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Sustainable economic analysis and length weight relationship of Bullet Tuna (*Auxis rochei*) fishery in east area of Bali Strait, Indonesia

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Abstract. *Bintoro G, Sutjipto DO, Lelono TD, Semedi B, Sartimbul A, Wahyuni MT. 2023. Sustainable economic analysis and length weight relationship of Bullet Tuna* (Auxis rochei) *fishery in east area of Bali Strait, Indonesia. Biodiversitas 24: 3528-3535.* Bullet tuna (*Auxis rochei*) is a small pelagic fish with an important economic value and is mainly caught by fishermen in the east area of Bali Strait, Indonesia. The high market demand for this fish has increased fishing efforts to achieve maximum catch, and this uncontrolled fishing activity will threaten its sustainability and economic potential. This study was conducted to determine stock status both biologically and economically. The length-weight relationship was calculated by measuring the length and weight of 1,200 samples of fish landed in the Pengambengan Archipelago Fishing Port (AFP) in Jembrana Bali Province from February to March 2020. The calculation of maximum sustainable yield (MSY), maximum economic yield (MEY), and equilibrium of open access (OA) were done by using secondary catch data from 2008 to 2019. Gordon Schaefer's model analysis found that the values of Y_{MSY} and f_{MSY} were 3,314 tonnes year^{-1} and 3,503 trips year^{-1}, respectively. While the values of Y_{MEY} and f_{MEY} were 3,160 tonnes year^{-1} and 2,750 trips year^{-1}, respectively, which gave a maximum profit of about 1.4 billion USD year^{-1}. In addition, the equilibrium of OA would be achieved when the fishing effort reaches 5,500 trips year^{-1} and the amount of catch reaches 2,237 tons year^{-1}. The growth pattern of the bullet tuna was isometric, which indicates that the bullet tuna in the east area of Bali Strait has a proportional body shape. The utilization status of bullet tuna (*A. rochei*) is over-exploited.

Keywords: Maximum economic yield, maximum sustainable yield, pelagic fish, total revenue, utilization status

INTRODUCTION

Bali Strait is a stretch of waters with an area of about 2,500 km^2 between the Java and Bali islands. The Bali Strait connects the Indian Ocean and the Java Sea, providing plenty of fishery resources. These fisheries resources are dominated by pelagic fish, which has characteristic of pelagic shoaling species such as Bali sardinella (*Sardinela lemuru)* (Simbolon et al. 2017), scads (*Decapterus* spp.), and bullet tuna (*Auxis rochei*). Species of pelagic fish have a high propensity to migrate. Purse seines are the primary fishing gear in most fishing activities because these fishing gears can catch pelagic schooling fish effectively. Fishing activities around the east area of the Bali Strait are concentrated in Jembrana waters, with a fishing port located in Jembrana Regency, namely Pengambengan Archipelago Fishing Port (AFP), with bullet tuna as one of the potential fishery resources (Harlyan et al. 2022).

Bullet tuna is a fishery resource with a high economic value which is a targeted species to be exploited, and the main catch landed in the Pengambengan AFP. The bullet tuna landed at the Pengambengan AFP in 2017 was 1,997 tons. This catch increased to 5,542 tonnes in 2018 (Pengambengan 2018). The nutritional content of bullet tuna includes a high percentage of moisture (74.3%), high protein (22%), high distribution of lipids within its body (3.1%), glycogen (0.3%), and minerals (1.2%) (Mudumala et al. 2017). However, the exploitation of bullet tuna has increased annually due to the high demand for this fish resource. Consequently, it may affect the continued presence of bullet tuna resources in the Bali Straits waters. The utilization of marine resources has a general nature, namely open access, where fishery resources can be exploited freely as long as profits can still be obtained. The availability of fish stocks in the waters will be significantly impacted by exploitative behavior contrary to the rules, excessive, and typically destructive. (Kekenusa et al. 2015).

Analysis of the level of resource exploitation is one of the efforts to control the level of exploitation. Ineffective and destructive resource management will disrupt the sustainability of resources. Endeavors to control management sustainability can be handled by combining economic and biological aspects to produce estimates of fishery stocks and water conditions (Anna et al. 2017). Several studies indicate that pursuing economic goals in fisheries plays an important role in overfishing and the decline of marine ecosystems. This statement is supported by several major causes, including private-beneficial decisions made by individual fishers, which can lead to overfishing and lower profits, and short-term profit motives in managed fisheries, leading to unilateral political pressure to establish unsustainable harvest levels (Asche et al. 2018).

