BIOECONOMIC MODEL OF GLASS EEL RESOURCES IN COASTAL WATERS SUKABUMI, INDONESIA

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ABSTRACT

This research was aimed to identify the potential of glass eel (*Anguilla bicolor*), applying of Copes model, Effort optimum, Maximum Sustainable Yield (MSY), and Open Access Equilibrium (OAE). To identify aspects of biology and economics in the utilization of glass eel at coastal waters Sukabumi. This research was held in April of 2019 at coastal waters Sukabumi, West Java. Indonesia. The method used in the study was case-study quantitative descriptive. The results of this study were operation of the glass eel arrest to achieve a maximum production level of 495523.92 trips per year. The real condition of catching glass eel on the coast of Sukabumi is still under the permissible rate of capture, or in other words, the capture can be increased again. Utilization of glass eel resources with the maximum catch is achieved in MSY condition of 25,968.2374 Kg per year with a maximum of sustainably the highest eel fish that can be captured without threatening population sustainability biologically eel fish resources. The level of MEY's production demonstrated with the optimum production (H_{MEY}) = 18,432.108 Kg per year with an effort rate (E_{MEY}) of 228,581.527 trips per year. The value showed the production rate of MEY, The output limit was based on the Total Allowable Catch (TAC) is 20774.5896 Kg/year. Then the profit will be reduced even more will get a rente equal to zero ($\pi = 0$) at condition open access for the catch of H_{OA} = 24,830.321 Kg.

Keywords: Bioeconomic, Copes Model, glass eel*, sirib* (lift net),

1. INTRODUCTION

Eel fish are exported in the form of life-size consumption, fillet or processed. This eel fish enlargement business still uses seeds from natural catches, because there is no technology capable to perform the eel hatchery effectively, both from the business operational and also the effectiveness of breeding in a controlled environment. Fisheries practices such as this in the MSC (Marine Stewardship Council), included in the enhance fisheries, where the practice of fishing in the seed phase (glass eel) was taken from nature for the fulfillment of cultivation needs (WWF 2019). The tropical eel found on the coast of Sukabumi is of *Anguilla bicolor* and *Anguilla marmorata* (Aoyama 2003, 2009; Fahmi 2015)

Bioeconomics developed by Parvival Copes used an output approach, i.e. production or yield. The Copes model was a distinct assumption with the Gordon-Schaefer model which was an early model of the development of fisheries bioeconomics. In the Gordon-Schaefer model, the price per unit of output was assumed to be constant. While in the Copes model, the price per unit of output can be fluctuating. The cost of arrest in Bioeconomics study of Copes model following the research study of Gordon Schaefer was assumed that only the arrest factors were taken into account, so that the cost of arrest could be defined as the cost per day of operation (trip) and the cost of arrest was considered constant (Copes 1970;Fauzi and Anna 2005).

The input parameters needed in analyze bioeconomic models on the utilization of fish resources consist of natural capital, human capital (fishermen) and man made capital (unit Armada/capture equipment). Eel Fish are one of the commodity of fishery that has an important economic value with open market opportunities (especially the purpose of exports)(King, 1995; Pauly et al.2002: Sajise 1995). The eel resource that needs to be known to its potential is in the coastal waters of Sukabumi especially in the waters of river estuary, where the glass eels are captured by fishermen.

The main principle in the Copes model is to determine the bioeconomics balance of demand-and supply-based fisheries (Clarke et al. 1992)

The government set the eel export policy as standard in the bidding system of deals between producers and consumers to create a balance of economic surplus, therefore the theory of economic surplus is very beneficial in analyzing the impact of government interference. Government interference is considered worse if the total loss of economic surplus (loss of consumer surplus and producer surplus) is increasingly the so-called deadweight loss.

Catching glass eel is done in one-day fishing. The arrest is repeated with a *sirib* (lift net) until the *koja*/seed container is full of glass eel, the fishermen will climb inland two to three times until the morning.

2. METHODOLOGY

This research was conducted in April of 2019 in the coastal waters of Sukabumi, West Java, Indonesia. The method used in the study was case-study quantitative descriptive. Case study or case research is research on the status of the subject of research relating to a specific or distinctive phase of the overall personality (Nabunome 2007). The study conducted in this study aimed to provide a detailed overview of the status of resources of glass eel catches. The data collected in this study is the primary data and secondary data. Primary data was the data obtained directly from the research object with observations and interviews (Nazir 2005).

