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Status of pink ear emperor (*Lethrinus lentjan*) fishery in the Sinjai and Bone waters, South Sulawesi, Indonesia

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Abstract

The pink ear emperor (*Lethrinus lentjan*) is a type of coral fish belonging to the *Lethrinidae* family, they usually eat mainly at night, namely benthic invertebrates or fish. *L. lentcan* included in the main family of food coral fish that live in coral reef ecosystems and in sandy bottom coastal waters. Good management of fisheries resources is by utilizing fish populations without having to deplete fishery resources. If fishing is carried out continuously without taking into account the ability to renew, over exploitation will occur. The research was conducted from March to May, 2023, in Sinjai and Bone waters, south sulawesi Indonesia which focused on fishing ports with *L. lentjan* landing potential. The highest class length was obtained in Sinjai Regency and in Bone regency which was negative allometric. Lc in Sinjai regency uses basic gillnet, and in Bone regency 21.9 uses basic longline. Gender comparison between *L. lentjan* males and females in Sinjai regency is 45% : 55%. Meanwhile for Bone regency it is 41% : 59%. *L. lentjan* males and females have a ratio of 1: 1.43 with the results of the chi square test $t_{count} < t_{table}$, this condition shows that H_0 accepted, there is no real difference between the number of male and female biota. gonad maturity level *L. lentjan* in Sinjai regency it is 24 cm with a length range of 23 – 25 cm, and in Bone regency it is 24.6 cm with a length range of 24-25 cm.

Keywords: *L. lentcan*; Biological Aspect; Reproductive Aspect; Fishery Aspect

1. Introduction

The area of Indonesia's marine waters is estimated to reach 5.8 million km^2 with a coastline length of 81,000 km^2 and is known to have quite high potential for biological resources, including fisheries biological resources [1]. Coral reef ecosystems function as a source of nutrients for organisms in the ecosystem. Apart from that, coral reefs also function as coastal protectors from degradation and abrasion. The biota that live on coral reefs consists of various types of organisms such as coral fish, molluscs, crustaceans, sponges, algae, seagrass and other biota [2].

The pink ear emperor (*Lethrinus lentjan*) is a type of coral fish belonging to the family *Lethrinidae* [3]. *L. lentjan* is a carnivorous fish, coastal fish, which ranges on or near coral reefs. They usually feed mainly at night on benthic invertebrates or fish [4, 5].

L. lentjan included in the main family of coral fish for consumption and are one of the largest contributors to production in the coral reef ecosystem [6]. *L. lentjan* lives in coastal waters, sand bottoms, generally measuring 25 to 35 cm and can reach a length of 40 cm [7]. Good management of fisheries resources is by utilizing the population *L. lentjan* without having to completely deplete the fisheries resources.

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If the management of fisheries resources is carried out by fishing continuously without taking into account the ability of these resources to renew, it will result in overfishing [8] which results in longer fishing times, fishing locations are farther away, catch per unit effort (CPUE) decreases, and fishing costs increase, causing fishermen's profits to decrease [9].

2. Material and methods

2.1. Method of collecting data

The research was conducted from March to May, 2023, in Sinjai and Bone waters, South Sulawesi, Indonesia which focused on fishing ports with *L. lentjan* landing potential. Data collection is divided into primary data and secondary data. The method used during the research was the survey method, by visiting fishing boats to take samples, taking fish samples based on the ships that landed, observing, measuring and dissecting the fish samples. Data collection is carried out by recording the data used.

2.2. Data analysis

2.2.1. Frequency Distribution

The length frequency distribution is obtained by determining the number of class intervals with the frequency of each class. The frequency distribution of lengths that have been determined in the same class interval is then plotted in a graph [10] and arranged according to certain interval classes or according to certain categories in a list [11].

