FISHERIES RECOURCES STATUS OF RASBORA (RASBORASP) IN RAWAPENING, SEMARANG, CENTRAL JAVA: BIOECONOMIC ANALYSIS

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ABSTRACT
Rasbora (Rasborasp) is natural resources which have potency to catch in RawaPening Swamp. Total production of rasbora was 11,930 kg in 2014. The research objectivesto analyzed rasbora bioeconomic status with Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), and Open Access (OA) indicators in RawaPening. Bioeconomic analysis for Rasbora used Gordon-Schaefer Model. Primary data obtained with census and the total respondents were 31 gillnet fishers. Primary data were gillnetefforts, price and cost of rasbora fishing. Secondary data used Rasbora (Rasborasp) production for 10 years from 2003-2012. The result of Gordon-Schaefer model for Maximum Sustainable Yield produced of rasbora (C_{MSY}) of 44,100 kg/year with fishing efforts (E_{MSY}) 21,000 efforts/year. The Maximum Economic Yield status (C_{MEY}) 35,916.08 kg/year with effort maximum (E_{MEY}) of rasbora 11,953 efforts/year. Meanwhile, limitation of the rasbora production in Open Access Equilibrium (C_{OAE}) was 43,000 kg/year and effort maximum (E_{OAE}) 23,766 efforts/year. Rasbora resources in RawaPening status is in underfishing condition.

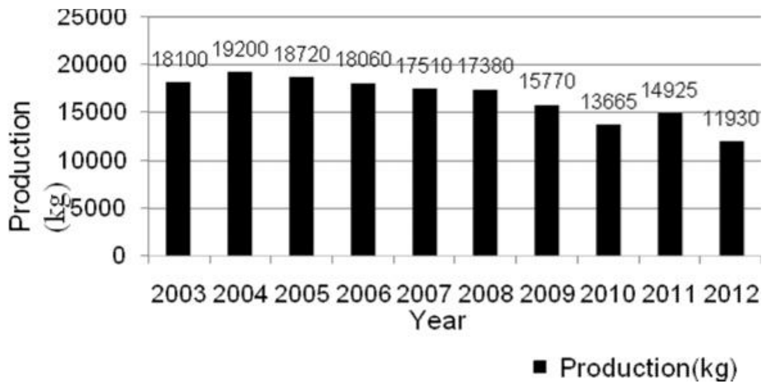
Keywords: Rasbora (Rasbora sp), Gordon-Schaefer Bioeconomic Model, Rawa Pening

INTRODUCTION

Rasbora is one of the endemic fish species living in RawaPeningSwamp, Semarang, Central Java. Rasbora local name is "Wader". According to the State Agency of Animal Husbandry and Fisheries Semarang (2013), production of wader (Rasborasp) within the last 10 years are likely to decline. According to Figure 1., the decrease of rasbora (Rasborasp) fishing production occurred from 2004 to 2010. In 2011 had increased again. However, in 2011-2012, rasbora's total production declined significantly from 14925 kg to 11930 kg. The decreased of rasbora production become a question in this research. Was it associated with increased activities in the waters of RawaPening, both from the fishing fleets nor the fishing trip? Therefore, it needs the required arrangement of fishing that leads to the concept of environmental sustainability by measured he status of rasbora utilization in Rawa Pening Swamp.

One of the concepts in the management of rasbora resources (Rasborasp) that can be applied, is the concept of MSY (Maximum Sustainable Yield). The concept of MSY is maximum sustainable results is recommended as one of the goals of the fisheries management. MSY can be used as reference for arrangement of fishing exploitation from a fish recources.

According to Effendie (2002), many of the assumptions, that the MSY has the only purpose formanagement of fisheries resources. The concept of MSY has been known for years, but the concept is much criticism because it does not include a parameter of the population. However, the criticism is not valid on open waters such as reservoirs or lakes because at open waters, the fish migration to other waters does not occur. The objectives of this research were to analyzingrasbora (Rasborasp) bioeconomic status in Rawa Pening, using bioeconomic Gordon-Schaefer model with three indicators inter alia, MSY (Maximum Sustainable Yield), MEY (Maximum Economic Yield) and the OAE (Open-Access Equilibrium) condition.



Source: State Agency of Animal Husbandry and Fisheries Semarang, 2013.

