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Percentage of Live Coral Cover in The Regional Water Conservation Area of the Sawo – Lahewa Water Tourism Park, North Nias District

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Abstract

Coral reefs are vital ecosystems facing serious threats due to climate change and human activities. This research aims to evaluate the condition of live coral cover in the Sawo-Lahewa Aquatic Tourism Park (TWP) Regional Marine Conservation Area (KKPD), North Nias Regency, as an important step in conservation and sustainable management efforts. Data was collected at 8 research stations using the Underwater Photo Transect (UPT) method. The research results show that the condition of coral reefs in this area is in the damaged to moderate category, with the percentage of live coral cover ranging between 12.33-45.37% and an average of 26.65%. The highest percentage of coral cover was found on Sarangbaung Island (45.37%) in the medium category, followed by Makora Island (42.13%), Gita Island (35.35%), and Lafau Island (31.07%). Meanwhile, locations with the lowest cover in the damaged category include Gosobaohi_01 Island (18.25%), Gosobaohi_02 Island (15.60%), Sifahandro Sea Waters (13.13%), and Bengkuang Bay Waters (12.33%). This research also looks at the abundance of coral juveniles, coral fish, and megabenthos to provide a broad picture of the health of the coral reef ecosystem. The results of this research can become a scientific basis for developing more effective management strategies. Apart from that, it is also a form of supporting conservation efforts, helping restore damaged ecosystems, and increasing the resilience of coral reefs to future environmental threats.

Keywords: Coral Reefs; Regional Marine Conservation Area; North Nias

INTRODUCTION

The initiation of reservations and the establishment of marine conservation areas are based on indications of threats to the sustainability of biological resources, decline in the ecological function of ecosystems and habitat damage in coastal areas and small islands. Apart from that, the reservation of marine conservation areas supports the sustainable use of resources and opportunities for local communities to play an active role in their management. In reality, pressure on water resources can occur naturally, such as natural disasters or caused by human activities. Therefore, reserving and establishing marine conservation areas is very important to anticipate the crisis in coastal and small island resources, both short and long-term.

The reservation of marine conservation areas as a protection measure in Nias Regency, North Sumatra Province, during the COREMAP II Program, known as Regional Marine Conservation Areas (KKLD). The KKLD reservation has been determined through Nias Regent Decree Number 050/ /K/2007, covering coastal waters and small islands in Sawo and Lahewa Districts with an area of 29,000 ha. Per the applicable regulations, the term KKLD has been changed to Regional Water Conservation Area abbreviated as KKPD. The next process is area zoning and preparing a management plan as a condition for determining the KKPD at both regional and national levels. In its development, the follow-up to the formation of the KKPD did not go as expected, one of the contributing factors was the expansion of Nias Regency into

several districts/cities in 2009, thus making the KKPD increasingly neglected. In terms of current administration, the KKPD location that has been reserved is entirely in the waters of North Nias Regency, as one of the districts resulting from the expansion, and is the responsibility of the district to follow up on proposals and manage them. To protect, preserve and utilize the potential of fisheries and important habitats such as coral reefs, mangroves and seagrass as well as important species such as turtles, dolphins, manta rays, napoleon, lola, dugong, clams, whale sharks, sea bamboo, roots bahar, goat's head, trumpet triton, sea cucumber and hollow nautilus, to support efforts to develop water tourism and recreation, it is necessary to conserve the Sawo Lahewa water area and the surrounding waters of North Nias Regency in North Sumatra Province.

The natural disaster of the earthquake and tsunami that occurred on the coast and small islands of the northwestern part of Sumatra on 26 December 2004 had a negative impact on the aquatic environment and its ecosystem. Coral reef ecosystems, coastal ecosystems, and other small islands in North Nias waters experienced much damage and reduced area due to the pressure of currents and waves from tsunamis and earthquakes. The aftershock event without a tsunami in March 2005 on Nias Island resulted in land lifting starting at 2.5-2.9 meters, so the land area increased. Still, the area of reefs and other ecosystems decreased (Wilknson et al., 2006). CRITC-LIPI (2006) reported that coral conditions before the earthquake and tsunami in May-June 2004 in several locations (Lahewa and Sawo, 6 stations) were quite good to good, with an average live coral cover of 48.31%. Still, after the earthquake, conditions declined drastically, whereas until 2008, conditions were not good, with an average live coral cover of only 19.82% (Siringoringo & Budiyanto, 2008). Protection of the aquatic environment and ecosystem along the coast and small islands of North Nias after the 2004-2005 earthquake and tsunami must be done to reduce human-induced pressure and give the ecosystem a chance to recover.

The exploitation of natural resources in coastal areas and small islands on a large scale without considering their sustainability has an impact on reducing the quality of the environment in these areas, including coral reefs. According to research results from the LIPI Oceanology Development Center (P2O) conducted in 2000, the condition of Indonesia's coral reefs was 41.78% in damaged condition, 28.30% in moderate condition, 23.72% in good condition, and 6.20% in very good condition. This shows that there has been considerable pressure on the existence of coral reefs in Indonesia in general by various threats and factors that cause damage.

Efforts to manage coral reefs in the context of managing Regional Marine Protected Areas (KKLD) are part of the management of coastal areas and small islands based on the Marine, Coastal and Small Island Spatial Planning Plan, which is the authority of the Regional Government of Bengkayang Regency as regulated in Law Number 32 of 2004 concerning Regional Government. Efforts to manage coral reefs require planning and development that is environmentally sustainable, covering coastal and marine areas and is community-based. The management of coastal areas and small islands itself, according to Law Number 27 of 2007, is defined as a process of planning, utilization, supervision and control of Coastal and Small Island Resources between sectors, between the Government and Regional Government, and between ecosystems. Land and sea, as well as between science and management to improve community welfare. This research aims to see the condition of the percentage of coral cover, coral fish, megabenthos and coral saplings in the TWP Sawo – Lahewa

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Regional Water Conservation Area, North Nias Regency.

