Trammel net design engineering for operation with the sweeping method (Ciker net)

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**ABSTRACT**

The active operation of a trammel net by a sweeping technique is commonly used by fishermen in Cilacap, which are often referred as ciker nets. They are operated by lowering the net in a straight line and pulling the tail end from a ship moving in a full circle, while the other end functions as a circular axis. The effect of active operation allows for changes in performance with time, such as easy lifting or less buoyancy, and the unstable display of gears. This makes it necessary to perform design engineering, especially on buoys, sinkers, and high nets. However, the suitable quantity of these components for ciker net has never been ascertained. Calculations about how many buoys, sinkers, and net height to add need to be done to enhance ciker net construction for active operation. This research aimed to determine the optimum configuration of buoys, sinkers, and net height, and determine the engineering design of ciker nets based on the optimum ratio of buoyancy force to the sinking force of the trammel net. Therefore, the parameters measured include hanging ratio, stretched net length, bouyancy force, and sinking force. The results showed that the optimum configuration of buoys, sinkers, and net height was 59 pieces, 341 pieces, and 1.5 m respectively. Changes in the design of ciker nets, especially in the three components that affect the addition of buoyancy and sinking force ratio were based on the comparison of the trammel nets which was 1.5 greater than the design owned by fishermen at 1/4.

**Introduction**

A Trammel net is used to catch fishes by capturing in a net (Aulia \textit{et al.}, 2020). The construction consists of three sheets of nets, namely two sheets in the outer net having larger mesh size, and 1 sheet of inner net having small mesh size. (Subani and Barus, 1989). Mangunsukarto \textit{et al.} (1993) stated that low shrimp production from the trammel net is highly related to the method of use or operation, specifically as a set bottom trammel net. Therefore, Mangunsukarto \textit{et al.} (1993) recommended that the net be operated by the sweeping method, because actively operated gears increase the chances of more shrimp being touched and then caught. Generally, these nets are operated in coastal waters with a sandy or muddy base, or a mixture of both intended for shrimp fishing (Martasuganda, 2008).

The operation of trammel net by active or passive means involves different processes. The first way is to operate passively, during which this net is set at the sea bottom or drifted (Subani and Barus, 1989). The second is by active operation, which involves lowering the net in a straight direction then pulling the tail end of the net with a vessel moving in a trajectory that forms a full circle or semicircle, while the other end serves as a circular shaft (Matuda and Kitahara 1967; Nomura and Yamazaki 1977). This second way is called the sweeping trammel net technique, and is a type of entanglement fishing gear operated by a circular or semi-circular sweeping of the sea bed (Kitahara, 1968; Kitahara and Matuda, 1967; Matuda and Kitahara, 1967; Purbayanto, 2001; Purbayanto \textit{et al.}, 2008, 2000; Tupamahu and Latumeten, 2006). Currently, the sweeping trammel net method has been used by fishermen in various places, including on the southern coast of Java Island, and the coast Cilacap, where they are known as ciker nets.

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The imperfection of the ciker net design to operate actively by sweeping the sea bed or pulling, is one of the problems that should be avoided, as fishermen want to catch fishes located at or near the bottom of the water. Considering that the target fish type is on or near the seabed, this is required that this sweeping process effectively reaches the seabed, in order to reach and catch the target fishes (Purbayanto et al., 2000). Kartawijaya et al. (2011) stated that during fishing, sweeping trammel nets allow the end of the net that is close to the ship to be slightly lifted due to the pull of the ship. Therefore, a sinking force configuration similar to an adequate sinker, is required for seabed sweep. The targeted shrimps may also jump to avoid being caught, which necessitates the appropriate configuration of buoyancy force and net height (mesh depth) to maintain the gear appearance in the water. These three things are important in the operation of sweeping trammel nets, to prevent the escape of shrimp past the bottom or top of the ciker net.

