

ANALYSIS OF THE POTENTIAL BANANA PRAWN (*Penaeus merguensis*) IN THE NORTHERN WATERS OF REMBANG REGENCY

*Analisis Potensi Sumber Daya Udang Putih (*Penaeus merguensis*) di Perairan Utara Kabupaten Rembang*

Oleh:

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ABSTRACT

*This study aims to describe the characteristics of mini bottom trawl fishing gear and fishing season, as well as to estimate the stock density and sustainable potential of banana prawn (*Penaeus merguensis*), in Rembang Regency. This study was conducted from September to October 2020, in the Northern Waters of Rembang Regency, with an area of 1409.7 km², using both primary and secondary data. Primary data was collected directly from observations, measurements, and interviews with fishermen, while secondary data, including data on the number and types of fishing gear, as well as production and production values, was obtained through a literature review. The results of the study found that banana prawn in the northern waters of Rembang Regency was caught using two types of fishing gear, and these are sotok/mini bottom trawls and trammel nets. The total length of mini bottom trawl in this study are 15.77 m, 16.5 m, 20.44 m, and 25.2 m. The fishing season for banana prawn is from June to September. The average stock density value is 16.22 kg/km² (range 4.37 to 41.14 kg/km²), the Cmsy value is 2.625 kg, the Emsy value is 4.172 trips and the average utilization rate is 44% (range 23 to 82%).*

Keywords: Rembang, banana prawn, stock density, and MSY.

ABSTRAK

Penelitian ini bertujuan untuk menggambarkan karakteristik alat tangkap arad; musim penangkapan udang putih (*Penaeus merguensis*); menentukan kepadatan stok udang putih (*Penaeus merguensis*); mengestimasi potensi lestari udang putih (*Penaeus merguensis*) di Kabupaten Rembang. Penelitian ini dilaksanakan pada bulan September hingga Oktober 2020 di Perairan Utara Kabupaten Rembang dengan luas wilayah 1409,7 km², menggunakan data primer dan data sekunder. Data primer diperoleh melalui observasi, pengukuran, dan wawancara dengan nelayan, sedangkan data sekunder berupa data jumlah dan jenis alat tangkap, serta nilai produksi dan produksi diperoleh melalui studi pustaka. Hasil penelitian menunjukkan bahwa udang putih (*Penaeus merguensis*) di Perairan Utara Kabupaten Rembang ditangkap menggunakan dua jenis alat tangkap yaitu sotok/ arad (*mini bottom trawl*) dan jaring gondrong atau *trammel net*. Ukuran alat tangkap Arad yang digunakan dalam penelitian ini masing-masing berukuran 15.77 m, 16.5 m, 20.44 m, dan 25.2 m. Musim penangkapan udang putih terjadi pada bulan Juni sampai dengan September. Nilai rata-rata kepadatan stok sebesar 16,22 kg/km² (range 4.37 hingga 41,14 kg/km²), nilai Cmsy 2.625

kg, nilai Emsy 4.172 trip serta nilai rata-rata tingkat pemanfaatan sebesar 44% (range 23 hingga 82%).

Kata kunci: Rembang, Udang Putih, Kepadatan Stok, and MSY.

INTRODUCTION

In Rembang Regency, fisheries and marine are the key sectors and it is located in Indonesia Fisheries Management Area 712, known as WPPNRI 712. Based on the Decree of the Minister of Maritime Affairs and Fisheries, WPPNRI 712 covers the Java Sea, and is a strategic fishing area in Indonesia, with an estimated potential fish resources of 981,680 tons/year (Ma'mun *et al.*, 2018). Data from Department of Maritime Affairs and Fisheries of Rembang Regency (2020a,b) stated the total production in 2015, 2016, and 2018 was 2,100 kg, 676 kg, and 596 kg, worth IDR. 84,180,000.00; IDR 29,400,000.00 and IDR 59,780,000.00, respectively.

Banana prawn (*Penaeus merguensis*) is a capture fishery product with high economic value and is highly sought by most consumers, as indicated by the high price range of IDR. 80,000.00-100,000.00 per kilogram (Solihin *et al.*, 2011; Wijayanto *et al.*, 2013; Badriuzzaman and Yulianto, 2014; Sa'adah and Milah, 2019). These species are generally caught using trawl, trammel net, danish seine, dogol net, guiding barrier (*belat*), and sero (Subani and Barus 1988).

In Java, the price of this prawn is quite varied, ranging from IDR. 50,000-IDR. 55,000 per kilogram for size 100 (i.e. 100 prawns per 1 kilogram), in 2019 and early 2020, on the Island of Java, except the Banten area. However, the prices surged with prices of IDR. 50,000-IDR. 55,000/kg for size 100, IDR. 60,000-IDR. 65,000/kg for size 70, and above IDR. 75,000/kg for size 40, recorded by mid-May. Subsequently, the prices continued to fluctuate, with a downward trend recorded at the end of October (Zulfikar, 2020). According to Manadiyanto *et al.*, (2017a), the price of banana prawn (*Penaeus merguensis*) was IDR. 80.000,00 – IDR. 100,000.00, IDR. 60,000 – IDR. 80.000,00, and IDR 50,000.00 - IDR 80,000,00, per kilogram, in Pati, Gresik and Demak, respectively.

The fishing gear used by fishermen in Indonesia comprises various types, constructions, operating methods, and parts designed to the catch target (Nurulludin *et al.*, 2016;

Tirtadanu *et al.*, 2018; Wijayanto *et al.*, 2019). In marine prawn and shrimp fisheries, a mini bottom trawl gear is usually used to catch small prawn and shrimp in shallow waters, while banana prawn (*Penaeus merguensis*) is caught using trammel nets (Jamal, 2015; Nurdin and Kembaren, 2015; Tirtadanu and Ernawati, 2016; Tirtadanu *et al.*, 2017; Tirtadanu and Panggabean, 2018; Tirtadanu and Chodrijah, 2020). Based on the Regulation of the Minister of Maritime Affairs and Fisheries Number 59 of 2020 concerning Fishing Paths and Placement of Fishing Equipment as well as Fishing Aids in WPPNRI, a trammel nets is a static and passive fishing tool (API), operated using a mesh with a size above 1.5 inches, and a P ris rope below 500 m.

