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Exploring Coral Reef Distribution and Health at Post 1, West Bali National Park

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ABSTRACT

Coral reef ecosystems are essential for coastal protection, biodiversity, and resources for food and medicine. Menjangan Island, located within the West Bali National Park, is a prime site for marine ecotourism and coral reef conservation. This study analyzed the condition and distribution of coral reefs at Post 1, Menjangan Island. Data collection used underwater photography and CPCe software for analysis. The results revealed that live coral cover constituted 40.01%, while non-coral elements, dead coral, and abiotic components accounted for 0.19, 14.51, and 44.34%, respectively. The findings classify the coral reef condition as high, highlighting the need for enhanced regulations and increased awareness among tourists to mitigate damage caused by tourism activities. This study underscores the significance of sustainable practices for coral reef conservation in high-tourism areas.

INTRODUCTION

Indonesia is an archipelago of islands surrounded by vast oceans. Indonesia's location in the tropics allows shallow marine ecosystems such as coral reefs to grow and develop. Coral reefs are one of Indonesia's potential marine wealth, which if managed and utilized properly will be able to provide high economic value for the community **(Giyanto *et al.*, 2017)**. The West Bali National Park area is one of the tourist destinations that is also a conservation area on the island of Bali, especially in Jembrana Regency and Buleleng Regency. Based on the Decree of the Minister of Forestry No.493/Kpts-II/1995 dated 15 September 1995, West Bali National Park has an area of 19,002.89 Ha consisting of a land area of 15,587.89 Ha and a water area of 3,415 Ha **(Mahmud *et al.*, 2015)**.

The establishment of West Bali National Park as a protected area aims to enhance the conservation of flora, fauna, and ecosystems, ensuring environmental balance while

supporting recreation, education, culture, research, and tourism. Administratively, West Bali National Park (TNBB) spans two districts—Buleleng and Jembrana—in Bali Province. Geographically, it is located on the western side of the island of Bali at a coordinate position between 8°05′ 20″ to 8°15′ 25″ LS and 114°25′ 00″ to 114°56′ 30″ East. The waters of Menjangan Island are included in the western part of Bali Island. These waters are a protected tourist area and are visited by many international and local tourists to enjoy the beauty of corals and fish on the seabed.

Indonesia's coastal ecosystems consist of coral reefs, estuaries, seagrasses and mangroves. Coral reefs are one of the main ecosystems in waters that have a very high level of biodiversity. Coral reef ecosystems have many roles, in addition to protecting the coast from the threat of abrasion as well as providing important compounds for food, supplements and medicines. From an ecological aspect, coral reefs are a good habitat for aquatic organisms. Basically, coral reefs are formed from massive deposits of calcium carbonate (CaCo3) produced by reef-building coral organisms (hermatic corals) from the phylum Cnidaria, order Scleractia that live symbiotically with zooxanthellae and a little extra from calcareous algae and other organisms that secrete calcium carbonate **(Kordi, 2018)**. The diversity, distribution, and hermative growth of corals depend on their environment. These conditions are not always fixed but often change due to disturbances **(Zurba, 2019)**.

Based on the 2019 data from 1153 reefs, there are about 390 reefs (33.82%) categorized as poor, 431 reefs (37.38%) categorized as fair, 258 reefs (22.38%) categorized as good, and 74 reefs (6.42%) categorized as excellent **(Hadi *et al.*, 2019)**. Indonesia's coral reefs represent 18% of the world's total coral reef area. Coral reefs are one of the most productive and bio-rich ecosystems on earth and have many ecological functions, including as a habitat, feeding ground, nursery ground, spawning ground, attractant for marine organisms to increase fishing efficiency, and maintain the balance of the food chain cycle **(Ilyas, 2008)**. Coral reef conditions are very vulnerable to environmental changes, even though it seems that this ecosystem is a very strong and stable system **(Sahami & Hamzah, 2013)**. Corals will be able to live normally if the chemical parameters of temperature, pH, DO and salinity are normal. The optimal seawater temperature for coral growth and distribution ranges from 25- 30°C **(Souhoka, 2013)**. However, coral reefs can tolerate temperatures up to 36- 40°C.