Cilacap fishermen generally operate ciker nets in an active way to catch shrimp, but ciker nets are mainly designed as a passive fishing gear. This ciker net design has a buoyancy and sinking force that are not optimal for active operation. When the ciker net is operated in an active way, i.e. pulled, this causes the net to be lifted easily due to the resultant upward forces influencing the net. The factors that determine the effectiveness of ciker nets in sweeping the seabed include the float, sinker, and net height configurations. (Prado, 1990; Harlyan et al., 2013) confirmed that buoys not only add additional buoyancy, but also balance the total gear weight, because the total weight is largely determined by the high contribution of the attached sinker to the catch. In addition, Quevedo (2001) emphasized that active shrimp nets with high net openings and good sea bed sweeps possess a higher fishing power. The effectiveness of trammel nets can be improved by applying net engineering (Hartono et al., 2016). A new design for ciker nets was therefore created, to include additional buoyancy, sinking force, and net height. The number of buoys, sinkers, and net height also have to account for the swimming layer of the targeted shrimp, which can be determined through calculations. The new configuration is expected to create stability in sweeping the seabed to enable more effective and efficient fishing operations.

The amount of change must be determined based on a number of calculations. The addition of sinker will increase the weight of the net (Harlyan et al., 2013), and the addition of buoys also enlarge the opening of the net (Sasmita, 2013). The buoys added should be according to the height of the net as well (Prado, 1990). Furthermore, the ratio of buoyancy to sinking force is an important aspect in determining the design of the ideal ciker net for active operations. This study aims to determine the configuration of optimum buoys, sinkers, and net height of ciker nets for active operations.

Materials and Methods
Research location and time
Field research was conducted in October 2019 in Penyu Bay, Cilacap Regency, Central Java. During the field research has been carried out identification of the design and construction of ciker nets that operated by fishermen. Location identification of ciker net design and construction presented in Figure 1.

Figure 1. The map of the research location and operation.

Figure 2. The sketch of the sweeping trammel net operation in the waters.

Tools and materials
Field research is carried out in the form of identification of ciker net design and construction. Research materials are the component of ciker nets that consisting of three layers of nets in the form of squares with different mesh sizes, buoys, ropes, and
sinkers. The identified ciker net consists of 1 net piece with a design commonly used by fishermen for the operation of sweeping trammel nets. If in one unit the net consists of 8 net pieces then the measured only 1 piece of net represents one unit of net (Figure 2). The dimensions and quantity of each component of the ciker net are measured using the appropriate measuring instrument. Identification is performed on the type of material, the number of each component, and the size of the ciker net component. The identification process uses guidelines published by the net manufacturer. While the size of the length and weight of materials such as buoys, webbing, ropes, etc. use measuring instruments such as caliper, and scales. In addition, it is also carried out the process of measuring the weight of each component of ciker nets in seawater for analysis of the ratio of buoyancy and sinking force. This process uses seawater as a medium of measurement.

**Data collection**

Data identifications are required to test the operation of ciker nets in pools and perform ciker net engineering. Trials to see the performance of the net as preliminary information to engineering the ciker net. The trial was conducted in a pool filled with water without currents. This trial used 1 net piece that represents the net ciker owned by fishermen. The nets are assembled with additional components consisting of triangular ropes, swivel, buoys, and three stones as ballast each with the composition as in Figure 2. Next, the net is stretched inside the pool, and pull one of the net end’s twists sweeping the bottom until it forms a semi-circular. The data obtained in this trial consists of the height of the net and the shape of the net before and during the pulled. Data from the trial results were used to sharpen the discussion of the results of ciker net engineering research.

The dimensions of the ciker nets owned by fishermen are necessary to determine the design and construction suitable for the operation of sweeping trammel nets. These dimensions are preliminary input data obtained from identification in field research in Penyu Bay. Field research is carried out by direct identification and measurement of ciker net components. Identification is carried out on one unit of the net while measurements are carried out on one net piece that is still intact and not damaged. The net components of the measured consist of the type of material and dimensions of the ropes, buoys, selvage net, inner net, outer net, and sinkers.