The optimal utilization of bullet tuna resources is very important in order to avoid the occurrence of overexploitation. The level of utilization that exceeds the optimal limit will threaten the sustainability of fish resources. According to (Lelono et al. 2023), a prudent way to deal with the administration of the fish asset should be considered guaranteeing that the level of exploitation is underneath the MSY point. The present research aimed to analyze Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), equilibrium of Open Access (OA), the status of fish resource utilization based on the number of allowable catches (Y_{TAC}), and the relationship between length and weight. The surplus production models, such as Schaefer and Fox, are used to estimate the MSY in this research. These data can be used to analyze the status of fish resources in the East area of Bali Strait, Jembrana, Bali. These methods have been applied to justify fisheries resource sustainability not only in Bali Strait (Bintoro et al. 2021a) but also in several waters such as south of East Java waters (Bintoro et al. 2021b) and the west area of Java Sea (Bintoro et al. 2022a).

MATERIALS AND METHODS

Description of the Study

The research method used in this study is quantitative descriptive with random sampling to collect the data. The research was conducted from February to March 2020 in the East of Bali Strait, Jembrana, Bali, Indonesia (Figure 1). The primary data collection in the sustainable economic analysis was obtained by interviewing 15% of purse seine fishing gear owners at Pengambengan AFP with 15 respondents. Data on economic aspects include the price of bullet tuna, operational costs and income, and vessel investment. Secondary data includes production data, production value, and total trips at the Pengambengan AFP in 12 years. Parameters to be analyzed estimate MSY, MEY, OA, and utilization status of bullet tuna based on the allowable catch (Y_{TAC}) using the production surplus model, namely the Schaefer 1954 and Fox 1970 models and the Gordon Schaefer model for the sustainable economic analysis. MSY is Maximum Sustainable Yield, which is often used as a target when maximizing yield (Punt et al. 2014), MEY is the effort that gives the maximum profit (Pauly and Froese 2020). Meanwhile, OA is the catch and effort equilibrium occurrence in an Open Access condition where no profit is obtained.

Data analysis

Standardization of fishing gear

Justification of fishing effort in this research was drawn based on fishing gears operated by fishermen who landed their catch in Pengambengan AFP Jembrana, Bali. Three types of fishing gears were operated at Pengambengan AFP, namely purse seine, gillnet, and hand line. However, in this study, standardization of fishing effort was not carried out because there was only one fishing gear which was capable of catching the bullet tuna (*A. rochei*) in this fishing base, namely purse seine. Therefore, purse seine could be directly used as standard fishing gear to justify catch and effort time series data of the bullet tuna (*A. rochei*) fishery in east area of the Bali Strait waters (Bintoro et al 2022b). Other researchers also mentioned that certain fishing gear can be decided as standard fishing gear if it has the highest productivity among the others (Tidd et al., 2015). In addition, purse seines have complete data in time series (Griffiths et al., 2019).

