Catch comparison of sweeping trammel nets (ciker net) with different towing paths

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Abstract. The sweeping trammel net (ciker net) is operated by lowering the net in a straight line and then pulling the last end of the net with a ship moving in a full circle where the other end functions as a circular axis (M1 method). An alternative way is for the net to be lowered and then towed by the fishing vessel along two opposing semi-circular paths (M2 method). The success of fishermen using this net is determined by the swept area. Therefore, the catch for each net section can vary when using the M1 method but is relatively similar in the M2 method. This study compared the catch per net section from the same sweep axis operated with different towing line paths. The experimental fishing was carried out using 1 ciker net unit consisting of 6 pieces. The catch produced by the two operating methods was significantly different as indicated by $t = -3.7852$, $df = 5$, $\alpha = 0.05$, and $p$-value = 0.01282. The average catch per section ($n = 3$) was 21 individuals for M1 operation and 47 individuals for M2 operation. The M1 method produced less catch than the M2 method.

1. Introduction

Sweeping trammel net is a three-layer gill net operated by the method of sweeping the seabed. Mangunsukarto et al., (1993) that the production of shrimp from the trammel net is low, strongly related to the way this tool is operated as a set bottom trammel net [1]. Therefore, they suggest that the nets be operated by the sweeping method because actively operated tools increase the chances of more shrimp being touched and then caught. In Japan, it is used for capturing demersal species [2]. However, according to Martasuganda (2008) these nets are generally operated to catch shrimp in coastal waters where the seabed is sandy or muddy or a mixture of both [3].

Currently, sweeping trammel net is already used by fishermen in various places, in the southern coastal area of Java Island, including on the coast of Cilacap called ciker net. Sweeping trammel net operation can be performed in two sweeping ways. The first way is to lower the net in a straight direction, then draw the last end of the net with a moving vessel with a trajectory that forms a full circle (called M1 = circular) where the other end of the first serves as a circular axis [4]. The second way (called M2 = semi-circular), that is, starting with the drop of the net in a straight direction then pulling...
the last end of the net with a trajectory until it forms a semicircle where the other end becomes the axis of the circle, then continues with the withdrawal of the other end with movement until it forms another half circle but with the opposite circular direction where the first end serves as the axis of the circle. The first method is the original method in Cilacap. While the second way is as applied by fishermen in Shimane or Ehime, Japan [4].

One of the problems that should be avoided if fishermen want to catch shrimp that are or near the bottom of the water is the imperfect configuration of ciker nets when sweeping the seabed. Given that the target fish species is on or near the seabed, the sweeping process must ensure the seabed is effectively swept away in order for the net to touch and catch the target fish [2]. The two methods of operation produce different swept areas, especially in the swept area of each net section from the end of the axis to the far end of the axis. This wide difference in swept will affect the catch per net section and the catch in total. The catch of the ciker net should be known if the operation in the first method is different from the second method to determine the choice of good operating methods. It is also important to be aware in assessing the status of fish resources exploited by the ciker net fleet [4]. The more perfect the ciker nets sweeping the seabed means the higher the fishing effort with the more effective and efficient chances of this fishing operation [5].

The success of fishermen using this net is determined by the swept area; the wider the seabed that is swept getting higher the chance of obtaining a catch. The swept area of each net section is determined by the position of the installation. Therefore, the swept area of each net section of the two operating methods may differ. This study aims to compare the catch per net section from the same sweep axis operated with different towing line paths (M1 = circular and M2 = semi-circular)

2. Materials and Methods

2.1. Location and time
The research was conducted in October 2019 in Penyu Bay, Cilacap Regency, Central Java. The research has been done identifying the catch of ciker nets operated by fishermen. The research site is presented in Figure 1.

![Figure 1. The Map of the research location.](image-url)
2.2. Tools and materials
The field research is carried on in the form of identification of catches. The research material is a ciker net in the shape of a rectangle consisting of three layers of nets with different mesh sizes and components consist of buoys, sinkers, and ropes. This net is a common design used by fishermen for sweeping trammel net operations. One ciker net unit consists of 6 pieces with a net section length of 31.5 m operated for the M1 and the M2 method in waters with depths of up to 7 - 10 m (Figure 2).