Measurement of rope components consists of the type of use of ropes, materials, length, diameter, and the rope pattern. Measurement of buoy consists of number, type, and buoy material. Selvage, inner, and outer nets consist of material types, mesh size, number of vertical and horizontal mesh. Sinker consists of quantity, type, and material. Furthermore, part of the measurement results is used to support the calculation of the weight of component types in seawater. The process of collecting data for the weight of component types is carried out by laboratory-scale research using seawater. Samples from each identification component are first sorted which ones have a buoyancy force or sinking force in the water. Then each of these components is measured separately to get the actual force in the seawater. The process of measuring the buoyancy force and sinking force of the components follows Fridman (1986) like Figure 3.

Data processing includes the calculation of the number of buoys, sinkers, vertical net meshes on the selvage net, inner net, and outer net. Calculation of suitable vertical net meshes for the addition of optimal net height. The calculation will affect or produce a hanging ratio, comparison of the height of the outer and inner net, and composition of buoys and sinkers alternatively than owned by fishermen. The next data processing is an analysis of the buoyancy and sinking force ratio of one net piece that can be used to calculate the comparison of buoyancy and sinking force one unit of the net by multiplying the number of net pieces used. The final result of buoyancy and sinking force data processing becomes an assessment of ciker net based on preferences. The standard force ratio used is the force ratio on the trammel net.

![Figure 3. The illustration of how to measure the force on each component of the ciker net in the water (a). buoyancy force of floating components, (b), the sinking force of sinking components (Fridman, 1986).](image-url)
Data analysis

The identification and measurement of ciker nets were performed to obtain the design and construction of existing ciker nets. Furthermore, these results are used to engineer optimum design and construction as an alternative to shrimp fisheries. Each of these designs will be analyzed using a calculation of buoyancy and sinking force ratio, where an optimal ratio signifies a good design. According to Najamuddin et al. (2011), this difference in buoyancy and sinking forces determines the position of fishing gear in the water.

Design and construction

The calculation for the design and construction engineering consists of hanging ratio, net height, number of mesh, and stretched length of the net in meters. Determining the hanging ratio is an important first step (Mardiah and Pramesthy, 2019). Hanging ratio calculation using formula in Martagusanda et al. (2000).

\[
S_a = \frac{L_a}{L}; \quad S_b = \frac{L_b}{L}
\]

Where \(S_a\) is hanging ratio of the head rope, \(S_b\) is hanging ratio of the ground rope, \(L\) is the length of the stretched net (cm or m), \(L_a\) is the length of the head rope (cm or m), and \(L_b\) is the length of the ground rope (cm or m).

The net height calculation can be used to find a comparison between the height of the outer and inner net. The height of the net can be determined by using the formula in Martagusanda (2008).

\[
Md = m \times n \times \sqrt{2S} - S^2
\]

Where \(Md\) is the net height, \(S\) is the average of hanging ratio of the hanging ratio on head and ground ropes (%), \(m\) is two bars (mesh size), and \(n\) is the number of mesh depth in vertical required.

The number of meshes needed for a unit of 1 m length is very important to net engineering. The net height can be determined by using the formula in Martagusanda (2008).

\[
L = \frac{L}{MS}
\]

Where \(L\) is the number of meshes needed for a unit length of 1 m, \(L\) is the stretched length of the net (cm or m), and \(MS\) is the mesh size (cm or m).

The stretched length of the net horizontally and vertically is needed to calculate the number of mesh and hanging ratio. The unit can be cm or m depending on the required design. Calculation of the stretched length of the net using the formula below.

\[
L = MS \times n
\]

Where \(L\) is the stretched length of the net (cm or m), \(MS\) is the mesh size (cm or m), and \(n\) is the number of mesh depth on vertical required.

Buoyancy and sinking forces

The net weight depends on the net, rope, buoy, and sinker components. The net weight depends on the material and size of the net (mesh length; mesh depth), yarn size, and mass density of the net. While the rope weight depends on the material, diameter, and rope length, and mass density of the rope. The buoy and sinker weight depend on the form and size (diameter and length) as well as the mass density of both. The weight of such components is required to calculate the ratio of buoyancy and sinking forces of ciker net. Buoyancy and sinking forces were determined using the formula in Martagusanda (2008).

\[
F = W \left( \frac{1}{L} - 1 \right)
\]

\[
S = W \left( 1 - \frac{1}{L} \right)
\]

With \(F\) is the buoyancy of the component, \(S\) is the sinking power of the component, \(W\) is the weight of the component in the air (grf/kgf), \(C\) is the mass density of component (gr/kg), and \(1\) is the mass density of seawater (1,025 gr/cm$^3$ or kg/dm$^3$).

