Selectivity of Fishing Gear for *Scomberomorus guttatus* (Bloch & Schneider, 1801) Commodities in Pangandaran Fishing Ground, West Java

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Authors' contributions

This work was carried out in collaboration among all authors. Author LPD designed the study. Author SK retrieved the data, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IR and IG managed the analyses of the study. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Scomberomorus guttatus is a large pelagic fish commodity in Pangandaran Regency. It has the highest amount and production values, therefore it needs to be maximally utilized but remains its sustainability. The purpose of this research is to determine the most selective fishing gear for *Scomberomorus guttatus* commodities based on the frequency of *Scomberomorus guttatus* length, the proportion of the main catch and by-catch in Pangandaran Regency for sustainable and environmentally friendly capture fisheries management. The data used in this study are the number of catches, catch weight and length of the *Scomberomorus guttatus* catches from gillnet, longline, and beach seine. Data used in research collected during November 2018-January 2019 in Pangandaran Regency. Analysis data used in the study is the analysis of the selectivity of the types of catches and the selectivity of the length of the catchable *Scomberomorus guttatus* from each of fishing gears. The results showed that of the three fishing gears used to catch

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Scomberomorus guttatus, gillnet is the most selective and productive fishing gear for utilizing *Scomberomorus guttatus* commodity because it has a 43,2% of main catch, 84,6% of the feasible *Scomberomorus guttatus* size. Longline is a fishing gear that is only selective to the length size of the *Scomberomorus guttatus* that has a percentage of decent size catch equal to 86,4%, while beach seine isn't selective fishing gear and unproductive for *Scomberomorus guttatus* commodities due to it designed to catch a demersal fish.

1. INTRODUCTION

The Pangandaran Regency waters area is a mainstay for the tourism and capture fisheries sector which provides a major contribution to the Pangandaran Regency region and community [1]. The main livelihood of the Pangandaran people is mostly as fishermen. The Pangandaran Regency fishermen operate in the fisheries management area (WPP) 573 which has a large potential of capture fisheries resources in large pelagic fish commodities.

Scomberomorus guttatus is a catch of main large pelagic fish in WPP 573 which is also landed in the waters of Pangandaran Regency. *S. guttatus* is a major commodity of pelagic fish in Pangandaran Regency due to its available throughout the year and has high economic value. Based on statistics from the Department of Maritime Affairs and Fisheries of West Java Province from 2005-2014 *S. guttatus* in Pangandaran Regency has a total production of 861,24 tons with a production value of Rp. 19.222.709.000,-. Therefore *S. guttatus* needs to be utilized maximally by remains its sustainability.

One of the efforts that can be done to remains the sustainability of fish resources is by using selective fishing gear [2]. Fishing gear selectivity is the ability of a fishing gear to catch a target fish at a certain size and type during a fishing operation [3]. Selective fishing gear can increase catches, especially in main commodities and reduce bycatch. Selective fishing gear has the ability to reduce unwanted catch that does not fit in size [4]. Fishermen in Pangandaran Regency use gillnet fishing gear, longline fishing, and beach seineers to utilize *S. guttatus*.

The purpose of this research is to determine the most selective and productive fishing gear to catch *S. guttatus* commodities in the waters of Pangandaran Regency. Fishing gear that suits to the catch target can increase the amount of catch and protect the Pangandaran Regency's fisheries ecosystems for the sustainable capture fisheries production especially on *S. guttatus* commodities.

2. MATERIALS AND METHODS

The tools used in this study were gillnet, longline, and beach seine to catch *Scomberomorus guttatus*, a meter with a precision of 0,1 cm to measure the length of the *S. guttatus*, a scale with a precision of 0,1 gram to determine the weight of the catches, camera to document research activities, and stationery to record the results of data on the number, weight, and length of *S. guttatus* as research objects. This research was conducted during November 2018-January 2019 at Cikidang Fish Auction, Pangandaran Fish Auction, and Nusawiru Fish Auction in Pangandaran Regency. The determination of sampling place is based on where the most catch of *S. guttatus* landed.

