Simplification of trammel net construction to increase catch results

[1]Gondo Puspito, [2]Sugeng Hartono, [1]Rizki Ghiffari

[1] Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, IPB University, Indonesia; [2] Marine Biology Department, Faculty of Marine Science, King Abdulaziz University, Saudi Arabia. Corresponding author: S. Hartono, shartono@stu.kau.edu.sa

Abstract. This research aims to simplify the trammel net construction for increasing catch, without reducing the species composition. The trammel net construction was simplified. It consisted of two net layers only, with mesh size of 66.04 cm and 4.445 cm, which was placed behind. The net with small mesh size has two distributions of vertical slackness, in the middle and lower side of the net. The simplified and normal trammel nets were operated simultaneously and arranged alternately. The results showed that both trammel nets caught the same species of fish and shrimp, namely: shrimp (*Penaeus* spp.), swimming crab (*Portunus sanguinolentus* Herbst, 1783), flounder (*Cynoglossus* sp.), saddle grunt (*Pomadasys maculatus* Bloch, 1793), pony fish (*Leiognathus equulus* Forsskål, 1775), threadfin (*Eleutheronema tridactylum* Bleeker, 1849), spotted sicklefish (*Drepane punctata* Linnaeus, 1758), Bombay duck (*Harpadon nehereus* Hamilton, 1822), stingrays (*Dasyatis* sp.), and anchovies (*Stolephorus purpureus* Fowler, 1900). The simplified trammel net caught 1090 individuals, 2.06 times more compared to the normal trammel net (528 individuals).
Key Words: hydrodynamic force, simplified trammel net, slackness, trammel net.

Introduction. Sweeping trammel net is classified as a gill net. It is operated by dragging, to sweep the surface of the sea floor, forming from a quarter of a circle to a semicircle (Dudley & Tampubolon 1985). The fishing targets are demersal organisms, especially shrimps (Fauziyah et al 2018). Its construction consists of two layers of outer net and one layer of inner net. The outer net has a bigger mesh size compared to the mesh size of the inner net, but its size is smaller.

Fishermen assume that the inner net of the trammel net will produce a pocketing shape, either vertically or horizontally, while being operated. The pocketing shape and the size of the trammel net are determined by the construction of the outer net (Thomas et al 2003). Fishes and shrimps swept by trammel net will be pocketed and entangled. Yet, that not might be the case, in its entirety.

The trammel net has three net layers made of multifilament polyamide (PA) that are submerged in the water (Palabiyik & Bahadur 2002). Its density is 1.14 kgf m^{-3}, heavier than sea water density, which is 1.025 kgf m^{-3} (Webb 2021). The existences of buoys on the upper side of the trammel net and weights on its lower side make both outer nets stretched in the water. Some parts of the inner net will be stretched, and the other parts will produce slackness, piled up on the surface of the sea floor (Figure 1a). The catch of trammel net will be accumulated in the lower side.

One solution to distribute the catch in more parts of the trammel net is to create the slackness of the inner net in several areas vertically. Mardiah et al (2016) distributed the slackness in three positions, namely upper side, middle side, and lower side of the trammel net (Figure 1b). The result was a catch 2.1 times more productive compared to the normal trammel net (Figure 1a). Fishes and shrimps were only caught in the middle and lower side. The lack of the catch occurred because the collection process was difficult due to the existence of the outer net in the front side. Rihmi et al (2017) enlarged the mesh size of both outer nets (Figure 1c), to obtain a bigger pocket. It doubled the catch

compared to the normal trammel net. The collection process of fishes and shrimps was also easier.

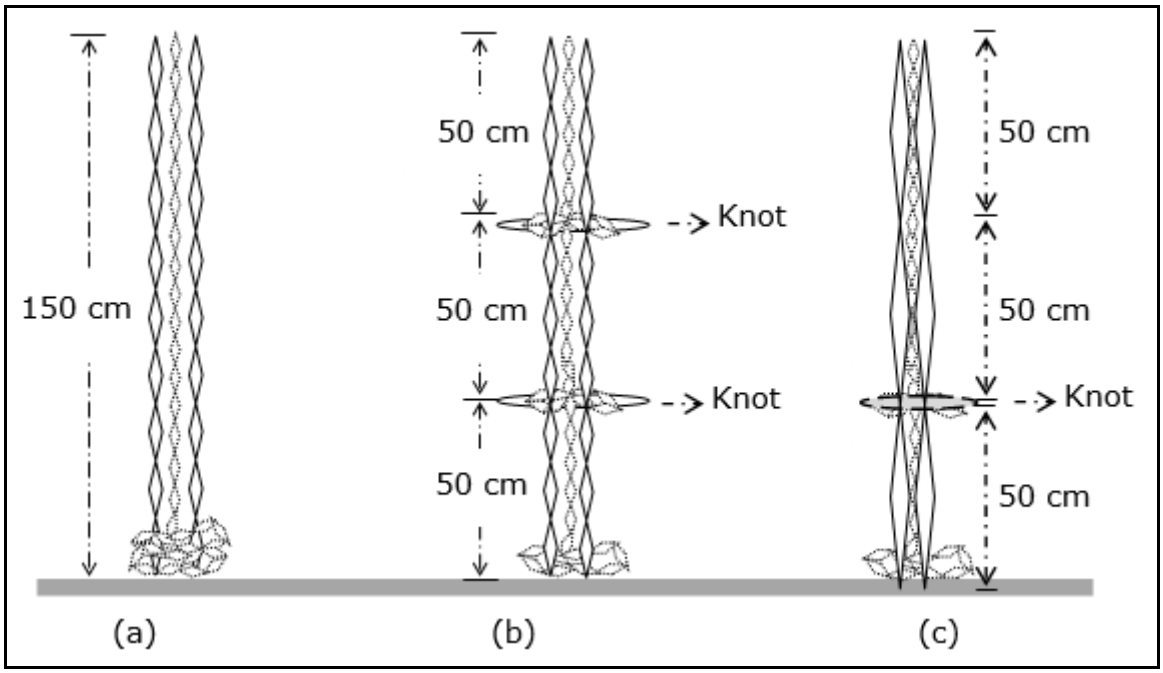

Figure 1. a - side view of a normal trammel net; b - Mardiah et al (2016); c - Rihmi et al (2017).