Fish stock density is a significant indication of fishery potential in an area, and several studies related to the stock density of prawn and shrimp resources in WPPNRI have been reported, including the report by Hargiyatno *et al.*, (2015), where the stock of banana prawn or jerbung prawn (*Penaeus merguensis*) in the Arafura Sea were estimated. In addition, a study by Tirtadanu and Ernawati (2016) identified the biomass and stock density of Penaeid shrimp resources in the Java Sea which consists of 6 genera comprising 16 species, with southern velvet shrimp (*Metapenaeopsis palmensis*) as the most dominant. The study also discovered other commercial species such as greasyback shrimp (*Metapenaeus ensis*), green tiger prawn (*Penaeus semisulcatus*), and banana prawn (*Penaeus merguensis*). The average prawn and shrimp stock density, catch rate, and biomass in the Java Sea are estimated at 21.34 ± 16.81 kg/km², 1 ± 0.5 kg/hour, and 9,938 tons, respectively. A study by Tirtadanu *et al.*, (2018) showed the average prawn and shrimp catch rate in the eastern waters of Kalimantan with trawlers was 0.83 kg/hour, with the highest catches found at depths below 40 m, and obtained an average prawn and shrimp stock density of 16.5 kg/km² based on calculations.

The high utilization of resources cause degradation and impairment in the development of fishery stocks (Saputra *et al.*, 2013; Ma'mun *et al.*, 2018). Inadequate monitoring,

controlling and surveillance are possible factors responsible for the high utilization of these resources (Umamah et al., 2017; Akoit and Mardit, 2018; Suruan et al., 2020). This study, therefore, aims to describe the characteristics of *mini bottom trawl* fishing gear as well as the fishing season, and estimate the stock density as well as sustainable potential of banana prawn in Rembang Regency, using the swept area method. The findings from this study are expected to serve as a basis for efficient, sustainable, and sustainable management of this species.

METHOD

This study was conducted from September to October 2020, in the Northern Waters of Rembang Regency, with an area of 1409.7 km² (Figure 1), using both primary and secondary data. Primary data was collected directly from observations, measurements, and interviews with fishermen, while secondary data, including data on the number and types of fishing gear, as well as production and production values, was obtained through a literature review.

Sampling was performed using the simple random method, and this required 5 fishing trips at 5 different bases with 11 fishing operation points carried out from September to October 2020. This sampling method assumes the samples taken are homogeneous or have the same characteristics, therefore, each individual has the opportunity to be sampled. In this study, banana prawn was the selected sample, based on the species' status as a catch with economic value and the dominance within the northern waters of Rembang Regency.

Subsequently, data analysis was carried out using 4 methods, the analysis of the *mini bottom trawl* fishing gear ratio to determine the *mini bottom trawl* fishing gear's characteristics, and the analysis of the fishing season index (IMP) to determine the fishing season for banana prawn, as well as the swept area analysis to determine stock density and surplus production model for estimating maximum sustainable yield (MSY) of banana prawn.

The analysis of fishing gear was based on SNI 01-7233-2006 "Standard Forms of Trawl Construction" to determine the ratio between the length of the trawl's parts and the total trawl length. Furthermore, the fishing season patterns or Fishing Season Index (IMP %) were analyzed using the moving average method, based on the steps by Dajan (1983)

and the formula developed by Wiyono (2001), as in the following equation.

- (1) Calculate the monthly CPUE series over 5 years.

$$N_i = CPUE_i \dots\dots\dots (1)$$

Where:

- i : indicates the 1,2,3,... and
- N_i : represents order I.

- (2) Compile a series of monthly CPUE values for 12 months.

$$N_p = \sum_{j=p-6}^{p+6} CPUE \dots\dots\dots (2)$$

Where:

- p : connotes 7,8,...,n-5,
- N_p : depicts the p-the order
- J : signifies the jth order in the series N_i.

- (3) Compile a series of 2 months for each month.

$$N_r = \frac{1}{24} \sum_{m=r-6}^{r+6} CPUE_k \dots\dots\dots (3)$$

Where:

- r : represents 7,8,...,n-5,
- N_r : indicates the r-the order
- m : connotes the mth order in the N_q series.

- (4) Calculate the average ratio for each month.

$$\text{Average ratio} = \frac{CPUE}{\text{Rata-rata 2 bulanan}} \dots\dots\dots (4)$$

- (5) Compile the monthly average ratio value and calculate the average or seasonal variation, as well as the fishing season index, using the equations below.

$$\text{The average ratio for jth month} = \frac{1}{4} \sum_{i=1}^4 X_{ij} \dots\dots\dots (5)$$

$$\text{Total average ratio} = \frac{1}{4} \sum_{j=1}^{12} \sum_{i=1}^4 X_{ij} \dots\dots\dots (6)$$

$$\text{Correction factor (FK)} = \frac{1200}{\text{Jumlah rasio rata-rata}} \dots\dots (7)$$

$$(\text{IMP \%}) = \text{Average ratio for jth month} \times \text{correction factor}$$

The potential analysis includes the stock density value, MSY, and utilization rate. The stock density value is obtained using the swept area calculation method, based on the swept area traversed (Sparre and Venema, 1998;

Pezzuto *et al.*, 2008), while the area covered by each trawling in each sweep was calculated using the following equation.

$$a = S \cdot DF \dots\dots\dots (8)$$

Where:

S : v. t

a : represents area of the swept area (mile² or km²)

S : the length or sweep distance (miles or km)

DF: opening width of nets (m)

v : the speed of the ship during towing in knots (1 knot = nautical miles/hour)

t : the time of towing (hour)

$$a = C \times HR \times V \times H \dots\dots\dots (9)$$

Where:

a : represents the area swept

C : the constant width of the net's mouth at the time of operation (0.5)

HR : head rope length

V : the speed of the boat when towing

T : the towing duration

The stock density was calculated using the formula below (Sparre and Venema, 1998).

$$Q = Cw/a \times ef \dots\dots\dots (10)$$

Where:

Q : indicates the density of demersal fish per sweep area (kg/km²)

Cw : fish catch per area sweep(kg)

a : the area of the swept area surveyed (km²)

ef : denotes the constant 0.4

Meanwhile, the opening of the otter board and the net's mouth, as well as the rope's length were calculated using the formula by Prado and Dreimere (1990).

$$D=(BA). F+AD=2 \sin d F+A \dots\dots\dots (11)$$

Where:

D : represents the approximate opening of the otter board (m)

A : indicates the width formed by the sheet rope inside (m)

B : signifies the width formed by the sheet rope outside (m)

F : connotes the slambar rope length from inside width to otter board (m)

Furthermore, the Schaefer model was used to calculate the MSY and optimum effort

of banana prawn. The optimum effort and MSY are obtained using the formula below. Also, the relationship between effort and catch produces a symmetrical parabolic curve (Sparre and Venema, 1998; Sibagariang *et al.*, 2011; Simbolon *et al.*, 2011).

$$fmsy = \frac{-a}{2b} \dots\dots\dots (12)$$

$$MSY = \frac{a^2}{4b} \dots\dots\dots (13)$$

The total allowable catch was calculated using the formula below.

$$TAC = MSY \times 80\% \dots\dots\dots (14)$$

Meanwhile, the percentage utilization rate was calculated using the formula below.

$$TP = x 100\% \frac{y}{MSY} \dots\dots\dots (15)$$

Where:

y : represents the catch

f : fishing effort

a : the intercept

b : the slope

TAC : indicates the total allowable catch

MSY : the maximum sustainable catch.