The results of α and β regression coefficients were used to calculate the level of arrest attempts made to achieve maximum production (E_{MSY}). By decreasing the equation of sustainable production function, the first derivative of the number of catches (h) of the arrest effort (E) equals zero (Copes 1977; Fauzi 2005).

The producer surplus measurement was essentially the selling price of an item minus its production cost. Therefore, in analyzing the process of forming surplus manufacturers (company surplus) will be explained through the approach of production costs and additional marginal profits; In this case is the marginal cost (MC), the average variable cost (AVC), the total average cost (AC) and the additional profit (MR).

Mathematically the LRAC and LRMC curves could be lowered through the equation TC = cE by replacing effort with sustainable yield namely:

$$h = \alpha E - \beta E^2 \tag{1}$$

Then:

$$-\beta E^2 + \alpha E - h = 0 \tag{2}$$

$$E = \frac{-\alpha \pm \sqrt{\alpha^2 - 4\beta h}}{2\beta} \tag{3}$$

With $\alpha^2 > 4\beta h$

By replacing the positive E-value, the total cost can be written as the function of the output:

$$TC = c\left[(-\alpha \pm \sqrt{(\alpha^2 - 4\beta h)})/2\beta\right] \tag{4}$$

According to Fauzi (2003), to determine afishery supply curve, we must create a long-run marginal cost curve (LRMC) and long-term cost curve (LRAC). The mathematical equations for the LRAC and LRMC curves can be derived from equation (Fauzi 2003):

$$LRAC = \frac{TC}{h} = -\frac{c}{2h\beta}\left(\alpha + \sqrt{\alpha^2 - 4\beta h}\right) \qquad (5)$$

Furthermore, the long-term marginal cost curve can be derived from the LRTC against H or:

$$LRMC = \frac{\partial TC}{\partial h} = \frac{c}{\sqrt{\alpha^2 - 4\beta h}} \qquad (6)$$

The price variable of fish (p) was determined based on the average real price per year during the period 2004 -2018 with the base price 2007 = 100.
The operating cost of the capture was obtained from the variable costs that were considered constant, the cost of catching per trip obtained by using the average calculation cost of the arrest of the 79 fishermen. The average arrest cost is divided by the average fishing attempt conducted by the fishermen per year.

One of the economic aspects necessary in analyzing bioeconomics was the price factor. Price affects the amount of acceptance gained in the arrest of the assumption in the study was not constant. This real price was obtained by converted the nominal price of glass eel with the data time series with the Consumer Price Index (CPI) of the Sukabumi Regency for the commodity of fresh fish. This was conducted to eliminate or remove the impact of the price change due to inflation (Fauzi 2004, 2010; Fauzi and Anna 2005). The consumer price Index (CPI) used as the base year is CPI 2007 .

3. RESULTS AND DISCUSSION
3.1. Production of Glass Eel in Sukabumi

Result of harvest glass eel in the estuary of Sukabumi using *Sirib* as a capture tool dominant special capture glass eel. Type of eel caught in the coastal waters of Sukabumi dominated by the type of *Angguilla bicolor.* The development of the catch of glass eel captured around the river estuary is presented in Figure 1. The arrest of glass eel in Sukabumi coastal waters tends to fluctuate during the 2004-2018 period. Based on Figure 1, the highest capture of glass eel with *Sirib* is occurring in 2013 as much as 54,338 kg. An increase in the capture of glass eel using the sirib is accompanied by a high number

of catches, which were 1200 units that operate. The lowest catch occurred in the year 2018 which is 2,412 kg with the number of capture equipment as many as 789 units.
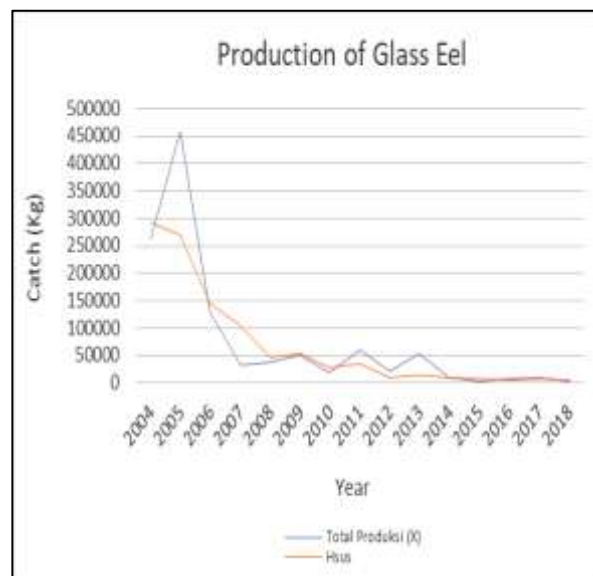