Trammel net construction from research by Rihmi et al (2017) can be simplified further to increase the catch, make collection easier, and reduce the cost of trammel net making. One of the outer nets could be removed because lack of function. The slackness in the upper side can also be removed due to its side becoming flat when the trammel net is being operated. The upper side only has the function of luring fish into middle and lower sides of the net.

Research related to inner net slackness of trammel net is difficult to find. Most studies focus on selectivity (Fabi et al 2002; Park et al 2011; Kalaycı & Yeşilçiçek 2012; Olguner & Deval 2013). Some recent studies discuss the discard reducing of trammel nets (Gökçe et al 2015), and technical characteristic and trammel net design (El-Bokhty 2017). The aim of study was to prove that the simplification of trammel net construction can produce more catch than normal trammel net, without reducing the species composition.

Material and Method

Time and location of the study. The experimental study of the trammel net was conducted with 28 repetitions in April 2021. Fishing time started at 05.00 AM and finished at 15.00 PM. The trammel net was operated in Sangrawayang waters, Sukabumi District, West Java Province, Indonesia, in a water depth between 7 and 15 m (Figure 2).

Construction of trammel nets. The construction of simplified trammel net (ST) was different from the normal trammel net (NT) (Figure 3). The backside net was removed because it did not help in producing the pocketing shape. The upper side was only one layer net made of multifilament polyethylene (PE), thread diameter 0.4 mm, and mesh size 4.44 cm. The other parts of net layers were made of multifilament polyamide (PA). Front net consisted of mesh of 66.04 cm, bigger than in the other net with 4.44 cm in size. Furthermore, net layers made of PA were tied up horizontally on each other to create two slackness areas in the form of a pocket, namely the upper and lower pockets. Specifications of both trammel nets are detailed in Table 1.

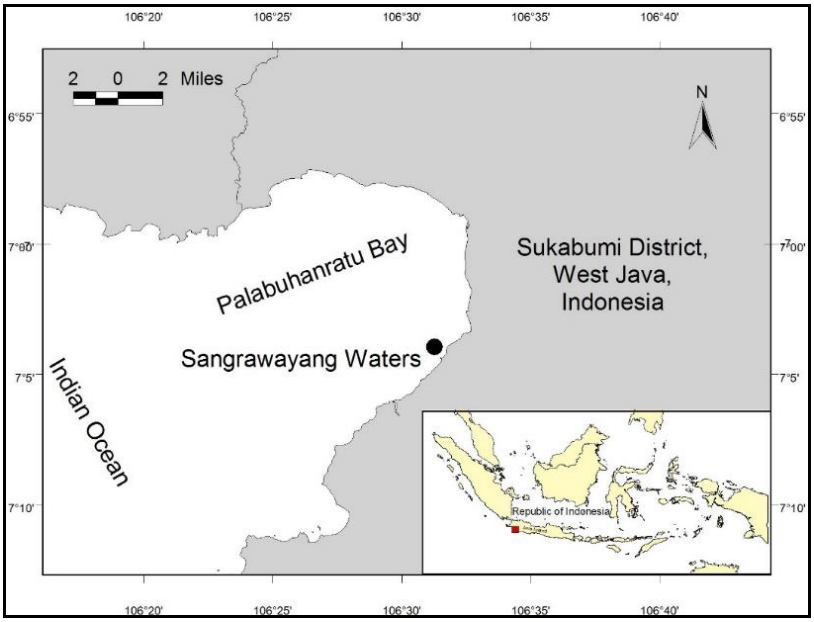

Figure 2. Location of experimental study of trammel net.

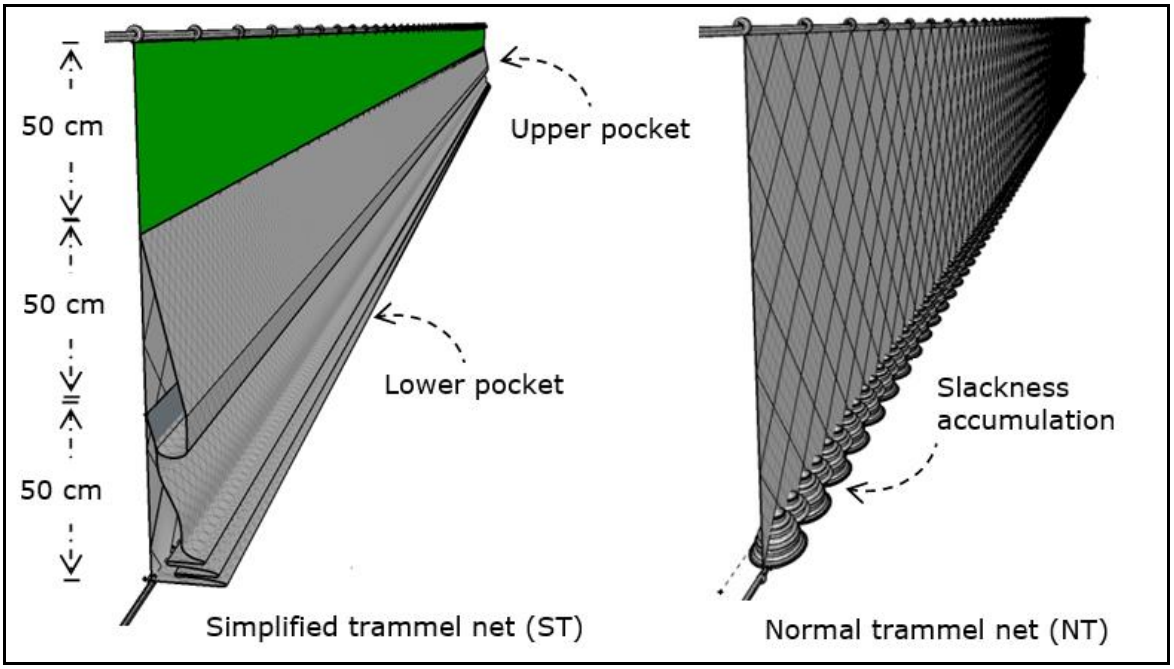

Figure 3. Trammel net constructions.