RESEARCH METHODS

The research was conducted on the West Coast of North Sumatra, namely the Marine Conservation Area of Sawo-Lahewa Aquatic Tourism Park, North Nias Regency. Data collection on the condition of coral reefs and coral fish was carried out at eight observation locations in the Sawo-Lahewa Regional Marine Conservation Area (KKP), North Nias Regency (Figure 1). The locations are: Lahewa District and Sawo District. This research was conducted from December 2022 to May 2023.

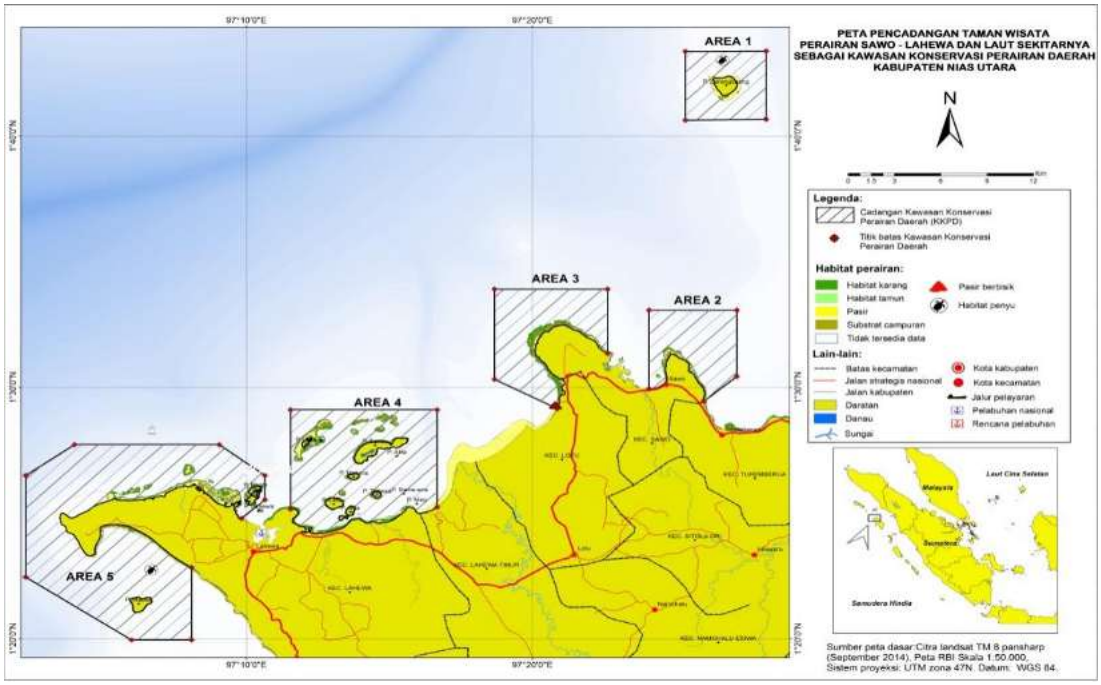

Figure 1. Map of KKPD TWP Sawo - Lahewa Research Locations, North Nias Regency

The equipment used to collect ecological data in the field in this research consisted of a rubber boat, transect (50 m), quadrat transect (1x1 m), Global Positioning System (GPS), underwater digital camera, underwater stationery, diving equipment using Self-Contained Underwater Buoyancy Apparatus (SCUBA), and equipment for collecting water parameter data. Meanwhile, a questionnaire was used to collect socio-economic and institutional data.

To collect data on live coral cover, the methods used in this research, the Underwater Photo Transeck (UPT) and Underwater Visual Cencus (UVC) methods for collecting data on coral fish and mega benthos and data on coral saplings (young coral) carried out using the method quadrat transect, recorded using 1 m x 1 m. This research was carried out using SCUBA tools. Data collection at each point uses an underwater camera such as a G16 or Olympus TG 6. Using the UPT method can shorten the time for data collection in the field so that divers do not need to spend a long time diving underwater. The photos can also be used as documentation or archive photos, which can be viewed again at any time (Giyanto, 2010).

The data collection method is carried out as follows (Figure 3.2). First, stretch the roll meter 50 meters long parallel to the coastline at a depth of 2-10 meters, then take pictures on the coral frame odd for the

left and even for the right (Figure 3), then take pictures at a height of approximately 1 meter above coral frame that will be photographed in the water. Then, the photos are corrected with the Photoscape application. Correction aims to correct the area of the image in the photo according to the appropriate size in the field. Correction is useful for clarifying images and reducing errors influenced by weather, brightness, currents and waves when taking photos in the field. The corrected image was then digitized using CPCe 4.0 software to classify corals based on the photos taken; then, to determine the percentage of live coral (HC), the percentage was calculated using Microsoft Excel 2010 software.

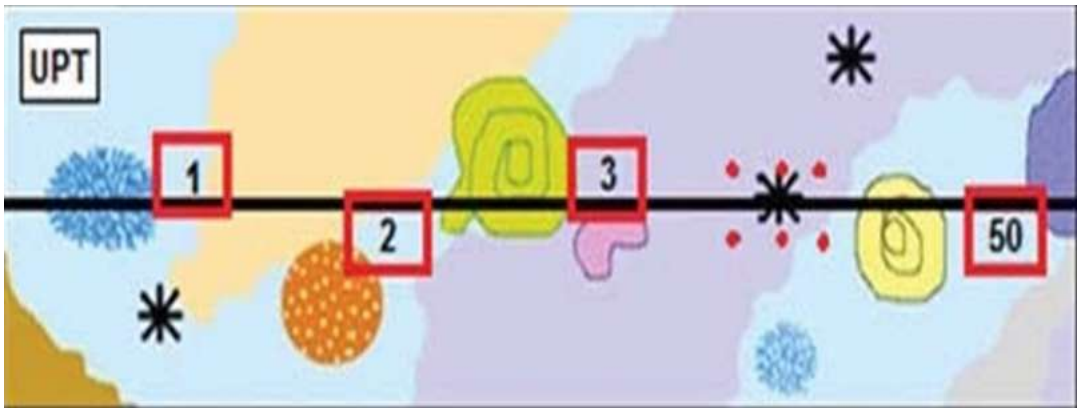

Figure 2. Illustration of the Use of Transect Frames

Reef fish data were collected using a modified Underwater Fish Visual Census (UVC) method adopted from English et al. (1997), fish were observed on a roll meter stretched 70 meters long. Reef fish abundance was measured visually at a radius of 2.5 meters to the left and right along the transect line for fish measuring > 10 cm, and for fish, < 10 cm, data was collected at a radius of one meter to the left and right.