Figure 1
Rasbora Production in RawaPening 2003-2012

METHODOLOGY

Data Collections

Respondents taken in the village of Bejalen with consideration of number of gill net in Bejalen was the most numerous compared to other villages. Respondent was fishers using gill net with mesh size ¾ inch to catch rasbora. The number of rasbora fishers (gill net ¾ inches) in Bejalen was 31 people. Methods of data retrieval by using census techniques. This research used primary and secondary data. Primary data was the number of fishing fleets, fishing trips, and the fishing costs (investment costs, fixed costs and variable costs), rasbora price/kg, boat and fishing gears of rasbora (Rasbora sp.). While secondary data was fish production data of wader (Rasbora sp) 2003 – 2012 in Rawa Peningfrom State Agency of Animal Husbandry and Fisheries Semarang.

Data Analysis

Analysis of static model bioekonomi Gordon-Schaefer, developed based on Schaefer logistic growth function by Gordon. The logistic growth functions model combined with the principles of economy, namely with how to entry of the price per unit factor of the capture results and cost-per-unit effort on the equation of the function. There are three conditions of equilibrium in Gordon-Schaefer model inter alia, MSY (Maximum Sustainable Yield), MEY (Maximum Economic Yield), and OAE (Open-Access Equilibrium) (Fauzi, 2006).

Data analysis in this study with processing primary data and secondary data analysis using bioekonomi Gordon-Schaefer model. Data calculation of total trip per year used formulation as follows:

Total trip = trip average/year x total of fishing fleets in (i) year (1)

Time series data of rasbora production (yield) and fishing effort used to predict biology and economic parameters in bioeconomic model. Rasbora production data per year divided with fishing effort per year to calculate Catch Per Unit Effort (CPUE). According to Gulland (1969),CPUE can be calculated with formula:

$$CPUE = \frac{Yt}{ft} \qquad (2)$$

Where as **CPUE** is Catch Per Unit Effort (kg/trip),***Yt*** is Rasbora production per year (kg),***ft*** is fishing effort to catch rasbora per year (trip).

Bioeconomic model consists of a combined calculation of stock size in biology and economics. Method in this research used Gordon Schaefer Surplus Production Model to analyze bioeconomic parameter. Bioeconomic model consist of biology and economic resources availability estimation. Biology parameter using Schaefer modelwas MSY using input data (Sparre and Venema, 1998):

f(i) = total of fishing effort in i (year), i = 1,2, ..., n (3)

Where **Y/f** is yield per unit effort in i (year). Y/f can be derived from yield, Y(i), on year i to calculate fisheries resources extraction and related with effort, f(i) can be write as:

Y/f = Y(i) / F (i), i = 1, 2, ..., n (4)

The formula to describe yield per unit effort (Y/f) as an effort function was using linear model that suggested by Schaefer (1954) in Spare and Vennema (1998):

Y (i) / f (i) = α + β.f (i) jika f (i) ≤ -α/β (5)

Where as **Y(i)/f(i)** is fish catching function, **F(i)** is effort, **α** is regression intercept, **β** is regression slope.

Schaefer also related fish production (Q) with fishing effort (E):

$$Q = q\,E \longrightarrow q = \alpha - \beta.E \qquad (6)$$

$$= (\alpha - \beta E)E$$

$$= \alpha E - \beta E^2$$

Estimation of MSY according to Schaefer formula's (Schaefer, 1957 in Sobari et.al., 2008 and Susilo, 2009):

$$C_{MSY} = \frac{\alpha^2}{4\beta}... \qquad (7)$$

E_{MSY}= - $\frac{\alpha}{2\beta}$.... (8)

The maximum sustainable yield is easily found with the Schaefer logistic modelby setting the first derivative of the catch equation with respect to effort – the slope of theproduction function – equal to zero.

Next step was combining economic element to estimate Maximum Economic Yield (MEY). Hartwick and Olewiler (1986) in Dewi (2010) explain that in open access condition, where fisheries resources can be exploited without control, fishers total revenue (TR) with an assumption price of per unit fish catching (p) constant, it can be expressed as follows :

TR = p Q whereas $Q = \alpha E - \beta E^2$

$= p (\alpha E - \beta E^2)$ (9)

And according to Gordon (1954) cost per unit effort (c) also constant, and Total Cost (TC) can be calculated:

TC = c E (10)

With combined economic element from Gordon Model to Schaefer Model (Gordon, 1954) in Noordiningrum *et.al* (2012), the fishers profit can be expressed as follows:

π = TR – TC

$= p (\alpha E - \alpha E^2) - c E$

$=p(\alpha-2\beta E)-c$ (11)

Where **TR** is total revenue and **TC** is total cost. The equilibrium profits from the fishery can be described bothas a function of stock size and effort (Foley et.al., 2012).

