The Status Of Catch Per Unit Effort (Cpue) And Utilization Rate Of Skipjack Tuna (Katsuwonus Pelamis) In The Kolaka Waters, Southeast Sulawesi, Indonesia

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Abstract: The waters of Kolaka Regency, covered info the WPP RI 713, is located in the eastern part of Bone Bay and potentially for skipjack fishery.This research was aimed at analyzing the catch per unit effort (CPUE), the maximum sustainable yield and the utilization rate of the fish in the waters. The method used in this research was a descriptive research using a case study. Data were collected from two sources, namely the recording data at the Fishery Office of Kolaka Regency and the local fishermen. About 144 samples of fishermen were gathered, consisting of various operating fishing such as pole and line, purse seine, handline, kite-line fishing, and boat lift net. The gathered data were analyzed to construct the status of CPUE, MSY, and the utilization rate. The results exhibit that the trends of CPUE undergo a fluctuation during the 2011 to 2017. The average production of this fish for those years is about 0.95 tons/trip. Both the Catch Maximum Sustainable Yield (^{C}MSY) and Economic Sustainable Yield (^{E}MSY) are 9,130.34 tons/year, and 4,767.78 trips/years, respectively. The use rate and the fishing effort of this species, are still under the ^{C}MSY (1.093.85 tons/year) and E_{MSY} (1,075.71 trips/year).

Keywords: Kolaka, Skipjack, CPUE, MSY, Utilization Rate

1 INTRODUCTION

The skipjack tuna (Katsuwonus pelamis) is one of fast swimming pelagic fish with its main habitats in tropical and sub-tropical waters. Currently, this fish is predicted becoming about the 60% of the global tuna catch [1; 2]. This pelagic fish is one of high value fishery resource and being an intensively international trade commodity for canning industries [3;4], distributing at almost all waters of Indonesia [5], and having the broad markets, both domestic and overseas. Of Seven main tuna species, this species is the highest proportion of catch, 45 percent of total catch in Indonesia [6]. Furthermore, Psycologically and morphological, it plays an important role in determining habitats and regarding area of distributions [7;8]. Fishing activity of skipjack tuna in Indonesia, in general, utilizes various fishing gears dominating by pole-and-line and purse seine in different levels of technology and production inputs (for instance the size of fishing vessels) [9]. The fishery business of skipjack tuna also contributes on the economic development of Indonesia. This fish is detected in the Fishery Management Area (Wilayah Pengelolaan Perikanan, WWP 713) which is predicted possessing biomass and potency sustainably of 56,888 tons/year and its abundance index of 94 kgs/km² [10]. The business perspective, especially capture fishery cannot be separated by some issues of problems such as overfishing, illegal fishing, postcapture handling, fisherman welfare, and others. Therefore, the issued policies by the government for overcoming those problems are needed regarding the activity programs in the fishery sector mainly for determining fishery management, for this context, is the fishery of skipjack tuna. Some aspects should be paid in attention of the fishery are the mechanism of management, controlling, and preserving the resource condition at a certain level sustainably.

The waters of Kolaka Regency, covered into the WPP RI 713, is located in the eastern part of Bone Bay. This bay commonly is bordered by Flores Sea in the south. Biologically, this bay is tropical area productively due to be passed by the Indonesian Throughflow (Arus Laut Lintas Indonesia, Arlindo) which becomes potentially for skipjack fishery in Indonesia [11]. The potency of this kind of tuna in the waters of Kolaka Regency, during the last six years (in the period of 2011 to 2016) is predicted to become the range of 2,158 to 1,181 tons/year. This trend grows up fluctuatively according to the fish productivity [12]. The productivity of this fish at the last three yeas tended to be decreased, however, at the period of 2015 to 2017. It lifts up due to several factors, one of them is an un-optimal effort in managing this fishery business. This decrease certainly affects the resource use in the aspect of fishery management sustainably. The saltwater fishery activity is crucial and enables all stakeholders should be paid in attention to taking actions keeping the sustainable business and to increase the fisherman welfare at the downstream level. A successfull management is more likely conducted if the stakeholders are well informed [13]. Hence, it is important for scientists to communicate their best available works for the managers, stakeholders, users, and communities in a broader scale of fishery world. The fluctuation of fish catch gathered through the serial data is important. A tendency of decreasing fish catches collecting for a certain period, and fishing grounds should be analyzed further to predict the optimal potency and the utilization rate. Hence, the fluctuation tendency of skipjack tuna fishing catch through various fishing gears in Kolaka Regency for some recent years should be studied. This study was related to the catch per unit effort (CPUE), maximum

