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Bioeconomic Analysis on Squid (*loligo sp*) Resources Use in the 718 Fishery Management Area (FMA)

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Abstract

In order, to maintain the balance of squid resources it is necessary to evaluate the level of utilization with the ability to be used as a basic for security in sustainable resource management of squid. The purpose of this study has to determine the optimal level of resource utilization of squid on the basic of bio-economic considerations. The research was conducted at Nizam Zachman Ocean Fishing Port of Jakarta (PPSJ) and Muara Angke Port. The main focus of the research the fishermen aboard the squid nets and squid fishing line that catch the squid in FMA 718 and landed the catch in DKI Jakarta Province. Method used is the quantitative research method and case study. The management of squid resource use based on the condition of MEY has seen to provide better solution in resource management in terms of environment or community resource and economy. The utilization rate of squid fishery resources in FMA 718 since 2006 until 2015 has not been over than Total Actualy Catch (TAC), meaning the utilization of squid resources has not been overfished and can still be developed.

Key words: Bioeconomic; Optimal Management; Squid; FMA 718.

1. Introduction

In the last ten years, approximately 200 trawlers of rings, longline and tuna rivers have diversified into squid vessels both squid and squid fishing lines [1].

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The transfer of target species and fishing gear is one of the efforts to avoid out of fishing business, especially to secure investment in order not to disappear its value. The most dominant fishing gear used to catch the squid in the Aru Sea, Arafura Sea and East Timor Sea, most of which catch is landed in Jakarta area is squid nets and squid fishing line. Fishery assets are depicted from the number of fishing gear, number of vessels and number of machines [2].

Taxonomically, squid belongs to the Loliginidea family with 4 genera Loligo sp., Ommatrephes sp., Todarodes sp., And Illexillecebrosus sp. [3]. Type of squid Loligo sp. is a species found in any waters not far from the beach, life is clustered or solitary, both while swimming or resting on the sea floor at night [4]. Squid are attracted to light (positive phototaxis), therefore often captured using the aid of light [5]. Cuttlefish is found in almost all Indonesian waters, such as the waters of the West Coast of Sumatra (Aceh and northern Sumatra), southern Java (West Java and East Java), southern Malacca (Aceh, North Sumatra and Riau), eastern Sumatra (South Sumatra and Lampung) , northern Java (Jakarta, Central Java, West Java and East Java), Bali, NTB, NTT, south west Kalimantan, South Sulawesi and Central Sulawesi, South Sulawesi, Maluku and Irian Jaya [6]. Life, species richness, abundance, biota distribution, and oceanographic properties and phenomena, such as upwelling [7].

Bioeconomic fish resources are used for simultaneous events / changes between the economic activities of the fishery and its biological resources activities. In determining the optimal catch level, sustainability aspects need to be known biological, economic, social and technological aspect. The management of fishery resources is strongly influenced by 2 (two) main aspects, namely biological aspect and economic aspect, [8]. The management of these resources is done through a biological factor approach, ie by calculating the maximum Maximum Sustainable Yield (MSY) [8]. Reference [9] Revealed that to overcome the catching conditions more necessary regulation of fish resource utilization. The Maximum Economic Yield approach is an approach that produces the most optimal economic rents. The balance of open access is the balance of fish resources in open access condition and without any regulation [9]. The balance of open access in the economic viewpoint leads to inappropriate allocation of natural resources due to the excess of production factors (labor and capital) so that open access will lead to economic overfishing conditions [10].

The high production of squid that has exceeded MSY is a matter that needs to be observed so as not to drastically decrease the resources of squid. Therefore, to maintain the balance of squid resources it is necessary to evaluate the level of utilization by considering the ability of resources (biological aspects) as well as economic aspects to be used as a basis for sustainable management of resources in squid.

The main objectives of this research are:

1) To know the relationship between Catch per unit effort (CPUE) with effort in squid resource utilization effort in WPP 718;
2) Analyzing the resources of squid on MSY, MEY and OAE conditions;
3) Analyzing the current condition of the utilization rate of squid resources in WPP 718 landed in DKI Jakarta.

