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Trialing the Effectiveness of a Modified Trawl Net in the Northern Java Sea, Indonesia

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Abstract

Overfishing has occurred in several regions around Indonesia, including the Northern Java Sea, primarily due to the large number of artisanal fishers and fishing boats, and the use of "un-environmentally friendly fishing gear", such as trawl nets. Consequently, Presidential Decree No. 39 was enacted on July 1, 1980, which prohibited trawl operations in Indonesia to reduce fishing and social conflicts, and to protect resources. Fishers have responded to this government regulation by modifying their gear to elude its enforcement. However, these modifications are oriented more economic than conservation benefits.

To rectify this issue, an environmentally-friendly trawl net that enables resource conservation needs to be developed and authorized. Therefore, in this study, a modified trawl net that included a flapper, selector, and square mesh was trialed and compared with a conventional trawl net following the experimental design. It was found that the modified trawl net has the potential to contribute to fishery resource preservation with no associated economic loss to fishers.

Key words : Trawl, Modification, Northern Java Sea

Background

There are currently approximately 2.2 million fishers in Indonesia out of a total population of 225 million. One approach to increasing fishery production, particularly of marine fishes, has been the development of small-scale fisheries, and trawl nets were considered an appropriate tool for this purpose.

However, although trawl nets are effective, their development as a tool to increase income for small-scale fishers has caused some issues due to fishers tending to innovate by installing fishing devices in them. Such gear maintains their effectiveness in the same manner as otter boards, which are prohibited in Indonesia for resource conservation purposes, and results in overfishing and damage to non-target species ; for example, in the case of shrimp fisheries, the bycatch of shrimp trawlers is 19 times that of the shrimp catch.

In response to this issue, the Indonesian Government prohibited the use of trawl nets in shrimp fisheries on July 1, 1980 though the enhancement of Presidential Decree No. 39. This aimed to address both fisheries' resource conservation (as trawls are not considered to be "friendly to the ocean"), and social conflicts at that time between artisanal and commercial fishers, as it is the government's duty to ensure fishery resource sustainability and fishers' safety. However, it was not easy for artisanal fishers to switch to other types of fishing gear or other sources of income since they had been doing this job for many years and few alternate job opportunities were available. Therefore, many fishers were forced to modify their fishing gear to be able to continue to fish productivity. These modifications took on many different forms, but most have had the primary goal of maximizing the catch.

The economic crisis that occurred in 1997 also had a serious impact on fishers, particularly those involved in fish processing. Under such circumstances, fishers, including industrial fisheries, are liable to continue to use trawl nets by modifying the gear, e.g., by downsizing it or changing the design or materials, so that it does not fall in the prohibited category. This allows them to deceive the fisheries management authority and officers, who do not always enforce compliance unless the modified fishing gear resembles the standard of trawl net that is described in the regulation.

Problem Statement

Since trawl nets are considered the most effective fishing

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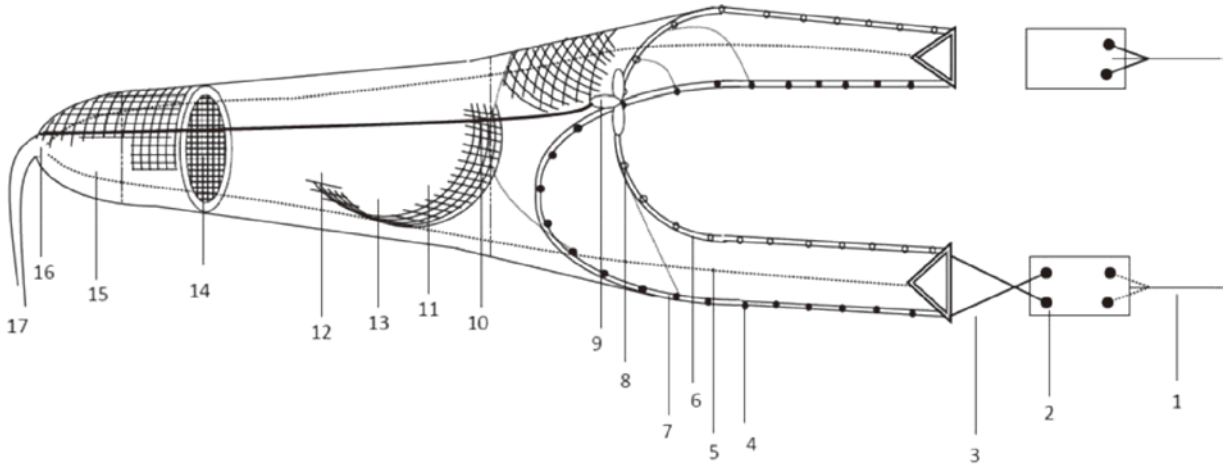