![Figure 2](image)

Figure 2. Sketch the operation of the sweeping trammel net in the water.

2.3. Data collection
The operation of each sweeping method is carried out 3 times respectively. Each sweeping method is operated with a different towing path, both the operation of the M1 and M2 methods. The operating model of both sweeping methods is illustrated in Figure 3.

![Figure 3](image)

Figure 3. The theoretical illustration of the swept area for each net peace is based on its installation position (a). Operation with M1, and (b). Operation with M2.

The study used an experimental fishing method. The data are a catch separated by net section, the vertical plane position of the net section (down and up net section), and the type of shrimp. The catch, especially shrimp, is identified by their type, the number of individuals, and the weight of the catch. Identification of the type of catch refers to [6].
2.4. Data analysis

2.4.1. Analysis of catches. To find out the composition of the catch type by using the following formula [7]:

\[ p_i = \frac{n_i}{N} \times 100\% \]

Where \( p_i \) is the relative abundance of catches (%), \( n_i \) is the number of species catches to \(-i\) (kg), and \( N \) is the total Catch.

The ability of the fishing gear represents the catch in gram/kg/ton units [8].

\[ CR = \frac{catch}{effort} \times 100 \]

Where CR is the catch rate (kg/hour), Catch (kg), Effort (trip day operation)

2.4.2. T test for catch comparison. Comparison of catches between two different sweeping methods using the t test. This analysis was conducted to find out if there was an average difference between the catch of each net section or the total net section on the M1 and the M2 method. Paired t tests conducted are part of comparative hypothesis tests or comparison tests using R Studio devices.

The hypothesis used in the paired sample t test follows [9]:

\[ H_0: \text{average catch of M1 method} = \text{average catch of M2 method} \]
\[ H_1: \text{average catch of M1 method} \neq \text{average catch of M2 method} \]

The guidelines for concluding in this test are:

a) If the value of the p-value > 0.05, then \( H_o \) was accepted and \( H_1 \) was rejected.

b) If the value of the p-value < 0.05, then \( H_o \) was rejected and \( H_1 \) was accepted.

3. Result

3.1. The catch of Sweeping trammel net

The percentage of ciker net catches based on shrimp and non-shrimp in both operating methods differs from each other. The percentage of the catch consists of 53% shrimp and non-shrimps of 47% on M1 operation. Meanwhile, the percentage of shrimp and non-prawns in M2 operation is 58% and 42% respectively. This percentage can be seen in Figure 4. The number of shrimp and non-shrimp catches is 2.36 kg and 2.13 kg on M1, respectively. Similarly, in M2 there are 4.29 kg and 3.06 kg of shrimp and non-shrimp catches, respectively.

![Figure 4. Composition of shrimp and non shrimp (A) method M1, (B) method M2.](image-url)
Figure 5 and Figure 6 shows the percentage of ciker net catches based on the weight of the shrimp species, both on the M1 and M2 methods. The weight percentage of shrimp species on M1 consists of *Penaeus merguiensis* (74%), *Penaeus indicus* (8%), *Penaeus monodon* (15%), *Metapenaeus ensis* (1%), *Metapenaeus tenuipes* (1%), *Penaeus semisulcatus* (1%), and *Metapenaeus monoceros* (0%). The weight of the shrimp catch on M1 consists of *Penaeus merguiensis* of 1,751 kg, *Penaeus indicus* is 0.188 kg, *Penaeus monodon* is 0.341 kg, *Metapenaeus ensis* is 0.022 kg, *Metapenaeus tenuipes* is 0.017 kg, *Penaeus semisulcatus* is 0.032 kg, and *Metapenaeus monoceros* is 0.006 kg. The study showed there were 7 shrimps caught on the M1 operation.