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sustainable yield (MSY) and effort rate of skipjack tuna. This research was aimed at analyzing the catch per unit effort (CPUE) of this fish and its potential maximum sustainable yield as well as utilization rate in the waters. It was conducted to bolster the fishery activity of this resource at this Regency.

2 MATERIALS AND METHODS

2.1 Materials and Technique of Data Collection

The data of skipjack fish were collected from the records of the landing fishing ports in the Kolaka Regency. All fishing records were stored to the Fishery Office of Kolaka Regency, Southeast Sulawesi Province. In addition, for some un-reported primary data, one of authors also conducted a field observation through following the fishermen activities of fishing. Interviews to skipjack tuna fishermen were carried out directly based on their fishing gears used. Furthermore, the secondary data was composed by the number of annual fish production and types of fishing gears used of skipjack tuna fishing as well as the fishing effort also supplied from the Fishery Office of Kolaka Regency.

2.2 Research Method

This research was a case study, and its technical explanation conducted descriptively. A descriptive method is used to investigate a human group status, an object, a condition, a thinking system, or an event class in a current condition aims to gain a systematic description, figuring or depiction, factually and accurately facts, propreties, and relationship between phenomena that are being examined. Furthermore, this research focused on the Catch Per Unit Effort (CPUE) which is a standardized fishing method [14;15] conducted for estimating a certain fish stock [16], and a utilization rate of skipjack tuna in the waters of Kolaka Regency.

2.3. Data Analysis

Data analysis in this research consisted of catch-per-unit effort (CPUE), maximum sustainable yield (MSY), and utilization rate. The results of analysis were presented in tables and graphics and then followed by explanation descriptively. The relationships among investigated variables and other relevant factors were also described deeply in the discussion. Following is the description of each used analysis.

a) CPUE (Catch per Unit Effort)

CPUE (Catch-per-Unit-Effort) is a method used to estimate the fishery resource stocks based on the used fishing gears after going through a standardization process [14;15; 16]. According to Noija et al [17], a formula to estimate the CPUE is taken based on the following approach.

$$CPUE_t = \frac{Catch}{Effort}$$

Where the $CPUE_t$ is the catch per effort in the t-year (kg/trip), $Catch_t$ is catch in the t-year (kg), and the $Effort_t$ is the effort in the t-year (trip). Before conducting a CPUE estimated, prior standardization of fishing gears should be carried out [15]. Based on the available data especially the recorded data at the Fishery Office of Kolaka Regency that were only five main fishing gears used to catch skipjack tuna (K. pelamis) namely Pole and line, purse seine, handline, and lift net. Each of these fishing gears has a different fishing power index (PI) to catch the fish. Therefore, those five fishing gears had standardized earlier using as a reference for further analysis. The standardization process was taken following the two steps steps such as
determining the CPUE, and calculating the fishing power index (FPI). The defined of the catch rate (CPUE) was an average CPUE of each fishing gear. The fishing gear with the highest CPUE was chosen as the standard of fishing gear. Furthermore, the standardization was carried out by investigating the value of Fishing Power Index (FPI). The standard of fishing gear had the FPI equal to 1.0 and others of FPI values were compared to this standard. The formula of analyzing the fishing power index (FPI) for skipjack was referred to [18].