1. Towing rope	7. Bottom rope	13. Flapper
2. Otter board	8. Float ball	14. Selector
3. Otter rope	9. Buoy	15. Body III
4. Sinker	10. Longitudinal line	16. Cod end
5. Wing	11. Body I	17. Cod end line
6. Upper rope	12. Body II	

Fig. 1. Modified trawl net design.

gear for obtaining an income for small-scale fishers, these fishers tend to use modified trawl nets that do not violate the standard rules for trawl nets. The regulatory authority is unable to make enforcements on modified fishing gear unless this gear is different from the standard, even though the function of the modified gear is actually the same as the prohibited trawl net. Consequently, fishers are likely to continue their fishing activities by modifying their fishing gear, such as by changing the gear form or adding devices that keep the mouth of the net open. It was intended that the trawl net prohibition in 1980 would alleviate the pressure of trawl nets on fisheries resources and overfishing. However, because the regulatory authority has allowed gear modification by fishers to continue, these expected benefits have not been achieved, and the issues with overfishing and resource depletion still exist in Indonesian waters. Fishers would not accept nor observe the simple prohibition of this effective fishing gear because the resultant loss of catch would damage their livelihood.

One approach to addressing this issue is the development and authorization of a new allowable standard of trawl net that can meet the very difficult task of balancing efficient production with sustainable resource use. Therefore, the purpose of this study was to recommend fishing gear modification for trawl nets that not only preserves fisheries resources, but also remains profitable and acceptable to fishers, balancing the needs of the government and fishers alike.

Modified Trawl Net Design

To meet the difficult task of alleviating fishing pressure on fishery resources while also considering fishing productivity, several possible trawl net modifications were considered, including the use of a flapper, a selector on the body of the net, and a square mesh on the cod end (Fig. 1). From a fisheries management perspective, it is necessary to understand the selective performance of any new fishing gear prior to its introduction into the fishery (Tokai et al., 1996). A flapper is a non-return device that prevents fish from escaping once they have entered the net ; a selector is a grid net that is woven with square mesh, allowing the fish to be separated by size in the cod end ; and the use of square mesh in the cod end allows small fish to pass through the net more easily, resulting in the preservation of resources.

Flappers (Fig. 2) are usually mounted on fyke nets, hoop nets, and other types of fishing gear such as fishing traps. The efficiency of netting panels as bycatch separators and excluders has been examined in several crustacean trawl fisheries (Campos et al., 2003) ; and oblique netting panels placed ahead of the cod end that occupy the entire vertical cross-section of the net and lead to escape openings were studied by Karlsen (1976, 1988). The use of a flapper on the trawl net was inspired by the use of the non-return devices that are commonly found in small traps made of wood or wicker, without which the trap's funnel-like entrance (mouth of the gear) will easily lead captured fish back out. There-

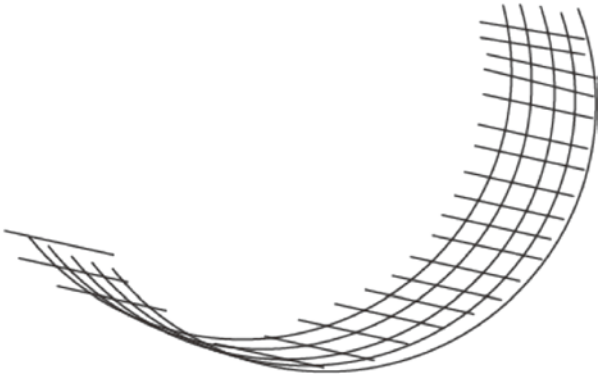


Fig. 2. Flapper design.

