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Grouper Fishery Management Options in the Waters of Mursala Island, Central Tapanuli District, Indonesia

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ABSTRACT: Sustainable fisheries are becoming increasingly difficult to achieve due to the decreasing ability of the aquatic environment to support the availability of fish resources [8]. In order to overcome the problem of fishery resource stocks, especially grouper fish, the Indonesian government, in this case the Ministry of Maritime Affairs and Fisheries (KKP), has also issued Decree of the Minister of Maritime Affairs and Fisheries No. 2021 on Grouper Fishery Management Plans in the State Fisheries Management Area of the Republic of Indonesia No. 2021 2021. With regard to the production value of grouper in Central Tapanuli, the availability of specific data on fishing units and operating locations is still not available. Information on the alleged pressure of fishing technology on the condition of the aquatic environment (coral reefs) and grouper fish resources on Mursala Island is still very limited. This means that studies to obtain information related to biological, environmental and technological aspects have a high urgency to be carried out so that they can be synchronized with the area management program of Mursala Island as a KKDP as well as a fishing area**.** The methods of observation and interviews are more focused on biological and technological aspects and environmental data. The research results show that the fishing activities in the waters around Mursala Island are characterized by fishing activities targeting coral fish with fishing gear in the form of traps, hand lines and arrows. The fish habitat in the form of coral reefs in the waters around Mursala Island has been degraded since 2004. The damage to the coral reefs is caused by the use of destructive methods such as bombs and toxic materials (cyanide).

KEYWORDS: Coral reefs, Biological, Fishing Technology, Grouper.

I. INTRODUCTION

Mursala Island is a Regional Water Conservation Area (KKPD) in Central Tapanuli Regency. This KKPD was established by the Decree of the Governor of North Sumatra No. 188.44/629/KPTS/2017 on the Reservation of Regional Water Conservation Areas in North Sumatra Province. The KKPD of Central Tapanuli Regency covers most of Tapian Nauli Bay and Mursala Island and its surroundings, covering an area of 81,243 ha. The KKPD of Central Tapanuli has also been outlined in the North Sumatra Province Regional Regulation No. 4 of 2019. The Mursala Water Area has also been selected as a Coral Reef Rehabilitation and Management Program (COREMAP) area since 2020.

The orientation of fishery business actors seems to be focused only on the goal of meeting market demand, so fishermen try to increase production volume. On the other hand, fishermen do not yet have information and guidance from the fishery management (DKP Tapanuli Tengah) on the size of fish suitable for catching that can maintain the sustainability of grouper fish resources. KP Ministerial Regulation No. 14 of 2021 on Fishery Product Standards has not yet been implemented by the fishery business actors (fishermen). This means that the fishermen need to be guided and educated on the options for using the grouper caught if the fish caught does not meet the market demand, one of which is through aquaculture development policy. This could be a solution to the rampant fishing of juvenile grouper, as the dominance of juvenile catches could potentially lead to a decline in stocks and even threaten the sustainability of grouper fish resources in Mursala waters. The results of the research on grouper resource management options are expected to provide opportunities for fishermen to participate in the conservation of the fish. The government and the community certainly hope that the grouper resource management options will preserve the stock and the survival of the fishermen in Mursala waters and its surroundings. Symbolon [1] further stated that the dominance of catches of fish in the category not yet biologically suitable for fishing (illegal size) can lead to growth overfishing and recruitment overfishing. As a logical consequence, the fish stocks in the waters decrease and, ultimately, the productivity of fishermen decreases.

Aspects of the aquatic environment, which is the habitat of grouper fish, are also important variables that need to be monitored in Mursala Waters. This is based on the idea that environmental degradation will have a direct impact on the decline in the potential of grouper fish and will ultimately

affect the sustainability of fishermen's businesses. Scientific evidence has shown that the degradation of the aquatic environment has an impact on the decline of fish stocks [1]. A decrease in fish stocks as a result of overfishing can also have an impact on decreasing production in the long term [2] and ultimately cause a shift (spatial change) in fishing areas [1].

High levels of exploitation combined with the use of non-selective fishing gear can potentially cause pressure on the SDI. This condition will affect the survival of grouper fish. However, studies to obtain information on the potential, catch productivity, level of exploitation and level of degradation of grouper in the waters of Mursala Island have never been carried out. On the other hand, the information obtained from preliminary research results shows that the fishermen's catches are decreasing and the size of the grouper caught tends to be smaller. These symptoms are considered to be an indication of the degradation of fishing areas [1].

The types of fishing gear used by fishermen to catch grouper in the waters of Mursala Island are traps, fishing rods and arrows [3]. These gears have different productivity because each gear has different catchability. Higher catchability is usually directly proportional to productivity. More productive gear will result in higher utilization rates. The annual production of grouper caught with traps, rods, and arrows tends to decrease during the 2017-2021 period (Figure 1).

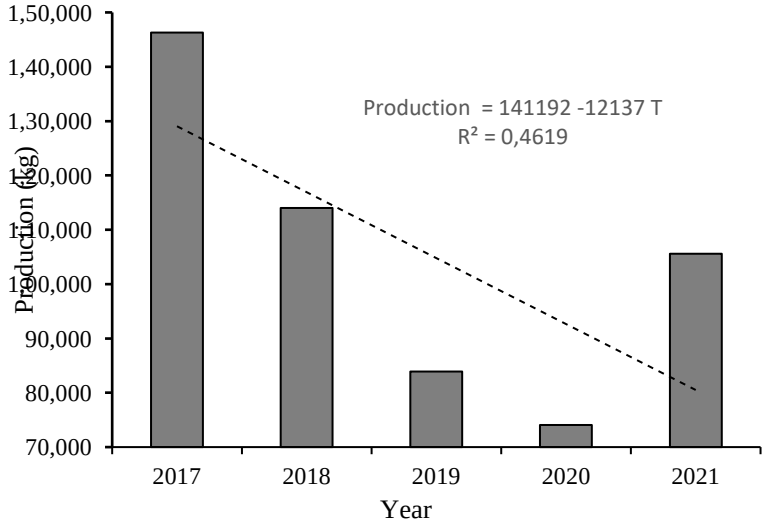


Figure 1. Annual production of grouper catches 2017-2021 [1]

The annual production of grouper fish in Figure 1 illustrates that the pressure on the environment and grouper fish resources in the waters of Mursala Island has reduced the productivity of the fishermen. Looking at the increase in grouper production in 2021, this naturally raises questions about the pattern of grouper exploitation. This increase could be due to increased fishing effort in the form of additional fishing units or expansion of fishing areas. However, this assumption still needs to be proven through research activities so that the results can be used as input for the government in formulating policies for managing the use of grouper fish resources on Mursala Island.