RESULT

The coastal area of Rembang Regency is located on the regency's northern coast and cuts into 6 sub-districts; Kaliori, Rembang, Lasem, Sluke, Kragan, as well as Sarang, each with has at least one Fish Auction Place (TPI), except for Lasem sub-district. Rembang Regency has 10 TPIs, including TPI Tunggulsari, Tanjungsari, Tasik Agung I, Tasuk Agung II, Banggi Market, Pangkalan, Views, Karanglincak, Karanganyar, and Sarang. Of these TPIs, there are 1 in Kaliori District (Tunggulsari Village), 4 in Rembang District (1 in Tanjungsari Village, 2 in Tasik Agung Village, and 1 in Pasar Banggi Village), 1 in Sluke District (Pangkalan Village), 3 in Kragan District, (1 in the Village Views, 1 in Karanglincak Village, and 1 in Karanganyar Village), and 1 in Sarang District (Karangmangu Village). In addition to these, there is also 1 PPP in Rembang District (Tasik Agung Village), 2 PPIs in Kragan District (Karanganyar Village) and Sarang District (Karangmangu Village). Figure 2 shows the capture fisheries production in Rembang Regency has a fairly large value.

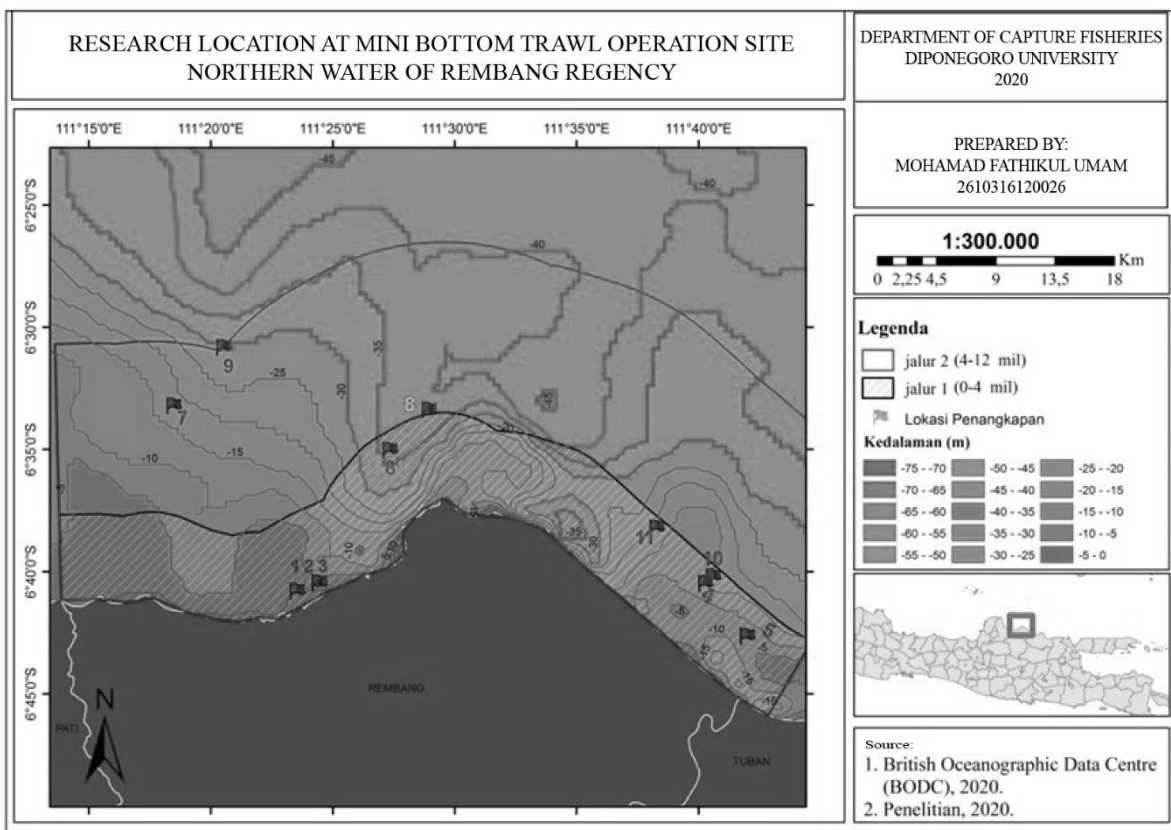


Figure 1 A map of the study area in the Northern Waters of Rembang Regency. Source: Research, 2020.

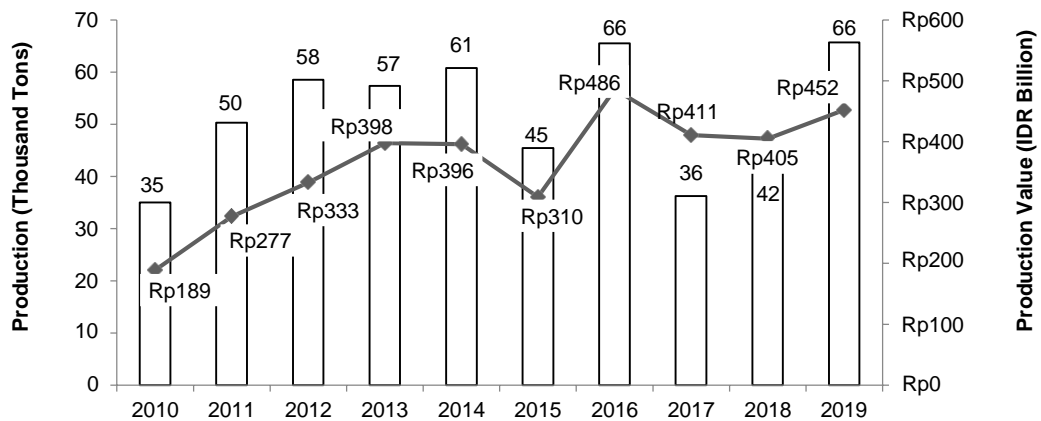


Figure 2 Capture Fisheries production in Rembang Regency from 2010 - 2019.

