Asian Journal of Aquatic Sciences, April 2024. Vol 7, Issue (1) 44-51

e-issn: 2716-4608
p-issn: 2655-366X

POTENTIAL AND UTILIZATION LEVEL OF KRAI TUNA (*Auxis thazard*) LANDED AT SIBOLGA ARCHIPELAGO FISHING PORT NORTH SUMATERA PROVINCE

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ABSTRACT

Krai tuna (*Auxis thazard*) is the most dominant catch in Sibolga Archipelago Fishing Port and has economic value, so the community widely consumes it. The magnitude of the potential of fisheries in Sibolga makes it important to analyze the stock of krai for the development and processing of the capture fisheries sector. The research method used is the survey method, the data needed is secondary data in the form of catch data and fishing effort for seven years (2016-2022), the data analysis used is the surplus production method with the Schaefer and Fox model approach, From the results of the study, it was concluded that the sustainable potential of krai using the production surplus approach method is more suitable using the Schaefer approach model because it has a low JTB of 1508 tons with a utilization rate status of 98.94% and is already in a fully-exploited condition or has reached the saturation point (catch-intensive). Utilization is almost near saturation point, so it is necessary to reduce fishing effort so that the catch remains and stock availability is maintained.

Keywords: Krai tuna, Utilization, Surplus production

1. INTRODUCTION

The Sibolga Archipelago fishing port is a type of fishery found on the west coast of Sumatra. Fishing ports are important infrastructure and centers of economic growth and development in the western region of Indonesia, which are based on fishing activities, making fishing ports a meeting point between fishing activities at sea and fishing activities on land[1].

Various fishing gear used at the Sibolga Nusantara Fisheries Harbor include purse seines, boat charts, gill nets, hand lines, and traps. Among the five fishing gears with the highest catch results are purse seines, boat charts, and hand lines. Purse seines are considered one of the most effective fishing tools for catching fish species[1].

Krai tuna (*Auxis thazard*) is the most dominant catch in the Sibolga archipelago fishing port. It has economic value, and the public widely consumes it. This results in high consumer demand in the market, so fishermen carry out fishing on a large scale, which can later disrupt the growth cycle and decrease the population. Catching krai is increasing every year with a variety of fishing gear. Krai cob is an essential economic value in Indonesia, and one of its distribution areas is in West Sumatra, especially in the waters around Sibolga[3].

Based on the annual report on the catch of krai fish at the Sibolga Archipelago Fisheries Port, production data shows a fluctuating trend. Production reached 2.140 tons in 2016, 953 tons in 2017, 1.956 tons in 2018, 2.480 tons in 2019, 2.732 tons in 2020, 1.547 tons in 2021, and 1.420 tons in 2022. These data show the considerable fisheries potential in the Sibolga archipelago fishing port, which makes it essential to analyze the stock of krai for the development and processing of the capture fisheries sector.

Seeing this problem, a study is needed to understand the status of fish stocks in the Sibolga archipelago fishing

Received : 17 January 2024
Accepted : 9 March 2024

e-issn: 2716-4608
p-issn: 2655-366X

port, especially the presence of krai tuna in the coastal waters of the west coast of Sumatra. The policy for sustainable management of krai tuna resources is well supported by information and data regarding its potential and level of utilization. Research on potential and utilization levels is the primary basis for developing management strategies for sustainable resource use.

2. RESEARCH METHOD

Time and Place

The research was conducted for two months, from July to August 2023, at the Sibolga Archipelago Fishing Port, Tapanuli Tengah Regency, North Sumatra Province.

Methods

The method used in this research is a survey method, namely, going directly to the field at the Sibolga Archipelago Fishing Port.

Procedures

The data collected is in the form of secondary data. Secondary data was obtained from the Sibolga Archipelago Fishing Port. Secondary data includes catch and effort data for krai fishing gear over seven years (2016-2022).