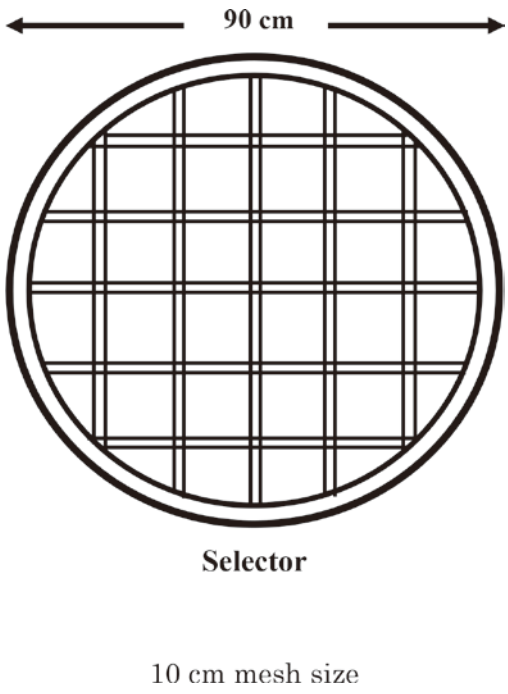
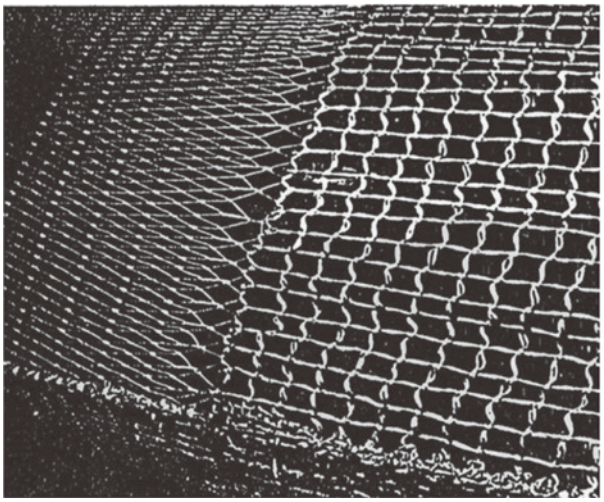


Fig. 3. Selector design.

fore, the addition of a swinging flapper at the funnel entrance of the trap will complicate the passage of the catch so that once the fish have entered the nets they cannot get out again (Brandt, 1984).

A selector (Fig. 3) is a type of square mesh net woven with thread that is attached to a circular frame made of rattan rod. This is the same tool that is commonly used as a Turtle Excluder Device (TED) in Georgia TED seine nets and trawl fishing nets in countries that have implemented TED regulations. TEDs were originally intended to release turtles that were incidentally caught in shrimp trawl nets without reducing shrimp catch. However, selectors are now used as selective fishing gear to release under-sized catch in order to preserve fish stocks.

In the Atlantic seabob shrimp (*Xiphopenaeus kroyeri*) fishery off Suriname, trawls are required by law to be equipped



Diamond mesh and square mesh (2.5 cm)

Fig. 4. Diamond and square mesh.

with two widely-used devices : a square-mesh panel Bycatch Excluder Device (BED) and a super-shooter TED. These trawl adaptations have proven effective in reducing the bycatch of non-target teleost fish (Polet et al., 2010) and sea turtles, respectively, in this fishery, with the average bycatch levels having been reduced to 20-30% of the total catch by weight, and most bycatch species being assumed to be within safe biological limits (Polet et al., 2010 ; Southall et al., 2011).

