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Research Article

Growth and Mortality Rate of Scad (*Decapterus macrosoma*, Bleeker 1851) landedat Inengo Fish Landing Base, Bone Bolango, Gorontalo

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Abstract

This study aimed to determine the growth pattern and mortality of Scad (*Decapterus macrosoma*) landed at Inengo Fish Landing Base. A total of 400 fish samples were obtained from the catches of fishers who landed their catch at the landing base using the layered random sampling method. Sampling was carried out from February to March 2021 by measuring the length and weight of the fish samples. Data were analyzed using Microsoft Excel and the FiSAT II application. The results showed that the growth pattern of *D. macrosoma* was positive allometric with the asymptotic length ($L\infty$)= 279.54 mm, the coefficient of growth rate (K)= 0.49, and the theoretical age of fish (t0)= -0.18 years. The fishing mortality (F) was 2.44 per year; the natural mortality (M) was 0.43 per year; the exploitation (E) was 0.85.

Keywords: Bone Bolango, *Decapterus*, Layang, Mortality, Scad, Tomini Bay

1. Introduction

Bone Bolango is one of the regencies located in Gorontalo Province with about 1984.58 km^2, situated at an altitude of 0-15000 meters above sea level (Lihawa, 2019). The district is directly adjacent to Tomini Bay to the south, with fishery resources that can be developed for the regional evolvement (Pasisingi et al., 2020a). The Inengo Fish Landing Base is a marketing center for fish catches in the Gorontalo area in Bone Bolango established by the local government to lift the fishers's economy.

Gorontalo fishers catch various marine species in Tomini Bay (Pasisingi & Abdullah, 2018; Pasisingi et al., 2020b; Mustika et al., 2021; Pasisingi et al., 2021a; Pasisingi et al., 2021b), then some land their catch at the Inengo Fishing Port. However, uncontrolled fishing undertakings might threaten the sustainability of the fish resources. The catch of scad fish was recorded at 510,458 tons/year, mackerel 147,987 tons/year, tuna as much as 57,825 tons/year, and skipjack 40,615 tons/year (PSDKP South Leato, 2020). One species of Scad that is often found in the Inengo Fish Landing Base is *Decapterus macrosoma*.

The management of scad fish resources must be carried out sustainably (Najamuddin, 2013) to ensure the availability of the scad fish stocks to breed and reproduce. Therefore, this study aimed to determine the growth pattern, Von

Bertalanffy growth parameter values, mortality rate, and exploitation of Scad (*D. macrosoma*) landedat Inengo Fish Landing Base to demonstrate the fish stock condition in Tomini Bay.

2. Materials and Methods

Sampling was carried out four times, with a sampling time interval of two weeks from February to March 2021. The research location is Fish Landing Base Inengo, Huangobutu Village, Kabila Bone District, Bone Bolango Regency, Gorontalo (Figure1).

Figure 1. Map of sampling location of Scad fish (*D. macrosoma*)

Sampling in this study used the layered random sampling method by measuring the length and weight of fish caught by purse seine fishers who landed at the Inengo Fish Landing Base. The total samples measured were 400 fish which were randomly sampled from the baskets caught by fishers. During sampling, the number of fishing vessels operating is at least four units per day. Therefore, 25 fish were taken from each boat. The total length of the sample was measured using a ruler with an accuracy of 1 mm and then weighed using a digital scale with a minimum accuracy of 0.01 gram.

2.1. Age Group

The age group was determined using the Bhattacharya method (Sparre & Venema, 1999), specifically by grouping the collected data into several length range sizes, which were then calculated by the logarithm of the frequency of each length group. The logarithm difference of the length class group was mapped as follows: the middle class's median value was used as the X-axis, and the difference in the logarithm of the frequency of the length class was used as the Y-axis. By drawing a straight line from the point representing the value of the significant logarithm difference to the most minor point, the age group was obtained at the intersection of the X-axis with a straight line.