![Image of shrimp species composition](image1)

**Figure 5.** Composition of shrimp species (A) metode M1, (B) metode M2.

![Image of shrimp species](image2)

**Figure 6.** Species of shrimp that be catches.

While the percentage of ciker net catches based on the weight of shrimp species on M2 consists of *Penaeus merguiensis* (93%), *Penaeus indicus* (6%), *Metapenaeus tenuipes* (0%), and *Penaeus
semisulcatus (1%). The weight of the shrimp catch on M2 consists of Penaeus merguiensis of 4,006 kg, Penaeus indicus of 0.248 kg, Metapenaeus tenuipes of 0.002 kg, and Penaeus semisulcatus of 0.029 kg. The operation of the M1 method is only 4 shrimps caught in the operation of the M1.

3.2. Catch rate
The operation of the eiker net by applying both methods shows the species of Penaeus merguiensis is more dominant than all species of shrimp that caught, based on the number of individuals, weight, and rate of capture. While the lowest catch below 10 individuals consisted of Penaeus monodon, Metapenaeus ensis, Metapenaeus tenuipes, Penaeus semisulcatus, and Metapenaeus monoceros. Table 1 presents the characteristics of ciker net catches based on the species of shrimp, both method M1 and M2.

Table 1. Number of individuals, weight (kg), catch rate (kg/h) on each species of shrimp caught by ciker nets with M1 and M2 methods.

| Species            | Metode M1 | Metode M2 | CR differences |
|--------------------|-----------|-----------|----------------|
|                    | Shrimps   | Percentage (%) | Weight Percentage (%) | CR | Shrimps | Percentage (%) | Weight Percentage (%) | CR |
| Penaeus merguiensis| 106       | 84.13     | 1.751          | 74.29 | 29.18 | 263       | 94.27           | 4.006 | 93.49 | 66.77 | -37.58 |
| Penaeus indicus     | 10        | 7.94      | 0.188          | 7.98  | 3.13  | 13        | 4.66            | 0.248 | 5.79  | 4.13  | -1.00  |
| Penaeus monodon     | 4         | 3.17      | 0.341          | 14.47 | 5.68  | 0         | 0               | 0.00  | 0.00  | 0.00  | 5.68   |
| Metapenaeus ensis   | 1         | 0.79      | 0.022          | 0.93  | 0.37  | 0         | 0               | 0.00  | 0.00  | 0.00  | 0.37   |
| Metapenaeus tenuipes| 3        | 2.38      | 0.017          | 0.72  | 0.28  | 1         | 0.36            | 0.002 | 0.05  | 0.03  | 0.25   |
| Penaeus semisulcatus| 1        | 0.79      | 0.032          | 1.36  | 0.53  | 2         | 0.72            | 0.029 | 0.68  | 0.48  | 0.05   |
| Metapenaeus monoceros| 1       | 0.79      | 0.006          | 0.25  | 0.10  | 0         | 0               | 0.00  | 0.00  | 0.00  | 0.10   |
| Amount             | 126       | 100       | 2.357          | 100   | 39.28 | 279       | 100             | 4.285 | 100   | 71.42 | -32.13 |

Based on the species of shrimp obtained the highest catch rate is Penaeus merguiensis, both operation M1 and M2 at 29.18 kg/hour (74.29 % of the total M1 CR) and 66.77 kg/hour (93.49 % of the total M2 CR). Next followed by Penaeus monodon on method M1 at 5.68 kg/hour (14.47% of the total M1 CR) and Penaeus indicus on the M2 method at 4.13 kg/hour (5.79% of the total M2 CR). While the CR of Metapenaeus monoceros is low in M1 and Metapenaeus tenuipes on M2.

The resulting capture rate indicates a difference between M1 and M2 that varies with each species of catch. The difference in catch rate was shown by 4 species namely Penaeus merguiensis, Penaeus indicus, Metapenaeus tenuipes, and Penaeus semisulcatus because these four types of shrimp were caught in M1 and M2. The catch rate of Penaeus merguiensis and Penaeus indicus on the M1 is smaller than M2 with differences of 37.58 kg/hour and 1.00 kg/hour respectively. While the catch rate of Metapenaeus tenuipes and Penaeus semisulcatus on M1 is greater than M2 with a difference of 0.25 kg/hour and 0.05 kg/hour respectively. As for Penaeus monodon, Metapenaeus ensis, and Metapenaeus monoceros are only caught on the M1 method and not on the M2 method. Totally, the catch rate obtained by method M1 is 39.28 kg/hour smaller than 71.42 kg/hour on the M2 method.