2.2.2. Length Weight Relationship

Calculation of the length-weight relationship is carried out with the aim of estimating the growth pattern of aquatic organisms [12]. The relationship between length and weight follows the cubic law pattern, namely that the weight of the fish is the cube of its length. Length and weight analysis was carried out to determine growth patterns using an exponential relationship model [13]. The relationship between length (L) and weight (W) of fish can generally be expressed by the equation [14]:

$$\boldsymbol{W = a.L^b}$$

Then the transformation is carried out into logarithms, into linear equations or straight lines so that the equation becomes [15]:

$$\boldsymbol{Ln\,W = Ln\,a + \mathbf{b\ Ln\ L}}$$

Information :

W = fish body weight (grams);
L = Fish body length (mm);
a and b = Constant

Parameters a and b are obtained from regression analysis with Ln W as 'y' and Ln L as 'x', so that the following regression equation is obtained [16]:

$$\mathbf{Y = a + bX}$$

Information:

Y = Dependent variable (dependent variable)
X = Independent variable (independent variable)
a = Constant (value of Y when X = 0)
b = Regression coefficient (positive or negative influence)

The values a and b are obtained from regression analysis with Ln W as the y axis and Ln L as the x axis. To find out the value of b=3 or b≠3, a t-test is carried out with the following hypothesis:

H_0 : Isometric growth (b=3), namely the growth of the fish is proportional to the increase in weight.
H_1 : Allometric growth (b≠3), b < 3 means growth is negative allometric, i.e. length growth is faster than weight growth, b > 3 means growth is positive allometric, i.e. weight growth is faster than length growth.

The collection rules are as follows:
$t_{count} > t_{table}$: reject
$t_{count} < t_{table}$: accept

To test whether b is the same or the same as 3, it is tested using the t_{test} :

$$\mathbf{t_{count}} = \frac{\mathbf{3-b}}{\mathbf{S^2}}$$

S^2 = estimation of the variance of the length-weight relationship equation and b is the exponent of the length-weight relationship. The t-test is used to test the increase in length where b = 3 [17]. From this equation, the growth pattern of the fish can be seen by looking at the b value obtained:

1. If b = 3, growth is isometric, that is, the increase in length is the same as the increase in weight.
2. If b > 3, then the growth pattern is positive allometric, that is, the increase in weight is faster than the increase in length.
3. If b < 3 then the growth pattern is negative allometric, that is, the increase in length is faster than the increase in weight

2.2.3. Length at First Caught (Lc50%)

The Lc value is obtained by plotting the percentage of the cumulative frequency of caught fish with the length of their forks, where the intersection point between the curve and 50% of the cumulative frequency is the length at fish caught (Lc) [18]. The size of the first catch is calculated using the following equation [19].

$$\boldsymbol{SL}\frac{\mathbf{1}}{\mathbf{1+\exp(\boldsymbol{S1-S2\ x\ L}})}$$

$$\boldsymbol{Ln}\left[\frac{\mathbf{1}}{\boldsymbol{SL}}-\mathbf{1}\right]=\boldsymbol{S1-S2\ x\ L}$$

$$\boldsymbol{L50\%}=\frac{\boldsymbol{S1}}{\boldsymbol{S2}}$$

Information :
SL = logistic curve (length-based tool selectivity)
S1 & S2 = constants in the length-based logistic curve formula
S1 = a
S2 = b

2.2.4. Sex Ratio

To determine the sex ratio, use the following formula [20]:

$$\mathbf{NK} = \frac{\sum \boldsymbol{J}}{\sum \boldsymbol{B}}$$

Information :
NK = sex ratio
$\sum$J = number of male fish (fishes)
$\sum$B = number of female fish (fishes)

After the gender ratio in percentage is obtained, to find out whether there is a real difference between the ratio of male and female individuals, it is carried out through testing and the X^2_{test} (chi square) with the formula according to [21]:

$$\boldsymbol{x}^2=\frac{(\boldsymbol{fo-fh})^2}{\boldsymbol{fh}}$$

Information :

x^2 : chi square
f_o : frequency of biota observed
f_h : expected biota frequency

The X^2_{value} is obtained from this calculation, then the value is compared with the X^2_{table} value with a 95% confidence level of degrees of freedom (db) = 1 (one) with the hypothesis:

H_0 : there is no real difference between the number of male and female biota
H_1 : there is a real difference between the number of male and female biota

If,

$X^2_{count} < X^2_{table}$ = accepted, , rejected
$X^2_{count} > X^2_{table}$ = rejected, , accepted

2.2.5. First Mature Gonad Size (Lm)

Calculated using the Spearman-Karber equation which was developed by Finney (1971) as referred to [22] where:

$$\mathbf{M = X_k + \frac{d}{2} - (d \sum Pi)}$$

Information:

m = Logarithm of the long class at its first maturity
d = The difference in the logarithm of the increase in the middle value of the length
k = Number of long classes
xk = Logarithm of the middle value of the length at which the fish is 100% gonad mature (or where pi = 1)
Analyzing the equation above, Lm can be estimated.

The Lm value is obtained by plotting the cumulative percentage proportion of mature gonad fish with each fish's fork length, the size of the first mature gonad is calculated using the following formula.

$$\mathbf{P = \frac{1}{1+e^{-r(L-Lm)}}}$$

Information :
P: Gonad mammary proportions

2.2.6. Catch Per Unit Effort (CPUE)

CPUE can also be used as an indicator of the level of technical efficiency of effort. In other words, a higher CPUE value reflects a better level of efficient use of effort [23]. The CPUE value is a comparison between catches per unit of fishing effort which is formulated as follows [24]:

$$\mathbf{CPUE = \frac{Cath}{effort}}$$

Information :

Catch (C) = Total catch (kg)
Effort (F) = Total arrest attempts (trips)
CPUE = Catch per fishing effort (kg/trip)

2.2.7. Maximum Sustainable Yield (MSY)

Maximum Sustainable Yield (MSY) is a management parameter produced by assessing fisheries resources. Estimating these parameters requires annual production level data (time series). MSY can be estimated using the Schaefer model with data on catch and fishing effort over several years. MSY can be estimated using the formula [24]:

$$\textbf{Catch Per Unit Effort} = \frac{Y}{f} = \frac{Y(i)}{f(i)},\ i=1, 2, ...n$$

Information :
Y(i) : Catch in year i, i=1, 2, ...n
f(i) : Catching effort in year i, i=1,2, ...n

Determining the value of a (intercept) and b (slope) requires a linear regression of f(i) against Y(i)/f(i). After the values a and b are obtained, the optimum effort (fMSY) and maximum sustainable catch (MSY) can be calculated using the formula.

$$f_{MSY} = -\frac{a}{2b} \text{ dan } MSY = -\frac{a^2}{4b}$$

3. Results and discussion

3.1. Frequency Distribution

Total sample of *L. lentjan* are 717 fish consisting of 405 fish in Sinjai regency and 312 fish in Bone regency, along with maximum and minimum lengths and weights *L. lentjan* in Sinjai regency and Bone regency.

Table 1 Maximum and Minimum Length and Weight of *L. lentjan.*

Location	Amount Sample (fish)	Length (cm)		Weight (grams)	
		Max.	Min.	Max.	Min.
Sinjai regency	405	30	16.5	460	87
Bone regency	312	28	14	459	70

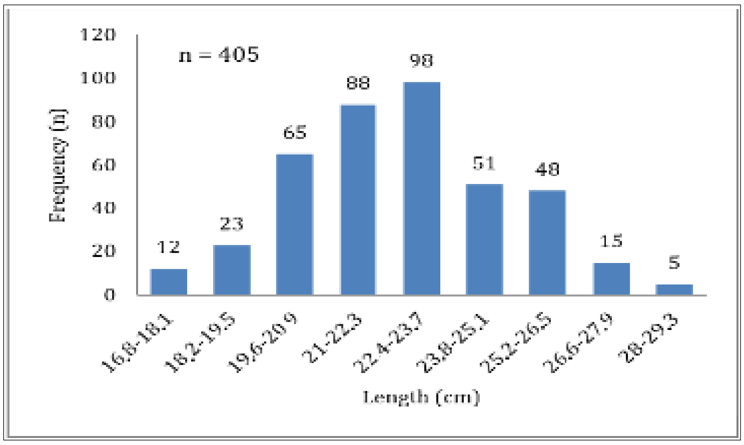

Figure 1 Frequency Distribution of *L. lentjan* Length in Sinjai Regency.

