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Fisheries Bioeconomic Analysis of Eastern Little Tuna (*Euthynnus affinis*) in The Nusantara Fishing Port (PPN) Palabuhanratu West Java

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ABSTRACT

This research analyzed bioeconomic model of eastern little tuna (*Euthynnus affinis*) resources exploitation in various condition of fishery management of Gordon Shaefer model. This research was conducted from October 2017 to March 2018 using survey methods. The data was analyzing by using quantitative descriptive analysis and surplus production Gordon Shaefer analysis. This research used primary data and secondary data. Primary data was obtained purposively sampling from the fihshermen who catch the eastern little tuna in PPN Palabuhanratu by using *payang*. Secondary data was obtained from the time series data period 2007-2017 about production data capture fisheries, gear types dan fishing effort *payang* in PPN Palabuhanratu. The result showed that effort of Maximum Sustainable Yield (MSY) condition is 183 trips with productions aproximately 48,720 tonnes. Efforts of Maximum Economic Yield (MEY) condition was 180 trips with total productions was 48,706 tonnes. Efforts of open access fisheries (OA) was 360 trips with total productions was 3,265 tonnes.

KeyWords

Bioeconomics, Eastern little tuna, PPN Palabuhanratu.

Introduction

Sukabumi district is one of district that has the a quite large potential of fisheries in Indonesia. This fishery's potential can be seen from Teluk Palabuhanratu (gulf) coastline that is approximately 115 km starting from the Cibareno village which is on the border between the Sukabumi district of Banten province until Tegal Buleud regency of Cianjur (Dinas Keluatan dan Perikanan Kabupaten Sukabumi 2014). Sukabumi district also has a port that Nusantara Fishery Port (PPN) Palabuhanratu which provide an important contribution to the fisheries sector in West Java with superior commodity of tuna, cob and skipjack.

Eastern little tuna (Euthynnus affinis) is one type of tuna in PPN Palabuhanratu. Other types of tuna that can be encountered in PPN Palabuhanratu are gray cobs, krai cobs and Lingsong cobs. According to the PPN Palabuhanratu, most of eastern little tuna is caught by fishermen who use payang as their fishing girl meanwhile eastern little tuna caught by other fishing gear such as fish pole, gill net and purse seine as a bycatch.

Based on data from Statistics PPN Palabuhanratu (2017) the number of production eastern little tuna caught by seine fishing gear payang in 2017 amounted to 18.448 tons, with a production value of Rp 321.755 million. The results are an increase of 43% from the previous year 12.87 tons with the production value of Rp 234.554 million. The increasing number of the eastern little tuna production showed that the eastern little tuna resources is one of the fish resources are in demand by fishermen in PPN Palabuhanratu.

Increasing the number of eastern little tuna production in PPN Palabuhanratu is a good achievement. However, it needs to be explored further as an anticipation of overfishing, in which fisheries resources are public goods, in which the property regime is common property with the access regime that is open access (Zulbainarni 2016). The impact is overfishing, whether it is biological (bioligy overfishing) and economically (economic overfishing).

The purpose of this study is clicking bio-economic analysis of the utilization of eastern little tuna (*Euthynnus affinis*) in PPN Palabuhanratu with various conditions of Gordon Shaefer fisheries management models.

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Methods

The experiment was conducted using a survey method and descriptive quantitative analysis and production surplus Gordon-Shaefer analysis. According to Effendi and Tukiran (2012) the survey method is a study by taking a sample from a population and using questionnaires as a data collection tool that is fundamental to obtain better information on specific locations on specific issues. This survey method conducted through observation with questionnaire and interview to fisherman *payang* in PPN Palabuhanratu catching eastern little tuna.

This research used primary and secondary data. Primary data was obtained from interviews who are community fishermen who use fishing gear *payang* in the area of PPN Palabuhanratu. Secondary data are the periodic data (time series) consisting of eastern little tuna production data, the number of seine boats, fishing effort by *payang* ship, commodity tuna fish production value and general condition of research area. Secondary data used data from 2007-2017.

Sampling method used in this research is purposive sampling method. According Sugiyono (2014) purposive sampling is a type of non-probability sampling with intentional picking of respondents based on certain criteria and considerations. This research is limited only to fishermen with outboard motor boat and fishing gear that catch eastern little tuna. The sample taken in this research is as much as 36 fishermans from total fisherman counted 427 people.

