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A TECHNICAL STUDY OF MODIFIED GILLNET IN KENDAL REGENCY WATERS

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ABSTRACT

Gillnets are the fishing gear selected by Kendal fishermen particularly in small-scale artisanal fisheries because gillnets need relatively small capital, have easy operation, use medium- or small-sized fishing vessels, and are selective towards catches. Modifications were made by increasing the performance of the fishermen gillnet to get more economical fish catches. This study aims to technically analyze the modified gillnet on the catch composition. The study was conducted in Kendal waters in April 2019 with a 1 GT vessel using a comparative design with experimental fishing. The modified gillnet was a net made from PA multi-monofilament of 0.20 x 10 ply with 4-inch mesh size with the specifications of the mounted length of netting of 50 meters and the mounted height of netting of 5.9 m for one net with a hanging ratio of 0.55. Based on the paired sample t-test results, t_{count} value = 7.690 is greater than t_{table} (0.05) = 1.796. H_0 is rejected and H_1 which states that there is a difference in the number and weight of fish caught by the fishermen gillnet and the modified gillnet is accepted. Dominant species caught by the modified gillnet were *Euthynnus affinis* which were mostly allowable to catch both caught by the fishermen gillnet (51%) and the modified gillnet (95%) and *Scromberomorus commersoni* which were mostly not allowable to catch both caught by the fishermen gillnet (89%) and the modified gillnet (64%).

KEY WORDS

Gillnet, modification, Kendal, technical specifications, allowable to catch.

Utilization of fish resources in Kendal Regency waters is still dominated by small-scale fishing using various kinds of fishing gears, such as bottom gillnets, danish seine, fish traps, gillnets, mini bottom trawls, mini purse seines, and seine nets (Pratiwi and Rahardjo, 2017). Gillnets are a mainstay fishing gears in Kendal fishing community. Based on previous study conducted by Pratiwi and Rahardjo (2017), catch composition of the fishermen gillnet in Kendal waters showed that around 15% types of demersal fish were caught. It was due to the fishing operation area in shallow waters of 15-30 m with a quite high net height of 11-13 m, causing a high catch of demersal fish. Therefore, to limit the target and increase fish catches, the fishermen's gillnet were modified. Modifications were made by increasing the performance of the fishermen gillnet to get more economical fish catches.

Getting a lot of catches is an expectation of local fishermen. However, if marine resources are captured continuously without regard to allowable-to-catch fish, the catches will be increasingly reduced because gonadal immature fish have no time to breed. Therefore, technical analysis calculations are needed in order to create a gillnet with large catches, yet remains selective to maintain marine sustainability. Effective and selective fishing methods can reduce current overfishing. Catching accuracy is expected to increase fishermen's income.

Thus, a more in-depth study of the modified gillnet in terms of design, construction, and selectivity is needed. This study aims to technically analyze the modified gillnet on the catch composition in Kendal waters.

METHODS OF RESEARCH

This study was conducted in April 2019 in Kendal waters at positions between S 060 ° 47,536 ' - S 06 ° 52,658' and E 109 ° 00,559 ' - E 110 ° 57,467' with a depth of between 15 - 30 meters.

The method used in this study was a comparative design with experimental fishing conducted in Kendal Waters, i.e. by comparing the trial of fishing operations using the fishermen gillnet and the modified gillnet.

To find out the technical criteria for the modified gillnet construction, calculations of the hanging ratio, the net height, the buoyant and sinking forces were conducted using the following formula (Prado, 1991):

$$E_{La} = \frac{L_a}{L_{0a}}$$

Where: E_{la} - above hanging ratio; L_a - above mounted length of netting; L_{0a} - above stretched length of netting.

Vertical hanging ratio ($E_{vertical}$):

$$E_{tegak} = \sqrt{1 - E_{La}^2}$$

The position of the net in the water can be calculated using the following formula:

$$h = H \sqrt{1 - E_{tegak}^2}$$

Where: h - Mounted height of netting; H - Stretched height of netting; E - Hanging ratio mean.

