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Analysis of the level of environmental friendliness of fishing gear gill nets in Java Sea waters, Bangkalan Regency, East Java, Indonesia

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Abstract
Fish is one of the resources that can recover (renewable resources) but if the use and management are carried out irrationally in the long term these fish resources are feared to be extinct, therefore it is necessary to manage fish resources responsibly and sustainably. Gill nets or in the world of international fisheries better known as "gillnet" are fishing devices in the form of rectangular mesh sheets with the same size mesh and equipped with buoys, ballasts, upper ropes and with or without bottom ropes to block the swimming direction of fish, so that the target fish will be entangled in the net or bounced on body parts dragnet. The method used in this study is a descriptive method, namely direct observation in the field and interviews with fishermen and secondary data followed by determining the sample population and random sampling. The purpose of this study is to analyze variability, selectivity and determine the level of environmental friendliness of folding bubu type fishing gear in Java Sea Waters, Bangkalan Regency. The results of the study obtained variability and selectivity of gill net catches with the main catch (main catch) is crab (Portunus pelagicus) as much as 118 kg or 76.4% of the total catch and bycatch (by catch) is crab (*Scylla* sp.)as much as 7.8 kg or 5.1%, Gulama Fish (*Johnius trachycephalus*) as much as 10.5 kg or 6.8%, Tongue Fish (*Cynoglossus arel*) as much as 10 kg or 6.5% and Manyung Fish (*Arius thalassinus*) as much as 8 kg or 5.2% of the total catch while the catch is wasted (discard)) none. Thelevel of environmental friendliness of crab net type fishing gear obtained an assessment score of 26.8 which shows that this type of fishing gear is classified as Environmentally Friendly fishing gear.

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Keywords: Eco-friendly fishing gear, knitting net, knitting, Java Sea, Bangkalan Regency

1. Introduction

Agriculture is one of the main sources of income in Bhutan, as approximately 57% of the Bhutanese population depends on agricultural resources for a living (Chhogyel & Kumar, 2018) [5]. Bhutan's diverse agro-climatic conditions are ideal for growing a wide variety of horticultural crops. Mandarin, along with a variety of other horticultural crops, is the most widely grown fruit plant in Bhutan. Mandarin is one of the most essential fresh fruits exported to India and Bangladesh. As a result, it contributes to the economy through export revenue (National Statistical Bureau [NSB], 2021). Furthermore, Tshering *et al*. (2020) [20] reported that in 2017, mandarin accounted for 38.28% of the income earned from the sale of fruits.

However, Bhutan has witnessed a rapid decline in mandarin production in recent years, which the government ascribes to infestations of citrus greening, phytophthora rot, citrus fruit fly, and powdery mildew. Piao *et al*. (2010) [15], claimed that climate change is widely regarded as the greatest threat to the world of the twenty-first century. Moreover, Salinger (2005) [17] states that

Fish resources must be managed and utilized responsibly, namely by taking into account the sustainability of fish resources and the environment, so that fish resources can be used as sustainable development resources. The principle of responsible fisheries in question refers to the Code of Conduct for Responsible Fisheries (CCRF).

Environmentally friendly and sustainable fishing technology is a fishing technology using fishing gear that does not have a negative impact on the environment (Huspa & Siregar1, 2018) [7]. It can be seen by the extent to which the fishing gear does not damage the bottom of a water, the possibility of loss of fishing gear, and its impact on pollution. Another factor is the impact on biodiversity and target resources, namely the composition of catches, the presence of by catch and the catch of young fish (Rasdani, 2005) [12]. Theselection of the right fishing technology to be applied in the development of capture fisheries needs to consider several things, including environmentally friendly technology, technically and economically profitable technology and sustainable technology (Septifitri *et al*., 2010) [14].

Based on data on fish catch production for the last 4 (four) years in Bangkalan Regency, in 2019 it was 26,070.4 tons, in 2020 it was 25,639.8 tons, there was a decrease in production by 1.65% from the previous year and in 2021 it was 26,304.2 tons, there was an increase in capture fisheries production by 2.59%, then in 2022 it was 26,279.7 tons, there was a decrease in fishing production by 0.09% from the previous year (Dinas Perikanan Kabupaten Bangkalan, 2023) [4].

