Recent Status of Coral Reef Ecosystem in Penuktukan Bali, Indonesia: the Implication for Sustainable Marine Tourism Implementation

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Abstract

Recent development of marine tourism in Penuktukan Village, Sub district Tejakula of the Buleleng Regency in Bali has been contributed to the coral reef ecosystem. The aim of the research was to determines the coral reefs coverage, coral reef and fishes diversity in Penuktukan Villages, Sub district Tejakula of the Buleleng Regency. Result of the research confirms that coral reef coverage in Penuktukan was varied from 53 to 56%, indicates human impact to coral reefs ecosystems. The coverage level can be influenced by tourist activities. Based on the observation it is clear that Coral Foliose types weredominant. Diversity index (H') of coral reefs ranging from 1.754 to 1.814; while the evenness index (E) was ranging from 0.8435 to 0.9468. The coral reefs diversity is able to support underwater marine tourist program, but tourism behavior should be managed to protect coral reef biodiversity. The observed fish was less than 25 individual.These fishes taxonomically belong to *Serranidae*, *Lutjanidae*, *Letherinidae*, *Caesionidae*, *Scaridae*, *Haemulidae* and *Chaetonodae*. It was lower compared to the standard for population in healthy water. The implementation of marine based tourism in Penuktukan Village should be controlled through visitor management and coral reef ecosystem conservation.

Keywords: Bali, coral reefs, marine tourism, sustainable tourism.

INTRODUCTION

Recently, marine tourism is growing significantly in the world. Marine tourism focuses on the use of marine resources and its environment as tourism attractions. Marine is home of numerous creatures which is considered interesting among tourist. Tropical regions are one of the riches regions in term of marine creature. The development of marine tourism in tropical region has been viewed as one of the machine for local development. It is especially important because many tropical countries are developing countries, in which technology, infrastructure and human resources was limited [1,2,3].

Marine creature has been reported fragile to human disturbance, and tourism potentially contributes to the marine biodiversity disturbance. There are numerous report shows that impact of human activity in marine which is contributes significantly in marine ecosystem. Coral disturbance, decline of fish population, and water pollution often reported as crucial issues in marine tourism. Sustainable tourism should be able to minimize tourist impact to environment. In such a case, the proper management of marine resources was important. Scholars point out that the proper planning and management of marine resources for tourism will contribute to the sustainability of marine resources. It is especially crucial to enhance the sustainable use of resources [4,5].

For a long time, Bali has been recognized as tourism destination. Cultural and landscape of Bali has been explored by tourism industry [6,7]. Recent grows of marine tourism has been identified as an important strategy for rural coastal development due to numerous economic benefit derived from tourism activity. Marine tourism in Bali has been grown as an important variant of tourism product. Demand for leisure in marine environment increase significantly. In Bali, snorkeling and diving has been recognized as main marine tourism activity. The interaction between tourist and coral reefs as for few studied. Therefore, it is especially important to study the coral reef status for future sustainable management practices of marine tourism. The aims of the research was to determines the coral reefs coverage, coral reef and fishes diversity in Penuktukan Village, Sub district Tejakula of the Buleleng Regency. It is especially important for sustainable marine tourism planning and management.

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MATERIAL AND METHODS
Study area

Research was done in Penuktukan Village, Sub district Tejakula of the Buleleng Regency, Bali (Fig.1). This village has wide coastal and marine area which are used as tourism destination sites. Administratively, Penuktukan Village covers an area about 625 Ha. The majority of area was dominated by forest 250 Ha and orchards 275.66 Ha. The southern part of the villages was Bali Sea, in which biologically water ecosystems rich in term of marine creature (Fig. 1). The marine is rich in term of coral reefs and fish reefs. The development of tourism in southern part of Bali Island has been considered important because this area was lowest developed compared to the southern area. The development of tourism in Penuktukan was addressed to improve local community prosperity, in which local people involve and receive benefits from tourism industry. Following the potential sites of marine environment in Penuktukan villages as dive sites, local authority and community proposed such area as new dives sites in Bali called Taman Segara. Recently, these area is one of the favorites diving sites in northern Bali Island.

Methods

Field survey was done in coastal area of Taman Segara, Penuktukan village. Three area which used for diving activities was observed, including Angel Canyon (zone A), Coral Reef (zone B) and Coral Starway (zone C). The selection of such place was based on the asumption of the place become habitat for coral reefs and fish, and diving activity was done in the area. Coral reef covering has been identified through transect line at three zone. Observation was done at 50 m transect length, started from zero point (0 m from initial point in beach) to 50 m in the sea. Design for transect was given in Figure 2. Reef coverage at the observation plot was observed systematically. Coral reefs species was identified and the coral reefs coverage was measured.