BEDs were first used in Indonesia in 1982. Various experiments in the Straits of Malacca showed that BEDs could reduce bycatch to 30% and increase shrimp catch to 7% (Sadhori, 1973). Modification of the net with a circular grid-like selector sorts the catch by size : when large fish are the target, they can be led by the selector to the cod end, while undersize fish pass through the selector to leave the net ; and when small fish are the target, they will pass through the selector to enter the cod end, while larger fish can be intercepted by the selector and released. Thus, the selector prevents the final catch from mixing in the net via this sorting process. There is now a regulation for the use of BEDs in trawl nets in Indonesia, with the main aim of reducing the capture of small fish, particularly those that comprise the basic biota, as reported by Subani and Barus (1989). TEDs differ from BEDs in the form or shape of the hole that functions as a door or window to collect the catches. Since the conventional trawl nets that are used in Indonesia do not have such a hole installed in the net, the inclusion of such a device would be expected to improve the catch conditions.

The use of square mesh (Fig. 4) at the end part of the cod end has an advantage over the regular diamond shaped mesh that is used in trawl nets. It has previously been shown that increasing the minimum permitted cod end mesh size or changing the mesh shape improves the selectivity of crustacean trawl nets (Campos et al., 2002, 2003). Square mesh

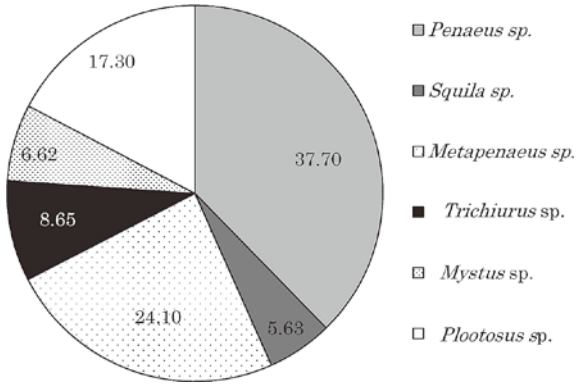


Fig. 5. Shrimp and fish catches using a modified trawl net.

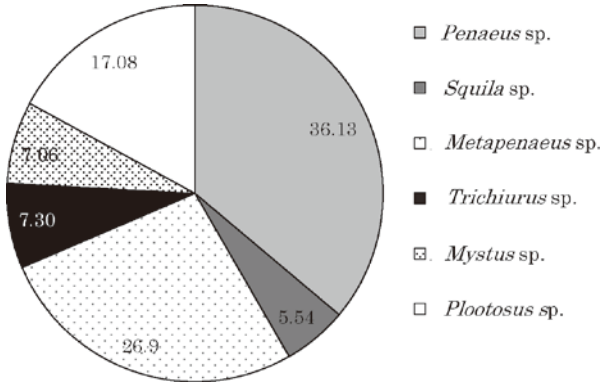


Fig. 6. Shrimp and fish catches using a conventional trawl net.

allows the mesh to remain open under water during the operation, providing opportunities for small fish to escape. The effectiveness of square mesh results from the different behaviors of shrimp and fish in response to the net, whereby fish tend to keep their distance from the moving and are washed into the cod ends. Thus, the square mesh cod end was found to have an improved selectivity for red mullet (*Mullus surmuletus*), with 50% higher retention time than the diamond-mesh cod end (Tokac et al., 1998).

The fish will try to escape through the top or the bottom of the bag net, whereas the shrimp have a more limited reaction to trawling. Thus, the flow of water will force the shrimp away from the mouth of the net, carrying them to the bottom of the net and the cod ends (http://www.fisheries.nsw.gov.au).

Methodology and Result

In this study, a gear experiment was conducted that compared a modified trawl net with a conventional trawl net as a control (Nazir, 1988). The specifications of these two net types are provided in Tables 1 and 2.

Compositions of the catches using these two net types are shown in Figs. 5 and 6, respectively. The catch weight of *Penaeus* sp. shrimp was higher in the modified trawl net than in the conventional trawl net (12.9 kg vs. 12.2 kg, respectively), but this difference was not significant. Similarly, the catch weights of *Squilla* sp. and *Metapenaeus* sp. were also higher in the modified trawl net than the conventional net, increasing from 1.82 kg to 1.98 kg and from 7.8 kg to 9.6 kg, respectively (Tables 3 and 4). These increases in shrimp catch may have resulted from the flapper preventing the shrimp from escaping through the entrance after entering the net.

