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Condition of Coral and Reef Fish in Four Diving Areas Frequently Visited During Marine Tourism in Bunaken National Park

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Abstract

Bunaken National Park is one of the special interest tourism destinations with diving as its main attraction. Bunaken National Park is not only famous for its diversity of marine biota, such as fish, mammals, and marine reptiles, but also for the uniqueness of marine animals such as pygmy seahorses and nudibranchs. Bunaken National Park, especially on Bunaken Island, is also famous for its unique underwater landscape in the form of coral reef walls. The purpose of this study was to see the condition of coral cover and the diversity of reef fish in 4 diving areas on Bunaken Island. The data collection locations were Pangalisang, muka kampung, Likuan 3 and Fukui. Data were taken using the Line Transect and visual census. The results obtained were that the coral conditions in the Pangalisang, Likuan 3, and Fukui diving areas were in good condition, while the Muka Kampung area was in moderate condition. The diversity index in these 4 diving areas is moderate.

Keywords: Bunaken, Coral, Reef Fish, Diving Areas, Diversity

INTRODUCTION

Marine tourism is one of the sectors that contributes to the economic growth of the North Sulawesi region. Marine tourism destinations in North Sulawesi have been widely known worldwide for their beauty and uniqueness, these destinations are Bunaken National Park and Lembeh Strait. Bunaken National Park is known for its natural landscape in the form of coral reef walls filled with coral reefs and various interesting marine biota. Lembeh Strait is also a paradise for underwater photography, because there are various types of unique marine biota that are found on the sand and mud substrate. Therefore, Lembeh Strait is known by divers as Muck Diving, namely diving in sandy or muddy areas to look for strange small animals (critters).

In tourism, especially coastal and marine areas, diving and snorkeling are activities that are very popular (Zhang & Chung, 2015). This tourism activity provides economic benefits but also has a negative impact on the coral reef ecosystem (Zhang *et.al.,* 2016). For various reasons, such as saving fuel for boats, the safety of novice divers, some diving areas in Bunaken Island are often visited so that they have exceeded their carrying capacity. This causes coral damage, which is thought to be caused by boat anchors moored on coral reefs, boats hitting coral and divers who intentionally or unintentionally hold or step on coral. According to Lucrezi *et.al.,* 2017, in order to be sustainable, coral reef-based tourism management is very important and urgent to minimize the impact of damage.

There are approximately 30 dive sites (Dive spots or dive sites) in Bunaken National Park and most of these dive sites are on Bunaken Island. The existence of diving tourism activities can encourage conservation activities, provide income and help local communities. There are at least 58 genera (families) of coral in Bunaken National Park. It is estimated that there are 2,000 species of fish living in Bunaken National Park (Mehta, 1999).

Coral reef ecosystems have various roles in coastal areas, including as a place of shelter, residence, feeding and breeding ground for various marine biota (Sutono, 2016; Rafli, 2022), in addition to also acting as a wave barrier against coastal abrasion, a producer of fish and seaweed of high economic value and as a tourism industry (Rafli, 2022). Exploitation of coral reefs for tourism activities can disrupt the growth of coral reefs and the abundance of reef fish (Rahman 2021). Periodic coral reef research will help monitor the condition of coral reefs on Bunaken Island, which have declined from year to year due to the increasing amount of waste entering Bunaken waters (Luasunaung *et.al.* 2015). The purpose of this study was to see the condition of coral reefs and the diversity of reef fish in 4 frequently visited diving areas on Bunaken Island, namely Pangalisang, Muka Kampung, Likuan 3 and Fukui.

RESEARCH METHOD

Data collection was carried out using the Line Intercept Transect (LIT) technique, with a transect length of 50 meters. Each coral passed by the transect was recorded according to its category in centimeters.

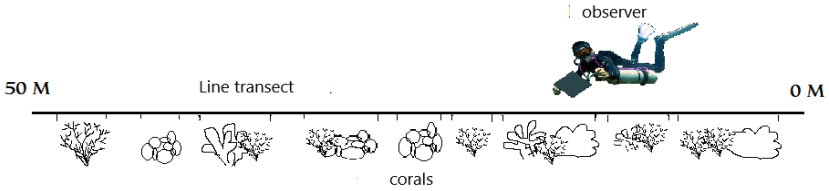

Figure 1. Line Intercept Transect

The total percentage of coral cover was analyzed using the formulation (Gomez & Yap, 1988):

$$Percent\ cover\ (\%) = \frac{Total\ length\ of\ transect\ covered\ by\ corals}{Transect\ length\ (50m)} x\ 100$$

Decree of the Minister of State for the Environment: KEP - 04/MENLH/02/2001 Concerning Standard Criteria for Coral Reef Damage is the benchmark for determining the condition of coral reefs in Bunaken National Park.