Megabenthos data collection using the Underwater Fish Visual Census (UVC) method was observed on a 70-meter-long roll meter.

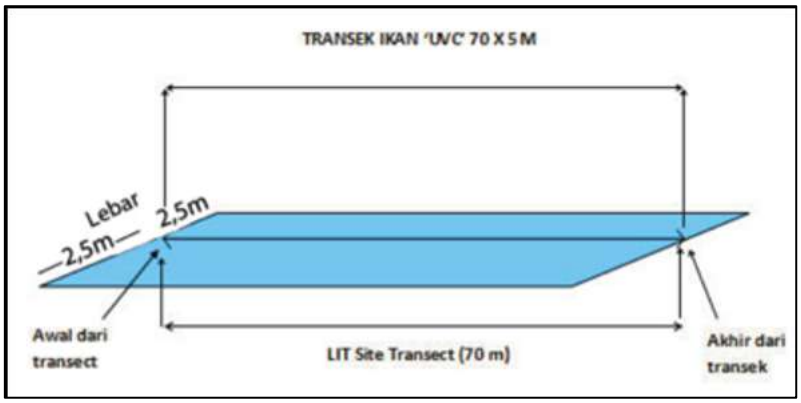

Figure 3. Illustration of the Underwater Visual Census Method

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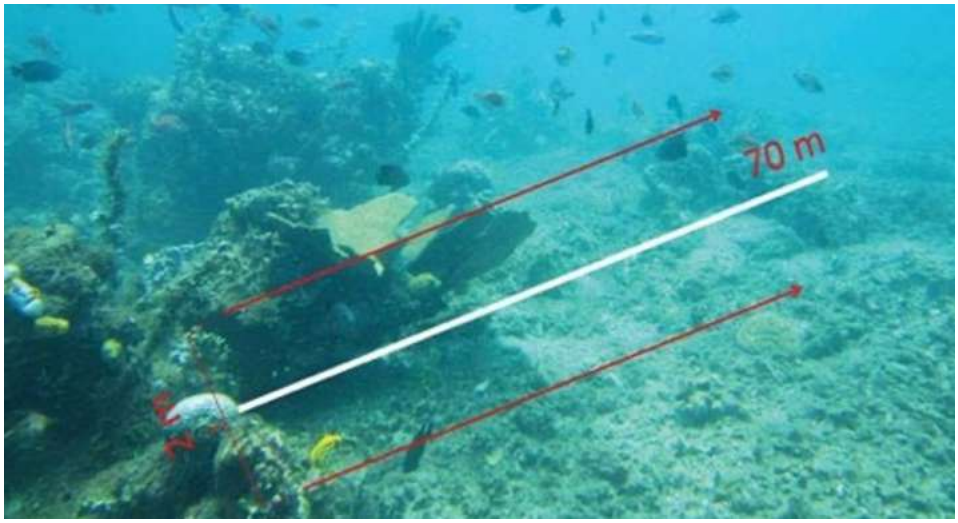

Figure 4. Illustration of the Underwater Visual Census Method

Data collection on coral saplings (young coral) was carried out using the quadrat transect method, recorded using 1 m x 1 m placed on benthic substrate transects following coral cover transects at 10-meter intervals (Hill and Wilkinson 2004).

Percentage of Live Coral Cover

Coral data analysis was obtained using the UPT underwater photo transect method, which was processed using the Coral Point Count for Excel (CPCe) data processing application version 4.0. with a total of 30. Corals measuring <10 cm were counted in each quadrat transect. The quadrat transects are laid at points 10, 20, 30, 40 and 50 m. Observations of coral saplings (young corals) are carried out in line with coral observations. Random points in each photo data for a total of 50 photo data (Kohler & Gill, 2006). Each point is identified according to the code for each biota group and substrate in Table 1 (Giyanto, 2013).

Table 1. Code for Each Group of Coral Reef Growth Forms

Code	Information
H.C	Hard Coral = Live Hard Coral = AC+NA
- AC	Acropora = rock coral Acropora genera: ACB, ACD, ACE, ACS, ACT
- NA	Non-Acropora = corals other than the Acropora genera: CB, CE, CS, CF, CHL, CM, CME, CTU, CMR
D.C	Dead Coral = dead coral
DCA	Dead Coral with Algae = dead coral that has been overgrown with algae = DCA + TA (Turf Algae)
S.C	Soft Coral = soft coral
SP	Sponge = sponge
F.S	Fleshy Seaweed = algae = MA (Macro Algae) + AA (Algae Assemblage)
OT	Other Fauna = other fauna = CA (Coraline Algae) + HA (Halimeda) + ZO (Zoanthid) + OT
R	Rubble = coral fragments
S	Sand = sand
SI	Silt = mud
R.K	Rock = rocks

Based on the photo analysis process carried out on each photo frame, the percentage value of the coral category cover for each frame can be obtained, calculated based on the following formula:

$$Category\ Cover\ Percentage = \frac{(the\ number\ of\ points\ of\ the\ category)}{(the\ number\ of\ random\ points)}\ x\ 100\%$$

Abundance of Reef Fish

To determine the abundance of coral fish at each station it is calculated according to Hill and Wilkinson (2004) with the formula:

$$Reef\ Fish\ Abundance = \frac{\sum Fish\ Species\ Area}{Area}$$

Note:
Number of fish species = Individual (i)
Area = 350 m²
Data processing is carried out with the help of Excel and pivot tables.

