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The Condition of Coral Reefs Ecosystem in Poncan Gadang Island Sibolga City and Management Efforts

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ABSTRACT

Poncan Gadang Island is one of the islands in Sibolga City. The island is utilized by the community for various activities, such as beach tourism, underwater tourism and capture fisheries. This study aims to assess the coral reef condition of Poncan Gadang Island and provide recommendations for its management efforts. The research was conducted in February 2023 using the Underwater Photo Transect method to assess coral cover. The Underwater Photo Transect method was selected for its ability to provide permanent photographic records for further analysis, comparison over time and efficiency in capturing large- scale coral conditions. Management recommendations were analyzed using the SWOT analysis method. SWOT analysis was selected because provided a structured framework for management decision-making. The results indicated that the average percentage of live coral cover was 24.01%, classifying the coral reefs as damaged condition. This degradation is likely influenced by anthropogenic activities and environmental stressors. Based on the SWOT analysis, it is recommended that Poncan Gadang Island's management address internal weakness to mitigate external threats. The SWOT analysis shows that management efforts should focus on addressing internal weaknesses, such as inadequate of local awareness and conservation policies to counteract external threats like unsustainable tourism practices and climate change. Implementing stricter tourism regulations, community- based conservation efforts and coral reef restoration for enhance reef resilience.

Keywords: Coral Reefs, Ecosystem, Management, Poncan Gadang,

1. Introduction

Sibolga is a city on the West Coast of Sumatra. This city has an area, a small part of which is land and the rest is sea. Even though it is known as a small town, the city of Sibolga has a lot of potential whose natural resources are still stored and are interesting to explore.

Sibolga, a coastal city, consists of several small islands, one of which is Poncan Gadang Island. According to the Directory of Indonesian Small Islands (2012), administratively, the island is included in the Pasar Belakang Village area, Sibolga Kota District, Sibolga City, North Sumatra Province. This island is one of the tourist destinations in Sibolga City. The vegetation that grows is dominated by coconut plants, grass, bushes, seagrass, mangroves and other higher plants. This island is an island with a population of around 23 people or 12 families. There are cottages and several taverns equipped with simple docks for boats to dock.

The marine potential of Poncan Gadang Island is so large that many people use it for various activities, such as beach tourism, underwater tourism, and capture fisheries. These activities make the waters around the island a key route for ship transportation, a fishing ground and an underwater tourism site. uman activities such as careless anchor deployment, illegal fishing practices, and irresponsible behavior by tourists pose serious threats

to the coral reef ecosystem. The growing intensity of these activities on Poncan Gadang Island raises concerns about potential damage to its coral reefs. In response to these threats, it is essential to conduct a study assessing the current condition of the coral reef ecosystem on Poncan Gadang Island. The findings from this study can serve as a valuable reference for future management and conservation efforts aimed at protecting and sustaining the island's coral reefs.Despite its ecological importance, limited studies have assessed the current state of coral reefs in Poncan Gadang Island. Understanding the extent of degradation is crucial for implementing effective conservation strategies.

1. Methods

2.1. Time and Description of Research Locations

The research was conducted in February 2023. Data sampling was carried out on Poncan Gadang Island Sibolga and was a one-time sampling on a day, covering multiple research sites.

Poncan Gadang Island is situated at coordinates 01º42'38" N and 98º45'52" E. Administratively, it falls under Pasar Belakang Village, Sibolga Kota District, Sibolga City, in North Sumatra Province. The research site was selected using the Purposive Sampling method, with sampling points chosen based on the existence of coral reefs and human activities around the research area. This method ensured that the study included both areas influenced by anthropogenic activities and those that remain relatively undisturbed, allowing for a thorough evaluation of coral reef conditions. The location of the research stations is illustrated in Figure 1.