Field test. The experimental method was used in the research by operating five simplified trammel nets and five normal trammel nets simultaneously in the field. Both types of trammel net were arranged alternately to reduce data bias. The procedure of operation was as follows:

1. Marker buoys were deployed, anchor lowered, and then the first trammel net was deployed.
2. The fishing boat moved toward the currents and the next trammel net was deployed.
3. The end of the trammel net upper rope was knotted with 10 kg weight and to the fishing boat by using other ropes with 10 m and 30 m in length, respectively.
4. The trammel net was dragged to form a semicircle from a quarter circle (Figure 4).
5. The trammel net was lifted onto the fishing boat and the catch was collected from the net.

6. The amount and species composition of each catch was determined.
7. The fishing activity was conducted next in a different location.

Table 1

Specifications of the trammel net

Name of parts	*Trammel net*	
	Simplified trammel net	*Normal trammel net*
1. Net	Front side	Inner net
Material and mesh size	PA 210 D/6; ◇ 4.445 cm	PA 210 D/6; ◇ 4.445 cm
Net dimension	33×2 (m); 1.440×53 (mesh)	33×2 (m); 1.440×53 (mesh)
Length	33 m	33 m
Primary hanging ratio	51.56%; 85.68%	51.56%; 85.68%
	Back side	Outer net
Material and mesh size	PA 210 D/6; ◇ 66.04 cm	PA 210 D/6; ◇ 66.04 cm
Net dimension	33×1 (m); 75×2 (mesh)	33×1.5 (m); 252×7 (mesh)
Primary hanging ratio	65.33%; 75.71%	51.56%; 85.68%
3. Buoy rope	PE; ø 4 mm; 33 m; 0.05 kgf	PE; ø 4 mm; 33 m; 0.05 kgf
4. Weight rope	PE; ø 4 mm; 33 m; 0.05 kgf	PE; ø 4 mm; 33 m; 0.05 kgf
5. Buoy	40 Plastic (3.04 kgf)	40 Plastic (3.04 kgf)
6. Weight	116 Lead (4.20 kgf)	116 Lead (4.2 kgf)

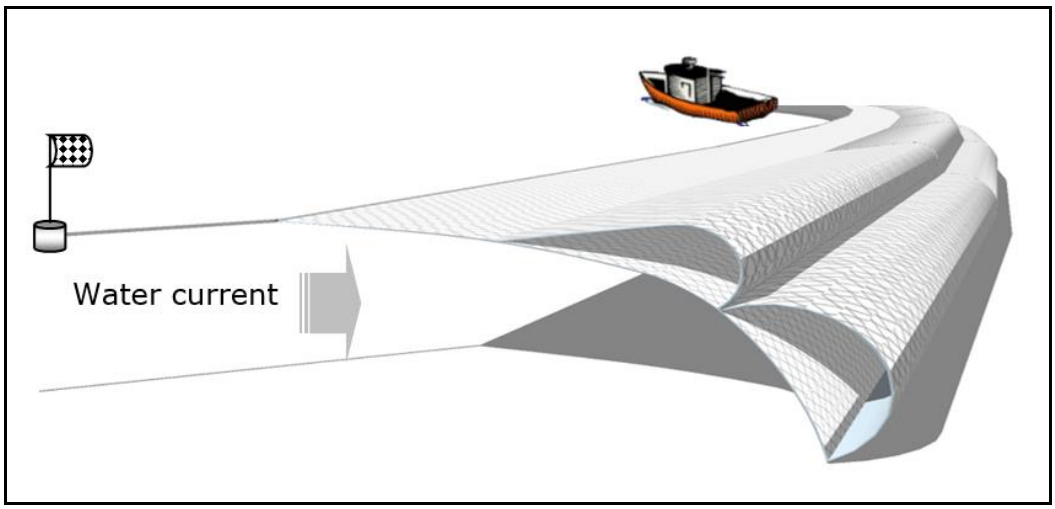

Figure 4. The view of the trammel net in the waters.

Data analysis. Data was collected from the catch of trammel net, for both fish and shrimp. Data analysis used descriptive statistics and statistics test. Descriptive statistics consisted of data tabulation and presenting grouping data by using diagrams and figures (Walpole 1982). The experimental design used in this study was CRD (Completely Randomized Design), while ANOVA statistic test applied in this study was to calculate the significancy different of treatment toward the catch. As a post-hoc test, Duncan's test was conducted with a probability level of 5%. Based on Argyrous (2005), the statistics test must be applied to data normally distributed. Therefore, normality test was applied in advance by Kolmogorov-Smirnov tests.

Results and Discussion

Catch composition. Both simplified and normal trammel net caught ten species of demersal organisms, namely shrimp (*Penaeus* spp.), swimming crab (*Portunus sanguinolentus*), flounder (*Cynoglossus* sp.), saddle grunt (*Polypedates maculatus*), pony fish (*Leiognathus equulus*), threadfin (*Eleutheronema tridactylum*), spotted sicklefish (*Drepane punctata*), Bombay duck (*Harpadon nehereus*), stingrays (*Dasyatis* sp.), and anchovies (*Stolephorus purpureus*). The total catch was 1618 individuals and is detailed in Figure 5.