An increase in seawater temperature above the normal temperature will cause coral bleaching, subsequently the color of the coral becomes white. For water acidity, **KLH (2004)** specifies a pH range of 7– 8.5 as suitable for marine biota. Dissolved oxygen (DO) levels in sea surface waters typically range from 5.7 to 8.5ppm **(Sutamihardja, 1978)**, while coral reefs grow and develop at their best within a narrower DO range of 4.27- 7.14ppm. For salinity, the ideal range supporting coral growth and development is 25- 40ppt **(Eliza, 1992)**, with Nontji **(Sudiarta, 1995)** noting that corals can tolerate salinity levels between 27- 40ppt.

Human activities, particularly marine tourism, significantly impact coral reef health. Destructive practices include diving, snorkeling, freediving, and other direct-contact marine activities. Research demonstrates an inverse relationship between area utilization and coral reef coverage - as human activity increases, reef coverage decreases **(Juhasz *et al.*, 2010)**. Major stressors include recreational tourism, exploitative fishing methods (such as blast and cyanide fishing), and extractive activities like anchor damage **(Uar *et al.*, 2016)**.

Scientific studies consistently show that coral reef cover declines in areas with high development and anthropogenic pressure **(Indrabudi & Alik, 2017)**. Furthermore, coral reefs in tourist areas exhibit higher disease prevalence compared to undisturbed sites **(Lamb & Willis, 2011)**, highlighting the fragile balance between marine tourism and reef conservation.

MATERIALS AND METHODS

This research was conducted in the West Bali National Park area, precisely at Post 1 Menjangan Island, West Bali, Bali. Post 1 itself is one of several dive sites on Menjangan Island. The following are dive sites located on Menjangan Island.

Fig. 1. Dive sites in Menjangan Island

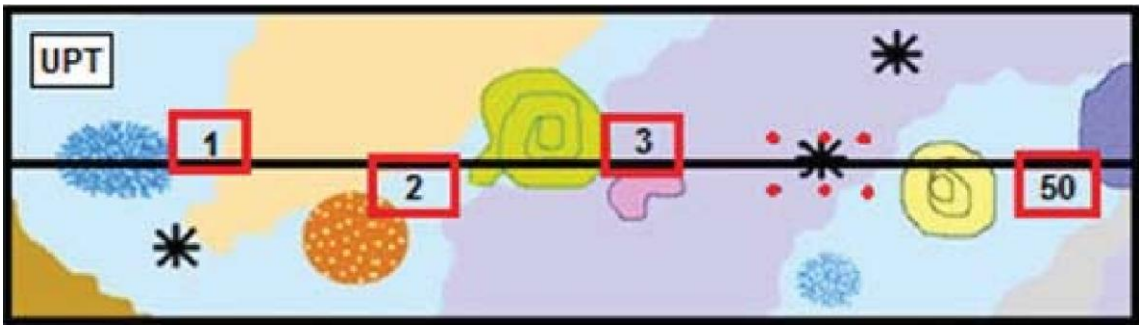
Fig. 2. Station sampling data

Fig. 3. Station sampling data zoom in

For the two stations at Post 1 of Menjangan Island, the coordinate points at station 1 are 8° 5'46.69 S and 114°30'12.43 E, while station 2 has coordinates of 8° 5'46.19 S and 114°30'9.42 E. In this study, data were collected covering two places with coral reef ecosystems on Menjangan Island. The tools used in this research are thermometer, secchi disk, thermometer, Global Positioning System (GPS), SCUBA tool, underwater camera, roll meter, stationery, slate and waterproof paper. Water quality data were needed to determine the condition of the aquatic environment at the research site. The condition of the aquatic environment is one of the limiting factors that affect the growth rate and development of coral reefs. Physical and chemical factors that limit the aquatic environment include light, depth, temperature, salinity, brightness and substrate. Parameters measured to support water quality data were temperature, salinity and water brightness. Coral reef data collection was done by diving and using the UPT method.

The UPT method is a method that utilizes technological developments, because in this method, digital camera technology and computer software are used **(Fadhillah *et al.*, 2021)**. Data collection in the field is only in the form of underwater photographs which will then be further analyzed using a computer to obtain quantitative data. Data collection in the field using the UPT method was carried out with underwater photography using a

digital camera. A 50- meter long transect was laid out, and photographs were taken with frame boundaries at every meter. Shooting was carried out from the 1st meter on the left side of the transect line, followed by shooting at the 2nd meter on the right side. Shooting continued until the end of the transect. Thus, the odd meters (1st, 3rd, 5th) were taken on the left, while the even meters (2nd, 4th, 6th) were taken on the right.