Results

Identification, design and construction

One unit of ciker net usually consists of 6-8 net pieces connected with each other. This study identified 1 net piece representing 1 unit of net. The identified materials include nets, ropes, buoys, and sinkers. The results of identification and calculation of ciker nets owned by fishermen are shown in Table 1.

The inner and outer nets are made of clear nylon (monofilament) in sizes of 0.12 mm and 0.28 mm, respectively. The mesh size of inner and outer nets are 44.45 mm and 139.70 mm, respectively. Furthermore, the number of horizontal mesh are 2,057 ML (91.44 m) and vertical mesh 50.5 MD (2.04 m) for the inner net, while the outer net consists of 524 ML horizontal (73.15 m), 8.5 MD vertical (1.01 m). Selvage nets were made of nylon d/6, mesh size 44.45 mm, number of horizontal mesh 2,640 ML (117.35 m), vertical mesh 50.5 MD (0.11 m) both on the upper and lower selvage.

The ropes used by fishermen for ciker nets include float line, head, sinker and ground ropes. The float line consists of 2 ropes and the head rope consists of 1, each using a diameter of 5 mm and 6 mm with the same length of 35.20 m. Furthermore, the sinker and ground ropes use the same dimensions that are 3 mm in diameter and 41.44 m in length. Fishermen also use plastic buoys with factory standard W-3 sizes of 45 pieces to offset the
amount of the sinker weighing 8.03 kg in the air (260 pieces multiplied by the 30.88 gr) used.

Generally, fishermen determine the size and number of net mesh, ropes, floats, and sinker based on their benchmark habits. This is necessary to ensure a uniform design and construction among ciker net fishermen. The results of the identification were used to calculate the hanging ratio, specifically the upper and lower hanging ratios of the three sheets of net. Hanging ratios from the design and construction were different from the inner and outer nets, and these differences are shown in Figure 4.

Table 1. Specifications of ciker nets owned by fishermen (specifications for 1 net piece).

| No | Components        | Materials  | Dimensions            |
|----|-------------------|------------|-----------------------|
| 1  | Ropes             |            |                       |
|    | - Head rope       | Polyethylene (PE) | Ø 6 mm, 35.20 m       |
|    | - Ground rope     | Polyethylene (PE) | Ø 3 mm, 41.44 m       |
|    | - Float line      | Polyethylene (PE) | Ø 5 mm, 35.20 m (2x)  |
|    | - Sinker line     | Polyethylene (PE) | Ø 3 mm, 41.44 m       |
| 2  | Nets              |            |                       |
|    | - Upper selvage net | Polyethylene (PE) | 380 d/6, MS 44.45 mm, 2,057 ML, 3.5 MD |
|    | - Lower selvage net | Polyethylene (PE) | 380 d/6, MS 44.45 mm, 2,057 ML, 3.5 MD |
|    | - Inner net       | Polyamide (PA) monofilament | Ø 0.12 mm, MS 44.45 mm, 2,057 ML, 50.5 MD, E upper 0.38, E lower 0.45 |
|    | - Outer net       | Polyamide (PA) monofilament | Ø 0.28 mm, MS 139.70 mm, 524 ML, 8.5 MD, E upper 0.48, E lower 0.57 |
| 3  | Float             | Plastic, PVC (W-3) | 17.28 grf/pieces, 45 pieces |
| 4  | Sinker            | Plumbum (Pb) | 30.88 grf/pieces, 260 pieces |

Figure 4. Design of ciker nets owned by fishermen (1 net pieces).

Engineering, design and construction

Engineering was performed to improve the performance of ciker nets as actively operated trammel nets for sweeping the sea bed. Problems that occur during active operation include the unnecessary lifting or flying of the net, reduction in the net height during use, and the loss of the effective area of the net body during active operation. This is more effective whenever the same design with the set bottom trammel net is operated by sweeping method. Therefore, changes were made relative to the above problems, specifically in buoys, sinkers, and net height. Some other components of the net also changed according to the improvement in these three components, as shown in Table 2, and Table 3.