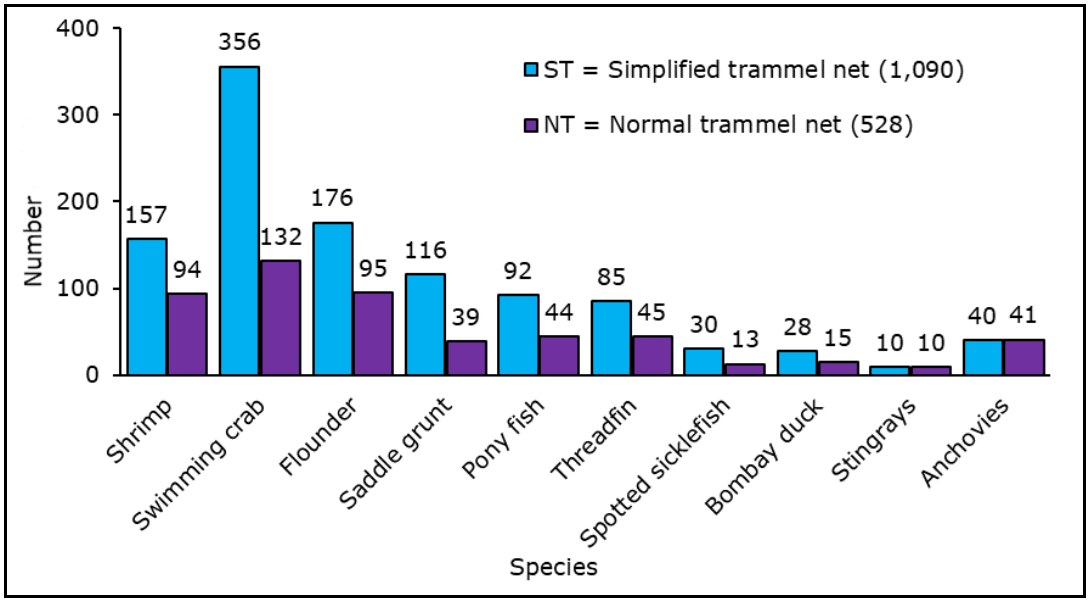

Figure 5. Catch composition of each species

Swimming crab was the dominant catch of the trammel net, with 488 individuals, or 30.16% of total catch. Shrimp was the main target of fishing, and 251 individuals (15.51%) were captured. Both swimming crab and shrimp are dominant because the fishing was conducted in the fishing season for swimming crab and shrimp, which is mid-April (Kitada & Shiota 1990) and February-April (Ernawati et al 2017), respectively. The trammel net was also operated by sweeping the surface of sea floor, which is the habitat for swimming crab (Thomas et al 2003; Hamid et al 2016; Asphama et al 2015) and shrimp (Hindley 1975; Marcia 2004; Fauziyah et al 2019), increasing the probability of catching the two species.

The most caught demersal fish was the flounder, with 271 individuals (16.75%), followed by saddle grunt (155 individuals; 9.58%), pony fish (136 individuals; 8.41%), and threadfin (130 individuals; 8.03%). The possibility of catching all four organisms was high, because the fishing season of flounder and pony fish is throughout the year (Vinagre et al 2006; Imran & Yamao 2014), while for saddle grunt and threadfin is in January-April (Falahatimarvast et al 2012). The trammel net fishing area was located in the coast and estuary. It is the natural habitat for flounder, saddle grunt, pony fish, saddle grunt, and threadfin (Yasuda et al 2010; Peterson & Lowe 2019; Anshary et al 2002; Lee et al 2011; Childs et al 2008; Kulbicki et al 2009; Asriyana et al 2018; Rustandi et al 2019).

Meanwhile, demersal organisms caught in small amounts are Bombay duck (43 individuals; 2.66%), spotted sicklefish (43 individuals; 2.66%), and stingrays (20 individuals; 1.24%). All four organisms were captured in small numbers because their fishing season did not match the fishing activity of the study. Bombay duck fishing season occurs in September-October and May-June (Bapat 1970), spotted sicklefish fishing season in June-August (Pillai & Devadoss 1975), and stingray fishing season in September-February (Paulangan et al 2020).

There were 1090 organisms, or 67.37% of total catch, produced by the simplified trammel net. Meanwhile, the normal trammel net only caught 528 individuals (32.63%). Duncan's test showed an F_{value} of 9.73, higher than F_{table} of 4.06, meaning that simplified trammel net was more productive compared to the control variable with confidence level 5%. The advantage of the simplified trammel net is its high slackness. High slackness creates more flexibility, so, when dragged by fisherman, it will create bigger pockets and catching more fish. According to El-Bokhty (2017), the success of trammel net fishing is determined by the inner net slackness that create pockets. The existence of pockets in two positions made two-thirds of the simplified trammel net body to produce a high possibility to catch the organisms. On the other hand, normal trammel net caught fish and shrimps in small amounts, because its slackness accumulated in the lower side of the net. The pockets were not made while the trammel net was being operated.

The effect of trammel net dragging. The operation of trammel nets by towing one of the ends causes the trammel net shape to change. The upper rope is affected, thus, the net body will be pulled down and curved (Figure 4). The situation affects the different number of fish and shrimp caught according to the position on the net body vertically.

Figure 6 shows the total number of catch with both trammel nets according to its position on the net body vertically. The catch was mostly distributed in the lower side of the trammel net, with 1088 individuals, or 67.24% of all the catch. Furthermore, 466 individuals (28.80%) were distributed in the middle side and 64 individuals (3.96%) in the upper side. The number of catch in every position of the net body and the total number in each trammel net mainly affected by the shape of the fishing net during the dragging process.