The production of capture fisheries in Rembang Regency fluctuated, and tended to increase steadily from 2010 to 2012, but decreased slightly in 2013 from 58,496,891 kg to 57,369,913 kg (Figure 2). However, from 2014-2019 the value tended to fluctuate with a significant decrease and increase in 2016-2017 and 2018-2019, respectively. The banana prawn production increased steadily from 2010 to 2014, but decreased

significantly, from 2014 to 2019 (Figure 3). However, the values for 2017 and 2019 were not recorded because the values were infinitesimal. The decrease in production due to natural factors or the surrounding aquatic environment, as well as the unpredictable seasonal or weather factors tend to affect the fishing season for banana prawn.

Figure 4 shows the production and price of banana prawn, valued at IDR. 40.000,00 -

IDR. 150,000.00, depending on the size per kilogram. According to the fishermen at Rembang Regency, Banana prawn (*Penaeus merguensis*) with 40-50 or >50 individuals per kilogram is valued at IDR. 40,000, while the counterparts of 30-40, 20-30, and <20 are valued at IDR. 90,000, 120,000.00, and IDR 150,000.00, respectively. However, with very low production in 2017 and 2019, the production value fell to IDR. 0.

In Rembang Regency, prawn and shrimp catching are performed using 2 types of fishing gear, these are sotok or mini bottom trawls and trammel nets. The mini bottom trawl is usually used to catch small prawn and shrimp, while trammel nets is for certain species, including banana prawn (*Penaeus merguensis*) and giant tiger prawn (*Penaeus*

monodon). Figure 5 shows a graph of the number of trammel net fishing gear used in Rembang Regency. A total of 4 *mini bottom trawl* nets were used in this study, each with a total length of 15.77 m, 16.5 m, 20.44 m, and 25.2 m. Table 1 and Figure 6 show detailed construction of *mini bottom trawl* or sotok nets. Table 2 shows the ratio of the *mini bottom trawl* net's standard form differs in each part of the construction and refers to the SNI for the standard form of trawl nets. Based on Figure 5, the number of trammel net fishing gear was relatively stable over the years, albeit with slight fluctuation in 2014, where the number of trammel nets decreased significantly from 1977 to 1583 fishing gear units.

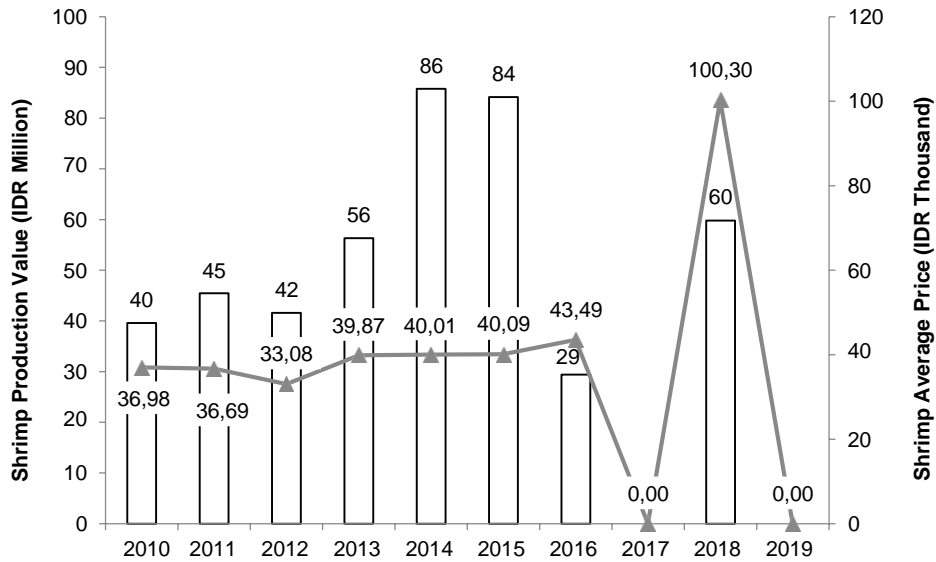


Figure 4 The banana prawn production in Rembang Regency in 2010 - 2019.

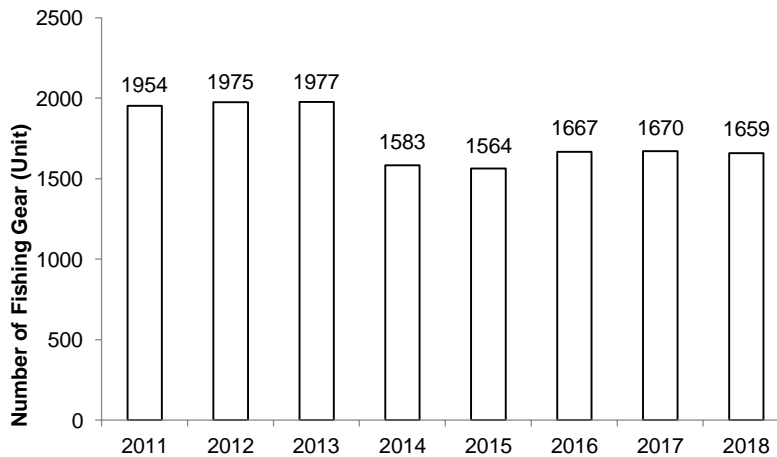


Figure 5 The number of Trammel net in Rembang Regency from 2010 – 2019.

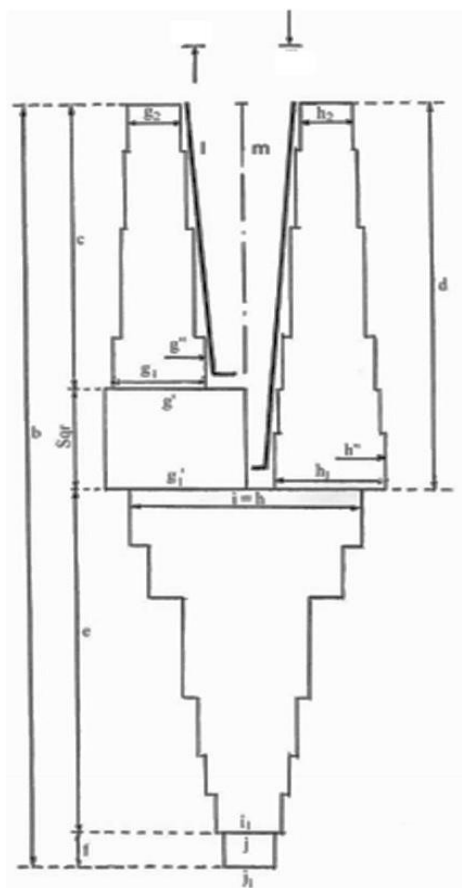


Figure 6 The design and Construction of *mini bottom trawl nets*
(Source: Research (2020) ; Badan Standarisasi Nasional (2006)