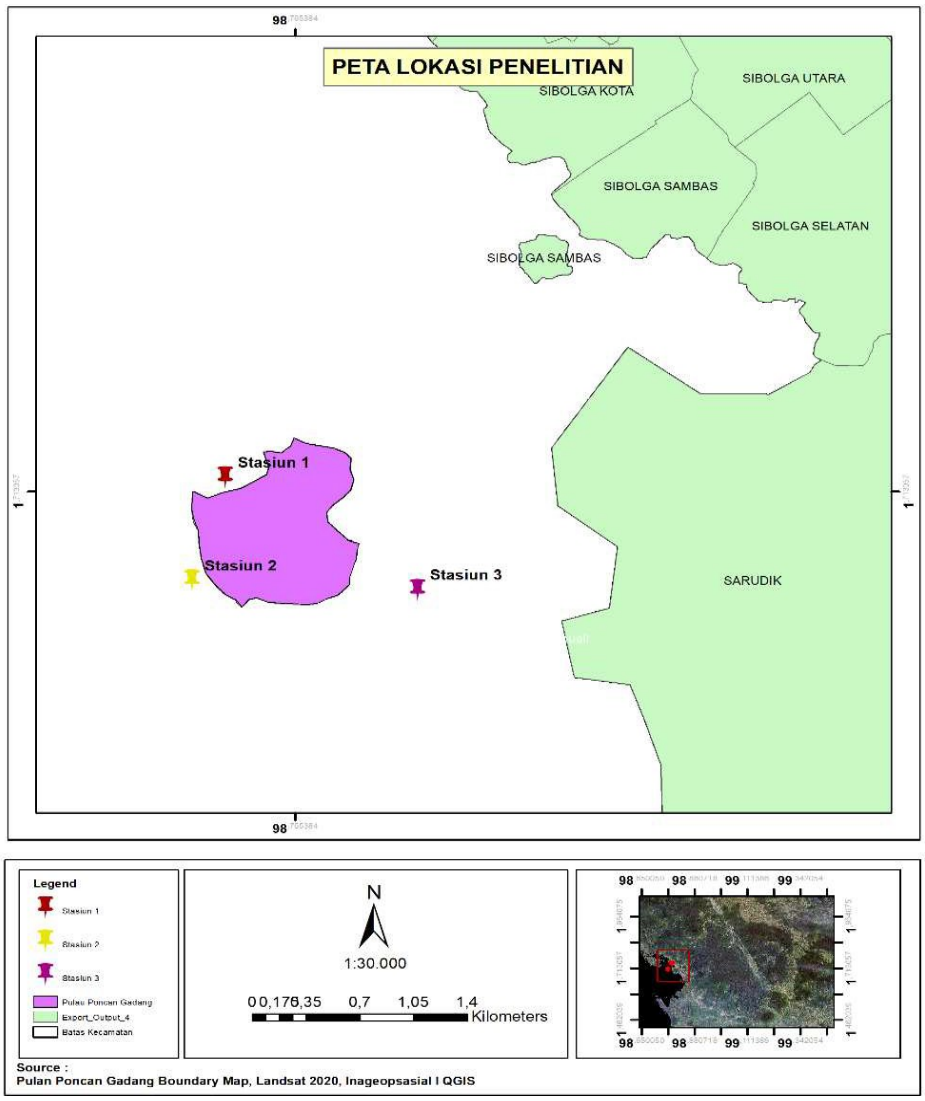

Figure 1. Map of the research location

2.2 Tools and Materials

This research utilized a range of tools, including SCUBA diving gear, boats, underwater cameras, roll meters, GPS devices, transect frames (iron frames measuring 58x44 cm), refractometers, pH meters, dissolved oxygen (DO) meters, thermometers, stopwatches, measuring balls, Secchi discs, underwater writing tools, laptops, and CPCe software. The materials observed during the study included various types of coral, reef fish, and megabenthos species found within the coral reef ecosystem surrounding Poncan Gadang Island.

2.3 Methods for Retrieving Water Physics and Chemistry Data

Researchers collected physical and chemical water data through direct field measurements using various instruments, with all results recorded on-site in real time. The limiting factors identified during the study are presented in Table 1.