Fishing technology and the use of fishing gear that is less environmentally friendly and less selective may also raise concerns about the degradation, and even depletion, of grouper fish stocks in Mursala Island. [4] have made observations on the degradation of fishing areas based on biological indicators, which include fish length, and environmental indicators in terms of pollution levels. Changes in water conditions, which are the habitat of grouper fish, will affect the life and growth rate of the fish themselves [5]. [6] further stated that capture fisheries activities must pay attention to aspects of spawning, life cycle and sustainability of coral habitat.

Monitoring the extent and condition of coral reefs can be done either by surveying coral reef ecosystems or through remote sensing technology [7]. [1] classifies three main indicators that cause the degradation of fishing areas, namely biological, ecological, and technological indicators. Biological indicators can be assessed through fish stock potential, length and catch composition. Environmental indicators can be seen from the extent of coral cover. Technological indicators can be seen from the level of production of grouper fish resources, the efficiency of fishing operations and the effectiveness of fishing technology on target fish.

Sustainable fisheries are becoming increasingly difficult to achieve due to the decreasing ability of the aquatic environment to support the availability of fish resources [8]. In order to overcome the problem of fishery resource stocks, especially grouper fish, the Indonesian government, in this case the Ministry of Maritime Affairs and Fisheries (KKP), has also issued Decree of the Minister of Maritime Affairs and Fisheries Number 2021 concerning Grouper Fishery Management Plans in the State Fisheries Management Area of the Republic of Indonesia Number 2021 2021. Priority issues in the sustainable management of grouper fisheries are the following: (1) fish resource and environmental status; (2)

social and economic; and (3) governance. In capture fisheries, resource and environmental issues are often a concern. Resource and environmental issues include: (1) degradation of fish stocks and coral ecosystems, (2) use of fishing gear that has low selectivity, (3) limited data and information for grouper fisheries, and (4) identification of potential fishing areas and grouper species.

In the development and management of grouper fish resources in the waters of Mursala Island, Central Tapanuli Regency, namely to ensure the goal of optimal catches on a sustainable basis in the long term to achieve the objectives of the management of fishery resources in waters. If we look at the production value of grouper in Central Tapanuli, the availability of specific data on fishing units and operational locations is still not available. On the other hand, the reporting of fish catch certificates (SHTI) as described in fishermen's logbooks is also often manipulated [9]. Information related to the alleged pressure of fishing technology on the condition of the aquatic environment (coral reefs) and grouper fish resources on Mursala Island is still very limited. This means that studies to obtain information related to biological, environmental and technological aspects have a high urgency to be carried out so that they can be synchronized with the area management program of Mursala Island as a KKDP as well as a fishing area.

Based on the basic data/information on the biological, environmental and technological aspects mentioned above, an analysis of the problems, strengths, opportunities and constraints of the grouper fishery in Mursala Island will be identified. The results of this identification will be used to develop management options for the district government to further develop the grouper fishery development policy. Apart from that, the regional government of North Sumatra Province can use the results of this study in developing policy directions for the management of Mursala Island as a KKPD.

II. MATERIALS AND METHODS

A. Time and Place

The research was conducted from May to August 2024 in the waters around Mursala Island, Central Tapanuli Regency. Data collection activities include observing the fishing conditions in the waters around Mursala Island, Central Tapanuli Regency for field checks (ground truth) and proving or confirming the existence of fisheries management problems in the waters around Mursala Island, Central Tapanuli Regency. Data collection activities were carried out on the coast of Mursala Island, especially in the water area which is the operational area of fishing traps, fishing rods and arrows whose target catch is grouper fish. The research site is shown in (Figure 2).