3.3. Distribution of catches
Each part of the ciker net has different catching capabilities, either vertically categorizing the down and up nets, or based on the position of the net section of the circular axis. Form 6 presents the distribution of the catch vertically differentiated, both method M1 and M2. The number of individual shrimp
catches at the downward part of the M1 method is 105 individuals (26.12 %) and 213 individuals (52.99 %) M2 method. While at the upward part of the M1 method of 20 individuals (4.98 %) and 64 individuals 15.92 %) M2 method. Figure 7 show the distribution of the number of individuals in the downward part and upward part indicates the M1 is smaller than the M2.

![Figure 7. Distribution of the shrimp catch vertically in the net area (down and up part). The height of the attached net is 1.3 m divided into two parts each to 0.65 m.](image)

The distribution of shrimp by species on the down and up part ciker nets is different from each other. Figure 8 shows that the species of *Penaeus merguiensis* is more dominant, followed by *Penaeus indicus*, while the distribution of other species is relatively low.

![Figure 8. Distribution of the shrimp based on species catch vertically in the net area (down and up part). The height of the attached net is 1.3 m divided into two parts each to 0.65 m.](image)
The number of individual species of shrimp in the M1 method at the down part of the net is dominated by *Penaeus merguiensis* as many as 92 individuals (22.886 %) followed by *Penaeus indicus* as many as 6 individuals (1.493 %). While relatively few species under 5 individuals are *Penaeus monodon* as many as 4 individuals (0.995 %), *Metapenaeus tenuipes* as many as 1 individual (0.249 %), *Penaeus semisulcatus* as many as 1 individual (0.249 %), and *Metapenaeus monoceros* as many as 1 individual (0.249 %). The up part of the net is also dominated by *Penaeus merguiensis* as many as 14 individuals (3.136 %). While the other species are relatively few under 5 individuals namely *Penaeus indicus* as many as 3 individuals (0.746 %), *Metapenaeus ensis* as many as 1 individual (0.249 %), and *Metapenaeus tenuipes* as many as 2 individuals (0.498 %).

Furthermore, the number of individual species in the M2 method at the down part of the net is also dominated by *Penaeus merguiensis* as many as 200 individuals (49.751 %) followed by *Penaeus indicus* as many as 11 individuals (2.736 %). *Penaeus semisulcatus* relatively slightly that is as many as 2 individuals (0.498 %). While at the up part of the net is also dominated by *Penaeus merguiensis* as many as 62 individuals (15.423 %). The other species are relatively few under 5 individuals namely *Penaeus indicus* as many as 1 individual (0.249 %), and *Metapenaeus tenuipes* as many as 1 individual (0.249 %).

The individual distribution of the catch is relatively different in each net section, particularly in the operation of the M1 method, the swept area of the net section close to the circular axis tends to be smaller which affects the small catch. While the operation of the M2 method allows the same sweep on each net section. Figure 9 shows that the number of M1 catches is smaller at the net section located close to the circular axis starting from the net section 6 near the axis to the net section 1 furthest from the axis. While in the operation of M2 the catches at both ends of the circle are almost the same.

![Figure 9](image_url)  
*Figure 9.* The distribution of shrimp catches per net section between method M1 and method M2.