Megabenthos Density

Megabenthos data contains several main parameters, such as the type or group of megabenthos fauna observed, the name/code of the station and the number of individual megabenthos fauna at each station. From these data, abundance is sought using the formula (Harvey, 2008):

$$Density\ X = \frac{(\text{total number of individuals X})}{belt\ transect\ area\ (140m^2)}$$

Growth of Coral Saplings

Coral saplings (young coral) are the number of new corals found at one observation location per unit area of the observation transect. The formula can calculate the abundance of selected communities:

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

Information:
Xi = Abundance of young coral i (colony/m²)
ni = number of i-th coral saplings at the observation station (colony)
A = Observation transect area (m²)

RESULTS AND DISCUSSION

Condition of Coastal Waters in North Nias Regency

Coastal Water Tourism Park Sawo-Lahewa Marine Conservation Area, North Nias Regency, is an area in the northern part of Nias Island with a coastline of ± 231 km from the village. In this research, there were 8 research stations which were used as places to measure water quality parameters. Based on the measurements carried out, the results of the quality of physical and chemical parameters in North Nias waters can be seen in Table 1.

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Table 2. Physical and Chemical Parameters of Water in North Nias

No	Station	Parameter							
		DO (mg/l)	Temperature (°C)	pH	Salinity (ppt)	Brightness (%)	Turbidity (NTU)	Current (cm/sec)	Depth (m)
1	Gosobaohi Island_01	8.65	29.70	8.30	33	70	1.16	9.00	6
2	Gosobaohi Island_02	8.29	28.90	8.25	33	60	1.05	8.90	6
3	Lafau Island	7.25	27.90	8.35	31	100	1.68	7.08	5
4	Gita Island	7.85	29.80	8.30	31	90	1.35	6.80	6
5	Makora Island	7.25	28.30	8.30	30	100	1.77	7.96	6
6	Sifahandro Sea Waters	7.70	28.90	8.30	30	80	1.18	8.26	10
7	Bengkuang Bay Sea Waters	8.10	29.00	8.40	30	90	1.17	9.62	6
8	Sarangbaung Island	8.65	30.10	8.00	29	60	1.11	10.94	10

Based on Table 2, the dissolved oxygen content ranges between 7.25 and 8.65 mg/l, temperature ranges between 27.90 and 30.10 oC, pH ranges between 8.00 and 8.35, salinity ranges between 29 and 33 ppt, brightness ranges between 60 and 100%, turbidity ranges between 1.05 and 1.77 NTU, currents range from 7.08 to 10.94 cm/sec, and depths range from 6 to 10m.

Dissolved oxygen (DO) is the level of oxygen dissolved in water expressed in units of mg/l. Dissolved oxygen measurements carried out in North Nias waters ranged from 7.25 – 8.65 mg/l. According to Minister of Environment Decree no. 51 of 2004 concerning sea water quality standardsThe concentration of dissolved oxygen that is good for marine biota is >5 mg/l. High and optimal DO values are important for maintaining adequate oxygenation processes for coral reef ecosystems. Decreased dissolved oxygen content to extreme levels can cause stress and mass death on coral reefs (Nelson and Altieri, 2019). Dissolved water oxygen comes from photosynthesis from marine plants and phytoplankton (Dewi et al, 2023).

The measurement results at the research location ranged from 27.90 – 30.10°C. Surface water temperatures generally range between 28 – 31°C (Schaduw, 2018). The temperature fluctuations obtained are thought to be caused by the influence of solar heat received by the surface layer of seawater. Apart from these factors, other influencing factors are surface currents, cloud conditions, evaporation, upwelling and convergence, especially in estuary areas and along the coast (Amri et al., 2014). Increasing seawater temperatures cause mass coral bleaching events, which can cause significant coral death and restructuring of coral reef ecosystems (Hughes et al., 2017).

The pH range between 8.00 – 8.35 obtained at the research station shows that the waters have a stable pH character that tends to be alkaline. This range is classified as normal in accordance with general marine pH conditions. Coral reefs are facing increasing pressure caused largely by rising sea temperatures and a global decline in pH. Temperature and pH positively correlate throughout the day due to solar heating and light-driven metabolism (Cyronak et al, 2019).

The salinity range is between 29 – 33 ppt. This range is within the normal range in general marine or saltwater

environments and has a salinity value above 30 ppt. Coral reefs can adapt to fluctuating salinity but are generally more suited to stable and natural salinity suited to marine habitats. Low salinity values can cause coral stress by losing the homeostasis control process, which causes a decrease in zooxanthellae and chlorophyll concentrations, thereby inhibiting growth and reproduction and resulting in the most severe impact, namely coral bleaching (Samlansin et al. 2020).

Brightness ranges from 60 – 100%. Brightness is quite important for coral reefs because they need sunlight to photosynthesize. High brightness can also allow coral reefs to grow well. Mainassy (2017) states that Murky water conditions cause low brightness values due to the large amount of suspended solids, one of which is domestic waste. This relatively high brightness value is followed by a low turbidity value obtained during the research, namely 1.05 – 1.77 NTU.

The current speed measured during the research ranged from 7.08 – 10.94 cm/sec, current is needed to distribute nutrients and oxygen. The coral reefs in this study are located at a depth of 5 -10 m, including the shallow sea category. This level of depth is considered good because corals need light to carry out photosynthesis. Generally, the intensity of light received by coral will decrease as the depth of the water increases (Purnama et al, 2020).