This research uses a survey method with quantitative descriptive analysis. The sampling method used in this was purposive sampling, which is a sampling technique based on certain considerations taken based on the research objectives. The data used in this study include primary and secondary data. Primary data consist of a number of catches, catch weight and length of catching *S. guttatus*, while secondary data include the amount of production, production value, number of fishermen and the number of fish auction in Pangandaran Regency. Measurement of length and weight of fish aims to determine the variation in weight and length of fish individually and in groups [5]. Measurement of fish length and weight is useful to know the growth rate, productivity and gonad maturity level [6].

All data were processed with Microsoft Excel software and analyzed descriptively to determine the rate of capture, the selectivity of the type of catch, selectivity of the size of the *S. guttatus* catch of each fishing gear.

2.1 Selectivity of Catch Type

The selectivity analysis of the catch type is to determine the percentage of the number and weight of the catch. Fishing gear selectivity is the ability of a fishing gear to catch fish of a certain species and size [7]. The catches of each fishing gear used to catch *Scomberomorus guttatus* are grouped based on the main catch and bycatches to determine the selectivity of the fishing gear and to know the type of catch that dominates from each catch. Selective fishing gear has the percentage of main catch ≥ 60% [8].

1) Percentage number of catches

$$\text{Main Catch(\%)} = \frac{\text{Amount of Main Catch}}{\text{Total of Catches}} \times 100\%$$

$$\text{Bycatch(\%)} = \frac{\text{Amount of Bycatches}}{\text{Total of Catches}} \times 100\%$$

2) Catch weight percentage

$$\text{Main Catch(\%)} = \frac{\text{Weight of Main Catch}}{\text{Total Weight of Catches}} \times 100\%$$

$$\text{Bycatch(\%)} = \frac{\text{Weight of Bycatches}}{\text{Total Weight of Catches}} \times 100\%$$

2.2 Selectivity of the *Scomberomorus guttatus* Length that Feasible to Catch

The selectivity of the *Scomberomorus guttatus* length that feasible to catch determine the level of selectivity of the fishing gear from the length of the *S. guttatus* in percentage. The catch is feasible if it has a length ≥ lenghth at first maturity (Lm). The initial level of *S. guttatus* gonad maturity when it reached 42.3 cm in length [9]. the maturity level of gonads in fish influenced by eating habits, age, size and physiological condition of the fish [10]. Selective fishing gear has a percentage of decent/feasible length size ≥ 60%. Grouping the length of the catch *S. guttatus* is done by making a long frequency distribution as follows:

1) To determine the number of *Scomberomorus guttatus* length classes

   $K=1+3,3 \log n$

   (K= number of *Scomberomorus guttatus* classes, n= total data)

2) Width Determination of each *Scomberomorus guttatus* length class

$$C = \frac{\text{Largest data - Smallest data}}{\text{Number of classes}}$$

   (C= Width interval of each *Scomberomorus guttatus* length class)

3) Determine the lowest limit of the first classes

4) The frequencies numbers of each *Scomberomorus guttatus* length class be writtendown.

3. RESULTS AND DISCUSSION

3.1 *Scomberomorus Guttatus* in Pangandaran Regency

Scomberomorus guttatus is a type of pelagic fish which is the main fishing commodity in Pangandaran Regency because it has a high selling price and its availability throughout the season. *S. guttatus* is an important commodity in which its availability carried out intensively to meet domestic and foreign market needs [11]. In Pangandaran Regency, *S. guttatus* has a selling value of Rp 45.000-60.000,- / kg. According to data from the Marine and Fisheries Office of West Java in 2005-2014 the value of *S. guttatus* production in Pangandaran Regency reached Rp 19.222.709.000,-.

According to the production data of the West Java Maritime and Fisheries in 2005-2014, *S. guttatus* classified into the top 10 of main pelagic fish commodities in WPP 573. Based on catch production data in Pangandaran Regency in 2005-2014 *S. guttatus* entered classified into the top 10 commodities in Regency waters Pangandaran.