The catch weight of fish was higher for the modified trawl net than the conventional trawl net for all species except *Trichiurus* sp., which decreased from 2.8 kg to 2.6 kg. By contrast, in terms of the number of individual fish caught, the conventional trawl net caught more fish than the modified trawl net for all species except *Trichiurus* sp., for which the reverse was true.

Considering the different parts of the net, the modified trawl net caught a total of 11.22 kg of fish in the selector area, and 26.18 kg of shrimp and fish in the cod end (Table 5).

The combined trash and bycatch hold at the selector of the modified trawl was 19.0 kg (34.7% of the total catch) compared with 30.0 kg (48.1%) in the conventional trawl net (Table 6), with some variation in the amount of each between replicates. This large difference demonstrates that the modified trawl net is effective in avoiding unnecessary catch such as trash and bycatch, thus serving as environment friendly fishing gear.

Table 1. Specifications of the modified trawl net.

Component	Material	Mesh size (inch)	Upper (mesh)	Lower (mesh)	Vertical (mesh)
Wing I	PE	2.5	146	184	50
Wing II	PE	2.0	184	230	60
Square	PE	1.25	444	350	42
Body I	PE	1.25	406	374	30
Body II	PE	1.25	374	304	30
Body III	PE	1.25	304	206	30
Flapper	PE	1.25	100	100	45
Cod end	PE	0.5	206	206	30

Table 2. Description of conventional trawl.

Component	Material	Mesh size (inch)	Upper (mesh)	Lower (mesh)	Vertical (mesh)
Wing I	PE	2.5	146	184	50
Wing II	PE	2.0	184	230	60
Square	PE	1.25	444	350	42
Body I	PE	1.25	406	374	30
Body II	PE	1.25	374	304	30
Body III	PE	1.25	304	206	30
Cod end	PE	0.5	206	206	30

Table 3. Shrimp and fish catches using the modified trawl net.

Repetition	*Penaeus* sp.	*Squilla* sp.	*Metapenaeus* sp.	*Trichiurus* sp.		*Mystus* sp.		*Plotosus* sp.		Bycatch	Trash
	kg	kg	kg	kg	No.	kg	No.	kg	No.	kg	kg
1	0.8	0.1	1.3	0.2	2	0.4	5	1.7	9	0.1	2.5
2	0.7	0.05	1.0	0.2	2	0.3	2	0.5	6	0.2	2.0
3	1.5	0.3	0.8	0.3	3	0.2	2	0.5	5	0.2	1.3
4	1.1	0.2	0.5	0.1	1	0.5	3	0.3	2	0.2	2.5
5	1.7	0.03	0.6	0.4	3	0.1	2	0.1	1	0.1	1.5
6	2.0	0.2	1.1	0.5	4	0.01	1	0.4	3	0.3	1.4
7	1.6	0.1	1.5	0.3	2	0.2	3	1.6	7	0.2	2.3
8	2.2	0.5	0.6	0.2	2	0.01	1	0.2	1	0.2	0.6
9	0.9	0.2	1.7	0.2	3	0.3	3	0.5	5	0.1	1.7
10	0.4	0.3	0.5	0.2	2	0.5	4	0.3	3	0.1	1.5
Total	12.9	1.98	9.6	2.6	24	2.52	26	6.1	42	1.7	17.3
CPUE	1.29	0.20	0.96	0.26	2.4	0.25	2.6	0.61	4.2	0.17	0.17

Table 4. Shrimp and fish catches using conventional trawl net.