2.2. Length-Weight Relationship

Fish growth patterns can be identified by determining the relationship between length and weight of fish based on the following equation calculation (De Robertis & Williams, 2008):

$$W = aL^b$$

description:

W : fish body weight (gram)

L : total body length (mm)

a, b : length-weight equation coefficient

To test the relationship between the length and weight of the fish data, an analysis of the correlation coefficient (r) was carried out using Microsoft Excel uses the following formula:

$$r = \frac{n\,\Sigma x_i y_i - (\Sigma x_i \,.\, \Sigma y_i)}{\sqrt{[n\Sigma x_i^2 - (\Sigma x_i)^2][n\Sigma y_i^2 - (\Sigma y_i)^2]}}$$

description:

r : correlation coefficient of length-weight body fish relationship

n : the number of total samples

yi : weight of fish samples

xi : length of fish samples

2.3. Fish Growth

Estimation of growth parameters using the growth formula of Von Bertalanffy(Sparre & Venema, 1999) is as follow:

$$Lt = L_{\infty} (1 - e^{-K\,(t-to)})$$

description:

Lt : fish length at age t (mm)

L∞ : asymptotic length of fish (mm)

K : growth rate coefficient

t0 : theoretical age when the fish at 0 mm in length (year)

t : fish age (year)

2.4. Mortality Rate and exploitation

Natural mortality was estimated by using Pauly Empirical equation (Pauly, 1984)

$$\text{Ln } M = 0.8 \exp(-0.152 - 0.279 \text{ Ln } L_\infty + 0.6534 \text{ Ln } K + 0.4634 \text{ Ln } T^0C)$$

description:
L_∞ : asymptotic length (mm)
K : growth rate coefficient
T : average water surface temperature (^{0}C)

Total mortality was estimated by the equation proposed by Beverton and Holt (1956) formula as follow (Sparre & Venema, 1999):

$$Z = K \frac{L_\infty - \bar{L}}{\bar{L} - L'}$$

description:
Z : total mortality rate (per year)
K : growth rate coefficient
L_∞ : asymptotic length of fish (mm)
$\bar{L}$: an average length of fish caught (mm)
L' : the minor limit of the size class length of fish caught (mm)

Capture mortality and exploitation rates were calculated using the following formula (Sparre & Venema, 1999):

$$F = Z - M$$

$$E = \frac{F}{Z}$$

description:
F : fishing mortality rate (per year)Z
: total mortality rate (per year)
M : natural mortality rate (per year)E
: exploitation value

3. Results and Discussion

3.1. Results

Scad is a type of fish belonging to the small pelagic fish group of the Carangidae family, which has an essential economic value in Indonesia (Figure 2). The total length of the Scad (*D. macrosoma*) in this study ranged from 180 - 235 mm, with an average length of 203 mm. While the bodyweight of the fish obtained ranged from 44 to 129 grams, with an average value of 77.19 grams.

Figure 2. Scad Fish (*Decapterus macrosoma*, Bleeker 1851)

The total number of *D. macrosoma* obtained in this study has a total-length range of 180 – 235 mm. The mapping result of the logarithm of the total length-frequency to the average overall fish length shows two age groups of Scad fish (Table 1). The first and the second age group (L1, L2) have an average total length of 194.52 mm and 223.17 mm, respectively.

Table 1. Distribution of the total length of each age group of Scad (*D. macrosoma*) landed at Inengo Landing Base

Age Group	Total-Length Range (mm)	Number of Fish	Percentage (%)
I	180 – 185	45	11.25
	186 – 191	59	14.75
	192 – 197	66	16.5
	198 – 203	58	14.5
	204 – 209	46	11.5
II	210 – 215	20	5
	216 – 221	32	8
	222 – 227	40	10
	228 – 233	24	6
	234 – 239	10	2.5
Total		400	100%

The results of the analysis of the relationship between the length and weight of the Scad (*D. macrosoma*) in each sampling period have a high correlation coefficient (r > 0.9), as shown in Figure 3, Figure 4, Figure 5, and Figure 6.