Coral Reef Coverage Percentage

The Regional Marine Conservation Area (KKPD) of the Sawo-Lahewa Aquatic Tourism Park is dominated by stretches of coral reef with a relatively sufficient percentage of live coral cover. These reefs are characterized by a sandy substrate with a fairly gentle slope at the bottom of the water. Coral reefs in this region are dominated by several genera, such as Acropora, Porites, and Heliopora.

The condition of coral reefs in the Sawo Lahewa marine conservation area, North Nias Regency, is in the damaged to moderate category (12.33-45.37%), so the average abundance is 26.65 in the damaged category, according to the Decree of the State Minister for the Environment Number 4 of 2001. Percentage The highest coral cover was found on Sarangbaung Island, namely 45.37% and was in the medium category, then followed by Makora Island (42.13%), Gita Island (35.35%), Lafau Island (31.07%) while Gosobaohi_01 (18.25%), Gosobaohi_02 Island (15.60%), Sifahandro Sea Waters (13.13%) and Bengkuang Bay Sea Waters (12.33%) have the lowest cover in the damaged category (Figure 4). The coral identification results are presented in Figure 5.

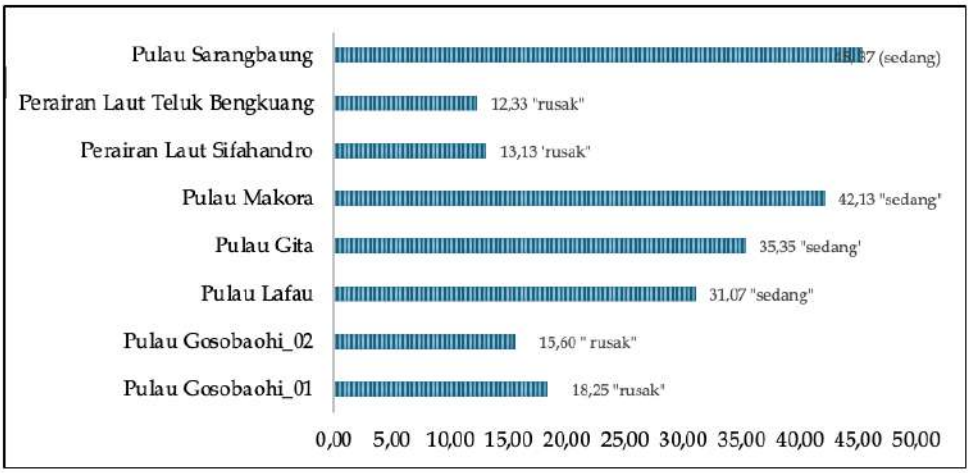

Figure 5. Percentage of Coral Reef Cover in the Sawo – Lahewa TWP Regional Water Conservation Area, North Nias Regency

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The high percentage of coral reef cover in the Sarang Baung Island area is because it is a special target location for the proposed re-reservation of the North Nias KKPD, which was not included in the initial reservation. The inhabited small island (around 4 families) is located in the northwestern part of Nias Regency at position 1°42'24.5387" N - 1°41'36.7829" N and 97°27'8.6218" E - 97 °26'17.2255"E. Administratively, Sarang Baung Island is included in the Sisirahili Village area of Siabang Bay, Sawo District, North Nias Regency, North Sumatra Province, consisting of one hamlet with 4 heads of families. The difficulty of access and limited educational and health facilities have caused the population on this island to continue to decrease, and it is currently uninhabited. Research results from the North Sumatra Province Maritime and Fisheries Service (2014) and the North Nias Marine Protected Area (KKPD) Final Review Report (2014) have the highest percentage of coral cover. Well-protected areas have gradually increased the growth of coral reefs. This is supported by Christie et al. (2002), who stated that there was a significant increase in live coral cover in protected areas.

The marine waters of Bengkuang Bay have the lowest percentage of coral cover compared to other stations. The low coral cover at this station is thought to be due to the high catch of coral fish, especially for potassium fishermen. Apart from that, this location is a location where coral reef growth is dominated by Porites and sand corals, making it difficult for new corals to grow in this area. For areas with low growth of live coral, more optimal management is needed than in other areas, such as providing new substrates to encourage the growth of coral saplings, transplanting corals so that coral growth is more diverse and reducing fishing activities so as not to disturb the growth of coral reefs in the area. Likewise, for the Sifahandro marine station, which has a low percentage of coral growth, Gosobaohi_01 Island and Gosobaohi_02 Island have a low percentage.

The growth of coral reefs at the North Nias KKPD location tends to be stable, although it is experiencing changes compared to the results in 2022. The percentage of coral cover in 2014 at this location occurred due to the recovery from the tsunami earthquake that hit Aceh Nias. Bombing and coral bleaching are also thought to influence coral bleaching still. Coral's ability to bleach takes a long time. McClanahan (2000) stated that research is still being carried out on the time required for coral bleaching to recover.

Slow coral growth and increasing algae cover make coral reef recovery difficult. The ability of coral reefs to recover is greatly influenced by water quality (Suharsono 1984) and human activities. According to Westmacot et al. (2000), coral reefs that are not disturbed by human activities have more ability to recover if supported by optimal environmental conditions for coral growth.

Coral cover conditions will increase in 2022 because coral reefs begin to adapt to temperature and the environment. Improving management systems also influences the increase in coral cover, one of which is by limiting fishing gear. Using fishing gear is the most appropriate step to preserve coral reefs and coral fish. This is in accordance with Simorangkir's (2015) statement that area management is the right step to help maintain coral growth.

Growth of Coral Saplings

The abundance of baby coral colonies at the time of observation was included in the very high category, with an average abundance of 10.23 colonies/m2. The abundance of baby coral colonies at each location was as follows: the highest abundance was at the Makora Island location, namely 16.6 colonies. /m2, then Sarang Baung Island has 14.6 colonies/m2, Gosobaohi_01 Island has 10 colonies/m2,

Gosobaohi_02 Island has 9.4 colonies/m2, Sifahandro Sea has 8.6 colonies/m2, Gita Island has 8.2 colonies/m2. m2, Lafau Island had 7.6 colonies/m2, which had the lowest growth of coral saplings in Bengkuang Bay Sea Waters, with 6.8 colonies/m2. The abundance of coral saplings can be seen in Figure 6 below.