Tabel 1. Standard Criteria for Coral Reef Damage

Standard Criteria for Coral Reef Damage	
Bad	0 - 24,9
Medium	25 - 49,9
Good	50 - 74,9
Very Good	75 - 100

Data collection for coral fish abundance was conducted using the visual census method. In this data collection, divers swam using a line transect, where every 5 meters the diver

stopped to conduct sampling with a transect of 5x5 meters, namely 2.5 meters on the left and right.

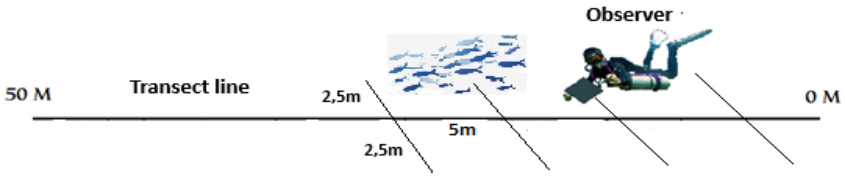

Figure 2. Visual Census

The abundance of coral fish is the number of coral fish found at an observation location per unit area of the observation transect. The abundance index can be calculated using the formula (Labrosse, 2002):

$$K = \frac{ni}{A}$$

Where:
K : abundance of coral fish (ind/m2)
ni : number of coral fish at the observation station (ind)
A : observation transect area (m2)

The diversity index formula us Shannon Wiener (Di Bitetti, 2000 *in* Riyantini *et.al*, 2023):

$$H = -\sum_{i=1}^{s} p_i \ln(p_i)$$

Where:
H = Shannon index value
p_i = the proportion of individuals found in the *i*th species
ln = natural logarithm
s = the number of species in the community

The Shannon-Wiener diversity index is categorized as follows (Fachrul, 2007 *in* Armanto *et al*., 2022):
H'<1 = Low diversity
1<H'<3 = Medium diversity
H'>3 = High diversity

RESULT AND DISCUSSION

This research was conducted on Bunaken Island, Bunaken National Park, North Sulawesi. The research location was in 4 frequently visited diving areas, namely: Pangalisang, Muka Kampung, Likuan 3 and Fukui. The research implementation period was 3 months starting from June to August 2024.

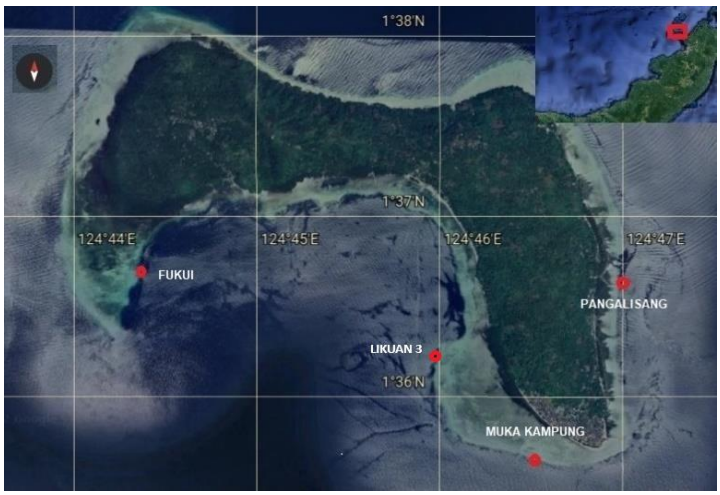

Figure 3. Research Location Bunaken Island

The water temperature in the research area ranges from 26 ^{o}C to 29^{o}C, while the salinity is in the range of 27$^{o}/_{oo}$ to 33$^{o}/_{oo}$.

Tabel 2. Geographical location of the diving area and parameters.