In static condition Gordon-Schaefer (Nabunome, 2007), that Maximum Economic Yield (MEY) equilibrium occured when π (rent) attain maximum level (MR = MC or $d®/dE$ = 0) with condition $d^2\pi/d^2E < 0$, which can be expressed as follows:

$d\pi/dE = p (\alpha - 2\beta E) – c = 0$ (12)

And E_{MEY} dan Q_{MEY} can be expressed as follows:

$E_{MEY} = \alpha/2\beta - c/2\beta p$ (13)

$Q_{MEY} = MEY = \alpha^2/4\beta – c^2/4\beta p^2$ (14)

Using the open-access management objective, total revenues **TR** are set equal to total costs to find the optimal level of effort for a common property fishery. Mathematically,
the OAE solution is found as follows:

$E_{OA} = 2 . MEY$ (15)

$Q_{OA} = OA = \alpha.E_{OA} - \beta.E_{OA}^2$ (16)

RESULT AND DISCUSSION

CPUE (*Catch per Unit Effort*)

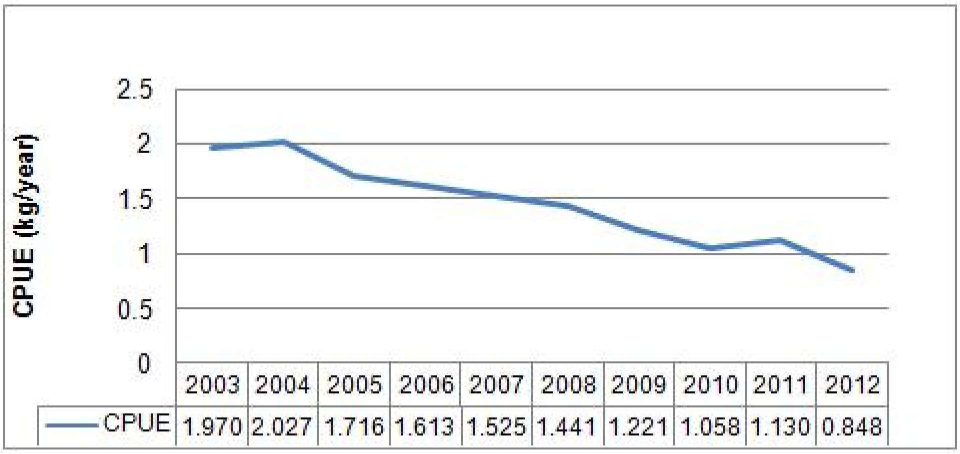
In RawaPening, wader (Rasbora sp) were captured using set gill net with mesh size ¾ inches. Fishing fleets arerowboat made from wood. It is an artisanal fishery. Total gillnets operated in Rawa Pening were 245 fleets. Meanwhile, gillnet with ¾ inches mesh size was 49 fleets. Total trips of gillnets ¾ inches were 14,063 trips per year in 2012. Fishing trips per gillnet fleet was 287 trips/year. The production of rasbora in 2012 was 11,930 kg. CPUE of Rasbora in Rawa Pening in 2012 was 0.848 kg/trip.Every gillnet fishers in Rawa Pening were operated 30 – 40 pieces of gillnet.

The calculation of CPUE was formulated from rasbora total production and total rasbora fishing trips in a year. In Rawa Pening, there is only one type of fishing gear to capture rasbora, namely “wader gill net” with mesh size ¾ inches. Total trips and production data were used to calculates rasboraCPUE from 2003 – 2012.

Table 1
Rasbora Fishing Trips, Production, and CPUE in RawaPening From 2003-2012

Year	Trips	Production (kg)	CPUE (kg/trip)
2003	9184	18100	1,971
2004	9471	19200	2,027
2005	10906	18720	1,716
2006	11193	18060	1,614
2007	11480	17510	1,525
2008	12054	17380	1,442
2009	12915	15770	1,221
2010	12915	13665	1,058
2011	13202	14925	1,131
2012	14063	11930	0,848
Average	11738,3	2685,5	1,455

Source: Research Data, 2014.