2. Material and Methods

The study was conducted from September 2016 to April 2017, at the Ocean Fishing Port of Nizam Zachman Jakarta (PPSJ) and Muara Angke Port. Focus on squid fishing vessels and squid fishing line in the Fisheries Management Area (WPP) 718. Using quantitative research methods, with case-based approaches. The calculation of the number of samples can be done using the formula:

$$n = \frac{NZ^2\ x\ 0{,}25}{(d^2 x\ (N-1)) + (Z^2\ x\ 0{,}25)}$$

Information :

n = Number of samples of fishermen

N= Population

Z = Standard deviation

d = The error rate

Data analysis methods performed using microsoft office software 2013 and Maple 18. Standardization of fishing gear follow the formula [11] :

$$\mathrm{E} = \sum FPI_i \,.\, E_i$$

Information :

E = Total effort or number of catch effort from standardized fishing gear and standard fishing gear (trip)

FPI_i = Fishing power index from i fishing gear

E_i = Effort from standardized fishing gear and standard fishing gear (trip).

The parameters used for the calculation are the biological parameters of r (instrisic growth), q (capture index), and K (carrying capacity) used to calculate MSY, and economic parameters, c (cost per unit effort) and price Real (real price) to calculate MEY. The maximum sustainable production (MSY) is calculated using the logistic growth function. To estimate the effort level (E,) on MSY conditions is directly proportional to half of the natural growth rate (r) and inversely proportional to the capture coefficient q of the device used. This effort level (E) is then used to estimate the optimal biomass (x) level under MSY conditions.

$h_{MSY} = -\ 0{,}25\,\frac{a^2}{b}$

$E_{MSY} = -0{,}5\,\frac{a}{b}$

Basically the advantage is obtained by reducing the total revenue with total cost.

$$\pi = TR - TC = ph - cE$$

Information :

π : Advantages of resource utilization

p : average price of catch fish

c : the cost of fishing per unit effort

TR : total acceptance

TC : The total cost of fishing

The bioeconomic balance occurs when total revenue is reduced by total cost equal to zero. This bioeconomic balance occurs when the level of effort is at the level of open access effort. At TR = TC, the gain is equal to zero (π = 0).

$TR - TC = 0$ or $TR=TC$

$TR = ph$

$h=qEx$

$TC = cE$

Then :

$TR=pqEx$

And the profit function is :

$$\pi = pqEx - cE$$

In the balance of the bioeconomics of the Gordon-Shaefer model, where the rate of profit is equal to zero (π = 0), in other words the biomass rate gain (x) is proportional to the value of the unit cost of extraction per unit (c) divided by the price of fish per unit weight) And the capture power coefficient (q) or can be denoted as :

$$x_{OA} = \frac{c}{pq}$$

In open access condition, the equation of growth function (logistic function) $f(x) = rx(1 - \frac{x}{K})$, then the level of open access production can be known as follows :

$$h_{OA} = \frac{\mathrm{rc}}{pq}\left[1 - \frac{\mathrm{c}}{pqK}\right]$$

As for the estimation for MEY and effort on MEY condition mathematically the equation is as follows :

$$x_{SO} = \frac{K}{2}\left[1 - \frac{c}{pqK}\right]$$

By substituting the growth function equation $f(x) = rx\left(1 - \frac{x}{K}\right)$, Then it can produce economically sustainable production rates as follows :

$$h_{SO} = \frac{rK}{4}\left[1 + \frac{c}{pqK}\right]\left[1 - \frac{c}{pqK}\right]$$

$$E_{SO} = \frac{r}{2q}\left[1 - \frac{c}{pqK}\right]$$

The utilization rate is expressed by percent (%) and is obtained using the formula [9]:

$$TP_i = \frac{ci}{MEY}\ x\ 100\%$$

Information :