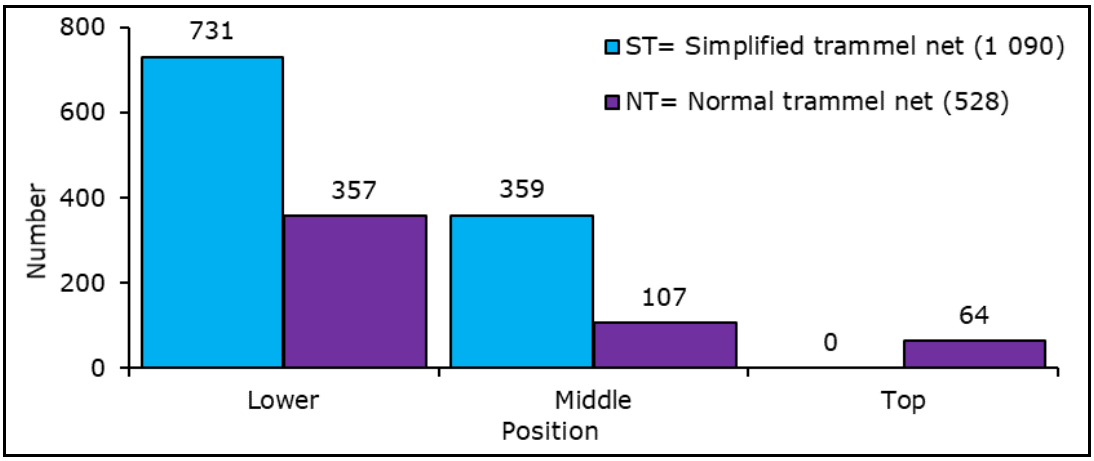

Figure 6. The catch of simplified trammel net and of the normal trammel net based on its position on the net body vertically.

The upper side of the trammel net tends to be flat against currents or in the direction of dragging. Therefore, its main function is only to steer fish and shrimp. The condition of its inner net is also tight, which makes fish and shrimp hard to catch. Different conditions occurred on the middle and lower side. The shape tends to be upright against the currents. Therefore, the possibility of fish and shrimp to be captured is very high. The catch in the lower side apparently was in large amount due to the trammel net operated by sweeping the surface of the sea floor, its main target being demersal organisms (Batista et al 2009).

The shape of the simplified trammel net and normal trammel net is different while being operated (Figure 7). The causes are the existence of hydrodynamic pressures toward the net, either due to currents or the motion of the trammel net. Fridman (1986) explained that the area of net exposed to the currents certainly produces hydrodynamic pressures on the fishing gear. Fujiishi et al (1992) and Puspito et al (1997) explained that the interaction between the lower side rope and the surface of sea floor causes

friction. The combination of these factors causes the trammel net to form a curvature to the surface of the sea floor.

Simplified trammel net only consists of two layers of net, but with the inner net exposed directly against the currents. Hydrodynamic pressure received by the simplified trammel net increases compared to that of the normal trammel net, with its inner net only accumulated in the lower side of the trammel net. The main advantage of the simplified trammel net is that both the middle and lower sides of the net body create slackness and many pockets. Therefore, many fish and shrimp are caught easily in these areas. Any attempts from fish or shrimp to escape will make them more likely tangled (Losanes et al 1992). Meanwhile, the slackness of the normal trammel net is very low, and fish or shrimp are rather difficult to catch.

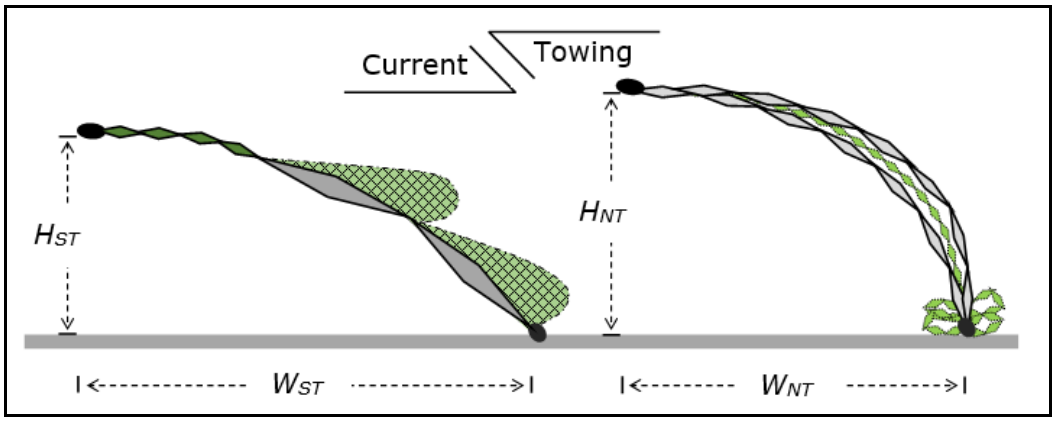

Figure 7. Side view of the trammel net while being operated; H_{ST} - simplified trammel net; H_{NT} - normal trammel net; W_{ST} - sea floor surface covered by simplified trammel net; W_{NT} - sea floor surface covered by normal trammel net.

Another advantage of the simplified trammel net is its higher hydrodynamic pressure and its shape, which is more curved than that of a normal trammel net. Therefore, the probability of fish or shrimp being caught by the simplified trammel net is higher than that of a normal trammel net, since the area under the net becomes wider. The main rope in the upper side of the simplified trammel net (H_{ST}) is lower to the ground than in the normal trammel net (H_{NT}). The area of sea floor surface covered by simplified trammel net (W_{ST}) is also larger compared to the normal trammel net's covering area (W_{NT}).