No	Station	Latitude	Longitude	Temp (^{O}C)	Salinity ($^{O}/_{oo}$)
1	Pangalisang	1^{o} 36' 36"	124^{o} 46' 58"	26,07	29,03
2	Muka Kampung	1^{o} 35' 43"	124^{o} 46' 27"	28,27	28,34
3	Likuan 3	1^{o} 36' 15"	124^{o} 45' 59"	29,12	27,00
4	Fukui	1^{o} 36' 44"	124^{o} 44' 20"	28,41	33,87

The coral condition at station 1 (Pangalisang) is in good condition with coral cover of 73.88%. The largest category is branching coral (CB) with a percentage of 48.54% and massive coral with a percentage of 20.3%. The percentage of dead coral with algae (DCA) is 14%. The coral condition at station 2 (Muka Kampung) is in moderate condition with coral cover of 49.16%, where the largest category is massive coral (CM) with a percentage of 24.76% and branching coral 21.32%. The percentage of dead coral with algae (DCA) is 17.64%.

Station 3 (Likuan 3) coral cover condition is good with a percentage of coral cover of 73.72%. Although the number of dead coral with algae (DCA) is quite large, namely with a percentage of 22.72%. The percentage of massive coral (CM) is quite large, namely 45.96% while branching coral (CB) is 12.94%. At station 4 (Fukui) coral cover is in good condition with a cover percentage of 71.04%. This diving area has branching coral with a percentage of 37.24%.

Coral fish at station 1 are mostly found from the *Pomacentridae* and *Chaetodontidae* families. The number of coral fish in the Pangalisang diving area is 859 with an abundance of 3.43 ind/m2. The diversity index at Pangalisang station is 2.319 or is in the moderate category. At station 2, the coral fish that are often found are from the *Pomacentridae, Chaetodontidae, Acanthuridae* and *Labridae* families with a diversity index of 2.206 or is in the moderate category.

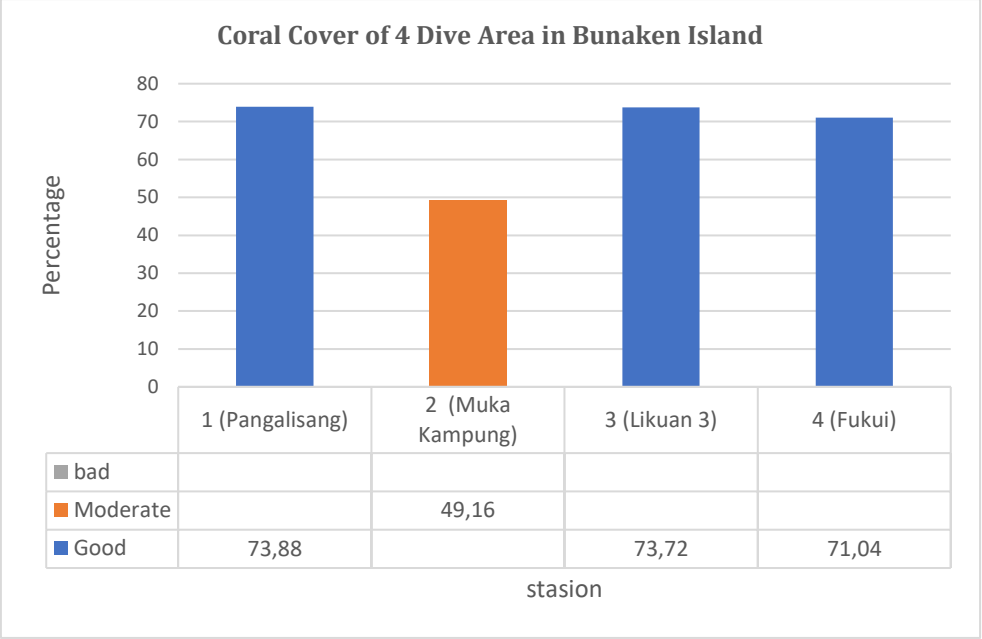

Figure 4. Coral Cover of 4 dive areas in Bunaken Island.

The number of fish in this diving area is 690 with an abundance of 2.76 ind/m2. The type of coral fish that is often found at station 3 is the *Pomacentridae* family while the diversity index is 2,30, which is in the moderate diversity category. The number of fish in the Likuan 3 area is the smallest, namely 171 with an abundance of 0.68 ind/m2.