The bioeconomic analysis in this research used the Gordon-Shaefer Production Surplus model. The model is used to determine the condition of fisheries management under the conditions of management of MSY (Maximum Sustainable Yield), MEY (Maximum Economic Yield), and OA (Open Access) (Nurhayati 2013). The formula used to calculate the three equilibrium conditions is as follows (Table 1):

Table 1. Bio-economic Analysis Gordon Shaefer Model

Variables	MEY	MSY	OA
Production (h)	$(ap-c)/2\beta p$	$a/2\beta$	$(ap-c)/\beta p$
Efforts to arrest / Fishing effort (E)	E_{MEY} *(ap+c/2p)*	$aE_{MSY} - \beta E_{MSY}^2$	E_{OA} *(c/p)*
Economic Rent (π)	(P.hMSY) - (c.EMSY)	(P.hMEY) - (c.EMEY)	(P.hOA) - (c.EOA)

Result and Discussion

a. Fihing in PPN Palabuhanratu

Capture fishery resource utilization activities is inseparable from the role of fishermen as the main actors of the production of fishery products. According to Law (Undang-Undang Repulik Indonesia no. 7 Year 2016) fisherman is every person whose livelihood is fishing. Fishing conducted aims to benefit from fish resources produced both for the life of fishermen in meeting the needs of his life or for the community widely.

Based on the data of Pelabuhan Perikanan Nusantara Palabuhanratu/PPNP (Fishery Port of Palabuhanratu) (2017), the number of fishermen *payang* vessels in PPN Palabuhanratu decreased by 1,758 people or 80% within 11 years. The number of fishermen in 2007 is the highest number of fisherment is 2.211 fishermen. The lowest number of fishermen in 2016 is 400 fishermen. The depletion was cause by the decrease of the number of *payang* fleets in the the PPN Palabuhanratu. payang fleet dereased by 104 units or 71% from 147 units in 2007 and 43 units in 2017. The decrease can be see in Figure 1.

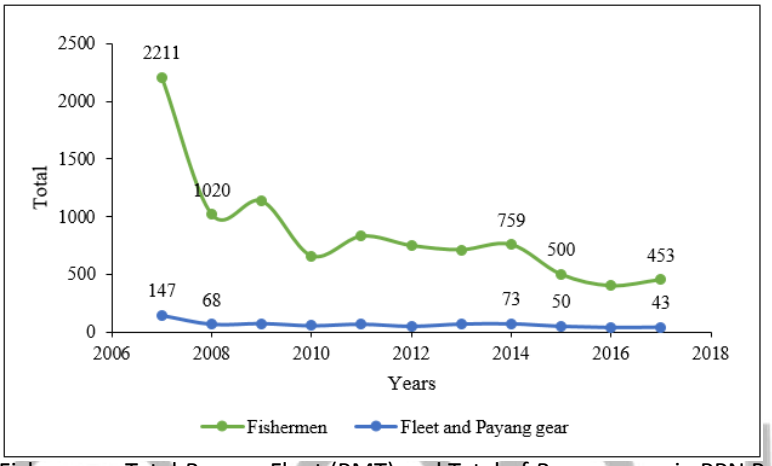

Figure 1. The number of Fishermen, Total *Payang* Fleet (PMT) and Total of *Payang* gear in PPN Palabuhanratu 2007-2017

Depletion in the number of fishermen, *payang* fleets and fishing gear in the PPN Palabuhanratu occurs because of the difficult things to avoid climate change that fluctuates and unpredictable climate change. Based on DKP (2014), in 2014 there is a tidal wave reaching 2-4 meters causing the ship in some TPI (The Center of Fish Auction) suffered severe damage even there are some fishing boats that broke and drowned. Recorded depletion in the number of *payang* boats from 2014 to 2015 amounted to 23 units resulting in 259 fishermen lost their jobs.

b. Biological Aspects of Eastern Little Tuna Resources Utilization

The production of catch fish of eastern little tuna from 2007-2017 is fluctuate with the average production amount every year that is 17, 324 tons. The lowest production data occurred in 2012 which amounted to 5.138 tons and in 2007 amounted to 5.181 tons. The depletion in the number of production of the catch is allegedly due to the depletion in the number of trips made by the *payang* ship in the PPN Palabuhanratu. The depletion in the number of production of the catch is allegedly due to the decrease in the number of trips made by the *payang* in the PPN Palabuhanratu. The depletion in the amount of production did not last long and in 2013 the production of catches increased to 55.454 tons. The increase in production is influenced by the increasing number of fishing fleets and the increasing number of trips made by the fishing fleet. The following is the production of the catch of eastern little tuna in PPN Palabuhanratu (Figure 1).