TP(i) : Level of utilization year i

C(i) : Total catch (catch) year i

MEY : *Maximum Economic Yield*

3. Results

3.1 Catch, Fishing areas and Season

The type of squid caught from a squid netting ship is a squid from the Lolinginidae family, the genus Loligo spp. The highest production is in Purse Seine fishing gear in 2010 until 2015, the highest production of Purse Seine in 2014 [12]. For fishing equipment Jaring Cumi in 2010 sd 2015 also increased. At that time, it can be said that the production of Squid Catch fishing equipment is stable [12]. The lowest squid landing production in the period 2010 - 2015 occurred in February, so that on the Moon it can be said to be the lowest season [12]. After February, production increased until May, and then dropped until July and began to rise again in August to November. While in December the production of squid back down. The peak of the catching season of squid occurs in August to November. The occurrence of squid fishing season in August may be suspected Because of the catching area in WPP 718 waters in the Arafura Sea, there is an upwelling or abundant squid food that is available in July-July in the aged season [13].

3.2 Utilization rate

The utilization rate of squid fishery resources landed in Jakarta is presented in Table 1.

Table 1

Year	Total Production (ton)	Utilization Rate (%)
2006	77	0,20
2007	121	0,31
2008	118	0,30
2009	865	2,21
2010	5,315	13,56
2011	7,044	17,97
2012	9,832	25,08
2013	10,761	27,45
2014	10568	26,96
2015	12,920	32,96

3.3 Catch

The production of squid catches with squid nets and squid fishing gear tends to increase in the period of 2006-2015. During this period, the lowest production was recorded in 2006, at 77 tons, while the highest production occurred in 2015 of 12,920 tons [12].

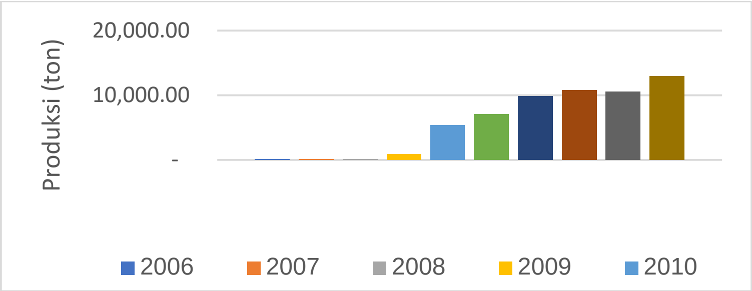

Figure 1: Graph of squid Production at PPS Jakarta 2006 - 2015

3.4 Effort

Effort to catch the squid in 2006-2015 always increase steadily. The actual average of catching effort in 2006-2015 is 367 trips per year.

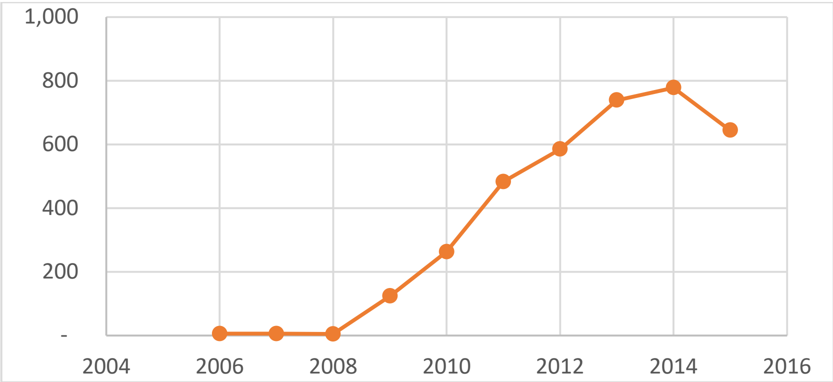

Figure 2: Graph of the development of squid fishing effort landed in Jakarta in 2006-2015

The relationship between effort and actual production shows that the higher the effort then the actual production is also increasing.