Fishing gear is a tool used by fishermen to find and catch fish in the sea (Fachrussyah, 2017) [5]. Gill nets or known as "gillnets" are fishing devices in the form of rectangular mesh sheets with the same size mesh and are equipped with buoys, ballasts, upper ropes and with or without bottom ropes to block the swimming direction of fish, so that the target fish will be entangled in the net or bounced on the body of the net. Gillnet (gillnet) is one type of fish fishing tool from net material that is rectangular in shape where the size of the net (mesh size) is the same (Septifitri *et al*., 2010) [14].

2. Research method

This research was conducted in the northern Java Sea, Bangkalan Regency, with the research time carried out from April to June 2023 on fishermen in Lajing Village, Arosbaya District, with Gill Net type fishing gear.

2.1. Data retrieval methods

The data used in this study consists of 2 types of data, namely primary data and secondary data. Primary data were obtained from direct observations in the field and interviews with fishermen, while secondary data were obtained from various related sources, namely the Bangkalan Regency Fisheries Service and the Central Bureau of Base Statistics.

The sampling method in this study was taken by purposive sampling. The number of samples of fishermen who used gill net fishing gear was 24 people.

2.2. Data analysis methods

All data obtained from observations and interviews with fishermen who use gill net fishing gear, then data processing is carried out so that a conclusion can be drawn according to the purpose of the study. The data analysis carried out is:

2.2.1. Catch variability method

The calculation of variability of fish catches is obtained by weighing the catch of each species, then the data is processed to determine the composition of the catch calculated using the formula, as follows (Salim & Kelen, 2017) [13]:

$$Catch\ (100\ \%) species\ i = \frac{Hasil\ tangkapan\ (\text{kg}) species\ i}{\text{Total catch (kg)}} \times 100$$

Where I is the type of fish or biota caught.

2.2.2. Catch selectivity method

The assessment to determine the selectivity of fish catches is based on three indicators, namely the main catch, bycatch, and discarded catch using the comparison method of three indices Data processing, the composition of fishery catches can be calculated by formula, as follows (Salim & Kelen, 2017) [13]:

$$Main\ Catch\ (100\ \%) = \frac{\sum Main\ Catch}{\sum \text{Total Catch}} \times 100$$

$$By\ Catch\ (100\ \%) = \frac{\sum By\ Catch}{\sum \text{Total Catch}} \times 100$$

$$Discard\ (100\ \%) = \frac{\sum Discard}{\sum \text{Total Catch}} \times 100$$

2.3. Fishing gear environmental friendliness method

Scoring analysis is used to explain the level of environmental friendliness of fishing gear based on 9 criteria that can be used as scoring parameters. The value weighting of the fishing gear is one (1) to four (4). In detail, the criteria for assessing the level of environmental friendliness of fishing gear are shown in table 2.

Processing of fishing gear environmental friendliness data from the data obtained, then calculated by the following formula (Sima, A.M. Yunasfi, Harahap, 2015) [15]:

$$X = \frac{\sum Xn}{\sum N}$$

Information:

X = Assess the level of environmental friendliness of fishing gear

Xn = Total number of value weights

N = Number of respondents

The score obtained is then analyzed based on the weighting of the level of environmental friendliness which is divided into 4 (four) score criteria (FAO, 1995) [6], as follows:

Table 1: Level weighting environmental friendliness of fishing gear

Number	Environmental Friendliness Category	Score (X)
1	Very Eco-friendly	28 - 36
2	Environmentally friendly	19 – 27.9
3	Not Environmentally Friendly	10 – 18.9
4	Very Unfriendly Environmentally	9

Table 2: Criteria for assessing the level of environmental friendliness of fishing gear.