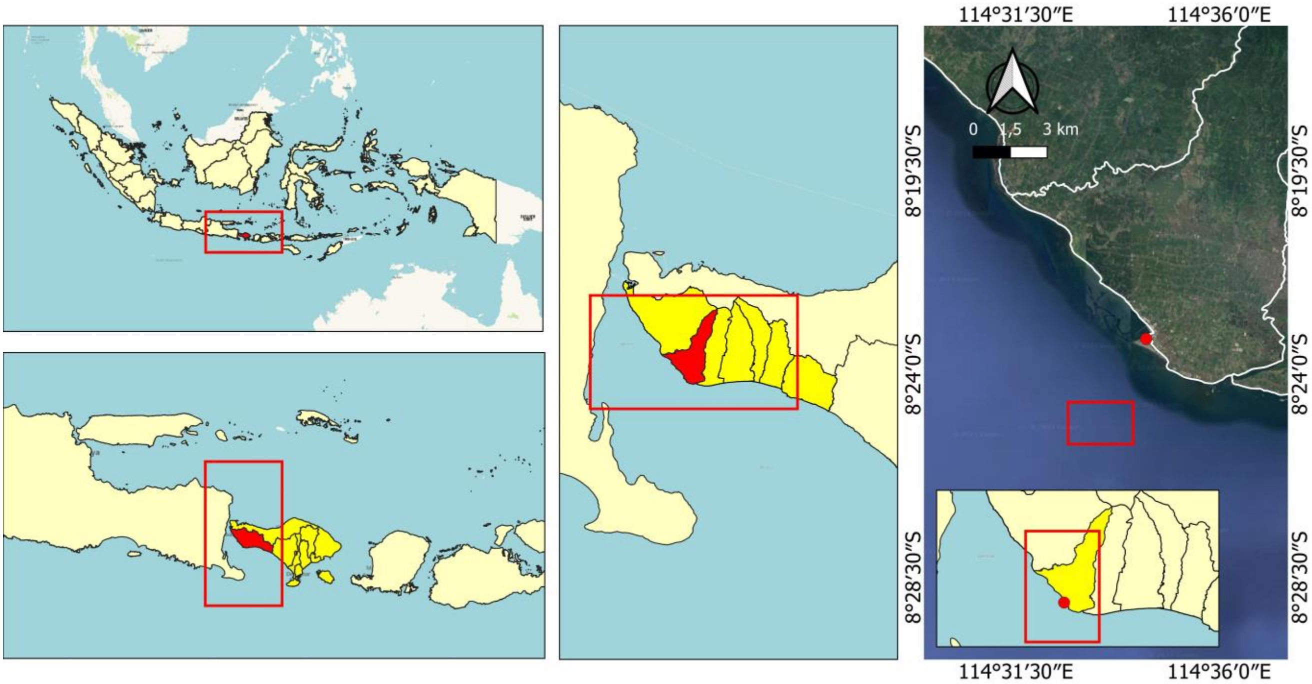

Figure 1. Research location, east area of Bali Strait, Indonesia (bullet tuna fishing ground)

Those data are available in the statistical data of Pengambengan AFP Jembrana, Bali. Those data are needed to facilitate the analysis process that will be carried out in this study, where the data from previous years are needed as a comparison and reinforcement of the results in this study.

Schaefer's model (1954)

The CpUE can be calculated by dividing the total production of bullet tuna by the fishing effort. The relationship between CpUE and effort (f) Schaefer's model is written in the form of regression (Malik et al. 2019) as follows:

$CpUE = a + bf$ …………………………………… (1)

A is the intercept, and b is the slope in a linear relationship. Therefore, the equation of the relationship between catch and effort is as follows:

$C = af + bf^2$ ………………................................ (2)

Optimum fishing effort (f_{opt}) is obtained by making the first derivative of the catch-on effort equal to zero.

$C' = a + 2bf = 0$

$f_{opt} = -(a/2b)$ ………...(3)

MSY is obtained by substituting the fopt value into equation (3) to obtain:

$C_{MSY} = a(-a/2b) + b(a^2/4b^2)$

$MSY = C_{max} = -a^2/4$ …………......................... (4)

Fox's model (1970)

The relationship between CPUE and effort (f) Fox model can be written by the formula (Bintoro et al. 2022b) as follows:

$CPUE = \exp^{(c+df)}$ ……………............................ (5)

C and d are natural anti-logarithms (ln) of the intercept or regression coefficient of the relationship between ln CPUE and effort, which is a linear relationship. Using equation (5), the relationship between catch and effort is as follows:

$C = f \exp^{(c+df)}$ ……………................................. (6)

Optimum fishing effort (f_{opt}) is obtained by equating the first derivative of the catch to effort equal to zero. The optimum effort value (f_{opt}) is as follows:

$f_{opt} = -\frac{1}{d}$ …………………................................. (7)

MSY is obtained by substituting the f_{opt} value into equation (7) so that the following formula is obtained:

$MSY = -\frac{1}{d} \exp^{(c-1)}$ ……….......................... (8)

Gordon schaefer model.

The sustainable economic analysis of the Gordon Schaefer model begins by determining the relationship between catch (C) and effort (f) with the following formula (Bintoro et al. 2022a):

$C = af + bf^2$ …………..………………………… (9)

The values of a and b are obtained by regressing CPUE against the effort, namely equation (9) divided by the effort so that it becomes:

$\frac{C}{f} = a + bf$ ……………………………………….. (10)

Based on equation (10), when the maximum catch (C_{MSY}) can be achieved when the first derivative of f is equal to zero, $f_{MSY} = -a/2b$, and the maximum catch $C_{MSY} = -a/4b$.