S. guttatus production in Pangandaran Regency from 2005-2014 has decreased. The highest number of *S. guttatus* production was in 2006 with 212,57 tons, while the lowest production was in 2009 with 39,1 tons. In 2007 there was a drastic decline in *S. guttatus* production by 166,47 tons, a decrease in production occurred due to the tsunami phenomenon that occurred in Pangandaran Regency in 2006. The tsunami disaster that occurred in Pangandaran District decreased fishing activities due to damaged facilities and fishing infrastructure. In addition, fish production is also influenced by the trip, the size of the ship, the number of fishing gear and the experience of the captain and his crew very significantly influence fish production.
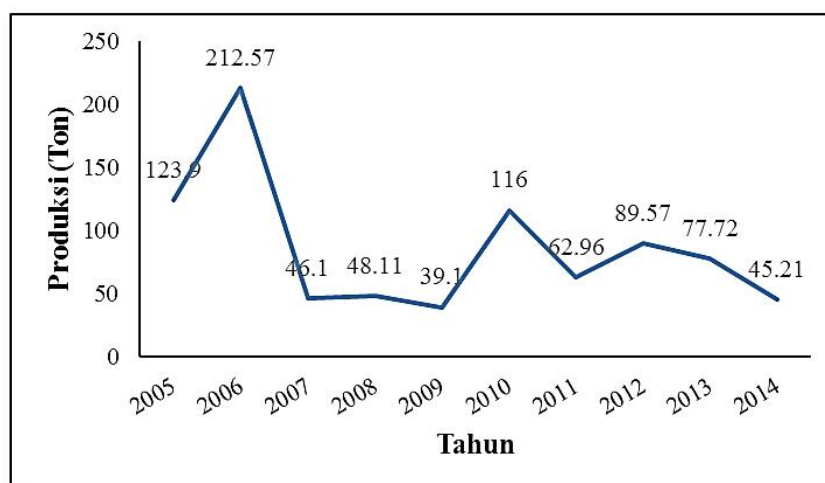
Fig. 1. *Scomberomorus guttatus* production in pangandaran regency

Indonesian waters have optimum temperatures for *S. guttatus* growth and breeding, which is around 28-31°C [12]. *S. guttatus* scattered throughout the coast of the Indonesian archipelago from Sabang to Merauke [13]. The catch of *S. guttatus* in Pangandaran Regency waters is affected by the fishing season. Fishing activities by fishermen in Pangandaran Regency are mostly done in the east season compared to the west season, this is because the fish catch in the west season is less than the catch in the east season [14]. Based on interviews with fishermen in Pangandaran Regency, the *S. guttatus*ing season affects the number of catches, catch size and distance of the fishing grounds. In *S. guttatus* season, the number of captured fishes is higher, with a larger size and not too far fishing area.

The *S. guttatus* season in the Java Sea occurs twice a year, namely in the period April to June and October to November each year [15]. Based on interviews with fishermen in Pangandaran Regency the *S. guttatus* season occurs in August-September which is the peak of the eastern season (summer season) with a large number of *S. guttatus* catches and also has a larger size.

S. guttatus live shoaling and a type of pelagic fish with a limited migration area, only migrate along coastal waters unlike other types of mackerel [16]. *S. guttatus* fish habitat is at a depth of 15-200 m and is sometimes found in estuarine waters [17]. Presence of *S. guttatus* in the waters is dynamic, always changing or moving with the movement of environmental conditions. These changes are strongly affected by the conditions of oceanographic parameters such as sea surface temperature and chlorophyll-a [18]. In the summer season, the chlorophyll-a in the waters of Pangandaran Regency is concentrated in the coastal area, while in the rainy season it is spread evenly in the waters. *S. guttatus* area in Pangandaran Regency affected by the different distribution of chlorophyll-a in each season. Chemical oceanographic factors such as chlorophyll-a attract fish looking for food. Chlorophyll-a influences the mackerel fish catch, while the distribution of SPL with the catch does not show a significant effect because there are still other factors that influence oceanographic and technical production factors [19].

In Pangandaran Regency in the east monsoon the wind speed is higher than in the west monsoon, but due to the different wind direction, the current velocity in the west monsoon is higher than in the east monsoon. High current velocity in the west monsoon causes waves in Pangandaran Regency waters higher than in the east monsoon. Surface water temperatures in Pangandaran Regency in the west season tend to be increasingly towards the mainland the temperature is higher, while in the east season sea surface temperatures follow the direction of surface current motion [20].

3.2 Fishing Gear in Pangandaran Regency

Gillnet is the type of fishing gear which widely used by fishermen in the Pangandaran Regency.