Figure 1. Production of Glass Eel year 2004 – 2018

This was caused in the previous year the capture effort is high enough that the glass eel resources have no restrictions on arrest and An exploit. From 2014 to 2018 the decline was due to some possible declining stock availability, pollution caused by the development of the PLTU, and the availability of captured fish, catching seasons, and catching areas.

3.2. Value Of Capture Equipment Productivity (CPUE) Glass Eel

The magnitude of CPUE can be used as an indicator of the level of engineering efficiency of the capture effort, in other words higher CPUE values reflect the efficiency of the use of better capture efforts. The value of CPUE is estimated annually within 15 years (table 1). The catch is in principle the output of the arrest activities, while the necessary arrest efforts in principle the input of the arrest activities.

Based on table 1, the method of data analysis with simple linear regression method results in the value of a regression coefficient of α and β is α = 0,10481 and β =-10575800, so mathematically the equation of sustainable production function of fisheries glass eel in the coastal Sukabumi is H = 0,10481 E-10575800 E^2.

Table 1 Production and Effort of Harvest's Glass Eel

	Year	Production	Effort
1	2004	11.557	109.560
2	2005	12.048	123.000
3	2006	11.085	137.940
4	2007	13.095	152.880
5	2008	9.849,43	167.820
6	2009	10.562	182.760
7	2010	9.623	131.800
8	2011	10.703	106.320
9	2012	1.651	151.720
10	2013	54.388	144.000
11	2014	10.890	168.000
12	2015	3.800	162.000
13	2016	7.000	96.000
14	2017	1.032	156.000
15	2018	2.412	94.680

Based on table 1, the method of data analysis with simple linear regression method results in the value of a regression coefficient of α and β is α = 0,10481 and β =-10575800, so mathematically the equation of sustainable production function of fisheries glass eel in the coastal Sukabumi is $H = 0,10481\,E - 10575800\,E^2$.
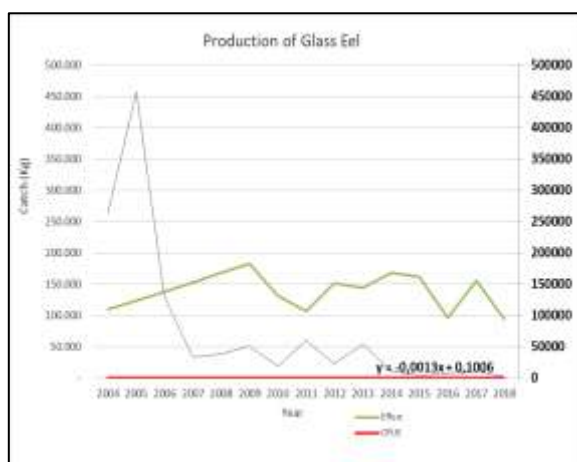

Figure 2.   The Relationship of Production of Glass Eel , Effort and CPUE

The decrease of CPUE in certain periods of the year was due to the reduced area of the current and the effects of changes in natural conditions/environment (weather, wind, salinity,

season) of population and resource communities. In the year 2012 glass eel logging Station amounted to 9 stations while in 2018 the collection unit decreased to 6 stations (Department of Fisheries and Marine Sukabumi District 2018) . If you see the rate of sedimentation on some river estuary such as Bareno River was 97.1 tonnes per year. The sedimentation rate was influenced by sedimentation from the river basin. This greatly affects the area of arrest including freshwater flows to the Indian Ocean.

From the equation, it could be explained that each addition of the arrest of one unit of arrest by 1 unit of arrest effort will occur a reduction of CPUE glass eel amounting to 0.84236 Kg per trip, increasing the number of attempts to arrest the effort, it will further decline the results of its efforts (CPUE) while according to Nabunome (2007) stated that if connected between CPUE and the arrest effort, the greater the arrest effort then CPUE increasingly reduced, So that production was reduced, meaning that the CPUE is inversely proportional to the arrest effort, which with each addition of the arrest effort was the lower the catch per business unit (CPUE).