The maximum level of effort to use sustainably and economically is determined by the Gordon-Schaefer model in the equation:

$\pi = TR - TC = pC - cf$ ………………………… (11)

Where:

π : profit economic

TR : total revenue

TC : total cost

p : average price of fish resources

C : total catch

c : catch cost per unit effort

f : catching effort

Utilization rate

Analysis of the utilization rate of fishery resources can be determined by the formula (Santoso et al. 2015) as follows:

$TP = Yi/Y_{TAC} \times 100\%$ ……….......................... (12)

Where:

TP : utilization rate

Yi : average catch of the last 12 years

Y_{TAC} : number of allowable catches (tonne)

Length-weight relationship

Analysis of the relationship between length and weight can be determined by the equation (Froese 2006; Bintoro et al. 2021b; Bintoro et al. 2021c) as follows:

$W = aL^b$ ………………………………………… (13)

Where:

W : weight (gram)

L : length (cm)

a : *intercept*

b : *slope*

Equation (13) is then transformed into a linear equation so that it becomes an equation (Bintoro et al. 2022c) as follows:

$\ln W = \ln a + b \ln L$ ………………….………… (14)

To test the value of b = 3 or b 3, a t-test (partial test) was carried out (Bintoro et al. 2021d).with the hypothesis:

H0: b = 3, the growth pattern is isometric, which means that the length and weight relationship is balanced.

H1: $b \neq 3$, the growth pattern is allometric, meaning the length and weight relationship is not balanced. There are two types of allometric, as follows:

Positive allometric if the value of b>3 (weight growth is faster than length growth).

Negative allometric if the value of b<3 (length growth is faster than weight growth).

RESULTS AND DISCUSSION

Production of bullet tuna (*A. rochei*)

Based on the statistical data of Pengambengan Archipelago Fishing Port (AFP), the production of bullet tuna in 12 years (2008-2019) caught by purse seines fluctuated. Catch data of the bullet tuna were recorded by Pengambengan AFP officials based on fish landed and caught by purse seines. The total production of bullet tuna reached 33,789 tonnes, averaging 2,815.8 tonnes/year. In 2008 the production of bullet tuna was 2,287 tonnes; in 2009, it increased by 2,854 tonnes. In 2010 its production fell to 2,334 tonnes. The production of bullet tuna experienced ups and downs to the highest production peak, namely in 2018 of 5,542 tonnes, and then experienced a drastic decline in 2019 to 779 tonnes (Table 1).

Fishing effort of bullet tuna (*A. rochei*)

This study's indicator of effort to catch bullet tuna used the number of purse seine boat trips that carried out fishing operations at Pengambengan AFP. The fishing activities of bullet tuna in Pengambengan AFP fluctuate. The average effort to catch bullet tuna from 2008-2019 was 2,977 trips/per year. The highest fishing effort occurred in 2019, with 6,141 trips, while the lowest occurred in 2017, with 1,224 trips (Table 1).

Catch per Unit Effort (CpUE)

The highest production of bullet tuna was in 2018 at 5,542 tonnes, and the lowest was in 2019 at 779 tonnes. The number of attempts to catch bullet tuna in 2008 was 2,142 trips. These fishing efforts have increased from year to year and, in 2019, reached 6,141 trips. The highest CPUE value of bullet tuna occurred in 2017 at 1.63 tonne/trip, and the lowest CPUE occurred in 2019 at 0.13 tonne/trip. This is because the greater the effort to catch, the lower the CPUE value and vice versa. Based on the CPUE value and the production of bullet tuna, which tends to decrease yearly. It indicates that overfishing occurs in the waters of the Bali Strait (Table 1).

Schaefer model (1954)

The analysis of CPUE and effort using the Schaefer model obtained an intercept value (a) of 1.8919, a slope (b) of -0.000270048, and an R^2 of 0.6791 (Figure 2). The relationship between the linear equations of the Schaefer model is y = -0.000270048x + 1.8919, which means that if an effort is made of x units/year, the CPUE value will decrease by 0.0003 tonne/year. On the other hand, if efforts are not made, the resources that can be utilized are 1.8919 tonne/year.

The estimation of Maximum Sustainable Yield (MSY) Schaefer model 1954 obtained results of 3,314 tonnes/year with optimal effort (f_{opt}) of 3,503 trips/year (Figure 3). The fishing effort should not exceed 3,503 trips/year, and the maximum production is 3,314 tonnes/year so that the efforts to utilize bullet tuna resources can be sustainable. If the increase in effort exceeds f_{opt}, the catch will decrease below the MSY value.