Number	Criteria	Sub Criteria	Score
1	Has high selectivity	Catch more than three species of fish with vastly different size variations	1
		Catch three or fewer species of fish with vastly different size variations	2
		Catch fewer than three species of relatively uniform size	3
		Catching fish of one species with a relatively uniform size	4
2	Does not damage habitat	Causing habitat destruction over large areas.	1
		Causing habitat destruction in narrow areas.	2
		Causes partial destruction of habitat in a narrow area.	3
		Safe for habitat.	4
3	Produce high quality fish	Dead and rotten fish.	1
		Dead, fresh, physically deformed fish.	2
		Dead and fresh fish.	3
		Live fish.	4
4	No harmtofishermen	Can result in death to fishermen.	1
		Can result in permanent disability in fishermen.	2
		Only temporary health disorders.	3
		Safe for fishermen.	4
5	Production does not harm consumers	Highly likely to cause death to consumers.	1
		Opportunity to cause health problems to consumers.	2
		Relatively safe for consumers.	3
		Safe for consumers.	4
6	By-catch is low	By-catch how many species there are and do not sell well in the market.	1
		By-catch how many species there are and there are types that sell well in the market	2
		By-catch less than three species and sell well in the market.	3
		By-catch less than three species and have a high price.	4
7	Impact on biodiversity	Leads to the death of all living things and damages habitats.	1
		Causes the death of some species and damages habitats.	2
		Causes the death of some species but does not damage habitats.	3
		Safe for biodiversity	4
8	Does not harm protected fish	Protected fish are often caught.	1
		Protected fish are caught several times.	2
		Protected fish once caught.	3
		Protected fish are never caught.	4
9	Socially acceptable	Low investment costs.	1
		Auspicious.	2
		Does not conflict with the local culture.	3
		Does not contradict existing regulations.	4
Total Score			36

3. Results and discussion

3.1. Catch variability

Based on the identification of fish caught gill net fishing gear shows that the fishing gear obtained 4-5 types of species. The total weight of the total catch was 154.3 kg with the order of total weight of the highest gill net fishing gear catch was crab (Portunus pelagicus) which weighed 118 kg with a percentage of 76.4%, i kan gulama (*Johnius trachycephalus*) which has a total weight of 10.5 kg with a percentage of 6.8%, the catch of ikan lidah (*Cynoglossus arel*) which weighs as much as 10 kg with a percentage of 6.5%, the catch of manyung fish (*Arius thalassinus*) which weighs as much as 8 kg with a percentage of 5.2% while for the lowest catch is crab (*Scylla* sp.) which has a catch weight of only 7.8 kg with a percentage of 5.1% of the total weight of the catch. The data can be seen in the following table:

Table 3: Number of catches with gill net fishing gear

Number	Types of catches	Weight (kg)	Percent
1	Knitting (*Portunus pelagicus*)	118	76.4 %
2	Crab (*Scylla* sp.)	7.8	5.1 %
3	Gulama Fish (*Johnius trachycephalus*)	10.5	6.8 %
4	Tongue Fish (*Cynoglossus arel*)	10	6.5 %
5	Manyung Fish (*Arius thalassinus*)	8	5.2 %
Total		154.3	100 %

3.2. Catch selectivity

The catch of 24 fishermen in 1 trip obtained the main catch (main catch) consisting of 1 type of species, namely crab (Portunus pelagicus) with a total catch weight of 118 kg or about 76.4% of the total catch and bycatch (by catch) consisting of 4 types of species, namely k epiting (*Scylla* sp.,), gulama fish (*Johnius trachycephalus*), lidah fish (*Cynoglossus arel*) and manyung fish (*Arius thalassinus*) with a total catch weight of 36.3 kg or about 23.6% of the total catch, while for wasted catches (discard) from gill net catches does not exist, because all types of catches are sold in the market. The data can be seen in the Following table.

Table 4: Selectivity of gill net catches

Number	Types of catches	Weight (kg)	Percent
	Main catch		
1a.	Knitting (*Portunus pelagicus*)	297	92.5 %
	By catch		
1b.	Crab (*Scylla sp.*)	7.8	5.1 %
2b.	Gulama Fish (*Johnius trachycephalus*)	10.5	6.8 %
3b.	Tongue Fish (*Cynoglossus arel*)	10	6.5 %
4b.	Manyung Fish (*Arius thalassinus*)	8	5.2 %
	Discard		
	-	-	-
Total Catch (*1a+1b+2b+3b+4b*)		154.3	100 %

Gill nets fall under the criteria of low selectivity fishing gear because they catch more than 3 species. Alat catch that catches more than 3 species of much different sizes, then the fishing gear has low selectivity (FAO, 1995) [6].

3.3. Fishing gear environmental friendliness level

The results of the weighting of the value of the level of environmental friendliness of gill net fishing gear, can be seen in the following table:

Table 5: Results of environmental friendliness level value when catching gill nets

Number	Fishing Gear Criteria Environmentally friendly	Score				Total Score
		1	2	3	4	
1	Has high selectivity	24	0	0	0	24
2	Does not damage habitat	0	0	72	0	72
3	Produce high quality fish	0	8	60	0	68
4	Does not harm fishermen	0	0	0	96	96
5	Production does not harm consumers	0	0	0	96	96
6	By-catch is low	0	48	0	0	48
7	Impact on biodiversity	0	48	0	0	48
8	Does not harm protected fish	0	0	0	96	96
9	Socially acceptable	0	0	0	96	96
Total Number of Values						664
Average Grade						26.8

From the results of the assessment weights in the table above, it can be explained.