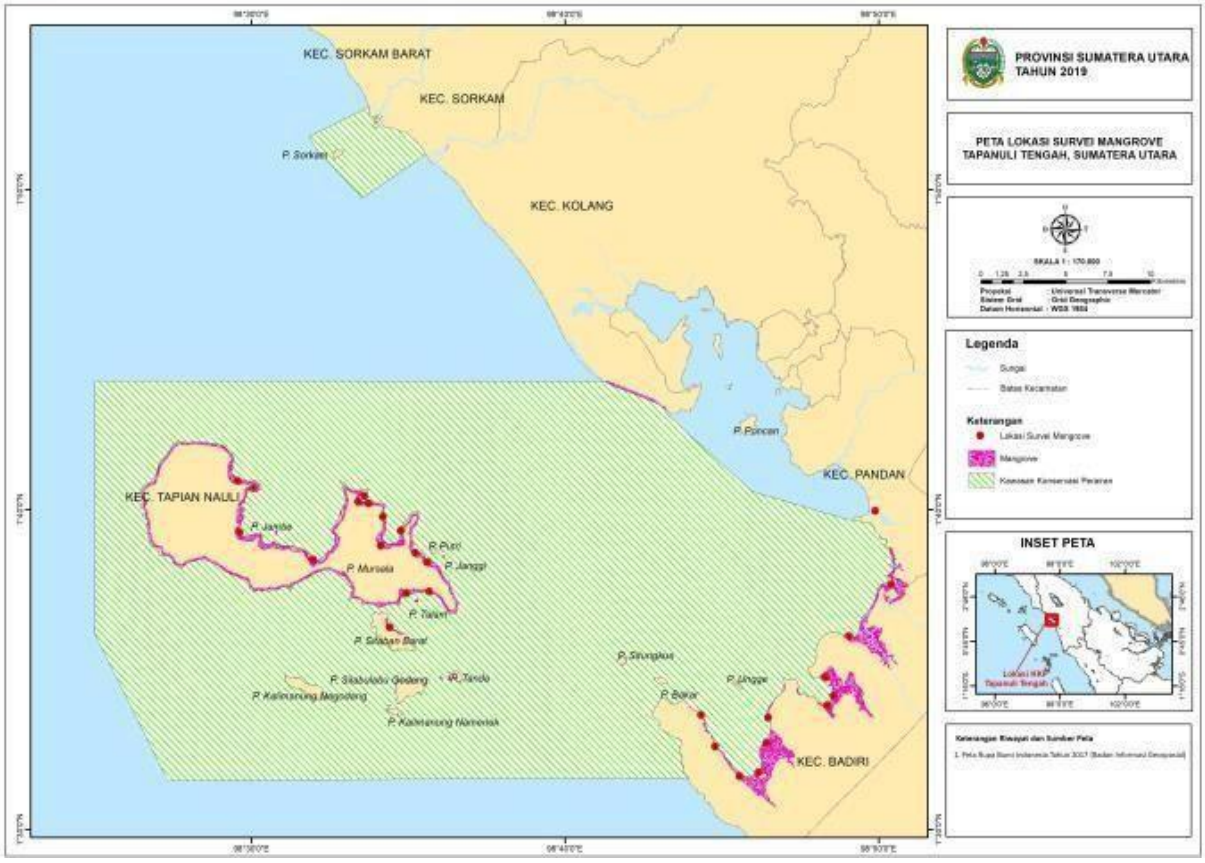


Figure 2. Map of the Research Location.

B. Tools and Materials

The equipment used in this research includes rulers, scales, cameras, software, GIS applications, and questionnaires. The specifications and uses of the equipment can be seen in Table 1.

No	Tools/materials	Specification	Utility
1	Kuiter and Tonozuka-200 grouper identification book		Identifying groupers by species
2	FISHBASE/SeaLifeBase		As a reference for determining the size of the first mature gonads of grouper fish
3	Camera	1200D	Record and document information on biological aspects, fishing technology and the environment of grouper fishing areas
4	Ruler/Length measuring tool		Measuring the length of the fish
5	Digital scales		Measuring the weight of the fish
6	Questionnaire		Collect data/information through interviews
7	Enumeration form		Makes it easy to input data from measurement and research results
8	Software		
9	Microsoft Excel	Excel 2016	Data processing and analysis (long frequency and weight of grouper)
10	Geographic information system applications	ArcGIS 10.7	Process spatial data on biological aspects, fishing technology and the environment

C. Data collection

The data collected to develop a description of capture fishing activities that take place in the waters around Mursala Island are: Some of the data were obtained from direct observations in the field, others were obtained from library materials with relevant information. Direct field observations were accompanied by interviews with 10 respondents. Field observations were carried out on 10 fishing units using traps, rods and arrows.

Interviews were conducted with stakeholders from organizations representing the government in Sibolga and non-governmental organizations (including fishermen). The regional government respondents were 5 people from the Sibolga PPN management who had the competence and capacity to explain the fishing conditions in the waters around Mursala Island, while the non-government respondents were 5 people, namely from Tangkahan and fishermen. The fisher respondents were asked to explain the fish traps, fishing rods and arrows used to catch fish in the waters of Mursala Island and its surroundings.

The sampling method used to determine the fisher respondents was through accidental sampling. Accidental sampling is a random sampling technique in which the researcher accidentally encounters someone who is deemed appropriate or suitable as a data source [10]. The accidental sampling technique was chosen considering that the research participants are highly mobile and active, making it difficult to determine their presence in the fishing centers. Therefore, the accidental sampling technique was chosen for respondents who came from non-government stakeholders. The number of fisher respondents is at least 10% of the population [11].

D. Data Processing

In this research, the data processing was carried out in 3 stages, namely:

1. Editing checks the list of obtained interviews (questionnaires). The purpose of editing is to avoid errors in the questionnaire such as: (i) completeness of answers, (ii) legibility of writing, (iii) clarity of meaning of answers, (iv) relevance of answers, and (v) consistency of answers.
2. Coding is the process of identifying and classifying in alphabetical and numerical form. Alphabets are used for stakeholder codes such as: (i) fishermen with N, and employees of Sibolga Nusantara Fisheries Port with PPNS. Meanwhile, numbers are used to code the serial number of each stakeholder. The coding is done on the questionnaire sheet to facilitate the data entry and to keep the identity of the respondents secret.
3. Tabulation is the stage of creating tables using Microsoft Excel software. Tabulation will classify: (i) grouping of stakeholder responses, (ii) grouping of biological aspects, (iii) grouping of technological aspects, and (iv) grouping of environmental aspects.

E. Data Analysis

The implementation of this research was divided into three stages:

1. Preparatory stage. This stage takes the form of data review and literature search, national and provincial regulations and policies related to the management of grouper fisheries in the waters of Mursala Island, Central Tapanuli Regency.
2. Survey/data collection phase. The next stage of the activity is to collect secondary data from related agencies. Studies related to this activity will be complemented by primary data, which will be carried out using survey methods by studying the management of grouper fisheries in the waters of Mursala Island, from a biological, technological and environmental aspect approach.

3. Tabulation is the stage of creating tables using Microsoft Excel software. Tabulation will classify: (i) grouping of stakeholder responses, (ii) grouping of technological aspects, (iii) grouping of fish resource aspects and (iv) grouping of environmental aspects.