b) Maximum Sustainable Yield (MSY) Analysis

The concept of management sustainable yield (MSY) is intended on a biological approach of gathered maximum production and excepting the fish production of a certain captured fish years to years [19]. Estimating the potential of skipjack tuna could be analyzed by using the catch and effort. The relationship between these variables referred to the surplus production method of Schaefer model [18]. Steps of this method were taken by plotting the f value towards the c/f, and estimating the intercept (a) and slope (b) using a linear regression. Further, the catch MSY (CMSY) and effort MSY (EMSY) were calculated. The formula of the linear regression was utilized as follows.

$$y = a - bx$$

where y is a dependent variable (CPUE) in kg/trip, x is an independent variable (effort) in trip, and both a and b are regression parameters. The regression parameters (a and b) were estimated according to the following formulas.

$$a = \sum \frac{Xi}{n} - \sum \frac{yi}{n} \quad ; \quad b = \frac{n.\sum((xi)(yi) - (\sum yi)}{n.\sum(xi2) - (\sum xi)2}$$

where a is an intersept (constant), b is a slope, and both xi and yi are effort in the i-period, and catch per unit effort of the i-period, respectively. Furthermore, to determine the catch maximum sustainable yield (CMSY) and effort maximum sustainable yield (EMSY) referred to the Schaefer model which was styled as follows.

$$CPUE = a - b\,(f);\ C = af - b(f)^2.$$

Where CPUE or C is the number of catch per effort (kg/trip), both a and b are intercept and regression coefficient (f variable), and f is the effort (trip) in a i-period. This Schaefer model is only applicable if the parameter (b) is negative. This means that every increase effort will decrease the CPUE value. Hence, when estimating the coefficient (b) becomes positive, the calculation of potency and optimum effort should not be preceded due to this indicates additional effort is still possible to uplift the catch. Furthermore, the estimation of optimum catch and optimum effort can use the following formula [18].

$$E_{MSY} = \frac{a}{2b}$$

$$C_{MSY} = \frac{a^2}{4b}$$

Where both a and b are intercept and regression coefficient (f variable), E_{MSY} is an optimum effort, and C_{MSY} is the optimum catch.

c) Utilization Rate

A utilization rate is intended to seek the use status of utilized resources. The utilization rate for both catch and effort are calculated separately. At catch perspective, it can be calculated by comparing the catch (C_i) and maximum catch (C_{MSY}) and then multiply with 100%. Further, the effort is counted using the same pattern, by comparing the effort (E_i) and maximum effort (E_{MSY}), and then multiply with 100%. The formula of estimating utilization rate for catch and effort are presented below [18-19].

$$TP_C = \frac{C_i}{C_{MSY}}\ x\ 100\%$$

$$TP_e = \frac{E_i}{E_{MSY}}\ x\ 100\%$$

Where TP_C is a utilization rate for catch (%), C_i is the catch for certain i-year (kg), C_{MSY} is the catch maximum sustainable yield (kg), TP_e the utilization rate for effort (%), E_i is the effort at a certain i-year (trip), and E_{MSY} is the effort maximum sustainable yield (trip).

3. RESULTS

3.1 The Potential of Skipjack in Kolaka Regency Waters

Skipjack tuna production fluctuated every year, it was caused by seasonal factors and also the number of fishing gear usage (Figure 1).

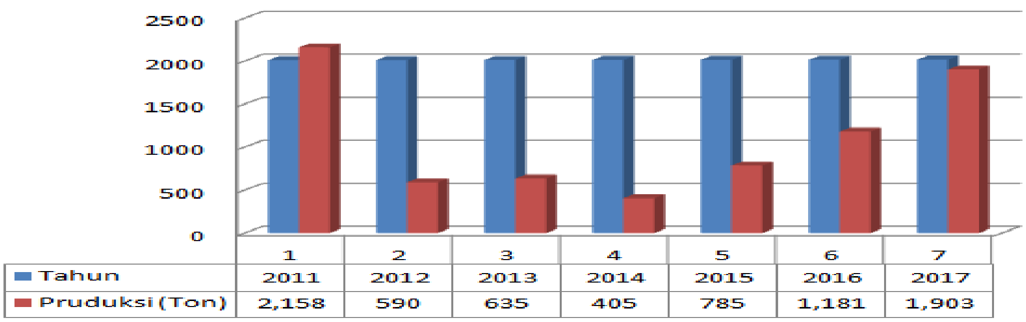

Figure 1. *Production of Skipjack in the TPI Kolaka Regency 2011 – 2017 (TPI Kolaka 2017)*