1. Has High Selectivity

This criterion gets a score of 1 as much as 100%, which is catching more than three species of fish with far different size variations. Based on the identification of gill net fishing gear catches during the study, there were 5 types of fish caught by gill nets, namely crabs, crabs, gulama, tongue fish and manyung fish.

2. Does not damage the habitat

This criterion gets a score of 3 as much as 100%, which causes partial damage to habitat in a narrow area because often anchors or gill net ballast are exposed or acute on coral reefs as habitats or homes for marine life so that when the net is lifted it will damage some of the affected coral reefs.

3. Produce high quality fish

This criterion gets a score of 3 as much as 83.3%, namely dead and fresh fish, but there are criteria that get a weight value of 2 as much as 16.7%, namely the condition of dead, fresh, physically disabled fish, this usually occurs in the type of bycatch, namely fish due to being trapped in gill nets for too long before being picked up or taken by fishermen.

4. Does not harm fishermen

This criterion gets a score of 4 as much as 100%, which is safe for fishermen. The use of gill net fishing gear is very safe for fishermen to use because there are no things that can injure or injure users and do not cause explosions or careless.

5. Production does not harm consumers

This criterion gets a score of 4 as much as 100%, which is safe for consumers. The catch of gill nets such as crabs, crabs and other types of fish is very safe for consumption, because the use of this fishing gear there are no elements of explosives or poisons that can contaminate the species caught.

6. By-catch is low

This criterion gets a score of 2 as much as 100%, namely by-catch how many species and there are types that sell well in the market. The catch using gill net fishing gear in Lajing Village, Arosbaya District, obtained 5 types of species, namely crabs, crabs, gulama fish, tongue fish and manyung fish. Where this crab is the main catch while crabs, gulama fish, tongue fish and manyung fish are by-catches. Bycatch in the form of fish when sold in the market but sells or has a selling value but the price is cheap, in addition to the type of crab bycatch that has a high selling price if it is included in export or restaurant sizes.

7. Impact on biodiversity

This criterion gets a score of 2 as much as 100%, which causes the death of several species and destroys habitat. The death of several species caught by gill nets is caused by the technique of operating gill nets that are so long about 6-8 hours, starting from stocking until the gill net fishing gear is pulled back to take the catch so that the types of species caught are partially in a fresh dead condition.

8. Does not harm protected fish

This criterion gets a score of 4 as much as 100%, that is,

protected fish have never been caught. There has never been any information from fishermen about the capture of protected species or fish caught by gill nets in Lajing Village, Arosbaya District, all species or fish caught are fish that are commonly consumed.

9. Socially acceptable

This criteriongets a score of 4 as much as 100%, namely fishing gear meets all criteria items as a socially accepted fishing tool, namely this type of gill net fishing gear is economically a cheap and profitable investment, and the use of this fishing gear doesnot conflict with local culture and as a rule does not contradict existing rules.

Set gillnet (Fixed Gill Net) is a mesh size of ≥ 2 (greater than or equal to two) inches and a length of upper rope ≤ 500 m (less than or equal to five hundred meters), motor vessels measuring ≤ 10 (less than or equal to ten) gross tonnage, and operated on Fishing Lines in all WPPNRI (Menteri Kelautan dan Perikanan, 2020) [9].

Based on the results of respondents of 24 gill net fishing gear fishermen, an environmental friendliness score of gill net fishing gear was obtained of 26.8 which shows that gill net type fishing gear is classified as environmentally friendly fishing gear. This is according to research (Lisna *et al*., 2019) [8] which states that gill net fishing gear is included in environmentally friendly fishing gear.

4. Conclusion

The level of environmental friendliness of gill net type fishing gear obtained an assessment score of 26.8 which shows that this type of fishing gear is classified as Environmentally Friendly fishing gear. The case of the conclusions written by the author must be valid, important, and answer the purpose of the study. The conclusion case claimed by the author is supported by sufficient research and analysis data. Conclusions can also be supplemented with suggestions and recommendations.

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