Caption:

- 1) Length of sections of the longitudinal cut net:
 - a) The length of the top rope : l
 - b) The length of the bottom ris strap : m
 - c) Length of the net's mouth : a
 - d) Total length of the net : b
 - e) Length of upper wing : c
 - f) The length of the lower wing : d
 - g) Length of square section : (dc)
 - h) Length of the net's body : e
 - i) Length of mesh bag section : f

- 2) The length of the cross-sectional sections of the net:
 - a) Circumference of net opening : a
 - b) Half of the net opening's circumference : h
 - c) Width of the upper wing's front end : g2
 - d) Width of the rear tip of upper wing : g1
 - e) Width of the lower wing's forewings : h2
 - f) Width of the lower wing's hind wings : h1
 - g) Width of the front end square : g'
 - h) Width of the back end square : g
 - i) Width of the body's front end : i
 - j) Width of the body's rear end : i1
 - k) Width of the pouch's front end : j
 - l) Width of pouch's back end : j1

Table 1 The *mini bottom trawl* Net Construction Sizes

No	Part Name	Net Size (m)			
		1	2	3	4
1	Width of the front end of the body	3.4	3.8	4.6	5.2
2	Width of front end square	3.05	3.25	4.25	4.85
3	Width of upper wing's rear tip	2.95	3.1	4	3.87
4	Width of the upper wing's tip	1.43	1.62	1.65	1.67
5	The width of the lower wing's hind wing	3.25	3.6	4.38	4.3
6	Width of the lower wing's front end	1.43	1.62	1.65	1.67
7	Width of the back end of the body	0.8	0.88	0.95	0.9
8	The width of the pocket's front end	0.75	0.85	0.9	0.85
9	The width of the pocket's back	0.75	0.85	0.9	0.85
10	Top strap length	11.9	13.8	19.2	20.8
11	Bottom strap length	16.37	18.3	22.4	25.2
12	Upper wing length	5.76	6.9	9.2	9.8
13	Lower wing length	7.44	9	10.4	12.2
14	Length of square section	1.92	2.34	1.54	2.32
15	The length of the net's body	6.52	4.25	6.82	4.65
16	Mesh bag section length	1.25	3.15	1.68	3.2
17	Total length of the net	15.77	16.5	19	25.2
18	Around the net's mouth	6.8	7.6	9.2	9
19	Sheet Length (m)	27.2	80	40	40
20	Sample Rope Length (m)	1	1	1	1
21	Distance Between Branches (cm)	17	25	23	24
22	Distance Between Sample Branch Lines (cm)	48	60	57	49
23	Sweep rope length(m)	3	14.4	9.6	0.5
24	Buoy (seed)	30	30	28	25
25	Weight (kg)	5	6	7	10
26	Float material	PVC	PVC	PVC	PVC
27	Ballast material	Lead	Lead	Lead	Lead

Source: Research, 2020.

Table 2 Calculation of the Ratio Value of the Standard Form of Mini Bottom Trawl Nets

No	Calculation Formula	Ratio Value				
		SNI	1 net	2 net	3 net	4 . net
1	i/h	1,000	1,000	1,000	1,000	1,000
2	g'=g/h	0.585-0.715	0.897	0.855	0.924	0.933
3	g1/h	0.420-0.520	0.868	0.816	0.870	0.744
4	g2/h	0.240-0.305	0.421	0.426	0.359	0.321
5	h1/h	0.505-0.620	0.956	0.947	0.952	0.827
6	h2/h	0.245-0.305	0.421	0.426	0.359	0.321
7	i1/h	0.470-0.580	0.235	0.232	0.207	0.173
8	j/h	0.210-0.265	0.221	0.224	0.196	0.163
9	j1/h	0.210-0.266	0.221	0.224	0.196	0.163
10	l/b	0.725-0.895	0.755	0.836	0.939	0.825
11	m/b	0.965-1.190	1.038	1.109	1.096	1,000
12	c/b	0.340-0.420	0.365	0.418	0.450	0.389
13	d/b	0.470-0.580	0.472	0.545	0.509	0.484
14	sqr/b	0.130-0.165	0.122	0.142	0.075	0.092
15	e/b	0.395-0.490	0.413	0.258	0.334	0.185
16	f/b	0.040-0.055	0.079	0.191	0.082	0.127
17	l/m	0.675-0.830	0.727	0.754	0.857	0.825
18	a/b	0.995-1.220	0.431	0.461	0.450	0.357

Source: Research, 2020.

An analysis of the potential resources of banana prawn (*Penaeus merguensis*), including the stock density was calculated using the swept area method, an approach used to determine the total density of fish resource stocks in any given area of water (Table 3).

There are 2 fishing seasons for banana prawn in Rembang Regency. The west season usually occurring in the rainy season, between January and March. Then, the east season usually occurring in the dry season, between June and August (Figure 7).

Based on Table 3, the total stock density of banana prawn in the Northern

Waters of Rembang Regency is 13.07 kg/km², with biomass of 1,654.98 tons. This is very low, compared to the annual total production, where the highest value recorded in the last 10 years was 2,144 kg in 2014. Meanwhile, the monthly total catch of Banana prawn in the last 10 years was 2,160 kg, 1,637 kg, and 1,528 kg, for January, February, and July, respectively. Furthermore, the lowest catches of 265 kg, 112 kg, and 414 kg were recorded between October and December, respectively, the transition season from the dry to the rainy season.

In addition to banana prawn, several other species are caught using the *mini bottom trawl* fishing gear, including speckled shrimp or Kasap or Dogol or Flames (*Metapenaeus monoceros*), southern velvet shrimp

(*Metapenaeopsis palmensis*), and giant tiger prawn (*Penaeus monodon*). Based on the total catch from *mini bottom trawl* fishing gear, the banana prawn catch was much smaller, compared to speckled shrimp (*Metapenaeus monoceros*) and southern velvet shrimp (*Metapenaeopsis palmensis*) counterparts. Table 5 shows the details of the catch obtained using sotok gear.

According to Table 5, the total catch was dominated by speckled shrimp (*Metapenaeus monoceros*). The highest catch was obtained on the 4th fishing trip, with a total catch of Banana prawn (*Penaeus merguensis*), speckled shrimp (*Metapenaeus monoceros*), and southern velvet shrimp (*Metapenaeopsis palmensis*) of 0.924, 12, and 3.5 kg, respectively.