Gillnet basic construction has the buoyant and sinking forces so that the net can stretch vertically in the water. The buoyant and sinking forces can be calculated using the following formula:

$$B_1 = W \left(\frac{\partial_{sw}}{\partial_w} - 1 \right)$$

Where: B_1 - Buoyant force of component (kgf); W - Weight of component in air (kgf); ∂_w : Density of component (gr/cm^3); ∂_{sw} - Density of seawater(gr/cm^3).

$$S_1 = W_n \left(1 - \frac{\partial_{sw}}{\partial_w} \right)$$

Where: S_1 - Sinking force of component (kgf); W - Weight of component in air/volume (kgf); ∂_w - Density of component (gr/cm^3); ∂_{sw} - Density of seawater (gr/cm^3).

Data on collected catches was analyzed using descriptive comparative analysis by knowing the type, number, and characteristics as well as their relation to water conditions. Meanwhile, to find out the differences between treatments, an analysis was performed using the Paired sample t-test. According to Sugiyono (2006), the Paired sample t-test is a different test of two samples in pairs. Paired samples are the same subject but experience different treatments, with the following analysis:

H_0 = It is suspected that there is no difference in catches between the fishermen gillnet and the modified gillnet;

H_1 = It is suspected that there is a difference in catches between the fishermen gillnet and the modified gillnet;

If $t_{count} > t_{table}$ then H_0 is rejected and H_1 is accepted;

If $t_{table} > t_{count}$ then H_1 is rejected and H_0 is accepted.

Gillnet selectivity test analysis was conducted by performing the length data collection which was then entered into the pre-determined class interval, then entering the frequency of

each class so that the mean length at first capture/ L_c was obtained. Estimation of L_c or $L_{50\%}$ was done by make a "logistical curve" graph i.e. the relationship between the length of the fish (x) and the number of fish expressed by the cumulative percentage (y) to form a Sigmoid shaped curve. Data were analyzed using the selectivity formula (Sparre, P & S.C. Venema in Anggareini et al., 2017):

$$F(c) = \left(\frac{ndL}{s\sqrt{2\pi}} \right) e^{-\frac{(L''-L)^2}{2S^2}}$$

Where: $F(c)$ = the frequency of fish in a length class; n = number of samples in the sampling; dL = length class interval; s = standard deviation; π = constant 3.14; L'' = mid-length class value; L = the mean length of one fish cohort.

Furthermore, the estimation of the mean and standard deviation of fish length in each sample was done by changing the equation in linear form as follows:

$$\Delta \ln F_c(z) = a - bx \left(L + \frac{dL}{2} \right)$$

Where: $\Delta \ln F_c(z)$ = logarithm difference of two length classes; $L + dL/2$ = the upper limit of each class length; a, b = constants.

The mean and standard deviation values of fish length in each particular age group were estimated using the following formula:

$$L_c = \frac{a}{b} \text{ and } s^2 = -\frac{dL}{b}$$

Then, the comparison between the L_c value and the L_m (length at first maturity) value was conducted.

The following are the technical specifications of the fishermen gillnet and the modified gillnet used in the study:

Table 1 – Gillnet specifications

No	Description	Size (1 piece)	
		Fishermen Gillnet	Modified Gillnet
A.	Size / dimension		
1	Stretched length (meter)	100 yard / 91.44	100 yard / 91.44
2	Mounted length (meter)	46	50
3	Net height (mesh)	140	70
B.	Net body		
1	Mesh size (inch / mm)	4 / 101.6	4 / 101.6
2	Net material	PA Multi-Monofilament	PA Multi-Monofilament
3	Number of yarns	0.20 x 10 ply	0.20 x 10 ply
C.	Rigging		
1	Head rope	PE Ø 7 mm	PE Ø 7 mm
2	Float line	PE Ø 7 mm	PE Ø 7 mm
3	Sinker line	PE Ø 3 mm	PE Ø 3 mm
D.	Floats		
1	Material / type	PVC, Y-8	PVC, SH3
2	Number of floats	22	61
3	Distance between floats (cm)	255	83
E.	Sinkers		
1	Material	Lead	Lead
2	Number of sinkers	5 pieces @ 500 gr	4 pieces @ 500 gr
3	Distance between sinkers(mesh)	225	112
F.	Additional floats		
1.	Material	PVC, bottle type	Styrofoam
2.	Number (pieces)	3	9