Table 2. Ciker nets engineering specifications (for 1 net piece).

| No | Components        | Materials  | Dimensions            |
|----|-------------------|------------|-----------------------|
| 1  | Ropes             |            |                       |
|    | - Head rope       | Polyethylene (PE) | Ø 6 mm, 35.20 m       |
|    | - Ground rope     | Polyethylene (PE) | Ø 3 mm, 41.44 m       |
|    | - Float line      | Polyethylene (PE) | Ø 5 mm, 35.20 m       |
|    | - Sinker line     | Polyethylene (PE) | Ø 3 mm, 41.44 m       |
| 2  | Nets              |            |                       |
|    | - Upper selvage net | Polyethylene (PE) | 380 d/6, MS 44.45 mm, 2,057 ML, 3.5 MD |
|    | - Lower selvage net | Polyethylene (PE) | 380 d/6, MS 44.45 mm, 2,057 ML, 3.5 MD |
|    | - Inner net       | Polyamide (PA) monofilament | Ø 0.12 mm, MS 44.45 mm, 2,057 ML, 50.5 MD, E upper 0.38, E lower 0.45 |
The next change involved the improvement of the net height. This was based on the number of the outer net vertical mesh, the selvage net, and the average hanging ratio of the upper and lower outer nets. Net height improvement was performed to anticipate shrimp jumps and the shape or performance of nets in seawater during use or operation. The hanging ratio on the inner and outer layer nets obtained is shown in Figure 5. Meanwhile, the improvement of net height started with the addition of the number of mesh in the vertical direction. The mesh depth (MD) number of the outer net was 1.5 MD added to 10 MD in the engineered design, and the number of mesh depth in the upper and lower selvage nets was 1 MD added to 3.5 MD respectively. Therefore, using the formula of Martasuganda (2008) the appropriate net height of the engineered ciker net was 1.5 m. The difference in height of engineered ciker nets is 0.3 m higher than the conventional net ciker owned by fishermen.

**Ratio of buoyancy and sinking forces**

The weight of each component of the measured ciker net consists of the weight in both air and seawater. The results of the measurement and calculation of weight on nets, ropes, buoys, and sinkers are shown in Table 4. Measurements conducted against samples from each component that form the ciker net involved the method from Fridman (1986).

![Figure 5. Engineering design of ciker nets from (1 net piece).](image-url)
The measured weight of samples were analyzed to obtain the unit weight of each component for its suitability as an input for ciker net engineering. For each component, the weight in the air consists of an inner net weighing 0.001 grf per net mesh, outer net weighing 0.021 grf per net mesh, selvage net 0.035 grf per net mesh, buoy rope 15 grf per piece, head rope 19 grf per m, sinker and ground rope 5 grf per m, buoy weighing 19 grf per piece, and sinker weighing 31 grf per piece. However, in seawater, the weight in consists of an inner net weighing 0.001 grf per net mesh, outer net weighing 0.018 grf per net mesh, selvage net 0.030 grf per net mesh, buoy rope 6 grf per m, head rope 6 grf per m, sinker and ground rope 3 grf per m, buoys weighing 4 grf per piece, and sinkers weighing 29 grf per piece.

The results of weight calculation in both air and seawater are then used to calculate the total weight and ratio of buoyancy and sinking force, including the ones owned by fishermen and the engineered design. The total weight of ciker nets owned by fishermen in seawater was smaller than the engineered design at varying weights of 9.59 kgf and 11.84 kgf, respectively. The comparisons of buoyancy forces and sinking forces of both ciker net designs are shown in Table 5. The results of the comparison calculation of buoyancy and sinking force showed that the engineered ciker net of 1:5 achieved the maximum ratio of trammel net, compared to the fishermen’s design of 1:4.