Table 1. Physical and Chemical Parameters of Water

Parameter	Material	Unit	Measurement
Temperature	*Thermometer*	ºC	*In situ*
pH	pH meter	-	*In situ*
DO	DO meter	mg/L	*In situ*
Brightness	*Secchi disc*	M	*In situ*
Salinity	*Refractometer*	Ppt	*In situ*
Depth	*Deep Gauge*	M	*In situ*
Surface Current	Guess Ball	m/s	*In situ*

2.4 Coral Lifeform Data Collection Method

Coral lifeform data were collected using the Underwater Photo Transect method, which involved capturing underwater photographs along a 50-meter transect line. A transect frame measuring 58x44 cm (covering an area of 2,552 cm²) was used to define the photo area. Photos were taken at 1-meter intervals along the transect, resulting in a total of 50 photo frames per station (Giyanto et al., 2014). Figure 2 provides an illustration of the data collection process using the Underwater Photo Transect technique.

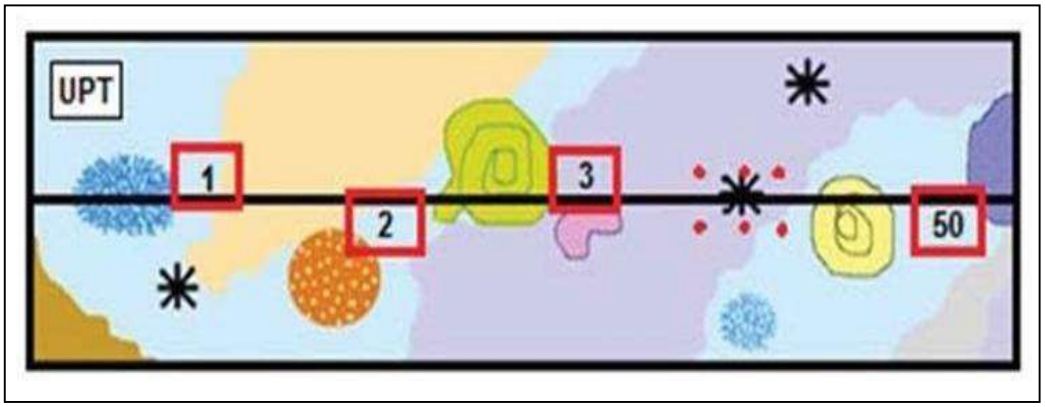

Figure 2. Illustration of the UPT (Underwater Photo Transect) Method (Giyanto et al., 2014).

2.5 Coral Lifeform Data Analysis

Researchers analyzed underwater photographs taken at 1-meter intervals along the transect line to determine coral cover percentages. Each photo frame was examined by selecting random point samples, a technique that involves defining a set number of random points for analysis. In this study, 30 random points were used per frame, which is considered sufficient to estimate the percentage cover of different substrate types and biological categories (Giyanto et al., 2014). Only the biota and substrates located precisely at the randomly assigned point positions, as generated by the CPCe software, were recorded for data analysis.

Based on the photo analysis process carried out on each photo frame, the percentage value of coral cover will obtained. Next, the category of coral reef condition will determined according to KepMenNeg LH No. 4 of 2001 concerning Standard Criteria for Coral Reef Damage which refers to the criteria presented in Table 2.

Table 2. Coral Reef Condition Categories

Coral Reef Condition Category	Percentage of Coral Lifeform
Very Good	≥75%
Good	50 - < 75 %
Moderate	25 % -< 50 %
Damaged	< 25 %

2.6 Analysis of Management Efforts

Management recommendations were developed using the SWOT analysis method, which applies a logical framework to optimize strengths and opportunities while simultaneously reducing weaknesses and mitigating threats (Rangkuti, 2001).