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A large number of gillnets used is due to high economic value catches such as cob, *Trichiurus lepturus* and *Scomberomorus guttatus* [21]. Fishermen in Pangandaran Regency operate surface gillnet and bottom gillnet types whose use is based on the fish target. Gillnet captures various species depending on the mesh size [22]. A surface gillnet is commonly used to catch *Scomberomorus guttatus*.

The Gillnet fishing gear commonly used to catch *Scomberomorus guttatus* in Pangandaran Regency has a 4-inch mesh size. Gillnet with a 4-inch mesh size has a good selectivity to the catch of *Scomberomorus guttatus* [23]. A fishing gear unit consists of 18 pieces of nets with a total length of 720 m and a width of 12 m. The number of pieces of net used will affect the number of catches.

This fishing gear is operated by 2 to 3 fishermen using a motorboat with a size of 2-3 GT. Gillnet fishing gear commonly used is in the peninsula and pangandaran bays with a travel time of 1,5 hours. In one trip, fishing gear set 1-2 times. To operate the gillnet fishing gear requires 30 minutes for setting, 30 minutes for immersing and 2 hours for hauling.

Longline fishing gear in Pangandaran Regency is only operated in certain seasons at the bottom of the water (Bottom long line). Longline is a passive fishing gear that causes the fish approach to the fishing line by himself to eat the bait. The main target of longline fishing gear is demersal fish. Besides catching demersal fish, this fishing gear also catches pelagic fish. Longline fishing gear commonly operated in Pangandaran bay, Pananjung bay, and Nusakambangan with 2-3 days of operating.

Longline fishing gear in Pangandaran Regency has a length of 1.500-3.500 m for the main rope, a 4-5 m of branch length and the distance between branch ropes with 7-7,5 m. The number of hooks used is 300-500 pieces with a hooks size of 8. The number of hooks used on the longline fishing gear affected the number of catches. Longline commonly operated by a 4-5 fisherman in 10 GT vessels, in a day the number of the fishing gear setting is 1-2 times. At the setting stage, it takes 1.5 hours to attach the branch line to the main rope and set gear to the water. In the hauling stage, it requires 2-3 hours for the main rope to be pulled.

Beach seine fishing gear is a type of seineer that is still traditional. Beach seine in Pangandaran Regency is the most commonly found in the east coast region. This fishing gear is operated during the day in the coastal area with the main target of demersal fishing.

Beach seine in Pangandaran Regency has a mesh size of 1.3 cm in the bag section, a total length of the net is 100 m with a main rope length of 300 m. Beach seine operated by 15-20 fishermen by doing 3 fishing gear settings in each operation. At the setting stage, it takes 30 minutes to reach the fishing area and to re-tether the main rope. Then in the hauling stage, it required 1,5 hours for the net to be pulled manually.

3.3 Type of Catch Selectivity

The analysis of the catch type analysis is done by comparing the percentage of the catch of *Scomberomorus guttatus* (amount and weight) as the main catch with bycatches.

Table 1. Gillnet catches during the research

No	Catch	Amount of fish	Weight (Kg)
1	*Scomberomorus guttatus*	513	496,6
2	*Tylosurus crocodilus*	21	21
3	*Carcharinus sorrah*	89	51,1
4	*Euthynnus affinis*	141	150,4
5	*Rastrellinger sp*	185	48,2
6	*Chirocentrus dorab*	45	36,3
7	*Sphyraena barracuda*	25	32,6
8	*Auxis rochei*	49	14,6
9	*Selaroides leptolepis*	119	15,9
Jumlah		**1.187**	**866,7**