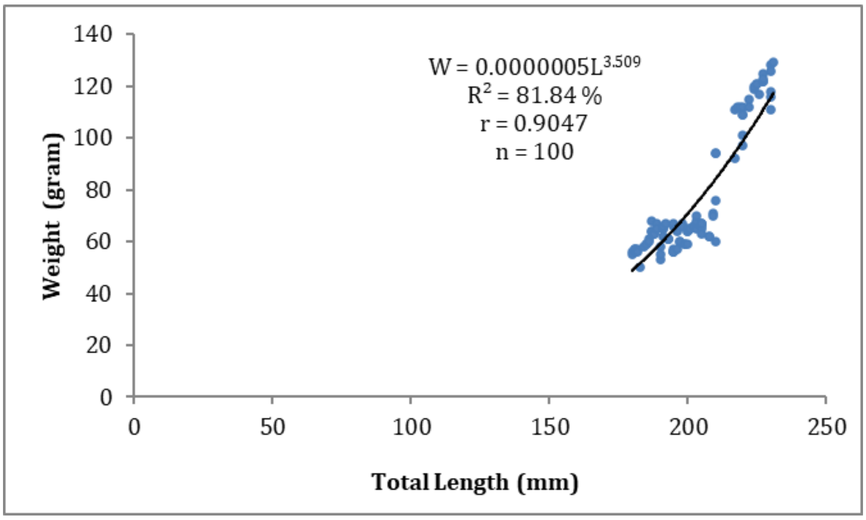

Figure 3. The relationship between the length and weight body of *D. macrosoma* in the first sampling

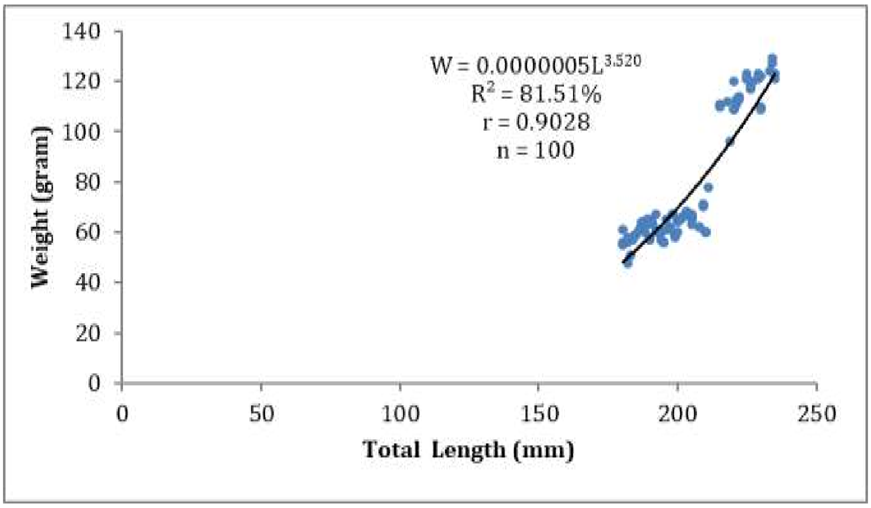

Figure 4. The relationship between the length and weight body of *D. macrosoma* in the second sampling