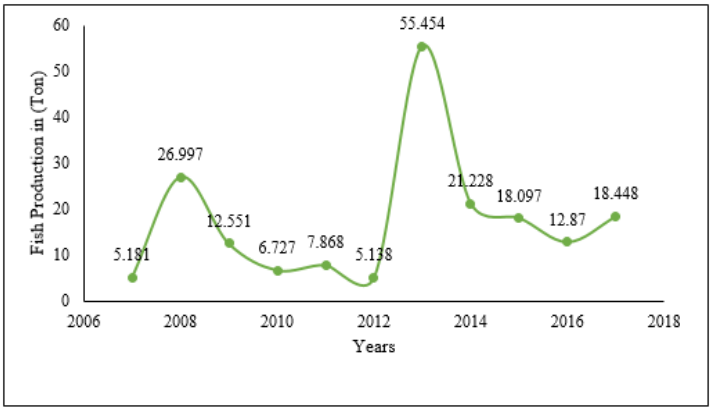

Figure 2. Production of Eastern Little Tuna with Payang gear in PPN Palabuhanratu Over 2007-2017

Based on figure 2, in 2014-2016 the production of the catch decreased again to 21.229 tons, 18.097 tons and 12.87 tons. The number of catches in 2014-2016 is less than the previous year that is in 2013. The depletion occurred along with the depletion in the number of fleets and fishing gear that is used from 73 units to 40 units in 2016. But based on observations of fishermen and parties PPN Palabuhanratu, the long-lasting drop in hauls is thought to be due not only to the depletion in the number of fishing fleets and the number of trips, but because of the capture by large ships with better technology and fishing gear. The large ships capture pelagic fish in migration routes or spawning areas of most pelagic fish in the Indian Ocean. It is also influenced by other factors such as environmental factors and biological factors of the fish that result in changes in the catch or stock of fish in the sea.

Based on stratistic data PPN Palabuhanatu 2017, the effort to capture the *payang* fleet in PPN Pelabuhanratu from year to year fluctuated due to the changing number of *payang* fleets in the PPN Palabuhanratu (Figure 3).

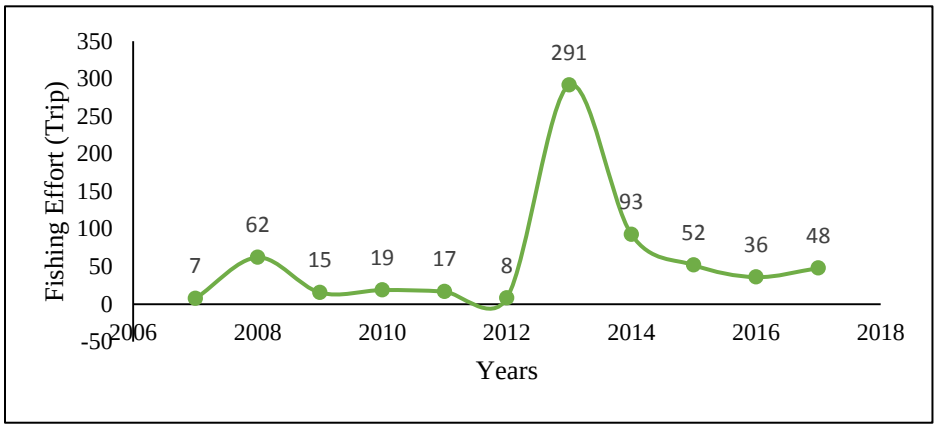

Figure 3. Total of Trip Payang in the Utilization of eastern little tuna (Eutynnus affinis) in PPN Palabuhnaratu 2007-2017

Based on the picture above (Figure 3), it can be seen that the lowest number of trips in the fishing activity of eastern little tuna occurred in 2007 as many as 7 trips and the highest number occurred in the year 2013 of 291 trips. The high and low effort given in commodity fishing is influenced by the number of available fleets and environmental factors. Destruction of fishing activity in 2014 is caused by the tidal wave reaching 2-4 meters causing the ship in some TPI (The Center of Fish Auction) suffered severe damage even there are some fishing boat which broke and drowned (Dinas Kelautan dan Perikanan 2014). The depletion in the number of trips also continued until 2016 due to the decrease in the number of paying fleets in the PPN Palabuhanratu until in 2017 the number of fleets increased again followed by the increase of trip trips to 48 trips.