Distribution of catch by group of organisms. Figure 8 presents the number of catch on the net body by its position vertically. Anchovies were not listed in the figure, because they are classified as pelagic fish species and are not the target of trammel net fisheries. The trammel nets caught anchovies by accident when the trammel nets were lifted onto the boat.

The distribution of shrimps was spread at the lower and middle sides of the net, with a percentage of 53.78% and 40.64% of all shrimp catch, respectively. Meanwhile, the distribution in the upper side only reached 5.58%. Most of the shrimps caught in the two positions of the net because the shrimp inhabit the sea floor. The disturbance caused by the friction between the lower net rope and the surface of the sea floor surprised the shrimps, which moved off the sea floor (Dingle & Caldwell 1969). Wassenberg & Hill (1984) explained that shrimps can jump as high as 10-100 cm, so the possibility of shrimps caught in the lower and middle sides of the net are very high. Only few shrimps were caught in the upper side of all types of trammel nets because it had no slackness. Therefore, the possibility of catching shrimp caught is very small.

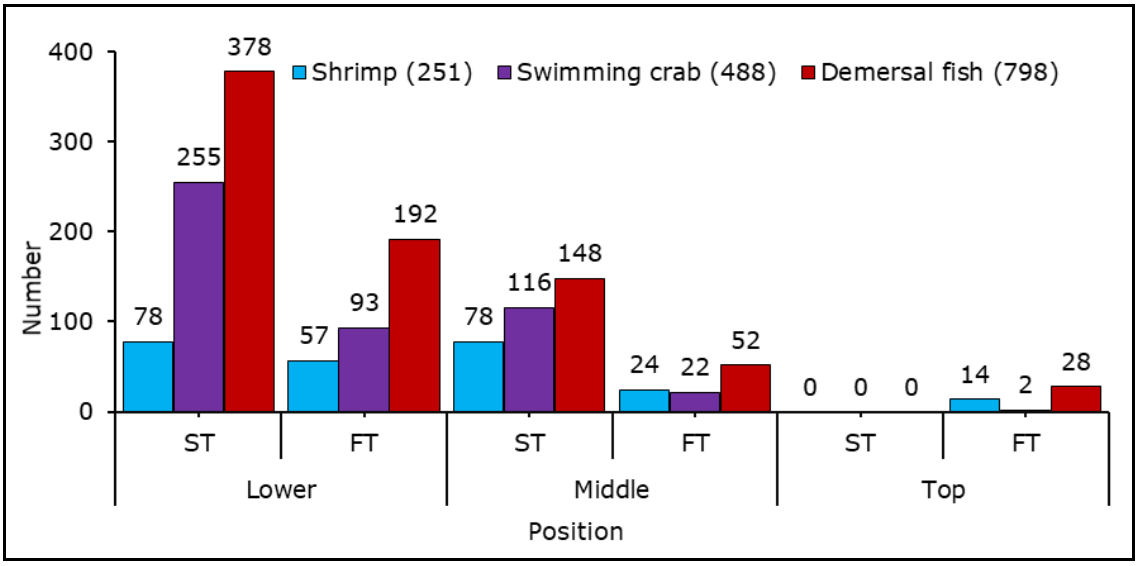

Figure 8. Number of catch on net body based on vertical position.

The percentage of swimming crabs caught in the lower side was 71.31% of the total catch of swimming crab. The next catch was in the middle side (28.28%), followed by catch in the upper side (0.41%). Swimming crab accumulated in the lower side because the trammel net was operated by dragging on the surface of the sea floor, which is the swimming crab's habitat. As a result, the net part that has the highest probability to catch swimming crabs is the lower side of the net. Furthermore, a small proportion of swimming crabs caught in the middle part was caused by the position of the net body, which was close to the surface of the sea floor, due to the curvature of the trammel net while being operated. According to Sukumaran & Neelakantan (1997), swimming crabs can swim vertically for a moment and they can be caught by the trammel net in the middle part, which tends to face downwards. However, almost no swimming crabs were caught in the upper side of the net, because the vertical movement of swimming crabs is limited.

Most demersal fish were caught in the lower part of the net, with 71.43% of the total number of demersal fish, while the rest were caught in the middle (25.06%) and upper side (3.51%). A high number of demersal fish were caught in the lower side because demersal fish inhabit the surface of sea floor during the day, when the trammel net was being operated. For example, the flounder has a swimming depth slightly above the surface of the seabed (Main & Sangster 1981).

The lower side of the net was structurally close to the lower rope dragged on the surface of the sea floor, so the possibility of catching demersal organisms is notably high. Moreover, the number of demersal fish caught in the middle side was large because the vertical movement of demersal fish was covered by the curvature of the net body (Davoren et al 2006). The catch in the upper side was the lowest because it had no slackness available. Almost all demersal fish that hit it would be dragged along the curvature of the trammel net and caught in the middle or lower side of the net.

Conclusions. The study concluded that catch composition of simplified and normal trammel nets consisted of ten species: shrimp (*Penaeus* sp.), swimming crab (*P. sanguinolentus*), flounder (*Cynoglossus* sp.), saddle grunt (*P. maculatus*), pony fish (*L. equulus*), threadfin (*E. tridactylum*), spotted sicklefish (*D. punctata*), Bombay duck (*H. nehereus*), stingrays (*Dasyatis* sp.), and anchovies (*S. purpureus*). The simplified trammel net caught 1090 individuals, being 2.06 times more productive compared to the normal trammel net (528 individuals). Duncan's test proved that the simplified trammel net showed significant differences compared to normal trammel net with F_{value} 9.73 or higher to F_{table} (4.06).