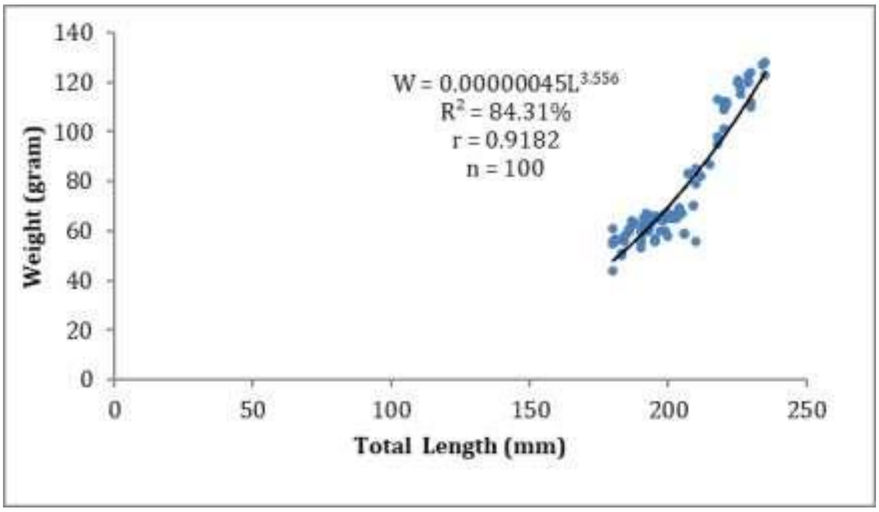

Figure 5. The relationship between the length and weight body of *D. macrosoma* in the third sampling

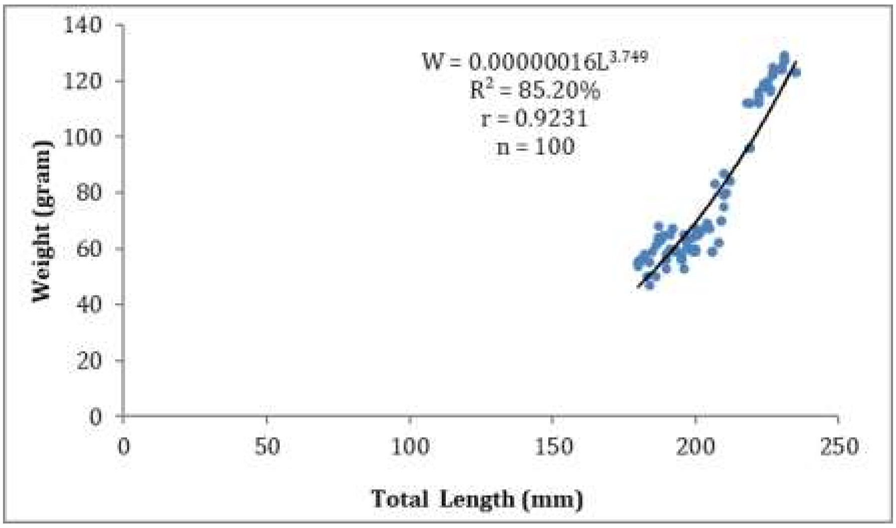

Figure 6. The relationship between the length and weight body of *D. macrosoma* in the fourth sampling

Based on the collective data analysis for four sampling times, the equation of the Von Bertalanffy model of *D. macrosoma* that landed at Inengo Fish Landing Base is $L_t = 279.54\ (1 - e^{-0.49\,(t + 0.18)})$ as presented in Figure 7. The length growth of the Scad (*D. macrosoma*) will slow down as the fish ages and become relatively constant when they reach their asymptote length.