Table 3 The results of the swept area

No.	Calculation	Results
1.	Sweeping Area of Catch	0.4768km ²
2.	Area of Research Waters	1,409.7 km ²
3.	Percentage of Research Area Sample	0.034 %
4.	Total Catch Banana prawn (<i>Penaeus merguensis</i>)	3.116 kg

Source: Research, 2020.

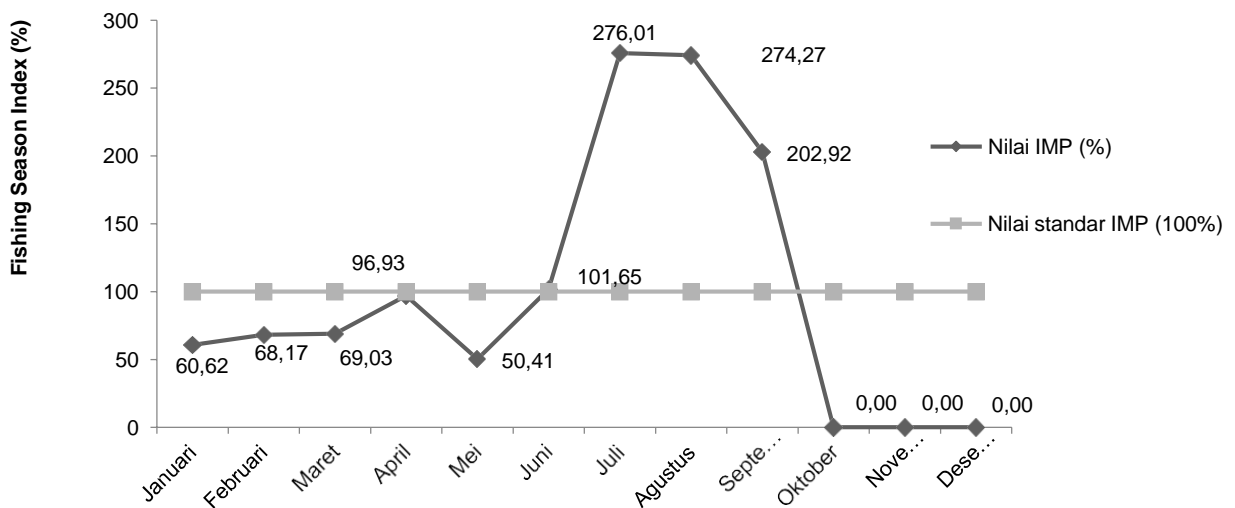


Figure 7 The seasonal Index of Banana prawn Catch in Rembang Regency from 2012 – 2016

Table 4 The Stock Density.

Trip	Point	Catch (kg)	Swept Area (km ²)	Depth (m)	Stock Density (kg/km ²)
1	1,2,3	0.722	0.0351	0-5	41.14
2	4,5	0.924	0.1434	5-10	12.89
3	6,7	0.357	0.0955	15-35	7.48
4	8,9	0.94	0.1237	30-40	15.20
5	10,11	0.173	0.0791	10-20	4.37
Average					16.22

Source: Research, 2020.

Table 5 Types of Captured Prawn and Shrimp Stock

Trip	Types of Shrimp Catch	Quantity (g)
1	Banana prawn (<i>Penaeus merguensis</i>)	722
	Giant tiger prawn (<i>Penaeus monodon</i>)	295
	Southern velvet shrimp (<i>Metapenaeopsis palmensis</i>)	179
	Speckled shrimp (<i>Metapenaeus monoceros</i>)	197
2	Banana prawn (<i>Penaeus merguensis</i>)	940
	Speckled shrimp (<i>Metapenaeus monoceros</i>)	2683
	Southern velvet Shrimp (<i>Metapenaeopsis palmensis</i>)	473
3	Banana prawn (<i>Penaeus merguensis</i>)	357
	Speckled shrimp (<i>Metapenaeus monoceros</i>)	10000
	Southern velvet Shrimp (<i>Metapenaeopsis palmensis</i>)	2371
4	Banana prawn (<i>Penaeus merguensis</i>)	924
	Speckled shrimp (<i>Metapenaeus monoceros</i>)	12000
	Southern velvet Shrimp (<i>Metapenaeopsis palmensis</i>)	3500
5	Banana prawn (<i>Penaeus merguensis</i>)	173
	Giant tiger prawn (<i>Penaeus monodon</i>)	103
	Speckled shrimp (<i>Metapenaeus monoceros</i>)	163

Source: Research, 2020

Production Surplus Analysis

The analysis of surplus production is a model created to regulate the allowable fishing effort to capture fish resources without exceeding the maximum sustainable yield (MSY) (Sparre and Venema, 1998). This analysis was carried out using the schaffer

model, where the CPUE (Catch Per Unit Effort) value is the result of the comparison between the catch value and the effort. The CPUE value was obtained from production data and fishing trips for banana prawn using a trammel net from 2010 to 2018, therefore the fishing gear do not need to be standardized (Figure 8).