3.5 Catch Per Unit Effort (CPUE)

The highest squid fishing gear productivity in 2008 with CPUE amounted to 23.60 ton / trip while the lowest score in 2009 was 6.98 ton / trip. In 2006 it was seen that with few catches the catch is large enough, whereas in 2015 considerable catch effort was relatively small. The use of squid fishing equipment in 2006 can be said to be more efficient when compared to 2015 because the value of CPUE in 2006 is greater. The decline in production in 2009 occurred due to the operation of foreign ships indicated by Illegal, Unreported, and Unregulated (IUU) Fishing and many other fishing gear in the form of Trawling, even though the cultivation of squid has been growing from the previous year. From the Figure, the catch per catch of squid during the period 2006-2015 (Figure 3).

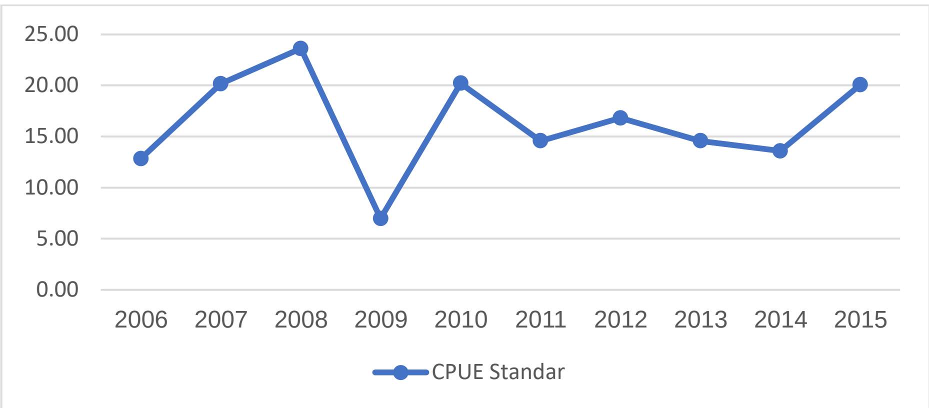

Figure 3: Graph of the development of catches per catching of squid landed in Jakarta in 2006-2015

Correlation between CPUE with effort should be known, so the tendency of productivity of squid fishing gear can be known also. The relationship of CPUE to effort is shown in Figure 4. Based on Figure 4, the correlation between CPUE and effort is obtained by the equation Y = -0.0019X + 17,034 with R2 value of 0.0159 with Y is CPUE and X is effort.

In Figure 4. it can be seen that the relationship of CPUE to the capture effort showed a downward trend this can be seen the negative slope value. This means that the correlation between CPUE with the effort of catching the squid shows that the higher the catch effort, the lower the CPUE value. The negative correlation between CPUE and catch effort indicates that the productivity of squid fishing gear will decrease if fishing effort improves.

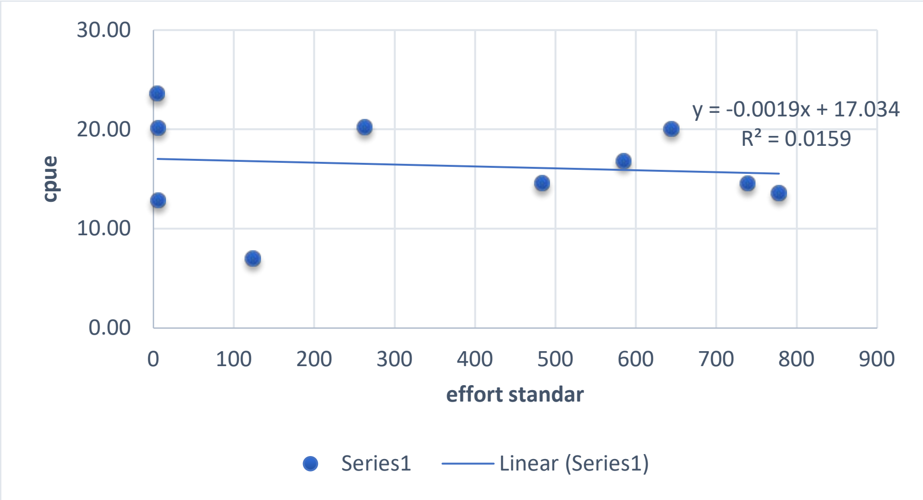

Figure 4: Graph of CPUE and Effort relationship of squid resources landed at PPS Jakarta in 2006 – 2015

3.6 Biological Parameters

Biological parameters were estimated using Fox model, the estimated parameters include intrinsic growth rate (r), environmental carrying capacity (K) and capture power coefficient (q). The estimation results of these three parameters are useful for determining sustainable production levels, such as Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and Open Access conditions. The result of processing biological parameters of squid resource based on Fox model can be seen in Table 2.

