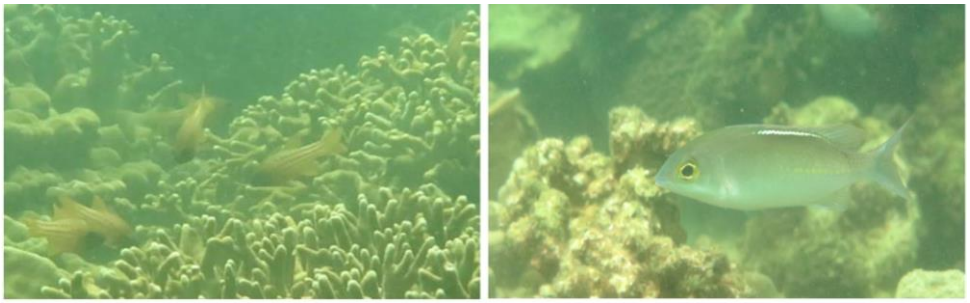
Generally, coral branching species live in waters with no strong currents, high brightness, and low turbidity. Coral branching has a soft structure. So, the current was limiting factor for coral reefs growth, where as brightness and turbidity will affect photosynthesis process, Suryanti *et al.* (2011) stated that coral reefs that live in areas protected from waves have a form of branching growth. This is what causes corals from Acropora with life form branching to be found at stations 1 and 2. Furthermore, the percentage of Non-Acropora life form branching coral cover types is also found at the station. Other life forms found on Unggeh Island are submassive, encrusting, foliose and mushroom. The shape of the submassive colony is similar to that of a massive chunk of rock or like a dome. Encrusting has a colony like growth form that runs along the substrate to form. Foliose is a form of growth like leaves and mushroom has a form of growth like mushrooms. These forms of coral life form together with coral branching and massive become a beautiful panorama in the waters of Unggeh Island. In the utilization of marine ecotourism, coral cover not only assesses hard coral, but also soft corals that are categorized as live corals. The purpose of visitors in the dive is not only limited to enjoy the hard coral but soft coral is also an object in diving and snorkeling. Added with the presence of other biotas such as soft coral, algae and also reef fish with a variety of shapes and colors can be a tourist attraction when snorkeling and diving.

3.6 The Diversity of reef fish

Fish is always moving from one location to another, it can not be determined that the number of fish species in one place or one point of observation location is always the same. Coral fish is a potential resource around the coral reefs that are the target of observation other than coral community cover. The presence of marine life that lives in the coral reef ecosystem, is part of the scenery in the activities of snorkeling and diving. This pattern was also observed in the previous study in the Seribu Island (Maduppa *et al*., 2013) and also research in Aceh Utara (Rudi, 2010).

Grouping of reef fish communities is divided into three categories of fish, namely indicator, target and major. The indicator fish are reef fish species which are used as an indicator of coral health, target fish are reef fish species which have high economic value and are often caught by a fisherman, and fish major is fish with a very large amount. (Dartnal and Jones, 1988 *in* Rembet *et al*., 2011).The abundance of reef fish will add to the beauty of the underwater panorama. Reef fish can be a special attraction in diving and snorkeling. The more variety of reef fish species in the coral reef community will add value to the development of tourist areas.

Major fish on Unggeh Island come from the families Pomacentridae, Labridae, and Apogonidae. Pomacentridae family is the most widely found on this island. According to Utomo *et al*. (2013), the high abundance of the Pomacentridae family is due to the characteristics of certain types of fish in this family that have a herdlike nature so that each time it is found it is usually in very large numbers. Fish species from the family Pomacentridae also have interesting colors. This is according to the opinion of Wijayanti (2017) in his book which states that around the world there are around
320 species of fish from the family Pomacentridae with small size and colorful. The target fish found at the study site came from the families Serranidae, Lutjanidae, Lethrinidae, Siganidae, and Achanturidae. This target fish group is active in the coral reef ecosystem.



Apogon compressus *Scolopsis ciliata*

Figure 5. Reef fishes in site observation (source : primary data)

The target fish is also a consumption fish and has economic value. Serranidae is one of the target fish with high economic value (Sahetapy *et al*., 2018). Like the major fish groups, this fish group also has colorful and attractive shapes. Some are small, medium to large. Furthermore, Madupa (2013) states that the presence of the target fish in the coral reef ecosystem is due to searching for food (feeding ground) or spawning and nursery. The existence of indicator fish is an indication of the health of coral reefs because it is a true reef dweller type. Najamuddin *et al*. (2012) argue that indicator fish groups generally live solitary and are species of fish commonly used as indicators for the health of reef ecosystems. Indicator fish species on Unggeh Island are Chaetodon trifasciatus and Zanclus cornutus. Both species of fish are rare fish with beautiful shapes and colors. The common name for the species *C. trifasciatus* is Melon Butterflyfish or Redfin Butterflyfish while *Z. cornutus* is known by the name Moorish Idol. Both of these fish species are included in the IUCN Red List of Threatened Species (Pyle *et al*., 2010 and Carpenter *et al*., 2016). The existence of fish from the major fish groups, targets and indicators with variations in shape, size, and color becomes an attraction for tourists who do snorkeling and diving activities. Locally rare and scarce fish from the indicator fish group is also an attraction for tourists. Lelloltery *et al*. (2018) also stated The rarer these fishes found will be an attraction for tourists to see it directly in their habitat

The existence of reef fishes is related to the condition of coral reefs. Coral reefs that are still good with a high number of coral species and a high percentage of live coral cover will cause an increase in the number of species and individual reef fish. The results showed that the highest number of species and reef fish individuals were at station 1. The least number of reef fish species were at station 2. Station 4 was the location with the lowest number of reef fish individuals. This relates to the percentage of live coral cover, dead coral and also the number of life forms at each of these stations. Station 1 has the highest number of coral life forms among other stations. The percentage of dead coral cover at this station is also not too high. The number of coral life forms for station 2 is the same as for station 3. The difference is that station 2 has the least live coral cover percentage among others while station 3 has the highest percentage of dead coral cover among other stations. The existence of live coral with various life forms invites more reef fish to live in that location. The high productivity of coral reef ecosystems with various life forms provides benefits for other biotas, especially reef fish as a place to find food and a place to protect from predators.