The SWOT analysis involved identifying a range of internal and external factors. Internal factors were derived from field observations, while external factors were gathered through discussions with local stakeholders, including fishers, tourists, and local agencies. These internal strengths and weaknesses were then compared with external opportunities and threats to formulate strategic management approaches for Poncan Gadang Island in Sibolga City.

Tabel 3. SWOT Analysis Matrix Model

Internal / External	Strength (S)	Weakness (W)
Opportunity (O)	S-O Strategy (Strategy that uses strength and takes advantage of opportunities)	W-O Strategy (Strategy that minimizes weaknesses and takes advantage of opportunities)
Threats (T)	S-T Strategy (Strategy thatuses force and overcomes threats)	W-T Strategy (Strategy that minimizes weaknesses and avoids threats)

(Source: Rangkuti, 2001).

3. Result and Discussion

3.1 Aquatic Environmental Conditions

The condition of coral reef ecosystems is greatly influenced by environmental factors that exist in the waters where coral biota live. Based on the results of measurements of several environmental factors in the waters of Poncan Gadang Island, parameter data was obtained as in Table 4.

Table 4. Results of Measurements of limiting factors for the coral reef ecosystem of Pocan Gadang

Paramater	Stations		
	I	II	III
Depth (m)	14	12	11
Temperature (°C)	29	30	30
Salinity (ppt)	33	33	32
DO (mg/L)	5,5	5,8	5,2
pH	8,4	8,4	8,3
Surface Current Speed (m/s)	0,116	0,267	0,133
Brightness (m)	4	6	8

Research on the coral reef ecosystem of Poncan Gadang Island was carried out at a depth of between 8-14 meters, where at station I at a depth of 14 meters, station II at a depth of 12 meters and station III at a depth of 11 meters. This is following the literature by Nybakken (1992) which states that coral growth is also limited by depth, good growth occurs at depths of less than 25 m. At a depth of 50 – 70 m coral reefs cannot develop well. This is what causes many coral reefs to be found in the waters around the edges of the islands.

The results of temperature measurements at each observation station range between 29-30 oC. This temperature condition is the optimal temperature condition for the coral reef ecosystem. Purba (2013) stated that coral reefs are generally found to be limited to water temperatures between 18-36oC, while the optimal value for coral growth ranges between 26-28oC.

The results of water salinity measurements at the three observation stations ranged from 32-33 ppt. The salinity levels in the waters of Poncan Gadang Island show agreement with the literature of Dahuri (2003) which states that in general, coral grows well in areas near the coast at a salinity of 30-35 ppt.

The DO value measured at stations I and II was 5.5 mg/L, while the DO value at station III was 5.2 mg/L. DO levels in the waters of Poncan Gadang Island range between 5.2 mg/L – 5.5 mg/L, with this value the DO content for coral growth in the waters of Poncan Gadang Island is good for coral growth. Based on KEPMEN LH No. 51 of 2004, the DO level that is good for the survival of marine biota is more than 5 mg/L.

The pH value measured at stations I and II was 8.4, while the pH at station III was 8.3. According to the literature by Zamani and Maduppa (2011), the range of pH values suitable for coral reef growth is 7-8.5. Therefore, the pH value at each research station is suitable for coral reef growth.

Haruddin (2011) states that a good current for coral reef growth is < 20 cm/s (0.2 m/s). Current conditions at the research location have a range of 0.116-0.267 m/s, with an average current condition of 0.1915 m/s. Overall, the currents in the waters of Poncan Gadang Island are quite good for coral growth.

3.2 Conditions of Coral Lifeform

The types of life coral found in the waters of Poncan Gadang Island, Sibolga City are: Acropora Branching, Acropora Encrusting, Coral Branching, Coral Encrusting, Coral Foliose, Coral Heliopora, Coral Massive, Coral Millepora, Coral Mushroom and Coral Submassive. The percentage of coral lifeform found when observing coral reefs on Poncan Gadang Island can be seen in Table 5.