Data Analysis

Study the potential and utilization of krai tuna resources at the Sibolga Archipelago Fisheries Port using quantitative and descriptive analysis. The quantitative analysis calculates the maximum sustainable catch potential value using the production surplus approach with the Shaefer and Fox model. The descriptive analysis explains the sustainable potential condition and krai tuna resources' utilization level at the Sibolga Archipelago Fishing Port.

Analysis of Standardization of Efforts (FPI)

The fishing effort is the multiplication of the number of fleets (fishing vessels) by the number of trips to sea. The CPUE (s) and FPI (s) calculation is as follows[4]:

$$CPUE(s) = \frac{\text{Catch (s)}}{\text{Effort (s)}}$$

Information:
Catch (s) : Total catch
Effort (s) : Total capture attempts

$$FPI(s) = \frac{Catch\ (s)}{CPUE}$$

Information:
Catch (s) : Total catch
CPUE : Catch per fishing effort

Analysis of Maximum Sustainable Potential Value (MSY)

The Schaefer and Fox model estimates the MSY of fishery resources and optimal fishing effort. The magnitude of parameters a and b can be found mathematically using a simple regression equation with the formula[4] :

$$Y = a + bx$$

Information:
a : intercept
b : slope

Next, parameters a and b can be searched using the formula:

$$a = \frac{(\sum Y) - b(\sum f)}{n}$$

$$b = \frac{n \sum f.Y - (\sum f)(\sum Y)}{n \sum f^2 - (\sum f^2)}$$

Information:
x : Catching attempts in the period
y : Catch per unit effort in the period
n : Number of samples

The magnitude of parameters a and b can be found mathematically using a simple regression equation[4].

Model Schaefer (Model Linear)

The relationship between fishing effort and catch per unit effort: CPUE = a + bf. a and b are the intercept and slope, respectively, and the relationship is linear. Thus, the equation of the relationship between catch and fishing effort is: C = of + bf^2

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

$$C = of + bf^2$$

$$C = a + 2bf = 0$$

$$f_{opt} = - (a/2b)$$

a and b are, respectively, intercept and slope. Maximum sustainable catch (MSY) is obtained by substituting the value of optimum fishing effort to obtain:

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

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

Fox Model (Exponential)

According to Sparre & Venema[4], the relationship between fishing effort and catch per unit effort: CPUE = exp (c + df)

c and d are, respectively, the anti-natural logarithm (Ln) of the intercept or the regression efficiency of the relationship between Ln CPUE and fishing effort, which is linear. The relationship between effort and catch is: $C = f^{\exp(c + df)}$

Optimum fishing effort (fopt) is obtained by equating the first derivative of catch to fishing effort equal to zero:

$$Fopt = -(1/d)$$

d is the anti-Ln regression coefficient of the relationship between Ln CPUE and fishing effort. Maximum sustainable catch (MSY) is obtained by substituting the value of optimum fishing effort so that:

$$MSY = -(1/d) \exp(c-1)$$

Rate of Utilization

According to Sparre & Venema[4], the utilization rate expressed in percent (%) is obtained using the formula:

$$TP(i) = (Ci/MSY) \times 100\%$$

Information:
TP(i) = Utilization rate of year i
There = catch of year i
MSY = Maximum sustainable yield

Rate of Ability

In calculating the level of fishing gear effort, the thing that must be done is to determine the optimum fishing effort. The level of effort is calculated by dividing the number of fishing trips by the optimum fishing effort value[5]. The equation used is as follows:

$$T_{could} = \frac{be}{fopt}$$

Information:
T_{could} : Level of empowerment
be : Attempts to capture the ith year
Fopt : Optimum fishing effort.

This is done to prevent the extinction of resources due to excessive exploitation and to encourage the creation of highly effective fishing activities without damaging the sustainability of these resources[6].

On the other hand, managing utilization rates by considering the enrichment level can maintain the sustainability of the resource in the future.

3. RESULT AND DISCUSSION

Production of Krai Tuna at PPN Sibolga can be seen in Table 1.