3.2 CPUE (Catch per Unit Effort)

Capture fishery of skipjack tuna in Kolaka Regency is conducted through five types of fishing gears such as pole and line, purse seine, handline, kite line, and lift net. The CPUE of each type of fishing gears is presented in the following table

Tabel 1*. Production and values of Skipjack tuna in the waters of Kolaka Regency*

	CPUE (Ton/Trip)				
Year	Pole and Line	Handline	Purse Seine	Kite line	Lift Net
2011	1.122437673	0.01322314	0.25462963	0	0.040892193
2012	0.833753149	0.018181818	0.25462963	0	0.056179775
2013	0.869627507	0.004104478	0	0	0.043478261
2014	0.719298246	0.005932203	0.058270677	0	0.046153846
2015	0.909547739	0.019467401	0.25462963	0.020041322	0.041237113
2016	1.014409222	0.024973051	0.275462963	0.029958678	0.037974684
2017	1.198535253	0.025815217	0.220779221	0.027995521	0.046793478
Total	6.667608789	0.111697308	1.318401751	0.077995521	0.31270935
Average	0.952515541	0.015956758	0.188343107	0.011142217	0.044672764

Source: Primary data processed 2018.

Based on Table 1 above, the highest productivity of fishing gears is revealed by pole and line. This fishing gear is used as the standard or the Fishing Power Index equal to 1, and all other fishing gears should be compared to this fishing gear. The results of calculating the total production, standard effort, and standardized CPUE is presented in the following Table 2.

According to table above, the highest and the lowest production of skipjack tuna in the waters of Kolaka Regency are 2011 (2,158 tons) and 2014 (405 tons), respectively. Further, the relationship between the standardized effort and standardized CPUE of Skipjack tuna is plotted on a linear regression as the following graphic (Figure 2).

Table. 2 The Calculation Result of Total Production, Standard Effort, and CPUE's Standard

Year	Total Production (Ton)	Standard Effort (Trip)	CPUE's Standard (Ton/Trip)
2011	2158	1922	1.122788762
2012	590	697	0.846484935
2013	635	730	0.869863014
2014	405	563	0.719360568
2015	785	863	0.909617613
2016	1181	1168	1.011130137
2017	1903	1587	1.199117832
Total	7657	7530	6.678362862
Average	1093.85	1075.71	0.954051837

Based on the relationship graphic above (Fig. 1), the regression formula for this relationship and the R^2 are Y=0.0003x+0.6273, and 0.8577, respectively. This relationship is positive (+) meaning every increase of one trip will escalate the CPUE as high as 0.627 kg/trip. The fluctuation of CPUE values is due to the increase or decrease of both fishing gears used and trips of efforts in this period. An estimation of MSY has to be based on the time-series data of catch yearly. Based on the calculation, the MSY of skipjack tuna in the waters of Kolaka Regency is about 9,130.34 tons. The maximum yield and optimum CPUE are about 4,767.78 tons/year, and 1.92 (ton/trip), respectively. Furthermore, the allowable catch quota for this kind of tuna is about 7,304 tons/year.