Table 5. Percentage of Coral Lifeform in Poncan Gadang Island

Category	Stations		
	I	II	III
Acropora Branching (ACB)	0.30%	0.93%	0.00%
Acropora Digitate (ACD)	0.00%	0.00%	0.00%
Acropora Encrusting (ACE)	0.00%	0.20%	0.53%
Acropora Submassive (ACS)	0.00%	0.00%	0.00%
Acropora Tabulate (ACT)	0.00%	0.00%	0.00%
Coral Branching (CB)	1.47%	1.80%	0.53%
Coral Encrusting (CE)	0.47%	5.13%	2.80%
Coral Foliose (CF)	0.53%	2.73%	2.80%
Coral Heliopora (CHL)	0.00%	1.30%	0.50%
Coral Massive (CM)	16.13%	8.57%	18.10%
Coral Millepora (CML)	0.17%	0.00%	0.00%
Coral Mushroom (CMR)	0.30%	0.97%	0.00%
Coral Submassive (CS)	5.77%	0.00%	0.00%
Coral Tubipora (CTU)	0.00%	0.00%	0.00%
Total	**25.13%**	**21.63%**	**25.27%**
Average		**24.01%**	

From the results, it is known that at station I the percentage of coral lifeform was 25.13%, at station II it was 21.63% and at station III it was 25.27%. The highest percentage of coral lifeform was at station III and the lowest was at station II. The percentage of each lifeform obtained from the three stations can be seen in Table 6.

Table 6. Percentage of Cover in Coral Reef Observations in Poncan Gadang Island

Category	Stasiun		
	I	II	III
Coral (HC)	25.13%	21.63%	25.27%
Recent Dead Coral (DC)	1.57%	4.40%	0.53%
Dead Coral with Algae (DCA)	10.23%	9.97%	16.30%
Soft Coral (SC)	0.00%	0.77%	0.10%
Sponge (SP)	0.00%	0.17%	0.00%
Fleshy Seaweeed (FS)	1.70%	20.20%	2.23%
Other Biota (OT)	0.80%	3.37%	1.37%
Rubble (R)	9.20%	12.37%	15.50%
Sand (S)	49.93%	26.40%	36.10%

Category	Stasiun		
	I	II	III
Silt (SI)	1.43%	0.00%	0.00%
Rock (RK)	0.00%	0.73%	2.60%
Total	**100%**	**100%**	**100%**

The percentage of coral lifeform shows the condition of the coral reef ecosystem. The higher the percentage of live coral obtained, the better the condition of the coral reef ecosystem in the waters. The condition of coral lifeform in the waters of Poncan Gadang Island is generally classified as damaged with an average percentage value of 24.01%. According to the standard coral reef condition categories, a coral cover of less than 25% is considered poor, indicating damaged condition.

3.3 SWOT Analysis Results

The results of the SWOT analysis were obtained from giving weights and ratings to each component of internal and external factors. The Internal Factors Evaluation (IFE) matrix model is used to describe strengths and weaknesses, while the External Factor Evaluation (EFE) matrix model is used to describe opportunities and threats.

Table 7. Internal Factor Evaluation Matrix

No	Strengths	IFE Matrix		
		Weight	Rating	Score
1	Good access	0.115	3.00	0.344
2	Good facilities and infrastructure	0.075	3.00	0.225
3	Community knowledge are good	0.097	3.00	0.291
4	Coral reef conditions are potentially good	0.145	2.00	0.291
	Total			1.151
	Weaknesses			
1	Lack of community participation	0.145	3.00	0.436
2	Poor supervision activities	0.128	3.00	0.383
3	The existence of fish is not abundant	0.145	3.00	0.436
4	Law enforcement is not strict	0.150	3.00	0.449
	Total			**1.704**
	Total	**1**		**2.855**
	X= (S-W)			**-0.533**

Based on the results of rating and weighting each component in the IFE matrix table, the total strength score is 1.151 and the number of weakness scores is 1.704 with an accumulated strength and weakness score of 2.855.