III. RESULTS AND DISCUSSION

Grouper Fishing Units around Mursala Waters

The types of fishing units used by fishermen to catch grouper in the waters around Mursala are traps, fishing rods, and arrows. The evolution of the number of fleets, based on the type of fishing gear that landed catches in PPN Sibolga in 2018-2023 is shown in Figure 5. Fish traps are the most common type of fishing gear used to catch grouper, followed by fishing rods and arrows. The number of trap fleets fluctuated from 2018 to 2023. Fish traps increased from 2018 to 2020 and then decreased until 2023. The smallest grouper fishing fleet is the arrow fleet, and the number tends to decrease from 2028 to 2023. The pattern of development in the number of fishing fleets is more constant from 2018 to 2023 compared to traps and arrows, although there is a downward trend. The types of fishing units used by fishermen to catch grouper in the waters around Mursala are traps, fishing rods, and arrows. The evolution of the number of fleets, based on the type of fishing gear that landed catches in PPN Sibolga in 2018-2023 is shown in Figure 5. Fish traps are the most common type of fishing gear used to catch grouper, followed by fishing rods and arrows. The number of trap fleets fluctuated from 2018 to 2023. Fish traps increased from 2018 to 2020 and then decreased until 2023. The smallest grouper fishing fleet is the arrow fleet, and the number tends to decrease from 2028 to 2023. The pattern of development in the number of fishing fleets is more constant from 2018 to 2023 compared to traps and arrows, although there is a downward trend.

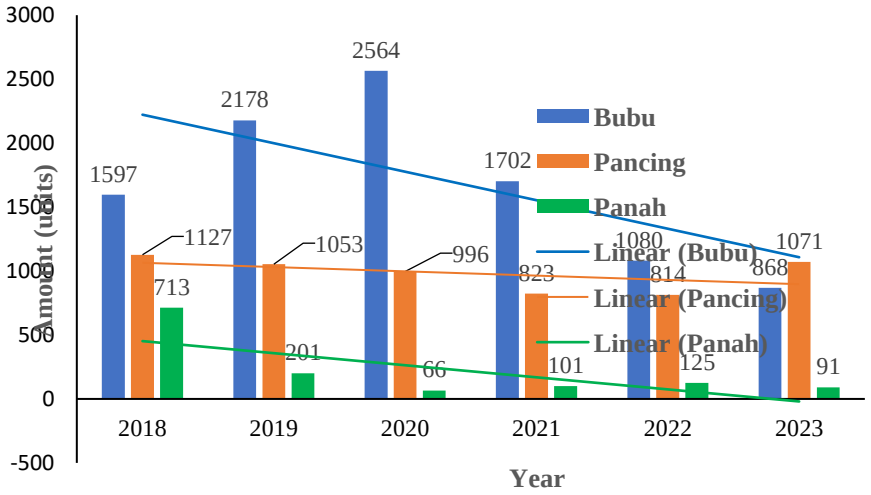


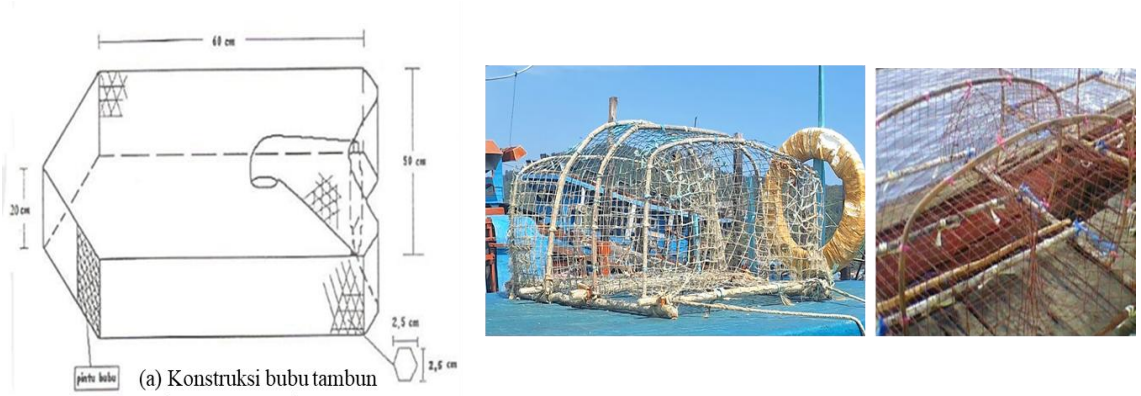
Figure 3. Number of fishing vessels by type of fishing gear operated in 2018-2023 [3]

The fishing fleet experienced a drastic decline in 2020. The results of interviews with sources showed that the decline of this fleet was also triggered by the rise of fishing with trawl nets, which were free to operate in fishing zones on the West Coast, Indian Ocean, and West Sumatra. Trawlers or trawl nets, which are usually called bottom trawlers, are "rampant" catching marine products such as fish, shrimp, squid and others ranging in size from small to large. Trawlers operate in the area around the west coast, still in the coastal zone, which is only about 20 miles away. In fact, trawlers are often seen around Mursala Island and can easily move in and out of the area without any supervision from law enforcement officials.

The decline in fleet size may also be caused by climate variability (extreme weather). According to Azizi et.al (2017), the increased frequency of large waves due to extreme weather is a challenge for fishermen to reach the fishing grounds. The current pattern that occurs in the waters of Mursala Island is strongly influenced by the tides. The tidal type in the coastal waters of Mursala is a mixed daily double inclined type. In one day there are two high tides and two low tides with different times and heights. Therefore, trap fishing equipment is easily damaged.