### Table 4. Weight of the main components of ciker nets measured in air and seawater (kgf).

| Components   | Materials | Dimensions | Weights (kgf) Air | Weights (kgf) Sea water |
|--------------|-----------|------------|------------------|------------------------|
| Inner net    | Polyamide | Ø 0.12 mm, MS 44.45 mm, 400 ML, 50.5 MD | 0.030 | 0.022 |
| Outer net    | Polyamide | Ø 0.28 mm, MS 139.70 mm, 200 ML, 8.5 MD | 0.035 | 0.030 |
| Selvage net  | Polyethylene | 380 d/6, MS 44.45 mm, 400 ML, 2.5 MD | 0.035 | 0.030 |
| Float line   | Polyethylene | Ø 6 mm, 5 m | 0.075 | 0.030 |
| Head rope    | Polyethylene | Ø 5 mm, 5 m | 0.095 | 0.030 |
| Ground rope  | Polyethylene | Ø 3 mm, 10 m | 0.050 | 0.030 |
| Sinker lines | Plastic   | Ø 3 mm, 10 m | 0.050 | 0.030 |
| Floats       | PVC (W-3) | 1 peace | 0.019 | 0.004 |
| Sinkers      | Plumbum   | 1 peace | 0.031 | 0.029 |

### Table 5. Comparison of buoyancy force and sinking force between the engineered and the ones owned by fishermen (existing) (kgf) 1 net piece

| No. | Components | Existing Buoyancy force (kgf) | Sinking force (kgf) | Engineered Buoyancy force (kgf) | Sinking force (kgf) |
|-----|------------|-------------------------------|---------------------|---------------------------------|---------------------|
| 1   | Inner net  (PA)+ | 0.044                        | 0.044              |                                  |                     |
| 2   | Outer net  (PA)+ | 0.013                        | 0.015              |                                  |                     |
| 3   | Upper selvage (PE)- | 0.033                        | 0.036              |                                  |                     |
| 4   | Lower selvage (PE)- | 0.033                        | 0.036              |                                  |                     |
| 5   | Float line (PE)- | 0.634                        | 0.317              |                                  |                     |
| 6   | Head rope (PE) | 0.458                        | 0.458              |                                  |                     |
| 7   | Ground rope (PE)- | 0.083                        | 0.083              |                                  |                     |
| 8   | Sinker line (PE)- | 0.083                        | 0.083              |                                  |                     |
| 9   | Buoy | 0.675 | 0.885 | | | |
| 10  | Sinker | 7.540 | 9.889 | | | |
|     | Total | 1.998 | 7.597 | 1.897 | 9.948 |

Ratio of buoyancy force and sinking force

\( \frac{\text{Buoyancy force}}{\text{Sinking force}} = \frac{1}{4} \) for existing and \( \frac{1}{5} \) for engineered.

### Discussion

Each piece of existing ciker net is equipped with 5 additional weights of 0.5 kg per piece, therefore, the total weight contribution to the sinking force is 1.67 kgf. The addition of the sinker will increase the sinking force. Alternatively, on the engineered ciker net, the contribution of the sinker to the sinking force is 9.89 kgf. When the buoyancy is fixed, caution is required when adding a sinker. This is because it causes an increase in the net tension, especially on both layers of the outer net, causing it to become tense due to its short height compared to the inner net. Furthermore, this is shown in the composition of the number of mesh in Figure 4 and Figure 5.

Although both outer nets have larger net mesh than inner nets (Gabr and Mal 2016). The presence of buoys and sinker makes the outer net stretch over the surface of the sea bed (Puspito et al., 2019). When the net is pulled, the net tension increases due to the resistant force. Furthermore, buoyancy increases with the addition of buoys, which causes a higher net tension. It must be ensured that the speed of net pull when sweeping the seabed does not cause a resultant force that exceeds the tolerance of net integrity. The normal pull speed of ciker nets ranges between 0.565 m/s – 0.788 m/s (1 knot – 1.5 knots) depending on water conditions. High sinking force in the engineered nets will affect...
sea bed sweep and makes the net not easily lifted. Therefore, the addition of a comparable buoyancy configuration is required, especially the number of buoys attached, to balance the total weight of the fishing gear in the water. The effectiveness of the net in sweeping the seabed is determined by the resultant force that the net inflicts on the sea bed. The more optimal the force, the more evenly the net touches the sea bottom. Although buoyancy force and sinking force are both large, when the resultant force is small, the net will not effectively sweep the sea bed. The ratio of buoyancy and sinking forces in existing ciker nets was 1:4 while that of the engineered ciker net is 1:5. Therefore, the engineered ciker net will be more effective in sweeping the sea bed.