The total effort of catching by the *payang* fleet to catch the eastern little tuna for 11 years is 649 trips with the average effort of catching 58 trips/year. In addition, the catching effort in a period of one year also has differences due to the catching season is peak season, season and season famine. Peak season is a very lucrative season for fishermen because during peak season fishermen will easily get fish compared to other seasons. Fishermen will do a lot of fishing because it is supported by good sea conditions and abundant fish.

The fishing activities conducted by the fishermen in PPN Palabuhanaratu certainly require inputs in the form of efforts to obtain targeted resources from the fishing (output) in the form of fish. Comparison between inputs and outputs in economic terms is the technical efficiency level of each given output unit or in other words the catch per unit effort of catch (Catch Per Unit Effot or CPUE). The value of CPUE of eastern little tuna with fishing gear from 2007-2017 can be seen in Figure 4.

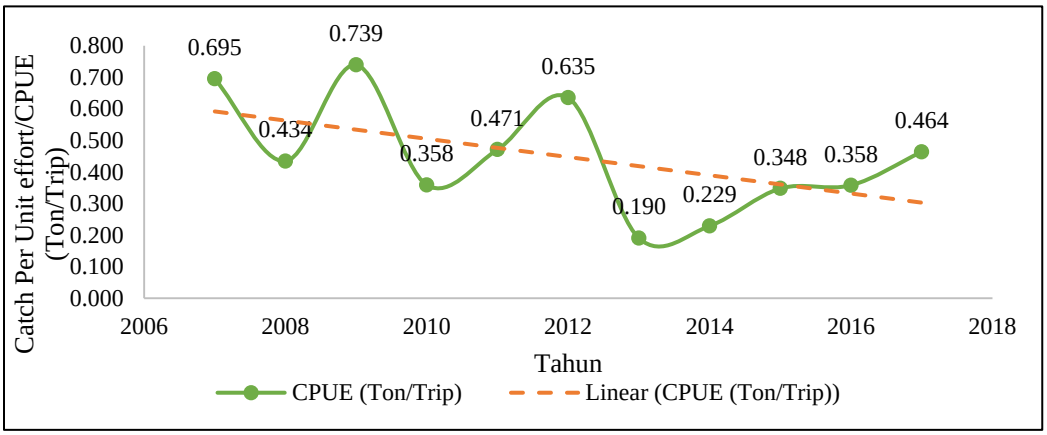

Figure 4. Graph value of CPUE on the Eastern Little Tuna in PPN Palabuhanratu 2007-2017

According to Zulbainarni (2016) the value of CPUE reflects the productivity of fishing gear used to catch fish in a particle. The higher the CPUE value, the higher the productivity of fishing gear used (Fauzi 2010). The productivity of *payang* in PPN Palabuhanratu each year has fluctuated up and down which tend to decrease. The following is the result data of the capture, fishing effort and CPUE of eastern little tuna with the catch gear *payang* in 2007-2017 (Table 2).

Table 2. Data of Catch, Fishing Effort and CPUE of eastern little tuna (*Eutynnus affinis*) in PPN Palabuhanratu Tahun 2007-2017

Year	Eastern little tuna production (tons)	Effort (trip)	CPUE (tonnes / trip)
2007	5,181	7	0,695
2008	26,997	62	0,434
2009	11,401	15	0,739
2010	6,727	19	0,358
2011	7,868	17	0,471
2012	5,138	8	0,635
2013	55,454	291	0,190
2014	21,228	74	0,288
2015	18,097	52	0,348
2016	12,87	36	0,358
2017	18,448	48	0,385
Average	17,219	57	0,446

Based on Table 2, the largest CPUE decrease occurred in 2013 with a value of 0,190 tons / trip. This value indicates that the fish resources are overfishing. It can be seen from too much effort of given effort that is 291 trip with result of catch 55,454 ton. If viewed in terms of efforts and the amount of production alone, the effort of catching and the amount of production has increased from the previous year. But if it is compared, then the catch of each fishing effort produces a small value which means the productivity of fishing gear is also decreasing.

High capture efforts will increase the yield of the catch if viewed from an economic point of view. But, it is different with the use of fish resources. The addition of fishing effort will not always be proportional to the catch. It is see from the nature of eastern little tuna resources that need time to grow and multiply to restore fish stocks. the existence is also influenced by the carrying capacity of the environment.