Bubu fishing technology

Bubu is a fishing tool commonly known among fishermen, which is in the form of a trap and is passive. Bubu are often called traps and guide barriers. This tool is in the form of a cage like a closed room so that the fish cannot get out. Bubu is a passive, traditional fishing tool in the form of fish traps made of traps, rattan, wire, iron, nets, wood and plastic woven in such a way that fish that enter cannot get out. The basic principle of a trap is to block the fish's view so that the fish is trapped inside. This tool is often called a fishing pot or basket.



(a) Konstruksi bubu tambun (Pramono 2006)

(b) Bubu yang dioperasikan di sekitar perairan Mursala

Figure 4. Construction of trap fishing gear (a) and traps operated around Mursala (b)

Table 2 Dimensions of traps used in Mursala waters

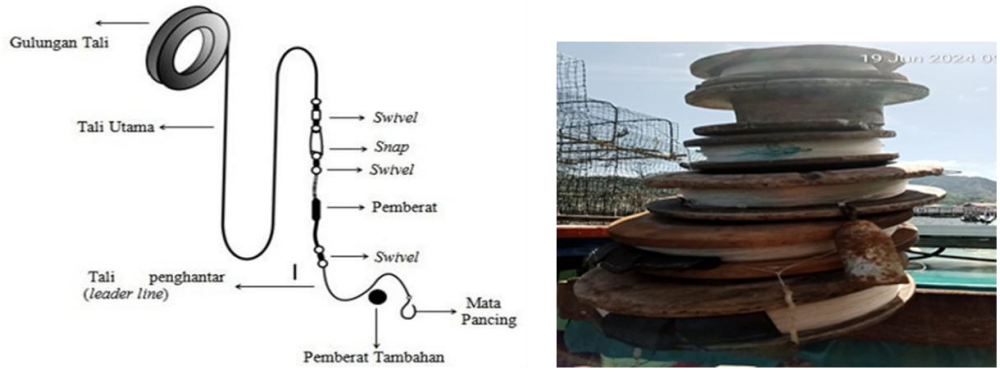
Number	Construction	Description
1.	Trap body material	Kawat welding, Kayu dan rotan
2.	Shape of bubu	Cube
3.	Mouth shape	Conical cylinder
4.	Wire mesh size	5 cm x 5 cm
5.	Long	150 cm
6.	Width	100 cm
7.	High	40 cm
8.	Outer mouth width	44 cm
9.	Center of mouth width	29 cm
10.	Inner mouth width	25 cm
11.	Center of mouth height	30 cm
12.	Inner mouth height	15 cm
13.	Mouth length	75 cm

The method of catching this bubu fishing gear is by attracting the target catch with bait so that the target catch enters the bubu and is caught. Bubu fishing gear is known as one of the environmentally friendly fishing gear. However, if the operation is carried out in parallel in a large water area, it can be said that this fishing gear is not environmentally friendly. The operation of bubu in this way can be detrimental to other fishermen because it interferes with the fishing activities of other fishermen. Such treatment of coral reefs will always threaten the sustainability of these ecosystems. The impact of habitat destruction by fishing gear depends on the type of gear and habitat conditions. Even the bubu, which is known as an environmentally friendly fishing gear, is often operated by digging and damaging coral reefs.

In the context of evaluating the environmental friendliness of a fishing gear, it is necessary to consider many aspects, both in terms of socio-economics of fishermen, consumers and ecosystems. The characteristics of fishermen as users of fishing gear are known to be firm and hard, so socialization and continuous support are needed in the use of environmentally friendly fishing gear. The government as a policy maker is expected to be able to provide policies to support that fishing activities do not adversely affect the environment.

Fishing rod

Fishing rod is a fishing tool that is well known to the general public, especially to fishermen. In principle, this fishing rod consists of two main components, namely a rope (line) and a fishing rod (hook). Fishing lines are usually made of cotton thread, - nylon, - polyethylene and plastic (string). Meanwhile, the fishing hook is made of steel wire, brass or other stainless materials. These fishing hooks usually have hooked ends, but there are also those without hooks. The hook consists of only one piece with a numbered size. 0.5-0.8, is a set of hooks consisting of line and hook and additional reels. A general description of the fishing gear used by fishermen to catch grouper around Mursala waters can be seen in the figure 5.



(a) Konstruksi pancing (Karyanto 2014) (b) Pancing yang dioperasikan di perairan Mursala

Figure 5. Construction of hand lines (a) and fishing lines operated around Mursala waters (b).

This method of operating handline fishing equipment has several stages, namely preparation, setting, dipping and hauling. The preparation stage is the first stage in the operation of hand line fishing equipment, where all the equipment used is prepared and the condition of the fishing line is checked. Fishing lines that have started to rot are immediately replaced with new ones. This is to ensure that the line does not break during hauling. Setting is the lowering of fishing gear or rods. The thing to remember when setting is that dropping or throwing fishing gear into the water must be done properly and not carelessly. This is to avoid tangling or entangling the line.

Table 3 Specifications for hand line fishing gear used in Mursala waters

No.	Construction	Information
1.	Ballast	Lead, 0,7 - 0,9 kg
2.	Tool Strap	(PA) No. 110-140 Nylon monofilament,
3.	Towing Rope	(PA) Nylon Monofilamen No. 110-140 50 m
4.	Weighted Rope	(PA) No. 75 Nylon monofilament , 3 m
5.	Kili-kili	Steel No 4
6.	Fishing Eyes	Steel
7.	Fishing Line Winder	Plastic

The use of fishing poles is likely to contribute very little to damage to coral reef ecosystems. Nylon ropes and hooks that become entangled in coral reefs and break are thought to have little impact on coral reef growth. The economic use of fishing poles (in terms of number of catches) is relatively low compared to traps and arrows, but higher compared to the other fishing gear observed in this study. Apart from the relatively good catches obtained, this tool causes relatively little technical damage to coral reefs. Thus, up to a certain number of fishing gears can be operated in coral reef areas.