Table 1. Production (kg) of Krai Tuna (*Auxis thazard*) at PPN Sibolga

Years	Purse Seine	Lift Net	Hand Line
2016	1.907.240	231.540	1760
2017	612.140	180.580	1700
2018	1.735.940	207.810	11.850
2019	2.269.090	190.370	20.450
2020	2.493.310	222.920	15.800
2021	1.441.863	87.680	17.330
2022	1.334.166	59.050	20.630
Amount	11.793.749	1.179.950	89.520
Average	1.684.821,286	168.564,286	12.788,571

Based on the Table 1, it can be seen that the production of krai tuna tends to change. The highest catch of krai tuna caught by fishing gear purse sein was found in 2019, amounting to 2.269.090 kg; where in 2017, the catch was very low, namely

612.140 kg, but in the following year it increased then in 2022 it decreased again, namely 1.334.166 kg, the cause of this decrease was due to pressure in the form of indications decline in water quality (physics, chemistry, biology), excessive fishing activities (overfishing), and destructive fishing patterns (destructive fishing).

Data on catches of krai tuna landed at Sibolga archipelago fishing port in 2016-2022 cannot be used as the only measure that can explain or reflect the abundance of this resource. This is because many factors, such as fishing effort, season, weather, fishing gear technology, fishing techniques, and the success rate of fishing operations, influence the catch fluctuations. Therefore, one of the appropriate approaches to estimate the abundance of krai tuna resources is to calculate the catch per fishing effort or catch per unit effort (CPUE).

Based on KEPMEN KP RI No. 121 in 2021 concerning the Krai Tuna, Skipjack, and Management Plan, the estimated potential and utilization rate of frigate tuna in 11 WPPNRI in the form of maximum sustainable production / MSY has not been determined. Total production in 2018 was 54.446 fifty-four thousand four hundred forty-six) tons and production from 2005-2018 averaged 144.179 tons/year. In this case, the utilization rate of krai tuna until 2018 is uncertain.

Table 2. CPUE of Krai Tuna (*Auxis thazard*)

	CPUE (kg/Trip)		
Years	Purse Seine	Lift net	Hand line
2016	1011.178	213.598	3.340
2017	359.026	183.330	3.052
2018	938.853	168.404	25.817
2019	1255.028	143.459	45.852
2020	1426.379	184.079	38.257
2021	848.654	92.004	43.763
2022	902.073	61.962	56.987
Amount	6831.191	1046.836	216.912
Average	975.884	149.548	30.987

Based on Table 2 shows that changes in CPUE values over seven years tend to fluctuate. The highest CPUE occurred in 2019 and 2020, namely 1255.028 kg/trip and 1426.379 kg/trip produced by fishing gear purses, while the lowest CPUE was produced by handline fishing at 3.052 kg/trip in 2017.

Model Schaefer

The trend of CPUE value on the fishing effort of krai in Sibolga archipelago fishing port over seven years (2016-2022).

The relationship effort and CPUE of Krai tuna in Sibolga Archipelago Fishing Port for 2016-2022 obtained a linear result equation y = -0.5291 + 1997.8 with R2 = 0.0995 (Figure 1). The regression coefficient (b) of 0.5291 states a negative relationship between production and effort, and each subtraction (because of the negative sign) is one trip effort, which will cause CPUE to increase by 0.5291 kg/trip. However, effort increases by one trip, and CPUE is also predicted to experience a decrease in production of 0.5291 kg/trip. If the negative sign (-) indicates the direction of the relationship is inverse, then an increase in variable X will decrease variable Y and vice versa. The coefficient of determination (R^2) is 0.0995 or 09.95%. This means that the variation or rise and fall in CPUE of 09.95% is caused by the rise and fall of the effort value, while the remaining 98.05% is caused by other variables not discussed in this research. The correlation coefficient (R) of 0.31 indicates that CPUE and effort have a moderate relationship. Level of utilization and empowerment