The sequence of individual catch distribution of net section 1 near the ship and away from the circular shaft to the net section 6 which is in the axis of the circle are net section 1 as many as 23 individuals (5.68 %), net section 2 as many as 33 individuals (8.15 %), net section 3 as many as 35 individuals (8.64 %), net section 4 as many as 24 individuals (5.93 %), net section 5 as many as 8 individuals (1.98 %), and net section 6 as many as 3 individuals (0.74 %). While the operation of the M2 allows both ends of the net to be located in the circular axis also away from the circular axis alternately. If the sequence of net section 1 to 6 is based on the withdrawal of the first semicircular net, it is obtained net section 1 as many as 24 individuals (5.93 %), net section 2 as many as 50 individuals...
sweeping method that consisting of the M1 method in a circular and semi-difference of 32.13 kg/hour. The optimal with trammel net also affects the total catch rate as well as on the species of shrimp caught. This is in line is higher than other types. This research shows that the difference is smaller than M2. Meanwhile, based on the species of shrimp obtained capture production Mangunsukarto et al. (1993) trammel net Species of Penaeus merguiensis, Penaeus indicus, Metapenaeus tenuipes, Penaeus monodon, Metapenaeus ensis, Metapenaeus tenuiipes, Penaeus semisulcatus, and Metapenaeus monoceros. While the type of shrimp caught in the M2 method is fewer than 4 species of shrimp namely Penaeus merguiensis is more widely caught, both in the M1 and M2 methods is more species of shrimp because this species is the main target of the capture of ciker nets in Cilacap as well as the location of data collect, is the fishing ground of this species. Based on this composition also shows the M1 method more species of shrimp catches is not a very different percentage, although shrimp is still more than non-shrimp, both on M1 and M2. This occurs because research is carried out on the right fishing ground but not shrimp season. Pangesti (2017) Penyu bay area in Cilacap is a shrimp catching area [13]. PPSC (2015) reported October is the moderate season for shrimp catching in Cilacap [14]. But observations and discussions with the fisherman in the field when research has entered the bad sea son due to uncertain season. Fewer shrimp catches on the M1 operation than from the M2, as well as non-shrimp catches. These researches show that differences in sweeping methods can induce an outcome on the composition of shrimp and non-shrimp catches. The efficiency of fishing is determined by the sweeping method that touches the bottom of the water [15]. Similarly, the composition of shrimp species in the M1 method is less than M2. Even so, the number of individuals caught on the M1 is more than M2. Species of Penaeus merguiensis is more widely caught, both in the M1 and M2 methods because this species is the main target of the capture of ciker nets in Cilacap, as well as the location of data collect, is the fishing ground of this species. Based on this composition also shows the M1 method more species of shrimp caught as much as 7 types namely Penaeus merguiensis, Penaeus indicus, Penaeus monodon, Metapenaeus ensis, Metapenaeus tenuiipes, Penaeus semisulcatus, and Metapenaeus monoceros. While the type of shrimp caught in the M2 method is fewer than 4 species of shrimp namely Penaeus merguiensis, Penaeus indicus, Metapenaeus tenuiipes, and Penaeus semisulcatus. Purbayanto (2005) Species of Penaeus merguiensis, Penaeus monodon, and Metapenaeus sp. generally caught with a trammel net [10].

Trammel net operated by the sweeping method aims to increase the effectiveness of shrimp catching. Mangunsukarto et al. (1993) improved the method of catching trammel net to increase shrimp production [1]. The effectiveness of ciker net based on the sweeping method can be seen from the capture rate obtained on M1 and M2. Totally, the operation of the M1 method obtained a capture rate higher than other types. This research shows that the difference in the sweeping method of the trammel net also affects the total catch rate as well as on the species of shrimp caught. This is in line with Kurniawan et al. (2017) ciker nets operated by the original method (M1 method) have not been optimal [16]. This research shows that the rate of capture of the M1 method is smaller than M2 with a difference of 32.13 kg/hour.

The strategy to increase the catch of shrimp in ciker nets is to apply a sweeping method. The sweeping method that consisting of the M1 method in a circular and semi-circular M2 each has a

3.4. Comparison analysis of catches

Shapiro-wilk’s normality test of catches in the M1 and M2 methods showed that the catch distribution normally with p-values of 0.4089 and 0.2175 respectively. The results of the paired t test show that the average catch of the M1 method is not the same as the average catch of the M2 method. This result signs that the operation of the ciker net uses 6 net sections with the M1 method less catch than M2. The catch produced by the two operating methods was significantly different as indicated by t = -3.7852, df = 5, α = 0.05, and p-value = 0.01282.