Arrow

This arrow fishing tool in Karimun Java waters is known locally as "shoot" because it is operated by shooting at fish. Arrows used in Mursala waters are known as "spears". The main fishing area for fishermen who operate arrows is in the coral reef area with the aim of catching consumption of coral fish [12]. Arrows consist of several components, namely the bow holder, the string, the arrow, and the rope, one end of which is tied to the arrow, while the other end is connected to a float. The general shape of a bow is that of a pistol. The arrow has a diameter of 0.5 cm and a length of 80 cm. The front end of the arrow is equipped with a hook to prevent the fish from escaping. The arrows are equipped with a control string to prevent the arrow from being lost when shot. When you catch a fish, the control line also functions to pull the shot fish out of the water. The arrow launcher is a rubber spring attached to the arrow body. A fishing tool consisting of a rod (wood, bamboo) with a hook at the end (spearhead) and a drag line tied to the spearhead. The towing rope is held by the fisherman and when the spear hits the target, the rope is pulled to collect the catch. A general description of the spear fishing gear used by fishermen to catch grouper in Mursala waters can be seen in Figure 6.

(a) Konstruksi panah ((Subani & Barus 1998) (b) Panah yang dioperasikan di perairan Mursala

Figure 6. Construction of the arrow (a) and general description of the arrow used around Mursala waters (b).

The technique for operating an arrow fishing device begins with making sure the device is in good condition. Then the butt of the arrow is hooked to the front rubber spring, then the rubber spring is pulled towards the bow handle. The rubber spring is then connected to the trigger and locked. When the trigger is pulled, the rubber spring launches an arrow aimed at the target fish. The use of arrows can be categorized as environmentally unfriendly because, based on observations, if the target that is shot enters between the coral and cannot be reached by hand, the coral reef is damaged (dismantled) to take the biota that has been shot. Treating coral reefs in this way will always threaten the sustainability of this ecosystem. The impact of habitat damage from fishing gear depends on the type of gear and habitat conditions.

Results Of Grouper Fishing In Mursala Waters

The dominant fish caught in Mursala waters are grouper, snappers, lencam and lardfish. Observation results show that there are 3 genera of grouper caught and traded by fishermen operating around Mursala Island, namely Epinephelus, Cephalopholis, Plectropomus and Variola. The genus Epinephelus has 2 species, namely Epinephelus areolatus (batik grouper) and Epinephelus coioides (mud grouper). The genus Plectropomus has only 1 species, namely Plectropomus leopardus (Sunuk grouper). The genus Variola also has only 1 species, Variola albimarginata (white crescent grouper). Apart from the four grouper species mentioned above, Mursala's waters also have the potential for Red Snapper (Lutjanus argentimaculatus), Sign Snapper (Lutjanus fulviflamma), Lencam (Lethrinus olivaceus) and Salmon (Diagramma pictum).

Grouper caught in traps

Based on the results of observations, the trap fishing equipment made 2 trips around Mursala waters. The total catch of the traps was recorded as 600 kg with an average of 300 kg/trip/1 unit. There were 8 species of fish caught with traps, consisting of 4 species of main catch (HTU) and 4 species of bycatch (HTS). The HTU was recorded at 250 kg and this amount was lower than the amount of HTS (350 kg). The fish species that are the main target species or HTU for trap fishermen are groupers consisting of Batik grouper (Epinephelus areolatus), Mud grouper (Epinephelus coioides), Sunuk grouper (Plectropomus leopardus) and White crescent grouper (Variola albimarginata).

Fish species in the HTS or by-catch category for trap fishermen are red snapper (Lutjanus argentimaculatus), sign snapper (Lutjanus fulviflamma), lencam/ketambak (Lethrinus olivaceus) and lard (Diagramma pictum). Four species of grouper were caught, which were the main target of the trap fishermen, amounting to 250 kg or 41.67% of the total catch. Other species caught as bycatch are snapper, lencam and lard fish. The most dominant grouper of the four species is the mud grouper (Epinephelus coioides), which represents 15% of the total catch. The number of fish included in the bycatch category is higher compared to the HTU, namely 350 kg (58.33%). Even the lencam (Lethrinus olivaceus) found in the HTS group is the most dominant species of all the fish caught, namely 110 kg (18.33%). Fish trap fishermen determine grouper as the main target species for fishing or HTU because this fish species has high economic value both in local and export markets.

Grouper caught with a fishing rod

Fishing catches around Mursala waters were obtained from 2 fishing trips. The total catch during the 2 trips was 800 kg consisting of 5 species. The main catch (HTU) consists of grouper fish consisting of 3 species and the by-catch (HTS) consists of snapper and lencam fish. The composition or percentage of each species of fish caught by pole and line is shown in Figure 9. The catch of the fishers is dominated by HTS, namely 500 kg of lencam fish (62%), and this number is much higher than that of HTU. The species that dominate the HTS group for line fishermen are the same as for trap fishermen. The main catch was grouper fish of 228 kg or 28.50% of the total catch. The largest composition of the main catch is batik grouper at 13.50%, followed by sunuk grouper at 9.38% and mud grouper at 5.63%. Batik grouper (Epinephelus areolatus) is the main species that dominates the fishing catch, while mud grouper (Epinephelus coioides) is the main species that dominates the trap catch.

Grouper caught with an arrow

The number of arrowhead catches in Mursala waters has been recorded at 250 kg, consisting of 4 species, namely Batik grouper (Epinephelus areolatus), Mud grouper (Epinephelus coioides), Snapper (Lutjanus argentimaculatus) and Lencam (Lethrinus olivaceus). The main catch or target species for arrow fishers is grouper. In addition to the main catch, arrowhead fishermen also catch by-catch in the form of snapper and lencam. The number of catches in the main

catch category is more dominant, namely 150 kg (60%) compared to HTS which is 100 kg or 40% of the total catch.