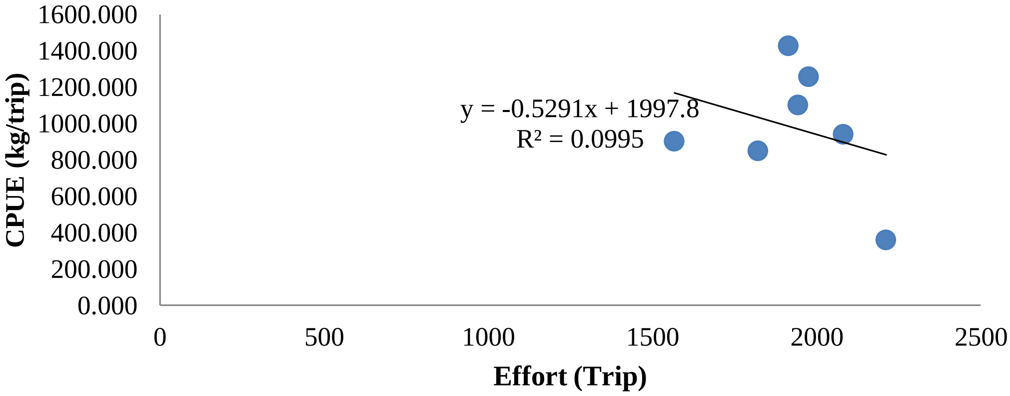

Figure 1. Relationship between CPUE and Effort

Knowing the value of optimum fishing effort (Fopt) and optimum catch yield (MSY) of krai tuna, the level of utilization and effort in the last seven years can be known. Based on the correlation value of determination (R^2) of 0.995 or 09.95%, the correlation value between variables is "very low". This is following the statement from Sugiyono[7] regarding the interpretation value of the correlation coefficient that 0.00 – 0.199 is a very low relationship, 0.20 - 0.399 is a low relationship, 0.40 - 0.599 is a medium relationship, 0.60 - 0.799 is a strong relationship and 0.80 - 0.100 is a very strong relationship.

Based on the CPUE (Catch per Unit Effort) value fluctuates from 2016-2022. The highest CPUE value in 2020 was 0.86 kg/trip, and the lowest in 2017 was 0.24 kg/trip. The high and low CPUE values occurred because, during this period, there were additions and reductions in the use of fishing gear and fishing trips (effort). The highest increase in CPUE value occurred in 2018-2020, with an increase of 0.32 kg/trip. In 2017, the CPUE value experienced depletion because the previous fishing effort was so high that the fish resources obtained decreased. However, in the following years, CPUE increased, and fish resources recovered.

Level of Utilization and Ability Krai Tuna (*Auxis thazard*)

Knowing the value of optimum fishing effort (Fopt) and optimum catch yield (MSY) of krai tuna, the level of utilization and effort in the last seven years can be known.

The average utilization rate of krai tuna is 98.949%, with utilization status in categories fully exploited. This means krai tuna can still be utilized at 1.051% of its maximum sustainable potential or 19.821.686 kg. The average level of effort for krai tuna fish is 102.303%. This means that the level of effort for krai tuna fish is excessive for 2.303% of the optimum fishing effort or 43 trips/year.

Fisheries resources that are not used optimally by fishermen cause losses to existing resources[8]. On the other hand, the level of utilization that is used to the maximum, even exceeding the limit, will impact fish resources in the Sibolga archipelago fishing port waters. Based on the data that has been processed, the results show that in 2016, 2018, 2019, and 2020, the utilization rate was 113.497%, 103.691%, 131.491%, and 144.859%. This shows that in that year, there were more fishing efforts (over-exploited).

Although in some years it happens to over-exploited, which could be a factor in overfishing, in the last seven years, namely in 2016-2022, the average level of

e-issn: 2716-4608
p-issn: 2655-366X

utilization of krai tuna in PPN Sibolga has almost reached the optimum level of potential sustainable resources (MSY) of tuna; namely, 98.949% in the status category fully-exploited.