Source : **(Giyanto *et al.*, 2014)**

Coral reef health indicators consist of live coral cover and other reef benthics, reef fish consisting of corallivorous, herbivorous and target fish, and megabenthos and are supported by the health of other ecosystems, such as seagrass beds and mangroves. Coral reef health indicators were analyzed using CPCe (Coral Point Count with Excel extension) software to obtain the percentage value of coral cover **(Ramadhani *et al.*, 2019)**.

RESULTS AND DISCUSSION

Based on data processing using CPCE software, the results of the percentage of coral reef cover are shown in Tables (1, 2).

Table 1. Percentage coral reef major category

Major category (% of transect)	%
Coral (C)	40.01
Non-coral (NC)	0.19
Dead coral (DC)	14.51
Other biota (OTHER)	0.95
Algae (ALGAE)	0
Abiotic (ABIOTIC)	44.34

Table 2. Percentage coral reef subcategories

Subcategories (% of transect)	%
Coral (C)	
Acropora branching (ACB)	8.1
Acropora digitate (ACD)	0.33
Acropora submassive (ACS)	29.37
Coral massive (CM)	2.04
Coral millepora (CME)	0.08
Coral submassive (CS)	0.08
Non-coral (NC)	
Non-coral (NC)	0.19
Dead coral (DC)	
Dead coral with algae (DCA)	14.51
Other biota (OTHER)	
Ascidians, anemones, gorgonians, giant clams, etc (OT)	0.1
Soft corals (SC)	0.08
Sponges (SP)	0.77
Abiotic (ABIOTIC)	
Rock (RCK)	6.63
Rubble (R)	27,31
Sand (S)	10.31
Silt (SI)	0.08

The processed coral reef data from stations 1 and 2 at Post 1, Menjangan Island reveals a live coral cover percentage of 40.01%. The coral life forms are distributed as follows: Acropora branching (ACB) 8.1%, Acropora digitate (ACD) 0.33%, Acropora submassive (ACS) 29.37%, Coral massive (CM) 2.04%, Coral millepora (CME) 0.08%, and Coral submassive (CS) 0.08%. According to **Mumby *et al.* (2017)**, this level of live coral cover is qualified as high with the following categories:

Table 3. Category live coral reef cover

No.	Category	Criteria
1	Low	Live coral cover < 19%
2	Middle	19% < Live coral cover < 35%
3	High	Live coral cover >35%

The data reveal additional benthic components at the study site, with non-coral organisms comprising 0.19% of coverage. Dead coral accounted for 14.51% of coverage,

showing visible algal colonization on its surfaces. Other biota represented 0.95% of the composition, consisting of soft coral (0.08%) and sponge (0.77%). As demonstrated by **Subagio and Aunurohim (2013)**, sponge communities serve as effective bioindicators of marine water quality due to their sessile nature and limited dispersal capability of eggs and larvae, which makes them particularly sensitive to local environmental conditions.

The benthic composition analysis revealed abiotic components comprising 44.34% of coverage, including rock substrate (6.63%) that serves as critical habitat for coral reproduction, rubble (27.31%) consisting of degraded coral fragments from both natural erosion and human impacts **(Fox *et al.*, 2003)**, sand (10.31%), and silt (0.08%). The substantial rubble presence correlates strongly with anthropogenic pressures at Post 1, particularly intensive tourism activities (snorkeling, freediving, and diving) and frequent anchoring by fishing vessels whose dropped anchors directly damage reef structures. These findings align with **Thovyan *et al*. (2017)**, who identified three primary destructive human impacts: pollution discharge, unsustainable fishing practices, and physical reef contact by tourists. Given Menjangan Island's ecological value and high visitation rates, its reef ecosystem faces significant stress from both human activities and natural factors like predation **(Febrianti *et al.*, 2018)**, with the rubble percentage serving as a clear indicator of these cumulative impacts.

CONCLUSION

The study emphasizes that the coral reef cover at Post 1, Menjangan Island, West Bali, falls within a high category, reflecting the need for continued and enhanced conservation efforts. The health of the reef can be further improved by strengthening regulations and fostering greater tourist awareness regarding the importance of coral reefs. Such measures are essential to minimize human impacts, particularly from tourism and other anthropogenic activities, which threaten the coral ecosystem. By implementing better regulations and educating visitors, the coral reef ecosystem's resilience and condition can be preserved and even improved over time.

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