Fox model (1970)

The ln CPUE analysis by Fox 1970 model obtained an intercept value (c) of 1.2921, a slope (d) of -0.0005, and an R2 of 0.7358 (Figure 4). The relationship between the linear equations of the Fox model is y = -0.0005x + 1.2921, which means that if an effort is made of x units/year, the value of ln CPUE will decrease by 0.0005 tonne/year. On the other hand, if efforts are not made, the resources that can be utilized are 1.2921 tonne/year. Estimated Maximum Sustainable Yield (MSY) Fox 1970 model obtained results of 2,954 tonne/year with optimal effort (f_{opt}) of 2,206 trips/year (Figure 5). For efforts to utilize the resources sustainability of bullet tuna, the utilization of effort should not exceed 2,206 trips/year and maximum production of 2,954 tonne/year.

Estimated utilization rate and status

Based on the analysis of the two models, it is known that the Fox model has a higher R^2 value than the Schaefer model. This shows that the utilization rate of bullet tuna in the East area of Bali Strait uses the Fox model. The utilization rate of bullet tuna in Pengambengan AFP is 235%, meaning the bullet tuna fishery is in overfishing conditions with a resource rate exploited more than MSY. Based on the calculation of the Fox model, the f_{opt} value is 2,206 trips/year, and Y_{TAC} is 2,363 tonnes/year (Table 2).

Gordon schaefer sustainable economic analysis model

The results of the sustainable economic analysis under MSY conditions obtained a maximum catch of 3,314 tonnes, greater than the MEY condition of 3,160 tonnes and OA of 2,237 tonnes. A small OA value indicates that the effort to utilize bullet tuna resources is not controlled and can affect the amount of fish stock in the future. In actual conditions, the total catch of bullet tuna was 2,371 tonnes, smaller than the management of MSY and MEY. This is because the current fishing effort is still not optimal.

The maximum profit that can be generated from the utilization of bullet tuna resources in MEY conditions is 20,715.3 million Indonesian dollar rupiah (IDR) or 1,391.3 million United State Dollars (USD). This advantage is greater than the condition of MSY, which is 9,161.8 million IDR or 615,3 thousand USD, and OA condition when zero profit is obtained. MEY conditions can be achieved with an effort of 3,160 trips with a catch of 2,750 tonnes.

In the OA condition, the total expenditure is equal to the total income, so the profit earned is zero. The effort to catch in OA conditions is 5,500 trips with a catch of 2,237 tonnes. Compared to the MSY and MEY conditions, the required fishing effort level in the OA condition was much greater (Table 3).

Based on Figure (7), it is known that if the MEY income level is greater than the fisherman's expenditure, a large profit will be obtained at the f_{MEY} point. If the effort is continued to the point of f_{MSY}, the total catch will be even greater, but the profits obtained at this point will decrease because the total costs incurred are also getting bigger. The fishing effort that continues to be increased until it reaches the f_{OA} point will make the catch decrease compared to the MSY and MEY conditions, causing the business to be no longer profitable (Figure 6).

Table 1. The effort, catch, CpUE, and Ln CpUE of bullet tuna (*Auxis rochei*)

Year	Effort (trip)	Catch (tonne)	CpUE (tonne/trip)	Ln CpUE (tonne/trip)
2008	2,142.00	2,287.00	1.07	1.07
2009	2,909.00	2,854.00	0.98	0.98
2010	3,675.00	2,334.00	0.64	0.64
2011	1,874.00	2,986.00	1.59	1.59
2012	2,722.00	3,700.00	1.36	1.36
2013	2,380.00	3,305.00	1.39	1.39
2014	3,662.00	2,890.00	0.79	0.79
2015	2,800.00	2,745.00	0.98	0.98
2016	2,012.00	2,371.00	1.18	1.18
2017	1,224.00	1,996.00	1.63	1.63
2018	4,186.00	5,542.00	1.32	1.32
2019	6,141.00	779.00	0.13	0.13
Average	2,977.00	2,815.80	1.09	-0.06

Table 2. Result analysis of Schaefer Model 1954 and Fox 1970

Variable	Analysis	
	Schaefer	Fox
Intercept	1.891893629	1.292090597
Slope	-0.000270048	-0.000453410
R Square	0.679070127	0.735778771
F_{MSY} (trips/year)	3,503	2,206
Y_{MSY} (tonne/year)	3,314	2,954
Y_{TAC} (tonne/year)	2,651	2,363
Utilization Rate	209%	235%
Utilization Status	Over exploited	Over exploited