Repetition	*Penaeus* sp.	*Squilla* sp.	*Metapenaeus* sp.	*Trichiurus* sp.		*Mystus* sp.		*Plotosus* sp.		Bycatch	Trash
	kg	kg	kg	kg	No.	kg	No.	kg	No.	kg	kg
1	0.5	0.02	0.8	0.4	2	0.5	7	0.3	7	0.3	2.5
2	1.0	0.3	1.1	0.2	1	0.02	1	0.5	10	0.5	2.4
3	0.9	0.6	0.5	0.1	1	0.4	5	1.1	13	1.2	2.0
4	0.3	0.01	0.4	0.2	1	0.2	3	1.0	6	0.2	1.7
5	1.6	0.05	0.6	0.4	3	0.3	4	0.4	7	2.0	2.3
6	2.2	0.02	1.2	0.3	2	0.01	1	1.0	8	0.1	2.6
7	1.4	0.08	0.4	0.3	2	0.01	1	0.4	7	0.3	2.1
8	2.5	0.5	1.5	0.5	3	0.15	3	0.3	5	1.7	3.0
9	0.8	0.2	0.5	0.2	1	0.05	1	0.4	3	0.6	2.2
10	1.0	0.04	0.8	0.2	1	0.5	5	0.2	3	0.7	1.6
Total	12.2	1.82	7.8	2.8	17	2.14	31	5.6	69	7.6	22.4
CPUE	1.22	0.18	0.78	0.28	1.7	0.21	3.1	0.56	6.9	0.76	2.24

Conclusion

The results indicate that the modified trawl net was effective and did not result in a loss of catch, with no significant differences in the catch composition of the two types of nets (Table 5 and 7). Furthermore, the modified trawl net caught less trash and bycatch, which will further facilitate the sorting of the catch in the cod end, improving the catch quality as shown in Table 6.

Fishers generally have responded well to the idea of using modified trawl nets rather than conventional nets, and so there appears to be an opportunity to make fishers convert their fishing activities to these modified nets assuming that there is no associated loss of catch. Using the experimental methods of Nazir (1988), the results indicated that the shrimp and fish catches obtained by the modified trawl net, although these differences were not statistically significant. Previous research

Table 5. Catches in each part of the modified trawl net.

Replicate	Selector (kg)	Cod end (kg)
1	2.30	2.30
2	1.00	1.95
3	1.00	2.80
4	0.90	2.00
5	0.60	2.43
6	0.91	3.60
7	2.10	3.40
8	0.41	3.50
9	1.00	2.90
10	1.00	1.30
Total	11.22	26.18
Average	1.122	2.618

Table 7. Number and percentage of shrimp and fish catches using modified and conventional trawl net.

No.	Species	Modified			Conventional		
		Weight (kg)	No.	Percentage	Weight (kg)	No.	Percentage
1	*Penaeus* sp.	12.90	-	36.13	12.20	-	37.70
2	*Squilla* sp.	1.98	-	5.54	1.82	-	5.63
3	*Metapenaeus* sp.	9.60	-	26.90	7.80	-	24.10
4	*Trichiurus* sp.	2.60	24	7.30	2.80	17	8.65
5	*Mystus* sp.	2.52	26	7.06	2.14	31	6.62
6	*Plotosus* sp.	6.10	42	17.08	5.60	69	17.30
	Total	35.70	92	100.00	32.36	117	100.00

Table 6. Weight and percentage of target and non-target catches using modified and conventional trawl net.

Type	Modified		Conventional	
	Weight (kg)	Percentage	Weight (kg)	Percentage
Shrimp and Fish	35.7	65.3	32.36	51.9
Trash and bycatch	19.0	34.7	30.00	48.1
Total	54.7	100.0	62.36	100.0

by Tokac et al. (1998) also showed that for a given mesh size, the use of square mesh on cod ends increased the retention time of red mullet by more than 50% compared with diamond mesh. The use of square mesh in the cod end reduces the resistance of the net in the water compared with the conventional diamond mesh that is commonly used by Indonesian fishers due to the mesh generally remaining open ; and this reduced water resistance will also result in increased fuel efficiency fishing operations. However, it should also be noted that fishers tend to expect a large increase in their catch whenever they are requested to modify their conventional fishing gear, and so it will take some time to convince both the regulatory authority to allow the use of a modified trawl net and fishers to convert their fishing gear into the modified trawl net.

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