Reef fish observation was done through Underwater Fish Visual Census (UVC) methods. Fishes which are found at 2.5 m in left and right sides of transect line were listed and the number was counted. The total area for observation was about 5 x 50 m or equal to 250m^2.

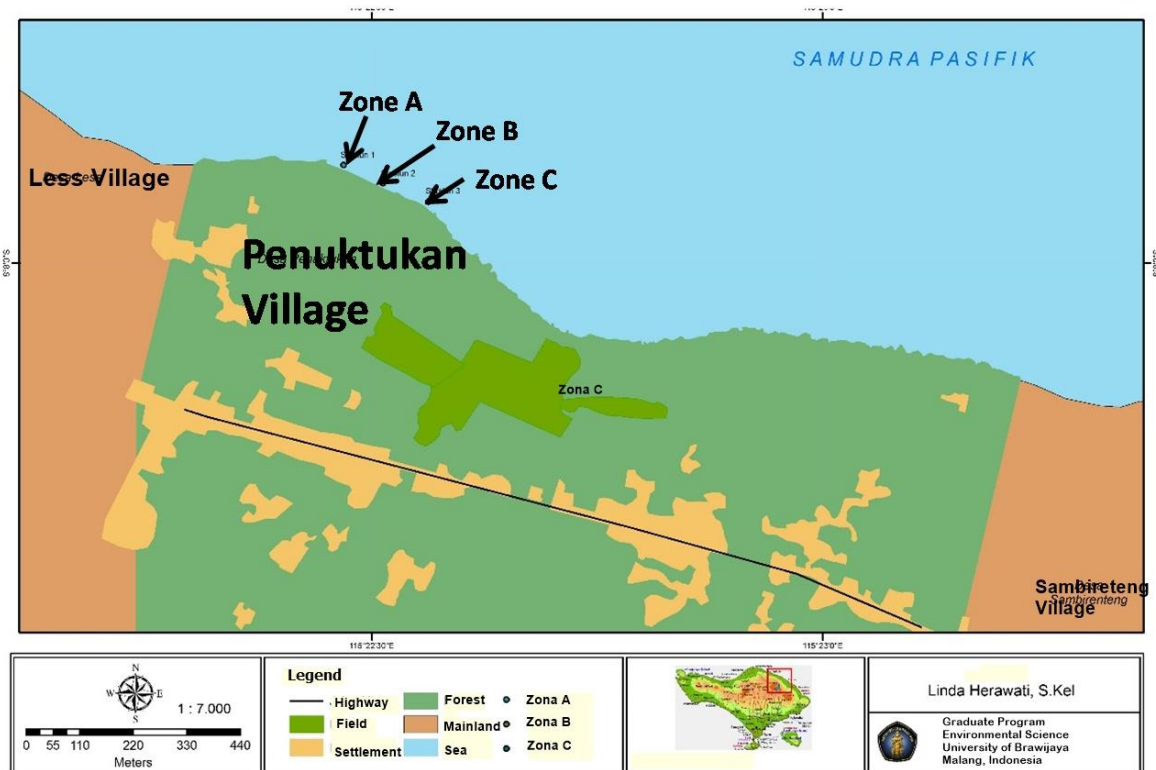Coral fish density was calculated in individual/transect. Observation was done three times as shown in Figure 3.
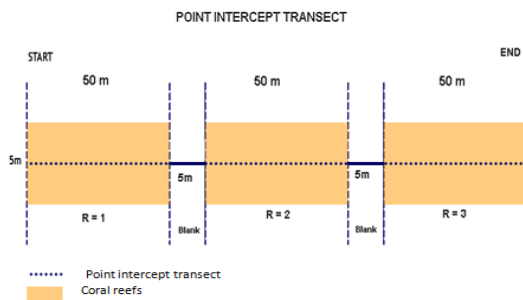

Figure 1. Map of Study Area

Figure 2. Observation Design by Point Intercept Transect

Figure 3. Fish Belt Transect Design for Reef Fish Observations

Data Analysis

The coral reefs coverage was calculated using formula:

$$N = \frac{\sum ni}{A} \times 100\%$$

The interpretation of data was following CRITC – COREMAP from Indonesian Institute of Sciences as follow :