Figure 1 – Design of the Modified Gillnet PA Multi-Monofilament of 0.20 x 10 ply; 4 inch

RESULTS AND DISCUSSION

Kendal Regency waters are one of the most potential demersal and pelagic fish distribution areas in the northern waters of Central Java. Diverse fish resource potentials include small pelagic fish, large pelagic fish, demersal fish, reef fish, hard skin animals (crustaceans), soft skin animals (mollusks), and other aquatic animals. Based on Kendal Regency Fishery Statistics Data in 2018, the total production of Kendal Regency fisheries was 2,762 tons with a production value of IDR 27,749,713,000. Small pelagic fish dominated the production of 1,850.54 tons, followed by large pelagic fish production of 138.1 tons, demersal fish of 745.74 tons, and other fish of 27.62 tons. Large pelagic fish utilization was not optimal when compared to small pelagic fish utilization.

A gillnet is a mounted perpendicular net in the water to block the fish swimming direction. Targets species of gillnet are pelagic fish and/or demersal fish, depending on the gillnet position stretched in the water column. Based on observations, fish are caught by being enmeshed in the netting or entangled in the net body. If the fishing gear catches a lot of fish by entangling, the mesh as trappers cannot function properly. Fishes larger or smaller than the mesh can be caught in the net without having to penetrate the mesh (Razak et al,

2014). The modified gillnet is a gillnet operated in the middle of the water column to catch pelagic fish.

Gillnets components according to SNI 01-7215-2006 are as follows:

1. A float line is a rope used to place and tie floats;
2. A float is an object which has the buoyant force, is attached on the upper net, and functions as a float for the net;
3. An upper selvedge line is a rope located between the float line and the head rope functioning as a reinforcement of the upper net rope;
4. A head rope is a rope used to hang the net body;
5. An upper selvedge is a sheet of netting attached above the net body functioning as a reinforcement of the upper net body;
6. A net body is a rectangular sheet of netting with equal or even mesh size;
7. A lower selvedge is a sheet of netting attached under the net body functioning as a reinforcement of the bottom net body;
8. A side line is a rope attached to the sides of the net body functioning as a gillnet height limits;
9. A ground rope is a rope used to limit the movement of the net to the side;
10. A lower selvedge line is a rope located between the ground rope and the sinker line functioning as a reinforcement of the bottom net rope;
11. A sinker line is a rope used to place and tie sinkers;
12. A sinker is an object which has the sinking force, is attached on the bottom net, and functions as a sinker for the net.

Gillnet technical analysis was directed to calculations related to the hanging ratio or elongation, the mounted height of netting, and the comparison of the buoyant and sinking forces. These calculations were very necessary to examine the technical feasibility of the design and to provide recommendations for the gillnet to work optimally. The following are the gillnet technical calculations adjusted to the SNI 01-7215-2006 technical provisions on the standard form of multifilament surface gillnet construction without recommendation:

Table 2 – Technical calculations of the fishermen gillnet and the modified gillnet

No.	Component	Calculation Value		
		Fishermen	Modified	SNI 01-7215-2006
1	Hanging ratio (Elongation)	0.5	0.55	0.50 – 0.65
2	Mounted height (h)	12.23 meter	5.9 meter	-
3	Yarn diameter (dt)	0.2 mm	0.2 mm	0.1 – 1.8 mm
4	Buoyant & sinking forces			
	- Head rope	0.080 (-)	0.092 (-)	
	- Float line	0.080 (-)	0.092 (-)	
	- Sinker line	0.010 (-)	0.017 (-)	
	- Net	1.160 (+)	0.580 (+)	
	- Floats	1.760 (-)	1.708 (-)	
	- Sinkers	2.270 (+)	1.800 (+)	
5	Comparison of buoyant & sinking forces (W per B)	1.178	1.25	1.20 – 1.45

Based on the above table, it can be seen that the modified multi-monofilament gillnet of 10 ply; 4 inch was in accordance with or was still in the range of SNI 01-7215-2006. The elongation value of modified gillnet was 0.55. The increased hanging ratio was intended to open the mesh wider. A higher hanging ratio results in wider openings in the mesh with lower slack levels. Conversely, a smaller hanging ratio will result in lower net openings with higher slack levels. Higher net slack will increase the entanglement of the net against the catches (Prado, 1991).