Amount

Weight

Fig. 2. Catches percentage of gillnet

Amount

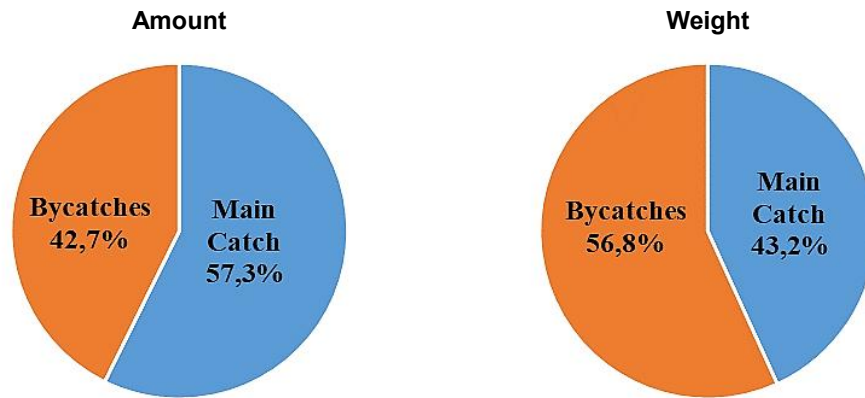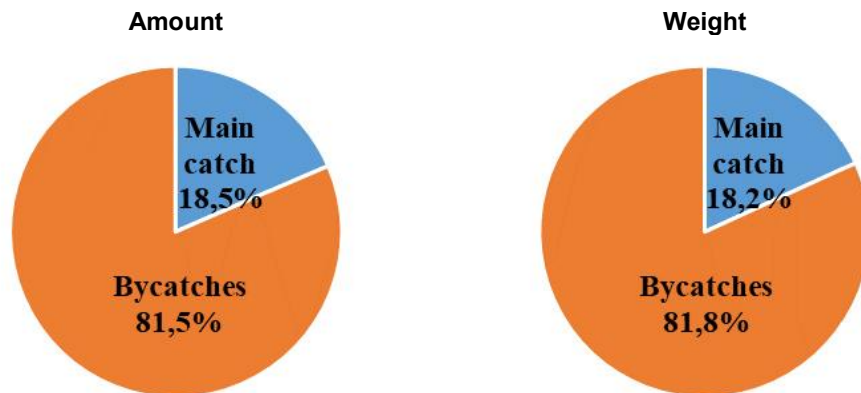**Weight**

Fig. 3. Catches percentage of longline

The catch of gillnet fishing gear obtained during the research is 1.187 fish with a catchweight of 886,7 kg. The gillnet type used during the operation is surface gillnet with a 4-inch mesh size, therefore the catch is dominated by large pelagic fish. *S. guttatus* that obtained during the research amounted 513 fish with a percentage of 43,2% to the total amount of catch. The total weight of caught *S. guttatus* is 496,6 kg with 57,3% compared to the total catch. While the bycatch consists of 8 fish species totaling 674 fish with a percentage of 56,8% and a weight of 390,1 kg with a percentage of 41,7%.

The gillnet fishing gear used has a construction and operating area that is adjusted to the main target of catching the *S. guttatus*, which causes the *S. guttatus* catch has the highest number and weight compared to other types of catches. The diversity of caught species is due to the similarity of habitat between the main catch and bycatches, therefore there are other pelagic fish species that caught during the operation. Gillnet fishing gear can also trap the fish with a size that

matches the mesh size, even the fish are nontargeted fish [24].

S. guttatus caught by gillnet has the highest number of catches compared to other fish species but has a smaller percentage of main catch compared to bycatch. Gillnet fishing gear that operated in Pangandaran Regency waters can be said less selective due to the higher percentage of bycatch compared to the main catch.

Longline fishing gear catches are 953 fish with a catchweight of 1.223,4 kg. The catch dominated by demersal fish, it caused due to the fishing gear is designed to catch demersal fish as its main target. *S. guttatus* that obtained during the research amounted to 176 fish (18.5%). The total weight of caught *S. guttatus* is 222,8 kg with a percentage (18,2%). While the bycatch consists of 6 fish species totaling 777 fish (81,5%) and a weight of 1.034,8 kg with a percentage of 81,8%. *S. guttatus* is not the main catch of longline fishing gear because it has the lowest percentage number of catches and weight.

Table 2. Longline catches during the research

No	Catch	Amount of Fish	Weight (Kg)
1	*Scomberomorus guttatus*	176	222,8
2	*Carcharinus sorrah*	145	87,5
3	*Euthynnus affinis*	79	81,8
4	*Caranx ignobilis*	15	84,5
5	*Lutjanus bitaeniatus*	177	318,6
6	*Hexanematichthys sagor*	205	236,4
7	*Epinephelus merra*	156	191,8
Total		**953**	**1.223,4**

