

## OVERFISHING AND OVERCAPACITY SMALL SCALE FISHERIES IN SEMARANG CITY

### **KAPASITAS PENANGKAPAN BERLEBIH DAN TANGKAP LEBIH PERIKANAN SKALA KECIL DI KOTA SEMARANG**

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#### ABSTRACT

*Fisheries in Semarang City are dominated by small-scale fisheries. This is indicated by the use of the largest fishing fleet of 10 gross tons operating near the coast. This study aims to analyze the status of small-scale fisheries in Semarang City for sustainable management. Sustainable management is management that guarantees the availability of natural resources and environmental services for future generations. The study was conducted for three months, namely September-November 2018 in the coastal waters of Semarang City, which was part of the Fisheries Management Region (WPP) 712. The method used in this study is the analysis of time series surplus production, namely data from the catch (ton/year) and the number of fishing gear (unit) within 10 years (2007-2016), to calculate the catch per-unit effort (CPUE), maximum sustainable yield (MSY), optimum effort ( $f_{opt}$ ), utilization rate (TP) and capacity level (TK). This study was obtained results of a downward trend in CPUE; the existing fishery catch or production in 2016 has exceeded the MSY value is 479 tons/year (Schaefer) and 439.11 tons/year (Fox); utilization rate of more than 100% which is 108-127% (Schaefer) and 118-138% (Fox), so that small-scale fisheries in Semarang City are at the level of over-exploited. Based on the  $f_{opt}$  analysis, the number of fishing gear used ( $f_{existing}$ ) has exceeded the optimum effort with a fishing capacity exceeding 100%, so that small-scale fisheries in Semarang City have experienced overcapacity.*

**Keywords:** CPUE, MSY, overfishing, overcapacity, small scale fisheries, Semarang

#### ABSTRAK

Perikanan di Kota Semarang didominasi oleh perikanan skala kecil. Hal ini ditandai dengan penggunaan armada perikanan paling besar 10 gros ton yang beroperasi di dekat pantai. Penelitian ini mempunyai tujuan menganalisis status perikanan skala kecil di Kota Semarang untuk pengelolaan berkelanjutan. Pengelolaan berkelanjutan yang dimaksudkan yaitu pengelolaan yang menjamin tersedianya sumber daya alam dan jasa lingkungan bagi generasi yang akan datang. Penelitian dilakukan selama 3 bulan yaitu September-November 2018 di perairan pesisir Kota Semarang yang menjadi bagian dari Wilayah Pengelolaan Perikanan (WPP) 712. Metode yang dipakai dalam penelitian ini adalah analisis data runtun waktu (*time series*) produksi surplus yaitu data dari hasil tangkapan (ton/tahun) dan jumlah alat tangkap (unit), dalam kurun waktu 10 tahun (2007-2016), untuk menghitung nilai *catch per-unit effort* (CPUE), potensi maksimum lestari (MSY), jumlah *effort* optimum ( $f_{opt}$ ), tingkat pemanfaatan (TP) dan tingkat kapasitas (TK). Penelitian ini diperoleh hasil adanya tren penurunan CPUE; hasil tangkapan/produksi perikanan eksisting telah melewati nilai MSY-nya yaitu sebesar 479 ton/tahun (Schaefer) dan 439,11 ton/tahun (Fox); tingkat pemanfaatan lebih dari 100% yaitu sebesar 108-127% (Schaefer) dan 118-138% (Fox), sehingga perikanan skala kecil di Kota Semarang berada pada tingkat *over-exploited*. Berdasarkan analisis  $f_{opt}$  menunjukkan jumlah alat tangkap yang digunakan ( $f_{existing}$ ) telah melebihi jumlah optimumnya dengan tingkat kapasitas penangkapan melebihi 100%, sehingga perikanan skala kecil di Kota Semarang telah mengalami kelebihan kapasitas penangkapan (*overcapacity*).

**Kata kunci:** CPUE, MSY, overfishing, overcapacity, perikanan skala kecil, Semarang

## I. INTRODUCTION

The coastal waters of Semarang City are part of the North Coast of Central Java, including in the Fisheries Management Area (WPP) 712. Estimated fish resources in WPP 712 according to Ministerial Decree Maritime Affairs and Fisheries No.47/KEPMEN-KP/2016, concerning estimates of potential fish resources, the number of catches allowed and the level of utilization of fish resources is 981,680 thousand tons/year. The existence of fisheries resources is essential for the Indonesian economy, which is a source of animal protein, absorbs a lot of labor in fisheries and contributes to the country's income.