The buoy is one of the components of ciker nets that need to be changed for improvement of sweep quality. They are made of cylindrical synthesis material, and function to maintain the balance of the net against sinkers. In addition, buoys help to sustain net performance in water during operation. A non-maximal buoyancy force will cause the net performance to be poor during active operation. Furthermore, Harlyan et al. (2013) stated that buoys will lose their function due to an increase in net pull speed. They also determine the size of the buoyancy force.

According to Martasuganda (2006), the number, type, weight and volume of buoys used in one piece will determine the buoyancy. Najamuddin et al. (2011) observed that the size of buoyancy attached to a piece will significantly influence the volume of the catch. The increase in the number of buoys adjusts to the number of sinkers used, in order to improve the performance of nets in the water. Sasmita (2013) stated that the addition of buoys enlarged the mouth openings of actively operated nets. Further increase in the number of buoys on the engineered design also adjusted to the height of the net. Prado (1990) stated that the number of buoys have to be in line with the height or the depth of the nets. Another factor that plays a role in the effort of catching shrimp with ciker nets is the height of the attached net. Improvements were made on the addition of high nets in order to solve the high jump of shrimp catch targets. The operation of ciker nets allow for the lowering of the filtered water column because the height of the net is reduced when the net is pulled. The jump of white shrimp *Penaeus merguiensis* according to (Jayanto et al., 2013) can reach 100 cm. In addition, the ciker net when pulled will lean forwards, thereby making the top of the net to be a barrier for shrimp to escape. This is because when withdrawing the trammel net, its body tends to fall down (Rihmi et al., 2017).

Figure 6. Illustration of the position of the net during the pull trial on the water without current, when the withdraw arises trust force (R) against the net so that the shape of the net changes from the starting position (Ao) to skewed forward (A1). While the buoyancy force becomes reduced as seen previously the net stretches to the surface (B) turns into a sink in position (B’). While the sinking force (W) leads to the bottom of the water.

Trials of the withdrawal of ciker nets in water without currents with a pull speed of 1 knot (optimum speed of pull of ciker nets) showed the net lying forward up to 90 cm from the starting upright position. This was followed by a reduction in net height of up to 50 cm measured straight from the sinker line to the float line. The position of the net during the trial is illustrated in Figure 6. The height of the attached net in the existing ciker net was only 1.2 m.

In addition, from the field observations on the fishing operation of existing ciker nets, there were shrimp caught on the very top mesh of the inner net. That way the shrimps had the potential to escape through the height of the net. Therefore, the addition of net height for the engineered design of 1.5 m, is 30 cm greater than the height of the existing ciker net owned by the fisherman. This height increase is calculated from the hanging ratio and increasing the number of mesh depth (MD). The addition of this net height aims to block the shrimp from passing through the top of the net, and also to produce appropriate slackness. The increase
in the number of weights, buoys, and height of the net as a whole is controlled based on the comparison of buoyancy force and the sinking force of the trammel net.

Besides the configuration of components to form the design and construction of nets, the hanging ratios, shortening, and slackness also play an important role in efforts to catch shrimp. The hanging ratio is the ratio between the hanging of the attached net and the fully stretched net. The hanging ratio affects the height of the attached net which directly affects the catch. According to (El-Bokhty 2017; Khikmawati et al., 2017) hanging ratio also influences the shape and efficiency of trammel net, including how organisms are caught on the net.