Based on Figure 1, the number of fish sample in Sinjai regency was 405, we obtained the distribution of lengths of *L. lentjan* with the smallest size being between 16.8 to 18.1 cm in 12 samples and the largest size being 28 to 29.3 cm in 5 samples, the length of the dominant class is 22.4-23.7 cm for 98 samples.

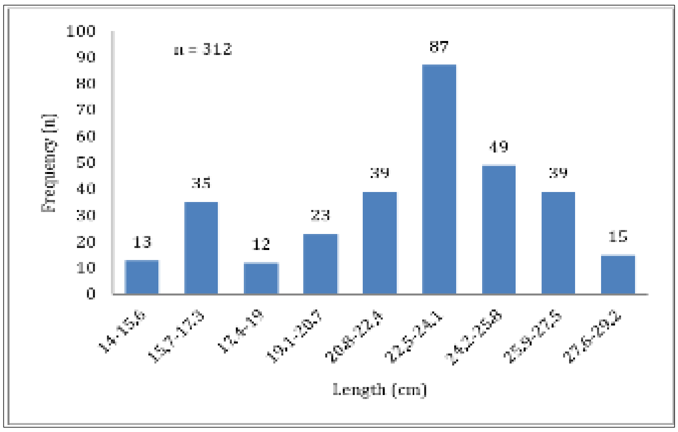

Figure 2 Length Frequency distribution of *L. lentjan* in Bone regency.

Based on Figure 2, the number of fish sample in Bone regency was 312 fish. Length distribution of *L. lentjan* with the smallest size being between 14 to 15.6 cm in 13 samples and the largest size being 27.6 to 29.2 cm in 15 samples, while the dominant class length was 22.5 to 24.1 cm in 87 sample.

3.2. Length Weight Relationship

The results of the analysis of the relationship between length and weight of *L. lentjan* were obtained as many as 405 fish in Sinjai regency and 312 fish in Bone regency. Can be seen in table 2.

Table 2 Relationship between length and weight of *L. lentjan*

Sample	A	b	R^2	r	N	$W = aL^b$	t-test	Nature of Growth
Sinjai regency	9.06	2.22	0.63	0.79	405	$W = 9.06L^{2.22}$	$t_{count} > t_{table}$	Negative allometric
Bone regency	9.25	2.67	0.82	0.91	312	$W = 9.25L^{2.67}$	$t_{count} > t_{table}$	Negative allometric

The results of calculating *L. lentjan* in Sinjai regency were 405 fish with the equation $W = 9.06L^{2.22}$ with a coefficient of determination (R^2) of 0.63, meaning that 65% of the increase in fish body weight occurs due to an increase in body length of the fish. The results of the analysis show a value of $b < 3$, namely 2.22. The b value shows that *L. lentjan* have a negative allometric growth pattern, namely an increase in the length of *L. lentjan* faster than weight gain.

The results of calculating *L. lentjan* in Bone regency were 312 fish with the equation $W = 9.25L^{2.67}$ with a coefficient of determination (R^2) of 0.82, it means that 82% of the increase in fish body weight occurs due to an increase in fish body length. The results of the analysis show that the b value is <3, namely 2.67. The b value shows that the *L. lentjan* has a negative allometric growth pattern, namely the increase in length of the *L. lentjan* is faster than the increase in weight.