Table 3. Results of Gordon Schaefer's model

Variable	Actual (2019)	MSY	MEY	OA
Catch (tonne)	779.00	3,314.00	3,160.00	2,237.00
Effort (trip)	6,141.00	3,503.00	2,750.00	5,500.00
Revenue (Thousand USD)	530.70	2,257.70	215,333.50	1,524.00
Cost (Thousand USD)	1,701.80	970.70	762.00	1,524.00
Profit (Thousand USD)	-1,171.00	1,287.00	1,391.30	0

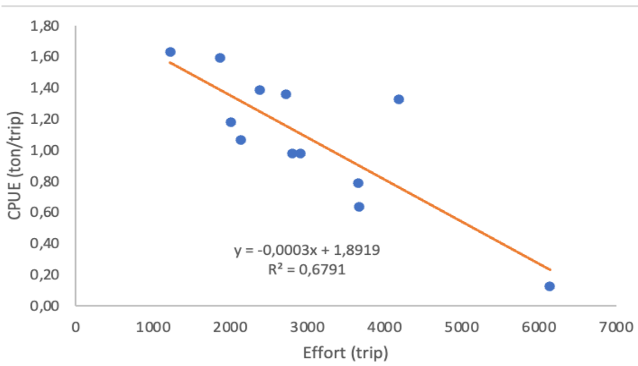

Figure 2. Relationship between CpUE and effort based on Schaefer Model

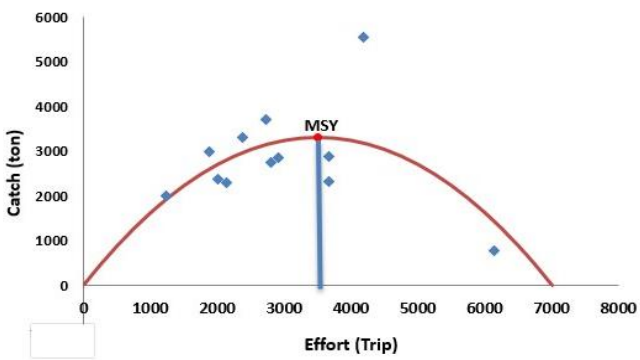

Figure 3. Relationship between catch and effort based on Schaefer Model

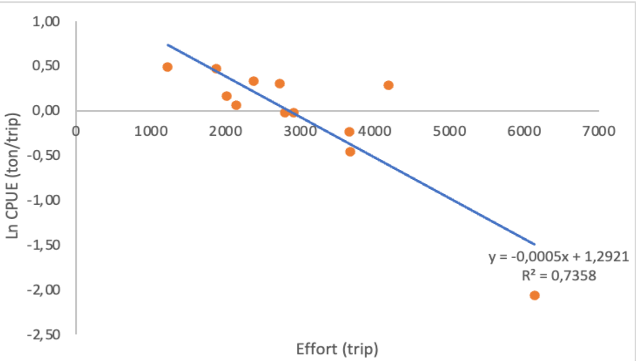

Figure 4. Relationship between Ln CPUE and effort based on Fox Model

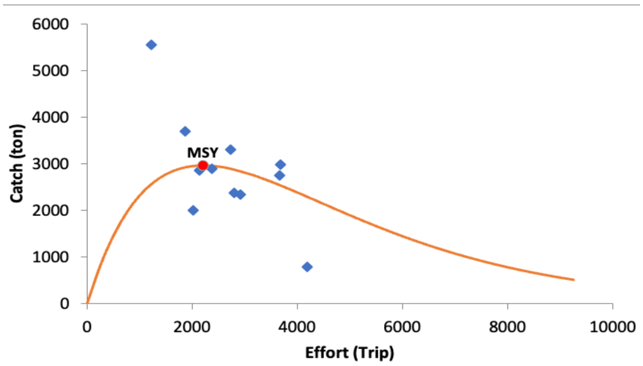

Figure 5. Relationship between catch and effort based on Fox Model

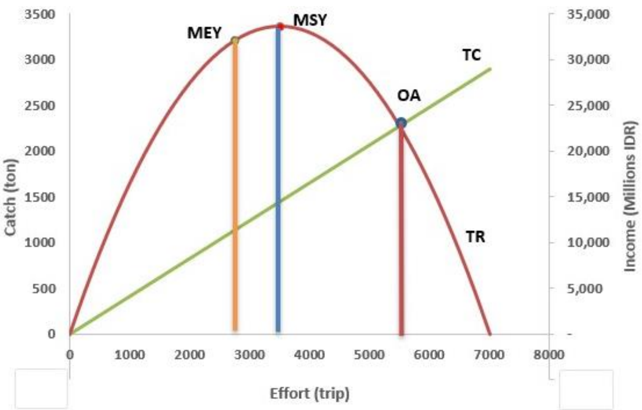

Figure 6. Gordon Schaefer's sustainable economic curve

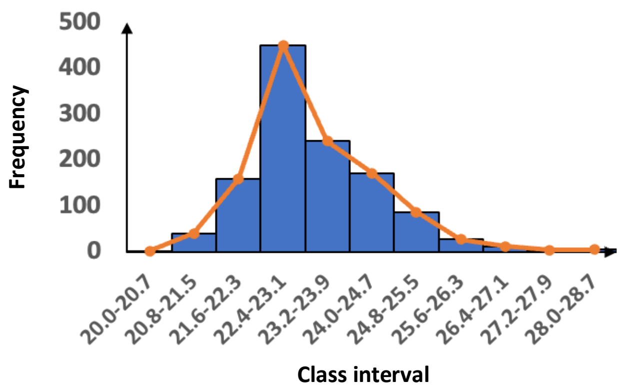

Figure 7. Length frequency of bullet tuna (*Auxis rochei*)

Length-weight relationship

Analysis of the length-weight relationship of bullet tuna from samples of as many as 1,200 fish taken during February-March 2020 informed that length and weight ranged from 20.8 cm to 28.7 cm and 79 g to 252 g, respectively (Figure 7). This analysis also obtained that the length-weight relationship equation is $W = 0.0117\ L^{2.9687}$ and $R^2 = 0.8335$ (Figure 8). Justification of the length-weight relationship condition was done through the t-test analysis, which informed that the value of the t-count (0.82) was higher than that of the t-table (1.96). It was concluded that H_0 was accepted, which meant that the growth pattern of bullet tuna caught in the east area of Bali Strait was isometric, so there was a balanced growth in length and weight (Figure 8).

Discussion