Table 3. Beach seine catches during the research

| No	Catch	Amount of fish	Weight (Kg)
1	*Scomberomorus guttatus*	114	66,4
2	*Trichiurus lepturus*	278	43,4
3	*Pampus argenteus*	60	35,4
4	*Johnius trachycephalus*	213	18,5
5	*Leiognathus equulus*	823	43,5
6	*Selaroides leptolepis*	486	25,7
7	*Geres punctatus*	180	10,4
8	*Saurida tumbil*	170	58,2
9	*Nemipterus nemathophorus*	237	18,5
10	*Caesio cuning*	270	23,9
11	*Isettodes irumei*	192	27
Total		**3.023**	**370,9**

Amount   **Weight**
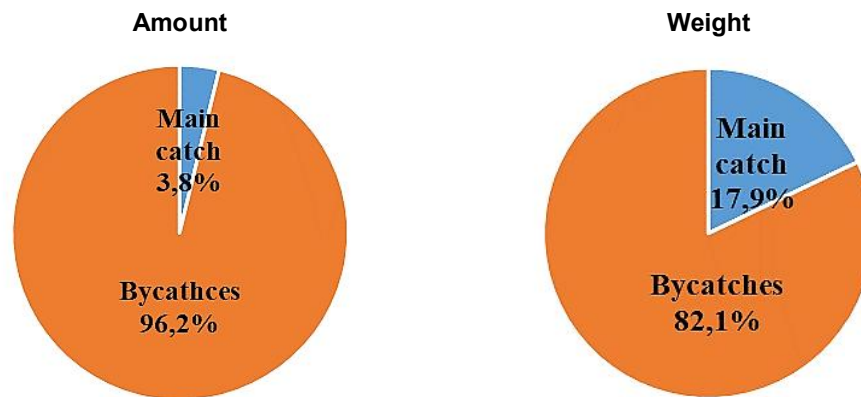
Fig. 4. Catches percentage of beach seine

Longline fishing gear that operated in Pangandaran Regency is designed to catch demersal fish so that the number of demersal fish species caught is more than *S. guttatus*. The types of fish that are targeted for longline fishing are *Lutjanus bitaeniatus*, *Epinephelus merra*, and *Hexanematichthys sagor*. Longline fishing gear can catch pelagic species such as *S. guttatus* and *Euthynnus affinis*, although it has a demersal fishing target.

The catch data obtained during the study shows that the *Hexanematichthys sagor* is the catch with the highest number of catches, while the catch with the highest weight is the species of red snapper. The percentage number of *S. guttatus* catches (if classified as the main target) that used the longline fishing gear is only 18,5% and lower than the percentage of bycatch that reaches 81,5%, so it can be said that longline fishing gear wasn't selective on the catch of *S. guttatus*.

The catch of beach seine fishing gear during the research was 3.023 fish with the catchweight of 370,9 kg. The catch is obtained using a beach

seine with a small mesh size (0,4 cm), therefore the type of catch varies and is dominated by demersal fish. *S. guttatus* obtained during the research amounted to 114 fish (3,8%). The total weight of caught *S. guttatus* is 66,4 kg (17,9%). While the bycatch consists of 10 fish species totaling 2.909 fish (96,2%) and a weight of 304,5 kg. *Leiognathus equulus* is the type of catch with the most amount of 823 fish, while *S. guttatus* is the type of catch with the highest weight.

Based on the catch of beach seine during the research, can be assumed that *S. guttatus* is a type of catch with a small amount, but has a larger weight compared to other types of catches. Beach seine has a larger number of bycatches compared to its main target due to beach seine itself designed to catch a demersal fish. Beach seine is designed to catch demersal fish and small pelagic fish that live on the coast. Although the percentage of *S. guttatus* weight is low, *S. guttatus* has a size and weight greater than other types of catches.

The percentage of *S. guttatus* caught by beach seine if classified as the main target is only 3,8%, its lower than the percentage of bycatch that reaches 96,2%, so it can be said that beach seine fishing gear wasn't selective on the catch of *S. guttatus*.

Based on the percentage of the amount and weight obtained from 3 fishing gear that can be used to catch *S. guttatus*, gillnet has the highest percentage (43,2%) of the main catch compared to other fishing gear. The high percentage of gillnet fishing gear in the main catch is due to only Gillnet fishing gear being operated on the surface, while longline and beach seine are operated at the bottom with demersal fishing targets. Therefore, of the three fishings gear that can be used to catch *S. guttatus*, only gillnet fishing gear is the most selective to catch *S. guttatus*.