Source: Research Data, 2014

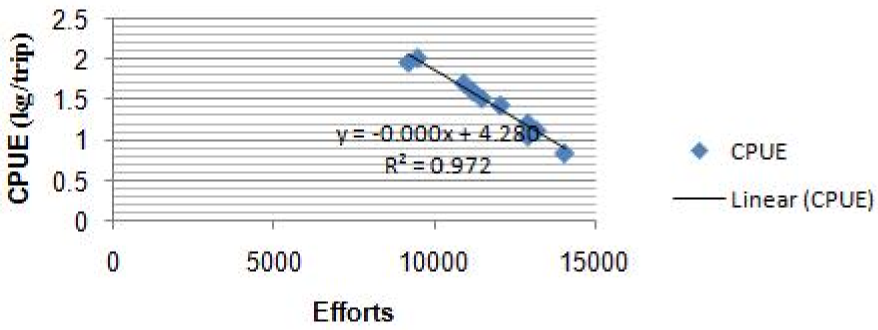
Figure 2
CPUE of Rasbora Fishing in Rawa Pening 2003-2012

Rasbora CPUE value in RawaPening from 2003 – 2012 were tends to decline. Percentage of CPUE decreased in 2003 – 2012 was 7.71%. Rasbora CPUE value is inversely proportional to the number of trips. The smallest CPUE values in 2012 was 7.81 kg/trip and average CPUE from 2003 – 2012 of 14,53 kg/trip. Simple linear regression analysis subsequent to figure out the equation of a regression of relationship data effort (X) and CPUE(Y). The results of the regression equations derived were:

$$Y = 4{,}2 - 0.0001x$$

With result of Regression function had Corellation Coefisient (R) 0.98 and Determination Coefisient (R^2) was 0,97. It meant that corellation (R) between CPUE and Effort of rasbora fishing is quite strong. The additions effort of rasbora fishing can caused yield decreasing. Meanwhile the R^2 give a percentage of variations in effort can give 97% description of rasbora yield (CPUE) in Rawa Pening fishing activities.

Based on the results of the regression equation above, it can be explained that any addition of one trip or effort fishing operation then production will be decrease by 0.0001 kg. Linear regression graphic of CPUE and fishing effort shown in Figure 3.



Source: Research Analysis, 2014

Figure 3
Linear Regression of Rasbora Fishing Effort and CPUE in Rawa Pening 2003-2012

Bioeconomic Condition

A fishery can be thought of as a stock or stocks of fish and the enterprises that have the potential to exploit them. It can be a very simple system where a fleet of similar vessels from a single port exploits a single stock of fish (Anderson and Seijo, 2010). The study of over-exploitation attempted to use economic analysis on the interface between human society and the biological resources. This resulted into the development of what has become to be known as bioeconomic models, analyzing the interaction between human harvestingpressures and biological resource regeneration (Clark,1976 in Lokina, 2000). Bioeconomic models are based on the work of Gordon (1954) and Schaefer (1957) who developed what has come to be known as the basic bioeconomic model of fisheries management (Lokina, 2000).

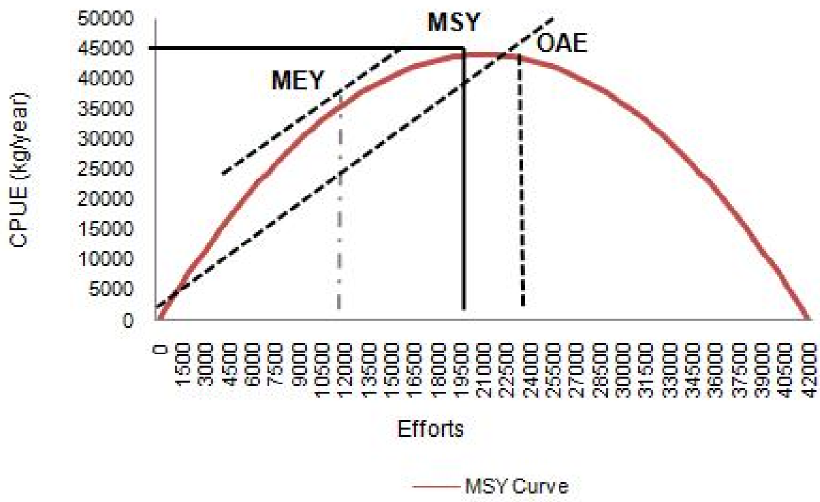
Maximum Economic Yield (MEY) estimation was based on α and β values from linear regression function result that used to estimate MSY (Schaefer Model). Based on the results of the analysis with the Gordon Schaefer model bioeconomic, obtained as a result of the value of the MSY, MEY and OAE resources of rasbora inRawaPening can be seen in Table 2. A bioeconomic equilibrium occurs when there is no change in either stock size or the level of effort (Anderson and Seijo, 2010).