After knowing the trend of CPUE from year 2007-2017, then done withdrawal line between value of CPUE to catch effort. The line will show the correlation relationship between the value of CPUE with the effort of catching. The correlation relationship need to be known to see the tendency of productivity of fishing gear used, because the higher the catching effort the CPUE value will be low, which means the productivity of fishing gear will decrease (Zulbainarni 2016).

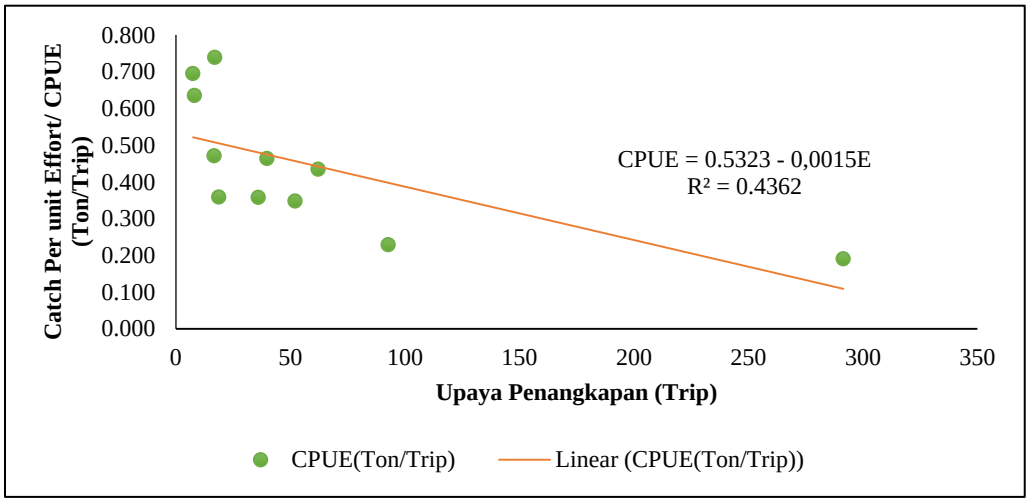

Figure 5, The relationship of fishing effort with the value of CPUE Eastern little tuna in PPN Palabuhanratu 2007-2017.

Based on result of linear regression analysis (Figure 5), obtained by value of intercept (α) equal to 0,5323 and slope value (β) equal to -0,0015. The coefficients α and β are obtained from the linear regression between the capture effort as the independent variable (x) and CPUE as the dependent variable (y). The value generates the following equation:

CPUE = 0.5323 to 0.0015 E

The equation explains that each additional fishing effort for E units in the year there will be a reduction in the value of CPUE eastern little tuna by 0.15 x 10^{-2} tonnes per trip. Therefore, the higher the amount of fishing effort will be the lower amount of production every effort is made.

Table 2. Rregression analysis the influence of variables fishing effort (Trip) against the value of CPUE

Variables	Coefficient	Variables	Coefficient
Slope	= -0.0015	p-Value	= 0.0284
R Square	= 0.4362	F count	= 6.9630
multiple R	= 0.6557	Significant F	= 0.0269

Description: Real to the level of 5%

Source: Adapted from Primary Data, Data Capture Fisheries Statistics PPN Palabuhanratu and Statistics Department of Marine and Fisheries Sukabumi, West Java

Based on Table 3, the result of regression analysis showed that the value of F arithmetic is 6,789 with significant level of 0,0269 or (0,0269 <0,05). These results indicate that the fishing effort significantly influence the value of CPUE eastern little tuna. The coefficient of determination or the value of R square (R^2) is 0.4362, it means the variable fishing effot the effect of 43.62% to the diversity in the value of CPUE Eastern little tuna. Then from the regression analysis got the value of correlation coefficient (Multiple R) of 0.6557 or 65.57% which shows the percentage value of closeness between fishing effort with CPUE. The value of p-Value obtained is 0.0269, which means the input on the variable E (total effort) significantly influence the value of CPUE because the value of p-Value is less than the real level of 5% (0.05).