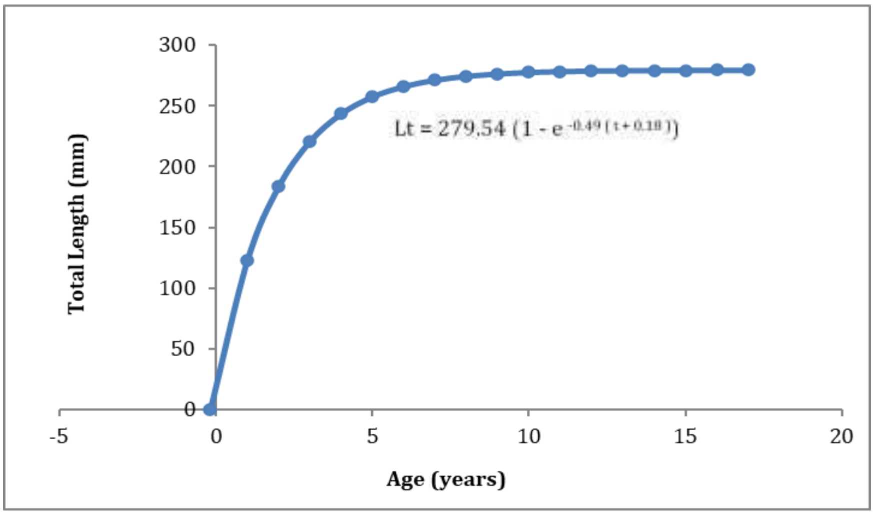

Figure 7. The growth curve of *D. macrosoma* landed at Inengo Fish Landing Base

The total mortality, natural, and scad fishing in this study showed a reasonably high number. The quotient of the value of fishing mortality (F) with total mortality (Z) will increase the exploitation rate, as presented in Table 2.

Table 2. Mortality value and exploitation rate of *D. macrosoma*

Parameters	Estimation Value
Total mortality (Z)	2.87 per year
Natural mortality (M)	0.43 per year
Fishing mortality (F)	2.44 per year
Exploitation (E)	0.85

3.2. Discussion

Age Group

The Scad Fish length is 250 mm at a minimum and can grow to a length of 300 mm. The two common characteristics are a finlet behind the dorsal fin and a lateral scute on the lateral line. The fish is a fast-swimming, pelagic, and migratory species (Astin, 2015).Based on the estimation of the age group and the frequency distribution in each class, it was found that the fish caught were at the young age group. 68.5% of the distribution of fish caught were in the first age distribution (Table 1). It indicates that the Scad fish landed at the Inengo Fish Landing Base are generally still in the early stages of growth. This phenomenon has the potential to threaten the sustainability of the species in nature due to Desmawanti et al (2013) stated that the large number of fish caught at a young age would raise the suspicion that there has been growth overfishing where many fish caught at a young age resulting in a minor number of fish reaching their old age. The opportunity for fish to grow and regenerate is minimal.

Length Weight Relationship

The correlation coefficient value of the fish weight equation in this study indicates that the relationship between the length and weight of the *D. macrosoma*has has a solid correlation. Damayanti (2013) states that the correlation coefficient value, which ranges from 0.9 - 1.0, indicates a robust correlation. The results of the t-test conducted on the value of the b coefficient showed that the growth pattern of *D. macrosoma* was positive allometric, where weight growth was more dominant than length growth. It is similar to Lawadjo et al. (2021) reported that *D.russelli* has a positive allometric growth pattern. Different results were reported by Radongkir et al. (2018) based on the sampling of *D. macrosoma* in March – June 2015 from Manokwari Regency Waters, which showed a negative allometric growth pattern.

According to Pasisingi et al. (2020), fish with a positive allometric growth pattern have a relative plumper body than fish with negative and isometric allometric growth patterns. Variances in growth patterns based on the value of the b coefficient do occur in the same species and in the same population at different times and areas. This circumstance is affected by differences in aquatic environmental conditions (Effendie, 1979 *in* Wulan, 2017), food availability, and seasons (Pasisingi et al., 2021b).

Growth Parameters

Based on the growth curve, it can be seen that the growth of the fish initially runs fast and then begins to slow down as it approaches its maximum length. The value of the growth rate coefficient (K) in this study categorizes a high data rate, so it takes a little time to reach its asymptotic length. This is in line with the research results conducted byNursinar & Panigoro (2015), with a sampling time of once a week during April – June 2015 in Gorontalo waters. The study showed that the coefficient value of the growth rate of *D. macrosoma* is included in the high category, equal to 0.49, with only a tiny amount of time to reach its maximum length. In addition, the value of K can also describe the recovery condition of a population of fishery resources. The higher the K value, the faster the recovery of fish stocks in a population will be. Meanwhile, if the K value is low, the slower the condition of fish recovery in the waters (Wulan, 2017). K is a curvature parameter that determines how quickly the fish reaches its asymptotic length (Sparre & Venema, 1999). Therefore, the high and low value of K is relative. The recovery condition may vary for each species, predisposing by environmental, biological, and mortality rates (Atmaja & Nugroho, 2019).