Acknowledgements. We appreciate the valuable collaboration between the Fishing Gear Laboratory of Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, IPB University and Arteria Daya Mulia (ARIDA) as the fishing gear company in completing the study. We would like to thank the general manager of ARIDA, Mr. Arief Yudhi Susanto for his assistance in providing, producing, and assembling the trammel net. Special thanks to Rizki Ghiffari BSc for his participation and work in collecting the data from the fishing trips.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

Anshary J. H., Yamamoto E., Miyanaga T., Ogawa K., 2002 Infection dynamics of the monogenean *Neoheterobothrium hirame* among young wild Japanese flounder in the Western Sea of Japan. Fish Pathology 37(3):131-140.

Argyrous G., 2005 Statistics for research: With a guide to SPSS. 2nd Edition. Sage Publications Ltd., London, 416 p.

Asphama A. I., Amir F., Malina A. C., Fujaya Y., 2015 Habitat preferences of blue swimming crab (*Portunus pelagicus*). Aquacultura Indonesiana 16(1):10-15.

Asriyana, Irawati N., Indrayani, 2018 Trophic ecology of twoblotch ponyfish *Nuchequula blochii* in Kendari Bay, Southeast Sulawesi, Indonesia. AACL Bioflux 11(1): 66-82.

Bapat S. V., 1970 The Bombay duck, *Harpodon nehereus* (Ham.). Bulletin of the Central Marine Fisheries Research Institute 21, 87 p.

Batista M. I., Teixeira C. M., Cabral H. N., 2009 Catches of target species and bycatches of an artisanal fishery: the case study of a trammel net fishery in the Portuguese coast. Fisheries Research 100(2):167-177.

Childs A. R., Cowley P. D., Naesje T. F., Booth A. J., Potts W. M., Thorstad E. B., Okland F., 2008 Estuarine use by spotted grunter *Pomadasys commersonnii* in a South African estuary, as determined by acoustic telemetry. African Journal of Marine Science 30(1):123-132.

Davoren G., Anderson J. T., Montevecchi W. A., 2006 Shoal behavior and maturity relations of spawning capelin (*Mallotus villosus*) off Newfoundland: demersal spawning and diel vertical movement patterns. Canadian Journal of Fisheries and Aquatic Sciences 63:268-284.

Dingle H., Caldwell R. L., 1969 The aggressive and territorial behavior of the mantis shrimp *Gonodactylus bredini* Manning (Crustacea: Stomatopoda). Behaviour 33:115-136.

Dudley R. G., Tampubolon G. H., 1985 [Trammel net shrimp fishery of Java, Indonesia]. Oceanology in Indonesia 19:41-56. [In Indonesian].

El-Bokhty E. A., 2017 Technical and design characteristics of trammel nets used in Lake Manzalah, Egypt. Egyptian Journal of Aquatic Biology and Fisheries 21(3):1-10.

Ernawati T., Sumiono B., Maduppa H., 2017 Reproductive ecology, spawning potential, and breeding season of blue swimming crab (Portunidae: *Portunus pelagicus*) in Java Sea, Indonesia. Biodiversitas 18(4):1705-1713.

Fabi G., Sbrana M., Biagi F., Grati F., Leonori I., Sartor P., 2002 Trammel net and gill net selectivity for *Lithognathus mormyrus* (L., 1758), *Diplodus annularis* (L., 1758) and *Mullus barbatus* (L., 1758) in the Adriatic and Ligurian seas. Fisheries Research 54(3):375-388.

Falahatimarvast A., Poorbagher H., Lokman P. M., 2012 The reproductive biology of *Pomadasys kaakan* (Osteichthyes: Haemulidae) in the northern Persian Gulf. Cahiers de Biologie Marine 53(1):25-34.

Fauziyah, Agustriani F., Purwiyanto A. I. S., Putri W. A. E., Suteja Y., 2019 Influence of environmental parameters on the shrimp catch in Banyuasin Coastal Water, South Sumatra, Indonesia. Journal of Physics Conference Series 1282(1):012103, 8 p.

Fauziyah, Agustriani F., Putri W. A. E., Purwiyanto A. I. S., Suteja Y., 2018 Composition and biodiversity of shrimp catch with trammel net in Banyuasin coastal waters of South Sumatera, Indonesia. AACL Bioflux 11(5):1515-1524.