Small-scale fisheries are fisheries with fishermen who carry out fishing activities using fishing vessels with the largest size of 10 gross tons (Law No. 7 of 2016); (Garcia *et al.*, 2008); (Batista *et al.*, 2013); with short catching distances and near the coast (FAO, 2017); low cost and the catch for consumption and sold locally (King, 2007); have fewer fleet crews (Guyader *et al.*, 2012); its existence depends on local resources and it affected by the environment (Mc Clanahan and Castilla, 2007); alternative models of activities that prioritize ecological policies and sustainability (Trimble and Johnson, 2012).

Based on Central Java capture fisheries statistics for 2012-2016, the trend in fish catches has begun to decline in Semarang from 2014 to 2016, while the number of fishing units has continued to increase from 2012-2016. The increase in the number of fishing units has caused the rate of exploitation to continue to grow. Excessive growth in exploitation indicates an overcapacity. Overcapacity causes a decrease in stock. Overcapacity will cause other problems, namely overfishing; stock depletion; environmental degradation; risk of conflict in fisheries; many fishermen experience a decline in profits and a decrease

in quality of life (poverty); lack of contribution of fisheries to employment, food security and development; lack of management and weak law enforcement; lack of access and information; weak institutional mechanisms and governance. These problems become complex and challenging to deal with partially, so it needs to be managed so that it is sustainable. This study aims to analyze the status of small-scale fisheries in Semarang City for sustainable management.

Determining the status of small-scale fisheries in the Semarang City is done through estimation of maximum sustainable yield (MSY), optimum effort ( $f_{opt}$ ) and utilization rates and fishing capacity levels by following the concepts of the Schaefer and Fox models. This determination is based on the analysis of surplus production data, namely from the catch data and the number of efforts in 10 years. Fisheries can be managed based on a surplus production model if available catch and effort data (Omori *et al.*, 2016).

## II. RESEARCH METHODS

### 2.1. Types, Sources and Collection Methods of Data

The type of data used in this study is primary and secondary data. Primary data were obtained from interviews and questionnaires with local fishermen, employees of the Semarang City Fisheries Agency and employees of the Central Java Province Fisheries and Marine Agency. This primary data collection is intended to find out conditions in the field related to policy implications. While secondary data was obtained from documentation/report studies, namely from time series documents/marine fisheries statistics reports for the last ten years available (2007-2016). The data used are data on the production or catch of marine fisheries (tons/year) and data on the number of fishing gear (units).

**2.2. Location and Time of Study**

This study was carried out in the coastal waters of Semarang City, Central Java Province, which was part of the Fisheries Management Area (WPP) 712, as in Figure 1. Data collection and analysis was carried out for three months, September-November 2018.

**2.3. Data Analysis Method**

Data on the amount of production or catch and data on the number of fishing gears are analyzed to calculate (i) catch per unit effort (CPUE), (ii) maximum sustainable yield (MSY) and optimum effort ( $f_{opt}$ ), (iii) the level of utilization of fish resources (TP)

and the capacity level of fishing units (TK).

**2.3.1. Catch per Unit Effort (CPUE)**

CPUE value is calculated based on the total amount of production or total catch (tons/year) compared to the total effort (units). In Tinungki (2005), Zulbainarni (2016), CPUE can be formulated as follows:

$$CPUE = \frac{\sum Catch_t}{\sum Effort_t} \dots\dots\dots (1)$$

Information: CPUE = catch per unit effort (tons/year/units),  $\sum Catch_t$  = total catch (tons/year), dan  $\sum Effort_t$  = total effort (units).