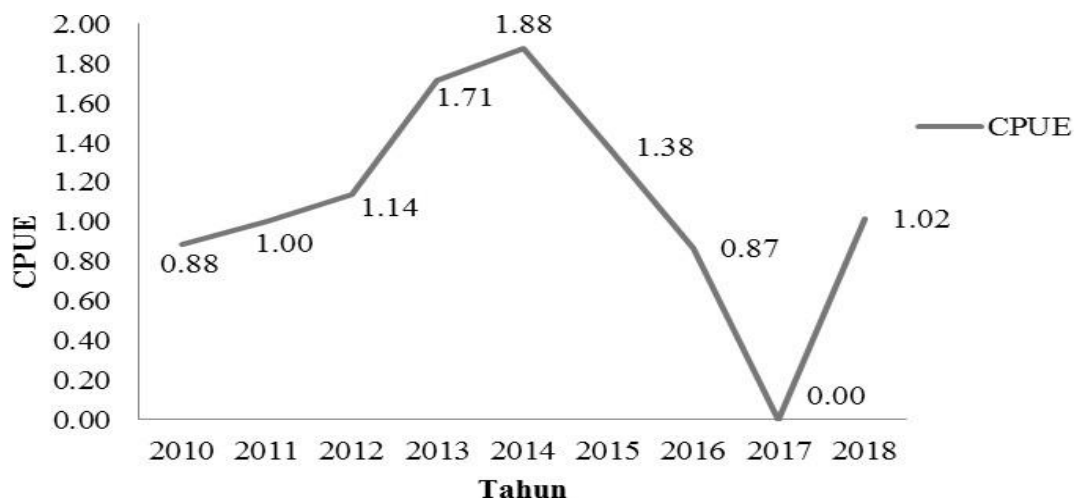


Figure 8 The CPUE of Banana prawn in Rembang Regency from 2010 – 2018

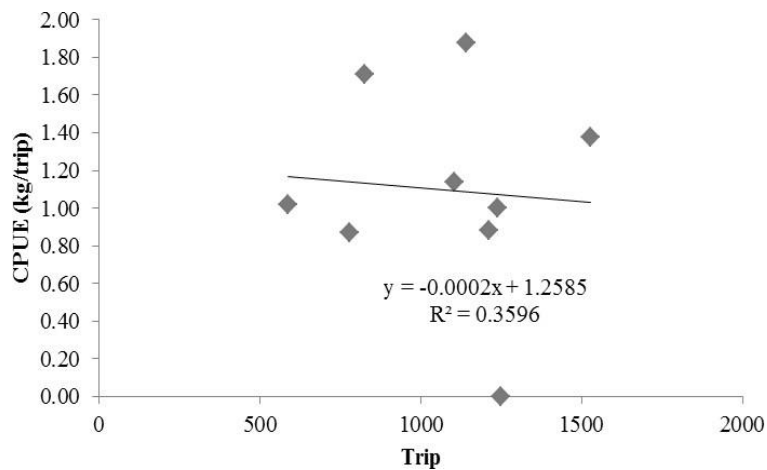


Figure 9 The relationship between CPUE and the fishing trips (R Square Value) of banana prawn in Rembang Regency from 2010 - 2018

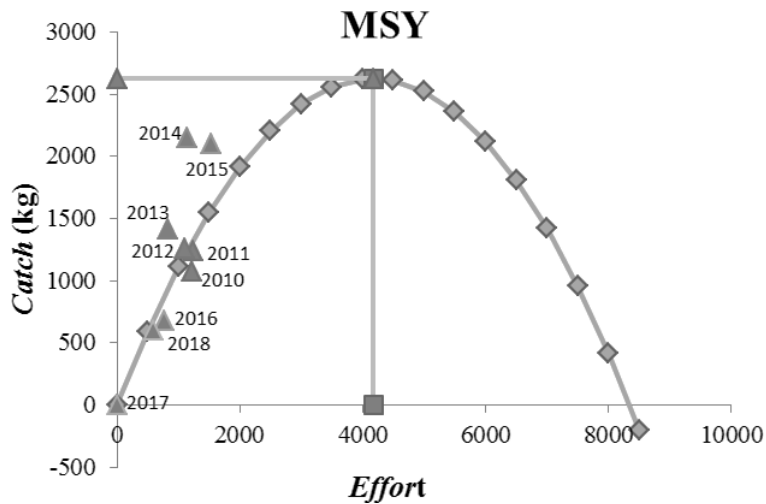


Figure 10 The MSY (Maximum Sustainable Yield) of banana prawn in Rembang Regency

Table 6 The utilization rate of banana prawn

Year	C (kg)	CMSY(kg)	TP (%)
2010	1070	2625	41%
2011	1238	2625	47%
2012	1257	2625	48%
2013	1412	2625	54%
2014	2144	2625	82%
2015	2100	2625	80%
2016	676	2625	26%
2017	0	2625	0%
2018	596	2625	23%
Average			44%

DISCUSSION

Data analysis using the swept area method was performed to obtain information

on the condition of banana prawn fishery in the Northern Waters of Rembang Regency, for instance, the fishing grounds, seasons, and gear used, as well as the potential resources.

The Condition of Banana prawn (*Penaeus merguensis*) Fishery in Rembang Regency

The drastic decline in 2017 and 2019 of banana prawn production was occurred due to natural factors, the surrounding aquatic environment, and unpredictable seasonal or weather factors. According to Ma'mun *et al.*, (2018), the fluctuation and trend of reduction in the sustainable potential of demersal fish within WPPNRI 712, from 2011-2015, recorded an average annual decline of 12.1% due to fishing pressure, indicating conditions of overfishing and resource degradation. In addition, Mustaruddin *et al.*, (2016) stated these production fluctuations are often triggered by salinity, temperature, offshore current (coastal currents), swells, and local winds in fishing grounds. To limit the conditions of overfishing and resource degradation, fishery management need to be implemented through a fisheries management plan. The main objective of the fisheries management plan is to sustain fishery resources by considering stock, environment, social and economic factors. If the stock can recover, it can result higher catch rates and then decrease the cost per unit catch (Hart and Reynolds, 2002; Grimm *et al.*, 2012).

Banana prawn is the most expensive prawn, and is, therefore, a major target for fishermen in Rembang Regency. According to Manadiyanto *et al.*, (2017a; b), the price per kilogram of banana prawn in Pati was IDR. 80.000,00 - IDR. 100.000.00, while the species marketed in Tuban are speckled shrimp and banana prawn. Furthermore, there are several classifications of prawn size determined by the supplier based on the exporter's specifications of Supersize I (15-24 individu per kilo gram), size II (25-30 individu per kilo gram), size III (31-40 individu per kilo gram), and size IV (41-50 individu per kilo gram). At the time of the study and the supplier level, the price of prawn per kg was, size I IDR.180.000,- size II IDR.160.000,- size III 120.000,- and size IV IDR.100.000,-. The size at the supplier level refers to the Japanese size classification (Japan size standard for first-class prawn).

Characteristics of Banana prawn (*Penaeus merguensis*) Fishery in Rembang Regency

In Rembang Regency, prawn and shrimp are caught using 2 types of fishing gear: sotok or mini bottom trawls, and trammel

nets. Sotok nets or *mini bottom trawl* is used irrespective of season, while trammel nets are only used during the prawn and shrimp season (Kartikaningtyas *et al.*, 2018; Dewanti *et al.*, 2019; Ihsan and Tajuddin, 2019). According to the results, most of the *mini bottom trawl* used have a ratio value outside the existing SNI value, determined through a comparison between the widths of the net sections. Table 1 shows only the comparison value of net width (j and j1) for nets 1 and 2 which follows the SNI. Furthermore, the net length counterparts mostly follow the SNI value, and all have a value between 0.995 as well as 1220.

Based on Table 2, the nets used by fishermen in Rembang tend to be smaller, compared to the SNI, indicating the nets are narrower, compared to the standard value. Sasmita *et al.*, (2013) as well as Ambarwati and Adi (2019), showed fishermen's cantrang nets have a smaller forewing-net width (g2/h) ratio and wider wingtips to increase the catch probability, while the lower body has a narrow width to prevent fish from leaving the net after getting caught.