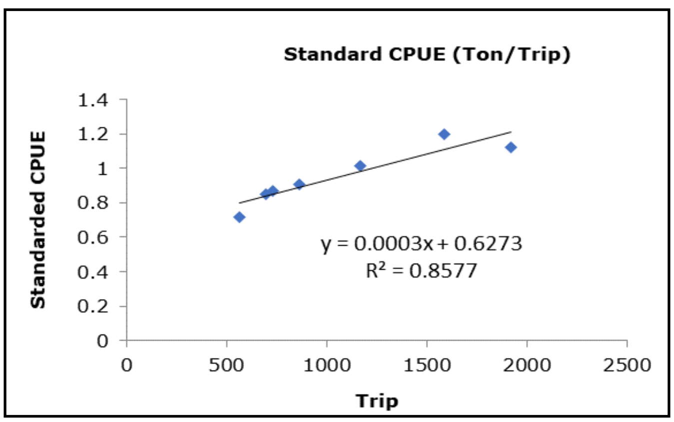

Figure 2. *The relationship graphic of effort and CPUE of skipjack in the waters of Kolaka Regency during 2011 – 2017.*

3.3 Maximum Sustainable Yield (MSY)

3.4 Utilization Rate

The rate of utilization for Skipjack tuna in the waters of Kolaka Regency during the last seven years is fluctuation. The highest and the lowest utilized rate of this fish refer to the total production each year which are approximately 23.64 % (2011) and 4.44% (2014), respectively. Table 3 below presents the utilization rate of Skipjack tuna in the waters of Kolaka Regency for the last seven years. It can be seen in the following Table 3.

Table. 3*. Utilization Rate (%) and Fishing Effort Rate (%) of Skipjack which Standardized in 2011 – 2017*

Year	Production (Ton)	Effort (Trip)	Utilization Rate (%)	Fishing Effort Rate (%)
2011	2158	1922	23.64	40.31
2012	590	697	6.46	14.62
2013	635	730	6.95	15.31
2014	405	563	4.44	11.81
2015	785	863	8.60	18.10
2016	1181	1168	12.93	24.50
2017	1903	1587	20.84	39.91
Total	7657	7530	83.86	164.56
Average	1,093	1,075	11.98	23.51