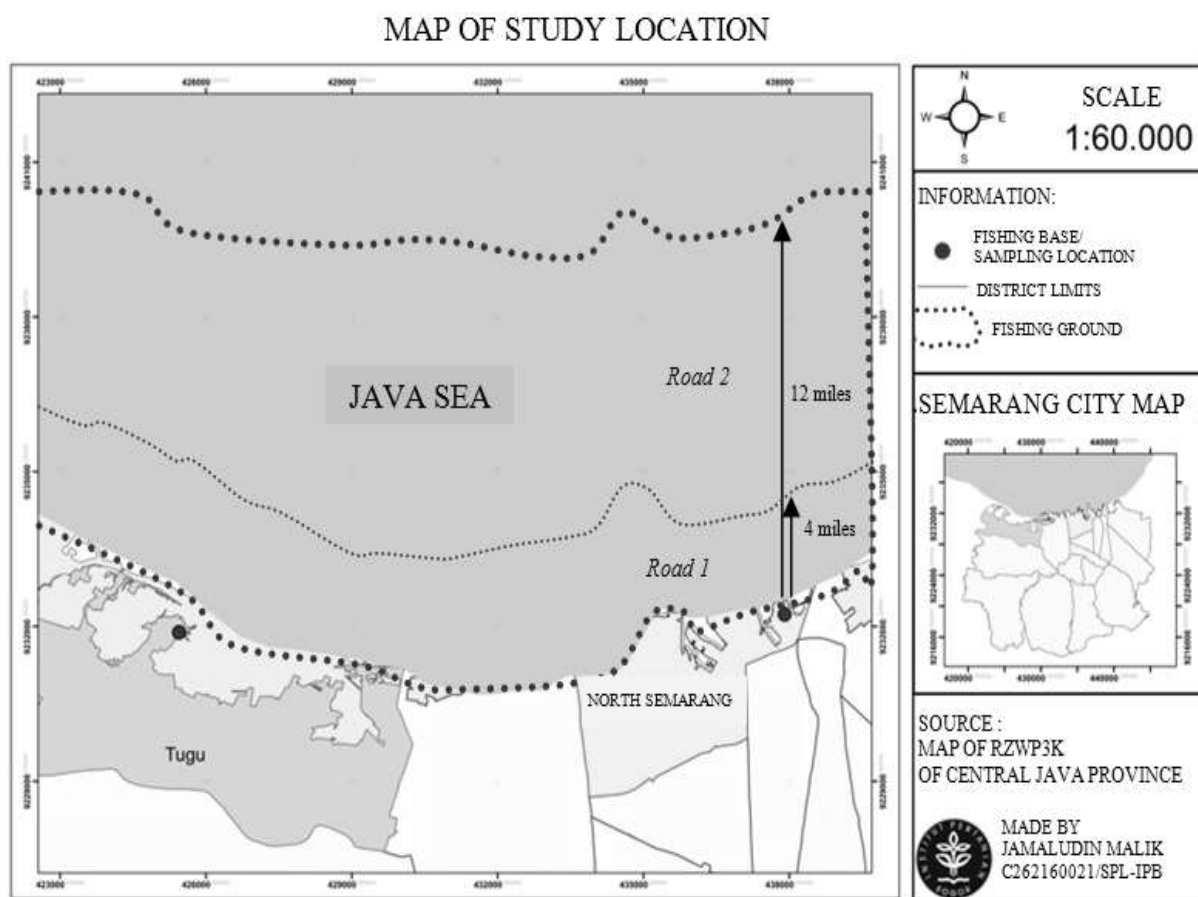


Figure 1. Map of study location.

**2.3.2. MSY and  $f_{opt}$**

Estimation of maximum sustainable yield (MSY) and the amount of optimum effort ( $f_{opt}$ ) can be done using the Schaefer and Fox model (Pauly, 1983) in (Nugraha *et al.*, 2012), (Istikasari *et al.*, 2016) as follows:

**2.3.2.1. MSY and  $f_{opt}$  Schaefer (Linear)**

**Model**

1. Relationship between CPUE and effort (f)  
 $CPUE = a + bf$  ..... (2)  
 Information, from linear relations CPUE and effort (f), is obtained: a: intercept, b: slope.
2. Relationship between catch and effort  
 $C/f = a + bf$   
 $C = af + bf^2$  ..... (3)
3. The optimum effort ( $f_{opt}$ ) is obtained from the first derivative of the catch (C) with an effort equal to zero.  
 $C' = af + 2bf$   
 $C' = a + 2bf = 0$   
 $2bf = -a$   
 $f_{opt} = - (a/2b)$  ..... (4)
4. The MSY value is obtained by substituting the optimum effort ( $f_{opt}$ ) in equation 3, so that it is obtained:  
 $C_{max} = a(-a/2b) + b(a^2/4b^2)$   
 $= -a^2/2b + a^2/4b$   
 $= (-2a^2 + a^2)/4b$   
 $MSY = C_{max} = - (a^2/4b)$