In catching activities, there are several factors that have a big effect on the magnitude of the value of CPUE. These factors are the factors of fish presence, the amount of fishing efforts, and the success rate of fishing operations (Laveastu and Favorite 1988 *in* Sriati 2011). According to Sriati (2011) the catch is not only influenced by the abundance of fish at any given moment, but also depends on the amount of units and the efficiency of the fishing gear unit, the duration of fishing operation and the availability of the fish to be caught. Basically the regression equation only takes into account the input factor (catching effort) and the output factor (the production of the catch), therefore natural conditions such as growth and availability of fish stock are not described in the equation.

c. Economic Aspects of Eastern Little Tuna Resources Utilization

According to Gordon-Schaefer in Fauzi (2004) to understand the economic factors in the bio-economic model there are several assumptions used that the unity price of output (Rp / Kg) is assumed to be constant or the demand curve assumed to be perfectly elastic, the cost per unit effort (c) is considered constant, fish resources are single species, market structure is competitive and only catching factors are taken into account. The operational cost structure in this research is obtained from the interview with the *payang* fisherman in PPN Palabuhanratu. The calculation for the cost per effort of catching eastern little tuna is done by summing all operational costs of fishing activity of eastern little tuna and then divided by the total amount of fishing gear. The price structure of eastern little tuna obtained from Palabuhanratu PPN statistical data in 2007-2017 (Table 4).

Table 4, The Estimated parameters economic Eastern Little Tuna in PPN Palabuhanratu

Parameter	**Unit**	**Value (USD)**
Cost	(USD / Trip)	106 993
Price	(USD / Ton)	11,794,446

The interview result shows that the average cost of catch per effort of catching eastern little tuna in PPN Palabuhanratu is Rp 106,993 per trip and the price is considered constant. Then the average price of eastern little tuna in PPN Palabuhanratu is 11,794,446 million per ton.

d. Sustainable Production Function of Eastern Little Tuna Resources

Sustainable production function (MSY) of Eastern little tuna resources can be known through the substitution of α and β coefficient into the equation h = αEmsy-βEmsy^2. The α and β coefficient of linear regression calculation yield the value of α = 0.525352569 and β = -0.001392946, so that the function of sustainable eastern little tuna resource in the PPN Palabuhanatu produces the equation h = 0.5323 E - (-0.0015 E2). By lowering the equation is then obtained these results the following equation:

$$\frac{h}{E} = \alpha - 2\beta$$

$$E_{msy} = \frac{\alpha}{2\beta E}$$

$$E_{msy} = 183 \text{ trip}$$

The effort required in sustainable production conditions is 183 trips per year. The value of sustainable productive fishing effort (E_{msy}) shows the amount of effort required by fishermen to achieve the sustainable production of eastern little tuna in PPN Palabuhanratu. The figure below is a graph of the effort of catching effort with the production result at the maximum condition of sustainable production (Figure 6).

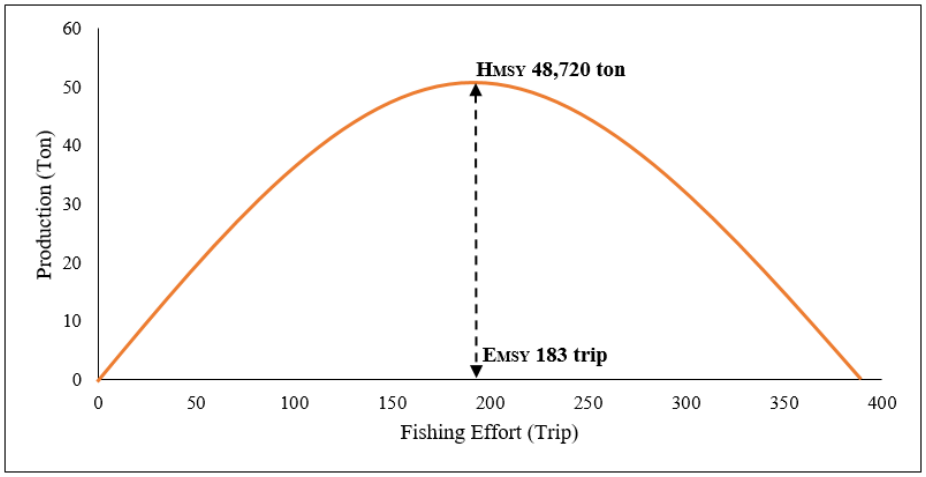

Figure 6. Quadratic relationship between fishing effort with Production of Eastern Little Tuna at PPN Palabuhanratu 2007-2017

Quadratic relationship between fishing effort and production result shows production result (hMSY) of 48,720 tonnes with catch effort (EMSY) equal to 183 trip within one year (Figure 6). The parabolic chart shows that to produce maximum catch, the effort required is 183 trips per year. However, if the amount of effort given exceeds EMSY, the catch will be reduced or degradation of fish resources. This means that efforts in the utilization of commodity fish resources can not exceed the maximum catch effort of 183 trips. The goal gives time to the fish to reproduce and multiply so that fish stocks in the waters will remain preserved sustainability.