Following the opinion of Utomo *et al*. (2013) and Tombokan *et al*. (2017) which states that the function of coral reef ecosystems for other biota is as a feeding ground, nursery ground and spawning ground. Some types of reef fish that are types of coral polyps eaters such as fish from the family Cahetodonidae, must be very dependent on the existence of live corals. However, not all reef fish eat coral polyps, there are species of reef fish that eat phytoplankton, zooplankton, and algae that exist in coral reef ecosystems.

3.7 Aquatic chemicals physics parameters

Aquatic chemicals physics parameters on Unggeh Island are in normal condition and still support the life of biota that live in the waters. The type of substrate on this island is sand at all research stations. The depth and brightness of the waters range between 3-6 m. This means the brightness of the waters on the island is 100% so that the bottom of the water can be seen from the surface of the water. This brightness condition is very supportive of marine tourism activities because tourists can see the basic conditions of the waters from the surface so that it attracts interest in snorkeling or diving.

The current velocity on Unggeh Island is also supportive of marine tourism activities because the speed range is not too strong, ranging from 0.05-0.08 m/s. Yusuf *et al*. (2012) added the current velocity of 0.5 m / s is an indicator of strong currents so that the current velocity below can be classified as low to moderate. The currents that are too strong will make it difficult for tourists in snorkeling and diving activities. Flow velocity in water is very necessary because it is useful for the availability of current flow that brings with it food, oxygen, and microorganisms from other regions (Muhlis, 2011).

Waters pH at all research stations is 7.9, according to the decision of the Minister of Environment Number: 51 the year 2004 concerning Sea Water Quality Standards, pH values ranging from 7-8.5 support for marine tourism activities and marine biota. The magnitude of the value of salinity according to the minister's decree of environment of Indonesia Republic is also still supportive for the life of biota on the reef that is between 33-34 ‰.

Water temperature is related to dissolved oxygen. Dissolved oxygen is oxygen that is dissolved in water. An increase in temperature causes a decrease in DO. The content of dissolved oxygen in the waters is very important for the life of aquatic biota because it is associated with the process of respiration. Elevating in temperature causes the biota respiration process to

increase due to an increase in oxygen consumption so that the oxygen content in the waters decreases. In addition, the movement and rest of the boat's waste caused a rise in surface temperature also.

The temperature at all research stations is 31°C. According to the Decree of the State Minister for the Environment Number: 51 of 2004 concerning Sea Water Quality Standards, the temperature range for corals is 28-30°C. The results of the study are not following it but are almost the same as the research conducted by Karuppanapandian *et al.* (2007), states that the observed values of temperature showed only a narrow fluctuation among all stations including the control station range between 29.4 ± 0.29° C to 32.6 ± 0.31°C. Gaol *et al*. (2013) *in* Andaris *et al*. (2015) states that the monthly average SST in Indonesian waters ranges from 26 to 31°C which means that the temperature is still stable or normal.

Dissolved oxygen research results ranged from 4-4.8 mg/l. This result is lower when compared to the Decree of the State Minister for the Environment Number: 51 of 2004 concerning Sea Water Quality Standards of> 5 mg/l. Dissolved oxygen measurement results on Unggeh Island can still support marine life. This is in accordance with the opinion of Salmin (2005) which states that the minimum dissolved oxygen content (DO) is 2 ppm in the normal state and is not polluted by toxic compounds that are sufficient to support the life of the organism. Furthermore, Nelson and Altieri (2019) stated that hypoxic habitats as a stressor in the coral reefs ecosystem have been defined as environments where the dissolved oxygen level is below a certain threshold, most commonly around 2 mg/l.

3.8 Feasibility analysis and carrying capacity of marine ecotourism in Unggeh Island

Activity or disruption on coastal will affect to the coral reef ecosystem. So, regulation to types of marine activity was important as integrated coastal management. Regulation of the number of tourists is needed to limit tourism activities. Thus, it does not exceed the carrying capacity of the coastal ecosystem. To preserve the resources of the coral reef ecosystem without causing continuous damage. According to Clark (1996) stated the existing carrying capacity was more often applied as the limit of ecotourism activities. Carrying capacity was the maximum number of visitors that limited by the condition of the ecosystem as a natural limit. Ecosystem natural limit for ecotourism based on the results of conformity assessment activities for various types of ecotourism capacity (Romadhon *et al*., 2014). The calculation of carrying capacity of the area shall be conducted for each type of tourism which is considered under the assumption that the tourist who comes is specified based on the type of tourism activity.

The concept of carrying capacity was developed to prevent damage or decline in natural resources and the environment so that its sustainability, existence, and function are maintained (Yulianda, 2007).

4. Conclusion

In general, the condition of coral reefs in Unggeh Island threatened damage. However, the development of marine ecotourism for diving and snorkeling activity is a potential or suitable category. The regional carrying capacity is 3054 people/day. It was important to do coral transplantation particularly in station 2, the condition was very bad. The new coral reefs are being overgrown at damaged site and also protect it from potential breakage by human activities so that the tourism suitability category can be increased.

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Author's Contributions

ZAH suveyed and collected the data, analyzed data and drafted manuscript. IES helped in collecting references and adding result and discussion.

Conflict of Interest

The authors declare that they have no competing interests

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