In Rembang Regency, banana prawn is mostly caught during certain seasons. Figure 6 shows the highest total IMP of 276.01% was recorded in July, while the least values of 0% were recorded from October to December. Furthermore, PMI values above 100% were recorded from June to September, indicating this is the species' peak season, while values between 50% and 70% were recorded from January to May. This is reinforced by Subagio (2019), stating the peak prawn and shrimp season in the waters of Surabaya City lasts for 6 months: January, April, May, June, November, and December.

In addition, the highest IMP value during the peak season was recorded in May (380.85%), followed by June (166.16%), April (140.03%), December (138.27%), and January (107.20%). A study by Mosha and Gallardo, (2013) also reported similar findings in the temporal distribution of *P. monodon* and *P. indicus* in Saadan, a Tanzanian estuary area, observed between January and February (dry season) and March and April (rainy season). This was confirmed in the report by Amron *et al.*, (2009), stating the banana prawn fishing season occurs throughout the year, and peaks during the dry season (April - September). Similarly, Tirtadanu and Chodriyah (2020) showed the highest speckled shrimp and banana prawn catch from Cilacap waters using trammel nets,

were obtained in March and August, respectively.

Meanwhile, Ihsan and Tajuddin (2019) showed the peak prawn and shrimp fishing season in the waters of Pangkep Regency, occurred in January, February, March, and April, indicating several factors influence the species' peak season in waters of the Republic of Indonesia.

Swept Area

The highest stock density was recorded on trip 1, with a swept area, depth, and stock density of 0.0351 km², 0-5 m, and 41.14 kg/km², respectively (Table 4). Meanwhile, the mini- mum density was obtained on trip 5, with a swept area, depth, and stock density of 0.0791 km², 10-20 m, and 4.37 kg/km², respectively (Table 4). In addition, the average stock density value from all fishing locations was 16.22 kg/km². Fish stock density is an indication of fishery potential in a region. The difference in stock density values may be due to differences in research time or differences in seasons (Sumiono *et al.*, 2011). According to Nuruliuddin *et al.*, (2016); and Tirtadanu *et al.*, (2018) the average prawn density in East Kalimantan and the Java sea are 16.5 kg/km² and 21.34 ± 16.81 kg/km², respectively, while the average prawn catch rate in the West Sumatran waters is 2.3 kg/hour with a stock density of 0.053 tons/km².

In this study, the prawn and shrimp catches were dominated by speckled shrimp (*Metapenaeus monoceros*), while the highest total catch was obtained on the 4th fishing trip, with a total catch of 0.924 Kg, 12 Kg, and 3.5Kg for banana prawn (*Penaeus merguensis*), speckled shrimp (*Metapenaeus monoceros*) and southern velvet shrimp (*Metapenaeopsis palmensis*), respectively. These results were obtained from fishing operations at the highest depth compared to other fishing operations performed between 25-40 m depth. Tirtadanu *et al.*, (2017) stated the highest vertical prawn and shrimp stock density in the Java Sea is obtained at a depth of 40 to 50 m, presumably because most fishermen carry out intensive fishing at depths below 20 m.

Production Surplus Analysis

Figure 8 shows the fluctuations in the CPUE value, where an increase occurred from 2010 to 2014, and the peak value of 1.88 kgh / trip occurred in 2014, while a significant reduction occurred from 2014 to 2017, where

a value of 0 was recorded. According to the head of the Rembang UPT (TPI Management Unit), the banana prawn catch in this year was infinitesimal, and, therefore, not recorded. Also, the relationship between the CPUE value and the number of trips is illustrated in the results of simple linear regression analysis, using secondary data from 2010 to 2018.

The graph of the banana prawn catch against fishing effort forms a negative linear graph, where the catch per type of effort is bound to decrease with an increase in the number of fishing trips (Figures 9 and 10). In addition, a score of $R^2 = 0.3596$ implies the number of fishing trips has a 35.96% effect on the CPUE value, with the remaining influence coming from other factors, including environmental factors. The graph also shows a linear equation, $y = -0.0002x + 1.2585$, implying the slope has a value of -0.0002, meaning the fish stock decreases by 1.0002 kg, for every additional fishing effort. This was reinforced in the reports by Akoit and Mardit (2018) and Amir *et al.*, (2018), where the slope had a value of 0.00005, implying the fish stock decreases by 1.00005 Kg for every additional fishing operation, but increases by 1.00005 Kg, for every fishing operation is not carried out.

Based on Figure 9, the number of banana prawn catches during MSY or Cmsy conditions is 2,625 kg, while the number of fishing efforts under MSY or Emsy conditions is 4,172 fishing trips. Knowledge of the Cmsy value enables the TAC (Total Allowable Catch) to be calculated, and this value was determined to be 2,100 (kg) or 80% of the Cmsy value obtained. This is reinforced by Umar *et al.*, (2020), stating the Total Allowable Catch (TAC) is 80% of the existing potential, thus, the allowable catch is 8,331.94 tons.

Table 5 shows the utilization rate of banana prawn in the Rembang Regency from 2010 to 2018, where the highest sustainable potential value of 82% was obtained in 2014, indicating full exploitation in 2014. The exploitation of fish resources is categorized as full in cases where the number of catches of fish resource groups per year is above 80% of the estimated potential set (PERMEN-KP No. 29 of 2012). Meanwhile, the average utilization rate is 44% of the potential value obtained, indicating moderate utilization. The exploitation of fish resources is categorized as moderate in cases where the number of the catch of fish resource groups per year is below

80% of the estimated potential set (PERMEN-KP No. 29 of 2012).

CONCLUSION

This study concluded banana prawn in the northern waters of Rembang Regency were caught using 2 types of fishing gear, and these are sotok or mini bottom trawls and trammel nets. As the main fishing gear in for catching the banana prawn, *mini bottom trawl* fishing gear construction measured in this study is 15.77 m, 16.5 m, 20.44 m, and 25.2 m, operated in fishing areas with a depth of 10-40 m, while the fishing season is from June to September. In addition, banana prawn resources in the northern waters of Rembang Regency have average stock density value of 16.22 kg/km² (range 4.37 to 41.14 kg/km²), Cmsy value of 2.625 kg, Emsy value of 4.172 trips and the average utilization rate of 44% (range 23 to 82%).

SUGGESTION

Management policies in recovery and utilization efforts need to be implemented to create sustainable and sustainable fisheries, while environmentally-friendly fishing policies need to be developed. Furthermore, the implementation of these policies ought to be closely monitored by involving relevant agencies in Rembang Regency.

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