However, based on statistical data, eastern little tuna in PPN Palabuhanratu has not been utilized optimally. This can be seen from the number of catches and fishing effort that is still under MSY. Comparison of catch and catch effort on actual with sustainable condition can be seen on overlay curve which is as follows (Figure 7):

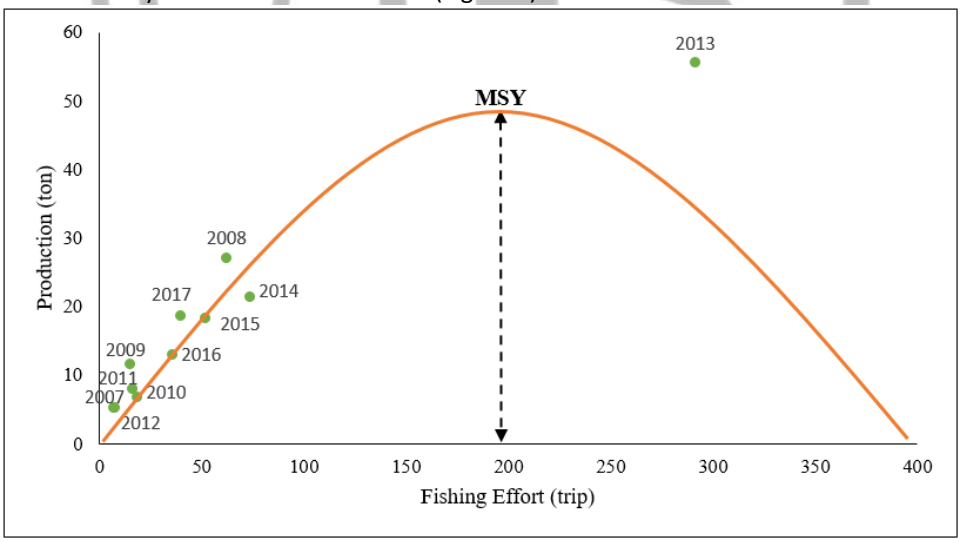

Figure 7. Comparison of Catch and Effort Catching Currents with MSY Condition Year 2007-2017

The comparison between catches and actual capture efforts on MSY conditions in the use of eastern little tuna in 2007-2017 generally results in less optimal utilization patterns. The pattern has not been optimal because the performance (productivity) of fishing gear has not been fully utilized. However, by 2013 the catch is above the maximum sustainable production amount, it indicates the occurrence of overfishng biologically and economically.

In the year 2013 the pattern of resource utilization of eastern little tuna has exceeded sustainable production. The year can be said biological overfishing and economical overfishing. Biological overfishing is influenced by the high catching efforts made so that the production of the catch exceeds sustainable production. If this continues to happen, it will lead to degradation and depletion of existing fish resources. In addition, these degressions and depletionations can be perpered by the presence of various environmental damage symptoms such as laxation, overfishing, coastal habitat destruction, spatial use conflicts and other matters (Fauzi and Anna 2003).

Meanwhile, economic overfishingis an effort that has exceeded the sustainable capture efforts resulting in a little economic rents. An increase in fishing effort that passes through sustainable fishing efforts will lead to an increase in input costs of eastern ittle tuna fishing. Continuous input costs increase will result in the turning point of the catching business activity so that it will give the economic rents equal to zero. This means that the benefits of catching fish resources have been lost.

e. Bio-economic Analysis of Eastern Little Tuna Resources Utilization

Bio-economic analysis of eastern little tuna resource utilization was conducted to determine the level of utilization of available resources and economic rents derived from the utilization activities. The bioeconomic balance is estimated by fisheries management regime approach including: Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and Open Access (OA) fishery. The bioeconomic estimation used in the calculation of this eastern little tuna resource is the Gordon-Shaefer model approach. The result of bioeconomic calculation as follows (Table 5):

Table 5. Results of bio-economic analysis of Eastern Little Tuna (*Euthynnus affinis)* Resources in PPN Palabuhanratu

Variables	Condition			Currents
	MEY	MSY	OA	
Effort / E (trip / year)	180	183	360	48
Catch / h (ton)	48.706	48.720	3.265	18.448
TC (USD)	19,252,259	19,586,052	38,504,519	5128283
TR (USD)	574 462 205	574 629 101	38,504,519	217 583 931
Economic rents (USD)	555 209 945	555 043 049	0	212 455 647

Source: data processing

Based on Table 5, the yield, effort, total cost, total revenue and economic rents from loyal to the management regime have different values. The maximum sustainable yield (MSY) yields the largest number of catches compared to other utilization codes. However, if seen economically, the highest profit (rent) is in the condition of management of maximum economic yield (MEY). While the condition of exploiting of resources in open access only yields economic rent equal to zero that is total cost incurred equal to total revenue.