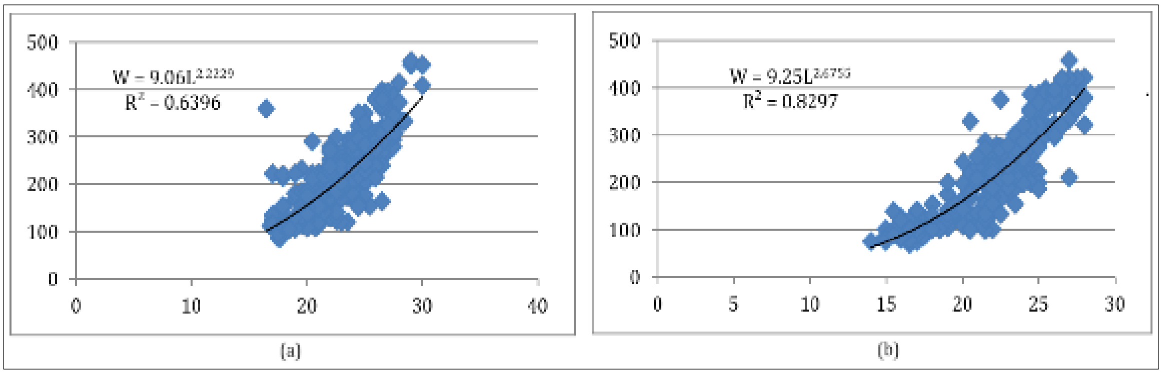

Figure 3 The Relationship between Length and Weight *L. lentjan* in Sinjai regency (a) and Bone regency (b).

Based on the t_{test} at a 95% confidence interval, it was found that the growth pattern of *L. lentjan* in both locations was the same, namely negative allometric.

3.3. Length at first caught (Lc)

Based on the analysis results in Figure 4, it shows that Lc *L. lentjan* in Sinjai Regency uses bottom gillnet, namely 22.6 cm which has a length of between 16.5-30 cm.

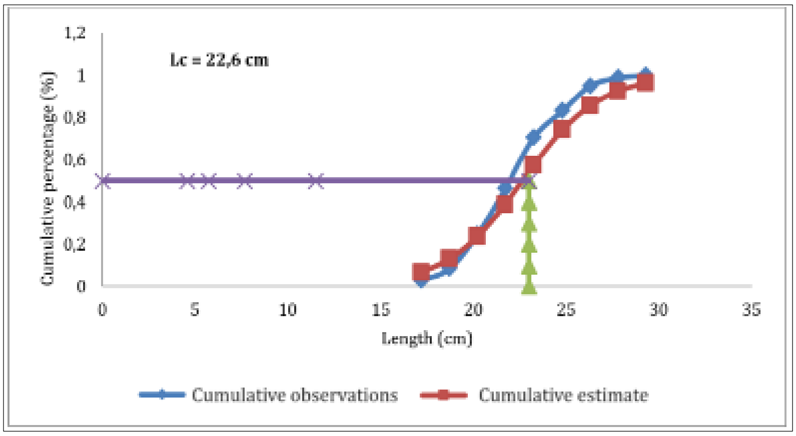

Figure 4 Lc of *L. lentjan* in Sinjai regency.

Based on the analysis results, it was found that the average Lc length of *L. lentjan* in Bone regency using bottom longline fishing gear was 21.9 cm. Calculation of the average size Lc was carried out using the cumulative frequency of each length class of fish caught.

3.4. Sex Ratio

Knowledge of the sex ratio is very necessary to determine the sex ratio so that the population balance of male and female fish can be predicted [25]. In general, fish in the *Lethrinidae* family include the *L. lentjan* belongs to the group of protogynous hermaphrodites, namely species that undergo a change of sex (gonads) from male to female [26]. The number of *L. lentjan* samples dissected during practice in Sinjai regency was 53 samples.

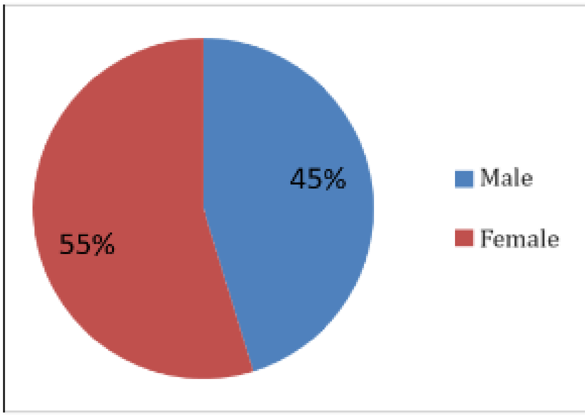

Figure 5 Gender of *L. lentjan* in Sinjai Regency

To determine whether the *L. lentjan* population is in ideal conditions to maintain its sustainability, it is necessary to test the sex ratio value which is 1:1.22 or 45% male versus 55% female. Is the value 1 : 1. This test uses the chi square test with degrees of freedom (db) = 1 and a confidence level of 95%.