**2.3.2.2. MSY and  $f_{opt}$  Fox (Exponential)**

**Model**

1. Relationship f with CPUE  
 $CPUE = \exp(a + bf)$   
 information:  
 a and b are the natural anti log (ln) of intercept
2. Relationship between f and C

$C = f * (\exp ^ (a + bf))$  ..... (5)

$f_{opt}$  is obtained from the first derivative  $C/f = 0$

$f_{opt} = - (1/b)$  ..... (6)

5. MSY is obtained by substituting  $f_{opt}$  into equation 7 so that it is obtained:

$MSY = - (1/b) * e ^ (a-1)$  ..... (7)

**2.3.3. Utilization Level (TP) and Capacity Level (TK)**

According to Sparre and Venema (1999), utilization level is expressed in percent (%), expressed in formulas:

$TP_{(i)} = (C_i/MSY) \times 100\%$  ..... (8)

Information:  $TP_{(i)}$ : utilization level of the year I,  $C_i$ : the catch of year I, MSY: maximum sustainable yield

Likewise, the capacity level expressed in percent (%) and formulated:

$TK_{(i)} = (f_i/f_{opt}) \times 100\%$  ..... (9)

Information:  $TK_{(i)}$ : capacity level of arrest for the year i.

$f_i$ : effort for the year i

$f_{opt}$ : optimum effort

**III. RESULTS AND DISCUSSION**

**3.1. Catch per Unit Effort (CPUE)**

Calculation of CPUE value is commonly used to determine the development of fish stocks, and as an indicator of the efficiency and effective fishing operations without the need for as much data as other methods (van Hoof and Salz, 2001). The CPUE value is obtained by dividing the data between the catch and the amount of effort that has been standardized. The CPUE values of small-scale fisheries in Semarang City, 2007 until 2016 are presented in the following Table 1.

Table 1. CPUE values of small-scale fisheries in Semarang City 2007-2016.

Year	Production (tons/year)	Effort (units)	CPUE
2007	156.00	466	0.33
2008	164.00	784	0.21
2009	175.00	466	0.38
2010	372.00	466	0.80

Year	Production (tons/year)	Effort (units)	CPUE
2011	568.00	481	1.18
2012	583.00	481	1.21
2013	594.00	865	0.69
2014	606.00	1,032	0.59
2015	517.00	1,199	0.43
2016	352.00	1,199	0.29

The development trend or decrease in CPUE value can be seen from the relationship between CPUE and the effort. This CPUE trend can illustrate the indication of the status of utilization of fish resources in the waters. Regarding CPUE and effort relations on small-scale fisheries in Semarang City can be seen in Figure 2 below.

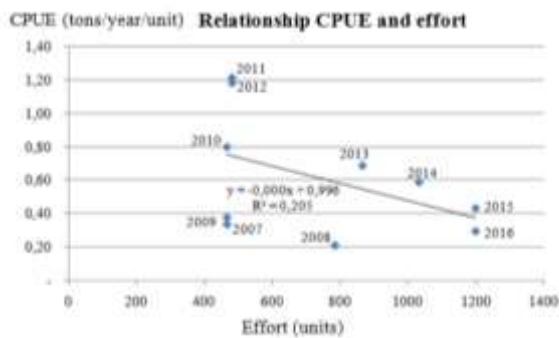


Figure 2. Relationship CPUE and effort.

In Figure 2, it can be seen that the CPUE and effort relationship is linearly negative, meaning that the CPUE value decreases with increasing effort. This decrease in CPUE value indicates that fish stocks began to decline, and the status utilization of fish resources in the waters of Semarang City indicates experiencing overfishing. This is by (Jaya *et al.*, 2017), which states the decrease in CPUE indicates the level of fish resource utilization is overfishing. A decrease in CPUE value can also indicate that capture operations are increasingly inefficient. This inefficiency occurs because the catches obtained are getting smaller with the use of an increasing amount of effort, so further analysis is

needed to be able to determine the optimum amount.