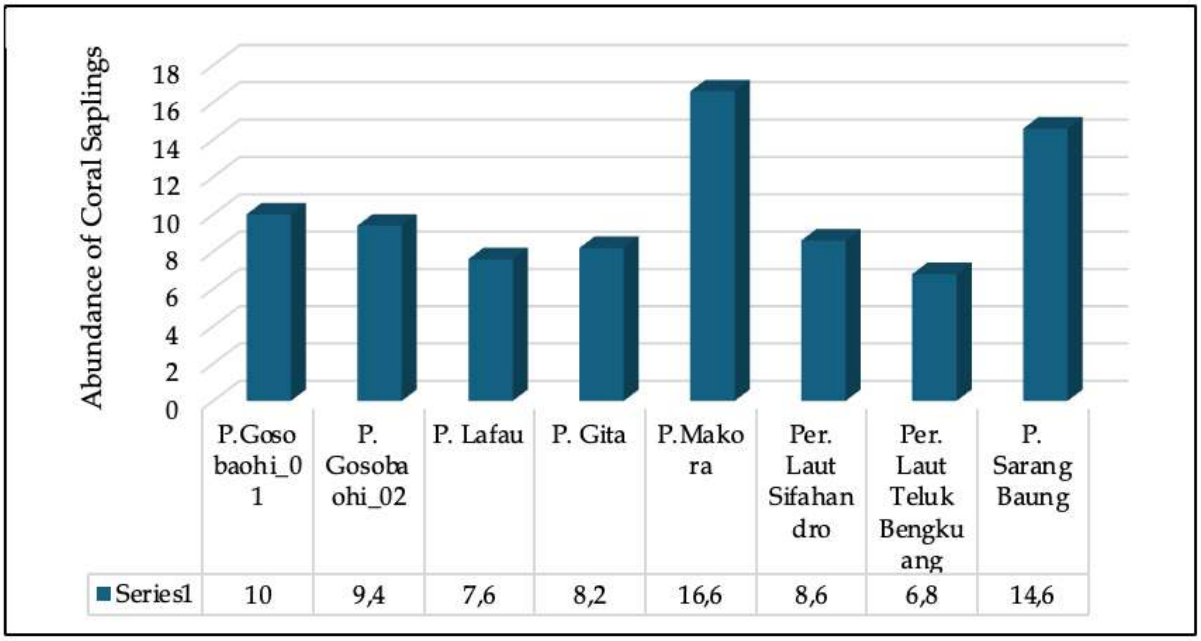

Figure 6. Abundance of coral saplings at the KKPD TWP Sawo Lahewa station, North Nias Regency.

The availability of coral larvae, good substrate and sufficient nutrients greatly influences the growth of coral saplings. The growth of coral recruitment identifies the recovery of coral reef ecosystems in an area. The low growth of coral recruitment is due to the high currents that occur during the East and Transitional seasons, which cause large sea waves. This is in line with the results of research studied by Suryanti et al. (2011), who stated that ecological pressure originating from nature in the form of large sea waves causes coral reefs to be damaged and uprooted from their substrate. In addition, the unstable condition of the substrate makes it difficult for coral recruits to attach. The growth of coral saplings (recruitment) in the Sawo Lahewa KKP DTWP, North Nias, was mostly found at the Makora Island station, with a growth of 43 types of coral saplings. The characteristics of the bottom of the waters greatly influence the success of coral recruits. These characteristics are related to the substrate type and space availability as a place for coral larvae to attach (Bachtiar et al. 2012). Timothy (2003) added that the water's bottom substrate condition greatly influences coral polyps' success in attaching and becoming new individual corals. The results of identifying and photographing coral saplings are presented in Figure 7.

Abundance of Reef Fish

The average abundance of coral fish in the Sawo Lahewa TWP KKPD, North Nias Regency, is 98 ind/350 m2 in the less abundant category. The abundance of coral fish can be seen in Table 3 below:

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Table. 3. Abundance of Coral Fish at each research station

No	Station (ind/350 m2)							
	District Lahewa					District Sapodilla		
	Gosobaohi Island_01	Gosobaohi Island_02	Lafau Island	Gita Island	Makora Island	Sifahandro Sea Waters	Bengkuang Bay Sea Waters	Sarang Baung Island
1.	83	73	82	103	141	85	62	156

Based on the data above, the highest abundance of fish is on Sarangbaung Island, namely ±156 ind/350 m2, and the location with the lowest abundance is in the Bengkuang Bay location, namely ±62 ind/350 m2 in the low category. This condition is due to the very high fishing in the Bengkuang Bay area. The higher the fishing, the lower the opportunity for fish to reproduce, affecting abundance. This is supported by the statement of Wang et al. (2016), improvements in fishing gear, increasingly sophisticated fishing technology and increased fishing have resulted in a decrease in fish biomass and size and low levels of target fish species. Charlton et al. (2008) added that reducing overfishing can protect the ecosystem