Table 2: Biological parameter estimation results based on Fox model

Parameter	symbol	Value
Natural growth rate	*r* (ton/year)	2,4764898640
Capability coefficient	*q* (ton/trip)	0,0002657262
Water carrying capacity	*K* (ton/year)	63.308,14

3.7 Economic Parameters

The data for the estimation of economic parameters consist of price and cost structure. The price used in this study is the real price.

Table 3: The average real price of squid resources in landed in PPS Jakarta in 2006 – 2015

Year	Rill Price (Rp / Ton)
2006	29.804.171
2007	30.761.034
2008	32.248.179
2009	31.694.329
2010	33.461.934
2011	36.794.458
2012	40.900.014
2013	29.825.382
2014	31.569.419
2015	32.941.080
Average	33.006.547

The calculation of the cost per unit of standardized effort and the total cost per year of squid fishery in Table 4.

Table 4: Cost per unit of squid fishing gear

Fishing gear	Cost / Trip / Unit	Total Cost / Year	Average Effort
Bouke Ami	690.080.567	225.886.372.101	327,33
Squid Jigging	377.566.020	2.978.576.380	7,89
Average	533.823.293	114.432.474.241	366,71

3.8 Sustainable Production

The result of estimation of biological parameters using Fox estimation model and the result of economic parameter estimation based on data processing can be seen in Table 5.

Based on the data from Table 5, the estimation of some sustainable yield conditions, among others on MSY conditions, open access and MEY (Maximum Economic Yield) conditions can be determined. The calculation results of each condition can be seen in Table 6.

Table 5: Summary of estimates of biological and economic parameters using the Fox model approach

Biological and economic parameters	Symbol	Value
Natural growth rate (r)	ton / year	2.7232213652
Capability coefficient (q)	ton / trip	0.0002922003
Water carrying capacity (K)	ton / year	57,572.24
Price (p)	Rp / ton	33.006.547
Cost (c)	Rp / trip	533.823.293

Table 6: Several estimates of sustainable yield (sustainable yield)

Component	MEY	Open Access	MSY
Biomass (x) (ton)	31.737,38	166,63	31.654,07
Production (h) (ton)	39.195,22	411,58	39.195,49
Effort (trip)	4.648	9,295	4.660
Benefit (million)	1.273.796.028,48	0	1.273.718.816,67

In Table 6. it can be seen that the value of squid resource rent in open access condition is zero. This means that if squid resources are left open for each person (open access), then the business competition in this condition becomes unlimited so that the level of risk borne by the fisherman becomes greater because of competition to get the catch. In this condition it means that the gain or rent earned is zero. In contrast to the MEY (Maximum Economic Yield) condition, the rented value obtained is the highest of the two other conditions or in other words the rents at maximum economic yield (MEY) are maximum.

The resulting MEY value can be applied as one of the strategies for squid resource management. When compared with the actual condition, it can be seen the condition of fishery resources operation of squid fishery. The comparison of actual and optimum value (MEY) of squid fishery resources is presented in Table 7.

Table 7: Comparison of actual value of 2015 and optimum of MEY squid fishery resources landed at PPS Jakarta

Component	Symbol	Optimum MEY	Actual 2015
Production (h)	ton / year	39.195,22	4.966,78
Effort to catch (E)	trip / year	4.659,85	366,71
Catch per trip	ton / trip	31.654,07	12.920
Fishing Gear	Unit	649	647

Table 7. shows the actual value of production, capture and fishing tools of squid resources have not passed the optimal condition obtained from the data processing that is respectively 4,966,78 tons / year, 366,71 trip / year and 647 units squid fishing gear, while for the optimal catch and fishing gear are 39,195,22 ton / year, 4,659,85 trip / year, and 649 units of squid catch. While the value of catch per trip in actual condition looks smaller than optimal condition that is equal to 12.920 ton / trip while optimal condition equal to 31.654,07 ton / trip.