Fridman A. L., 1986 Calculations for fishing gear designs. FAO Fishing Manual, Rome, 241 p.
Fujiishi A., Nagamatsu K., Teshima K., 1992 A comparison of the catch efficiency between existing topshell trammel nets and improved nets. JSFS 58(7):1243-1250.
Gökçe G., Bozaoğlu A.S., Eryaşar A.R., Özbilgin H., 2015 Discard reduction of trammel nets in the northeastern Mediterranean prawn fishery. Journal of Applied Ichthyology 32(3):427-431.
Hamid A., Wardiatno Y., Batu D. T. F. L., Riani E., 2016 Distribution, body size, and eggs of ovigerous swimming crab (*Portunus pelagicus* Linnaeus 1758) at various habitats in Lasongko Bay, Central Buton, Indonesia. International Journal of Aquatic Biology 4(2):108-116.
Hindley J. P. R., 1975 The detection, location and recognition of food by juvenile banana prawns, *Penaeus merguiensis* de man. Marine Behavior and Physiology 3(3):193-210.
Imran Z., Yamao M., 2014 Factors contributing to the decline of the anchovy fisheries in Krueng Raya Bay, Aceh, Indonesia. ATR 36(2):22-43.
Kalaycı F., Yeşilçiçek T., 2012 Investigation of the selectivity of trammel nets used in red mullet (*Mullus barbatus*) fishery in the eastern Black Sea, Turkey. Turkish Journal of Fisheries and Aquatic Sciences 12(4):937-945.
Kitada S., Shiota K., 1990 Estimation of mortality rates of female swimming crab *Portunus tribuberculatus* Meirs from single-release marking studies. JSFS 56(9):1449-1453.
Kulbicki M., Morize E., Wantiez L., 2009 Synopsis of the biology and ecology of *Pomadasys argenteus* (Haemulidae) in New Caledonia. Cybium 33(1):45-59.
Lee J. H., You Y. S., Park J. C., Cho H. S., 2011 Organotin compounds in olive flounder *Paralichthys olivaceus* and flathead mullet *Mugil cephalus* from Korean coastal waters. Toxicology and Environmental Health Sciences 3(4):220-226.
Losanes L. P., Matuda K., Fujimori Y., 1992 Estimating the entangling effect of trammel and semi-trammel net selectivity on rainbow trout (*Oncorhynchus mykiss*). Fisheries Research 15(3):229-242.
Main J., Sangster G. I., 1981 A study on the fish capture process in a bottom trawl by direct observations from a towed underwater vehicle. Scottish Fisheries Research Report no. 23, 23 p.
Marcia A. A., 2004 Juvenile penaeid shrimp density, spatial distribution and size composition in four adjacent habitats within a mangrove-fringed bay on Inhaca Island, Mozambique. Western Indian Ocean Journal of Marine Science 3(2):163-178.
Mardiah R. S., Puspito G., Mustaruddin, 2016 [Correction of trammel net slackness]. Jurnal Teknologi Perikanan dan Kelautan 7(1):1-10. [In Indonesian].
Olguner M. T., Deval M. C., 2013 Catch and selectivity of 40 and 44 mm trammel nets in small-scale fisheries in the Antalya Bay, Eastern Mediterranean. Ege Journal of Fisheries and Aquatic Sciences 30(4):167-173.
Palabiyik M., Bahadur S., 2002 Tribological studies of polyamide 6 and high-density polyethylene blends filled with PTFE and copper oxide and reinforced with short glass fibers. Wear 253(3-4):369-376.
Park H. H., Millar R. B., Bae B. S., An H. C., Chun Y. Y., Yang J. H., Yoon S. C., 2011 Size selectivity of Korean flounder (*Glyptocephalus stelleri*) by gillnets and trammel nets using an extension of SELECT for experiments with differing mesh sizes. Fisheries Research 107(1-3):196-200.
Paulangan Y. P., Rumbiak K., Barapadang B., 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay, Jayapura Regency, Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:012031, 8 p.
Peterson M. S., Lowe M. R., 2019 Implications of cumulative impacts to estuarine and marine habitat quality for fish and invertebrate resource. Reviews in Fisheries Science 17(4):505-523.

Pillai P. K. M., Devadoss P., 1975 A note of the fecundity and spawning period of *Drepane punctata* (Linnaeus). Indian Journal of Fisheries 22(1-2):262-264.
Puspito G., Yamamoto K., Hiraishi T., Nashimoto K., 1997 Lower line and tension of shrimp trammel net towed along the hypotenuse of right triangle. Fisheries Science 63(1):1-5.
Rihmi M. K., Puspito G., Wahju R. I., 2017 [Construction modification of trammel net: an effort to increase the catch]. Jurnal Teknologi Perikanan dan Kelautan 8(2):169-178. [In Indonesian].
Rustandi Y., Fahrudin A., Zairion, Arkham M. N., Zahid A., Hamdani A., Ramli A., Trihandoyo A., 2019 Distribution fisheries resources of Small Island in Estuary Area: an assessment in Bunyu Island, North Kalimantan, Indonesia. IOP Conference Series: Earth and Environmental Sciences 241:012003, 9 p.
Sukumaran K. K., Neelakantan B., 1997 Food and feeding of *Portunus* (*Portunus*) *sanguinolentus* (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus) (Brachyura: Portunidae) along Karnataka coast. Indian Journal of Marine Sciences 26(1):35-38.
Thomas S. N., Edwin L., George V. C., 2003 Catching efficiency of gill nets and trammel nets for penaeid prawns. Fisheries Research 60(1):141-150.
Vinagre C., Fonseca V., Cabral H., Costa M. J., 2006 Habitat suitability index models for the juvenile soles, *Solea solea* and *Solea seneglensis*, in the Tagus estuary: Defining variables for species management. Fisheries Research 82(1-3):140-149.
Walpole R. E., 1982 Introduction to statistics. 3rd Edition. Macmillan, 346 p.
Wassenberg T. J., Hill B. J., 1984 Moulting behavior of the tiger prawns *Penaeus esculentus* (Haswell). Australian Journal of Marine Freshwater Research 35(5):561-571.
Webb P., 2021 Introduction to oceanography. Rebus Community, 286 p.
Yasuda T., Kawabe R., Takahashi T., Murata H., Kurita Y., Nakatsuka N., Arai N., 2010 Habitat shifts in relation to the reproduction of Japanese flounder *Paralichthys olivaceus* revealed by a depth-temperature data logger. Journal of Experimental Marine Biology and Ecology 385(1-2):50-58.

Received: 09 January 2022. Accepted: 03 March 2022. Published online: 30 June 2022.
Authors:
Gondo Puspito, Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, IPB University, Agatis Street, IPB Campus Dramaga, 16680 Bogor, Indonesia, e-mail: gondo@apps.ipb.ac.id
Sugeng Hartono, Marine Biology Department, Faculty of Marine Science, King Abdulaziz University, 7404 Abdullah Sulayman, 22254 6382 Jeddah, Saudi Arabia, e-mail: shartono@stu.kau.edu.sa
Rizki Ghiffari, Fisheries Resource Utilization Department, Faculty of Fisheries and Marine Science Technology, IPB University, Agatis Street, IPB Campus Dramaga, 16680 Bogor, Indonesia, e-mail: gifnirizkighiffari12@gmail.com
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Puspito G., Hartono S., Ghiffari R., 2022 Simplification of trammel net construction to increase catch results. AACL Bioflux 15(3):1606-1616.