Table 3. Rate of Utilization and Ability of Krai Tuna in PPN Sibolga

Years	Catch Total (kg)	Total Std. Effort	Standard CPUE	Fopt	MSY	Utilization rate (%)	Ability rate (%)
2016	2.140.540	1944	1107.178			113.497	102.954
2017	794.420	2213	359.026			42.122	117.193
2018	1.955.600	2083	938.853			103.691	110.322
2019	2.479.910	1976	1255.028	1888	1.885.983	131.491	104.655
2020	2.732.030	1915	1426.379			144.859	101.445
2021	1.546.873	1823	848.654			82.019	96.539
2022	1.413.846	1567	902.073			74.965	83.012
Amount	13.063.219	13.521				692.647	716.124
Average	1.866.174	1931				98.949	102.303

According to FAO[9], the optimum utilization level is if the catch has reached a part of the sustainable potential (66.6% - 99.9%). Additional effort cannot increase the yield. Suppose the percentage utilization rate value (>100%) indicates that the catch exceeds the existing MSY value and is included in the overfishing category. In that case, this follows the opinion of Kartini et al.[10], which states that reducing and increasing efforts depends on the sustainable potential and level of utilization in the previous year.

To overcome overfishing conditions that exceed the environment's carrying capacity, it is necessary to take a precautionary approach through which the Total Allowable Catch (TAC), known as the number of permitted catches (JTB), can be applied. JTB or TAC is 80% of the maximum sustainable catch. So, the JTB for fisheries in Sibolga archipelago fishing port is 1508 tons. This JTB will be enough to overestimate (This is expected to ensure the sustainability and availability of tuna resources throughout the year.

The data above is supported by analyzing research results based on annual production data in the Sibolga archipelago fishing port by implementing the Schaefer model formula. This study also uses the Fox model in stock estimation. The difference between the Fox and Schaefer models lies in the values of a and b, wherein in the Fox model, the equation is obtained from the regression results of the anti-natural logarithm (Ln) of CPUE (as variable Y) and standard effort (as variable X).

The Schaefer model chart shows that the sustainable potential value is 1.885.983 kg with an optimum fishing effort of 1888 trips. In 2016, the catch was 2.140.540 kg. In 2018, the catch was 1.955.600 kg; in 2019, the catch was 2.479.910 kg; in 2020, the catch was 2.732.030 kg, all outside the MSY reflection line. This means that the catch in that year has exceeded the maximum sustainable potential value (MSY), whereas, in 2017, the catch was 794.420 kg; in 2021, the catch was 1.5546.873 kg; and in 2022, the catch was 1.413.846 kg, the catch in these three years is still within the MSY line, which means the catch has not exceeded the maximum sustainable potential value and is still within safe limits. Hence, it still has the potential to be developed. The permitted catch is 1508 tons.

The following are different images from the graph results of the MSY and Fopt values in the Schaefer and Fox models. The Fox model's sustainable potential value is 2,204,401 kg with an optimum fishing effort of 1051 trips. In 2016, 2018, 2019, and 2020, the catch has passed the MSY reflection, which means it has exceeded the estimated sustainable potential value, while in 2017, 2021, and 2022, the catch is still within the MSY line, which means the catch is below the MSY value even though the fishing effort made has exceeded the optimum effort value. The allowable catch for the Fox model is 1763 tons.