4. Discussion
Operation of ciker nets to catch shrimp as the main catch target. the main target of the trammel net is shrimp although non shrimp consisting of various types of fish is also widely caught by trammel net [10,11]. However, the catch obtained is not always dominant shrimp can even be more non shrimp. This kind of thing can be influenced by many factors, especially the fishing ground factor and the inappropriate catch season. Susanto & Nurdin (2019) wrote a season is highly influential catches. The composition of the shrimp and non-shrimp catches is not a very different percentage, although shrimp is still more than non-shrimp, both on M1 and M2. This occurs because research is carried out on the right fishing ground but not shrimp season. Penyu bay area in Cilacap is a shrimp catching area [13]. PPSC (2015) reported October is the moderate season for shrimp catching in Cilacap [14]. But observations and discussions with the fisherman in the field when research has entered the bad sea season due to uncertain season. Fewer shrimp catches on the M1 operation than from the M2, as well as non-shrimp catches. These researches show that differences in sweeping methods can induce an outcome on the composition of shrimp and non-shrimp catches. The efficiency of fishing is determined by the sweeping method that touches the bottom of the water [15]. Similarly, the composition of shrimp species in the M1 method is less than M2. Even so, the number of individuals caught on the M1 is more than M2. Species of Penaeus merguiensis is more widely caught, both in the M1 and M2 methods because this species is the main target of the capture of ciker nets in Cilacap, as well as the location of data collect, is the fishing ground of this species. Based on this composition also shows the M1 method more species of shrimp caught as much as 7 types namely Penaeus merguiensis, Penaeus indicus, Penaeus monodon, Metapenaeus ensis, Metapenaeus tenuiipes, Penaeus semisulcatus, and Metapenaeus monoceros. While the type of shrimp caught in the M2 method is fewer than 4 species of shrimp namely Penaeus merguiensis, Penaeus indicus, Metapenaeus tenuiipes, and Penaeus semisulcatus. Purbayanto (2005) Species of Penaeus merguiensis, Penaeus monodon, and Metapenaeus sp. generally caught with a trammel net [10].
different influence in forming the area of the sweep. The larger the sweep that is formed allows the greater the chance of shrimp catch. This research indicates the distribution of shrimp occurs vertically and horizontally along the net section that operated, both along with the M1 and M2 methods. The distribution of the catch at the down and up part of the net field vertically indicates that the M1 method is smaller than M2. More catches are at the bottom of the net, both M1 and M2 as the inner net accumulates at the bottom forming pockets. While the upper net tends to be tense and there is no buildup of the inner net. This net condition causes the shrimp to be uneven in both vertical parts of the net. The distribution of species is also uneven at both the down and up parts. The *Penaeus merguiensis* is more on both M1 and M2, especially on the down part of the net. The distribution of *Penaeus merguiensis* and *Penaeus indicus* comprise the down and up parts of the net. While *Penaeus monodon*, *Penaeus semisulcatus*, and *Metapenaeus Monoceros* only distribute on the down parts of the net.

Next is the distribution of the catch horizontally on each net section according to its placement of the circular axis. In the operation of the M1 method, the position of the net section determines the effectiveness of the catch. As illustrated in Figure 3 (a) above shows that the 6th net section on the axis is narrower in the swept area than the 1st section that away from the axis or close to the ship. Rihmi et al., (2017) the widest area is in the 1st net section and narrows in the net section approach to the axis [11]. While Figure 3 (b) indicates with the semi-circular method allows all net sections to receive the chance to make the same swept area. This is in line with the distribution of the catch on each net section indicated by the M1 and M2 methods. The distribution of the catch in method M1 is uneven from net section 1 to 6. The catch on the 1st net section is higher and getting smaller until the 6th net section that is on the circular axis. While the catch in method M2 is evenly distributed between the net section 1 and 6, and the greater in the middle between the 1st and the 6th net section. The spread of catches on the M2 is more numerous at net sections 2, 3, 4, and 5 because the sea bottom swept of these sections is more constantly not affected by the circular axis of the net. This process generally affects the distribution of captured catches obtained, both in the M1 and M2 methods. The average catch in M1 is smaller than M2. Statistically, there is a significant difference between M1 and M2.

5. Conclusion
The average catch per section (n = 3) was 21 individuals for circular method (M1) operation and 47 individuals for semi-circular method (M2) operation. The circular method produced less catch than the semi-circular method. The catch produced by the two operating methods was significantly different as indicated by t = -3.7852, df = 5, α = 0.05, and p-value = 0.01282.

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