3.3   Maximum sustainable yield (MSY)

Fishery resources MSY conditions were the thresholds of the utilization of fish resources allowable without disturbing or destructing the sustainability to grow back. The utilization of fish resources in the Coastal Waters of Sukabumi. MSY conditions were the maximum fishery conditions sustainably. According to Schaefer (1957) in Fauzi and Anna (2005), the results of simple linear regression analysis between the level of the arrest effort as a free variable (x) and CPUE as an unfree variable (y) will result in a regression coefficient of α and β used to suspect the function of sustainable production of capture fisheries on the equation $h = \alpha E - \beta E2$ The catch is expressed with H and the level of arrest efforts expressed by E 1957,2004

The total cost incurred by fishermen per trip in a year follows the equation of TC = 49388, 39E. The cost of arrest for the utilization of fishery resources Indonesian eel (glass eel) in the obtained average arrest cost per trip is IDR 49,388.39,-.

The arrest of glass eel in coastal waters Sukabumi tends to fluctuate during the 2004-2018 period. Based on Figure 2, the highest capture of glass eel with *Sirib* was occurring in 2013 as much as 54,338 kg. Increase in the capture of glass eel using the sirib is accompanied by a high number of catches, which are 1200 units that operate. The lowest catch occurred in the year 2018 which is 2,412 kg with the

number of capture equipment as many as 789 units, this was caused by the previous year the capture effort is high enough that the glass eel resources have no restrictions on arrest and exploitation. From 2014 to 2018 the decline was due to some possible declining stock availability, pollution caused by the development of the PLTU, and the availability of captured fish, catching seasons, and catching areas.

Estimated price of fish conducted by the method of consumer price index Sukabumi City referring to the price index of consumer prices in West Java for the fishery sector of the fresh fish sub-class, the price used was the average real price of glass eel during the period of 2004-2018 years.

This calculation used the program Maple 14 so it acquired E_{MSY} = 495523.92 trip per year. The value of E_{MSY} indicates the number of days of operation of the glass eel arrest to achieve a maximum production level of 495523.92 trip per year. The maximum production level of sustainable or glass eel fish catch in MSY condition can be known by entering the level of the arrest effort above into the sustainable function of capture fisheries. Calculations with mathematical approaches to MSY conditions could be written with the equation: H_{MSY} = 0.10481 E- 10575800 E^2.
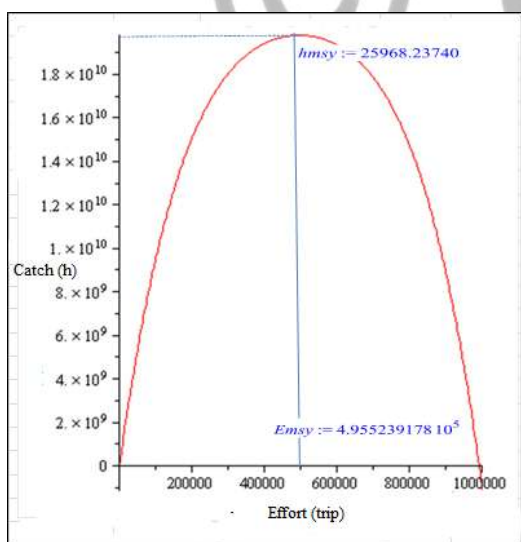

Figure 3. h$_{MSY}$ and E$_{MSY}$

Based on Figure 3, the result of h$_{MSY}$ value indicates that the maximum level of effort was sustainable (E$_{MSY}$) of 49,552,391.78 trip with the highest amount of glass eel catches or the threshold that could be captured by 25,968.237 kg without threatening the sustainability of the glass eel found on the coastal waters of Sukabumi.

Utilization of glass eel resources with the maximum catch were achieved in MSY condition of 25,968.2374 Kg per year with a maximum of sustainably the highest eel fish that could be captured without threatening population sustainability biologically eel fish resources. If the arrest exceeds 495,523.92 trips per year there will be a biological degradation of fish stocks, whereas if the arrest efforts under 495,523.92 trip per year then the stock of fish was biologically sustainable.

The output limit was based on the Total Allowable Catch (TAC) is 20774.5896 Kg/year, where 80 % of the production value was sustainable (MSY). Referring to figure 444,the utilization of fish in coastal waters Sukabumi reached almost the average of the actual catch of 2011 and exceeded the allowable catch amount (TAC).