- Disturbed (reef coverage 0-24.9%)
- Medium (reef coverage 25-49.9%)
- Good (reef coverage 50-74.9%)
- Very good (reef coverage 75-100%)

Criteria of fish density was classified as:

- Less, when number of individual along transect was < 25 individual
- Many, number of individual along transect was 25-50 individual, and
- Abundance when number of individual along transect was > 50 individual

The density index was calculated following formula:

$$(D_i) = \frac{n_i}{A}$$

Description:
Di =density of species$_i$
Ni= number of individual species$_i$
A =plot area size

Relative density was calculated using formula:

$$(R) = \frac{ni}{\sum n} \times 100\%$$

Description:
R = Relative density
ni = Number of individual of species
N = Total number of individual

RESULT AND DISCUSSION
Coral Reef Coverage

The coral reef coverage in Penuktukan Villagewas 56% in Zone A, 53% in Zone B and 56% in Zone C, indicates human impact to coral reefs ecosystems. The coverage level can be influenced by tourist activities. Among the observed sites, there are diversity of coral reef composition (Fig. 4). Seven forms of coral namely Acropora branching (ACB), Acropora tabulate (ACT), Acropora submassive (ACS),Coral massive (CM), Coral submassive (CS), Coral foliose (CF) and Coral mashroom (CMR) were found in Zone A. Similar form of coral reefs found in zone B, except CMR. Zone C has more coral reefs, including Acropora branching (ACB), Acropora tabulate (ACT), Acropora submassive (ACS), Coral massive (CM), Coral submassive (CS), Coral foliose (CF) Coral mushroom (CMR), Rabble (RB), Sand (S) and Rock (RCK).

The percentage of Coral foliose (CF) was high in Zone A and B, while Rubble was high in zone C. In marine ecosystem, the existence of Coral foliose was important because these corals provide shelter for numerous invertebrates and fish species. These corals often found grows and abundance in areas with high levels of sunlight. The ecological role of such form of coral was important.

The species of *Acropora* was found as coral with plates, slender and broad branches (Fig. 5). There are three types of *Acropora*, namely *Acropora* branching, *Acropora* tabulate, *Acropora* sub massive. These *Acropora* is important habitat for marine living creature. In Taman segara, *Acropora* commonly found in shallow reef environments [8].

The percentage of coral reefs in Penuktutan marine ecosystem indicates past human impact to reef ecosystem, including tourism (Fig. 6). Scholar point out that underwater tourism potentially contributes to the coral disturbance [9,10]. Through field survey, it was recorded that tourism activities was numerous, including swimming, diving and snorkling.

Effort to increase coral reef in Taman Segara was crucial. Increase of coral reef coverage and its biodiversity will provides spectacular underwater landscape for diving and snorkeling. Ecologically, it is also important to enhance the