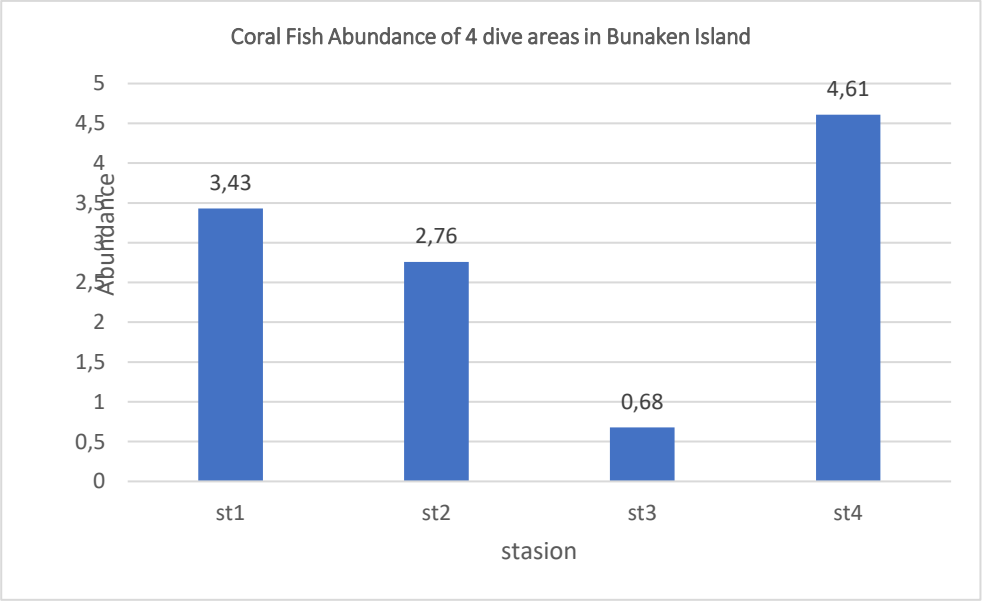

Figure 5. Coral Fish Abundance of 4 dive areas in Bunaken Island

In the Fukui diving area or station 4, many coral fish from *Pomacentridae, Chaetodontidae,* and *Acanthuridae* are found where the number of fish at this station is the largest, namely 1153, with an abundance of 4.61 ind / m2. While the diversity index is 1.933 or is in the moderate

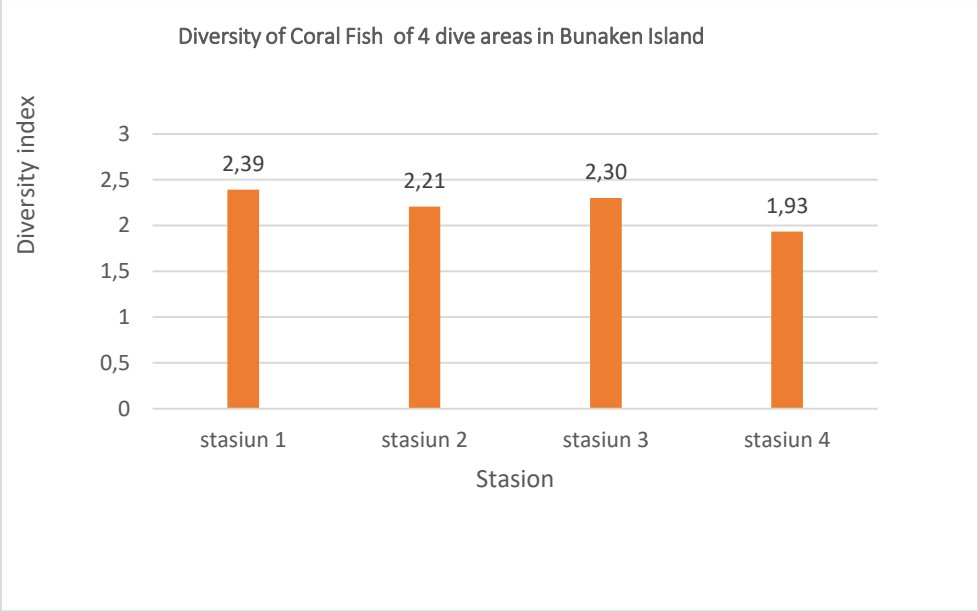

Figure 6. Diversity of Coral Fish of 4 dive areas in Bunaken Island

From the results of coral fish observations, there are 14 families, 36 genera, 54 species were obtained. The coral fish families are:: *Pomacentridae, Chaetodontidae, Acanthuridae, Labridae, Scaridae, Ptereleotridae, Zanclidae, balistidae, Holocentridae, Nemipteridae, Fistulariidae, Serranidae, Monacanthidae, Lutjanidae*