Thus, it could be categorized as overfishing. On the other hand, the actual catch value that continued to declines annually as well as the low sustainable catch value basically describe the dynamics of fish resources in coastal waters Sukabumi which is a function n of the exploitation itself and the condition of the aquatic habitat. The aquatic environment of coastal waters Sukabumi had long faced a problem, especially since its water had been caused significant pollution. Thus, the environmental carrying capacity for capture fisheries dropped, and the sustainable catch dynamics lowered. The implication of the policy on this problem is the question of how the environmental carrying capacity can be improved to allow for the increase of stock capacity by improving the aquatic environment using physical, biological and other techniques. The pollutant of the PLTU for the purpose of adjustment to the carrying capacity of the environment (Department of Fisheries and Marine Sukabumi District 2018) becomes a necessity for the development of capture fisheries, that can contribute to the economy of the local community as well as a to the food security. If coal waste in electrical processing can be managed so that the water temperature increase is irrigation of Cimandiri estuary can be overcome, then the flow of glass eel to the estuary of the river is not restrained.

Conversely, on the producer's side (fishermen), namely the bidding curve, the price increase will likely increase the arrest effort. However, the relationship of arrest and production efforts in capture fisheries is not linear. Under underfishing conditions, increased arrest efforts will increase production (positive relationships). However, in overfishing conditions, an increase in the capture effort led to a decrease in the

catch (negative relationship).

3.4 Maximum Economic Yield Conditions

The maximum economic catch (MEY) can describe a measure of the maximum profit gained at a particular production. If the actual catch was already above MEY condition then the profit will be reduced. The level of MEY's production demonstrated with the optimum production (h_{MEY}) = 18,432.108 Kg per year with an effort rate (E_{MEY}) of 228,581.527 trips per year. The value shows the production rate of MEY, the highest catch can be economically economical. If the catch exceeds the value obtained in MEY's condition, the profit will be decreased until the same rente with zero in open access conditions. Total Admission (TR) obtained from all the units of the glass eel arrest is from the results of times between the result of glass eel with the average price per year in a given time. This real price is obtained by converted the nominal price of glass eel with data time series with consumer price Index (CPI) of the Sukabumi Regency for the commodity of fresh fish.

3.5 Open Access Conditions

When the actual catch was still under MSY condition, MEY and Open Access, signifying still the low utilization of glass eel resources to get higher catch result then the arrest effort should be improved. But while it has reached the point of balance in open access condition or uncontrolled (table 4.) Then the profit will be reduced even more will get a rente equal to zero ($\pi = 0$), that is when the catch of h_{OA} = 24,830.321 Kg. To obtain the maximum profit economically can be obtained with the catch that is shown in the condition of MEY that results in a maximum profit of Rp 4,833,525,040 when the condition of demand and supply at a balanced condition, although the value of profit gained is below the value of profit in the present condition. Lower profit value can be caused by a lower price factor following the market balance condition, if there is more bidding then the price of glass eel will compete and tend to be cheaper.

Market strength has a strong effect on fisheries management. In addition, fisheries management was still often faced with the issue of open access fisheries, where everyone was allowed to enter into business. Under such circumstances people will continue to enter the fishery until the profit from such a low effort, so it no longer appeals to new business actors (new entrance). The inevitable consequences of the open access fisheries business was the loss of profit so that it leads to not economic efficiency, and if it cannot be enforced effective management action, it will occur over study.

CONCLUSION

The value of E_{MSY} indicates the number of days of operation of the glass eel arrest to achieve a maximum production level of 495523.92 trip per year Utilization of glass eel resources with the maximum catch is achieved in MSY condition of 25,968.2374 Kg per year with a maximum of sustainably the highest eel fish that can be captured without threatening population sustainability biologically eel fish resources. The level of MEY's production demonstrated with the optimum production (h_{MEY}) = 18,432.108 Kg per year with an effort rate (E_{MEY}) of 228,581.527 trips per year. The value shows the production rate of MEY,

The output limit was based on the Total Allowable Catch (TAC) is 20774.5896 Kg/year, where 80 % of the production value was sustainable (MSY). Then the profit will be reduced even more will get a rente equal to zero ($\pi = 0$), that is when the catch of h_{OA} = 24,830.321 Kg.

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