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diversity of marine creature, including coral fish. Recently community-based coral reefs conservation programs involved local community. Penuktukan villagers has been contributes to the recent coral reefs conservation.
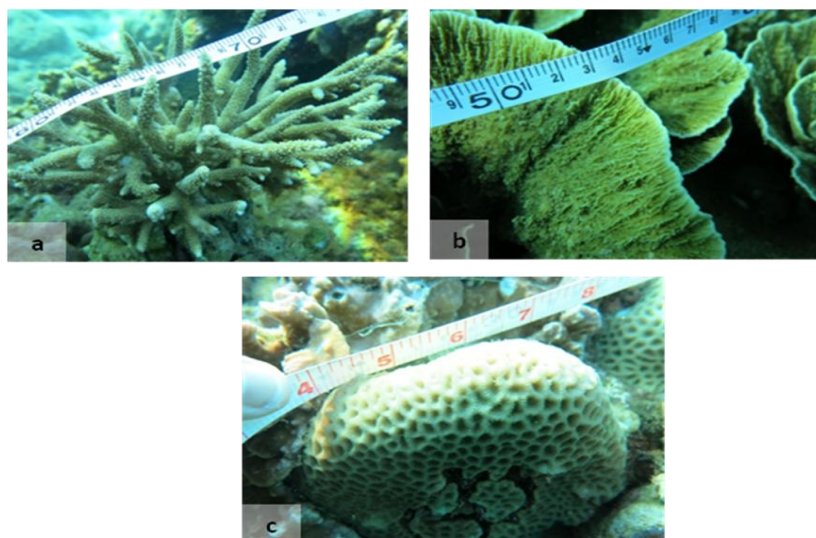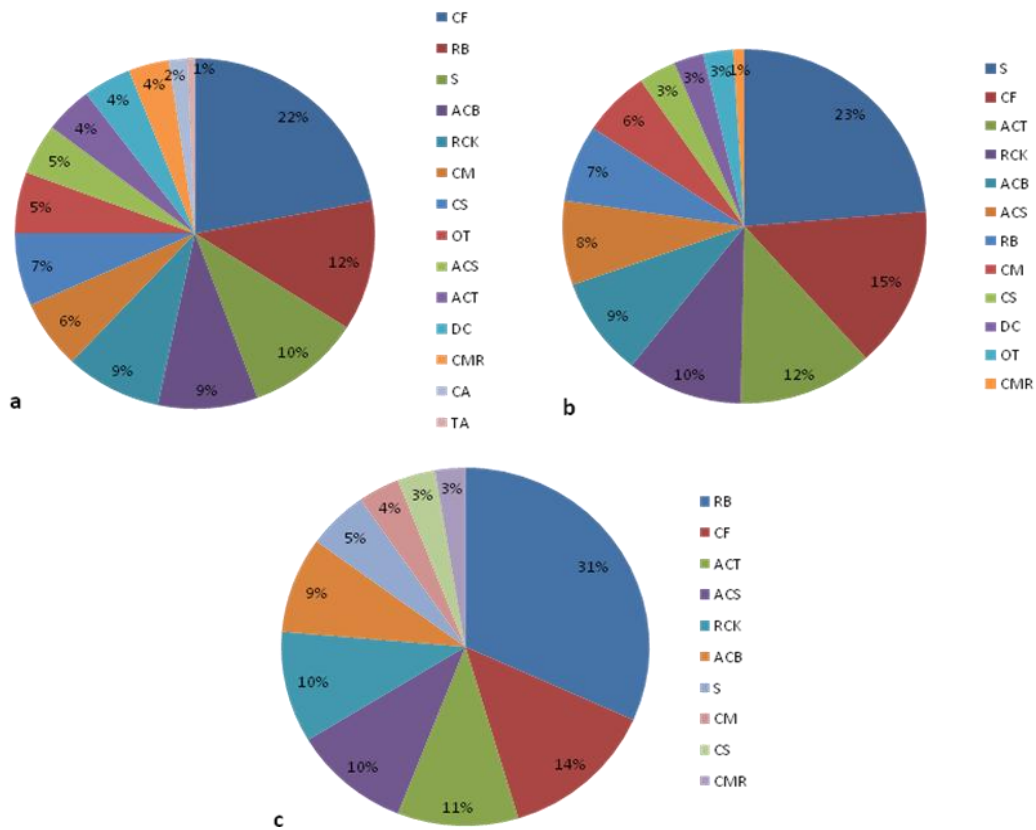

Figure 4. Coral Reef Percentage

Description: a) Zone A, b) Zone B, c) Zone C

CF: Coral foliose	RCK: Rock	ACS: Acropora sub massive	CA: Caroline algae
RB: Rabble	CM: Coral massive	ACT: Acropora tabulate	TA: Truf algae
S: Sand	CS: Coral submassive	DC: Dead Coral	
ACB: Acropora branching	OT: Other	CMR: Coral mushroom	

Figure 5. *Acropora* Coral Reef
Description: a) Acropora Branching (ACB), b) Acropora Tabulate (ACT), c) Acropora Submassive (ACS)

Figure 6. Coral Reefs Disturbance in Penuktukan village

Diversity of Coral Reefs

Based on the observation it is clear that Coral Foliose types was dominant. Visually, these coral types can be observed through the coral with skeletal form approximates broad flattened plate. The dominant of Coral Foliose can affect the water quality, especially in turbidity aspects. The high turbidity of sea water lead to the reefs species produce lime which lead the development of Coral Foliose.

Diversity index (H') of coral reefs ranging from 1.754 to 1.814; while the evenness index (E) was ranging from 0.8435 to 0.9468 (Table 1). The diversity of coral reef was medium. Compared to the other diving sites, the diversity level of coral reef in Penuktukan should be increase through numerous conservation programs, including reef transplantation [11].