Table 8. External Factor Evaluation Matrix

No	Opportunities	EFE Matrix		
		Weight	Rating	Score
1	Potential as a tourist destination	0.157	3.00	0.471
2	The community supports tourism development	0.100	3.00	0.300
3	There is support from the Central Government	0.114	2.00	0.229
4	There is participation from Universities	0.119	3.00	0.357
	Total			1.357
	Threats			
1	Increased visitors affect waste	0.191	3.00	0.571
2	Destructive fishing activities	0.091	3.00	0.271
3	Shipping activities that damage coral reefs	0.095	3.00	0.286
4	Global warming affects coral conditions	0.133	3.00	0.400
	Total			**1.529**
	Total	**1**		**2.886**
	X= (S-W)			**-0.172**

Based on the results of rating and weighting each component in the EFE matrix table, the total opportunity score is 1.357 and the total threat score is 1.529 with an accumulated opportunity and threat score of 2.886.

3.4 Management Efforts

The results of component analysis on the IFE and EFE matrix obtained the following results: the sum of strengths and opportunities (S+O) = 2.508, the sum of weaknesses and opportunities (W+O) = 3.061, the sum of forces and threats (S+T) = 2.680 and the number of weaknesses and threats (W+T) = 3.233. Based on the results of the calculation, it was concluded that the W+T strategy was the largest score result so it was chosen as the management strategy of Poncan Gadang island. The WT strategy shows that in the management of Poncan Gadang island, it is recommended to carry out a strategy by taking advantage of internal weaknesses to overcome external threats.

Based on the results of the evaluation carried out, a strategic plan for efforts to manage Poncan Gadang Island was obtained, which can be seen in the table 9.

Table 9. SWOT Matrix

		***Internal Factor Evaluation* (IFE)**	
	SWOT Matrix	**Strength (S)** 1. Good access 2. Good facilities and infrastructure 3. Community knowledgeare good 4. Coral reef conditions are potentially good	**Weakness (W)** 1. Lack of community participation 2. Poor supervision activities 3. The existence of fish is notabundant 4. Law enforcement is not strict
***External Factor Evaluation* (EFE)**	**Opportunities (O)** 1. Potential astourist destination 2. The communitysupports touristdevelopment 3. There is supportfrom the CentralGovernment 4. There is participation from the Universities	**S O Strategy** 1. Being a tourist destination location 2. Collaboration between the community and the management in the Poncan Gadang island tourism campaign 3. Collaboration with Universities by making Poncan Gadang island a marine education destination	**W O Strategy** 1. Counseling to the community in maintainingthe resources of Poncan Gadang island 2. Involving the responsibility of the Government and the community in the management of Poncan Gadang island resources
	Threats (T) 1. Increased visitorsaffect waste 2. Destructive fishing activities 3. Shipping activities thatdamage coralreefs global warmingaffect coral reefscondition	**S T Strategy** 1. Counseling, reminders and strict action for individuals who throw garbage carelessly 2. Creation of garbage disposal 3. Restricting cross-shipping lanes Coral reef transplant activities	**W T Strategy** **1.** Carry out community-based management so that the local community plays an active role in dealing with problems on the island of Poncan Gadang, for example routine beach cleanup activities **2.** Creation of a zone for theresource utilization of Poncan Gadang island **3.** Establishment of institutions in the context of monitoring coral reef ecosystems

4. Conclusions

The research found that the percentage of coral lifeforms observed on Poncan Gadang Island ranged from 21.63% to 25.27%, with an average coral cover of 24.01%. These findings indicate that the coral reef condition on the island falls into the damaged category. Based on the SWOT analysis, the recommended management approach is the W+T strategy, which suggests using internal weaknesses to address external threats. To implement this strategy effectively, the study recommends adopting community-based management that encourages local residents to actively participate in addressing environmental issues, such as through regular beach clean-up initiatives. Additionally, establishing designated zones for resource utilization and forming institutions focused on monitoring the coral reef ecosystem are essential steps to support sustainable management of Poncan Gadang Island.

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