3.9 Actual Condition of Squid Resource Utilization

Annual production of squid captured using squid fishing gear and landed in Jakarta shows an increase every year. The decline in production per trip of the resource of squid is thought to be due to the abundance of squid resources that have decreased as a result of overfishing done in previous years. While the increase in production that occurs due to increased fishing efforts, causing the catch becomes increasingly large. Biomass may decrease as the number of fishing attempts increases. This situation indicates that there is a link between the average production and fishing effort.

Squid cultivation efforts tend to increase every year. The increase or decrease in fishing effort can be caused by various things such as environmental and economic factors (Fauzi, 2001). Environmental factors can mean weather or seasons that affect fishing operations while economic factors are a tendency for fishermen to take into account the profit-loss in fishing operations, so that fishing efforts can fluctuate annually. This can be indicated by the shifting of large-volume vessels to squid naval vessels operating in the WPP 718 catchment area. A straightforward relationship between catch and effort over the past 10 years during which increased fishing efforts led to increased production squid.

Squid (Loligo) spawn throughout the year and peak in May - June, with this statement there is no constraint on the stock of squid resources because these commodities can breed in the absence of certain seasons so the stock recovery of squid in Waters can be done throughout the year.

3.10 Catch Per Unit Effort (CPUE)

The value of catch per unit effort (CPUE) appears to have a stable trend, while there is an increasing number of catching efforts in squid resource utilization. Stable CPUE while fishing efforts continue to increase can indicate no overfishing or excessive use of squid fishery resources.

3.11 Optimization of resource utilization of squid based on Maximum Economic Yield (MEY)

The result of Fox model calculation obtained shows that effort at MEY condition is lower than Open Access condition but higher than MSY condition, that is 4,648 trips per year but produces the biggest rent value or benefit among other management condition. It shows that at this level of production, the level of fishing effort has been carried out efficiently in order to obtain better catches and followed by maximum rents.

Based on Table 8, when compared to the actual condition of 2015 and the three utilization conditions (MSY, OA, MEY), the condition of the squid resource utilization landed at PPS Jakarta has not exceeded the limits allowed to be utilized. This can be seen from the production value of squid resource capture which is still below MSY and MEY and the total amount of effort per year. Resource management of squid fishery based on Table 8, seen condition of MEY yield value of rent / benefit which is bigger than MSY or Open Access condition that is 1,273,796,028,48 million rupiah. In this MEY condition the production of squid 39,195,22 ton / year with amount of effort effort 4,648 trip / year.

Table 8: Comparison of utilization rates among MSY, OA, MEY and Actual 2015 conditions

Component	MEY	Open Access	MSY	Actual 2015
Biomass (x) (ton)	31.737,38	166,63	31.654,07	
Production (h) (ton)	39.195,22	411,58	39.195,49	4.966,78
Effort (trip)	4.648	9,295	4.660	366,71
Benefit (million)	1.273.796.028,48	0	1.273.718.816,67	162.328.376,00

Utilization of resources managed under MEY conditions will provide maximum benefits or rents, since total revenues earned are greater than total expenditures. The implications seen from the input production or effort required in MEY condition is smaller than the condition of MSY or Open Access. Management of squid resource utilization based on MEY condition is better in resource management viewed from the aspect of resource and economy of society.

4. Conclusions

(1) The correlation of catch function per unit effort (CPUE) with effort is got negative slope which means more number of effort then CPUE value will decrease.
(2) The utilization rate of squid fishery resources in WPP 718 from 2006 to 2015 has not yet exceeded JTB. This can mean the utilization of squid fishery resources can still be developed.
(3) Utilization of resources of squid has not been overfishing.

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