### 3.2. MSY and $f_{opt}$

The results analysis of maximum sustainable yield (MSY) in small-scale fisheries in Semarang City according to the Schaefer model are 479 tons/year and the optimum fishing gears can be operated ( $f_{opt}$ ) is 962 units. According to the Fox model, the MSY results are 439.11 tons/year, and  $f_{opt}$  is 1,003 units, as presented in Figure 3 and 4 below.

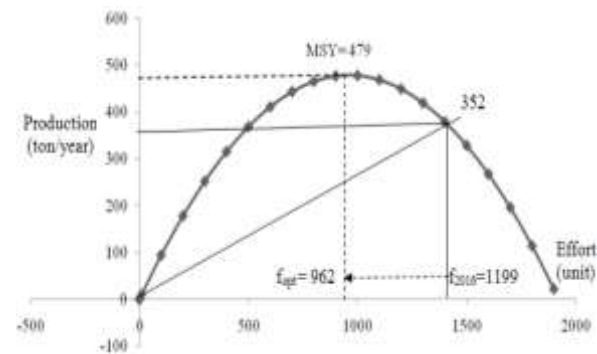


Figure 3. MSY and  $f_{opt}$  Schaefer model.

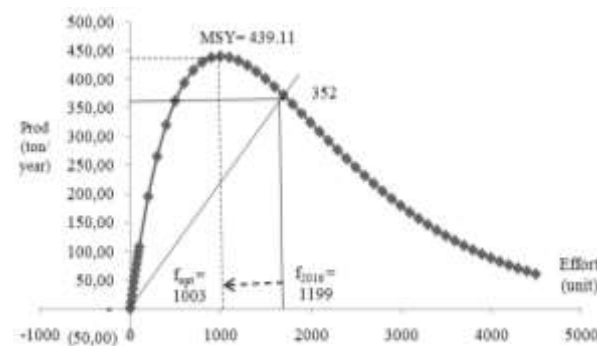


Figure 4. MSY and  $f_{opt}$  Fox model.

In Figure 3 (Schaefer Model) it can be seen that the number of fishing units used by fishermen ( $f_{\text{existing}}$ ) in Semarang City in 2016 (amounting to 1,199 units) has exceeded the number of optimum fishing gear (1,003 units), so overcapacity has occurred. This overcapacity caused Semarang City's small-scale fisheries production in 2016 to amount to 352 tons per year past the sustainable potential value (MSY) of 479 tons per year. This shows that overfishing in small-scale fisheries in Semarang City has occurred. Regarding policy, this overcapacity certainly needs to be reduced so that fisheries resources can be managed sustainably. Based on the Schaefer model, the number of  $f_{\text{existing}}$  1,199 units should be reduced by 237 units to return to their optimum conditions of 962 units. In the Schaefer model it has a disadvantage, namely with the addition of continuous effort (uncontrolled), then over time, the potential of fisheries resources will be exhausted ( $Y_t = 0$ ). This can be seen in the form of an inverted parabola graph in Figure 2 with the final production equal to 0 (exhausted), whereas in reality fisheries resources can recover (renewable resources) and can regenerate, so it is impossible to completely run out. For this reason, the Fox model is also considered to cover the weaknesses found in the Schaefer model.

In Figure 4 (Fox Model), there is an exponential graph, where continuous pressure on fisheries resources by the number of excessive effort, fisheries resources is not up to extinction ( $Y_t \neq 0$ ). This condition is certainly more realistic by conditions in the field that fisheries resources are renewable resources. The results calculation of the MSY value on this Fox model were obtained

at 439.11 tons per year with the optimum effort devices of 1,003 units. Whereas in the existing conditions namely small-scale fisheries production in Semarang City in 2016 amounted to 352 tons per year with a total effort of 1,199 units which also exceeded the MSY value, so it was included in the category of overfishing, with an excess effort of 196 units must be decreased.

The occurrence of overfishing conditions in small-scale fisheries in Semarang City is also reinforced (Anas *et al.*, 2011), which states that the status of utilization of fish resources in the waters of Cirebon (which is the North Coast of Java and part WPP 712) has overfishing. This is indicated by the volume of catches to be getting smaller, the size of the fish caught is getting smaller and the time used to go to sea is getting longer. The same opinion was also conveyed (Triarso, 2012), which states that the potential of fisheries resources in Central Java is indicated to experience overfishing, due to the pressure of arrests carried out by small-scale fisheries which generally operate on the coast.