Grouper Fish Habitat in Mursala Island Waters

Mursala Island has development potential for tourism and fishing activities. However, Mursala Island is also designated as a protected area. Fishing activities were carried out on Mursala Island before it was declared a protected area. This means that the condition of Mursala Island as a fishing area needs to be maintained so that it can fulfill the ecosystem that the protected area is expected to support. Therefore, a fish habitat analysis needs to be carried out by observing the condition of the coral reef ecosystem. This analysis is intended to determine the percentage of coral life forms found at the two designated observation stations, and then determine the condition of living corals in the waters of Mursala Island. In general, the AOI area was defined as follows: 8000 ha, coral reef area 2833.9 ha, percentage of coral reefs in AOI 8000 ha: 35.4 (%), zoned geomorphic area 1960.2 ha, zoned geomorphic percentage of AOI (8000 hectares): 24.5 (%), benthic habitat area: 1842.2 ha, percentage of benthic habitat of AOI 8000: 23.0 (%).

Observations were made at two observation stations, namely Mursala Island Waterfall area and Labuan Banjou Bay (Figure 11). Mursala Island Waterfall is located at coordinates 10 41'52" N and 980 26' 92" E. Mursala Island Waterfall is located on a steep cliff facing directly into the Indian Ocean. The water comes from a short river that is 400 meters wide and 700 meters long. The water cascades down the brownish-red cliffs as high as 35 meters and joins the salt water of the ocean below. Labuan Banjou Bay, which is Station II, is located at coordinates 10 64' 31" N and 980 36' 57" E. The color of the water in this bay tends to be bluish green.

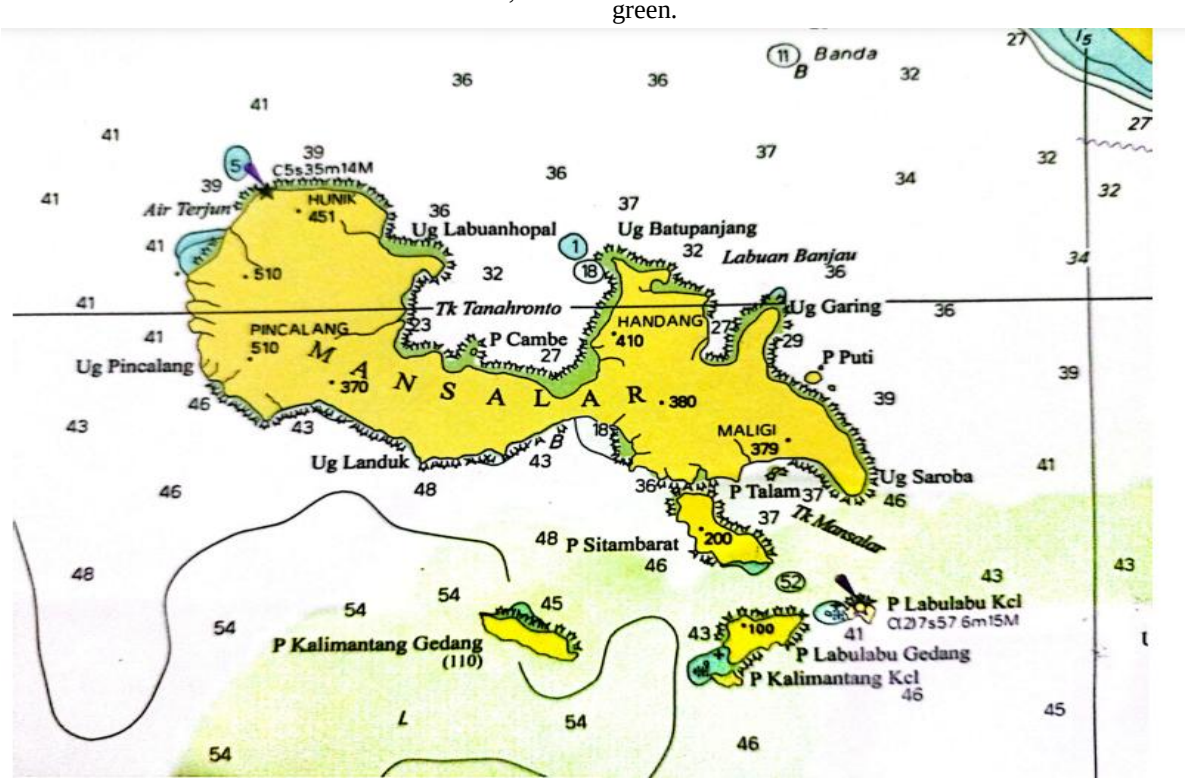


Figure 7. Observation of the habitat around the waters of Mursala Island.

The image in Figure 7 shows that coral reefs are widespread along the coastline of Mursala Island. In addition to the coral reef ecosystem, there are several other habitats along the shoreline of Mursala Island. Some of the main

Categories identified are sand, rubble, rock, seagrass, coral/algae, and microalgae (microalgae mats). Unknown areas are marked in dark blue, while "points of interest" are marked with purple circles at two locations.

Figure 8. Habitat types and distribution along the coast of Mursala Island

The distribution of coral reefs or algae that surround most of the coastline is in the red area. The size of the area is quite significant, occupying the coastline. These coral reefs play an important role in coastal ecosystems, providing habitat for various marine biota and protecting beaches from erosion. Light green areas indicate the distribution of seagrass beds, which are usually found in shallow waters and act as nutrient filters and habitat for many marine species. In addition, the yellow area indicates sand, while the brown area indicates the presence of rock or hard substrate.

The image interpretation in Figure 7 reflects that the coral reef ecosystem on Mursala Island plays an important role in ecological sustainability and coastal protection. In addition, the different habitat types found on Mursala Island have strong interactions with each other that influence the sustainability of the marine ecosystem as a whole. The image in Figure 8 shows the mapping of coral reefs along the coastline of Mursala Island, where white areas are shown as "Reef" and pink areas are shown as "Not Reef". This image uses a masking method or separation between coral reef areas and other areas that are not coral reefs. This interpretation indicates that the coastal area indicated by the white area is a coral reef habitat that surrounds most of the coastline.