The external factor is one of the elements that can influence the fall in catch fisheries productivity. These variables include sea surface temperature, rainfall, typhoons, and wind speed. The main cause of the loss in fisheries production is increased sea surface temperature. Furthermore, the existence of fish, the number of fishing efforts, and the success rate of fishing operations strongly impact the fall in fishery production (Nguyen 2022).

The CPUE value is opposite to effort, where increasing effort will decrease CPUE. This happens because resources will tend to decrease if fishing continues to increase. While the amount of CPUE can be used as an indicator of the efficiency level of fishing technology, or it can be interpreted as a large CPUE that will describe a good level of effort capability. The more efforts made, the lower the CPUE obtained (Habib et al. 2014).

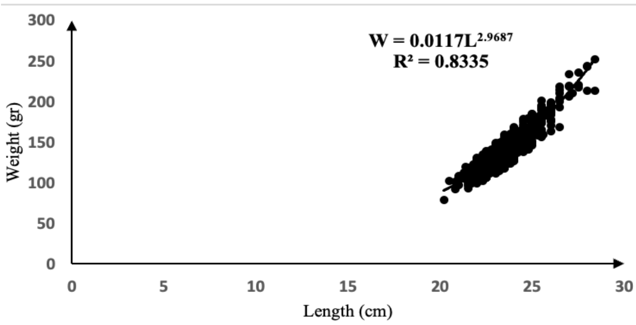

Figure 8. Length-weight relationship of bullet tuna (*Auxis rochei*)

The addition of effort not accompanied by an increase in the catch of bullet tuna will cause a decrease in the CPUE value. The decrease in CPUE indicates that the utilization of bullet tuna resources in the waters of the Bali Strait is already high. In this condition, the increasing effort will cause the catch of bullet tuna in the following year to decrease. This is due to the limited stock of fish resources that are jointly sought, so the catch for each fishing vessel is getting smaller, along with the number of ships entering the waters (Zhou et al. 2015).

Fishery resources have a renewable nature. However, the update process takes quite a long time. If the exploitation process exceeds the ability of fishery resources to renew themselves, it can result in these resources becoming depleted and non-renewable (Cinner and McClanahan 2006). The increase in fishing effort by fishermen is thought to be because they consider the higher the catch. This happens because continuous fishing will not allow fish to grow and reproduce, so the catch obtained decreases (Froese et al. 2016).