### 3.3. Utilization Level (TP) and Capacity Level (TK)

The utilization level of fisheries resources shows a comparison of the amount of annual catch production with its maximum sustainable yield (MSY) and expressed in percent. Similarly, the level of fishing capacity is a comparison of the amount of existing annual effort with the optimum effort expressed in percent. The results calculations regarding the utilization level of fisheries resources and the capacity level in small-scale fisheries in Semarang City are shown in Table 2 below.

Table 2. The utilization level and capacity levels of small-scale fisheries in Semarang City 2007-2016

Year	Production (tons/year)	Effort (units)	TP* (%)	TP** (%)	TK* (%)	TK** (%)
2007	156	466	33	36	48	46
2008	164	784	34	37	81	78

Year	Production (tons/year)	Effort (units)	TP* (%)	TP** (%)	TK* (%)	TK** (%)
2009	175	466	37	40	48	46
2010	372	466	78	85	48	46
2011	568	481	119	129	50	48
2012	583	481	122	133	50	48
2013	594	865	124	135	90	86
2014	606	1032	127	138	107	103
2015	517	1199	108	118	125	120
2016	352	1199	73	80	125	120

\* (Schaefer model) with MSY = 479 tons/year and  $f_{opt} = 962$  units

\*\* (Fox model) with MSY = 439,11 tons/ year and  $f_{opt} = 1,003$  units

In Table 2, it can be seen that the utilization level of fisheries resources in Semarang City since 2011 has exceeded its sustainable potential (MSY), both for the Schaefer and Fox models. This is indicated by the acquisition of the utilization level (TP) that exceeds 100% whereas the capacity level has exceeded its optimum value from 2014 to 2016. This can be seen from the acquisition of the capacity level value (TK) more than 100%.

### 3.4. Management Policy

Based on CPUE analysis trends that have decreased since 2013 to 2016; MSY's analysis that shows the catch or fishery production (existing) has exceeded its sustainable potential, so that fish resource stocks decline; and analysis of utilization level (TP) that exceed 100%, so small-scale fisheries in Semarang City are included in the category of over-exploited. This is following the stipulation by FAO (1995), the status of fish resource utilization has been over-exploited with the marked stock of fish resources already declining due to exploitation exceeding their MSY.

Based on the analysis of optimum effort ( $f_{opt}$ ) which shows the number of  $f_{existing}$  operations in 2016 has exceeded its optimum value ( $f_{existing} > f_{opt}$ ), and the analysis of fishing capacity levels (TK) obtained results in TK values of more than 100% since 2014-2016 so that small-scale fisheries in Semarang City have overcapacity.

Overcapacity due to excessive effort should be reduced for the preservation of fish resources can be restored and not disturbed, so that the utilization of fish resources can be sustainable. However, fisheries management policies with overcapacity reduction in small-scale fisheries, implementation in the field have many factors that influence and be considered, including socio-economic implications (development of the number of fishers, livelihoods/ employment opportunities, income and dependence of fishermen on local resources). The solution offered by Pomeroy (2011) to resolve overcapacity in small-scale fisheries is (1) limitation environmentally unfriendly fishing gear; (2) creating alternative livelihoods; (3) forming institutions.

## IV. CONCLUSION

The status of small-scale fisheries in Semarang City is an over-exploited level. It is indicated by observations in the field, which showed that the volume of the catch tends to be smaller, and the size of the fish caught tends to be smaller. Based on a declining CPUE trend analysis, MSY analysis, which shows that existing catch production has exceeded its potential sustainability and utilization level analysis that exceeds the MSY value ( $> 100\%$ ). Overcapacity is the cause of overfishing, based on the optimum effort analysis ( $f_{opt}$ ) which shows the number of fishing gear operating ( $f_{existing}$ ) has exceeded its optimum

value; and analysis of capacity level (TK) levels that have reached more than 100%. Management policy solutions that can be carried out by the Regional Government to be sustainable, including restrictions/reduction of fishing gear due to overcapacity.

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