Table 3 Chi-Square Test for *L. lentjan* in Sinjai regency

Sample	F_o	f_h	$f_o- f_h$	$(f_o- f_h)^2$	$(fo-fh)^2/fh$	$\sum (f_o - f_h)^2/f_h$	x^2 table
Female	29	26.5	2.5	6.25	0.235849	0.4716	3.84
Male	24	26.5	-2.5	6.25	0.235849		
	53				0.471698		

Based on the results of the analysis (table 3), it was found that t_{count} = 0.4716 and t_{table} = 3.84, so that the chi-square value (x^2_{count}) < chi-square (x^2_{table}) ($x^2_{count} < x^2_{table}$). This condition shows that H_0 It is accepted that there is no real difference between the number of male and female biota. The number of *L. lentjan* samples dissected during practice in Bone regency was 61 samples.

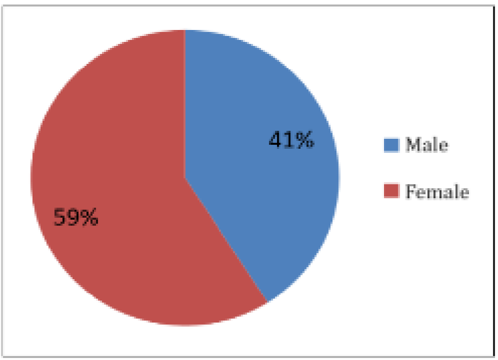

Figure 6 Sex Ratio of *L. lentjan* in Bone regency

To determine the *L. lentjan* population in ideal conditions to maintain its sustainability, it is necessary to test the sex ratio value which is 1:1.43 or 41% males compared to 59% females. Is the value 1 : 1. This test uses the chi square test with degrees of freedom (db) = 1 and a confidence level of 95%.

Table 4 Chi Square Test of *L. lentjan* in Bone regency.

Sample	**F_o**	**f_h**	**f_o- f_h**	**$(f_o$- $f_h)^2$**	***$(fo$-$fh)^2/fh$***	**$\sum (f_o - f_h)^2/f_h$**	**x^2 table**
Female	36	30.5	5.5	30.25	0.991803	1.9836	3.84
Male	25	30.5	-5.5	30.25	0.991803		
	61				1.983607		

Based on the results of the analysis (table 4), it was found that t_{count} = 1.9836 and t_{table} = 3.84, so that the chi-square value (x^2_{count}) < chi-square (x^2_{table}) ($x^2_{count} < x^2_{table}$). This condition shows that H_0 It is accepted that there is no real difference between the number of male and female biota.

3.5. The Length at first maturity (Lm)

The Length at first maturity (Lm) is the size where 50% of the fish are in a maturity condition. Determination of Lm uses the Advanced Yolked (AY) oocyte development level, namely the development of oocytes where the fish begins to enter the adult class [27]. The results of observations that have been made regarding the Lm can be seen in table 5.

Table 5 *L. lentjan* when the length at first maturity (Lm).

Area	**Lm (cm)**	**95% level trust**
Sinjai Regency	24	23 - 25 cmFL
Bone Regency	24.6	24 – 25.23 cmFL

The length at first maturity (Lm) with a 95% confidence level in 53 samples of *L. lentjan* in Sinjai regency, it is estimated that the Lm of *L. lentjan* is 24 cm with a length range of 23 to 25 cmFL. Meanwhile, 61 samples of *L. lentjan* in Bone regency were 24.6 with a length range of 24 to 25.23 CmFL. Fish are said to have mature gonads, namely at GML III and GML IV. The higher the level of gonad maturity, the closer to spawning time. Gonad maturity is followed by the physiology of the fish's stomach getting bigger. This is because the eggs in the gonad increase in diameter before being expelled.