Based on the results of the management of MSY condition, MEY and the condition of the OA (Table 4), it can be seen that management which gives big economic rents without damaging the existing fish resource is management in MEY condition. This MEY condition produces optimal production and effort with maximum economic rents compared to others. The relationship between TC (Total Cost), TR (Total Revenue), and economic rent of eastern little tuna in MSY, MEY, OA condition and actual fishery management can be seen on the curve as follows:

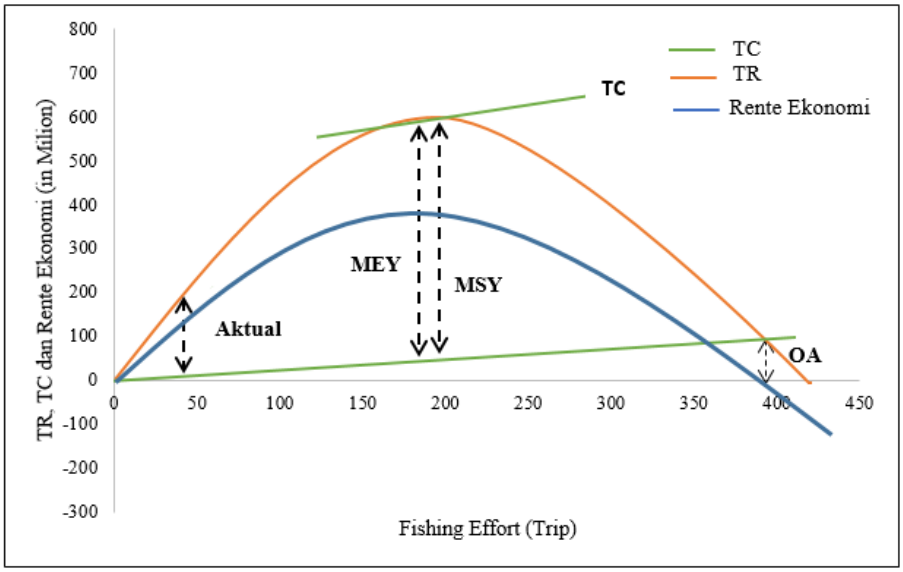

Figure 8. The relationship between TC, TR, and economic rent eastern little tuna on condition MSY, MEY, OA and actual management of fisheries in PPN Palabuhanratu

Based on the figure 8, it can be seen that the level of fishing effort given at actual condition has not reached MEY condition nor MSY condition (maximum). If seen in the picture, the fishing activity of eastern little tuna at PPN Palabuhanratu has not experienced

biological overfishing or economical overfishing. Fish resources can be said to be biological overfishing if actual utilization has exceeded production and sustainable fishing efforts (MSY), while economical overfishing occurs when fishing activities no longer provide favorable revenue (Hakim dkk 2014).

The results are in accordance with Keputusan Menteri Kelautan dan Perikanan No.45/MEN/2011 (the Minister of Maritime Affairs and Fisheries Decree No.45 / MEN / 2011) which shows that the tuna fish in WPP (Fishery Management Area) 573 is still at moderate level which means that fishery management in WPP has not been fully utilized. Based on the appendix II and III of the minister's decree, eastern little tuna belong to a group of small pelagic fish (non tuna) and tuna fish management is included into the skipjack group. The value of the potential of small pelagic fishery resources that can be utilized in WPP 573 is 210,600 tons per year and based on the curve in appendix III shows that the resources of skipjack fish in WPP 573 can still be improved in both fishing and production. The location of WPP 573 includes the Indian Ocean to the south of Java to the south of Nusa Tenggara, Sewu Sea and the West Timor Sea.

Conclusion

The results showed that the effort on the actual condition of 48 trips with a production amount of 18.448 tons. Efforts on MSY conditions are 183 trips with total production of 48.720 tons. Efforts on MEY conditions are 180 trips with total production of 48.706 tons. Efforts on open access fisheries (OA) is 360 trips with total production of 3,265 tons. This means that the fishing activity of eastern little tuna (*Euthynnus affinis*) in PPN Palabuhanratu has not been better captured biologically or economically.

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