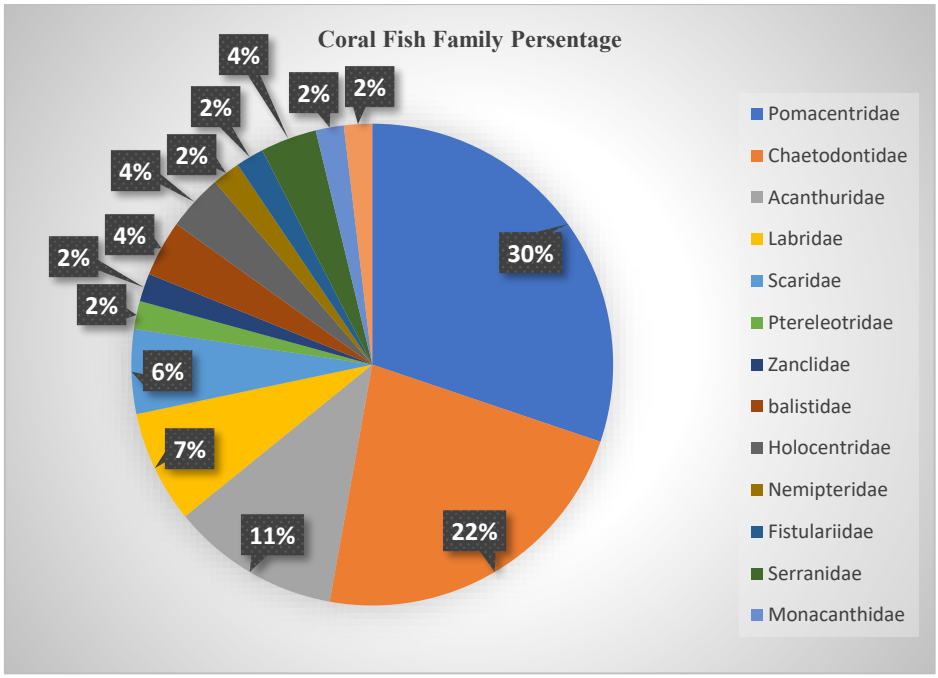

Figure 7. Percentage of Coral Fish Families.

From the results obtained, it can be seen that the 3 diving areas have coral cover in the good category, while the diving area in front of the village is in the moderate category, this shows that human activities close to the diving area disrupt coral growth and even damage it. Some things that may happen are damage to coral due to the activities of fishing boats or passenger boats passing through this diving area. The use of bamboo poles and anchors from boats often damage coral reefs.

Some things that also disrupt coral reefs are human activities that result in the infiltration of liquid waste from washing activities or activities from the bathroom or toilet. Detergents containing alkali will greatly affect coral growth or other marine biota. Detergents are thought to be one of the ingredients that cause overpopulation of coral predators, namely Acanthaster plancii or crown of thorn starfish (Kamagi *et.al.* 2022).

According to several studies (Sutono, 2016; Rani *et.al.,* 2019; Riyantini *et.al.,* 2023; Rondonuwu *et.al.* 2019) coral cover affects the abundance of reef fish, but at station 3, namely Likuan 3, although the coral cover is good, the number of fish is very small compared to other stations. This is because at the time of data collection there were many visitors diving, which disturbed the reef fish community in the area. Overall, the diversity of reef fish in these 4 diving areas is in the moderate category. The abundance of reef fish in the Fukui diving area is the largest, but further research is needed to determine whether there is an effect of live coral cover on fish abundance.

CONCLUSION

From the survey results, it was found that the coral conditions in 4 diving areas on Bunaken Island that were in the good category were station 1 Pangalisang with a value of 73.88%, station 3 Likuan 3 with coral cover of 73.72% and station 4 Fukui with coral cover of 71.04%. At Station 2 Muka Kampung, coral cover was at a value of 49.16%, which was in the moderate category. The diversity of coral fish in the 4 diving areas was in the moderate category with an index value at station 1 of 2.39; station 2 of 2.21; station 3 of 2.30 and station 4 of 1.93.

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