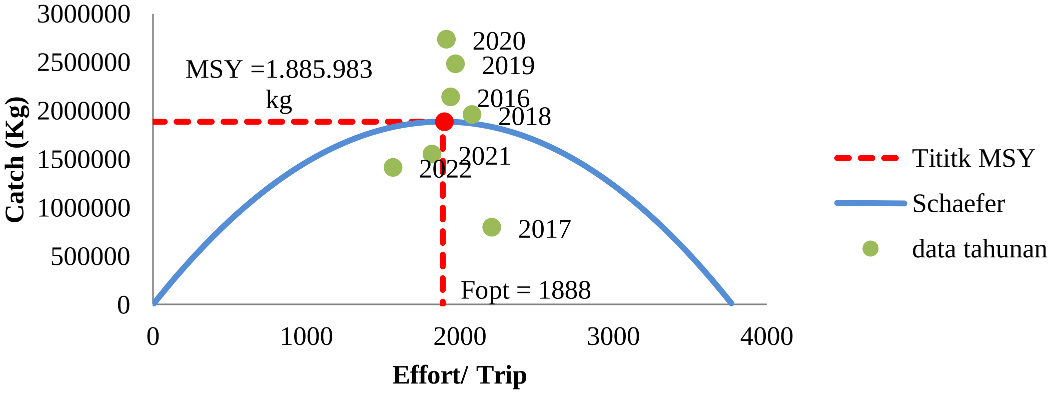

Figure 2. Schaefer Model MSY and Fopt Chart

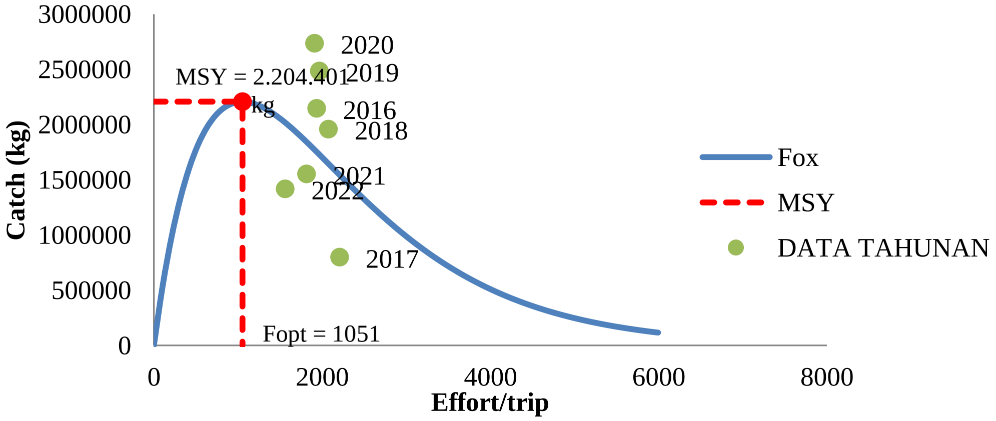

Figure 3. Fox Model MSY and Fopt Chart

Table 4. Comparison of the Schaefer and Fox Models in Determining the Best Model

Mark	Schaefer	Fox
Sign Conformity	In accordance	In accordance
Coefficient	0.0995	0.1855
Validation	-0.9994	-21.9288
MSY	1.885.983.474 kg	2.204.400.737 kg
Fopt	1888 trip	1051 trip
JTB	1.508.786.779 kg	1.763.520.590 kg

The 2019 fish stock assessment book explains that the criteria for selecting the best model is the model with the lowest average validation estimate value. According to Passingi11, the best model to use is the model with the lowest JTB. So, in these two models, the most suitable model to use to estimate the potential of the tuna krai fishery in the Sibolga archipelago fishing port is the Schaefer model where which model has the lowest average validation estimate value, namely with a value of -0.9994 and with a value of the Number of Allowable Catches (JTB) was the lowest, namely 1.508.786.779 kg.

4. CONCLUSION

The research results concluded that the sustainable potential of krai tuna at the Sibolga Archipelago Fishing Port using the production surplus approach method is more suitable for the Schaefer approach model. The sustainable potential value of krai tuna amounts to 1.885.983.474 kg per year and an optimum effort of 1888 trips per year. The average value of the utilization rate for krai tuna is 98.949%, with the utilization status fully exploited. This means krai tuna can still be utilized at 1.051% of its maximum sustainable potential or 19.821.686 kg. The average level of effort for krai tuna is 102.303%. This means that the level of effort for krai tuna is excessive for 2.303% of the optimum fishing effort or 43 trips/year. The total allowable catch is 1.508.786.779 kg. Utilization is almost approaching saturation point, so it is necessary to reduce fishing efforts so that catches remain available and stock availability is maintained.

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