4. DISCUSSION

Skipjack becomes the main catch of fishermen in the waters of Kolaka Regency and being one of economic fishery importantly in Indonesia [20]. The waters of Kolaka Regency is located sweeping away, geographically, on 3º36' S - 4º35' S and 120º45'E - 121º52' E. The western part of this regency is the Bone Bay which is well recognized as one of the most potential fisheries for skipjack tuna. The bio-physical characteristics of this bay to Flores Sea play an important role in providing the potential richness of fishing grounds for skipjack tuna in Indonesia [21]. A research conducted by [20] assessing the distribution of this fish in Bone bay using acoustic method indicating the highest density is located in around Kolaka Regency especially at a geographic coordinate of 4^{0}55'11.06"S and 121^{0}10'.08"E. Furthermore, the peak catching season of skipjack in this bay in span time of three years since 2011 to 2014 is on the fourth quartal namely October, November, and December [22]. Skipjack is a vast migratory and fast swimming fish. It is mainly captured using various fishing gears in the Bone bay consisting of pole and line, handline, and gillnets in different yields [23;24]. Globally, using a variety of gear types (e.g gillnet, hook and line, long-line, purse seine, ring net, pole-and-line and classified) is conducted to capture a significant amount of skipjack in the Philippines and Indonesia. Furthermore, small but locally important artisanal fisheries for skipjack and other tuna (specially using traditional methods and trolling) also happen in many of the Pacific Islands [25]. In the context of the waters of Kolaka, this fish is hugely captured using five types of fishing gears namely pole and line, purse seine, handline, kite line, and lift net. The skipjack fishery in the waters of Kolaka undergoes fluctuation year to years due to the season and fishing gears used. Data presented in Table 1 indicates this fluctuation in both production and value during 2011 to 2017. The highest and the lowest production of this fish are 2011 (2,158 tons) and 2014 (405 tons). Furthermore, during three years (2012 to 2015) the supply of this fish in the market was decrease and its prices was increase twice exceeding Rp 28,000 per kg. The price of this fish also is affected by the quality fish catch at both landing and receiving by the fish agents. Moreover, a fluctuated production influences the catch per unit effort (CPUE) of this fish after averaging all fishing gears used. Both the highest and the lowest CPUE on the current research occurred on 2017 (1.199 ton/trip) and 2014 (0.719 ton/trip). The current result is seemly different with the research conducted by [26] indicating a trend of decreasing CPUE of skipjack in the northern part of Bone bay (Luwu Regency at South Sulawesi Province), though this research just focused on one fishing gear namely pole and line without any standardization of fishing gear. The CPUE of skipjack in the waters of Kolaka possess a different trend with the same commodity of Banda Sea like a research carrying out by [27]. These differences may be happened because of some factors such as the used fishing gears, variation of fishing gears, fishing grounds, duration of fishing, record and report of fish catch, and natural factors like seasons and oceanography conditions. The abundance index of skipjack tuna was heavily affected by the year and quarter; however, it did not relate with the vessel's capacity [28]. Declining trend over the years of observation also have been detected. The maximum sustainable yield (MSY) is commonly used to know whether a certain fishery activity is optimum or not in terms of seeking the limit of overfishing activity according to the time-series available data. [29] define MSY as the highest potency that can be captured of a certain available fish stock without any affecting the sustainability of that fish stock. In the current research, Schaefer model is taken to estimate the MSY of skipjack in the waters of Kolaka. The optimum catch and actual value catch of this fishery activity are about 4,767.78 tons annually and 1,075. This optimum effort is far below the sustainable catch limits namely 9,130.3 tons per year with an actual value of 1.093. This result is slightly different with other researches conducting in different waters such as [29] found the MSY for the skipjack in the waters of Boalemo Regency at Tomini bay that is about 3,112.45 tons annually and only 705.55 trips for effort. [30] reported the MSY for the fish in Prigi waters of East Java Province using Fox model is about 1,219 tons/per year. [18] Reported the MSY and optimum effort of skipjack in the waters of Bone bay are about 22,561.4 tons and 1,730 standard units, respectively. The MSY for a broader scale of landing (this case happening in Nizam Zachman Fishing Port, Jakarta), is recorded by [31] that the MSY of skipjack landing in that fishing port during 2004 to 2013 is about 109.535,302 tons. Therefore, the current result deduces the needs of more fishing effort should be taken in the Kolaka Waters to optimize the fishery production of skipjack. Furthermore, in terms of exploitation rate, the skipjack tuna fishery in the waters of Kolaka Regency is categorized is still affordable to be increased. The highest and the lowest exploitation rates for the years of 2011 to 2017 are approximately 23.64 % (2011) and 4.44% (2014), respectively. While for a larger context of Bone Bay. [18] reported the averaga production for skipjack in the Bone bay, in general, is about 14,357 tons and level of explointation is approximately 63.64%. The reseach indicates that the level of exploitation of skipjack tuna resources in the waters of Bone Bay does not over exploited every year except in 2017. For the context of fishing, [32] revealed the skipjack condition in the western part of Bone bay, Makassar Strait, is consisted of three aspects such as the fish is dominated by small sizes, low growth, and tend to be decreased. This condition is highly influenced by mortality due to fishing activities. Even though this condition is under exploitation rate, a circumspection is needed to be not exceeded the allowable catch quota which is 80% of MSY [33]. When the exploitation rate reaching over the MSY of the fish, it can threat the fish resources and the fish cycle of life which in turn the fish stock is going to be decreased [34]. Reversely, an unoptimally utilized fish resource (underfishing), of course, will inflict a financial lost because of the available fish abundance is going to face natural mortality and or even be used by foreign fishermen which does not give optimally for the local people [35;36]. Hence, an integrated management approach to make the fish resource will be sustainable for the next generation.

5. CONCLUSION

CPUE for Skipjack (Katsuwonus pelamis) in the waters of Kolaka Regency experience a fluctuating condition during 2011 to 2017 with an annual value of 0.954 ton/trip. Both the gathered catch maximum sustainable yield (CMSY) and optimum effort of the fish are about 9,130.34 tons/year and 4,767.78 trips/year. There will be about 7,304 tons/year for the allowable catch quota. This indicates that the skipjack in the waters of Kolaka Regency is in a underfishing condition which is available to add more fishing efforts in a reasonable limit (based on the current condition).

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