3.6. Catch Per Unit Effort (CPUE)

Based on Figure 7, it can be seen that CPUE experienced fluctuations, where CPUE in 2019 was 0.252 tons/trip and increased in 2020, namely 0.2577 tons/trip and fell again in 2021 to 2022, namely 0.221 tons/trip to 0.177 tons/trip then increasing again in 2023 amounting to 0.248 tons/trip. The highest CPUE was produced in 2020, namely 0.257 tons/trip, and the lowest CPUE in 2022, namely 0.117 tons/trip.

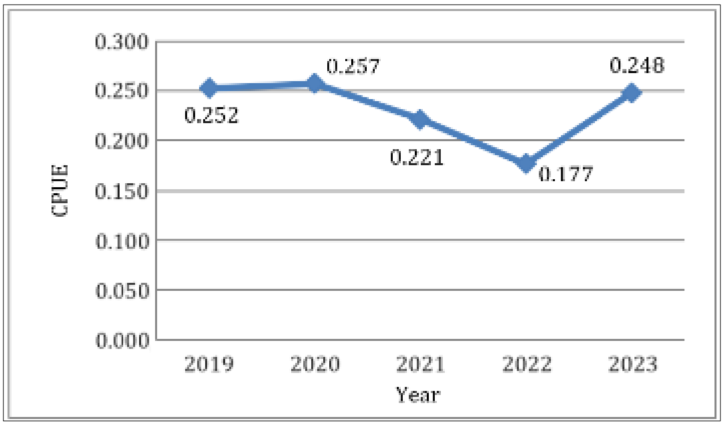

Figure 7 CPUE of *L. lentjan* in Sinjai regency.

Based on Figure 8, it can be seen that CPUE experienced fluctuations, where CPUE in 2019-2023 decreased, namely 0.263 tons/trip to 0.197 tons/trip and increased again in 2023, namely 0.235 tons/trip. The highest CPUE was produced in 2020, namely 0.263 tons/trip, and in 2022 the lowest CPUE was 0.197 tons/trip.

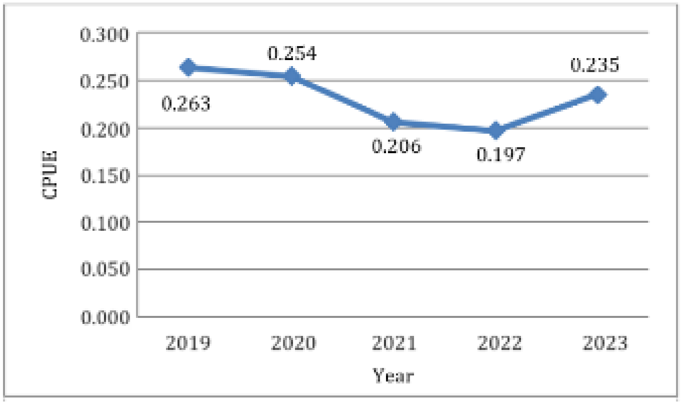

Figure 8 CPUE graph of *L. lentjan* in Bone regency.

3.7. Maximum Sustainable Yield (MSY)

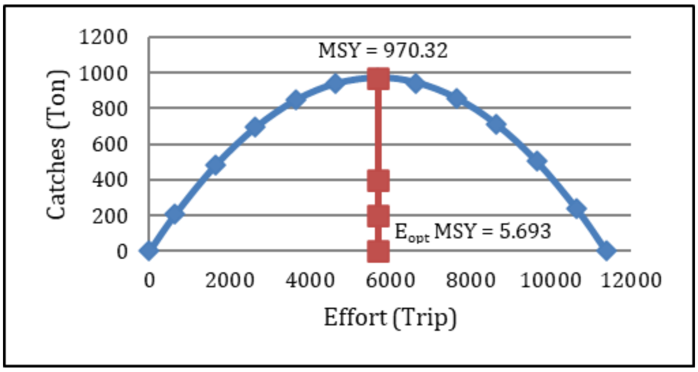

Figure 9 Maximum Sustainable Yield in Sinjai regency.