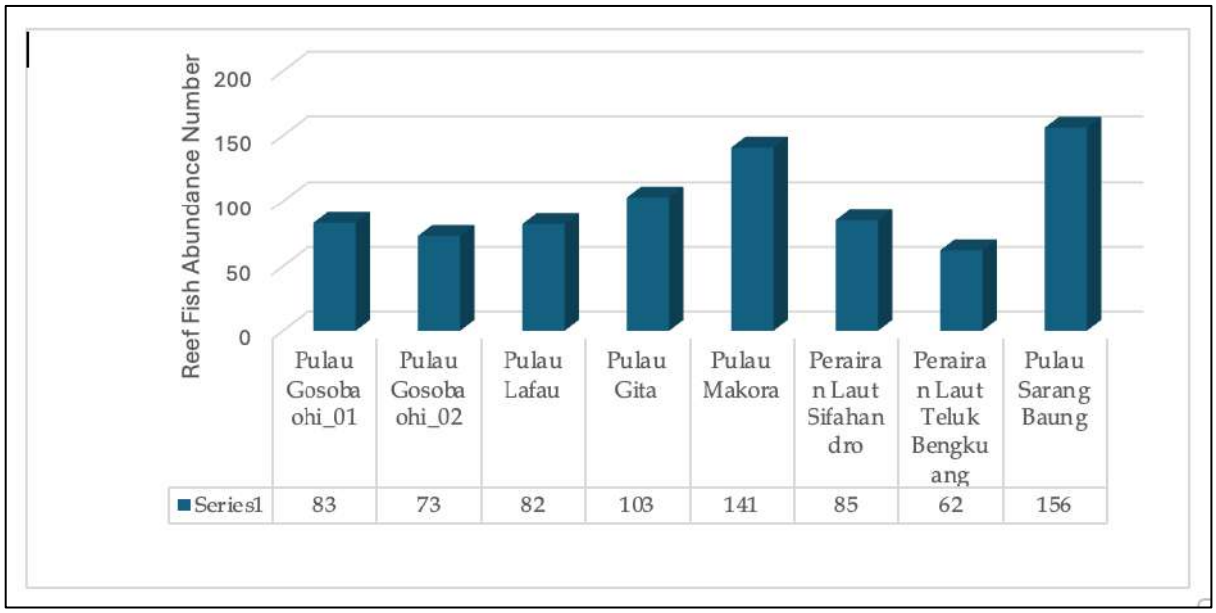
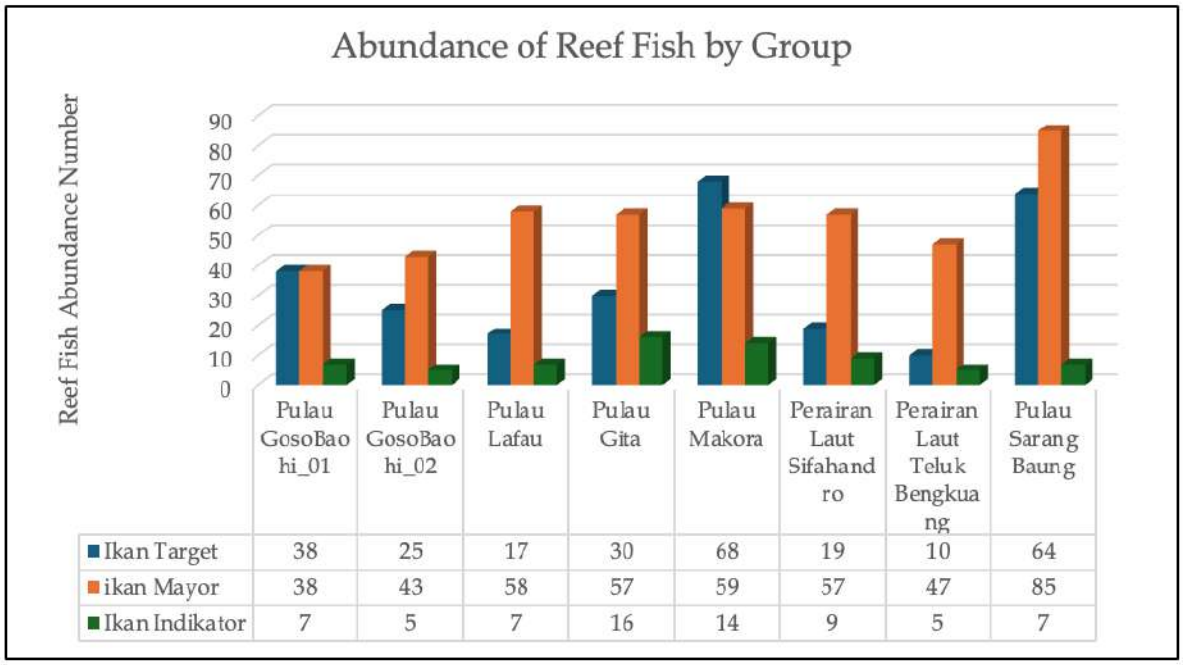


Figure 7. Abundance of coral fish in KKPD TWP Sawo Lahewa North Nias Regency

Sarang Baung Island is located at the tip of the West Coast directly facing the Indian Ocean, this location is a little far from residents. This area has a beach but has strong current movements because it is influenced by incoming and outgoing currents during tides. For this reason, fishermen rarely catch fish in this area, citing the distance and strong currents which make it difficult for fishermen to fish and shoot. Based on these conditions, it is suspected that there is a high abundance of coral fish on Sarang Baung Island. This is in accordance with the results of research conducted by Wang et al. (2016) showed that total fish biomass increased as fishing effort was shifted/reduced. Based on differences in the abundance of coral fish at each station, management of coral fish is also different. Stations with low fish

abundance such as Lafau Island, Gosobahoi_02 Island and Bengkuang Bay must reduce their fishing activities, so that the abundance of coral fish in the future remains stable. This is to prevent overfishing in certain areas, especially catching fish that fishermen target, such as grouper which has a high selling value. According to the community, grouper fish (Plectropomus leopardus) are rarely found in every area in the Sawo Lahewa TWP KKPD due to high market demand.

Measurements of coral fish were carried out based on three groups, namely major fish, target fish and indicator fish. Major fish are the fish with the highest presence in each research location with an average abundance of ±56 ind/350 m2, this number is much higher than the abundance of target fish which is only ±34 ind/350 m2 (Figure 3.5). The high abundance of major fish is due to the fact that the largest number of these fish are found in the waters. As in the families Pomacentridae, Balistidae and Labridae. These fish are most often found on coral reefs and have the most types, namely around 300 species. This fish is a diurnal group of fish (active during the day) and several types also live in groups (Terangi 2004).