According to Al Hizaz's research (2011), the higher entanglement in the bottom gillnet with a hanging ratio of 0.45 had an impact on the total number of fish caught in the bottom gillnet. The compositions of *Decapterus spp* catches by the bottom gillnet were 73% of fish was entangled, 16% of fish was wedged, and 11% of fish was gilled. The smaller the hanging ratio was, the more fish would be caught and the fish were entangled. It means that the gillnet was not selective. The hanging ratio was ineffective in gillnet selectivity. Therefore, by

increasing the hanging ratio of 0.55, the modified gill net was expected to catch large fish only.

The modified gillnet height was 5.9 m. Net body cutting from 140 mesh into 70 mesh was conducted. It aimed to adjust to the depth of the fishing ground area ranged only between 15-30 m and was in accordance with the swimming layer of the catch target i.e. *Euthynnus affinis* and *Scromberomorus commersoni* fish. Based on previous study conducted by Pratiwi and Rahardjo (2017), catch composition of the fishermen gillnet in Kendal waters showed that around 15% types of demersal fish were caught. It was expected that net body cutting allowed a high pelagic fish catches.

The comparison of the buoyant and sinking forces of the modified gillnet was 1: 1.25. The comparison of the buoyant and sinking forces shows the net position on the water surface. Net position is determined by stretch tension of the net body. According to Ayodhya (1981) in Al Hizaz (2011), stretch referred to here is stretch in the width as well as stretch in the length. This stretch tension will result in tension on the float line and the net body. If the net is stretched too tight, then the fish will be difficult to get entangled and the entangled fish will easily escape. The stretch tension of the net body will be determined primarily by the buoyant force of floats, the net body weight, the rigging, the sinking force of sinkers, and the shortening used.

The net mesh size of 4 inches (101.6 mm) was aimed for pelagic fish catch targets such as *Euthynnus affinis* and *Scromberomorus commersoni*. This is in line with the research results of Pratiwi, M (2010), Hantardi et al (2013), and Marliani (2016) stating that a gillnet with 4 inch/101.6 mm mesh size was used for pelagic fishing i.e. *Euthynnus affinis* and *Scromberomorus commersoni*.

Based on the technical analysis, the modified gillnet performance, in general, can be operated properly. The setting process took around 30 minutes. Floats on the gillnet can work well because they were able to withstand the sinking force of the net. It means that the buoyant force worked well as was shown when the hauling was performed. The top of the net was not twisted and the position of the net body sheet stretched across the water column. Sinkers on the gillnet also worked well because they were able to offset the buoyant force, causing the net sheet to stretch across the water column. The hanging ratio of 0.55 made fish caught by being enmeshed or entangled. The captured fish were in accordance with the target, i.e. catching large-sized pelagic fish according to 4-inch mesh size.

Table 3 – Composition of gillnet catches

No.	Fish Species	Fishermen Gillnet		Modified Gillnet	
		Number (fish)	Weight (kg)	Number (fish)	Weight (kg)
1	<i>Formio niger</i>	2	0.74	1	0.56
2	<i>Saurida tumbil</i>			1	0.15
3	<i>Rhizoprionodon acutus</i>	1	0.87		
4	<i>Pomadasys maculatus</i>	21	11.28	2	1.32
5	<i>Johnius trachycephalus</i>	2	0.25		
6	<i>Rastrelliger brachysoma</i>	14	0.75	28	1.3
7	<i>Eleutheronema tetradactylum</i>			2	2.03
8	<i>Istiophorus platypterus</i>			1	3.75
9	<i>Trichiurus lepturus</i>	1	0.14		
10	<i>Arius thalassinus</i>	8	5.22		
11	<i>Lutjanus Mahogoni</i>	7	5.31	4	2.84
12	<i>Chirocentrus dorab</i>			2	0.33
13	<i>Dasyatis sp</i>	1	0.52		
14	<i>Leiognathus equulus</i>	5	0.76		
15	<i>Psettodes erumeri</i>	3	0.75		
16	<i>Selaroides leptolepis</i>	3	0.21	11	1.03
17	<i>Scomberoides commersonianus</i>			2	1.85
18	<i>Scromberomorus commersoni</i>	45	47.6	94	194.41
19	<i>Euthynnus affinis</i>	39	29.82	58	87.85
Total		152	104.22	206	297.42