3.4 Selectivity of the *Scomberomorus guttatus* Length that Feasible to Catch

Length of *Scomberomorus guttatus* measured to determine the feasibility of *S. guttatus* catch. The catch is feasible if the length has exceeded the length of the initial level of gonad maturity. Catch with a feasible size can provide opportunities for the fish to be able to spawn before being caught so that the recruitment process can proceed and maintain the stock resources. Knowing the length

size of the catches *S. guttatus* can be used to determine the level of catchment selectivity.

The total data of the *S. guttatus* length used were 803 fish which obtained from the catch of three different fishing gear, namely gillnet, longline fishing, and beach seine. Data of the *S. guttatus* length were obtained from each fishing gear are grouped into several classes with a frequency distribution, it's needed to be able to see the dominance and average size of the caught *S. guttatus.*

S. guttatus that caught using gillnet fishing gear has a total of 513 fish. *S. guttatus* caught using a gill net has a length size of 36,5-51,4 cm, with the most catches measured 47-48,4 cm totaling 99 fish and the least catch measured 36,5-37,9 cm totaling 12 fish. Gillnet fishing gear has an average of catch size with 45,9 cm. *S. guttatus* that caught by longline fishing gear has a total of 176 fish. *S. guttatus* that caught using longline fishing gear measured 40,3-57 cm, with the most catches has a size of 48,7-50,7 cm totaling 46 fish and the least catch size in length with 42,4-44,4 cm totaling 18 fish. Longline fishing gear has an average catch of 49,2 cm. *S. guttatus* that caught by beach seine has a total of 114 fish. Beach seine have an average catch of 41 cm.

Tabel 4. Feasible proportion of
***Scomberomorus guttatus* length catches**

No	Fishing Gear	Length of fish	
		> Lm (%)	< Lm (%)
1	Gillnet	84,6	15,4
2	Longline	86,4	13,6
3	Beach Seine	41,8	58,2

Length percentage of the *S. guttatus* catches on each fishing gear is to determine the selectivity level of the fishing gear based on its ability to catch *S. guttatus* with a decent/feasible size. Selective fishing gear has a percentage of decent/feasible length size ≥ 60%

Gillnet fishing gear has 84,6% percentage of *S. guttatus* catches with a decent size totaling 434 fish, while the *S. guttatus* that caught with unfeasible size was 15,4% totaling 79 fish. Longline fishing gear has 86,4% percentage of *S. guttatus* catches with a decent size totaling 152 fish, while the *S. guttatus* with unfeasible size of the catch was 13,6% totaling 24 fish. Beach seine has 41,8% percentage of the *S. guttatus* catches with a decent size totaling 48 fish, while the *S. guttatus* that caught with unfeasible size was 58,2% totaling 66 fish.

Gillnet and longline fishing gear can be classified into selective fishing gear to catch *S. guttatus* with a decent size because it has a percentage value of feasible catch ≥ 60%, while beach seine isn't selective cause it only has 41,8% of the feasible catch. Gillnet fishing gear has a high percentage causes it has a large mesh size so that only fish that accordance in size can be caught in the net. The use of mesh size affects the size of the catch. In addition, the fishing area affects the catch of gillnet fishing gear.

Longline fishing gear has the highest percentage compared to other fishing gear due to its operating area which is farther away (0-4 miles) from the coast and also caused by the use of large fishing hook that can only be eaten by large fish. The size of the hook affects the size or size of the fish caught that related to the fish's mouth.

Beach seine is the fishing gear with the lowest level of selectivity, this is caused due to the operating area that limited in coastal areas. So it has limitations in utilizing fishery resources. In addition, beach seine also has a small mesh size so it is not selective about the size of the catch.

4. CONCLUSION

Based on the results of research it can be concluded that of the three fishing gear used to catch *Scomberomorus guttatus*, gillnet fishing gear is the most selective and productive fishing gear for utilizing *Scomberomorus guttatus* commodity because it has a 43,2% of main catch, 84,6% of the feasible *Scomberomorus guttatus* size. Longline fishing gear is a fishing gear that is only selective to the size of the *Scomberomorus guttatus* length that has a percentage of decent size catch equal to 86,4%, while beach seine isn't selective fishing gear and unproductive for *Scomberomorus guttatus*ing commodities due to it designed to catch a demersal fish.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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