Based on figure 9 data on *L. lentjan* production in the last 5 years (2019 to 2023), sustainable fisheries production or MSY can be calculated using the Schaefer surplus production method. The sustainable potential value and optimum efforts of *L. lentjan* in Sinjai regency can be determined. Based on Schaefer model, obtained an optimum fishing effort value of 5693 trips per year and a maximum sustainable catch value of 970.32 tons per year. Has exceeded *Total Allowable Catch* (TAC) which is 80% of the MSY value, namely 776.25 Tons/year.

Based on Figure 10, *L. lentjan* production data in the last 5 years (2020 to 2024), sustainable fisheries production or MSY can be calculated using Schaefer's production surplus method. The sustainable potential value and optimum efforts of *L. lentjan* in Bone regency can be determined. Based on the Schaefer model, the optimum fishing effort value was found to be 4,910 trips per year and the maximum sustainable catch value was 726.76 tons per year. Has exceeded TAC which is 80% of the MSY value, namely 581.34 tons/year.

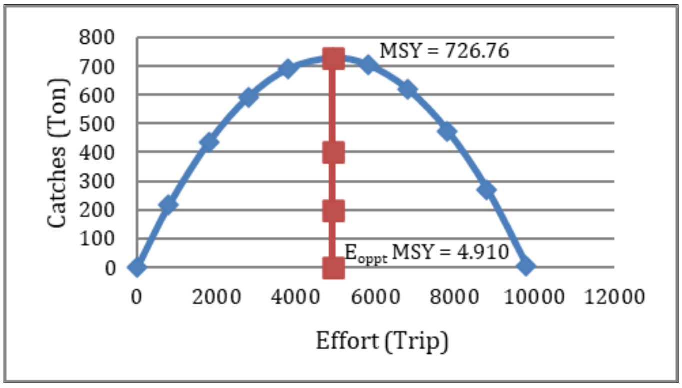

Figure 10 Maximum Sustainable Yield in Bone regency.

Based on international commitments made by FAO in *Code of Conduct for Responsible Fisheries* (CCRF) the potential of marine resources that can be utilized is around 80% of the maximum sustainable harvest level (TAC) of 80% of MSY [28].

4. Conclusion

- *L. lentjan* obtained during practice, namely 717 consisting of 405 samples in Sinjai regency and 302 samples in Bone regency, the highest class length was obtained in Sinjai regency, namely 22.4 to 23.7 cm for 98 samples and in Bone regency 22.5 to 24.1 cm in a total of 87 samples, samples of *L. lentjan* in both places were allometrically negative, namely the increase in length of *L. lentjan* was faster than the increase in weight.
- The sex ratio between male and female *L. lentjan* in percentage terms in Sinjai regency is 45% : 55%. From these percentages it is known that male and female *L. lentjan* have a ratio of 1 : 1.22 with the results of the chi square test $t_{count} < t_{table}$, Meanwhile for Bone regency it is 41% : 59%. From this percentage, it is known that male and female *L. lentjan* have a ratio of 1 : 1.43 with the results of the chi square test $t_{count} < t_{table}$, this condition shows that H_0 accepted, there is no real difference between the number of male and female biota.
- From the results of observations that have been carried out on the level of gonad maturity, it is estimated that the first length of gonad maturity in *L. lentjan* in Sinjai regency is 24 cm with a length range of 23 to 25 cm, while in Bone regency it is 24.6 cm with a length range of 24 to 25 cm.
- The highest CPUE in Sinjai regency was produced in 2020, namely 0.257 tons/trip, and the lowest CPUE in 2022, namely 0.117 tons/trip, while in Bone regency the highest CPUE was produced in 2020, namely 0.263 tons/trip, and in 2023 the lowest CPUE namely 0.197 tons/trip.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest to be disclose.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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