Estimation of fish growth rate aims to determine the speed of change in fish growth in a population in a particular time and to know the growth rate of fish. Based on the Von Bertalanffy growth model analysis on the growth parameters of *D. macrosoma* (L_∞, K, and t_0), the asymptote length (L_∞), growth rate coefficient (K), and theoretical ageof fish (t_0) were obtained which varied compared to several values of the growth parameter of Scad sampled from the other waters (Table 3).

Table 3. Comparison Von Bertalanffy growth parameters of Scad Fish in several areas

Species	Sex	L_∞ (mm)	K	t_0	Sampling Area	Sampling Period	References
D. macrosoma	Male & Female	279.54	0.490	-0.180	Tomini Bay	February 2021 – March 2021	This research
D. macrosoma	Male & Female	306,35	0.330	-0.030	Bone Bay	November 2012 – December 2012	Sari (2013)
D. macrosoma	Male & Female	210.80	0.740	-	West Papua Waters	April 2013 – September 2013	Sururi et al. (2017)
D. russelli	Male & Female	288.00	1.018	0.509	Riau Islands	March 2013 – May 2013	Desmawanti et al (2013)
D. macrosoma	Male & Female	257.60	0.499	-0.467	Gorontalo Waters	April 2012 – June 2012	Nursinar & Panigoro (2015)
D. russelli	Male & Female	242.50	1.030	-0.163	Malacca Strait	April 2016 –	Faizah & Sadiyah (2019)

						September 2016	
D. russelli	Male	223.76	1,634	-0.265	Gorontalo Waters	April 2015 – June 2015	Thalib (2016)
	Female	218.60	1.190	-0.167			

Mortality Rate and Exploitation

Two factors cause a reduction in the number of fish in the wild, namely natural mortality (M) and mortality due to fishing activities (F). Death is caused by disease, predation, and other natural factors (Pasisingi, 2011). As for fishing mortality (F), death is all caused by fishing activities. The mortality rate of *D. macrosoma* based on this study showed that fishing activities mainly caused the rate. It can be seen in the value of fishing mortality greater than natural mortality (F > M). It indicates that the *D. macrosoma* landed in Inengo is under fishing pressure. According to Zamroni et al (2019), the fishing mortality value is higher than the natural mortality value; it indicates that fishing pressure has occurred. The high value of fishing mortality and the low value of natural mortality can describe the condition of overfishing.

According to Pauly (1984), the optimal exploitation value is 0.5. Therefore, the exploitation value in this study (E = 0.85) indicates that the utilization of Scad (*D. macrosoma*) resources by fishers in Inengo has exceeded the optimum catch limit. The results of this calculation have the same value as the research conducted by Sari (2013) and are slightly different from some of the other previous studies (Table 4). The results vary possible due to environmental factor and the population condition that need to be reviewed in detail which is in this research was not assessed.

Table 4. Mortality Rate and Exploitation of Scad Fish from several water areas

Species	M	F	Z	E	Area	Sampling Period	References
D. macrosoma	0.43	2,44	2.87	0.85	Tomini Bay	February–March 2021	This research
D. macrosoma	0.37	2,07	2.44	0.85	Bone Bay	November–December 2012	Sari (2013)
D. macarellus	1.10	1.20	2.30	0.53	Sulawesi Sea	January–November2018	Zamroni (2019)
D. russelli	0.97	1.11	2.08	0.53	Malacca Strait	March 2020	Alnanda et al (2020)
D. macrosoma	1.68	0.82	2.50	0.33	West Papua Waters	April–September2013	Sururi et al (2017)

Conclusion

The growth pattern of Scad Fish (*Decapterus macrosoma*) landed at Inengo Fish Landing Base, Gorontalo, was a positive allometric based on the sampling period from February to March 2021. The asymptotic length (L∞) was 279.54 mm, the coefficient of growth rate (K) was 0.49, and the theoretical age of fish (t_0) was -0.18 years. The fishing mortality value (F) was 2.44 per year, the natural mortality rate (M) was 0.43 per year, and the exploitation value (E) was 0.85.

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