Figure 8. Masking method in coral reef mapping

The condition of the coral reef ecosystem on Mursala Island is shown in Figure 9. It can be seen that the waters of Mursala Island consist of several ecosystem categories, including shallow and deep lagoons, inner and outer reef flats, reef crests, protected and unprotected reef slopes, and several other features such as patch reefs (isolated reefs) and plateaus (highlands). An important and interesting phenomenon was discovered based on image interpretation in Figure 14. The light and dark blue areas indicate the lagoon, which is an area of calm water between the coral reef and the beach. These lagoons are important to coastal ecosystems because they provide habitat for various types of marine organisms. Coral reefs in the inner and outer reef flats are shown in purple and pink. This zone is very important for maintaining

biodiversity in the ecosystem because it can serve as the primary habitat for coral species and other marine organisms that are important for maintaining biodiversity in this ecosystem. The reef crest and slope are shown in red and dark green. This zone is part of an important coral reef structure with a slope that descends into deeper water, providing habitat for various fish and invertebrate species. Isolated reefs (patch reefs), shown in orange, and plateaus, shown in brown, indicate separate or prominent reef areas, often unique areas in the coral reef ecosystem.

Figure 9. State of the coral reef ecosystem on Mursala Island

Damage to coral reefs in Indonesia is often caused by human activities. The damage caused by human activities in the Mursala Waters is clearly visible from the large number of coral debris caused by the use of fishing gear and ship anchors, as well as the large number of dead corals and the extent of coral reef fragments caused by fish bombing and the use of potassium based on direct observations seen in these waters. Low public knowledge of marine resource conservation issues results in low public awareness and participation in efforts to manage coral reef ecosystems. Therefore, it is necessary to conduct studies on coral reef communities in order to provide recommendations to local governments and other stakeholders on how to manage coral reef ecosystems to prevent further damage.

Unsustainable fishing practices are believed to contribute to habitat degradation. On Mursala Island, the use of fish bombs, fish poisoning, and ship anchors are suspected of damaging coral reefs. This is evidenced by the presence of coral reef fragments, coral mortality, and the presence of coral fractures (rubble). Coral and sand mining activities generally contribute to the exploitation of reef ecosystem resources, but such cases were not found at the study site. Indarjo, et al. (2004) stated that damage to coral reef ecosystems is of concern to many parties due to the extinction of marine biota on small islands and the disruption of ecological balance, and will cause a reduction in fish populations. Coral reef ecosystems are the most productive ecosystems in the ocean. As a result, coral reefs have the potential for a high diversity of biota types and are of great economic value. Coral reefs provide habitat for coral fish such as grouper, red snapper and napoleon wrasse, marine ornamental fish, sea cucumbers and clams. The potential of coral reefs also provides environmental services because of their beauty and also as a resource for the marine ecotourism industry. However, the potential of coral reef resources in Indonesia is declining and threatened with destruction.

In 2016, a coral bleaching phenomenon was reported by NOAA throughout the Indian Ocean region. In Indonesia, this phenomenon occurred along the southern coasts of Sumatra, Java, Bali and Nusa Tenggara. One of the COREMAP III coastal sites, Central Tapanuli, also experienced the same event. Coral bleaching is more massive and widespread. Apart from that, there are many newly dead corals with blackish characteristics like burnt jets, but the corals are still intact, not reduced to rubble. Live coral has also been found competing with greenish algae. Nevertheless, the coral remains alive. In general, at all stations the substrate cover is dominated by dead coral algae (DCA) with a very high percentage reaching 56.95%. The average value of live coral cover showed a very sharp decrease, from 44.47% in 2015 to 18.82% in 2016. The percentage decline, which reached a value of 25.65% for the percentage of live coral cover, indicates that massive coral mortality has occurred. This may be due to extreme temperature increases and the influence of sedimentation that occurs, especially in stations located on the mainland.

CONCLUSIONS

1. Capture fishing activities that take place in the waters around Mursala Island are characterized by fishing activities that target coral fish using fishing equipment in the form of traps, hand lines and arrows. The types of coral fish targeted by the fishermen include grouper, snapper, lencam and lard fish. This fishery is classified as a small-scale fishery. The annual trend of coral fish production from these waters shows a decline.

2. The fish habitat in the form of coral reefs in the waters around Mursala Island has been deteriorating since 2004. Damage to coral reefs is caused by the use of destructive methods such as bombs and toxic materials (cyanide). The use of traps, fishing rods and arrows also has the potential to damage coral reefs. These destructive activities continue despite regulations and socialization. The destruction of fish habitat is strongly suspected to be the cause of the decline in fish catches in these waters.
3. The above two problems may be caused by the fishermen's limited understanding of the concept of sustainable fisheries, the obstacles faced by the North Sumatra provincial government in implementing management, and the easier access to the waters around Mursala Island. Therefore, the scope of fisheries management objectives in the waters around Mursala Island includes the integrity of fish habitat, restoration of sustainable potential, employment opportunities, harmonious use of space, and effective governance. The proposed strategy is to restore the condition of coral reefs, restore reef fish stocks, develop the marine tourism sector in synergy with the fisheries sector, spatial planning, develop effective governance.

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To overcome the problems of fishing in the waters of Mursala Island, it is recommended to increase the education of fishermen on sustainable fishing and to encourage the use of environmentally friendly fishing gear. Habitat restoration efforts will be carried out through coral reef rehabilitation and the establishment of protected zones. Law enforcement needs to be strengthened with strict monitoring and sanctions against destructive practices. The development of marine ecotourism in synergy with the fisheries sector and integrated marine spatial planning can be a long-term solution. In addition, effective governance must be supported by multi-stakeholder cooperation and regular monitoring to ensure ecosystem sustainability and improve the welfare of fishing communities.

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