Hanging ratio in engineered ciker net design is almost similar to the design used by fishermen because it uses the same size and number of horizontal net meshes. Furthermore, shortening on engineered design is similar to the design owned by fishermen. The shortening value of the upper inner net was 61.51% on the existing design, and 61.51% on the engineered design, while the shortening value of lower inner net was 54.68% on an existing design, and 54.68% on engineered design. The shortening value of the upper outer net was 51.35% on the existing design, and 51.01% on the engineered, while that of the lower outer net was 43.35% on an existing design, and 42.32% on the engineered. Shortening on gillnet significantly influences catches, and the shortening value is 30 % - 40 % for target fish caught gilled, and 35 % - 60 % for target fish caught entangled (Fridman, 1986; Nomura and Yamazaki, 1977; Sudirman and Mallawa, 2012).

The shortening value differs especially in the outer net because the mesh length (ML) used varies between existing and engineered designs. The number of ML in the existing design is 524 ML and 514 ML in engineered design. The determination of ML in the existing design utilized the 100 YRD net length from the factory, while in the engineered design the determination of ML based on the comparison of ML outer net with ML inner net was 1:4 (1 ML outer net equals 4 ML inner net). Furthermore, shortening is an attached mesh opening influenced by the length of the attached net and the length of head or ground ropes used. The principle of fishes caught is influenced by the value of shortening (Dermawati et al., 2019). Shortening also affects the slackness of the net, and its value is different from the hanging ratio value in the engineered design.

The hanging ratio values tend to be larger at the bottom and smaller at the top. Conversely, the shortening value is greater at the top and smaller at the bottom. This agrees with Najamuddin (2011) which observed that a shortening value at the top is greater than at the bottom, therefore the size of the fishing equipment at the bottom becomes longer than the top. This is to ensure that the position of the fishing equipment at the time of operation can be stretched well in the water. According to Martasuganda (2008), the shortening value on the head rope should be slightly greater than the ground rope, with the aim that the position of the net during operation can be stretched well in the water.

The difference is not only in the overall net height but also on the ratio of net height, or ratio of the vertical mesh from the outer and inner net (slackness). Slackness on the existing design was 2.0, and on the engineered design 1.7. Therefore, the slackness in the engineered design met the appropriate ratio. According to Martasuganda (2008), the difference between the height of the outer and inner net called "slackening" ranges between 1.1 and 1.9. Gabr and Mal (2016) stated that the vertical slack is a comparison between the depth of the inner net (small net mesh) and the depth of two outer nets, ranging from 1.66 to 1.68 (rounded to 1.7 for all units).

There are two types of forces that work as a result of the weight collaboration of net components, namely buoyancy and sinking force. The force occurs due to differences in the mass density of component material used and the seawater. Each component of the net measured their mass densities in seawater to get the buoyancy and sinker forces. Therefore, the buoyancy and sinking forces are determined from the addition of both forces of the materials on construction. The determination of these forces is important to anticipate changes in the appearance of the net during operation, especially on seabed sweeps. The sweeping process can cause the lower net to lift, which causes the fish escape. In addition, Cilacap waters are relatively open and have large waves in certain seasons.

Najamudin (2011) stated that in order to make changes, it is necessary to recalculate the forces that work on the net. Therefore, it takes a suitable configuration of buoyancy and sinker force to keep the net upright and sweep the seabed optimally. When the value of force ratio in engineered design
is greater than the existing design, the amount reaches the standard maximum limit. According to Prado (1990), the ratio of buoyancy and sinking force ranges from 1:3 to 1:5. Mass density configuration of net components that produced buoyancy force in 1 meter was 54.20 grf in the engineered design and 57.08 grf in the existing design. Furthermore, the sinking force in 1 meter was 242.63 grf in the engineered design and 185.29 grf in the existing design. Buoyancy force and sinking force per meter on both of these designs were still normal. According to Martasuganda (2008) total buoyancy can utilize 8.0 to 261.0 grams / m, while the sinking force may utilize 29.0 to 291.0 grams / m.

Conclusion
This study showed that the optimal configuration of buoys, sinkers, and net height of engineered ciker nets are 59 pieces, 341 pieces, and 1.5 m, respectively. Changes in ciker net design, especially in the three components, influence the addition of buoyancy and sinking force ratio to the maximum based on the comparison on the trammel net, which is 1:5 greater than the conventional design owned by fishermen at 1:4.

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