Utilization rates that exceed MSY will threaten the sustainability of fish resources (Agus et al. 2018). As a result, the availability and viability of fishery resources will be disrupted, and stocks will decrease. This will certainly be detrimental to all parties who depend on the economic sector in the fisheries sector (Santoso et al. 2015). Efforts that can be made if a fishery resource has been overfished include establishing regulations regarding restrictions on the size of fish that can be captured through mesh-size limits.

Based on the results of sustainable economic analysis, the maximum catch is 3,314 tonnes/year, with an effort of 3,503 trips year^{-1}. This value is the maximum production on the utilization of bullet tuna, which can be done without disturbing its sustainability. The utilization of bullet tuna in MEY conditions obtained a maximum profit of 20,715.3 million IDR or 1,391.3 million USD with a production of 3,160 tonnes/year and an effort of 2,750 trips/year. The profit obtained in the MEY condition is greater than that of the MSY condition, which is 19,161.8 million IDR or 615,3 thousand USD, and OA condition, where the profit was zero. The advantage is the optimal profit, both economically and socially. The effort required to reach the optimum MEY point is smaller than the MSY point, so the MEY point is more friendly to the environment (Guillen et al. 2013).

OA equilibrium is perfectly demonstrated by the dynamics of expenditure and income, which indicate that both fisheries are moving toward zero profit since the expenditure is equal to the income (Ba et al. 2017). Compared to MSY and MEY conditions, the required level of fishing effort in OA conditions is much larger, while the total catch produced is smaller. This refers to Gordon's theory which states that a lot of effort characterizes the balance of OA with a small total catch.

The results showed that the bullet tuna in the East area of Bali Strait had an isometric growth pattern where the increase in length was directly proportional to the increase in weight. This indicated that the bullet tuna fish had a proportional body. This result is similar to the study in the Banda Sea, which showed that the growth pattern of bullet tuna was also isometric (Amri et al. 2019). Factors that influence fish growth patterns are temperature, salinity, food supply, genetics, sex, age of fish, and density (Bœuf and Payan 2001; Denderen et al. 2020; Denechaud et al. 2020). Different b values can also be affected due to the level of gonad maturity, seasonal differences, and fishing activities in an area that affect fish population growth with a fairly high number of fishing activities (Pillin and Tawari 2015). Finally, it can be concluded that the bullet tuna caught in the East area of Bali Strait has an isometric growth pattern, meaning the fish has a proportional body. Meanwhile, bullet tuna's Length at First Maturity (Lm) is 28.39 cm, natural mortality is about 1.17/year, and the exploitation rate E is 0.17/year (Lelono and Bintoro 2019).

The estimation of bullet tuna resources shows that sustainable production in the East area of Bali Strait is 3,314 tonnes year^{-1}, the optimum fishing effort is 3,503 trips/year, and the total allowable catch is 2,651 tonnes/year. The economic rent is 33,520.0 million IDR or 2,251.3 million USD. Meanwhile, in MEY conditions, production reached 3,160 tonnes/year, with fishing efforts as much as 2,750 trips/year and profit reaching 20,715.0 million IDR or 1,391.3 million USD. Balanced condition or open access is achieved at a production level of 2,237 tonnes/year with a fishing effort of 5,500 trips/year. The utilization rate of bullet tuna in the east area of Bali Strait showed over-exploited conditions due to a very high exploitation level, as big as 209%. This result is under the study conducted in Talaud Waters, North Sulawesi, which obtained that the exploitation level of bullet tuna is over-exploited (Kekenusa et al. 2015). Meanwhile, the study in the South Indian Ocean of Sumbawa found that bullet tuna's exploitation level is fully exploited (Asrial et al. 2020).

In conclusion, this research provided information about sustainable exploitation levels and maximum economic yield. The catch values at MSY, TAC, and MEY levels were 3,314 tonnes year^{-1}, 2,651 tonnes year^{-1}, and 3,160 tonnes year$^{-1,}$ respectively. In contrast, the value of the maximum possible profit that can be achieved was 20,715.30 million IDR or 1,391.30 million USD. Another analysis showed that fishing activity had zero profit when catch and effort reached 2,237 tonnes year^{-1} and 5,500 trips year$^{-1,}$ respectively. Additionally, other findings informed that the growth pattern of fish was negatively allometric, which meant that growth weight was slower than growth length. In contrast, the status of the bullet tuna resources based on exploitation level was in over-exploited condition.

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