The gillnet catch target was pelagic fish. There were 19 species of fish caught. Based on paired sample t-test results, the t_{count} value = 7.690 while the t_{table} (0.05) value = 1.796. From the significance test results, it was found that the t_{count} value is greater than the t_{table} value. Thus, it can be concluded that H_0 is rejected and H_1 stating that there is a difference in catches between the fishermen gillnet and the modified gillnet is accepted. The modified gillnet was able to catch more pelagic fish based on the number and weight of fish.

Composition of gillnet catches from the fishermen gillnet and the modified gillnet varied. However, selectivity testing required fish species often caught in both nets. Fish species often caught were *Euthynnus affinis* and *Scromberomorus commersoni*. The fish were used for selectivity analysis test material which showed the selectivity level between the two different hanging ratios. It is confirmed by Argent and Kimmel (2005) in Putri et al (2018) that all types of nets generally catch all fish species, but significantly different types of fishing nets catch more diverse fish species. Thus, the tested species are fish species often caught by all nets.

Selectivity testing was employed to see how much the number and size of fish caught categorized as allowable to catch. According to Sparre & Venema in Anggareini et al., (2017), the less the number of catches is entangled, the more likely the fishing gear is selective. The number or proportion of fish caught with gillnet by being entangled highly determines gillnet selectivity. Thus, it is important to know the proportion of catch and the way fish are caught.

Table 4 – Measurement results of the length, weight, and girth of *Scromberomorus commersoni* fish

Measurement parameters		Fishermen gillnet	Modified gillnet
Fork length (cm)	Size range	35.40 – 79.00	39.00 – 93.50
	Mode	48.00	64.00
	Mean	48.99	65.55
Weight (gram)	Size range	510 – 2.780	1.020 – 4.300
	Mode	750	1.071
	Mean	2.000	2.068
Girth (cm)	Size range	16.00 – 28.50	21.00 – 39.00
	Mode	21.00	26.40
	Mean	21.64	26.39

Table 5 – Measurement results of the length, weight, and girth of *Euthynnus affinis* fish

Measurement parameters		Fishermen gillnet	Modified gillnet
Fork length (cm)	Size range	26.10 – 50.00	26.00 – 55.50
	Mode	31.20	45.00
	Mean	35.28	44.18
Weight (gram)	Size range	220 – 2.300	290 – 2.500
	Mode	410	1.300
	Mean	765	1.515
Girth (cm)	Size range	17.00 – 32.00	18.40 – 35.00
	Mode	22.50	32.00
	Mean	23.15	28.39

To determine the gillnet selectivity, an analysis of the proportion of allowable-to-catch fish was conducted, i.e. the estimation of the size of fish caught categorized as allowable to catch. The proportion of allowable-to-catch fish was known by measuring L_c using the fork length-frequency distribution and then being compared to the length at first maturity. This study did not calculate the L_m value of fish caught. The L_m values of mackerel and tuna were based on the L_m value of the references.

The results showed the L_c values of *Scomberoides commersonnianus* caught by the fishermen gillnet ($L_c = 59.97$ cm) and the modified gillnet ($L_c = 63.99$ cm) were smaller than the L_m value (65-70.9 cm). These results provided information that *Scomberoides commersonnianus* fishing using the gillnets was not good ($L_c < L_m$), because the mean of fish caught was in immature conditions. The gillnets were not selective against *Scomberoides commersonnianus* fish because they caught immature *Scomberoides*

commersonnianus fish. Whereas, the Lc values of *Euthynnus affinis* caught by the fishermen gillnet (Lc = 33.9 cm) and the modified gillnet (Lc = 41.66 cm) were greater than the Lm value (33.7 cm). It provided information that *Euthynnus affinis* fisheries were in good condition because of the value of $L_c > L_m$.