	Pulau GosoBaohi_01	Pulau GosoBaohi_02	Pulau Lafau	Pulau Gita	Pulau Makora	Perairan Laut Sifahandro	Perairan Laut Teluk Bengkuang	Pulau Sarang Baung
Ikan Target	38	25	17	30	68	19	10	64
ikan Mayor	38	43	58	57	59	57	47	85
Ikan Indikator	7	5	7	16	14	9	5	7

Figure 8. Abundance of coral fish by group in KKPD TWP Sawo Lahewa North Nias Regency

Indicator fish are fish that show the health condition of coral reefs in an area. The abundance of indicator fish is seen from the abundance of Chaetodontidae fish. The higher the presence of these fish, it can be ensured that the condition of the coral reef will be healthier. The average presence of indicator fish in the area is 9 fish/350 m2, which indicates that it is in the medium category. This condition is thought to influence the abundance of coral cover in the area. The research results of Maharbhakti (2009) stated that the percent coral cover had a large influence on the abundance of Chaetodontidae fish. This result was strengthened by the results of analysis of the food found in the intestines of the fish, 52% of the contents of the intestines contained lime (from coral reefs). The reduction in Chaetodontidae fish also affects the abundance of Porites corals compared to branching corals. Maddupa's research results (2006) stated that Porites has a high density so that

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predation tends to be avoided by Chaetodontidae fish.

The presence of target fish at the research location is dominated by nocturnal fish (active at night), consisting of the Caesonidae and Serranidae families. Some fish from this family are solitary fish. Most of these fish hide in coral crevices as a place of shelter. Apart from that, this fish is a target catch for fishermen because it has very high economic value. This condition is thought to be the cause of the low presence of target fish when collecting data. Wang et al. (2016) stated that high fishing of certain target fish causes low abundance of target fish.

The results of observations of coral fish communities in the Sawo Lahewa TWP KKPD have an average diversity index of 2.510981 in the medium diversity category, an average uniformity index of 0.872207 in the high uniformity category and an average dominance index of 0.112134 in the low dominance category (Table 4). These results indicate that the level of fish diversity in the Sawo Lahewa TWP KKPD is moderate and not dominated by certain fish. According to the Shannon-Winner theory, if a good diversity index indicates high ecosystem productivity, the pressure on the ecosystem is reduced, and the ecosystem tends to be stable. Based on the number of species, it is categorized as less abundant because it has a total of 44 species from 11 families of coral fish.

Table 4. Diversity Index, Uniformity Index and Dominance Index at research stations

Species Name	Diversity Index	Uniformity Index	Dominance Index
	H`	E`	C`
1	2	3	4
Gosobaohi Island_01	2.501249	0.865373	0.108434
Gosobaohi Island_02	2.709726	0.920286	0.080128
Lafau Island	2.333281	0.841553	0.141880
Gita Island	2.546255	0.849961	0.105476
Makaro Island	2.901714	0.925441	0.065439
Sifahandro Sea Waters	2.250889	0.877557	0.141315
Bengkuang Bay Sea Waters	2.096526	0.843704	0.167534
Sarang Baung Island	2.748205	0.853778	0.086867

Megabenthos Abundance

Species Composition and Density of Megabenthos

From the results of observations at 8 monitoring stations, 8 types of target megabenthos were found. A total of 246 individuals/140 m2 target megabenthos have a distribution pattern as presented in Table 5 below:

Table 5. The Pattern of presence of megabenthic species at each station in the waters of North Nias Regency

Species Name	District Lahewa					District Sapodilla		
	Gosobaohi Island_01	Gosobaohi Island_02	Lafau Island	Gita Island	Makora Island	Sifahandro Sea Waters	Bengkuang Bay Sea Waters	Sarang Baung Island
1	2	3	4	5	6	7	8	9
Spiny Starfish	+			+				+
Sea	+	+	+	+	+	+	+	+

Urchins								
Sea Cucumber	+	+	+	+		+	+	+
Blue Starfish		+		+			+	+
Kima	+	+	+		+	+	+	+
Drupella Snail	+	+	+	+	+	+		+
Trochidae Snails	+	+	+	+		+		+
Lobster			+		+			+

The number of individuals of each species or group of megabenthos species obtained at all research stations shows that two species or groups of megabenthos are found in dominant numbers. The two species or groups of megabenthos species are sea urchins and Drupella snails. The density of all target megabenthos found, sea urchins were found at 0.71 ind/m2 (100 individuals), and Drupella snails were found at 0.61 ind/m2 (86 individuals). Meanwhile, species or groups of megabenthos species that were found in moderate numbers included sea cucumbers found at 0.11 ind/m2 (16 individuals), Trochidae snails found at 0.11 ind/m2 (16 individuals), clams found at 0.11 ind/m2. m2 (15 individuals), blue starfish were found at 0.04 ind/m2 (5 individuals), spiny starfish were found at 0.04 ind/m2 (5 individuals) and lobsters were found at 0.02 ind/m2 (3 individuals).

The data shows that the Gosongbaohi_01 Island observation station has the lowest percentage of megabenthos diversity compared to other observation stations. The only megabenthos found at the Bengkuang Bay waters station were sea urchins, numbering 27 individuals. The small diversity of megabenthos found at this location is possible because DCA and sand predominantly dominate the substrate conditions. In accordance with the nature of sea urchins as algae feeders, the presence of DCA is directly proportional to the number of sea urchins found along the transect.

CONCLUSION

Based on the results of the discussion above, this research concludes that the average per cent coral cover is 26.65%. The average fish abundance was 98 individuals/350 m2, the abundance of coral juvenile colonies was 10.23 colonies/m2, and the abundance of meganbenthos was 246 individuals/m^2 with fairly good water conditions.

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