Table 2
MEY, MSY, & OA Estimation of Rasbora in Rawa Pening

	MSY	MEY	OAE
Catch (C)	44,100 kg/year	35,916.08kg/year	43,000 kg/year
Effort (E)	21,000 trips/year	11,953 trips/year	23,766 trips/year
Revenue (TR)	731,222,100	595,524,615	712,980,000
Cost (TC)	630,000,000	358,605,030	712,980,000
Profit	101,222,100	236,919,585	0

Source: Research Analysis, 2014

Cost average (c) per trip for rasbora fishing was IDR 30,000.00, average price of rasboraper kilo's was IDR 16,581.00.



Source: Research Analysis, 2014

Figure 4
MSY, MEY, and OAE of Rasbora Fishing in RawaPening

MSY (*Maximum Sustainable Yield)*

A formula based on the model of Gordon Schaefer then obtained as a result of alleged potential sustainable fish resource. Equilibrium for MSY reaches point for production of wader (Rasbora sp) in RawaPening waters in MSY status was catch optimum (C_{MSY}) estimation44,100 kg/year andoptimum effort (E_{MSY}) 21,000 trips/year. It can be calculated that every boat can captured rasbora 180kg/year. Total Revenue (TR) in MSY condition was Rp. 731,222,100and Total Cost (TC) of Rp. 630,000,000.TR is the product of price and equilibrium harvest and TC is the product of unit cost of harvest and equilibrium harvest. The unit cost of harvest decreases with rising catchability and stock size (Foley, 2012). Profit was Rp. 101,222,100. Average CPUE values from 2003 – 2012 were 1.45 kg under the CPUE values in conditions of MSY (Maximum Sustainable Yield) at 2.5 kg with an average number of trips of 11.738 trips/year.Actual condition of rasbora production in RawaPening was still under-fishing condition. Yield of rasbora from 2003-2012 were below E_{MSY} limitation (44,100 kg/year). And yield of rasbora was in range 11,930-19,200 kg/year.

MEY (*MaximumEconomicYield*)

Maximum Economic Yield (MEY) condition for Rasbora sp can be describe with equilibrium of production in the Rawa Pening waters 35,916.08 kg/year (C_{MEY}) and effort ($E_{MEY)}$ was 11,953 trips/year. Fishers Total Revenue (TR) 595,524,615.00 IDR per year. Meanwhile, Total Cost of fishing operation (TC) was 358,605,030.00 IDR. Profit of rasbora fishing 236,919,585.00 IDR. C_{MEY} production was not differ much from the value of CMSY, it was 8183.92 kg. Economic benefits will occur when the biggest difference between Total Revenue (TR)and Total Cost (TC) of fishing exploitation. Profits generated in conditions of

MEY 236,919,585.00 IDR was higher than MSY conditions. Economically, the condition of wader (Rasbora sp) was in under fishing. It can be shown by Total Cost Average of fishing exploitation from 2003-2012 325,149,000.00 IDR is lower than Total Cost in MEY status. Fishing operation of Wader gillnet can be more longer operated in Rawa Pening waters. Actual condition of Rasbora fishing in Rawa Pening Total Revenue per year of 49 gillnetter was 197,811,330.00 IDR.

OAE (*Open-Access Equilibrium*)

Open-access equilibrium status is the equilibrium conditions of open access without any restrictions or limitations in the number of fishing fleets or trips. Meanwhile, in open access equilibrium status total of costs for fishing operations incurred will be equal to fishing revenue (total revenue) so the fishing operations gain no profit (profit is zero). Based on the analysis of the OAE condition, CPUE (C_{OAE}) of wader (Rasbora sp) in Rawa Pening waters was 43,000 kg/year. With Total Effort (E_{OAE}) limitation is 23,766 trips/year. Total Revenue and Total Cost of rasbora fishing production is 712,980,000.00 IDR. It produce zero profit for rasbora fishers. Open Acces status give an allert for fishing exploitation limitations especially to the Rawa Pening fishers.

CONCLUSION

The result of Gordon-Schaefer bioeconomic model for Maximum Sustainable Yield (MSY) status of rasbora production was 44,100 kg/year and the effort of MSY (E_{MSY}) 21,000 trips/year. Maximum Economic Yield (MEY) of rasbora production was 35,916.08kg/year and the effort of MEY (E_{MEY}) 11,953 trips/year. Meanwhile, for Open Acces (OA) condition rasbora production was 43,000 kg/year with maximum effort (E_{OAE})23,766 trips/year. Actual condition of rasbora resources in RawaPeningwasunderfishing in biology and economic status.

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