Figures 2 & 3. Graph of Lc of *Scomberoides commersonnianus* caught by the gillnets

Figures 4-5 – Graph of Lc of *Euthynnus affinis* caught by the gillnets

Saranga et al (2019) stated that if the value of $L_c < L_m$, then the condition of fish resources is not good because it can lead to the growth of unhealthy fish stocks as a result of fishing pressure. If this condition is left continuously, it will endanger fish stock conditions because there is no recruitment process. This condition can be minimized by catching mature fish only. However, it is certainly a challenge for stakeholders in implementing the rules.

Table 6 – The size of fish caught compared to the Lm value of the references

Fish species	Lc value (cm)		Lm value (cm) based on the references	
	Fishermen Gillnet	Modified Gillnet		
<i>Scomberoides commersonnianus</i>	59.97	63.99	65 70.9 85.0	Ramadhan (2008) Boesono <i>et al</i> (2017) www.fishbase.org
<i>Euthynnus affinis</i>	33.9	41.66	33.7 39.8	Hidayat <i>et al</i> (2018) www.fishbase.org

Table 7 – Proportion of gillnet catch size

Criteria	Fishermen gillnet				Modified gillnet			
	<i>Scomberoides commersonnianus</i>		<i>Euthynnus affinis</i>		<i>Scomberoides commersonnianus</i>		<i>Euthynnus affinis</i>	
	Number (fish)	(%)	Number (fish)	(%)	Number (fish)	(%)	Number (fish)	(%)
< Lm	40	89	19	49	60	64	3	5
> Lm	5	11	20	51	34	36	55	95
Total	45	100	39	100	94	100	58	100

Based on the proportion of gillnet catch size for 2 (two) dominant species caught, *Euthynnus affinis* were mostly allowable to catch, both caught by the fishermen gillnet (51%) and the modified gillnet (95%). *Scomberoides commersonnianus* were mostly not allowable to catch, both caught by the fishermen gillnet (89%) and the modified gillnet (64%). It is in line with Boesono et al's (2017) research that most fish caught by the millennium gillnet in Pati waters were not allowable to catch. Because of the number of allowable-to-catch fish <60%, it can be said that the millennium gillnet was less environmentally friendly. Fish catching above the size at first maturity can provide opportunities for the target fish to reproduce and spawn before being caught.

The proportion of allowable-to-catch fish and the composition of the main target catch showed the gillnet selectivity. When the proportion of allowable-to-catch fish and the produced main catches is greater, then the fishing gear can be said to be selective in terms of species. According to Efkipano (2012) in Boesono et al (2017), fishing gear selectivity is the ability of fishing gear to catch target fish at a certain size and species during fishing operation. Regulation on fishing gear selectivity aims to optimize the sustainable use of fish resources including increasing catch value and protecting certain species. The target fish is determined by considering the minimum size or weight of the allowable-to-catch fish.

CONCLUSION AND SUGGESTIONS

The modified gillnet made from PA Multi Monofilament of 0.20 x 10 ply with 4-inch mesh size had technical specifications of a hanging ratio of 0.55, mounted height of netting on the water column of 5.9 meters, the total buoyant force of 1.909 kgf, and the total sinking force of 2,380 kgf. Thus, the comparison of the buoyant and sinking forces was 1: 1.25 in accordance with the SNI 01-7215-2006 technical provisions on the standard form of multifilament surface gillnet construction without recommendation.

Based on the paired sample t-test results, t_{count} value = 7.690 is greater than t_{table} (0.05) = 1.796. H_0 is rejected and H_1 which states that there is a difference in the number and weight of fish caught by the fishermen gillnet and the modified gillnet is accepted.

The gillnets were not selective against *Scomberoides commersonnianus* fish because they caught immature *Scomberoides commersonnianus* fish.

Dominant species caught by the modified gillnet were *Euthynnus affinis* which were mostly allowable to catch, both caught by the fishermen gillnet (51%) and the modified gillnet (95%) and *Scomberoides commersonnianus* which were mostly not allowable to catch, both caught by the fishermen gillnet (89%) and the modified gillnet (64%).

Suggestion that can be given is in designing new fishing gear oriented to increasing the number and weight of fish catches, the security and management of fish resources should be considered. For example, for *Scomberoides commersonnianus* and *Euthynnus affinis* fishing in Kendal waters, increasing the size of fish caught is performed by reducing the number of fishing trips or the number of fishing operations to 1/2 or 1/3 of the total fishing trips during the spawning season.

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