Table 1. Diversity and Evenness Indices of Coral Reefs Ecosystems in Three Zones

Zone	Indv	Total	E	Class	H'	Class
A	8	64	0.87	High	1.81	Med
B	8	36	0.95	High	1.97	Med
C	8	43	0.84	High	1.75	Med

The highest number of species and complexity provides spectacular seascapes which are become main target of tourist. The evenness index shows that the underwater environment of Penuktukan was similar, and there are no single sites with unique characters. In the perspective of tourist's satisfaction, the diversity of coral reef provide the physical complexity that important to increase under-water destination competeveness. The diversity level is important and contribute significantly in divers satisfaction It is especially relevant with the motives of divers to joint marine tourism program, in which divers explore the diversity and uniqueness of coral reefs [12].

Population Structure

The structure of population significantly shows the health of ecosystem. This indicators often used to evaluate the ecosystem integrity in destinations. The evaluation of fish population will contribute to the marine management, especially in sustainable tourism development issues. Fish observation was done in similar observation sites to assess coral reef. The structure and composition of fishes was given in Table 2. From these data, it is clear that the number of observed fish was lower compared to the standard indicator. The observed fish was less than 25 individual. These fishes taxonomically belong to *Serranidae*, *Lutjanidae*, *Letherinidae*, *Caesionidae*, *Scaridae*, *Haemulidae* and *Chaetonodae*. This data indicated that the potential of fish in Taman Segara was less. *Serranidae*, *Lutjanidae* and *Chaetonodae* consistently found in three observed station with significant amount of density, indicate that the fishes easily able to observed by divers.

Less number of fishes seems to be related with the fisherman activity. In the field, it is observed that the exploitation of fish without considering the stock and sustainability of fish lead to the limited number of fish in observation area. Poor of fisherman understanding about coral reef conservation and sustainable fishing becomes the limitation of coral reef conservation. It is also has positive relationship with the competitiveness of dive sites.

We consider that the carrying capacity of Penuktukan underwater ecosystem use for tourism is important [13]. As far, the carrying capacity of marine tourism has been few discussed. There are few attention to the abundance number of visitor in marine environment which area potentially affect the degree of sustainability.

Table 2. Fish Family in Penuktukan Marine Area

No	Family	Rdi (%) Abundance (%)				D ind.m^{-2}			
		Zones				Zones			
		A	B	C	∑	A	B	C	∑
1	*Serranidae*	15.8	12.0	23.6	17.4	0.013	0.0040	0.0120	0.012
2	*Lutjanidae*	17.4	20.0	7.8	15.0	0.014	0.0066	0.0040	0.004
3	*Letherinidae*	4,7	4.0	2.6	3.9	0.004	0.0013	0.0013	0.001
4	*Caesionidae*	9.5	0.0	15.7	9.5	0,008	0.0000	0.0080	0.008
5	*Scaridae*	9.5	16.0	28.9	16.6	0.008	0.0053	0.0146	0.014
6	*Haemulidae*	3.2	4.0	0.0	2.3	0.002	0.0013	0.0000	0.000
7	*Chaetonodae*	39.6	44.0	21.0	34.9	0.033	0.0146	0.0106	0.010
	Total	100.0	100.0	100.0	100.0	0.084	0.0333	0.0506	0.500

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The success of marine tourism in Penuktukan Bali is especially related with the quality of coral reefs ecosystem. Issue to maintain and conserve coral reef should become the priority program for marine tourism development. Recently, there is emerging consensuses that marine tourism should be following sustainable marine tourism principles. It is especially relevant to conserve marine creature in Penuktukan, while in the same time program to increase local economic development can be implemented [14].

CONCLUSION

Marine environment in Penuktukan has its potentiality to developed as marine based tourism destination. Coral reefs and fish is the crucial resources for marine tourism development in Penuktukan. The foliose coral was dominant in Penuktukan water. The coverage's of coral reef in zone A (Angel canyon) was about 64% (good), in zone B (Coral starway) was about 40% (fair) an in zone C was about 43% (fair). Tourism contribute to the coral reef disturbance and recent coral reefs and fish diversity. Carying capacity should be performed to minimize tourism impact to marine ecosystem, including coral reefs and coral fish. Marine tourism in Bali need the comprehensive planning and management. It s especially crucial because tourism activity potentially contribute to the coral reef degradation.

Recommendation

The management of Taman Segara in Penuktukan should increase the effort of conservation. Program should be paid to countermeasure the illegal harvesting and other human activity which area contributes to the coral reef degradation. The community in Taman Segara, Penuktukan village should be involved in coral reef conservation. Community-based tourism can be an effective strategy to involve community in coral reef conservation programs.

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